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**Reference Document 2005/04**

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# Stock Assessment of Georges Bank (5Zhjmn) Yellowtail Flounder for 2005

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## ABSTRACT

The combined Canada/US yellowtail flounder (*Limanda ferruginea*) catch increased from 1995 to 2001 and in 2004 was 7,275 t, 10% more than the 6,632 t caught in 2003. Adult biomass (ages 3+) has generally increased from 2,000 t in the mid 1990s but remains low at about 10,000-19,000 t in 2005, indicating that more stock rebuilding is needed. Recruitment has improved compared to the period 1980 to the mid 1990s, averaging 21 to 27 million age-1 fish during the past five years. Fishing mortality for fully recruited ages 4+ has been close to or above 1.0 between 1973 and 1994, declined to less than 0.6 in 2002 and 2003, well above the reference point of $F_{ref}$ = 0.25, and increased in 2004 to above 1.0. Truncated age structure in the surveys and change in distribution indicate current productivity may be limited relative to historical levels. Assuming a 2005 catch equal to the 6,000 t quota, a combined Canada/US yield of about 2,100-4,200 t in 2006 has a neutral risk, about 50%, of exceeding $F_{ref}$ = 0.25. A combined yield below about 3,000 t to 3,500 t would be required to ensure a low risk of not achieving a 20% biomass increase from 2006 to 2007.

## RÉSUMÉ

Les prises combinées de limande à queue jaune (*Limanda ferruginea*) du Canada et des États-Unis ont augmenté de 1995 à 2001 et elles se chiffraient à 7 275 t en 2004, ce qui était supérieur à celles de l'année précédente (6 632 t). La biomasse des adultes (âges 3+) a généralement augmenté par rapport à ses 2 000 t du milieu des années 1990, mais elle reste faible, se situant alentour de 10 000-19 000 t en 2005, ce qui reflète la nécessité d'un rétablissement du stock. Le recrutement s'est amélioré par rapport à la période allant de 1980 au milieu des années 1990; il s'est chiffré en moyenne à 21-27 millions de poissons d'âge-1 au cours des cinq dernières années. La mortalité par pêche parmi les poissons des âges 4+ pleinement recrutés s'est située alentour ou au-dessus de 1,0 entre 1973 et 1994, puis elle est descendue sous 0,6 en 2002 et 2003, ce qui était bien supérieur au point de référence $F_{réf.}$ = 0.25; elle a augmenté en 2004 et dépassé 1,0. La structure d'âges tronquée dans les relevés et le changement dans la distribution révèlent que la productivité actuelle pourrait être limitée par rapport à ses niveaux historiques. Si on se fonde sur des prises égales au quota de 6 000 t en 2005, un rendement combiné du Canada et des États-Unis d'environ 2 100-4 200 t en 2006 représente un risque neutre, soit d'environ 50 %, de dépassement de $F_{réf.}$ = 0,25. Un rendement combiné inférieur à environ 3 000-3 500 t serait nécessaire pour que le risque de ne pas atteindre une hausse de 20 % de la biomasse de 2006 à 2007 soit faible.

# INTRODUCTION

The Georges Bank yellowtail flounder *(Limanda ferruginea)* stock is a transboundary resource in Canadian and US jurisdictions. This paper updates the last stock assessment of yellowtail flounder on Georges Bank, completed by Canada and the US (Legault and Stone 2004) taking into account advice from the 2005 benchmark review (TRAC 2005). Last year, the outlook was more uncertain than in previous years due to an increase in the retrospective pattern seen in the age-based analytical assessment and major divergence between the age-based assessment, production model, and forward projecting age structured assessment program (ASAP) results. The increased uncertainty in current stock status, the divergence in model results, and the failure to explain the absence of older fish in the catch gave very little confidence in projection results. The calculated catch for 2005 from the VPA (3,800 t) was thought to be overly optimistic to achieve $F_{ref}$ but was offset by ASAP results that hypothesized a dome-shaped selectivity pattern due to Closed Area II which had a much higher calculated catch for 2005 (8,000 t) under the same $F_{ref}$.

In 2005, the TRAC conducted a benchmark review of the Georges Bank yellowtail flounder stock assessment with separate meetings to discuss data issues and assessment model formulations (TRAC 2005). A primary objective of the benchmark review was to address the retrospective pattern that had been apparent from assessments conducted during the past several years. As part of this review, a number of important changes were made to the input data used for virtual population analysis (VPA), the main analytical approach used to evaluate the status of this stock. These changes included revision of the DFO survey age-specific indices of abundance for 1987-2003, the inclusion of yellowtail flounder discards from the Canadian offshore scallop fishery for 1973-2003 in the Canadian catch at age (CAA), and revisions to the US dredge discards. During the second benchmark assessment meeting, several analytical models were reviewed all of which indicated that the catch at age and survey abundance at age show differences which can not be reconciled; suggesting an increase in natural mortality, a large amount of unreported catch, or a change in survey catchability since 1995. The consensus view from this meeting was that management advice for 2005 should be formulated on basis of results from several approaches:

- Analysis of data from survey and fishery (trends in relative F and Z)
- Base run VPA model formulation from 2004 assessment
- Two new VPA model formulations with minor & major changes to base run

The analytical methods used in the current assessment are based on revised model formulations adopted during the 2005 TRAC benchmark review 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 30 and 70 m. A major concentration occurs on Georges Bank from the northeast peak to the east of the Great South Channel. Yellowtail flounder have previously been described as relatively sedentary, although a growing body of evidence counters this classification with off bottom movements (Walsh and Morgan 2004; Cadrin and Westwood 2004), limited seasonal movements (Royce et al. 1959; Lux 1963; Stone and Nelson 2003; C. Glass pers. comm.), and transboundary movements to the east and west across the international boundary (Stone and Nelson 2003; S. Cadrin pers. comm.). 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; Cadrin 2003). 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.

Historical and new information as it pertains to the current management unit used to delineate the Georges Bank yellowtail flounder stock was reviewed for the 2005 benchmark assessment. Tagging observations, larval distribution, vital population parameters (i.e. growth, survival, recruitment, reproduction, abundance), 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 (Royce et al. 1959; Lux 1963; McBride and Brown 1980; Neilson et al. 1986; Begg et al. 1999; Cadrin 2003; Stone and Nelson 2003). Based on new information from the comprehensive review by Cadrin (2003) and recent results from cooperative science/industry tagging programs conducted by Canada and the US, there does not appear to be any justification for redefining the geographic boundaries of the Georges Bank yellowtail flounder stock management unit.

The management unit currently recognized by Canada and the US 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 US employ the same management unit. The quota sharing agreement between the two countries requires that catches from all sources be counted against the national allocations, regardless of whether the catch was landed or discarded.

## The Fisheries

Exploitation of the Georges Bank stock began in the mid-1930's by the US trawler fleet. Landings (including discards) increased from 400 t in 1935 to 9,800 t in 1949, then decreased in the early 1950s to 2,000 t in 1956, and increased again in the late 1950s (Fig. 2). The highest annual catches occurred during 1963-1976 (average: 17,500 t) and included modest catches by foreign fleets (Table 1). 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 3,500 t between 1985 and 1994, then dropped to a record low of 1,183 t in 1995 when fishing effort was drastically reduced in order to allow the stock to rebuild. The US 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, as well as net regulations and limits on days fished. In 2004, a Yellowtail Special Access Program in Closed Area II opened up the area to a US bottom trawl fishery for the first time since 1995. A directed Canadian fishery began on eastern Georges Bank in 1993, pursued mainly by small otter trawlers (< 20 m). Catches by both nations (including discards) have steadily increased (with increasing quotas) from a record low of 1,183 t in 1995, when the stock was considered to be in a collapsed state, to 7,857 t in 2001. In 2004, combined catches for the US and Canada were 7,275 t.

### *United States*

The principle fishing gear used in the US fishery to catch yellowtail flounder is the otter trawl, but scallop dredges contribute some landings. In recent years, otter trawls caught greater than 98% of total landings from the Georges Bank stock, while dredges caught 0-2% of annual totals. US trawlers that land yellowtail flounder generally target multiple species on the southwest part of the Bank, and on the northern edge along the western and southern boundaries of Closed Area II. The Special Access Program (SAP) in Closed Area II from June to September accounted for a large portion of the 2004 landings. Current levels of recreational fishing are negligible and there have been no foreign catches since 1995.

In May of 2004 a new electronic dealer reporting system for US landings was implemented. This new reporting system did not allow the typical proration to stock area scheme using logbook data as described in Cadrin et al. (1998) because the gear code was not included in many records. Gear codes were assigned to permits that had only used a single gear based on logbook records. This allowed the typical proration scheme to be used. Examination of patterns of landings reported in the dealer database and those in the logbook records show similar trends in terms of time of year, gear, and port. Thus, there is no indication of a systematic bias in these allocations. Total yellowtail landings (excluding discards) for the 2004 directed fishery were 6,208 t, an increase of 86% from 2003, and the highest landings since 1983 (Table 1; Fig. 2).

Discarding of yellowtail in the US trawl fishery increased in 2004 due to both an overall increase in landings and a prohibition of landings in November and December. The large landings of yellowtail caused fish to be discarded that were slightly above the minimum size regulation as well as those below the minimum size regulation. In 2004, 81% of yellowtail flounder discards originated from the trawl fishery (446 t), while the remainder came from the scallop fishery (104 t). The scallop fishery focused most of its effort in the Mid-Atlantic region, even when a Special Access Program for scallops in Closed Area II was implemented in November and December. Due to the negligible landings of yellowtail in the scallop fishery, the regression method to estimate discards of yellowtail from landings of scallops from the benchmark assessment was employed for this fishery. The trawl fishery estimates of discards were obtained from discard to kept ratios of yellowtail based on observer data. Comparison of these d:k ratios from observers and logbooks showed that logbook values were much less than observer values for similar time periods, but the same pattern over time was present.

Total US catches in 2004, including discards, were 6,757 t. The US quota for fishing year 2004 (1 May 2004 to 30 April 2005) was set at 6,000 t. Monitoring of the US catches relative to the quota was based on Vessel Monitoring Systems (VMS) and a call-in system for both landings and discards. The assessment methodology and the monitoring methodology to estimate landings and discards were compared for a six month period of overlap, July to December 2004. During this period, the assessment methodology estimated catch to be 3,466 t while the monitoring methodology estimated catch to be 3,000 t (13% less).

### ***Canada***

Canadian fishermen began directing for yellowtail flounder in 1993. Prior to 1993, Canadian landings were small, typically less than 60 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 464 t in 1995. Since then both quotas and landings have increased steadily and in 2001 were 2,913 t. The majority of Canadian landings of yellowtail flounder are made by otter trawl from vessels less than 20 m, tonnage classes 1-3. The Canadian fishery generally occurs from June to December, with most landings reported in the third quarter. In 2004, landings were 96 t (against a quota of 1,900 t), and were down 95% from 2003 (Table 1). Unlike other years, Canadian fishermen were unable to find commercial quantities of yellowtail in 2004 and the directed fishery ceased in 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 reporting practices. For the 2004 fishery, the proportion of yellowtail catch in unspecified flounder landings was estimated 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 2004 estimated to be yellowtail, were 0.1 t and 0.4 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 2004, summer flounder catches of 2.2 t were identified and reported as a separate species in the commercial landings data, so no adjustments to the total yellowtail landings were required.

The Canadian directed fishery for yellowtail 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 2004 was comparable to that observed over the previous five years, but catches were small throughout 5Zjm (average= 60kg/tow) (Fig. 3).

*Bycatch Estimates*

The Canadian offshore scallop fishery is considered to be the main source of Canadian yellowtail flounder discards/bycatch on Georges Bank. Discards from the Canadian scallop fishery have not been included in past stock assessments, however, as a result of the recent benchmark review, these data are now incorporated into the Canadian fishery catch and catch at age for 1973-2004. Prior to 1996, landing of groundfish bycatch by the Canadian scallop fishery on Georges Bank was permitted, however, it is generally acknowledged that all the yellowtail flounder bycatch was not landed. To account for the total bycatch for 1973-1995, it was necessary to augment the landings by the scallop fishery with the discarded amounts of bycatch. Management measures established in 1996 prohibit the landing of groundfish (except monkfish) by the Canadian scallop fishery and all bycatch of yellowtail flounder is now discarded. Discards, whether pre or post 1996, are not recorded in the Canadian fishery statistics and can only be estimated from observer deployments.

Prior to 2001, very few Canadian scallop trips on Georges Bank had at-sea observer deployments, with only nine trips monitored from 1991 to 1998. More recently, in response to a Fisheries Resource Conservation Council recommendation, a monitoring program was conducted by the Canadian offshore scallop industry in 2001 and 2002 to gather data on bycatches. Twelve trips were observed which covered all months except January and October. Starting in August 2004, routine observer deployment on vessels participating in the Canadian scallop fishery on Georges Bank was initiated, with a total of five trips observed in 2004.

Van Eeckhaute et al. (*in prep*) provide the methodology used for yellowtail flounder discard estimation from the Canadian scallop fishery from 1973-2004 based on observer data. The analysis was done separately for two periods:

1996-2004: landing of yellowtail flounder not permitted, high observer coverage
1973-1995: landing of yellowtail flounder permitted, low observer coverage

For 1996-2004, when landing of yellowtail flounder was not permitted, effort in the scallop fishery was prorated by the observed discard rate of yellowtail to effort to obtain an estimate of discards. While the available data did not support any unit area trends in discard rates, there appeared to be a tendency for higher discard rates in April, May and June and lower discard rates in November and December. Therefore, the proration was conducted using discard rate by quarter. Quarterly discard rates for periods when no observed trips were available were derived by interpolation and application of a seasonal pattern. To estimate discards for year 1996 and later, the quarterly discard rates were applied to the total quarterly effort of the scallop fleet. For 1973-1995, the number of observed trips was very limited and the ratios were subject to influence by anomalous outliers. An effort-based proration was used without the seasonal factors applied in the 1996-2003 period because that refinement was not considered warranted given the limitations of the available information for this period. The approach used for both periods is dependent on the assumption that the bycatch population density, i.e. the *discard+landed / scallop effort* ratio for observed scallop fishing is representative of that for the scallop fishery as well as on the assumption that discarding practices are representative.

Discard estimates from 1973-2004 averaged 546 t and ranged from a low of 268 t in 1995 to a high of 815 t in 2001 (Table 1). Discards represent nearly all of the Canadian catch from 1973-1992 (Fig 2; Fig. 4, upper panel), and result in a slight increase to the total catch from 1973-2004 compared to the total catch used in the 2004 assessment (Fig. 4, lower panel). When Canadian yellowtail flounder catches are revised to include the discard estimates from the offshore scallop fishery, the annual quota for 1994 to 2003 is exceeded in all years by an average of 440 t (range: 251-683 t). For 2004, the total Canadian catch including estimated discards was 518 t, down 82% from 2003 and well below the 2004 TAC of 1,900 t.

**Length and Age Composition**

In 2004, the Canadian fishery was well sampled for lengths by sex, with 2,009 measurements available from 8 port samples (Table 2). Sea samples from 1 commercial trip provided an additional 954 length measurements by sex. Examination of the size composition from at-sea samples and port samples collected during the same quarter showed that the size composition by sex was quite similar and that there was a distinct seasonal pattern with more females present in the catch during the 2$^{nd}$ quarter, shifting to male predominance in the 3$^{rd}$ quarter (Fig. 5). This suggests a movement of males into (or females out of) the Yellowtail Hole during the 3$^{rd}$ quarter. Given the similarity between the two sources of size information (i.e. port vs observer), length data from the observed trip was combined with the DFO/Industry port-sampling program to characterize the size composition of the Canadian fishery. The protocol of combining size composition data from both sources has also been used in past assessments.

Canadian at-sea length frequency information for 2004 also indicated that culling on the basis of length was not a major concern in the 2004 fishery (Fig. 5). 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 below 1% for the past three years (Fig. 6). In 2004, only 0.8% of fish in the Canadian commercial catches were less than 30 cm.

The average size of yellowtail flounder in the Canadian fishery increased between 1994 and 2002 from 33 to 35 cm total length for males and from 35 to 41 cm for females (Fig 7). While the average size of males in the fishery did not change in 2004 (35 cm), the mean size of females declined to 39 cm. The proportion of males in the catch increased from 25% in 1999 to 65% in 2002, but declined to 52% in 2004.

The number of US port samples increased in 2004, with 7,964 length measurements available from 74 samples (Table 2). This compares with 4,877 measurements from 48 samples in 2003. At-sea sampling also increased in 2004 and provided an additional 19,403 length measurements, which were combined with the port samples to characterize the size composition of the US catch. At-sea sampling was considerably higher in 2004 due to increased observer coverage from the Yellowtail Special Access Program (SAP) in Closed Area II. Landings could not be easily classified as coming from the yellowtail SAP. However, samples from observers could be compared for trips fishing inside and outside the SAP. This comparison showed no difference in size composition of the catch (Fig. 8), so the stratification of SAP or not SAP was not deemed important for length and the usual approach to length and age composition was followed.

The US landings are classified by market category (large, small, and unclassified) and this categorization is used to determine the size and age distributions. Both the amount and the proportion of yellowtail landed in the large market category have increased since 1995 from approximately 50% to approximately 75%. Examination of the size distributions for the two market categories shows some overlap in the 35-40 cm range, but overall discrimination between the groups (Fig. 9). The proportion of the landings within the large market category that are 45 cm and larger has increased since 2000; 5%, 8%, 12%, 22%, 20% for years 2000 through 2004, respectively.

The US discard length frequencies were generated from observed trips, expanded to the total weight of discards by gear type and half year or quarter. No differences in length frequency were observed between trips inside and outside Closed Area II during the Special Access program for trawl gear, with discards during this period dominated by sub-legal fish. In the fourth quarter, trawl discards had a similar length frequency as the third quarter catch because landings were prohibited during most of the fourth quarter.

A comparison of the catch at size by nation indicated that the Canadian fishery has generally captured a higher proportion of smaller-sized fish than the US fishery since 2002 (Figs. 10-11). The Canadian fishery in 2004 was comprised mainly of fish in the 31-45 cm size range, while the USA fishery proportionately captured more large fish (31-52 cm), as was the case in 2003 (Fig. 11). Most of the US fishery catches (87%) and all of the Canadian catches (100%) occurred during the second and third quarters (Table 2). Seasonal and geographic differences between Canadian and US fisheries may account for some of the difference in size composition observed over the past two years. Net selectivity, specifically cod end mesh sizes used by US and Canadian fishers may also influence size composition. The slightly smaller Canadian cod end mesh size (i.e. 155 mm square) has the potential to retain more small fish than the larger cod end mesh used in the US fishery (i.e.165 mm square or diamond).

Although otoliths are used to determine age for Grand Bank yellowtail, scales are the preferred structure for aging Georges Bank yellowtail. During a recent yellowtail flounder aging workshop, it was concluded that otolith thin sections are the preferred structure to use for age determinations for this species on the Grand Banks (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 annuli 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 disappointing with < 55% agreement on these structures between expert age readers. In 2004, scale samples were collected from the Canadian fishery for aging by the experienced NMFS age reader. A total of 70 male and 92 female ages were used to produce separate-sex age-length keys which were applied to Canadian length samples to construct the catch at age (CAA) by sex for the 2004 commercial fishery. A test for consistency by the NMFS age reader on the Canadian fishery age material indicated 86% agreement with a low CV (2.52).

Prior to 2004, no ALKs are available for the Canadian fishery, and the practice has been to borrow separate sex ALKS based on scale age determinations from the same year NMFS fall survey plus second half US commercial fishery and apply these to the Canadian fishery catch at size by sex. While this protocol differs from that used for US landings, it was considered appropriate if there were sufficient ages in the sexed ALKs. During the 2005 benchmark review of assessment input data, it was considered best practice to pool all available ALK information from US port sampling, US sea sampling and NMFS surveys to compile half-year ALKs that could be applied to the length composition from the Canadian fishery. While the ALK sample sizes for these keys were substantially greater than what was used before, the changes in catch at age were nominal (Fig. 12). No Canadian fishery sampling data is available for years prior to 1993 when landings were low. Therefore, the catch at age for Canadian landings prior to 1993 was derived for combined sexes by multiplying the proportion of Canadian landings to US landings by the US fishery numbers at age.

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 season; Lux 1969), and apportioned to age using pooled-sex age-length keys in half year groups. Landings were converted by market category and half-year while discards were converted by gear and half year, except for trawl in the second half which was split into quarters.

Ages 3, 4 and 5 (2001, 2000 and 1999 year classes, respectively) dominated both Canadian and US catches in 2004, with a greater proportion of fish aged 4 and older and fewer age 2’s compared to the 2003 fishery (Fig. 13). Generally the US fishery had a higher percentage of fish aged 4+ in 2004 compared to the Canadian fishery. The mean weight at age (kg) for the Canadian and US fisheries were quite similar (same ALKs are used) and generally were more variable at older ages (5+) from the mid 1980s to the mid 1990s (Figs. 14 & 15). A trend of increasing weight at age is apparent in both fisheries for all ages since 1995, with a slight decline in the most recent year, but generally the mean weights have been less variable during this period compared to pre 1995.

The size and age composition of yellowtail flounder discards from the Canadian offshore scallop fishery were estimated using DFO and NMFS survey length composition adjusted for scallop dredge selectivity as described by Stone and Gavaris (2005). (Note: The actual discarded size composition was used for years when this information was available, i.e. 2001, 2002 and 2004). For each year, the trimmed proportion at size composition from the spring and fall surveys was prorated to the total estimated bycatch at size using the corresponding half year length-weight relationship and the estimated half year bycatch from Van Eeckhaute et al. (in prep). The half year age length keys used for aging yellowtail flounder discards at size from the offshore scallop fishery were developed using the following combined ages: Half 1 US commercial fishery + Half 1 US observer sampling + NMFS spring survey, and Half 2 US commercial fishery + Half 2 US observer sampling + NMFS fall survey.

The estimated discarded catch at age for 1973-2003 was generally dominated by ages 2, 3 and 4, with high numbers of age 1 fish in some years (Fig. 16; Table 3). The weight at age for discards was fairly consistent for ages 1 through 6, but was somewhat more variable for ages 7 and older due to low numbers of age samples for large fish (Fig. 17; Table 4). Generally, the method was considered to be appropriate for estimating the discarded age composition of yellowtail flounder from the Canadian offshore scallop fishery and the estimated discards at age were added to the Canadian fishery CAA to give the total CAA for Canada.

Overall, the 2004 catch age composition was represented by the 2001 (age 3) and 2000 (age 4) and 1999 (age 5) year classes, with age 4 predominant (Fig. 18, Table 5). Notable in 2004 is the presence of more fish aged 4 and older in the catch. Since the mid 1990s, ages 2-4 have represented 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.

Fishery mean weights at age for each of the Canadian and US landings and discards were derived using the applicable ALKs, LFs and length-weight relationships. These were then combined for an overall fishery weight at age, weighting by the respective catch at age (Table 6; Fig. 19). A trend of increasing weight at age is apparent for all ages since 1995, with a decline in the most recent year, but generally the mean weights have been less variable during this period compared to pre 1995. Current WAA values are within the range of past WAA calculations since 1973.

## ABUNDANCE INDICES

### *Commercial Fishery Catch*

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 ($n$=1433), and were assumed to represent directed fishing activity for yellowtail flounder. For the 2004 fishery, only 16 “directed trips” were available for CPUE analysis. A model with main effects of year (1993-2004), month (June-December) and tonnage class (1-3) was used to standardize the Canadian CPUE series:

$$ln(CPUE_{ijk}) = \mu + Year_i + Month_j + Tonnage\ Class_k + e_{ijk}$$

Analysis of variance results (Table 7) indicate that the overall regression and individual main effects were significant ($P < 0.05$) and that the model explained 63% (multiple $r^2$) of the variability in the data. No trends were apparent in the pattern of residuals (Table 7, bottom) and the standardized series tracked the nominal series (weighted mean) quite well (Fig. 20, 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, due to a greater than five-fold increase in effort from 1999 to 2001, and remained at low levels through 2002 and 2003, reaching the lowest level in the series in 2004, when fishery catches were extremely poor. 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. 20, lower panel). The Spearman rank correlation coefficient for these two series (1993-2004) was not significant ($r_s$=0.021; $P$=0.948; $n$=12), 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. Notable is the strong decline in the DFO survey index for 5Z2 in 2005 (Fig. 20, lower panel).

During the May 2004 industry consultation, fishermen indicated that catch rates have been low for the past three years (2001-2003), despite a very modest increase in 2002. At the May 2005 industry consultation, it was confirmed that catch rates were very low during the 2004 fishery and that commercial quantities of yellowtail flounder were difficult to find in the Yellowtail Hole area. Although the standardized series provides useful anecdotal information on recent trends in the Canadian commercial fishery catch rates, it is not used as a tuning index for the VPA model. This is because the catch rate series represents relative abundance from only a small geographic area on the Canadian side of the management unit. A comparable CPUE series from the US fishery in combination with the Canadian series would be required in order to develop indices which represent the entire management area, but still may not index abundance due to Closed Area II.

***Research Vessel Surveys***

Bottom trawl surveys are conducted annually on Georges Bank by DFO in the spring (February) and by the US 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. 21). NMFS spring and fall bottom trawl survey catches (strata 13-21), NMFS scallop survey catches (scallop strata 54, 55, 58-72, 74), 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.

Biomass indices for the three groundfish surveys track each other reasonably well over the past two decades. The DFO survey biomass series followed an increasing trend from 1995 to 2001 (the highest value in the series), then declined from 2002 through 2004, followed by a slight increase in 2005 (Table 8, Fig. 22). The current level is still considerably higher than that observed during the mid-1990s, when the stock was in a collapsed state. The NMFS spring series is longer, and tracks the DFO series well during the years of overlap up to 1999, then shows a decline through to 2001 followed by a sharp increase in 2002 (Table 9, Fig. 22). Similar to the DFO series, the NMFS spring biomass index follows a sharp decline from 2002 to 2004, the lowest value since 1994, then increases slightly in 2005. 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 10, Fig. 22). This series showed a strong decline between 2001 and 2002, but has increased through 2003 and 2004. The NMFS fall index is still at a relatively high level compared to the mid 1990's when the stock was at low levels. Note that both the NMFS spring and fall survey series showed high inter-annual variability during the previous periods of high abundance, the 1960s and 1970s, which may be reflective of the patchy distribution of yellowtail on Georges Bank and the low sampling density of NMFS surveys.

Since 1996, most of the DFO survey biomass and abundance of yellowtail flounder has occurred in Stratum 5Z4, which includes the lower portion of Closed Area II on the US side where no commercial groundfish fishing has occurred from 1995 through 2003 (Fig. 23). Although survey estimates for this stratum tend to be quite variable due to low sampling intensity, there was an increasing trend from 1996 to 2003 followed by a sharp decline in 2004, and then a strong increase in 2005. Some of the decline in 2004 was attributed to reduced sampling of the traditional high abundance area in the eastern part of Closed Area II, since most of the tows for Stratum 5Z4 in 2004 fell either north or south of this region. Stratum 5Z2 (CDN portion of Georges < 90 m depth) has also shown an increasing trend in biomass and abundance since 1996, but at a lower level than 5Z4. However, the 2005 survey indicates that both biomass and abundance have declined within this strata, despite the fact that there was only a limited Canadian fishery in 2004, and that abundance has increased in 5Z4 where a large US fishery took place in CAII during a special access program in 2004.

