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The history of commercial fisheries for European eel commenced only a century ago

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Abstract

The stock of the European eel is in decline throughout its distribution area—for decades, if not for centuries. Its population dynamics are not well understood. The extremely scattered occurrence, as well as the general lack of quantified information before 1950, prevents a straightforward analysis. This article discusses the history of eel fisheries across Europe, reviewing the literature published before 1940. A follow-up study is advocated, to unearth primary information in archives across Europe.

In the late 1800s, development programmes were initiated in central Europe, complementing the widespread subsistence fisheries with "modern" commercial exploitation of new areas, new markets and new products. In the early 1900s, increasing fisheries and trade were reported throughout northern Europe, and new developments started in the south. This lasted until about 1950—when the current multidecadal decline set in. The eel fisheries have never experienced a period of stable, sustainable exploitation. The decline in the stock is probably not a simple case of overfishing, but a continent-wide serial depletion of local resources—eventually depleting the whole stock—in times of growing non-fisheries impacts. Consequences for the European eel protection programme and for the derivation of restoration targets are discussed.

KEYWORDS

Anguilla, eel, eel smoking, fisheries, history, serial depletion

1 | INTRODUCTION

The stock of the European eel *Anguilla anguilla* (Linnaeus, 1758) is at a historical minimum. For more than half a century, stock abundance and fishing yield have declined by about 5% per year, to less than 10% of its historical level (Dekker, 2003a, 2004a; ICES, 2017). And from 1980 to 2010, recruitment of young eel (glass eel) from the ocean towards the continent dropped consistently by approximately 15% per year, to 1%–10% of its former levels (Dekker, 2000a; ICES, 2017; Moriarty, 1990). The causes of these downward trends are not clear, and consequently, remedies and mitigation measures are hard to design (Dekker, 2016).

The eel constitutes the most widespread, single fish stock in Europe, occurring all over the European continent and the Mediterranean (Dekker, 2003b). Noting the remarkable low genetic variation in adult eels across the distribution area, the stock is considered to constitute a single, panmictic population (Palm, Dannewitz, Prestegaard & Wickstrom, 2009). Monitoring this stock, however, is notoriously difficult, due to the extreme scattering over numerous local substocks, in small habitat units (Dekker, 2000a). Hence, the dynamics of the population are only marginally known (Dekker, 2004a)—in the current relatively well-documented years, and even more so for the decades that the stock declined (Dekker, 2016).

To address the bad state of the stock, the European Union adopted a protection and recovery plan in 2007 (Anonymous, 2007a). This so-called Eel Regulation instructed EU Member States to develop national Eel Management Plans by 2009, aiming at a common objective: to reduce human mortality in order to restore a spawner run of at least 40 % of the notional pristine run (Dekker, 2016). Additionally, the European eel was listed on Appendix II of the CITES convention (Anonymous, 2007b)—since the end of 2010, trade of European eel to or from the EU has been effectively prohibited.

Whether or not this European protection framework can be expected to lead to a recovery depends crucially on our understanding of the dynamics of the stock, both at the international level (stock-to-recruit relation) and for each national Eel Management Plan (recruit-to-stock survival rates). To this end, monitoring programmes have been established, and models of stock dynamics developed (e.g., the reviews in De Leo, Melià, Gatto & Crivelli, 2009; Walker et al., 2013). Almost all modelling studies, however, apply biological process models parameterised on current field data from local substocks, and do not address the historical decline, nor the continent-wide scale. Whether these models adequately represent the stock dynamics during the historical period of decline remains an open question. Restoration targets (minimal survival rates) derived from these modelling studies may or may not be appropriate for the recovery of the depleted stock.

For the period of stock decline (since 1960, but more likely as early as the mid-1800s; Dekker & Beaulaton, 2016a), some local studies have been made (e.g., Aschonitis, 2017; Dekker, 2004b), but for the stock as a whole, remarkable little information is available. Trends in recruitment have been analysed by Moriarty (1990), Dekker (2000a) and ICES (2017); landings by Dekker (2003a); restocking (redistribution of young eels) by Dekker and Beaulaton (2016a); a Procrustean assessment of continent-wide average fishing mortality by Dekker (2000b). The stock–recruit relation has been analysed by Dekker (2004a) and ICES (2005, 2013). Stock abundance, as well as fishing and other human impacts (including habitat loss or inaccessibility), however, remains largely unquantified.

Noting the poor understanding of the dynamics of the eel, there is an urgent need to uncover historical information on the status of stock and human impacts before the onset of the decline. This study reports on the history of the eel fisheries in Europe, from the mid-1800s onwards. Although the information presented will not truly allow quantification, it will describe a planned, continent-wide development of an eel industry, leading to a major increase in catches and markets. Subsequently, the fisheries before the mid-1800s will be described, the development plans in the late 1800s, and their effect on fisheries and markets in the (early) 1900s. Finally, consequences for the current views on stock dynamics, and on protection and recovery of the stock, will be discussed.

2 | THE OLD AND A NEW PARADIGM ON THE DEVELOPMENT OF EEL FISHERIES

Eel fishing has been practised for millennia. Archaeological remains (Kettle, Heinrich, Barrett, Benecke & Locker, 2008), historical artefacts (Gabriel & Wendt, 2003) and oral and written records (Koch, 1925; Noël, 1815; Radcliffe, 1921; Yarrell, 1836) sketch the picture of a widespread but small-scale fishery, using many different fishing gears, supplying local markets and some long-distance trade (Van Dam, 1998; Ypma, 1962). How that small-scale fishery eventually developed into the well-known and flourishing commercial eel fisheries of the mid-1900s is usually not exactly put in words. Tsukamoto and Kuroki (2014) provide a romantic picture of the culture and traditions around eel throughout the world, sketching a gradual development, enabled by technical progress and increasing catches—with a marked increase after WW II (Rindom et al., 2014). Some authors even claim that the fishery has experienced a long and stable period throughout the 1900s, until it started to decline in the late 1900s (e.g., Tesch, 2003).

However, reading the original literature from the late 1800s (19th century) and early 1900s (20th century), all over Europe (Dekker & Beaulaton, 2016a,b; Dekker, 2016; sources documented below), a totally different picture emerges: The well-remembered commercial eel industry of the mid-1900s did not gradually and autonomously develop from the medieval subsistence fisheries. Instead, a deliberate, coherent and effective policy has been executed in the late 1800s (and extending far into the 1900s) to develop an eel industry in large parts of Europe. The success of this development gave rise to the eel fisheries of the mid-1900s, increasing the impact of fishing by an order of magnitude or more. It is this deliberate and radical modernisation of eel fishing in the late 1800s and early 1900s that is documented and discussed here.

3 | INFORMATION SOURCES

This study is primarily a literature review, based on a full literature search (using Google Scholar) for publications referring to eel (eel, Aal, anguille, Anguilla, anguila) published before 1940. Additionally, the literature referred to in those publications is analysed, for as far as it appeared relevant to the topic. This process was repeated, until eventually most secondary references referred to publications already analysed. Where historical publications provided enough detail on their data, a reanalysis of those data was made. More recent publications, discussing the history of the eel fisheries, are relative scarce (Aschonitis et al., 2017; Briand, Bonhommeau, Beaulaton & Castelnaud, 2008; Dekker, 2003a, 2004a,b; Dekker & Beaulaton, 2016a,b), and in most cases, they do not identify their information sources (e.g., Tsukamoto & Kuroki, 2014, and the chapters on individual countries therein).

In this study, no new primary information has been analysed, or new paper archives disclosed. For the discussion of eel smoking (the hot-smoking process), however, a quantitative analysis of the online Dutch newspaper archive (www.delpher.nl) is made, complemented with information on the primary people involved, derived from genealogical websites, town archives, Jewish history sites and more.

In the sections below, the available information is grouped into a number of thematic reviews. Clearly, this thematic grouping

constitutes a post hoc created abstraction, structuring the information unearthed over a period of several years.

In the 1870s, Benecke (1880) compiled a systematic overview of the fisheries in Prussia, concluding "While we tried to sketch a picture of the rivers running in our provinces, in particular with regard to the interests of the fishery, the result unfortunately is rather deficient, since there was scarce material and simple inquiries did not yield much more information either." This adequately sketches the limits of this study, too.

4 | PREPARATION AND CONSERVATION, HOT SMOKING

Ultimately, the eel is exploited as a food source. The historical literature indicates that major changes occurred in the preparation and conservation of eel, triggering the development in the fisheries. Hence, the analysis starts here with a review of processing and cooking recipes, with special attention for the development of the eel smoking process.

For the period before 1850, no sources are known quantifying what processing was applied to the freshly caught eel. Cookbooks provide a range of recipes for eel (and other fish), most of which concern the processing of fresh eel for consumption, not for preservation—but it remains unclear what preparation methods were most common. Recipes describe stewing, roasting, braising, making pies, soup, sauces and sausages from eel, etcetera. In comparison with other (fresh water) fish, the eel is often applied to lard unrelated products, for example, Turkey with Eel ("Dindons aux Anguilles"; La Chapelle, 1735).

Most eel appears to have been consumed fresh; only a very limited number of conservation methods are described. Jellied eel and eel in vinegar resulted in products that could be stored for months, but not overwintered. The only real preservation method, effectively, was a combination of salting/brining, drying and smoking (Birkmeyer, 1845; Buchner, 1813; Corvinus, 1715; Leuchs, 1829, 1862; Molokhovets, 1901). Recipes differ in the relative importance of these three treatments, sometimes applying only two. The eel is skinned, gutted, subcutaneous fat ("the second skin") rubbed off, herbs added and the skin reapplied. Following a period of salting or brining (up to 3 months), the eel is dried for some days. The final treatment—smoking—differed fundamentally from modern smoking procedures: The eel was hung in a smokehouse of about the same build as those for bacon and sausages, and left there for periods from 2 to 3 days up to 4 weeks or more. Although no temperature is specified, the lengthy smoking period in smokehouses suggests that temperatures did not exceed 30°C—that is: A cold-smoking process in which the meat is not cooked, proteins did not coagulate, and the flesh remains firmly attached to the bones. Friedreich (1846) states "over-smoking makes the eel hard, tough and difficult to digest, while under-smoking gives a rancid product that easily spoils." To prepare for final consumption, the smoked eel was cooked, by braising or boiling in water for about an hour (von Reider, 1825), apparently to dilute the bitter taste of the smoking and make the meat more toothsome (protein coagulation). Indirect evidence of the appearance of cold-smoked eel comes from the German word "Spickaal" (literally: bacon-eel), used for nicknaming either a skinny person in spacious cloths (Hopf, 1846) or the leather sheathe for a rifle-bayonet in the Franco-Prussian war (Rosenthal, 1910). Although drying, salting and cold-smoking had been practised for centuries, recipes for cold-smoking eel were only found from 1715 (Corvinus) until 1901 (Molokhovets), and recent studies reflecting on the early 1900s (e.g., Selling, 2009); in mainland Europe, from the Netherlands until Russia, in Scandinavia, in France; for the UK, only an English translation (Gouffé, 1871) of a French text (Gouffé, 1869) was found. This cold-smoked eel was readily available and cheap staple food throughout central Europe, appreciated for its fat content and durability, but often disgusted for its taste. There are some records of trade in cold-smoked eel at a price equal to that for fresh eel (Neuenhahn, 1806) and several records of use for military rations (e.g., Anonymous, 1876, describing a 1627 soldiers' ration).

