

Between Adaptation and Mitigation

The Nineteenth-century North Sea Storm Surges and the Entangled Socio-Natural Transformation of the Limfjord Region, Denmark

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Editorial

The hybridity of nature is a crucial concept in this thematic issue of the *Journal for the History of Environment and Society*. When environmental historians talk about hybrid nature, they argue that nature is continuously reworked, transformed or coproduced by humans. Nature invariably is 'second nature' which would not have existed without human interference. This is certainly the case in today's 'anthropogenic' world, but the roots of this hybridity are situated in a more distant past. After all, even hunter-gatherers could significantly modify their environment, by selective hunting or by fostering the spread of certain species. Conceiving nature as a hybrid does not imply an idea of human control or active 'steering' of nature. On the contrary, if there is anything we learned in 2021, it is that nature cannot be controlled. For almost two years now, people all over the world are struggling to mitigate the impact of the Covid-19 pandemic on health and wellbeing. The zoonosis which most probably triggered the pandemic might have been linked to human-induced climate change, or human interference in the natural habitat of certain species, but it was not actively 'steered' by humans. In the same way, the river floods which ravaged Eastern Belgium and Northwestern Germany in July 2021, as well as the massive droughts and wildfires in Mediterranean Europe, the Southwest of the United States and the boreal forests of Siberia and the Arctic were dangerous coproductions of anthropogenic climate change and human management of forest resources. Time and again, we see governments, households and individuals desperately trying to manage and mitigate the impact of a seemingly endless series of natural disasters, coproduced but not controlled by society.

The coastal environments which are central in this issue are perfect illustrations of this hybridity. From Venice to the French Atlantic coast and the North Sea, coastal environments have been constantly reworked by humans for centuries, thereby unleashing dynamics which could not be controlled. Storm surges (Bo Poulsen) or molluscs (the shipworms in the contribution by Michael-W. Serruys) unleashed socio-environmental changes which were not actively planned for by humans, although humans usually adapted to them along the lines of prevailing economic and power relations. But coastal landscapes are also hybrids in other ways: they are 'terraqueous', as the editors of this special issue, Romain Grancher and Michael-W. Serruys, explain in the introduction to the volume, they are

both water *and* land, the two intrinsically linked to one another. And just like humans tried – in vain – to stabilize coastlines as clear demarcations between land and sea, historians have tried – equally in vain – to approach coasts either from the sea (as part of marine history) or the land (as part of the history of land reclamation). The hybrid, terraqueous, approach advanced in this volume unravels the variable ways in which humans tried to deal with this hybridity of the coast. To cite but two examples: the article of Solène Rivoal shows how both the Venetian authorities and the farmers of fish grounds strategically conceived the lagune as either ‘land’ or ‘water’ in order to appropriate its resources. And in his contribution to this special issue, Mathias Tranchant explores the relocation of port cities along the Atlantic coast of France and the Low Countries in response of shifting coasts and estuaries, and also the reasons why this flexibility in land-use did not persist into the later Middle Ages and the Early Modern period.

Finally, we want to remind the readers that the *Journal for the History of Environment and Society* is open for contributions of all kinds irrespective of their disciplinary nature, provided that they have a broad scope and are dealing with the environment in a broad sense of the word, and place the interactions between human behavior and the physical environment in their historical context. All articles of the journal are submitted to a high-standard procedure of blind peer-review. Once the editorial process has been finalized, the articles will be immediately published in open-access, which will greatly enhance their circulation and impact. On the other hand, the publisher does provide a printed version, further extending the outreach. As a result, we are fully convinced that JHES continues to fulfill its role as a leading journal in the field of environmental history.

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Between Adaptation and Mitigation

The Nineteenth-century North Sea Storm Surges and the Entangled Socio-Natural Transformation of the Limfjord Region, Denmark

▼ **ABSTRACT** This article presents an assessment of nineteenth century socio-natural transformations in the Limfjord region of northwest Denmark in light of the dramatic impact of several storm surges. The 1825 storm surge breached the narrow isthmus previously separating the North Sea from the brackish Limfjord, while later storm surges affected both the shore and the fjord. The consequences of particular historical events highlight the value of combining the impact of natural hazards at the North Sea shoreline, with socio-economic developments in the hinterland as well as what unfolded beneath the surface. Inspired by contemporary disaster history the first section discusses the immediate and intermediate flood responses. The second section focuses on the development of infrastructure, trade and commerce in the face of a changing natural environment. Enthused by marine environmental history, the third section revolves around the changing connectivity between humans and life in the sea providing an assessment of local fisheries and the changing marine ecosystem in the Limfjord. The multitude of socio-natural transformation processes shows how sudden events such as storm surges can reverberate for several decades in constant interaction with underlying structural socio-natural developments, moving at a pace unrecognized in their own era.

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▼ **KEYWORDS** Natural hazards, Marine Environment, Fisheries, Socio-Natural Sites, Coastal History

Introduction

In early February 1825, a violent storm hit the Eastern shores of the North Sea from the Netherlands to Denmark, and drowned the low-lying areas of the Waddensea and up the river Elbe to Hamburg. Densely populated areas in the Netherlands and in Hamburg were devastated. In total, 800 lives were lost to the immediate impact of the storm. The Danish west coast at first seemed less hard hit by the 1825 storm than most of the more southerly stretches of the North Sea shoreline. Danish newspaper reports at first centered on the losses in Hamburg and the Waddensea area. Only after a couple of weeks, did the gravity of the ensuing flood in the Limfjord area in the Northwestern part of the country emerge in the Danish newspaper reports. To the North of the Danish part of the Waddensea, the shoreline extended into sparsely populated areas with sandy beaches and no natural harbours, or manmade ports for that matter, all the way to the tip of the Jutland peninsula at Skagen. On the night between 3 and 4 February, the violent storm surge coming from the North Sea ripped open a sizeable gap into the dunes at Agger and Harboøre, in North West Jutland, where an isthmus had hitherto separated the sea from the brackish Limfjord. Until 1825, the Limfjord area had been sealed off from the North Sea by a 20 km long and c. 500-3000 meter wide barrier consisting of sand dunes. The Limfjord was an actual fjord or inlet with the only entrance to the water system on the Eastern Kattegat side of the Jutland peninsula at the town of Hals. To the west of the dunes, the North Sea roamed with a salinity of 35 parts per thousand, while the deepest part of the fjord behind the dunes was brackish containing less than 10 parts per thousand (see Figure 1).

