NAFO Sci. Coun. Studies, 16: 137–142

Managing Transboundary Flatfish Stocks: Sources and Consequences of Uncertainty

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Abstract

The development in the mid-1980s of fisheries for flatfish in the area outside the Canadian 200-mile boundary on the Grand Bank has caused some problems in the assessment of the American plaice and yellowtail flounder stocks. These include uncertainties about the nominal catch, inadequate sampling data to determine catch-at-age for some fleets, and the lack of appropriate catch-per-unit-effort information for fleets fishing outside the 200-mile boundary. Catches of some fleets in recent years have included large numbers of juvenile flatfish, although total removals and their effect on the stock have not been fully quantified. The effects of these uncertainties on the recent assessments of the two flatfish stocks are discussed.

Introduction

When Canada extended its jurisdiction to 200 miles from its coastline in 1977, a boundary was created which divided the continental shelf on the Nose and Tail of the Grand Bank, NAFO Div. 3LNO (Fig. 1). This boundary meant that about 9, 41 and 4% of the area (the area from the boundary line to the contour line at 732 m) in Div. 3L, 3N and 3O, respectively, lay outside Canadian jurisdiction. Among the more important fish stocks affected were the flatfish, American plaice (*Hippoglossoides platessoides*), and yellowtail flounder (*Limanda ferruginea*). Prior to 1977, fleets of various countries fished these stocks over most of the Grand Bank, restricted only by the total allowable catches (TACs), which were introduced in 1973. After 1 January 1977, access to the large portion of fishing grounds inside the 200-mile boundary was denied to many non-Canadian vessels, as allocations of fish to those vessels were reduced. In the early 1980s, fleets of some countries began fishing outside the 200-mile boundary in the area referred to as the "NAFO Regulatory Area". Total catches of American plaice and yellowtail flounder in Div. 3LNO then increased rapidly, leading to overruns of the TACs in some years.

This paper examines some of the difficulties encountered in the recent management of these transboundary flatfish stocks. It focuses on the sources of uncertainty which have arisen in the assessment of these resources caused by the separate fisheries which have developed on either side of the 200-mile boundary.

Distribution on the Grand Bank

American plaice is distributed widely over the Grand Bank, with the largest concentrations being found where the slope of the bank is in contact with the cold Labrador current (Pitt, 1967). Most of these areas occur in the north (Div. 3L), in depths from 80 to 250 m, where bottom temperatures are often between −1.5° and +1.0° C (Wells *et al.*, MS 1988). Between one-half and two-thirds of the American plaice population on the Grand Bank is found in Div. 3L (Brodie *et al.*, MS 1990a). Research vessel surveys conducted before the recent developments on the Grand Bank have indicated that the proportion of American plaice outside 200 miles in each division was generally equivalent to the proportion of the area outside 200 miles, i.e. about 9% in Div. 3L, 41% in Div. 3N and 4% in Div. 3O. However, Brodie *et al.* (MS 1990a) showed that the total percentage of American plaice biomass outside 200 miles has declined since 1979, and was in the range of 11–22% from 1987 to 1990, compared to 26–46% from 1979 to 1986 (Fig. 2).

Yellowtail flounder is a shallow-water species, occurring principally in 35–85 m (Pitt, 1970a), with a concentration on the Grand Bank around the Southeast Shoal (strata 375 and 376 in Fig. 1). They are found mainly in warmer water, e.g. 1° to 4° C, but do occur in colder water, when lower temperatures are prevalent in the Tail of the Bank area (Wells *et al.*, MS 1988). Research vessel surveys have shown that about 70% of the yellowtail population is usually found in Div. 3N, with most of the remainder being in Div. 3O (Brodie *et al.*, MS 1990b). There is virtually no yellowtail flounder outside 200 miles in Div. 3L, and the percentage is generally less than 5% in Div. 3O. In Div. 3N, the percentage of biomass outside 200 miles ranged from 28 to 41% from 1979 to 1985, but exceeded 20% only once from 1986 to 1990 (Fig. 3).

