Changing attitudes 1970–2012: evolution of the Norwegian management framework to prevent overfishing and to secure long-term sustainability

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Fisheries have been important for livelihood in Norwegian coastal communities for centuries. The development of new fishing technology and increasing fishing capacity posed challenges for the sustainability of the fisheries. The Norwegian spring spawning herring was depleted in the 1960s—with dire consequences. This event, and the subsequent efforts to rebuild the stock, was paramount to the gradual development of a coherent Norwegian policy to prevent overfishing and secure long-term sustainability. Nevertheless, overfishing continued during the ensuing transitional decades when a range of new management tools were developed and made effective. Internationally, the extension of the economic zones to 200 nautical miles, and agreement on sharing and management of joint stocks were important elements. At the national level, the development of measures to curb overcapacity, improvement of exploitation patterns through technical regulations, ban on discard and the evolution of procedures for rational decision-making for setting total allowable catches (TACs) on the basis of harvest control rules, were all decisive elements. Another crucial factor was the creation of a whole new profession of fishery inspection. We describe a system of close collaboration between specialists—scientists, fishery managers, and stakeholders—each with a distinct role in building a solid framework to prevent overfishing and secure long-term sustainability.

Keywords: harvest control rules, management, Norwegian/Barents Sea, scientific advice.

Introduction

The term “overfishing” is frequently used in fishery discussions. Norway experienced dramatic effects on fisheries and coastal communities due to overfishing and the subsequent collapse of the large Norwegian spring spawning herring stock in the late 1960s (Dragesund et al., 1980), and overfishing had detrimental effects on the large fish stocks in the Barents Sea (Jakobsen and Ozhhin, 2011), the Norwegian Sea (Skjoldal et al., 2004), and the North Sea (Skjoldal and Misund, 2008) following rapid technical progress and increased efficiency in the fisheries.

In everyday parlance, overfishing is a rather normative description of fishing pressure measured in tonnes or fishing mortality leading to stock depletion. The term is often used imprecisely or with different content. According to Pauly (1983), growth overfishing
occurs when fish are caught at a smaller average size than what would produce maximum yield per recruit; 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; and ecosystem overfishing occurs when the ecosystem is irreversibly altered by overfishing. However, as argued by Murawski (2000), so far there are neither any agreed indicators that identify ecosystem overfishing, nor any biological attributes that can guide management decisions.

In a recent evaluation, the fisheries management system in Norway attained the highest score for compliance (Pitcher et al., 2009a) to the UN Code of Conduct for Responsible Fisheries (FAO, 1995), in which prevention of overfishing is among the central principles (No. 6.3). Overall compliance to the Code of Conduct by Norway was about 60%, still indicating considerable potential for improvement (Pitcher et al. 2008, 2009a). In a similar evaluation of progress, in implementing ecosystem-based management of fisheries (EBFM), Norway ranked second after the USA, with an overall performance score slightly above 60% (Pitcher et al., 2009b). Scores for adherence to EBFM principles and EBFM indicators are high, but the scores for EBFM implementation are lower. Moreover, the rather positive evaluations cited above must be seen against the backdrop of a similar evaluation of the management effectiveness of world fisheries, in which the probable sustainability of Norway’s fisheries ranked rather low, largely due to excess fishing capacity (Mora et al., 2009).

The present paper attempts to describe the construction of the Norwegian framework to prevent overfishing. Over the past few decades the authors have had leading roles as scientists, managers and administrators in the Norwegian fisheries management system (Mikalsen and Jentoft, 2003), and have worked in close collaboration. But our roles have been very different: the scientists advised on the basis of the best possible science and data, quality-assured by the International Council for Exploration of the Sea (ICES) system; the administrators in the Royal Norwegian Ministry of Fisheries and Coastal Affairs developed a foundation for political decisions based on scientific advice supplemented by input from managers in the Directorate of Fisheries, taking into account economic and societal aspects; the managers were also responsible for the implementation of regulatory measures. The present analysis attempts to link biological knowledge and scientific advice with political and societal objectives, and the management challenges that follow.

The collapse of the Norwegian spring spawning herring

In a Norwegian context, the collapse of the Norwegian spring spawning herring is a standard example of overfishing (Røttingen, 2004). Traditional herring fishing was carried out with small wooden vessels in coastal waters, and schools of herring were located by using indirect signs such as the presence of birds and sea mammals. However, traditional fishing was eventually supplanted by industrialized offshore fishing using larger vessels, sophisticated electronic search instruments and high-capacity fishing gear. As catches increased, the fishery became non-sustainable. The experience with the Norwegian spring spawning herring included elements such as open access, increasing number and size of fishing vessels, more efficient equipment, and lack of international and national regulatory measures, which all eventually contributed to overfishing. The collapse of the Norwegian spring spawning herring stock in the late 1960s led to a paradigm shift in Norwegian fisheries management. Until then the prime objective of fisheries management had been to assist the industry in their various efforts to increase catches and improve productivity and profitability. Gradually the management of resources now emerged to become the top management priority.

