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Stock Assessment of Georges Bank (5Zhjmn) Yellowtail Flounder for 2003.

Évaluation du stock de limande à queue jaune du banc de Georges (5Zhjmn) pour 2003.

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ABSTRACT

The combined Canada/USA yellowtail flounder (*Limanda ferruginea*) catch has been increasing since 1995 and in 2002 was 6,100 t, less than the 7,800 t caught in 2001. Biomass has been generally increasing since the mid 1990s and recent year classes have generally increased since the mid 1980s and are comparable to those in the 1960s and 1970s. Fishing mortality rates were high in the past, but recently have been reduced. The population age structure displays a recent expansion, however, there are fewer fish in the oldest age classes in both the catch and surveys than would be expected given the perception of recent low exploitation. The increased uncertainty in current stock status, more severe retrospective pattern, and the divergence in model results as well as the failure to explain the absence of older fish in the catch gives no confidence in projection results. Considering the trends in survey abundance and recruitment, status quo catch may be an appropriate management approach until these issues are resolved.

RÉSUMÉ

Les prises canado-américaines combinées de limande à queue jaune (*Limanda ferruginea*) sont à la hausse depuis 1995. Elles se chiffraient à 6 100 t en 2002, soit un volume inférieur aux 7 800 t capturées en 2001. En général, la biomasse est à la hausse depuis le milieu des années 1990. Les effectifs des classes d'âge récentes ont augmenté depuis le milieu des années 1980 et se comparent à ceux des années 1960 et 1970. Les taux de mortalité par pêche, élevés par le passé, ont récemment diminué. La structure par âge de la population montre une expansion récente, toutefois, tant les prises que les relevés indiquent que les vieilles classes d'âge comptent moins d'individus qu'on s'y attendait à la lumière de la baisse apparente du taux d'exploitation. L'incertitude accrue qui entoure l'état actuel du stock, un profil rétrospectif plus marqué et la divergence des résultats du modèle, ainsi que l'incapacité d'expliquer l'absence de limandes âgées dans les prises mettent en doute les résultats des projections. Compte tenu des tendances de l'abondance et du recrutement établies par relevé, le statu quo au niveau des prises peut constituer une approche de gestion appropriée jusqu'à ce que ces problèmes soient résolus.

INTRODUCTION

Georges Bank yellowtail flounder *(Limanda ferruginea)* are a transboundary resource in Canadian and US jurisdictions. This paper updates the last stock assessment of yellowtail flounder on Georges Bank, completed separately by Canada (Stone 2002) and the USA (NEFSC 2002). Similar methods are used in the current assessment, with updated catch information and indices of abundance from both countries.

Yellowtail flounder range from southern Labrador to Chesapeake Bay and are typically caught at depths between 37 and 73 m. A major concentration occurs on Georges Bank from the northeast peak to the east of the Great South Channel. Yellowtail flounder appear to be relatively sedentary, although limited seasonal movements have been reported (Royce *et al.* 1959; Lux 1963). On Georges Bank, spawning occurs during late spring and summer, peaking in May. Eggs are deposited on or near the bottom and after fertilization float to the surface where they drift during development. Larvae are pelagic for a month or more, then develop demersal form and settle to benthic habitats. Based on the distribution of both ichthyoplankton and mature adults, it appears that spawning occurs on both sides of the international boundary. Growth is sexually dimorphic, with females growing at a faster rate than males (Lux and Nichy 1969; Moseley 1986). Yellowtail flounder appear to have variable maturity schedules, with age two females considered 40% mature during periods of high stock biomass to 90% mature during periods of low stock biomass.

Tagging observations, larval distribution, life history traits, and geographic patterns of landings and survey data indicate that Georges Bank yellowtail flounder comprise a relatively discrete stock, separate from those occurring on the western Scotian Shelf, off Cape Cod and southern New England (Lux 1963; Neilson et al. 1986). The management unit recognized by Canada and the USA for the transboundary Georges Bank stock includes the entire bank east of the Great South Channel to the Northeast Peak, encompassing Canadian fisheries statistical areas 5Zj, 5Zm, 5Zn and 5Zh (Fig. 1a) and U.S. statistical reporting areas 522, 525, 551, 552, 561 and 562 (Fig. 1b). Both Canada and the USA employ the same management unit.

The Fisheries

Exploitation of the Georges Bank stock (NAFO Statistical Areas 5Zhjmn) began in the mid-1930s by the US trawler fleet. Landings (including discards) increased from 300 t in 1935 to 7,300 t in 1949, then decreased in the early 1950s to 1,600 t in 1956, and increased again in the late 1950s (Fig. 2). The highest annual catches occurred during 1963-1976 (average: 16,300 t) and included modest catches by foreign fleets. No foreign catches of yellowtail have occurred since 1975. In 1985, the stock became a transboundary resource in Canadian and US jurisdictions. Catches averaged around 3,000 t between 1985 and 1994, then dropped to a record low of 788 t in 1995 when fishing effort was drastically reduced in order to allow the stock to rebuild. The USA fishery in the management area has been constrained by spatial expansion of Closed Area II in 1994 (Fig. 1b) and by extension to year-round closure in 1995. A directed Canadian fishery began in 1993, pursued mainly by small otter trawlers (< 20 m). Catches by both nations have steadily increased (with increasing quotas) from a record low of 788 t in 1995, when the stock was considered to be in a collapsed state, to 7,776 t in 2001. In 2002, combined catch (including discards) for the USA and Canada were 6,123 t.

USA

The principal fishing gear used in the US fishery to catch yellowtail flounder is the otter trawl, but scallop dredges and sink gillnets contribute some landings. In recent years, otter trawls caught greater than 95% of total landings from the Georges Bank stock, dredges caught 2-5% of annual totals, and gillnet landings were less than 0.1%. US trawlers that land yellowtail flounder generally target multiple species on the southwest part of the Bank, and on the northern edge just west of the closed area adjacent to the international boundary. Current levels of recreational and foreign fishing are negligible.

US yellowtail landings were prorated to stock area using logbook data as described in Cadrin et al. (1998). Since 1995, the proportion of total yellowtail landings accounted for in logbooks has exceeded 90% (e.g., in 1999, 97% of total landings were accounted for). However, in 2000 the proportion dropped to 85% (primarily resulting from low proportions in the fourth quarter of the year), then increased to 88% in 2001 and 92% in 2002. This reduced proportion adds uncertainty to the estimate of yellowtail landings by stock area, particularly for 2000 and 2001. Total Georges Bank yellowtail landings (excluding discards) in the 2002 USA fishery were 2,532 t, 33% lower than 2001 (Table 1).

Discarding of small yellowtail in the US fishery has been an important source of mortality due to intense fishing pressure, discrepancies between minimum size limits and gear selectivity, and recently imposed trip limits for the scallop dredge fishery within Closed Area II. In 2002, 96% of yellowtail flounder discards originated from the offshore scallop fishery (445 t), while the remainder came from bottom trawl catches (21 t). Total US catches in 2002, including discards, were 2,998 t.

Canada

Canadian fishermen began directing for yellowtail flounder in 1993. Prior to 1993, Canadian landings were small, typically less than 100 t (Table 1, Fig. 2). Landings of 2,139 t of yellowtail occurred in 1994, when the fishery was unrestricted. After a TAC of 400 t was established, yellowtail landings dropped to 472 t in 1995. Since then they have increased steadily and in 2001 were 2,913 t. In 2002, landings were 2,642 t (against a quota of 2,884 t), down 10% from 2001 (Table 1). The majority of Canadian landings of yellowtail flounder are made by otter trawl, from vessels less than 20 m, tonnage classes (TC) 2 and 3. The Canadian fishery generally occurs from June to December, with 75% of landings in 2002 reported in August and September.

Flatfish landed as "unspecified" in the Canadian fishery have been significant in previous years, and generally consist of yellowtail on Georges Bank. Neilson et al. (1997) revised the landings data for earlier years of the fishery (1993-1995) to account for catches of unspecified flounder species. The unspecified flounder problem has become less significant recently, due to improved monitoring of the landings. For the 2002 fishery, unspecified flounder landings were obtained by applying the monthly proportions of known yellowtail landings in 5Zm and 5Zj (based on the ratio of known yellowtail catch to known yellowtail + other flounder species catch) to unspecified flounder landings from matching area/month strata. Total unspecified flounder landings in 2002 estimated to be yellowtail, were 0.5 t and 8.5 t for 5Zj and 5Zm, respectively, and are included as part of the Canadian landings (Table 1).

In 2001, summer flounder (*Paralichthys dentatus*) was captured in the Canadian fishery (mostly August through October), and was reported as "unspecified" since it is uncommon in Canadian waters. This amount (estimated to be 1%) represented 26 t of the total yellowtail catch and was subtracted from the total landings (including unspecified estimated to be yellowtail) to give the revised total of 2,913 t for 2001. In 2002, the summer flounder catches of 3 t were identified and reported as a separate species in the commercial landings data, so no adjustments to the total yellowtail landings were required.

Canadian yellowtail directed fishing activity is concentrated in the southern half of the Canadian fishing zone, in the portion of 5Zm referred to as the "Yellowtail Hole". Overall, the fishery distribution in 2002 was comparable to that observed over the previous five years, but with some catches occurring further north along the edge of the international boundary (Fig. 3). Fishermen have indicated that this northward extension of the fishing area occurred when some vessels moved north to avoid high catches of skates early in the season (August).

In past years, there have been landings of yellowtail flounder in the Canadian offshore scallop fishery on Georges Bank. Management measures established in 1996 prohibit the landing of yellowtail flounder by this fleet. However, no records of discarded quantities have been available since 1996, when at-sea observer records estimated the amount of discarded yellowtail flounder as 11 t. More recently, a monitoring program was conducted by the Canadian offshore scallop industry in 2001-2002 to examine yellowtail flounder bycatch (along with cod, haddock and monkfish). Twelve observer deployments on offshore scallop vessels were conducted between May 2001 and April 2002 with most trips occurring in 5Zj (Tables 2 and 3). During each observed trip, approximately 80% of the scallop tows were monitored for yellowtail bycatch, so yellowtail catches were prorated to represent the total bycatch per trip. Since there is a seasonal component to the groundfish movements on the bank, yellowtail bycatch ratios (weighted averages) were calculated as a percentage of total scallop catch and total effort for observed trips grouped by trimester. These ratios were then multiplied by the 2001 and 2002 offshore scallop catch and effort (for each trimester) and summed to provide estimates of total yellowtail bycatch for these two years.

The yellowtail flounder discard estimates for 2001, based on offshore scallop effort and catch, were 566 t and 551 t, respectively (Table 2). Since the offshore scallop fishery is under quota management, it was assumed that the effort-based calculations would be more reflective of yellowtail bycatch. Similarly, the yellowtail flounder discard estimate for 2002, based on offshore scallop effort was 483 t (Table 3). Revised total Canadian catches in 2001 and 2002 including discards and unspecified flounder catches were 3,479 t and 3,125 t, respectively and exceed the TAC for these years (2001: 3,450 t; 2002: 2,884 t).

Length and Age Composition

In 2002, the Canadian fishery was well sampled for lengths by sex, with 5,472 measurements available from 26 port samples (Table 4). In addition to regular Department of Fisheries and Oceans (DFO) port sampling staff, the fishing industry funded their own port sampling technician, which greatly increased the number of samples available for the 2002 fishery. Although sampling was adequate during the third and fourth quarters when most of the fishery occurred, no samples were obtained for the month of September, when 40% of the total landings occurred. Sea samples from 12 commercial trips provided an additional 9,026 length measurements by sex. Examination of the size composition from at-sea samples and port samples collected during the same month showed that the size composition by sex was quite similar and that sex determinations by observers were accurate in 2002 (Fig. 4). Therefore, length information from 12 observed trips was combined with the DFO/Industry port-sampling program to characterize the size composition of the Canadian fishery.

Canadian at-sea length frequency information for 2002 also indicated that culling on the basis of length was not a major concern in the 2002 fishery (Fig. 4). While the Canadian fishery currently has a minimum fish size limit of 30 cm total length, this size regulation is seldom enforced. Since 1993, the percentage of undersized fish (i.e. < 30 cm by number) has rarely exceeded 4% of the total reported catch and has been well below 1% for the past three years (Fig. 5). In 2002, only 0.8% of fish in the Canadian commercial catches were less than 30 cm.

Although the overall number of US port samples has increased in recent years, the number of samples taken from the Georges Bank fishery continues to be low, especially during the 1st and 2nd quarters, when most of the yellowtail flounder landings occur (Table 4). Only 2,533 measurements from 26 port samples were available in 2002, compared to 2,937 in 2001 (25 samples) and 3,300 in 2000 (27 samples). At-sea sampling provided an additional 1,928 length measurements, which were combined with the port samples to characterize the size composition of the US fishery.

The mean length of yellowtail flounder in the Canadian fishery has increased between 1994 and 2002 from 33 to 35 cm total length for males and from 35 to 41 cm for females (Fig 6). While the size composition in the Canadian fishery has been stable over the past four years, there has been an increasing proportion of males in the catch since 1999. Males represented 65% of the total catch in 2002, compared to 60%, 46% and 25% in 2001, 2000 and 1999, respectively. A comparison of the catch at size by nation indicated that in 2002 the US fishery had a different size composition than the Canadian fishery (Fig. 7). A large portion of the Canadian catch occurred in the 30-36 cm size range with a peak at 34 cm, while US catches were represented mainly by fish in the 34-44 cm range. Most of the US fishery catches (83%) occurred during the first half of the year, while all of the Canadian catches occurred during the second half (Table 4). Seasonal and geographic differences between Canadian and US fisheries may account for some of the difference in size composition observed in 2002. The US fishery catch at size includes discards from bottom trawl and offshore scallop fisheries. Yellowtail flounder discards from the Canadian offshore scallop fishery are not included in the Canadian fishery CAS because observer sampling for length information was not proportional to the catch.

As in past assessments, no age determinations were available for the Canadian fishery. Canada collects age determination material, but the age determination program is not yet operational. During a recent yellowtail flounder aging workshop, it was concluded that otolith thin sections are a useful structure to use for age determinations in this species on the Grand Bank, particularly for larger, older fish since scale age determinations are only accurate to about age 6-7 (Walsh and Burnett 2001). However, precise age determination of Georges Bank yellowtail flounder using otolith thin sections is hampered by the presence of weak, diffuse or split opaque zones and strong checks, which can make interpretation of annulii subjective and difficult (Stone and Perley 2002). Age determination results from recent inter-laboratory exchanges (i.e. DFO/NMFS and DFO/CEFAS) of scales and otoliths collected during DFO bottom trawl surveys have so far been very disappointing with < 55% agreement on these structures between expert age readers. Therefore, all age length keys used in the current assessment continue to be based on scale age determinations by NMFS. Separate-sex age-length keys from combined 2002 US fall survey and second half commercial port sample ages were applied to Canadian length samples to construct the catch at age (CAA) by sex for the Canadian portion of the management area. A total of 146 male and 214 female ages were available (compared to 151 male and 185 female ages available for the previous assessment). The low number of age determinations has once again compromised the reliability of the age length keys.

For the US fishery, sample length frequencies were expanded to total landings at size using the ratio of landings to sample weight (predicted from length-weight relationships by sex and season; Lux 1969), and apportioned to age using pooled-sex age-length keys. Commercial landings at age were derived from first and second half commercial port samples, while commercial discards were derived from first half commercial port sample ages plus spring RV ages and second half commercial port sample plus fall RV ages.

In 2002, age 2 males and age 2-4 females made up most of the Canadian catch, with more age 2's (2000 year class) present overall for both sexes compared with 2001 (Fig. 8). The average length at age for males and females in the Canadian CAA has generally been fairly consistent over the past 5 years, although a slight increasing trend is apparent in females for ages 2 through 4 (Table 5). The Canadian CAA for females also indicates a much broader age distribution than males (i.e. 1-9 for females *vs* 1-5 for males).

The US age composition is not available by sex (CAA is done for combined sexes and also includes discards) but in 2002 it was dominated by ages 3 and 4 (1999 and 1998 year classes, respectively), which represented 42% and 26% of the catch. Compared with the 2001 US fishery age composition, there were fewer at age three but more at ages 2, 4, and 5 in 2002. In contrast, the Canadian catch in 2002 was dominated by ages 2 (2000 year class) and 3 (1999 year class), which represented 53% and 30% of the catch, respectively. Overall, the 2002 catch age composition was represented by the 2000 (age 2) and 1999 (age 3) year classes in equal proportions, but with age 2 dominant in Canadian catches (2^{nd} half) and age 3 in US catches (1^{st} half) (Fig. 9, Table 6). Ages 2-4 make up most of the exploited population, with very low catches of age 1 fish since the implementation of larger mesh in the cod end of commercial trawl gear.

Mean weight at age was calculated from Canadian (separate sex) and USA (combined sex including discards) fishery CAA data (Table 7, Fig. 10). The commercial fishery mean weight at age data was revised in the 2000 assessment to include calculated weights for age 1 fish rather than the assigned value of 0.01. Since the actual mean weight at age 1 calculated for 2002 was unusually high (0.257), an average for 1997-2001 was used (0.169) instead. A slight increase in WAA for ages 2-4 has occurred since 2001, but a more pronounced increase is apparent for ages 5 and 6+ from 1997 to present. However, recent WAA values are within the range of past WAA calculations since 1973, and have varied considerably over the time series.

ABUNDANCE INDICES

Commercial Fishery Catch Rates

A standardized catch rate series was developed for the Canadian fishery using a multiplicative model that was solved using standard linear regression techniques after *ln* transformation of nominal CPUE (t/hr) data (Gavaris 1980, 1988a). For this analysis, only trips in 5Zm with ≥ 2.0 t of yellowtail landed were included (n=1193), and were assumed to represent directed fishing activity for yellowtail flounder. A model with main effects of year (1993-2002), month (June-December) and tonnage class (2,3) was used to standardize the Canadian CPUE series:

$$ln(\text{CPUE}_{ijk}) = \mu + \text{Year}_i + \text{Month}_j + \text{Tonnage Class}_k + e_{ijk}$$

Analysis of variance results (Table 8) indicate that the overall regression and individual main effects were significant ($P < 0.05$) and that the model explained 65% (multiple r^2) of the variability in the data. No trends were apparent in the pattern of residuals (Table 8, bottom) and the standardized series tracked the nominal series (weighted mean) quite well (Fig. 11, upper panel).

Standardized catch rates decreased between 1993 and 1994 but increased by a factor of two between 1994 and 1995, with a further increase in 1996. Catch rates were stable from 1996 to 1998 then increased considerably in 1999 when some of the fleet switched to more efficient flounder gear. In 2000, catch rates dropped sharply, with a continued decline in 2001 to the second lowest level in the series, and then increased slightly in 2002. In comparison with the DFO spring survey biomass index for stratum 5Z2 (Canadian portion of the Bank <90 m), the CPUE series tracks the index up to 1999, but falls off rapidly thereafter (Fig. 11, lower panel). The Spearman rank correlation coefficient for these two series was not significant (r_s=0.383; P=0.276; n=10), suggesting that catch rates within the Yellowtail Hole have declined more rapidly in recent years than the Canadian portion of the Bank (< 90 m) as a whole. Results from tagging studies (Lux 1963, Stone unpublished data) indicate that yellowtail flounder are sedentary and do not move very far, therefore, localized depletion could occur in the Yellowtail Hole area. Although it is assumed that some fish would move in to the Yellowtail Hole from adjacent areas (i.e. Closed Area II), the rate of immigration may not keep up with removals from fishing.

At the March 2001 DFO/industry consultation, it was confirmed that catch rates were lower during the 2000 fishery and fishermen with a history of fishing yellowtail clearly noted a decline. When the 2001 fishery commenced in August, fishermen noted an absence of fish in the Yellowtail Hole and reported low catches up to early September. Catch rates for yellowtail in 2001 were considered to be much poorer than past years, but more winter flounder and summer flounder were present as bycatch. Fishermen also expressed concern about the high abundance of skates. The presence of summer flounder on the Bank may indicate that environmental conditions in 2001 were different (i.e. warmer bottom water temperatures) when the season commenced, and could have resulted in yellowtail temporarily moving out of traditional fishing areas.

During the May 2003 industry consultation, fishermen indicated that catch rates were better in 2002. Some of this may be due to an increase in effective effort from modifications to the gear (i.e. use of 3 lengths ground warp between the net and doors *vs* 2 in the past) which would increase the herding effect and area swept clear. However, not all vessels made these changes, so that some of the increase in 2002 may be related to an increase in relative abundance. It was also reported that skates could be more abundant in the Yellowtail Hole area in early summer, forcing the yellowtail flounder out of the region thereby reducing catch rates for yellowtail. Commercial catch rate indices will require further investigation before they are used as an index of abundance for VPA calibration.

Research Vessel Surveys

Bottom trawl surveys are conducted annually on Georges Bank by DFO in the spring (February) and by the United States National Marine Fisheries Service (NMFS) in the spring (April) and fall (October). Both agencies use a stratified random design, though different strata boundaries are defined (Fig. 12). NMFS spring and fall bottom trawl survey catches (strata 13-21), NMFS scallop survey catches, and DFO spring bottom trawl survey catches (strata 5Z1-5Z4) were used to estimate relative stock biomass and relative abundance at age for Georges Bank yellowtail. Conversion coefficients, which compensate for survey door, vessel, and net changes in NMFS groundfish surveys (1.22 for old doors, 0.85 for the Delaware II, and 1.76 for the 'Yankee 41' net; Rago et al. 1994) were applied to the catch of each tow.

For all three groundfish surveys, the distribution of catches in the most recent surveys were comparable with those distributions observed in the previous five year period (Figs. 13a and 13b). The 2002 and 2003 DFO surveys continued to show good catches on the Canadian side in the "Yellowtail Hole" and on the US side in Closed Area II. While sampling intensity by the NMFS surveys is always lower, there were good catches during the 2002 NMFS spring survey in the closed area, around the "Yellowtail Hole" and along the northern edge of the bank. The 2003 NMFS spring survey had fewer sets with good catches on both sides of the international boundary. Catches during the 2002 NMFS fall survey were poor and there were only three tows with moderate catches on the northeastern portion of the bank.

The DFO spring biomass index continued to be high in 2003. This series follows an increasing trend from 1995 to 2001 (the highest value in the series), then drops off slightly in 2002 and 2003 (Table 9, Fig. 14). The NMFS spring series is longer, and tracks the DFO series well during the years of overlap up to 1999, but shows a decline though to 2001 followed by a sharp increase in 2002 with a slight decline in 2003 (Table 10, Fig. 14). The NMFS fall survey, which is the longest running time series, also shows an increase from 1995 to 1999, with a slight drop in 2000 followed by a large increase in 2001 (Table 11, Fig. 15). This series showed a strong decline between 2001 and 2002, but is still at a relatively high level compared to the mid-1990's when the stock was considered to be in a collapsed state.

Since 1996, most of the DFO spring survey total biomass and total number for yellowtail originates from Stratum 5Z4, which includes much of Closed Area II on the US side where no commercial fishing occurs (Fig. 15). Although survey estimates for this stratum tend to be quite variable due to low sampling intensity, the trend is clearly increasing from 1996 to present. Stratum 5Z2 (CDN portion of Georges < 90 m depth) has also shown an increasing trend in total biomass and total number since 1996, but at a lower level than 5Z4.

The length composition of the catch of yellowtail flounder taken in the DFO surveys has been fairly consistent since 1999 (Fig. 16) with little change in the average size of each sex (Fig. 16). In the 2002 and 2003 surveys, catches of fish < 28 cm were low compared to earlier years (1999-2001). Only 52% of the 2003 survey catch was comprised of males, compared to over 60% during the past three years (2000-2002).

Age-structured indices of abundance for NMFS spring and fall surveys were derived using survey-specific age-length keys. Since age interpretation of yellowtail otoliths collected from the DFO survey are not available for any year, age-length keys from NMFS spring surveys were substituted to derive age composition for same-year DFO spring surveys. Both spring series show a strong 1999 year class (age 3) in 2002 (Tables 9-10; Fig. 17) and a strong 2000 year class at age 3 in 2003. The 2002 NMFS fall survey shows lower abundance for all age groups and that the 2000 year class (age 2) is more abundant than the 1999 year class (age 3) (Table 11; Fig. 17). Overall, age-structured indices from the surveys do not track cohorts well and there are some indications of year-effects within the time series. However there appears to be some consistency with the strong 2000 year class in the 2002 NMFS fall survey (at age 2) and both 2003 spring surveys (at age 3).

The NMFS scallop survey is used as an index of “mid-year” age 1 yellowtail recruitment since small yellowtail are a common bycatch in this survey. The time series was updated from the 2001 assessment to include index values for 2001 and 2002. While the 1999 and 2000 values have shown a decrease since 1998, the overall trend is one of increasing age 1 abundance since the early 1990’s (Table 12).

ESTIMATION OF STOCK PARAMETERS

Calibration of VPA

The Virtual Population Analysis (VPA) used annual catch at age, $C_{a,t}$, for ages a = 1 to 6+, and time t = 1973 to 2002, where t represents the beginning of the time interval during which the catch was taken. The VPA was calibrated to bottom trawl and scallop survey abundance indices, $I_{s,a,t}$, for:

s = DFO spring, ages a = 2 to 6+, time t = 1987 to 2003
s = NMFS spring (Yankee 36), ages a = 1 to 6+, time t = 1982 to 2003
s = NMFS spring (Yankee 41), ages a = 1 to 6+, time t = 1973 to 1981
s = NMFS fall, ages a = 1 to 6+, time t = 1973.5 to 2002.5
s = NMFS scallop, age a = 1, time t = 1982.5 to 2002.5

Zero observations for abundance indices were treated as missing data as the logarithm of zero is not defined. Data were aggregated for ages 6 and older to mitigate against frequent zero observations. The fishing mortality rate for the 6 plus group was calculated according to the "alpha" method (Restrepo and Legault 1994).

The adaptive framework, ADAPT, (Gavaris 1988b) was used to calibrate the sequential population analysis with the research survey abundance trend results. The model formulation employed assumed that the random error in the catch at age was negligible. The errors in the abundance indices were assumed independent and identically distributed after taking natural logarithms of the values. The annual natural mortality rate, M, was assumed constant and equal to 0.2. The fishing mortality rates for age groups 5 and 6+ were assumed equal. These model assumptions and methods were similar to those applied in the last assessment (NEFSC 2002, Stone 2002). Both analytical and bootstrap statistics of the estimated parameters were derived. For consistency with the risk analysis, bias adjusted VPA results were based on bootstrap statistics.

The population abundance estimates show greater relative error (41%) and bias (8%) for age 2 while the relative error for ages 3-5 is lower (23-37%) and the bias is smaller (2-6%) (Table 13). Relative error and bias for age 2 is much lower than estimated from the previous assessment in 2002 since the 2001 year class was captured in all three bottom trawl surveys. Survey calibration constants were slightly higher this year compared to last year’s estimates and indicate a slight increase in catchability for all surveys (except the NMFS spring Yankee 41 series which remained unchanged). The average magnitude of residuals was large and negative for both the 2003 DFO and NMFS spring surveys for ages 4 and older (i.e. model predicts higher abundance than surveys) and for ages 3 and older from NMFS 2002 fall survey (Figs. 18-23). These large negative residuals will impact parameter estimates of current abundance. Retrospective analysis indicates a strong tendency to underestimate average fishing mortality on ages 4-5 and to overestimate spawning stock biomass and age 1 recruitment (Fig. 24). These strong retrospective patterns seriously affect the potential to provide reliable estimates of current population abundance, recruitment and projected catch biomass.

In this assessment, VPA calibration was performed using DFO software and US FACT software, which due to slight differences in search algorithms, bias correction, and computations can produce slightly different results. Results are presented from the DFO model configuration.

SURPLUS PRODUCTION ANALYSES

As was done last year, and recognizing the uncertainties in the age-structured information, an assessment method that does not rely upon age-structured data was also used. The ASPIC non-equilibrium surplus production methodology (Prager 1995) requires total catch and one or more indices of abundance. The indices used were DFO spring survey (1987 to 2003, lagged one year to reflect end of previous year biomass), NMFS spring (1968 to 1972; 1982-2003, lagged one year), and NMFS fall (1963 to 2002). The NMFS spring survey was subdivided into two periods when theYankee-36 trawl was used. The NMFS spring Yankee-41 trawl series (1973-1981) has been omitted from recent assessments since it is not considered to be influential. Yield input (1963-2002) includes estimates of USA discards and Canadian discards in 2001 and 2002. Estimates of initial biomass (B_1), maximum sustainable yield (MSY), intrinsic rate of increase (r), and catchability of each survey (q) were obtained using nonlinear least squares of survey residuals. Following the advice of Prager (1995), the first five years of output from ASPIC are not presented, since the starting biomass in the first year is poorly estimated.

STOCK STATUS

Virtual Population Analysis

Although there are concerns with the reliability of the CAA and age-specific indices of abundance, the results from the standard lognormal model formulation were used to evaluate the status of the stock in 2003 and 2004. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias and used to construct the history of stock status (Tables 14-15). The fishery weights at age, assumed to represent mid-year weights, were used to derive beginning of year weights at age (Table 16), and these were used to calculate beginning of year population biomass (Table 17).

Population biomass (Ages 1-6+) declined from about 32,000 t in 1973 to a historical low of about 3,600 t in 1988 and has subsequently increased steadily to over

38,000 t at the beginning of 2003 (Table 17, Fig. 25). The increasing trend is due principally to improved recruitment from the mid-1990's onward, but was also enhanced by increased survivorship of young yellowtail through reduced exploitation. The biomass of adult fish (ages 3+) shows a similar trend and was estimated at 26,000 t at the beginning of 2003. However, these estimates are considerably lower than those from the 2002 assessment (i.e. 58,000 t and 42,000 t for age 1+ and 3+ biomass, respectively; Stone 2002). The strength of the 2000 year-class was estimated to be 48 million at age 1, the largest since 1980 (Table 14, Fig. 26), but this recent estimate was considerably lower than the 2002 estimate of 62 million recruits for this year class. The 2002 assessment also indicated a strong 1997 year class (59 million in 2002) which has now declined to 28 million in 2003. Current indications for the 2001year class (estimated at 44 million recruits) indicate that it may be above average.

The fully recruited (4+) exploitation rate underwent a marked decline from 1994-2002 and the current assessment indicates that it has dropped below 20% (equivalent to $F_{0.1}$ =0.25) to 18% for the first time in 2002 (Fig. 27). This is a substantial difference from the 2002 assessment, when age 4+ F was estimated to be below F0.1 since 2000 and was at 9% exploitation for 2001, the lowest level for the time series. Exploitation on age 3 has not decreased proportionately and appears to have increased from 20% in 1996 to 33% in 2001, but then declined again to 20% in 2002. The age 3 partial recruitment to the fishery has increased over the past 5 years (i.e. from 0.734 in 1998 to 1.122 in 2002). The large change in PR is of concern given the poor sampling and few age samples available for the 2002 fishery.

