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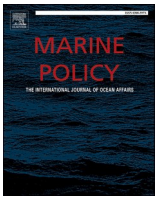

The role of path–dependent institutions during the collapse and rebuilding of a fishery

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ABSTRACT

This article presents a historical analysis of the Norwegian spring spawning herring fishery. Theoretically, the study is rooted in new institutional economics (NIE). The study shows that the fishery collapsed during the 1960s because of overfishing. The underlying key drivers were unregulated open access management, technological progress, and excess capacity building. The analysis further discloses that the initial responses to the resource crisis exacerbated the underlying issues; subsidies introduced to support a fishing fleet that was not adapted to the catch base. Also, fishing for juvenile herring was allowed to protect the income of the fishers. The study argues further that the breakdown of the herring fishery represented a historical event that marked a paradigm shift from open access to closed entry fisheries management. The building of formal institutions supported the turnaround in the management path. In the aftermath of the crisis, the fishery was closed, total allowable catch regulations (TACs) were introduced, and individual vessel quotas followed a few years later. During the 1990s, the stock recovered, and herring reemerged as a key revenue driver for the pelagic fleet. Finally, some economic effects for the pelagic vessels brought about by the changed management path are outlined in the paper.

1. Introduction

North [72] defines institutions as "the rules of the game in a society" or, more formally, "the humanly devised constraints that shape human interaction" (p. 3). He claims that institutions can affect the performance of economies, both at a given time and duration. For example, in some resource-based industries such as fisheries, institutions stimulate growth and wealth for the actors, whereas other institutions induce stagnation and decline. North further states that institutions represent the incentive structure in an economy, and organizations, such as commercial fishing vessels, are the teams that "play the game." They will thus strive to exploit opportunities within their given institutional framework. Path dependence is another fundamental concept in institutional theories. It refers to complex processes "unable to shake free of their history" ([31], p. 19). The key idea is that the past sequence of events affects later events. Path dependence has the potential to explain the persistence of existing dysfunctional institutions and the creation of new, more functional ones [34].

The overall objective of modern fisheries management is to sustain healthy marine ecosystems and the fisheries they support [46]. Path dependency is one way to examine historical fisheries management strategies. In the concept of path dependency, early events and decisions establish institutional paths that have lasting effects on subsequent events and decisions [7]. This suggests that fisheries management is historically conditioned. Hence, the future direction is dependent on the paths laid down in the past. Path dependency often relates to technology [67]. However, path dependency is also about the development of institutions. It can relate to any form of behavior that has its origin in the past and has become so entrenched that it becomes locked-in [90].

The present study is a historical analysis of institutional change and path dependence in a commercial fishery. The research question is as follows: What was the role of path-dependent institutions in the collapse and rebuilding of the Norwegian spring-spawning (NSS) herring fishery? It is difficult to predict which path will emerge in the future. Only ex-post analyses will allow the tracing of paths [34]. Thus, a chronology of critical events shows the fishery's environment changes, especially related to the design of formal institutions that could again turn a collapsed fishery on a sustainable path [10,69]. Gullestad et al. [45] claim that the influence of the herring stock's historic collapse in the 1960s due to overfishing is of particular significance to understand a fishery's subsequent change of management path. It is surprising that such an extensive ecological disaster as the NSS herring collapse has not been the subject of greater scientific attention from neither historians nor economists [25,26].

Furthermore, there has been little work on longer-term economic outcomes after introducing new fisheries management strategies [35]. Investments in vessels and quotas occur over time [17]. A long-term study would assess how institutions (e.g., formal regulations) affect these investments economically. As data become gradually available, the economic effects of new management strategies can now be

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evaluated. The long-term institutional analysis of a fishery that changed management path from open access to closed entry is the topic of the present study.

Several studies have addressed various aspects of the NSS herring fisheries and their development. This applies for example to Bjørndal [20], who investigated the management of the straddling NSS herring fishery, Bjørndal et al. [21], who presented a bio-economic simulation model of the NSS herring fishery, and Bjørndal and Ekerhovd [22], who discussed the management of pelagic fisheries in the Northeast Atlantic including NSS herring. Gordon and Hannesson [43] explored the role of technological progress when the NSS herring stock collapsed, while Bertheussen et al. [18] examined the institutional and financial entry barriers using the NSS herring fishery as empirical context. Finally, Bertheussen and Vassdal [15] applied the new institutional economic (NIE) perspective to explore how formal institutions can shape the economic attractiveness of a resource-based industry exemplified by the NSS herring industry.

However, none of the above studies have taken a long-term NIE perspective to explore the relationship between the collapse of the NSS herring fishery in the 1960s and the subsequent successful rebuilding, supported by comprehensive formal institution development. The studies mentioned above examined parts of the problem complex addressed in the present study.

This study contributes to the literature in several ways. The study's main finding is that there is a relationship between the quality of the institutions regulating the fishery and the industry's economic development. The paradigm shift in the management of NSS herring around 1970 from open access to closed entry was triggered by the great herring collapse. The crisis highlighted that open-access management was unable to maintain a sustainable herring fishery at that historical point in time. The new closed entry institution was thus founded on the ruins of one that had failed. Politically, it became legitimate to implement radical measures to rebuild the fishery, and closed entry was eventually initiated through government interventions. The empirical findings of this study further show that the new management path that was established has been a success for the last 30 years, at least in biological and economic terms. It seems reasonable to assess closed entry as a high-quality management institution of the Norwegian herring fishery.

This study further shows that the quality of an institution can change as a result of technological progress (also, see Gordon and Hannesson [43]). Open access management contributed to biological, economic, and social sustainability along the Norwegian coastline until the herring collapse. But in the face of radically more efficient fishing technology and a sharp increase in fishing capacity, an institution based on free entry and unregulated fishing failed. The centuries-old high-quality fisheries management institution degraded to a low-quality institution during a single decade in the 1960s

Probably, the main reason for the successful rebuilding of the NSS herring fishery from the 1990s was the improved institutional framework introduced in the wake of the great herring collapse. Initially, basic institutions such as the closing of the fishery and TAC regulations were implemented to protect the herring stock against extinction. A few years later, private harvesting rights (individual vessel quotas) were introduced to protect the fishers' finances against a destructive race to fish. None of the above institutions were present when the fishery was managed with open access.

This study further argues that the relationship between the economic performance of the herring fishery in the last three decades and the introduction of high-quality institutions in the two decades before was hardly accidental. It is reasonable to assume that these events also were causally related as there was both an intended and realized connection between them. In this historical institutional analysis, open access (up to 1970) is compared with the subsequent period of closed entry. There were no fishery regulations in the first period, whereas in the second period, the fishery was strictly regulated. Accordingly, the first period acts as an implicit counterfactual to the second. Nevertheless, in real-world social studies, one must be cautious with claims of causality.

