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The Record of the Last Sturgeons Caught in the Po River (North Italy) Tells a Cautionary Tale of Reasons of Their Silent Disappearance

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ABSTRACT

Three sturgeon species—the common European (*A. sturio*), beluga (*H. huso*), and Adriatic sturgeon (*A. naccarii*)—coexisted in the Po River Basin until the mid-1970s, representing centuries of bio-cultural heritage for northern Italy's riverine communities. Despite their historical and cultural significance, the dynamics of their decline remain undocumented in scientific literature. This study reconstructs the final chapter of natural sturgeon populations in the Po River through systematic analysis of quantitative data from 1970 to 1990, including catch records obtained during scientific monitoring campaigns, fish market auction records, gray literature, and interviews with veteran fishermen. Our findings reveal distinct extinction trajectories: the beluga sturgeon disappeared by 1974, while the last common sturgeon was captured in 1984. The Adriatic sturgeon showed greater resilience, persisting longer in the Po Delta with low but stable populations. Overfishing emerges as the primary driver of decline. Historical fishing practices targeted spawning migrations along the entire river course, while mechanization from the 1960s—motorized boats and nylon nets—intensified fishing pressure. Coastal trawling in the northwestern Adriatic further impacted anadromous species throughout their life cycle. The 1987 ministerial decree establishing a 100 cm minimum catch size came too late to prevent extinctions. This research establishes the first comprehensive baseline of pristine sturgeon populations in the Po River system, revealing how intensive exploitation dismantled centuries-old ecological and cultural relationships. These findings provide crucial historical context for ongoing restoration efforts and highlight the interdependence between functional river ecosystems and human societies.

1 | Introduction

Overall, sturgeons are threatened by multiple hazards (Billard and Lecointre 2000; Gessner et al. 2024; Sayer et al. 2025), having led some of them to extinction or to be classified as critically endangered (Congiu et al. 2023).

While overexploitation undoubtedly reduced populations of numerous species, impairment of riverine and coastal ecosystems has also played a role (Anderson et al. 2022). In Europe, a dramatic decline of sturgeons has occurred over the past two centuries (Gessner et al. 2024; Macias et al. 2025). An emblematic case within the Mediterranean Sea is the Po River and delta (Giorgi 2006), where three species of sturgeons were present until the late 1980s: the European or common sturgeon (*A. sturio*), the beluga sturgeon (*Huso huso*), and the cobice or Adriatic sturgeon (*A. naccarii*). A consolidation of information indicates that the common and beluga sturgeons, which used to spend most of their lives in coastal waters of the northwestern Adriatic (Bronzi et al. 2006), moving upstream the Po for reproduction (Paccagnella 1948; Bronzi et al. 2011, and references therein), are now extinct (EX, according to the last IUCN assessment). The Adriatic sturgeon, instead, is still present in the Po and other large rivers outflowing into the Adriatic, as a result of long-lasting restocking programs (CR, as according to the last IUCN assessment; Friedrich et al. 2018, and references therein; P. Bronzi pers. comm.). Quantitative historical data on the three species' occurrences along the Po River are scarce, and their decline is not documented, nor have its potential causes been examined. To infer the most likely cause of their decline, we conducted a systematic review of peer-reviewed articles and gray literature, historical sturgeon records from archives, handwritten documents (e.g., fish market auction records), and interviews with the old fishermen who were still in force at the time when sturgeons disappeared. This approach highlighted the interdependence between a functional river and human societies (Oloriz and Parlee 2020), as well as the historical economic relationships between these species and local communities of the Po River. Overall, the aim of this research is to set a baseline of pristine natural sturgeon population occurrences and use it to infer on the most influential causes of their decline.

2 | Methods

2.1 | The Study Area

The Po is Italy's longest river at 652 km. It drains a basin of around 75,000 km^2 and flows into the northern Adriatic Sea. The Po basin is the most densely populated, cultivated, and industrialized area in Italy, generating around 40% of the country's gross domestic product. Indeed, it is one of the European regions that contribute the most nitrogen (N) and phosphorus (P) to the northern Adriatic Sea. This makes its delta and the surrounding coastal waters a hotspot for eutrophication (Soana et al. 2024).

