Publication Date: 15 December 2023
Archs Sci. (2023) Volume 73, Pages 21-23, Paper ID 20235.
https://doi.org/10.62227/as/7305

The Guardian of Lake Geneva: From Glacial Epochs to the Era of Global Warming

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Abstract The manuscript presents an in-depth exploration of the Arctic char, a native species in Lake Geneva, tracing its lineage back to the post-glacial era approximately 13,000 years ago. This study delves into the historical documentation of the species, starting from a notable manuscript in 1150, and continuing through various historical records, including acts and laws. The systematic classification of the Arctic char in Lake Geneva has been a topic of considerable scientific discourse, marked by differing species descriptions over time. Current consensus recognizes Salvelinus alpinus as the sole species inhabiting the lake. The research also examines the socio-economic aspects of Arctic char fishing in the region, highlighting its dual role as both an economic resource and a recreational pursuit. Notably, the manuscript addresses the significant surge in fishing yields during the 1990s, followed by a persistent decline in recent years. This study not only provides a historical perspective on the Arctic char but also underscores the dynamic interplay between environmental changes and fishing activities in Lake Geneva.

Index Terms Salvelinus alpinus, Lake Geneva, fishery management, systematic.

Figure 1: The future Lake Geneva region during the last ice age. © Cantonal Museum of Geology, Lausanne. Reproduced with the permission of the Cantonal Geology Museum of Lausanne.

I. Formation of Lake Geneva

The genesis of Lake Geneva's formation has long been a subject of debate, ranging from seismic upheaval, tectonic faulting, glacial influences to fluvial erosion [1]. Contemporary consensus suggests that the Lake Geneva basin took shape at the conclusion of the last Würm glaciation (70,000 to 18,000 years BC) through the erosive forces of glaciers. During the peak of glaciation, the ice cover reached approximately 1000 m above Vevey and 800 m vertically above Nyon [1] (Figure 1). It was only around 13,000 years ago that the glacier-carved basin became filled with water, sometimes at altitudes differing from today, marking the commencement of fish colonization.

II. Arrival of Arctic Char in Lake Geneva and Initial Historical References

The Arctic char, originating from marine environments, entered Lake Geneva as the ice retreated at the conclusion of the last glaciation [2]. Early inhabitants likely engaged in fishing activities to catch this species. Unfortunately, archaeological excavations along the lake's shores were not specifically designed to uncover potential remains of fish-based meals. However, through historical research [3], evidence of Arctic char presence in Lake Geneva has been traced back for an extended period: The initial documentation of Arctic char in Lake Geneva is found in a 1150 text, where the canons of Ste-Marie d'Aoste granted the priory of St- Jean de Genève, for the annual payment in wine, wheat, and substantial fish (trout, char, pike), essential for their refectory. In 1288, char makes another appearance in the accounts of the Châtelain of Chillon, noting that 140 char, 7 char, and 11 large trout, received from the Châtelain of the Island of Geneva, were dispatched to the Count of Savoy at Le Bourget. An act by Amédée, Count of Savoy, dated April 23, 1376, establishing the fish prices at the Villeneuve market, already indicates that trout and char were the most expensive fish in the lake. They were valued at 6 Lausanne deniers per pound during Lent, 3 deniers from Easter to All Saints' Day, and 5 deniers from All Saints' Day to Lent. In comparison, pikes were worth 4, 2, and 3 deniers during the corresponding periods. Notably, in 1396, the Châtelain relinquished his right to fish for char around the castle for 40 sous, as recorded in the Chillon accounts. This right was later revoked from the fishermen of Villeneuve by

Figure 2: Jean Duvillard (Geneva 1539-1610). Description of nineteen kinds of fish, 1581 Pen and ink, watercolor, heightened with white gouache on paper in two sheets: 32.8

a decree from their Excellencies of Berne on July 16, 1541, which prohibited fishing and trading around the castle. Char is also documented on the 1581 map of Syndic of Geneva, Jean du Villard, who describes "19 types of fish found in Rosen and Lake Geneva and their true season for eating" (FIgure 2). The description of char reads: "Good fish- It resides in the lake at depths of up to 15 pounds, favouring rocky areas, and its feeding season occurs in January.

Among the benefits of the bailiwick of Nyon, as listed in 1613, it is stated that all fishermen must present their fish to the castle and sell them at prices fixed in advance. Large trout and Arctic char are the most expensive fish. They are valued at 6 cents per pound from Easter to St. Michael's Day, 7 cents from St. Michael's Day to Mardi Gras, and 8 cents during Lent. In comparison, perchettes are only paid a penny per pound throughout the year. [4] finally mentions that on December 13, 1621, Jacques and Jean Pappan of Morges sold to Pierre Paccard of Geneva all the fish they could catch until next Easter, including "ambles" (char) at 4 sols per pound before Lent and 5 sols during Lent.

Lunel (1874), in his "Natural History of Fish in the Lake Geneva Basin," mentions that "the fishermen and fish merchants of Lake Geneva assure that the yellow-orange color of the char is due to the influence of a tuff quarry which is located in the vicinity of the places where these fish spawn, because, according to them, the Chars taken outside this locality show no trace of this coloring" (Figure 3). However, he refutes this argument by mentioning that these are simply mature char, displaying their spawning livery, which is captured at this time, in this place.