A feature common to both flatfish stocks is the occurrence on the Grand Bank of nursery areas, which contain high concentrations of juveniles. Research

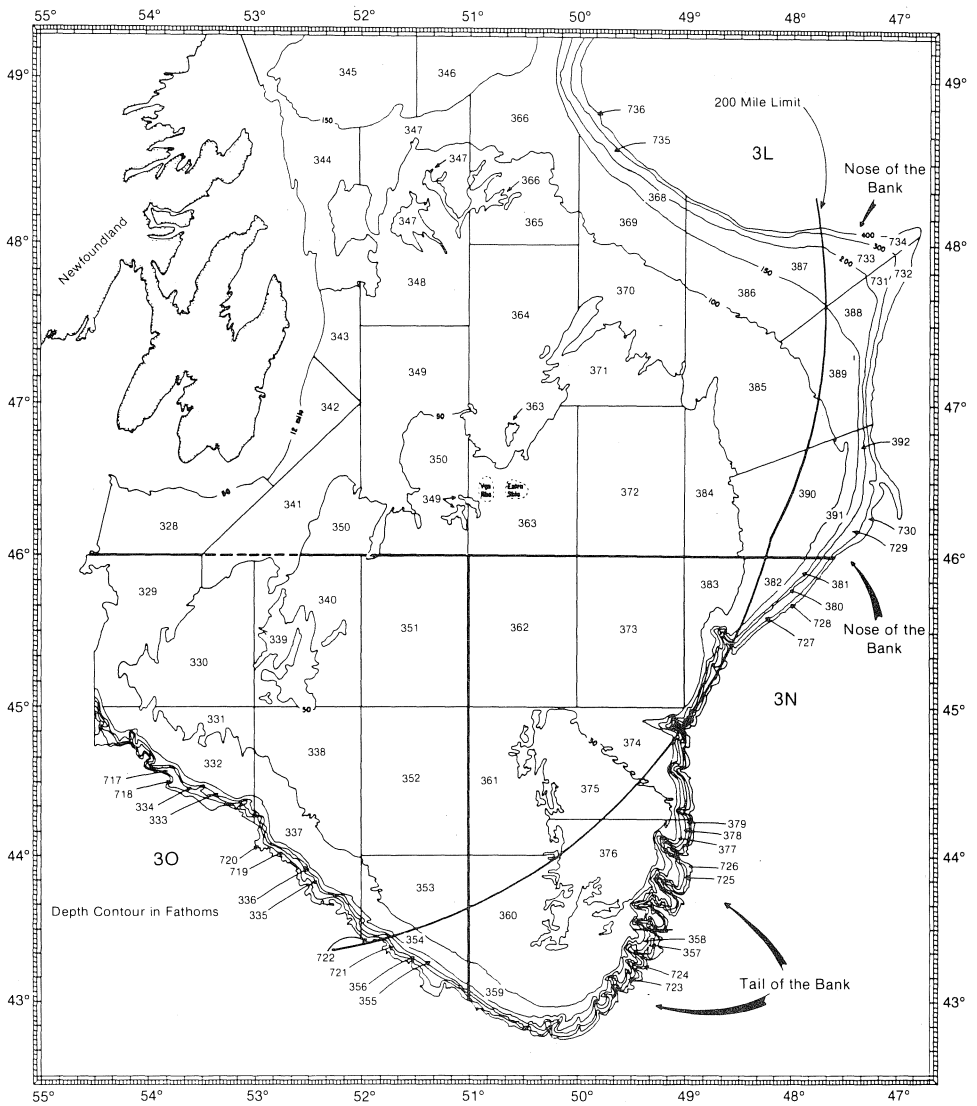

Fig. 1. The Grand Bank, NAFO Div. 3LNO, showing the Canadian 200-mile boundary and the depth stratification scheme (fath.) used in Canadian research vessel surveys.