Fishery policy objectives

In the 1960s and 1970s, Norwegian fishery policy had several broadly recognized objectives (Anon., 1978):

(i) the fisheries sector had a major responsibility for the maintenance and development of the population base and employment in coastal communities;

(ii) the fisheries sector had to be sufficiently profitable to offer wages and living conditions similar to those provided by other sectors in the Norwegian economy; and

Figure 1. Development of the Norwegian fisheries sector: total catch, number of fishers, and catch per fisher during 1945–2011 (source: Norwegian Directorate of Fisheries).

Figure 2. Indices and linear regressions of mean real income in all industries (full squares and solid regression line) and of mean real first-hand price of fish (open squares and dotted regression line) in Norway during the period 1970–2011 (sources: Norwegian Directorate of Fisheries and Statistics Norway). Figure explanation: 1970 = 100. Linear regressions: Index: mean real income in all industries $= -5481.22 + 2.83^*Year, R^2 = 0.875, p < 0.001, n = 42$; Index: mean real first-hand price of fish $= -2055.85 + 1.10^*Year, R^2 = 0.431, p < 0.001, n = 42$. 

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(iii) with the collapse of the Norwegian spring spawning herring stock around 1970, a third objective emerged: fish stocks should not be overfished and depleted.

A series of financial problems, caused by either low catches or deteriorating world market prices for fishery products, combined with the political objectives listed above, led the Government and the Norwegian Fishermen’s Association (NFA) to sign a General Agreement on financial support to the industry in 1964 (Jentoft and Mikalsen, 1987). The intention was that this support would help the industry mitigate economic difficulties that were regarded as temporary, short-term problems. But the subsidies soon became an integral part of the management system where the industry annually negotiated with the government for next year’s support package.

In retrospect, it is easy to recognize that the financial problems were not of a temporary or short-term nature. The fisheries sector could no longer solve its financial problems under the existing social policy objectives of being the backbone in securing employment and maintaining the population base in coastal Norway (Jentoft and Mikalsen, 1987).

One fundamental reason was that catches—which had been rapidly growing in the 1950s and 1960s thanks to technological progress and increased efficiency—stagnated and started to decline due to overfishing and dwindling stocks (Figure 1). Another fundamental reason was that real prices of fish on the world market increased less than real wages in Norway. In the period 1970–2011 real wages in Norway increased by 1.93% annually, whereas the annual weighted real price of fish landings only increased by 0.87% (Figure 2). With more than 95% of Norwegian fishery products being exported, this meant that for every passing year, fishers would have to land more fish, or receive more in subsidies, to keep up with the standard of living of their non-fishing neighbours.

Changes of policy and policy objectives may occur only gradually and slowly (Rice, 2011), even though often triggered by initial shocks like the herring stock collapse. Trends that in hindsight may look like obvious and clear historical facts did not show the same face at the time when they happened. This may be even more the case when strong interests are connected to the status quo and continuation of existing policies. It takes time to adapt policies, attitudes and behaviour to new realities (Mikalsen and Jentoft, 2003).

**Limiting access**

The overfishing and collapse of the Norwegian spring spawning herring stock gave impetus to the process of limiting access to Norwegian offshore fisheries. A new law regulating participation in fisheries entered into force in 1972 (Norwegian Government, 1972), and over subsequent years all offshore fisheries were gradually closed to new entrants, starting with regulations concerning access to pelagic fisheries in 1973. In parallel, the United Nations Conference on the Law of the Sea eventually led to the extension of exclusive economic zones (EEZs) to 200 nautical miles in 1977, limiting foreign fleets’ access to the waters of coastal states, and conferring on these states both rights and obligations with regard to the management of their living marine resources. In the case of Norway, this also meant extended cooperation, especially with the Soviet Union/Russia and the EU, as nearly all economically important fish populations are shared stocks.

By 1990, the stock situation for Northeast Arctic cod had become critical because of overfishing, and Norwegian authorities saw it as necessary to limit access to cod for most of Norway’s coastal fisheries. This was a draconian step, in a country where open access to fishing had been regarded more or less as a human right since time immemorial. At the time, this first comprehensive access regulation of a coastal fishery was explained and defended politically as a pure emergency measure which would be repealed as soon as the stock situation had improved. With time, however, it was gradually but reluctantly accepted that this was not merely an emergency measure, but one of the permanent steps necessary to curb overfishing, regardless of the stock situation. In the late 1990s and early 2000s a number of coastal fisheries became subject to access regulations, and since 2004 the remaining open access opportunities in coastal fisheries are all small scale and in many cases regulated by overall quotas, and thus in general have only a minor impact on fish stocks and do not encourage fishers to make new investments.