In Germany and Russia, a variant of this basic recipe is found, in which each individual eel was wrapped in paper during (most of) the smoking process. This variant occurred in the same periods and areas as the basic recipe. The laborious individual wrapping appears to have improved the taste, probably by reducing the impact of the smoke. However, noting that the duration of the smoking process was not reduced, the temperature applied must have remained below 30°C. Anonymous (1765) identifies a shop in Paris, selling "Petersburg smoked eel," that is "much appreciated by some." Reichskanzler Otto von Bismarck (1815–1898) regularly had smoked eel for breakfast (Pötzl, 2015). That is, this paper-wrapped variant of smoked eel was more appreciated than the basic cold-smoked eel, but there are no indications of any progress towards the modern hot-smoking process.

The earliest record of hot-smoking appears to be Sauvage (1883), who made a study trip from France to the Netherlands, during which he visited Harderwijk and other places. In Harderwijk (the only fishing village located on a main railway line in the Netherlands), he reports a total catch of 41 tons of eel from nets and traps set in the estuarine Zuiderzee in 1881, and describes the smoking process: "Eels are smoked everywhere without any special constructions. It is merely a barrel, the bottom of which is removed, in which the fish are suspended from sticks. A fire giving a lot of smoke is made on the ground, covered by the barrel, in such a way that the eel is just as well cooked as smoked." Clearly, this describes small-scaled processing, at higher temperatures, yielding a "cooked" product—hot-smoking! Additionally, this indicates that Sauvage did not know about hot-smoking before. No indication is given of markets, hygienic quality, or durability of the product.

In the decades after, most cold-smoked eel was rapidly replaced by hot-smoked eel, in cookbooks and on the market. In the absence of market and consumption statistics, information on the temporal developments is derived here from the archive of Dutch newspapers, Delpher (www.delpher.nl). Selecting newspaper advertisements

containing the words "eel" ("aal" or "paling"), in combination with a word describing different processing methods (in many spelling variants), information was obtained on the frequency with which different products were offered, from the early 1600s until the late 1900s (Figure 1); in doing so, offers for plain eel (without processing method) are squarely missed. In the second half of the 1800s, first ads about eel appeared (this timing is likely reflecting the development of railway networks that enabled the trade, not anything specific on eel), advertising various products, mostly jellied eel; the number of ads per year varied around 20. In 1893, however, 59 ads for smoked eel appear (and 6 for other products), of which 42 were published by a single wholesaler from Amsterdam: Christiaan Saur (or Saür, 1849–1928). Saur took over his father's fish shop in 1879, and began a passionate campaign to develop (new) fish products and new markets, especially for the urban elite. He was awarded a "gold medal" for "smoked river fish" at the 1887 exhibition of food products in Amsterdam. The first years, Saur offered "smoked eel" in a newspaper ad, about once or twice a year. But then, on the 22th of August 1893, he offered "Hollandsche gerookte Paling [Dutch smoked eel]," half a kg for Dfl 1.50 (≈18 €/kg, 2,000 price level); fresh eel was about half that price. The day after, and almost any day in the 2 years following, he advertised "Dutch smoked eel," often alongside with some other eel products. In 1895, 148 of the ads (out of 233 in total) were from Saur. On 31st of October 1895, Saur published his last ad for "Dutch smoked eel"—in later ads, the eel appears less prominently, and other new species and products get more attention.

In the mid-1890s, a few ads appeared in Dutch newspapers, offering smoked eel from Flensburg (Germany). Noting that these would be sent by mail (steam train), it is highly unlikely that this concerned perishable hot-smoked eel. By 1899, however, Stevenson (1899) describes fish preservation methods in the United States, including a detailed description of hot-smoking of eel. He attributes the eel smoking primarily to the German population in New York. Noting the contacts between Amsterdam and Hamburg, Saur's success in Amsterdam might have been copied to Hamburg.

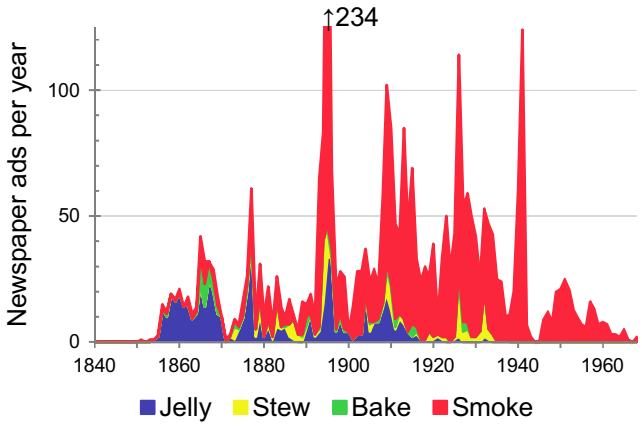

FIGURE 1 Frequency of newspaper ads for different eel products in Dutch newspapers, from 1840 until 1970. Data from www.delpher.nl

In 1908, Doose wrote: "The eel, formerly a cheap folk food, has in general become a table fish, and smoked a delicacy, which can only be obtained for expensive money." Catch volumes and the price for smoked eel increased consistently, and eel fisheries became the principal source of income for the inland fisheries (Ehrenbaum, 1930). Struck (1965) reported that more than 80% of the German catches and imports was smoked. Although quantitative information was lacking (Ehrenbaum, 1930), hot-smoking appears to have been the dominant processing technique throughout the 1900s (Friedrichs, 1942; Tesch, 2003). Although we cannot judge how the eel fisheries would have developed without the hot-smoking process, its invention in the 1890s marks the onset of the major expansion of eel fisheries throughout (northern) Europe, supplying a new and extensive market segment.

Although the "smoking gun" is missing, it appears that Christiaan Saur learned about the hot-smoking technique in the 1880s, scaled it up for commercial purposes, and actively developed a new market in Amsterdam from 1893 until 1895—where-after the technical and commercial knowledge rapidly spread over the rest of the continent. At the turn of the century, in about 15 years' time, the eel—a cheap folk food on the countryside before—had become a well-appreciated, urban luxury good.

5 | MARKETS AND TRADE ROUTES

There are numerous publications on local history across Europe, referring to marketing and trade in eel, but very few allow quantification of the volumes involved. This section discusses that information, extracts indirect information from price levels in Germany, and discusses the developing trade networks.

Many publications describe trade in eel before the mid-1800s, for example: from Holland to St. Petersburg (Anonymous, 1724); from Comacchio to Vienna (Friedlander, 1872); from Holland to Paris (de Massy, 1862); from Comacchio to London (Dodd, 1856). However, only few provide details enabling quantification of the volumes of eel concerned, and identify the origin of those eels. Probably the longest running and best documented is the trade from the Netherlands (various harbours, eventually Heeg and Workum in Friesland), collecting eel in the Netherlands and the Baltic, and transporting that to London. Above all, their exclusive market rights at Billingsgate, lasting from 1666 to 1938, has attracted attention. According to Ypma (1962), this trade involved salted eel in the 1400s, but switched to live eel in the 1600s. Van Dam (1998) reports a total volume of approximately 40 ton per year; Leuchs (1862) reported 50 ton for the same; but McCulloch (1835) quotes the "Report on the Channel Fisheries" for 72 cargoes of 10 tonnes each. Below, the claim is made that the catch from subsistence/small-scaled fisheries, even in areas as remote as mid-Sweden, was in the order of hundreds or thousands of tons. That is, the well-known trade to London represented a negligible part of the total landings and probably became well documented exactly because it was uncommon, not representative.

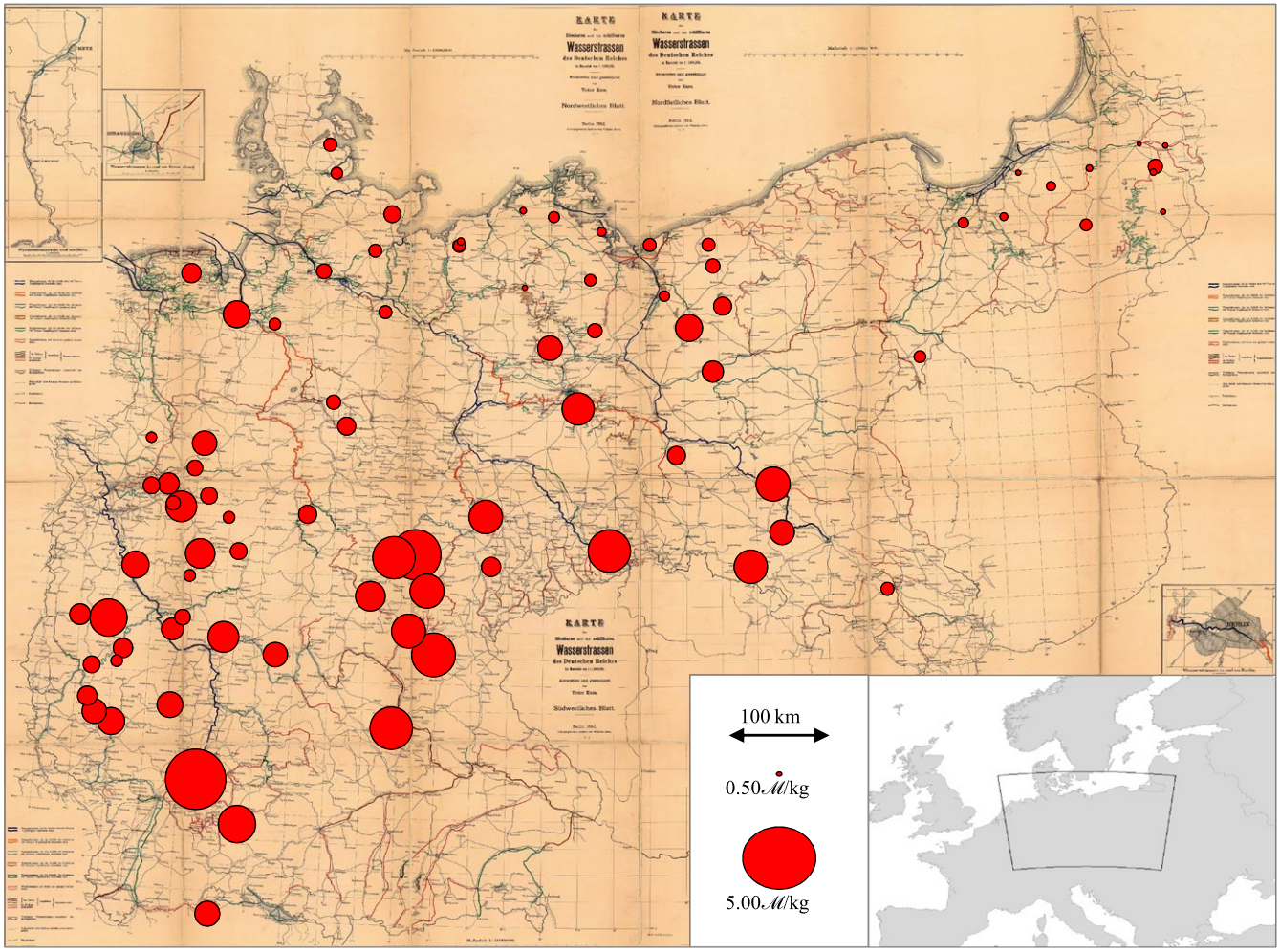

FIGURE 2 Price per kilogram of eel across the German Reich, as reported by Wittmack (1875). In the background, the map of Kurs (1894) showing the developing waterways in Germany (Albers projection). Prices in ℳ/kg (1 ℳ ≈ 4.23 €, 2000 price level)

