Ocean and Society
2025 • Volume 2 • Article 9365
https://doi.org/10.17645/oas.9365

cogitatio

ARTICLE

Open Access Journal

A Data-Driven History of Gloucester's Fisheries Architecture

Rafael Sousa Santos and André Tavares

Center for Studies in Architecture and Urbanism, Faculty of Architecture of the University of Porto, Portugal

Correspondence: Rafael Sousa Santos (rssantos@arq.up.pt)

Submitted: 4 October 2024 **Accepted:** 6 January 2025 **Published:** 26 February 2025

Issue: This article is part of the issue "Global Maritime Flows and Local Implications: A Worldwide Taxonomy and Glossary of Port City Regions" edited by Mina Akhavan (TU Delft), Yvonne van Mil (TU Delft), and Carola Hein (TU Delft), fully open access at https://doi.org/10.17645/oas.i442

Abstract

This article presents the methods and preliminary results of research into the socio-ecological history of the Gloucester fisheries, with a focus on the interactions between humans and marine ecosystems. It explores how these interactions are reflected on land through the built environment and assesses the impact of human activity on marine life. The study is part of a broader research project examining the industrialization of fisheries along the North Atlantic coast. The objectives of this research are to establish a historical timeline of the Gloucester fisheries between 1880 and 1930, integrate statistical and geospatial data, and explore modalities for visualization and communication. Using a mixed-methods approach, the study is organized around five datasets that combine written, statistical, and geospatial evidence: Fishing Grounds, Fishing Fleets, Population Shifts, Industry Footprint, and Processing Plants. Although the results are still inconclusive, this research aims to lay the groundwork for an experimental methodology that will be further developed. The goal is to enhance historical analysis by introducing an environmental perspective, assessing the pressures on ecosystems, and grounding the analysis in quantitative statistical and geospatial data.

Keywords

digital humanities; environmental studies; fisheries; fishing architecture; marine ecosystems; urban history

1. Introduction

In Gloucester, Massachusetts, Atlantic cod fishing played a key role in shaping the urban landscape, with its iconic schooner fleet anchored at the inner port wharves and large areas dedicated to drying racks (Figure 1). Cod's dominance began to decline in the 19th century as shifts in market demand and advancements in fish processing and storage facilitated the rise of other species. Throughout its history, Gloucester has exemplified the close interconnection between urban development and fishing activities.

Figure 1. Drying fish, Gloucester, 1906. Source: Library of Congress (1906).

This article is part of a broader research project on the history of the North Atlantic, examining human–environment interactions through the development of the fishing industry. The research presented here centers on the case study of Gloucester and its fisheries, focusing on key species such as Atlantic cod (*Gadus morhua*), Atlantic halibut (*Hippoglossus hippoglossus*), haddock (*Melanogrammus aeglefinus*), mackerel (*Scomber scombrus*), herring (*Clupea harengus*), and menhaden (*Brevoortia tyrannus*).

The main research question driving this study is as follows: How do changes in the exploitation of marine resources correspond to transformations in the built environment? The study examines a 50-year period in Gloucester's history, from 1880 to 1930, and integrates this timeline with statistical and geospatial data analysis. This approach not only complements traditional historical analysis—since a single perspective is often insufficient to explain the complex relationship between humans and their ecosystems (Ojeda et al., 2022)—but also strengthens it by incorporating diverse sources and data types. Additionally, the study explores methods for visualizing and communicating data, shedding light on the historical connections between human activity and the marine environment.

The article outlines the methodology used in this ongoing research, detailing the procedures for data collection, processing, and analysis, as well as the types of evidence considered. To demonstrate the potential of the adopted strategy, preliminary results are presented and discussed, supported by a series of graphic materials. In doing so, the article highlights the contributions that a data-driven historical approach can offer, emphasizing the interoperability of the tools used to draw conclusions.

2. Historical Background

At the turn of the 20th century, New England's fisheries, including those in Gloucester, experienced significant changes. Until this time, fishing methods had remained largely consistent for centuries, relying on artisanal, small-scale approaches operated by family-owned and community-based fisherfolk (McKenzie, 2018). With the onset of industrialization, the fishing sector evolved, altering how fish were caught, processed, distributed, and sold (Murawski, 2005).

The selected time frame, from 1880 to 1930, highlights two significant milestones in regional fish landings and their environmental impacts. The first, in 1880, marks a peak in the cod fishery on Georges Bank, with 294 million pounds landed (Lear, 1998). The second, in 1930, records a milestone for the Massachusetts ground fishery, which landed 37 million haddock in Boston, while it is estimated that 70 to 90 million juvenile haddock were discarded at sea (Murawski, 1995).

During the 1800s, Gloucester became the largest fishing hub in the US, with its fleet reaching 352 schooners by 1889, surpassing cities like Boston (referenced in the Fishing Fleets dataset). This period saw the transition from sail-powered to engine-powered vessels, leading to significant changes in fishing methods and onshore operations. The adoption of otter trawlers introduced a new approach to marine resource extraction, resulting in notable impacts on fish stocks (Bolster, 2012).

Gloucester's population also grew significantly, peaking at 28,211 in 1895 (as shown in the Population Shifts dataset). The expansion of the fishing industry supported the development of businesses both directly and indirectly linked to fishing, further integrating the city's economy with its waterfront. A large share of the population was employed in fishing-related activities (mentioned in the Industry Footprint dataset).

Another key development during this time was the shift from salted to fresh fish, enabled by advances in filleting and quick-freezing technology (Lear, 1998). This shift impacted the urban landscape and influenced the configuration of processing facilities (as seen in the Processing Plants dataset).

2.1. A Multispecies Perspective

For over four hundred years, Gloucester has been both economically and culturally linked to groundfishing (Murawski, 1995). Although cod has historically been the most significant species, driving the development of Gloucester's fishing industry and often highlighted in literature, such as Rudyard Kipling's (1897) *Captains Courageous*, the reality of this history is characterized by a diverse array of species.

Around the mid-19th century, mackerel emerged alongside cod as a major food fish and eventually surpassed it in catch volume. By the latter part of the century, previously overlooked species like halibut, herring, haddock, and various shellfish also rose in popularity in the marketplace (Johnston, 1984).

This transition to new fish species is closely related to the methods of fish processing and preservation, especially with the introduction of icing in the 1840s and the installation of ice houses on vessels. Previously, most fish in New England were salted at the time of capture, then washed and dried on fish flakes after being landed. Depending on the species and market, they could also be smoked or pickled in brine. The first

experiments with canning began in the 1840s, but it wasn't until the 1870s that it became established, particularly for herring and mackerel (Johnston, 1984).

With the growing demand for fresh fish in the Boston market—the most important market in New England—species that had previously been less targeted gained relevance and began to be intensively fished. One such case is halibut, previously regarded as a trash fish (Johnston, 1984).

Before the introduction of ice in this fishery, unsold halibut was preserved using traditional methods such as salting, smoking, or drying. However, owing to the species' large, irregular size and variable body thickness, these methods were less effective at maintaining its quality, making halibut less desirable for commercial marketing. The growing demand for fresh fish led to a significant increase in halibut fishing by 1852, with distribution expanding rapidly across the eastern US and into the eastern Canadian provinces. The market for iced halibut was particularly aimed at middle- and upper-class consumers in US society (Vose, 2010).

In response to the growing demand from Boston for fresh halibut, a handline fishery was established on Georges Bank. By 1848, seasonal landings of halibut ranged from 845–1,625 tons. However, by 1850, the fishery had become unprofitable, prompting fishers to shift their efforts to Seal Island Bank, Brown's Bank, and Sable Island Bank. By the 1870s, the Gloucester fleet was primarily operating in deeper waters, employing two-masted schooners, each outfitted with six dories. Fishing was conducted using longlines, with each line holding 350 to 380 hooks. Bait included herring, mackerel, menhaden, cod, haddock, hake, and even birds. In 1878, approximately 4,842 tons of fresh or iced halibut were landed in Gloucester (Cushing, 1988).

This is an example of the adaptability of the Gloucester fisheries, responding on the one hand to market demands and, on the other, to environmental conditions and the state of fish populations, which required them to move to increasingly distant fishing grounds, thus increasing the risks for the fisherfolk. As Vose (2010) notes, the halibut fishery had the highest mortality rate, with the famous story of Howard Blackburn serving as a notable example (McKenzie, 2018).

2.2. A Multisectoral Perspective

While great fleets of vessels sailed to fishing banks, such as the Grand Banks of Newfoundland, a multitude of shore-side businesses operated in downtown Gloucester to support the fishing industry. These included sail lofts, spar sheds, ice houses, chandleries, cooperages, blacksmith shops, and foghorn makers (Murawski, 1995).