This study also indicates that building a high-quality institution on the foundation of a collapsed one was not straightforward. Before establishing high-quality institutions, subsidies and fishing of juvenile herring were allowed to remedy the fisher's weakened economy following the intensified resource crisis. However, the low-quality institutions exacerbated the original problem of overfishing and a declining herring stock and therefore acted counterproductively (e.g., see Flaaten [40]).

Finally, the low-quality subsidy institution was not terminated with the change from open access to closed entry despite significant overcapacity in the fleet. The subsidies thus served as an institutional "layer" that continued under different institutional management paths. A suboptimal institution thus emerged as persistent [92]. Finally, it was wound up because of pressure from Norway's external trading partners in the 1990s [40].

The paper proceeds as follows. The next section describes the historical and dramatic collapse of the NSS herring stock in the 1960s. The crisis that arose strongly contributed to a paradigm shift from open access to closed entry in the herring fishery management. Thereafter, the path-dependent institutional rebuilding process to make the herring stock again sustainable is explored. Finally, the article investigates the relationship between path-dependent fisheries management and long-term industry performance.

2. The dramatic collapse of the herring stock

The collapse of the herring stock in the 1960s is in the present study characterized as a historical event in line with [7] when stating that "… to be those events or conditions that are outside the ex-ante knowledge of the observer–beyond the resolving power of his 'model' or abstraction of the situation." For Arthur then, a historical event has to do with an actor's inability to predict it. At the time of the herring collapse, the stock was managed open access.

This study interprets the collapse of the herring stock as the prelude to the paradigm shift in the management of Norwegian fisheries. NSS herring was at the time one of the world's largest fish stocks. It was allowed to collapse in front of the eyes of marine scientists, and fishery managers without them showing any signs of concern. Fig. 1 shows the catch volumes in 1,000 tons of NSS herring landed in Norway in the period 1946–2019 by domestic and foreign vessels.

Fig. 1 presents that after World War II (1946), catches of NSS herring increased significantly. The fishery peaked in 1956 when more than 1.1 million tons were caught. However, catches dropped sharply in the late 1950s and hit the bottom by 1963 at a modest 61,000 tons (first collapse in Fig. 1). A new peak followed in 1966 of approximately 460,000 tons. But this peak was temporary as it was followed by a steep decline that culminated in 1968 (second collapse in Fig. 1). The recovery phase followed thereafter and lasted until 1993 when there practically was no NSS herring landed at all (the recovery phase in Fig. 1). From 1993 the stock was rapidly rebuilt.

At the time, alternative explanations were presented of the NSS herring collapse [26]. First, an understanding was emerging over the hardships in managing commons. Second, one theory was that the herring had changed its migration pattern so that fishers could no longer find it. Another explanation was that the size of the stock was significantly reduced because of temporal fluctuations. Technological innovations and capacity building was highlighted as a fourth cause of the collapse and overfishing a fifth. In the following paragraphs, all these explanations are discussed in more detail.

2.1. Struggle to govern the commons

A common consists of valuable scarce natural resources with benefits that are readily accessible to all and thus prone to misuse [42,50,77]. A wild fish resource is an example of a common, with overfishing a

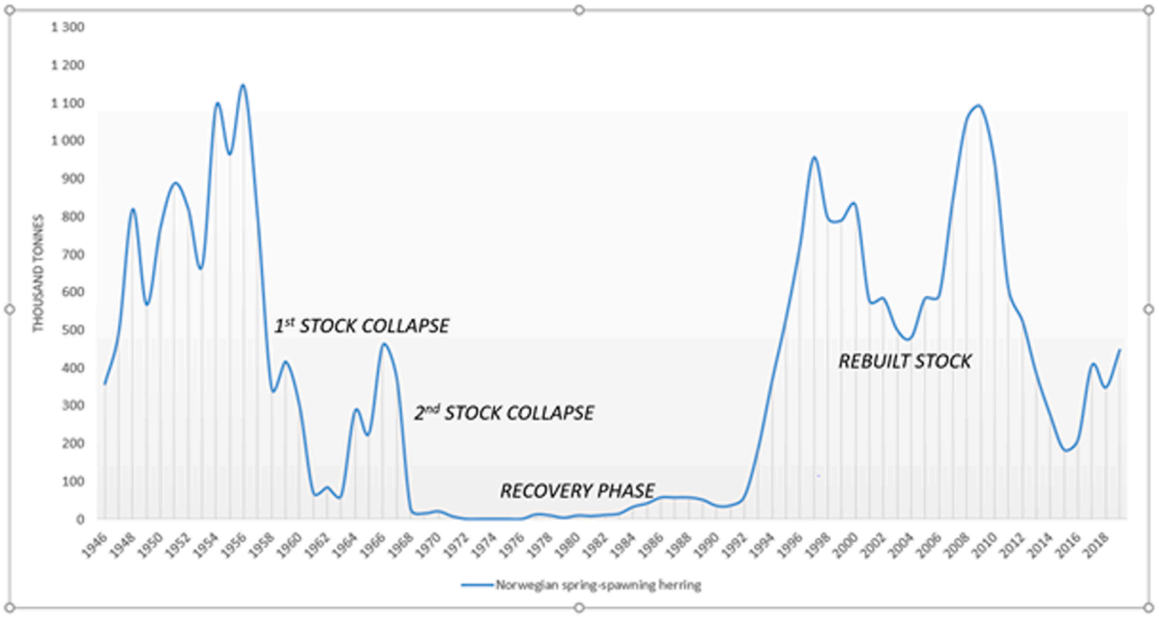

Fig. 1. Catch volumes in thousand tons of NSS herring landed in Norway by domestic and foreign vessels in the period 1946–2019. Sources: Statistics Norway and The Norwegian Directorate of Fisheries.

conventional commons problem. From an economic perspective, a user of a common is assumed to act rationally, be norm-free and be opportunistically seeking to maximize her short-term self-interests [2]. In the absence of regulations that limit access and define rights and duties, a user will typically neglect the long-term interests of the collective of the common [23]. The aggregate result of individual rational behavior is, however, overexploitation of the natural resource although this is collectively irrational. Open access fisheries frequently lead to depletion of the stocks and dissipation of the potential resource rent. Open access, therefore, represents an ineffective adaptation and waste of socioeconomic values.

Economists have identified several processes that provoke the chances of tragic outcomes in a common. Free riding is one such process. When free riding takes place, some actors enjoy benefits created from collective efforts without contributing much themselves [75]. Other processes that can block joint action to avoid collective problems are players shunning away because they rather wait for others to respond. Having conflicting interests or lacking capabilities can also generate passive actors [2]. In fisheries, the restraining forces at worst lead to the depletion of stocks. To prevent such disasters requires commons to be governed.

