The Capacity Trend Method: A new approach for enumerating the Newfoundland cod fisheries (1675–1790)

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ABSTRACT
We apply a novel methodology to the study of the Newfoundland cod fisheries in order to determine a reasoned and acceptable chronological value series for total catch amounts in the early modern period where data are scarce. The paper focuses on the two main protagonists in the Newfoundland fisheries arena in that period: France and England. The period 1675–1790 has been selected as a viable and representative chronology for a case study where data, while available in part, are limited and often missing. The new methodology proposed here enables further exploration, input and assessment such that an ever-greater level of accuracy, integrity and robustness may be achieved in future.

KEYWORDS
Capacity Trend Method; scale of fisheries; Newfoundland cod fisheries; dry; wet; green; fresh cod; fishing effort

Introduction
The cod fisheries off Newfoundland and on the Grand Banks were the largest single-species fishery in the early modern age. Their importance is well established, not least thanks to the work of Pope (2004) and Turgeon (2009). However, quantitative information has been limited to predominantly English-language evidence for the period 1675–1790, while historians realize that the main fishery was carried out by French vessels. A review of the English evidence reveals that it is patchier than previously assumed. Our objective is therefore to find a means by which reliable, calculated estimates of fishing effort of the European cod fisheries in Newfoundland may be derived for periods where there is only patchy data available due to the lack of records, researched archival materials or references that pertain to this period. To this end, a case study was developed which addresses these gaps by delivering a robust method of extrapolation and trend-based calculation of French and English cod fish landings in the period 1675–1790. The results will be of significance to historians as well as fisheries scientists who have largely built on findings by precedent specialists like Lounsbury (1934), Innis (1978), La Morandière (1962), and Pope (1995).

Overview of the Newfoundland cod fisheries
Newfoundland’s fisheries began in the 16th century when the cod-rich coasts and banks were identified by European navigators looking for a passage to Asia. It is in this context that Portuguese, Spanish and French fishermen sailed to Newfoundland. The growth was such that, by the middle of the 17th century, we can talk of a Fish Revolution, which quadrupled supplies to the European fish market (Holm et al. 2019). By the end of the 1570s, a new important contributor in Newfoundland fishing emerged: the English, who effectively squeezed out the Iberians while the French kept the upper hand. With booming European population growth and an increase in long-range shipping from Europe, a demand for cod fish in the markets Western and Northern Europe, as well as the Mediterranean, was met; the Newfoundland fisheries expanded apace to meet demand. English fishing concentration in the mid to later 17th century shifted from Iceland to Newfoundland, and the French effort remained buoyant. With English expansion, French dominance in the cod fishing trade was challenged through economic and industrial means, but also through active conflict. From the second half of the 17th until the 20th century, Franco-English confrontation for dominance and control in Newfoundland was a vital factor in fishing effort and became central in the control of the globalized fish market.
The sources

In short, the sources used for this methodological paper come from two different types of data. For France we have notarial records and censuses of vessels sent to Newfoundland while the English records are reports by naval commanders of fish landings in Newfoundland ports and landing areas.

An estimate of the scale of the French cod fisheries in Newfoundland and Canada from the 17th century onward is not a straightforward task. Sources are hard to read, often in poor condition, but above all, are too numerous to be analyzed effectively with limited resources. These difficulties have discouraged most specialists who have studied this topic in the past. For the purpose of this paper, varying information types were collated at source from the major ports in France where records are held. Notarial records are the best source for observing the beginning and the expansion of the Newfoundland cod fisheries from the 16th century onwards. Several types of contract (such as charter party and bottomry loans) and other collateral documents provide crucial data such as the names of ships and their captains, named crew, port of registry, destination and strategic information on tonnage of the vessels concerned. The admiralty data (which include ships’ logbooks, captains’ reports, crew rolls, passports, etc.) largely commence from the 17th century but provide a deeper insight into Newfoundland shipping by furnishing more detailed information. The panorama of the activity can be completed with other administrative sources such as vessel censuses and foreign correspondence documents relating the size of the French Newfoundland fleet. In addition, we have reviewed and used the findings by specialists who have similarly mined these abundant sources to evaluate the size of the fleets and fishing effort of the cod fisheries since the 19th century. The data from manuscript and published sources were compiled into several tables containing the various French port cities involved in the cod fishery. The published sources included a plethora of works, including: Abreu-Ferreira (2004), Allaire (1999), Balcom (1984), Barrey (1917), Barrey and Bréard (1906), Beatty and Fougeré (1957), Bernard (1984), Black (1960), Bois (1990), Bréard and Bréard (1889), Brière (1978, 1979, 2008, 1990), Brunson and Comber (2015) Candow (2009), Cell (1969), Collins (1984), Dardel (1941), Darsel (1967), Davies (1980), Delafosse (1962), Delobette (2001), Delumeau (1959), Dommergues (1982), Froger (1976), Giraud (1989), Gautier (1988), Gosselin (1876), Graham (1948), Harvey and Todd (1983), Harvut (1873), Hersart de la Villemarqué (1995), Hillmer and Tiao (1982), Hutchings and Myers (1995), Innis (1956, 1978), Kupp (1974), Kydland and Prescott (1990), La Morandière (1962), La Roncière (1910), Lamigueiro (2014), Le Corre (1958), Léon (1903), Lespagnol (1997), Loundsbury (1934), Matthews (1968), Mauduch (1978), McLeod (1993), Mercer (2002), Michon (1999, 2010), Mollat du Jourdin (1952), Musset (1892), Peret (2010), Pfister-Lagay (1985), Richard (1976), Rín (1938), Robinson et al. (2009), Sierra Nava (1998), Thibodeau (1959, 1960, 1962a, 1962b), Trocmé and Delafosse (1952), Turgeon (1986, 1997, 1985, 2009), Wallace (1949), and Zysberg (1999).