The area consisted of two parishes with less than a couple of thousand inhabitants in total. The direct impact of the storm surge did not cause any deaths, but within the following weeks, years and decades, the consequences of this one event, and several successive storm surges – chiefly in 1839 and 1862 – unfolded in a variety of ways. The following sections present an assessment of how the storm affected the entanglements between nature and society in nineteenth century North West Jutland; and how both the natural and the social system responded. This article seeks to combine the realm of these two systems into one coherent story, where the consequences of particular historical events highlight the value of

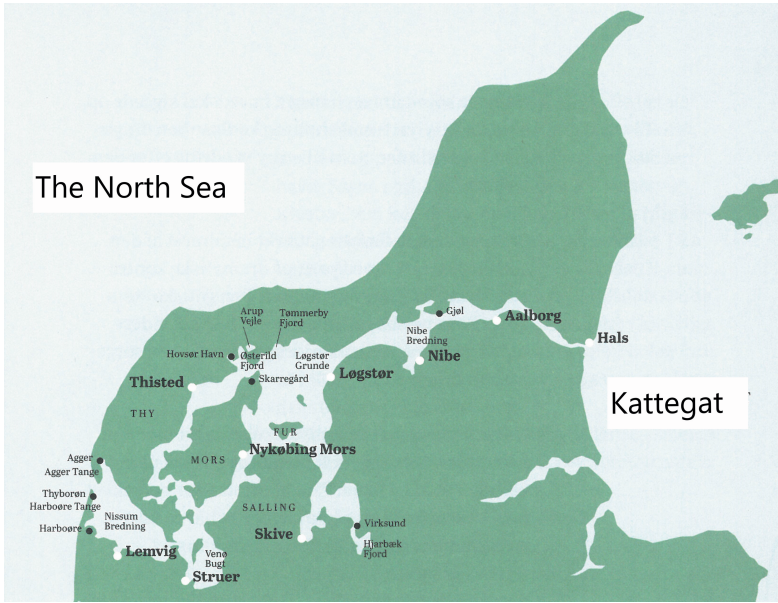


Figure 1: The Limfjorden area in the Jutland peninsula, Denmark.

Source: map adapted from Poulsen, (2019a).

combining the impact of natural hazards at the North Sea shoreline, with socio-economic developments in the hinterland as well as what unfolded beneath the surface.

Embedded in the systemic approaches of socio-natural transformation (Gross-Winiwarter, 2015; Winiwarter-Schmid, 2020) the following assessment points towards the destruction, development and transformations of several socio-natural niches. As a concept, socio-natural sites, sometimes referred to as socio-ecological sites, is a concept used to investigate interactions in the world of hybrids between society and nature without reproducing ontological differences between the two. This approach is inspired by the field of social ecology, emphasizing the transformative aspects of systemic frameworks over time (Winiwarter et al., 2013). Three sections below explore the spheres of socio-natural connectivity over time.

Inspired by contemporary disaster history the first section discusses the immediate and intermediate flood responses. Commentators used to consider natural disasters as something outside of the realm of human society, but during the last 15-20 years scholars have sought to bridge the natural and societal worlds. Now, disasters are looked upon as a human construct of the impact of a natural hazard (Mauch-Pfister, 2009; van Bavel-Curtis, 2016; van Bavel et al., 2020). This opens the field for discussions as to how, in both past and present, disasters are contingent

upon, and entangled into human experience and societal developments. Hence, they are historical constructs just as much as more traditional historical concepts such as class, race and gender. These developments are reflected in important works on the impact and nature of both storms and floods (de Freitas-Dias, 2013; Soens, 2013; van Dam, 2017; Soens, 2018), earthquakes (Parrinello, 2015) and more gradual disasters such as desertions due to soil erosion (De Keyser, 2016).

Nonetheless, by no means does this render the historiography of social and economic history superfluous. We will see in this article's second section on trade and commerce in the Limfjord region how the inclusion of geography in the more traditional *histoire totale* ambition has informed previous scholarship on the development of trade and commerce in a changing natural environment (Holm, 1999; Olesen-Ringskou, 2009; Braudel, 1972; Wallerstein, 2011; Holm, 1991). The analytical framework of structural societal history, emphasizing the importance of recurring events lends itself well to interdisciplinary undertakings. The third section of the article deals with just that.

The third section of socio-natural transformation revolves around the changing connectivity of man and life in the sea providing an assessment of the changing marine ecosystem in the Limfjord, enthused by the field of marine environmental history. Marine environmental history has evolved over the past couple of decades as a subfield of both marine ecology and environmental history. In much marine environmental history, such as this article, there is a desire to use historical documents and past local ecological knowledge to reconstruct past ecosystems and the links with past human society (Schwerdtner Máñez-Poulsen, 2016; Schwerdtner Máñez et al., 2014; Poulsen et al., 2007). The combination of marine environmental history and the history of disasters have previously been studied in the context of the river Danube (Winiwarter et al., 2013), yet this article is among the first attempts to do so in a North Sea setting.

Facing the sea between adaption and mitigation

This first section explores in two parts the way Danish society and local communities along the North Sea coast responded to frequent storm surges over the course of the nineteenth century. Adaptation to the changes brought about by the storms and storm surges marks the period until 1870. Then, from c. 1870, the Danish state intervened with the construction of 55 groynes along the coastline. This intervention is a marked departure from early, essentially early modern adaptive strategies to cope with storm surges. This marks a socio-natural transition towards mitigation of the impact of future storms and storm surges. This is not to say that mitigation did not take place before. The creation of small, locally maintained

dikes made from dung from middens was a feature before the eighteenth century. In the same way, efforts were made since the seventeenth century to cover the dunes with sand rye grass (Vrist Langer 1980). But, as we will see below, the coping strategies until c. 1870 included a plethora of adaptive measures ranging from outbound migration to fewer child births per household. From 1825 onwards immigration was frequently supported by relief aid, and several times complete resettlement of small villages was on the table.

The Danish west coast development mirrors, albeit on a smaller scale, the transformation of Dutch coastal lands, where early modern adaptation strategies gave way for modern control mechanisms (van Dam, 2017). Research lies ahead to assess whether or not there was a class divide as to who suffered more than others did, when violent seas hit the shore of the Danish west coast. This is evident in other studies of the natural hazards in the North Sea area. (Soens, 2013; De Keyzer, 2019) Therefore, it is very likely that adaptive strategies were available at an uneven scale across the specter of social stratification, but this is the topic of current (2019-2023) research project, *Living on the Edge*, and beyond the scope of this paper (Poulsen, 2019b).

Adaptive strategies

The 1800s was a period of demographic transition all over Europe. Falling mortality rates in combination with a high birthrate caused the population to rise, Denmark was no exception. In the countryside, more and more people had to live off the land, and there were limits to how much new land could be tilled. Thus, migration intensified to towns and to the city of Copenhagen in particular. Only towards the end of the 1800s did birth rates start to drop (Johansen, 2000). However, in the two parishes on the Limfjordstangen, Agger and Harboøre, population numbers stagnated during the 1800s. This suggests two developments differing slightly from developments in most other rural parishes in this era. Firstly, based on parts of the then resident population, one commentator has suggested that the fishing families in the area had fewer children per household than elsewhere, on average only 2-3 children (Christiansen-Mathiesen, 1974). To test this hypothesis, further research is needed, but the idea suggests that the inhabitants of these particular coastal areas had developed a peculiar coping strategy. Something Maïka de Keyzer has shown to exist in sandy heathland areas in Flanders as well (De Keyzer, 2016). Secondly, there was on balance an outbound migration away from the area, in part linked to the devastating storm surges. Church registers in Denmark in this period sometimes hold records of who was moving in and out of the parish. For Agger parish these are preserved, and in addition to the routine,

annual migration of servants in and out, a handful of entire families moved away in the aftermath of some of the great storms of the 1800s.¹