The transition from sailing vessels to engine-powered vessels had significant consequences not only for the exploitation of marine resources but also for the businesses associated with navigation, the built environment, and the local material culture. This transition profoundly transformed Gloucester's urban landscape (Kurlansky, 2010). However, just as fisherfolk continually adapted to shifts in target species and fishing grounds, the city also adapted.

As the industry expanded, innovative uses for surplus fish and by-products emerged, significantly reducing waste. Fish heads, tails, and bones were processed into fish meals, which served as both fertilizer and animal feed. Skins of dried cod and cusk were transformed into glue, while swim bladders were utilized to produce isinglass, an essential clarifying agent in beer and wine production (Vose, 2010).

Fishing companies themselves were highly diversified. One example is the menhaden fisheries, a fish that, prior to 1855, had little commercial value, being used mainly as bait, with some barrels salted and shipped to the West Indies, and widely applied as fertilizer in coastal fields (Goode, 1880). In 1875, a new industry emerged, using menhaden for oil production. As a source of oil, menhaden became the most important marine species, surpassing whale, seal, and cod oil production in America. By 1876, the yield of the menhaden fishery was more than twice that of any other fishery in the US. In terms of product value, it was surpassed only by the cod and mackerel fisheries (Goode, 1880).

2.3. A Multiscale Perspective

The history of Gloucester's fisheries is deeply intertwined with regional networks and dependencies, encompassing both land-based and maritime aspects. Several initial factors, such as its proximity to the rich fishing grounds of the Gulf of Maine and major market hubs like Boston, played a crucial role in Gloucester's development. The opening of a major fish pier in Boston in 1914 modernized docking facilities and the marketplace, streamlining the distribution of fresh fish (Johnston, 1984). Similarly, Gloucester's closeness to Essex, a significant center for fishing vessel construction, fostered strong business ties between fisherfolk and boat builders.

The subsequent expansion of Gloucester's fishing industry was driven by the growth of these networks, as noted by Vose (2010). Four key technological advancements were instrumental in enabling the long-distance distribution of perishable goods: the railroad, faster vessels, preserved ice, and the telegraph.

By 1880, the state of New England supplied about one-third of the nation's total fish output, with the remaining supply coming from the southern Atlantic and Pacific Northwest regions (Johnston, 1984). The efficient distribution of Gloucester's fish relied on a network of cities, which was greatly enhanced by the development of railroads in the late 19th and early 20th centuries. Work on extending a steam-powered rail service from New York to Boston began in 1837, and by 1847 Gloucester was connected to this network. This rail infrastructure opened new markets in cities like New York, Philadelphia, Chicago, and Montreal (Vose, 2010).

Maritime advancements were equally vital. One of the most significant developments was the introduction of engines to the fishing fleet—first steam, then gasoline, and eventually diesel. Initially added to schooners as auxiliary power, these engines significantly extended the vessels' range and allowed for faster trips to and from the fishing grounds (Johnston, 1984). Another important factor was the emergence of trawlers (Murawski, 2005). These two developments were fundamental in expanding and intensifying the offshore sector of the fishing industry (Johnston, 1984).

Improvements in cold storage, marketing, and distribution also transformed the industry, making it possible to deliver fresh fish to areas far from the coast. The development of fish filleting techniques, along with effective methods for freezing and storing fish, allowed Americans in inland regions access to fresh seafood for the first time (Murawski, 1995).

The invention of the telegraph also played a pivotal role in Gloucester's fishing industry. Telegraph services, along with transatlantic cable, enabled distant fleets to receive market price updates and storm warnings

(Kurlansky, 2011). Before the telegraph, vessels returning from offshore trips often had to sail between ports such as Gloucester, Boston, or New York, searching for the best market price for their catch—an inefficient and time-consuming procedure given the perishable nature of the goods. With the telegraph, this process became far more efficient, eliminating the need for such time-consuming detours (Vose, 2010).

3. Sources and Methods

This research is a data-driven historical analysis, incorporating both quantitative and qualitative data, thus following the principles of mixed methods research (Feilzer, 2010; Tashakkori & Creswell, 2007). The aim is to enhance historical analysis by incorporating multiple approaches, drawing on different sources of evidence, analytical methods, and data types.

From a methodological standpoint, the first phase of this study was exploratory. It examined the available sources for the period under consideration (between 1880 and 1930) with a focus on systematically organizing data that would enable the identification of trends and changes during this period, as well as how to digitize, process, analyze, and correlate this data.

Regarding sources, the research conducted thus far has relied on digital archives, where primary and secondary materials have been collected and analyzed. The primary digital archives used include Digital Commonwealth, the Fitz Henry Lane Archive, the Library of Congress, the US National Archives and Records Administration, the New York Public Library, and the Cape Ann Museum. Additionally, the digital collections of the City of Gloucester Archive and Sawyer Free Library provide important historical records from the period under analysis.

The archival materials are divided into four types of data: written records, statistical data, geospatial data, and visual data. For written data, since these are digitized publications, no transcription was necessary, and Atlas.ti was used for thematic analysis. For statistical data, despite being part of digitized publications, the processing required a lengthy transcription into Excel for subsequent statistical analysis and visualization using PowerBI. For geospatial data, particularly historical maps and nautical charts, the process involved considerable time in adjusting the base materials, followed by georeferencing using QGIS. Visual data, particularly architectural drawings, were digitized using AutoCAD to produce vectorized and scaled drawings.

As will be detailed in the results section, a central procedure of the analysis is correlating these different data types to enhance the insights derived from them. Moreover, processing historical data with digital tools enables the generation of new information not present in the original sources. One example of this is the integration of statistical and geospatial data. This process of merging different data types for analysis requires the use of multiple software tools, with the integration of Excel and QGIS being central to this research.

4. Results

4.1. Fishing Grounds

The objective of this dataset is to identify and map fishing pressure—i.e., the intensity of fishing activities in a given area (Stewart et al., 2010)—with a focus on the fishing grounds utilized by New England's fishing fleet.

The source for this dataset is a publication by Walter H. Rich from 1929, which includes historical nautical charts and statistical data on fisheries in the Gulf of Maine. The 1929 data is detailed, specifying captured species, their weight and value, fishing areas, fishing trips conducted, and the port of landing, namely Gloucester, Boston, or Portland. Statistical data from 1916 to 1929 is also presented, but it is less detailed, providing only total catches, their value, and the port of landing.

Statistical data from the *Report of the Commissioner* (US Commission of Fish and Fisheries, 1894–1929) was also considered. Similar to the data presented by Rich, this covers a longer period, allowing us to expand the analysis. However, there are large amounts of data still being processed.

This dataset involved a two-step process because of the different types of evidence. Nautical charts were first georeferenced using QGIS and then digitized, focusing primarily on the fishing grounds. Concurrently, the statistical data was digitized into Excel and linked to the geospatial file, assigning information to vectorized objects. This included naming the fishing grounds, specifying the species present in each, and detailing seabed types. Additionally, statistical data on catches were matched with each port.

The combination of geospatial data related to the fishing grounds and its integration with fishing statistics from various years within the period under analysis allows us, in the initial phase, to identify the marine territory that encompasses Gloucester and its fishing grounds, based on the targeted species and seabed types (Figure 2).

The GIS file also enables us to extract information not mentioned in the sources such as the linear distance from Gloucester's port to specific fishing spots, to calculate the area assigned to fishing grounds in nautical