**The end of subsidies**

The subsidies to the Norwegian fisheries sector peaked around 1980 when they amounted to about one third of the first-hand value of fish (Figure 3). The subsidies were gradually reduced in the 1980s, increased temporarily during the aforementioned cod crisis, but have been negligible since the mid 1990s. An important factor that politically facilitated this transition was an international commitment to phase out subsidies, which was part of an agreement signed in 1989 (Christensen and Hallenstvedt, 2005) on free trade in fish under the European Free Trade Agreement (EFTA).

Besides the intended positive effect of maintaining (artificially) a high level of employment in the fisheries sector, the subsidies had several negative effects (Jentoft and Mikalsen, 1987). The most obvious one was that they preserved fleet overcapacity, and even contributed to its increase, putting stocks under permanent pressure and threat of overfishing. Another one was the annual negotiation process for financial support to the industry itself. In these negotiations, prognosis of next year’s prices and catch levels were decisive factors in estimating how big an income gap the subsidies would need to fill. The government, obviously wanting to minimize subsidies for budgetary reasons, had a strong incentive to be optimistic about next year’s catch opportunities. The system as such invited short-sightedness with respect to stock conservation (Hannesson, 1985).
Reducing overcapacity

Limiting access and eliminating subsidies in fisheries were, however, not sufficient to reduce overcapacity and the risk of overfishing. During the 1980s, some of the monetary support to the sector was utilized to finance scrapping schemes to reduce fleet capacity. From the 1990s, such schemes were gradually replaced by voluntary license aggregation schemes, e.g. voluntary scrapping of one offshore vessel entitles the owner to transfer the old vessel’s fishing licences to another existing vessel for a period of 20 years (Norwegian Government, 2005). For coastal vessels (> 11 m) 80% is transferred, whereas 20% of the fishing opportunities are returned to the common benefit of all vessels in the relevant fleet (Norwegian Government, 2003). Limits are set on how many licences may be aggregated onto one vessel or by one owner. This policy has succeeded in reducing the number of fishing vessels and halted the growth in fishing capacity as measured by aggregate horsepower of the fleet (Figure 4).

Distribution of annual fishing opportunities: stakeholder participation

The national distribution of quotas between fleet groups and between vessels within each group has been a contentious and time-consuming issue, particularly up until around 2003. Since then, however, the most important distributional issues have been settled, and durable, long-term solutions seem to have been found. In this process the NFA, which organizes fishers and vessel owners from most fleet segments, played a vital role in the delicate task of negotiating relatively robust compromises between its members. Recent catch history of fleet groups was one of the more important components in reaching solutions. The intensive efforts of the NFA in this context have been appreciated and the compromises have to a large extent been respected in practical politics of the Parliament and changing governments. This has contributed to political stability on these often very sensitive issues.

The general experience is that consultation and stakeholder participation in the regulatory process has contributed significantly to the development of sustainable fisheries management and to the industry’s acceptance of regulatory measures (Jentoft and McCay, 1995). Specifically, NFA’s involvement and influence on distributional issues have been considerable, and gradually a majority of the stakeholders are embracing the long-term sustainability perspective on fisheries management.

International cooperation and agreements

As most fish stocks harvested in the Norwegian fisheries are shared with other nations, international cooperation in research and management has been instrumental for the development of sustainable fisheries management systems. For the Barents and Norwegian Seas fisheries, the close and long-standing cooperation between Norway and the Soviet Union/Russia has been of particular importance. In recent times, close cooperation in research was initiated in 1957 and further developed and extended over the years (Alekseev et al., 2011), while the cooperation in fisheries management was formalized by the establishment of the Joint Russian–Norwegian Fisheries Commission in 1976. This long-time relationship between Norway and Russia in the Barents Sea is considered to be a successful example of bilateral coastal state cooperation on the management of shared stocks (Hønneland, 2012; Hammer and Hoel, 2012).

Norway’s international efforts have focused on reaching agreement on sharing of resources, sustainable long-term management plans, efficient harvest control rules, improved technical regulations (including the ban on discards and Real-Time Closures for the protection of juveniles), and enforcement and surveillance issues. Promotion of and support for the introduction of international measures, including blacklisting of IUU-vessels and Port State Control Measures, has been a priority.

Exploitation pattern and discard policy

Potential yield from a fish stock is related both to exploitation level and the issue of recruitment overfishing, and to exploitation pattern and the issue of growth overfishing. Figure 5 illustrates that Northeast Arctic cod nearly doubles its potential yield if harvested as nine-year-old fish rather than as three-year-old fish.

Comprehensive efforts have been made over the years to improve the exploitation pattern of Norwegian fisheries. Fundamental steps...
were the introduction of a system of Real-Time Area Closures in 1984, the discard ban for cod and haddock in 1987, and the mandatory sorting grids in shrimp trawl and ground fish trawl in 1991 and 1997, respectively. Today the discard policy applies to most species. Although the discard ban in itself is admittedly difficult to enforce (Valdemarsen and Nakken, 2003; Gezelius, 2006), together with the accompanying measures to improve exploitation patterns it is considered to have contributed significantly to the ecological as well as economic sustainability of Norwegian fisheries. (Gullestad et al., unpublished data) Nevertheless, quantification of discarding is still an issue in the assessments of NEA cod and haddock (Yaragina et al., 2011, Russkikh and Dingsør, 2011).