The length composition of yellowtail flounder captured in DFO surveys has been fairly consistent, with little change in the average size of males over the past 5 years (2001-2005), and a slight decline in the average size of females from 2004 to 2005 (Fig. 24). During this period, males have averaged 34 cm TL and females have averaged 38-40 cm TL. An increase in abundance is evident for males in 2005 but not for females. Both DFO and NMFS surveys generally show similar size composition with more fish captured in DFO surveys due to higher sampling density (Fig. 25). Yellowtail flounder captured in all three surveys had an average size of 34 cm TL. Throughout the DFO survey time series (1987-2005), the sex ratio has been slightly above 50% for males, but increased from 58% in 2004 to 71% in 2005, the highest level in the series (Fig. 26). The percentage of males is much more variable in the CDN fishery compared to the survey, likely due to seasonal and geographic variation in the distribution of fishing effort.

The average weights at length were examined by sex for three length ranges of yellowtail flounder (29-31 cm, 34-36 cm and 39-41 cm) for DFO surveys conducted from 1987-1991 and 1996-2005 (note: weights were not recorded for the1992-1995 DFO surveys) (Fig. 27). This measure, which is used to reflect condition, has not changed appreciably over the past decade with the exception of a decline from 2003-2005 for the larger size categories.

Age-structured indices of abundance for NMFS spring and fall surveys were derived using survey-specific age-length keys. In the past, age-length keys from NMFS spring surveys have been substituted to derive age composition for same-year DFO spring surveys, since no ages were directly available from the DFO surveys because of difficulties associated with age interpretation from otolith sections (Stone and Perley 2002). To avoid borrowing, NMFS has offered to age material collected on DFO surveys. In 2005, scales were collected during the DFO surveys for age interpretation by the NMFS age reader (as was done in 2004). A total of 212 male and 205 female ages were used to produce separate-sex age-length keys which were applied to abundance at length to generate the 2005 DFO age-specific indices of abundance. A test for consistency by the NMFS age reader on the DFO survey age material indicated 92% agreement with a low CV (1.79).

As part of the 2005 benchmark assessment review for Georges Bank yellowtail flounder, the DFO survey age-specific indices of abundance for 1987-2003 were re-calculated using NMFS spring survey age length keys (traditional method) augmented with additional ages borrowed from first half US port sampling and sea sampling to “fill out” missing ages at length. This was considered the best practice for the available data. The revised DFO indices with the enhanced ALKs showed some differences from age-specific indices used in the 2004 assessment (Fig. 28), but were considered to provide better representation of the age at length, although their inability to track strong/weak year classes is still of concern.

For the DFO, NMFS spring and NMFS fall groundfish surveys, the current year relative abundance for ages 1-2, 3-4 and 5+ was compared to the average abundance for the previous ten years. (Note: The boundaries of Closed Area II (CAII) were included in these plots to illustrate differences in age-specific abundance inside and outside the closed area). In 2005, the area of highest abundance for the DFO survey fell within CAII (Stratum 5Z4) for all age groups, but over the past 10 years, abundance appears to be similar both inside and outside CAII for most ages, with the possible exception of age 5+ which may have higher abundance within the closed area (Fig. 29). For the 2005 NMFS spring survey, abundance was higher for ages 1-2 and 3-4 in CAII but not age 5+, which had low abundance overall (Fig. 30). Over the past 10 years, the relative abundance of all age groups appears to be similar both inside and outside of CAII. Higher abundance was apparent for all ages in CAII during the 2004 NMFS fall survey (Fig. 31). Over the past 10 years, relative abundance of ages 1-2 and 3-4 was similar inside and outside of CAII, however, age 5+ fish may be more abundant in CAII during the fall. These plots provide some evidence for slightly higher abundance of older fish within the closed area, but whether CAII can be considered to be a refuge for older fish is not clear. Although recent tagging studies (Stone and Nelson 2003; Cadrin 2005) indicate that movement occurs both into and out of CAII across the international boundary, there is little information on residence time within the closed area.

Both the DFO and NMFS spring series show that the 2002 year class (Age 3) is predominant in 2005, and that the overall abundance of ages 3 to 6+ is higher than 2004 (Tables 8-9; Fig. 32). The 2004 NMFS fall survey also shows greater abundance levels of all age groups compared to 2003 (Table 10; Fig. 32). Similar to the 2005 DFO and NMFS spring surveys, the 2002 year class (Age 2) is predominant in the 2004 NMFS fall survey. 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 2002 year class in the 2004 NMFS fall survey and both 2005 spring surveys.

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 2004 assessment to include index values for 2004. While the 2004 value shows a decrease from 2003, the trend from 1990-2003 has been of increasing age 1 abundance (Table 11).

Trends in relative fishing mortality and total mortality from the surveys were examined as part of the consensus benchmark formulations agreed to at the second benchmark assessment meeting in April, 2005. Relative fishing mortality (fishery biomass/survey biomass, scaled to the mean for 1987-2004) was quite variable but followed a similar trend for all three surveys, with a sharp decline to low levels in 1995 (Fig. 33). In contrast, calculations of total mortality rates from the surveys for ages 2, 3 and 4-6 are without trend and indicate no reduction in mortality over time (Fig. 34). While these calculations are clearly noisy, they do not show signs of any interventions or overall changes in total mortality rate during the time series, as would be expected from the management measures implemented by both Canada and the US. This may be due to the inherent noisy nature of these surveys or could reflect ineffective management measures.

## ESTIMATION OF STOCK PARAMETERS

Assessment results from analyses conducted in the most recent years have displayed retrospective patterns, residual patterns that are indicative of a discontinuity starting in 1995, and fishing mortality rates that are not consistent with the decline in abundance along cohorts that is evident in the survey data. Essentially, the catch at age data and assumed natural mortality cannot be reconciled with the high survey abundance at ages 2 and 3 and low survey abundance at ages 4 and older.

The empirical evidence suggests that significant modifications to population and fishery dynamics assumptions are required to reconcile the observations from the fishery and the survey. Models that adopt these modifications to assumptions imply major consequences on underlying processes and/or fishery monitoring procedures. The magnitude of implied changes to natural mortality rate, survey catchability relationships and/or unreported catch are so great that it makes the acceptability of models that incorporate these effects suspect.

In view of the reservations about the implications to underlying processes, adoption of a benchmark formulation, that incorporates these modifications to assumptions, as the sole basis for management advice was not advocated (TRAC 2005). Therefore the TRAC recommended that management advice be formulated after considering the results from 3 VPA approaches described below.

### *1. Base VPA*

The Base Virtual Population Analysis (VPA) used revised annual catch at age (including US and Canadian discards), $C_{a,t}$, for ages $a$ = 1 to 6+, and time $t$ = 1973 to 2004, 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:

$s_1$ = DFO spring, ages $a$ = 2 to 6+, time $t$ = 1987 to 2005
$s_2$ = NMFS spring (Yankee 36), ages $a$ = 1 to 6+, time $t$ = 1982 to 2005
$s_3$ = NMFS spring (Yankee 41), ages $a$ = 1 to 6+, time $t$ = 1973 to 1981
$s_4$ = NMFS fall, ages $a$ = 1 to 6+, time $t$ = 1973.5 to 2004.5
$s_5$ = NMFS scallop, age $a$ = 1, time $t$ = 1982.5 to 2004.5

Data were aggregated for ages 6 and older to mitigate against frequent zero observations. Two independent sets of software were used for the analyses; the Canadian ADAPT software and the US NFT VPA v2.1.7 software. Results from the two approaches have always been quite similar, but slight differences exist in the minimization routines, treatments of the plus group, and utilization of bias correction. The fishing mortality rate for the 6 plus group was calculated according to the "alpha" method (Restrepo and Legault 1994) in the Canadian ADAPT software, while an average of fishing mortality on younger ages was used in the US NFT VPA software. Canadian scientists and managers have traditionally utilized bias correction in presentation of results, while US scientists and managers have not. Nonetheless, the results have been so similar between the methods that differences often cannot be seen on graphs, but rather must be observed in tables of results.

Both the Canadian and US software packages use the adaptive framework, ADAPT, (Gavaris 1988b) 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. Zero observations for abundance indices were treated as missing data as the logarithm of zero is not defined. The annual natural mortality rate, M, was assumed constant and equal to 0.2 for all ages. The fishing mortality rates for age groups 5 and 6+ were assumed equal. These model assumptions and methods were the same as those applied in the last assessment (Legault and Stone 2004). Both point estimates and bootstrap statistics of the estimated parameters were derived.

### *2. Minor Change VPA*

A VPA using the expanded/revised annual catch at age (including US and Canadian discards), $C_{a,t}$, for ages $a$ = 1 to 12, and time $t$ = 1973 to 2004, where $t$ represents the beginning of the time interval during which the catch was taken. The error in the catch at age was assumed to be negligible compared to the error in the survey indices. Natural mortality was assumed to be 0.2 for all ages and years.

The VPA was calibrated to bottom trawl survey indices, $I_{s,a,t}$, for:

$s_1$ = DFO spring, ages *a* = 4, 5, 6-9, time *t* = 1987 to 2005
$s_2$ = NMFS spring (Yankee 41), ages *a* = 4, 5, 6-9, time *t* = 1973 to 1981
$s_3$ = NMFS spring (Yankee 36), ages *a* = 4, 5, 6-9, time *t* = 1982 to 2005
$s_4$ = NMFS fall, ages *a* = 4, 5, 6-9, time *t* = 1973.5 to 2004.5
$s_5$ = NMFS scallop, age *a* = 1, time *t* = 1982.5 to 2004.5

The aggregated ages 6-9 survey indices were compared to ages 6-9 population abundance. The error in the indices were assumed to be independent and identically distributed. The relationship between indices and population abundance for all ages are assumed to be proportional. Population abundance at age 1 in the terminal year was assumed equal to the geometric mean over the most recent 10 years. Population abundance in the terminal year was estimated for ages 4-6 where the results were deemed reliable and calculated for ages 7-11 based on a weighted average F for ages 4-5. Abundance at ages 2 and 3 in terminal year was based on average PR to fishery for the previous 5 years. The survivors at age 13 in all years were assumed to be few and were set to 1,000 fish.

The Minor Change VPA was not accepted during the 2005 assessment due to a large change in partial recruitment to the fishery for young ages in 2004 compared to the terminal year of the assessment reviewed during the 2005 benchmark assessment methods meeting (Tables 12-13).

### *3. Major Change VPA*

A VPA using the expanded/revised annual catch at age (including US and Canadian discards), $C_{a,t}$, for ages *a* = 1 to 12, and time *t* = 1973 to 2004, where *t* represents the beginning of the time interval during which the catch was taken. The error in the catch at age was assumed to be negligible compared to the error in the survey indices. Natural mortality was assumed to be 0.2 for all ages and years.

The VPA was calibrated to bottom trawl survey indices, $I_{s,a,t}$, for:

$s_1$ = DFO spring, ages *a* = 2 to 5, 6-9, time *t* = 1987 to 1994
$s_2$ = DFO spring, ages *a* = 2 to 5, 6-9, time *t* = 1995 to 2005
$s_3$ = NMFS spring (Yankee 41), ages *a* = 1 to 5, 6-9, time *t* = 1973 to 1981
$s_4$ = NMFS spring (Yankee 36), ages *a* = 1 to 5, 6-9, time *t* = 1982 to 1994
$s_5$ = NMFS spring (Yankee 36), ages *a* = 1 to 5, 6-9, time *t* = 1995 to 2005
$s_6$ = NMFS fall, ages *a* = 1 to 5, 6-9, time *t* = 1973.5 to 1994.5
$s_7$ = NMFS fall, ages *a* = 1 to 5, 6-9, time *t* = 1995.5 to 2004.5
$s_8$ = NMFS scallop, ages *a* = 1, time *t* = 1983.5 to 1994.5
$s_9$ = NMFS scallop, ages *a* = 1, time *t* = 1995.5 to 2004.5

Splitting the survey time series at 1995 could not be justified based on changes in the survey design or implementation, but rather are considered to be aliasing unknown mechanisms causing the retrospective pattern in the Base VPA. The aggregated ages 6-9 survey indices were compared to ages 6-9 population abundance. The error in the indices was assumed to be independent and identically distributed. The relationship between indices and population abundance for ages 4 and older was assumed to be proportional while that for younger ages (1-3) was permitted to be a power relationship. Population abundance at age 1 in the terminal year was assumed equal to the geometric mean over the most recent 10 years. Population abundance in the terminal year was estimated for ages 2-6 where the results were deemed reliable, and calculated for ages 7-11 based on a weighted average F for ages 4-5. The survivors at age 13 in all years were assumed to be 1,000 fish.

***Diagnostics***

The population abundance estimates for the Base VPA show greater relative error in model fit (43%) and relative bias (8%) for age 2 while the relative error for ages 3-5 is lower (33-37%) and the bias is smaller (3-5%) (Table 14). The population abundance estimates for the Major Change VPA show greater relative error (21% age 2 to 87% age 6) and relative bias (<1% age 2 to 24% age 6) in model fit with increasing age (Table 15). Survey calibration constants (q's) for the Base VPA decline at older ages for the DFO survey but continue to increase with increasing age for both NMFS surveys. Survey calibration constants (q's) for the Major Change VPA are considerably higher in the recent period (1995 to present) for all three surveys, particularly for ages 1-3, which are fitted to the model with a power function.

The average magnitude of residuals for the 2005 DFO and NMFS spring surveys from the Base VPA showed some improvement over 2004, being more mixed (both positive and negative) and smaller in magnitude (Fig. 35). Most of the residuals were positive for the 2004 NMFS fall survey, they were also smaller in magnitude compared to the 2003 fall survey. In general the Base VPA model predicts higher abundance than surveys prior to1995, then lower abundance up to 2003, then higher again for older ages in recent years. Although this pattern has shown some improvement in the current assessment, there is concern that these large residuals will impact parameter estimates of current abundance. The residual pattern for the Major Change VPA has improved compared to Base VPA and has become more mixed (fewer positives) since 1994 as expected by splitting the survey time series in 1995 (Fig. 36). The average magnitude of residuals has also has also decreased compared to the Base VPA.

Retrospective analysis for the Base VPA indicates a strong tendency to underestimate fishing mortality on ages 4-5 and to overestimate spawning stock biomass and age 1 recruitment (Fig. 37). Although the magnitude of the retrospective pattern from 2003 to 2004 is much less than in previous years, the Base VPA continues to display a retrospective pattern, updating population biomass estimates to lower values than previously determined and compromising interpretation of results. Retrospective analysis for the Major Change VPA did not exhibit a consistent retrospective pattern, updates were both above and below previously estimated values (Fig. 38).

## STOCK STATUS

***Virtual Population Analysis***

Results from the Base VPA and Major Change VPA model formulations were used to evaluate the status of the stock in 2004. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias and used to construct the history of stock status from the Canadian ADAPT software (Tables 16-19). Since the percent bias was low for almost all estimates, the bias corrected estimates are not much different from the non-bias corrected estimates. In the absence of an unbiased point estimator with optimal statistical properties, this approach was considered preferable by Canadian, but not US, scientists and managers. The fishery weights at age, assumed to represent mid-year weights, were used to derive beginning of year weights at age (Table 20), and these were used to calculate beginning of year population biomass (Tables 21-22). In the US, spawning stock biomass is the preferred metric for biomass and is computed assuming maturity at age and the proportion of mortality within a year that occurs prior to spawning (p). These results and status determinations were also reported as a part of the 2005 Groundfish Assessment Review Meeting (GARM) held in Woods Hole 15-19 August 2005.

Beginning of year population biomass (Ages 1+) declined from about 32,000 t in 1973 to a historic low of about 4,000 t in 1988 and has subsequently increased to either 22,000 t (Base VPA) or 13,000 t (Major Change VPA) at the beginning of 2005 (Tables 21-22). Age 3+ (adult) biomass followed a similar trend, and either continued its increase from a low of 2,222 t in 1995 to 19,079 t in 2005 (Base VPA) or else increased from a low of 2,088 t in 1995 to 11,587 t in 2001 and fluctuated about 10,000 t since then (Major Change VPA) (Fig. 39). Spawning stock biomass in 2004 was estimated at 14,185 t (Base VPA) or 8,475 t (Major Change VPA). However, the retrospective pattern observed in the Base VPA has resulted in decreases to the terminal year spawning stock biomass to lower levels when updated, averaging 34% decrease over the past 5 years (range: 16% to 59% decrease) with the most recent update exhibiting a 24% decrease. In contrast, the Major Change VPA retrospective results have been both positive and negative over the past 5 years, averaging a 5% increase (range: 30% decrease to 39% increase), with the most recent update exhibiting a 39% increase.

Age 1 recruitment has improved compared to the period 1980 to the mid 1990s, averaging 25 million age-1 fish (Base VPA) or 21 million age-1 fish (Major Change VPA) during the past five years (Figure 39; Tables 16-17). Previous assessments had indicated the presence of some larger recruitment for these years, but their magnitudes have subsequently been estimated to be much smaller. Current indications for the 2003 year class (estimated at 14 or 15 million recruits for Base and Major Change VPA's, respectively) indicate that it may be of lower strength than year classes from the past 5 years, but given the strong retrospective pattern observed in the current and previous assessments, the strength of this year class may be even lower.

Fishing mortality for fully recruited ages 4+ has been close to or above 1.0 between 1973 and 1994, declined to less than 0.6 in 2002 and 2003 from both VPAs, well above the reference point of $F_{ref}$ = 0.25, and increased in 2004 to above 1.0 (Fig. 40, upper panel). This contrasts with the perception of fishing mortality below $F_{ref}$ from previous assessments. Noteworthy is that the lack of trend in the total mortality estimates from the surveys (Fig. 34) is not consistent with the VPA results since 1994, while the pattern exhibited by the relative F is similar (Fig. 33). The fully recruited (4+) exploitation rate averaged 62% (Base VPA) or 64% (Major Change VPA) from 1972-1994, underwent a strong decline in 1995, but increased dramatically in 2004 and is now estimated at 63% (Base VPA) or 77% (Major Change VPA), which is well above the 20% exploitation equivalent to $F_{ref}$ (Fig. 40, lower panel).

## 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 from the past yield per recruit analysis of Neilson and Cadrin (1998). ($F_{0.1}$ for ages 4+ = 0.25; exploitation rate=20.0%). This is the same value as the $F_{MSY}$ proxy of $F_{40\%MSP}$ used for US management (NEFSC 2002).

### *Stock and Recruitment*

There is evidence of reduced recruitment at low levels of age 3+ biomass (Fig. 41). However, management actions by both countries appear to have been successful in building the population to levels where the probability of good recruitment may be enhanced. Based on the spawning stock biomass and recruitment relationship observed in a previous stock assessment, the $B_{MSY}$ level of 58,800 t of spawning stock biomass was set as the rebuilding goal in the US for this stock (NEFSC 2002). Current levels of SSB are considerably lower than the rebuilding goal.

## OUTLOOK

Yield was projected using the bias adjusted 2005 beginning of year population abundance estimates, assuming a 2005 catch equal to the 6,000 t quota. Recruitment in 2005 and 2006 was set equal to 21.0 million (Base VPA) or 18.6 million (Major Change VPA) age-1 fish (geometric mean of the previous ten years), and fishery partial recruitment was estimated as the average of the previous three years. Projected total Canada/US yield at $F_{ref}$= 0.25 in 2006 would be 4,227 t (Base VPA; Table 23) or 2,121 t (Major Change VPA; Table 24). If fished at $F_{ref}$ in 2006, the total biomass is projected to increase slightly from 22,132 t in 2006 to 24,645 t by the beginning of 2007 (Base VPA) or from 11,940 t in 2006 to 15,342 t at the beginning of 2007 (Major Change VPA). The 2005 quota of 6,000 t causes projected fully recruited F to be above $F_{ref}$ in 2005 under both models.

The outlook is provided in terms of the possible consequences for alternative catch quotas in 2006 with respect to the harvest reference points. Uncertainty about stock size generates uncertainty in forecast results. This uncertainty is expressed in the outlook as the risk of exceeding $F_{ref}$ = 0.25 and as the risk that 2007 beginning of year biomass for ages 3+ would be less than a 20% increase over the 2006 biomass. The risk calculations provide a general sense of the uncertainties and assist with evaluating the consequences of alternative catch quotas. These calculations do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting or the possibility that the model may not reflect the stock dynamics closely enough. Also, the risk calculations are dependent on the model assumptions and data used in the analyses. The assumptions in the two model formulations used were deemed plausible. The consequences of adopting action on the basis of one model if the other model was more appropriate can be evaluated from the risk results. A combined Canada/US yield of about 4,200 t in 2006 has a neutral risk, about 50%, of exceeding $F_{ref}$ according to the Base VPA but would result, with almost certainty, in exceeding $F_{ref}$ according to the Major Change VPA (Fig. 42). A combined yield as low as 2,100 t in 2006, would be required to achieve a neutral risk of exceeding $F_{ref}$ according to the Major Change VPA. A combined yield below about 3,000 t or about 3,500 t would be required to ensure a low risk of not achieving a 20% biomass increase for the Base VPA and Major Change VPA respectively.

If the Base VPA overestimates biomass, as indicated by the retrospective pattern, then calculated catch quotas for 2006 will be overly optimistic to achieve the F reference level. Currently, it is not possible to predict what the retrospective adjustment for 2006 will be. However, if the past five year average of 34% was applied to adjust the Base VPA catches, the 2006 TAC would be closer to the TAC from the Major Change VPA. Medium term projections were not conducted due to uncertainties in the assessment including future recruitment.

Age structure, fish growth, and spatial distribution reflect stock productivity. The current age structure indicates that very little rebuilding of ages 5 and older has occurred and that the population is still dominated by younger ages 1 through 4 (Fig. 43). Both VPA formulations estimate far fewer older fish (6+) in comparison with the population at equilibrium, which is inconsistent with the perception of recent low exploitation. The spatial distribution patterns in 2004/2005 suggest a westward shift. Truncated age structure in the surveys and change in distribution indicate current productivity may be limited relative to historical levels.

## MANAGEMENT CONSIDERATIONS

This assessment is hampered by inconsistencies between the age structure of the catch and the age-specific indices of abundance. Although the catch of old fish has increased in the most recent year, it is still less than would be expected given the increases seen in the age-specific indices of abundance. The noisy character of the indices cause difficulty in tuning age structured models.

Consistent management by Canada and the US is required to ensure that conservation objectives are not compromised.

Both VPA formulations have difficulties with interpretation (see benchmark report for full details, TRAC 2005). The Base VPA has a strong pattern in residuals and a strong retrospective pattern. The Major Change VPA adds parameters to decrease these patterns in residuals and the retrospective, but the mechanism for the changes in survey catchability are not easily explained. These changes in survey catchability are most appropriately thought of as an aliasing of an unknown mechanism that produces a better fitting model.

Catching the TAC of 6,000 t in 2005 will result in a fishing mortality rate above $F_{ref} = 0.25$ under both VPA formulations (0.40 Base, 0.82 Major Change). With an assumed total catch of 6,000 t in 2005, the combined Canada/US 2006 catch at $F_{ref}$ would be 2,100-4,200 mt.

The benchmark review was unable to reconcile some of the conflicting results from last year's assessment. While there is still uncertainty about which model to use, concordance between the results from the two models gives more confidence in the determination of status than in the 2004 assessments. Both models indicate that more stock rebuilding is necessary.

## ACKNOWLEDGMENTS

Canadian port sampling was provided by Gilbert Donaldson, Susan Arsenault and Emilia Williams. Many people in the Woods Hole lab assisted in the compilation of the US data. Vaughn Silva processed a large volume of age samples in short order, and Jay Burnett processed age data.

