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Status and trends of the major roundfish, flatfish, and pelagic fish stocks in the North Sea: thirty-year overview

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Changes in the status of the major roundfish, flatfish, and pelagic stocks in the North Sea over the past 30 years are reviewed. Synopses are presented on trends in catches, fishing mortality, spawning-stock biomass, and recruitment for eight stocks (cod, haddock, whiting, saithe, plaice, sole, herring, and mackerel), together with an evaluation of the current state of these resources and the most recent management advice provided by the ICES Advisory Committee on Fishery Management.

Key words: cod, flatfish, haddock, herring, mackerel, management advice, North Sea, pelagic stocks, roundfish, saithe, status and trends, stocks and fisheries, whiting.

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Introduction

At the time of the 1975 ICES Symposium on "North Sea Fish Stocks – Recent Changes and Their Causes" (Hempel, 1978), striking transformations were under way in both the status and management of North Sea fisheries. The stocks of herring and mackerel were collapsing due to recruitment overfishing and catches from the roundfish stocks, which had increased markedly in the mid-1960s and early 1970s owing to improved recruitment, were at the beginning of a sustained 20-year decline (Fig. 1). New management authorities and responsibilities were evolving as a consequence of the onset of extended fisheries jurisdiction; in 1977 the European Community (now European Union) assumed management control of fishery resources within EC waters, and in 1978 a new convention for the North-East Atlantic Fisheries Commission (NEAFC) was enacted (Parrish, 1988). A metamorphosis was also occurring in the development and provision of scientific advice to fisheries managers as the ICES Advisory Committee on Fishery Management (ACFM), a body comprising national scientific experts from each ICES Member Country, replaced the ICES Liaison Committee in 1978 (Serchuk and Grainger, 1992). Fisheries assessment science was also rapidly changing due to the full development and widespread use of computer-based analytical procedures such as virtual population analysis and the emergence of multispecies models (Andersen and Ursin, 1978).

In this article we review the changes that have occurred in the status of the major roundfish, flatfish, and pelagic stocks in the North Sea during the past 30 years. Synopses are presented on trends in catches, fishing mortality, spawning-stock biomass (SSB), and recruitment for eight stocks (cod, haddock, whiting, saithe, plaice, sole, herring and mackerel), along with an evaluation of the current state of these resources and the most recent management advice provided by ACFM. Our information is drawn from the latest reports available from the ICES Working Groups responsible for the assessment of these stocks (ICES, 1995a, 1996a, b), and from the 1993, 1994 and 1995 ACFM Reports (ICES, 1994, 1995b, 1996c). In all cases, the time series of data presented are those which the Working Groups and ACFM believe best characterize the evolution of the stocks and their associated fisheries.

Stock synopses

North Sea cod (*Gadus morhua*) (Fig. 2)

Landings increased from 108 000 t in 1963 to a record-high 341 000 t in 1972. Annual landings fluctuated

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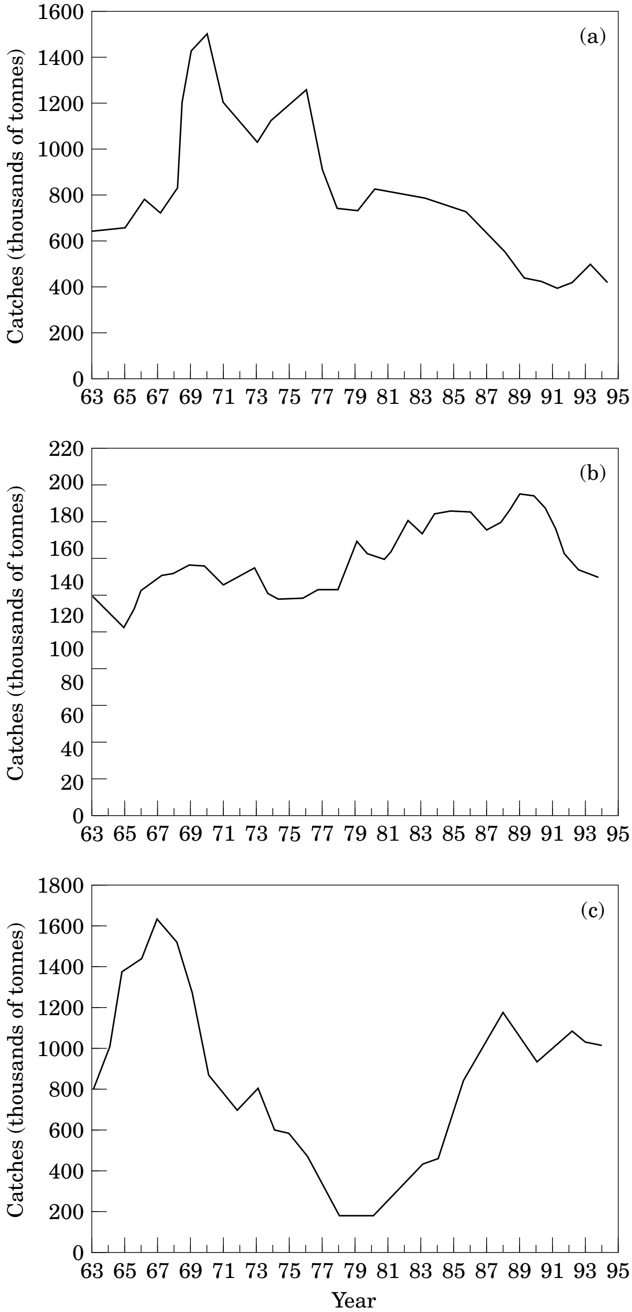


Figure 1. Total catches of: (a) North Sea roundfish (cod, haddock, whiting, saithe); (b) North Sea flatfish (plaice and sole); and (c) North Sea herring and mackerel, 1963–1994. Catches of haddock and whiting include estimated discards. Catches of herring include landings of North Sea autumn-spawning herring taken in the North Sea (Subarea IV), the Eastern English Channel (Division VIId), and the Kattegat and Skagerrak (Division IIIa). Catches of mackerel include landings taken only in the North Sea (Subarea IV), but from both the North Sea and Western mackerel stocks.

considerably between 1965 and 1981, but subsequently steadily declined to 88 000 t in 1994, the lowest level since 1956. Estimates of total discards are not available but discards of 1-year-old cod have been considerable in some years. Fishing mortality (F) has increased continuously during the past 30 years, doubling between 1963 and 1989. Since 1991, F has stabilized at record-high levels ($F \approx 0.90$), in excess of the biological reference