Historically, the entire Po ecosystem, including its tributaries, the delta, and the associated coastal waters, was characterized by high productivity. This is evident from the abundance of fish that sustained numerous fisheries and local populations (Frascaroli et al. 2021). Sturgeons were particularly valued for their culinary uses, with traditions dating back to Roman times. They remained economically important until the mid-20th century (Bellon 1553; de Lalande 1779; Longhi 1979; Zaccaria and Masini 1991). The high economic value of the catches was guaranteed by their trade and consumption confined to the nobility and religious elites of the most important towns of the area, a valuable market that persisted from the 15th century until recent decades (Bronzi et al. 2011, last historical Po River fisherman pers. comm.). Although these culinary and commercial traditions were well documented, quantitative historical records of sturgeon abundances remained almost null and disaggregated (Bronzi et al. 2011; Paccagnella 1948).

2.2 | Literature Review

To summarize all the historical information reporting the presence of the three sturgeon species that once coexisted along the Po River, an extensive literature review was performed as a starting point. Systematic research was conducted using the Scopus database (www.scopus.com; last accessed 10 April 2025). The string used was: TITLE-ABS-KEY (sturgeon* OR acipenser* OR huso*) AND TITLE-ABS-KEY (ital*) AND TITLE-ABS-KEY (river* OR adriatic). The research was then restricted to the Po catchment. Afterwards, the updated PRISMA protocol (Page et al. 2021) was used to assess extracted papers and select which were deemed to be included in the study. To ensure a comprehensive review of all available information, alternative sources such as gray literature, archival sources, and handwritten documents were also examined, such as fish market auction records from the markets located in Milan, in the Po Delta (Donada and Scardovari), in Venice, and in Goro (Ferrara). In addition, the bio-cultural heritage in the memory of old fishermen was considered (Oloriz and Parlee 2020), after expert validation of the data provided.

Overall, the collection and analysis were limited in time to natural populations of all three sturgeon species before 1990, considered as a temporal threshold between the existence of natural populations and the point at which the common and beluga sturgeon were already extinct, and artificially reproduced Adriatic sturgeon specimens began to be reintroduced (Arlati et al. 1999, P. Bronzi pers. comm.).

2.3 | Data Analysis

Sturgeon catches data obtained for the targeted species from the only available scientific monitoring programs that occurred until 1990 were plotted against time. Another source of information was the collection of auction slips from the fish stock markets in Milan, Scardovari, and Donada (in the province of Rovigo) and Goro (in the province of Ferrara). Donada market was the only source of sturgeon's sales for the period investigated, specifically reporting *A. naccarii* sales. This enabled the reconstruction of this species' catch in the Po Delta during the final years of the wild population's existence, from 1981 to 1988. Specimens were grouped by seasons into four different size classes referring to different age classes (sensu Rossi et al. 1991): 50–69 cm (2–4 years), 70–89 cm (4–6 years), 90–109 cm (6–10 years), and > 110 cm (> 10 years). Loess smoothing was used to describe the

remnant natural sturgeon stock trend. All data visualization was performed using R software v.4.1.3 (R Core Team 2022). No statistical analysis was carried out since no comparisons were made.

3 | Results

No reference was found in Scopus before 1990, and from 1996 to 2025 a total of 16 peer-reviewed articles were found and further screened. None were found to be relevant to the search criteria and time period (Figure S1). An additional reference was published after the last access to Scopus, providing further data regarding the historical presence of *A. sturio* in the Po River and thus was included in the dataset (Brevé et al. 2025 and references therein).

Gray literature search provided information on locations where common European sturgeons and beluga were fished during their reproductive migration, distributed along almost the entire course of the Po River but never on the most important right bank tributaries. The same sources reported that the Adriatic sturgeon was fished throughout the year, with most catches of migrating specimens occurring in the lower stretches of the Po and its delta, as shown in Figure 1.