Indirect evidence on trade in eel comes from later reports, analysing the potential for development of the fisheries and markets in the late 1800s. Wittmack (1875) provides a thorough inventory of the status of inland fisheries in the newly formed Deutsches Reich, setting a baseline for the development of those fisheries in the years coming. His report includes verbal information on the status and trends of fisheries on all commercially valuable species (most of which were in decline), and for each species a table of prices per region—in case of the eel, for 86 regions all over the country (plotted in Figure 2). Predictably, results indicate that eel prices were higher, further away from the coast where eel was less abundant. Superimposed on that general trend, however, we find strong local variation: Prices may vary by 200%–400%, at a distance of just 10–50 km, near the coast as well as far inland. That is, prices reflected very local conditions, and exchange of volumes of fish between nearby sites was restricted, in a time that improved means of transport already broke down the "friction of distance" (Knowles, 2006). Equally well, Wittmarck was able to determine price levels, indicating that some eel was traded locally, and not all was used for one's own subsistence. In 1880, however, Benecke reports that "the increase of postal services, steamers and railways has fundamentally altered the former traffic conditions." While former transports were restricted to few miles only, modern transport on ice allowed transport of fresh fish over distances as far as from the Kurisches Haff (Curonian lagoon, now Lithuania) to Paris (Benecke, 1880, p. 417).

In the first decade of the 1900s, trade networks for eel expanded immensely. Malm (1904) describes a German trader (Louis Friedrichs, Wittenberge, Bezirk Potsdam) travelling to the west coast of Sweden, for buying eel—and later on even providing fishing gear to fish for eel. Malm describes that fishery as "eel fishery (a novelty)." In the decades following, long-distance transports became well established, dedicated trade firms specialised in klondiking across large areas, life storage (often until late fall) and international transport. Examples of this are as follows: Nilsson (1996) describing a firm in southern-Sweden, running from 1921 to 1980, transporting circa 500 tons per year; and Devall (1998) describing a station in the Thames estuary, England, running from 1924 until 1968, transporting up to 600 tons per year.

In conclusion: The available evidence indicates that, until the late 1800s, the bulk of the eel trade was locally constrained; international

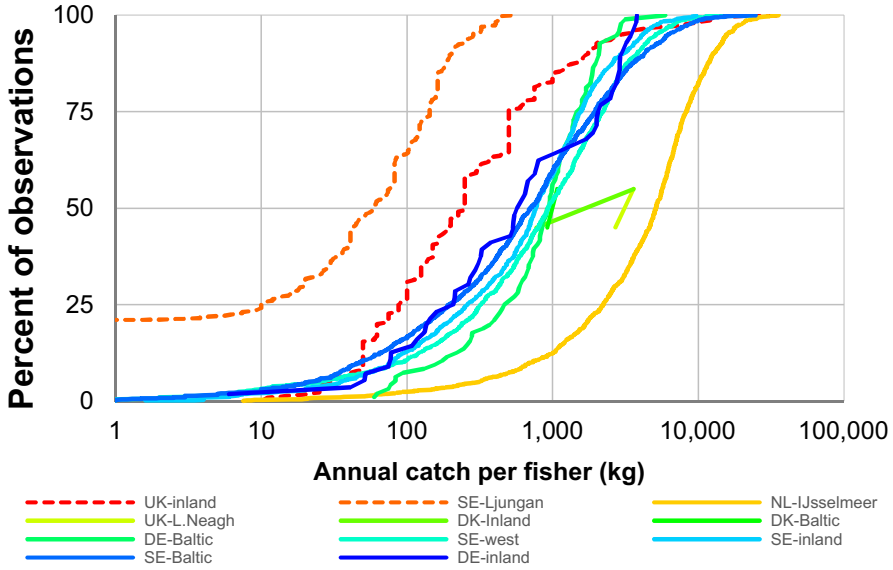

FIGURE 3 Cumulative frequency distribution of the catches per fisher per year, for historic fisheries (dashed lines) and for selected modern fisheries (solid lines). Data: Nordberg (1977), Anonymous (1086), three unpublished series from the author, Van Densen (2001), Michael Pedersen (pers.comm.), Derek Evans (pers. comm.) and Malte Dorow (pers.comm.). If only annual mean catch per fisher was documented, the interannual range is plotted around their median

trade was restricted to a few cases of restricted volumes. At the turn of the century, trade networks rapidly expanded, in the 1920s structurally attaining international dimensions, transporting volumes of several thousands of tons.

6 | FISHING COMPANIES AND GEARS

To characterise the fishing companies, information on the annual catch per company in the past and present, and on the location of historical fishing sites is presented.

For the period before the mid-1800s, only two sources are available providing information on the catch per fisher per year, and both of these are related to taxation of the fisheries: Anonymous (1086), that is the Domesday Book, surveying English eel fisheries across the country; and Nordberg (1977) describing eel fisheries in the River Ljungan catchment (central Sweden) from 1550 to 1940. According to Dekker and Beaulaton (2016b), using taxation records runs the risk to select the more profitable sites applying fixed fishing gear, while neglecting the harder-to-arrest smaller catches, made by moving gear. If so, the presented results might be overestimating the average catch per fisher. The Domesday Book data (Figure 3) show a median catch per site of 250 kg/year, while Nordberg's data for the River Ljungan have a median of 61 kg site^{-1} year^{-1}. Modern data have a median catch from 569 to 5,127 kg fisher^{-1} year^{-1}; the fishery in Lough Neagh (N-Ireland) has an average catch of 2,700 to 3,600 kg per fisher per year. That is, the yield made by modern fisheries is at least an order of magnitude higher than the historic ones.

The eel fisheries described by Nordberg (1977) relate to so-called eel-houses ("ålhus"): small wooden houses in the river bed, built around a wooden grating system for harvesting the out-migrating silver eel; many of the eel-houses had leading stone ridges, rebuilt from boulders in the river bed annually. Nordberg names those houses, and those site names have now been located (Figure 4). The distribution of the eel-houses is restricted to the lower part of the River Ljungan drainage area, where the eel was most abundant. More in detail, almost all Ljungan eel-houses were located in a tributary, near to its outflow into the main river—but not in the main river itself. For the Domesday Book data in England too, Dekker and Beaulaton (2016b) found that fisheries were restricted to the smaller tributaries, with little or no documented cases in larger rivers and lakes. In Germany (Wittmack, 1875), the larger waterbodies (rivers, lakes, lagoons) that hosted a major fishery in the 1900s, appear to be missing in the 1800s: Kurisches Haff, Frisches Haff, Masurisches Seenplatte, Stettiner Haff, Boddenküste, Waddensee, Nordseeküste (Figure 2). Jacoby (1880) stated "Germany has … numerous … brackish areas, which today are useless, if not harmful. They could become the sources of the richest [eel] production and true levers of prosperity for the common people," referring specifically to the example of the Lebasee (now Polish: Lake Łebsko), next to his house, with 71 km^2 surface area still an order of magnitude smaller than the unexploited lakes referred to above. The fisheries in Lake IJsselmeer (the Netherlands; Dekker, 2004b) and in Lough Neagh (N.Ireland; Rosell, Evans & Allen, 2005) developed only in the 1900s. It is only in the Mediterranean, that some commercial fisheries in larger waterbodies occurred before the late 1800s. The fishery in the Comacchio lagoons (Italy) yielded 500–1,000 t/a (Aschonitis et al., 2017), but that fishery was already identified as an exceptional case in the mid-1800s (Coste, 1855). The fishery in the Albufera de Valencia (Spain) was yielding 750 t/a (Sanez-Reguart, 1791), supplying unknown markets. Elsewhere, exploitation of the larger waterbodies was generally restricted to a small-scale subsistence fishery along the shores (e.g., Beerbohm, 1872; Trybom & Wollebaek, 1904); in the absence of exploitation of the open water surface, catch volumes remained too small to develop a noticeable market.