English data were primarily obtained from The National Archives (TNA), Kew, London, UK. Data series were assembled in two distinct tranches: 1675–1692 and 1698–1833. TNA data were largely extracted from Colonial Office papers in the General Series CO1. These manuscripts include population census data, port data and ship census data, and incorporate both quantitative and qualitative information. These data tranches led to the collation and publication of two datasets: HMAP Dataset 5 (Haines 2004) and HMAP Dataset 6 (Pope 2003). In compiling these datasets, further data were extracted from Council for Trade and Council for Foreign Plantations papers also held at Kew, as well as analyses of published works on the subject by R. G. Loundsbury, Peter Pope, Keith Mercer, Ralph T. Pastore, J.K. Hiller and Nicholas Landry amongst others. Information was also gleaned from the French Colonial Archives.

The period between the two data series (i.e., 1693–1697) was one of unrest due to war and related instability. The fishing effort was severely compromised, as was the ability of port authorities to maintain coherent records; the War of the League of Augsburg (1688–1697) prevented any meaningful fishing to be carried out until 1698 when records again appear (Haines 2004).

Both datasets are conspicuous in their many gaps in data coverage. This situation is exacerbated by the fact that over 100 landing ports are annotated in Newfoundland, but very few contain coherent and continuous strings of data. At first glance, an aggregated sum of annual values provides a total catch figure, but with critical analysis, the missing values show a patchy and incomplete picture. Missing values may be due to documented values that are lost from the archival sources or were simply never recorded; the former is more likely in the case of the English records which tend to be comprehensively formatted in accordance with Royal Naval standards. In the case of missing French values, the nature of the records
(typically a form of insurance indemnity which stipulates a vessel’s weight, value and crew compliment) depends on the successful filing of a multitude of individual reports, which leaves these archives less well filled as documents may have been lost over time, or never filed in the first instance. In all instances, wherever missing records are recovered in future, the gaps may be better filled with their new information and the trends described here can be adjusted to accommodate these introduced values.

In the case of the French records, numbers of vessels, supplied with relevant vessel weights and crew compliments (where available) enabled calculations of typical landing weights of fish for these vessels. All weights were converted into metric tonnes, accounting for the differences between dried and fresh fish delivered to the French ports. In contrast, the English landing values were provided in metric tonnes, albeit with many gaps in the data that are explored in the applied method.

**Weights, measures, and conversions**

**Quintals, pounds, tuns, tons, and tonnes**

Wherever practical, weights expressed in this work are given in metric tonnes. The typical measure applied to determine the weight of cod in the early modern Newfoundland English fishery was the quintal. Peter Pope cites John Delabarre, a merchant who “… instructs Thomas Bredcake, master of the Faith, to load 4000 quintalls of: ‘good merchantable drie Newfoundland fishe of 112 lbs. weight to the quintall’” (Pope 2004).

Metric tonnes should not be confused with Imperial tons (sometimes referred to as tuns), a measure commonly used during the period as well, and roughly equating to a metric tonne. The adopted metric conversion rates, following Peter Pope’s and Mike Haines’ original documented works (Pope 2003; Haines 2004) and confirmed in British Weights and Measures (Zupko 1977) are:

1 quintal = 112 lbs (English pounds)

2,240 lbs = 1 ton (English long ton)

1 ton/tun = 1.01605 tonnes (Metric)

The adopted metric conversion rates for the French data are similar to the English data but employ the measure of French tons, and are confirmed in French Weights and Measures before the Revolution (Zupko 1978):

1 quintal = 48.95 kg (Metric)

20 quintals = 1 ton (French ton)

1 ton = 0.979 tonnes (Metric)