Property rights to nature capital can be open access, private, communitarian, or state [81]. Property rights to goods are about "the right to use, the right to derive income from the use of, the right to exclude, and the right to exchange" ([72], p. 18). Ownership and property rights are different substances. An owner has legal control over her property and can lend it or rent it to others for a limited period. Ownership, thus, does not change, but the right to use the property does. Property rights to an ecosystem are the rights, privileges, and restrictions about its use [94].

Hardin [50] claimed that common resources must either be managed by a central authority or be privatized to avoid extinction. A government can, for example, privatize and introduce full property rights as they have the legitimacy, authority, and resources to do so. Ostrom [77], however, opposed Hardin's and argued that alternatively, individuals themselves can come together and collectively establish institutions or rules that regulate the use of common-pool resources. She [77,79] and her colleagues (e.g., [32,80]) investigated Hardin's claim theoretically, empirically, and by studying behavior experimentally. She found that both of Hardin's solutions are problematic because successful management of commons can also take place through locally initiated rules and their enforcement. She believed that proximity to the resource, and thus to both profits and losses, is an important prerequisite to ensure sustainable commons. She also found through experiments that several people are willing to incur private costs to punish those who break common norms [78].

In a review of Ostrom and Hardin on the commons, Araral [3] suggested that Ostroms' critique of Hardin is valid in the special case of small-scale, locally governed commons. Hardin seemed, on the other hand, still according to Araral, justified for large-scale, regional, national, and global commons.

2.2. *Altered migration pattern and temporal fluctuations*

There have always been great temporal fluctuations in landings of herring [64,84]. Under the leadership of the Norwegian marine scientist Johan Hjort, the work of International Council for the Exploration of the Sea (ICES) Committee A (1902–1908) ("the migration committee") led to a paradigm shift from "migration thinking" to "population thinking" of the interpretation of fluctuations in herring landings [86]. Until around 1900, marine scientists believed that all herring belonged to the same stock. The researchers then explained the herring fisheries in different places and at different seasons by herring migration [63]. However, the ICES concluded that the change in fisheries was due to fluctuations in the stock size of separate spawning populations of the same fish species. This knowledge contributed to a paradigm shift in marine research in the twentieth century, from migration thinking to population thinking. Sinclair [86] claimed that … "Under migration thinking, stock abundance was considered to be relatively constant, with major fluctuations caused by variations in migration patterns. Under population thinking, year-class variability generates fluctuations within geographically limited populations" (p. 1654).

Of the North Atlantic herring species *Clupea harengus*, there are more than 10 larger spawning populations and several smaller local stocks [57]. These populations have different but also overlapping distributions. The herring populations extend from the east coast of Canada to the Baltic Sea in the west and from the Barents Sea in the north to the English Channel in the south. It is visually difficult to distinguish herring from the different populations, but they have adapted to local conditions, and they spawn in different places. They must therefore be

managed as separate units [57].

At the outset, NSS herring was named the "Atlanto-Scandinavian" herring. However, this was before research had clarified that the term Atlanto-Scandinavian herring refers to several separate North Atlantic herring populations, i.e., NSS herring, Icelandic spring-spawning herring, and Icelandic summer-spawning herring [33]. NSS herring is in a special position among the various spawning populations of the North Atlantic herring species as it is very large and has a longer lifespan. Moreover, the population covers larger geographical areas, and it performs longer migrations than other herring populations. NSS herring may be one of the world's largest fish stocks [33]. However, written sources dating back to the saga period show that herring did not reach the Norwegian coast for long periods of time [27]. A "herring period" could last for 50–80 years. Thereafter, herring could stay away from the traditional spawning grounds for 20–50 years [1]. In the 1950s and 1960s, many believed that the current herring period in Norwegian waters was coming to an end [73].

2.3. Technological innovations and capacity building

The technological development in the herring fishery began to accelerate at the beginning of the 20th century [61]. Most significant was the transition from oars and seals to powered engines in the fleet. At about the same time, the conversion from land nets to purse seines in the herring fisheries began. This paved the way for more continuous fishing, which could also take place further out at sea. These technological leaps led, in the long run, to more and more catch. Cushing [30] called this period "the first industrialization of fishing".

The number of vessels that participated in the fishery more than doubled from 1946 to 1957 [39]. However, Norway's leading herring researcher at this time, Finn Devold, claimed that the fishers did not have sufficient catch capacity to influence the enormous size of the NSS herring stock [73].

Furthermore, in the mid-1950s, ground-breaking technological innovations appeared on the assembly line in the form of the echo meter and sonar. The new exploration equipment made it possible to search large sea areas for fishable occurrences of herring. About the same time, the radar and Decca Navigator came into general use. These systems made it easier, more accurate, and safer for the boats to navigate to and from the fishing grounds. Similarly, the Decca Navigator was useful when setting and finding fishing gear in shutters and cloudy weather. Cushing [30] labeled this period "the second industrialization of fishing."

In purse seine fishing with large and heavy vessels, the introduction of side propellers became a significant innovation. With side propellers, a boat could easily position itself quickly before the net was cast. Additionally, these extra propellers prevented the vessel from drifting into the net while securing the catch [61]. Another advancement was fish pumps, which were used to take the catch up from the net. These were very efficient and contributed to less strain on the net and greater opportunities to save the cast. At the end of the 1960s, cooling tanks were installed on board to take better care of the quality of the herring.

However, one of the most important technological advances was the development of the purse seine net itself, wherein its cotton material was replaced by much stronger nylon material. This made it possible to fish with significantly larger nets than before. The power block was another and related major technological innovation used to set and haul in the seine [43]. The power block meant above all a more efficient fishing. On larger boats, the crew was reduced by seven to eight men after the installation of a power block. Thus, crew wages, which were determined by the share of revenues, became larger on the remaining crew on board. At the same time, hard manual work was greatly reduced. With its better wages and less tiring work, the job had attracted more fishers [43].

2.4. Overfishing

Overfishing has been identified to occur when a species of fish is removed from a body of water at a higher rate than the species itself can replenish [37]. In the first two decades after World War II, there was a widespread perception among marine scientists concerning the notion that fishing had little impact on recruitment. Devold argued that large variations in the catch of herring were caused by natural population fluctuations and not by overfishing [73].

However, the postwar declines in herring fisheries led to increased attention to the "possible importance of man-made factors as major determinates" of the recruitment of the stocks ([86], p. 1656). Hempel [51] concluded that the influence of man on the recruitment of herring had so far been relatively small. Hence, "… environmental factors seem to be dominant in determining the strength of recruitment" (p. 21). The consensus among marine scientists, at the time, was that fishing played a secondary role when it came to the condition of a fish stock [86]. Nonetheless, concerns over the degradation of coastal fisheries were present already in preindustrial times, whereas ocean fish resources were held to be practically inexhaustible until modern times [41].