Sampling data from a monitoring campaign conducted ad hoc by the University of Ferrara (northern Italy) along the Po Delta in the periods 1972–1975 and 1984–1989 are reported in an article published in Italian by Rossi et al. (1991). Through these data, it was possible to assess the remnant natural pristine occurrences of all the three sturgeon species. The last beluga sturgeon was caught in 1974, whereas the last specimens of common sturgeon were caught in 1984 (Figure 2, top panel) (Figure 2, central panel). For the Adriatic sturgeon, however, a reverse trend was observed, with low levels of increasing abundance to the end of the investigated timeframe (Figure 2, bottom panel).

Sales data obtained from Donada fish market (Figure 3A–D) clearly show that sold specimens were immature, mostly measuring between 50 and 69 cm in length. Sales were distributed throughout the year, with a sharp decrease in winter (see Figure 3D) and a steep decline from 1985 onwards.

4 | Discussion

The data summarized in this article clearly show that overfishing played a major role in the decline of the sturgeon population along the Po River. Historically, fishermen focused their efforts on catching sturgeon during the spawning migration (April–June),

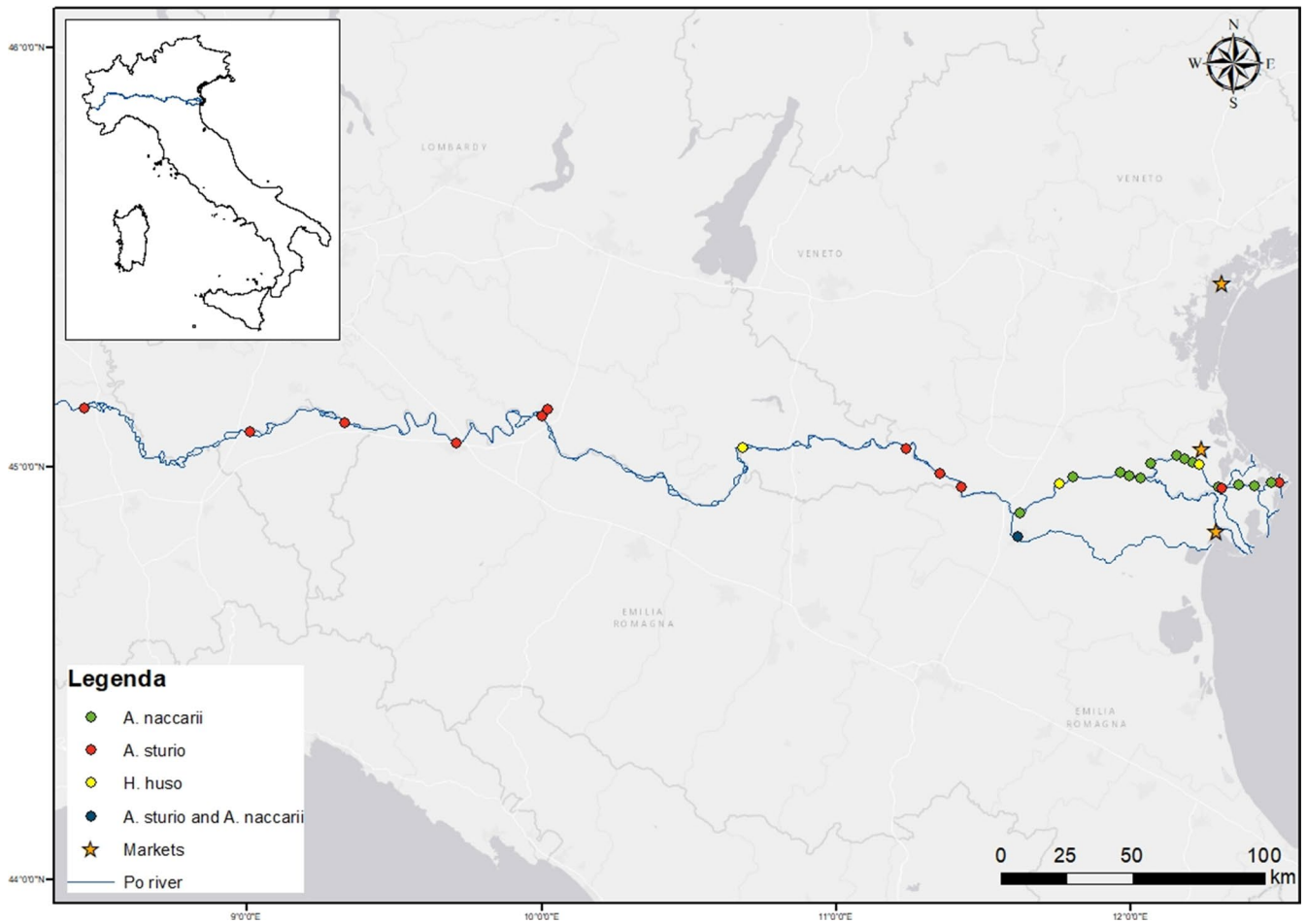

FIGURE 1 | Map of the Po River, highlighting the most relevant stretches for professional fishing of *A. sturio* (red dots), *H. huso* (yellow dots) and *A. naccarii* (green dots). Blue dots indicate areas where catches overlapped. Orange stars highlight the fish markets in Venice, Donada and Goro, from north to south respectively. References are provided in Table S1. [Color figure can be viewed at wileyonlinelibrary.com]