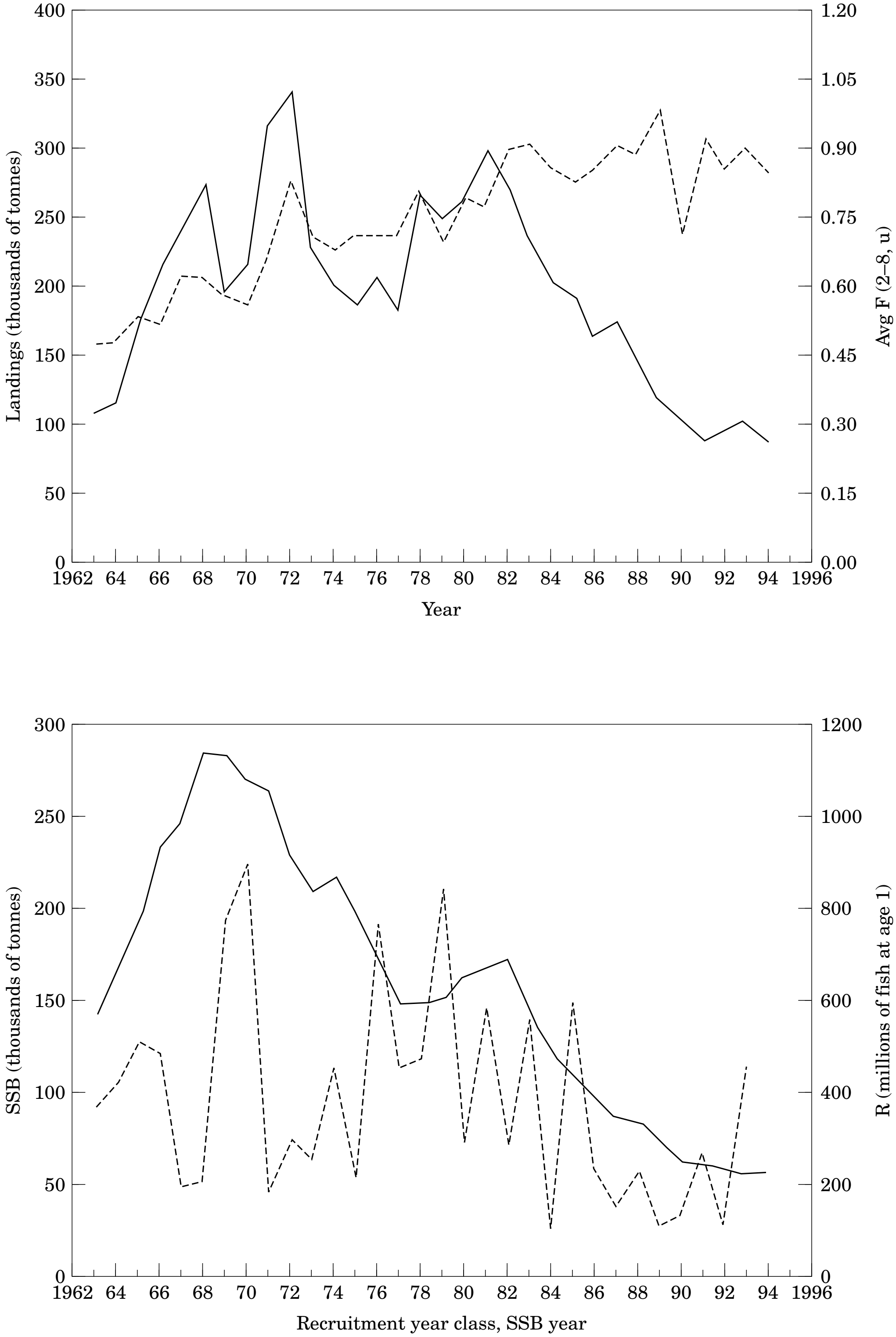


Figure 2. Trends in landings (——) and fishing morality (– – –) (top) and spawning-stock biomass (——) and recruitment (– – –) (bottom) for North Sea cod, 1963–1994 (data from ICES, 1996c).

points[1], F_{max} (0.24) and F_{med} (0.81). The present exploitation pattern is far from optimal, with landings dominated by 2-year-old immature fish.

SSB peaked at about 280 000 t in 1968 but has sharply declined since 1970, reaching record-low levels in 1993 and 1994 (<60 000 t). Since 1983, SSB has been well below the minimum biologically acceptable level (MBAL)[2] of 150 000 t, despite above-average recruitment from the 1981, 1983, 1985, and 1993 year classes. The stock is presently considered to be at a level where reduced low spawning-stock size has affected recruitment. Apart from the 1993 cohort, all year classes from 1987 onward have been below average, with most of these among the lowest observed in the assessment time series.

Given record-high exploitation rates (less than 1% of age 1 recruits presently survive to become mature) and record-low SSB and recruitment levels, ACFM has since 1990 considered the North Sea cod stock to be "outside safe biological limits". ACFM has noted that "seen in isolation, fishing effort on cod should be reduced to zero" to increase the stock towards the MBAL level at the fastest possible rate. Recognizing that effort on cod is to a large extent directed through mixed demersal fisheries (and that other North Sea roundfish stocks have also been close to or outside safe biological limits), ACFM has for the past 5 years recommended that "fishing effort in the directed fisheries on North Sea roundfish, except saithe, be reduced significantly and on a sustained basis relative to effort levels in the most recent years". In the advice for 1995, a significant reduction in fishing effort was defined to be "as a minimum, a reduction to 70% of the effort level in recent years, implemented in such a way that a similar reduction in fishing mortality is achieved". ACFM has stressed that reductions in fishing effort are required since the management approaches that have been used to date (e.g. total allowable catches [TACs] and technical measures) have not resulted in the desired reductions in fishing mortality. As a consequence, the cod stock remains in an overfished condition. Medium-term projections indicated that if fishing mortality were reduced by 30%, SSB would (with a high degree of assurance) rapidly increase to above the MBAL level.

North Sea haddock (*Melanogrammus aeglefinus*) (Fig. 3)

During 1963–1968, total catches (human consumption, industrial by-catch, and discards) averaged 307 000 t per year. Catches dramatically increased in 1969 to a record-high of 929 000 t due to outstanding recruitment from the 1967 year class. Catches markedly declined afterwards before stabilizing at about 200 000 t during 1980–1988. Catches fell to a record-low level of 86 000 t in 1990, but increased after 1991 due to improved recruitment. Since 1969, fishing mortality has ranged between 0.71 (1982) and 1.11 (1978), well in excess of F_{max} ($F=0.39$) and F_{med} ($F=0.57$). Apart from the early 1980s and early 1990s, F has remained very high (≥ 0.90).

SSB increased to over 500 000 t in 1965, reached a record-high in 1970 (>800 000 t), but subsequently declined to around 100 000 t in 1979. SSB increased during 1980–1982 but afterwards fell, reaching a record-low of about 60 000 t in 1991. Since then, SSB has significantly increased, doubling between 1991 and 1994.

During 1990–1993, ACFM considered the North Sea haddock stock to be "outside safe biological limits" as: (a) SSB was lower than MBAL (100 000 t); (b) fishing mortality was at a record-high and in excess of F_{med}; (c) the exploitation pattern was suboptimal, with only 2% of the age 0 recruits surviving to reach maturity; and (d) recruitment of the 1987–1989 year classes were the poorest on record. Despite these conditions, SSB has begun to recover due to improved recruitment, and increased above MBAL in 1993. Because SSB was expected to remain at or above 150 000 t in the short and near term, ACFM in 1994 (and again in 1995) considered the North Sea haddock stock to be "within safe biological limits". However, as the stock is heavily dependent on incoming year classes, ACFM noted that this situation could quickly change if exploitation rates remained high and recruitment declined. Thus, the advice for 1995 reiterated the previous ACFM recommendation that "fishing effort in the directed fisheries on North Sea roundfish, except saithe, be reduced significantly and on a sustained basis relative to effort levels in the most recent years". In practice, however, no significant reductions in fishing mortality have occurred in recent years.

North Sea whiting (*Merlangius merlangus*) (Fig. 4)

The fishery for whiting is part of the mixed trawl fishery in which cod and haddock are also taken. Total catches

[1]Biological reference points (BRPs) "represent a set of signposts that enable scientists and managers to judge the state of exploitation of the stocks. They are of two types: BRPs defined by values of fishing mortality rate on the yield-per-recruit curve [and] BRPs based on the sustainability of recruitment at different levels of fishing mortality" (ICES, 1992). F_{max} is the level of fishing mortality – for a given exploitation pattern, growth rate and natural mortality – that results in maximum yield-per-recruit. F higher than F_{max} is considered to represent "growth overfishing". F_{med} is the level of F – for a given set of environmental and ecological conditions – at which it is probable that recruitment will in the long term be sufficient to maintain a stock. F higher than F_{med} is considered to represent "recruitment overfishing".

[2]MBAL is the "level of spawning stock size below which the probability of poor recruitment increases as spawning stock size decreases" (ICES, 1992). When SSB is below MBAL (or expected to fall below MBAL in the near future), the stock is categorized as "outside safe biological limits".