However, the "Grand Synthesis" presented by Cushing [29] represented a turning point. Cushing distinguished between growth overfishing and recruitment overfishing. Growth overfishing occurs when fish are caught at a smaller average size than what would produce maximum yield per recruit, whereas recruitment overfishing occurs when the mature part of a fish population is reduced to such a degree that the population can no longer reproduce itself. Cushing claimed that herring suffered from recruitment overfishing, that is, death by fishing was great enough to reduce future recruitment.

Saville [83], on the other hand, stated that the early to mid-1970s were faced both with the collapse of the fisheries for NSS herring, two herring stocks in the Icelandic area, and North Sea herring. He further noted that the scientific community through ICES had not provided clear advice to management. Saville concluded that essentially all herring stocks had collapsed because of recruitment failure generated by declining spawning stock biomass and improved catchability due to increased catch capacity of the fishing fleets. He further claimed that management advice must include a constraint for keeping the spawning biomass at some minimum level to safeguard recruitment. In his final point, Saville thus advocated that a "Precautionary Approach" to the management of fisheries was required.

3. Path-dependent institutional rebuilding

As more and more people adopt an institution, the return on its use will increase [72]. Once a path has taken root, various processes can lead to self-reinforcement. This can, for example, come from network externalities or increasing returns due to scale, scope, or learning [95]. When a path is stabilized by self-reinforcing processes, this phenomenon is commonly known as "lock-in." Lock-in is manifested in situations where actors cannot move to a new state despite those involved would rather do so. The path's inability to reverse stems from actors having already invested in the dominant path. As a result, they will incur "sunk costs" if they switch to another path. The more the path becomes entrenched, the less likely it will be replaced [34].

Institutions have several important attributes. They can be formal, such as laws and regulations, or informal such as norms or codes of behavior. Institutions may evolve continually over time or be radical and created as responses to shocks. North [72] argues that path dependence is the analytical key to understand long-term institutional and economic change. The theoretical lens he represents includes scarcity, competition, and incentives from neoclassical economic theory as driving forces. Firm behavior is connected to macrolevel incentives provided by the institutional framework. Path dependence results from increasing returns mechanisms that reinforce the direction of a given path [72]. A path can though be altered from decline to stagnation and

growth (or vice versa) from intended institutional changes (e.g., from open access to closed entry fisheries management), unanticipated consequences of policy choices (e.g., from industry subsidies), external shocks (e.g., a sudden drop in fish stock abundance), and sometimes from forces exogeneous to the theoretical framework.

This study argues that the collapse of the herring stock formed the prelude to a paradigm shift [65] in the management of Norwegian fisheries. A paradigm is in the present context defined as the set of assumptions held common and taken for granted in the community of fishers, fishery organizations, fishery managers, and fishery politicians [87]. The collapse represented an exogenous shock that disturbed open access management, and the "unlocking" of this management path occurred as the ultimate outcome. In this particular case, policymakers intervened to "steer" the process out of lock-in [62].

Until the collapse, the primary management objective had been to assist the industry in its efforts to increase catches and revenues [26]. After the collapse, sustainable ecological management of the herring stock emerged as the top priority [71]. The overfishing that led to the collapse of the NSS herring stock thus initiated the process of creating a new management path with closed entry to fishing ([45]; also see Table 1).

The paradigm shift took swiftly place through the fact that the authorities established several formal institutions to protect the fish stock from being exterminated. Overall, the paradigm shift was carried out in three consecutive but partly overlapping time periods. First, and immediately after the herring collapse in the 1960s, the failing open access management path was terminated as formal institutions were established to create a new closed entry management path (1970–1995). Thereafter, this path was stabilized and reinforced through the introduction of individual transferable vessel quotas (1996–until today). Consequently, the establishment of new formal institutions was fundamental to the paradigm shift that occurred.

Table 1 provides an outline of the main formal institutional responses before, under, and after the herring crisis. The overarching political goal was to rebuild the stock and the resulting revenues and social impact of the fishery [71].

4. Path collapse: open access

Open access was not a deliberately designed management path but emerged as a result of centuries of coastal fishing practices [45]. The more individuals over generations took part in open access fishery, the more societally accepted and the more deeply engrained and locked-in this path has become [7]. Accordingly, the prospect that fishers would divert from it declined. Once a critical mass of fishers had adopted it, ever more people oriented their decisions on the basis of open access as very many others had already done so [34]. Thus, this management path was stabilized.

Open access fitted well with small-scale, labor-intensive, coastal fishing [39]. Conservatism is a prominent feature of path dependency, as it is often not worth the costs of changing everything to gain a small improvement of one particular element [7]. Hence, when a fishery is managed open access for countless generations, it takes a lot to get off this path. For hundreds of years, this management path contributed to a social, economic, and ecological sustainable fishery.

The fishery collapsed because of efficiency improvements and uncontrolled capacity building that created a greater fishing pressure from competitive profit-seeking actors than the unregulated stock could withstand. Therefore, it caused a misfit between the large-scale efficient technology that eventually became dominant and the fisheries management, which was accessed openly without catch limitations. Furthermore, free riding and the lack of a coordinated resource extraction among the fishers contributed to the problem [75,77].

Table 1
Path collapse, creation, and reinforcement in the wake of the Norwegian herring crisis.