**Fresh vs dried fish ratios**

In order to enable comparison, it is important to convert the historical information of dried or light-salted fish into live weight metric tonnes. Attempts at converting dried fish weights to “fresh” fish are fraught with complication. In this case, “fresh” fish refers to freshly caught live fish that have undergone no treatment or processing. Many factors may be considered, and in the case of English fisheries in Newfoundland, the processing operation, despite being carried out on an industrial scale, would arguably have been less technologically developed and less scientifically approached than by today’s standards. Nevertheless, it is certain that a primary purpose of drying fish was to maximize profit by enabling vessels to carry as much as possible. Furthermore, dried cod often fetched relatively higher prices on English markets than wet or fresh cod, and they had a much longer “shelf-life” enabling far better chances of survival over lengthy journeys to markets. The task of drying required highly skilled and experienced workers; dried fish had to be “cleaned” and salted to exacting proportions as too little salt led to the fish spoiling early, and too much was an unacceptable added cost (Cutting 1955; Beatty and Fougère 1957, 47–54). The process included expert filleting of the animal on an individual basis retaining only the flesh for drying; by-products and waste were separately handled. The “clean” flesh was salted and dried outdoors by exposure to dry cold winds, sunlight and moonlight. The conditions on the Newfoundland coast were largely suited to this purpose. The same process is true for the French effort where drying was carried out at French controlled ports in Newfoundland. While the French data series used in this case study relies on actual French European mainland port data, the French effort certainly involved many ports local to Newfoundland.

Modern fish drying processes include the use of machinery, so direct comparisons are difficult to draw. A similar, albeit climatically different modern example may, however, be derived from the Bangladeshi Fisheries Research Forum in its scientific research into weight loss from fresh (live) to dry fish (Paul et al. 2018). This research highlights the traditional Bangladeshi open air, wind drying process for several local species. Whole fish exposed to the elements are dried over 3 or 4 days resulting in weight loss ratios ranging from 1:2.5 to 1:5.97. The different characteristics of the species involved, their “non-cleaned” (i.e., whole and ungutted) aspect and their relative sizes are major factors in the ratios determined. The highest dehydration factor (1:5.97) is afforded to the Loitta (Harpadon nehereus) (WoRMS
2019), a predator not very dissimilar from cod in terms at least of its habits, its harvesting by humans and its apparent palatability as the source of the oddly named “Bombay Duck.” This comparison is intended to highlight the possibilities of simple open-air drying in terms of conversion ratios (Hossain et al. 2015).

For Atlantic cod (Gadus morhua) (WoRMS 2019), the subject of this case study, dry to fresh (live) ratios have been quoted as low as 1:2.6 and as high as 1:4.9 (Kimball 2005, 26) and even 1:7.7 (Jónsson 1994). These factors bear some comparison with the Nordic fisheries of the early modern period which operated on an industrial scale, and deployed methodologies similar to those used in the Newfoundland fisheries. Norwegian “stockfish” of good quality cod was reduced to about 24% of its original weight (Nedkvitne 2016) but “klipfish” (salt-dried cod, similar to Newfoundland produce) is not specifically referenced. Retaining the Nordic theme, Icelandic (and Shetland) stockfish was dehydrated far more than Norwegian cod and no salt was used; the fish was dehydrated to the extent that in the 16th century it required softening with a hammer before rehydration (Wubs-Mrozewicz 2009). This may account for the very high ratio cited by Jónsson who quotes Skúli Magnunsson from a 1785 document where it is proposed that “80 pounds of un gutted cod gave 10 pounds of flatfish, which gives a conversion factor of 7.7” (Jónsson 1994, 5).

Jónsson further states that the modern industry conversion standard is based on a conversion ratio of 1:7; as the former Director of the Icelandic Fisheries Agency, he presumably drew on direct observation for this awareness. He argues that the difference between 1:7 and 1:7.7 derives from the fact that current Icelandic stockfish (so-called “hangfish”) does not have its backbone removed. A present-day fish merchandising company that specializes in dried and cured fish cites that a cod of 11 Kg will be reduced to a “klipfish” of 3–3.5 kg (Dybvik 2013).

These contemporary and present-day ratios vary according to the conditions, the processes deployed and the purposes behind drying the fish. With values as low as 1:2.6 and as high as 1:7.7, the Newfoundland ratio needs to be considered in its own relevant terms and conditions. The figure of 1:4.9 refers to Peter Pope’s assessment of dry/fresh ratios based on calculations around the effort, gear and conditions of the English Newfoundland fishery. An example given of the effort of the English Newfoundland fishery between 1660 and 1690 shows that around 6,000 fishermen were deployed, typically five to a boat, and they were active daily in onshore fishing. These boats were each “expected to produce about 200 quintals of dried cod in a season” (Pope 1995; Yonge 1963, 57). Pope identifies that English fishermen of the period caught live cod at about 50,000–60,000 tonnes per annum (Pope 1995, 11).

Pope derived the fresh to dry ratio of 1:4.9 by recognizing that 1 quintal of dry fish equates to a quarter of a tonne of freshly caught fish. However, he also identified that a minor proportion was in fact shipped “wet,” also referred to as “green,” and that this was less than 10% of the overall catch. Wet or green fish were fresh fish that had been “cleaned” (headed and gutted) and typically retained in brine without any other processing. Such a conversion may reduce the overall ratio to a figure of around 1:4.7 of dry to fresh fish (Pope 1995, 36).