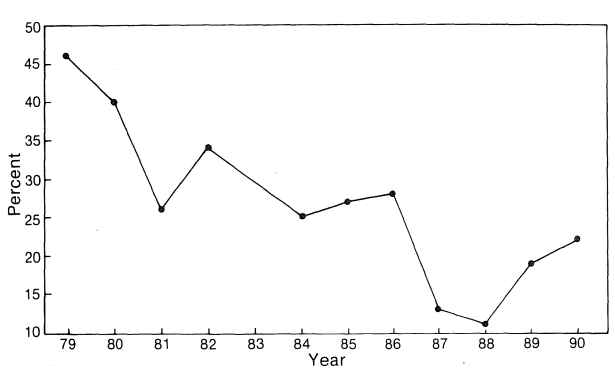

Fig. 2. Percentage of American plaice biomass in Div. 3N located outside 200 miles, as determined by Canadian research vessel surveys from 1979 to 1990.

vessel surveys directed at juvenile flatfish have been conducted in Div. 3LNO since 1985, using a modified shrimp trawl as a standard sampling gear and employing a stratified-random survey design (Walsh, MS 1990a, b). These surveys, which concentrated on estimating abundance and biomass of American plaice and yellowtail flounder, have identified areas of high juvenile abundance. There are two main nursery areas for American plaice on the Grand Bank, one located on the northern slope of Div. 3L in depths of 93–183 m and the other in the southern transboundary area in Div. 3NO (Fig. 1). The southern area contains a larger concentration of juveniles in the age range of 1 to 4 years than the northern area and any possible linking mechanism between the two areas in unknown. The

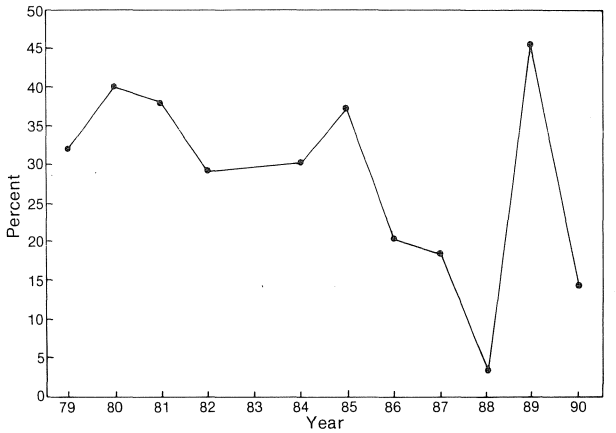

Fig. 3. Percentage of yellowtail flounder biomass in Div. 3N located outside 200 miles, as determined by Canadian research vessel surveys from 1979 to 1990.

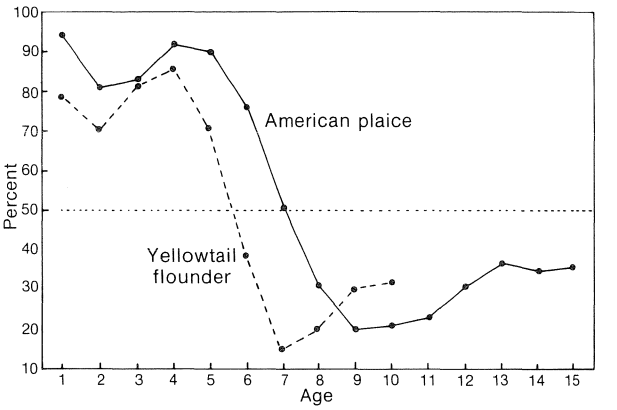

Fig. 4. Percentage of American plaice and yellowtail flounder abundance-at-age in Div. 3N which is outside the 200-mile boundary, as determined by juvenile flatfish surveys from 1986 to 1989.

yellowtail flounder nursery area also includes the 200-mile boundary in Div. 3N, with most of the concentrations of juveniles in the age range of 1 to 4 years, in strata 360 and 376 (Fig. 1) which are mainly outside the 200-mile boundary (Walsh, MS 1990b).

An examination of the distribution of catch-at-age (numbers) from the combined 1986 to 1989 juvenile surveys, separated into catch outside and inside the 200-mile boundary in Div. 3N, showed remarkable similarities in the areas of concentration of both species. For American plaice, 70–94% of the catches of fish aged 1–6 years were located outside 200 miles, while age 7+ fish were located mainly inside the boundary (Fig. 4). Similarly, yellowtail flounder aged 1 to 5 years were located mainly (71–85%) outside the boundary with older fish being more abundant inside.