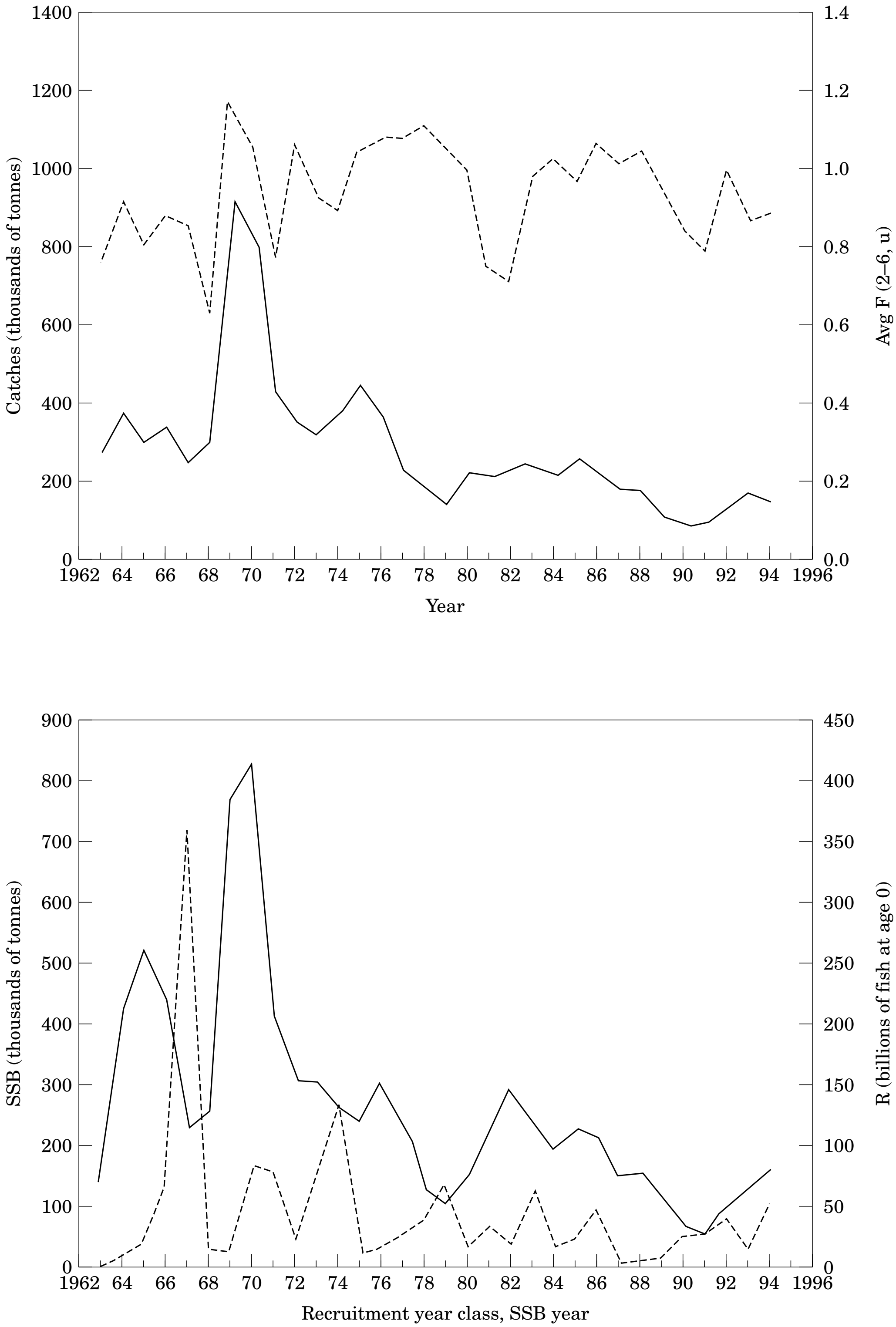
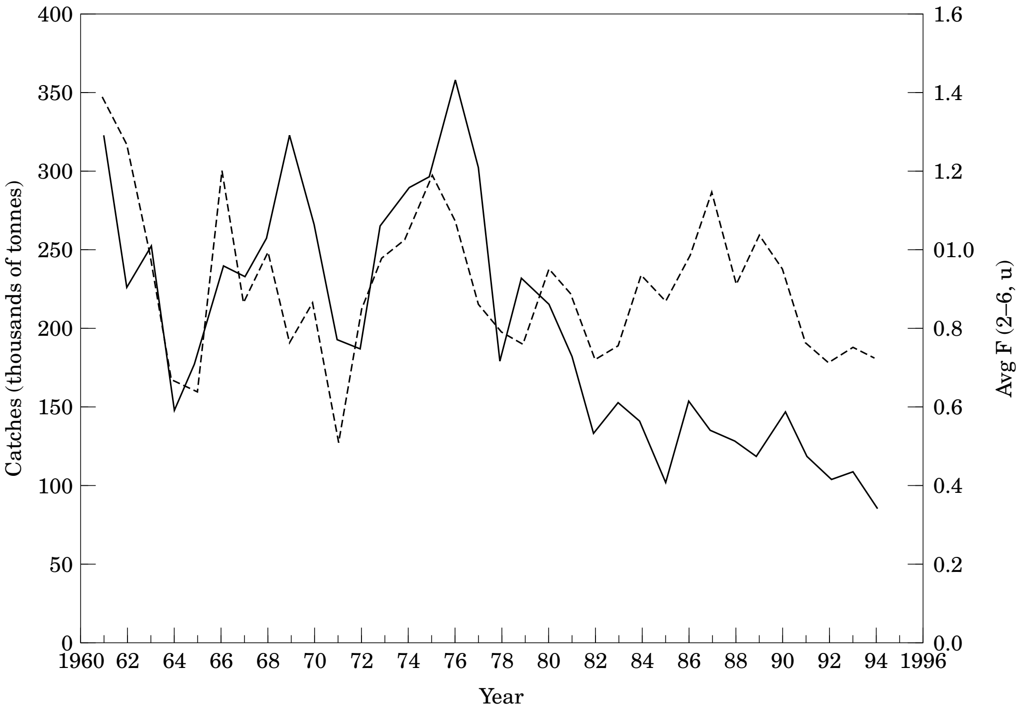


Figure 3. Trends in catches (——) (including discards) and fishing mortality (– – –) (top) and spawning-stock biomass (——) and recruitment (– – –) (bottom) for North Sea haddock, 1963–1994. (data from ICES, 1996c).



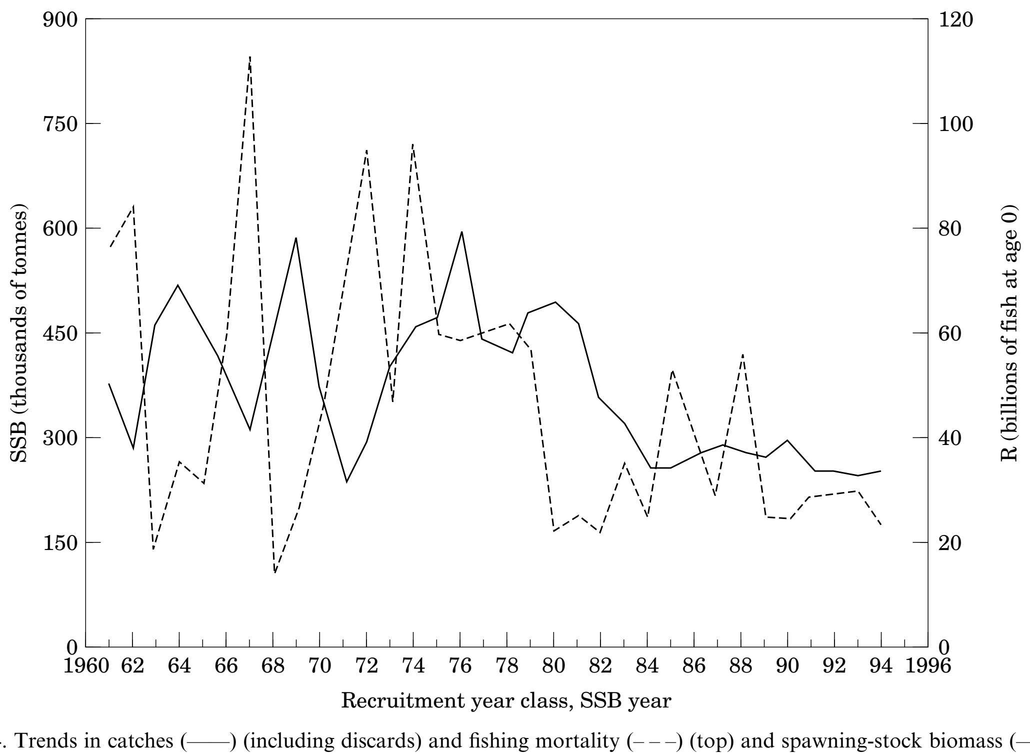


Figure 4. Trends in catches (——) (including discards) and fishing mortality (– – –) (top) and spawning-stock biomass (——) and recruitment (– – –) (bottom) for North Sea whiting, 1961–1994 (data from ICES, 1996c).

of whiting (human consumption, industrial by-catch, and discards) ranged between 147 000 and 361 000 t during 1960 and 1976, but declined to a stable level of about 125 000 t after 1985. Catches decreased to 85 000 t in 1994, the lowest level in the 1960–1994 time series. In all years, industrial by-catches and discards account for more than half the total catch. Fishing mortality has been variable, ranging between 0.50 (1971) and 1.50 (1960). There have been no consistent trends over the past 30 years. Since 1990, F has been slightly below F_{med} (0.80).