To help the victims and to support the migrants, several initiatives were taken to provide finances, in particular through charities. The dire situation of the area was recognized as far away as the nation's capital – Copenhagen. In Copenhagen, student societies established a charity in support of people wishing to move away from the area. To raise awareness of the charity the most popular Danish poet at the time, Adam Oehlenschläger (1779-1850) composed the poem 'Oversvømmelsen', where he asks for the God of the ocean, Neptune, to intervene and curtail his anger with people. Sympathy rose nationwide, and in total 3,562 Rigsdaler was collected to help families in need on the narrow stretch of land and dunes between the North Sea and the Limfjord (Vrist Langer, 1980). A similar phenomenon occurred in The Netherlands, where many more lives were lost, and songs commemorating the events in 1825 became a popular trope in national folklore (Jensen, 2019). The next challenge was to allocate the funds in a fair and orderly manner. The county sheriff in Thisted was keen on seeing funds directed at the poor, which he felt would have the hardest time recovering from the natural disaster. The local district bailiff on the other hand, differed in his opinion. He also chaired the local board of overseers for poor peoples' house and at a meeting with the people of the Røn settlement (later Thyborøn) on the isthmus, he declared that 'It is ungratefulness towards providence and reckless behavior to ask for help for no good reason, and many people who are fully capable of helping themselves actually have complained' (Vrist Langer, 1980). In the end, some of the collected funds were saved for future disasters, but help did go out for families wanting to move away and resettle elsewhere. In 1825 and 1826, 72 people moved away from the Harboøre parish. The destination was not far away. Some 30 kilometer to the east at Lyngs parish on the Thyholm peninsula a colony developed with each family acquiring a plot of land near the shores of the Limfjord (Christiansen-Mathiesen, 1974). Following the 1839 storm flood, a nationwide charity was set up again, aiding the push from another wave of emigration. This time some of the fishing families resettled further inland, but still next to the Limfjord around the Salling peninsula and the island of Mors. Here, they would typically rent land close to the fjord from a local proprietor to allow them to continue fishing, while maintain a base for shelter and caretaking of their fishing gear (Graugaard, 1992).

The 1862 storm was next to wreak havoc to the extent that houses, and farmed areas were destroyed on a large scale. and this storm surge cut a new hole between the North Sea and the Limfjord just north of the Røn

¹ Rigsarkivet, Agger Sogns Kirkebog, 1814-1868.



Figure 2: Once the isthmus was breached, maps from the nineteenth century appear to indicate how rapidly the small stretch of land was shifting in an easterly direction. Almost all land c. 1800 is now in the North Sea. The current isthmuses are fixated by the groynes built in the last few decades of the nineteenth century.

Source: Map adapted from Poulsen, 2019a.

settlement. Applying for government relief aid to the Ministry of Interior, a sizeable portion of the local population moved away on funds partly left over from the 1825 and 1839 storms. From the village of Agger in the northern part of the isthmus, 12 families left simultaneously on the same day to form a new fishing village, Lyngby some 20 kilometers to the north. From Harboøre Sogn 29 people moved to the small island Jegindø in the Limfjord, where they joined former villagers who had moved from Harboøre to Jegindø in 1841. In the following years another 70 people settled in Jegindø, a small island, where the settlers from the North Sea coast heavily influenced the local culture. The level and intensity of fishing as well as certain fish dishes testify to the changes occurring at Jegindø (Poulsen, 2019a). Figure 3 shows the spikes in outbound annual migration clearly linked to the turbulence caused by storm surges over the same decades.

Meanwhile on the isthmus the situation remained dire, and in 1866, county sheriff Voigt suggested in a letter to the Ministry of Interior that all the remaining 20 families at Røn should abandon their homestead and resettle near the town of Struer facing the Limfjord some 40 kilometers to the east. His idea was to allocate 3-4 acres of land for each family as well as letting them continue their fishing. As the railroad had just reached Struer, they would have the opportunity of reaching new export markets with fresh fish in this way. The government in Copenhagen looked favourably at the plan, and allocated 3,000 Rigsdaler for the project to materialize, which it never did. The government was hopeful that at least some of the inhabitants would remain in the area, but the mass exodus never took place. One reason being that yet another storm in 1868 gave cause for alternative proposals (Vrist Langer, 1980).

On 6 February 1868, another North Sea storm hit the west Jutland shoreline. The water rose so much as to inundate the entire southern part of the isthmus at Harboøre. All dikes broke and the Nørlander settlement disappeared in the sea altogether. Several people needed rescue from the rising waters, but no one drowned. Once more, the Achilles Heel of the area was considered the lack of proper coastal protection. At Nørlander for instance, the dikes were constructed using dung from the farms' middens (Vrist Langer, 1991). This traditional method was increasingly insufficient from the point of view of greater societal expectations, but also due to the 19th intensification of coastal erosion in the area. The dynamic effects of the breach of 1825 appear to have functioned as a tipping point for a more volatile coastal zone.

Mitigation

The 1870s marked a new era of trying to mitigate the impact of the forces of nature as opposed to mainly adapt, which in recent decades had meant moving away. The Danish government formed a commission in 1874 to recommend how to re-inforce the 1862 hole in the isthmus and protect the coastline at large. The next year in 1875, the first of many groynes was constructed aimed at stopping the water from stripping the isthmus from too much sand. Over the course of the next three decades, 200 men assisted by an interim railroad track and an onsite cement factory built no less than 55 groynes over a stretch of c. 30 kilometers. By 1909, the system of groynes was complete. The violent storms continued, sometimes providing a backlash to the construction work, but since then the impact from storms and storm surges has never reached the same level of disaster along the shores of the Agger Tange and Harboøre Tange (Vrist Langer, 1980). Moreover, the Røn settlement, from then on known as Thyborøn, was fitted with a quay on the leese of the Thyborøn Canal, as the 1862 opening is still known today. Soon a town developed, and from 1914, the

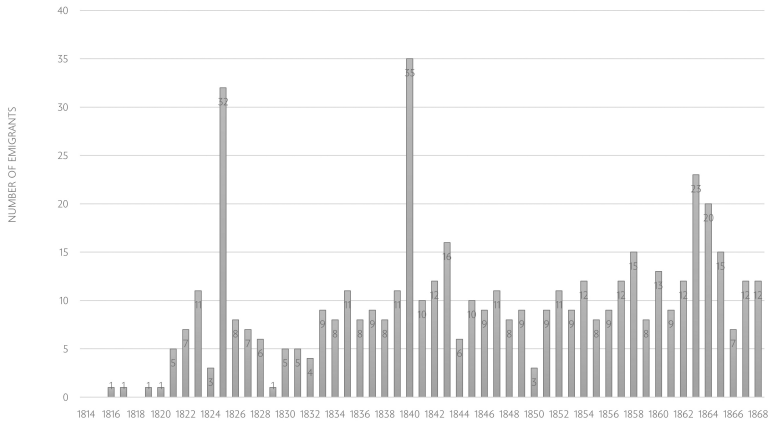


Figure 3: Church registers from Agger parish (1814-1868) show the annual number of emigrants from the parish. Three spikes occur in connection with major floods in 1825, 1839 and 1862.

Source: Rigsarkivet, Agger Sogns Kirkebog

government supported a modern port accommodating both fishermen, transportation and a shipyard (Ringskou, 2009). Towards the end of the nineteenth century, the net-decrease in population had stopped in the two parishes situated right between the North Sea and the Limfjord, and now the area more than re-populated with migrants from elsewhere looking for a job in the growing maritime sector (Vrist Langer, 1980).