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Table 1. Annual catch (000s t) of Georges Bank yellowtail 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 | 0.122 | - | 1.800 | 18.321 |
| 1969 | 15.944 | 2.600 | 0.327 | - | 2.400 | 21.271 |
| 1970 | 15.506 | 5.533 | 0.071 | - | 0.250 | 21.410 |
| 1971 | 11.878 | 3.127 | 0.105 | - | 0.503 | 15.610 |
| 1972 | 14.157 | 1.159 | 0.008 | 0.515 | 2.243 | 18.039 |
| 1973 | 15.899 | 0.364 | 0.012 | 0.378 | 0.260 | 16.953 |
| 1974 | 14.607 | 0.980 | 0.005 | 0.619 | 1.000 | 17.211 |
| 1975 | 13.205 | 2.715 | 0.008 | 0.722 | 0.091 | 16.750 |
| 1976 | 11.336 | 3.021 | 0.012 | 0.619 | 0.000 | 14.988 |
| 1977 | 9.444 | 0.567 | 0.044 | 0.584 | 0.000 | 10.639 |
| 1978 | 4.519 | 1.669 | 0.069 | 0.687 | 0.000 | 6.944 |
| 1979 | 5.475 | 0.720 | 0.019 | 0.722 | 0.000 | 6.935 |
| 1980 | 6.481 | 0.382 | 0.092 | 0.584 | 0.000 | 7.539 |
| 1981 | 6.182 | 0.095 | 0.015 | 0.687 | 0.000 | 6.979 |
| 1982 | 10.621 | 1.376 | 0.022 | 0.502 | 0.000 | 12.520 |
| 1983 | 11.350 | 0.072 | 0.106 | 0.460 | 0.000 | 11.989 |
| 1984 | 5.763 | 0.028 | 0.008 | 0.481 | 0.000 | 6.280 |
| 1985 | 2.477 | 0.043 | 0.025 | 0.722 | 0.000 | 3.267 |
| 1986 | 3.041 | 0.019 | 0.057 | 0.357 | 0.000 | 3.474 |
| 1987 | 2.742 | 0.233 | 0.069 | 0.536 | 0.000 | 3.580 |
| 1988 | 1.866 | 0.252 | 0.056 | 0.584 | 0.000 | 2.759 |
| 1989 | 1.134 | 0.073 | 0.040 | 0.536 | 0.000 | 1.783 |
| 1990 | 2.751 | 0.818 | 0.025 | 0.495 | 0.000 | 4.089 |
| 1991 | 1.784 | 0.246 | 0.081 | 0.454 | 0.000 | 2.564 |
| 1992 | 2.859 | 1.873 | 0.065 | 0.502 | 0.000 | 5.299 |
| 1993 | 2.089 | 1.089 | 0.682 | 0.440 | 0.000 | 4.300 |
| 1994 | 1.589 | 0.158 | 2.139 | 0.440 | 0.000 | 4.326 |
| 1995 | 0.292 | 0.038 | 0.464 | 0.268 | 0.000 | 1.183 |
| 1996 | 0.751 | 0.071 | 0.472 | 0.388 | 0.000 | 1.682 |
| 1997 | 0.966 | 0.058 | 0.810 | 0.438 | 0.000 | 2.272 |
| 1998 | 1.822 | 0.116 | 1.175 | 0.708 | 0.000 | 3.821 |
| 1999 | 1.987 | 0.484 | 1.971 | 0.597 | 0.000 | 5.038 |
| 2000 | 3.678 | 0.408 | 2.859 | 0.415 | 0.000 | 7.360 |
| 2001 | 3.792 | 0.337 | 2.913 | 0.815 | 0.000 | 7.857 |
| 2002 | 2.532 | 0.248 | 2.642 | 0.493 | 0.000 | 5.915 |
| 2003 | 3.343 | 0.373 | 2.107 | 0.809 | 0.000 | 6.632 |
| 2004 | 6.208 | 0.548 | 0.096 | 0.422 | 0.000 | 7.275 |

Table 2. Port samples used in the estimation of landings at age for Georges Bank yellowtail flounder in 2004 from Canadian and US sources.

| **USA** | **Port Samples** | | | | *Sea Samples* | | | **Landings** |
|---|---|---|---|---|---|---|---|---|
| Quarter | Size | Trips | Lengths | Ages | Trips | Lengths | Ages | (t) |
| 1 | All | 18 | 1,884 | 454 | 17 | 1,997 | 0 | 731 |
| 2 | All | 30 | 3,278 | 659 | 19 | 5,851 | 0 | 2,344 |
| 3 | All | 20 | 2,264 | 446 | 45 | 9,625 | 0 | 3,061 |
| 4 | All | 6 | 538 | 133 | 24 | 1,930 | 0 | 71 |
| All | All | 74 | 7,964 | 1,692 | 105 | 19,403 | 0 | 6,207 |
| **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 | 2 | 500 | 28 | 1 | 954 | 0 | 33 |
| 3 | All | 5 | 1,272 | 108 | 0 | 0 | 0 | 63 |
| 4 | All | 1 | 237 | 26 | 0 | 0 | 0 | 0 |
| All | All | 8 | 2,009 | 162 | 1 | 954 | 0 | 96 |

Table 3. Estimates of discards at age (numbers in 000's) for yellowtail flounder bycatch in the Canadian offshore scallop fishery, 1973-2004.

| | Age | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 6+ | **Total** |
| 1973 | 12 | 282 | 312 | 190 | 69 | 25 | 5 | 1 | 1 | 0 | 0 | | 31 | **897** |
| 1974 | 224 | 527 | 387 | 257 | 97 | 25 | 12 | 2 | 2 | 0 | 0 | 0 | 42 | **1535** |
| 1975 | 264 | 1100 | 314 | 146 | 90 | 37 | 14 | 6 | 0 | 1 | | | 58 | **1971** |
| 1976 | 20 | 905 | 350 | 77 | 42 | 18 | 17 | 8 | 6 | 1 | | | 49 | **1444** |
| 1977 | 48 | 483 | 604 | 117 | 23 | 9 | 5 | 2 | 1 | 0 | | | 18 | **1293** |
| 1978 | 303 | 405 | 485 | 229 | 74 | 16 | 7 | 5 | 4 | 0 | 2 | | 34 | **1530** |
| 1979 | 88 | 988 | 333 | 186 | 71 | 26 | 16 | 5 | 5 | | | | 52 | **1718** |
| 1980 | 9 | 389 | 741 | 99 | 26 | 9 | 1 | 1 | 1 | | | | 12 | **1277** |
| 1981 | 52 | 367 | 600 | 353 | 57 | 13 | 1 | 2 | 3 | | | | 19 | **1448** |
| 1982 | 100 | 574 | 344 | 148 | 62 | 6 | 1 | 4 | | | | | 12 | **1239** |
| 1983 | 5 | 237 | 495 | 138 | 49 | 12 | 3 | 8 | 4 | | | | 26 | **950** |
| 1984 | 86 | 98 | 263 | 302 | 202 | 36 | 0 | 22 | | | | | 58 | **1009** |
| 1985 | 317 | 994 | 233 | 160 | 102 | 12 | 3 | | | | | | 15 | **1821** |
| 1986 | 19 | 524 | 131 | 35 | 40 | 27 | 0 | 8 | | | | | 36 | **785** |
| 1987 | 16 | 586 | 317 | 203 | 57 | 8 | 6 | 5 | 4 | | | | 23 | **1202** |
| 1988 | 16 | 586 | 317 | 203 | 57 | 8 | 6 | | | | | | 14 | **1193** |
| 1989 | 5 | 612 | 429 | 157 | 40 | 6 | 4 | 0 | | | | | 11 | **1253** |
| 1990 | 12 | 177 | 831 | 172 | 32 | 3 | 3 | | | | | | 6 | **1229** |
| 1991 | 251 | 92 | 230 | 479 | 77 | 8 | | | | | | | 8 | **1138** |
| 1992 | 25 | 736 | 401 | 177 | 82 | 13 | 0 | 1 | 1 | | | | 14 | **1435** |
| 1993 | 40 | 182 | 416 | 337 | 65 | 11 | 1 | | | | | | 11 | **1052** |
| 1994 | 14 | 100 | 136 | 77 | 39 | 5 | 2 | 0 | | | | | 7 | **374** |
| 1995 | 36 | 75 | 335 | 219 | 50 | 6 | 4 | 1 | | | | | 11 | **726** |
| 1996 | 3 | 157 | 408 | 251 | 68 | 3 | 3 | 2 | | | | | 9 | **896** |
| 1997 | 18 | 135 | 269 | 339 | 102 | 10 | 6 | 2 | 1 | | | | 18 | **882** |
| 1998 | 35 | 442 | 504 | 314 | 168 | 63 | 5 | 2 | 0 | 1 | | | 71 | **1534** |
| 1999 | 16 | 436 | 410 | 161 | 101 | 38 | 10 | 1 | 1 | | | | 50 | **1175** |
| 2000 | 3 | 304 | 287 | 151 | 46 | 25 | 10 | 2 | 0 | | | | 37 | **828** |
| 2001 | 30 | 335 | 775 | 294 | 107 | 42 | 18 | 5 | 1 | | | | 66 | **1607** |
| 2002 | 21 | 248 | 351 | 179 | 77 | 24 | 16 | 11 | 2 | 1 | | | 54 | **931** |
| 2003 | 13 | 473 | 655 | 285 | 99 | 41 | 22 | 8 | 4 | 1 | 1 | | 76 | **1602** |
| 2004 | 5 | 116 | 309 | 218 | 74 | 36 | 20 | 9 | 6 | 6 | 2 | | 79 | **800** |

Table 4. Estimates of mean weight at age at age (kg) for yellowtail flounder bycatch in the Canadian offshore scallop fishery, 1973-2004.

| | Age | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1973 | 0.129 | 0.281 | 0.431 | 0.510 | 0.604 | 0.727 | 0.845 | 0.872 | 1.043 | 0.000 | 1.170 | |
| 1974 | 0.178 | 0.332 | 0.445 | 0.540 | 0.623 | 0.654 | 0.843 | 1.059 | 1.218 | 0.000 | 1.496 | 1.496 |
| 1975 | 0.151 | 0.319 | 0.479 | 0.550 | 0.643 | 0.737 | 0.753 | 0.748 | 0.688 | 0.751 | | |
| 1976 | 0.176 | 0.323 | 0.562 | 0.624 | 0.783 | 0.800 | 0.888 | 1.046 | 1.155 | 1.444 | | |
| 1977 | 0.162 | 0.344 | 0.510 | 0.615 | 0.736 | 0.747 | 0.760 | 0.834 | 0.631 | 0.704 | | |
| 1978 | 0.165 | 0.306 | 0.507 | 0.738 | 0.866 | 0.931 | 1.031 | 1.139 | 1.157 | | 0.971 | |
| 1979 | 0.143 | 0.313 | 0.484 | 0.706 | 0.797 | 0.893 | 0.955 | 1.038 | 1.421 | | | |
| 1980 | 0.149 | 0.294 | 0.496 | 0.661 | 0.853 | 0.991 | 1.022 | 1.048 | 1.239 | | | |
| 1981 | 0.145 | 0.311 | 0.474 | 0.622 | 0.708 | 1.047 | 0.899 | 1.599 | 1.104 | | | |
| 1982 | 0.172 | 0.279 | 0.467 | 0.652 | 0.849 | 1.203 | 1.213 | 1.397 | | | | |
| 1983 | 0.165 | 0.289 | 0.460 | 0.666 | 0.786 | 1.081 | 0.957 | 1.610 | 1.239 | | | |
| 1984 | 0.163 | 0.227 | 0.398 | 0.501 | 0.686 | 0.776 | | 1.020 | | | | |
| 1985 | 0.188 | 0.356 | 0.534 | 0.624 | 0.714 | 0.755 | 0.721 | | | | | |
| 1986 | 0.216 | 0.330 | 0.537 | 0.776 | 0.983 | 1.192 | 0.704 | 1.345 | | | | |
| 1987 | 0.195 | 0.363 | 0.543 | 0.735 | 1.030 | 1.251 | 1.099 | 0.704 | 0.746 | | | |
| 1988 | 0.181 | 0.336 | 0.562 | 0.719 | 0.810 | 1.021 | 0.838 | | | | | |
| 1989 | 0.105 | 0.283 | 0.484 | 0.712 | 0.835 | 0.872 | 1.005 | 1.128 | | | | |
| 1990 | 0.192 | 0.243 | 0.381 | 0.623 | 0.681 | 0.683 | 0.855 | | | | | |
| 1991 | 0.155 | 0.218 | 0.371 | 0.512 | 0.712 | 1.057 | | | | | | |
| 1992 | 0.177 | 0.264 | 0.340 | 0.550 | 0.674 | 0.931 | | 1.303 | 1.303 | | | |
| 1993 | 0.138 | 0.268 | 0.396 | 0.517 | 0.582 | 0.728 | 0.747 | | | | | |
| 1994 | 0.154 | 0.226 | 0.335 | 0.487 | 0.628 | 0.837 | 0.826 | 1.496 | | | | |
| 1995 | 0.165 | 0.222 | 0.310 | 0.465 | 0.612 | 0.779 | 0.898 | 0.532 | | | | |
| 1996 | 0.157 | 0.257 | 0.390 | 0.526 | 0.689 | 0.841 | 1.093 | 1.324 | | | | |
| 1997 | 0.177 | 0.287 | 0.422 | 0.566 | 0.730 | 0.885 | 0.827 | 1.218 | 1.113 | | | |
| 1998 | 0.176 | 0.286 | 0.413 | 0.539 | 0.750 | 0.996 | 1.124 | 1.171 | 0.000 | 1.397 | | |
| 1999 | 0.173 | 0.334 | 0.488 | 0.687 | 0.819 | 0.989 | 1.336 | 1.496 | 1.822 | | | |
| 2000 | 0.169 | 0.332 | 0.475 | 0.661 | 0.854 | 0.988 | 1.049 | 1.158 | 1.104 | | | |
| 2001 | 0.274 | 0.338 | 0.449 | 0.634 | 0.810 | 1.051 | 1.138 | 1.303 | 1.433 | | | |
| 2002 | 0.214 | 0.346 | 0.446 | 0.653 | 0.842 | 1.061 | 1.183 | 1.359 | 1.492 | 1.428 | | |
| 2003 | 0.186 | 0.346 | 0.459 | 0.642 | 0.809 | 0.959 | 1.047 | 1.136 | 1.324 | 1.397 | 1.708 | |
| 2004 | 0.229 | 0.283 | 0.418 | 0.567 | 0.738 | 0.920 | 1.045 | 1.161 | 1.140 | 1.204 | 1.421 | |

Table 5. Total catch at age including discards (number in 000's) for Georges Bank yellowtail flounder, 1973-2004.

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | **Total** |
| 1973 | 359 | 5175 | 13565 | 9473 | 3815 | 1285 | 283 | 55 | 23 | 4 | 0 | 0 | 34037 |
| 1974 | 2368 | 9500 | 8294 | 7658 | 3643 | 878 | 464 | 106 | 71 | 0 | 0 | 0 | 32982 |
| 1975 | 4636 | 26394 | 7375 | 3540 | 2175 | 708 | 327 | 132 | 26 | 14 | 0 | 0 | 45328 |
| 1976 | 635 | 31938 | 5502 | 1426 | 574 | 453 | 304 | 95 | 54 | 11 | 2 | 0 | 40993 |
| 1977 | 378 | 9094 | 10567 | 1846 | 419 | 231 | 134 | 82 | 37 | 10 | 0 | 0 | 22799 |
| 1978 | 9962 | 3542 | 4580 | 1914 | 540 | 120 | 45 | 16 | 17 | 7 | 6 | 0 | 20748 |
| 1979 | 321 | 10517 | 3789 | 1432 | 623 | 167 | 95 | 31 | 27 | 1 | 3 | 0 | 17006 |
| 1980 | 318 | 3994 | 9685 | 1538 | 352 | 96 | 5 | 11 | 1 | 0 | 0 | 0 | 16000 |
| 1981 | 107 | 1097 | 5963 | 4920 | 854 | 135 | 5 | 2 | 3 | 0 | 0 | 0 | 13088 |
| 1982 | 2164 | 18091 | 7480 | 3401 | 1095 | 68 | 20 | 7 | 0 | 0 | 0 | 0 | 32327 |
| 1983 | 703 | 7998 | 16661 | 2476 | 680 | 122 | 13 | 16 | 4 | 0 | 0 | 0 | 28672 |
| 1984 | 514 | 2018 | 4535 | 5043 | 1796 | 294 | 47 | 39 | 0 | 0 | 0 | 0 | 14285 |
| 1985 | 970 | 4374 | 1058 | 818 | 517 | 73 | 8 | 0 | 0 | 0 | 0 | 0 | 7817 |
| 1986 | 179 | 6402 | 1127 | 389 | 204 | 80 | 17 | 15 | 0 | 1 | 0 | 0 | 8414 |
| 1987 | 156 | 3284 | 3137 | 983 | 192 | 48 | 38 | 26 | 25 | 0 | 0 | 0 | 7890 |
| 1988 | 499 | 3003 | 1544 | 846 | 227 | 24 | 26 | 3 | 0 | 0 | 0 | 0 | 6172 |
| 1989 | 190 | 2175 | 1121 | 428 | 110 | 18 | 12 | 0 | 0 | 0 | 0 | 0 | 4054 |
| 1990 | 231 | 2114 | 6996 | 978 | 140 | 21 | 6 | 0 | 0 | 0 | 0 | 0 | 10485 |
| 1991 | 663 | 147 | 1491 | 3011 | 383 | 67 | 4 | 0 | 0 | 0 | 0 | 0 | 5767 |
| 1992 | 2414 | 9167 | 2971 | 1473 | 603 | 33 | 7 | 1 | 1 | 0 | 0 | 0 | 16671 |
| 1993 | 5233 | 1386 | 3327 | 2326 | 411 | 84 | 5 | 1 | 0 | 0 | 0 | 0 | 12773 |
| 1994 | 59 | 1432 | 6631 | 1856 | 568 | 95 | 23 | 1 | 0 | 0 | 0 | 0 | 10666 |
| 1995 | 62 | 233 | 1428 | 986 | 211 | 17 | 23 | 4 | 2 | 0 | 0 | 0 | 2967 |
| 1996 | 54 | 566 | 1922 | 941 | 234 | 11 | 9 | 3 | 0 | 0 | 0 | 0 | 3740 |
| 1997 | 60 | 745 | 1502 | 1827 | 442 | 36 | 55 | 11 | 5 | 0 | 0 | 0 | 4683 |
| 1998 | 64 | 1496 | 3224 | 2134 | 782 | 143 | 26 | 3 | 0 | 2 | 0 | 0 | 7872 |
| 1999 | 37 | 3694 | 3583 | 1731 | 743 | 180 | 34 | 1 | 1 | 0 | 0 | 0 | 10003 |
| 2000 | 155 | 3840 | 5985 | 3120 | 832 | 340 | 43 | 36 | 1 | 0 | 0 | 0 | 14352 |
| 2001 | 284 | 3065 | 7622 | 2824 | 1093 | 293 | 254 | 23 | 9 | 0 | 0 | 0 | 15468 |
| 2002 | 256 | 4437 | 3854 | 1845 | 670 | 263 | 113 | 62 | 11 | 5 | 0 | 0 | 11517 |
| 2003 | 160 | 3818 | 4965 | 2297 | 777 | 328 | 213 | 93 | 39 | 15 | 1 | 0 | 12708 |
| 2004 | 78 | 1336 | 3491 | 4093 | 2088 | 919 | 429 | 85 | 73 | 20 | 2 | 0 | 12613 |

Table 6. Mean weight at age (kg) for the total catch including US and Canadian discards, for Georges Bank yellowtail flounder, 1973-2004.

| | Age | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1973 | 0.101 | 0.348 | 0.462 | 0.527 | 0.603 | 0.690 | 1.063 | 1.131 | 1.275 | 1.389 | 1.170 | |
| 1974 | 0.115 | 0.344 | 0.496 | 0.607 | 0.678 | 0.723 | 0.904 | 1.245 | 1.090 | | 1.496 | 1.496 |
| 1975 | 0.113 | 0.316 | 0.489 | 0.554 | 0.619 | 0.690 | 0.691 | 0.654 | 1.052 | 0.812 | | |
| 1976 | 0.108 | 0.312 | 0.544 | 0.635 | 0.744 | 0.813 | 0.854 | 0.881 | 1.132 | 1.363 | 1.923 | |
| 1977 | 0.116 | 0.342 | 0.524 | 0.633 | 0.780 | 0.860 | 1.026 | 1.008 | 0.866 | 0.913 | | |
| 1978 | 0.102 | 0.314 | 0.510 | 0.690 | 0.803 | 0.903 | 0.947 | 1.008 | 1.227 | 1.581 | 0.916 | |
| 1979 | 0.114 | 0.329 | 0.462 | 0.656 | 0.736 | 0.844 | 0.995 | 0.906 | 1.357 | 1.734 | 1.911 | |
| 1980 | 0.101 | 0.322 | 0.493 | 0.656 | 0.816 | 1.048 | 1.208 | 1.206 | 1.239 | | | |
| 1981 | 0.122 | 0.335 | 0.489 | 0.604 | 0.707 | 0.821 | 0.844 | 1.599 | 1.104 | | | |
| 1982 | 0.115 | 0.301 | 0.485 | 0.650 | 0.754 | 1.065 | 1.037 | 1.361 | | | | |
| 1983 | 0.140 | 0.296 | 0.441 | 0.607 | 0.740 | 0.964 | 1.005 | 1.304 | 1.239 | | | |
| 1984 | 0.162 | 0.239 | 0.379 | 0.500 | 0.647 | 0.743 | 0.944 | 1.032 | | | | |
| 1985 | 0.181 | 0.361 | 0.505 | 0.642 | 0.729 | 0.808 | 0.728 | | | | | |
| 1986 | 0.181 | 0.341 | 0.540 | 0.674 | 0.854 | 0.976 | 0.950 | 1.250 | | 1.686 | | |
| 1987 | 0.121 | 0.324 | 0.524 | 0.680 | 0.784 | 0.993 | 0.838 | 0.771 | 0.809 | | | |
| 1988 | 0.103 | 0.328 | 0.557 | 0.696 | 0.844 | 1.042 | 0.865 | 1.385 | | | | |
| 1989 | 0.100 | 0.327 | 0.520 | 0.720 | 0.866 | 0.970 | 1.172 | 1.128 | | | | |
| 1990 | 0.105 | 0.290 | 0.395 | 0.585 | 0.693 | 0.787 | 1.057 | | | | | |
| 1991 | 0.121 | 0.237 | 0.369 | 0.486 | 0.723 | 0.850 | 1.306 | | | | | |
| 1992 | 0.101 | 0.293 | 0.365 | 0.526 | 0.651 | 1.098 | 1.125 | 1.303 | 1.303 | | | |
| 1993 | 0.100 | 0.285 | 0.379 | 0.501 | 0.564 | 0.843 | 1.130 | 1.044 | | | | |
| 1994 | 0.195 | 0.255 | 0.348 | 0.469 | 0.620 | 0.810 | 0.723 | 1.257 | | | | |
| 1995 | 0.167 | 0.246 | 0.352 | 0.463 | 0.584 | 0.766 | 0.805 | 0.532 | 0.810 | | | |
| 1996 | 0.140 | 0.292 | 0.412 | 0.563 | 0.721 | 0.916 | 1.062 | 1.287 | | | | |
| 1997 | 0.206 | 0.319 | 0.421 | 0.537 | 0.690 | 0.837 | 0.878 | 1.184 | 1.126 | | | |
| 1998 | 0.184 | 0.325 | 0.447 | 0.543 | 0.690 | 0.903 | 0.932 | 1.195 | | 1.473 | | |
| 1999 | 0.190 | 0.369 | 0.503 | 0.638 | 0.756 | 0.900 | 1.030 | 1.496 | 1.822 | | | |
| 2000 | 0.220 | 0.379 | 0.481 | 0.613 | 0.762 | 0.915 | 1.020 | 0.996 | 1.229 | | | |
| 2001 | 0.225 | 0.343 | 0.456 | 0.624 | 0.808 | 1.013 | 1.023 | 1.272 | 1.483 | | | |
| 2002 | 0.263 | 0.382 | 0.489 | 0.668 | 0.829 | 0.983 | 1.062 | 1.282 | 1.389 | 1.433 | | |
| 2003 | 0.226 | 0.360 | 0.477 | 0.652 | 0.830 | 0.945 | 1.033 | 1.148 | 1.273 | 1.432 | 1.708 | |
| 2004 | 0.194 | 0.292 | 0.436 | 0.581 | 0.723 | 0.884 | 1.001 | 1.206 | 1.207 | 1.306 | 1.421 | |

Table 7. ANOVA results from a multiplicative model with main effects for year (1993-2004) month (June-Dec) and tonnage class (TC1-3) for the Canadian yellowtail flounder fishery CPUE.

**REGRESSION OF MULTIPLICATIVE MODEL**

| | |
|---|---|
| MULTIPLE R............. | 0.791 |
| MULTIPLE R SQUARED..... | 0.626 |

**ANALYSIS OF VARIANCE**

| SOURCE OF VARIATION | DF | SUMS OF SQUARES | MEAN SQUARES | F-VALUE |
|---|---|---|---|---|
| INTERCEPT | 1 | 2.185E3 | 2.185E3 | |
| REGRESSION | 19 | 4.659E2 | 2.452E1 | 124.660 |
| YEAR | 11 | 4.383E2 | 3.984E1 | 202.568 |
| MONTH | 6 | 2.863E1 | 4.772E0 | 24.264 |
| TONNAGE CLASS | 2 | 8.993E¯1 | 4.496E¯1 | 2.286 |
| RESIDUALS | 1413 | 2.779E2 | 1.967E¯1 | |
| TOTAL | 1433 | 2.929E3 | | |

**PREDICTED CATCH RATE**

| | LN TRANSFORM | | RETRANSFORMED | | | |
|---|---|---|---|---|---|---|
| YEAR | MEAN | S.E. | MEAN | S.E. | CATCH | EFFORT |
| 1993 | ¯1.3727 | 0.0259 | 0.276 | 0.044 | 111 | 402 |
| 1994 | ¯2.1682 | 0.0019 | 0.126 | 0.005 | 1138 | 9025 |
| 1995 | ¯1.1459 | 0.0052 | 0.350 | 0.025 | 370 | 1057 |
| 1996 | ¯0.6235 | 0.0054 | 0.590 | 0.043 | 369 | 626 |
| 1997 | ¯0.5764 | 0.0033 | 0.619 | 0.035 | 723 | 1168 |
| 1998 | ¯0.6886 | 0.0027 | 0.554 | 0.029 | 1094 | 1976 |
| 1999 | ¯0.3848 | 0.0017 | 0.750 | 0.031 | 1871 | 2494 |
| 2000 | ¯1.0388 | 0.0012 | 0.390 | 0.014 | 2673 | 6850 |
| 2001 | ¯1.6728 | 0.0012 | 0.207 | 0.007 | 2747 | 13269 |
| 2002 | ¯1.5665 | 0.0012 | 0.230 | 0.008 | 2593 | 11263 |
| 2003 | ¯1.7413 | 0.0019 | 0.193 | 0.008 | 1663 | 8606 |
| 2004 | ¯2.8765 | 0.0139 | 0.062 | 0.007 | 71 | 1150 |

**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 8. 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 | 7 | 8 | 9 | 10 | 11 | 12 | Total | (000s t) |
| 1987 | 0.12 | 0.99 | 2.00 | 0.64 | 0.12 | 0.00 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 3.91 | 1.250 |
| 1988 | 0.00 | 1.59 | 1.29 | 0.76 | 0.30 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.96 | 1.235 |
| 1989 | 0.11 | 0.94 | 0.58 | 0.36 | 0.09 | 0.01 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 2.13 | 0.471 |
| 1990 | 0.00 | 2.36 | 3.38 | 1.06 | 0.32 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.15 | 1.513 |
| 1991 | 0.02 | 0.86 | 1.53 | 3.23 | 0.72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.37 | 1.758 |
| 1992 | 0.06 | 10.74 | 3.97 | 1.03 | 0.30 | 0.01 | 0.00 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 16.14 | 2.475 |
| 1993 | 0.08 | 2.24 | 3.26 | 4.41 | 1.64 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.69 | 2.642 |
| 1994 | 0.00 | 6.06 | 3.46 | 3.01 | 0.78 | 0.13 | 0.03 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 13.51 | 2.753 |
| 1995 | 0.21 | 1.19 | 4.28 | 2.55 | 0.79 | 0.05 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.11 | 2.027 |
| 1996 | 0.45 | 6.65 | 8.58 | 6.61 | 1.01 | 0.09 | 0.02 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 23.45 | 5.303 |
| 1997 | 0.02 | 9.78 | 14.67 | 17.96 | 4.32 | 0.53 | 0.11 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 47.49 | 13.293 |
| 1998 | 0.89 | 3.18 | 4.89 | 4.50 | 2.02 | 0.46 | 0.03 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 16.01 | 4.293 |
| 1999 | 0.16 | 11.84 | 27.24 | 7.95 | 7.30 | 2.21 | 0.34 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 57.07 | 17.666 |
| 2000 | 0.01 | 9.47 | 32.90 | 17.80 | 5.54 | 2.96 | 0.32 | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 | 69.22 | 19.949 |
| 2001 | 0.29 | 15.18 | 47.13 | 13.35 | 3.70 | 1.95 | 0.90 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 82.60 | 22.158 |
| 2002 | 0.09 | 9.67 | 33.73 | 11.27 | 5.97 | 1.54 | 0.95 | 0.38 | 0.08 | 0.00 | 0.00 | 0.00 | 63.68 | 20.699 |
| 2003 | 0.07 | 6.76 | 27.36 | 13.45 | 3.57 | 0.86 | 0.62 | 0.25 | 0.12 | 0.04 | 0.00 | 0.00 | 53.09 | 16.249 |
| 2004 | 0.03 | 3.60 | 16.26 | 9.21 | 2.27 | 0.63 | 0.23 | 0.46 | 0.09 | 0.00 | 0.00 | 0.00 | 32.79 | 9.000 |
| 2005 | 0.60 | 1.60 | 27.96 | 20.56 | 5.70 | 1.04 | 0.40 | 0.10 | 0.01 | 0.01 | 0.00 | 0.00 | 57.99 | 13.357 |