SSB peaked in both 1969 and in 1976 at about 600 000 t, but declined between 1980 and 1984. Since 1984, SSB has been very stable, varying between 260 000 and 300 000 t. Recruitment was relatively high during 1961–1978, low during 1980–1984, and slightly below average during 1985–1994. The 1985 and 1988 year classes, however, were above average.

The assessment of the whiting stock has always been of lower precision than most other North Sea roundfish stocks, and VPA estimates of recruitment and trends in SSB do not correlate well with survey data. Nonetheless, given that recent SSB and recruitment levels have been stable, ACFM has considered that the stock is probably "within safe biological limits", although the exact state of the stock is uncertain. In principle, there is no direct need to reduce fishing mortality on whiting. However, because of the mixed species nature of the directed roundfish fisheries, a reduction in fishing effort for cod and haddock cannot be implemented independently of that for whiting. Thus, ACFM has recommended that "fishing effort in the directed fisheries on North Sea roundfish, except saithe, be reduced significantly and on a sustained basis relative to effort levels in the most recent years". The quality of the assessment is not sufficiently high to conclude that the apparent recent decline in F reflects a real reduction in effort.

North Sea saithe (*Pollachius virens*) (Fig. 5)

Saithe are primarily taken in a directed trawl fishery that began in the 1970s. Total landings (human consumption and by-catches in the industrial fishery) increased in the early and mid-1970s, peaking in 1976 at 320 000 t. Landings declined in the late 1970s, increased to about 200 000 t in 1984 and 1985, but subsequently declined and have remained stable at record-low levels ($\leq$100 000 t) since 1988. Fishing mortality increased gradually during the early 1970s, peaked in 1976, and then declined sharply during 1977–1981. Subsequently, F increased to a record-high in the mid-1980s, followed by a marked decline. F in 1994 was estimated to be about twice as high as F_{max} (0.22), but nearly identical to F_{med} (0.47).

SSB peaked in 1973 at nearly 500 000 t, but steadily declined afterwards, reaching a record-low of about 80 000 t in the early 1990s. Strong year classes were produced in 1973 and during 1981–1983. Apart from the 1990 cohort, recruitment from 1984 onwards has been below-average.

Although the saithe stock remained near historically low levels in 1993 and 1994, ACFM has considered the stock to be "close to safe biological limits" based on the declining trend in F since 1986 and the slight improvement in SSB since 1992. However, ACFM noted that any increases in fishing mortality would "have a high probability of reducing the stock below safe biological limits" and therefore recommended "that fishing mortality should not be increased".

North Sea plaice (*Pleuronectes platessa*) (Fig. 6)

Plaice are primarily taken by beam trawl fleets in a mixed fishery for plaice and sole in the southern and south-eastern North Sea, where large numbers of juveniles are discarded. However, quantitative estimates of discards are lacking. Larger plaice are also taken in directed seine and gillnet fisheries and by beam trawlers in the central North Sea. Landings of plaice have risen steadily during the past 30 years, increasing by nearly 2.5 fold between 1957 and the late 1980s. Since 1990 landings have declined, falling to about 110 000 t in 1994. Fishing mortality has steadily increased since the 1950s, more than doubling over the time period. Average F during 1991–1994 (0.44) was well above both F_{max} (0.24) and F_{med} (0.28).

SSB increased during the early and mid-1960s, attaining a record-high of nearly 500 000 t in 1967 due to outstanding recruitment from the 1963 year class. During the next 13 years, SSB declined, but increased again in the 1980s, reaching a peak of more than 400 000 t in 1989, owing to excellent recruitment. Since 1990, SSB has declined to a record-low level (<300 000 t). Recruitment was relatively high during the 1980s, with the 1981 and 1985 cohorts the strongest on record. Since 1986, recruitment has declined to the levels of the late 1960s and early 1970s. The 1988–1993 year classes were the poorest in a decade.

Prior to 1993, ACFM considered the plaice stock to be "within safe biological limits". However, in 1993 SSB declined below MBAL (300 000 t), while fishing mortality continued at a record-high[3]. Short and medium-term projections indicated that continued fishing at current levels of fishing mortality would reduce SSB even further. Since 1994, ACFM has therefore considered the stock to be "outside safe biological limits" and recommended "a significant and sustained reduction in fishing mortality" to allow SSB to increase to above MBAL within a few years. In 1995, ACFM indicated

[3]In the 1994 assessment, unreported landings in 1988–1991 were revised downwards, resulting in lower recent stock sizes.