Gains in fishable biomass may be partitioned into those associated with somatic growth of yellowtail which have previously recruited to the fishery and those associated with new recruitment to the fishery (Rivard 1980). We used age 2 as a convenient age of first recruitment to the fishery. On average, growth contributes about 50% of total production, ranging from 36-79% since 1973 (Fig. 28). Surplus production is defined as the gains in fishable biomass which are in excess of the needs to offset losses from natural mortality. When the fishery yield is less than the surplus production, there is a net increase in the population biomass. Since 1995, there was considerable production in excess of fishery removals up to 1999, dropping off slightly in 2001, then increasing sharply in 2002. The 2002 surplus production was estimated to be at 14,100 t compared to 8,000 t in 2001. The high value observed in 2002 is likely influenced by the strong 2000 year-class and the trend of increasing size at age (Table 5) observed in males and females after 1998. The yield for Age 2+ in 2002 was estimated to be 5,300 t, lower than the 2001 estimate of 7,400 t.

A number of sensitivity analyses were conducted in an attempt to determine the cause of the retrospective pattern.

1. The number of ages estimated in the terminal year was reduced to one and both a flat-topped and domed partial recruitment vector applied to force a given pattern in the terminal year.
2. The plus group was reduced to ages 5 and older.

3. The age 6 indices were not used for tuning.
4. The discards were artificially increased in recent years to the levels observed in 1994.

None of these sensitivity analyses substantially reduced the retrospective pattern, and many had additional problems with their solutions, such as patterns in residuals. A second form of sensitivity analysis changed the natural mortality rate from 0.1 to 1.0 in steps of 0.1. As M increased from 0.1 to 0.7 the fit improved and the residual pattern was reduced, it was absent for M=0.7. As M increased from 0.7 to 1.0 the fit become worse and the residual pattern increased, but in the direction of underestimating SSB and overestimating F, the reverse of the retrospective pattern seen in the base assessment. Although a natural mortality rate of 0.7 gave the best fit and did not show a retrospective pattern, it was not considered to be a reasonable value for such a long lived species and was not adopted.

Surplus Production Analyses

Correlations among survey biomass indices were strong (r= 0.82, 0.84, and 0.91; Appendix A). Most of the variance in survey indices was explained by the model (R^2= 0.76, 0.63, and 0.85). There were some apparent residual problems, with biomass residuals in the last year being moderate and negative for the NMFS and DFO spring surveys (*i.e.* surveys generally indicate lower current biomass than the model) and large and positive for the NMFS fall survey. The nonlinear solution was sensitive to the starting conditions when default convergence criteria were used (Prager 1995). Therefore, convergence criteria were made more restrictive (same as in previous 2002 assessment). Survey residuals were randomly resampled 500 times for bootstrap estimates of precision and model bias. A large portion of bootstrap trials did not meet the convergence criteria, indicating that bootstrap variance is probably underestimated. The bootstrap analysis indicated that MSY, and r were very well estimated (the relative interquartile ranges, IQR, were < 5%), but that B_1 and survey q's were more variable (relative IQRs = 2%-14%). Bootstrap calculations of K, B_{MSY}, and F_{MSY} were stable (relative IQRs=3-5%,), but ratios of current conditions to MSY conditions (F_{2001}/F_{MSY} and B_{2002}/B_{MSY}) were less precise (relative IQRs=6-8%).

ASPIC results indicate that a maximum sustainable yield of 14,580 t can be produced when the stock biomass (B_{MSY}) is 42,120 t at equilibrium. The population biomass in 2003 continues to increase, and is now estimated to be 65,000 t. Trends in biomass indicated from the surplus production analyses are very similar to those obtained from the VPA for 1+ biomass up to 1994, but then increase at a faster rate (Fig. 25). Biomass estimates from ASPIC are higher than those from the VPA since 1994. The exploitation rate on total biomass in 2002 (0.086) decreased slightly from 2001 (0.117) and is considered to be low.

The surplus production model attempts to describe long term population dynamics in a simple model which projects past stock productivity forward. However, it is not clear whether past stock productivity will always be a good predictor of stock dynamics. Further, surplus production models may fail to capture the dynamic changes that occur in recruitment, growth and exploitation patterns at age. To address these problems, an age structured production model was also examined. The model, called ASAP, employs a forward projection of an age structured population to fit the indices and assumes error in the catch at age data. While this model was not thoroughly tested or reviewed, it did show general agreement with the surplus production model, indicating a large decrease in fishing mortality rate and large increase in SSB since 1994. However, the catch at age was predicted to contain a higher proportion (11-14%) in the age 6 plus group than that observed in recent years (1-3%).

Research Vessel Total Mortality Estimates

Annual estimates of total mortality can be generated from each of the research vessel abundance at age estimates. The negative of the natural log of survivors divided by initial abundance the previous year is an estimate of the total mortality rate. A number of ages are used in each year to smooth the estimates, which are often still quite variable. For the US Fall and Spring surveys, the population abundance in numbers was summed for ages 4 through 7 and divided by the sum of ages 3 through 6. For the Canadian survey, the sum of ages 4 and 5 was divided by the sum of ages 3 and 4. The total mortality estimates from all three surveys were highly variable, as expected, but indicated a high level with no indication of reduction in recent years (Figure 29).

FISHERY REFERENCE POINTS

Yield per Recruit Reference Points

Although the yield per recruit analysis was not updated this year, an estimate of $F_{0.1}$ for ages 4+ was calculated based on the equilibrium age structure from the past yield per recruit analysis of Neilson and Cadrin (1998). ($F_{0.1}$ for ages 4+ = 0.25; exploitation rate=20.0%).

Stock and Recruitment

There is evidence of reduced recruitment at low levels of age 3+ biomass (Fig. 30). However, management actions by both countries appear to have been successful in building the population to levels where the probability of good recruitment is enhanced.

OUTLOOK

Surplus Production Analyses

While the historical population reconstruction from the VPA and the surplus production model show concurrence, projections from the two models diverge significantly. The projection results from the surplus production model imply high equilibrium recruitment levels that are not consistent with historical estimates. Accordingly, only the VPA projection results are considered reliable.

Virtual Population Analysis

Yield projections were done using the bias adjusted 2003 beginning of year population abundance estimates. The abundance of the 2003 and 2004 year-classes were assumed to be 30 million at age 1, a conservative starting point, given that the average for the 1998-2002 was 38 million recruits. Fishery weights at age and beginning of year population weights at age were averaged over the previous 5 years (1998 through 2002) for use in the 2004 forecasts. Partial recruitment to the fishery for ages 1, 2 and 3 was averaged for the past 5 years (1998-2002, Table 18). There has been an increase in PR on ages 2 and 3 since 1998, implying greater exploitation at younger ages. If this change is real, it has important implications to harvest strategies and conservation (spawning potential). The PR values used in this year's projection calculations (average of 1998-2002) are similar to the values used last year (i.e. age 2: 0.30 *vs* 0.28; age 3: 0.87 *vs* 0.88). Beginning of year weights at age were slightly higher for most age groups compared to last year's values (Table 16).

Projected total Canada/USA yield at $F_{0.1}$ = 0.25 in 2004 would be about 7,932 t (Table 18). This yield is based on the assumption that the Canada/USA yield in 2003 is 6,123 t (i.e. same as total landings reported in 2002). If fished at $F_{0.1}$ in 2004, the total biomass is projected to increase slightly from 41,896 t in 2004 to 42,708 t by the beginning of 2005, with a 2% increase in the 3+ beginning of year biomass from 32,470 t in 2004 to 33,283 t in 2005 (Fig. 31). The dominant 2001 and 2000 year-classes are expected to contribute about 59% of the expected yield as ages 3 and 4 in 2004, and comprise about 49% of the total biomass.

Uncertainty about year-class abundance generates uncertainty in forecast results. This uncertainty was expressed as risk of achieving reference targets. For example, with a *status quo* combined Canada and USA catch of 6,100 t in 2004, there is a 20% chance of exceeding $F_{0.1}$ and a high probability (100%) that beginning of year 3+ biomass will not increase from 2004 to 2005 (Fig. 32). These uncertainty calculations do not include variations in weight at age, partial recruitment to the fishery and natural mortality, or systematic errors in data reporting and model mismatch. Therefore, overall uncertainty would be greater, but these results provide guidelines.

The population age structure has improved in recent years and population biomass has increased. The current age structure indicates that some rebuilding of ages 4 and 5 has occurred but is still dominated by younger ages 1 and 2 (Fig. 33). In addition, there are far fewer older fish (6+) in comparison with a population at equilibrium, which is inconsistent with the perception of recent low exploitation.

MANAGEMENT CONSIDERATIONS

This assessment is hampered by considerable problems in estimating age structure of the catch and the age-specific indices of abundance. There are concerns with age determinations based solely on scales, particularly for larger, older fish, since the outer scale edge is subject to erosion over time. This may result in loss of annuli and an underestimate of the true age, especially after about 45 cm TL. Age estimation from otolith thin sections are hampered by the presence of many splits and checks, which cause much subjectivity in the identification of annuli. The result of limited sampling of the US catch and unavailability of age samples from the Canadian fishery and survey are that abundance of cohorts over time is not well monitored. Increased sampling intensity would allow consideration of sexually dimorphic growth for US catch at age. Availability of Canadian age samples would eliminate the need to borrow samples from other sources that may represent different components of the stock.

The outlook is more uncertain this year than in past years due to an increase in the retrospective pattern seen in the analytical assessment and divergence between the analytical assessment and production model results. The increased uncertainty in current stock status and the divergence in model results as well as the failure to explain the absence of older fish in the catch gives no confidence in projection results. Considering the trends in survey abundance and recruitment, status quo catch may be an appropriate management approach until these issues are resolved.

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LITERATURE CITED

Cadrin, S.X., W.J. Overholtz, J.D. Neilson, S. Gavaris, and S. Wigley. 1998. Stock assessment of Georges Bank yellowtail flounder for 1997. NEFSC Ref. Doc. 98-06.

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37: 2272-2275.

Gavaris, S. 1988a. Abundance indices from commercial fishing. p. 3-13 In: D. Rivard (ed) Collected papers on stock assessment methods. CAFSAC Res. Doc. 88/61. 167 p.

Gavaris, S. 1988b. An adaptive framework for the estimation of population size. CAFSAC Res. Doc. 88/29: 12 p.

Lux, F.E. 1963. Identification of New England yellowtail flounder groups. Fish. Bull. 63: 1-10.

Lux, F.E. 1969. Length-weight relationships of six New England flatfishes. Trans. Am. Fish. Soc. 98(4): 617-621.

Lux, F.E. and F.E. Nichy. 1969. Growth of yellowtail flounder, *Limanda ferruginea* (Storer), on three New England fishing grounds. ICNAF Res. Bull. No. 6: 5-25.

Mosely, S.D. 1986. Age structure, growth, and intraspecific growth variations of yellowtail flounder, *Limanda ferruginea* (Storer), on four northeastern United States fishing grounds. Univ. Mass. MS thesis.

NEFSC. 2002. Assessment of 20 Northeast groundfish stocks through 2001: a report of the Groundfish Assessment Review Meeting (GARM), Northeast Fisheries Science Center, Woods Hole, Massachusetts, October 8-11, 2002. Northeast Fish. Sci. Cent. Ref. Doc. 02-16.

Neilson, J.D., P. Hurley, and R.I. Perry. 1986. Stock structure of yellowtail flounder in the Gulf of Maine area: implications for management. CAFSAC Res. Doc. 86/64, 28 pp.

Neilson, J.D. and S.X. Cadrin. 1998. 1998 Assessment of Georges Bank (5Zjmnh) Yellowtail Flounder. Canadian Stock Assessment Secretariat Res. Doc. 98/67.

Neilson, J.D. , S. Gavaris and J.J. Hunt. 1997. 1997 assessment of Georges Bank (5Zjmnh) yellowtail flounder (*Limanda ferruginea*). Canadian Stock Assessment Secretariat Res. Doc. 97/55.

Prager, M.H. 1995. Users manual for ASPIC: a stock-production model incorporating covariates. SEFSC Miami Lab Doc. MIA-92/93-55.

Restrepo, V.R. and C.M. Legault. 1994. Approximations for solving the catch equation when it involves a "plus group". Fish. Bull. 93(2): 308-314.

Rivard, D. 1980. Back-calculating production from cohort analysis, with discussion on surplus production for two redfish stocks. CAFSAC Res. Doc. 80/23: 26 p.

Rago, P., W. Gabriel, and M. Lambert. 1994. Georges Bank yellowtail flounder. NEFSC Ref. Doc. 94-20.

Royce, W.F., R.J. Buller, and E.D. Premetz. 1959. Decline of the yellowtail flounder (*Limanda ferruginea*) off New England. Fish. Bull. 146:169-267.

Stone, H.H. 2002. Stock assessment of Georges Bank (5Zjmnh) yellowtail flounder for 2002. CSAS Res. Doc. 2002/057, 79 p.

Stone, H.H. and P. Perley. 2002. An evaluation of Georges Bank yellowtail flounder age determination based on otolith thin-sections. CSAS Res. Doc. 2002/076, 32p.

Walsh, S.J and J. Burnett. 2001. Report of the Canada-United States yellowtail flounder age reading workshop, November 28-30, St. John's Newfoundland. NAFO SCR Doc. 01/54. 57p.

Table 1. Annual catch (000s t) of Georges Bank yellowtail flounder. Canadian landings have been adjusted for catches of unspecified flounder.

Year	US landings	US discards	Canadian landings	Canadian discards	Foreign Catch	Total Catch
1963	10.990	5.600	-	-	0.100	16.690
1964	14.914	4.900	-	-	0.000	19.814
1965	14.248	4.400	-	-	0.800	19.448
1966	11.341	2.100	-	-	0.300	13.741
1967	8.407	5.500	-	-	1.400	15.307
1968	12.799	3.600	-	-	1.800	18.199
1969	15.944	2.600	-	-	2.400	20.944
1970	15.506	5.533	-	-	0.250	21.289
1971	11.878	3.127	-	-	0.503	15.508
1972	14.157	1.159	-	-	2.243	17.559
1973	15.899	0.364	-	-	0.260	16.523
1974	14.607	0.980	-	-	1.000	16.587
1975	13.205	2.715	-	-	0.091	16.011
1976	11.336	3.021	-	-	-	14.357
1977	9.444	0.567	-	-	-	10.011
1978	4.519	1.669	-	-	-	6.188
1979	5.475	0.720	-	-	-	6.195
1980	6.481	0.382	-	-	-	6.863
1981	6.182	0.095	-	-	-	6.277
1982	10.621	1.376	-	-	-	11.997
1983	11.350	0.072	-	-	-	11.422
1984	5.763	0.028	-	-	-	5.791
1985	2.477	0.043	-	-	-	2.520
1986	3.041	0.019	-	-	-	3.060
1987	2.742	0.233	-	-	-	2.975
1988	1.866	0.252	-	-	-	2.118
1989	1.134	0.073	-	-	-	1.207
1990	2.751	0.818	-	-	-	3.569
1991	1.784	0.246	-	-	-	2.030
1992	2.859	1.873	-	-	-	4.732
1993	2.089	1.089	0.675	-	-	3.853
1994	1.589	0.141	2.139	-	-	3.869
1995	0.292	0.024	0.472	-	-	0.788
1996	0.751	0.039	0.483	-	-	1.273
1997	0.966	0.058	0.810	-	-	1.834
1998	1.822	0.114	1.175	-	-	3.111
1999	1.987	0.484	1.971	-	-	4.442
2000	3.678	0.358	2.859	-	-	6.895
2001	3.792	0.505	2.913	0.566	-	7.776
2002	2.532	0.466	2.642	0.483	-	6.123

Table 2. Yellowtail flounder bycatch from 12 offshore scallop trips monitored by Canadian observers. Calculations for total yellowtail flounder bycatch during the 2001 Canadian offshore scallop fishery are also shown.

Trip	Month_YR	Observed sets (%)	Yellowtail catch (MT) Observed	Yellowtail catch (MT) Pro-rated	Scallop catch (MT)	Fishing days	NAFO
1	May_01	0.72	0.957	1.2250	153.862	8.92	5Zj
2	June_01	0.84	1.753	2.0335	166.772	7.94	5Zm
3	July_01	0.86	2.373	2.7052	164.497	8.92	5Zj
4	August_01	0.81	1.693	2.0147	178.881	7.92	5Zj
5	August_01	0.86	0.523	0.5962	160.136	7.91	5Zm
6	Sept_01	0.76	0.830	1.0292	166.225	9.95	5Zj
7	Sept_01	0.62	0.341	0.4706	157.102	9.95	5Zj
8	Nov_01	0.82	0.006	0.0071	139.156	9.96	5Zj
9	Dec_01	0.84	0.053	0.0615	116.014	8.93	5Zj
10	Feb_02	0.87	0.256	0.2906	144.118	8.92	5Zj
11	Mar_02	0.76	0.789	0.9784	122.867	7.94	5Zj
12	Apr_02	0.77	3.867	4.7564	139.741	7.94	5Zm

Sum of catch and effort

tri-1	4.912	6.025	406.726	24.8
tri-2	7.299	8.575	824.148	41.610
tri-3	1.230	1.568	578.497	38.790
Total	**13.441**	**16.168**	**1809.371**	**105.200**

weighted averages:

Trimester	%cat min	%cat max	mt/day min	mt/day max
tri-1	1.208	1.481	0.198	0.243
tri-2	0.886	1.040	0.175	0.206
tri-3	0.213	0.271	0.032	0.040
Total	**0.743**	**0.894**	**0.128**	**0.154**

Offshore scallop fishery catch/effort for 2001

Trimester	Catch (t)	Effort (d)
tri-1	17017.17	971.91
tri-2	24904.85	1413.79
tri-3	14853.04	951.57
Total	56775.06	3337.27

Yellowtail discards

Trimester	from effort min	from effort max	from catch min	from catch max
tri-1	192.501	236.132	205.515	252.096
tri-2	247.999	291.339	220.568	259.114
tri-3	30.174	38.473	31.581	40.267
Total	**470.674**	**565.945**	**457.663**	**551.477**

Table 3. Yellowtail flounder bycatch from 12 offshore scallop trips monitored by Canadian observers. Calculations for total yellowtail flounder bycatch during the 2002 Canadian offshore scallop fishery are also shown.

		Observed	Yellowtail catch (MT)		Scallop	Fishing	
Trip	Month_YR	sets (%)	Observed	Pro-rated	catch (MT)	days	NAFO
1	May_01	0.72	0.957	1.2250	153.862	8.92	5Zj
2	June_01	0.84	1.753	2.0335	166.772	7.94	5Zm
3	July_01	0.86	2.373	2.7052	164.497	8.92	5Zj
4	August_01	0.81	1.693	2.0147	178.881	7.92	5Zj
5	August_01	0.86	0.523	0.5962	160.136	7.91	5Zm
6	Sept_01	0.76	0.830	1.0292	166.225	9.95	5Zj
7	Sept_01	0.62	0.341	0.4706	157.102	9.95	5Zj
8	Nov_01	0.82	0.006	0.0071	139.156	9.96	5Zj
9	Dec_01	0.84	0.053	0.0615	116.014	8.93	5Zj
10	Feb_02	0.87	0.256	0.2906	144.118	8.92	5Zj
11	Mar_02	0.76	0.789	0.9784	122.867	7.94	5Zj
12	Apr_02	0.77	3.867	4.7564	139.741	7.94	5Zm

Sum of catch and effort				
tri-1	4.912	6.025	406.726	24.8
tri-2	7.299	8.575	824.148	41.610
tri-3	1.230	1.568	578.497	38.790
Total	**13.441**	**16.168**	**1809.371**	**105.200**

weighted averages:

Trimester	**%cat min**	**%cat max**	**mt/day min**	**mt/day max**
tri-1	1.208	1.481	0.198	0.243
tri-2	0.886	1.040	0.175	0.206
tri-3	0.213	0.271	0.032	0.040
Total	**0.743**	**0.894**	**0.128**	**0.154**

Offshore scallop fishery catch/effort for 2002

Trimester	**Catch (t)**	**Effort (d)**
tri-1	11368.688	722.1
tri-2	23883.562	1255.02
tri-3	20038.719	1216.27
Total	55290.969	3193.39

Yellowtail discards

	from effort		from catch	
Trimester	min	max	min	max
tri-1	143.022	175.439	137.299	168.418
tri-2	220.149	258.621	211.523	248.488
tri-3	38.567	49.176	42.606	54.326
Total	**401.738**	**483.236**	**391.428**	**471.232**

Table 4. Port samples used in the estimation of landings at age for Georges Bank yellowtail flounder in 2002 from Canadian and US sources.

USA	**Port Samples**				**Sea Samples**			**Landings**
Quarter	Size	Trips	Lengths	Ages	Trips	Lengths	Ages	(t)
1	All	7	637	144	2	20	0	971
2	All	8	775	169	8	1049	0	1139
3	All	3	287	70	24	774	0	132
4	All	8	834	169	6	85	0	289
Canada	**Port Samples**				**Sea Samples**			**Landings**
Quarter	Size	Trips	Lengths	Ages	Trips	Lengths	Ages	(t)
1	0	0	0	0	0	0	0	0
2	All	1	250	0	1	399	0	2
3	All	16	3359	0	9	7498	0	2237
4	All	9	1863	0	2	1129	0	403

Table 5. Average length of male and female yellowtail flounder by age group and year for the Canadian fishery, based on catch at age data for 1997 through 2002.

Year	Age						
	1	2	3	4	5	6	7
	Males						
1997	28.2	33.0	34.3	35.7	37.4	-	-
1998	29.2	32.2	36.8	44.2	47.3	51.0	-
1999	27.2	33.8	36.2	38.1	38.2	-	-
2000	26.7	33.9	35.8	38.2	39.4	41.3	48.0
2001	30.8	34.7	35.4	36.7	42.3	-	-
2002	29.1	34.3	35.9	39.6	-	-	-
	Females						
1997	-	34.1	37.5	39.8	42.7	42.8	43.7
1998	23.2	34.0	38.4	40.8	41.8	44.9	45.4
1999	28.7	35.7	39.4	41.6	44.1	45.9	46.0
2000	29.1	36.4	39.6	42.1	46.6	48.6	50.8
2001	30.8	35.8	38.3	41.9	43.9	46.4	47.3
2002	28.0	36.2	40.2	42.3	44.5	45.6	46.5

Table 6. Total catch at age (number in 000's) including Canadian (2002) and US discards, for Georges Bank yellowtail flounder, 1973-2002.

	Age								
Year	1	2	3	4	5	6	7	8+	Total
1973	347	4890	13243	9276	3743	1259	278	81	33117
1974	2143	8971	7904	7398	3544	852	452	173	31437
1975	4372	25284	7057	3392	2084	671	313	164	43337
1976	615	31012	5146	1347	532	434	287	147	39520
1977	330	8580	9917	1721	394	221	129	124	21416
1978	9659	3105	4034	1660	459	102	37	35	19091
1979	233	9505	3445	1242	550	141	79	52	15247
1980	309	3572	8821	1419	321	85	4	10	14541
1981	55	729	5351	4556	796	122	4	0	11613
1982	2063	17491	7122	3246	1031	62	19	3	31037
1983	696	7689	16016	2316	625	109	10	8	27469
1984	428	1917	4266	4734	1592	257	47	17	13258
1985	650	3345	816	652	410	60	5	0	5938
1986	158	5771	978	347	161	52	16	8	7491
1987	140	2653	2751	761	132	39	32	41	6549
1988	483	2367	1191	624	165	15	20	3	4868
1989	185	1516	668	262	68	11	8	0	2718
1990	219	1931	6123	800	107	17	3	0	9200
1991	412	54	1222	2430	293	56	4	0	4471
1992	2389	8359	2527	1269	510	20	7	0	15081
1993	5194	1009	2777	2392	318	65	9	1	11765
1994	71	861	5742	2571	910	99	37	1	10292
1995	14	157	895	715	137	13	11	4	1946
1996	50	383	1509	716	167	9	5	1	2840
1997	16	595	1258	1502	341	26	45	19	3802
1998	26	971	2792	1824	624	82	20	0	6871
1999	21	3287	3209	1498	651	137	25	0	8828
2000	100	3731	5747	2824	798	273	33	18	13524
2001	216	2754	6865	2586	1007	248	207	23	13907
2002	43	4070	3924	1891	719	186	128	66	11027

Table 7. Mean weight at age (kg) for the total catch, including US discards, of Georges Bank yellowtail flounder.

	Age							
Year	1	2	3	4	5	6	7	8+
1973	0.100	0.352	0.462	0.527	0.603	0.689	1.067	1.136
1974	0.108	0.345	0.498	0.609	0.680	0.725	0.906	1.249
1975	0.111	0.316	0.489	0.554	0.618	0.687	0.688	0.649
1976	0.106	0.312	0.542	0.636	0.741	0.814	0.852	0.866
1977	0.109	0.342	0.525	0.634	0.782	0.865	1.036	1.013
1978	0.100	0.315	0.510	0.684	0.793	0.899	0.930	0.948
1979	0.103	0.331	0.460	0.649	0.728	0.835	1.003	0.882
1980	0.100	0.325	0.493	0.656	0.813	1.054	1.256	1.214
1981	0.099	0.347	0.490	0.603	0.707	0.798	0.832	-
1982	0.112	0.301	0.486	0.650	0.748	1.052	1.024	1.311
1983	0.139	0.296	0.440	0.604	0.736	0.952	1.018	0.987
1984	0.162	0.240	0.378	0.500	0.642	0.738	0.944	1.047
1985	0.178	0.363	0.497	0.647	0.733	0.819	0.732	-
1986	0.176	0.342	0.540	0.664	0.823	0.864	0.956	1.140
1987	0.112	0.316	0.522	0.666	0.680	0.938	0.793	0.788
1988	0.100	0.325	0.555	0.688	0.855	1.054	0.873	1.385
1989	0.100	0.345	0.542	0.725	0.883	1.026	1.254	-
1990	0.100	0.293	0.397	0.577	0.697	0.807	1.230	-
1991	0.100	0.268	0.368	0.481	0.726	0.820	1.306	-
1992	0.100	0.295	0.369	0.522	0.647	1.203	1.125	-
1993	0.100	0.287	0.376	0.507	0.562	0.882	1.038	1.044
1994	0.150	0.256	0.350	0.472	0.628	0.848	0.896	1.166
1995	0.155	0.249	0.365	0.462	0.582	0.703	0.785	0.531
1996	0.137	0.298	0.405	0.568	0.725	0.910	1.031	1.209
1997	0.155	0.310	0.410	0.523	0.668	0.869	0.919	1.216
1998	0.185	0.333	0.453	0.542	0.670	0.829	0.886	-
1999	0.210	0.374	0.506	0.637	0.748	0.873	0.892	1.104
2000	0.185	0.379	0.480	0.612	0.756	0.933	1.001	1.278
2001	0.108	0.287	0.435	0.610	0.812	0.928	0.987	1.236
2002	0.169	0.361	0.484	0.663	0.833	0.994	1.051	1.324

Table 8. ANOVA results from a multiplicative model with main effects for year, month and tonnage class for the Canadian yellowtail flounder fishery CPUE, 1993-2002.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R............	0.804
MULTIPLE R SQUARED.....	0.646

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	1.582E3	1.582E3	
REGRESSION	16	3.940E2	2.462E1	133.966
YEAR	9	3.667E2	4.075E1	221.683
MONTH	6	3.373E1	5.622E0	30.587
AREA	1	1.391E0	1.391E0	7.570
RESIDUALS	1176	2.161E2	1.838E¯1	
TOTAL	1193	2.193E3		

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	CATCH	EFFORT
1993	¯1.3613	0.0243	0.278	0.043	111	400
1994	¯2.1635	0.0019	0.126	0.005	1138	9041
1995	¯1.1598	0.0049	0.343	0.024	370	1079
1996	¯0.6364	0.0052	0.579	0.042	369	638
1997	¯0.5271	0.0032	0.646	0.037	723	1119
1998	¯0.6773	0.0026	0.556	0.028	1094	1967
1999	¯0.3753	0.0017	0.753	0.031	1860	2471
2000	¯1.0369	0.0013	0.388	0.014	2500	6435
2001	¯1.6833	0.0012	0.204	0.007	2534	12450
2002	¯1.5476	0.0013	0.233	0.008	2273	9751

RESIDUALS

```
          3.5+
             |
             |     *
             |
             |
          2.0+
R            |
E            |       *  *    *
S            |     ** *  *   *
I            |      ************ *
D         0.5+  *  ***************
U            |  *  ***************
A            |     ***************
L            |     ***************
S            |     ***************
         ¯1.0+        *** * *  *
             |        **  ***
             |
             |              * *
             |
         ¯2.5+
            _/+---------+---------+
          ¯3.0     ¯1.5      0.0
             PREDICTED LN CATCH RATE
```

Table 9. Canadian DFO spring survey indices of Georges Bank yellowtail flounder abundance at age (stratified mean #/tow) and stratified total biomass (000s t).

	Age							Biomass
Year	1	2	3	4	5	6+	Total	(000s t)
1987	0.12	0.68	2.00	1.09	0.06	0.00	3.95	1.264
1988	0.00	0.66	1.89	0.80	0.59	0.01	3.96	1.235
1989	0.11	0.78	0.80	0.32	0.10	0.02	2.13	0.471
1990	0.00	1.27	4.62	1.12	0.43	0.01	7.45	1.578
1991	0.02	0.59	1.72	2.91	0.99	0.00	6.24	1.759
1992	0.22	10.04	4.52	1.21	0.16	0.00	16.14	2.475
1993	0.33	2.16	5.04	3.47	0.62	0.00	11.63	2.642
1994	0.00	6.03	3.33	3.08	0.75	0.33	13.51	2.753
1995	0.21	1.31	4.07	2.22	1.14	0.11	9.07	2.027
1996	0.45	5.54	8.44	7.49	1.37	0.16	23.45	5.304
1997	0.10	9.48	15.16	19.09	3.11	0.54	47.49	13.292
1998	0.92	3.10	3.81	5.15	2.44	0.59	16.01	4.292
1999	0.22	13.05	24.78	9.07	6.85	3.10	57.07	17.666
2000	0.06	9.18	31.22	18.56	5.77	4.42	69.22	19.948
2001	0.29	5.97	51.67	16.65	4.41	3.61	82.62	22.157
2002	0.10	9.30	33.10	11.41	6.75	1.95	62.61	20.624
2003	0.02	9.14	27.11	10.39	2.71	2.31	53.09	16.249

Table 10. NMFS spring survey indices (stratified mean #/tow) of Georges Bank yellowtail flounder abundance at age and total biomass (stratified mean kg/tow).