Why then, did the Danish government show such an interest in an area hitherto regarded as belonging to the edge of society far from Copenhagen, and far from the more affluent areas and towns along the Kattegat and the Western Baltic Sea? This links in no small amount to the political development elsewhere. Following the 1864 war with Prussia, the southern half of the Jutland peninsula, forming the duchies of Schleswig and Holstein, fell to the emerging German empire. Losing the duchies, Denmark lost its direct shipping access to the North Sea. Through public-private partnership, the North Sea port of Esbjerg became the key infrastructural development, when finished in 1868, but in the northwestern part of Jutland, the canal connecting the Limfjord to the North Sea was vital to secure access from the towns of western Jutland with the open sea.

Summing up the history of direct nineteenth-century encounters between coastal settlements and the sea, an attempt to adapt to the changes brought about by the storms and storm surges marks the period until 1870. The decision to create a series of groynes and a new port at Thyborøn, as well as the still ongoing effort to sustain a navigable route

between the North Sea and the Limfjord, designates the rise of a more modern discourse of controlling nature, where the impact of storms are mitigated right on the beach. The deployment of modern technology as well as investments from the Danish government created a new socio natural site, sustaining life on the terms of modern society. The prime motor for this development is the emerging fossil fueled economy of the industrial revolution. The groynes was a manageable option in the context of how the industrial revolution had brought about railroads, steam technology and industrial cement plants. On the level of national politics, the investments in a corner of Denmark quite far from Copenhagen is seen here in light of a regional development policy of creating a modern infrastructure to facilitate trade and commerce.

Trade and industry responses

This second section of the article focuses on the development of trade and commerce in the face of a changing natural environment. In the case of the Western parts of the Limfjord, nature caused the initial opening of canals, while human labour and construction opened a second canal in the central Limfjord area in 1862. Thereby, this peripheral region obtained direct access to the economic centres of London, Amsterdam and Hamburg, bypassing the more semi-peripheral town of Aalborg. Trade and industry prospered tremendously in the Western part of the fjord in the decades following the opening of a navigable route between the North Sea and the Limfjord. Following Wallerstein (2011) and Heerma van Voss (2005), The Limfjord and Northwest Jutland region can hence be conceived as a peripheral region, influenced and transformed by economic and political centers, with the seas and rivers as the primary modes of transportation and connectivity (see Holm, 1991 and 1999 on the Skagerrak and Kattegat).

While officially a town with town rights, Lemvig, was in so many ways an inferior place before 1825. Located in the deepest part of the fjord, it was very complicated to engage in trade on more than a regional North Jutland scale. One commentator wrote of the town in 1735, that the church tower had fallen 50 years earlier with no repair in sight. The population of 298 people lived almost all in poor buildings timbered with thatched roofs. Formerly there had been a mill, but now there was not enough water in the lake. Local fishing in the fjord was difficult with little or no reward. The only positive note was the final statement: 'thank God, there is a healthy and fresh air' (Christensen, 1919). In the summer period, the few merchants in Lemvig enlisted sailors from the North Sea shores to man the tiny fleet of three small vessels to ship butter and meat out of the Western Limfjord to the rest of Denmark and bring back timber (Hoff-

mann, 1769). Along the way however, trade and commerce were hindered by geographical as well as political boundaries (Damgaard, 2018). Sailing from the far west through the sounds and bays of the interior Limfjord, the merchants reached the greatest physical barrier, Løgstør Grunde, about midway through the fjord. Here, the predominantly western winds funnel the shallow water into a narrow stretch of water with shifting mud banks lurking dangerously just below the surface. On a late seventeenth century navigational map, the sailing route through the Løgstør Grunde reveals less than one meter between sea surface and the bottom. As a consequence, all cargo shipped passed the Løgstør Grunde had to be offloaded before the ship could traverse the area. Locally in the small town of Løgstør, the obstacles for maritime freight created a business opportunity. More than a hundred people lived directly or indirectly from the activities associated with offloading cargo, moving it several kilometers over land, and then loading it onto the ship again (Bloksgaard, 2018). While a local success, the overall trade in the Limfjord area suffered from having two otherwise fine transportation systems separated by the obstacles of crossing the Løgstør Grunde. Yet, one other town was satisfied with the existing system, Aalborg.

Aalborg was the largest town in the Limfjord area with an eighteenth century population of 4,000-5,000. Situated at another narrow junction of the fjord system some 25 kilometers from where the fjord exited at Hals, Aalborg was perfectly situated to exert political and economic dominance in the area. The local merchants traded agricultural products and salted herring from the Limfjord all over Denmark and northward to Norway. Norway was part of the Danish king's realm until 1815 and came to be quite dependent on grain imports from Denmark, while Norwegian wood, metals and dried cod were chief Norwegian exports to Denmark. Aalborg was at the nexus of this trade and home to 66 freight ships in the latter half of the eighteenth century (Holm, 1999).

In 1807, the first of two major disasters hit Aalborg as Denmark-Norway came involved in the Napoleonic Wars on the French side. With the continental blockade, the British effectively cut off most trade between Denmark and Norway, thereby ruining the business model of the Aalborg merchants. Privateering alternatives proved to be unprofitable alternatives for the North Jutland region (Jensen et al., 2017).

Agger Canal – canal by chance

The second disaster for Aalborg was the breach of Limfjordstangen in 1825. The flow of water through the canal at Agger quickly widened and deepened the new entrance to the fjord. This gave merchant skippers in the Western part of the fjord a new route to sea far from the controls of the Aalborg customs house. In 1830, the first vessel slipped through

the canal coming from the North Sea side, and in 1834 the first larger freight vessel, a *koff* entered the Limfjord this way. The *koff* has a flat bottom and leeboards to compensate for the lack of keel, ideally suited for shipping in shallow coastal waters (Svalgaard, 1977). Quickly, merchants in the small towns of the western Limfjord saw a business opportunity evolve, and from 1835 ships poured in and out of the new canal. The Danish government authorized a system where pilots would help navigate ships. The registers for pilotage allows for an estimation of the emerging direct trade between the Limfjord area and the wider world. From humble beginnings, the volume of trade grew steadily over the next decades: More than 1,500 vessels passed through the Agger Canal in the 1850s (Figure 4).

Over time the passage of the Agger Canal became very difficult. A flow of water and sand continued to drift in the system, and from the latter half of the 1850s the hitherto most used canal, the Agger Canal ceased to function as a safe passage due to sands drifting. The 1863 storm led the creation of another breach of the isthmus a bit further to the south. This gave society the chance to establish a new sailing route between the North Sea and the Limfjord a few kilometers south of the former canal (Svalgaard, 1977). Soon the so-called Thyborøn Canal became a transportation hub to rival the former Agger Canal, which gradually disappeared altogether.

Elsewhere in the Limfjord system other improvements in the transportation system had been created. Following the opening of shipping from the western part of the fjord to the North Sea, the abovementioned town of Lemvig was one of several towns, where the local merchants exploited the newly found opportunities and found ways to improve their local ports. Others were Nykøbing Mors and not least Thisted. In 1801, Thisted hosted 16 burghers registered as merchants. 40 years later that number had grown to 40. In 1841, two new docks were ready. 14 vessels operated out of Thisted in 1840, 54 in 1865, and in 1870 no less than 65 vessels sailed the seas with Thisted as their home port. Thisted had become the fourth largest port in Jutland, surpassed only by Aarhus, Aalborg and Fanø (Sørensen, 1994).