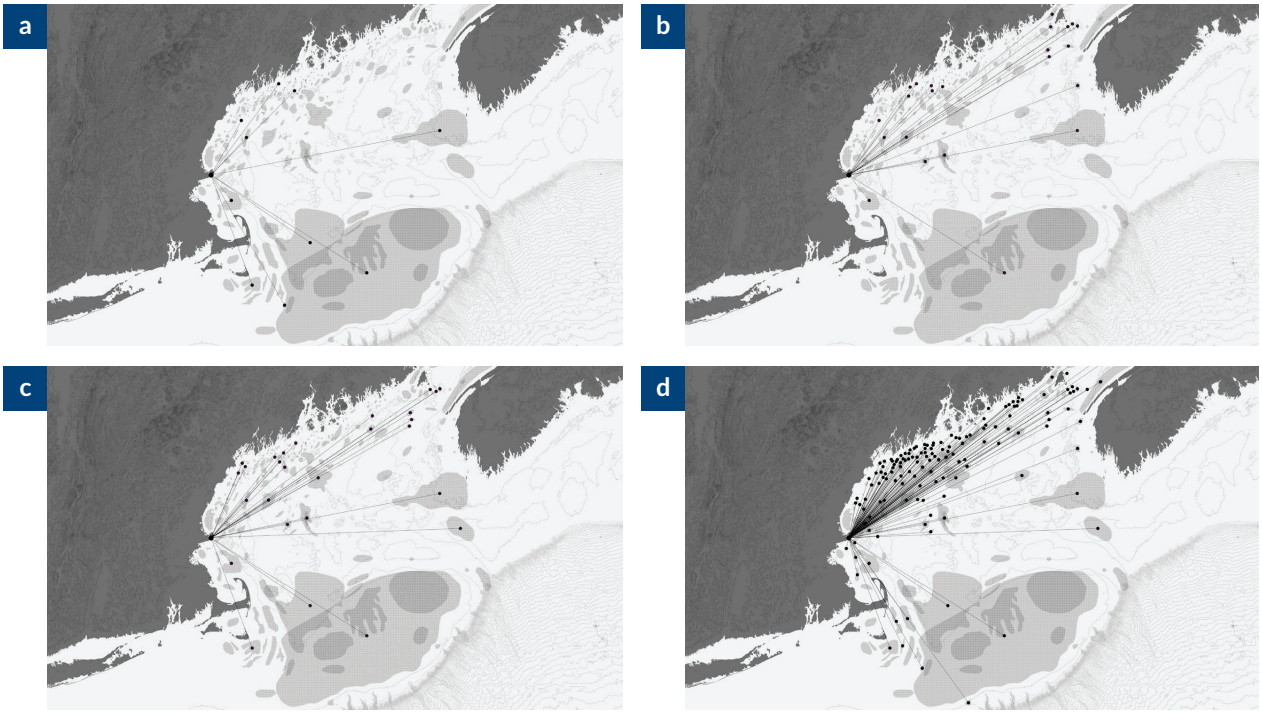


Figure 2. Distribution of fishing grounds by species. Notes: (a) Mackerel (*Scomber scombrus*); (b) Herring (*Clupea harengus*); (c) Atlantic halibut (*Hippoglossus hippoglossus*); (d) Atlantic cod (*Gadus morhua*). Note: This figure is adapted from the data in Rich (1929).

charts, or to derive bathymetric information. Additionally, it allows us to map fishing pressure based on the species captured in each fishing ground and observe how this changed year by year. For instance, as seen in Figure 3, in the Georges Bank group in 1929, haddock far surpassed cod catches a species that historically had greater significance in this same bank (Lear, 1998).

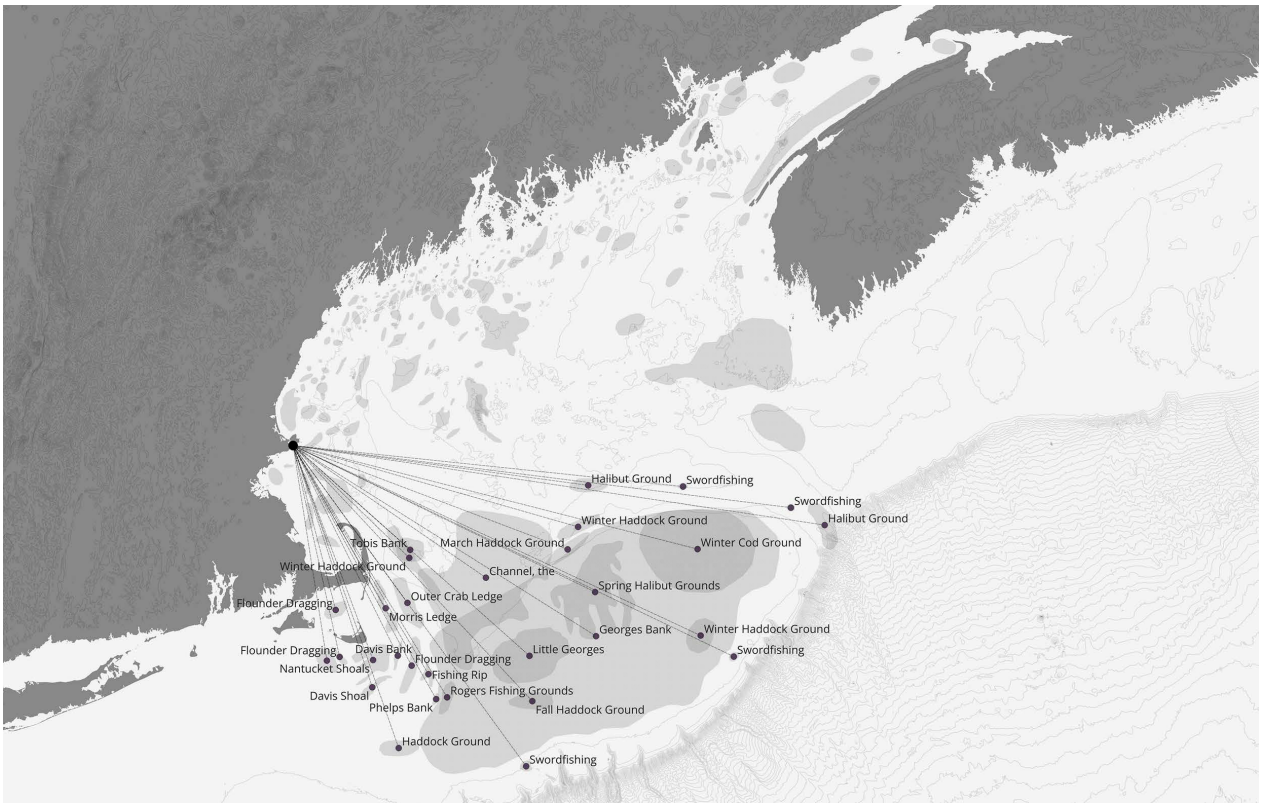


Figure 3. Selection of data from Georges Bank in 1929. Notes: In that year, fishing vessels from Gloucester made 3,499 trips to Georges Bank, with an additional 793 trips by otter trawlers, totaling 4,292 trips; the top three landed species were haddock (180,858,105 pounds), cod (41,471,219 pounds), and mackerel (9,652,991 pounds); the total landings from Georges Bank for the year amounted to 243,425,767 pounds. Note: This figure is adapted from the data in Rich (1929).

The next step will involve following the same procedure with another source (Goode, 1887), which maps fishing grounds outside the Gulf of Maine, such as Brown's Bank, Sable Island, Banquereau, and the Grand Banks of Newfoundland. On the other hand, continuing to process and analyze the statistical data will provide us with insights into the itinerancy of Gloucester's fleet, as well as the changes and trends in species and landing volumes for each fishing ground.

4.2. Fishing Fleets

The objective of this dataset is to characterize Gloucester's fishing fleet in comparison to other major American ports and to analyze how it changed.

Two sets of sources were used to compile this dataset. The first set consists of regular publications listing registered vessels in Gloucester and other American ports for the years 1870, 1880, 1889, 1900, and 1908. The second set comes from a publication titled *Fishermen of the Atlantic*, covering the years 1910 and 1920.

Both sources provide similar types of data, including vessel names, types, tonnage, construction locations, construction dates, and owners or companies. Data on vessel dimensions, such as length, breadth, and depth, began to appear in 1891 but was not included in this analysis.

As the data originated from publications, the first step was to digitize it into an Excel spreadsheet. The data was then standardized to address inconsistencies, such as different terms for the same types of vessels or variations in the naming of construction locations. Data iteration and analysis were performed using Power BI. Given that some of the data is geospatial, such as the port of registration and construction locations, it was also imported into QGIS for territorial distribution analysis.

The data reveals that Gloucester had the largest fishing fleet, surpassing even Boston's. For example, in 1900, Gloucester had a total of 309 vessels, compared to Boston's 54. Although this gap narrowed in subsequent years, Gloucester still had 180 vessels compared to Boston's 100 in 1920. Additionally, the number of sailing vessels in Gloucester decreased from a peak of 428 in 1870 to next to nothing by 1920 ($n = 7$), as they were replaced by engine-powered vessels (Figure 4). In 1910, screw vessels appeared in the data for the first time in Gloucester ($n = 45$), and their numbers more than doubled by 1920 ($n = 107$; Figure 5).