	Age									Biomass
Year	1	2	3	4	5	6	7	8+	Total	kg/tow
1968	0.149	3.364	3.579	0.316	0.084	0.160	0.127	-	7.779	2.813
1969	1.015	9.406	11.119	3.096	1.423	0.454	0.188	0.057	26.758	11.170
1970	0.093	4.485	6.030	2.422	0.570	0.121	0.190	-	13.911	5.312
1971	0.791	3.335	4.620	3.754	0.759	0.227	0.050	0.029	13.564	4.607
1972	0.138	7.136	7.198	3.514	1.094	0.046	0.122	-	19.247	6.450
1973	1.931	3.266	2.368	1.063	0.410	0.173	0.023	0.020	9.254	2.938
1974	0.316	2.224	1.842	1.256	0.346	0.187	0.085	0.009	6.265	2.719
1975	0.420	2.939	0.860	0.298	0.208	0.068	-	0.013	4.806	1.676
1976	1.034	4.368	1.247	0.311	0.196	0.026	0.048	0.037	7.268	2.273
1977	-	0.671	1.125	0.384	0.074	0.013	-	-	2.267	0.999
1978	0.936	0.798	0.507	0.219	0.026	-	0.008	-	2.494	0.742
1979	0.279	1.933	0.385	0.328	0.059	0.046	0.041	-	3.072	1.227
1980	0.057	4.644	5.761	0.473	0.057	0.037	-	-	11.030	4.456
1981	0.012	1.027	1.779	0.721	0.205	0.061	-	0.026	3.830	1.960
1982	0.045	3.742	1.122	1.016	0.455	0.065	-	0.026	6.472	2.500
1983	-	1.865	2.728	0.531	0.123	0.092	0.061	0.092	5.492	2.642
1984	-	0.093	0.809	0.885	0.834	0.244	-	-	2.865	1.646
1985	0.110	2.198	0.262	0.282	0.148	-	-	-	3.000	0.988
1986	0.027	1.806	0.291	0.056	0.137	0.055	-	-	2.372	0.847
1987	-	0.128	0.112	0.133	0.053	0.055	-	-	0.480	0.329
1988	0.078	0.275	0.366	0.242	0.199	0.027	-	-	1.187	0.566
1989	0.047	0.424	0.740	0.290	0.061	0.022	0.022	-	1.605	0.729
1990	-	0.065	1.108	0.393	0.139	0.012	0.045	-	1.762	0.699
1991	0.435	-	0.254	0.675	0.274	0.020	-	-	1.659	0.631
1992	-	2.010	1.945	0.598	0.189	-	-	-	4.742	1.566
1993	0.046	0.290	0.500	0.317	0.027	-	-	-	1.180	0.482
1994	-	0.621	0.638	0.357	0.145	0.043	-	-	1.804	0.660
1995	0.040	1.180	4.810	1.490	0.640	0.010	-	-	8.170	2.579
1996	0.030	0.990	2.630	2.700	0.610	0.060	-	-	7.020	2.853
1997	0.019	1.169	3.733	4.081	0.703	0.134	-	-	9.837	4.359
1998	-	2.081	1.053	1.157	0.759	0.323	0.027	-	5.400	2.324
1999	0.050	4.746	10.820	2.720	1.623	0.426	0.329	0.024	20.738	9.307
2000	0.183	4.819	7.666	2.914	0.813	0.422	0.102	-	16.916	6.696
2001	0	2.315	6.563	2.411	0.483	0.352	0.101	0	12.225	5.006
2002	0.188	2.412	12.333	4.078	1.741	0.378	0.408	0.086	21.624	9.563
2003	0.202	4.370	6.764	2.876	0.442	0.128	0.536	0.198	15.515	6.721

Table 11. NMFS fall survey indices (stratified mean #/tow) of Georges Bank yellowtail flounder abundance at age and total biomass (stratified mean kg/tow).

					Age						Biomass
Year	0	1	2	3	4	5	6	7	8+	Total	kg/tow
1963	-	14.722	7.896	11.226	1.858	0.495	0.281	0.034	0.233	36.746	12.788
1964	-	1.721	9.723	7.370	5.998	2.690	0.383	0.095	0.028	28.007	13.623
1965	0.014	1.138	5.579	5.466	3.860	1.803	0.162	0.284	0.038	18.345	9.104
1966	1.177	8.772	4.776	2.070	0.837	0.092	0.051	-	-	17.775	3.988
1967	0.106	9.137	9.313	2.699	1.007	0.309	0.076	0.061	-	22.708	7.575
1968	-	11.782	11.946	5.758	0.766	0.944	0.059	-	-	31.254	10.536
1969	0.135	8.106	10.381	5.855	1.662	0.553	0.149	0.182	-	27.023	9.279
1970	1.048	4.610	5.133	3.144	1.952	0.451	0.063	0.017	-	16.417	4.979
1971	0.025	3.627	6.949	4.904	2.248	0.551	0.234	0.024	0.024	18.586	6.365
1972	0.785	2.424	6.525	4.824	2.095	0.672	0.279	-	-	17.604	6.328
1973	0.094	2.494	5.497	5.104	2.944	1.216	0.416	0.171	0.031	17.996	6.602
1974	1.030	4.623	2.854	1.524	1.060	0.460	0.249	0.131	-	12.133	3.733
1975	0.361	4.625	2.511	0.877	0.572	0.334	0.033	-	0.031	9.420	2.365
1976	-	0.336	1.929	0.475	0.117	0.122	0.033	-	0.067	3.078	1.533
1977	-	0.928	2.161	1.649	0.618	0.113	0.056	0.036	0.016	5.614	2.829
1978	0.037	4.729	1.272	0.773	0.406	0.139	0.011	-	0.024	7.443	2.383
1979	0.018	1.312	1.999	0.316	0.122	0.138	0.038	0.064	0.007	4.041	1.520
1980	0.078	0.761	5.086	6.050	0.678	0.217	0.162	0.006	0.033	13.217	6.722
1981	-	1.584	2.333	1.630	0.500	0.121	0.083	0.013	-	6.345	2.621
1982	-	2.424	2.185	1.590	0.423	0.089	-	-	-	6.711	2.270
1983	-	0.109	2.284	1.914	0.473	0.068	0.012	-	0.038	4.898	2.131
1984	0.012	0.661	0.400	0.306	2.428	0.090	0.029	-	0.018	3.944	0.593
1985	0.010	1.350	0.560	0.160	0.040	0.080	-	-	-	2.200	0.709
1986	-	0.280	1.110	0.350	0.070	-	-	-	-	1.810	0.820
1987	-	0.113	0.390	0.396	0.053	0.079	-	-	-	1.031	0.509
1988	0.011	0.019	0.213	0.102	0.031	-	-	-	-	0.376	0.171
1989	0.027	0.248	1.992	0.774	0.069	0.066	-	-	-	3.176	0.977
1990	0.147	-	0.326	1.517	0.280	0.014	-	-	-	2.284	0.725
1991	-	2.100	0.275	0.439	0.358	-	-	-	-	3.172	0.730
1992	-	0.151	0.396	0.712	0.162	0.144	0.027	-	-	1.592	0.576
1993	-	0.842	0.136	0.587	0.536	-	-	-	-	2.101	0.545
1994	0.010	1.200	0.220	0.980	0.710	0.260	0.030	0.030	-	3.440	0.897
1995	0.070	0.280	0.120	0.350	0.280	0.050	0.010	-	-	1.160	0.354
1996	-	0.140	0.350	1.870	0.450	0.070	-	-	-	2.880	1.303
1997	-	1.392	0.533	3.442	2.090	1.071	0.082	-	-	8.611	3.781
1998	-	1.900	4.817	4.202	1.190	0.298	0.055	0.019	-	12.481	4.347
1999	-	3.090	8.423	5.527	1.432	1.436	0.260	-	-	20.168	7.973
2000	0.019	0.629	1.697	4.814	2.421	0.948	0.800	0.027	-	11.355	5.838
2001	0.037	3.518	6.268	8.091	2.601	1.718	0.714	1.344	-	24.282	11.553
2002	0.052	2.066	5.751	2.127	0.594	0.277	0.000	0.000	0.027	10.841	3.754

Table 12. NMFS scallop survey index (stratified mean #/tow) for Georges Bank yellowtail flounder age-1 abundance.

Year	Number per tow
1982	0.313
1983	0.140
1984	0.233
1985	0.549
1986	0.103
1987	0.047
1988	0.116
1989	0.195
1990	0.100
1991	2.117
1992	0.167
1993	1.129
1994	1.503
1995	0.609
1996	0.508
1997	1.062
1998	1.872
1999	1.038
2000	0.912
2001	0.789
2002	1.005

Table 13. Statistical properties of estimates for population abundance and survey calibration constants (10^{-3}) for Georges Bank yellowtail flounder.

Age	Estimate	Bootstrap Standard Error	Relative Error	Bias	Relative Bias
		Population Abundance			
2	39002	15878	0.407	3274	0.084
3	30412	11202	0.368	1960	0.064
4	13610	4628	0.340	667	0.049
5	7242	1685	0.233	147	0.020
		Survey Calibration Constants			
Scallop–1982-2002 (Age 1)					
	0.032	0.006	0.196	0.001	0.018
DFO Spr Survey – 1987-2003 (Age 2-6+)					
	0.251	0.055	0.218	0.006	0.022
	0.906	0.197	0.217	0.021	0.023
	1.325	0.288	0.217	0.031	0.023
	1.461	0.319	0.218	0.034	0.024
	1.614	0.405	0.251	0.050	0.031
NMFS Spr Survey – Yankee 36 –1982-2003 (1-6+)					
	0.004	0.001	0.239	0.000	0.027
	0.079	0.016	0.196	0.001	0.018
	0.200	0.038	0.190	0.004	0.018
	0.285	0.054	0.190	0.005	0.018
	0.371	0.071	0.191	0.007	0.018
	0.581	0.120	0.206	0.012	0.021
NMFS Spr Survey – Yankee 41 – 1973-1981 (1-6+)					
	0.008	0.002	0.313	0.000	0.049
	0.083	0.024	0.295	0.004	0.043
	0.106	0.031	0.295	0.005	0.043
	0.104	0.031	0.295	0.005	0.043
	0.083	0.024	0.295	0.004	0.043
	0.084	0.025	0.295	0.004	0.043
NMFS Fall Survey - 1973-2002 (Age 1-6+)					
	0.047	0.008	0.166	0.001	0.013
	0.106	0.017	0.162	0.001	0.013
	0.227	0.037	0.162	0.003	0.013
	0.251	0.041	0.163	0.003	0.013
	0.328	0.057	0.175	0.005	0.015
	0.422	0.084	0.200	0.008	0.020

Table 14. Beginning of year population abundance numbers (000's) for Georges Bank yellowtail flounder from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2003.

Year	Age Group								
	1	2	3	4	5	6+	1+	2+	3+
1973	27857	22950	28577	16854	6801	2940	105977	78120	55171
1974	49338	22494	14392	11572	5543	2310	105649	56311	33817
1975	67297	38460	10389	4748	2917	1607	125418	58122	19662
1976	22618	51153	9102	2265	895	1460	87492	64875	13721
1977	15642	17963	14350	2875	658	792	52280	36638	18675
1978	50294	12509	7049	2986	826	313	73976	23682	11173
1979	23135	32486	7451	2185	967	478	66703	43568	11082
1980	21884	18731	18066	3024	684	211	62600	40717	21986
1981	59983	17638	12121	6922	1209	191	98065	38082	20444
1982	21271	49060	13782	5143	1633	133	91023	69752	20692
1983	5753	15555	24496	4937	1332	271	52344	46592	31036
1984	8501	4083	5878	5872	1975	398	26706	18205	14123
1985	14338	6574	1631	1051	661	105	24360	10022	3448
1986	6564	11152	2400	608	282	133	21140	14576	3423
1987	6957	5232	3988	1090	189	160	17617	10660	5428
1988	19080	5569	1918	834	220	51	27673	8593	3023
1989	8446	15185	2443	514	133	37	26760	18313	3128
1990	11557	6748	11066	1401	187	35	30994	19437	12689
1991	21637	9264	3791	3611	435	89	38828	17192	7927
1992	15502	17343	7536	2008	807	43	43239	27737	10394
1993	11406	10541	6740	3905	519	122	33233	21827	11286
1994	8873	4700	7720	3034	1074	162	25563	16690	11990
1995	10077	7200	3073	1265	242	50	21906	11830	4629
1996	12680	8238	5753	1712	399	36	28819	16139	7901
1997	18976	10336	6399	3355	762	201	40028	21053	10716
1998	28079	15521	7926	4107	1405	232	57270	29191	13670
1999	35832	22966	11832	3987	1733	431	76780	40948	17983
2000	33831	29318	15842	6805	1923	781	88500	54669	25351
2001	48158	27608	20641	7822	3046	1446	108721	60564	32955
2002	43685	39233	20121	10745	4085	2159	120029	76343	37110
2003	30000	35728	28452	12943	7095	4123	118341	88341	52614

Table 15. Fishing mortality rate for Georges Bank yellowtail from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2003.

Year	Age Group						
	1	2	3	4	5	6+	3+
1973	0.014	0.267	0.704	0.912	0.912	0.912	0.804
1974	0.049	0.572	0.909	1.178	1.178	1.178	1.063
1975	0.074	1.241	1.323	1.469	1.469	1.469	1.392
1976	0.030	1.071	0.952	1.036	1.036	1.036	0.981
1977	0.024	0.735	1.370	1.048	1.048	1.048	1.295
1978	0.237	0.318	0.971	0.927	0.927	0.927	0.955
1979	0.011	0.387	0.702	0.961	0.961	0.961	0.787
1980	0.016	0.235	0.759	0.717	0.717	0.717	0.752
1981	0.001	0.047	0.657	1.244	1.244	1.244	0.896
1982	0.113	0.495	0.827	1.151	1.151	1.151	0.935
1983	0.143	0.773	1.228	0.716	0.716	0.716	1.120
1984	0.057	0.717	1.521	1.984	1.984	1.984	1.792
1985	0.051	0.807	0.787	1.115	1.115	1.115	0.960
1986	0.027	0.828	0.589	0.968	0.968	0.968	0.702
1987	0.022	0.803	1.365	1.398	1.398	1.398	1.374
1988	0.028	0.624	1.117	1.633	1.633	1.633	1.305
1989	0.024	0.116	0.356	0.809	0.809	0.809	0.456
1990	0.021	0.377	0.920	0.968	0.968	0.968	0.926
1991	0.021	0.006	0.435	1.298	1.298	1.298	0.886
1992	0.186	0.745	0.458	1.153	1.153	1.153	0.649
1993	0.687	0.111	0.598	1.091	1.091	1.091	0.797
1994	0.009	0.225	1.609	2.328	2.328	2.328	1.865
1995	0.002	0.024	0.385	0.952	0.952	0.952	0.576
1996	0.004	0.053	0.339	0.610	0.610	0.610	0.413
1997	0.001	0.066	0.243	0.670	0.670	0.670	0.415
1998	0.001	0.071	0.487	0.663	0.663	0.663	0.561
1999	0.001	0.171	0.353	0.529	0.529	0.529	0.413
2000	0.003	0.151	0.506	0.604	0.604	0.604	0.543
2001	0.005	0.116	0.453	0.450	0.450	0.450	0.452
2002	0.001	0.121	0.241	0.215	0.215	0.215	0.229

Table 16. Beginning of year weight (kg) at age for Georges Bank yellowtail. Age group 6+ is catch weighted. The 2003 value is the average for 1998-2002.

Year	Age Group					
	1	2	3	4	5	6+
1973	0.054	0.188	0.403	0.493	0.564	0.704
1974	0.063	0.186	0.419	0.530	0.599	0.758
1975	0.066	0.185	0.411	0.525	0.613	0.702
1976	0.059	0.186	0.414	0.558	0.641	0.738
1977	0.064	0.190	0.405	0.586	0.705	0.866
1978	0.055	0.185	0.418	0.599	0.709	0.882
1979	0.058	0.182	0.381	0.575	0.706	0.871
1980	0.054	0.183	0.404	0.549	0.726	0.905
1981	0.057	0.186	0.399	0.545	0.681	0.810
1982	0.069	0.173	0.411	0.564	0.672	0.878
1983	0.106	0.182	0.364	0.542	0.692	0.869
1984	0.108	0.183	0.334	0.469	0.623	0.784
1985	0.128	0.242	0.345	0.495	0.605	0.726
1986	0.131	0.247	0.443	0.574	0.730	0.827
1987	0.066	0.236	0.423	0.600	0.672	0.860
1988	0.054	0.191	0.419	0.599	0.755	0.893
1989	0.058	0.186	0.420	0.634	0.779	1.026
1990	0.061	0.171	0.370	0.559	0.711	0.886
1991	0.058	0.164	0.328	0.437	0.647	0.774
1992	0.059	0.172	0.314	0.438	0.558	0.941
1993	0.063	0.169	0.333	0.433	0.542	0.803
1994	0.116	0.160	0.317	0.421	0.564	0.747
1995	0.112	0.193	0.306	0.402	0.524	0.727
1996	0.091	0.215	0.318	0.455	0.579	0.789
1997	0.106	0.206	0.350	0.460	0.616	0.923
1998	0.130	0.227	0.375	0.471	0.592	0.770
1999	0.157	0.263	0.410	0.537	0.637	0.780
2000	0.149	0.282	0.424	0.556	0.693	0.858
2001	0.051	0.230	0.406	0.541	0.705	0.903
2002	0.077	0.230	0.357	0.466	0.688	0.971
2003	0.113	0.246	0.394	0.514	0.663	0.857

Table 17. Beginning of year biomass (t) for Georges Bank yellowtail from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2003.

Year	Age Group								
	1	2	3	4	5	6+	1+	2+	3+
1973	1500	4306	11524	8316	3834	2070	31549	30049	25743
1974	3115	4178	6026	6138	3318	1752	24527	21412	17234
1975	4456	7105	4267	2494	1790	1128	21239	16784	9679
1976	1335	9519	3767	1263	573	1078	17535	16200	6681
1977	1003	3420	5808	1685	464	686	13066	12063	8643
1978	2764	2318	2944	1789	585	276	10677	7912	5594
1979	1341	5910	2836	1257	683	417	12444	11103	5193
1980	1175	3427	7298	1661	497	191	14249	13074	9647
1981	3406	3286	4837	3774	824	155	16281	12875	9590
1982	1465	8469	5660	2902	1097	117	19711	18245	9776
1983	609	2832	8915	2675	922	235	16187	15579	12746
1984	920	746	1966	2754	1230	312	7928	7008	6262
1985	1841	1594	563	520	400	76	4995	3153	1559
1986	862	2752	1063	349	206	110	5342	4479	1728
1987	457	1234	1685	654	127	138	4295	3838	2604
1988	1027	1063	803	500	166	45	3605	2577	1515
1989	493	2821	1026	326	104	38	4808	4314	1494
1990	706	1155	4095	783	133	31	6904	6198	5043
1991	1260	1517	1245	1578	282	69	5950	4691	3174
1992	915	2979	2370	880	450	40	7634	6719	3741
1993	713	1786	2245	1689	281	98	6812	6099	4313
1994	1033	752	2447	1278	606	121	6237	5204	4452
1995	1126	1392	939	508	127	36	4129	3002	1611
1996	1155	1770	1827	780	231	28	5791	4637	2866
1997	2007	2130	2237	1544	469	186	8572	6566	4436
1998	3653	3526	2970	1936	832	179	13096	9443	5916
1999	5609	6041	4857	2142	1103	336	20088	14479	8438
2000	5041	8260	6712	3787	1333	670	25803	20762	12502
2001	2456	6350	8380	4232	2147	1306	24871	22415	16065
2002	3364	9024	7183	5007	2811	2096	29485	26121	17097
2003	3382	8803	11221	6658	4704	3532	38300	34918	26115

Table 18. Deterministic projection input assumptions and results for Georges Bank yellowtail for 2004 at $F_{0.1}$ using the bootstrap bias adjusted population abundance at the beginning of 2003.

Year	Age Group								
	1	2	3	4	5	6+	1+	2+	3+
Beginning of Year Population Numbers (000s)									
2004	30000	24534	27325	19114	8450	7324			
Partial Recruitment to the Fishery									
2004	0.005	0.301	0.874	1.00	1.00	1.00			
Fishing Mortality									
2004	0.001	0.075	0.218	0.250	0.250	0.250			
Weight at beginning of year for population (kg)									
2004	0.113	0.246	0.394	0.514	0.663	0.857			
Beginning of Year Projected Population Biomass (t)									
2004	3390	6035	10766	9824	5603	6277	41896	38506	32470
2005	3390	6035	7341	9242	8080	8620	42708	39318	33283
Projected Catch Numbers (000s)									
2004	34	1614	4879	3848	1701	1475			
Average weight for catch (kg)									
2004	0.171	0.347	0.472	0.613	0.764	0.953			
Projected Yield (t)									
2004	6	560	2303	2359	1300	1405	7932	7926	7366

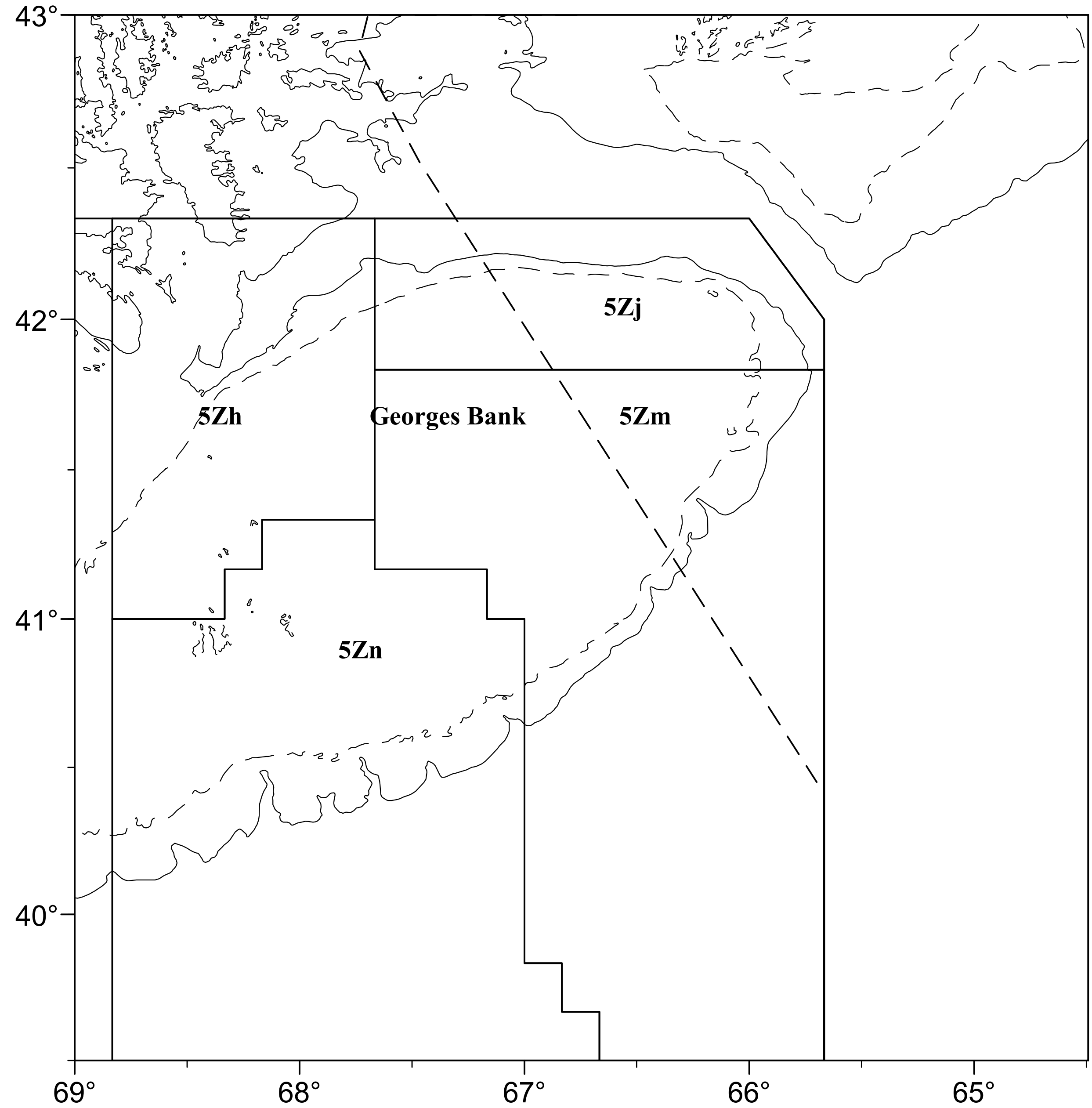


Fig. 1a. Location of Canadian fisheries statistical unit areas in NAFO Subdivision 5Ze.

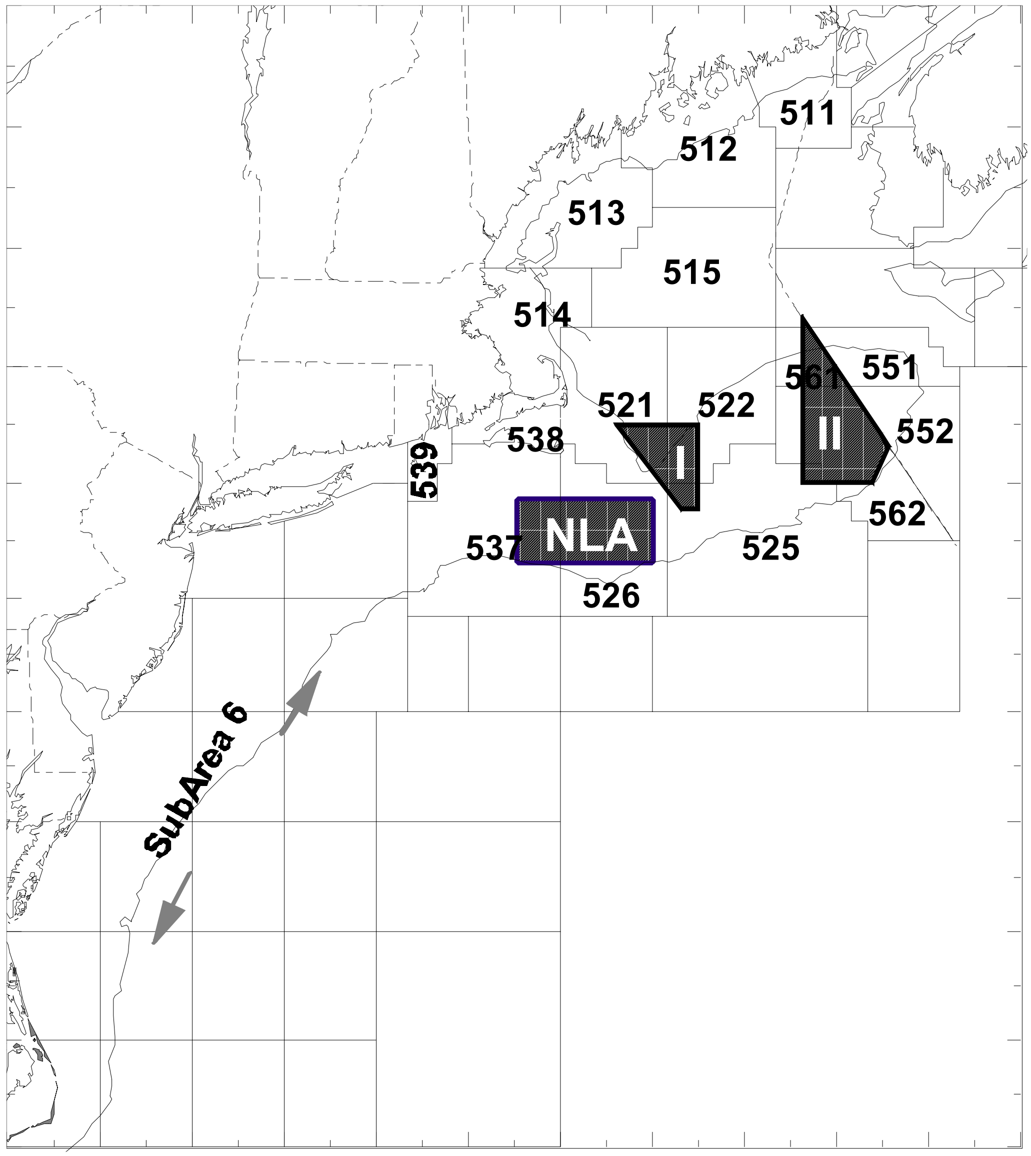


Fig. 1b. Statistical areas used for monitoring northeast U.S. fisheries. Catches from areas 522, 525, 551, 552, 561 and 562 are included in the Georges Bank yellowtail flounder assessment. Shaded areas have been closed to fishing year-round since 1994, with exceptions.