Table 9. 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 | 9 | 10 | 11 | 12 | Total | (kg/tow) |
| 1968 | 0.15 | 3.36 | 3.58 | 0.32 | 0.08 | 0.16 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.78 | 2.813 |
| 1969 | 1.02 | 9.41 | 11.12 | 3.10 | 1.42 | 0.45 | 0.19 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 26.76 | 11.17 |
| 1970 | 0.09 | 4.49 | 6.03 | 2.42 | 0.57 | 0.12 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.91 | 5.312 |
| 1971 | 0.79 | 3.34 | 4.62 | 3.75 | 0.76 | 0.23 | 0.05 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 13.56 | 4.607 |
| 1972 | 0.14 | 7.14 | 7.20 | 3.51 | 1.09 | 0.05 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 19.25 | 6.45 |
| 1973 | 1.93 | 3.27 | 2.37 | 1.06 | 0.41 | 0.17 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 9.25 | 2.938 |
| 1974 | 0.32 | 2.22 | 1.84 | 1.26 | 0.35 | 0.19 | 0.09 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 6.27 | 2.719 |
| 1975 | 0.42 | 2.94 | 0.86 | 0.30 | 0.21 | 0.07 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 4.81 | 1.676 |
| 1976 | 1.03 | 4.37 | 1.25 | 0.31 | 0.20 | 0.03 | 0.05 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 7.27 | 2.273 |
| 1977 | 0.00 | 0.67 | 1.13 | 0.38 | 0.07 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.27 | 0.999 |
| 1978 | 0.94 | 0.80 | 0.51 | 0.22 | 0.03 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.49 | 0.742 |
| 1979 | 0.28 | 1.93 | 0.39 | 0.33 | 0.06 | 0.05 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.07 | 1.227 |
| 1980 | 0.06 | 4.64 | 5.76 | 0.47 | 0.06 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.03 | 4.456 |
| 1981 | 0.01 | 1.03 | 1.78 | 0.72 | 0.21 | 0.06 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 3.83 | 1.96 |
| 1982 | 0.05 | 3.74 | 1.12 | 1.02 | 0.46 | 0.07 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 6.47 | 2.5 |
| 1983 | 0.00 | 1.87 | 2.73 | 0.53 | 0.12 | 0.09 | 0.06 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 5.49 | 2.642 |
| 1984 | 0.00 | 0.09 | 0.81 | 0.89 | 0.83 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.87 | 1.646 |
| 1985 | 0.11 | 2.20 | 0.26 | 0.28 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.00 | 0.988 |
| 1986 | 0.03 | 1.81 | 0.29 | 0.06 | 0.14 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.37 | 0.847 |
| 1987 | 0.00 | 0.13 | 0.11 | 0.13 | 0.05 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.48 | 0.329 |
| 1988 | 0.08 | 0.28 | 0.37 | 0.24 | 0.20 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.19 | 0.566 |
| 1989 | 0.05 | 0.42 | 0.74 | 0.29 | 0.06 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.61 | 0.729 |
| 1990 | 0.00 | 0.06 | 1.11 | 0.39 | 0.14 | 0.01 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.76 | 0.699 |
| 1991 | 0.44 | 0.00 | 0.25 | 0.68 | 0.27 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.66 | 0.631 |
| 1992 | 0.00 | 2.01 | 1.95 | 0.60 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.74 | 1.566 |
| 1993 | 0.05 | 0.29 | 0.50 | 0.32 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.18 | 0.482 |
| 1994 | 0.00 | 0.62 | 0.64 | 0.36 | 0.15 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.80 | 0.66 |
| 1995 | 0.04 | 1.18 | 4.81 | 1.49 | 0.64 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.17 | 2.579 |
| 1996 | 0.03 | 0.99 | 2.63 | 2.70 | 0.61 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.02 | 2.853 |
| 1997 | 0.02 | 1.17 | 3.73 | 4.08 | 0.70 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.84 | 4.359 |
| 1998 | 0.00 | 2.08 | 1.05 | 1.16 | 0.76 | 0.32 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.40 | 2.324 |
| 1999 | 0.05 | 4.75 | 10.82 | 2.72 | 1.62 | 0.43 | 0.33 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 20.74 | 9.307 |
| 2000 | 0.18 | 4.82 | 7.67 | 2.91 | 0.81 | 0.42 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.92 | 6.696 |
| 2001 | 0.00 | 2.31 | 6.56 | 2.41 | 0.48 | 0.35 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.23 | 5.008 |
| 2002 | 0.19 | 2.41 | 12.33 | 4.08 | 1.74 | 0.38 | 0.41 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 21.62 | 9.566 |
| 2003 | 0.20 | 4.37 | 6.76 | 2.88 | 0.44 | 0.13 | 0.54 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 15.52 | 6.719 |
| 2004 | 0.05 | 0.99 | 2.18 | 0.68 | 0.28 | 0.11 | 0.05 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 4.42 | 1.887 |
| 2005 | 0.00 | 2.01 | 5.08 | 2.40 | 0.27 | 0.04 | 0.05 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 9.88 | 3.401 |

Table 10. 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 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Total | (kg/tow) |
| 1963 | 14.72 | 7.90 | 11.23 | 1.86 | 0.50 | 0.28 | 0.03 | 0.16 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 36.75 | 12.791 |
| 1964 | 1.72 | 9.72 | 7.37 | 6.00 | 2.69 | 0.38 | 0.09 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 28.01 | 13.625 |
| 1965 | 1.14 | 5.58 | 5.47 | 3.86 | 1.80 | 0.16 | 0.28 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.33 | 9.104 |
| 1966 | 8.77 | 4.78 | 2.07 | 0.84 | 0.09 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.60 | 3.989 |
| 1967 | 9.14 | 9.31 | 2.70 | 1.01 | 0.31 | 0.08 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 22.60 | 7.577 |
| 1968 | 11.78 | 11.95 | 5.76 | 0.77 | 0.94 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 31.25 | 10.535 |
| 1969 | 8.11 | 10.38 | 5.86 | 1.66 | 0.55 | 0.15 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 26.89 | 9.278 |
| 1970 | 4.61 | 5.13 | 3.14 | 1.95 | 0.45 | 0.06 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.37 | 4.978 |
| 1971 | 3.63 | 6.95 | 4.90 | 2.25 | 0.55 | 0.23 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.56 | 6.362 |
| 1972 | 2.42 | 6.53 | 4.82 | 2.10 | 0.67 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.82 | 6.328 |
| 1973 | 2.49 | 5.50 | 5.10 | 2.94 | 1.22 | 0.42 | 0.17 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 17.87 | 6.600 |
| 1974 | 4.62 | 2.85 | 1.52 | 1.06 | 0.46 | 0.25 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.90 | 3.734 |
| 1975 | 4.63 | 2.51 | 0.88 | 0.57 | 0.33 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 8.98 | 2.365 |
| 1976 | 0.34 | 1.93 | 0.48 | 0.12 | 0.12 | 0.03 | 0.00 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.08 | 1.533 |
| 1977 | 0.93 | 2.16 | 1.65 | 0.62 | 0.11 | 0.06 | 0.04 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.58 | 2.828 |
| 1978 | 4.73 | 1.27 | 0.77 | 0.41 | 0.14 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.35 | 2.383 |
| 1979 | 1.31 | 2.00 | 0.32 | 0.12 | 0.14 | 0.04 | 0.06 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.00 | 1.520 |
| 1980 | 0.76 | 5.09 | 6.05 | 0.68 | 0.22 | 0.16 | 0.01 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.99 | 6.722 |
| 1981 | 1.58 | 2.33 | 1.63 | 0.50 | 0.12 | 0.08 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.26 | 2.621 |
| 1982 | 2.42 | 2.19 | 1.59 | 0.42 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.71 | 2.271 |
| 1983 | 0.11 | 2.28 | 1.91 | 0.47 | 0.07 | 0.01 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.90 | 2.131 |
| 1984 | 0.66 | 0.40 | 0.31 | 2.43 | 0.09 | 0.03 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.93 | 0.593 |
| 1985 | 1.35 | 0.56 | 0.16 | 0.04 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.19 | 0.709 |
| 1986 | 0.28 | 1.11 | 0.35 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.81 | 0.820 |
| 1987 | 0.11 | 0.39 | 0.40 | 0.05 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.03 | 0.509 |
| 1988 | 0.02 | 0.21 | 0.10 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 | 0.171 |
| 1989 | 0.25 | 1.99 | 0.77 | 0.07 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.15 | 0.977 |
| 1990 | 0.00 | 0.33 | 1.52 | 0.28 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.14 | 0.725 |
| 1991 | 2.10 | 0.28 | 0.44 | 0.36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.17 | 0.730 |
| 1992 | 0.15 | 0.40 | 0.71 | 0.16 | 0.14 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.59 | 0.576 |
| 1993 | 0.84 | 0.14 | 0.59 | 0.54 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.10 | 0.545 |
| 1994 | 1.20 | 0.22 | 0.98 | 0.71 | 0.26 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.43 | 0.897 |
| 1995 | 0.28 | 0.12 | 0.35 | 0.28 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.09 | 0.354 |
| 1996 | 0.14 | 0.35 | 1.87 | 0.45 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.88 | 1.303 |
| 1997 | 1.39 | 0.53 | 3.44 | 2.09 | 1.07 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.61 | 3.781 |
| 1998 | 1.90 | 4.82 | 4.20 | 1.19 | 0.30 | 0.06 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.48 | 4.347 |
| 1999 | 3.09 | 8.42 | 5.73 | 1.43 | 1.44 | 0.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.37 | 7.973 |
| 2000 | 0.63 | 1.70 | 4.81 | 2.42 | 0.95 | 0.80 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.34 | 5.838 |
| 2001 | 3.52 | 6.27 | 8.09 | 2.60 | 1.72 | 0.71 | 1.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.24 | 11.553 |
| 2002 | 2.09 | 5.75 | 2.13 | 0.59 | 0.28 | 0.00 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.90 | 3.760 |
| 2003 | 1.10 | 5.01 | 2.81 | 0.56 | 0.10 | 0.09 | 0.07 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.77 | 4.039 |
| 2004 | 0.88 | 5.51 | 5.01 | 2.11 | 0.92 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.60 | 5.117 |

Table 11. 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 |
| 2003 | 0.880 |
| 2004 | 0.330 |

Table 12. Beginning of year population abundance numbers (000's) for Georges Bank yellowtail flounder from the Minor Change VPA formulation using the bootstrap bias adjusted population abundance at the beginning of 2005 from Canadian ADAPT software.

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 1973 | 29579 | 24354 | 29811 | 17112 | 6142 | 2379 | 515 | 182 | 26 | 6 | 2 | 1 | 1 |
| 1974 | 51857 | 23892 | 15285 | 12291 | 5581 | 1645 | 804 | 170 | 100 | 2 | 2 | 1 | 1 |
| 1975 | 70056 | 40320 | 11060 | 5131 | 3270 | 1343 | 565 | 245 | 45 | 19 | 1 | 1 | 1 |
| 1976 | 24460 | 53174 | 9639 | 2529 | 1072 | 752 | 469 | 172 | 83 | 14 | 4 | 1 | 1 |
| 1977 | 16851 | 19452 | 15175 | 2999 | 802 | 366 | 214 | 115 | 56 | 20 | 1 | 1 | 1 |
| 1978 | 53583 | 13455 | 7807 | 3090 | 817 | 284 | 95 | 56 | 22 | 13 | 7 | 1 | 1 |
| 1979 | 24860 | 34905 | 7835 | 2323 | 832 | 192 | 125 | 37 | 31 | 3 | 5 | 1 | 1 |
| 1980 | 23543 | 20064 | 19141 | 3033 | 631 | 132 | 12 | 19 | 4 | 2 | 1 | 1 | 1 |
| 1981 | 62671 | 18989 | 12834 | 7037 | 1112 | 203 | 24 | 5 | 6 | 2 | 1 | 1 | 1 |
| 1982 | 22681 | 51213 | 14557 | 5183 | 1415 | 159 | 47 | 15 | 2 | 2 | 1 | 1 | 1 |
| 1983 | 6540 | 16619 | 25719 | 5251 | 1232 | 197 | 70 | 20 | 6 | 2 | 1 | 1 | 1 |
| 1984 | 10781 | 4721 | 6470 | 6298 | 2089 | 404 | 53 | 45 | 2 | 2 | 1 | 1 | 1 |
| 1985 | 16655 | 8363 | 2061 | 1292 | 737 | 147 | 72 | 3 | 4 | 2 | 1 | 1 | 1 |
| 1986 | 8493 | 12760 | 2950 | 745 | 332 | 147 | 55 | 51 | 2 | 3 | 1 | 1 | 1 |
| 1987 | 9001 | 6792 | 4739 | 1406 | 264 | 91 | 49 | 30 | 28 | 2 | 1 | 1 | 1 |
| 1988 | 22539 | 7228 | 2630 | 1103 | 283 | 46 | 32 | 6 | 2 | 2 | 1 | 1 | 1 |
| 1989 | 9803 | 18003 | 3232 | 782 | 159 | 32 | 17 | 3 | 2 | 2 | 1 | 1 | 1 |
| 1990 | 11354 | 7855 | 12779 | 1642 | 259 | 33 | 11 | 3 | 2 | 2 | 1 | 1 | 1 |
| 1991 | 22724 | 9088 | 4532 | 4236 | 476 | 87 | 9 | 4 | 2 | 2 | 1 | 1 | 1 |
| 1992 | 17886 | 18006 | 7307 | 2373 | 811 | 54 | 12 | 4 | 3 | 2 | 1 | 1 | 1 |
| 1993 | 13722 | 12469 | 6570 | 3324 | 636 | 133 | 14 | 4 | 2 | 2 | 1 | 1 | 1 |
| 1994 | 10004 | 6549 | 8960 | 2413 | 668 | 157 | 34 | 7 | 2 | 2 | 1 | 1 | 1 |
| 1995 | 11927 | 8137 | 4074 | 1495 | 344 | 52 | 44 | 8 | 4 | 2 | 1 | 1 | 1 |
| 1996 | 13995 | 9709 | 6451 | 2056 | 351 | 95 | 27 | 15 | 2 | 2 | 1 | 1 | 1 |
| 1997 | 18805 | 11409 | 7439 | 3557 | 843 | 80 | 68 | 15 | 10 | 2 | 1 | 1 | 1 |
| 1998 | 24988 | 15342 | 8669 | 4739 | 1284 | 297 | 34 | 7 | 2 | 4 | 1 | 1 | 1 |
| 1999 | 26642 | 20400 | 11212 | 4210 | 1974 | 357 | 116 | 5 | 4 | 2 | 1 | 1 | 1 |
| 2000 | 20863 | 21779 | 13378 | 5967 | 1899 | 951 | 132 | 64 | 4 | 2 | 1 | 1 | 1 |
| 2001 | 25347 | 16941 | 14375 | 5606 | 2105 | 811 | 474 | 70 | 20 | 2 | 1 | 1 | 1 |
| 2002 | 27535 | 20496 | 11112 | 4981 | 2072 | 750 | 401 | 162 | 36 | 8 | 1 | 1 | 1 |
| 2003 | 4649 | 22312 | 12790 | 5643 | 2426 | 1095 | 378 | 227 | 77 | 20 | 2 | 1 | 1 |
| 2004 | 5934 | 3662 | 14828 | 6027 | 2565 | 1289 | 602 | 120 | 102 | 28 | 3 | 1 | 1 |
| 2005 | 21410 | 4788 | 1801 | 8998 | 1309 | 266 | 244 | 114 | 23 | 19 | 5 | 1 | 1 |

Table 13. Fishing mortality rate for Georges Bank yellowtail from the Minor Change VPA formulation using the bootstrap bias adjusted population abundance at the beginning of 2004 from Canadian ADAPT software.

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 1973 | 0.013 | 0.266 | 0.686 | 0.920 | 1.117 | 0.885 | 0.909 | 0.402 | 2.469 | 1.123 | 0.163 | 0.000 | 0.000 |
| 1974 | 0.052 | 0.570 | 0.892 | 1.124 | 1.224 | 0.868 | 0.987 | 1.131 | 1.453 | 0.000 | 0.138 | 0.166 | 0.000 |
| 1975 | 0.076 | 1.231 | 1.276 | 1.366 | 1.269 | 0.852 | 0.989 | 0.884 | 1.001 | 1.450 | 0.000 | 0.000 | 0.000 |
| 1976 | 0.029 | 1.054 | 0.967 | 0.948 | 0.874 | 1.057 | 1.209 | 0.914 | 1.204 | 2.005 | 0.900 | 0.000 | 0.000 |
| 1977 | 0.025 | 0.713 | 1.392 | 1.100 | 0.839 | 1.152 | 1.139 | 1.466 | 1.237 | 0.803 | 0.000 | 0.000 | 0.000 |
| 1978 | 0.229 | 0.341 | 1.012 | 1.112 | 1.251 | 0.619 | 0.728 | 0.385 | 1.805 | 0.840 | 1.612 | 0.000 | 0.000 |
| 1979 | 0.014 | 0.401 | 0.749 | 1.103 | 1.637 | 2.608 | 1.693 | 2.131 | 2.642 | 0.471 | 1.157 | 0.000 | 0.000 |
| 1980 | 0.015 | 0.247 | 0.801 | 0.803 | 0.932 | 1.499 | 0.660 | 0.953 | 0.492 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1981 | 0.002 | 0.066 | 0.707 | 1.404 | 1.742 | 1.264 | 0.249 | 0.587 | 0.983 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1982 | 0.111 | 0.489 | 0.820 | 1.237 | 1.774 | 0.628 | 0.643 | 0.711 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1983 | 0.126 | 0.743 | 1.207 | 0.722 | 0.915 | 1.108 | 0.228 | 2.009 | 1.028 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1984 | 0.054 | 0.629 | 1.411 | 1.946 | 2.457 | 1.529 | 2.774 | 2.345 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1985 | 0.066 | 0.842 | 0.818 | 1.158 | 1.413 | 0.777 | 0.131 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1986 | 0.023 | 0.791 | 0.541 | 0.839 | 1.090 | 0.904 | 0.403 | 0.396 | 0.000 | 0.471 | 0.000 | 0.000 | 0.000 |
| 1987 | 0.019 | 0.749 | 1.258 | 1.404 | 1.539 | 0.859 | 1.879 | 2.408 | 2.545 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1988 | 0.025 | 0.605 | 1.014 | 1.735 | 1.964 | 0.826 | 2.157 | 0.806 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1989 | 0.022 | 0.143 | 0.477 | 0.905 | 1.371 | 0.908 | 1.609 | 0.099 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1990 | 0.023 | 0.350 | 0.904 | 1.039 | 0.889 | 1.112 | 0.848 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1991 | 0.033 | 0.018 | 0.447 | 1.454 | 1.983 | 1.747 | 0.715 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1992 | 0.161 | 0.808 | 0.588 | 1.116 | 1.611 | 1.115 | 0.981 | 0.273 | 0.324 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1993 | 0.540 | 0.131 | 0.802 | 1.405 | 1.200 | 1.161 | 0.535 | 0.339 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1994 | 0.007 | 0.275 | 1.591 | 1.747 | 2.354 | 1.068 | 1.307 | 0.249 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1995 | 0.006 | 0.032 | 0.484 | 1.248 | 1.089 | 0.438 | 0.865 | 1.019 | 0.683 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1996 | 0.004 | 0.066 | 0.395 | 0.692 | 1.277 | 0.136 | 0.424 | 0.258 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1997 | 0.004 | 0.075 | 0.251 | 0.819 | 0.845 | 0.661 | 2.037 | 1.689 | 0.767 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1998 | 0.003 | 0.114 | 0.522 | 0.676 | 1.079 | 0.742 | 1.680 | 0.511 | 0.000 | 0.696 | 0.000 | 0.000 | 0.000 |
| 1999 | 0.002 | 0.222 | 0.431 | 0.596 | 0.530 | 0.795 | 0.393 | 0.138 | 0.468 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2000 | 0.008 | 0.215 | 0.670 | 0.842 | 0.651 | 0.496 | 0.437 | 0.957 | 0.505 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2001 | 0.012 | 0.221 | 0.859 | 0.795 | 0.832 | 0.504 | 0.874 | 0.456 | 0.697 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2002 | 0.009 | 0.270 | 0.476 | 0.518 | 0.436 | 0.485 | 0.370 | 0.541 | 0.405 | 1.115 | 0.000 | 0.000 | 0.000 |
| 2003 | 0.038 | 0.166 | 0.544 | 0.583 | 0.430 | 0.396 | 0.944 | 0.596 | 0.794 | 1.746 | 0.388 | 0.000 | 0.000 |
| 2004 | 0.014 | 0.490 | 0.211 | 1.202 | 1.742 | 1.399 | 1.399 | 1.399 | 1.399 | 1.399 | 1.399 | 0.000 | 0.000 |

Table 14. Statistical properties of estimates for population abundance and survey calibration constants (x10[3]) for Georges Bank yellowtail flounder for the Base VPA using Canadian ADAPT software.

| | | Bootstrap | | | |
|---|---|---|---|---|---|
| Age | Estimate | Standard Error | Relative Error | Bias | Relative Bias |
| **Population Abundance** | | | | | |
| 2 | 12168 | 5284 | 0.434 | 974.613 | 0.080 |
| 3 | 21649 | 7528 | 0.348 | 670.991 | 0.031 |
| 4 | 15294 | 5074 | 0.332 | 574.990 | 0.038 |
| 5 | 1613 | 588 | 0.365 | 76.108 | 0.047 |
| **Survey Calibration Constants** | | | | | |
| *DFO Survey: 1987-2005 (Age 2-6+)* | | | | | |
| 2 | 0.279 | 0.060 | 0.213 | 0.006 | 0.022 |
| 3 | 0.860 | 0.178 | 0.207 | 0.019 | 0.022 |
| 4 | 1.300 | 0.266 | 0.205 | 0.023 | 0.018 |
| 5 | 1.511 | 0.300 | 0.199 | 0.017 | 0.011 |
| 6 | 1.166 | 0.248 | 0.213 | 0.031 | 0.026 |
| *NMFS Spring Survey: Yankee 41, 1973-1981 (Age 1-6+)* | | | | | |
| 1 | 0.007 | 0.002 | 0.331 | 0.000 | 0.044 |
| 2 | 0.077 | 0.024 | 0.306 | 0.002 | 0.032 |
| 3 | 0.098 | 0.030 | 0.310 | 0.005 | 0.056 |
| 4 | 0.096 | 0.030 | 0.310 | 0.005 | 0.054 |
| 5 | 0.076 | 0.024 | 0.309 | 0.002 | 0.032 |
| 6 | 0.076 | 0.023 | 0.298 | 0.004 | 0.051 |
| *NMFS Spring Survey: Yankee 36, 1982-2005 (Age 1-6+)* | | | | | |
| 1 | 0.004 | 0.001 | 0.234 | 0.000 | 0.016 |
| 2 | 0.077 | 0.014 | 0.182 | 0.001 | 0.014 |
| 3 | 0.191 | 0.034 | 0.179 | 0.005 | 0.027 |
| 4 | 0.261 | 0.046 | 0.174 | 0.004 | 0.016 |
| 5 | 0.325 | 0.059 | 0.181 | 0.005 | 0.016 |
| 6 | 0.437 | 0.085 | 0.195 | 0.006 | 0.013 |
| *NMFS Fall Survey: 1973-2004 (Age 1-6+)* | | | | | |
| 1 | 0.045 | 0.007 | 0.159 | 0.001 | 0.018 |
| 2 | 0.106 | 0.016 | 0.153 | 0.001 | 0.013 |
| 3 | 0.219 | 0.034 | 0.156 | 0.004 | 0.016 |
| 4 | 0.240 | 0.037 | 0.152 | 0.001 | 0.006 |
| 5 | 0.299 | 0.050 | 0.166 | 0.003 | 0.010 |
| 6 | 0.367 | 0.072 | 0.197 | 0.006 | 0.016 |
| *Scallop: 1982-2004 (Age 1)* | | | | | |
| 1 | 0.030 | 0.006 | 0.186 | 0.000 | 0.014 |

Table 15. Statistical properties of estimates for population abundance and survey calibration constants (x$10^3$) for Georges Bank yellowtail flounder for the Major Change VPA using Canadian ADAPT software. (Survey series are split into 2 periods with a break after 1994):

| | | Bootstrap | | | |
|---|---|---|---|---|---|
| Age | Estimate | Standard Error | Relative Error | Bias | Relative Bias |
| **Population Abundance** | | | | | |
| 2 | 12572 | 2691 | 0.214 | 73 | 0.006 |
| 3 | 12606 | 1729 | 0.137 | 220 | 0.017 |
| 4 | 6589 | 1278 | 0.194 | 81 | 0.012 |
| 5 | 784 | 359 | 0.458 | 56 | 0.071 |
| 6 | 192 | 167 | 0.867 | 46 | 0.238 |
| **Survey Calibration Constants** | | | | | |
| *DFO Survey: 1987-1994 (Age 2 to 5, 6-9)* | | | | | |
| 2 | 0.216 | 0.062 | 0.287 | 0.007 | 0.034 |
| 3 | 0.370 | 0.102 | 0.275 | 0.016 | 0.044 |
| 4 | 0.691 | 0.183 | 0.264 | 0.023 | 0.034 |
| 5 | 0.930 | 0.250 | 0.269 | 0.041 | 0.044 |
| 6-9 | 0.473 | 0.139 | 0.294 | 0.018 | 0.039 |
| *DFO Survey: 1995-2005 (Age 2 to 5, 6-9)* | | | | | |
| 2 | 1531.212 | 757.693 | 0.495 | -39.302 | -0.026 |
| 3 | 1832.756 | 619.026 | 0.338 | -12.030 | -0.007 |
| 4 | 2.337 | 0.526 | 0.225 | 0.070 | 0.030 |
| 5 | 2.576 | 0.624 | 0.242 | 0.117 | 0.045 |
| 6-9 | 1.921 | 0.444 | 0.231 | 0.048 | 0.025 |
| *NMFS Spring Survey: Yankee 41, 1973-1981 (Age 1 to 5,6-9)* | | | | | |
| 1 | 0.007 | 0.002 | 0.263 | 0.000 | 0.036 |
| 2 | 0.078 | 0.020 | 0.256 | 0.002 | 0.030 |
| 3 | 0.099 | 0.026 | 0.262 | 0.003 | 0.031 |
| 4 | 0.099 | 0.025 | 0.251 | 0.002 | 0.016 |
| 5 | 0.082 | 0.022 | 0.263 | 0.003 | 0.032 |
| 6-9 | 0.078 | 0.020 | 0.254 | 0.003 | 0.036 |
| *NMFS Spring Survey: Yankee 36, 1982-1994 (Age 1 to 5, 6-9)* | | | | | |
| 1 | 0.005 | 0.001 | 0.283 | 0.000 | 0.044 |
| 2 | 0.049 | 0.011 | 0.219 | 0.001 | 0.026 |
| 3 | 0.097 | 0.020 | 0.204 | 0.001 | 0.015 |
| 4 | 0.161 | 0.034 | 0.213 | 0.002 | 0.012 |
| 5 | 0.269 | 0.055 | 0.205 | 0.003 | 0.012 |
| 6-9 | 0.406 | 0.099 | 0.244 | 0.014 | 0.034 |
| *NMFS Spring Survey: Yankee 36, 1995-2005 (Age 1 to 5, 6-9)* | | | | | |
| 1 | 1707.919 | 1110.393 | 0.650 | -59.064 | -0.035 |
| 2 | 1462.626 | 749.504 | 0.512 | -38.122 | -0.026 |
| 3 | 634.290 | 615.668 | 0.971 | 9.428 | 0.015 |
| 4 | 0.537 | 0.116 | 0.217 | 0.018 | 0.033 |
| 5 | 0.529 | 0.122 | 0.231 | 0.016 | 0.030 |
| 6-9 | 0.432 | 0.099 | 0.228 | 0.011 | 0.024 |
| *NMFS Fall Survey: Yankee 36, 1982-1994 (Age 1 to 5, 6-9)* | | | | | |
| 1 | 0.042 | 0.007 | 0.168 | 0.001 | 0.013 |
| 2 | 0.092 | 0.015 | 0.158 | 0.001 | 0.010 |
| 3 | 0.167 | 0.026 | 0.158 | 0.003 | 0.016 |
| 4 | 0.198 | 0.031 | 0.158 | 0.002 | 0.011 |
| 5 | 0.300 | 0.053 | 0.175 | 0.005 | 0.015 |
| 6-9 | 0.328 | 0.068 | 0.208 | 0.008 | 0.024 |
| *NMFS Fall Survey: Yankee 36, 1995-2004 (Age 1 to 5, 6-9)* | | | | | |
| 1 | 3399.053 | 977.112 | 0.287 | 9.057 | 0.003 |
| 2 | 4458.297 | 888.561 | 0.199 | -2.265 | -0.001 |
| 3 | 2191.357 | 730.070 | 0.333 | 13.674 | 0.006 |
| 4 | 0.457 | 0.110 | 0.241 | 0.015 | 0.032 |
| 5 | 0.538 | 0.126 | 0.234 | 0.009 | 0.017 |
| 6-9 | 0.400 | 0.105 | 0.263 | 0.017 | 0.041 |
| *Scallop: 1982-1994 (Age 1)* | | | | | |
| 1 | 0.024 | 0.005 | 0.214 | 0.001 | 0.028 |
| *Scallop: 1995-2004 (Age 1)* | | | | | |
| 1 | 1280.278 | 971.511 | 0.759 | 1.589 | 0.001 |