The growth of the merchant fleet in the Western part of the fjord system facilitated a rapid modernization of society and industry. The export of agricultural products grew, and in the 1850s, the area saw the first attempt at creating a steamship company with the intent to ship live cattle across the North Sea to England. This effort was not viable, and the company soon liquidated, but the connection with Great Britain was immensely profitable. London was the economic center of Europe with an incessant interest in quality food products, while the coastal ports of Northeast England and Scotland supplied North West Jutland with coal and iron. In almost every town in the area, iron foundries were established during the 1840s and 1850s (Sørensen, 1994; Have Espersen, 2018). In rural

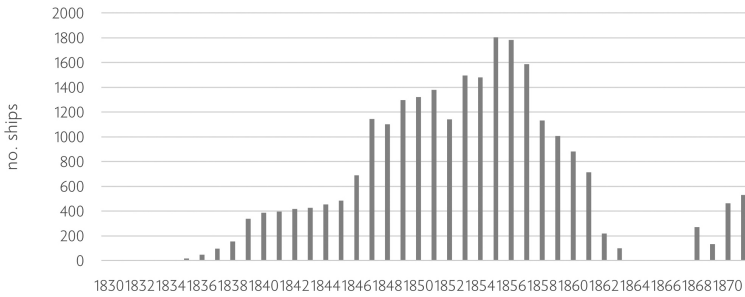


Figure 4: Ships passing through Agger Canal and subsequent Thyborøn Canal, 1830–1982.

Source: Svalgaard (1977).

Denmark, much of their production catered for the agricultural sector, where cast iron ploughs were a great improvement (Sørensen, 1994).

In short, a positive spiral of economic growth had started, and textile factories and tobacco manufacturing sprung alongside retail shops in many small towns. In fact, Thisted was the first place in Denmark, where a cooperative was successfully established, and indeed one of the first places outside Great Britain. The founding society wrote in the minutes of their first meeting that they wished to use the so-called ‘English organizational model’ for the cooperative (Hilson, 2018; Thestrup, 1986; Sørensen, 1994). This initiative suggests that the direct connections forming between the Limfjord towns and the largest economy in Europe included inspirations as for how to set up businesses.

Frederik VII’s Canal – canal by design

At least relatively speaking, Aalborg and Løgstør were the losers in the changing landscape of the Limfjord area. Thisted ceased to pay its annual fee for maintenance of the port of Aalborg, which lost much of the transport from the western part of the fjord. In the 1850s, the citizens and merchants of Aalborg faced another technological challenge from neighbouring town of Løgstør, where the Frederik VII’s Canal was constructed. While the Agger Canal connected the North Sea to the western part of the fjord, and the mouth of the fjord opened to Kattegat to the east at Hals, the Limfjord hosted a serious bottleneck in the middle at the Løgstør Grunde. Therefore, plans emerged in the 1850s to dig a manmade canal next to the shallow banks at Løgstør to secure safe and reliable passage through the future Frederik VII’s Canal. The dominant town of Aalborg opposed the plan stating that they saw no reason to make this investment, but all

the other towns in the area agreed. The Danish government found that all areas of North Jutland would benefit from such a canal, and funded two thirds of the costs. The counties surrounding the Limfjord area together paid for the last third, and in 1856 the Danish parliament passed a bill in support of the construction works (Bloksgaard, 2018). The actual construction fell into the hands of the experienced engineer Gustav Kröhnke (1826-1904) from Glückstadt in Holstein. Kröhnke hired more than 400 migrant workers from Germany to dig the canal with pickaxes, shovels and barrels. Four years later construction was completed. More than four kilometers long, 23-28 meters wide and three meters deep the new canal provided safe passage for sizeable ships. From the official inauguration in 1862, the canal was an instant success, and over the course of the following decades in between 500 to 1,500 vessels passed through each year, peaking in 1899 with 3,000 ships. A few years later the canal became superfluous as modern steam driven sand pumping vessels were able to keep a wider stretch of open water clear of treacherous sand banks (Bloksgaard, 2018).

In short, the ultimate impact of both the 1825 breach and subsequent unintended and unforeseen consequences on trade and commerce in the Limfjord area, can be summarized as follows: What was initially considered as a natural disaster turned out to be a blessing for trade and commerce. The towns in the western half of the fjord profited tremendously from the new trading opportunities that arose from changes in the landscape. Aalborg lost its grip on the trade in the fjord, and the newly found self-confidence in the Western towns prompted them to advocate the construction of the Frederik VII's Canal at Løgstør connecting the entire fjord into one system of shipping with two exits to the world market: one facing the North Sea and one facing the Kattegat.

Marine ecosystem dynamics

The socio-natural transformation of the Limfjord is not limited to floods, flood protection, waterways and shipping. It also revolves around the changing connectivity of man and the sea as a marine resource. Within the Limfjord, the marine fauna has totally changed in today's estuary compared to the situation before 1825. This is a result of a series of developments initiated by the breach of 1825. Events and new patterns were due to a plethora of human impact on the marine ecosystem, as well as ecosystem responses, different from species to species. In what follows, I will assess how fisheries mainly for herring, eel, whitefish and oysters developed very differently in light of the impact from the 1825 breakthrough of the North Sea into the Limfjord. Some fisheries disappeared altogether, but the disrupted fishing industry also displayed clear signs of skillful adaptation through innovation, while others left the fjord to fish elsewhere,

and others again simply abandoned fishing. First we look at what fishes disappeared, then we look at the successes of fishing for new species, and fishing with technologically improved fishing gear.

Herring halted

The Limfjord herring fishery was Denmark's single largest fishery from the 1600s until 1830, when it crashed completely. At some point in time, a sub-population of herring had begun spawning in the eastern half of the Limfjord on the shallow stretches of the estuary mainly between the towns of Løgstør and Nibe. In some periods over the past millennium, the amount of herring in the fjord provided work for several thousand people, fishing for herring with beach seines, pound nets, and gill nets. Others found work in the supply chain as coopers, net makers, salters or merchants selling the finished product, salted herring in barrels to faraway places such as present day Germany and Poland. During the first half of the 1700s and again from c. 1800-1830 the Limfjord herring fishery was among the top five European herring fisheries trailing only the Dutch, Scottish, Norwegian, and sometimes the Swedish west coast herring fisheries (Poulsen, 2008).

In the best years in the 1700s, c. 5,000-6,000 metric tonnes of salted herring went by the customs offices in Aalborg, while in the latter decades of the century, the fishery went into steep decline with a mere 1,000 tonnes produced annually (Poulsen et al., 2007). One 1769 commentator noted that 'we fear that the fisheries will come to a halt due to the fishermen's impoverishment'. (Hoffmann, 1769). This coincided with an upsurge in the Swedish Bohuslen herring fishery becoming the largest fishery in European history during the same period (Poulsen, 2008). Nonetheless, the herring fisheries in the Limfjord regained their former strengths from the year 1800, where the fish reportedly returned in great numbers, a full decade before the Swedish Bohuslen fishery collapsed. The Limfjord herring fishery once again was the largest Danish fishery. The 1820s saw the best decade ever for the herring fishery, peaking in 1828 with an estimate landing of 9,000 metric tonnes of herring (Poulsen et al., 2007). From then on, the herring fisheries went in steep decline once more, and the next year, 1829 witnessed a mere one tenth of the catches in the previous year. 1830 was even worse, and merchants and fishermen alike lost appetite for placing new investments in the failing industry. Some had substantial capital investments, which were lost, while most of the active fishermen and people occupied in the ancillary industries went into other businesses. Some fishermen tried their luck elsewhere, migrating away from the Limfjord and re-settling in the fjords and bays of the Kattegat Sea on the east coast of the Jutland peninsula (Poulsen et al., 2007). One of the entrepreneurial fishermen leaving the Limfjord was Christian Westergaard

from the Town of Nibe. Westergaard moved to Fredericia in the Southern part of Denmark, where he set up a fish salting business, and he later found work as possibly the first Danish government appointed fishery consultant. On his former townsmen in Nibe Westergaard wrote that, 'Now they are home, fallen into poverty's deepest forms of misery, completely incapable of acquiring their most basic needs' (Christensen, 1977).