PATH COLLAPSE: OPEN ACCESS (during the 1960s)	
Institutional foundation	Small-scale, labor-intensive, coastal fishing. No industry-specific institutions were intentionally designed to protect the stocks of fish [88]. The fish harvest industry was only subject to the general national free competition-based institutional framework [13].
Self-reinforcing lock-in mechanisms	The drama of the commons (see Section 2). Fishing of juvenile herring (see Sections 4.1 and 4.2) Subsidization of the fisheries (see Sections 4.1 and 4.2).
Business climate	No legal barriers to entry. No quota investments needed. Free competition and a "race" to fish.
Industry performance	The belief of a sustainable stock independent of fishing pressure was taken for granted. However, a misfit between catch capacity and the stock yield evolved and eventually led to a collapse. For this reason, the industry performed very badly (see Fig. 1).
PATH CREATION: CLOSED ENTRY (ca. 1970–1995)	
Institutional foundation	Immediately after the collapse, several formal regulations were introduced to rebuild the stock and avoid future overfishing. 1970 Halt in the registration of purse seiners [39]. 1971 Licensing schemes to control vessel entry and fleet capacity [4]. 1971 TAC regulations for herring [91]. 1972 A total ban on catching herring [39]. 1978 Nontransferable individual vessel quotas (IVQs) were introduced in 1978 for purse seiners fishing capelin and extended in the late 1980s to include mackerel and herring [4,8]. 1980s Condemnation programs to reduce overcapacity through scrapping vessels [4].
Institutional layering	Subsidies, which were introduced in the early 1960s and peaked in 1980, were mainly terminated in the early 1990s [40]. This practice was thus not terminated at the same time as open access, as it was extended more than 20 years into the closed entry period.
Self-reinforcing lock-in mechanisms	Strict TAC regulations to rebuild the stock and limit resource extraction. Measures introduced to reduce the catch capacity to better adapt it to the resource base.
Business climate	Sector-specific legal barriers to entry. No quota investments needed. Free competition and a race to fish within a closed fishery.
Industry performance	The volume of herring fishing is negligible but begins to pick up at the end of the period (see Fig. 1). Many vessel firms exited the fishery; 370 seagoing purse seiners were registered in 1970, whereas the corresponding number in 1992 was 102 [18].
PATH REINFORCEMENT: TRANSFERABLE HARVESTING RIGHTS (1996–until today)	
Institutional foundation	Private transferable harvesting rights were gradually introduced in the closed entry fishery [53]. In 1996 IVQ's were modified to a catch share system with restricted transfer options, the so-called unit quotas or UQs [52].
Self-reinforcing lock-in mechanisms	In 2005 UQs were modified to a catch share system with even more liberal transfer options, the so-called structure quotas [9,48,89]. By making individual catch shares transferable, divisible, and permanent (i.e., ITQs), it was in the quota holder's self-interest to preserve the fish stocks since larger stocks imply higher profitability and greater quota valuation for the fishers [44].
Business climate	Sector-specific legal barriers to entry. Free quotas for fishers who were active when fishing rights were introduced. For latecomers, significant quota investments were needed to enter [18]. There is no longer a race to fish among the relatively few remaining fishers.
Industry performance	Sustainable harvesting of a rebuilt stock (see Fig. 1) has led to above normal industry profitability [14,96]. Quota shares have in financial terms become very valuable for the holders [18,49]. The values created in the fishery are distributed among ever fewer and larger players [16].

4.1. Failed crisis management

In the 1950s and early 1960s, when the power block technology was not yet introduced, a large crew was needed to pull a heavy seine full of herring out of the sea by hand [43]. Fishing at this time was thus very labor-intensive. In the first phase of the crisis, it was a matter of vital importance to secure living wages to the fishers despite the sharp decline in herring catches from 1957 to 1961 (see Fig. 1). Politically, this was handled in two ways. First, it became legal to fish for juvenile herring in nine of the 12 months of the year from 1963 [38]. This management strategy, however, resulted in growth overfishing [29]. Second, in step with increasing economic deficits, the fishers' trade union Norwegian Fishermen's Association (NFA) negotiated with the state in 1963 for financial support in the form of price subsidies for the products sold [54]. The intention was to support the industry through hard times, which, at first, were regarded as temporary [40]. However, the subsidies soon became an integral part of the management system through annual agreements between the state and NFA, the so-called Main Agreement [56]. Pursuant to the Main Agreement, the state undertook to maintain the industry's profitability through subsidies [24]. The subsidies peaked in 1980 when they amounted to 40% of the gross value of all catches. In the 1980s, subsidies were gradually reduced, and they have been negligible since the mid-1990s [40].

The subsidy policy had several negative effects [24]. First, they upheld and even increased the fleets' overcapacity, which put the stock under permanent pressure of overfishing [60]. Another negative effect was determined to be a result of the negotiations. For socioeconomic reasons, the government wanted to minimize subsidies. They, therefore, had a strong incentive to be optimistic about next year's catch quotas. This attitude, however, provided a poor starting point for rebuilding the stock ecologically [47].

However, the Norwegian fishing industry exports approximately 90% of all fish produced. The dependence on exports means that the industry must adapt to the regulations for international trade. Accordingly, the General Agreement on Tariffs and Trade and The European Economic Area agreement (concluded in 1994) put a halt to the subsidy practice [40,54].

4.2. A crushing verdict on the initial policy responses

With today's knowledge of precautionary ecosystem-based fisheries management [36], it is tempting to pass a crushing verdict on the initial policy responses to the herring crisis, which was to start an intensive fishing for juvenile herring and to subsidize a fleet characterized by massive overcapacity. The issue, however, is that the fisheries' managers at the time lacked knowledge of the precautionary principle, which prescribes that lack of full scientific knowledge should not be used as a reason for postponing measures to prevent environmental degradation [66].

First, the herring fishery was of great economic and social importance to the local communities affected. Against this background, politicians prioritized social and economic impacts and not its ecological sustainability. Second, marine scientists of the time lacked knowledge of the causes of the large temporary and spatial fluctuations in the herring fishery that had always existed. They, therefore, believed that the main reason the herring fishing failed in the 1960s was a changed migration pattern of the herring. They thought that the herring was there, but that they just could not find it [73]. Third, marine scientists at the time lacked knowledge that overfishing could affect the stock's reproductive ability. Against this historical backdrop, the initial responses may not have been as irrational as they may look in retrospect. It takes time to adapt policies, attitudes, and behavior to new realities [69].

Nevertheless, the measures taken acted as self-reinforcing mechanisms that intensified the ecological and thereby the economic and social crisis. One self-reinforcing mechanism was to give the go-ahead signal for fishers to fish for juvenile herring to maintain their catch volumes although the stock was already heavily overfished. The subsidies also acted as a self-reinforcing lock-in mechanism as they locked the industry into overcapacity relative to the resource base. Hence, the instant policy measures taken exacerbated the basic problem of overfishing.

Historical institutionalists see institutions emerging from more or less conscious choices by collective actors at critical junctures [34]. Before 1970, the fishery was open access, and there were no capacity-reducing measures in the Norwegian purse seine fleet [88]. However, the collapse of the herring stock ended the established open access management path and gave way to a new path in its place.

5. Path creation: closed entry

The new closed entry path emerged at a critical juncture at which political actors established new rules during a window of opportunity for action. The selection of the pathway was opened through an ecological and societal crisis. Various stakeholders realized that it was not sufficient to secure the fishers' incomes through juvenile fishing or subsidies without ensuring a viable herring stock. After the collapse, policymakers intervened and implemented both input and output control measures to limit fishing [59]. Accordingly, a closed entry management path was in the making.

A crisis-triggered regulation scheme (see Table 1) exploited the potential to create a new management path relative to the failed open access. The resource crisis led to a halt in the registration of purse seiners and the introduction of licensing requirements in 1970. A hitherto unthinkable total ban on catching herring was introduced in 1972 [39]. The herring fishery was, thus, de facto closed. In the years that followed, condemnation arrangements and buy-back schemes were put into operation. The aim was to reduce overcapacity in the fleet.

When a stock is overfished, the priority should be to protect the fish from the fishers not only by limiting the fisher's effort but also by limiting their output [55]. Output controls seek to regulate the catch volume of a fishery by setting a total allowable catch (TAC) limit, which is an example of a harvest control rule. Thus, a TAC regulation was initiated in 1971. One advantage of output control is that when the TAC of a species is reached, fishing is then stopped. A weakness of output controls is its inability to cope with discards and misreported catches. This undermines the prospects to control fish mortality and further complicates the assessment of the stock size. Because of discards and misreporting, the basis of setting TACs can be biased. The setting of appropriate TAC levels can also be hampered by catchability changes because of technological progress [82].