Table 16. Beginning of year population abundance numbers (000's) for Georges Bank yellowtail flounder from the Base VPA formulation using the bootstrap bias adjusted population abundance at the beginning of 2005 from Canadian ADAPT software.

| Year | Age Group | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6+ | 1+ | 2+ | 3+ |
| 1973 | 29386 | 24172 | 29516 | 17301 | 6967 | 3013 | 110355 | 80969 | 56797 |
| 1974 | 52186 | 23735 | 15136 | 12051 | 5733 | 2392 | 111234 | 59048 | 35312 |
| 1975 | 70632 | 40589 | 10932 | 5010 | 3078 | 1708 | 131951 | 61319 | 20729 |
| 1976 | 24731 | 53646 | 9853 | 2427 | 977 | 1562 | 93196 | 68465 | 14819 |
| 1977 | 17280 | 19675 | 15555 | 3172 | 720 | 851 | 57252 | 39972 | 20297 |
| 1978 | 54436 | 13807 | 7988 | 3391 | 957 | 374 | 80952 | 26515 | 12709 |
| 1979 | 25511 | 35603 | 8122 | 2468 | 1074 | 560 | 73337 | 47827 | 12223 |
| 1980 | 24034 | 20596 | 19711 | 3267 | 748 | 240 | 68595 | 44561 | 23965 |
| 1981 | 62999 | 19390 | 13269 | 7498 | 1302 | 221 | 104679 | 41680 | 22290 |
| 1982 | 22847 | 51482 | 14885 | 5537 | 1783 | 156 | 96691 | 73844 | 22361 |
| 1983 | 6582 | 16754 | 25939 | 5517 | 1515 | 345 | 56653 | 50071 | 33317 |
| 1984 | 10842 | 4755 | 6579 | 6473 | 2305 | 486 | 31441 | 20599 | 15844 |
| 1985 | 16748 | 8413 | 2089 | 1379 | 871 | 137 | 29637 | 12888 | 4475 |
| 1986 | 8473 | 12837 | 2990 | 767 | 402 | 223 | 25692 | 17219 | 4382 |
| 1987 | 9199 | 6775 | 4801 | 1439 | 281 | 201 | 22696 | 13497 | 6722 |
| 1988 | 22878 | 7390 | 2617 | 1153 | 309 | 72 | 34419 | 11541 | 4151 |
| 1989 | 9732 | 18280 | 3364 | 771 | 198 | 54 | 32399 | 22667 | 4387 |
| 1990 | 11542 | 7796 | 13006 | 1749 | 250 | 47 | 34390 | 22849 | 15052 |
| 1991 | 22787 | 9241 | 4485 | 4419 | 562 | 104 | 41598 | 18811 | 9570 |
| 1992 | 18342 | 18058 | 7433 | 2335 | 956 | 67 | 47190 | 28848 | 10790 |
| 1993 | 13961 | 12842 | 6613 | 3427 | 606 | 134 | 37582 | 23622 | 10779 |
| 1994 | 10668 | 6744 | 9265 | 2447 | 749 | 157 | 30031 | 19362 | 12618 |
| 1995 | 11144 | 8681 | 4234 | 1735 | 371 | 83 | 26247 | 15104 | 6423 |
| 1996 | 13218 | 9068 | 6897 | 2186 | 544 | 53 | 31966 | 18748 | 9680 |
| 1997 | 18549 | 10773 | 6913 | 3921 | 949 | 230 | 41334 | 22786 | 12013 |
| 1998 | 24142 | 15132 | 8148 | 4309 | 1579 | 349 | 53660 | 29518 | 14386 |
| 1999 | 26086 | 19708 | 11040 | 3786 | 1625 | 472 | 62717 | 36631 | 16924 |
| 2000 | 22328 | 21324 | 12811 | 5826 | 1554 | 784 | 64627 | 42299 | 20975 |
| 2001 | 25862 | 18141 | 14003 | 5145 | 1991 | 1057 | 66199 | 40337 | 22196 |
| 2002 | 37965 | 20917 | 12093 | 4679 | 1699 | 1154 | 78508 | 40543 | 19626 |
| 2003 | 33271 | 30852 | 13135 | 6444 | 2180 | 1933 | 87815 | 54544 | 23692 |
| 2004 | 13757 | 27095 | 21819 | 6308 | 3218 | 2355 | 74552 | 60795 | 33700 |
| 2005 | 20972 | 11193 | 20978 | 14719 | 1536 | 1357 | 70756 | 49784 | 38590 |

Table 17. Beginning of year population abundance numbers (000's) for Georges Bank yellowtail flounder from the Major Change VPA formulation using the bootstrap bias adjusted population abundance at the beginning of 2005 from Canadian ADAPT software.

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 1973 | 29579 | 24354 | 29811 | 17112 | 6142 | 2379 | 515 | 182 | 26 | 6 | 2 | 1 | 1 |
| 1974 | 51857 | 23892 | 15285 | 12291 | 5581 | 1645 | 804 | 170 | 100 | 2 | 2 | 1 | 1 |
| 1975 | 70056 | 40320 | 11060 | 5131 | 3270 | 1343 | 565 | 245 | 45 | 19 | 1 | 1 | 1 |
| 1976 | 24460 | 53174 | 9639 | 2529 | 1072 | 752 | 469 | 172 | 83 | 14 | 4 | 1 | 1 |
| 1977 | 16851 | 19452 | 15175 | 2999 | 802 | 366 | 214 | 115 | 56 | 20 | 1 | 1 | 1 |
| 1978 | 53583 | 13455 | 7807 | 3090 | 817 | 284 | 95 | 56 | 22 | 13 | 7 | 1 | 1 |
| 1979 | 24860 | 34905 | 7835 | 2323 | 832 | 192 | 125 | 37 | 31 | 3 | 5 | 1 | 1 |
| 1980 | 23543 | 20064 | 19141 | 3033 | 631 | 132 | 12 | 19 | 4 | 2 | 1 | 1 | 1 |
| 1981 | 62671 | 18989 | 12834 | 7037 | 1112 | 203 | 24 | 5 | 6 | 2 | 1 | 1 | 1 |
| 1982 | 22681 | 51213 | 14557 | 5183 | 1415 | 159 | 47 | 15 | 2 | 2 | 1 | 1 | 1 |
| 1983 | 6540 | 16619 | 25719 | 5251 | 1232 | 197 | 70 | 20 | 6 | 2 | 1 | 1 | 1 |
| 1984 | 10781 | 4721 | 6470 | 6298 | 2089 | 404 | 53 | 45 | 2 | 2 | 1 | 1 | 1 |
| 1985 | 16655 | 8363 | 2061 | 1292 | 737 | 147 | 72 | 3 | 4 | 2 | 1 | 1 | 1 |
| 1986 | 8493 | 12760 | 2950 | 745 | 332 | 147 | 55 | 51 | 2 | 3 | 1 | 1 | 1 |
| 1987 | 9001 | 6792 | 4739 | 1406 | 264 | 91 | 49 | 30 | 28 | 2 | 1 | 1 | 1 |
| 1988 | 22539 | 7228 | 2630 | 1103 | 283 | 46 | 32 | 6 | 2 | 2 | 1 | 1 | 1 |
| 1989 | 9803 | 18003 | 3232 | 782 | 159 | 32 | 17 | 3 | 2 | 2 | 1 | 1 | 1 |
| 1990 | 11354 | 7855 | 12779 | 1642 | 259 | 33 | 11 | 3 | 2 | 2 | 1 | 1 | 1 |
| 1991 | 22724 | 9088 | 4532 | 4236 | 476 | 87 | 9 | 4 | 2 | 2 | 1 | 1 | 1 |
| 1992 | 17886 | 18006 | 7307 | 2373 | 811 | 54 | 12 | 4 | 3 | 2 | 1 | 1 | 1 |
| 1993 | 13722 | 12469 | 6570 | 3324 | 636 | 133 | 14 | 4 | 2 | 2 | 1 | 1 | 1 |
| 1994 | 10001 | 6549 | 8960 | 2413 | 668 | 157 | 34 | 7 | 2 | 2 | 1 | 1 | 1 |
| 1995 | 11907 | 8135 | 4074 | 1495 | 344 | 52 | 44 | 8 | 4 | 2 | 1 | 1 | 1 |
| 1996 | 13937 | 9693 | 6450 | 2056 | 351 | 95 | 27 | 15 | 2 | 2 | 1 | 1 | 1 |
| 1997 | 18748 | 11362 | 7425 | 3555 | 843 | 80 | 68 | 15 | 10 | 2 | 1 | 1 | 1 |
| 1998 | 24760 | 15295 | 8630 | 4728 | 1282 | 297 | 34 | 7 | 2 | 4 | 1 | 1 | 1 |
| 1999 | 26245 | 20214 | 11174 | 4179 | 1965 | 356 | 116 | 5 | 4 | 2 | 1 | 1 | 1 |
| 2000 | 20497 | 21454 | 13225 | 5936 | 1873 | 944 | 131 | 64 | 4 | 2 | 1 | 1 | 1 |
| 2001 | 23987 | 16642 | 14109 | 5482 | 2080 | 790 | 468 | 69 | 20 | 2 | 1 | 1 | 1 |
| 2002 | 22976 | 19383 | 10867 | 4766 | 1971 | 729 | 384 | 157 | 36 | 8 | 1 | 1 | 1 |
| 2003 | 20451 | 18580 | 11880 | 5443 | 2251 | 1013 | 361 | 213 | 73 | 19 | 2 | 1 | 1 |
| 2004 | 15352 | 16600 | 11777 | 5286 | 2402 | 1146 | 535 | 107 | 91 | 25 | 2 | 1 | 1 |
| 2005 | 18612 | 12499 | 12386 | 6509 | 728 | 147 | 131 | 61 | 12 | 10 | 3 | 0 | 1 |

Table 18. Fishing mortality rate for Georges Bank yellowtail from the Base VPA formulation using the bootstrap bias adjusted population abundance at the beginning of 2004 from Canadian ADAPT software.

| | Age group | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 3+ |
| 1973 | 0.014 | 0.268 | 0.696 | 0.905 | 0.905 | 0.905 | 0.796 |
| 1974 | 0.051 | 0.575 | 0.906 | 1.165 | 1.165 | 1.165 | 1.054 |
| 1975 | 0.075 | 1.216 | 1.305 | 1.435 | 1.435 | 1.435 | 1.366 |
| 1976 | 0.029 | 1.038 | 0.933 | 1.015 | 1.015 | 1.015 | 0.961 |
| 1977 | 0.024 | 0.701 | 1.323 | 0.999 | 0.999 | 0.999 | 1.248 |
| 1978 | 0.225 | 0.331 | 0.975 | 0.950 | 0.950 | 0.950 | 0.965 |
| 1979 | 0.014 | 0.391 | 0.711 | 0.994 | 0.994 | 0.994 | 0.806 |
| 1980 | 0.015 | 0.240 | 0.766 | 0.720 | 0.720 | 0.720 | 0.758 |
| 1981 | 0.002 | 0.064 | 0.674 | 1.237 | 1.237 | 1.237 | 0.902 |
| 1982 | 0.110 | 0.485 | 0.792 | 1.096 | 1.096 | 1.096 | 0.894 |
| 1983 | 0.125 | 0.735 | 1.188 | 0.673 | 0.673 | 0.673 | 1.074 |
| 1984 | 0.054 | 0.623 | 1.363 | 1.805 | 1.805 | 1.805 | 1.622 |
| 1985 | 0.066 | 0.834 | 0.802 | 1.032 | 1.032 | 1.032 | 0.925 |
| 1986 | 0.024 | 0.784 | 0.531 | 0.804 | 0.804 | 0.804 | 0.618 |
| 1987 | 0.019 | 0.751 | 1.227 | 1.338 | 1.338 | 1.338 | 1.259 |
| 1988 | 0.024 | 0.587 | 1.022 | 1.561 | 1.561 | 1.561 | 1.221 |
| 1989 | 0.022 | 0.140 | 0.454 | 0.925 | 0.925 | 0.925 | 0.564 |
| 1990 | 0.022 | 0.353 | 0.879 | 0.935 | 0.935 | 0.935 | 0.887 |
| 1991 | 0.033 | 0.018 | 0.453 | 1.331 | 1.331 | 1.331 | 0.920 |
| 1992 | 0.156 | 0.805 | 0.574 | 1.150 | 1.150 | 1.150 | 0.753 |
| 1993 | 0.528 | 0.127 | 0.794 | 1.321 | 1.321 | 1.321 | 0.998 |
| 1994 | 0.006 | 0.266 | 1.475 | 1.686 | 1.686 | 1.686 | 1.531 |
| 1995 | 0.006 | 0.030 | 0.461 | 0.960 | 0.960 | 0.960 | 0.631 |
| 1996 | 0.005 | 0.071 | 0.365 | 0.635 | 0.635 | 0.635 | 0.442 |
| 1997 | 0.004 | 0.079 | 0.273 | 0.709 | 0.709 | 0.709 | 0.458 |
| 1998 | 0.003 | 0.115 | 0.567 | 0.775 | 0.775 | 0.775 | 0.657 |
| 1999 | 0.002 | 0.231 | 0.439 | 0.691 | 0.691 | 0.691 | 0.527 |
| 2000 | 0.008 | 0.221 | 0.712 | 0.873 | 0.873 | 0.873 | 0.776 |
| 2001 | 0.012 | 0.205 | 0.895 | 0.907 | 0.907 | 0.907 | 0.902 |
| 2002 | 0.007 | 0.264 | 0.428 | 0.562 | 0.562 | 0.562 | 0.482 |
| 2003 | 0.005 | 0.137 | 0.529 | 0.491 | 0.491 | 0.491 | 0.515 |
| 2004 | 0.005 | 0.050 | 0.176 | 1.158 | 1.158 | 1.158 | 0.557 |

Table 19. Fishing mortality rate for Georges Bank yellowtail from the Major Change VPA formulation using the bootstrap bias adjusted population abundance at the beginning of 2004 from Canadian ADAPT software.

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 1973 | 0.013 | 0.266 | 0.686 | 0.920 | 1.117 | 0.885 | 0.909 | 0.402 | 2.469 | 1.123 | 0.163 | 0.000 | 0.000 |
| 1974 | 0.052 | 0.570 | 0.892 | 1.124 | 1.224 | 0.868 | 0.987 | 1.131 | 1.453 | 0.000 | 0.138 | 0.166 | 0.000 |
| 1975 | 0.076 | 1.231 | 1.276 | 1.366 | 1.269 | 0.852 | 0.989 | 0.884 | 1.001 | 1.450 | 0.000 | 0.000 | 0.000 |
| 1976 | 0.029 | 1.054 | 0.967 | 0.948 | 0.874 | 1.057 | 1.209 | 0.914 | 1.204 | 2.005 | 0.900 | 0.000 | 0.000 |
| 1977 | 0.025 | 0.713 | 1.392 | 1.100 | 0.839 | 1.152 | 1.139 | 1.466 | 1.237 | 0.803 | 0.000 | 0.000 | 0.000 |
| 1978 | 0.229 | 0.341 | 1.012 | 1.112 | 1.251 | 0.619 | 0.728 | 0.385 | 1.805 | 0.840 | 1.612 | 0.000 | 0.000 |
| 1979 | 0.014 | 0.401 | 0.749 | 1.103 | 1.637 | 2.608 | 1.693 | 2.131 | 2.642 | 0.471 | 1.157 | 0.000 | 0.000 |
| 1980 | 0.015 | 0.247 | 0.801 | 0.803 | 0.932 | 1.499 | 0.660 | 0.953 | 0.492 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1981 | 0.002 | 0.066 | 0.707 | 1.404 | 1.742 | 1.264 | 0.249 | 0.587 | 0.983 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1982 | 0.111 | 0.489 | 0.820 | 1.237 | 1.774 | 0.628 | 0.643 | 0.711 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1983 | 0.126 | 0.743 | 1.207 | 0.722 | 0.915 | 1.108 | 0.228 | 2.009 | 1.028 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1984 | 0.054 | 0.629 | 1.411 | 1.946 | 2.457 | 1.529 | 2.774 | 2.345 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1985 | 0.066 | 0.842 | 0.818 | 1.158 | 1.413 | 0.777 | 0.131 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1986 | 0.023 | 0.791 | 0.541 | 0.839 | 1.090 | 0.904 | 0.403 | 0.396 | 0.000 | 0.471 | 0.000 | 0.000 | 0.000 |
| 1987 | 0.019 | 0.749 | 1.258 | 1.404 | 1.539 | 0.859 | 1.879 | 2.408 | 2.545 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1988 | 0.025 | 0.605 | 1.014 | 1.735 | 1.964 | 0.826 | 2.157 | 0.806 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1989 | 0.022 | 0.143 | 0.477 | 0.905 | 1.371 | 0.908 | 1.609 | 0.099 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1990 | 0.023 | 0.350 | 0.904 | 1.039 | 0.889 | 1.112 | 0.848 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1991 | 0.033 | 0.018 | 0.447 | 1.454 | 1.983 | 1.747 | 0.715 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1992 | 0.161 | 0.808 | 0.588 | 1.116 | 1.611 | 1.115 | 0.981 | 0.273 | 0.324 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1993 | 0.540 | 0.131 | 0.802 | 1.405 | 1.200 | 1.161 | 0.535 | 0.339 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1994 | 0.007 | 0.275 | 1.591 | 1.747 | 2.354 | 1.068 | 1.307 | 0.249 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1995 | 0.006 | 0.032 | 0.484 | 1.248 | 1.089 | 0.438 | 0.865 | 1.019 | 0.683 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1996 | 0.004 | 0.066 | 0.396 | 0.692 | 1.277 | 0.136 | 0.424 | 0.258 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1997 | 0.004 | 0.075 | 0.251 | 0.820 | 0.845 | 0.661 | 2.037 | 1.689 | 0.767 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1998 | 0.003 | 0.114 | 0.525 | 0.678 | 1.081 | 0.742 | 1.680 | 0.511 | 0.000 | 0.696 | 0.000 | 0.000 | 0.000 |
| 1999 | 0.002 | 0.224 | 0.433 | 0.602 | 0.533 | 0.798 | 0.393 | 0.138 | 0.468 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2000 | 0.008 | 0.219 | 0.681 | 0.849 | 0.663 | 0.501 | 0.440 | 0.957 | 0.505 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2001 | 0.013 | 0.226 | 0.885 | 0.823 | 0.848 | 0.521 | 0.892 | 0.461 | 0.697 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2002 | 0.012 | 0.289 | 0.491 | 0.550 | 0.465 | 0.503 | 0.390 | 0.563 | 0.412 | 1.115 | 0.000 | 0.000 | 0.000 |
| 2003 | 0.009 | 0.252 | 0.607 | 0.615 | 0.474 | 0.437 | 1.019 | 0.652 | 0.862 | 1.846 | 0.388 | 0.000 | 0.000 |
| 2004 | -0.002 | 0.091 | 0.383 | 1.683 | 2.283 | 1.899 | 1.899 | 1.899 | 1.899 | 1.899 | 1.899 | 0.000 | 0.000 |

Table 20. Beginning of year weight (kg) at age for Georges Bank yellowtail. The 2005 value is the average for 2000-2004.

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 6+ |
| 1973 | 0.010 | 0.230 | 0.401 | 0.493 | 0.564 | 0.645 | 0.856 | 1.096 | 1.100 | 1.300 | 1.400 | 1.500 | 0.704 |
| 1974 | 0.010 | 0.230 | 0.415 | 0.530 | 0.598 | 0.660 | 0.790 | 1.150 | 1.100 | 1.300 | 1.400 | 1.500 | 0.755 |
| 1975 | 0.010 | 0.230 | 0.410 | 0.524 | 0.613 | 0.684 | 0.707 | 0.769 | 1.100 | 1.300 | 1.400 | 1.500 | 0.715 |
| 1976 | 0.010 | 0.230 | 0.415 | 0.557 | 0.642 | 0.709 | 0.768 | 0.780 | 1.100 | 1.300 | 1.400 | 1.500 | 0.767 |
| 1977 | 0.010 | 0.230 | 0.404 | 0.587 | 0.704 | 0.800 | 0.913 | 0.928 | 1.100 | 1.300 | 1.400 | 1.500 | 0.885 |
| 1978 | 0.010 | 0.230 | 0.418 | 0.601 | 0.713 | 0.839 | 0.902 | 1.017 | 1.100 | 1.300 | 1.400 | 1.500 | 0.918 |
| 1979 | 0.010 | 0.230 | 0.381 | 0.578 | 0.713 | 0.823 | 0.948 | 0.926 | 1.100 | 1.300 | 1.400 | 1.500 | 0.900 |
| 1980 | 0.010 | 0.230 | 0.403 | 0.551 | 0.732 | 0.878 | 1.010 | 1.095 | 1.100 | 1.300 | 1.400 | 1.500 | 0.907 |
| 1981 | 0.010 | 0.230 | 0.397 | 0.546 | 0.681 | 0.818 | 0.940 | 1.390 | 1.100 | 1.300 | 1.400 | 1.500 | 0.837 |
| 1982 | 0.010 | 0.230 | 0.403 | 0.564 | 0.675 | 0.868 | 0.923 | 1.072 | 1.100 | 1.300 | 1.400 | 1.500 | 0.895 |
| 1983 | 0.010 | 0.230 | 0.364 | 0.543 | 0.694 | 0.853 | 1.035 | 1.163 | 1.100 | 1.300 | 1.400 | 1.500 | 0.907 |
| 1984 | 0.010 | 0.230 | 0.335 | 0.470 | 0.627 | 0.741 | 0.954 | 1.018 | 1.100 | 1.300 | 1.400 | 1.500 | 0.796 |
| 1985 | 0.010 | 0.230 | 0.347 | 0.493 | 0.604 | 0.723 | 0.735 | 1.019 | 1.100 | 1.300 | 1.400 | 1.500 | 0.724 |
| 1986 | 0.010 | 0.230 | 0.442 | 0.583 | 0.740 | 0.844 | 0.876 | 0.954 | 1.100 | 1.300 | 1.400 | 1.500 | 0.867 |
| 1987 | 0.010 | 0.230 | 0.423 | 0.606 | 0.727 | 0.921 | 0.904 | 0.856 | 1.100 | 1.300 | 1.400 | 1.500 | 0.936 |
| 1988 | 0.010 | 0.230 | 0.425 | 0.604 | 0.758 | 0.904 | 0.927 | 1.077 | 1.100 | 1.300 | 1.400 | 1.500 | 0.925 |
| 1989 | 0.010 | 0.230 | 0.413 | 0.633 | 0.776 | 0.905 | 1.105 | 0.988 | 1.100 | 1.300 | 1.400 | 1.500 | 0.987 |
| 1990 | 0.010 | 0.230 | 0.359 | 0.552 | 0.706 | 0.826 | 1.013 | 1.135 | 1.100 | 1.300 | 1.400 | 1.500 | 0.866 |
| 1991 | 0.010 | 0.230 | 0.327 | 0.438 | 0.650 | 0.767 | 1.014 | 1.078 | 1.100 | 1.300 | 1.400 | 1.500 | 0.782 |
| 1992 | 0.010 | 0.230 | 0.294 | 0.441 | 0.562 | 0.891 | 0.978 | 1.304 | 1.100 | 1.300 | 1.400 | 1.500 | 0.917 |
| 1993 | 0.010 | 0.230 | 0.333 | 0.428 | 0.545 | 0.741 | 1.114 | 1.084 | 1.100 | 1.300 | 1.400 | 1.500 | 0.767 |
| 1994 | 0.010 | 0.230 | 0.315 | 0.422 | 0.557 | 0.676 | 0.781 | 1.192 | 1.100 | 1.300 | 1.400 | 1.500 | 0.702 |
| 1995 | 0.010 | 0.230 | 0.300 | 0.401 | 0.523 | 0.689 | 0.807 | 0.620 | 1.100 | 1.300 | 1.400 | 1.500 | 0.760 |
| 1996 | 0.010 | 0.230 | 0.318 | 0.445 | 0.578 | 0.731 | 0.902 | 1.018 | 1.100 | 1.300 | 1.400 | 1.500 | 0.836 |
| 1997 | 0.010 | 0.230 | 0.351 | 0.470 | 0.623 | 0.777 | 0.897 | 1.121 | 1.100 | 1.300 | 1.400 | 1.500 | 0.889 |
| 1998 | 0.010 | 0.230 | 0.378 | 0.478 | 0.609 | 0.789 | 0.883 | 1.024 | 1.100 | 1.300 | 1.400 | 1.500 | 0.812 |
| 1999 | 0.010 | 0.230 | 0.404 | 0.534 | 0.641 | 0.788 | 0.964 | 1.181 | 1.100 | 1.300 | 1.400 | 1.500 | 0.819 |
| 2000 | 0.010 | 0.230 | 0.421 | 0.555 | 0.697 | 0.832 | 0.958 | 1.013 | 1.100 | 1.300 | 1.400 | 1.500 | 0.861 |
| 2001 | 0.010 | 0.230 | 0.416 | 0.548 | 0.704 | 0.879 | 0.967 | 1.139 | 1.100 | 1.300 | 1.400 | 1.500 | 0.932 |
| 2002 | 0.010 | 0.230 | 0.410 | 0.552 | 0.719 | 0.891 | 1.037 | 1.145 | 1.100 | 1.300 | 1.400 | 1.500 | 0.972 |
| 2003 | 0.010 | 0.230 | 0.427 | 0.565 | 0.745 | 0.885 | 1.008 | 1.104 | 1.100 | 1.300 | 1.400 | 1.500 | 0.974 |
| 2004 | 0.010 | 0.230 | 0.396 | 0.526 | 0.687 | 0.857 | 0.973 | 1.116 | 1.100 | 1.300 | 1.400 | 1.500 | 0.922 |
| 2005 | 0.010 | 0.230 | 0.414 | 0.549 | 0.710 | 0.869 | 0.989 | 1.103 | 1.100 | 1.300 | 1.400 | 1.500 | 0.932 |

Table 21. Beginning of year biomass (t) for Georges Bank yellowtail from the Base VPA formulation using the bootstrap bias adjusted population abundance at the beginning of 2005 from Canadian ADAPT software.