Nevertheless, it is interesting to note that the fishermen had noticed that the char only came during the reproduction period

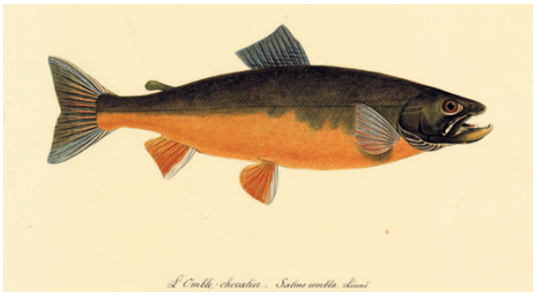

Figure 3: .

to a place rich in rock. Without knowing it, they perfectly described the migration of char in winter on the umbrellas! On the other hand, Lunel (1874) indicates a very surprising period for reproduction: "In the last fortnight of January, the Arctic char, which until then had remained in depths of up to two hundred meters and more, go up more or less and come to settle on the spawning grounds; this begins in February and sometimes extends well before March"(Figure 3). This apparent error in determining the reproduction period will have serious consequences for the char population since the spawners will no longer be protected and fishermen, legally, will catch them en masse between November and January for several years.

III. Evolution of Char Species in Lake Geneva: Historical Perspectives

Arrival of Char in Lake Geneva and First Historical Mentions

Arctic char, originating from marine environments, became entrapped in Lake Geneva at the conclusion of the last glaciation [5]. While archaeological evidence is scarce, historical records trace the presence of char in the lake over an extended period: The earliest mention dates back to 1150 in a manuscript where the canons of Ste-Marie d'Aoste granted the priory of St-Jean de Genève the annual supply of wine, wheat, and large fish, including char (trout, char, pike). By 1288, the Châtelain of Chillon's accounts noted the transfer of char and trout to the Count of Savoy, emphasizing their importance. In 1376, an act by Amédée, Count of Savoy, established the market prices for fish, with trout and char being the most expensive varieties. By 1581, a map by Syndic of Geneva, Jean du Villard, highlighted char as a prized fish, providing insights into its behavior and seasonal availability. In the early 17th century, records from the bailiwick of Nyon outlined the pricing structure for char, emphasizing their economic significance. Despite various historical mentions, the char population faced challenges, including legal restrictions and changes in fishing practices.

Reproduction and Variability of Char in Lake Geneva

Gessner's classification in 1568 proposed three char species in Lake Geneva. However, later accounts [6], consolidated the species into Salvelinus umbla.

The concept of three char varieties based on habitat variability: yellow char spawning in Yvoire, gray char in Meillerie, and white char in Locum. Subsequent research, led by [7], generally referred to a single species—either Salvelinus umbla or Salvelinus alpinus.

These historical perspectives provide insights into the evolution of char species in Lake Geneva, from their arrival after the last glaciation to the complexities of their reproduction and variability in habitat.

IV. Geographical Distribution of Arctic Char in Lake Geneva: Scientific and Economic Significance

Scientific Interest and Natural Range

The Arctic char, a species of certain scientific interest, exhibits remarkable adaptability across its range. Lake Geneva marks the southernmost limit of its natural distribution, with populations further south being artificially introduced. This adaptable freshwater fish, found as far south as the Kerguellen Islands, demonstrates significant plasticity in response to environmental variations.

Char Trade and Economic Implications

Char has long been celebrated for its exquisite flesh, often preferred over trout. Historical records indicate its status as an excellent and sought-after fish, commanding high prices. In the early 20th century, char was priced at a premium compared to other fish in Lake Geneva, and this trend continues today. The economic impact of char fishing is substantial, with professional and amateur fishermen contributing significantly to the local economy. Annual catches between 1995 and 2001 by professional fishermen alone totaled 33 tonnes, generating an income of approximately CHF 825,000 per year. Amateur fishermen, though not selling their catches, potentially contribute an additional CHF 875,000 per year. Thus, char fishing in Lake Geneva holds an economic weight of around CHF 1.7 million per year.

Char and Fishing Management

Fishing in Lake Geneva has a rich history, prompting the establishment of laws and regulations. Early concerns about fish depletion led to proposals, akin to modern fishing regulations, suggesting protective periods during spawning and regulating net mesh sizes. The evolution of fishing statistics reflects the state of fish populations, with notable declines in char catches during certain periods. The collapse between 1910 and 1920 resulted from a misinterpretation of protective measures, emphasizing the importance of effective fish management. Despite successful repopulation efforts in the 1980s, recent years have seen a decline in catches, raising questions about sustainable management practices.

Significance of Arctic Char Studies

From ecological, economic, and social standpoints, studies on Arctic char in Lake Geneva are crucial. As an indigenous species forming part of the natural heritage, char's adaptability provides insights into the effects of global warming on lake fauna. Economically, char fishing is a lucrative activity, contributing substantially to local economies. Socially, it remains a popular hobby among amateur fishermen, fostering competitions around the lake. In the context of sustainable development, multidisciplinary research aims to understand environmental mechanisms influencing char populations, ensuring their long-term preservation. This research program aligns with the objective of evaluating modifications in Lake Geneva to comprehend their impact on char populations.

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