**Adopted dry fish to fresh fish ratio: 1:4.7**

The two HMAP datasets (Pope 2003; Haines 2004) that we have used for our study provide weights in dried fish only, and we have used the conversion ratio of 1:4.7. It should be made clear that “bankers,” or vessels that caught fish and delivered these directly to the European markets, did not dry their catch, but they did maintain the fish in brine and some levels of cleaning took place onboard (such as gutting, heading, etc.). These vessels are included in this case study. English bankers accounted for a small proportion of the overall catch, amounting to about 1:30 with dried cod being overwhelmingly the focus of the fishery (Haines 2004).

The French catch figures assume the same dry to fresh (live) ratio as outlined above; the processes employed by the French where largely similar to the English. However, it is important to note that French markets were more partial to fresh or “green” fish (lightly salted and cleaned but not dried) whenever they could be obtained. A single banker could carry out up to three trips per year on the Banks to bring back green cod to Europe.

A major consideration for both the French and the English data was that in order to determine coherent catch values of cod, there had to be a clear understanding of the differences in fresh, light-salted (“wet” or “green”) and dry/dry-salted fish. Records typically reported dry-salted fish, which was transported to European markets, but also account for some fresh locally-caught fish which fetched higher prices than the dry. The preference for wet fish was weighed against the ability to transport far greater volumes of fish that had been dried in the Newfoundland ports before transport to Europe.
In the case of the French data, a conservative figure of 60% of all fish was regarded as dry. While this figure arguably reflects a very low estimate of dry fish compared with “wet” fish, thus reducing the overall catch tonnage data, it may provide a helpful buffer that takes into account the occasional transport by fishing vessels of other goods. This situation was especially true in the 16th century when French vessels were often reported as carrying mixed cargoes of cod (dry and wet) and hogsheads (barrels or “tonneau de mer” (Zupko 1978)) of fish oil or whale oil. In some instances, animal furs are also recorded (Allaire 1999, 60–5). Thus, the French values provide a low estimate of the overall converted catch.

Methodological approach

Trend analyses, trend methodologies and the application of data filters have been the subject of in-depth study in various fields of the sciences for centuries. Many recent academic papers describe and exemplify various trend methodologies, e.g., Pollock’s Methodology for Trend Estimation, applying a case study to airline travel (Pollock 2001). These analytical tools are applied to diverse areas of research ranging from socioeconomics (Harvey and Todd 1983) to geography (Hillmer and Tiao 1982), medical analysis (Kim and Delen 2016) to linguistics (Kilgarriff et al. 2015), food processing (Worley, Folwell, and McCracken 1993) to business economics (Kydland and Prescott 1990). While this list is by no means exhaustive, it highlights the plethora of mathematically complicated methods and techniques available. The method deployed here seeks to overcome obstacles to application by providing simple, text-based descriptions and practical means for deriving viable information pertinent to areas of historical time-series data. All data that has been used is available online at: https://figshare.com/articles/Franco-English_Combined_catch_data_1675-1790_xlsx/11860770.

Data structures and formats

French data, obtained directly from archival research in locations in France, was tabulated in a comma-separated value (CSV) spreadsheet format. The data was processed in order to determine annual values for effort (number of vessels), and catch values were determined from the calculated variable tonnage of vessels and reported landings, where available, from various combinations of archive materials and primary literature. The data comprise several port-city data entry points compiled into annual records. The process for determining the French data series involved determining numbers and tonnages of vessels from various French European ports that were specifically engaged in the Newfoundland cod fishery; these figures indicated a growth over time in the average tonnage of burthen weight, thereby highlighting an evolutionary increase in catch sizes per vessel. The process is described under the next heading. The complete French data series spans the period 1500–1790 and will be hosted within the public domain at a later date, but only the data between 1675 and 1790 were used for this methodological paper. These data are openly available (under Creative Commons license CC BY 4.0) at: https://figshare.com/articles/Franco-English_Combined_catch_data_1675-1790_xlsx/11860770.

In the case of the English data, the HMAP (History of Marine Animal Populations) project data series was based on two datasets related to the English Fisheries of Newfoundland, HMAP Dataset 5 (Haines 2004) and HMAP Dataset 6 (Pope 2003). As previously discussed, these series provide a wealth of data obtained from archival sources, but the data are temporally and spatially incomplete and were subjected to a complete analysis leading to the removal of incomplete and zero value entries. Once assessed and corrected, the English data were available in a similar comma-separated value (CSV) tabular format to the French data. Interestingly, initial access to the English data, published in the public domain under Creative Commons License, was temporarily withheld as the original provider had failed to maintain access via a long-standing website. The data were found to be held separately on a University of Hull (UK) server (https://hydra.hull.ac.uk/resources/hull:HMAPDisplaySet) and links were added to the OPI (Oceans Past Initiative) website to ensure continued accessibility (https://oceanspast.org/hmap_db.php). The data deployed in this case study (French and English Newfoundland cod fisheries 1675–1790) are available at https://figshare.com/articles/Franco-English_Combined_catch_data_1675-1790_xlsx/11860770 in their basic formats.