Table 1 illustrates how average age at landing of Northeast Arctic cod was reduced from 5.84 in the 1950s to 5.03 in the 1970s, and how subsequent efforts to improve the exploitation pattern increased the age to 5.64 in the last decade. From Figure 5 it can be derived that this increase has improved the present annual yield by 6.3% compared with the 1970s. The 2012 TAC of Northeast Arctic cod is 772,000 tonnes, and hence 6.3% corresponds to 48,600 tonnes with a landed value of approximately USD 100 million. It may be argued that this estimate is based on simplified assumptions of a more complex reality. Still, it underpins the magnitude of the potential economic benefits of improved exploitation patterns, and their importance in relation to overfishing.

Exploitation level—the precautionary approach, harvest control rules and the MSY approach

Even during the early years of ICES, growth overfishing was recognized as a potential problem, and a special Committee dealing with the topic was established in 1902. The laborious process of developing scientific advice for fisheries management and communicating the accrued knowledge to management bodies is described by Sætersdal (2008). The World Wars and lack of international agreements on shared stocks seem to be important reasons why it took about 70 years to get an advisory system into routine operation. From the mid 1970s the ICES Liaison Committee issued annual advice for several commercially important fish stocks, and this was continued and developed by the Advisory Committee for Fisheries Management (ACFM, 1978–2007) and by the Advisory Committee on Management (ACOM, from 2008). In the period 1976–1986 the main focus was to reduce “growth overfishing”, and the advice was based mainly on fishing mortality (F) reference points derived from calculation of yield per recruit (F_{\text{max}}, F_{0.1}) . From 1987 additional fishing mortality reference points derived from stock–recruitment relationships (\( F_{\text{med}} \), \( F_{\text{low}} \), \( F_{\text{high}} \)) were used for the advice. This reflects concerns about reduced reproduction capacity (too low spawning stock). The same concerns motivated introduction of the Minimum Biological Acceptable Level (MBAL) in 1992. In the period 1992–1997 clear and specific advice was given only in cases when the spawning stock was below MBAL. When the stock was “within safe biological limits” (above MBAL) the advice was left open to the manager’s choice; phrases like “the stock sustains current fishing” were used when the situation appeared rather stable, or “no long-term gain in increasing F” in cases when F was well above \( F_{\text{med}} \) or \( F_{\text{low}} \).

The precautionary approach, stating that lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation, was incorporated in official Norwegian fisheries policy through a White Paper to the parliament (Anon., 1997). This came as a response to the Declaration from the Rio Conference on Sustainable Development (Anon., 1992), the UN Fish Stocks Agreement (Anon., 1995), and the FAO Code of Conduct for Responsible Fisheries (FAO, 1995). In the following years, stock-specific target and limit reference points for the major fish stocks in Norwegian fisheries were developed through the ICES advisory working groups. Limit reference points refer to stock-specific, absolute values of spawning stock biomass (B_{\text{MSY}}) and fishing mortality (F_{\text{lim}}) levels that should be avoided. To take care of the uncertainty in data and assessment models, precautionary reference points (B_{\text{pa}}, F_{\text{pa}}) were defined (Table 2). These reference points formed the basis for introducing the Precautionary Approach (PA) in the advisory process.

Now uncertainty became an argument for a more conservative management. Earlier, uncertainty had often been used by the industry as an argument for increasing quotas (the stock might be larger than assessed by the scientists). In the ensuing years the very existence of accepted precautionary limits in combination with a general growing environmental awareness in the Norwegian society, led to increased “political costs” for non-precautionary or unsustainable fisheries management.

Throughout the 1990s the Norwegian spring spawning herring stock was increasing and eventually resumed its summer feeding migrations to the Norwegian Sea, thus becoming available for fishing outside Norwegian waters. Through a process in the Northeast Atlantic Fisheries Commission (NEAFC), based on a scientific consideration of catches and stock distribution, the coastal states agreed on a TAC allocation key (Rottingen, 2004). To stabilize catches and prevent stock from falling to critical levels, NEAFC initiated the development of a harvest strategy. In 1999 the coastal states agreed on a harvest control rule for Norwegian spring spawning herring, constructed as a function with the limit and precautionary reference points as triggers (Rottingen, 2004, Table 2). The agreement on the TAC allocation and the harvest control rule have given a stable management regime for Norwegian spring spawning herring for the last decade, and due to good recruitment in the later 1990s and early 2000s, the annual catches have varied between 0.766 and 1.687 million tonnes.

Development and construction of harvest control rules based on reference points proposed by ICES followed for all the major commercial fish stocks in Norwegian fisheries in the early 2000s. For Barents Sea species such as capelin, northeast Arctic cod and northeast Arctic haddock, the species-specific harvest control rules were developed and agreed upon by the Joint Norwegian Russian Fisheries Commission in the years 2000–2004, subsequent to modelling and testing within the ICES Arctic Fisheries Working Group.