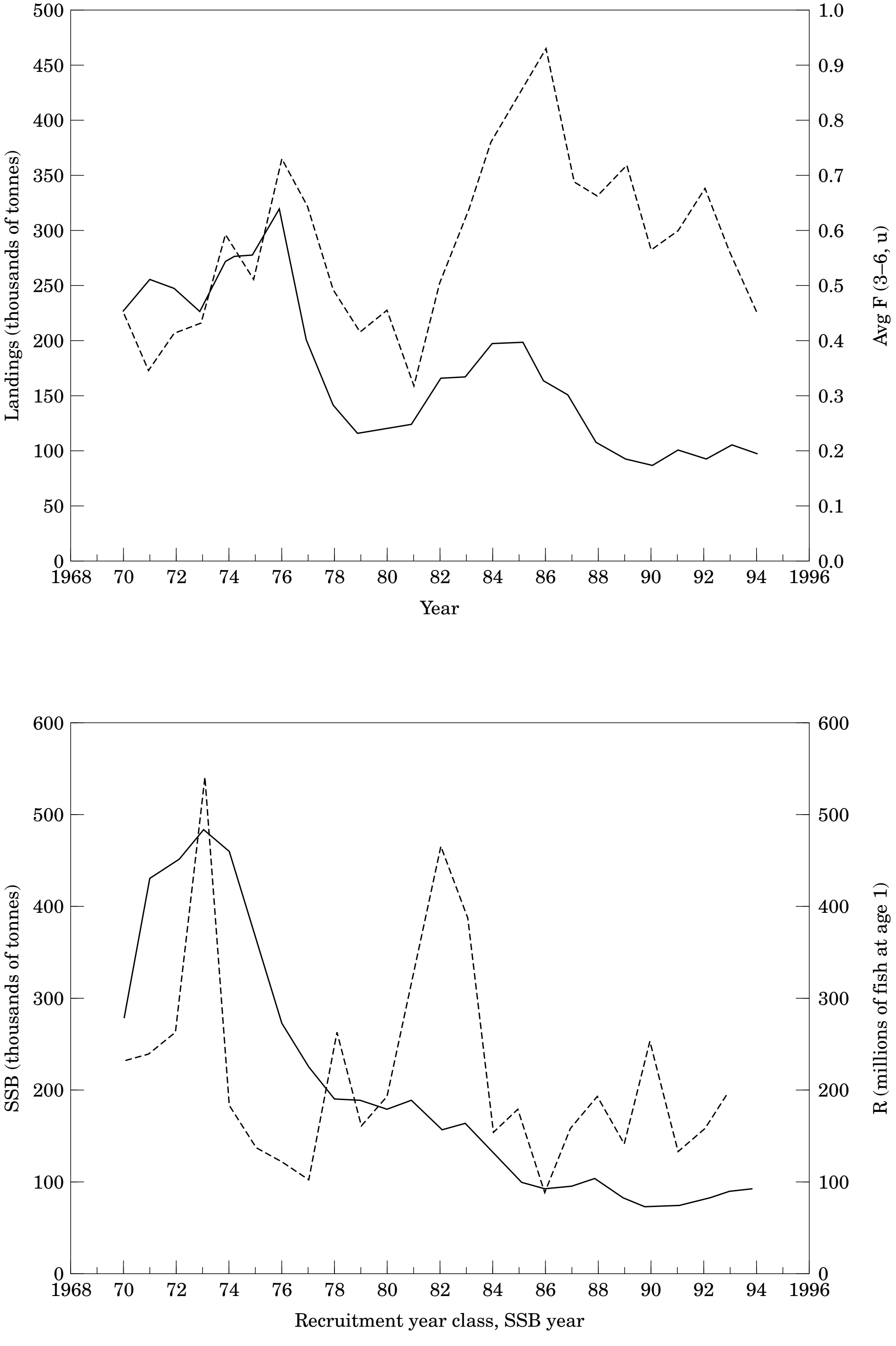
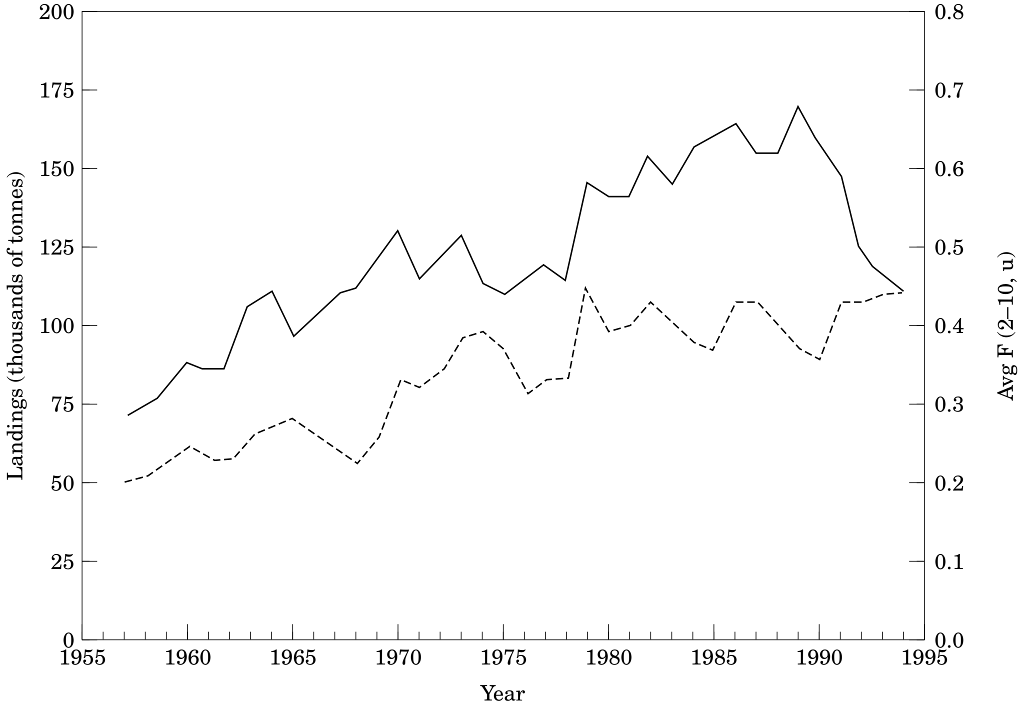


Figure 5. Trends in landings (——) and fishing mortality (– – –) (top) and spawning-stock biomass (——) and recruitment (– – –) (bottom) for North Sea saithe, 1970–1994 (data from ICES, 1996c).



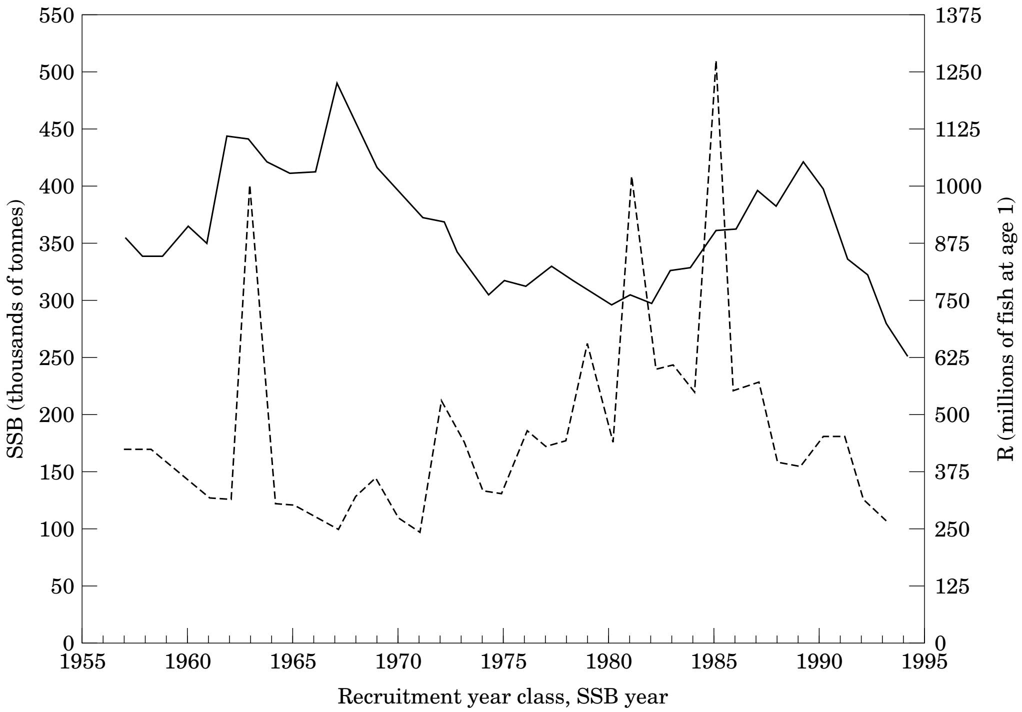


Figure 6. Trends in landings (——) and fishing mortality (– – –) (top) and spawning-stock biomass (——) and recruitment (– – –) (bottom) for North Sea plaice, 1957–1994 (data from ICES, 1996c).

that "a 40% reduction in F is the minimum reduction required to achieve a high probability of an increase in SSB above MBAL in the medium term". ACFM further noted that a reduction in F of more than 80% would be needed for SSB to increase above 300 000 t by 1997. However, as with other North Sea stocks, there has been no sign as yet that the TACs implemented have effectively constrained fishing mortality.

North Sea sole (*Solea solea*) (Fig. 7)

Sole are primarily exploited by beam trawl fleets in a mixed flatfish fishery in the southern North Sea. Sole are also taken in a directed gillnet fishery in coastal areas. Landings increased rapidly in the late 1950s–early 1960s, doubling between 1957 and 1961. In 1964, landings plummeted but recovered afterwards, increasing to over 30 000 t during 1966–1968. During the 1970s and 1980s, annual landings fluctuated around 20 000 t. Landings were sharply higher in 1990 and 1991 and averaged about 31 000 t during 1992–1994. Fishing mortality steadily increased by a factor of 4 from the mid-1950s through the mid-1980s and has remained high ever since, far beyond F_{max} (0.23) and well above F_{med} (0.33).

SSB peaked at nearly 150 000 t in 1961–1963 owing to outstanding recruitment from the 1958 year class, but dropped sharply in 1964 due to an extraordinary natural mortality caused by extremely low water temperatures in the severe winter of 1962/1963 (de Veen, 1978). In 1966–1967, SSB peaked at slightly above 100 000 t owing to excellent recruitment from the 1963 year class. Thereafter, SSB declined before stabilizing at around 40 000 t during 1973–1989. SSB more than doubled in 1990 due to recruitment from the very strong 1987 year class. In 1994, it increased again due to the strong 1991 year class.