Throughout the late 1800s and early 1900s, technical developments modernised the fisheries: Fishing gears were improved

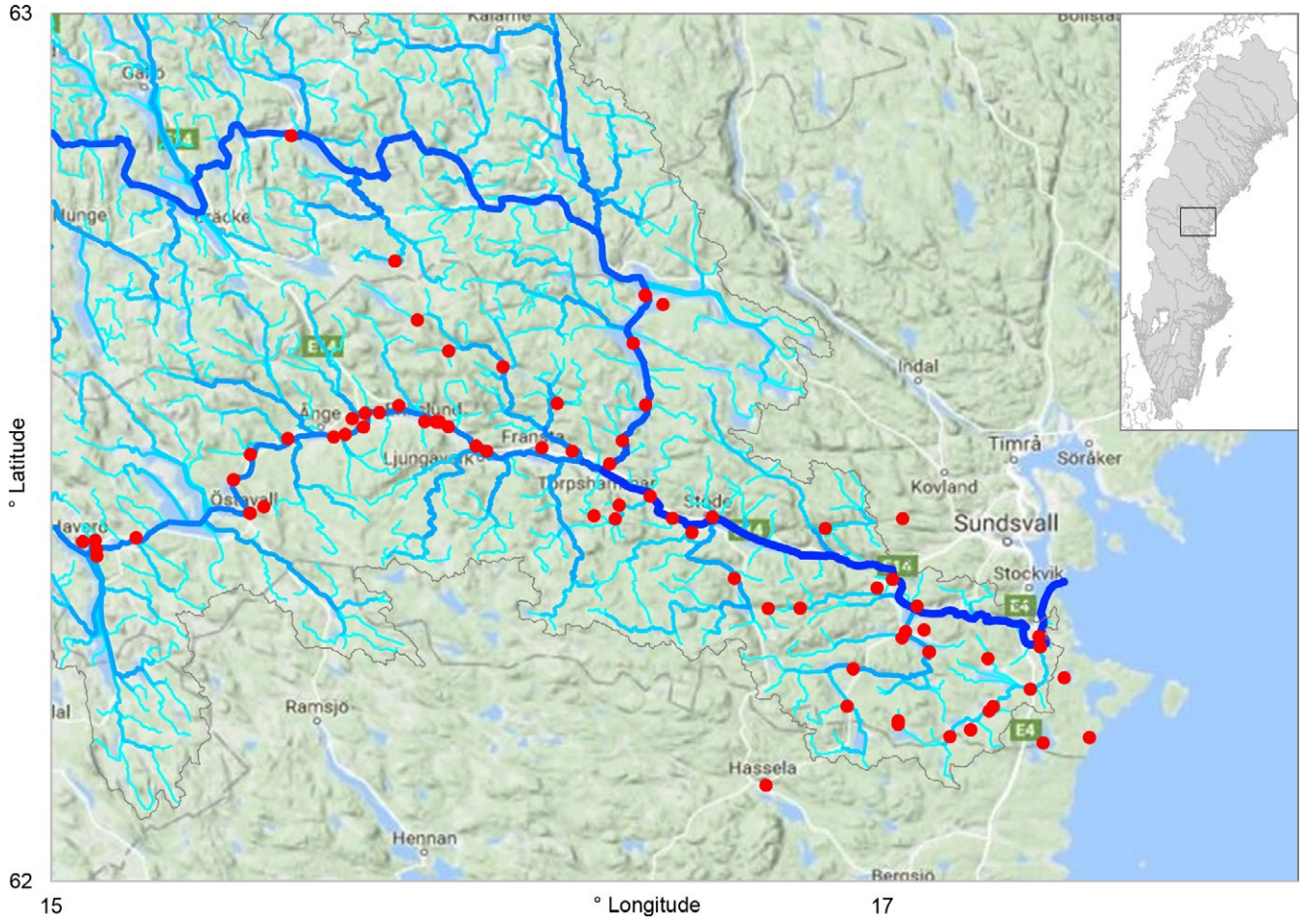

FIGURE 4 The spatial distribution of historical eel-houses ("ålhus") in the River Ljungan drainage area. In the background, a modern Google map, with the river network superimposed in blue, the hue reflecting Strahler stream orders. Data from Nordberg (1977)

and enlarged—affecting fisheries in inland and marine waters. In the late 1800s, a number of international exhibitions showed great technical progress, for example, the "Internationale Fischerei-Ausstellung zu Berlin 1880" (Lindeman, 1881). To my knowledge, most eel-specific developments were paralleled in other species. For the individual fishermen, the technical improvements meant a frequent renewal of gears, with ever-improving efficiency. For example: Lundberg (1881) describes the fykenets used along the Baltic coasts and in the Öresund (Sweden) in the 1870s, having a leader of 72–96 foot, that is, 22–29 m; in the 1960s, pound nets had a leader of 150–600 m in length (Henck, 1965), and even larger thereafter.

In conclusion: The modernisation and commercialisation of the eel fisheries in the late 1800s led to much larger companies, using more advanced and larger gear, exploiting larger waterbodies.

7 | PLANNING FISHERIES DEVELOPMENT

From 1850 onwards, interest in the development of inland fisheries and fish culture increased considerably, especially in relation to the (re)-invention of artificial reproduction of fish (Kinsey, 2006) and the simultaneous development of transport means (Dekker & Beaulaton, 2016a). Initially, this included eel, but the failure to achieve artificial reproduction eventually made the eel drop out. Predation of wild or restocked eel on salmon eggs and juveniles was considered a serious threat to the successful development of inland fish culture, for which reason, for instance, eel restocking in many areas in France was stopped (Dekker & Beaulaton, 2016a). For the development of the eel fisheries itself, attention remained focused on the reproduction (natural or artificial): the "Eel Problem" (Dekker & Beaulaton, 2016b).

In the late 1860s, however, Bettziech-Beta (1868) noted that "Germany has until now unexploited and even harmful eel regions which, by means of an adequate entrepreneurial spirit, certainly can be developed into healthy gold- and food-sources." While earlier treatises on fisheries development primarily focused their discussion about eel on the reproduction (e.g., Carbonnier, 1864; Coste, 1853; Haack, 1872), later treatises discussed the seasons and habitats of eel fisheries, gears, catch handling, preparation, marketing, etcetera (Gobin, 1889; Benecke, Dallmer & von dem Borne, 1886; Benecke, 1880; Borgmann, 1892; Walter, 1903; etcetera), and a large group of scientists became involved (e.g.,

TABLE 1 Annual yield of eel in Germany in the early 1930s, as reported by Röhler (1933). Röhler reported catches in units of Zentner (1 Ztr = 100 ℔ = 50 kg); the equivalent tonnage is added here

Water type	Area	Zentner	Tonnes
Coastal waters	Stettiner Haff	11,000	550
	Frisches Haff	11,000	550
	Kurisches Haff	4,103	205
	Ostseegebiete	8,100	405
	Nordsee	1,300	65
	Subtotal coastal waters	35,503	1,775
Lakes	450,000 ha in total	45,000	2,250
Rivers	Rhein	8,500	425
	Elbe	7,000	350
	Oder	2,000	100
	Weser	2,000	100
	Others	1,500	75
	Subtotal rivers	21,000	1,050
Others	Water mills (600 sites)	4,000	200
	Fixed eel traps (50–100 sites)	500	25
	Recreational catches	500	25
	Subtotal others	5,000	250
Total		106,503	5,325

Anonymous, 1886). Walter (1903) concluded that the eel is not fit for pond culture, and advocated the exploitation of wild eel stocks as "one of the main targets for all owners of a fishing water." Giving up on artificial reproduction and restocking—for the time being—the pressure on wild eel stocks increased rapidly. As early as 1881, Lindeman already noted: "In short time, eel fishing will have to be restricted if the eel is not to be completely out-fished in our waters."

In the late 1870s, der Deutsche Fischerei-Verein initiated a programme to stock the River Danube with glass eel, to establish a new stock in that river, which would reproduce in the Black Sea (Dekker & Beaulaton, 2016a). After 1897, when the Black Sea had been shown to be unfit for eel, Elsner (1899) discussed options for expansion of the eel fisheries in northern Germany, suggesting a complete infrastructure of distribution centres for glass eel for restocking, train services, and regulated prices, serving all of Germany. Eventually, a much smaller, but equally ambitious programme was implemented, transporting glass eel from Epney (UK) to Hamburg (DE), and then on by train to places all over northern Germany (Dekker & Beaulaton, 2016a).

In conclusion: A coherent development of the German eel fisheries in the last decades before the turn of the century—based on parallel, complementary, but not strongly planned and coordinated actions.

In the early 1900s, many more suggestions were made to develop the eel fisheries, especially in countries surrounding Germany. This included: Norway (Dahl, 1902), Sweden (Malm, 1904), Denmark (Petersen, 1904), Belgium (Gilson, 1908), France (Gandolfi Hornyold, 1931; Le Clerc, 1923), Tunisia (Heldt, 1931) and more. Those plans described their local stocks/habitats as un- or under-exploited, concentrating their discussion on two issues: establishing or enhancing the local eel stock by means of restocking, and improving the valorisation of the catch by means of hot-smoking and marketing. These development plans refer to recent achievements in Germany (or more generally: northern Europe) as their inspiration, often explicitly pointing at German efforts to increase their eel imports by stimulating the fisheries in the neighbouring countries. For instance, German traders offered new fykenets to Swedish fishers (Malm, 1904), and delivered large quantities of glass eel for restocking in Scandinavia, the Baltic States, central Europe, even the British Isles (Röhler, 1939). Trade networks were established, importing catches of yellow and silver eel from Scandinavia (Åklundh, 1992; Nilsson, 1996; Rollof, 1982), from the Mediterranean (Baan, 2015; Wiese, 1939), and the rest of the world (Devall, 1998). During times of war, state-organised agencies for import of eel were established in Germany ("Zentraleinkaufsgesellschaft Aalimport" during WW I, respectively "Aaleinfuhrgesellschaft" during WW II; Bundesarchiv, 2017), to ensure continued trade. In the interbellum period, the importance of imports into Germany grew from about 30% in 1926–1932 (Röhler & Schiemenz, 1934), via 50% in 1936–1937 (Schuldig, 1939), to 80% of the German market shortly before World War II (Friedrichs, 1942). While the German production in the 1930s stabilised at some 5,000 t/a (Table 1; Anonymous, 1933), the imports must eventually have come at about 20,000 t/a—an order of magnitude close to the total landings from all over Europe (Dekker, 2003a). In other countries too, international trade developed (e.g., 1,700–2,800 t/a imported to France in the mid-1930s; Anonymous 1939), often from the same sources (Denmark, Sweden, and others). In many countries, frequent market reports were published, detailing prices for various products (alive/dead, size categories, etcetera) in several countries; although no objectives for these market reports were identified, they will have had the effect to raise local prices to international standards, and possibly enhance the export.

In conclusion: Eel fisheries in the countries around Germany developed in the first decades of the 1900s, in many cases to enhance the export to Germany. Details appear to be more pre-planned than the earlier developments in Germany.

8 | ACHIEVEMENTS AND OUTCOMES

Evaluation of the outcomes of the developments in the late 1800s and early 1900s is hard to achieve, exactly because the fisheries had not been developed and no catch registration had existed before. Some information is found in the early studies (e.g., Wittmack, 1875; shown in Figure 2; Gourret, 1897), analysing the opportunities for developing the fisheries, but this information does not cover more

than a single snapshot of contemporary information. More informative are the reports on the first years after the onset of developments, but it remains unclear how well informed these were on the earlier, then already forlorn fisheries.

In 1922, Jacobsen and Johansen analysed the influence of temperature on the landings of eel from Danish coastal waters (including lagoons); for this, they used data from 1902 until 1916—Figure 5, below, copies some of their graphs. Clearly, catches were increasing rapidly, even though Jacobsen and Johansen considered the eel to remain under-exploited. As all catch trends in their publication—without any exception—showed a prolonged upward trend, they drew a very optimistic conclusion, that eel fisheries could be developed much further.