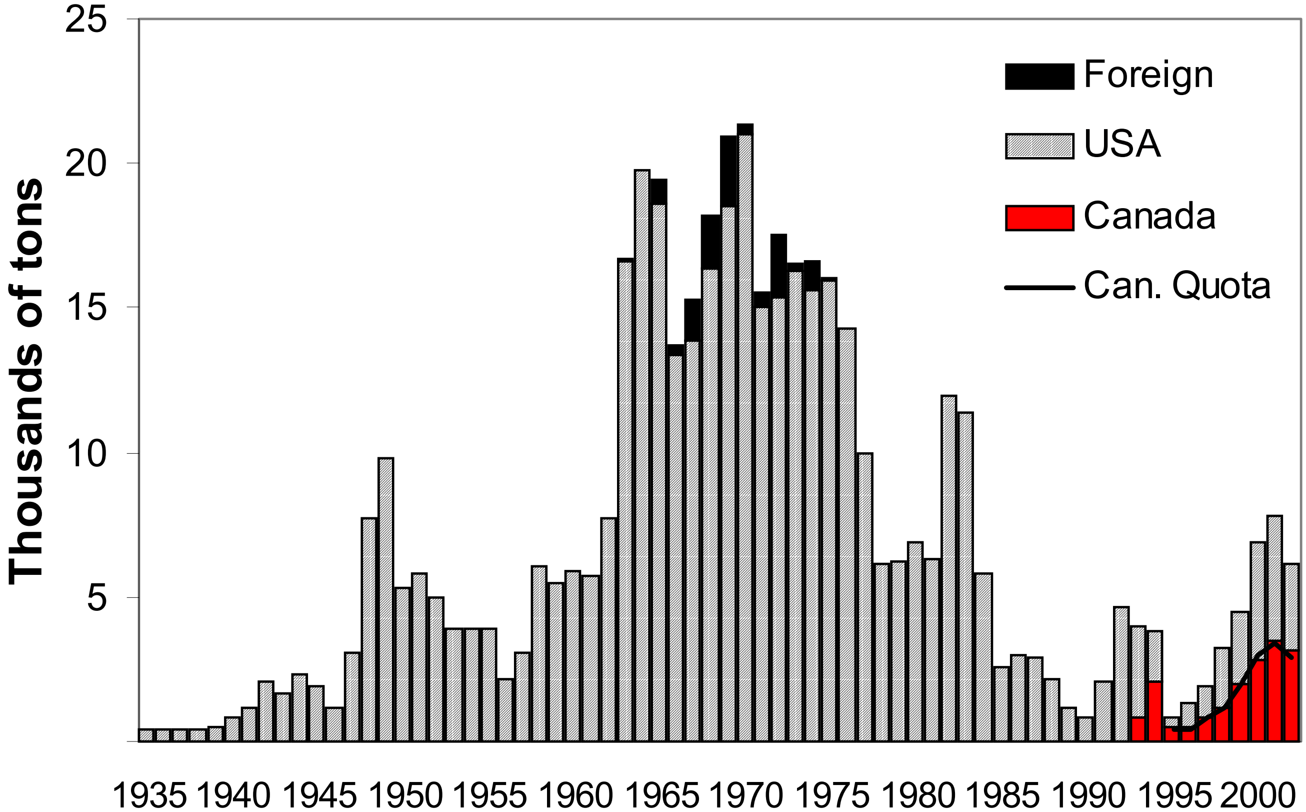


Fig. 2 . Landings (including discards) of Georges Bank yellowtail flounder by nation, 1935-2002. (Note: Yellowtail flounder discards from the Canadian offshore scallop fishery have been included in the 2001 and 2002 Canadian landings).

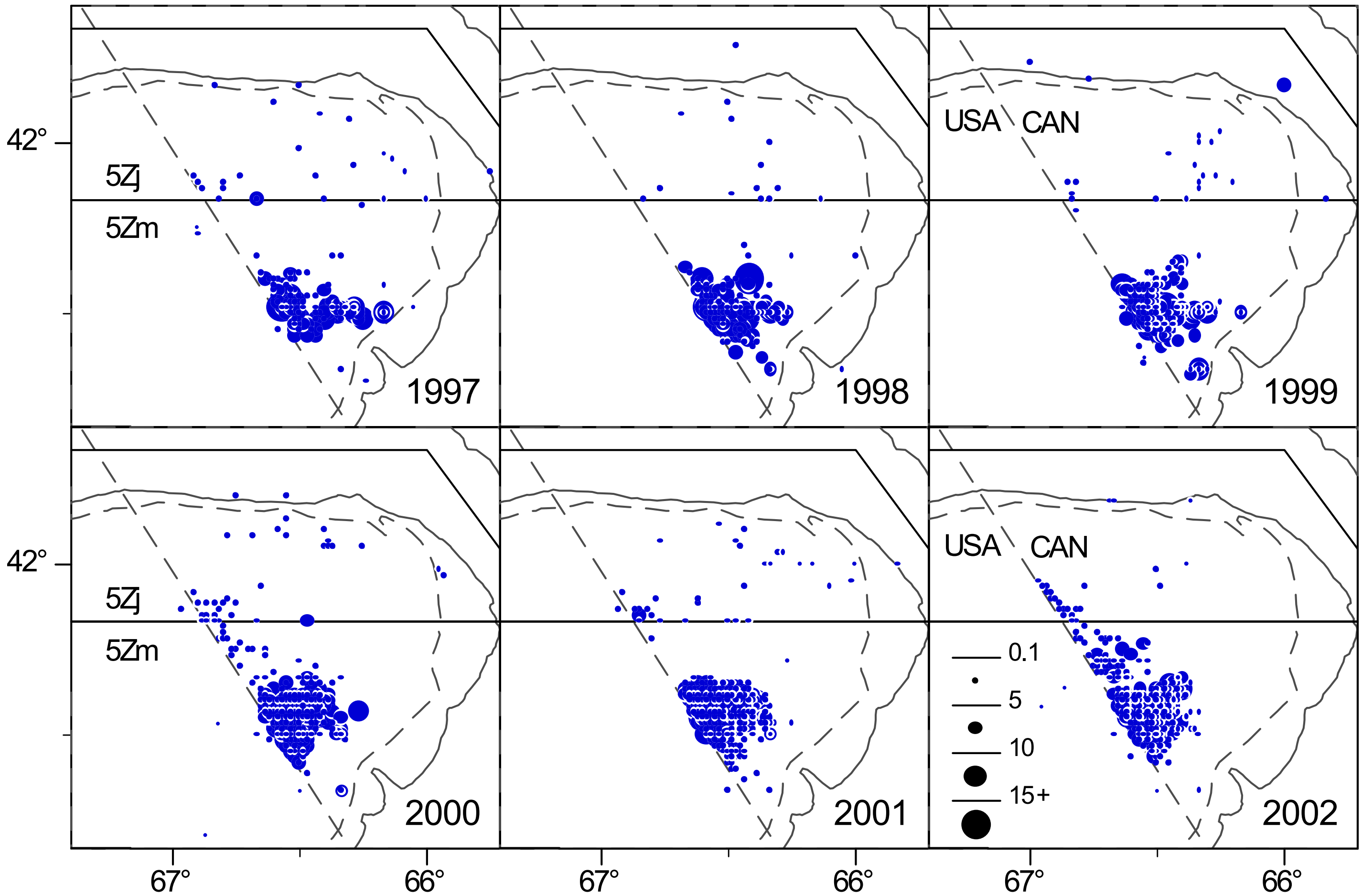


Fig 3. Distribution of Canadian mobile gear (TC 2 & 3) yellowtail flounder catches for 1997-2002 where trip landings were greater than 0.5t. Expanding symbols represent metric tonnes.

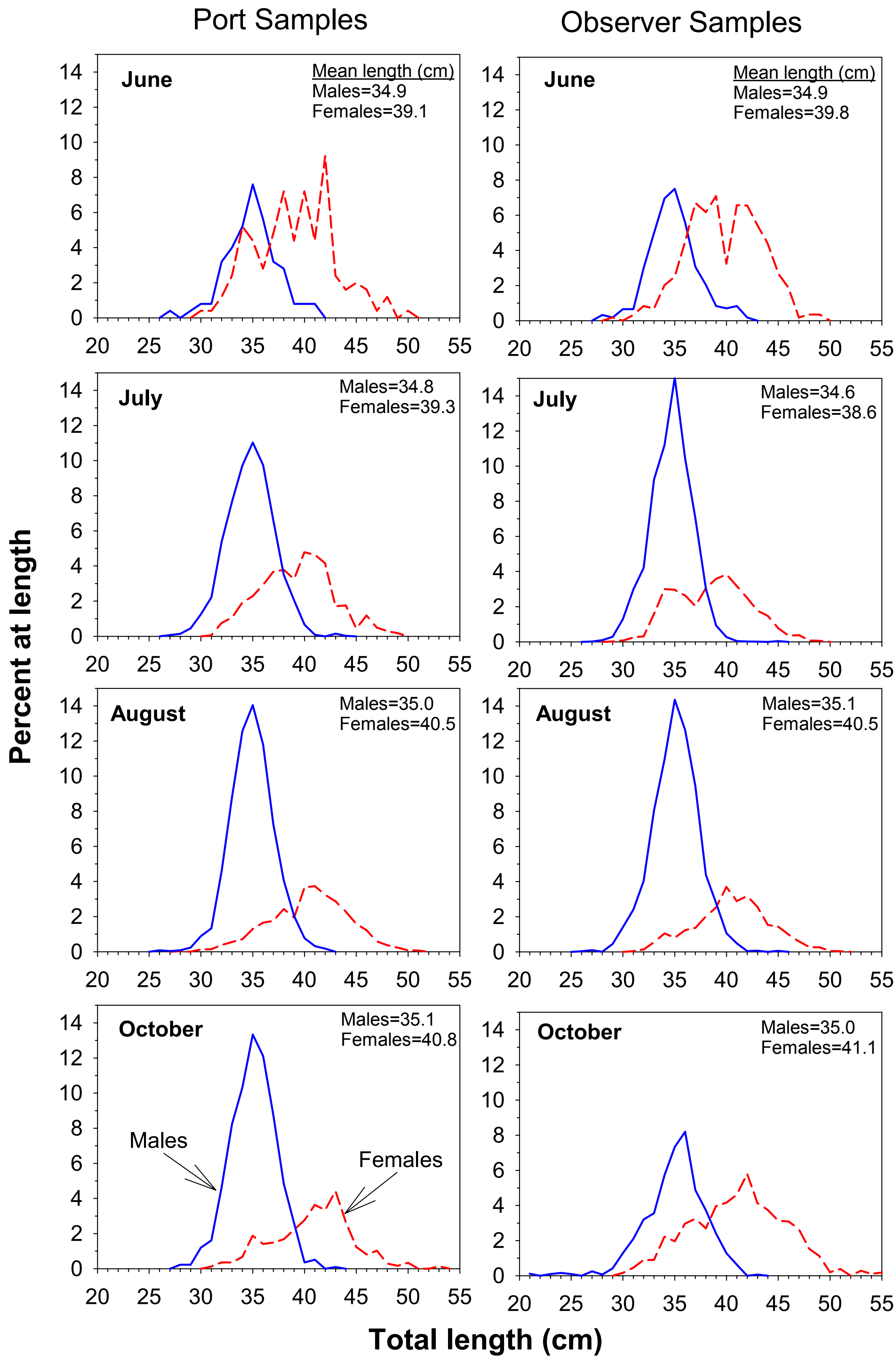


Fig. 4. Length frequencies of Georges Bank yellowtail flounder sampled by sex at dockside (left panels) and at sea (right panels) during the same month for the 2002 fishery.

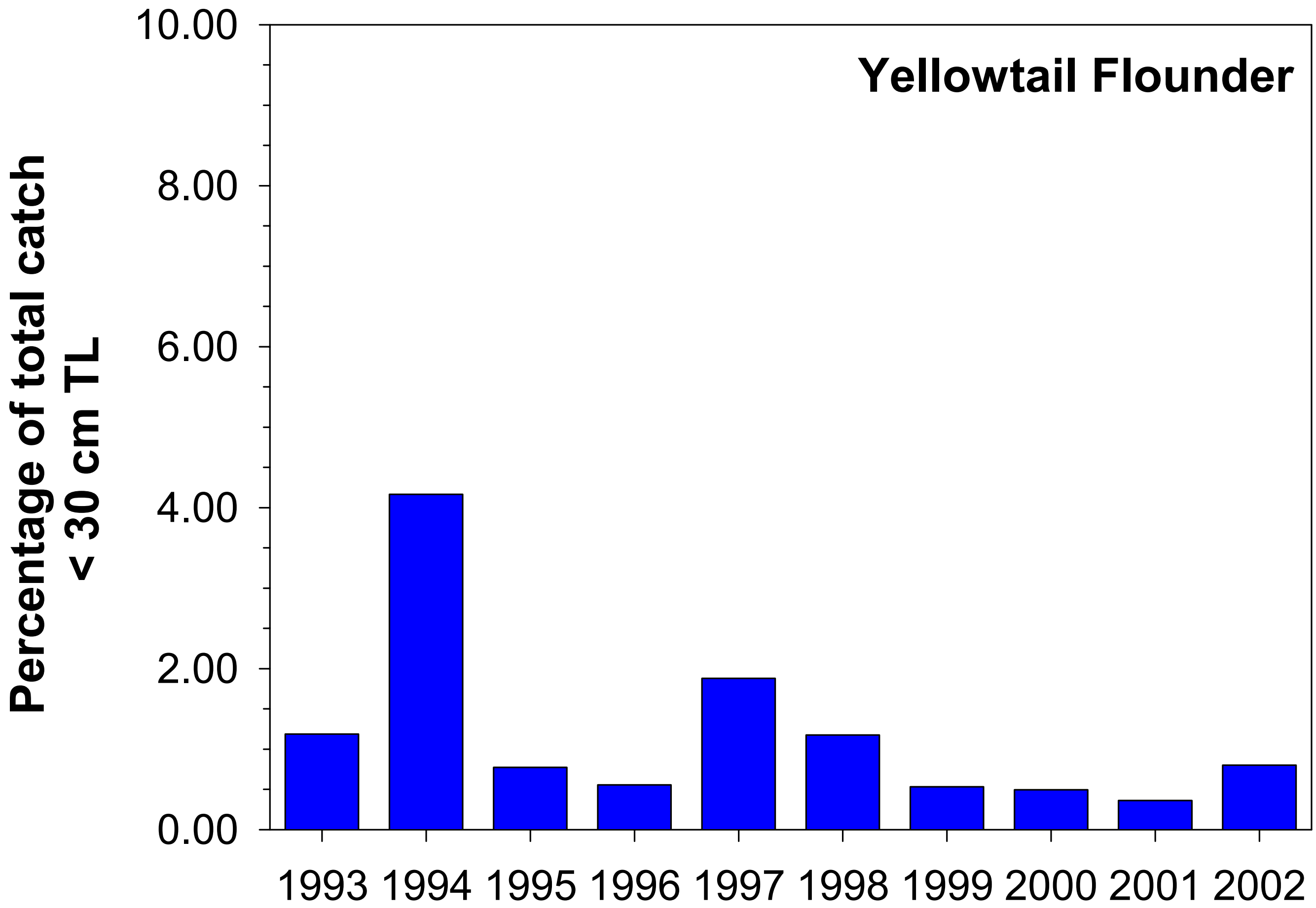


Fig. 5. Percentage of total catch of Georges Bank yellowtail flounder less than 30 cm total length from the Canadian fishery, 1993-2002.

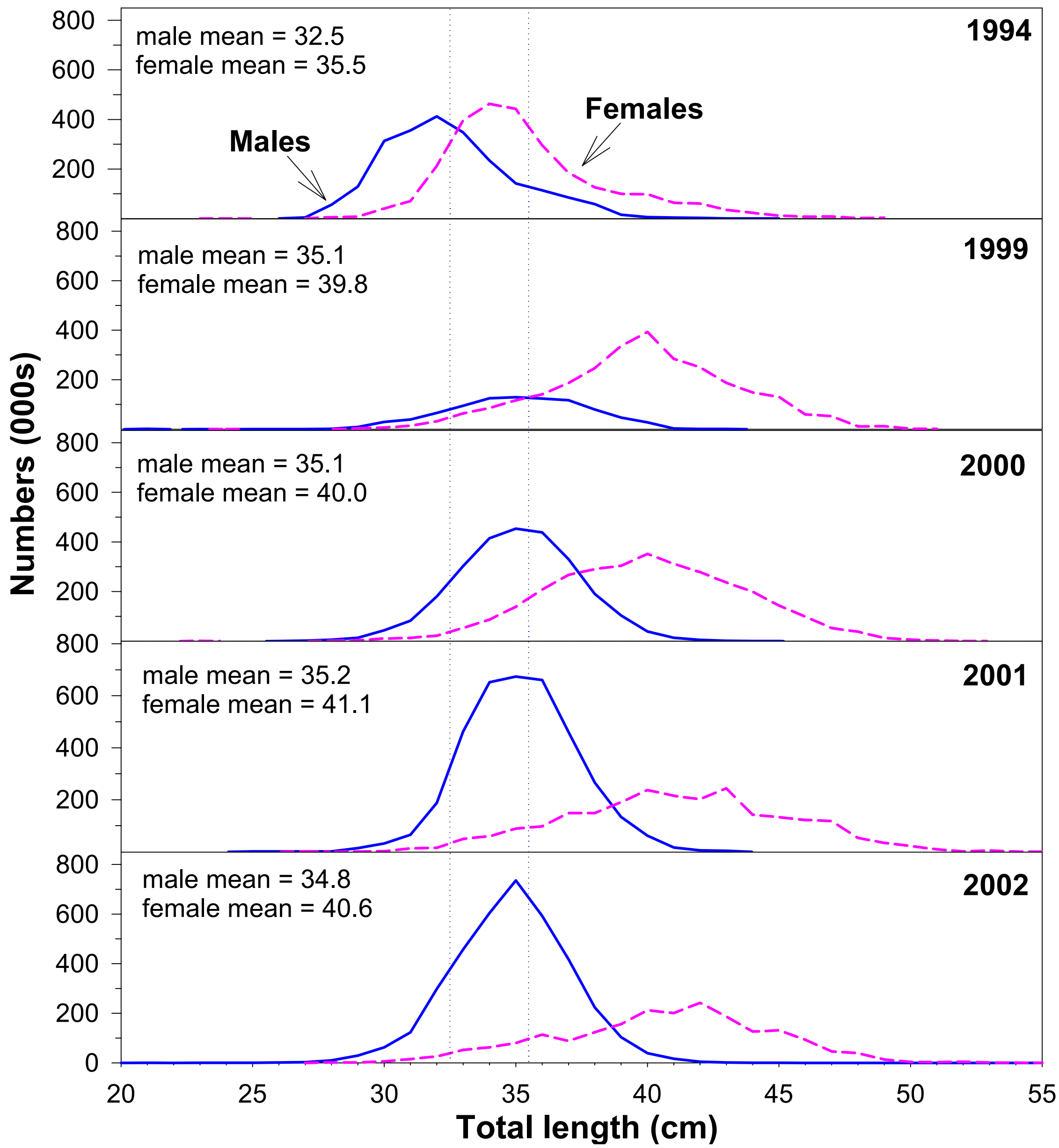


Fig. 6. Georges Bank yellowtail flounder length frequency composition by sex for the Canadian fishery in 1994 (beginning of exploitation period) and from 1999 to 2002.

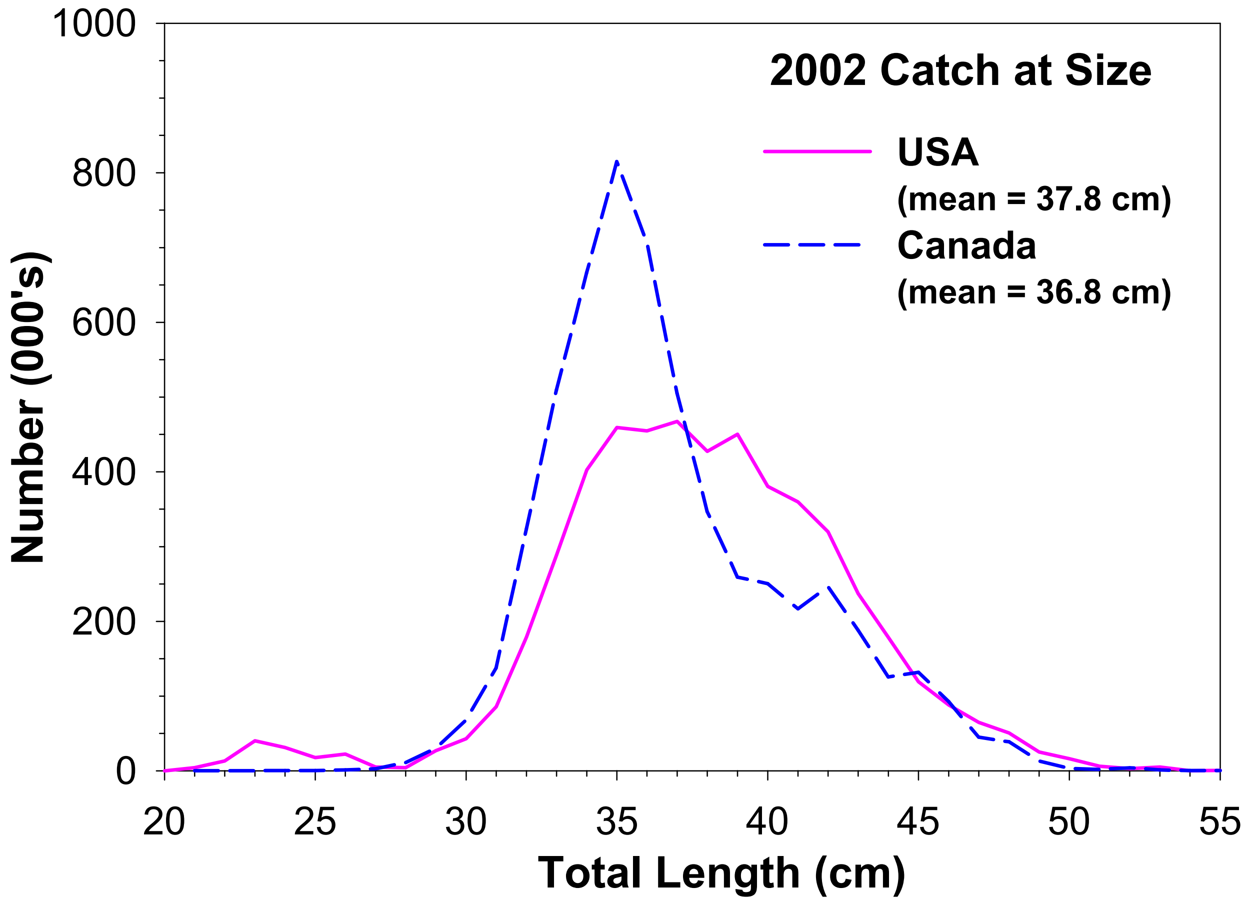


Fig. 7. Comparison of Georges Bank yellowtail flounder catch at size from the 2002 Canadian and USA fisheries. The US catch at size also includes discards from the offshore scallop and bottom trawl fisheries.

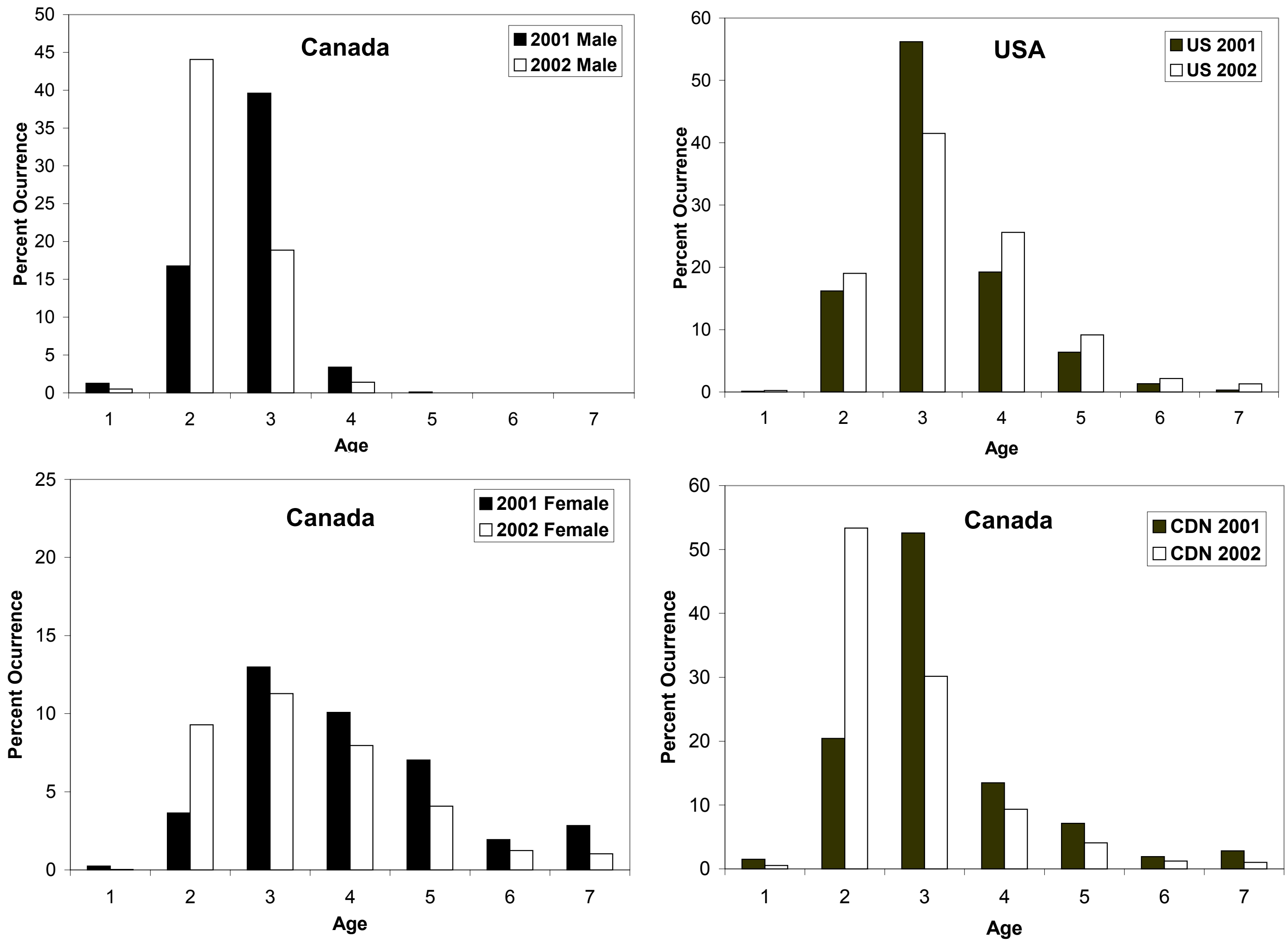


Fig. 8. Comparison of 2001 and 2002 Georges Bank yellowtail flounder fishery age composition for Canadian males and females (left panels), USA sexes aggregated (upper right panel) and Canadian sexes aggregated(lower right panel).

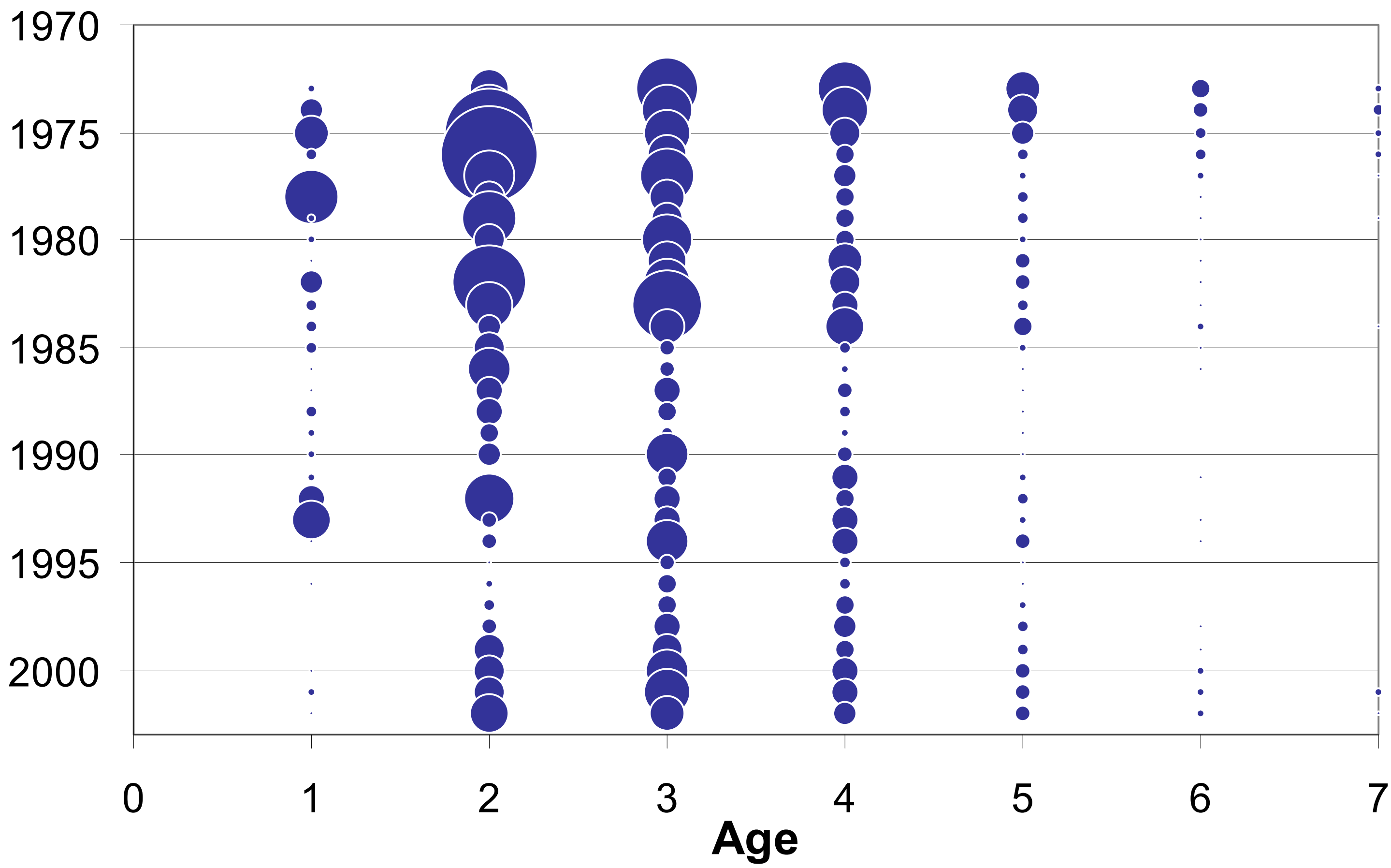


Fig. 9. Catch at age for Georges Bank yellowtail flounder, Canadian and USA fisheries combined, 1973-2003. (The area of the bubble is proportional to the magnitude of the catch).