Harvest control rules have become important tools in contemporary fisheries management [66]. Such rules intend that they should be able to deal with future uncertainty, support an ecosystem approach of management, and shelter management decisions from stakeholder pressure for short-term rent capture. Management strategies and harvest control rules based on the precautionary approach along with an extensive enforcement regime have contributed to the rebuilding of the depleted NSS herring stock (see Fig. 1).

Because initial decisions can have longstanding repercussions, managers need to recognize that what they choose to do at the start of an initiative or enterprise may lock them into a long-term path, which can be later difficult to change [67]. Therefore, the closed entry management path inherited several key characteristics of the open access path that collapsed. In the first years of the closed entry phase (1970–1978), no quota shares were introduced and there was thus in principle still free competition and a race to fish, although the catch volumes that were competed for were insignificant (see Fig. 1). Furthermore, the subsidy policy was not terminated in connection with the paradigm shift from open access to closed entry in 1970 despite significant overcapacity in the fleet. The subsidies thus served as an institutional "layer" [92] that continued also in the new closed entry management path. A suboptimal institution may thus emerge as persistent at least seen ex post and for

society in general [6]. This does, however, not imply that the institution was intended to operate in the way it emerged [34]. Eventually, Norway was forced, despite strong opposition from the industry, to phase out the subsidies in the early 1990s for the sake of international trade agreements [40].

At the beginning of the closed entry path, the formal rules had changed, e.g., closing of the fisheries and the introduction of TAC regulations, but the informal constraints did not, i.e., a race to fish the available TAC [19]. Accordingly, an ongoing tension rose between the informal constraints and the new formal rules. This tension became eventually resolved by the introduction of individual vessel quotas (IVQs), which were not transferable [53]. When the government implemented catch shares, a fisher had nothing to gain by spending excessive effort to obtain the allocated catch. Catch shares eliminated the competition between the fishers, and thus, the "race" to fish was terminated [19].

Based on their historical catch volumes, vessels that still participated in the fishery were allocated quota shares gratis by the authorities [71]. Thus, they achieved a competitive advantage as this unique historic event probably will never happen again [11]. For social reasons, a smaller vessel received a disproportionate quota share relative to a larger. To prevent too strong a quota concentration in a few fishers' hands and also to dampen regional concentration, several restrictions were introduced on quota trading (e.g., [18]).

The privatization of harvesting rights was gradually implemented in the fishery [53]. Nontransferable IVQs were introduced in 1978 for purse seiners fishing capelin and extended in the late 1980s to include mackerel and herring [4].

6. Path reinforcement: transferable harvesting rights

The IVQ system was modified in 1996 under the so-called unit quota (UQ) scheme [4] to reduce the number of vessels as the catch capacity still exceeded the available quota basis [52]. Furthermore, UQs were made transferable, allowing the vessel owner to concentrate up to two quotas per vessel provided that the old vessel was scrapped [4]. In 2000, the system was extended even further, allowing the merging of up to three quotas per vessel. In 2005, the UQ system was converted to a system named structure quotas as an additional measure to reduce catch capacity and increase efficiency. This was a more flexible and market-oriented system than the UQ system [48].

By making individual catch shares transferable, divisible, and permanent (i.e., ITQs), Grafton [44] argued that it is in the quota holder's self-interest to preserve the fish stocks since larger stocks imply higher profitability for the fishers. Through the privatization of the harvesting rights, it was now in the fisher's self-interest to comply with the overall quota regulations as the quota owners would also experience that the market value of their quota holdings depended on the biological yield of the stocks [5].

However, both input and output controls struggle in solving the problem with overcapacity resulting from the fact that fishers adopt new and more efficient technology over time [12]. Thus, another important goal with transferable catch shares was to make the fishers themselves responsible for removing overcapacity in the fishery. This was achieved by making the catch shares gradually more transferable, which is, in the literature, referred to as privatization of the commons [74].

As the economic value of the transferable vessel quotas has increased considerably over time [18,49,71], this feedback allowed for the societal acceptance and legitimacy of the established private harvesting institution. Thus, the closed entry path was stabilized through a self-reinforcing process. Commonly, this phenomenon is called a "lock-in." The path's inability to reverse stems from the fishers having already made significant investments (i.e., quota shares and larger vessels) in the dominant path so they will incur "sunk costs" if they switch to another path [34]. Both the input and output measures introduced in the management of the fishery closed the door to new entrants [18]. This ultimately had the potential to make the closed quota-regulated fishery an "exclusive rich man's club" [14,15].

The incremental institutional changes regarding harvesting rights implied that the parties (fishers including their organizations and the government) recontracted to capture some of the potential gains [72]. This required an institutional context that made it possible to bargain and compromise between the players. Thus, Norwegian political institutions provided an appropriate framework for evolutionary change. However, formally, Norway still does not manage its fisheries by ITQs, but, in reality, fisheries management has several similarities with such a system (e.g., [9,48,53,89]). As transferable quotas significantly eliminate the common property problem of fisheries, ITQ systems have been widely adopted in various forms worldwide in the last decades [58]. Costello et al. [28] found, after having compiled a global database of fisheries institutions and catch statistics, that the implementation of catch shares halts, and even reverses, the global trend toward widespread fisheries collapse. Their study concluded that institutional change has the potential for greatly altering the future of global fisheries.

7. Industry performance

To examine the historical role of institutions in the rebuilding of the collapsed herring fishery, quantitative data needed to be collected, covering the period before the crisis occurred (before 1961), the recovery period (1961–1992), and the period after the crisis was over (after 1992). Norwegian authorities have collected and published catch data from fisheries for more than 100 years. This study has gained access to catch data from the Statistics Norway for NSS herring covering almost the last century, i.e., from 1946 to 2019. As the NSS herring crises lasted for more than 30 years (1961–1992), this data series covers all three periods mentioned above. Furthermore, The Norwegian Directorate of Fisheries has supplied this study with revenue data for the NSS herring fishery for the period 1977–2019. This data series covers the 15 last recovery years (1977–1992) and the first 26 years after the herring crisis was over (1993–2019). The Norwegian Directorate of Fisheries has also supplied this study with profitability data (operating margin of the average pelagic vessel) for the period 1980–2019. It is primarily based on this data series that this study can describe outcomes of the institutional rebuilding process that took place in the aftermath of the collapsed herring fishery.