Röhler (1933) discusses the total eel production in Germany; his results are reproduced here in Table 1. For the traditional fisheries at water mills and fixed eel traps, Röhler derives an estimate of less

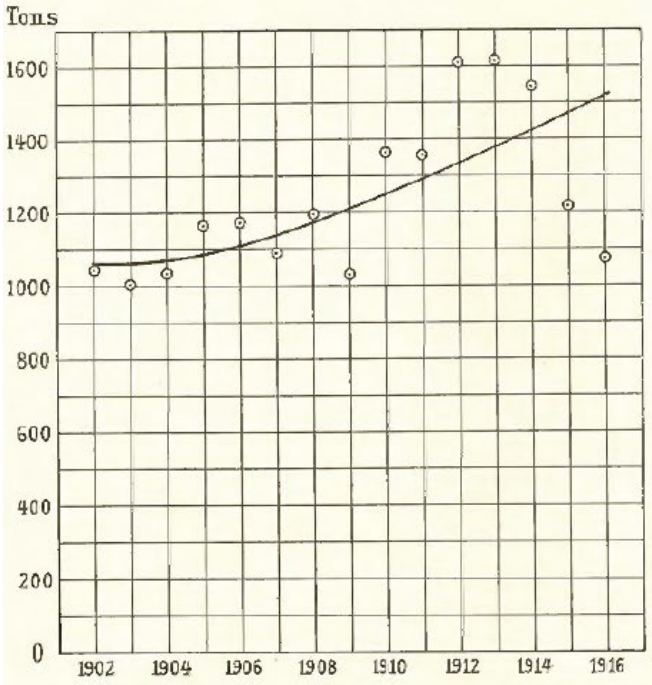

Fig. 4. Quantities of Eels caught in seines in Danish waters in 1902—16 (District 1—6, see Table 2).

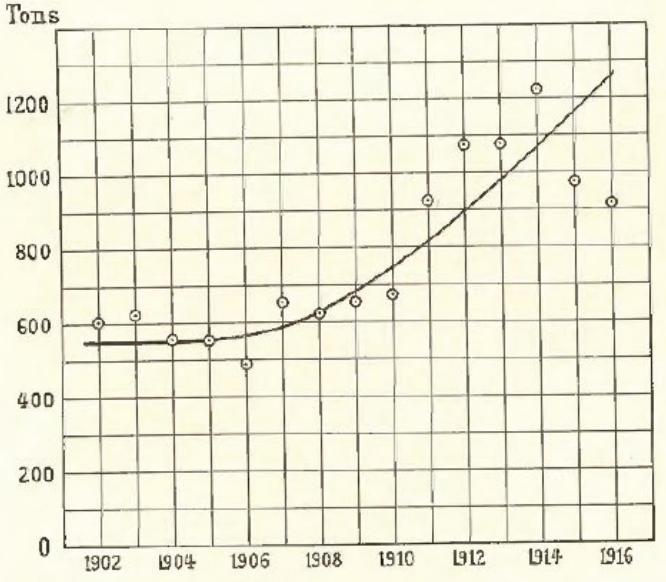

Fig. 5. Quantities of Eels caught by hooks and spear in Danish waters in 1902—16 (District 1—6, see Table 2).

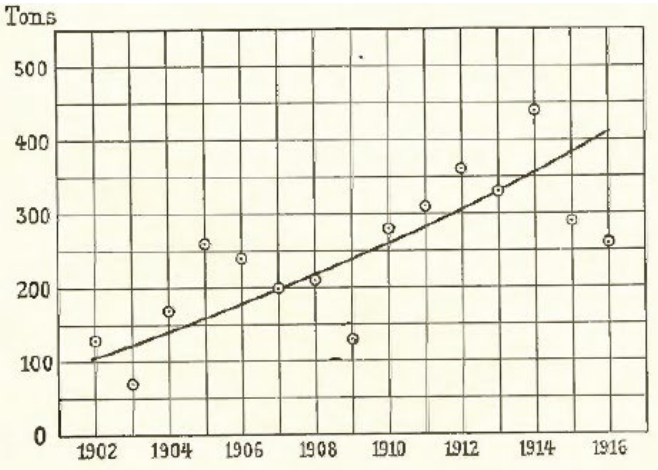

Fig. 6. Quantities of Eels caught in weels in the Limfiord in 1902—16.

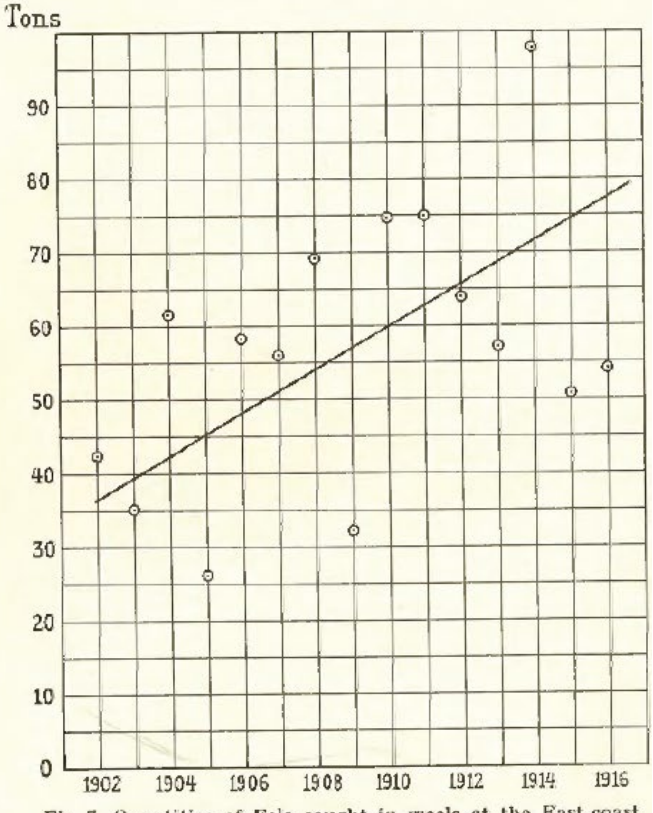

Fig. 7. Quantities of Eels caught in weels at the East-coast of Jutland in 1902—16.

FIGURE 5 Trends in eel catches over the years 1902–1916, analysed and presented by Jacobsen and Johansen (1922) on p. 10. In total, Jacobsen and Johansen show thirteen graphs in total, all with an upward trend

than 250 t/a, while the remaining fisheries, the "new fisheries" of his times, produce more than 5,000 t/a. He concludes: "that during the last decades there has been a considerable intensification of the eel economy."

For the Swedish west coast, Magnusson and Dekker (2017) recently analysed time series of eel catches spanning the whole 1900s. Their results indicate that the landings increased from almost nil in the early 1900s, via ca. 250 t/a in 1950, to more than 500 t/a in the late 1900s.

In conclusion: The development of a modern fishery in Germany and nearby countries in the early 1900s increased catches of eel considerably, by an order of magnitude or more. This gave rise to an optimistic view on the opportunities for further development of eel fisheries.

9 | DISCUSSION

"Eel fishing is … an old branch of the economy in Europe …, harvest levels have stayed essentially constant since 1885" (Tesch, 2003, p. 213). The information presented above, in contrast, evidences that commercial eel fisheries were purposely developed in the late 1800s (Germany) and early 1900s (elsewhere)—transforming a small-scale subsistence fishery supplying a localised market—into a booming commercial fishery, exploiting new areas by new fishing methods, served by and serving international markets, producing luxury foods for new customers. Commercial eel fishing, as of today, constitutes the offspring of ancient eel fisheries, but has itself a history of just over a hundred years.

The view that eel fisheries developed gradually over a period of centuries, is widely held (Tesch, 2003; Tsukamoto & Kuroki, 2014 and the chapters on individual countries therein), but rarely substantiated. This publication now reviewed, reanalysed and reinterpreted the original literature from the late 1800s and early 1900s, but did not disclose new archives or analysed new primary information. The transformation from a subsistence fishery to a commercial fishery around the turn of the century made the documentation improve—implying that the before period and the transition itself were not well documented. As a consequence, the evidence for the transformation from subsistence to commercial fisheries is rather bleak. Finding publications in several countries, however, describing the same set of developments from different angles, indicates that the transition was more than a local development. Moreover, literal quotes indicate that contemporary authors were aware of the transition, and hence, the transition must have been real (Doose, 1908; Ehrenbaum, 1930; Jacobsen & Johansen, 1922; Lindeman, 1881; Malm, 1904; Röhler, 1933). It will be worthwhile to consider much more detailed studies on the history of eel fisheries, unearthing primary information in national archives, and integrating results at a European level.

The commercialising and scaling-up of the eel fisheries began in Germany in the last decades of the 1800s, and radiated out in the early 1900s to Scandinavia and the rest of the Baltic, the Netherlands, northern Italy and Greece. However, less evidence was found for more southern countries, and most of that was from later decades—is that the limits of my own Germanic background, or were those countries truly trailing behind? Earlier studies did identify the central role of the German demand in the European eel market (Houvenaghel, 1989; Moriarty, 1997), but those studies might as well have a "northern bias." Evidently, the eel industry in Comacchio (northern Italy) was an exceptional case, developed long before (Coste, 1855; Friedlander, 1872), with trade routes in the Adriatic and the rest of Europe. Although the Comacchio eel industry (Coste, 1855) was the glorious example for France (Dekker & Beaulaton, 2016a), it has hardly influenced the developments in Germany (Bellini, 1910). While the fisheries in central and northern Europe increased rapidly in the early 1900s and additional imports were organised from the Mediterranean (Wiese, 1939), the Comacchio fisheries experienced a decline (Aschonitis et al., 2017). In England, markets were and are dominated by imports (Leuchs, 1862; McCulloch, 1835); only the Lough Neagh fishery in Northern Ireland reached a scale comparable to the commercial fisheries in mainland Europe, with peak production as late as the 1960s (Rosell et al., 2005), for export to Germany. For the Mediterranean, as well as for the British Isles and the Iberian Peninsula, the low prevalence of larger, permanent lakes might have been a limiting factor (Dekker, 2003b). For France, the hostile relationship with Germany—from the Franco-Prussian war (1870–1871) until World War II (1940–1945)—has troubled the exchange of expertise with Germany, and blocked trade relationships, for eel too (Dekker & Beaulaton, 2016a). All in all, the upscaling of the commercial eel fisheries appear to have begun in Germany, radiated quickly out towards northern countries, and—for various reasons—radiated only slowly southward and into the periphery. From the early 1900s until the development of Asian aquaculture in the 1980s (Crook, 2010), the international eel market throughout Europe has been demand-driven, the major demand located in Germany.