It is also noteworthy that a significant portion of Gloucester's fleet was built in Essex. Among the total vessels built during the period under analysis, Essex ranks first ($n = 1{,}188$), followed by Gloucester ($n = 386$), and then 104 other American towns ($n = 587$). This highlights the importance of the regional network in supporting the production of Gloucester's fishing fleet. Finally, the dataset reveals a trend of reduction and concentration in vessel ownership. The number of companies decreased from 54 in 1870, each owning an

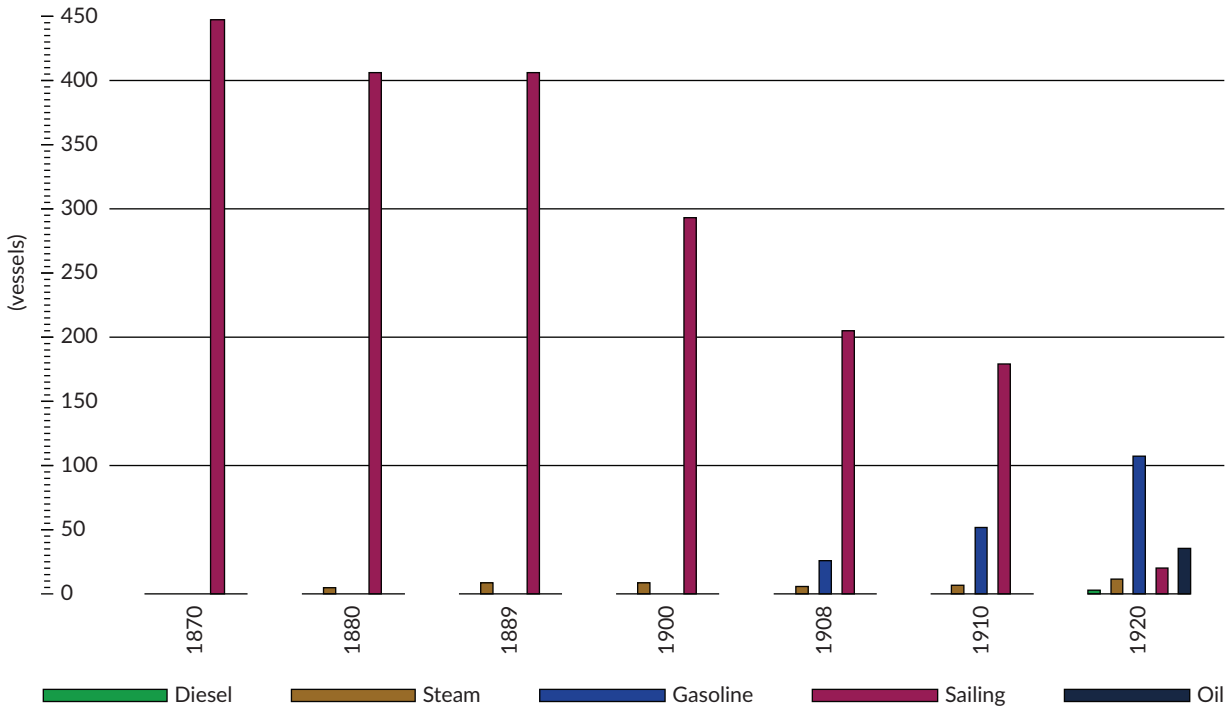


Figure 4. Different types of propulsion of fishing vessels registered at the port of Gloucester. Note: This figure is adapted from data in the *List of Vessels Belonging to the District of Gloucester* (Sawyer Free Library, 1869–1908) and *Fishermen of the Atlantic* (Fishing Masters' Association, 1910, 1920).

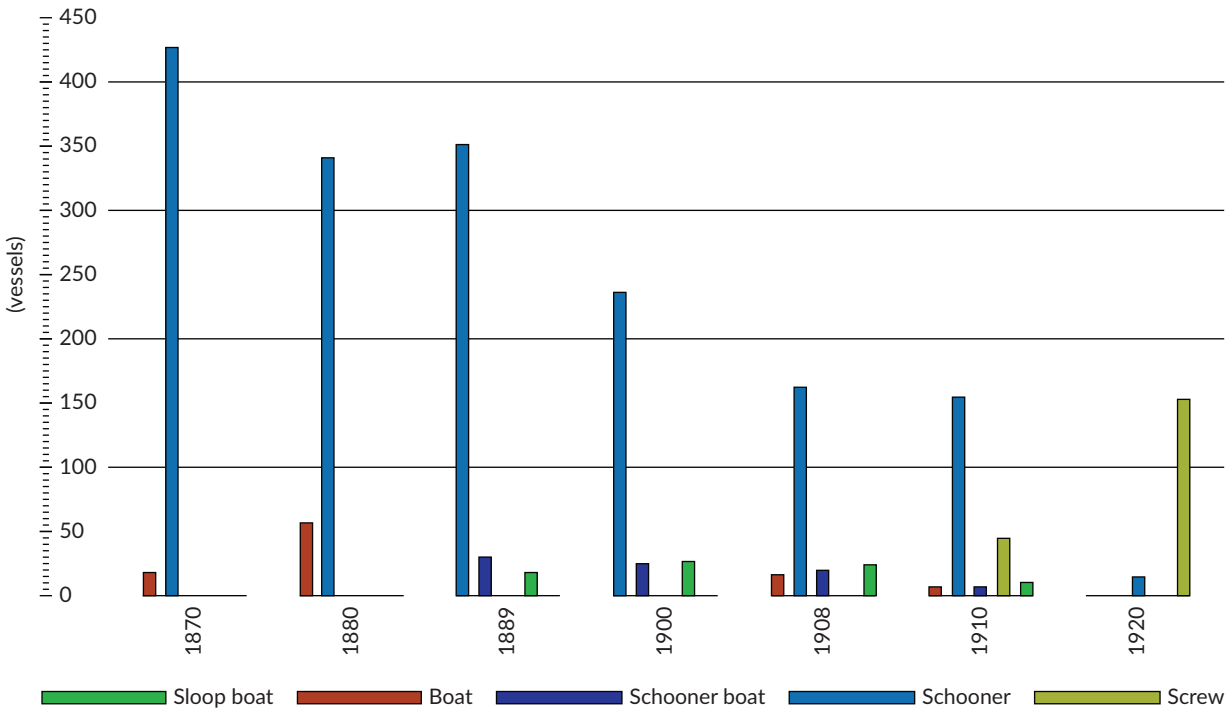


Figure 5. Different types of fishing vessels registered at the port of Gloucester. Note: This figure is adapted from data in the *List of Vessels Belonging to the District of Gloucester* (Sawyer Free Library, 1869–1908) and *Fishermen of the Atlantic* (Fishing Masters' Association, 1910, 1920).

average of seven vessels, to 13 companies in 1920. The Gorton-Pew Vessels Co. emerged as the largest in 1920, owning 43 vessels compared to an average of three vessels per company.

4.3. Population Shifts

This dataset aims to understand the population transformations in Gloucester in comparison to other New England cities, in order to establish a relationship between the development of fisheries and demographic fluctuations.

Two sources were used for collecting this population data: eight volumes of the *Gloucester City Directories*, from each decade between 1860 and 1930, and four volumes of the *Decennial Census*, from 1960 to 1990. The data collected for this dataset are limited to the population sizes of a group of American towns, including Gloucester, Beverly, Essex, Manchester, Marblehead, Salem, Boston, and Provincetown, at five-year intervals within the time period analyzed.

The sources used are historical publications and thus needed to be digitized into an Excel spreadsheet. In this case, automatic text recognition was effective, facilitating the digitization process. The data was double-checked, and since the volumes frequently reference previous years, cross-referencing was conducted to detect errors.

In 1900, Gloucester had a population of 21,161 while Boston had 560,892. In 1930, Gloucester's population was matched by Beverly ($n = 24{,}204$), which then surpassed Gloucester. One notable aspect is that Gloucester

experienced a population peak in 1895 (n = 28,211), after which the population stabilized for nearly a century, only reaching this number again in 1990 (Figure 6).