Table 1. Overview of average age at landing of northeast Arctic (NEA) cod in different decades from 1950–2010 (source: ICES, 2010).

| Average age of NEA cod at landing in different decades | 1950–1959 | 1960–1969 | 1970–1979 | 1980–1989 | 1990–1999 | 2000–2010 |
|--------------------------------------------------------|----------|----------|----------|----------|----------|----------|
| Age                                                     | 5.84     | 5.30     | 5.03     | 5.35     | 5.64     | 5.64     |
Table 2. Biological spawning stock (termed SSB or B) and management (fishing mortality termed F) reference points for the major commercial fish stocks in Norwegian waters, based on stock status given in recent updates of the ICES Advice 2011–2012.

| Species              | Management plan | MSY approach | Precautionary approach |
|----------------------|-----------------|--------------|------------------------|
|                      | SSB<sub>MP</sub> | F<sub>MP</sub> | B<sub>TRIGGER</sub> | F<sub>MSY</sub> | BLIM | B<sub>PA</sub> | F<sub>Lim</sub> | F<sub>PA</sub> |
| NEA cod              | 460 000 t       | 0.40         | 460 000 t              | 0.40           | 220 000 t | 460 000 t | 0.74 | 0.40     |
| NEA haddock          | 80 000 t        | 0.35         | 80 000 t               | 0.35           | 50 000 t  | 80 000 t  | 0.77 | 0.47     |
| NEA saithe           | 220 000 t       | 0.35         | n.d.                   | n.d.           | 130 000 t | 220 000 t | 0.58 | 0.35     |
| Greenland halibut    | n.d.            | n.d.         | n.d.                   | n.d.           | n.d.     | n.d.     | n.d. | n.d.     |
| Beaked redfish       | n.d.            | n.d.         | n.d.                   | 0.065<sup>a</sup> | n.d.     | n.d.     | n.d. | n.d.     |
| Golden redfish       | n.d.            | n.d.         | n.d.                   | n.d.           | n.d.     | n.d.     | n.d. | n.d.     |
| Northern shrimp      | n.d.            | n.d.         | 0.5 B<sub>MSY</sub> | F of B | n.d.     | n.d.     | 1.7 F<sub>MSY</sub> | n.d.     |
| Barents sea capelin  | SSB < B<sub>Lim</sub> (95% prob) | n.d. | n.d. | n.d. | n.d. | 200 000 t | n.d. | n.d. |
| NC cod               | n.d.<sup>a</sup> | n.d.<sup>a</sup> | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| NSS herring          | 5 000 000 t     | 0.125        | 5 000 000 t            | 0.15           | 2 500 000 t | 5 000 000 t | n.d. | 0.15     |
| Blue whiting         | 2 250 000 t     | 0.18         | 2 250 000 t            | 0.18           | 1 500 000 t | 2 250 000 t | 0.51 | 0.32     |
| Mackerel             | 2 200 000 t     | 0.20–0.22    | 2 200 000 t            | 0.22           | 1 670 000 t | 2 300 000 t | 0.42 | 0.23     |
| NS saithe            | 200 000 t       | 0.3          | 200 000 t              | 0.3            | 106 000 t  | 200 000 t  | 0.6  | 0.4      |
| NS cod               | 150 000 t       | 0.4          | 150 000 t              | 0.19           | 70 000 t   | 150 000 t  | 0.86 | 0.65     |
| NS herring           | n.d.            | function of SSB<sup>b</sup> | n.d. | 0.25 | 800 000 t | 1 300 000 t | n.d. | 0.25<sup>c</sup> |
| Sand eel<sup>d</sup> | 195 000 t       | n.d.         | n.d.                   | 195 000 t | n.d.     | n.d.     | n.d. | n.d.     |

Subscripts refer to types of management approaches (<var>MP</var> = management plan, <var>Trigger</var> = point defining change of action, <var>LIM</var> = critical level not to be exceeded, <var>PA</var> = target level management should aim for). Colours: green = stock status 2011–2012 within objectives for Management plan, MSY approach, or Precautionary approach; orange = increased risk of exceeding objectives of MP, MSY approach, or Precautionary approach; red = above objectives of MP, MSY approach, or Precautionary approach; n.d. = not defined. <sup>a</sup>Considered as a proxy for <var>F<sub>MSY</sub></var>. If SSB > 1.5 mill. t then <var>F<sub>2</sub>-6</var> = 0.25, if 0.8 < SSB < 1.5 mill. t then <var>F<sub>2</sub>-6</var> = 0.10. <sup>b</sup>F<sub>2</sub>-6 = fishing mortality for age groups 2–6 being targeted by Norwegian vessels. <sup>c</sup>Sand eel in the central eastern North Sea (Norwegian EEZ) where an experimental management plan has been applied since 2010. 