This study shows that the herring fishery in Norway has followed two different management paths after World War II, i.e., open access and closed entry. Fig. 2 illustrates the business climate and industry performance of the NSS herring fishery during this period. The horizontal axis in Fig. 2 specifies the operating times of the two management paths. The radical switch between open access and closed entry is, in the present study, described as a paradigm shift [65,72]. This shift is illustrated by the vertical bar in 1970. The closed entry period is further split into two shown by the vertical dotted bar in 1996. During the first period (1970–1995), there was closed entry and still a race to fish. However, in the second period, private harvesting rights ended the rivalry among the fishers. The bar in 1996 also suggests that the transition between the closed entry periods without and with private harvesting rights was incremental as the most significant characteristics of the first period also were part of the second. The associated catches of the different management paths are plotted as a continuous line along the vertical axis.

The performance of the herring industry in Fig. 2 resembles a U-shaped recovery. The fishery first experienced a sharp decline in output until 1968 followed by a long period of stagnation before finally rising back to its previous peak in 2009. The path switch from open access to closed entry that occurred after the collapse was supported by formal institutions such as closing the fishery and TAC regulations (see Table 1). This was an institutionally designed management path that can be characterized as a success as it eventually made the fishery ecologically sustainable again. It took, however, 25 years before it was possible to

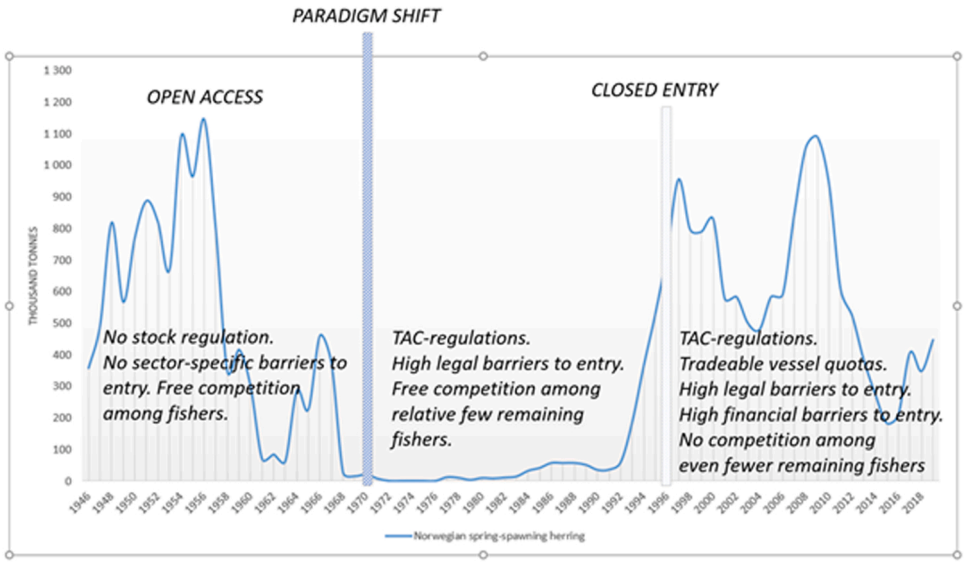

Fig. 2. Business climate (see textboxes embedded in the chart) and industry performance (continuous line illustrating yearly catches of herring in thousand tons) of the NSS herring fishery during 1946–2019.

measure the effect of the institutional rebuilding process in the fishery's catch statistics and in the financial accounts of the vessel firms [15].

Fig. 2 also shows that the business climate of the firms has changed radically during the period studied. The open access period was characterized by a fierce competition among the fishers to secure the largest possible share of the unregulated herring resource. There were no sector-specific barriers to entry, neither legal nor financial. The booming fishery (see Fig. 2) attracted 599 vessels in 1957 in comparison with 273 in 1946 [39].

As catches were marginal (see Fig. 2), the business climate worsened dramatically during the recovery period (1968–1992) despite the supply of significant subsidies [40]. In this period, significant legal barriers to entry were established, i.e., permit requirements, nationality requirements, residency requirements, activity requirements, and requirements for the vessel [18]. The barriers intended to deter entering the fishery as this would lead to a further capacity increase. The surviving incumbents were, conversely, highly protected from outside competition through the entry barriers. Weak profitability and condemnation programs contributed to a sharp decline in the number of participating vessels in the recovery period as 370 seagoing purse seine vessels were registered in 1970, whereas the corresponding number was 102 in 1992 [18].

The herring industry has been very attractive financially for the institutionally protected incumbents since the stock recovered in the mid-nineties. The annual catch volumes have been significant despite large annual variations (see Fig. 2). The real prices for herring have increased because a larger proportion of the catches now goes to human consumption. Higher demand for fishmeal and fish oil from the aquaculture industry has also contributed to higher herring prices [35]. The profitability of the vessels has been above normal [14,15]. Consequently, the vessels' quota values have increased significantly. The National Audit Office ([71], p. 80) shows that the quota prices for NSS herring have increased tenfold for the smallest coastal vessel group in the period 2009–2017. For the larger pelagic coastal vessels, quota prices have increased by five and six times in the same period.

Fig. 3 demonstrates the significance of rebuilding the herring fishery

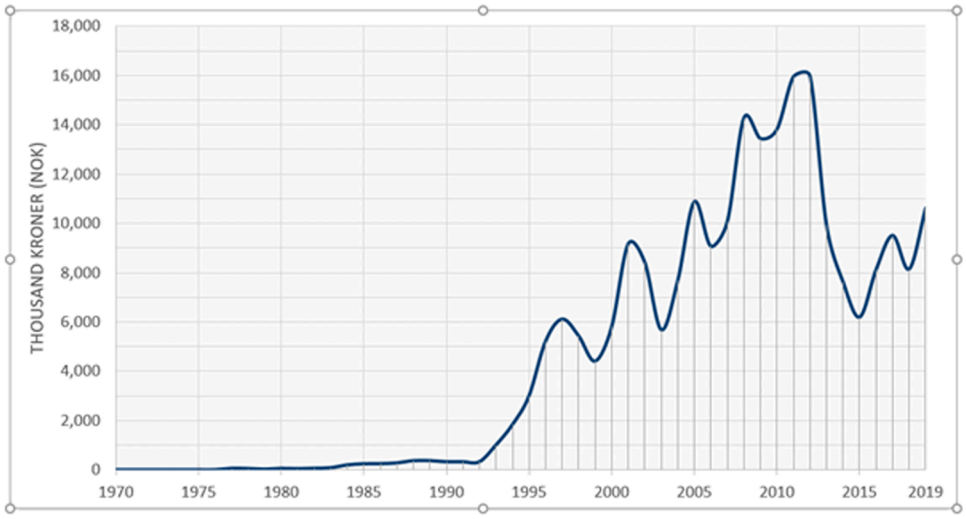

Fig. 3. Estimated average revenues from the catch of NSS herring per seagoing purse seiner in the period 1970–2019. The numbers are inflation-adjusted with base year 2019.
Sources: Statistics Norway and the Directorate of Fisheries, Norway.

for the average seagoing vessel's revenue development annually since 1970. During the 25-year period after the rebuilding of the stock (1995–2019), each vessel has earned NOK 11.3 million in real 2019-values (approximately 1.1 million euros) from fishing NSS herring. Together with revenues from mackerel fishing, this constitutes the most significant revenue item in the vessel's accounts [35].