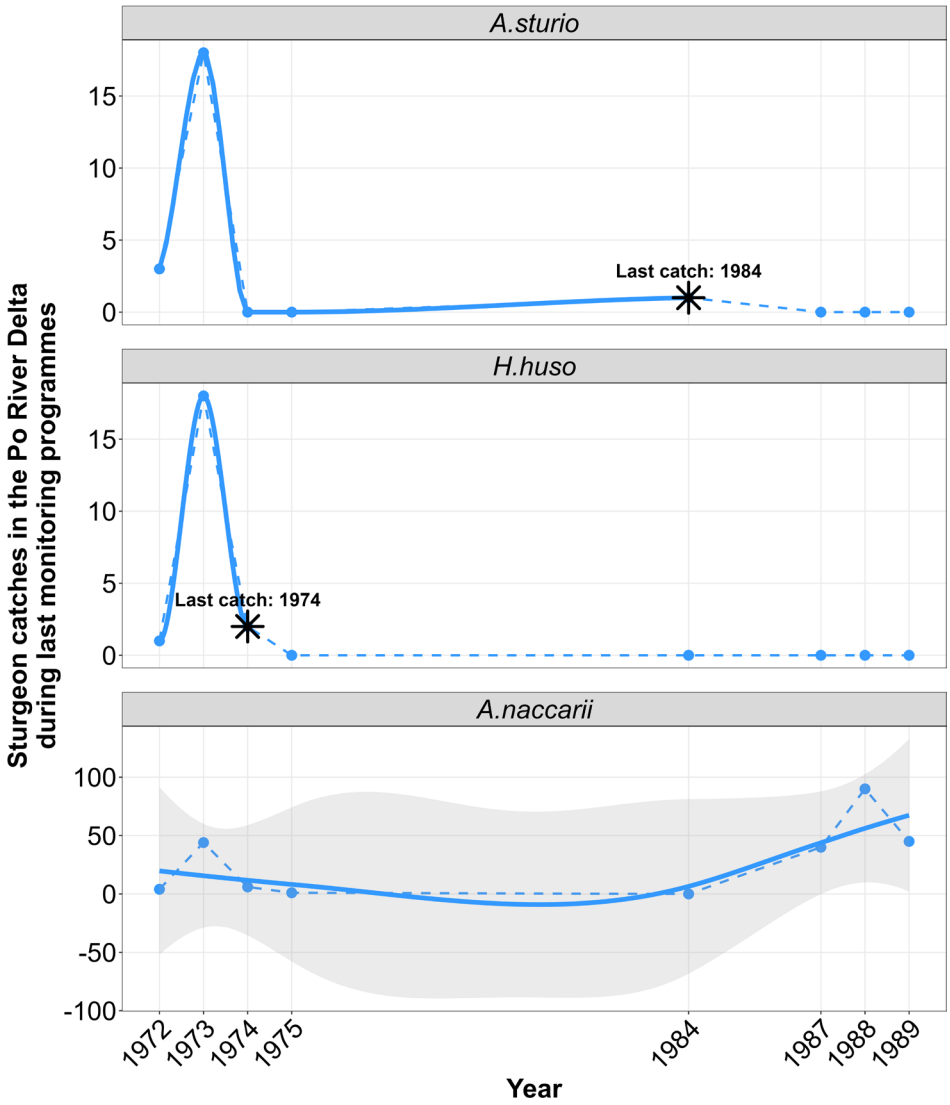

FIGURE 2 | Shows panels plotting the number of sturgeons caught during scientific monitoring campaigns in the Po Delta between 1972 and 1989. The solid lines represent loess curves plotted over sturgeon abundances (the dots), whereas the dashed lines connect the sampling events. Due to limited data points, only for *A. naccarii* (lower panel) was possible to calculate and display 95% confidence interval shade. Black stars truncating the loess curves indicate the latest evidence of species' occurrence. [Color figure can be viewed at wileyonlinelibrary.com]

almost the entire length of the river (D'Ancona 1942). The catch of a single female specimen provided sufficient income to support a family for two to three months or more (Roda and Centro etnografico ferrarese 1991). In contrast, sturgeon fishing in the delta provided local communities with an almost year-round economic foundation (see Figure S2A). According to periodical reports (D'Ancona 1942), fishing operations were conducted until the mid-1960s using traditional wooden rowing boats that methodically crossed between opposite riverbanks in an alternating pattern, deploying hemp fiber trammel nets throughout the water column (Figure S2C). In this manner, sturgeons migrating upstream easily became entangled in the mesh of fishing nets due to their bony scutes (Vecsei and Peterson 2004). Afterwards, directly on the riverbanks, the commercial process was facilitated by intermediaries known as "Sprocani," who managed immediate post-capture transactions and coordinated distribution to fish markets, underlining the sturgeon fishery's socioeconomic significance in the lower course of the Po (historical archives, Figure S2B). Caviar (sturgeon eggs) was either eaten fresh or prepared according to an ancient medieval recipe, which involved baking the caviar in a wooden container ("Libellus de arte coquinaria," cooking Medieval manuscript n.153, ~1450). This preparation method remained valued until World War II in Ferrara, the last city on the Po, before the delta.

From the 1960s onwards, the introduction of motorized boats equipped with nylon nets led to an extreme intensification of fishing efforts (personal communications from veteran fishermen operating in both the Po and the Adriatic; Labria et al. 2025). This was exacerbated along the northwestern Adriatic coast, where trawling was regularly carried out in front of the Po Delta and close to the coast, and there were no restrictions on it. In fact, the last common sturgeon specimens were reported in markets that only received fish from the sea, such as the one in Cesenatico (Ravenna Province; Bronzi et al. 2011).

Furthermore, the distribution of historical fishing records along the Po, confirmed by mapped historical records