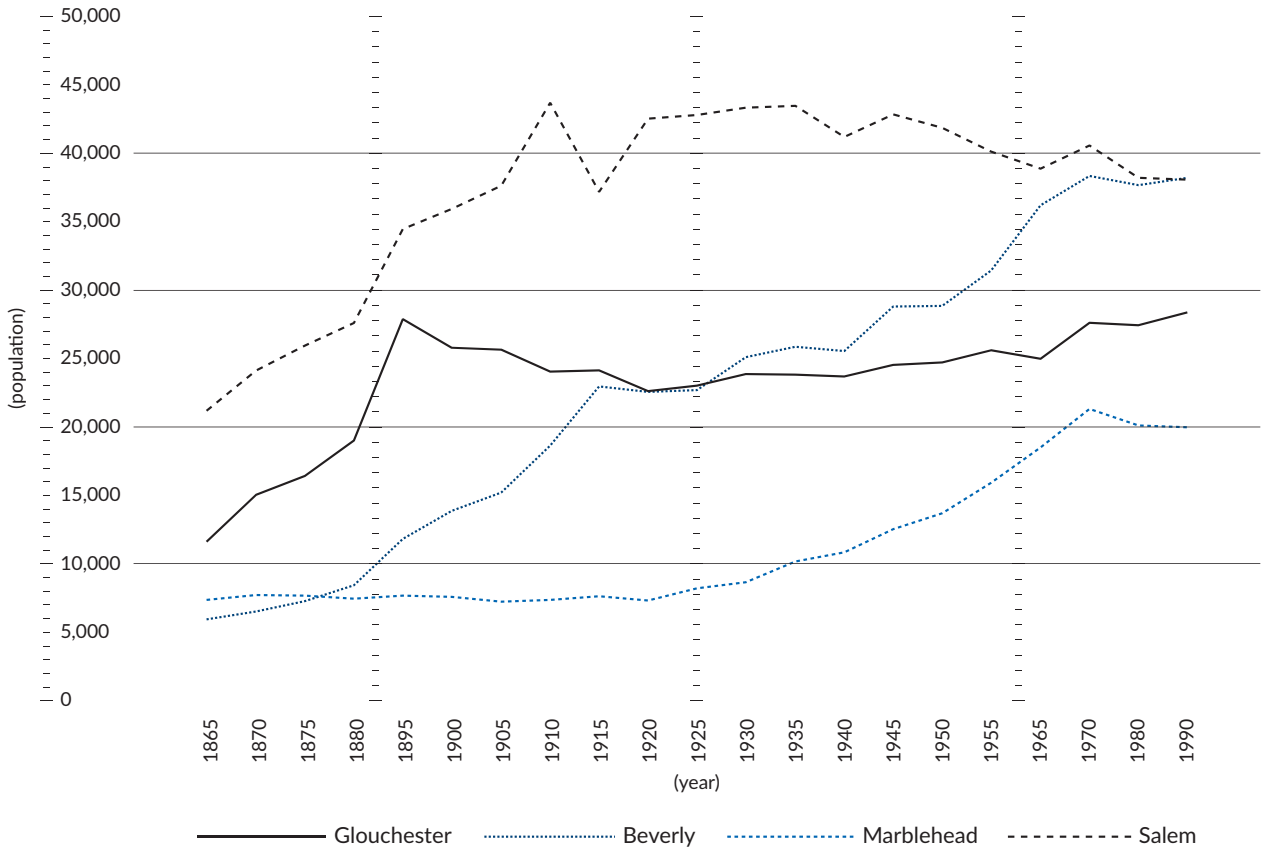


Figure 6. Demographic evolution of Gloucester and other neighboring cities. Note: This figure is adapted from data in the *Gloucester City Directories* (Sawyer Free Library, 1860–1930) and the *Decennial Census by Decade* (United States Census Bureau, 1960–1990).

4.4. Industrial Footprint

The objective of this dataset is to determine the footprint of the fisheries sector in the city of Gloucester, focusing on both fishing companies and employment.

The sources for this dataset include the *Gloucester City Directories* (Sawyer Free Library, 1860–1930), as used in the previous dataset, with a focus on the type of company and its registered name and address. Additionally, data was collected on Gloucester residents, including their names, professions, and addresses. Another source consists of a series of maps of the city produced by the Sanborn Map Company (1888–1949), along with two maps from the *Atlas of the City of Gloucester* (Geo. W. Stadly, 1899; Hopkins, 1884).

This is an ongoing dataset, and, so far, only the data from 1900 has been processed. The work process involved two main stages. The first stage was the digitization and processing of the city directory data. Since the data is in the form of scanned books, the digitization process is quite time-consuming. Additionally, some of the streets listed as addresses no longer exist—such as Vincent Street and Wharf Street—so all entries had to be manually inserted using the 1899 base map in GIS to extract coordinates. In the case of occupations, there

are 10,084 entries and for companies, there are 1,661 entries. The second procedure involved georeferencing the maps from the Atlas of the City of Gloucester using QGIS, followed by their digitization.

The cross-referencing of the 1900 city directory data with the 1899 historical maps makes it possible to visualize the industrial footprint in Gloucester at that time (Figure 7). From the perspective of the companies, we see that they are mainly located in the western part of the city. If we create a top-five list of streets most occupied by fisheries companies, Main Street ranks first (n = 60), followed by Commercial Street (n = 27), Duncan Street (n = 20), and Parker Street and Rogers Street (both n = 13).

From the perspective of fisheries-related employment, there is an even distribution across the city, except for two major areas to the west: one in the older central district and another near the beach. If we compile a top-five list of streets most occupied by fisheries-related workers, Main Street again ranks first (n = 298), followed by Friend Street (n = 161), Duncan Street (n = 112), Commercial Street (n = 76), and Locust Street (n = 70). Additionally, processing this data reveals the great diversity and number of businesses related to fisheries. It also reveals economic trends, such as the significative presence of Salt Fish Dealers (n = 55) compared to Fresh Fish Dealers (n = 9).

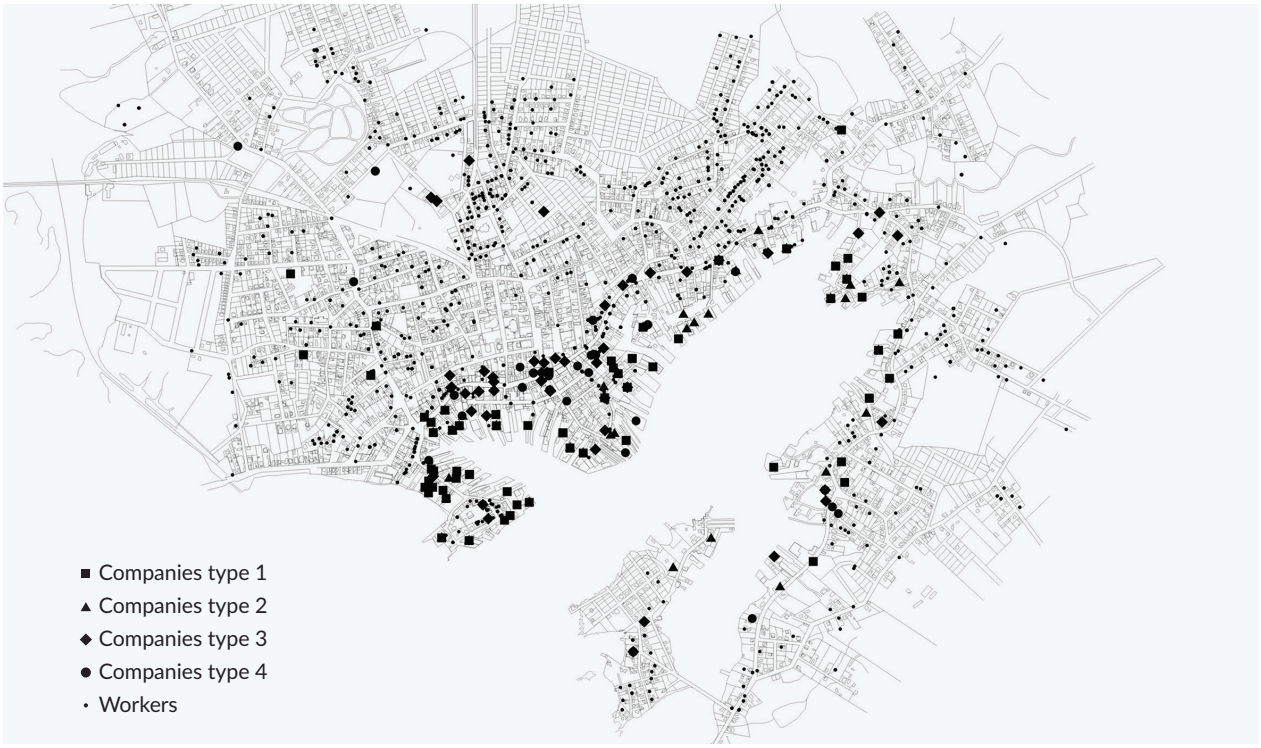


Figure 7. Mapping of companies and workers connected to the fishing industry in Gloucester in 1900. Notes: The companies were organized by type, based on how directly they were involved in fishing; type 1 includes fish dealers for fresh and salted fish; type 2 includes companies that process fish, such as fish criers, fish oil producers, and smokers and curers of fish; type 3 includes companies that produce equipment for the fishing sector, such as fisherfolk's outfits, fishing lines, rope and cordage, and bait and stop nets; type 4 includes companies related to shipbuilding in general, such as ship carpenters, boat builders, and ship chandlers; this figure is adapted from data in the *Gloucester City Directories* (Sawyer Free Library, 1860–1930) and the *Atlas of the City of Gloucester* (Geo. W. Stadly, 1899).

4.5. Processing Plants

The objective of this dataset is to trace the morphological development of a set of processing plants and their respective wharves.

The sources are divided into two types: historical cartography, primarily maps produced by the Sanborn Map Company (1888–1949) and two maps from the *Atlas of the City of Gloucester* (Geo. W. Stadly, 1899; Hopkins, 1884); and visual evidence, such as historical photographs or depictions of processing plants, which were often used as company emblems and appeared as headers on official documents.