Establishing a viable baseline

To evaluate and determine a trend, an analysis of existing data had to be undertaken. Geographic data points were cartographically examined for accuracy and availability, and combined annual figures were graphically assessed to determine levels of presence. The “R” programming platform was deployed in these efforts (R Core Team 2013). Specific analysis of Darwin Core elements of the data was carried out using the robis library of tools for the R platform.
Applying these tools enabled a rapid determination of missing data elements, areas of sparse data population, and inconsistencies in data provision.

Figure 1 indicates general fishing area distributions in terms of French or English influence. By the 1730s, however, English influence had expanded to incorporate the north and south of Newfoundland, but the French presence remained in parallel along much of the south and off Acadia; the Great (Grand) Banks was fished by all nations. Typically, fishing effort was carried out close to the coast and near to the landing ports, apart from the “bankers” which characteristically fished on the Banks and returned directly to Europe with their catch of “green” or lightly salted fish which was often headed to maintain freshness as far as possible.

Literal data from both the French and the English Newfoundland fisheries are sparse yet provide the means for extracting a viable series from 1675 to 1790. The unified focus of data collection was on fishing effort (in terms of the numbers of vessels deployed) and actual fish caught (in metric tonnes). While data are incomplete, and, in places, not available, a process of simple extrapolation (linear trend) has been used to provide a probable scenario.

However, in cases where data are incomplete to a very large extent, a simple linear progression would lead to highly inaccurate extrapolated numbers. In order to overcome this situation, an analysis of the data (R platform) confirmed which of the existing series held viably continuous strings, and these were deployed to determine a trend that could be applied to the poorly populated sub-series. The R analysis also highlighted several examples where a particular port had been recorded under different names, thereby providing several poorly populated ports which, when merged, formed good continuous data streams. For example, the major port of St Johns was severally listed as: St. Johns, St John’s, St. John’s Harbor and even Saint John; all references to ports and place names reflect either Newfoundland ports or French mainland European ports. A further consideration for the English data was that the two underlying existing datasets, while largely compatible, were not fully matched in terms of actual landing port location numbers. While many were like-for-like links, the earlier dataset (1675–1692) contained 57 ports while the later (1698–1790) had 105. The two were therefore considered separately in terms of the data assessment exercise but merged in the final output. The difference in the number of Newfoundland ports is due to a
combination of English expansion and establishment of new ports in the latter period (1698–1790), and also due to the issue of nomenclature where several ports are often cited as a collective in the latter dataset; the entire Bay is referenced rather than individual ports for several years, thus providing extra ports that had to be carefully identified and excluded where necessary.

In both French and English data series, multiple ports were identified as data series providers for annual figures. For the French figures, these ports are actual mainland European ports in France, whereas for the English effort, Newfoundland ports provide the relevant data. A baseline of clear, contiguous data had to be established to determine how and if the many port series could be viably populated with meaningful data. It was imperative to recognize any exclusions within the data series in order to rule out false positives and to provide a basis for analysis that was as similar as possible between the French and English data. To this end, these accepted values exclude fishing carried out by the Spanish, Portuguese, Dutch and any other efforts by non-French and English vessels during the period; the French and English were, by far, the most prolific, but the influence of these other fisheries should not be forgotten, despite reflecting a very minor level of effort in comparison. Based on preliminary analysis (not included in this case study) these figures may reflect less than 1% of the overall effort over the 1675–1790 period; Spanish and Portuguese fishing in the Grand Banks and Newfoundland peaked in the mid- to late 16th century and may not have exceeded more than 50 vessels per annum during this peak. Compared with the French peaks of c. 450 vessels and English peaks at c. 150 vessels (during the mid to late 16th century), these values are relatively minor. By 1640, no indication of any Spanish or Portuguese activity has been found, but it may be the case that occasional, very small numbers of vessels participated in Newfoundland fishing.

Similarly, the use of cargo vessels or “sack” ships that transported goods to the colonies in exchange for fish were excluded as a false positive to ensure uniformity of data; these data should not be considered unimportant however, and should be the subject of further research, but do not form part of the assessment carried out here. For a detailed overview of the cargo or “sack” ship activities, Peter Pope’s *Sack Ships in the Seventeenth-Century Newfoundland Trade* provides excellent insights (Pope 1999). In the case of “bankers” or vessels that fished directly on the Grand Banks and returned to European ports without landing at any of the Newfoundland ports for processing, these figures are included and provide an extended understanding of the overall fishing effort.