A management plan for Norwegian coastal cod, provisionally consistent with the precautionary approach is implemented, prescribing a defined percentage reduction in fishing mortality until survey index improves.

(Kovalev and Bogstad, 2011; Hønneland, 2012). Common elements of harvest control rules are a target F-value, mechanisms to reduce F when the spawning stock falls below a predetermined precautionary limit, and in many cases mechanisms to curb annual variation in TAC.

In 2010 the “MSY-framework” became the main basis for the ICES advice. This has shifted the focus from setting limits, which should be avoided, to aiming for targets such as maximum sustainable yield (MSY). Since the late 1990s the management bodies have adopted management plans with harvest control rules for a large number of stocks. Such rules are in most cases pre-agreed procedures for setting the annual TAC. When those rules are in accordance with the PA and/or MSY, ICES gives advice according to the rules. It is important to note that management plans may have other objectives than MSY, and nevertheless be fully sustainable and precautionary. An example is that in most cases MEY (maximum economic yield) generates a lower fishing mortality rate than F<sub>MSY</sub> due to the effect of reduced harvesting costs with increasing stock size. Sustainable management plans that could be regarded as optimal in a socioeconomic context should target F-values lower than or equal to F<sub>PA</sub>. It should also be noted that F<sub>MSY</sub> could be higher than F<sub>PA</sub> when uncertainty in the assessment of the stock is high. In such cases, fishing at F<sub>MSY</sub> should not be regarded as a sustainable outcome.

Within ICES there is no unique definition of the term “overfishing”. In view of the history described above any of the interpretations of a “scientific overfishing concept” illustrated in Table 3 could be valid.

Monitoring, control and surveillance

One of the lessons learnt over the last decades is that robust science and regulatory measures are necessary but not sufficient conditions for curbing overfishing. During the 1980s it became clear that

prudent control and enforcement, both at sea and in harbour, were essential elements in successful fisheries management, and that a more or less entirely new field and profession had to be established and developed to perform the task. Control was no longer limited to the inspection of mesh sizes and other gear-related issues. In particular the monitoring of catch quantities in relation to quotas and by-catch regulations have set requirements for the development of a range of new control methods and for new data tools, including satellite tracking and electronic logbook reporting.

Illegal fishing from Norwegian as well as foreign vessels put the rebuilding of stocks at risk, and a substantial and sustained effort has been necessary to reduce this problem to a manageable level and to keep it under control.
Over time, reduced overcapacity and increased stakeholder participation in management may ease the control tasks. Nevertheless, the common nature of fish resources requires a sustained effort in this respect.

The ecosystem approach to fisheries management
To advise on a more holistic management of living marine resources and the marine environment, ICES adopted an ecosystem approach strategy in 2002 (ICES, 2002), and an ecosystem approach is now a central principle for Norwegian fisheries management (Anon., 2002a). Since 2004 there has been a transition from separate fish and oceanographic surveys respectively, towards ecosystem cruises where the researchers attempt to investigate the ecosystem as a whole (Misund et al., 2011; Olsen et al., 2011). Still, single species assessments and single species advices on fishing quotas are standard, but ecosystem considerations are elaborated in the context of single species assessments. In the cod–capelin predator–prey relationship in the Barents Sea, the consumption of capelin by cod is taken account of when setting the fishing quota for capelin (Gjøsæter et al., 2011).

Integrated Ocean Management Plans
During the 1990s, the conflict of interest between an expanding off-shore oil and gas industry and the traditional fisheries regarding use of specific areas at sea became more pronounced. At the same time, environmental concerns were raised about effects of both pollution and traditional fisheries on vulnerable marine biota, including overfished fish stocks.

Therefore, the concept of Integrated Ocean Management Plans for the Norwegian waters was launched in 2002, and the Lofoten–Barents Sea was chosen as the first plan area. The Ocean Management Plans were expected to have a cross-sector, holistic approach. Representatives of all Ministries and their underlying directorates, as well as institutions that had responsibilities within the ocean areas, participated in the development of the plans. Given its overall responsibility for the environment in areas under Norwegian domain, the Ministry of Environment led the planning process. Reports on the marine environment and on living marine resources, on fisheries, shipping, offshore oil and gas activity, and on vulnerable and particularly valuable areas were prepared. Based on these reports, the government presented the first Lofoten–Barents Sea ocean management plan as a white paper to Parliament in March 2006 (Anon., 2006; Olsen et al., 2007; Winsnes and Skjoldal, 2008). To facilitate and regularize the planning process several groups were formed: an overarching management forum led by the Norwegian Polar Institute, a surveillance group led by the Institute of Marine Research, and a risk assessment group lead by the Norwegian Coastal Authority. A revised Lofoten–Barents Sea plan was presented to Parliament in March 2011 (Anon., 2011). A similar plan for the Norwegian Sea was presented to Parliament in 2009 (Anon., 2009; Ottersen et al., 2011), and one for the Norwegian sector of the North Sea was presented in April 2013.