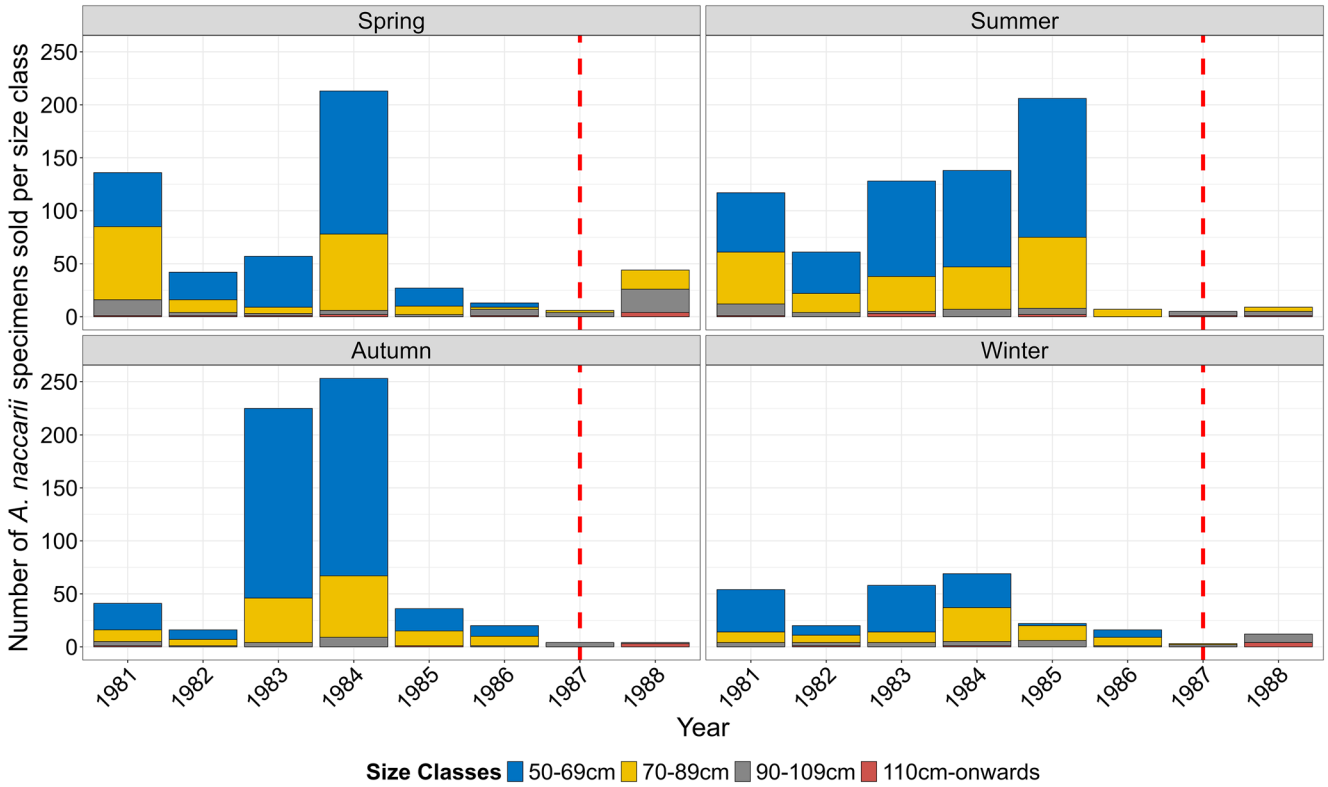

FIGURE 3 | Histograms reporting abundances of Adriatic sturgeon specimens, caught in the Po Delta and sold at the Donada fish market during 1981–1988. The red vertical dashed line marked the year in which the minimum marketable size was raised to 100 cm in length (Discussion for details). [Color figure can be viewed at wileyonlinelibrary.com]

(Figure 1), shows that most catches of common and beluga sturgeon occurred throughout the entire course of the Po, while Adriatic sturgeon catches were in the terminal stretch and deltaic areas (Figure 1). This figure draws attention to two facts. First, in line with the information available for other European ecosystems (Gessner et al. 2024 and references therein), the common sturgeon and the beluga sturgeon in the Po River spend most of their life cycle in the sea, migrating up the Po River only to reproduce, whereas the Adriatic sturgeon in the lower reaches of the Po River and in the delta (Figure 1), remains throughout the entire year, as confirmed by catches' temporal distribution (Figure 3). Secondly, the common and beluga sturgeon were the first to be affected by overfishing because they were targeted throughout their entire life cycle, both in coastal waters by trawl netting and in the Po during their spawning migration. The Adriatic sturgeon, whose main habitat was the lower Po and the delta, was affected by overfishing to a minor extent, as net fishing is more difficult in such a vast environment, and non-trawl netting was used. This has allowed the species to persist for longer and does not rule out the possibility of relict specimens.