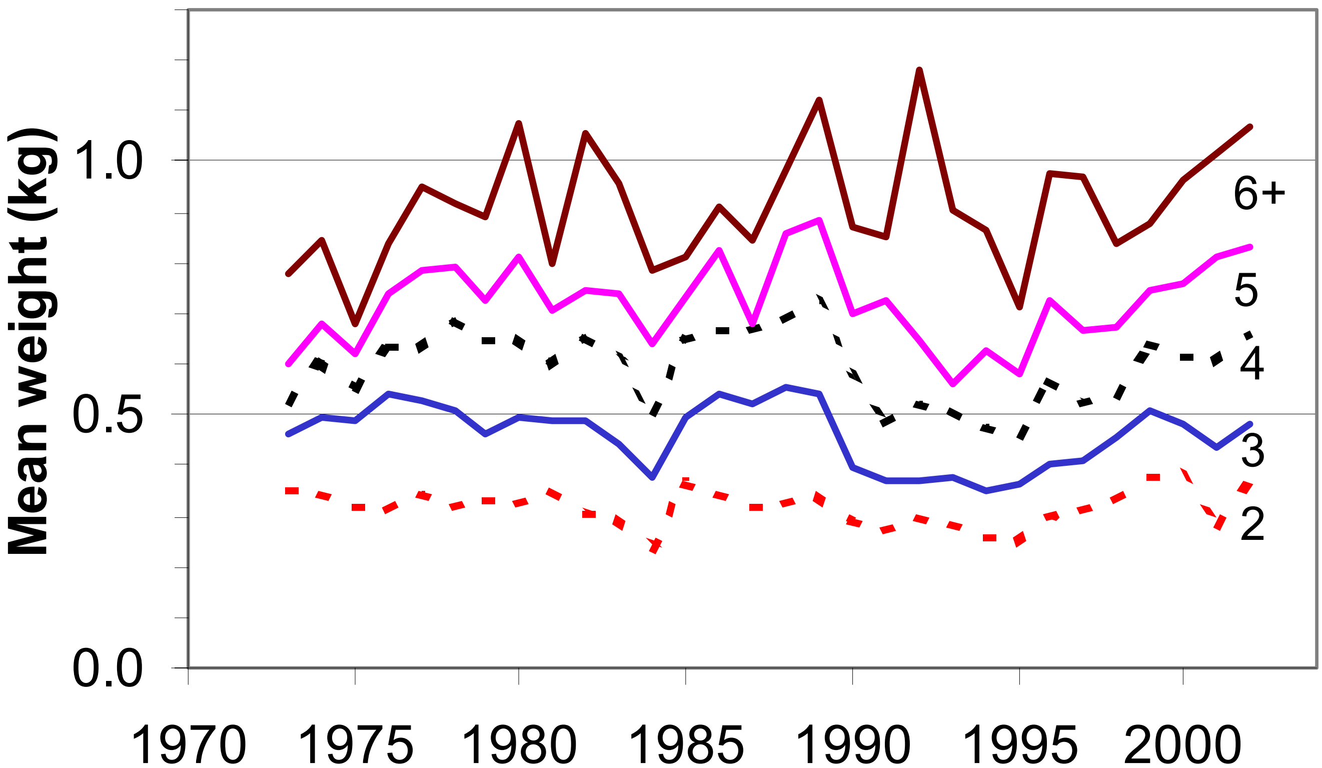


Fig. 10. Trends in mean weight at age from the 5Zjhmn yellowtail fishery, 1973 to 2002 (Canada and USA combined).

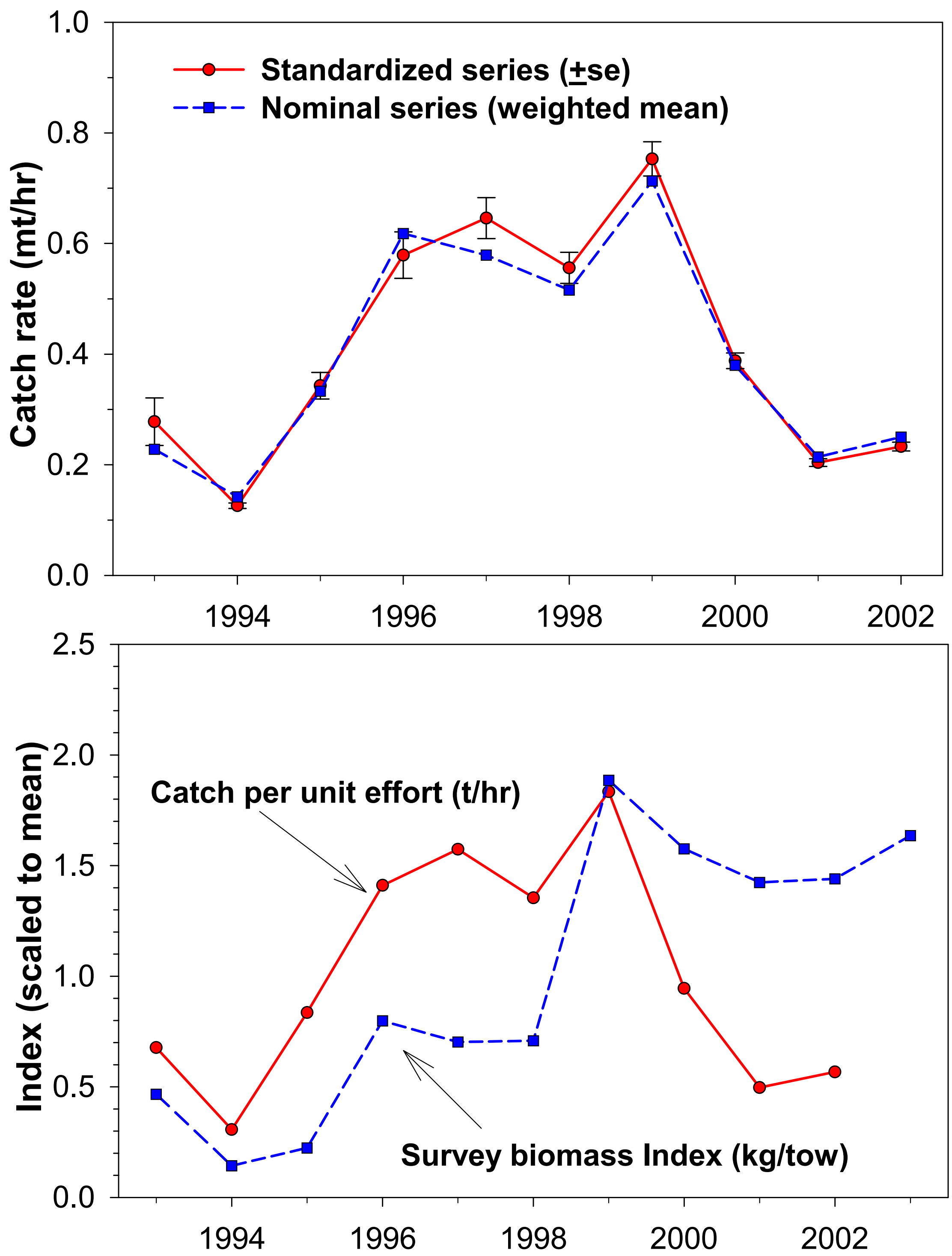
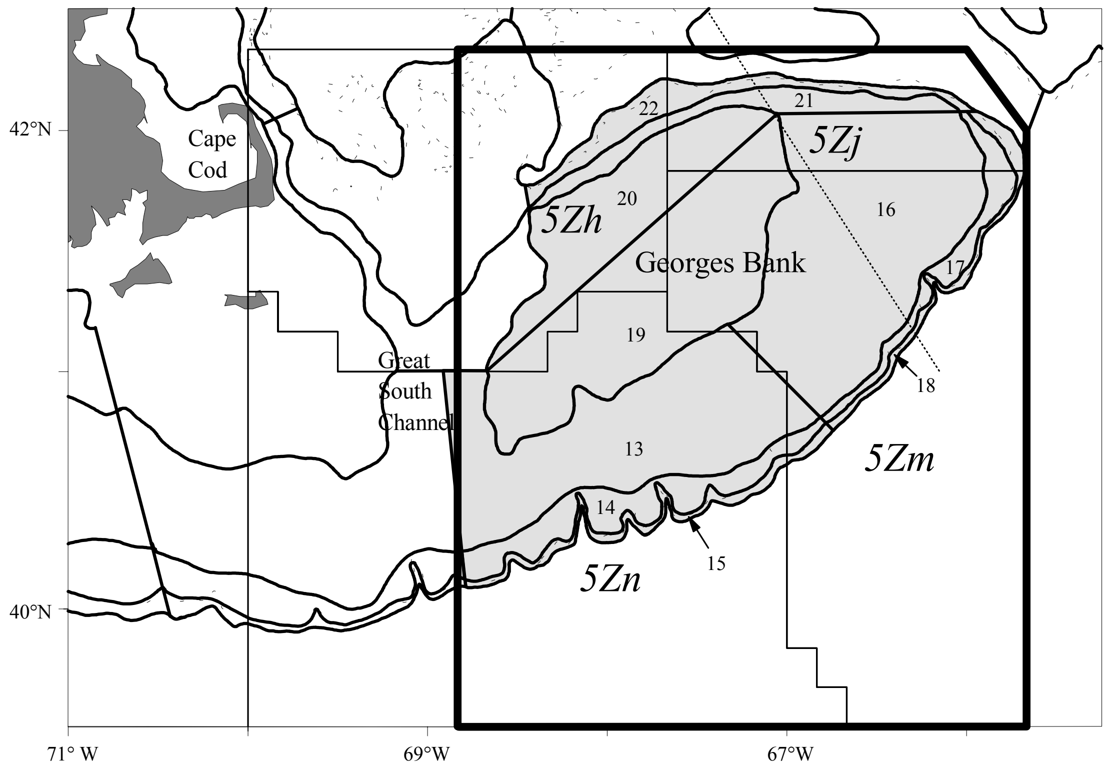


Fig. 11. Upper Panel: Nominal and standardized catch rates (tonnes/hour) for Canadian stern trawlers (TC 2-3) fishing for yellowtail flounder on Georges Bank based on directed trips in 5Zm with catches ≥ 2.0 t, 1993-2002. Lower Panel: Standardized CPUE for the Canadian fishery (1993-2002) and DFO spring survey biomass index for stratum 5Z2 (1993-2003).



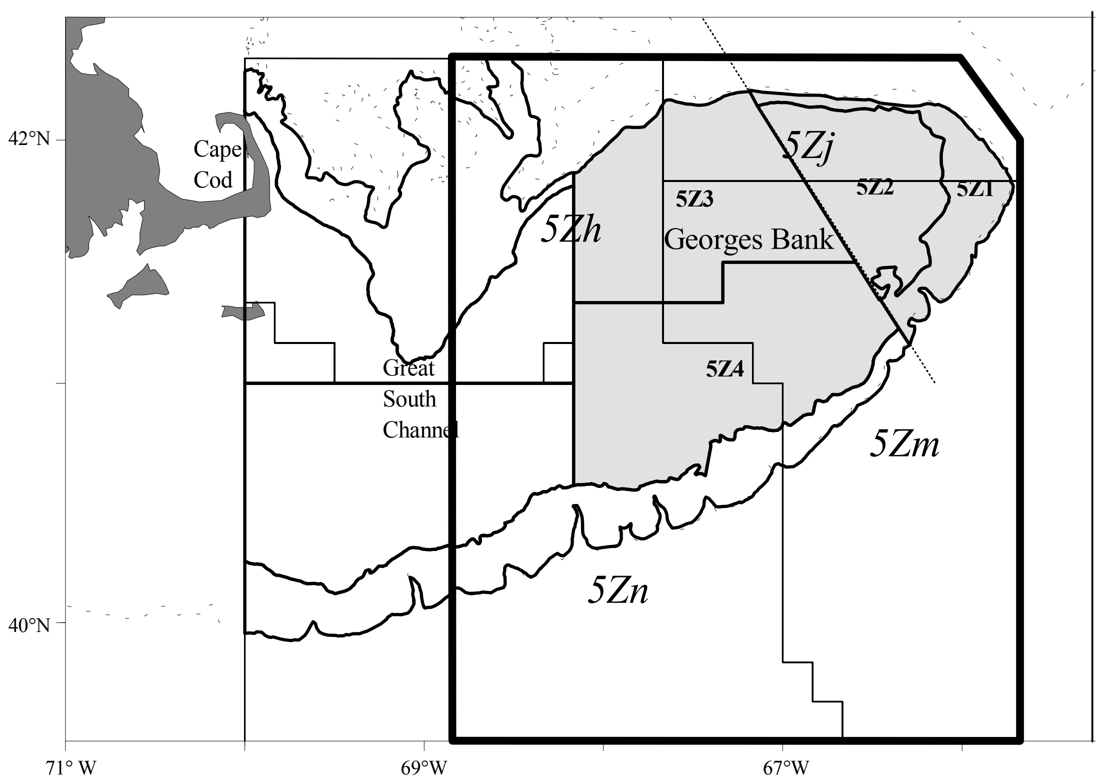


Fig. 12. NMFS (top) and DFO (bottom) strata used to derive research survey abundance indices for Georges Bank groundfish surveys.

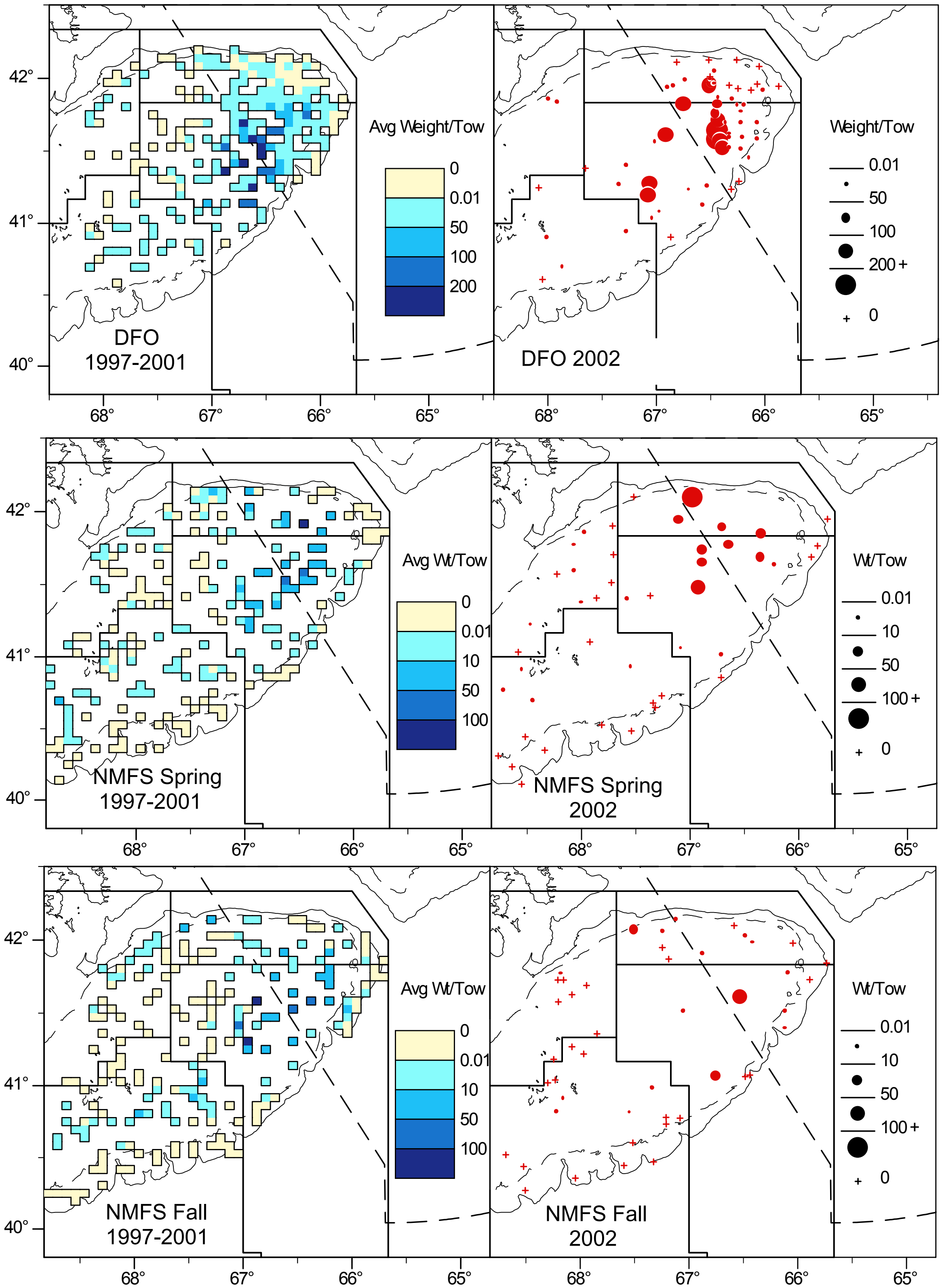


Fig. 13a. The distribution of catches (kg/tow) of yellowtail flounder (solid circles) in the DFO spring (2002), NMFS spring (2002) and NMFS fall (2002) surveys, respectively, compared with the average distribution in the previous five years (3x5 minute shaded rectangles).

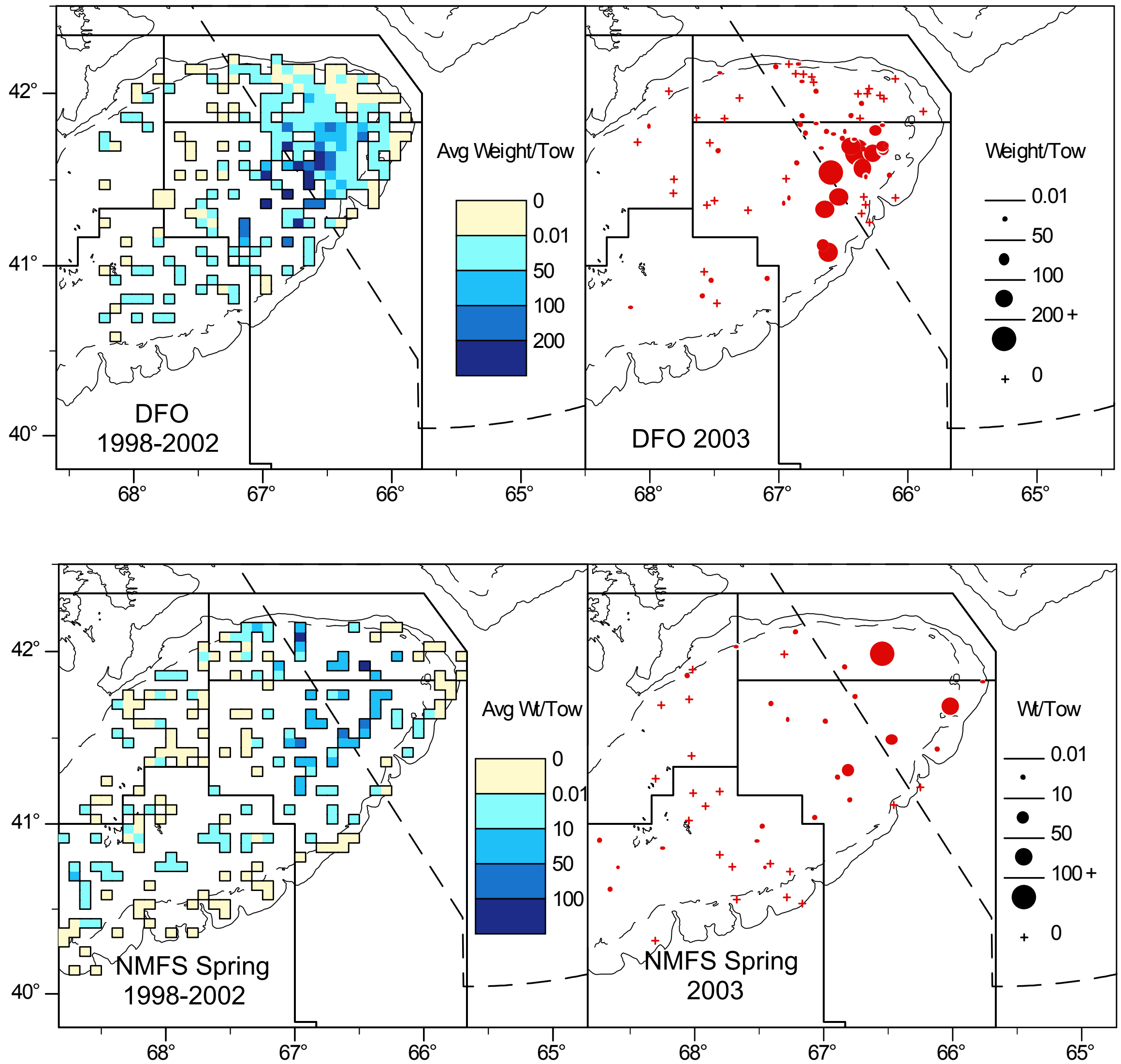


Fig. 13b. The distribution of catches (kg/tow) of yellowtail flounder (solid circles) in the DFO spring (2003) and NMFS spring (2003) surveys, respectively, compared with the average distribution in the previous five years (3x5 minute shaded rectangles).

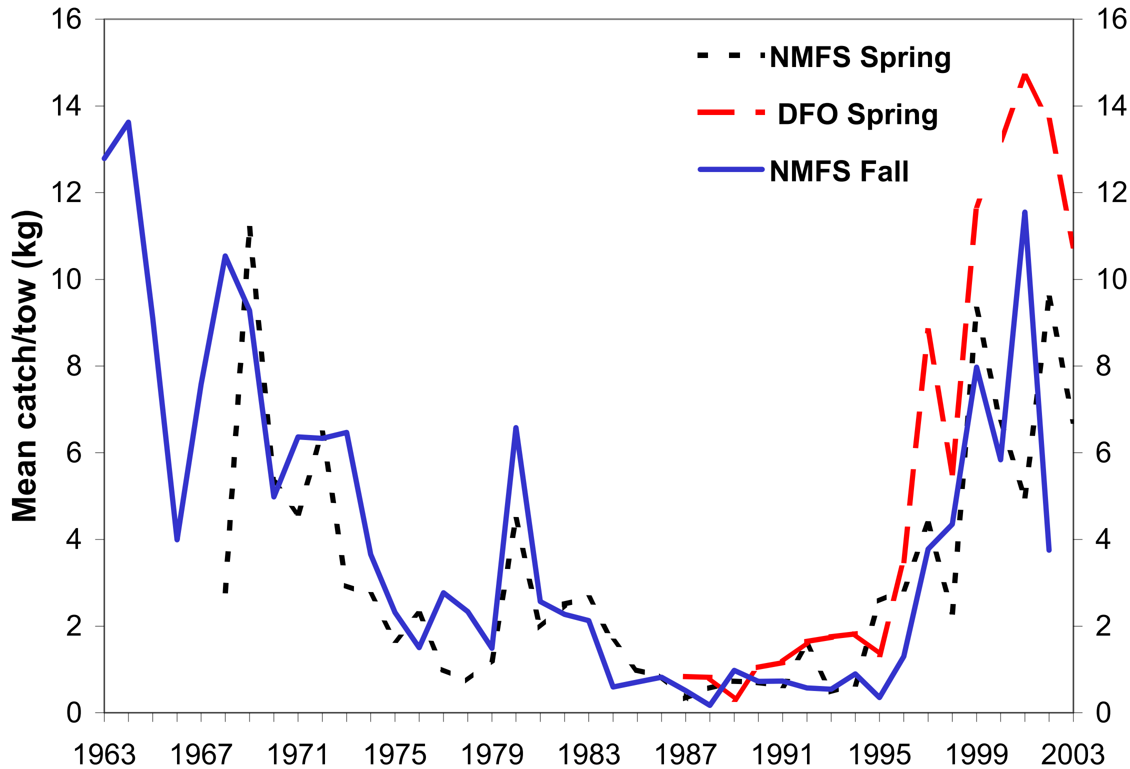


Fig. 14. NMFS and DFO spring and NMFS fall survey biomass indices for yellowtail flounder on Georges Bank. The DFO series was also adjusted for catchability differences.

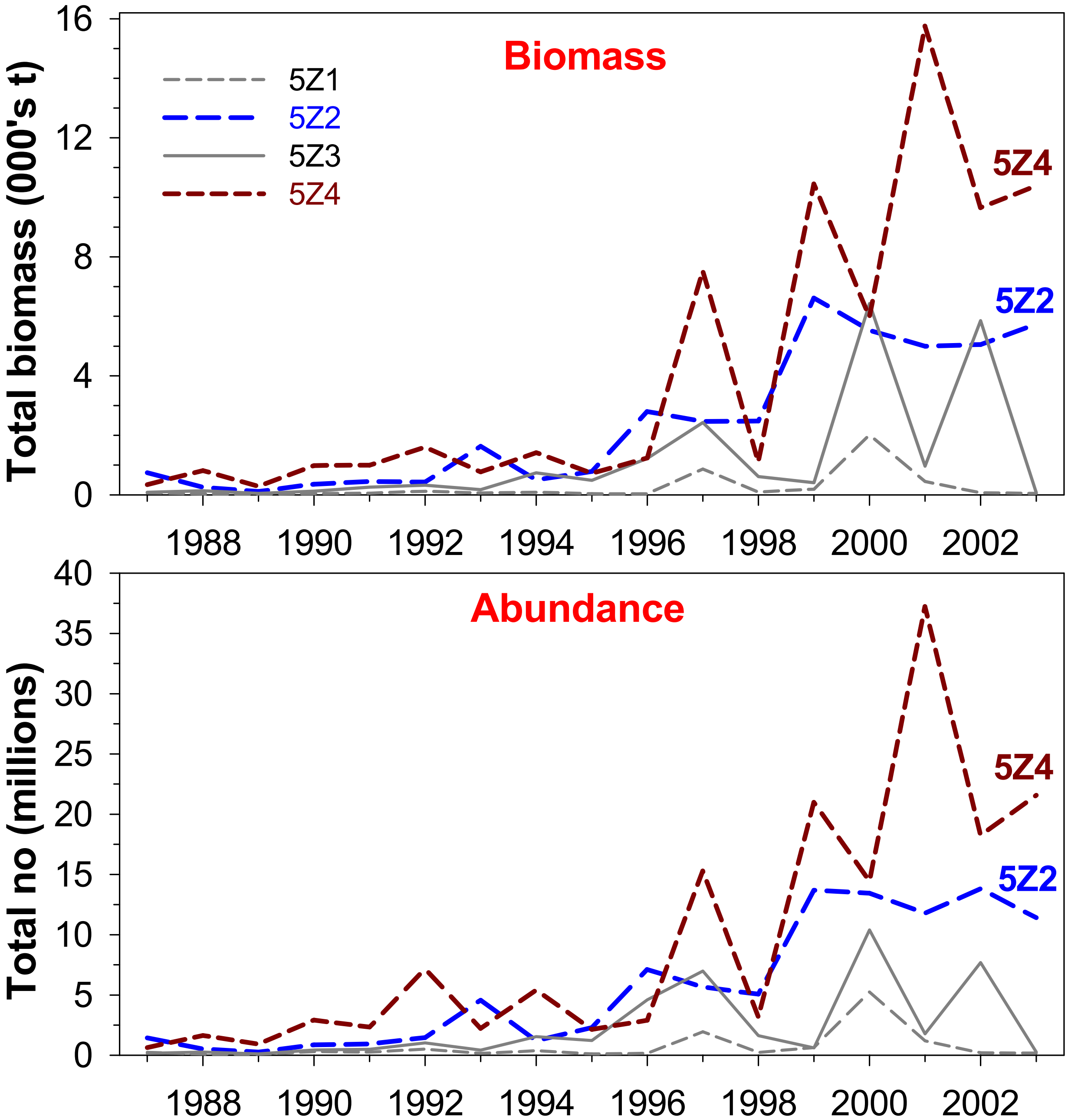


Fig. 15. DFO spring survey estimates of total biomass (top panel) and total number (bottom pannel) by stratum area for yellowtail flounder on Georges Bank, 1987-2003.

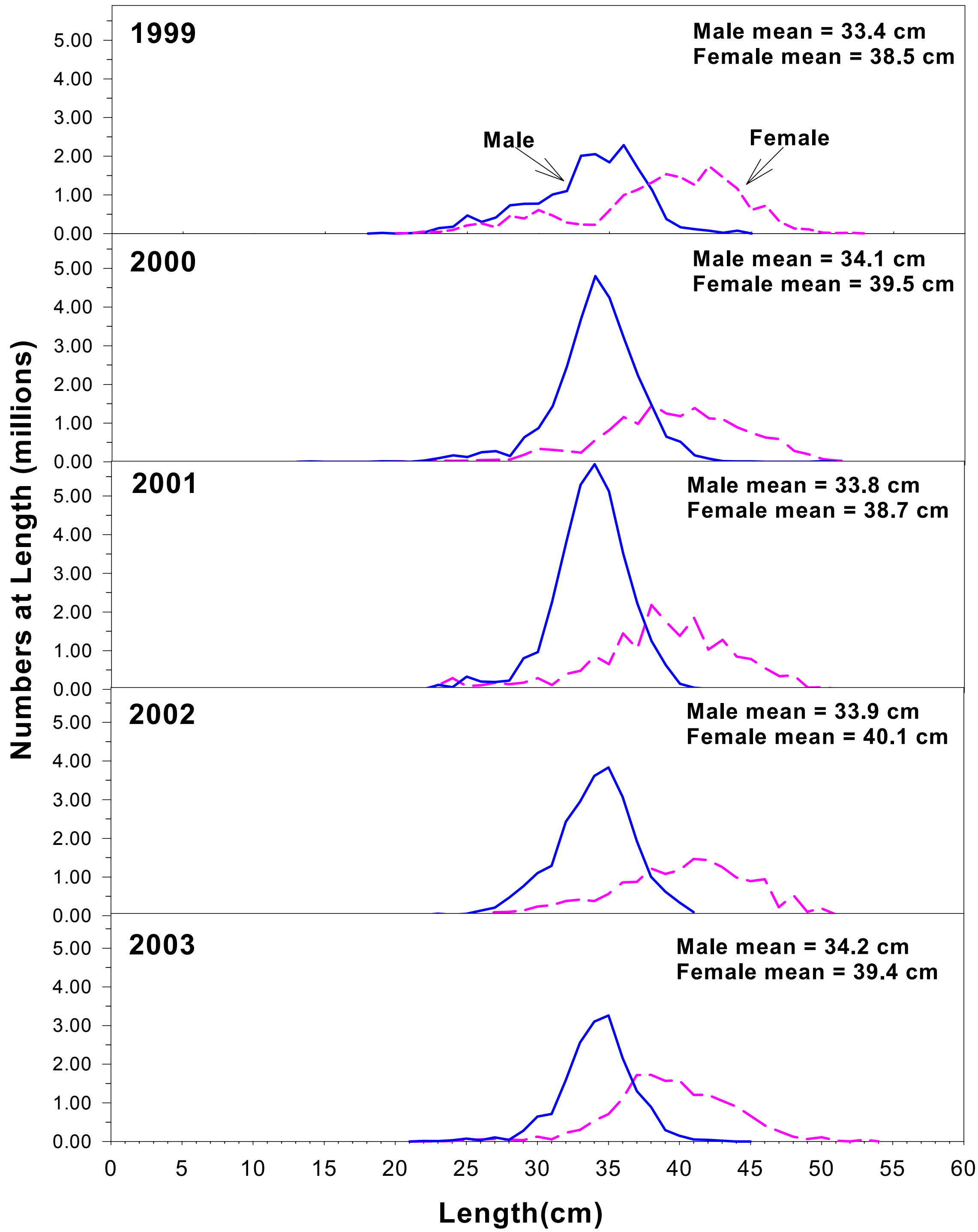


Fig. 16. Comparison of yellowtail flounder length composition in DFO spring surveys on Georges Bank, 1999-2003.