This dataset is still in its early stages. As with other datasets, the maps were georeferenced using QGIS for digitization. In this particular case, where morphological analysis is carried out through a direct comparison of the built configurations of the processing plants over time, digitization is crucial in more effectively relating different cases and mapping their transformations.

A set of companies was identified and analyzed, including Cunningham & Thompson, David B. Smith & Co., John F. Wonson & Co., John Pew & Son, Sylvanus Smith & Co., Slade Gorton, and Shute & Merchant, as the most significant in Gloucester before the formation of Gorton-Pew Fisheries Co. in 1906.

We provide the example of John Pew & Son (Figure 8). These four phases exemplify the transformation these structures underwent, which became particularly evident in the cartography from 1898 onward. In just 11 years, we observed a significant increase in the built area, particularly with the construction of a large, covered space that had previously been used for drying fish. This transformation is especially clear

Figure 8. Evolution of the John Pew & Son processing plant. Notes: (a) 1892; (b) 1898; (c) 1903; (d) 1919; this figure is adapted from data in the *Collection Sanborn Maps* (Sanborn Map Company, 1888–1949).

when cross-referenced with visual evidence, which shows how the external area functioned with drying racks and how its mass plan changed after its conversion into processing facilities (Figure 9).

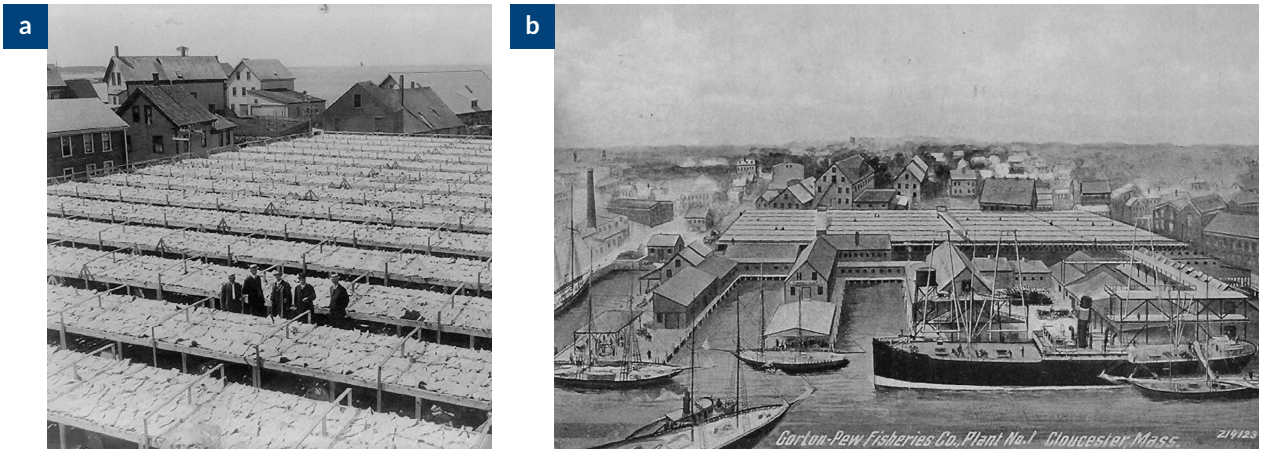


Figure 9. Evolution of the John Pew & Son processing plant. Notes: (a) John Pew & Son's Cod Flake Yard, 1899; (b) Gorton-Pew Fisheries' processing plant, 1923; this figure is adapted from data in the Library of Congress (1899, 1923).

5. Discussion

5.1. Gloucester's Fisheries

The period under analysis covers Gloucester's peak as the leading fishing power in the US and is characterized by a rich array of historical records. These records range from statistical data on fishing (Rich, 1929; US Commission of Fish and Fisheries, 1894–1929) and scientific research related to fisheries and species biology (Goode, 1887) to detailed information about Gloucester's fleet, including regular publications such as the *List of Vessels Belonging to the District of Gloucester* (Sawyer Free Library, 1869–1908). It also includes information about the companies and workers involved in the fishing industry, particularly the Gloucester Directory series from 1860 to 1930. A particularly valuable aspect is the cartographic evidence, which includes highly detailed surveys produced at short intervals, providing representations of the city at nearly decade-long intervals, especially the series produced by Sanborn Map Company from 1888 to 1949.

In a study relying on data-driven historical analysis, the availability of such extensive and consistent records is crucial in enabling meaningful conclusions to be drawn. On the one hand, the sheer volume of existing data is a key asset; on the other, the systematic nature and uniformity of this data over a defined period allow for the identification of patterns, trends, peaks, and changes. This has facilitated the establishment of five datasets—some already complete in terms of data collection and processing, while others are still under development. The diverse range of data from various types and sources is a deliberate strategy, allowing these datasets to be cross-referenced with the literature so that more robust insights can be generated and correlations identified.

From a literature perspective, extensive research has examined the history of fishing in New England, with Gloucester playing a key role (Cushing, 1988; Johnston, 1984; Lear, 1998; McKenzie, 2018) and the relationship between fisheries history and ecosystems (Bolster, 2008, 2012). Studies have also focused on key species such as Atlantic cod (Dybas, 2006; Kurlansky, 2010, 2011) and menhaden (Frye, 1978; Goode,

1880), as well as on broader multispecies analyses (Sutcliffe et al., 1977). However, the historical connection between fisheries and urban and architectural development remains underexplored.

This is significant because, in many coastal communities with economies essentially based on fisheries, the built environment reflects the fish–human relationship (Thurstan, 2022). One of the aims of this study is to explore this connection by examining how marine resource extraction has shaped the city's built environment, starting with changes to the coastline and wharves, the development of industrial and port areas, and the types of structures supporting fishing and fish processing, which have historically played a significant role.

From a methodological perspective, although they focus on different study objects and objectives, various inter and multidisciplinary studies in the fields of history and environmental history have utilized statistical data (Hayes et al., 2024; Holm et al., 2024), as well as statistical and geospatial data (Thurstan et al., 2024; Zu Ermgassen et al., 2024), highlighting the operational potential of these approaches.

5.2. A Data-Driven Historical Analysis

The preliminary results we present underscore the potential of combining historical analysis with statistical and geospatial data, not only to deepen and clarify existing knowledge but also to uncover new insights that were previously hidden. By complementing the literature, the combination of these methods enables us to refine and expand on themes already explored by previous studies.

For example, data-driven analysis allows for the quantification and verification of historical transitions, such as the characterization of Gloucester's fishing fleet over the period under analysis. In the Fishing Fleets dataset, we observe that, in general terms, the fishing fleet decreased from 409 vessels in 1880 to 180 in 1920. If we focus on schooners, the principal type of vessel in the late 19th and early 20th centuries (Vose, 2010), we see a drop from 342 schooners in 1880 to just 15 in 1920, with gasoline screws increasing to 107 by 1920. On the other hand, in the Population Shifts dataset, we observe a similar downward trend, with the population peaking in 1895 ($n = 28{,}221$).

The decline in both the fleet and the resident population may suggest Gloucester's waning status as a fishing power (Johnston, 1984) or, alternatively, that vessels and fishing methods became more efficient. According to Cushing (1988), pre-industrial fisheries required a large number of fisherfolk to achieve relatively small catches, a situation that was reversed with industrialization. This is an aspect that can be further analyzed by cross-referencing these datasets with catch statistics from the Fishing Grounds dataset, which is still under development. These transitions, often described in qualitative terms, gain new depth when supported by statistical evidence.

Another key aspect of this period, derived from the Fishing Grounds dataset, is the transition from salt to fresh fish. The data shows that in 1895, salted cod landed in Gloucester amounted to 43,227,963 pounds, compared to 4,105,526 pounds of fresh cod. Despite this large difference, these figures had evened out by 1914, with 14,743,280 pounds of both salted and fresh cod landed. With trends running in opposite directions, fresh cod would soon surpass salted cod. By 1919, fresh cod landed in Gloucester totaled 27,263,118 pounds, compared to just 4,722,851 pounds of salted cod.

As Lear (1998) notes, this transformation in the fishing sector was made possible by two technologies, both originating in New England: filleting and quick freezing. Filleting at source drastically reduced transportation costs per unit of edible product, while allowing waste materials to be converted into valuable by-products. This revolutionized the way fish products were packaged and handled, enabling brand differentiation and creating new opportunities for visual appeal and marketing. Quick freezing, in turn, transformed the industry by ensuring consistent quality and significantly improving the shelf life and portability of perishable goods over time and distance. It not only helped smooth out supply fluctuations but also opened new and far-reaching markets.

This shift from dried to fresh fish is also reflected in the Processing Plants dataset, where we see how large areas for fish flakes were replaced by facilities for storage and processing. The construction of the Gloucester State Fish Pier in 1937 (Figure 10) marked a pivotal moment of this change, as the city sought to assert its autonomy in relation to the Boston market, which had previously dominated the fresh fish trade.