So far these plans have had an important impact on decisions with regard to allowing oil and gas extraction in vulnerable areas. Their direct impact on fisheries management has been limited, but they have contributed to a general political appreciation of marine management that has been helpful in the evolution of an ecosystem-based fisheries management. At the same time, or on the other hand, to be successful these cross-sectoral plans will be completely dependent on comprehensive and effective ecosystem-based management of all relevant sectors, including fisheries.

The Marine Living Resources Act
On 1 January 2009 the Marine Living Resources Act entered into force (Norwegian Government, 2008). The previous act relating only to fisheries focused mainly on the exploitation of commercial stocks, whereas the new act applies to all living marine resources. The Marine Living Resources Act states that its purpose is to ensure sustainable and economically profitable management of the resources, and several provisions describe conservation of biodiversity as an integral part of sustainable management. The act reflects recent developments in international law with regard to conservation and fisheries. By integrating conservation and sustainable use as basic principles, the new law represents a regime shift in the management of fisheries.

Results in terms of improved ecological and economic sustainability
As in many other coastal states, Norwegian fisheries developed rapidly after 1945 (Figure 1). The broad picture is a fisheries development phase up to the 1960s, then a rather unmistakable overfishing phase with reduced yield that came to a head in the latter part of the 1980s, followed by rebuilding of major stocks, giving room for increased yield.

Management strategies and harvest control rules based on the Precautionary Approach, along with improved technical measures and an extensive enforcement regime, have contributed to the rebuilding of depleted stocks (Table 2), and laid the foundation for improved profitability in the fishery. Sustainability is radically improved. Aggregate spawning stock of ten of the economically most important stocks for Norwegian fisheries (Arctic cod, haddock and saithe, Greenland halibut, North Sea saithe and herring, mackerel, blue whiting, Norwegian spring spawning herring and Barents Sea capelin) has more than tripled since the latter part of the 1980s (Figure 6), so far contributing to a sustainable long-term annual aggregate Norwegian catch level of around 2.5
million tonnes (Figure 1). Not surprisingly, this level is lower than during the unsustainable peak years of the 1960s and 1970s, but it still represents an ~ 40% increase in aggregate catches over those in the latter half of the 1980s. The ambition expressed in Paragraph 31(a) of the Johannesburg Plan of Implementation: “to maintain or restore stocks to levels that can produce the MSY, with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015” (Anon., 2002b), had already been achieved in 2012 for nine of the ten stocks. [Greenland halibut spawning stock biomass has shown an increasing trend since 1992, but its status is uncertain due to lack of data (ICES, 2012).] Note that while the Johannesburg Plan of Implementation sets out clear ambitions in restoring stocks to levels that can produce MSY, it does not stipulate how stocks should actually be managed, as long as they are kept at or above such levels.

Mainly due to reduced stocks and catches, aggregate real income from fisheries decreased throughout the 1980s. From 1990 this trend was reversed as a consequence of the rebuilding of stocks and the possibility of gradually increasing sustainable catch levels (Figures 1 and 6). In combination with structural policy measures reducing the number of vessels, this has improved the profitability of the remaining fleet considerably. In recent years, the average operating margin in Norwegian fisheries has fluctuated between 12% and 22% (Figure 7). This is in stark contrast to the period when the industry failed to achieve satisfactory profitability, despite receiving substantial amounts in the form of subsidies.

Figure 4 reveals an apparent fleet overcapacity in technical terms, measured by aggregate horsepower. On the other hand, Figure 7 does not at present indicate overcapacity as measured in economic terms.

The reduction in numbers of fishers and vessels has facilitated increased productivity and profitability for those remaining in the industry (Figures 1 and 7). However, a decreased number of vessels and fishers have reduced the industry’s traditional role as the main contributor to employment and settlement in rural coastal communities. Fortunately, this departure from fishing occurred during a period with low unemployment rates and many alternative employment opportunities in Norway. This is likely to have been instrumental in enabling broad political consensus on the necessity of measures to reduce overcapacity. In this regard the situation in Norway has been more favourable, giving room for longer-term sustainability considerations than in many other countries.

In the face of declining participation in fisheries, countermeasures have been introduced to meet policy objectives with respect to regional stability and diversified ownership. Such countermeasures include regulations limiting ownership concentration and the transferability of fishing rights between geographical regions and between fleet groups. This has to some extent mitigated the adverse effects of fewer vessels and fishers.

Discussion

Since the collapse of the Norwegian spring spawning herring stock in 1970, Norway’s fisheries and fishery management system have gone through a long transitional period towards sustainability. Fisheries policy objectives have gradually shifted towards a stronger emphasis on ecological and economic sustainability, and a complex set of regulatory measures have been developed and put into force. The economically important fish stocks have responded, producing higher spawning stock biomasses enabling higher yield.