In terms of the French data, to derive a basic catch-based series, it was necessary to recognize that the original available data referenced numbers and burthen tonnages of vessels. The burthen weight trend of these vessels over time tended to increase, showing a marginal increase in vessel size and, therefore, in weights of fish carried. An “evolutionary” average of tonnage per vessel was determined over several tranches of 50-year periods from 1500 to 1790 in order to obtain a standard explanation for the increasing amounts caught; this factor may also reflect to some extent on technology creep which, while not specifically accounted for here, may be an element of the increase in vessel sizes over time (Figure 2). The actual numbers of vessels were multiplied by this factor in the appropriate 50-year tranche to determine the annual catch for the French Newfoundland fishing effort.

**Formulae for calculations**

It is important to note that the original English data applied was provided in quintals of landed fish and converted into metric tonnes. The French data was provided in numbers of vessels and factored values of weight of fish per vessel were applied along with conversion factors of fresh and dry fish ratios.

The formula used to calculate the English catch in metric tonnes is:

\[ q \times l \times \frac{k}{t} \]

where:
- \( q \) = quintal
- \( l = 112 \) (pounds per quintal)
- \( k = 0.45359 \) (kilograms per pound)
- \( t = 1000 \) (kilograms per tonne)

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| Period | Average Tonnage |
|--------|----------------|
| 1500   | 1549           |
| 1550   | 1599           |
| 1600   | 1649           |
| 1650   | 1699           |
| 1700   | 1749           |
| 1750   | 1790           |

**Figure 2.** Average tonnage in metric tonnes over 50-year periods of French fishing vessels in Newfoundland. Each period tonnage value is based on individual average vessel tonnages within that period, accounting for technology creep due to improved methods and actual vessel size (tonnage) increases.
The formula used to calculate the French catch in metric tonnes is:

\[
\frac{n}{C_3} \times f \times x1 + \frac{n}{C_3} \times x2
\]

- \( n \) = Number of vessels
- \( f \) = Factored weight of fish per vessel (see Figure 2)
- \( x1 = 60\% \) (conversion factor: dry fish)
- \( x2 = 40\% \) (conversion factor: fresh fish)
- \( w = 4.7 \) (conversion factor: dry to fresh fish ratio)

**Process: The Capacity Trend Method**

The principal undertaking of filling gaps in the data required an approach that determined where there were existing data that adequately provided a complete series of annual data for any ports, both French and English. The data files pertaining to this case study may be retrieved from: https://figshare.com/articles/Franco-English_Combined_catch_data_1675-1790_xlsx/11860770.

**A phased approach**

Several phases were deployed in determining the overall series for both French and English data. Phase One was to identify “Primary Ports,” Phase Two was to establish a trend based on the “Primary Ports.” Phase Three required the application of the established “Primary Ports” trend to “Secondary Ports” data fields, and Phase Four involved merging the trended “Secondary Ports” with the “Primary Ports” to gain an overall impression.

**Phase one: Primary**

A uniform methodology was applied to both the English and the French data which were sporadic and incomplete. An analysis of the French data highlighted that several of the ports’ data provided a reasonably contiguous stream of annual effort (numbers of fishing vessels). The complete dataset comprised 21 ports and/or collections of ports. Of these, seven were identified as being “Primary Ports” insofar as they provided the most reasonably continuous series. In much the same manner, 13 of the 57 early period English ports and 14 of the 106 later period English Newfoundland ports were identified as being reasonably complete. These “Primary Ports” had their relatively few missing data points filled through simple extrapolations.

The French and English “Primary Ports” are clearly indicated in the accompanying data tables that may be found at: https://figshare.com/articles/Franco-English_Combined_catch_data_1675-1790_xlsx/11860770.

**Phase two: Capacity Trend**

The seven identified French Primary Ports were compared and a simple progression extrapolation (variable trend) was extracted from their aggregated annual effort values to determine a complete annual capacity trend. An example is shown in Figure 3. The same practice was applied to the English data; the fourteen “Primary Ports” identified were analyzed and a capacity trend was extracted from the aggregated annual values.

**Phase three: Secondary**

The established “capacity trend” values for the French and English data were respectively utilized to fill the far less populated fields of the remaining “Secondary Port” series. This process was effectively completed by identifying missing strings of data between available values and applying the corresponding capacity trend value as a variable to determine a spline (variable trended line) between the two points.

The French data were processed sequentially and the “Secondary Ports” were fully populated by applying this method. The English data, however, presented several scenarios where a few of the ports provided so little data – in a very few cases just one or two data.

| Year | Bordeaux | La Rochelle | Sables D’Olonne | Saint Malo | Granville | Honfleur | Le Havre | Trend |
|------|----------|-------------|----------------|-----------|-----------|----------|----------|-------|
| 1784 | 3        | 5           | 16             | 106       | 93        | 17       | 3        | 35    |
| 1785 | 5        | 5           | 18             | 118       | 91        | 18       | 2        | 37    |
| 1786 | 5        | 5           | 18             | 120       | 105       | 26       | 1        | 40    |
| 1787 | 5        | 5           | 26             | 106       | 99        | 20       | 4        | 38    |
| 1788 | 5        | 5           | 19             | 91        | 95        | 16       | 6        | 34    |
| 1789 | 5        | 5           | 11             | 78        | 89        | 44       | 9        | 34    |
| 1790 | 3        | 5           | 9              | 73        | 84        | 50       | 7        | 33    |