At the same time, this methodology offers new insights by revealing relationships that were previously unseen. The spatialization of data, for instance, not only helps map the geographic spread of Gloucester's fishing grounds but also exposes the extent of the region's integration into broader national and international networks. These networks, which involved both the production of ships and the trade of

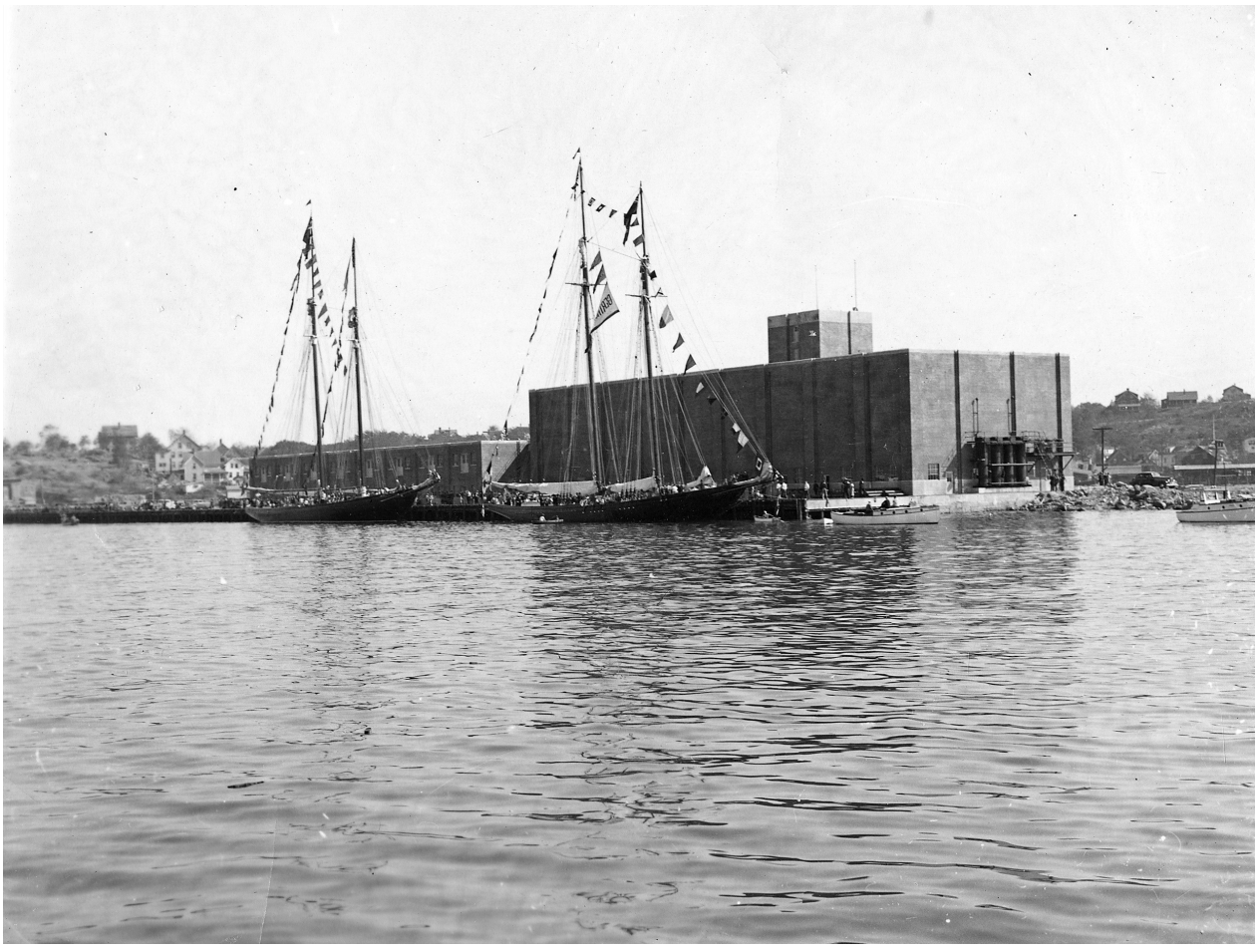


Figure 10. Gloucester State Fish Pier, 1939. Source: Curtis (1939).

marine resources, illustrate the large-scale nature of Gloucester's fishing industry, suggesting that it operated on a more extensive and interconnected scale than previously documented.

Geospatial analysis allows us to identify patterns in urban development that were not readily apparent from the historical record alone, such as the clustering of processing plants or the spatial dynamics of industrial decline and regeneration. In correlation, the built environment, the architectural forms, and the important city infrastructures—as we observed in the Processing Plants dataset—changed rapidly and drastically.

The combination of historical, statistical, and geospatial analysis has proven to be an effective method for revealing both well-documented and previously unseen aspects of Gloucester's fisheries and urban development. By supplementing existing literature with new data and perspectives, it is possible to gain a more detailed and nuanced understanding of the city's peak as a fishing center, its subsequent decline, the socio-economic transformations that accompanied these changes, and how these shifts were reflected in both the built environment and marine ecosystems.

5.3. Limitations and Future Work

One important limitation to underscore is the preliminary nature of these findings. However, they offer a promising glimpse into the kinds of connections our data may reveal, allowing us to forecast long-term trends in resource exploitation and the socio-economic dynamics of Gloucester.

The challenges we face are largely inherent to historical research: scarcity and fragmentation, lack of uniformity, and issues with sample representativeness. Additionally, the digitization of large amounts of information, especially from older publications, often with poor-quality scans, is a time-consuming process that requires meticulous attention to verification and validation.

Up to this point, our work has primarily addressed socio-economic factors and human interactions with the environment. In alignment with the study's objectives, future efforts should increasingly focus on environmental variables. Future research needs to place greater emphasis on understanding how these ecological factors interact with the socio-economic elements already under analysis.

A critical next step will be to expand the Fishing Grounds dataset, which contains statistical data on fish landings. If sufficiently comprehensive for the period in question, this dataset will be essential for cross-referencing with other datasets, as it serves as the primary indicator of both fishery productivity and its impact on marine ecosystems. By linking fishing statistics with data on fishing fleets and population shifts, or examining the relationship between fish species and quantities caught with Gloucester's fishing companies, workforce, and processing plants, we will gain valuable insights into the broader dynamics of the industry in relation to urban settlement.

6. Conclusion

This article has outlined the approach and initial findings of a broader investigation into the industrialization of fisheries in Gloucester, Massachusetts. Our research offers critical insights into the socio-economic and ecological transformations that have shaped the region, while also acknowledging the current limitations and

the work yet to be done. As a foundational study, this work presents a starting point for future research on this topic, which will require further development of the datasets and a more comprehensive analysis of patterns and changes over time.

One of the contributions is the systematic digitization and accessibility of historical data on Gloucester's fisheries. While much of this information has been available in fragmented forms, the process of organizing, digitizing, and integrating these sources into a coherent dataset reduces barriers to conducting more nuanced analyses. These datasets must and will be published according to FAIR principles. Additionally, the thorough documentation of our methodological approach provides a transparent and replicable framework for future research.

The development of advanced data visualizations represents another core contribution. Visual tools are essential for illustrating complex socio-ecological processes, and the visual representations generated in this research serve as effective mechanisms for communicating intricate historical dynamics. These visualizations enhance our understanding of long-term patterns and provide a foundation for the application of similar techniques in interdisciplinary studies, particularly in fields such as environmental humanities and the history of urbanism.

It is expected that this research will contribute to the growing intersection of digital humanities and environmental humanities by integrating historical, ecological, and socio-economic dimensions. Through this interdisciplinary approach, it seeks to provide a more comprehensive understanding of the complex interactions between human society and the marine environment. By bridging these areas, this work not only enhances our understanding of the North Atlantic's fishing industry but also lays the groundwork for future interdisciplinary collaborations that can address broader questions relating to environmental challenges and historical change.

Acknowledgments

The ongoing research that has generated the results presented in this article is supported by the Fishing Architecture project team. We are grateful for the collective discussions, valuable insights, feedback, and unwavering support and friendship. We also wish to extend our thanks to Patrícia Reis, a master's student in the Faculty of Architecture at the University of Porto, for her enthusiastic collaboration.

Funding

Fishing Architecture is a research project funded by the European Union (ERC, Fish-A,101044244).

Conflict of Interests

The views and opinions expressed are, however, those of the authors only and do not necessarily reflect those of the EU or the European Research Council. Neither the EU nor the granting authority can be held responsible for them.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors.