The sole stock is considered by ACFM to be "within safe biological limits". Although fishing mortality is at an historically high level, SSB is well above MBAL (35 000 t) and likely to remain so in the medium term. However, because fishing mortality has been above F_{max}, ACFM has indicated that no long-term gains in yield per recruit would be realized by increasing fishing mortality. Recognizing that sole are jointly harvested with plaice in the mixed-species fishery for flatfish, ACFM further noted that "any management measures (enacted for sole) should take into account the recommended reduction (advised by ACFM) in fishery mortality on plaice". Logistically, this has been quite difficult to accomplish and in practice the resultant regulations have not been very successful.

North Sea herring (*Clupea harengus*) (Fig. 8)

Total landings of North Sea herring include all catches from the North Sea autumn-spawning herring stock taken in the North Sea (Subarea IV), the Eastern English Channel (Division VIId), and in the Kattegat and Skagerrak (Division IIIa). Herring are taken in several fisheries in these areas including: (a) directed herring fisheries (mainly for human consumption) in the North Sea; (b) small mesh fisheries in the North Sea; (c) human consumption fisheries in Division IIIa; (d) the "mixed clupeoid" fishery in Division IIIa; and (e) other industrial fisheries in Division IIIa.

Total landings fluctuated between 600 000 and 800 000 t during 1951–1964 but increased to nearly 1.2 million t in 1965. Landings markedly declined afterwards, reaching extremely low levels (<50 000 t) in the late 1970s, but increased sharply in the early and mid-1980s, peaking at nearly 900 000 t in 1988. Since then, landings have again declined.

During the late 1950s and early 1960s, fishing mortality was relatively stable at about 0.40. Beginning in the mid-1960s, F rapidly increased, exceeding 1.00 during most of the 1968–1976 period. This reflected the rapid expansion of the purse seine fishery. In response to a precipitous decline and collapse in the stock, a total ban on herring fishing in the North Sea was enacted in 1977. As a result, fishing mortality dropped to negligible levels in 1978 and 1979. As the stock recovered, unavoidable by-catches induced significant fishing mortality, which increased further after the herring fishery was reopened in 1983 under a TAC regime. Since 1986, F has fluctuated around 0.50. However, exploitation on juvenile herring in the small-mesh fishery for sprat has increased significantly in recent years. These by-catches substantially reduce the long-term yield of adult herring and diminish the future reproductive potential of the stock.

Between 1947 and 1977, SSB declined by approximately two orders of magnitude (from nearly 5 million t to about 50 000 t) interrupted by only two short periods of increased recruitment. SSB steadily increased during the 1980s as recruitment improved (all year classes between 1981 and 1987 were above average) and during 1988–1990 again exceeded 1 million t. SSB subsequently declined, and fell below the MBAL of 800 000 t during 1992–1994. Outstanding year classes were produced in 1956 and 1960. Recruitment declined throughout the 1960s and mid-1970s, and by the early 1970s the stock had collapsed due to recruitment overfishing. The stock recovered in the 1980s because of above-average recruitment (including the very strong 1984–1986 cohorts).

For a number of years, ACFM advised that a relatively low fishing mortality on the North Sea herring stock would tend to stabilize catches and that no long-term gains in yield would accrue when fishing mortality was higher than 0.30. ACFM also consistently noted that reducing fishing mortality on juveniles would result in increased SSBs and higher long-term yields of adult herring. Total annual catches, however, have routinely

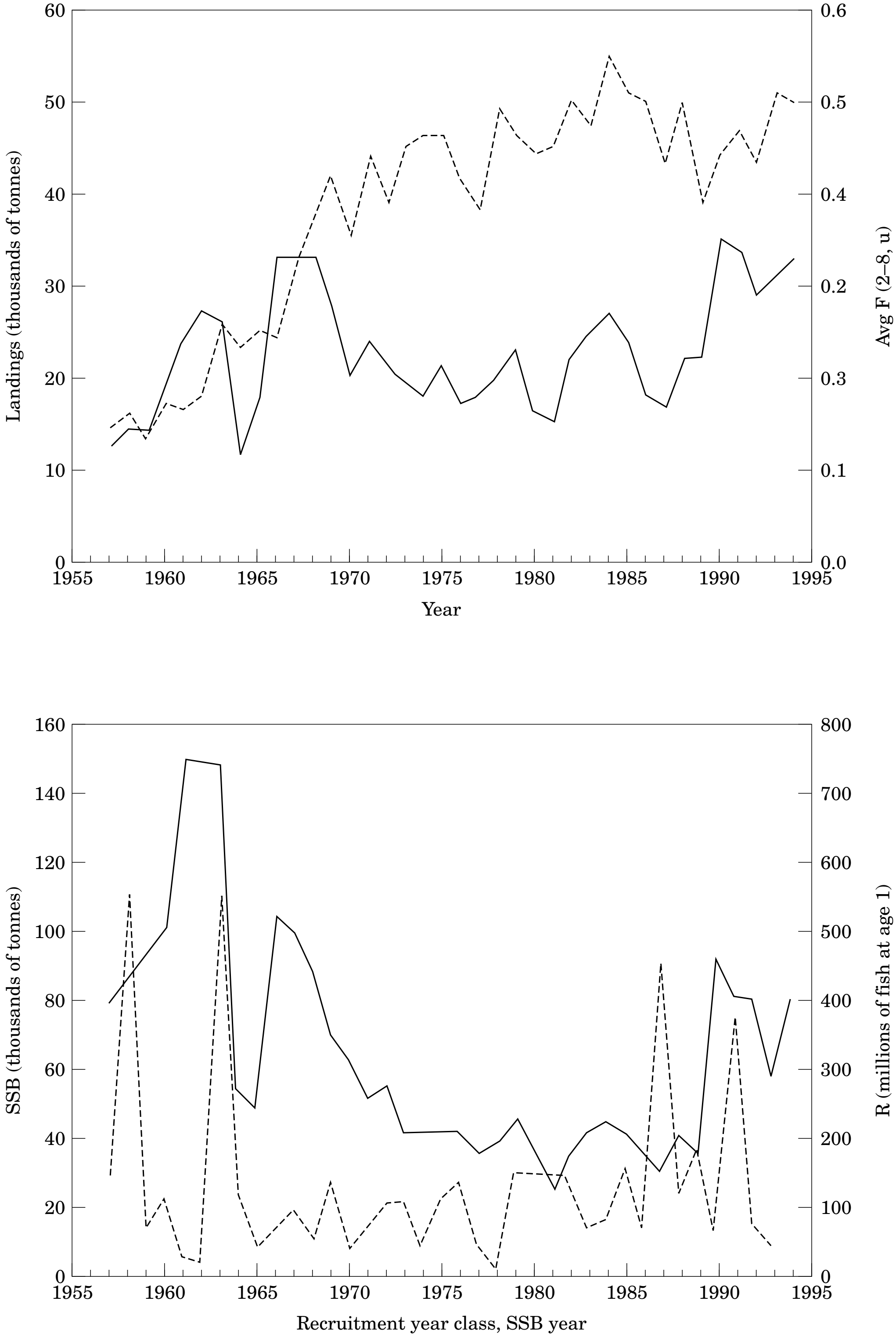


Figure 7. Trends in landings (——) and fishing mortality (– – –) (top) and spawning-stock biomass (——) and recuitment (– – –) (bottom) for North sea sole, 1957–1994 (data from ICES, 1996c).