The focus has been on rebuilding economically important fish stocks, and the positive results have to a very large extent been brought about within a traditional single species fisheries management context. Resources of minor economic significance have not been subject to the same research and management efforts, and some of these resources are in a depleted state. As part of the development of ecosystem-based fisheries management, more attention is now being directed towards the protection of vulnerable resources of little or no economic significance. This protection trend has been accentuated through the last decade, and the number of marine species on the official Norwegian Red List has been reduced from 33 in 2006 to 17 in 2010 (Anon., 2010). However, it must be added that the downgrading is largely due to better-informed assessments based on the availability of new data. Improving and broadening the database is an important element in efforts to approach an ecosystem-based fisheries management.

For these species, however, there is no movement towards a management regime identical to the one in place for resources of greater economic importance. There are a couple of reasons for this, the most important one being that it is not cost-effective. The research, monitoring, management and control costs of optimizing yield will very quickly exceed the surplus value that might be obtained from an optimally managed stock.

Secondly, in contrast to the large oceanic fish stocks, which in essence are harvested by a limited number of registered, professional fishers, these stocks are mainly coastal resources where a large and unknown number of recreational fishers may contribute significantly to the exploitation. Hence, the management and control tasks are much more challenging and costly (Dowling et al., 2013).

Stocks and species that account for nearly 90% of the total Norwegian catch value are already or could realistically be supported by adequate data and hence be subject to analytical assessment. These stocks will be managed with the objective of optimizing long-term yield or benefits. How this objective will evolve into revised harvest control rules in each individual case remains to be seen. However, in accordance with paragraph 7 of the Marine Living Resources Act (Norwegian Government, 2008), such harvest control rules must be consistent with the precautionary approach.

Stocks for which there is limited information, but which are of some economic importance, will be managed with the objective of
securing a high, and if possible, stable long-term yield. Catches may from time to time be higher, or lower, than what would have been regarded as optimal if more knowledge had been available. Such stocks account for ~ 5% of the total catch value.

For the many species and stocks that constitute the last 5% of total catch value, no such ambitious objectives have been set. The same applies for non-commercial species, including incidental bycatch of seabirds and marine mammals, for which there is no intended catch and the term “yield” is not meaningful. However, a general and absolute minimum objective for all species, stated in paragraph 7 of the Marine Living Resources Act, is the protection of biological diversity. More specifically: the objective is to ensure that fishing does not threaten either species or the functioning of ecosystems. The term “threaten” does not have a strict legal interpretation in this context. In addition to the official Norwegian Red List (Anon., 2010), input from ICES, the Institute of Marine Research, and other scientific sources may be relevant for this assessment. Beyond this environment-related minimum obligation, management becomes an issue of political, economic, and practical administrative balance: in each case one must decide how far one is willing to go to optimize long-term yield or, for that matter, maintain large populations of non-commercial species. The further one wishes to go towards ensuring optimal yield for fishery resources with low commercial value or managing non-commercial species, the more it would cost, not only in terms of research and management efforts, but also in terms of regulatory interventions targeting commercial and recreational fishing.

With this background, deciding on management objectives for the various species and stocks has turned out to be an integral part of the development of ecosystem-based fisheries management.

Promotion of species- and size-selective fisheries is an important foundation for Norwegian fisheries management. An international debate has emerged on whether more selective fishing really maximizes production and minimizes impacts, and more balanced harvesting of species and sizes is put forward as an alternative, on the basis of ecosystem modelling, showing that such a system may give higher total yield in the long run (Garcia et al., 2012). We are sceptical of such results—at least we do not find them applicable to Norwegian cold-water ecosystems—and argue that experiences from the last 50 years give convincing evidence of non-selective fisheries having a detrimental impact on stocks and yield.

As consensus emerges that we are now living in the Anthropocene time epoch (Svitski and Kettner, 2011), we have attempted to present the development of a management system that is able to prevent overfishing and secure long-term sustainability. With all the elements we have described in proper operation, we believe it should be possible to manage fisheries sustainably and ensure that fish can be a food source for future generations.

To further optimize management of the economically important stocks in an integrated ecosystem-based context, we anticipate further restructuring of the fleet through voluntary licence aggregation with the objective of keeping the fleet profitable. Likewise we foresee continued efforts to increase economic output through improvements in exploitation patterns and reduction of all forms of incidental and unwanted mortality from fishing. Further effort to optimize the long-term economic yield through revision of management strategies and harvest control rules is anticipated. As new scientific knowledge becomes available, additional ecosystem considerations will gradually be incorporated into management, including multispecies interactions, effects of fishing on benthic habitats, and effects of bycatch of fish, seabirds and marine mammals. With regard to the non-commercial and the economically less-important species, it is anticipated that efforts will be stepped up, both to prevent red-listing of new species and to enable downgrading of species that still remain on the list. Efforts to balance conservation and fisheries perspectives will continue as the ecosystem-based approach to fisheries management is integrated into the Ocean Management Plans.

The concept of overfishing, and the measures taken to curb it, has developed over time. With the introduction of an ecosystem-based approach to fisheries management, we conclude that this development has not come to an end.

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