In 1865, Anonymous reported that "the eels, that feed us, have almost disappeared from our small waters" in France. Walter (1910), discussing options to develop eel fishery, described "an increasing depletion of the inland waters of eels" in Germany. Benecke (1884), advocating eel ladders for the region around Königsberg (now Kaliningrad, Russia), stated that "[eel] migration has also been observed at so many places in our provinces [in times now past], even deep within the country," but was later blocked by water mills and other barriers. Between 1840 and 1879, a national restocking programme was developed in France, to repopulate upriver marshes and streams that had lost their natural eel abundance (Dekker & Beaulaton, 2016a). That is, many authors, in several countries, reported a declining abundance of the eel in the 1800s—in a time period that, it is claimed here, the commercial fisheries began to expand! This apparent contradiction is reconciled, by taking into account the habitat types involved: The deteriorating abundance occurred foremost in smaller streams and marshes, where the "old-school" subsistence fisheries took place; while the "new-school" commercial fisheries expanded into larger lakes, coastal lagoons and marine waters, exploiting new habitats

that had been only marginally exploited before. While the earlier authors identified migration barriers as the prime cause for the decline, the later authors advocating expansion primarily discussed logistical details (restocking, fishing gears, processing and marketing).

Starting from a traditional subsistence fisheries in upriver habitats that faded in the mid-1800s, then an expanding fishery exploiting new downriver habitats, and finally an expanding import network stimulating fisheries in other countries. Noting that long-term catch trends for most areas increased, peaked, and shortly after began to decline, this may well qualify as serial depletion of the stock. Noting the geographical distance between the former upriver habitats and the new locales of the expanding fisheries, it seems rather unlikely that the "old" and the "new" fisheries comprised the same people. Moreover, most of the expansion and modernisation of the fisheries was instigated by government officials, scientists and noblemen, who were new to eel fishing (Dekker & Beaulaton, 2016a). That is, nobody was personally involved in serial depletion, but nevertheless for the stock as a whole, it may have worked out like that.

In the late 1800s, the larger habitats that had remained essentially unexploited before, in all probability, produced a considerable amount of silver eel freely escaping towards the sea to spawn. In the early 1900s, the migration barriers in the upriver habitats had increased in number and efficacy, while the downriver habitats became progressively exploited. In all likelihood that will have resulted in a considerable reduction in silver eel escapement towards the sea. That is, while great efforts were made to expand and enhance the fisheries, by new techniques and into new areas, the spawner escapement likely declined significantly—the fishing impact on the stock increased substantially. This disqualifies the use of commercial landings data as a proxy for the stock size, as Dekker (2003a, 2004a) and ICES (2005, 2013) pursued. In the early 1900s, when catches increased, spawner escapement must have declined severely. Furthermore, noting that long-term catch trends for most larger lakes/lagoons increased, peaked and shortly after began to decline—never showing a period of high and sustained yield—the historical fisheries are a doubtful basis for setting management and restoration targets (Anonymous, 2007a; ICES, 2009). Additionally, noting the importance of upriver habitats for the eel in historic times (Dekker & Beaulaton, 2016b), and the loss of (accessibility to) those habitats already in the late 1800s, the potential for restoring the eel stock from current habitats might be restricted. Moreover, the assumption that local eel stocks are naturally restricted by the carrying capacity of their habitats, especially in the Bay of Biscay area (e.g., Moriarty & Dekker, 1997), is questionable, even though density-dependent processes might occur in the currently restricted habitats (e.g., Briand, Fatin, Fontenelle & Feunteun, 2005; Vøllestad & Jonsson, 1988). Protection and restoration targets should focus on anthropogenic mortalities (Dekker, 2016) for the current stock, irrespective of the habitats available—that is, the spawners per recruit, spawner potential ratio (%SPR).

All in all, a picture emerges of a rapidly expanding eel fishery in the late 1800s and early 1900s, enabled by technical progress (gears, transport), producing new products (hot-smoked eel) for new markets (cities, export)—expanding and developing in a time that non-fishing impacts on the eel stock (habitat loss, pollution) increased considerably, and the yield in the traditional fisheries was in decline. This process was later echoed in the development of the glass eel fisheries in the 1960s (Briand et al., 2008). The expansion and development of the fisheries have masked and mitigated the decline of the fisheries in the upriver habitats for the market—but in doing so, delayed attention for the deteriorating situation of the stock, and for the development of a sustainable eel fishery.

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REFERENCES

Åklundh, P. (1992). *Ålkvassar [Eel boats]* Småskrifter utgivna av Santa Annas Gille i Åhus (Vol. 20). Tollarp, Sweden: Winjetryckeriet.

Anonymous (1086). Liber de Wintonia. In J. Morris (Ed.) *The domesday book* (English translation 1977). Phillimore, London, UK: The University of Hull. Retrieved from http://hydra.hull.ac.uk/resources/hull:461

Anonymous (1724). *Resolutien van de Heeren Staaten van Holland en Westvriesland [Resolutions of the lordships' States of Holland and West-Frisia]*. Retrieved from https://books.google.nl/books?id=-rBJAAAAcAAJ&dq=%22gezouten+aal%22 (last accessed 1 February 2018)

Anonymous (1765). *Anguilles fumées [Smoked eels]*. L'Avantcoureur; feuille hebdomadaire. Paris, France: Lacombe. No 21: p. 319.

Anonymous (1865). *Pêche fluviale [River fishery]*. Rapport du Préfet et Procès-Verbaux des Séances et des Délibérations du Conseil General. Pau, France: Vignancour. pp. 70-72.

Anonymous (1876). *Een keukenlijst van vóor twee eeuwen [A shopping list from two centuries ago]*. Zondagsblad van het Nieuws van de Dag 3(20), Newspaper from Sunday 14th May 1876.

Anonymous (1886). [Untitled]. *Circulare des Deutschen Fischerei-Verein im Jahre 1886*. Berlin, Germany: W. Moeser Hofbuchdruckerei. pp. 20-21.

Anonymous (1933). Die deutsche Binnenfischerei; Denkschrift über ihre Lage und über die Wege zu ihrem Wiederaufbau [The German inland fisheries; Debate article about the situation and the ways to

reconstruction]. *Allgemeine Fischerei-Zeitung*, *58*(7), 99–103, 114-117, 132-135, 146-149.

Anonymous (1939). Renseignements Commerciaux, Poisson d'eau douce [Commercial Information, Freshwater Fish]. *Bulletin Français de Pisciculture*, *117*, 166–172.

Anonymous (2007a). *Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel*. Official Journal of the European Union L 248/17. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007R1100&from=EN (last accessed 1 February 2018)

Anonymous (2007b). *Consideration of proposals to amend the appendices I and II*. CoP14. Proposal 18. Fourteenth meeting of the Conference of the Parties, The Hague, The Netherlands. Retrieved from https://www.cites.org/sites/default/files/eng/cop/14/prop/E14-P18.pdf (last accessed 1 February 2018).

Aschonitis, V., Castaldelli, G., Lanzoni, M., Rossi, R., Kennedy, C., & Fano, E. A. (2017). Long-term records (1781–2013) of European eel (*Anguilla anguilla* L.) production in the Comacchio Lagoon (Italy): Evaluation of local and global factors as causes of the population collapse. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *27*(2), 502–520.

Baan, J. (2015). *Een zeegaand palingschip - de laatste der Mohikanen [A seafaring eel-ship – the last of the Mohikans]*. In: Anonymous 2015 Jaarboek 2015 (pp. 34-41). Sneek, Netherlands: Fries Scheepvaart Museum.

Beerbohm, W. (1872). *Die Fischerei des kurischen Haffs und der Nebengewässer desselben sowie der anliegenden Theile der Ostsee [The fishery of the Curonian lagoon and its tributaries, as well as the nearby parts of the Baltic Sea]*. Circulare des Deutschen Fischerei-Verein im Jahre 1872. Berlin: W. Moeser Hofbuchdruckerei. pp. 196-208.

Bellini, A. (1910). Aalzucht-Versuche [Trials to culture eel]. *Zeitschrift für Fischerei und deren Hilfswissenschaften*, *15*, 136–181.

Benecke, B. (1880). *Fische, fischerei und fischzucht in Ost-und Westpreussen [Fish, fishery and fish culture in eastern and western Prussia]*. Königsberg, Germany: Hartungsche Verlag.

Benecke, B. (1884). *Die Wanderung der Aalbrut und die Einrichtung von Aalbrutleitern [The migration of eel recruits and the development of elver leaders]*. Königsberg, Germany: Leupold.

Benecke, B., Dallmer, E., & von dem Borne, M. (1886). *Handbuch der Fischzucht und Fischerei [Handbook of fish culture and fishery]*. Berlin, Germany: Paul Parey Verlag.

Bettziech-Beta, H. (1868). *Die Bewirtschaftung des Wassers und die Ernten daraus [The exploitation of waters and the yield of that]*. Leipzig, Heidelberg, Germany: Winter Verlag.

Birkmeyer, J. M. (1845). *Vollständiges Kochbuch fur Kranke und Genesende [Complete cookbook for the ill and the recovering]*. Nürnberg, Germany: Zeh'schen Buchhandlung.

Borgmann, H. (1892). *Die Fischerei im Walde. Ein Lehrbuch der Binnenfischerei für Unterricht und Praxis [The fishery in the forest. A textbook of inland fisheries for education and practice]*. Berlin, Germany: Springer Verlag.

Briand, C., Bonhommeau, S., Beaulaton, L., & Castelnaud, G. (2008). An appraisal of historical glass eel fisheries and markets: Landings, trade routes and future prospect for management. In C. Moriarty (ed.), *The institute of fisheries management annual conference 2007* (pp. 1-21). Westport, Connecticut: The Institute of Fisheries Management.

Briand, C., Fatin, D., Fontenelle, G., & Feunteun, E. (2005). Effect of re-opening of a migratory pathway for eel (*Anguilla anguilla*, L.) at a watershed scale. *Bulletin Français de Pêche et de Pisciculture*, *378–379*, 67–86.

Buchner, K. (1813). *Allerneuestes Münchener Kochbuch für baierische Mädchen und Hausfrauen [The very newest cookbook from München, for young ladies and housewives in Bavaria]*. München, Germany: Fleischmannischen Buchhandlung.

Bundesarchiv (2017). *BArch R 8801, Aaleinfuhrgesellschaft mbH, 1917-1920*. Retrieved from https://www.archivesportaleurope.net/ead-display/-/ead/pl/aicode/DE-1958/type/fa/id/DE-1958_1bf4b010-881e-4b2a-b721-2657c465c81b (last accessed 1 February 2018)

Carbonnier, P. (1864). *Guide pratique du pisciculteur [Practical guide for fish culturists]*. Paris, France: Lacroix.