| Year | Age Group | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6+ | 1+ | 2+ | 3+ |
| 1973 | 294 | 5559 | 11835 | 8537 | 3928 | 2122 | 32275 | 31981 | 26422 |
| 1974 | 522 | 5459 | 6288 | 6382 | 3427 | 1806 | 23884 | 23362 | 17903 |
| 1975 | 706 | 9336 | 4484 | 2626 | 1887 | 1222 | 20261 | 19555 | 10219 |
| 1976 | 247 | 12339 | 4085 | 1352 | 627 | 1199 | 19850 | 19602 | 7264 |
| 1977 | 173 | 4525 | 6289 | 1862 | 507 | 753 | 14108 | 13935 | 9410 |
| 1978 | 544 | 3176 | 3336 | 2039 | 682 | 343 | 10119 | 9575 | 6400 |
| 1979 | 255 | 8189 | 3093 | 1427 | 765 | 504 | 14234 | 13979 | 5790 |
| 1980 | 240 | 4737 | 7938 | 1798 | 547 | 218 | 15479 | 15239 | 10501 |
| 1981 | 630 | 4460 | 5265 | 4092 | 886 | 185 | 15518 | 14888 | 10429 |
| 1982 | 228 | 11841 | 6000 | 3122 | 1203 | 140 | 22534 | 22305 | 10465 |
| 1983 | 66 | 3854 | 9450 | 2994 | 1051 | 313 | 17727 | 17662 | 13808 |
| 1984 | 108 | 1094 | 2204 | 3040 | 1445 | 387 | 8277 | 8169 | 7075 |
| 1985 | 167 | 1935 | 726 | 680 | 526 | 99 | 4133 | 3966 | 2031 |
| 1986 | 85 | 2953 | 1320 | 447 | 298 | 193 | 5296 | 5211 | 2259 |
| 1987 | 92 | 1558 | 2029 | 872 | 204 | 188 | 4944 | 4852 | 3294 |
| 1988 | 229 | 1700 | 1112 | 696 | 234 | 67 | 4037 | 3809 | 2109 |
| 1989 | 97 | 4204 | 1389 | 488 | 154 | 53 | 6386 | 6289 | 2085 |
| 1990 | 115 | 1793 | 4674 | 965 | 177 | 40 | 7765 | 7649 | 5856 |
| 1991 | 228 | 2125 | 1467 | 1936 | 366 | 81 | 6204 | 5976 | 3850 |
| 1992 | 183 | 4153 | 2186 | 1029 | 538 | 61 | 8150 | 7967 | 3814 |
| 1993 | 140 | 2954 | 2204 | 1466 | 330 | 103 | 7195 | 7056 | 4102 |
| 1994 | 107 | 1551 | 2918 | 1032 | 417 | 110 | 6135 | 6028 | 4477 |
| 1995 | 111 | 1997 | 1268 | 696 | 194 | 63 | 4330 | 4219 | 2222 |
| 1996 | 132 | 2086 | 2196 | 973 | 314 | 45 | 5745 | 5613 | 3528 |
| 1997 | 185 | 2478 | 2424 | 1844 | 591 | 204 | 7727 | 7542 | 5064 |
| 1998 | 241 | 3480 | 3077 | 2060 | 961 | 284 | 10104 | 9863 | 6382 |
| 1999 | 261 | 4533 | 4464 | 2022 | 1041 | 387 | 12707 | 12446 | 7914 |
| 2000 | 223 | 4905 | 5397 | 3235 | 1083 | 675 | 15519 | 15295 | 10391 |
| 2001 | 259 | 4172 | 5821 | 2819 | 1402 | 984 | 15457 | 15199 | 11026 |
| 2002 | 380 | 4811 | 4953 | 2583 | 1222 | 1121 | 15070 | 14690 | 9879 |
| 2003 | 333 | 7096 | 5607 | 3639 | 1623 | 1884 | 20181 | 19848 | 12752 |
| 2004 | 138 | 6232 | 8644 | 3321 | 2209 | 2171 | 22715 | 22577 | 16345 |
| 2005 | 210 | 2574 | 8619 | 8061 | 1101 | 1297 | 21863 | 21653 | 19079 |

Table 22. Beginning of year biomass (t) for Georges Bank yellowtail from the Major Change VPA formulation using the bootstrap bias adjusted population abundance at the beginning of 2005 from Canadian ADAPT software.

| | Age | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1+ | 2+ | 3+ |
| 1973 | 296 | 5601 | 11953 | 8444 | 3463 | 1534 | 441 | 200 | 29 | 8 | 3 | 2 | 31974 | 31678 | 26077 |
| 1974 | 519 | 5495 | 6350 | 6509 | 3336 | 1086 | 635 | 196 | 110 | 2 | 2 | 2 | 24242 | 23724 | 18228 |
| 1975 | 701 | 9274 | 4536 | 2690 | 2005 | 919 | 400 | 189 | 49 | 25 | 2 | 2 | 20790 | 20089 | 10815 |
| 1976 | 245 | 12230 | 3996 | 1409 | 688 | 534 | 360 | 134 | 91 | 18 | 5 | 2 | 19712 | 19468 | 7237 |
| 1977 | 169 | 4474 | 6136 | 1760 | 565 | 293 | 196 | 106 | 62 | 26 | 2 | 2 | 13791 | 13622 | 9148 |
| 1978 | 536 | 3095 | 3260 | 1858 | 583 | 238 | 85 | 57 | 24 | 17 | 10 | 2 | 9766 | 9230 | 6135 |
| 1979 | 249 | 8028 | 2984 | 1343 | 593 | 158 | 119 | 35 | 34 | 4 | 7 | 2 | 13555 | 13306 | 5278 |
| 1980 | 235 | 4615 | 7709 | 1670 | 462 | 116 | 12 | 21 | 4 | 2 | 2 | 2 | 14849 | 14614 | 9999 |
| 1981 | 627 | 4367 | 5092 | 3840 | 757 | 167 | 23 | 7 | 7 | 2 | 2 | 2 | 14893 | 14266 | 9899 |
| 1982 | 227 | 11779 | 5868 | 2922 | 955 | 138 | 43 | 17 | 2 | 2 | 2 | 2 | 21958 | 21731 | 9952 |
| 1983 | 65 | 3822 | 9370 | 2849 | 855 | 168 | 72 | 24 | 7 | 2 | 2 | 2 | 17238 | 17173 | 13351 |
| 1984 | 108 | 1086 | 2167 | 2957 | 1309 | 300 | 51 | 46 | 2 | 2 | 2 | 2 | 8032 | 7924 | 6839 |
| 1985 | 167 | 1923 | 716 | 637 | 445 | 106 | 53 | 3 | 4 | 2 | 2 | 2 | 4060 | 3893 | 1970 |
| 1986 | 85 | 2935 | 1303 | 435 | 246 | 124 | 48 | 49 | 2 | 4 | 2 | 2 | 5235 | 5150 | 2215 |
| 1987 | 90 | 1562 | 2003 | 852 | 192 | 84 | 44 | 26 | 31 | 2 | 2 | 2 | 4890 | 4800 | 3238 |
| 1988 | 225 | 1662 | 1117 | 666 | 214 | 42 | 29 | 7 | 2 | 2 | 2 | 2 | 3972 | 3747 | 2084 |
| 1989 | 98 | 4141 | 1335 | 495 | 124 | 29 | 18 | 3 | 2 | 2 | 2 | 2 | 6252 | 6154 | 2013 |
| 1990 | 114 | 1807 | 4593 | 906 | 183 | 27 | 11 | 3 | 2 | 2 | 2 | 2 | 7651 | 7538 | 5731 |
| 1991 | 227 | 2090 | 1482 | 1856 | 309 | 67 | 9 | 4 | 2 | 2 | 2 | 2 | 6054 | 5827 | 3736 |
| 1992 | 179 | 4141 | 2149 | 1046 | 456 | 48 | 12 | 5 | 3 | 2 | 2 | 2 | 8045 | 7866 | 3725 |
| 1993 | 137 | 2868 | 2189 | 1422 | 347 | 98 | 16 | 4 | 2 | 2 | 2 | 2 | 7090 | 6953 | 4085 |
| 1994 | 100 | 1506 | 2822 | 1017 | 372 | 106 | 27 | 8 | 2 | 2 | 2 | 2 | 5967 | 5867 | 4361 |
| 1995 | 119 | 1871 | 1221 | 600 | 180 | 36 | 36 | 5 | 5 | 2 | 2 | 2 | 4078 | 3959 | 2088 |
| 1996 | 139 | 2229 | 2053 | 915 | 203 | 69 | 25 | 15 | 2 | 2 | 2 | 2 | 5658 | 5519 | 3290 |
| 1997 | 187 | 2613 | 2603 | 1672 | 525 | 62 | 61 | 16 | 11 | 2 | 2 | 2 | 7758 | 7571 | 4958 |
| 1998 | 248 | 3518 | 3259 | 2261 | 781 | 234 | 30 | 7 | 2 | 5 | 2 | 2 | 10348 | 10100 | 6583 |
| 1999 | 262 | 4649 | 4518 | 2231 | 1259 | 281 | 111 | 6 | 4 | 2 | 2 | 2 | 13328 | 13066 | 8417 |
| 2000 | 205 | 4934 | 5572 | 3296 | 1306 | 785 | 126 | 65 | 4 | 2 | 2 | 2 | 16299 | 16094 | 11159 |
| 2001 | 240 | 3828 | 5865 | 3003 | 1464 | 694 | 453 | 79 | 22 | 2 | 2 | 2 | 15654 | 15414 | 11587 |
| 2002 | 230 | 4458 | 4450 | 2630 | 1418 | 650 | 398 | 180 | 39 | 11 | 2 | 2 | 14468 | 14238 | 9780 |
| 2003 | 205 | 4273 | 5071 | 3073 | 1676 | 897 | 364 | 235 | 81 | 25 | 3 | 2 | 15905 | 15700 | 11427 |
| 2004 | 154 | 3818 | 4666 | 2783 | 1649 | 981 | 521 | 119 | 100 | 33 | 3 | 2 | 14828 | 14675 | 10857 |
| 2005 | 186 | 2875 | 5127 | 3575 | 517 | 127 | 130 | 68 | 13 | 13 | 4 | 0 | 12635 | 12449 | 9575 |

Table 23. Deterministic projection input assumptions and results for Georges Bank yellowtail for 2006 at $F_{Ref}$ using the bootstrap bias adjusted population abundance at the beginning of 2005 from the Base VPA formulation.

**Projected Population Numbers** **Age**

| | 1 | 2 | 3 | 4 | 5 | 6+ |
|---|---|---|---|---|---|---|
| 2005.00 | 20972 | 11193 | 20978 | 14719 | 1536 | 1357 |
| 2006.00 | 20972 | 17110 | 8258 | 13217 | 8123 | 1597 |
| 2007.00 | 20972 | 17132 | 13113 | 5727 | 8428 | 6197 |

**Fishing Mortality**

| | 1 | 2 | 3 | 4 | 5 | 6+ |
|---|---|---|---|---|---|---|
| 2005.00 | 0.004 | 0.104 | 0.262 | 0.395 | 0.395 | 0.395 |
| 2006.00 | 0.002 | 0.066 | 0.166 | 0.250 | 0.250 | 0.250 |

**Partial Recruitment**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 2005.00 | 0.01 | 0.26 | 0.66 | 1.00 | 1.00 | 1.00 |
| 2006.00 | 0.01 | 0.26 | 0.66 | 1.00 | 1.00 | 1.00 |

**Weight at Beginning of Year for Population**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 2005.00 | 0.01 | 0.23 | 0.41 | 0.55 | 0.72 | 0.96 |
| 2006.00 | 0.01 | 0.23 | 0.41 | 0.55 | 0.72 | 0.96 |
| 2007.00 | 0.01 | 0.23 | 0.41 | 0.55 | 0.72 | 0.96 |

**Beginning of yea Projected Population Biomass (t)**

| | 1 | 2 | 3 | 4 | 5 | 6 | 1+ | 2+ | 3+ | 4+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2005.00 | 210 | 2574 | 8622 | 8066 | 1101 | 1297 | 21871 | 21661 | 19087 | 10465 |
| 2006.00 | 210 | 3935 | 3394 | 7243 | 5824 | 1526 | 22132 | 21922 | 17987 | 14593 |
| 2007.00 | 210 | 3940 | 5390 | 3138 | 6043 | 5925 | 24645 | 24435 | 20495 | 15105 |

**Projected Catch Numbers**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 2005.00 | 67 | 1005 | 4401 | 4377 | 457 | 404 |
| 2006.00 | 43 | 992 | 1148 | 2661 | 1635 | 321 |

**Average Weight for Catch (kg)**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 2005.00 | 0.23 | 0.34 | 0.47 | 0.63 | 0.79 | 1.10 |
| 2006.00 | 0.23 | 0.34 | 0.47 | 0.63 | 0.79 | 1.10 |

**Projected Catch Biomass (t)**

| | 1 | 2 | 3 | 4 | 5 | 6 | 1+ | 2+ | 3+ | 4+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2005.00 | 15 | 346 | 2055 | 2775 | 363 | 446 | 6000 | 5985 | 5639 | 3584 |
| 2006.00 | 10 | 341 | 536 | 1687 | 1298 | 355 | 4227 | 4217 | 3876 | 3340 |

Table 24. Deterministic projection input assumptions and results for Georges Bank yellowtail for 2006 at $F_{Ref}$ using the bootstrap bias adjusted population abundance at the beginning of 2005 from the Major Change VPA formulation.

**Projected Population Numbers**

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 2005.00 | 18612 | 12499 | 12386 | 6509 | 728 | 147 | 131 | 61 | 12 | 10 | 3 | 0 | 1 |
| 2006.00 | 18612 | 15065 | 7710 | 5575 | 2356 | 264 | 53 | 47 | 22 | 4 | 4 | 1 | 0 |
| 2007.00 | 18612 | 15185 | 11309 | 5255 | 3555 | 1502 | 168 | 34 | 30 | 14 | 3 | 2 | 1 |

**Fishing Mortality**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005.00 | 0.011 | 0.283 | 0.598 | 0.816 | 0.816 | 0.816 | 0.816 | 0.816 | 0.816 | 0.816 | 0.816 | 0.816 | 0.816 |
| 2006.00 | 0.004 | 0.087 | 0.183 | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 |

**Partial Recruitment**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.01 | 0.35 | 0.73 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

**Weight at Beginning of year for Population (kg)**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.01 | 0.23 | 0.41 | 0.55 | 0.72 | 0.88 | 1.01 | 1.12 | 1.10 | 1.30 | 1.40 | 1.50 | 1.50 |

**Beginning of Year Projected Population Biomass (t)**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 1+ | 2+ | 3+ | 4+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005.00 | 186 | 2875 | 5091 | 3567 | 522 | 129 | 132 | 69 | 13 | 13 | 4 | 0 | 2 | 12602 | 12416 | 9542 | 4451 |
| 2006.00 | 186 | 3465 | 3169 | 3055 | 1689 | 231 | 53 | 53 | 24 | 6 | 5 | 2 | 0 | 11940 | 11754 | 8289 | 5120 |
| 2007.00 | 186 | 3493 | 4648 | 2880 | 2549 | 1319 | 169 | 38 | 33 | 18 | 4 | 4 | 1 | 15342 | 15156 | 11663 | 7015 |

**Projected Catch Numbers**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005.00 | 192 | 2807 | 5104 | 3335 | 373 | 75 | 67 | 31 | 6 | 5 | 1 | 0 | 1 |
| 2006.00 | 59 | 1136 | 1174 | 1122 | 474 | 53 | 11 | 10 | 4 | 1 | 1 | 0 | 0 |

**Average Weight for Catch (kg)**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.23 | 0.34 | 0.47 | 0.63 | 0.79 | 0.94 | 1.03 | 1.21 | 1.29 | 1.39 | 1.56 | 1.56 | 1.56 |

**Projected Catch Biomass (t)**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 1+ | 2+ | 3+ | 4+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005.00 | 44 | 966 | 2384 | 2114 | 296 | 70 | 69 | 38 | 8 | 7 | 2 | 0 | 1 | 6000 | 5956 | 4991 | 2607 |
| 2006.00 | 13 | 391 | 548 | 712 | 377 | 50 | 11 | 12 | 6 | 1 | 1 | 0 | 0 | 2121 | 2108 | 1717 | 1169 |

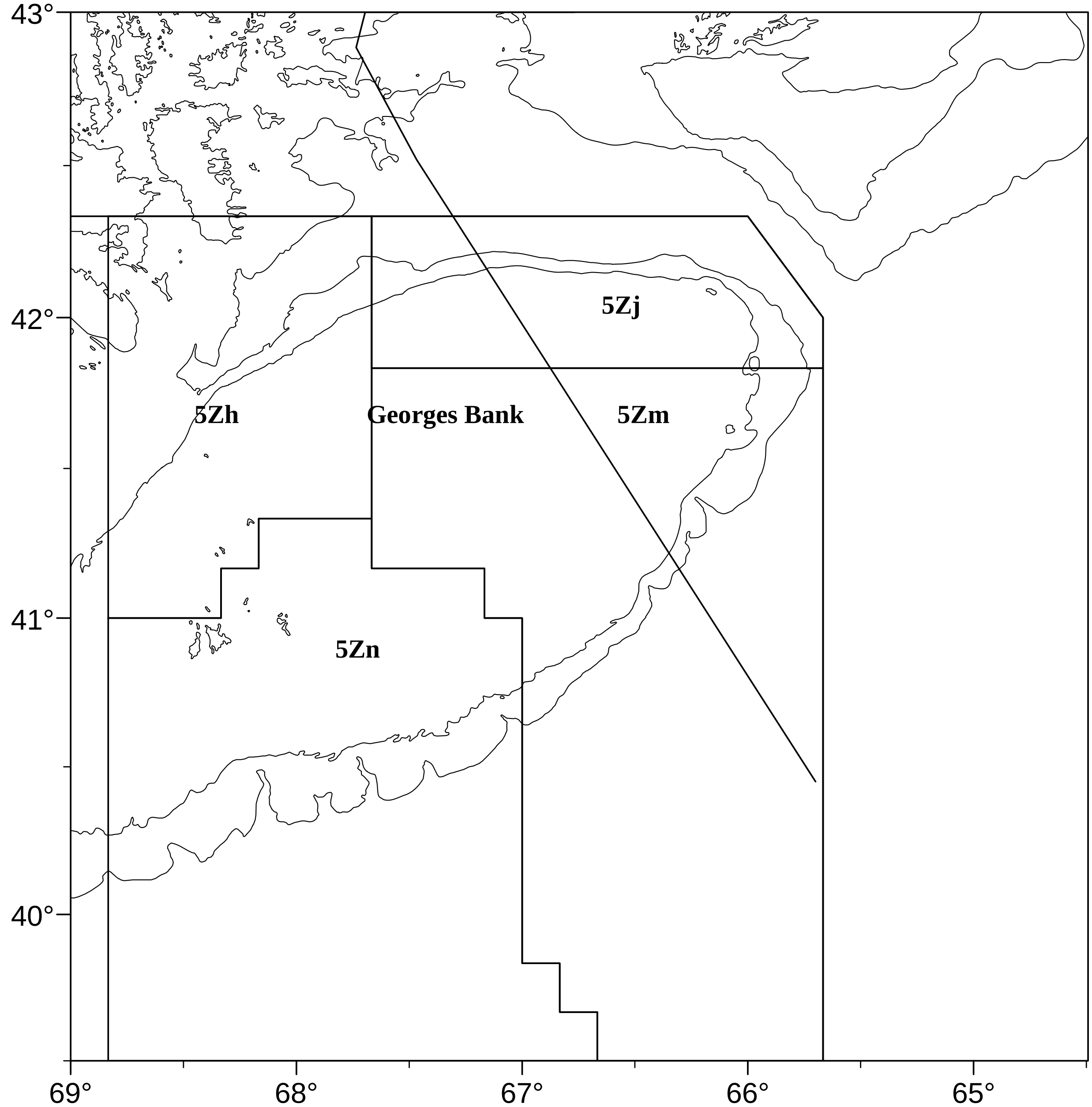



Fig. 1a. Location of statistical unit areas for Canadian fisheries in NAFO Subdivision 5Ze.

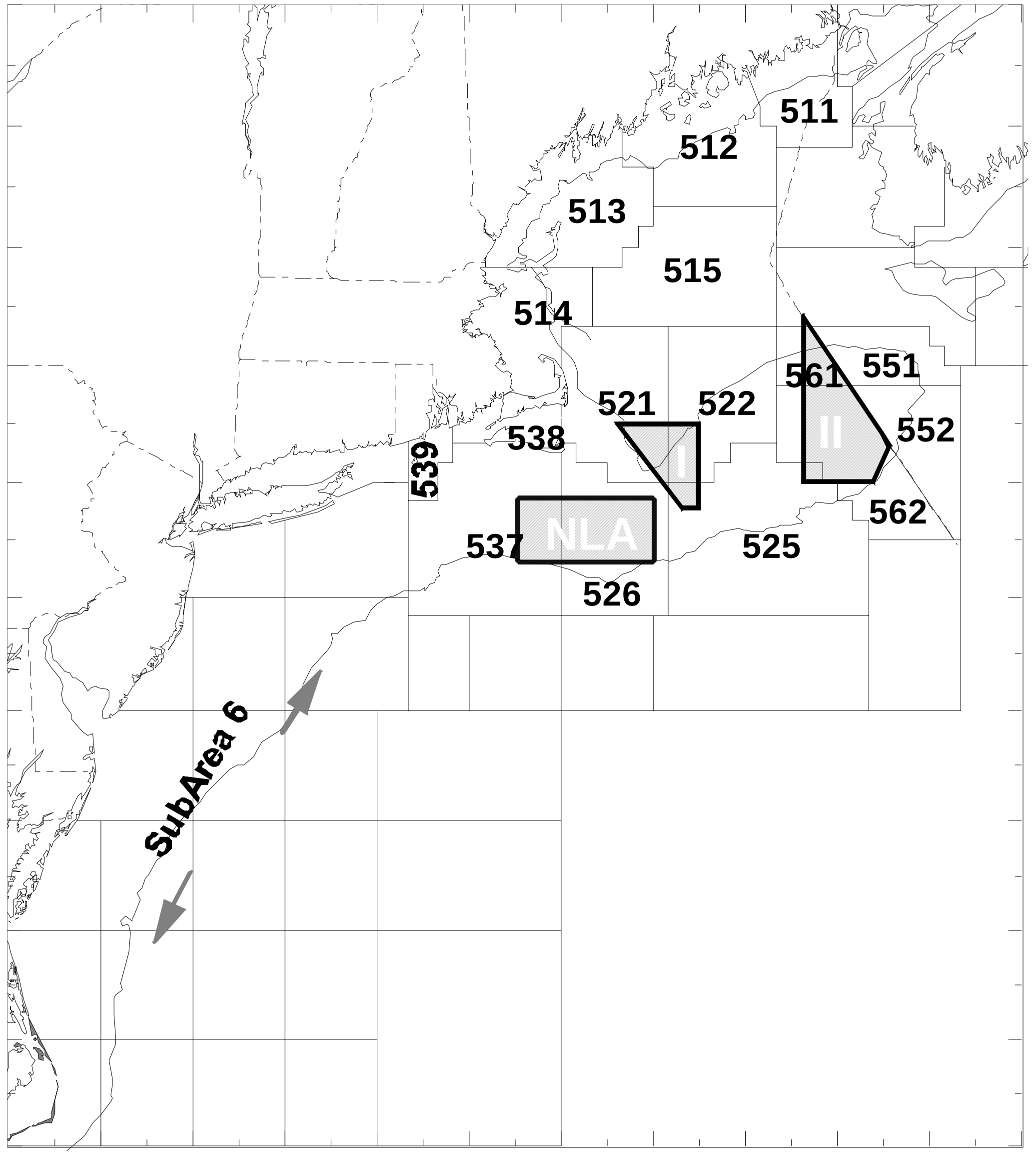



Fig. 1b. Statistical areas used for monitoring northeast U.S. fisheries. Catches from areas 522, 525, 551, 552, 561 and 562 are included in the Georges Bank yellowtail flounder assessment. Shaded areas have been closed to fishing year-round since 1994, with exceptions.

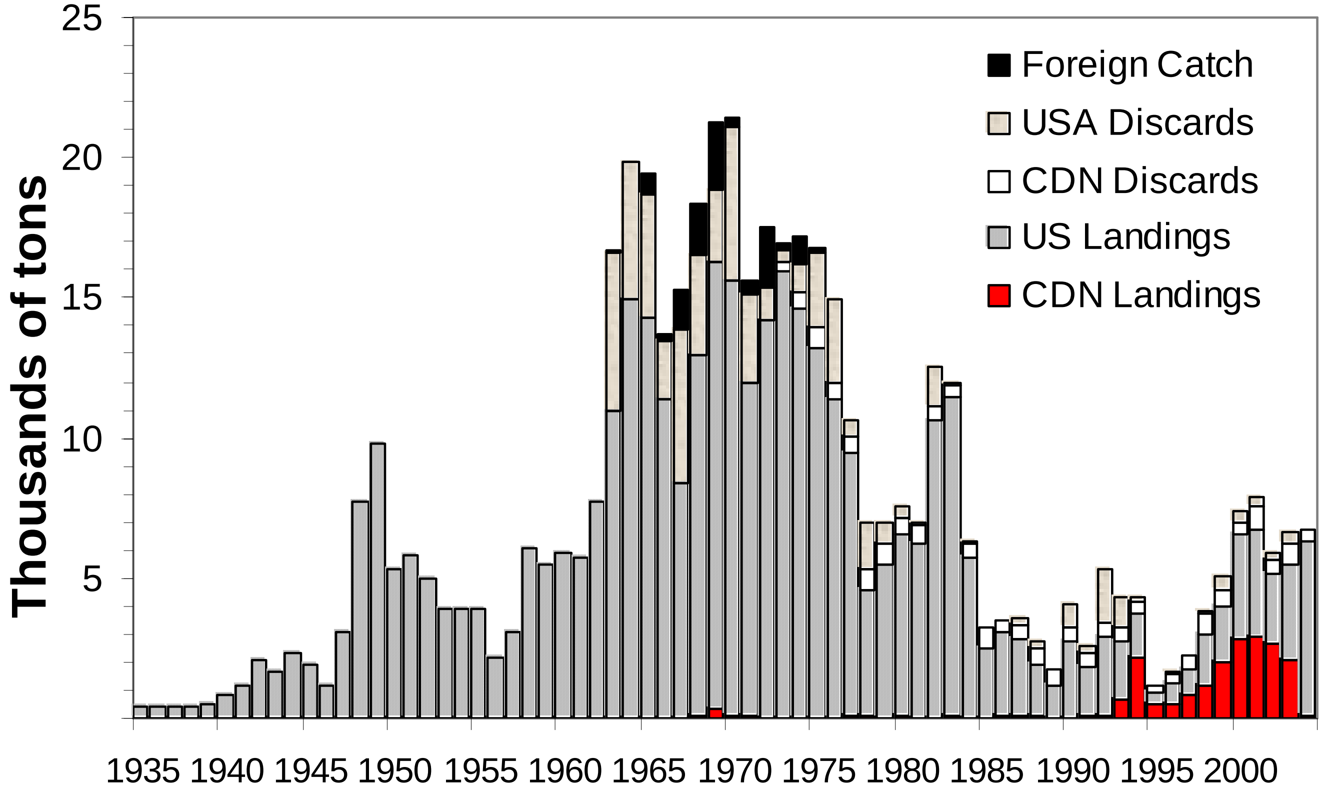



Fig. 2. Landings (including discards) of Georges Bank yellowtail flounder by nation, 1935-2004.