To contrast sturgeons' decline, the Italian Minister of the Merchant Navy set the minimum legal catch size for sturgeons to 100 cm in 1987 (Rossi et al. 1991). As a consequence, juveniles disappeared from market records after 1987 (Figure 3) but not necessarily from the illegal ones. The expected increase in size after the enactment of the cited decree was not observed in subsequent scientific monitoring campaigns (Bronzi et al. 2011; this study).

While habitat modification and loss, mostly attributable to damming, as well as pollution are widely recognized as factors in the decline of sturgeon populations around the world (Chen et al. 2023; Gessner et al. 2024 and references therein), there is a lack of strong evidence to suggest they are influential in relation to the Po River. Indeed, there are no dams in the lower and middle reaches of the Po River, and the level of pollution (e.g., chemical and thermal) is low–moderate and poorly explored (Viganò et al. 2015; Gavioli et al. 2024). Only two fish kills were reported in the middle course of the Po. The first occurred upstream of the Isola Serafini dam in the mid-1970s (M. Saroglia, pers. comm.) due to a high organic discharge, while the second occurred in 2010 during a large oil spill event from the Lambro River, a left tributary near Milan. This event affected the entire Po for days. In both cases, no mortality of sturgeon was reported. In the 2010 event, no fish mortality occurred in the lower stretches of the Po, and only gill inflammation and increased mucus production were detected in freshwater bream, used as a model species, sampled in the Po near Ferrara (Giari et al. 2012).

The abrupt decline in sturgeon populations caused not only a biodiversity loss (Congiu et al. 2023) but also generated a negative cascade effect on traditional fishing practices and the cultural identity of the river towns and, to a lesser extent, the economies of the Po and its delta (e.g., small-scale fisheries and typical restaurants). Indeed, sturgeons' traditional fisheries disappeared, and commercial interest was thus redirected mainly to caviar production via aquaculture facilities (Bronzi et al. 2019; Raposo et al. 2023).

Although habitat fragmentation and degradation are recognized as major drivers of sturgeon population declines (Gessner et al. 2024), our interpretation for the Po River indicates that overexploitation alone may account for the observed decline. This finding is encouraging for restocking initiatives, as it implies that potentially suitable habitats remain adequate to support the species. Future recovery initiatives will thus strengthen past restocking efforts, which have been carried out for the Adriatic sturgeon over the last 35 years (Congiu et al. 2023) and, more recently, for the beluga sturgeon with pilot releases (Labria et al. 2025).

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Ethics Statement

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Figure S1:** PRISMA flow diagram adapted from Page et al. 2021 regarding the outcomes of the screened literature. None of the papers aligned with the aim of the present work thus highlighting a lack of quantitative evidences on the historical distribution of sturgeon's species along the Po River and its delta. **Figure S2:** Panel of historical pictures testifying sturgeon relevance in the Po River. Captures in the Po River stretch close to Polesella (a town in province of Rovigo, near Ferrara, northern Italy) taken in the 1950s in which from a morphological inspection, all three species once present (beluga, common and Adriatic sturgeon) were present (left panel, A). Mediation and bargaining by one of the dealers or "Sprocani" (see main text for term explanation) for the purchase and subsequent sale of the recently caught common sturgeon in the terminal stretch of the Po River (top right panel, B). Fishermen ready to start fishing for sturgeons in the terminal stretch of the Po River, northern Italy, in 1940s (bottom right panel, C). **Table S1:** Table reporting details of sturgeon occurrences retrieved from multiple sources described in the manuscript (e.g., gray and peer-reviewed literature, historical pictures, etc.), which allowed to map areas along the Po River where professional fishermen were used to catch sturgeons.