References

Bolster, W. J. (2008). Putting the ocean in Atlantic history: Maritime communities and marine ecology in the Northwest Atlantic, 1500–1800. *The American Historical Review*, *113*(1), 19–47. https://doi.org/10.1086/ahr.113.1.19

Bolster, W. J. (2012). *The mortal sea: Fishing the Atlantic in the age of sail*. Harvard University Press.

Curtis, A. M. (1939). *Gloucester state fish pier, 1939* [Photograph]. Cape Ann Museum Archives.

Cushing, D. H. (1988). *The provident sea*. Cambridge University Press.

Dybas, C. L. (2006). Ode to a codfish. *BioScience*, *56*(3), 184–191. https://doi.org/10.1641/0006-*3568*(2006)056[0184:OTAC]2.0.CO;2

Feilzer, M. Y. (2010). Doing mixed methods research pragmatically: Implications for the rediscovery of pragmatism as a research paradigm. *Journal of Mixed Methods Research*, *4*(1), 6–16. https://doi.org/10.1177/1558689809349691

Fishing Masters' Association. (1910). *Fishermen of the Atlantic*. University of Maine. https://digitalcommons.library.umaine.edu/fisheries/145

Fishing Masters' Association. (1920). *Fishermen of the Atlantic*. University of Maine. https://digitalcommons.library.umaine.edu/fisheries/144

Frye, J. (1978). *The men all singing: The story of menhaden fishing*. Donning.

Geo. W. Stadly. (1899). *Atlas of Cape Ann, Gloucester, Rockport and Manchester, Essex County, Mass. : From official plans and actual surveys.*. https://ark.digitalcommonwealth.org/ark:/50959/mg74t813q

Goode, G. B. (1880). *American fisheries: A history of the menhaden*. Orange Judd.

Goode, G. B. (1887). *The fisheries and fishery industries of the United States* (Vol. 1–5). U.S. Government Printing Office.

Hayes, P., Holm, P., & Nicholls, J. (2024). *500 years of the once largest fishery in the world: A comprehensive catch reconstruction for the Newfoundland cod fishery (1508–2023)* [Data set]. Figshare. https://doi.org/10.6084/m9.figshare.27111478.v7

Holm, P., Hayes, P., & Nicholls, J. (2024). Historical marine footprint for Atlantic Europe, 1500–2019. *Ambio*, *53*(4), 624–636. https://doi.org/10.1007/s13280-023-01939-9

Hopkins, G. M., Jr. (1884). *Atlas of the city of Gloucester and town of Rockport, Massachusetts*. https://ark.digitalcommonwealth.org/ark:/50959/5138n263m

Johnston, P. F. (1984). *The New England fisheries: A treasure greater than gold: The Russell W. Knight collection of New England fishing scenes*. Peabody Museum of Salem.

Kipling, R. (1897). *Captains courageous*. Century Co.

Kurlansky, M. (2010). *The last fish tale: The fate of the Atlantic and our disappearing fisheries*. Random House.

Kurlansky, M. (2011). *Cod: A biography of the fish that changed the world*. Vintage.

Lear, W. H. (1998). History of fisheries in the Northwest Atlantic: The 500-year perspective. *Journal of Northwest Atlantic Fishery Science*, *23*, 41–73.

Library of Congress. (1899). *John Pew & Son's cod flake yard, 1899* [Photograph].

Library of Congress. (1906). *Drying fish, Gloucester, Mass*. https://www.loc.gov/resource/det.4a30427

Library of Congress. (1923). *Gorton-Pew fisheries' processing plant, 1923* [Postcard].

McKenzie, M. (2018). *Breaking the banks: Representations and realities in New England fisheries, 1866–1966*. University of Massachusetts Press.

Murawski, S. A. (1995). *Brief history of the groundfishing industry of New England*. NOAA Fisheries. https://www.fisheries.noaa.gov/new-england-mid-atlantic/commercial-fishing/brief-history-groundfishing-industry-new-england

Murawski, S. A. (2005). The New England groundfish resource: A history of population change in relation to harvesting. In R. Buchsbaum, J. Pederson, & W. E. Robinson (Eds.), *The decline of fisheries resources in New England* (pp. 11–24). Massachusetts Institute of Technology.

Ojeda, J., Salomon, A. K., Rowe, J. K., & Ban, N. C. (2022). Reciprocal contributions between people and nature: A conceptual intervention. *BioScience*, *72*(10), 952–962.

Rich, W. H. (1929). *Fishing grounds of the Gulf of Maine*. United States Bureau of Fisheries.

Sanborn Map Company. (1888–1949). *Collection Sanborn maps* [Item set]. Library of Congress. https://www.loc.gov/collections/sanborn-maps

Sawyer Free Library. (1860–1930). *Gloucester city directories* [Item set]. https://omeka-s.noblenet.org/s/gloucester/item-set/4386

Sawyer Free Library. (1869–1908). *List of vessels belonging to the district of gloucester* [Item set]. Sawyer Free Library. https://omeka-s.noblenet.org/s/gloucester/item-set/4382

Stewart, K. R., Lewison, R. L., Dunn, D. C., Bjorkland, R. H., Kelez, S., Halpin, P. N., & Crowder, L. B. (2010). Characterizing fishing effort and spatial extent of coastal fisheries. *PLoS ONE*, *5*(12), Article e14451. https://doi.org/10.1371/journal.pone.0014451

Sutcliffe, W. H., Jr., Drinkwater, K., & Muir, B. S. (1977). Correlations of fish catch and environmental factors in the Gulf of Maine. *Journal of the Fisheries Board of Canada*, *34*(1), 19–30.

Tashakkori, A., & Creswell, J. W. (2007). Differing perspectives on mixed methods research. *Journal of Mixed Methods Research*, *1*(4), 303–308.

Thurstan, R. H. (2022). The potential of historical ecology to aid understanding of human–ocean interactions throughout the Anthropocene. *Journal of Fish Biology*, *101*(2), 351–364. https://doi.org/10.1111/jfb.15000

Thurstan, R. H., McCormick, H., Preston, J., Ashton, E. C., Bennema, F. P., Bratoš Cetinić, A., Brown, J. H., Cameron, T. C., Costa, F., Donnan, D. W., Ewers, C., Fortibuoni, T., Galimany, E., Giovanardi, O., Grancher, R., Grech, D., Hayden-Hughes, M., Helmer, L., Jensen, K. T., . . . Zu Ermgassen, P. S. E. (2024). Historical dataset details the distribution, extent and form of lost *Ostrea edulis* reef ecosystems. *Scientific Data*, *11*(1), Article 1198. https://doi.org/10.1038/s41597-024-04048-8

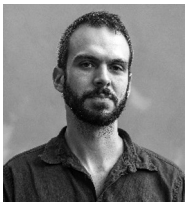
United States Census Bureau. (1960–1990). *Decennial census by decade* [Item set]. United States Census Bureau. https://www.census.gov/programs-surveys/decennial-census

US Commission of Fish and Fisheries. (1894–1929). *Report of the Commissioner* [Item set]. NOAA Central Library. https://library.oarcloud.noaa.gov

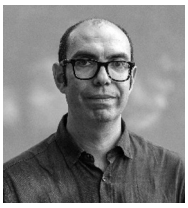
Vose, S. R. (2010). *Technology versus the Atlantic halibut (Hippoglossus hippoglossus) of the Gulf of Maine: The impact of railroads, sharpshooters, ice preservation, and the telegraph on this fishery, 1848–1868* [Unpublished master's thesis]. Harvard University.

Zu Ermgassen, P. S., McCormick, H., Debney, A., Fariñas-Franco, J. M., Gamble, C., Gillies, C., Hancock, B., Laugen, A., Pouvreau, S., Preston, J., Sanderson, W., Strand, Å., & Thurstan, R. H. (2024). European native oyster reef ecosystems are universally collapsed. *Conservation Letters*, 18(1), Article e13068. https://doi.org/10.1111/conl.13068

About the Authors



Rafael Sousa Santos is an architect and has been a PhD candidate in the Faculty of Architecture at the University of Porto since 2017. In 2021, he was a visiting researcher at Politecnico di Milano, and in 2022, at the Massachusetts Institute of Technology as a Fulbright Scholar. He edited the issue Collaborations: Rethinking Architectural Design, *Dimensions—Journal or Architectural Knowledge* (2023). Currently, he works as a research assistant in the research project Fishing Architecture (ERC, Fish-A, 101044244).



André Tavares is an architect and, since 2006, the coordinator of Dafne Editora, an independent publishing house in Porto. His published works include *The Anatomy of the Architectural Book* (Lars Müller/Canadian Centre for Architecture, 2016), *Vitruvius Without Text* (Verlag, 2021), and *Architecture Follows Fish* (MIT Press, 2024). He is currently a researcher in the Faculty of Architecture at the University of Porto, where he leads the research project Fishing Architecture (ERC, Fish-A, 101044244).