The co-incidence of the breakthrough of the Limfjordstangen and the disappearance of the herring understandably caught the imagination of contemporary and later commentators. Historians throughout the twentieth century echoed the notion that those two instances of disruption were somehow interlinked. First came the breakthrough, then the salt water followed by changes in the currents of the estuary (Holm, 1999; Rasmussen, 1997; Matthiessen, 1936; Christensen, 1977). More recent studies emphasize that previous breaches of the Limfjordstangen in the 1600s did not apparently influence the herring fisheries in the same way. Once the herring eggs are laid on the seabed, the eggs and later the larvae remain vulnerable to sudden hydrographic changes, but if the rest of the local population of herring is substantial, the lack of recruits from a couple of years, should not pose a serious problem (Poulsen, 2019a). Rather the marked increase in fishing intensity during the first three decades of the 1800s might be a more decisive culprit for the demise of the herring. The most important herring fisheries carried out with pound nets and beach seines respectively were both highly regulated in absolutist Denmark. As an object for taxation, the use of pound nets and beach seines depended on the buying, selling, rents and leases of licenses to fish. In good times in the eighteenth century the use of the different licenses expanded slightly but only up to a limit. In poor times for the fishery, much of the fishing intensity would still be in place due to the longevity (20-30 years) on the leasing contracts for fishing (Poulsen, 2019a). Yet, in the beginning of the 1800s, times were changing. Partly due to the rising population pressure in the countryside, and part due to the liberalist sentiments of the era, there was a successful move to set up more beach seine operation than what had hitherto been in place. During the 1810s and 1820s, the number of licenses in use in the Løgstør area more than doubled (Poulsen et al., 2007).

The beach seines were operated in teams of at least 6 fishermen. A minimum of three men based on shore hold on to one end of the gear, while the other half of the crew row out from the shore creating a half-circle shaped area to be fished, when they return to shore with the other end of the seine a few hundred meters down the shore (Drechsel, 1890). Due to the weight of the seines, they ended up effectively dragged over the seabed, causing lots of disturbance to the bottom fauna. Christian Westergaard, who was a pound net fisherman himself, worried that there was a lack of restriction surrounding the new beach seines. They were larger than before, and reaching across the entire fjord, they took everything with

them, when pulled through the water.² Contemporary natural scientist Henrik Beck observed in his personal notes that when the fishermen hauled in the net, they were able to fill barrels with herring fry, which had ended up in the seine. He concluded: 'I think, I have proven that the steady diminishment of the herring fry is not entirely due to the Limfjord being connected to the North Sea, but rather a direct consequence of the destruction of the offspring.'³ While conclusive arguments are hard to find, the circumstantial evidence indeed points towards fishing intensity as at least a contributing factor for why the herring fishery disappeared within a mere 4-5 years after the breakthrough of the Limfjordstangen (Poulsen, 2019a).

Eel fisheries and jellyfish jeopardy

There are 42 different traditional Danish dishes with eel as an ingredient (Westergaard, 1974). This is one measure of the culinary impact of Danish eel fisheries, and the historical centre for Danish eel fisheries was the Limfjord. Only in the Northern parts of the Netherlands and in the Po Valley in Italy, did eel play an equally important role for the local economy, diet and cultural expression as it did in the Northwestern parts of Denmark (Aschonitis et al., 2017; van Dam, 1998). During summer, eel was everywhere to be fished in the Limfjord. This coincided with a quieter period in the annual work cycle of the fishermen along the North Sea coast. At least since the 1500s it was custom for the fishermen from the sea to migrate into the fjord in summer months (24 June – 24 August) to fish for eel alongside local eel fishermen. In the beginning of the 1800s, this particular fishery attracted 700 fishermen just for the most important pulse seine fishery. The law allowed the pulse seine fishery for eel only in the two months between 24 June and 24 August. In addition, eel was targeted with hooks, traps, and spears (Limfjordmuseet, Holger Rasmussen Arkiv, no. 40A. 13-15). The pulse seine fishery required two boats fishing with a seine between them. Two men operated each boat, where one was holding the seine, while the other fisherman held a long club in his hands, which he rammed down into the water to scare up the eel, presumably hiding near the sea bed. The belief was that the loud sounds made by the club would scare the fish. For this reason, the fishery was highly regulated, as managers were afraid that the noise would destroy the fry of a number of fishes, so only fishermen with an official license to fish, were allowed to take part in the particular summer activity.

² KB, Beck. Add. 314-319. H. Becks Samlinger til Limfjordens topografi og Historie.

³ Idem.

The 1825 breakthrough of the North Sea affected the eel fisheries in at least three different ways, the first of which perhaps unexpected, as a new species, the common jellyfish (*Aurelia aurita*) flowed with the current into the Limfjord. Consisting of 98% water, the jellyfish is perhaps an unlikely troublemaker, but from the summer of 1827, they became a real nuisance. The existence and proliferation of the jellyfish, became problematic for the eel fishermen's activity, but it is also very likely that a sudden appearance of jellyfish blooming in the Limfjord were able to decimate the herring eggs and herring larvae (MacKenzie-Poulsen, 2010). We know this, thanks to the region's reliance on eel fisheries in the fjord. The number of licensed fishermen was in the hundreds, but in 1827 only three parties with a total of 12 men went fishing. The rest of them went home, and the reason cited in the records of the local district bailiffs checking the gear, was the incredible abundance of jellyfish in the fjord. The sheer number of jellyfish made it impossible to drag the seines between the two boats without destroying the net. It may seem surprising that such an animal can cause this damage, but the literature on modern fisheries describes the phenomenon as well. When a fishing net catches thousands of jellyfish, the net's counterweight wreak havoc to the nets when dragged through the water (MacKenzie-Poulsen, 2010). No hard scientific evidence exists for the 1820s, but the contemporary natural historian Henrik Beck, who corresponded with the fishermen, concluded that the incredible amounts of jellyfish made it impossible to fish for eel. This in spite of what he found to be an abundance of eel around the small island of Fur in the central part of the fjord.⁴ The summer fishery was an absolute highpoint in the annual life cycle for the fishermen, so there is no reason to believe they were exaggerating the severity of the calamity with the jellyfish bloom (MacKenzie-Poulsen, 2010).

The second way in which the 1825 breakthrough influenced the eel fisheries links to impact of the inflowing more saline water. During the years 1825-1835, countless reports state that the then current stock of eel fled the salt water and swam up the rivers and creeks that flow in the fjord system. The eel breeds far away from the Limfjord and the rest of Europe for that matter, in the Sargasso Sea situated between Florida, Bermuda and the Eastern Caribbean. The Sargasso Sea is about the size of the North Sea, and for all we know there were plenty of eel in the Atlantic Ocean in the 1800s. Therefore, new year-classes of eel gradually replaced the ones that had lived in the Limfjord during the time of sudden hydrographic changes (Poulsen et al., 2007).