Figure 3. Extract from the French “Primary Ports” data file showing annual effort (number of vessels). Figures shown with an asterisk (*) are extrapolated based on preceding and proceeding values. The “trend” field is an average value of the seven Primary Ports.
points - that even with an applied spline from the capacity trend it was dubious whether an accurate string could be presented. These values were in fact included following an assessment which led to the realization that in total, these ports represented less than 5% of the total effort. In order to highlight these fewer concrete ports' data, they were deemed to be "Tertiary Ports" and may therefore be easily identified for further analysis.

**Phase four: Merging**

The relatively simple process of merging the Primary Ports and Secondary Ports data was carried out by basically adding them together on an annual basis. In the English data case, the Tertiary Ports were added as well. Furthermore, the "bankers" value was added to the English data series to afford a more complete overview. In the case of the French series, a conversion factor was applied to account for rehydrated dry fish values to provide an overall figure in fresh cod in metric tonnes. Similarly, the English series were appropriately factored to ensure values were reflective of fresh cod in metric tonnes. This led to an overall total catch effort figure for the French and English fisheries (Figure 4).

**Combined Franco-English data**

The French and English annual catch data were then combined (added together) to reveal a compounded impression of the total catch for Newfoundland. The result highlights the difference in scale between the French and English fishing efforts. A simple overlay of an average annual value provides an impression of the overall impact of the fishery (Figure 4).

**Discussion**

**Franco-English fisheries in Newfoundland**

The original overall baseline data provided a simple series that only included actual reported landings of French and English fresh fish caught in Newfoundland and Grand Banks waters. While the results displayed in this paper are effectively a cauterized extract of the total French and English catches carried out in the Newfoundland cod fishery before 1800, they nevertheless provide a startling output. Quite simply, with a revised and corrected series of data, it is evident that catches for the early modern period average about 270,000 metric tonnes and exceed 600,000 metric tonnes in 1788.

French and English fishing for this period depict a reversal of fortunes. Early French catches vastly outdid the English fishing effort in terms of actual catch. Clearly the impact on European markets was primarily generated by French fishing efforts with the English fishery nevertheless playing an important part.
The much larger initial landings of the French may be explained by the fact that the English fisheries were mainly limited to the East coast and Banks of Newfoundland while the area of French activity extended as far as the Gulf of Saint Lawrence, Acadia, Gaspesia and the smaller Banks. However, by the early 1730s, the English fishing effort closely matched that of the French, and by the mid-1740s, the English had overtaken the French and went on to dominate the fisheries.

**Variations in annual values**

Peaks and troughs may be observed in the Franco-English catches from 1675 to 1790. These may be explained, at least in part, by the many conflicts between France and England during the period, and also other conflicts in which either or both protagonists were engaged. However, despite these conflicts, there was an evident overall growth in both French and English fishing until the early 1730s despite some specific setbacks for the industry. The rise and decline in catches of the last quarter of the 17th century was followed by a sustained increase in the first half of the 18th century from the treaty of Utrecht (1713) and the death of Louis XIV (1715) to the War of the Austrian Succession (1740–1748). This growth phase persisted despite the effect of several major European conflicts culminating in the Revolutionary and Empire wars (1790–1815) (Wallace 1949, 43–55).

More precisely, the origins of the gap in French and English catches visible in the last two decades of the 17th century may be realized in the checkered history of the period; an explanation lies in the military context of the War of the League of Augsburg (1688–1697). On this occasion, attacks on fishing fleets and colonial ports (Plaisance and St Johns) in Newfoundland sporadically disrupted activities. This pattern continued until 1697 with the Treaty of Ryswick when hostilities ceased and the industry recommenced. But the growth following this period of peace was halted by the War of Spanish Succession (1701–1714) which in effect had greater impact on European demand than on the Newfoundland fisheries (Wallace 1949, 43–55).

This troubled period was followed by a relatively long period of peace, unusual during this era of multiple and protracted conflicts in Europe, which enabled the fisheries to double in output until the War of Austrian Succession (1740–1748) interceded. The siege of Louisbourg during this conflict had a large impact on the Cape Briton French fisheries. The abrupt drop in French catches between 1759 and 1761 are explained by the near total cessation of French fisheries due to the Seven Years’ War (1756–1763). This conflict with Britain, nevertheless, saw activities resume by 1762, confirmed by the Treaty of Paris in 1763. With the exception of garrisons at Saint Pierre and the Miquelon Islands, France did not maintain a military capability in Newfoundland or Canada from this time, but cod fishing continued apace. The last major gap in data for the period 1780–1782 reflects another major slowdown in French fishing during the involvement of France in the American Revolutionary War (1775–1783); activities only resumed after the Treaty of Versailles in 1783 (Wallace 1949, 62–67).