Commercial Fisheries

The largest commercial fishery for American plaice in the Northwest Atlantic occurs on the Grand Bank (Pitt, 1967). The fishery began in the 1940s, after the introduction of the otter trawler to the Canadian fleet, and Canada took all or almost all of the landings from this stock until the mid-1960s (Pitt, 1970b). At this time, catches by other countries, mainly USSR, increased rapidly, with the total catch peaking at 94,000 tons in 1967 (Brodie *et al.*, MS 1990a). Catches declined subsequently, and remained stable around 45,000–50,000 tons from 1973 to 1982 (Fig. 5), as Canada once again became virtually the only nation involved in the fishery, particularly after the extension of jurisdiction in 1977. However, after 1982, other countries, notably Spain, Portugal, Panama, South Korea and the USA, began fishing for flatfish on the Nose and/or Tail of the Bank. This resulted in an increase in the catch up to 1986, after which time catches decreased due to a decline in stock abundance (Brodie *et al.*, MS 1990a). From 1971

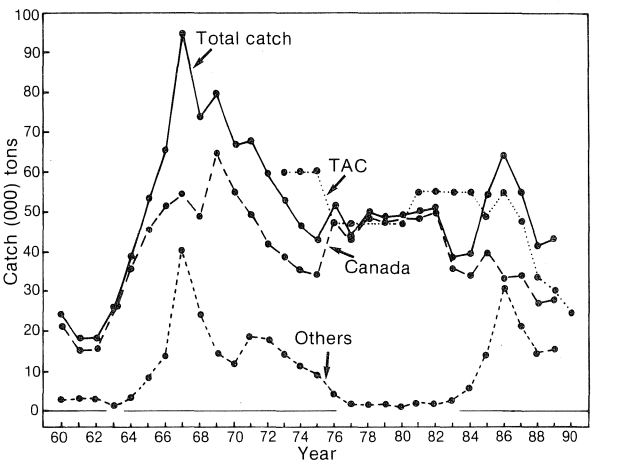

Fig. 5. Catches and TACs ('000 tons) of American plaice in Div. 3LNO.

to 1987, the Canadian catches of American plaice ranged from 33,000 tons to 50,000 tons, with about 5–10% of this total coming from the inshore sector.

The fishery for yellowtail flounder on the Grand Bank essentially began in 1965, with a catch of about 3,000 tons. Prior to this, catches were generally quite low (Pitt, 1970a), but after the demise of the Grand Bank haddock fishery in the early-1960s, catches of yellowtail flounder by the Canadian otter trawl fleet quickly increased (Pitt, 1975). Catches by USSR vessels also rose throughout the late-1960s and early-1970s, resulting in a peak catch of just over 39,000 tons in 1972 (Brodie *et al.*, MS 1990b). Catches averaged around 14,000 tons in the late-1970s and early 1980s, as non-Canadian catches dwindled to negligible levels following the Canadian extension of jurisdiction in 1977 (Fig. 6). With the arrival of fishing fleets from other countries on the Tail of the Bank in 1982, catches once again increased rapidly, reaching 30,000 tons in 1986,

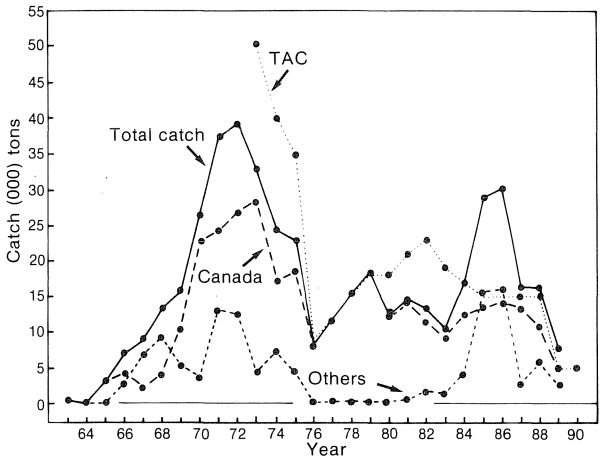

Fig. 6. Catches and TACs ('000 tons) of yellowtail flounder in Div. 3LNO.