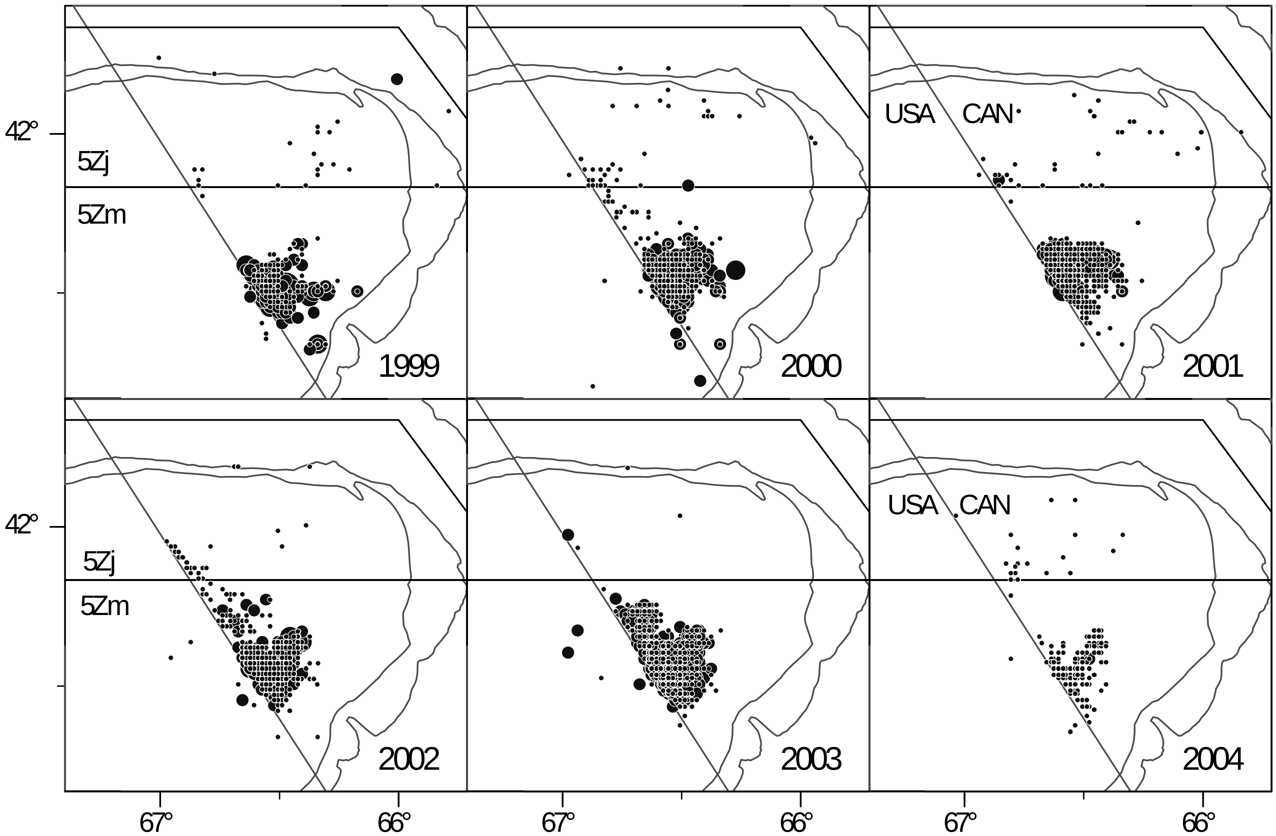



Fig 3. Distribution of Canadian mobile gear (TC 1-3) yellowtail flounder catches from commercial landings data for 1999-2003 where trip landings were greater than 0.5t. For 2004, catches > .100 t are shown. Expanding symbols represent metric tonnes.

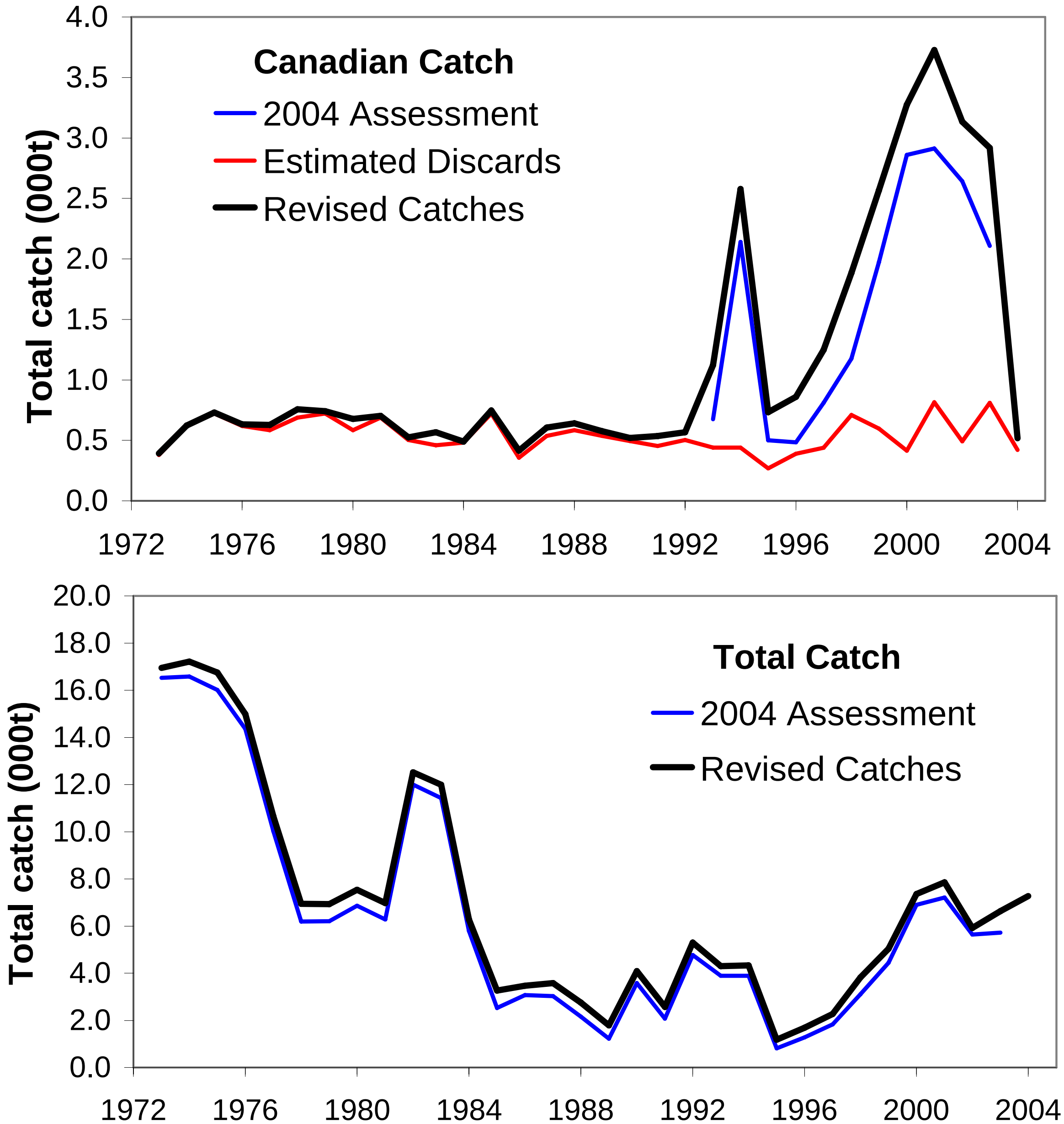



Figure 4. Canadian catch used in the 2004 assessment and revised Canadian catch which includes bycatch from the offshore scallop fishery (upper panel) to 2004, and total catch used in the VPA for the 2004 assessment and revised total catch used in the 2005 assessment.

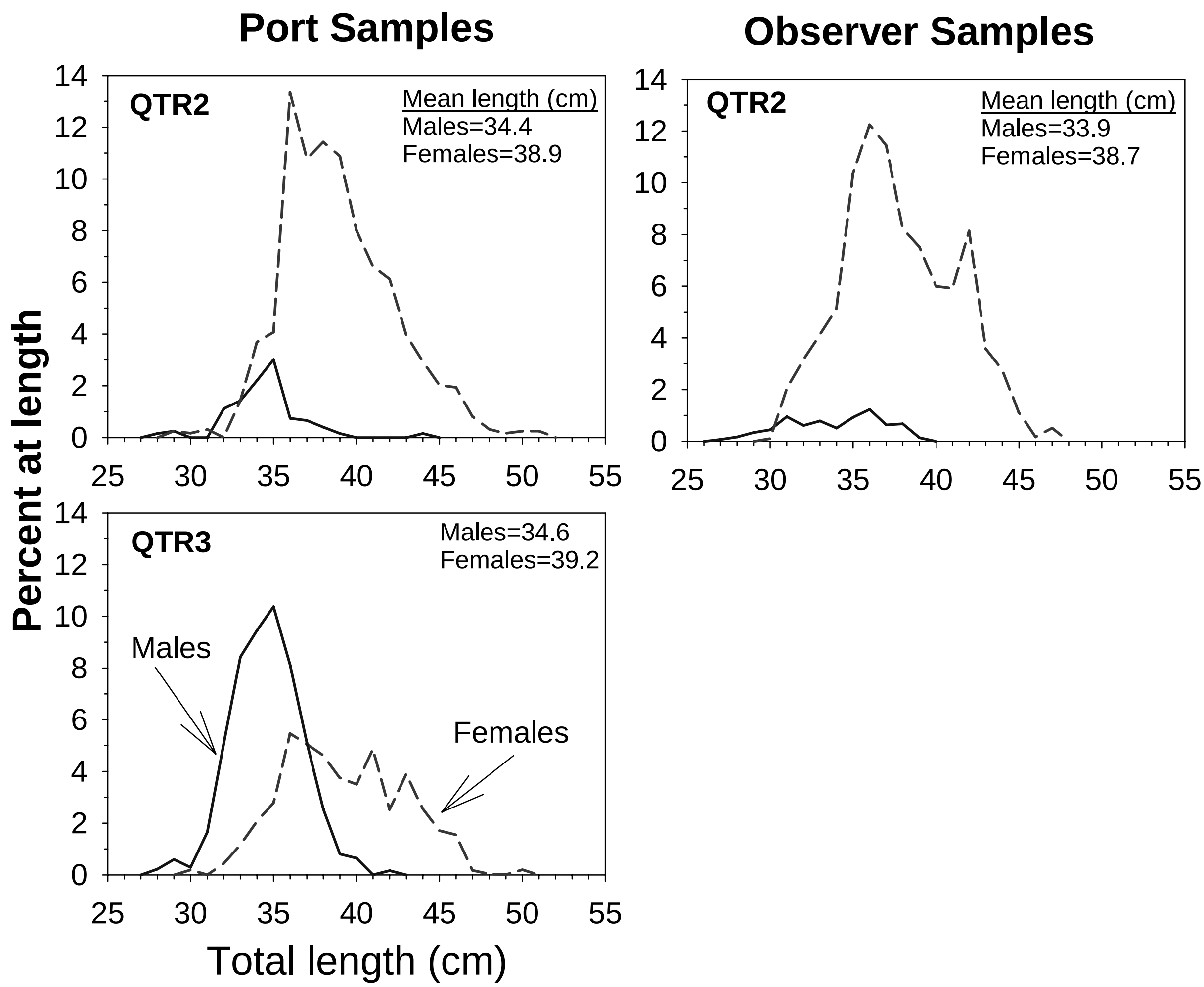



Fig. 5. Length frequencies of Georges Bank yellowtail flounder caught in the 2004 Canadian fishery sampled by sex at dockside (left panels) and at sea (right panel) during the same quarter.

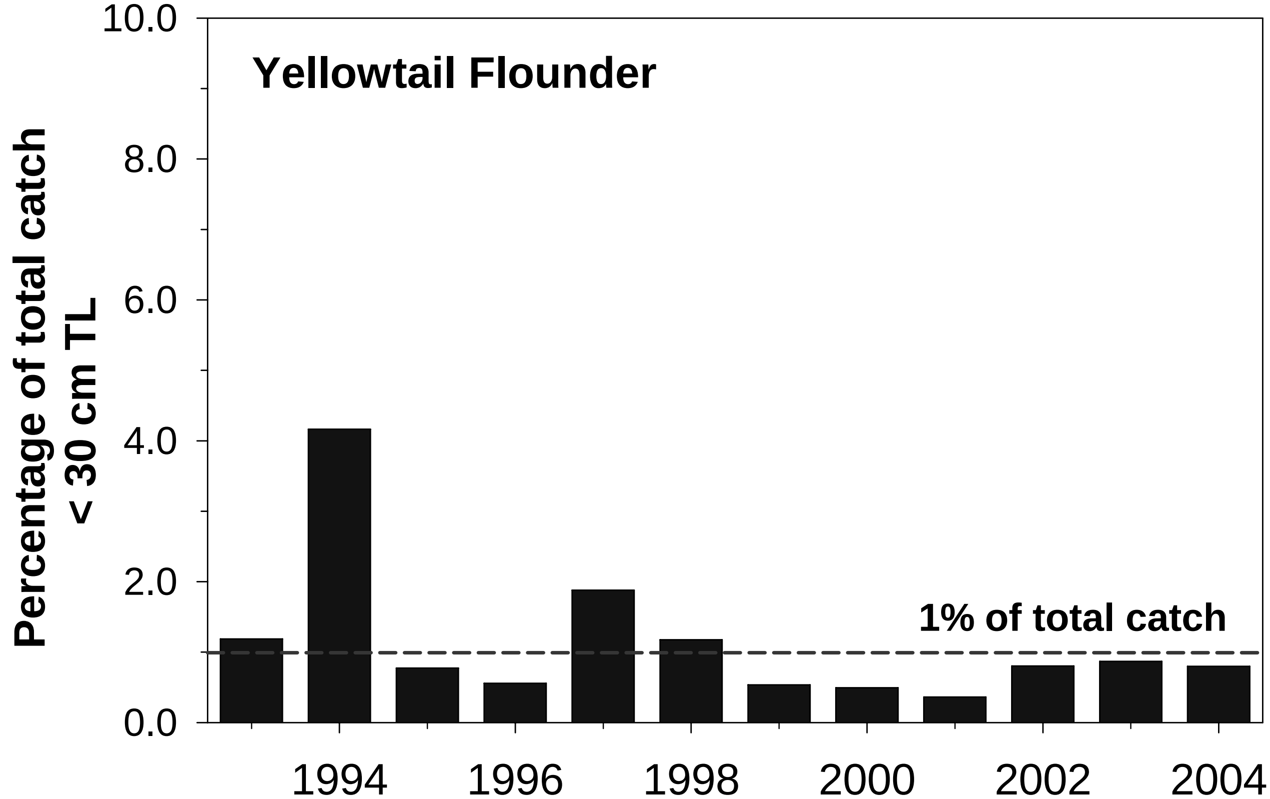



Fig. 6. Percentage of total catch of Georges Bank yellowtail flounder less than 30 cm total length from the Canadian fishery, 1993-2004.

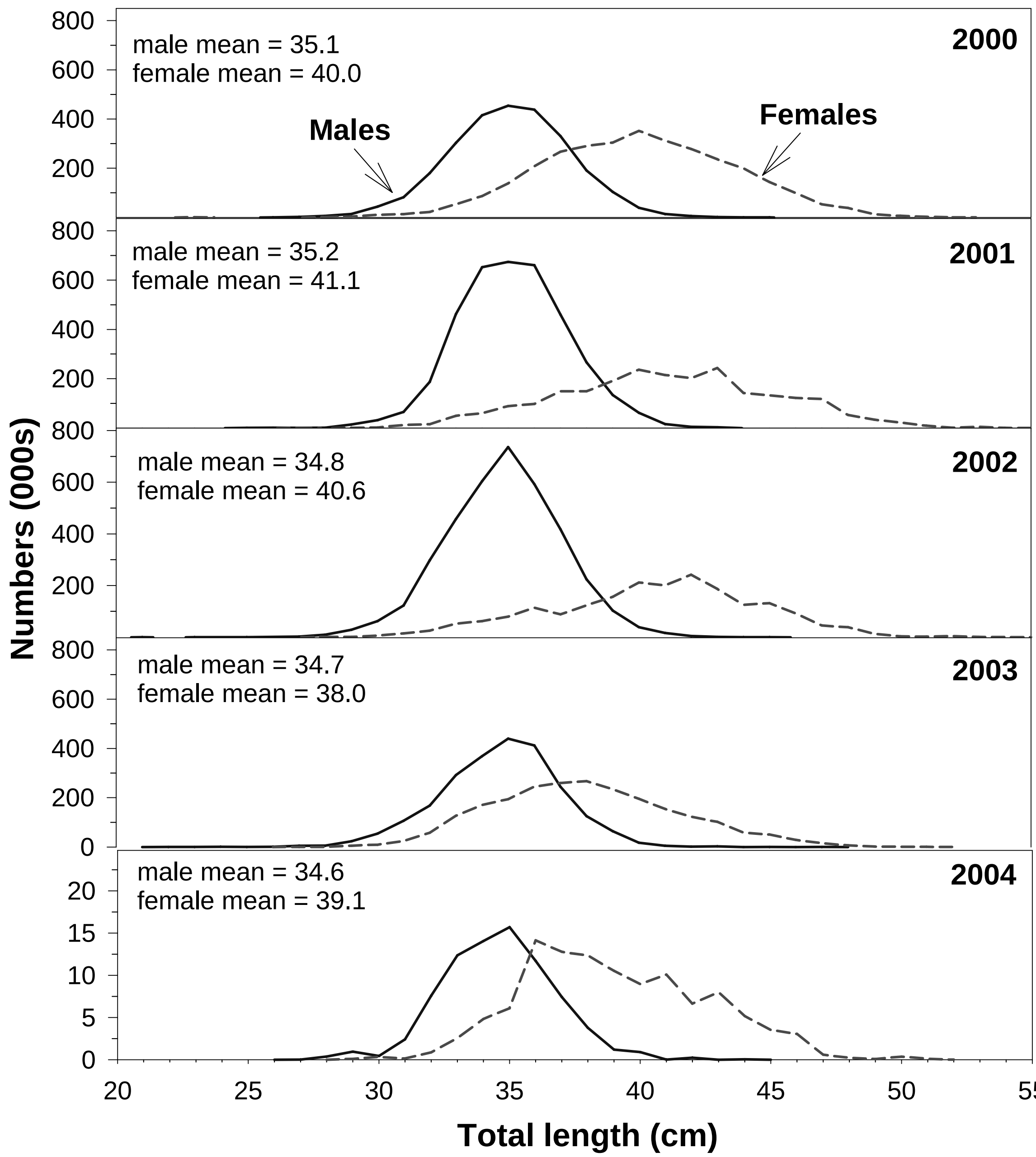



Fig. 7. Georges Bank yellowtail flounder length frequency composition by sex for the Canadian fishery, 2000-2004. (Note: scale is different for 2004).

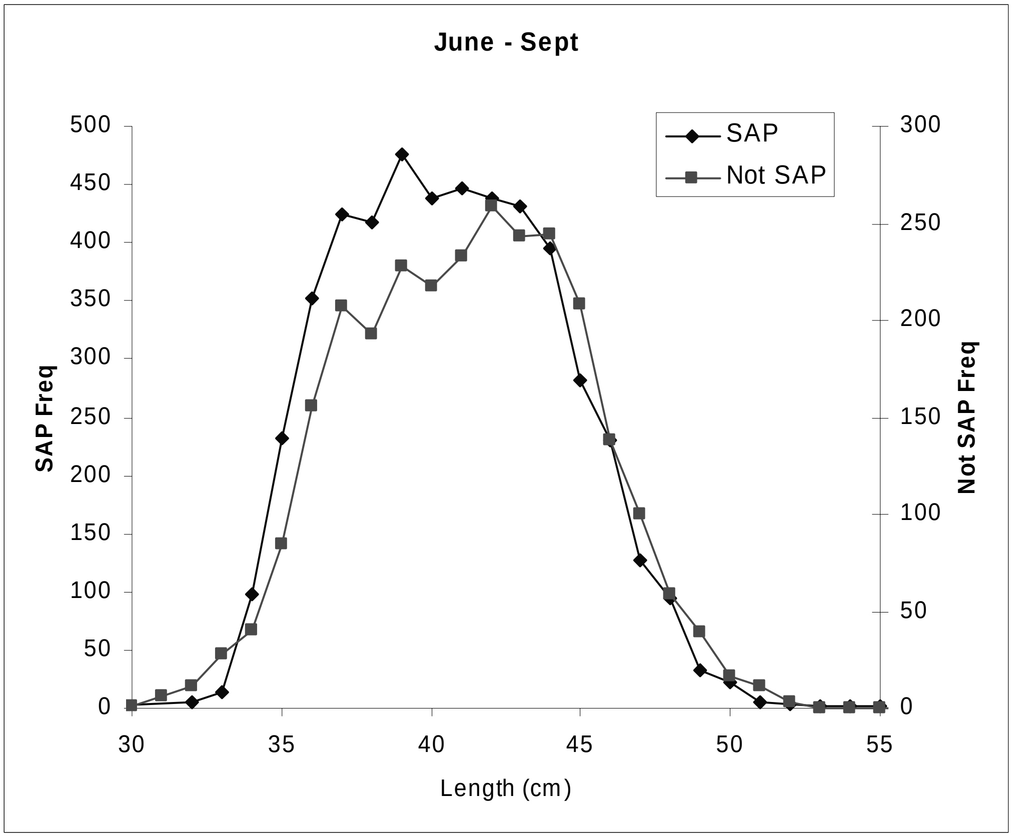



Fig. 8. Comparison of kept length frequencies from observer trips inside and outside Closed Area II during the Special Access Program (June to September).

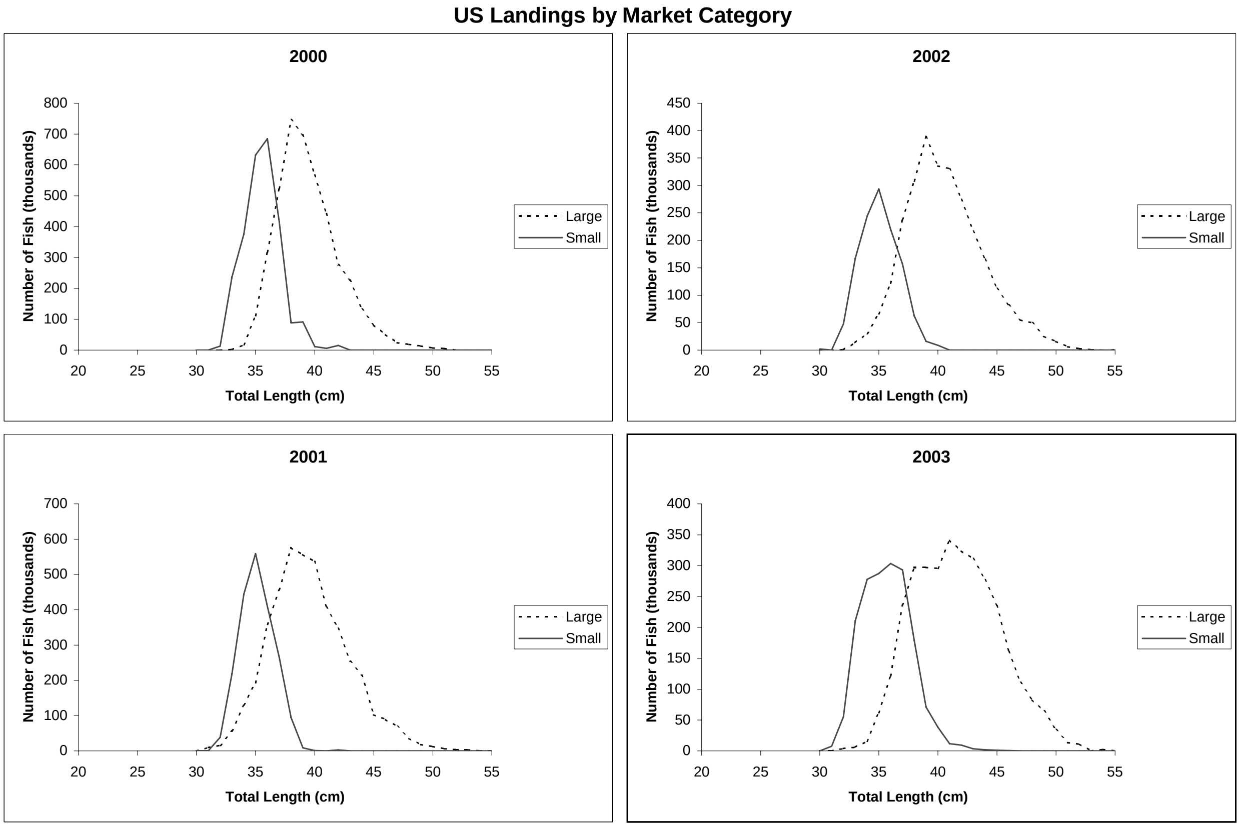



Fig 9. US landings of Georges Bank yellowtail by market category.

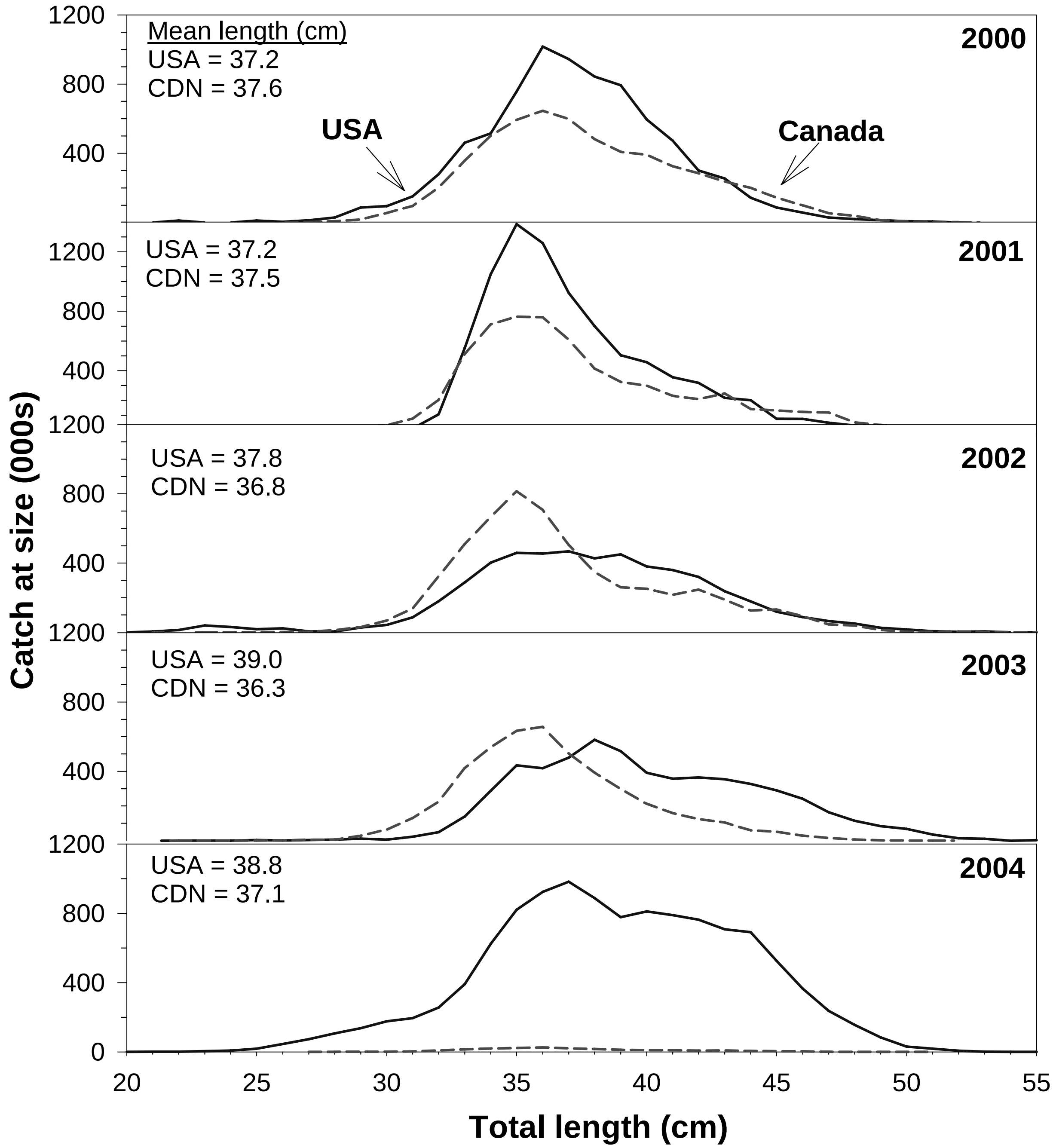



Fig.10. Comparison of Georges Bank yellowtail flounder catch at size from the Canadian and USA fisheries 2000-2004.