A further consideration is that the period when English fortunes begin to clearly rival those of the French in the 1730s, is when an active process of settlement began in preference of the defunct “admiral system.” Until 1729, the “admiral system” was the active means by which bays, beaches, and landing stations were established, mostly as temporary settlements for drying and processing fish. A fishing boat captain who was first to arrive at a likely landing stage would claim the location and become “admiral,” establishing the right to fish and land his catch for his crew and other vessels in his entourage; this “bye-boat” fishing effort led to multiple outlets for passing vessels to purchase the processed fish which was then transported to European or other markets. The Royal Navy effectively ended this process in 1729 by sending officers who governed Newfoundland ports, way stations and settlements, leading to more permanent settlements and a growth in population. The ports quickly developed into serviced and organized settlements and impacted the overall population of the island as numbers of planters increased and the island infrastructure grew to accommodate the increased economic and physical growth. The fisheries expanded in line with this level of organization and the English fishing effort prospered and grew while the French effort continued at a fairly uniform level until the late 18th century (Matthews 1968; Head 1976; Bannister 2003). While these major human interruptions certainly impacted the industry, many other smaller and unexplained variations are likely due to other factors such as disruptions in the European economy, logistics, weather or ecology; these factors may now be considered by future research based on the revised data presented here.

**Conclusion**

This paper presents a statistical extrapolation approach applied to a historical questioning, in this case: to the Newfoundland cod fisheries in early
modern times. This methodology has permitted a bypassing of a structural lack of data and to bridge missing chronologies in the sources in order to provide plausible scenarios in the scale of these fisheries in the 17th and 18th centuries. With the Capacity Trend Method, it was thus possible to work from two totally different types of sources (French notarial and English naval sources) and compare the respective levels of fishing output. This is a major step forward; while accomplished specialists have studied the Franco-English shipping to Newfoundland in the early modern period based on qualitative impressions, no historian has attempted to build a complete panorama of the scale and extent of these fisheries over three centuries.

The results obtained with this method have confirmed several historical trends and shocks (e.g., effects of warfare) which are corroborated by other sources and specialists, highlighting the variability of fishing, shipping and fish markets upheaval. The method used here for the Franco-English catches evaluation can later be applied to other nations such as Spain and Portugal to obtain a more complete landscape of the early modern cod fisheries in Newfoundland and Canada.

The revelation of this methodological paper is clearly the high level of fishing effort in Newfoundland and Grand Banks waters during the period. These levels (which do not consider French and English cargo and sack vessels) are fairly similar to those existing in the 20th century at the time of the depletion of cod stocks. This effectively extends and expands the baseline for the debate about the overexploitation of Newfoundland cod resources by a matter of centuries.

The method enables comparison and differentiation between data from multiple and variable sources that provide few comparative data points or indicators. The case study shown here highlights how variable data sources and outputs with few initial points of comparison may be analyzed and formatted to present a viable data series and display hitherto unavailable elements of awareness of an entire historical period. While the data may be augmented and bolstered by any new discoveries of fact, the immediate output is relevant and enables a current, deeper understanding and contextualization of the Newfoundland Fisheries. The analysis carried out here requires certain informed assumptions about the accuracy of the sourced data, and to this end, the lowest common factor was accepted; actual values may have been higher.

The confidence in the derived data may be augmented by corroborating factors. In the case of the English data, figures post-1729 were compiled largely by the Admiralty, providing an added level of certainty insofar as the data may be favorably compared where available; Naval governors were tasked with providing statistical data on vessel activities and fish landings at Newfoundland ports. Similarly, in the French case, the availability of several vessel censuses provides a strong level of validation for these years. For example, a Census of vessels in Normandy by Nicolas Langlois, sieur de Collemoulins in 1627 for the Cardinal de Richelieu (BNF Ms. Fr: 18596), a census by Cobert (Rapport du chevalier de Clerville) in 1664 (BNF Cinq Cents Colbert: 1), a 1683 partial census in Dunkerque (Rolle general des bastimens de mer employez au commerce, Dunkerque, Bibliotheque de la chambre de commerce de Dunkerque, (BNF serie B19: 2787), and a census in 1786 of Newfoundland cod vessels (Briere 1990, 125) In combination with the deliberate use of conservative estimates where applicable, the provided figures are deemed to be robust.

The Capacity Trend Method proposed in this paper may be used to provide similar and/or comparable results for data series that are complex, wide ranging and plagued with gaps. The state of medieval and early modern data clearly matches these criteria in many cases. The method provides a simple, transparent and practical means for researchers to develop quantitative information series such that periods of qualitative fogginess may be brought more readily into the light of quantitative clarity. It enables multi-disciplinary application across the sciences and the humanities, aiding avenues dependent on accurate historical information, such as fisheries science and fisheries policy research. It serves to underpin and reinforce efforts to provide a scientific approach that explains and adequately brings the unknown into the realm of the knowable and the known.

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