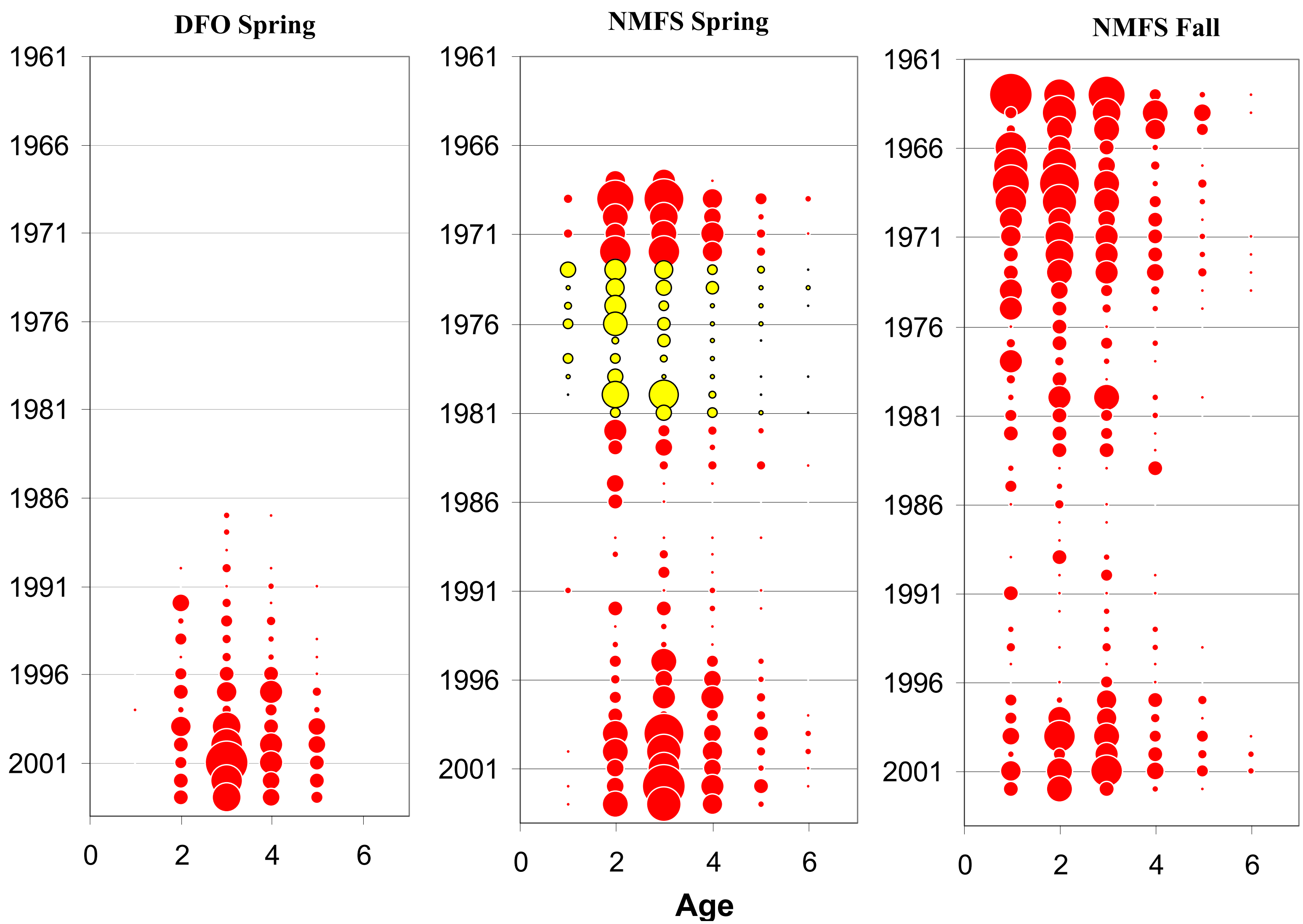


Fig. 17. Age specific indices of abundance for the DFO spring (1987-2003), NMFS spring (1968-2003), and NMFS fall (1963-2002) surveys (bubble is proportional to the magnitude). The grey shaded symbols in the NMFS spring series denote the period when the Yankee 41 net was used. Refer to Tables 5, 6 and 7 for the absolute value of the indices.

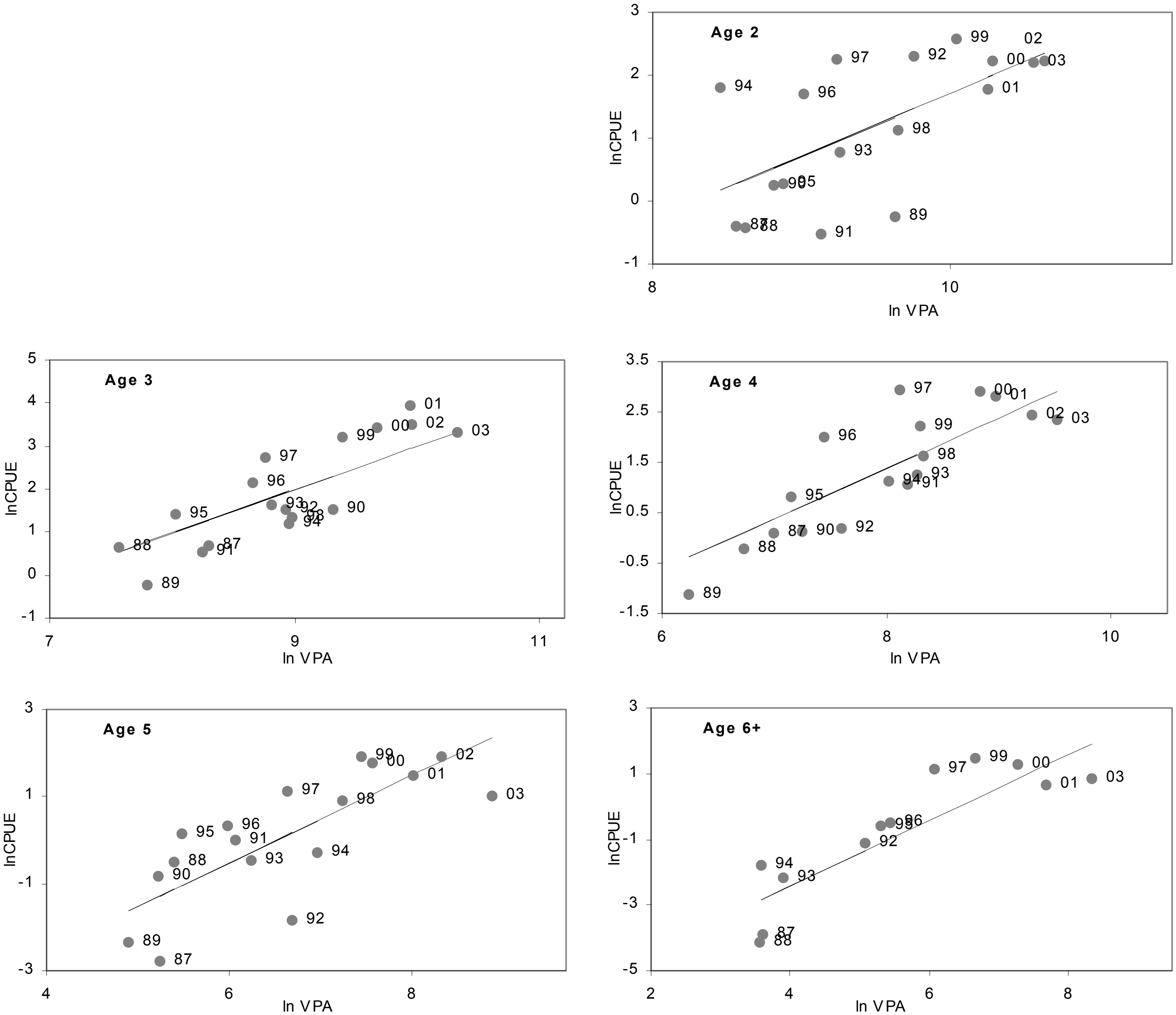


Fig. 18. Age by age plots of the observed and predicted ln abundance index vs population numbers for Georges Bank yellowtail flounder from the DFO spring survey 1987-2003.

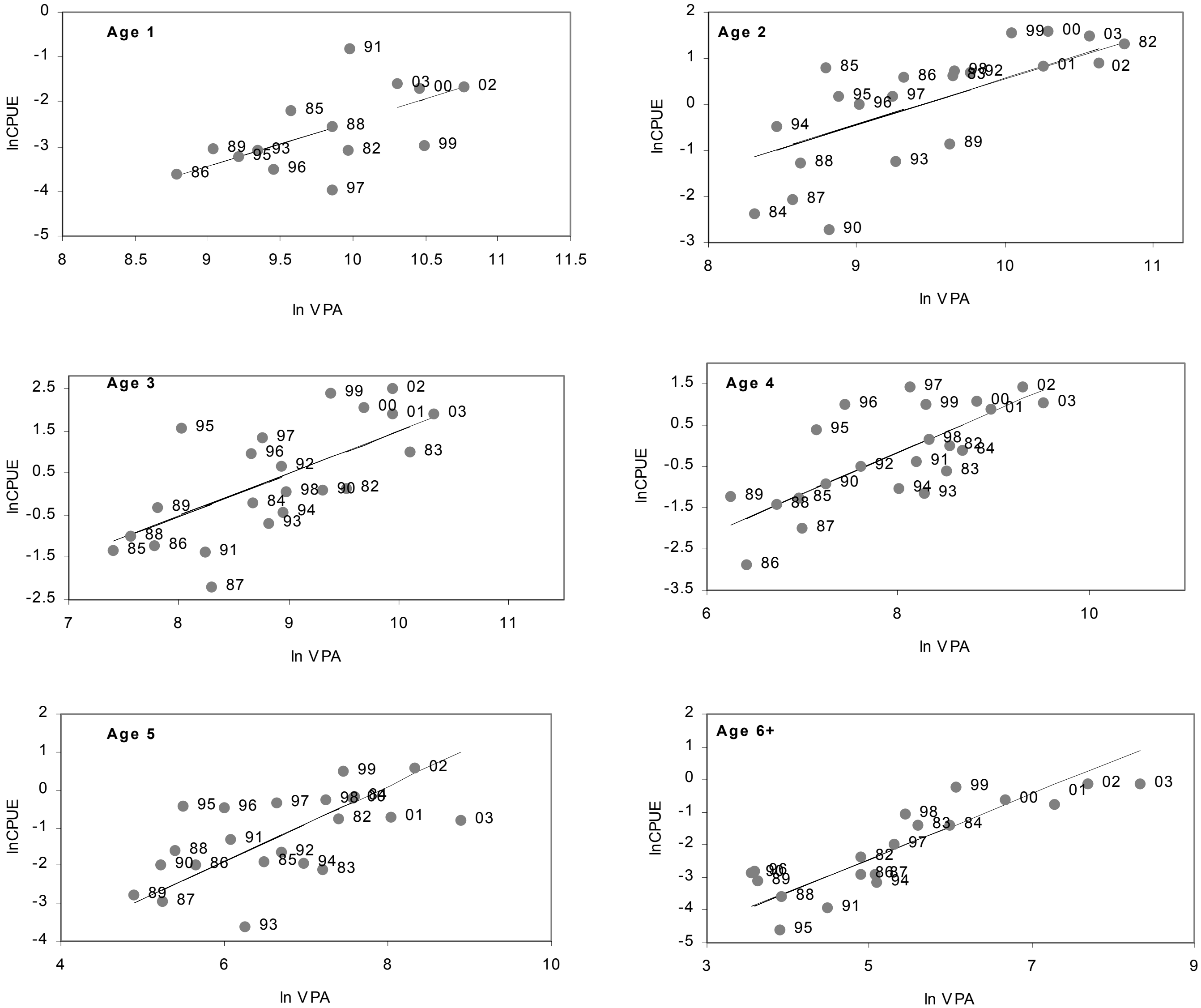


Fig. 19. Age by age plots of the observed and predicted ln abundance index vs population numbers for Georges Bank yellowtail flounder from the NMFS spring survey Yankee 36 series, 1982-2003.

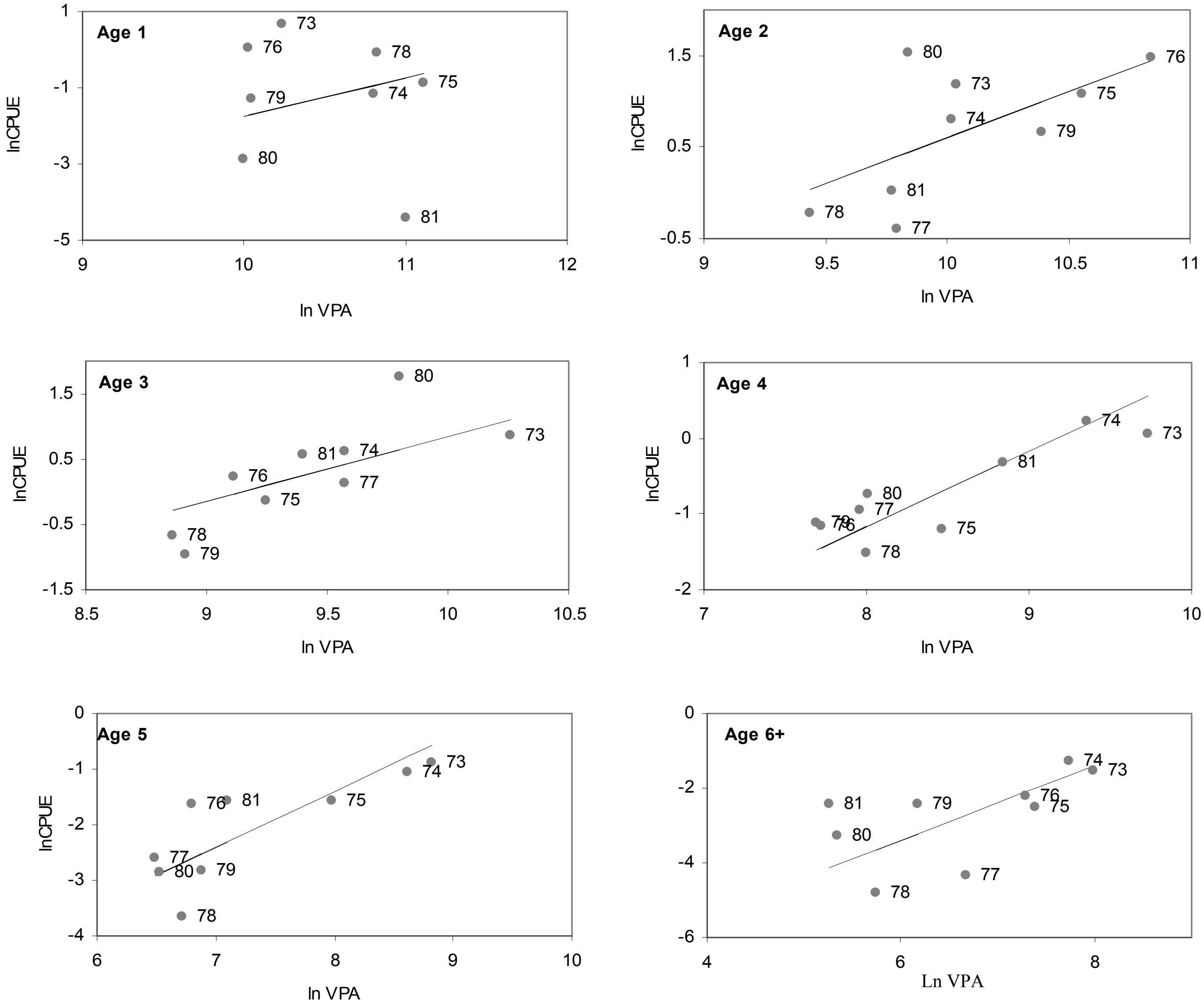


Fig. 20. Age by age plots of the observed and predicted ln abundance index vs population numbers for Georges Bank yellowtail flounder from the NMFS spring survey, Yankee 41 series, 1973-1981.

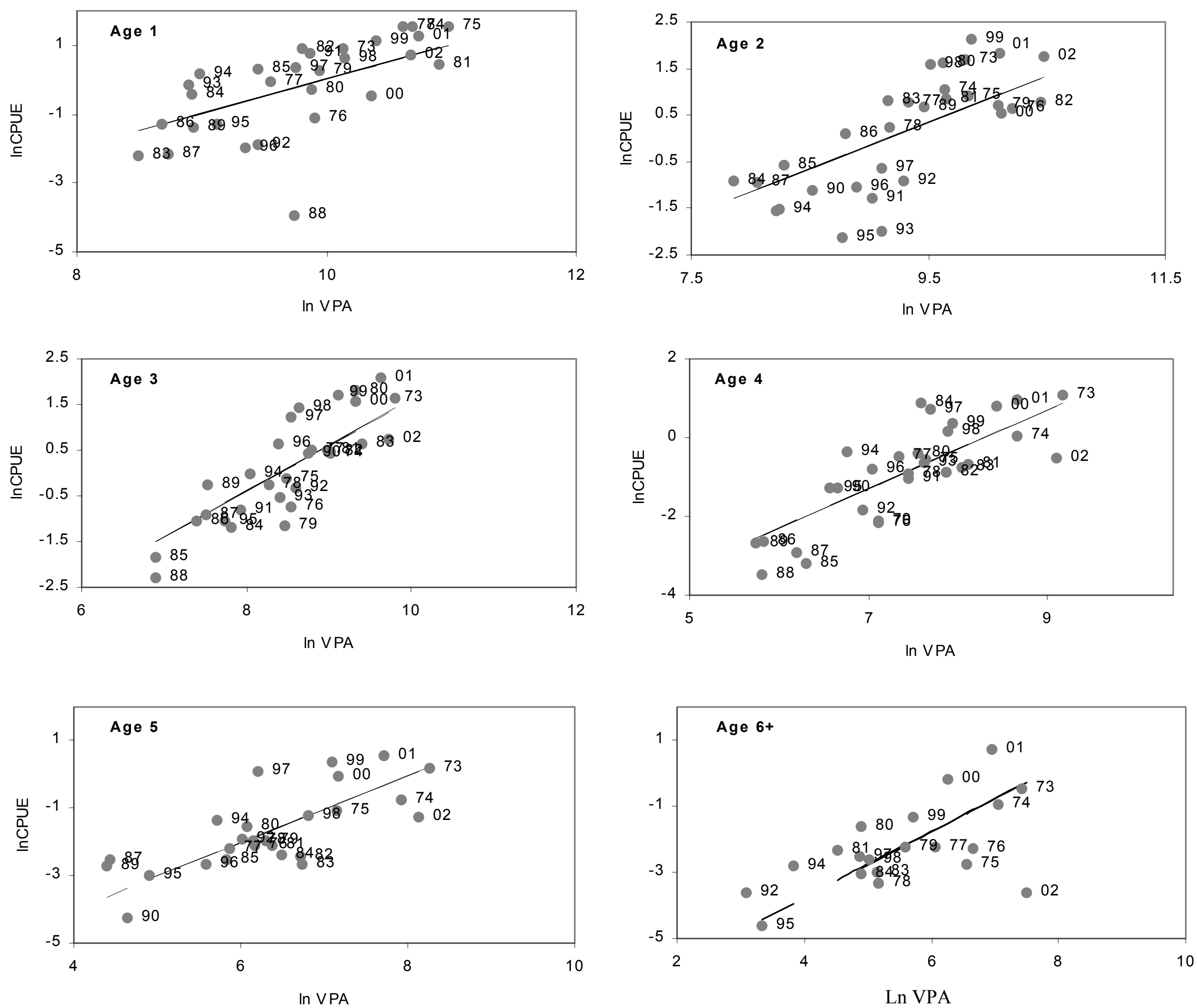


Fig. 21. Age by age plots of the observed and predicted ln abundance index vs population numbers for Georges Bank yellowtail flounder from the NMFS fall survey, 1973-2002.

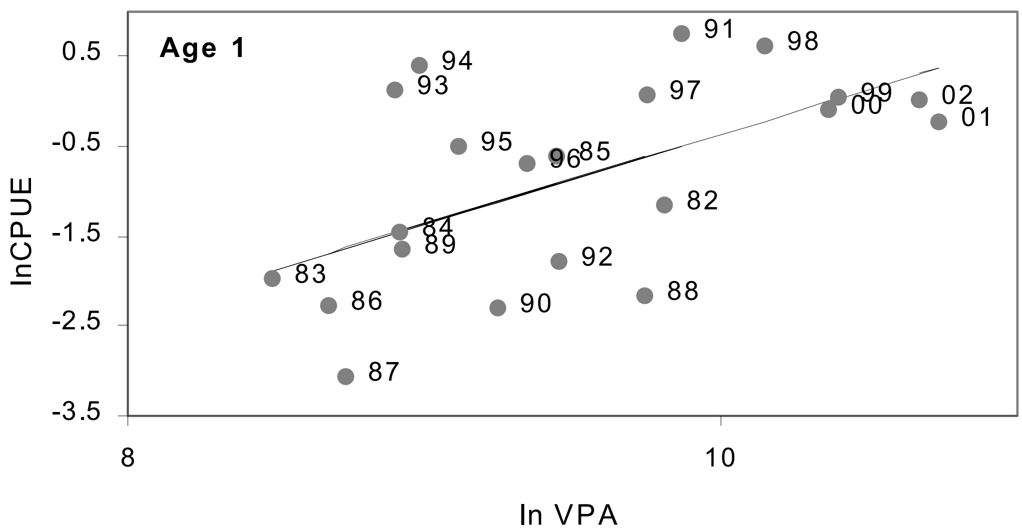


Fig. 22. Observed and predicted ln abundance index vs population numbers for Georges Bank age 1 yellowtail flounder from the NMFS scallop survey, 1982-2002

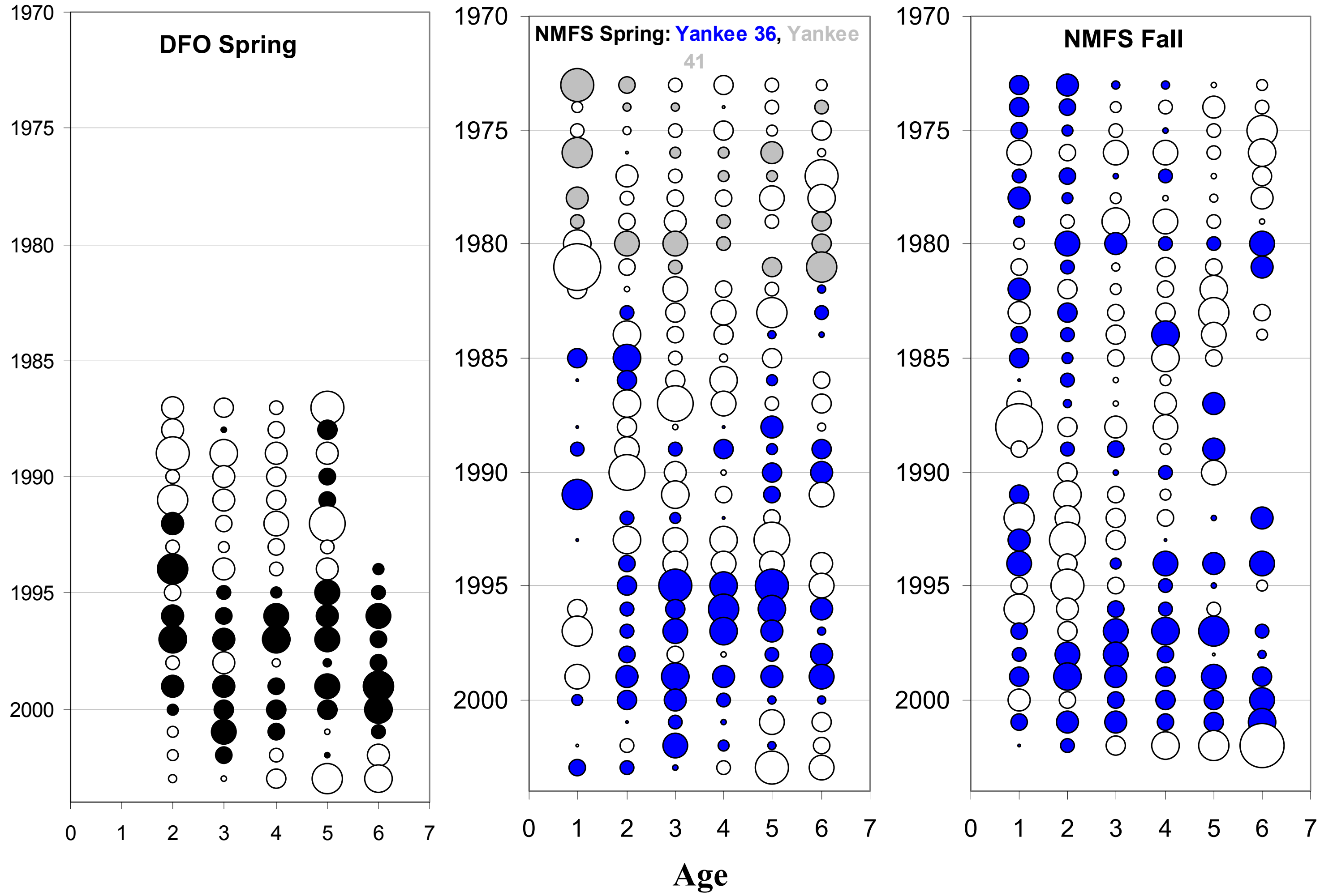


Fig. 23. Age by age residuals for the relationships between ln abundance index versus ln population numbers, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The grey shaded symbols in the NMFS spring series denote the period when the Yankee 41 net was used. The open symbols denote negative residuals, and closed symbols denote positive residuals.

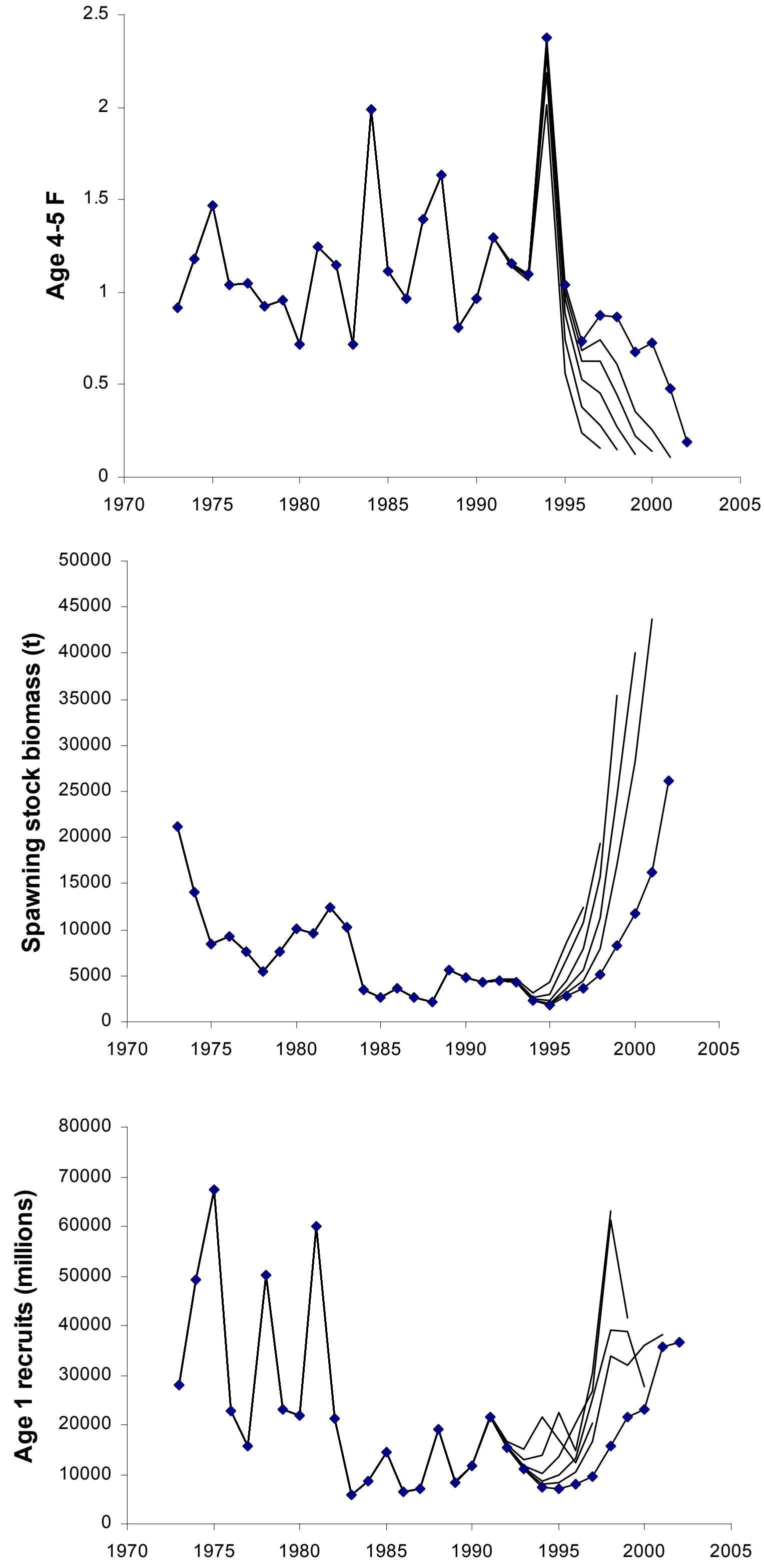


Fig. 24. Retrospective analysis of Georges Bank yellowtail flounder VPA for fishing mortality on ages 4-5 (top panel), spawning stock biomass (Middle panel) and age 1 recruits (lower panel) from the US FACT software.