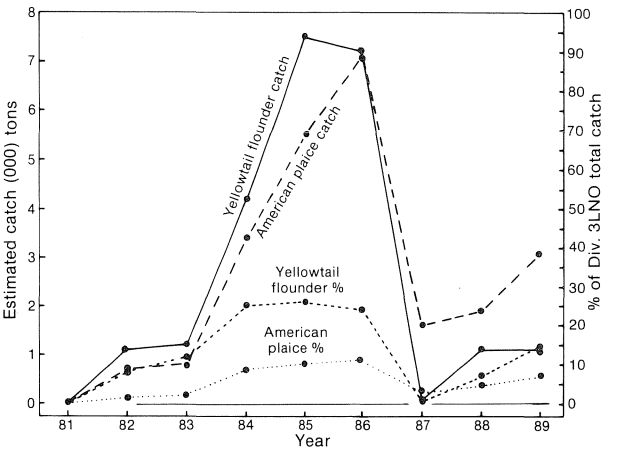

Fig. 7. Estimated catches ('000 tons) of American plaice and yellowtail flounder in Div. 3LNO and the percentage of the total catch represented by these estimates.

before decreasing in subsequent years as the stock declined. After peaking at over 28,000 in 1973, the Canadian catches of yellowtail flounder ranged from 8,000 tons to 18,000 tons in the period 1974–88.

In recent years, the Canadian fleet has directed very little effort towards flatfishes in the NAFO Regulatory Area, and has concentrated on the fishery inside the 200 miles where catch rates of flatfish have been usually much higher (Brodie, MS 1989). Fishing fleets of other countries remain restricted to the NAFO Regulatory Area, creating two distinct fisheries on the stocks which straddle the 200-mile boundary. The situation is further complicated by the participation in the fishery of vessels registered to countries which are not members of NAFO, and are therefore not obliged to observe the NAFO regulations governing fisheries in the area.

Uncertainties (Related to the 200-mile Boundary) in the Stock Assessments

Nominal catch. With the heavy involvement in the flatfish fishery of non-NAFO countries in the mid-1980s, some of which did not report their catches (e.g. Panama, Cayman Islands), it became difficult to get accurate statistics for total catches of flatfish stocks on the Grand Bank. The problem was compounded by the fact that South Korea, a non-NAFO country which did report catches, did not submit all of its substantial flatfish catch statistics on a species by species breakdown. To arrive at total catch figures, it was therefore necessary to use estimates of catch obtained from Canadian surveillance personnel, which were based on vessel sightings and some estimates of catch-per-day and species composition (*NAFO Sci. Coun. Rep.*, 1988, p. 53). These catches, combined with the estimated breakdown of the South Korean landings, comprised a substantial portion of the flatfish catches, particularly yellowtail flounder, from the Regulatory Area and from the stocks as a whole, for the years 1984–86 (Fig. 7). Thus, the catches from this period are considered to be less reliable than other years (Brodie *et al.*, MS 1990a, b).

Catch-at-age. The absence of sampling data, particularly length frequencies and otolith data, from large portions of the American plaice and yellowtail flounder catches have also caused difficulties in the assessments of these stocks. In the Regulatory Area there are no such data available for the unreported catches, and even for some of the reported catches, the sampling information has been less than adequate. The problem could have been overcome if the available data showed that the different fisheries were taking catches with similar age compositions. However, it has been documented (Brodie *et al.*, MS 1990a, b) that at least one major fleet, the Spanish fleet, has recently shifted its catch of flatfish toward much smaller animals compared with earlier years. For example, their catch of yellowtail flounder in 1989 was estimated to contain 12.4 million fish for a weight of 1,126 tons, compared to the Canadian catch of 9.8 million fish for a weight of 5,007 tons (*NAFO Sci. Coun. Rep.*, 1990, p. 104). Thus, the age compositions in the Spanish flatfish catches are considerably different to those in the Canadian catches (Fig. 8 and 9). These differences are very important when the total catch-at-age for the two stocks are calculated, recognizing that these data must be applied to the non-sampled catches as well. In a recent assessment of yellowtail flounder stock (Brodie *et al.*, MS 1990b), a major revision to the catch-at-age for 1988 was proposed (Fig. 10), based on the reassignment of a portion of the catch in the Regulatory Area to different sampling data and a revised estimate of the 1988 nominal catch. As can be seen from Fig. 11, there is little similarity in the catch-at-age for 1987 and 1988, despite the fact that the nominal catch was almost identical in those years. Brodie *et al.* (MS 1990b) con-