The third type of impact of the eel fisheries relates to transportation and exports. Eel was already a highly priced export commodity before

4 KB, Beck.Add.314d.fol.Aalefiskeriet paa Fuur 1831.

1825. Because of its fatty meat, eel is well suited for smoking and salting, and salted eel was a significant export product through the port of Aalborg, following in the routes created by the salted herring trade, and because of preserved trade statistics, this is the one eel trade, where the volume is most easily reconstructed. For the first three decades of the 1800s in between 50-80 metric tonnes of eel were shipped out of Aalborg every year. Then the eel export dropped to one tenth of the previous numbers. It is likely that the disappearance of the herring export crippled the export of eel, which by comparison was a niche product dependent on the bulk volumes of the herring to flourish (Poulsen, 2019a).

At any rate, the eel fisheries grew to unprecedented levels in the latter half of the 1800s, and the Limfjord led the way, as eel was one of the top three most important fisheries in Denmark until well into the 1920s. The impact from the breach was sudden, but not long lasting. The outburst of jellyfish appears to have peaked in 1827, the new year-classes of eel gradually replaced the ones fleeing the salty waters, and for the rest of the 1800s, the limit of the eel fishery was more likely to have been limitations in how the fish market developed than limits in natural abundance of the eel.

Whitefish wipeout

Whitefish (*Coregonus lavaretus*) was a definite casualty of the post-1825 saline conditions in the Limfjord. A distant cousin of salmon, whitefish is a tasty fish up to 70 centimeters long and dependent on fresh or brackish water for spawning. Today it is widespread in the Baltic Sea and the Bothnian Sea, and until 1825 a subpopulation residing in the Limfjord had adjusted to the local conditions (Poulsen et al., 2007). According to a 1741 government commission report, whitefish were fished all over the Western part of the Limfjord, with a total of 74 pound nets specially fitted for whitefish. Another 130 seines were in use, so in total it took the work of c. 500 men to operate the gear for the whitefish fisheries (Rasmussen, 1968). In the winter season, whitefish provided an important revenue for the coastal communities in the countryside, in particular in the northwestern part of the fjord in the Vester Hanherred district. In 1806, the county sheriff Gerhard Faye (1760-1845) visited the area to get a better understanding about who should be entitled to fish when and where. No less than 290 families depended on the whitefish fisheries as a supplement to their annual household income. Primarily a winter activity the whitefish fisheries took place at an otherwise quiet period for the farms in the area (Rasmussen, 1968).

Sales records, however, reveal that the whitefish was popular also on the regional fish markets. In October 1825, marketgoers in the town of Viborg could buy whitefish at 6 shilling per fish, or c. 10 times the price for

a fresh herring on the same day (Mortensdagsmarkedet i Viborg, 1825). The 1820s were an Indian summer for the whitefish fisheries. The annual catch rose from 26,000 fish in 1812 to 186,500 in 1821, and 120,000 in 1826, but then the fishery collapsed completely. In 1829, only 473 whitefish were caught, and the next year none (Poulsen, 2002). The reason was the stressful situation after 1825. All freshwater species suffered from the influx of saltwater. In the *Thisted Avis* newspaper, an article from 27 October 1827 connected the ill fate of the sweet water fishes with the salt water: 'as they congregated in great numbers in the small inlets, where they lay packed and one could catch them with bare hands, or they froze to death in the ice.'⁵ This lackluster performance was echoed in the response to an 1832 questionnaire on the state of local fisheries. 'Has there been any catches of whitefish, trout, pike, roach, perch, smelt etc....' as one of the questions ran. 'Very few', was the recurring answer, and in addition reports came in stating that the sweet water fishes tried to escape the salt by way of swimming up the rivers and creeks flowing into the Limfjord (Poulsen, 2002).

Whitefish disappeared from the Limfjord for good. Not just as a commercially interesting species, but completely extinct. The most likely scenario was the environmental stress from the changes in their habitat, which in turn caused the adult fish to stop reproducing (Poulsen et al., 2007).

A new place for plaice

The new and much more saline situation in the Limfjord provided a whole new habitat, where new species found a place – and in turn provided new opportunities for human exploitation. Plaice (*Platessa platessa*) and common flounder (*Pleuronectes flesus*) were among the most successful immigrants to the Limfjord during the first decade after 1825. During the 1600-1700s, the western part of the fjord hosted a very limited fishery for flounder (Rasmussen, 1968). They may have migrated with one of the more modest breaches of the fjord and adapted to brackish conditions. Plaice is typically less tolerant to brackish water than the flounder (Muus-Nielsen, 1998). Official Danish fisheries statistics covered the Limfjord only from the 1860s, but several qualitative pieces of evidence suggest that the plaice in particular fared well soon after 1825. From the Limfjord island Fur, district bailiff P.H. Hansen informed the country sheriff Rosenkrantz (1803-1884) in 1845 that 'The flatfishes now constitute the third most important species in the Limfjord, and it replaces to some

⁵ KB, Beck. Add. 314-319. H. Becks Samlinger til Limfjordens topografi og Historie.

extent the fisheries destructed by the breakthrough of the sea. They are caught in incredible amounts, and they spawn enormously...'⁶

Soon, from 1848, fishermen started targeting the flatfishes with a novel technology – the so-called 'Danish Seine,' or *snurrevod*, as it is named in Danish. Nearby to Fur, in the Salling area, farmer-fisherman Jens Væver (1822-1914) had a bright idea one day as he was out for a walk. At the time, plaice was caught using pulse seine nets, like the ones used for catching eel, but they had a limited reach as they were pulled in using two boats floating on the water. Thus, when the fishermen each pulled at their end of the gear, the vessels were drawn towards the net, just as much as the net was pulled through the water. Thus, by design the effect of trawling was limited. Væver's idea was to replace one of the two boats used for pulse seine fishing with an anchor. From the point of anchorage, one boat with only two men could now fish in all directions back and forth. This enabled them to fish a specific area more efficiently, both in terms of spatial coverage, and in terms of the effect of the pull on the net. When the full diameter around the central point was fished, the anchor was hoisted and the fishermen could move to the next location and start over (Hjorth Rasmussen, 1988). By the late 1850s, the Danish seine was a sensation in the entire region. 200 Danish seines were registered for plaice fishing in an 1859 state overview, and three years later the number had doubled. The combined Limfjord fisheries reaped a turnover of 168,000 Rigsdaler in 1859. About thirty percent stemmed from the new plaice fishery (Poulsen, 2002). Meanwhile within the eel fisheries the pulse seine fisheries outnumbered the new Danish seines, but only for a couple of decades. In 1880, only three pulse seine operations continued to exist in the fjord. The Danish seine was used in c. 300 different places around the Limfjord in addition to the 400 Danish seines used for fishing for plaice (Andersen, 1882; Poulsen, 2002).

The use of the Danish seine now spread into the rest of Denmark, and throughout the Kattegat and Baltic Sea. Adding modern winches, steam and motor propulsion to the Danish seine, the gear is known worldwide as far away as in Australia (Hjorth Rasmussen, 1991). Born out of the lackluster post-1825 performances of the Limfjord fisheries, the invention of the Danish seine appears to illustrate that 'necessity is the mother of invention'. The invention of the Danish seine did not relate to the introduction of fossil fuels, and indeed Danish fisheries at large were exceptions to the tendency for modernization processes in the latter half of the nineteenth century equaling the implementation of fossil fuel. Unlike the English, Dutch, Swedish and Norwegian fishing industries, the Danish

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fishing sector did not develop a fleet of steam trawlers in the 1880s and 1890s.