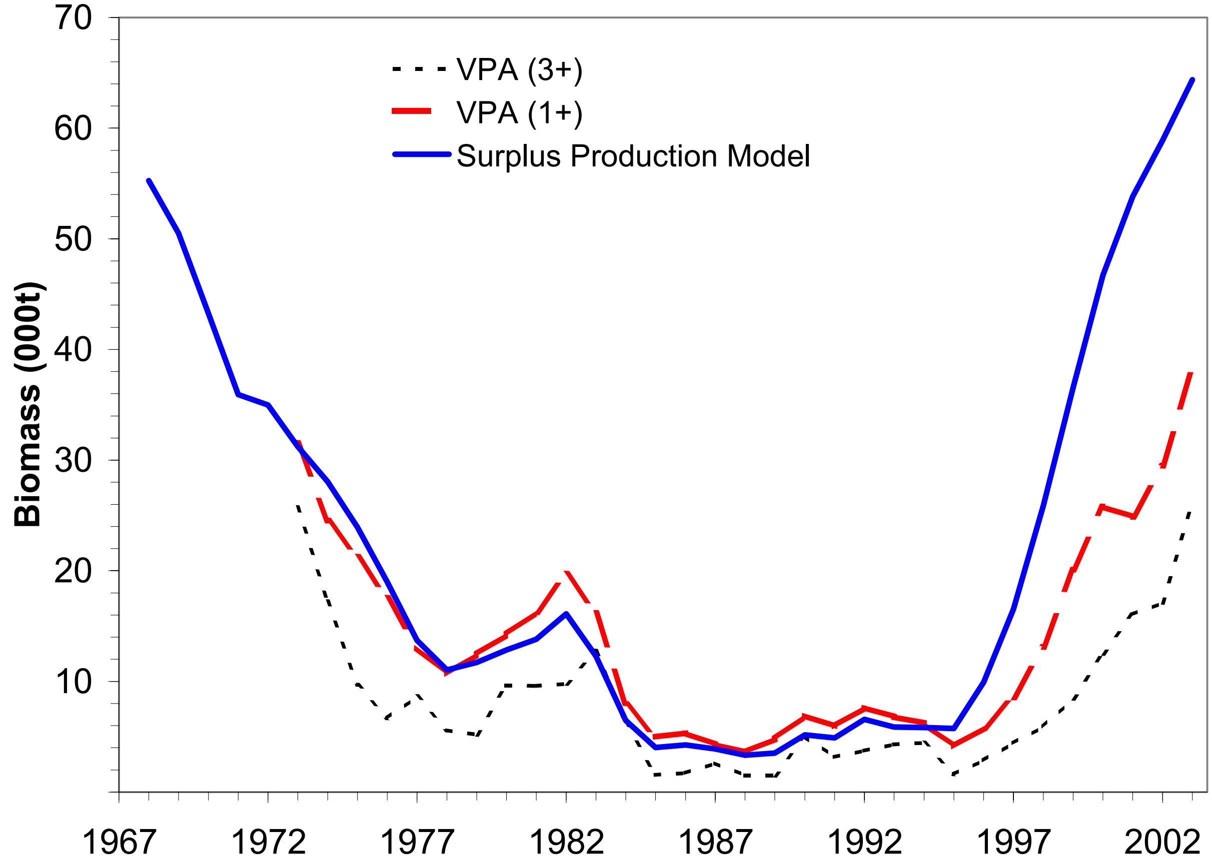


Fig. 25. Trends in total (1+) and adult (3+) beginning of year biomass (000s t) as indicated from the VPA and surplus production models for yellowtail flounder on Georges Bank.

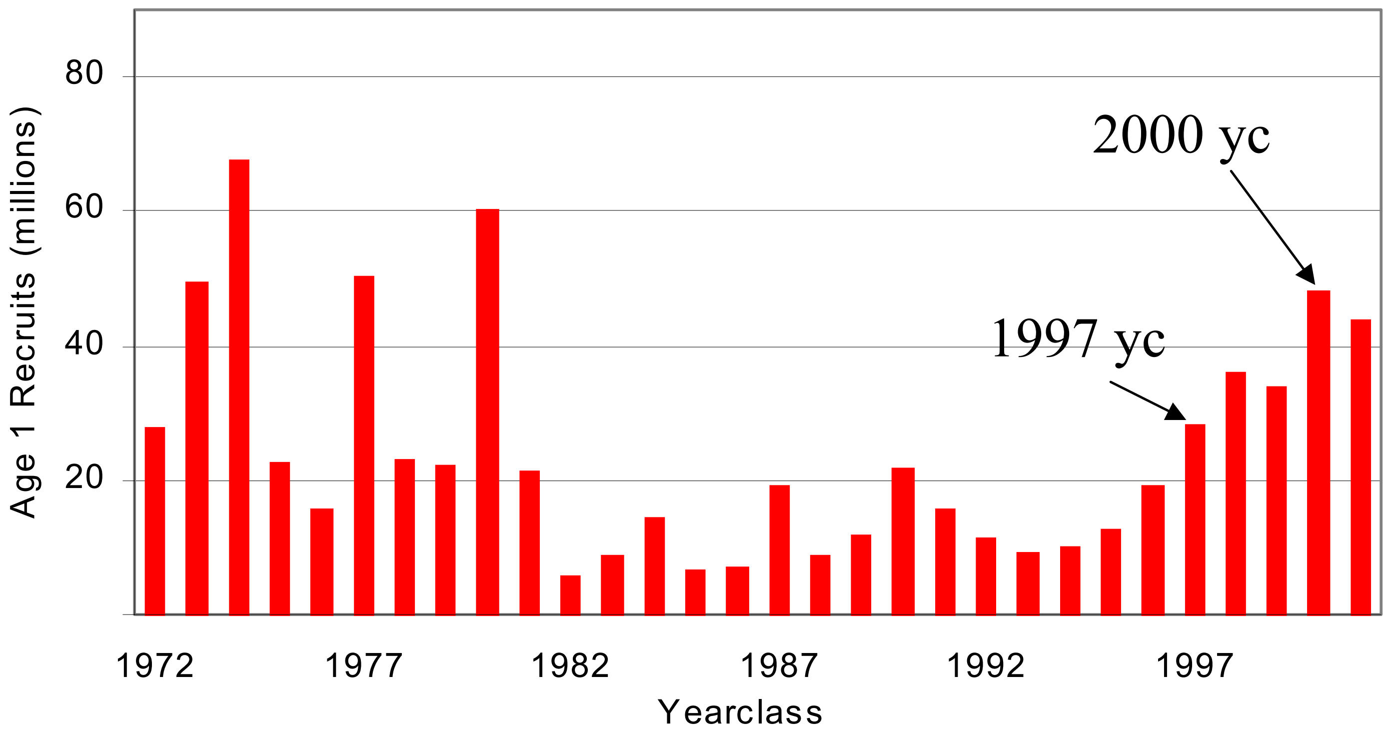


Fig. 26. Age-1 recruitment estimates for Georges Bank yellowtail flounder, 1972-2001. The 1997 and 2000 yearclasses are highlighted.

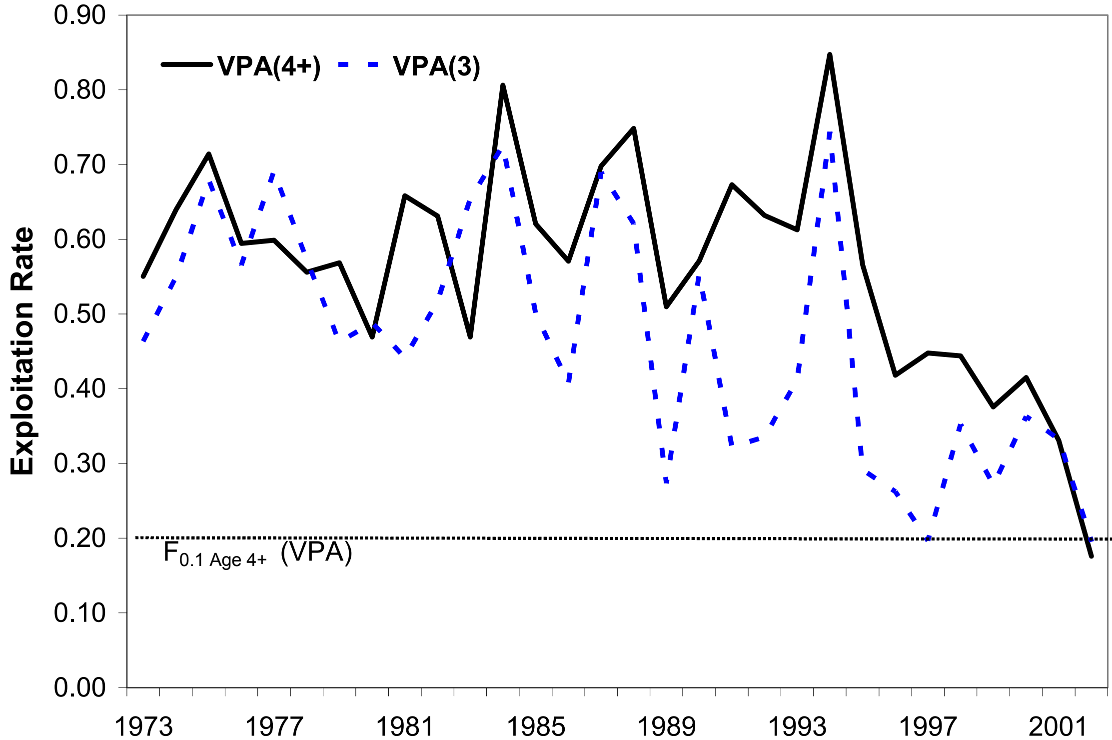
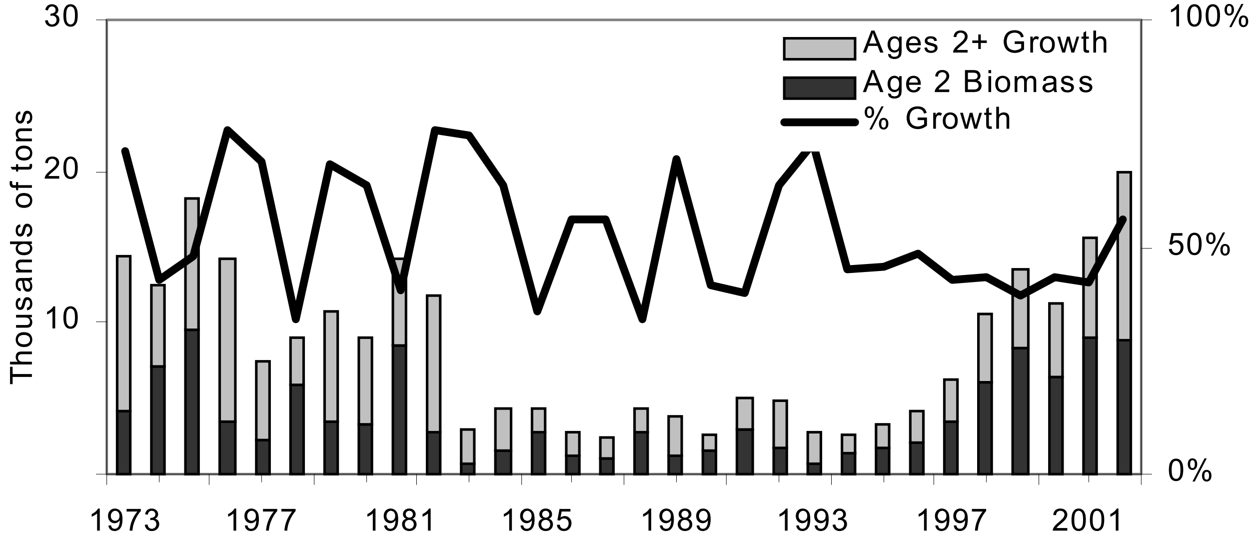


Fig. 27. Trends in age 4+ (fully recruited) and age 3 exploitation rate from the VPA for Georges Bank yellowtail flounder. Reference levels are shown for VPA age 4+.



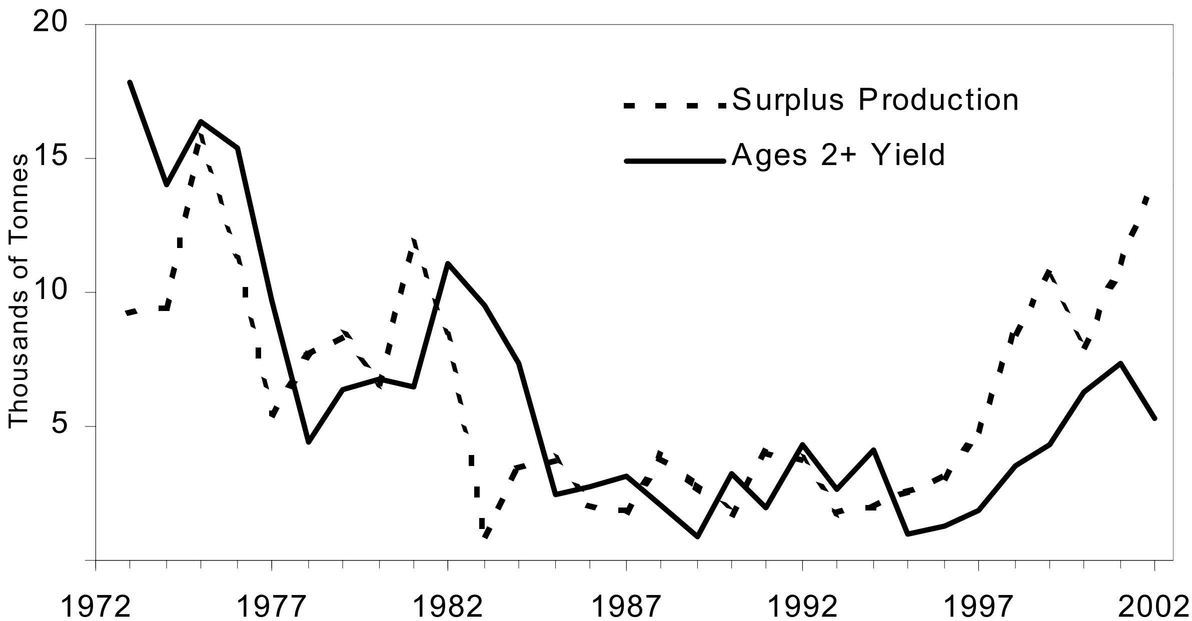


Fig. 28. Components of production (top panel), and production as indicated by the VPA, compared with fishery yield for Georges Bank yellowtail flounder.

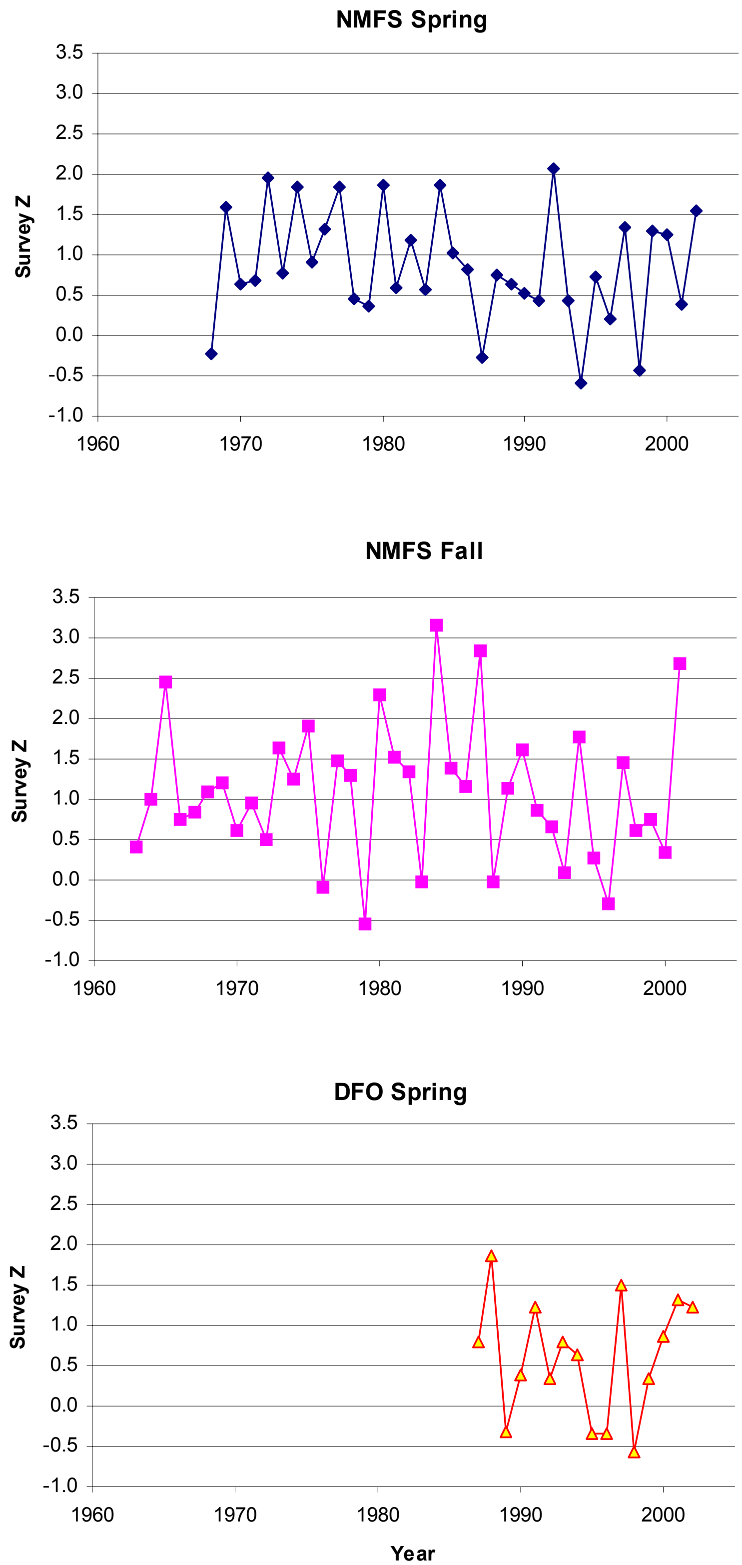


Fig. 29. Annual estimates of total mortality(Z) for each of the research vessel abundance at age estimates.

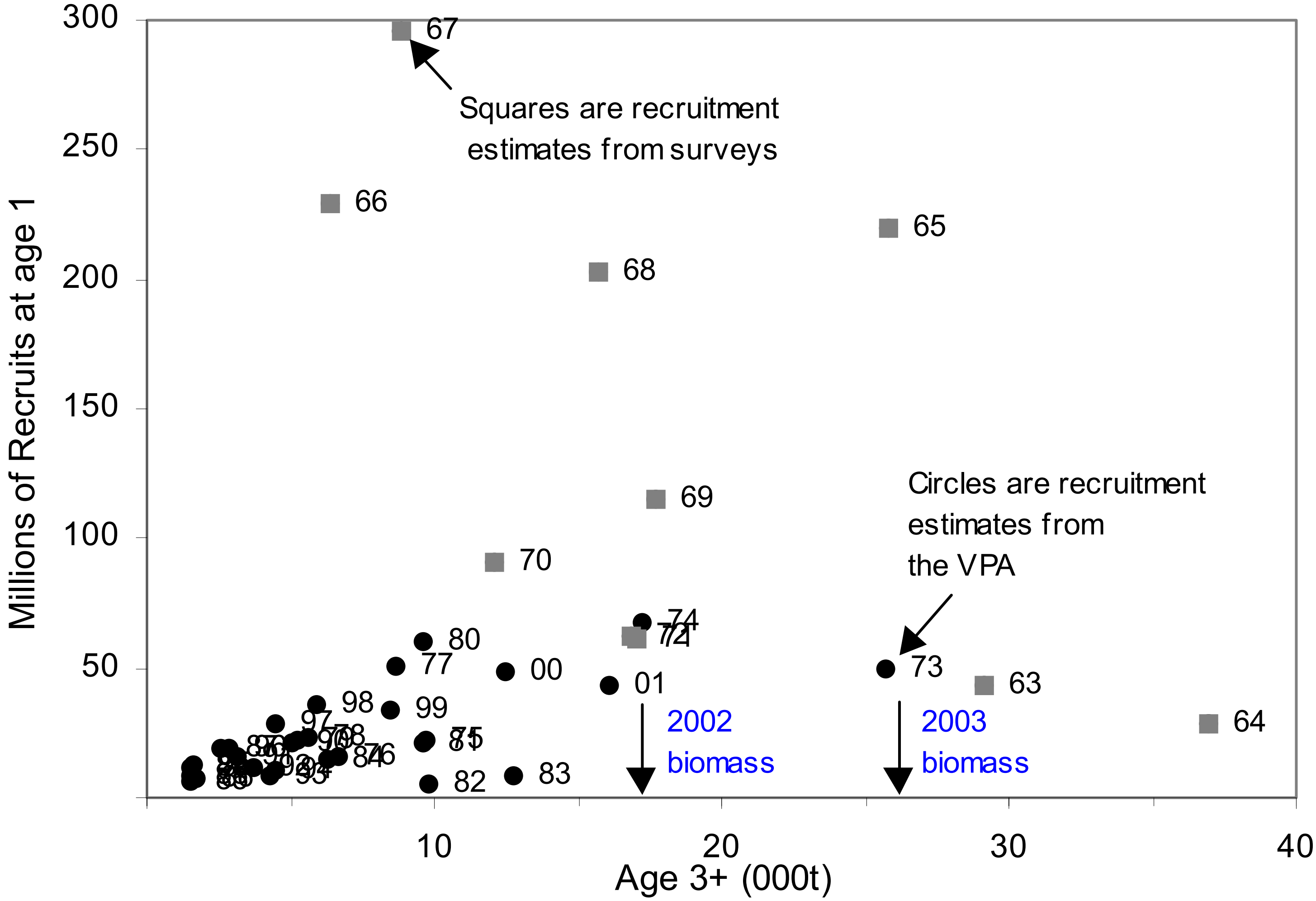


Fig. 30. Age 3+ biomass and age 1 recruitment relationship from the VPA for Georges Bank yellowtail flounder. The beginning of year age 3+ biomass for 2002 and 2003 from the VPA is also shown.

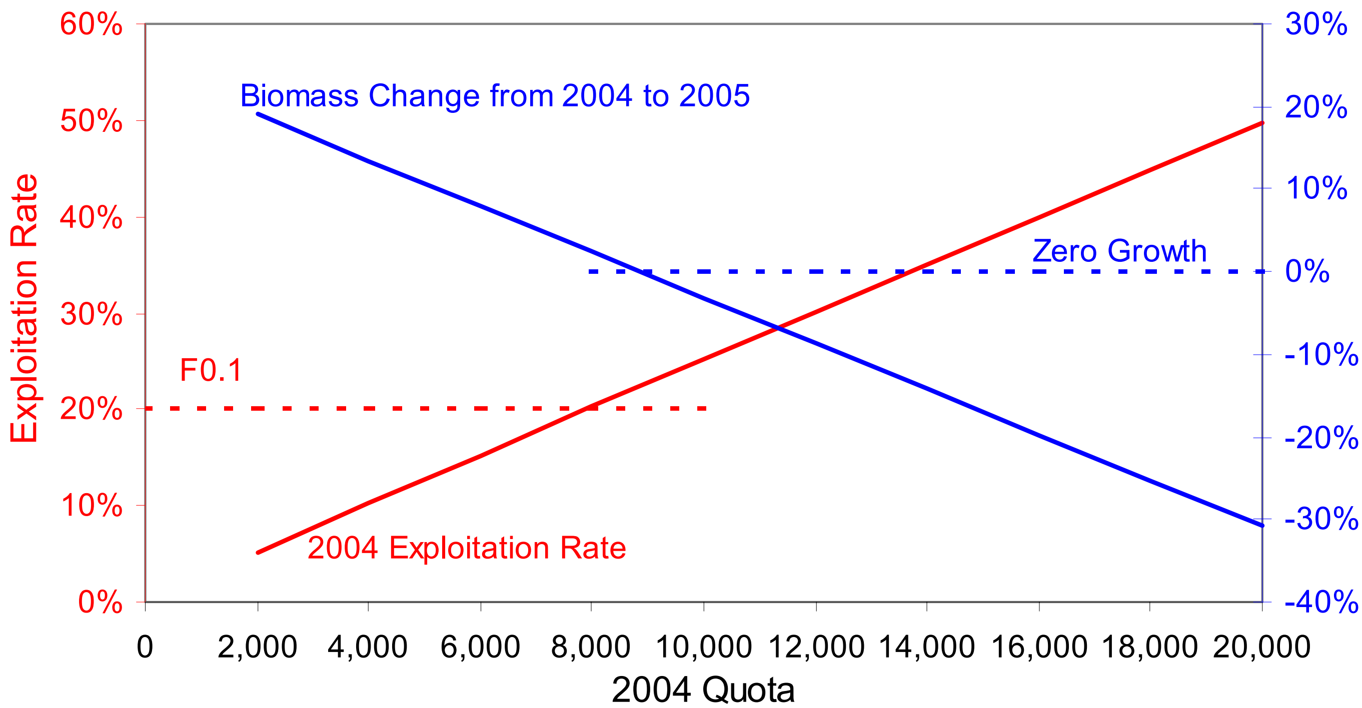


Fig. 31. Implications of various 2004 quotas (combined Canada and USA) on exploitation rate and change in the 3+ population biomass from 2004 to 2005.

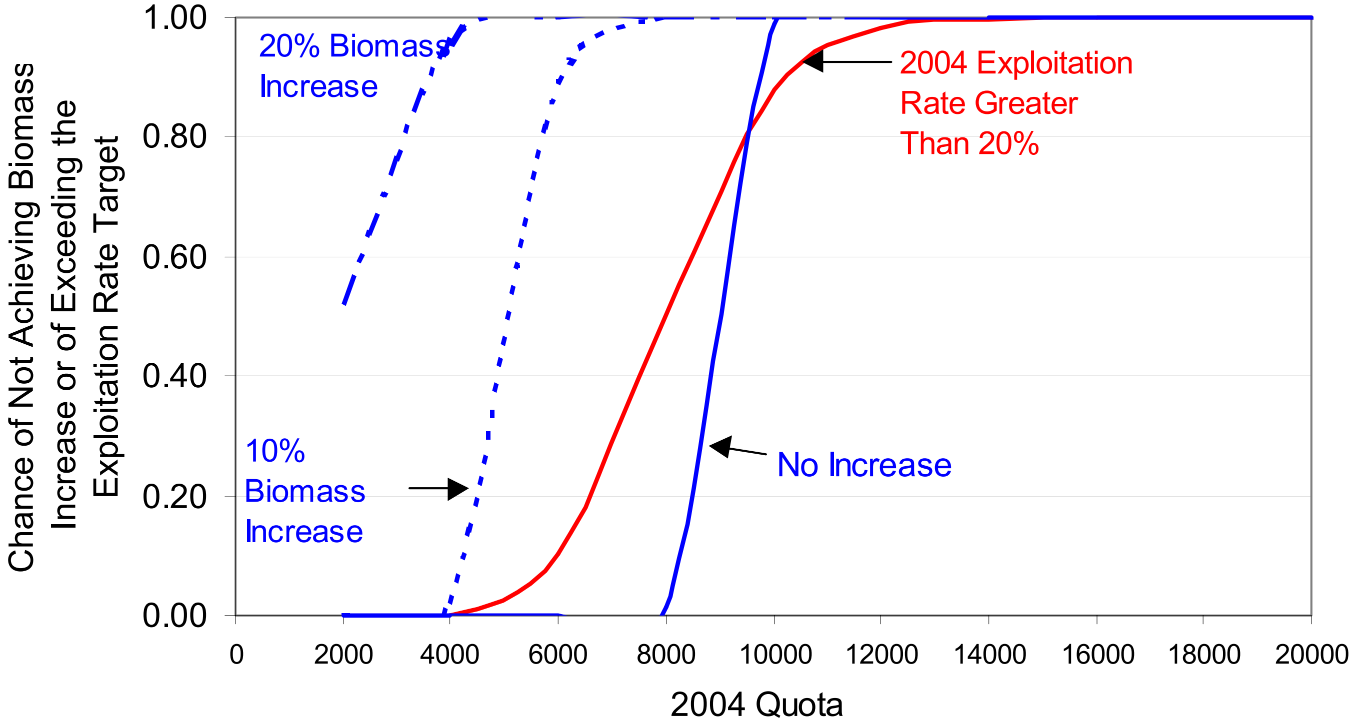


Fig. 32. Risk of exceeding the $F_{0.1}$ fishing mortality or not achieving increments of age 3+ population biomass growth at various quotas for the 2004 fishery, Georges Bank yellowtail flounder.

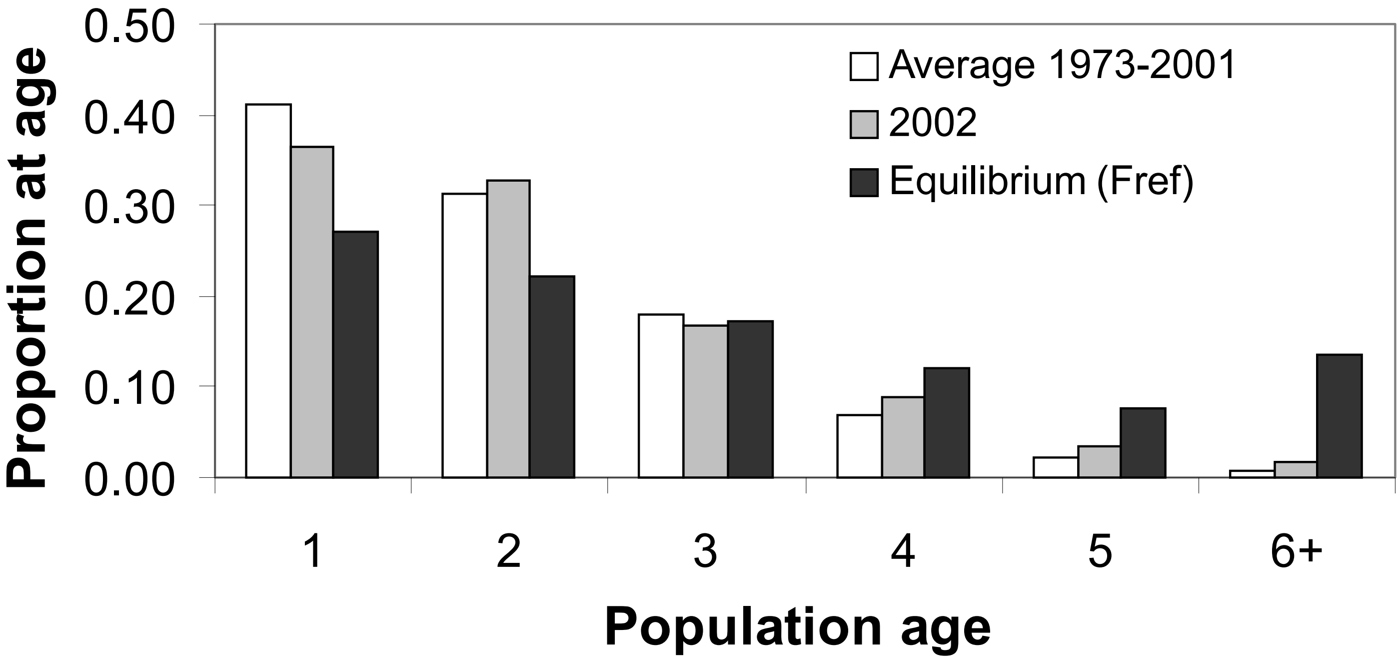


Fig. 33. Proportions at age for the Georges Bank yellowtail flounder population in 2002, for the average of 1973-2001 and when the population is at equilibrium.