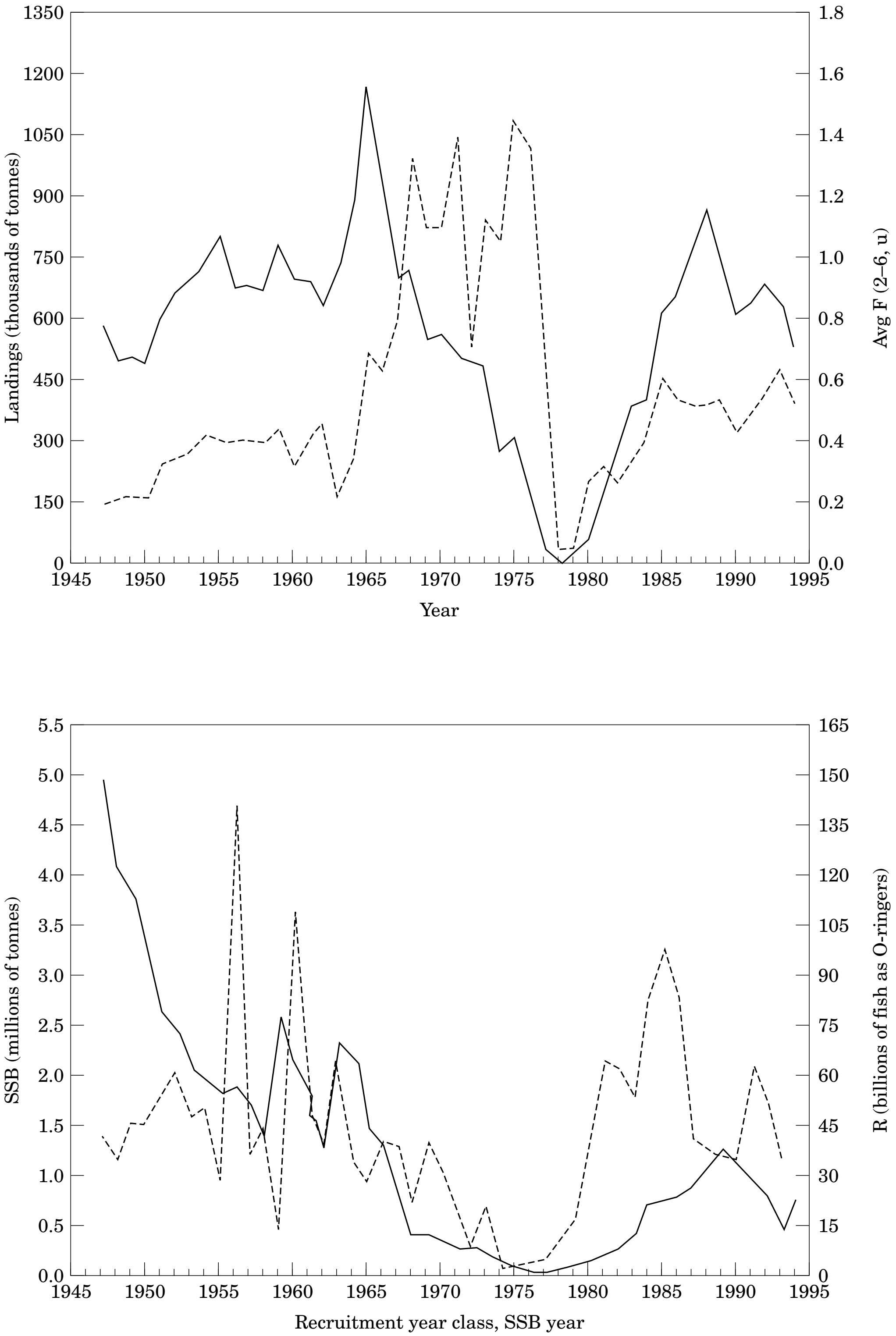


Figure 8. Trends in landings (——) and fishing mortality (– – –) (top) and spawning-stock biomass (——) and recruitment (– – –) (bottom) for North Sea herring, 1947–1994. Landings include all North Sea autumn-spawning herring (see also legend to Figure 1; data from ICES, 1996c).

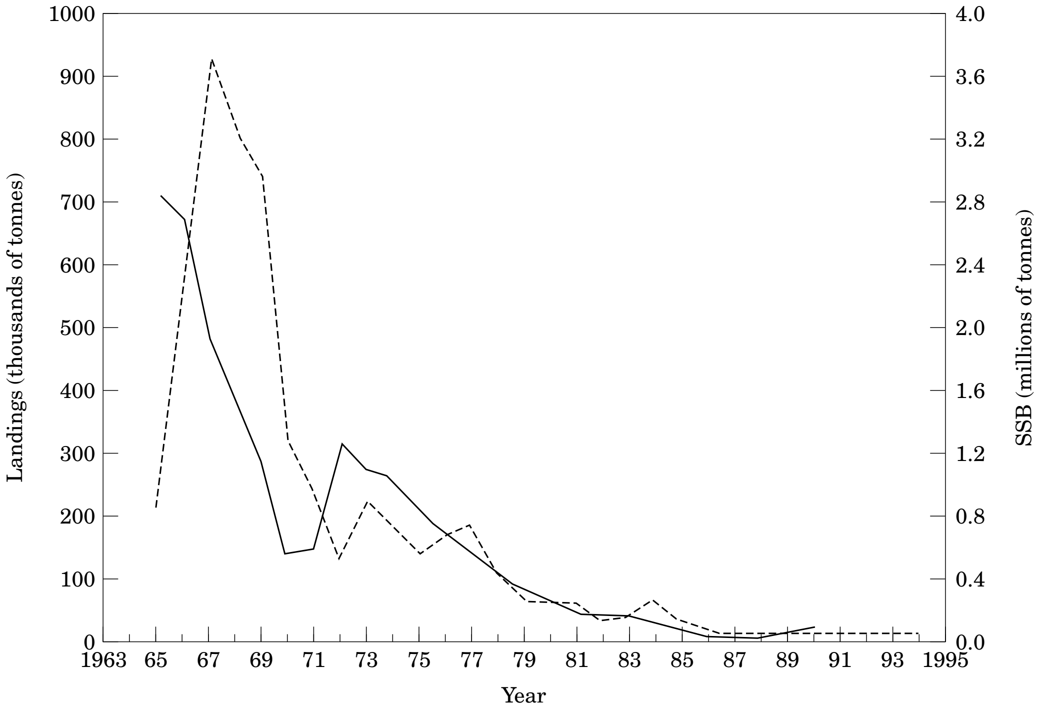


Figure 9. Trends in landings (– – –) and spawning-stock biomass (——) for North Sea mackerel, 1965–1990 (data from ICES, 1996c).

exceeded agreed TACs, in part because most of the juvenile catches are not counted against national quotas. To resolve these problems, ACFM has, since 1992, advised that the overall TAC for the North Sea herring stock be divided amongst the various herring fisheries and that these fishery quotas be individually and separately managed.

Prior to 1995, ACFM considered the North Sea autumn-spawning herring stock to be "within safe biological limits". Although SSB had declined below MBAL in 1993, the stock was expected to increase to about 1 million t in 1994 owing to improved growth (mean weights-at-age were very low in 1993) and significant recruitment to the spawning stock of the good 1991 year class. However, although SSB increased in 1994, it did not rise above MBAL[4]. In 1995, ACFM therefore considered the herring stock to be "outside safe biological limits" and noted that both short-term and medium-term projections indicated that the stock had a very high probability of remaining below MBAL at the currently high levels of exploitation. Accordingly, ACFM recommended "a significant reduction in exploitation in order to rebuild SSB and suggests that F in 1996 be reduced by at least 50% of (the) levels observed in 1994" and provided a catch forecast table by fleet indicating how this might be accomplished. However, TACs have seldom constrained fishing mortality as annual landings have typically exceeded agreed levels.

[4]In 1995, the assessment was calibrated with a modified acoustic survey series, in which biomass estimates from surveys conducted in 1987 and 1988 were excluded because they were considered to be anomalously low. The 1995 assessment resulted in a more pessimistic view of the state of stock than in previous assessments.

North Sea mackerel (*Scomber scombrus*) (Fig. 9)

The North Sea mackerel stock collapsed after being intensively exploited during the mid- and late 1960s. Prior to 1964, annual landings averaged less than 100 000 t. In 1964, purse seine fisheries developed in the North Sea and total catches rapidly increased, rising from about 200 000 t in 1965 to more than 900 000 t in 1967. Subsequently, landings plummeted, falling below 100 000 t after 1978. During 1979–1986, landings ranged only between 25 000 and 66 000 t. Since 1987 it has not been possible to allocate the catches of mackerel taken in the North Sea between the North Sea and Western mackerel stock units; from 1991 onwards, annual catches from the North Sea stock have been assumed to be 10 000 t.