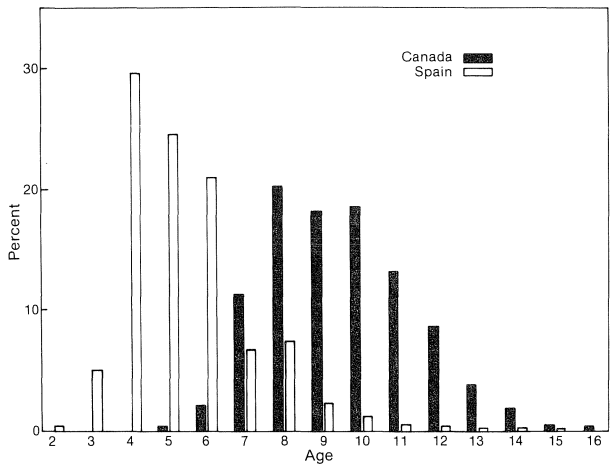

Fig. 8. Comparison of the catch-at-age of American plaice in Div. 3LNO between the Canadian and Spanish commercial fisheries in 1989.

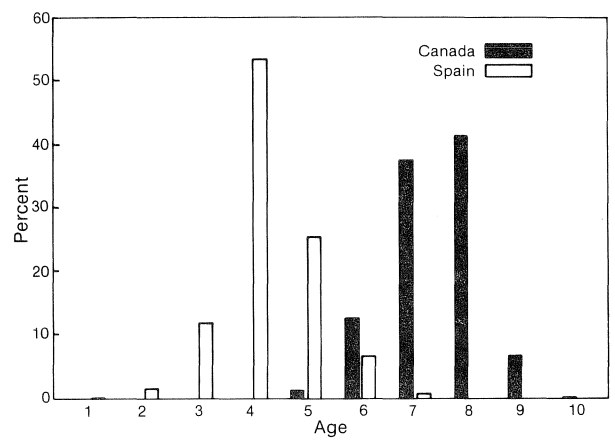

Fig. 9. Comparison of the catch-at-age of yellowtail flounder in Div. 3LNO between the Canadian and Spanish commercial fisheries in 1989.

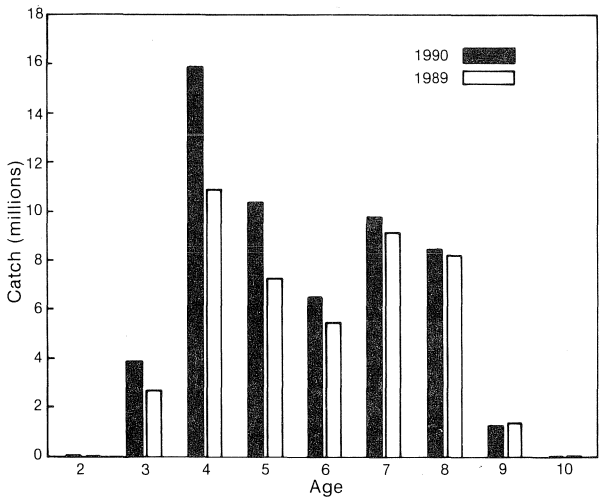

Fig. 10. Comparison of the catch-at-age of yellowtail flounder in Div. 3LNO between 1990 and 1989 assessments of the stock.