Corvinus, G. S. (1715). *Nutzbares, galantes und curiöses Frauenzimmer-Lexicon [Useful, gallant and curious women's room Lexicon]*. Leipzig, Germany: Gleditsch.

Coste, V. (1853). *Instructions Pratiques sur la pisciculture [Practical instructions on fish culture]*. Paris, France: V. Masson.

Coste, V. (1855). *Voyage d'exploration sur le littoral de la France et de l'Italie: Rapport à M. le ministre de l'agriculture, du commerce et des travaux publics, sur les industries de Comacchio, du lac Fusaro, de Marennes, et de l'Anse de l'Aiguillon [Exploratory trip to the coast of France and Italy: Report to the Minister of Agriculture, Trade and Public Works, on the industries of Comacchio, Lake Fusaro, Marennes, and l'Anse de l'Aiguillon]*. Paris, France: Imprimerie impériale.

Crook, V. (2010). *Trade in Anguilla species, with a focus on recent trade in European Eel A. anguilla*. TRAFFIC report prepared for the European Commission.

Dahl, K. (1902). Muligheder for Aalefiske i Norges Ferskvand [Opportunities for eel fisheries in Norway's freshwater]. *Norsk Fiskeritidende*, *21*, 728–737.

De Leo, G. A., Melià, P. A. C. O., Gatto, M., & Crivelli, A. J. (2009). *Eel population modeling and its application to conservation management*. In J. M. Casselman and D. K. Cairns (Eds.), Eels at the edge: science, status, and conservation concerns. Proceedings of the 2003 international eel symposium. American Fisheries Society symposium publication, *58*, 327–345.

de Massy, J. R. (1862). *De halles et marchés et du commerce des objets de consommation à Londres et à Paris [Halls and markets and trade in consumer goods in London and Paris]*. IIe partie. Paris, France: Imprimerie impérial.

Dekker, W. (2000a). The fractal geometry of the European eel stock. *ICES Journal of Marine Science*, *57*, 109–121.

Dekker, W. (2000b). A Procrustean assessment of the European eel stock. *ICES Journal of Marine Science*, *57*, 938–947.

Dekker, W. (2003a). Did lack of spawners cause the collapse of the European eel, *Anguilla anguilla*? *Fisheries Management and Ecology*, *10*, 365–376.

Dekker, W. (2003b). On the distribution of the European eel and its fisheries. *Canadian Journal of Fisheries and Aquatic Sciences*, *60*, 787–799.

Dekker, W. (2004a). *Slipping through our hands – population dynamics of the European eel*. (PhD thesis). Amsterdam, the Netherlands: University of Amsterdam, 186 pp. Retrieved from http://www.diad-fish.org/doc/these_2004/dekker_thesis_eel.pdf

Dekker, W. (2004b). What caused the decline of Lake IJsselmeer eel stock since 1960? *ICES Journal of Marine Science*, *61*, 394–404.

Dekker, W. (2016). Management of the eel is slipping through our hands! Distribute control and orchestrate national protection. *ICES Journal of Marine Science*, *73*, 2442–2452.

Dekker, W., & Beaulaton, L. (2016a). Faire mieux que la nature – the history of eel restocking in Europe. *Environment and History*, *22*(2), 255–300.

Dekker, W., & Beaulaton, L. (2016b). Climbing back up what slippery slope? Dynamics of the European eel stock and its management in historical perspective. *ICES Journal of Marine Science*, *73*(1), 5–13.

Devall, C. A. (1998). *Heybridge basin eel industry 1928-1968*. Maldon and the tidal Blackwater, Vol 1. Chelmsford, England: Devall.

Dodd, G. (1856). *The food of London: A sketch of the chief varieties, sources of supply, probable quantities, modes of arrival, processes of manufacture, suspected adulteration, and machinery of distribution, of the food for a community of two millions and a half*. London, England: Longman, Brown, Green and Longmans

Doose, W. (1908). Eine wenig bekannte Aalfangmethode [A less well known technique for catching eel]. *Allgemeine Fischerei-Zeitung*, *33*(18), 393–394.

Ehrenbaum, E. (1930). Der Flussaal [The river eel]. In R. Demoll & H. N. Maier (Eds.), *Handbuch der Binnenfischerei Mitteleuropas*, *Band III* (pp. 160–217). Stuttgart, Germany: Schweizerbart'sche Verlagsbuchhandlung.

Elsner, B. (1899). Ueber die Besetzung der Binnengewässer mit Aalen [On the stocking of inland waters with eel]. *Allgemeine Fischerei-Zeitung*, *24*(7), 107–111.

Friedlander, E. (1872). *La pesca nelle lagune di Comacchio [Fishing in the lagoons of Comacchio]*. Firenze, Italy: Coi tipi dei successore Le Monnier.

Friedreich, J. B. (1846). *Handbuch der Gesundsheitspolizei [Handbook of the health police]*. Ansbach, Germany: F.H. Gummi Verlag.

Friedrichs, M. (1942). Der Aal im Handel und in der Industrie [The eel in trade and industry]. *Monatshefte für Fischerei*, *10*(3), 44–46. Berlin, Germany: Verlag 'Das Fischnetz'.

Gabriel, O., & Wendt, T. (2003). Fishing methods. In F.-W. Tesch & J.E. Thorpe (Eds.), *The Eels*, *third edition* (pp. 243–293).

Gandolfi Hornyold, A. (1931). Un étrange poisson: L'anguille, ses moeurs et son intérêt économique [A strange fish: The eel, its habits and its economic interest]. *La Terre et la Vie*, *Revue d'Histoire Naturelle*, *11*, 657–674.

Gilson, G. (1908). L'anguille, sa reproduction, ses migrations et son intérêt économique en Belgique [The eel, its reproduction, its migration and its economic interest in Belgium]. *Annales de la Société royale Zoologique et Malacologique de Belgique*, *42*, 7–58.

Gobin, A. (1889). *La pisciculture en eaux douces [Fish culture in fresh water]*. Paris, France: Baillière et fils.

Gouffé, J. (1869). *Le livre des conserves [The book of preserves]*. Paris, France: Hachette.

Gouffé, J. (1871). *The book of preserves*. London, England: Sampson Low, Son and Marston.

Gourret, P. (1897). *Les Etangs saumâtres du midi de la France et leurs pêcheries [The brackish lagoons of southern France and their fisheries]*. Annales du Musée d'histoire naturelle de Marseille. Tome V, Memoire N°1.

Haack, H. (1872). *Die rationelle fischzucht [The rational fish farming]*. Leipzig, Germany: Peter's Verlag.

Heldt, H. (1931). *Le fumage de l'anguille*, *industrie possible dans les pays méditerranéens [The smoking of eels*, *an industry that is viable in the Mediterranean countries]*. Note du Station Océanographique de Salammbô, N° 21.

Henck, B. (1965). Bundgarnfischerei an der Ostküste Schleswig-Holsteins [Poundnet fishery on the east coast of Schleswig-Holstein]. *Fischerblatt*, *13*, 1–9.

Hopf, A. (1846). Spickaal auf der Berliner Kunst-Ausstellung im Jahre 1846. Charlottenburg, Germany: Egbert Bauer Verlag.

Houvenaghel, G. T. (1989). Assessment of the needs to culture the eel *Anguilla anguilla* in Europe. In N. De Pauw, E. Jaspers, N. Ackefors, & N. Wilkins (Eds.), *Aquaculture - a biotechnology in progress*. Proceedings of the International Conference Aquaculture '87, 2-5 June 1987, Amsterdam (pp. 169–178). Bredene, Belgium: European Aquaculture Society.

ICES (2005). *International council for the exploration of the sea*. Report of the ICES/EIFAC Working Group on Eels. ICES C.M. 2005/I:01.

ICES (2009). *Report of the 2008 session of the Joint EIFAC/ICES Working Group on Eels*. Leuven, Belgium, 3–7 September 2008. ICES CM 2009/ACOM:15.

ICES (2013). *Report of the joint EIFAAC/ICES working group on eels (WGEEL)*, *Copenhagen*, *Denmark*. ICES CM 2013/ACOM:18.

ICES (2017). *Report of the joint EIFAAC/ICES/GFCM working group on eels (WGEEL)*, *3–10 October 2017*, *Kavala*, *Greece*. ICES CM 2017/ACOM:15.

Jacobsen, J. P., & Johansen, A. C. (1922). On the causes of the fluctuations in the yield of some of our fisheries: 2. The eel fisheries. *Meddelelser fra Kommissionen for Havundersøgelser*, *6*(9), 1–32.

Jacoby, L. (1880). *Der Fischfang in der Lagune von Comacchio nebst einer Darstellung der Aalfrage [The fishery in the lagoon of Comacchio*, *as well as an account of the eel problem]*. Berlin, Germany: A. Hirschwald.

Kettle, A. J., Heinrich, D., Barrett, J. H., Benecke, N., & Locker, A. (2008). Past distributions of the European freshwater eel from archaeological and palaeontological evidence. *Quaternary Science Reviews*, *27*(13), 1309–1334.

Kinsey, D. (2006). Seeding the water as the earth: The epicenter and peripheries of a western aquaculture revolution. *Environmental History*, *11*, 527–566.

Knowles, R. D. (2006). Transport shaping space: Differential collapse in time–space. *Journal of transport geography*, *14*(6), 407–425.

Koch, W. (1925). *Die Geschichte der Binnenfischerei von Mitteleuropa [The history of the inland fisheries in central Europe]*. Handbuch der Binnenfischerei Mitteleuropas, Band IV. Stuttgart, Germany: Schweizerbart'sche Verlagsbuchhandlung.

Kurs, V. (1894). *Tabellarische Nachrichten über die flössbaren und schiffbaren Wasserstrassen des Deutschen Reiches [Tabular information on the navigable waterways of the German Reich]*. Berlin, Germany: Siemenroth & Worms.

La Chapelle, V. (1735). *Le Cuisinier moderne [The modern cook]*. Le Haye [The Hague], the Netherlands: De Groot.

Le Clerc, J. (1923). Une richesse trop peu exploitée: L'anguille d'avalaison [An underexploited resource: The down-migrating eel]. *Bulletin de la Société Centrale d'Aquiculture et de Pêche*, *4–6*, 33–35.

Leuchs, J. C. (1829). *Das Einsalzen und Räuchern nach den neuesten Verbesserungen [Salting and smoking according to the latest improvements]*. Nürnberg, Germany: Leuchs & Co.

Leuchs, J. C. (1862). *Vortheilhafte Benützung der Fische*, *des Fischrogens*, *der Fischteiche [Advantageous use of fish*, *fish fry*, *fish ponds]*. Nürnberg, Germany: Leuchs & Co.