Oyster opportunities

Inflow of the European Oysters (*Ostrea edulis*) was one of the most spectacular success stories following the salt water intrusion in to the Limfjord. The adult oyster is able to open and close its shell, but other than that, they are stuck to their incidental habitat on the seabed. To enter the Limfjord oysters relied entirely on the right currents in their larval state, where they float freely in the water column. On 28 May 1828, a ship from Norway entered the Limfjord from the eastern entrance at Hals carrying timber and oysters (Handels- og Søeefterretninger, 1828). Thus, there seem to have been a market for oysters within the Limfjord area. Had they existed in any greater quantity during the 1830s and 1840s, the impoverished local fishermen would have fished for them. One report from the Thisted area notes that a farmer-fisherman caught three oysters in 1831, while attempting to catch whitefish with a net.⁷ How they came there remains a mystery, but a new study of the history of Danish oysters mentions an unsuccessful attempt at releasing oysters in the Limfjord in the late eighteenth century. In the 1830s another attempt to create a local aquaculture through the release of oysters was undertaken (Jensen-Melbye, 2021).

Actual oyster banks appeared off Lemvig in the westernmost part of the Limfjord around 1850. The recent study raise doubt that the oysters had drifted there on their own (Jensen-Melbye, 2021). At any rate the post-1825 marine ecosystem proved a welcoming habitat for the oyster. The discovery was duly reported to the government, as oyster dredging was subject to royal privilege. To catch oysters you needed a license, and soon the state issued licenses all around the western part of the fjord, in particular around the island of Mors. In 1872, the Limfjord was the scene of a total catch of no less than 7.5 million oysters, but only a decade later the stock was depleted (Poulsen, 2019a). Towards the turn of the twentieth century the oyster fisheries made a comeback as the banks were replenished with fry artificially, building on knowledge established on Mors in preceding decades, as well the newest expertise from the Netherlands. Another peak was reached in the 1910s followed by another collapse in the 1920s (Knudsen, 1992). Ever since the breakthrough of the North Sea, oyster dredging has been a niche product in the overall regional economy, but at times a very profitable niche. Around 1870 the turnover

7 Rigsarkivet, Rentekammeret. 2426.215; Indkomne breve vedrørende limfjordsfiskeriet, 1831 – 40.

from the oyster dredging amounted to 25-60,000 Danish Rigsdaler, and it provided a job for c. 150 fishermen (Marboe, 2007).

Summarizing the situation before and after the breakthrough of 1825, provides a stark contrast between socio-natural sites. Before 1825, freshwater species such as whitefish dominated the deeper westernmost parts of the fjord. These perished or diminished greatly in numbers in the aftermath of the saltwater intrusion. The eel suffered temporarily, but made a comeback, while the ill fate of the herring was partly the result of saltwater, and jellyfish blossoming in the fjord. However, marking the dual impact of human society and environmental forcing, the impact of fishing was also a factor for the depletion of herring. While the initial event of the breakthrough was a natural event, the changes in the marine ecosystem were oysters added to the fjord's fauna. Lobsters, plaice and to a lesser extent cod were other new species thriving in the saline Limfjord post 1825. The resident fishing communities quickly exploited all of them. One could say the 1825 storm surge fed into the disruption of the fishing communities. The fishing communities in turn invented the so-called Danish seine to the benefit of eel and plaice fishing all around the fjord, and soon spreading into the Baltic. Novel socio-economic niches thus evolved around new species and new fishing grounds.

Conclusion

The 1825 breakthrough of the North Sea into the Limfjord was a major event in the history of North West Denmark. The direct and indirect impact of subsequent storm surges in the nineteenth century as well as changes in the marine ecosystem formed two distinct entanglements between society and nature. These entanglements were factors in an overall change from a socio-natural site, where adaptation to nature had long been the dominant coping strategy, towards a more modern coping strategy where mitigation played a much more pronounced role. Assessing the impact across spheres as diverse as natural hazard mitigation, the development of trade and commerce and the exploitation of marine resources is an opportunity to compare developments and trajectories across different sets of socio-natural transformations, all of them forming entangled paths of modernization.

Narrating the Limfjord area as a socio-natural site, the situation pre-1825 was one of relative stability. The fjord was home to different fish species accustomed to the brackish conditions, but on a political level the loser grip on fishing regulations of the Limfjord itself from c. 1800 onwards coincided with the emergence of more liberal policies, where more and more licenses to fish for herring were a factor in the local depletion of herring. Decades later, the liberalized fishing for mussels was

another example of the ill fate of a fishery with few restrictions. Liberalization was the order of the day in trade and commerce at large in the 1800s. The Danish absolutist political regime transformed in 1849 into a constitutional monarchy. A decade later, the central government abolished the old town rights replacing them with a more liberal attitude to trade. This undoubtedly added to the political decision making in relation to the exploitation of the new hole connecting the North Sea and the Limfjord.

Integral to the modernization process is the development of infrastructures which allowed the transition from adaptive coping strategies to mitigation of the challenges posed by the changing natural environment. The construction of two large infrastructure projects, groynes along the North Sea coast and the building of the Frederik VII Canal at Løgstør both facilitated the increase of trade in the area, while the groynes also secured the settlements on the isthmus between the North Sea and the Limfjord. Finally, the emergence of railroads fully connected the Limfjord to the rest of North West Europe, in the proximity of the global economic center in Great Britain, from where the cooperative movement was imported. The 400 migrant labourers dug the Frederik VII's Canal with hooks and shovels. On the other hand, modern railroad and cement factory technologies greatly aided the construction of groynes pinning the waves of the North Sea. Coal and iron were two major import commodities into the blossoming towns in post-1825 North West Denmark, and indeed these key ingredients in the industrial revolution were highly beneficial for the modernization process of Danish society over the 1800s. Within the marine ecosystem, the great invention of the Danish seine did not rely on the introduction of fossil fuels, neither did the transplantation of oysters, and indeed Danish fisheries at large were exceptions to the rule that modernization in the latter half of the nineteenth century equaled the implementation of fossil fuel. The inland advances of the railroad though, facilitated much quicker roads from a fishing vessel to a faraway dinner plate.

The Limfjord at c. 1880 was a new, changed socio-natural site, where a profound socio-ecological transformation had taken place. Human society led a series of transformative processes seeking to implement various aspects of modern life, politics, technology, and economy to a hitherto quite remote part of the World. This could be said for many parts of the world in the nineteenth century, but the 1825 breakthrough of the Limfjordstangen and the succession of storm surges in later decades is a very visible case of how interdependent modern society and the natural environment is. The environment transformed and was transformed by human society from the North Sea shores to the depth of the Limfjord seabed and increasingly connected to the wider World through merchant shipping of ancient and industrial products. The multitude of socio-natural transformation processes also serve to remind that sudden events, such as

a storm surges can offset waves rippling several decades later. They did so however, in constant interaction with underlying structural developments moving at a pace unrecognized in contemporary society. Both are of crucial importance for the understanding of historical entanglements of society and nature.

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