Prior to the development of the purse seine fisheries in the mid-1960s, SSB exceeded 3.0 million t (Jones, 1983). However, SSB declined precipitously (by nearly 80%) between 1966 and 1970. It improved during 1972–1974, due to strong recruitment from the 1969 year class, but

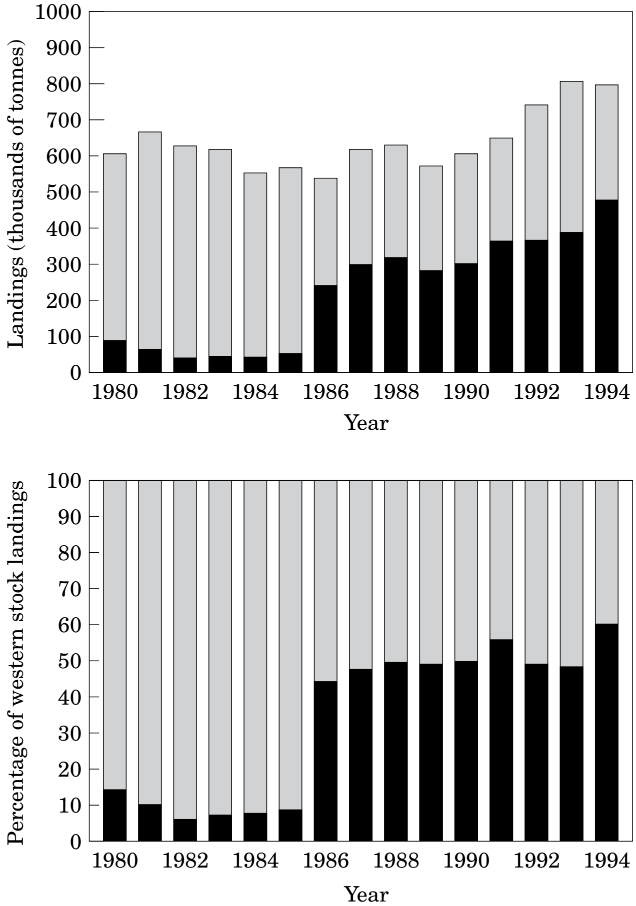


Figure 10. Total landings of Western mackerel (▨) and landings of Western mackerel taken in the North Sea (■) (top), and percentage of total Western mackerel landings taken in the North Sea (■) (bottom), 1980–1994 (data from ICES, 1996c).

declined afterwards, falling to below 200 000 t after 1980. Since 1985, SSB has been estimated, on the basis of egg surveys, to be stable at an extremely low level (50 000 to 100 000 t).

The stock is depleted and remains at an historically low level (about 2–3% of the stock sizes in the early 1960s). No significant recruitment has occurred since the mid-1970s; the last strong year class was the 1969 year class. Analytical assessments are no longer possible because of the lack of data.

The North Sea mackerel stock is considered by ACFM to be "outside safe biological limits". Since 1980, ACFM has advised that the stock requires the maximum possible protection to promote recovery, and has recommended that no catches be taken. Recognizing that this can only be achieved by closing mackerel fisheries in areas where North Sea mackerel occur, ACFM has since 1991 recommended: (a) no fishing for mackerel in Divisions IIIa and IVb, c at any time of the year; (b) no fishing for mackerel in Division IVa during the period 1 January to 31 July; and (c) that the 30 cm minimum landing size in effect in Division IIIa and Subarea IV be maintained and that existing by-catch regulations be continued.

Despite the collapse of the North Sea mackerel stock in the late 1970s and early 1980s, landings of mackerel from the North Sea (Division IVa) have increased nearly 10-fold in the past decade (from about 50 000 t in 1985 to almost 475 000 t in 1994; Fig. 10). This is due to a marked shift in the annual migration pattern of the mackerel from the Western stock into the North Sea during the past 15 years. Western mackerel are highly migratory and distribution of the stock changes seasonally. In winter (Jan–Mar), adult fish typically occur in the northern North Sea and waters west of Scotland, while during spring (Apr–Jun) the stock is usually concentrated on the spawning grounds south of Ireland. During the second half of the year, most of the fish return to the feeding and overwintering areas. Since 1986, landings of Western mackerel taken in the North Sea (Division IVa) have accounted for over 50% of the total landings from the stock. This contrasts with earlier years when catches from the North Sea accounted for less than 10% of the yields. Thus, the Western mackerel stock appears to have "replaced" the North Sea mackerel stock within the North Sea proper, at least during the latter half of each year.

Prior to 1994, the Western mackerel stock was deemed to be well within safe biological limits. However, SSB has since declined to a record low level while fishing mortality has increased to a record high. ACFM now considers that the combined mackerel stock complex (Southern, Western, and North Sea spawning components, of which the Western stock is the most dominant) "may be outside safe biological limits". To reverse the decline in SSB, ACFM recommended that there be "a significant reduction in fishing mortality" and that this apply to all areas in which mackerel are caught, including international waters. ACFM indicated that a 40% reduction in F in 1996 would be needed to prevent SSB from decreasing further and that a 60% reduction would be required for stock rebuilding.

Conclusions

North Sea roundfish

All of the major roundfish stocks (cod, haddock, whiting and saithe) are intensively exploited or over exploited. During the past two decades, fishing mortality rates increased to record high levels and exploitation rates have generally remained well above biological reference points, resulting in approximately 60% of the exploitable biomass being removed each year. As a consequence, the size of the stocks and the catches have become highly dependent on recruiting year classes. Moreover, in all four stocks large quantities of juvenile (immature) fish are landed or discarded. SSB has declined to very low levels in most cases, jeopardizing future recruitment success. Apart from whiting, each of the stocks has recently been, or is now, close to or outside safe biological limits. These conditions are unlikely to improve (and may deteriorate further) if fishing effort and fishing mortality are not significantly reduced.

The regulatory measures that have been implemented for roundfish (primarily TACs) have so far not resulted in reducing fishing mortality on any of the individual stocks or the combined roundfish stock complex. This is because TACs only constrain landings and not the true catches. In practice, not only have landings often exceeded agreed TACs, but catches of cod, haddock, and whiting have also frequently been discarded in the mixed-species roundfish fisheries when the TAC for any one of these species was reached. ACFM has since 1990 generally refrained from advising on individual TACs (except for saithe, which is mainly caught in a directed single species fishery). Instead, ACFM has emphasized that significant and sustained reductions in overall fishing effort on North Sea roundfish are required as the crux of a long-term strategy for recovery of all of the stocks.

North Sea flatfish

Exploitation of flatfish increased gradually during the past 20 years, reaching record-high levels for plaice in the 1990s and in the mid- and late 1980s for sole. Combined landings from both stocks peaked in 1989/1990, but have since declined to the levels seen in the 1970s (Fig. 1b). In both stocks, current fishing mortality rates are above F_{max} and F_{med}. Since 1993, the spawning stock of plaice has been below the MBAL. Although the sole stock is currently considered to be within safe biological limits, fishing mortality is above F_{med} and there is a risk that SSB could fall below MBAL after the strong 1987 and 1991 year classes have passed through the stock.

As plaice and sole are harvested together in the mixed flatfish fishery in the southern North Sea, regulatory measures for either stock should take into account the condition and impacts on the other stock. To date, TACs have not proved successful in managing these fisheries.

North Sea herring and mackerel

The North Sea herring and mackerel stocks collapsed in the mid-1970s following a period of intense exploitation. The herring stock recovered during the 1980s owing to the closure of the herring fishery in the late 1970s–early 1980s and subsequent increases in recruitment. However, fishing mortality rates also increased and SSB declined below MBAL after 1992. Catches have consistently exceeded agreed TACs, and exploitation of immature fish has markedly increased in recent years. Effort regulation is not an ideal alternative for schooling species, but management by TACs is likely to improve when the overall TAC is subdivided amongst the different herring fisheries and when these fishery quotas are separately managed.

The North Sea mackerel stock remains depleted and outside safe biological limits, even though the stock has probably received the maximum protection possible and by-catches have generally been insignificant. Because of the marked shift in the overwintering areas of Western mackerel, 50% of the landings of this stock are now taken inside the North Sea area. Although the Western stock outnumbers the North Sea stock, the overexploitation of the Western stock may well have limited the potential for the North Sea stock to recover. Further measures to protect the Western stock within the North Sea should also enhance the protection of the North Sea stock.

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