Lindeman, M. (1881). *Amtliche Berichte über die internationale Fischerei-Ausstellung zu Berlin 1880; II. Seefischerei [Official Report on the International Fisheries Exhibition in Berlin 1880; II. Sea fishing]*. Berlin, Germany: Paul Parey Verlag.

Linnaeus, C. (1758). *Systema naturae per regna tria naturae* (10 ed., Vol. 1). Holmiae [Stockholm], Sweden: Laurentius Salvius.

Lundberg, R. (1881). Om ålfisket med s.k. hommor vid svenska Östersjökusten samt Öresund [On the eel fishery with so-called 'hommor' on the Baltic Sea coast and Öresund in Sweden]. *Lantbruksakademins Handlingar och tidskrift*, *20*, 301–317.

Magnusson, K., & Dekker, W. (2017). *Fishing for high price*. Poster presented at the 1st UK International Eel Science Symposium, ZSL London, June 13th – 15th 2017.

Malm, A. H. (1904). *Berättelse öfver Göteborgs och Bohusläns hafsfisken under 1902–1903 [Report on the sea fisheries of Göteborgs and Bohus' län in 1902-1903]*. Göteborg, Sweden: Wald. Zachrissons Boktryckeri A-B.

McCulloch, J. R. (1835). *A dictionary*, *practical*, *theoretical*, *and historical*, *of commerce and commercial navigation*. London, England: Longman, Rees, Orme, Brown, Green and Longman.

Molokhovets, Y. (1901). *Podarok molodym khozyaykam ili sredstvo k umen'sheniyu raskhodov v domashnem khozyaystve. [Молоховец Е. 1901 Подарок молодым хозяйкам или средство к уменьшению расходов в домашнем хозяйстве. Gift to Young Housewives, or a means to reduce costs in the household - a frequently revised/expanded reprint of the 1861 original]*. St.Petersburg, Russia: Klobukova.

Moriarty, C. (1990). European catches of elver of 1928-1988. *Internationale Revue des gesamtes Hydrobiology*, *75*(6), 701–706.

Moriarty, C. (1997). The European eel fishery in 1993 and 1994: First report of a working group funded by the European Union Concerted Action AIR A94-1939. *Fisheries Bulletin (Dublin)*, *14*.

Moriarty, C., & Dekker, W. (Eds.) (1997). *Management of the European eel. Fisheries Bulletin*, Vol. *15*. Dublin, Ireland: The Marine Institute.

Neuenhahn, C. C. A. (1806). *Anleitung zum landwirtschaftlichen Handel, 1st Band [Guide to local agricultural trade, Vol 1]*. Erfurt, Germany: Kepfer.

Nilsson, S.-W. (1996). *A-B Ålexporten Åhus [Åhus eel export, inc.]*. Skrifter utgivna av Santa Annas Gille i Åhus, Vol. 16. Åhus, Sweden: Åhustryckeriet.

Noël, S. B. J. (1815). *Histoire Générale des Pêches Anciennes et Modernes [General History of Ancient and Modern Fisheries]*. Paris, France: L'imprimerie Royale.

Nordberg, P. (1977). *Ljungan: vattenbyggnader i den näringsgeografiska miljön 1550-1940 [The river Ljungan: water-related constructions in the context of business geographics 1550-1940]*. (PhD thesis). University of Umeå, Umeå, Sweden.

Palm, S., Dannewitz, J., Prestegaard, T., & Wickstrom, H. (2009). Panmixia in European eel revisited: No genetic difference between maturing adults from southern and northern Europe. *Heredity*, *103*, 82–89.

Petersen, C. G. J. (1904). *Aalen, hvad man ved om den samt anvisning paa at foröge udbyttet af aalefiskeriet [Eel, what one knows about them as well as an instruction for how to increase the yield of eel fishing]*. Copenhagen, Denmark: Det Schubotheske Forlag.

Pötzl, N. F. (2015). *Bismarck. Der Wille zur Macht [Bismarck. The will to have power]*. Berlin, Germany: Ullstein eBooks.

Radcliffe, W. (1921). *Fishing from the earliest times*. London, UK: John Murray.

Rindom, S., Tomkiewicz, J., Munk, P., Aarestrup, K., Als, T. D., Pedersen, M. I., … Anderberg, C. (2014). Eels in culture, fisheries and science in Denmark. In K. Tsukamoto & M. Kuroki (Eds.), *Eels and Humans* (pp. 41-60). Japan: Springer.

Röhler, E. (1933). Die Ergebnisse der Fischerei auf Aal in Deutschland [The outcomes of eel fisheries in Germany]. *Fischerei Zeitung*, *36*(45), 541–543, 555–558, 567–569.

Röhler, E. (1939). Bericht über die Aalbrutgewinnung im Frühjahr 1939 [Report on the elver harvest in spring 1939]. *Fischerei-Zeitung*, *42*(26), 305.

Röhler, E., & Schiemenz, F. (1934). Aalfang, Aaleinfuhr, Aalpreis in Deutschland [Eel fishing, eel import, eel price in Germany]. *Sammlung fischereilicher Zeitfragen*. Neudamm, Germany: Neumann Verlag, Heft *23*, 20–24.

Rollof, Y. (1982). *Från ålakusten till Kap Horn [From the Eel Coast to Cape Horn]*. Tollarp, Sweden: Winjetryckeriet.

Rosell, R., Evans, D., & Allen, M. (2005). The eel fishery in Lough Neagh, Northern Ireland–an example of sustainable management? *Fisheries Management and Ecology*, *12*(6), 377–385.

Rosenthal, N. E. (1910). *Aus großer Zeit, Erlebnisse eines Kriegsfreiwilligen von 1870/71 [It was a great time, experiences of a war volunteer from 1870/71]*. Berlin, Germany: Verlag Franz Seeliger.

Sanez-Reguart, D. A. (1791). *Diccionario Historico de los Artes de Pesca National [Historical Dictionary of National Fishing Arts]*. Imprenta de la Viuda de Don Joaquin Ibarra, Madrid. Cited on p.199 of : Berthelot, S. (1868). Études sur les Pêches Maritimes dans la Méditerranée et l'Océan. Paris, France: Challamel Ainé.

Sauvage, H. E. (1883). *Rapport sur la pêche en Hollande [Report on the fisheries in the Netherlands]*. Paris, France: Imprimerie nationale.

Schuldig, R. F. (1939). Die wichtigsten Aalfangebiete Deutschlands und ihre Erträge in den Jahren 1936 und 1937 [The most important eel fisheries areas in Germany, and their yield in 1936 and 1937]. *Fischerei-Zeitung*, *42*(27), 317–318.

Selling, J. (2009). *Långsam fisk. Torkning, rökning och saltning på skärgårdsvis [Slow fish. Drying, smoking and salting, the way of 'skärgården', the islands]*. Hjorted, Sweden: Ostkultur Förlag.

Stevenson, C. H. (1899). The preservation of fishery products for food. *Bulletin of the United States Fish Commission*, *18*, 335–563.

Struck, H. (1965). Die industrielle Verarbeitung des Aales [Industrial processing of eel]. In J. A. Keune & H. Struck (Eds.), *Der Aal; eine kleine Monographie über einen weltberühmten Wanderfisch [The eel, a small monography about a world-famous migratory fish]*. Praxis der Fischwirtschaft, Band 4 Der Aal (pp. 72-81). Hamburg, Germany: Keune.

Tesch, F.-W. (2003). *The Eel*. Oxford, UK: Blackwell Science.

Trybom, F., & Wollebaek, A. (1904) *Übersicht über die Seefischerei Schwedens an den Süd- und östlichen Küsten dieses Landes*. [Overview of the Swedish sea fisheries, on its south and east coast] Conseil permanent international pour l'Exploration de la Mer, Publications de Circonstance (13a), pp.27-59.

Tsukamoto, K., & Kuroki, M. (Eds.) (2014). *Eel and humans, humanity and the sea*. Tokyo, Japan: Springer.

Van Dam, P. J. E. M. (1998). *Vissen in veenmeren: de sluisvisserij op aal tussen Haarlem en Amsterdam en de ecologische transformatie in Rijnland 1440-1530 [Sluice fisheries and sluice regime, the eel fishery between Haarlem and Amsterdam and the ecological transformation in Rijnland]*. Hollandse Studiën 34, Hilversum, the Netherlands: Uitgeverij Verloren.

Van Densen, W. L. T. (2001). *On the perception of time trends in resource outcome*. Its importance in fisheries co-management, agriculture and whaling. (PhD thesis), University of Twente, Enschede, the Netherlands.

Vøllestad, L. A., & Jonsson, B. (1988). A 13-year study of the population dynamics and growth of the European eel *Anguilla anguilla* in a Norwegian river: Evidence for density-dependent mortality, and development of a model for predicting yield. *Journal of Animal Ecology*, *57(3)*, 983–997.

von Reider, J. E. (1825). *Das Ganze der Fischerei, ein Handbuch für Fischerei- und Teichbesitzer [The whole of fishing, a handbook for fishery and pond owners]*. Nürnberg, Leipzig, Germany: Zeh'schen Verlag.

Walker, A. M., Andonegi, E., Apostolaki, P., Aprahamian, M., Beaulaton, L., Bevacqua, D., … Schiavina, M. (2013). *Lot 2: Pilot project to estimate potential and actual escapement of silver eel*. Final project report, Service contract S12.539598, Studies and Pilot Projects for Carrying out the Common Fisheries Policy. Brussels, European Commission, Directorate - General for Maritime Affairs and Fisheries (DG Mare): 358 pp.

Walter, E. (1903). *Die Fischerei als Nebenbetrieb des Landwirtes und Forstmannes [The fishery as a secondary operation of the farmer and the forester]*. Neudamm, Germany: Neumann Verlag.

Walter, E. (1910). *Der Flußaal, eine biologische und fischwirtschaftliche Monographie [The eel, a biological and fishery-economic monography]*. Neudamm, Germany: Neumann Verlag.

Wiese, N. N. (1939). Besatszaale aus Griechenland markiert und in den masurischen Gewässern ausgesetzt [Restocking eel from Greece, marked and released into the Masurian lakes]. *Fischerei-Zeitung*, *42*(27), 322.

Wittmack, L. (1875). *Beiträge zur Fischerei-Statistik des Deutschen Reichs [Contributions to the fishery statistics of the German Reich]*. Berlin, Germany: W. Moeser.

Yarrell, W. (1836). *A history of British fishes* (Vol. 2, p. 472). London, UK: John van Voorst.

Ypma, Y. N. (1962). *Geschiedenis van de Zuiderzeevisserij [The history of the fisheries on the Zuiderzee]*. Amsterdam, the Netherlands: Publicaties van de Stichting voor het Bevolkingsonderzoek in de Drooggelegde Zuiderzeepolders No 27.

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