Appendix A
Surplus Production Analysis

```
Georges Bank Yellowtail (yield and biomass in k mt)                                                     Page 1
Georges Bank Yellowtail (yield and biomass in k mt)                                                     Page 1
                                                                                          16 May 2003 at 17:57.58
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.86)                                  BOT Mode

Author: Michael H. Prager; NOAA/NMFS/S.E. Fisheries Science Center                         ASPIC User's Manual
        101 Pivers Island Road; Beaufort, North Carolina  28516  USA                       is available gratis
                                                                                              from the author.
Ref:    Prager, M. H.  1994.  A suite of extensions to a nonequilibrium
        surplus-production model.  Fishery Bulletin 92: 374-389.

CONTROL PARAMETERS USED (FROM INPUT FILE)
------------------------------------------------------------------------------------------------------------------------
Number of years analyzed:                          40            Number of bootstrap trials:                        500
Number of data series:                              3            Lower bound on MSY:                          5.000E+00
Objective function computed:                in effort            Upper bound on MSY:                          5.000E+01
Relative conv. criterion (simplex):         1.000E-09            Lower bound on r:                            1.000E-01
Relative conv. criterion (restart):         3.000E-09            Upper bound on r:                            5.000E+00
Relative conv. criterion (effort):          1.000E-05            Random number seed:                            5844285
Maximum F allowed in fitting:                   5.000            Monte Carlo search mode, trials:            2     50000


PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                                                          code  0
------------------------------------------------------------------------------------------------------------------------
Normal convergence.

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
------------------------------------------------------------------------------------------------------------------------
                                       |
 1  USA Fall                           |  1.000
                                       |     40
                                       |
 2  USA Spring -lagged                 |  0.824   1.000
                                       |     27      27
                                       |
 3  Canada - lagged                    |  0.839   0.911   1.000
                                       |     17      17      17
                                        --------------------------------------------------
                                              1       2       3
```

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS

Loss component number and title		Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1)	SSE in yield	0.000E+00					
Loss(0)	Penalty for B1R > 2	0.000E+00	1	N/A	0.000E+00	N/A	
Loss(1)	USA Fall	8.438E+00	40	2.221E-01	1.000E+00	9.635E-01	0.760
Loss(2)	USA Spring -lagged	5.779E+00	27	2.312E-01	1.000E+00	9.256E-01	0.626
Loss(3)	Canada - lagged	2.666E+00	17	1.777E-01	1.000E+00	1.204E+00	0.849
TOTAL OBJECTIVE FUNCTION:		1.68833769E+01					

Number of restarts required for convergence:	65	
Est. B-ratio coverage index (0 worst, 2 best):	1.9193	< These two measures are defined in Prager
Est. B-ratio nearness index (0 worst, 1 best):	1.0000	< et al. (1996), Trans. A.F.S. 125:729

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1963	2.255E+00	1.000E+00	1	1
MSY	Maximum sustainable yield	1.457E+01	1.400E+01	1	1
r	Intrinsic rate of increase	6.877E-01	6.000E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	USA Fall	1.386E-01	1.000E-01	1	1
q(2)	USA Spring -lagged	1.526E-01	1.000E-01	1	1
q(3)	Canada - lagged	3.453E-01	3.000E-01	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	Related quantity
MSY	Maximum sustainable yield	1.457E+01	Kr/4	
K	Maximum stock biomass	8.476E+01		
Bmsy	Stock biomass at MSY	4.238E+01	K/2	
Fmsy	Fishing mortality at MSY	3.438E-01	r/2	
F(0.1)	Management benchmark	3.095E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	1.443E+01	0.99*MSY	
B-ratio	Ratio of B(2003) to Bmsy	1.534E+00		
F-ratio	Ratio of F(2002) to Fmsy	2.844E-01		
F01-mult	Ratio of F(0.1) to F(2002)	3.165E+00		
Y-ratio	Proportion of MSY avail in 2003	7.152E-01	2*Br-Br^2	Ye(2003) = 1.042E+01
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	USA Fall	2.480E+00	r/2q(1)	f(0.1) = 2.232E+00

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1963	0.205	9.558E+01	8.524E+01	1.746E+01	1.746E+01	-5.457E-01	5.957E-01	2.255E+00
2	1964	0.279	7.758E+01	7.090E+01	1.977E+01	1.977E+01	7.878E+00	8.109E-01	1.831E+00
3	1965	0.314	6.569E+01	6.143E+01	1.931E+01	1.931E+01	1.159E+01	9.145E-01	1.550E+00
4	1966	0.248	5.796E+01	5.721E+01	1.419E+01	1.419E+01	1.279E+01	7.212E-01	1.368E+00
5	1967	0.254	5.656E+01	5.596E+01	1.420E+01	1.420E+01	1.308E+01	7.378E-01	1.335E+00
6	1968	0.346	5.544E+01	5.291E+01	1.832E+01	1.832E+01	1.366E+01	1.007E+00	1.308E+00
7	1969	0.457	5.078E+01	4.693E+01	2.145E+01	2.145E+01	1.437E+01	1.329E+00	1.198E+00
8	1970	0.548	4.370E+01	3.974E+01	2.179E+01	2.179E+01	1.448E+01	1.595E+00	1.031E+00
9	1971	0.424	3.639E+01	3.587E+01	1.521E+01	1.521E+01	1.423E+01	1.233E+00	8.586E-01
10	1972	0.531	3.541E+01	3.338E+01	1.773E+01	1.773E+01	1.390E+01	1.545E+00	8.355E-01
11	1973	0.553	3.158E+01	2.988E+01	1.652E+01	1.652E+01	1.330E+01	1.608E+00	7.453E-01
12	1974	0.634	2.836E+01	2.615E+01	1.659E+01	1.659E+01	1.242E+01	1.845E+00	6.691E-01
13	1975	0.743	2.419E+01	2.154E+01	1.601E+01	1.601E+01	1.103E+01	2.162E+00	5.709E-01
14	1976	0.877	1.921E+01	1.637E+01	1.436E+01	1.436E+01	9.062E+00	2.551E+00	4.534E-01
15	1977	0.801	1.392E+01	1.251E+01	1.001E+01	1.001E+01	7.326E+00	2.328E+00	3.284E-01
16	1978	0.534	1.123E+01	1.158E+01	6.188E+00	6.188E+00	6.874E+00	1.554E+00	2.651E-01
17	1979	0.496	1.192E+01	1.248E+01	6.195E+00	6.195E+00	7.319E+00	1.443E+00	2.813E-01
18	1980	0.507	1.304E+01	1.352E+01	6.863E+00	6.863E+00	7.816E+00	1.476E+00	3.078E-01
19	1981	0.415	1.400E+01	1.512E+01	6.277E+00	6.277E+00	8.541E+00	1.207E+00	3.303E-01
20	1982	0.845	1.626E+01	1.420E+01	1.200E+01	1.200E+01	8.117E+00	2.458E+00	3.837E-01
21	1983	1.254	1.238E+01	9.108E+00	1.142E+01	1.142E+01	5.567E+00	3.647E+00	2.921E-01
22	1984	1.112	6.527E+00	5.207E+00	5.791E+00	5.791E+00	3.356E+00	3.235E+00	1.540E-01
23	1985	0.599	4.092E+00	4.206E+00	2.520E+00	2.520E+00	2.749E+00	1.742E+00	9.656E-02
24	1986	0.739	4.321E+00	4.142E+00	3.060E+00	3.060E+00	2.709E+00	2.148E+00	1.020E-01
25	1987	0.807	3.970E+00	3.687E+00	2.975E+00	2.975E+00	2.425E+00	2.347E+00	9.369E-02
26	1988	0.601	3.421E+00	3.522E+00	2.118E+00	2.118E+00	2.321E+00	1.749E+00	8.071E-02
27	1989	0.274	3.624E+00	4.409E+00	1.207E+00	1.207E+00	2.872E+00	7.962E-01	8.551E-02
28	1990	0.690	5.289E+00	5.173E+00	3.569E+00	3.569E+00	3.340E+00	2.006E+00	1.248E-01
29	1991	0.344	5.060E+00	5.894E+00	2.030E+00	2.030E+00	3.769E+00	1.002E+00	1.194E-01
30	1992	0.730	6.800E+00	6.486E+00	4.732E+00	4.732E+00	4.118E+00	2.122E+00	1.604E-01
31	1993	0.616	6.186E+00	6.251E+00	3.853E+00	3.853E+00	3.982E+00	1.793E+00	1.460E-01
32	1994	0.602	6.315E+00	6.422E+00	3.869E+00	3.869E+00	4.081E+00	1.752E+00	1.490E-01
33	1995	0.091	6.527E+00	8.617E+00	7.880E-01	7.880E-01	5.309E+00	2.660E-01	1.540E-01
34	1996	0.089	1.105E+01	1.427E+01	1.273E+00	1.273E+00	8.128E+00	2.595E-01	2.607E-01
35	1997	0.082	1.790E+01	2.244E+01	1.834E+00	1.834E+00	1.129E+01	2.377E-01	4.225E-01
36	1998	0.095	2.736E+01	3.262E+01	3.087E+00	3.087E+00	1.372E+01	2.753E-01	6.455E-01
37	1999	0.103	3.799E+01	4.312E+01	4.441E+00	4.441E+00	1.450E+01	2.996E-01	8.964E-01
38	2000	0.133	4.805E+01	5.168E+01	6.895E+00	6.895E+00	1.384E+01	3.880E-01	1.134E+00
39	2001	0.135	5.499E+01	5.760E+01	7.776E+00	7.776E+00	1.268E+01	3.927E-01	1.298E+00
40	2002	0.098	5.989E+01	6.263E+01	6.123E+00	6.123E+00	1.123E+01	2.844E-01	1.413E+00
41	2003		6.500E+01						1.534E+00

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) USA Fall

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Resid in log yield
1	1963	1.279E+01	1.182E+01	0.2048	1.746E+01	1.746E+01	-0.07901	0.000E+00
2	1964	1.362E+01	9.829E+00	0.2788	1.977E+01	1.977E+01	-0.32645	0.000E+00
3	1965	9.104E+00	8.515E+00	0.3144	1.931E+01	1.931E+01	-0.06688	0.000E+00
4	1966	3.988E+00	7.930E+00	0.2480	1.419E+01	1.419E+01	0.68739	0.000E+00
5	1967	7.575E+00	7.757E+00	0.2537	1.420E+01	1.420E+01	0.02379	0.000E+00
6	1968	1.054E+01	7.335E+00	0.3463	1.832E+01	1.832E+01	-0.36217	0.000E+00
7	1969	9.279E+00	6.505E+00	0.4571	2.145E+01	2.145E+01	-0.35511	0.000E+00
8	1970	4.979E+00	5.509E+00	0.5484	2.179E+01	2.179E+01	0.10108	0.000E+00
9	1971	6.365E+00	4.973E+00	0.4239	1.521E+01	1.521E+01	-0.24680	0.000E+00
10	1972	6.328E+00	4.627E+00	0.5312	1.773E+01	1.773E+01	-0.31316	0.000E+00
11	1973	6.602E+00	4.142E+00	0.5530	1.652E+01	1.652E+01	-0.46624	0.000E+00
12	1974	3.733E+00	3.625E+00	0.6344	1.659E+01	1.659E+01	-0.02943	0.000E+00
13	1975	2.365E+00	2.985E+00	0.7435	1.601E+01	1.601E+01	0.23295	0.000E+00
14	1976	1.533E+00	2.269E+00	0.8773	1.436E+01	1.436E+01	0.39196	0.000E+00
15	1977	2.829E+00	1.734E+00	0.8005	1.001E+01	1.001E+01	-0.48973	0.000E+00
16	1978	2.383E+00	1.605E+00	0.5344	6.188E+00	6.188E+00	-0.39516	0.000E+00
17	1979	1.520E+00	1.731E+00	0.4963	6.195E+00	6.195E+00	0.12970	0.000E+00
18	1980	6.722E+00	1.875E+00	0.5075	6.863E+00	6.863E+00	-1.27691	0.000E+00
19	1981	2.621E+00	2.097E+00	0.4150	6.277E+00	6.277E+00	-0.22326	0.000E+00
20	1982	2.270E+00	1.968E+00	0.8451	1.200E+01	1.200E+01	-0.14280	0.000E+00
21	1983	2.131E+00	1.263E+00	1.2541	1.142E+01	1.142E+01	-0.52342	0.000E+00
22	1984	5.930E-01	7.218E-01	1.1123	5.791E+00	5.791E+00	0.19649	0.000E+00
23	1985	7.090E-01	5.831E-01	0.5991	2.520E+00	2.520E+00	-0.19550	0.000E+00
24	1986	8.200E-01	5.742E-01	0.7387	3.060E+00	3.060E+00	-0.35627	0.000E+00
25	1987	5.090E-01	5.112E-01	0.8068	2.975E+00	2.975E+00	0.00423	0.000E+00
26	1988	1.710E-01	4.882E-01	0.6014	2.118E+00	2.118E+00	1.04905	0.000E+00
27	1989	9.770E-01	6.112E-01	0.2738	1.207E+00	1.207E+00	-0.46905	0.000E+00
28	1990	7.250E-01	7.171E-01	0.6899	3.569E+00	3.569E+00	-0.01091	0.000E+00
29	1991	7.300E-01	8.171E-01	0.3444	2.030E+00	2.030E+00	0.11272	0.000E+00
30	1992	5.760E-01	8.991E-01	0.7296	4.732E+00	4.732E+00	0.44526	0.000E+00
31	1993	5.450E-01	8.666E-01	0.6164	3.853E+00	3.853E+00	0.46374	0.000E+00
32	1994	8.970E-01	8.902E-01	0.6025	3.869E+00	3.869E+00	-0.00761	0.000E+00
33	1995	3.540E-01	1.195E+00	0.0914	7.880E-01	7.880E-01	1.21622	0.000E+00
34	1996	1.303E+00	1.978E+00	0.0892	1.273E+00	1.273E+00	0.41735	0.000E+00
35	1997	3.781E+00	3.111E+00	0.0817	1.834E+00	1.834E+00	-0.19512	0.000E+00
36	1998	4.347E+00	4.521E+00	0.0946	3.087E+00	3.087E+00	0.03935	0.000E+00
37	1999	7.973E+00	5.977E+00	0.1030	4.441E+00	4.441E+00	-0.28817	0.000E+00
38	2000	5.838E+00	7.165E+00	0.1334	6.895E+00	6.895E+00	0.20476	0.000E+00
39	2001	1.155E+01	7.984E+00	0.1350	7.776E+00	7.776E+00	-0.36947	0.000E+00
40	2002	3.754E+00	8.681E+00	0.0978	6.123E+00	6.123E+00	0.83837	0.000E+00

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1
                   -2       -1.5       -1       -0.5        0        0.5        1        1.5        2
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1963    -0.0790                                           ==|
1964    -0.3264                                      =======|
1965    -0.0669                                            =|
1966     0.6874                                             |==============
1967     0.0238                                             |
1968    -0.3622                                      =======|
1969    -0.3551                                      =======|
1970     0.1011                                             |==
1971    -0.2468                                        =====|
1972    -0.3132                                       ======|
1973    -0.4662                                    =========|
1974    -0.0294                                            =|
1975     0.2330                                             |=====
1976     0.3920                                             |========
1977    -0.4897                                   ==========|
1978    -0.3952                                     ========|
1979     0.1297                                             |===
1980    -1.2769                   ==========================|
1981    -0.2233                                         ====|
1982    -0.1428                                          ===|
1983    -0.5234                                   ==========|
1984     0.1965                                             |====
1985    -0.1955                                         ====|
1986    -0.3563                                      =======|
1987     0.0042                                             |
1988     1.0491                                             |=====================
1989    -0.4691                                    =========|
1990    -0.0109                                             |
1991     0.1127                                             |==
1992     0.4453                                             |=========
1993     0.4637                                             |=========
1994    -0.0076                                             |
1995     1.2162                                             |========================
1996     0.4174                                             |========
1997    -0.1951                                         ====|
1998     0.0394                                             |=
1999    -0.2882                                       ======|
2000     0.2048                                             |====
2001    -0.3695                                      =======|
2002     0.8384                                             |=================
                   ------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) USA Spring -lagged

Data type I2: End-of-year biomass index Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1963	0.000E+00	0.000E+00	0.0	*	1.183E+01	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	1.002E+01	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	8.842E+00	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	8.629E+00	0.00000	0.0
5	1967	1.000E+00	1.000E+00	0.0	2.813E+00	8.458E+00	-1.10087	-5.645E+00
6	1968	1.000E+00	1.000E+00	0.0	1.117E+01	7.747E+00	0.36597	3.423E+00
7	1969	1.000E+00	1.000E+00	0.0	5.312E+00	6.667E+00	-0.22718	-1.355E+00
8	1970	1.000E+00	1.000E+00	0.0	4.607E+00	5.551E+00	-0.18642	-9.441E-01
9	1971	1.000E+00	1.000E+00	0.0	6.450E+00	5.402E+00	0.17730	1.048E+00
10	1972	0.000E+00	0.000E+00	0.0	*	4.818E+00	0.00000	0.0
11	1973	0.000E+00	0.000E+00	0.0	*	4.326E+00	0.00000	0.0
12	1974	0.000E+00	0.000E+00	0.0	*	3.691E+00	0.00000	0.0
13	1975	0.000E+00	0.000E+00	0.0	*	2.931E+00	0.00000	0.0
14	1976	0.000E+00	0.000E+00	0.0	*	2.123E+00	0.00000	0.0
15	1977	0.000E+00	0.000E+00	0.0	*	1.714E+00	0.00000	0.0
16	1978	0.000E+00	0.000E+00	0.0	*	1.818E+00	0.00000	0.0
17	1979	0.000E+00	0.000E+00	0.0	*	1.990E+00	0.00000	0.0
18	1980	0.000E+00	0.000E+00	0.0	*	2.135E+00	0.00000	0.0
19	1981	1.000E+00	1.000E+00	0.0	2.500E+00	2.481E+00	0.00774	1.929E-02
20	1982	1.000E+00	1.000E+00	0.0	2.642E+00	1.889E+00	0.33558	7.532E-01
21	1983	1.000E+00	1.000E+00	0.0	1.646E+00	9.957E-01	0.50268	6.503E-01
22	1984	1.000E+00	1.000E+00	0.0	9.880E-01	6.243E-01	0.45908	3.637E-01
23	1985	1.000E+00	1.000E+00	0.0	8.470E-01	6.592E-01	0.25065	1.878E-01
24	1986	1.000E+00	1.000E+00	0.0	3.290E-01	6.057E-01	-0.61035	-2.767E-01
25	1987	1.000E+00	1.000E+00	0.0	5.660E-01	5.218E-01	0.08125	4.417E-02
26	1988	1.000E+00	1.000E+00	0.0	7.290E-01	5.528E-01	0.27664	1.762E-01
27	1989	1.000E+00	1.000E+00	0.0	6.990E-01	8.069E-01	-0.14353	-1.079E-01
28	1990	1.000E+00	1.000E+00	0.0	6.310E-01	7.720E-01	-0.20167	-1.410E-01
29	1991	1.000E+00	1.000E+00	0.0	1.566E+00	1.037E+00	0.41184	5.286E-01
30	1992	1.000E+00	1.000E+00	0.0	4.820E-01	9.438E-01	-0.67194	-4.618E-01
31	1993	1.000E+00	1.000E+00	0.0	6.600E-01	9.634E-01	-0.37822	-3.034E-01
32	1994	1.000E+00	1.000E+00	0.0	2.579E+00	9.958E-01	0.95161	1.583E+00
33	1995	1.000E+00	1.000E+00	0.0	2.853E+00	1.686E+00	0.52627	1.167E+00
34	1996	1.000E+00	1.000E+00	0.0	4.359E+00	2.731E+00	0.46744	1.628E+00
35	1997	1.000E+00	1.000E+00	0.0	2.324E+00	4.173E+00	-0.58540	-1.849E+00
36	1998	1.000E+00	1.000E+00	0.0	9.307E+00	5.796E+00	0.47367	3.511E+00
37	1999	1.000E+00	1.000E+00	0.0	6.696E+00	7.330E+00	-0.09046	-6.340E-01
38	2000	1.000E+00	1.000E+00	0.0	5.008E+00	8.389E+00	-0.51589	-3.381E+00
39	2001	1.000E+00	1.000E+00	0.0	9.563E+00	9.137E+00	0.04560	4.262E-01
40	2002	1.000E+00	1.000E+00	0.0	6.721E+00	9.916E+00	-0.38889	-3.195E+00

* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2

```
                   -2       -1.5       -1       -0.5        0        0.5        1        1.5        2
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967    -1.1009                       ======================|
1968     0.3660                                             |=======
1969    -0.2272                                        =====|
1970    -0.1864                                         ====|
1971     0.1773                                             |====
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0077                                             |
1982     0.3356                                             |=======
1983     0.5027                                             |==========
1984     0.4591                                             |=========
1985     0.2507                                             |=====
1986    -0.6103                                 ============|
1987     0.0812                                             |==
1988     0.2766                                             |======
1989    -0.1435                                          ===|
1990    -0.2017                                         ====|
1991     0.4118                                             |========
1992    -0.6719                                =============|
1993    -0.3782                                     ========|
1994     0.9516                                             |===================
1995     0.5263                                             |===========
1996     0.4674                                             |=========
1997    -0.5854                                 ============|
1998     0.4737                                             |=========
1999    -0.0905                                           ==|
2000    -0.5159                                   ==========|
2001     0.0456                                             |=
2002    -0.3889                                     ========|
                   ------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) Canada - lagged

Data type I2: End-of-year biomass index Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1963	0.000E+00	0.000E+00	0.0	*	2.679E+01	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	2.268E+01	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	2.001E+01	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	1.953E+01	0.00000	0.0
5	1967	0.000E+00	0.000E+00	0.0	*	1.914E+01	0.00000	0.0
6	1968	0.000E+00	0.000E+00	0.0	*	1.753E+01	0.00000	0.0
7	1969	0.000E+00	0.000E+00	0.0	*	1.509E+01	0.00000	0.0
8	1970	0.000E+00	0.000E+00	0.0	*	1.256E+01	0.00000	0.0
9	1971	0.000E+00	0.000E+00	0.0	*	1.223E+01	0.00000	0.0
10	1972	0.000E+00	0.000E+00	0.0	*	1.091E+01	0.00000	0.0
11	1973	0.000E+00	0.000E+00	0.0	*	9.792E+00	0.00000	0.0
12	1974	0.000E+00	0.000E+00	0.0	*	8.354E+00	0.00000	0.0
13	1975	0.000E+00	0.000E+00	0.0	*	6.634E+00	0.00000	0.0
14	1976	0.000E+00	0.000E+00	0.0	*	4.806E+00	0.00000	0.0
15	1977	0.000E+00	0.000E+00	0.0	*	3.879E+00	0.00000	0.0
16	1978	0.000E+00	0.000E+00	0.0	*	4.116E+00	0.00000	0.0
17	1979	0.000E+00	0.000E+00	0.0	*	4.504E+00	0.00000	0.0
18	1980	0.000E+00	0.000E+00	0.0	*	4.833E+00	0.00000	0.0
19	1981	0.000E+00	0.000E+00	0.0	*	5.615E+00	0.00000	0.0
20	1982	0.000E+00	0.000E+00	0.0	*	4.275E+00	0.00000	0.0
21	1983	0.000E+00	0.000E+00	0.0	*	2.254E+00	0.00000	0.0
22	1984	0.000E+00	0.000E+00	0.0	*	1.413E+00	0.00000	0.0
23	1985	0.000E+00	0.000E+00	0.0	*	1.492E+00	0.00000	0.0
24	1986	1.000E+00	1.000E+00	0.0	1.264E+00	1.371E+00	-0.08127	-1.070E-01
25	1987	1.000E+00	1.000E+00	0.0	1.235E+00	1.181E+00	0.04458	5.385E-02
26	1988	1.000E+00	1.000E+00	0.0	4.710E-01	1.251E+00	-0.97708	-7.803E-01
27	1989	1.000E+00	1.000E+00	0.0	1.578E+00	1.826E+00	-0.14617	-2.484E-01
28	1990	1.000E+00	1.000E+00	0.0	1.759E+00	1.747E+00	0.00662	1.161E-02
29	1991	1.000E+00	1.000E+00	0.0	2.475E+00	2.348E+00	0.05266	1.270E-01
30	1992	1.000E+00	1.000E+00	0.0	2.642E+00	2.136E+00	0.21251	5.058E-01
31	1993	1.000E+00	1.000E+00	0.0	2.753E+00	2.181E+00	0.23308	5.724E-01
32	1994	1.000E+00	1.000E+00	0.0	2.027E+00	2.254E+00	-0.10613	-2.270E-01
33	1995	1.000E+00	1.000E+00	0.0	5.304E+00	3.815E+00	0.32946	1.489E+00
34	1996	1.000E+00	1.000E+00	0.0	1.329E+01	6.182E+00	0.76546	7.110E+00
35	1997	1.000E+00	1.000E+00	0.0	4.292E+00	9.446E+00	-0.78884	-5.154E+00
36	1998	1.000E+00	1.000E+00	0.0	1.767E+01	1.312E+01	0.29765	4.548E+00
37	1999	1.000E+00	1.000E+00	0.0	1.995E+01	1.659E+01	0.18436	3.359E+00
38	2000	1.000E+00	1.000E+00	0.0	2.216E+01	1.899E+01	0.15433	3.169E+00
39	2001	1.000E+00	1.000E+00	0.0	2.062E+01	2.068E+01	-0.00275	-5.679E-02
40	2002	1.000E+00	1.000E+00	0.0	1.625E+01	2.244E+01	-0.32299	-6.195E+00

* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3

```
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0000                                             |
1985     0.0000                                             |
1986    -0.0813                                          ===|
1987     0.0446                                             |==
1988    -0.9771      =======================================|
1989    -0.1462                                       ======|
1990     0.0066                                             |
1991     0.0527                                             |==
1992     0.2125                                             |=========
1993     0.2331                                             |=========
1994    -0.1061                                         ====|
1995     0.3295                                             |=============
1996     0.7655                                             |===============================
1997    -0.7888              ================================|
1998     0.2976                                             |============
1999     0.1844                                             |=======
2000     0.1543                                             |======
2001    -0.0028                                             |
2002    -0.3230                                =============|
                   ------------------------------------------------------------------------------------
```

RESULTS OF BOOTSTRAPPED ANALYSIS

Param name	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
B1ratio	2.245E+00	2.255E+00	0.48%	9.692E-01	2.973E+00	1.886E+00	2.321E+00	4.346E-01	0.194
K	8.424E+01	8.476E+01	0.61%	8.051E+01	9.223E+01	8.290E+01	8.613E+01	3.233E+00	0.038
r	6.977E-01	6.877E-01	-1.43%	6.464E-01	7.405E-01	6.798E-01	7.137E-01	3.383E-02	0.048
q(1)	1.432E-01	1.386E-01	-3.19%	1.288E-01	1.514E-01	1.376E-01	1.470E-01	9.394E-03	0.066
q(2)	1.594E-01	1.526E-01	-4.29%	1.436E-01	1.787E-01	1.508E-01	1.704E-01	1.955E-02	0.123
q(3)	3.649E-01	3.453E-01	-5.37%	3.069E-01	4.150E-01	3.358E-01	3.868E-01	5.102E-02	0.140
MSY	1.458E+01	1.457E+01	-0.03%	1.393E+01	1.576E+01	1.437E+01	1.473E+01	3.561E-01	0.024
Ye(2003)	1.039E+01	1.042E+01	0.34%	9.100E+00	1.211E+01	9.773E+00	1.106E+01	1.291E+00	0.124
Bmsy	4.212E+01	4.238E+01	0.61%	4.026E+01	4.612E+01	4.145E+01	4.307E+01	1.617E+00	0.038
Fmsy	3.488E-01	3.438E-01	-1.43%	3.232E-01	3.702E-01	3.399E-01	3.568E-01	1.692E-02	0.048
fmsy(1)	2.450E+00	2.480E+00	1.25%	2.259E+00	2.682E+00	2.370E+00	2.548E+00	1.788E-01	0.073
fmsy(2)	2.208E+00	2.254E+00	2.10%	1.964E+00	2.432E+00	2.100E+00	2.327E+00	2.264E-01	0.103
fmsy(3)	9.733E-01	9.958E-01	2.31%	8.303E-01	1.117E+00	9.014E-01	1.030E+00	1.284E-01	0.132
F(0.1)	3.139E-01	3.095E-01	-1.29%	2.909E-01	3.332E-01	3.059E-01	3.211E-01	1.522E-02	0.048
Y(0.1)	1.443E+01	1.443E+01	-0.03%	1.379E+01	1.560E+01	1.423E+01	1.458E+01	3.526E-01	0.024
B-ratio	1.544E+00	1.534E+00	-0.69%	1.453E+00	1.620E+00	1.496E+00	1.584E+00	8.819E-02	0.057
F-ratio	2.823E-01	2.844E-01	0.74%	2.610E-01	3.051E-01	2.715E-01	2.932E-01	2.171E-02	0.077
Y-ratio	7.039E-01	7.152E-01	1.60%	6.162E-01	7.946E-01	6.587E-01	7.543E-01	9.553E-02	0.136
f0.1(1)	2.205E+00	2.232E+00	1.13%	2.033E+00	2.414E+00	2.133E+00	2.294E+00	1.610E-01	0.073
f0.1(2)	1.987E+00	2.028E+00	1.89%	1.767E+00	2.189E+00	1.890E+00	2.094E+00	2.038E-01	0.103
f0.1(3)	8.760E-01	8.962E-01	2.08%	7.473E-01	1.005E+00	8.113E-01	9.268E-01	1.156E-01	0.132
q2/q1	1.103E+00	1.100E+00	-0.21%	9.721E-01	1.264E+00	1.038E+00	1.180E+00	1.429E-01	0.130
q3/q1	2.501E+00	2.491E+00	-0.41%	2.103E+00	2.918E+00	2.281E+00	2.687E+00	4.062E-01	0.162

NOTES ON BOOTSTRAPPED ESTIMATES

- The bootstrapped results shown were computed from 500 trials.
- These results are conditional on the constraints placed upon MSY and r in the input file (ASPIC.INP).
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- The bias corrections used here are based on medians. This is an accepted statistical procedure, but may estimate nonzero bias for unbiased, skewed estimators.