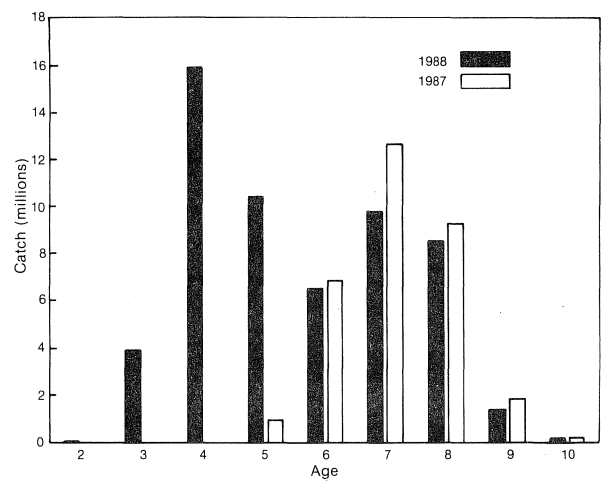

Fig. 11. Comparison of the catch-at-age of yellowtail flounder in Div. 3LNO between 1987 and 1988.

cluded that the uncertainties in the catch-at-age for this stock precluded its use in any assessment models which were based on sequential population analysis. Although the same problems exist to some degree in the American plaice database, they are not as limiting because a larger portion of the catch from that stock has adequate sampling.

Catch-per-unit-effort. The development of separate fisheries on either side of the 200-mile boundary has meant that additional sources of catch-per-unit-effort (CPUE) data should now be available. However, this is not the case. Effort data are usually not appropriate as these fisheries are often reported as directing for a mixture of species. Effort data, if present, are often reported to NAFO in days rather than hours. Lack of appropriate data precludes the calculating of CPUE for most of the fleets fishing outside 200 miles. Thus, at present, there is no reliable CPUE index for the portion of the American plaice and yellowtail flounder stocks in the Regulatory Area.

Prior to the onset of the fisheries in the Regulatory Area in 1982, only data from Canadian offshore trawlers were available from the Grand Bank flatfish fisheries. These data continue to be used as the only index of abundance from the commercial fisheries, despite the fact that these vessels no longer fish in the Regulatory Area.

Discussion

Perhaps the greatest uncertainties in the assessment of the Grand Bank flatfish stocks have come simply from the dynamics of the fisheries in the Regulatory Area. What were once relatively stable fisheries have become quite unpredictable with fluctuations in exploitation patterns between years and between fleets. In addition to the previously noted difficulties with assessment parameters such as catch-at-age and CPUE, these variabilities in the fishery make catch forecasting extremely difficult. For the preparation of catch

forecasts from analytical assessments, parameters such as mean weights-at-age, partial recruitment to the fishery, reference fishing mortality levels from yield-per-recruit analysis and the catch in the current (assessment) year must be used. With the exception of the latter, these values are usually derived from averaging recent (or sometimes long-term) values. Catches in the current year are usually assigned the value of the TAC.

In the case of the 1990 assessment of American plaice in Div. 3LNO, problems were noted in all the parameters, particularly with yield-per-recruit parameters and the catch for 1990 (*NAFO Sci. Coun. Rep.* 1990, p. 76–79). Thus, to assist managers evaluate the effects of a TAC overrun on the stock in 1990, catch and yield projections were provided using two values for catch in 1990; one equal to the TAC and the other roughly equal to the recent catch levels of the stock. For yellowtail flounder, the difficulty in trying to quantify the levels of uncertainty is more pronounced, as no analytical assessment has been possible in recent years.

At present, the consequences of many of the uncertainties in the assessments are largely unknown. The Scientific Council of NAFO has stated that these fisheries will be impossible to manage if catches by non-member countries increased from the low levels observed in 1988–89 to the levels observed in 1985–86 (*NAFO Sci. Coun. Rep.*, 1990, p. 77, 87). Perhaps the most immediate concern is the removal of large numbers of juveniles by some fleets in the Regulatory Area. One obvious management tool to control the exploitation of young flatfish would be the introduction of closed areas and/or seasons. However, at present, information on seasonal distribution of juveniles is lacking, as are the appropriate data on precise location of catches from commercial fisheries in the area (*NAFO Sci. Coun. Rep.*, 1990, p. 35). More information on the mixing rates of the juvenile and adult populations is also required before nursery areas can be delineated precisely. In addition, the effects of these fisheries on yield-per-recruit, recruitment to the fisheries inside 200 miles, and future spawning stock size are not yet quantified. Until a longer time series of more complete data becomes available, it is likely that managers (and assessment biologists) will continue to experience problems with the transboundary flatfish stocks on the Grand Bank.

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