Furthermore, Fig. 4 shows that the weighted inflation-adjusted total revenues for pelagic vessels have increased significantly between 1980 and 2019. The same comes to profitability (operating margin). While the average weighted inflation-adjusted revenue was approximately NOK 8.5 million per vessel in the 1980s, and the average operating margin 6.8%, the revenue per vessel increased to 28.1 million in the decade 2010–19 while the operating margin increased to 21.9%. In the 40 years, the development in revenues and operating margin is strongly correlated ($R^2 = 0.785$).

The total revenue of a pelagic vessel is included in the revenue numbers in Fig. 4. These numbers, therefore, include the revenue from NSS herring and mackerel, capelin, blue whiting, and other pelagic species. NSC herring, mackerel, and capelin are the most important species economically, and they are bundled in an overall quota vessel package. Some vessels may have additional quotas for blue whiting, sand eel, Norway pout, etcetera.

Closed entry with private harvesting rights has eventually ensured sustainability along the ecological and economic dimensions for the relatively few vessels who are allowed to still participate in the fishery. However, the open access fishery was dominated by a social logic as the sector played a major role in the maintenance and development of the population base in coastal communities [70]. This sustainability dimension is largely neglected in the new closed entry management path [71].

8. Conclusion

The present study demonstrates the pivotal role of institutions in rebuilding of the collapsed Norwegian herring fishery. The institutional measures chosen to create a closed entry management path arose from recognizing that it was impossible to ensure an economically sustainable fishery without also securing ecological sustainability [71]. Accordingly, there is a sharp distinction between the open-access crisis responses of fishing for juvenile herring and subsidies and the institutions designed to support the new, more sustainable management path. This study argues that the radical change of fisheries management that occurred in the 1970s has similarities to a paradigm shift [65]. However, the closed entry management path has, however, evolved gradually with transferable private harvesting rights as its most recent distinctive feature. Harvesting rights help to self-reinforce and stabilize the closed entry management path that already had been put in place. Changes in policy and policy objectives may occur gradually and slowly [53], although often triggered by initial historical events as illustrated in this study.

The review of policy responses to the NSS herring resource crisis (see Table 1) indicates that the initial responses were locked-in in the prevailing open-access management path. However, as the crisis endured, it was realized how deeply rooted it was ecologically. Eventually, the need for more radical changes emerged among key stakeholders [69]. Finally, the present study illustrates that institutions do not remain fixed but evolve. Design and legislation can also create or destroy institutions [93]. What was once a relatively effective path for managing a natural resource ceased when the technological conditions changed dramatically after World War II.

History can be a useful managerial resource, although historical lock-in, as demonstrated in the present study by clinging too long to an outdated open-access management path, does create inflexibility. There are several ways managers can use history [85]. First, fisheries' managers can learn from the past. Understanding the current socio-economic position of a fishery in the past can provide useful insights. For example, have there been historical trends or cycles of the past that can provide useful lessons for the future when promoting a social and not just an ecologically and economically sustainable fishery. How can the revenues created be distributed fairly, for example, between stakeholders

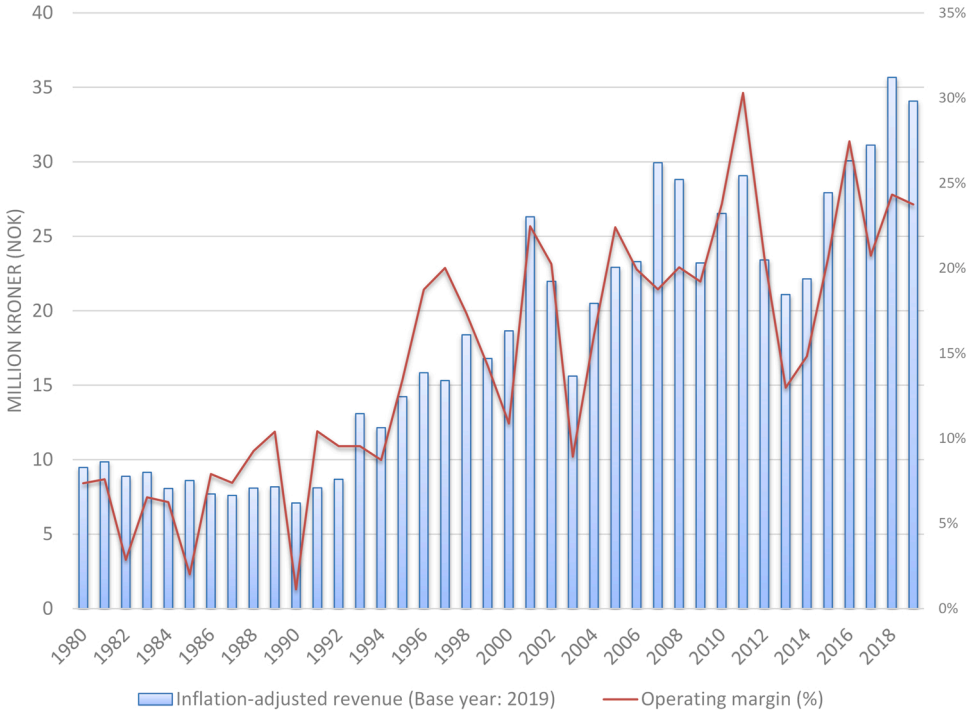

Fig. 4. Weighted inflation-adjusted average revenues (base year: 2019) for Norwegian vessels harvesting pelagic species in the period 1980–2019 (left axis) and their operating margin (right axis). The average number of vessels in the sample per year was 124. The average number of vessels in the population per year was 276. Source: Directorate of Fisheries, Norway.

such as small coastal and large seagoing vessels? What about the regional distribution of revenues along an elongated rural coastline that is in dire need of economic activity so as not to gradually fade away? Finally, history can be used as a resource to legitimize existing management paths or institutional change [2]. Past successes of effecting institutional changes may also be evidence of the management's potential of handling of change and innovation or encourage commitment to future changes.

Several herring stocks in the North Atlantic collapsed in the late 1960s [76]. The migratory NSS herring is one of these. Future research could be to identify and compare alternative institutional arrangements implemented in various nations to rebuild the herring stock (e.g., Iceland, the Faroe Islands, and the United Kingdom). From an NIE perspective, coordination costs associated with different institutional designs are of interest, as are the economic results caused by different institutional designs. One way of measuring the quality of an institution is to measure the net cost of implementing it, i.e., the institution's transaction costs.

Conflicts of Interest

The author declares no conflict of interest.

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