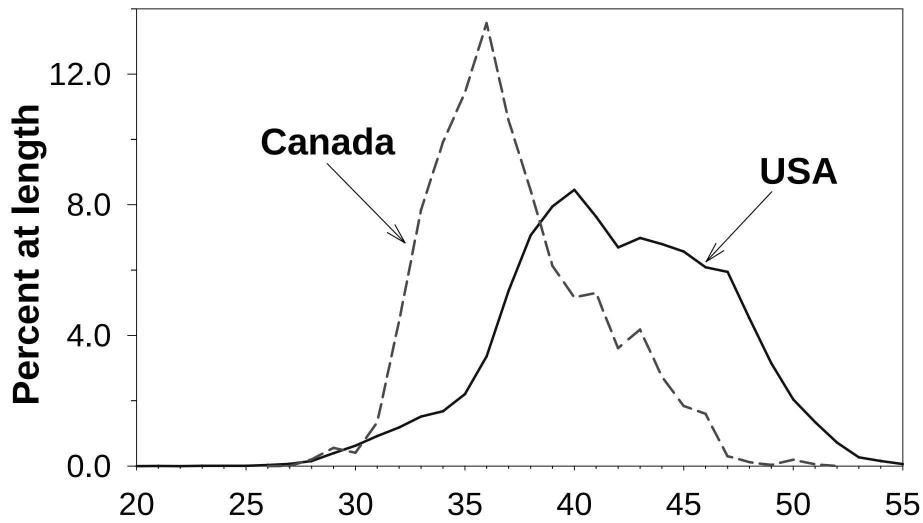
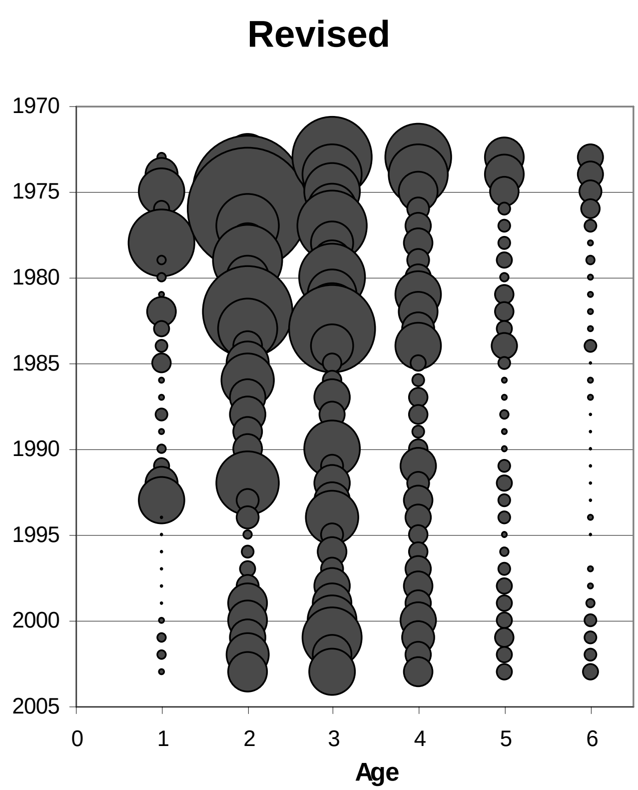



Fig. 11. Comparison of Georges Bank yellowtail flounder proportion at size from the Canadian and USA fisheries in 2004.



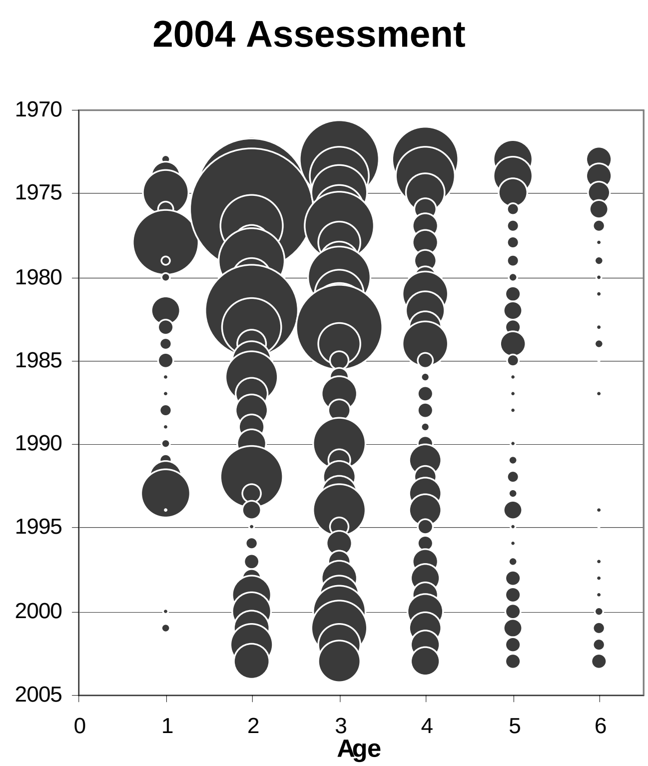




Fig. 12. Comparison of revised CAA from 2005 benchmark review and CAA from 2004 assessment for Georges Bank yellowtail flounder from the Canadian fishery, 1993-2003. (The area of the bubble is proportional to the magnitude of the catch).

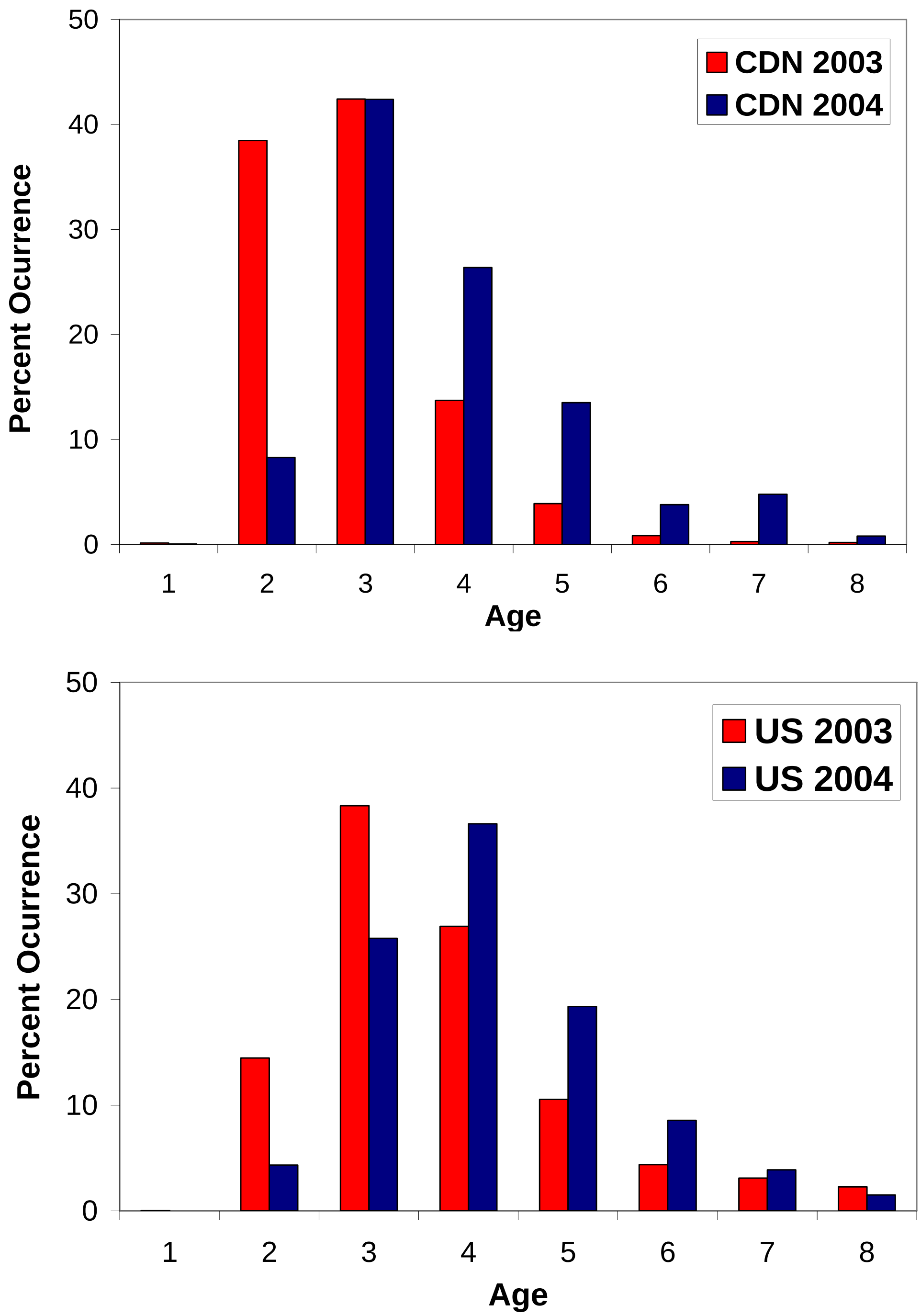



Fig. 13. Comparison of 2003 and 2004 Georges Bank yellowtail flounder landings at age for Canada (upper panel) and the USA (lower panel). (Note: discards for both nations are not included).

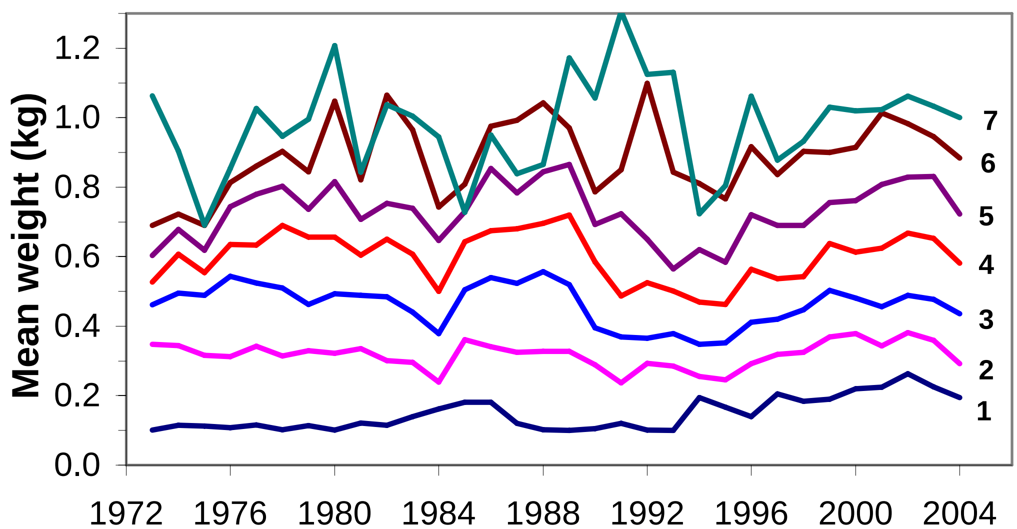



Fig. 14. Mean weight (kg) at age for yellowtail flounder from the Canadian commercial fishery, 1973-2004.

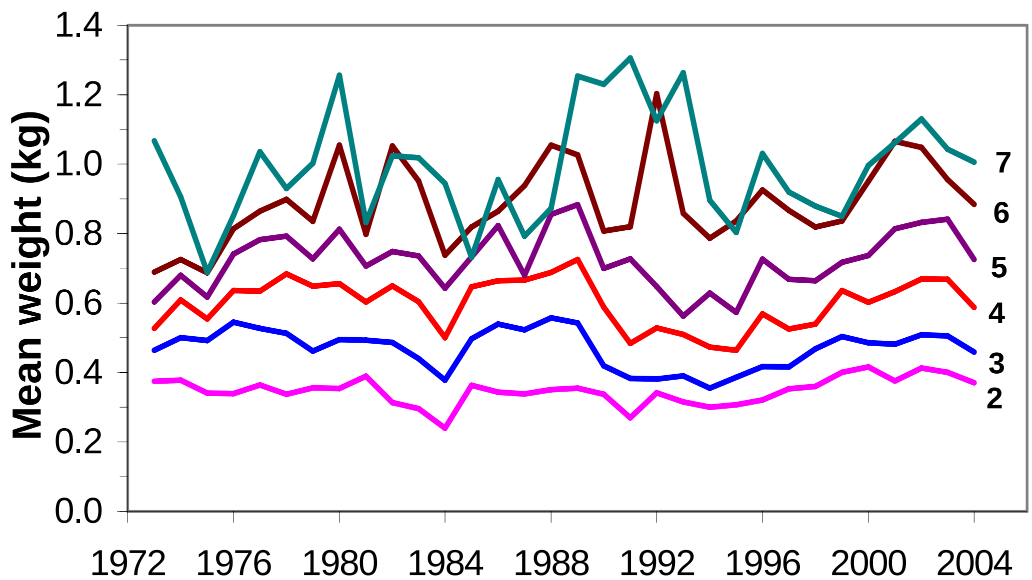



Fig. 15. Mean weight (kg) at age for yellowtail flounder from the US commercial fishery, 1973-2004.

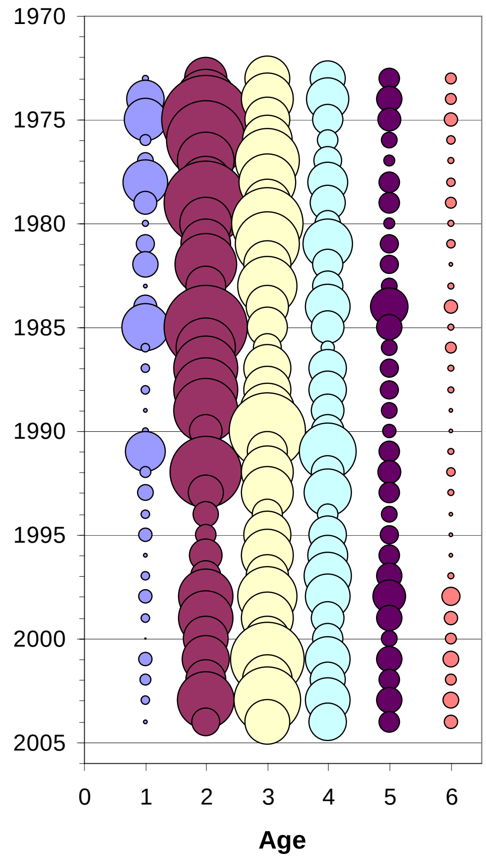



Fig. 16. Discards at age for yellowtail flounder from the Canadian scallop fishery on Georges Bank, 1973-2004. (The area of the bubble is proportional to the magnitude of the discarded catch).

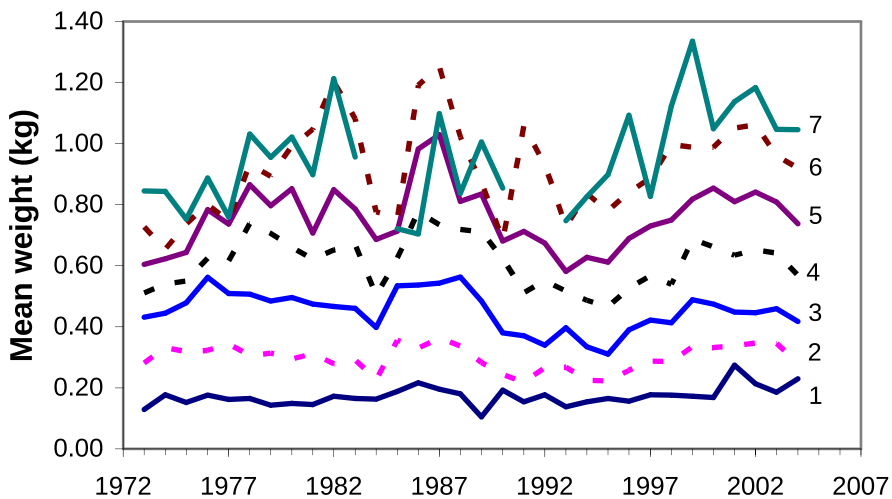



Fig. 17. Mean weight at age (kg) for yellowtail flounder from the Canadian scallop fishery on Georges Bank, 1973-2004.

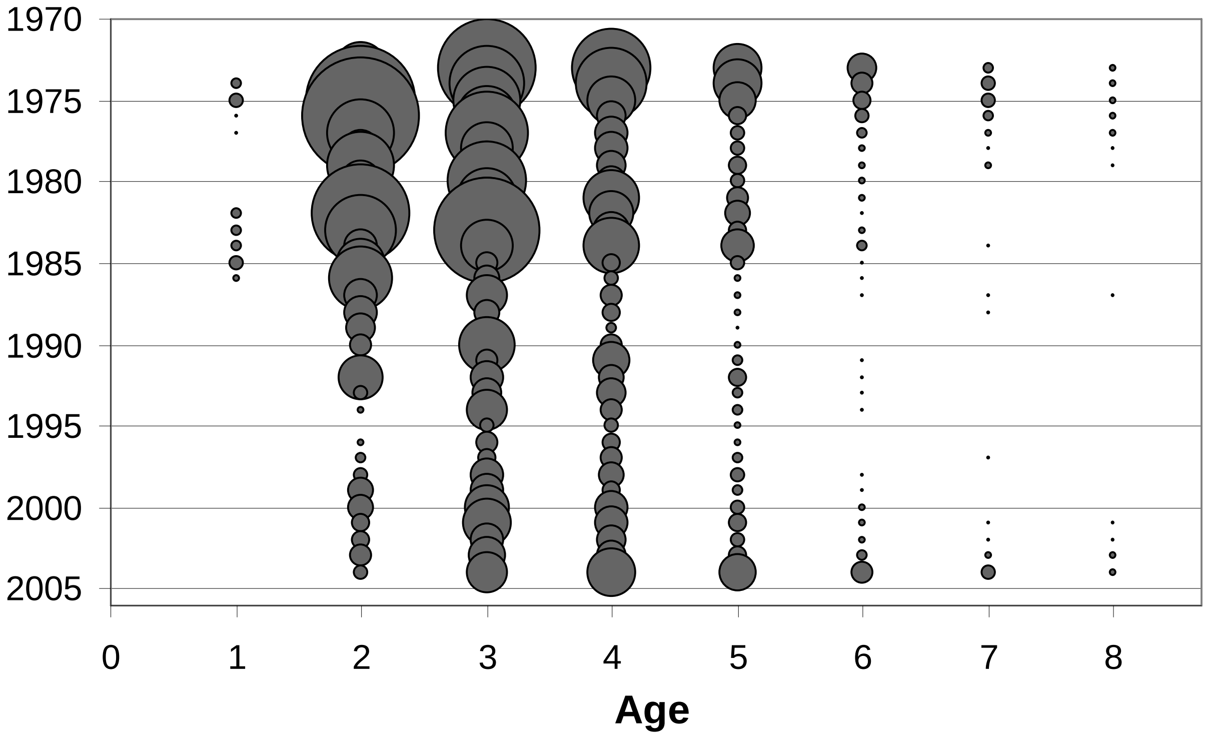



Fig. 18. Catch at age for Georges Bank yellowtail flounder, Canadian and USA fisheries combined, 1973-2004. (The area of the bubble is proportional to the magnitude of the catch).

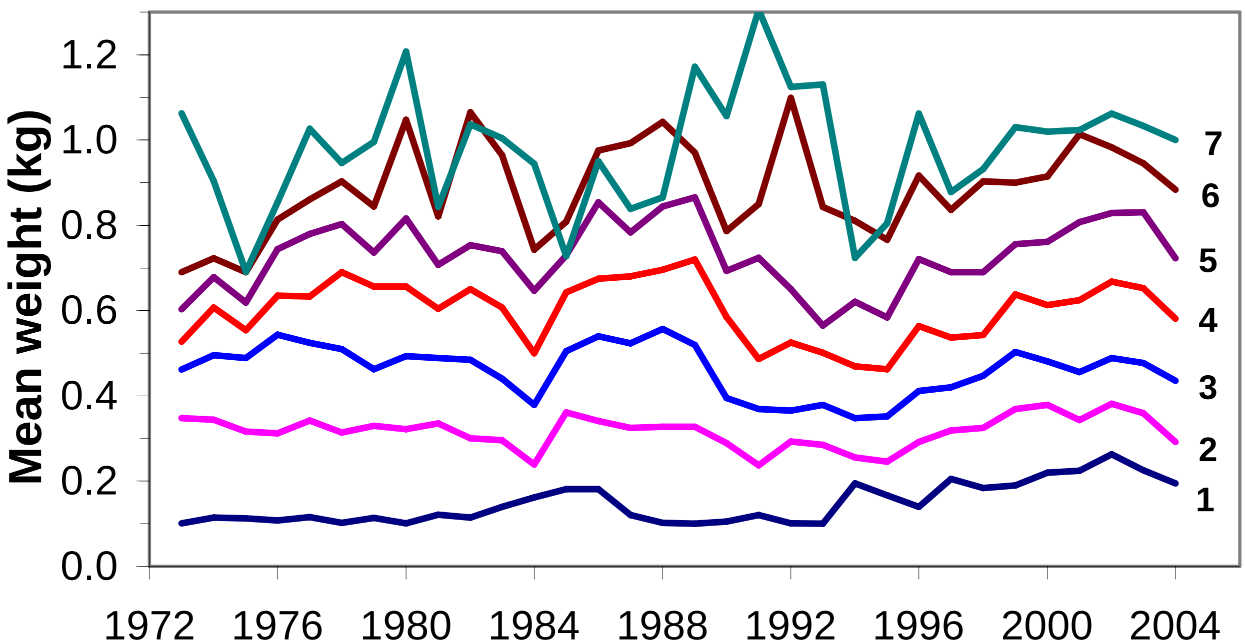



Fig. 19. Trends in mean weight at age from the 5Zjhmn yellowtail fishery, 1973 to 2003 (Canada and USA combined including discards).

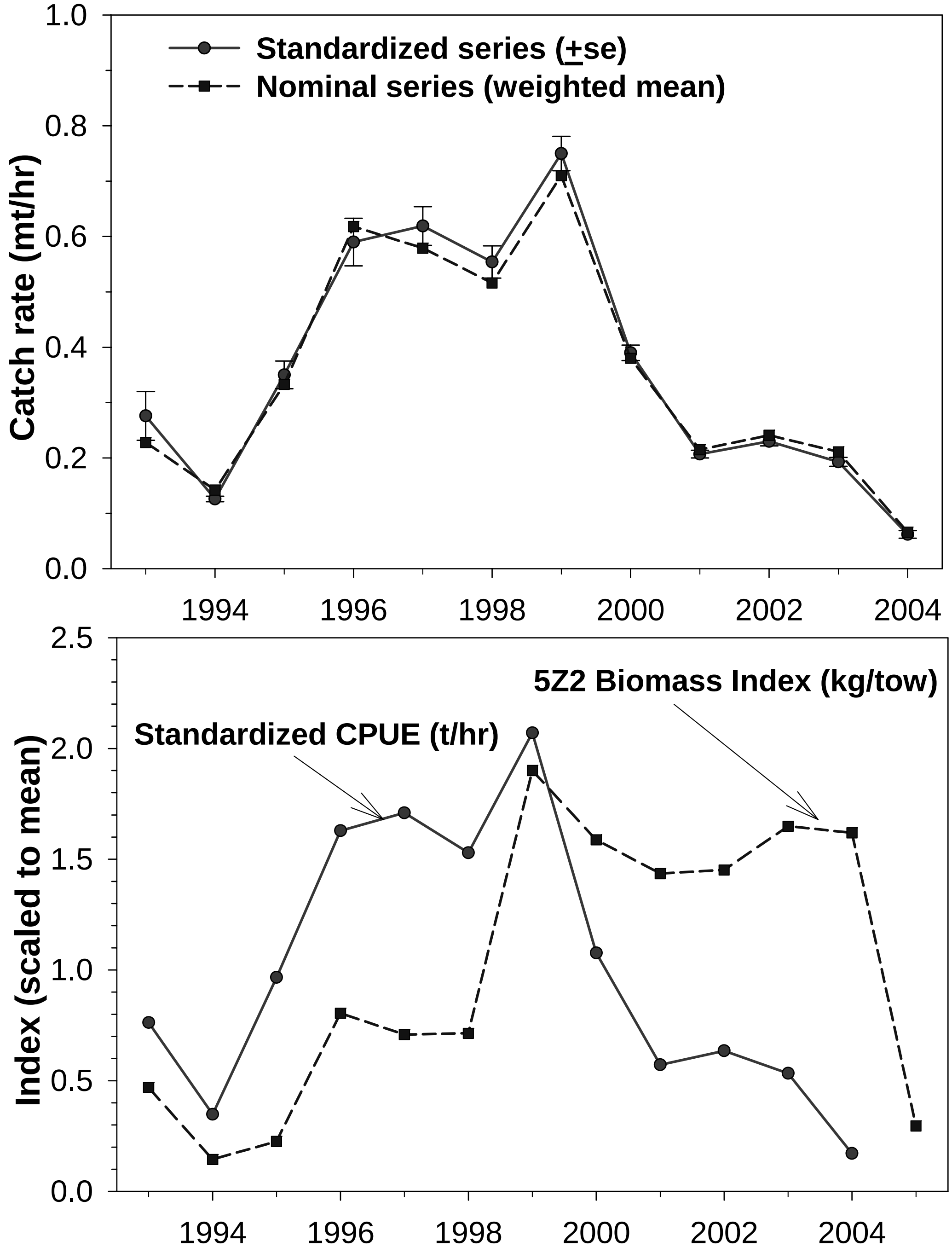



Fig. 20. Upper Panel: Nominal and standardized catch rates (tonnes/hour) for Canadian stern trawlers (TC 1-3) fishing for yellowtail flounder on Georges Bank based on directed trips in 5Zm with catches ≥ 2.0 t, 1993-2004. Lower Panel: Standardized CPUE for the Canadian fishery (1993-2004) and DFO spring survey biomass index for stratum 5Z2 (1993-2005).

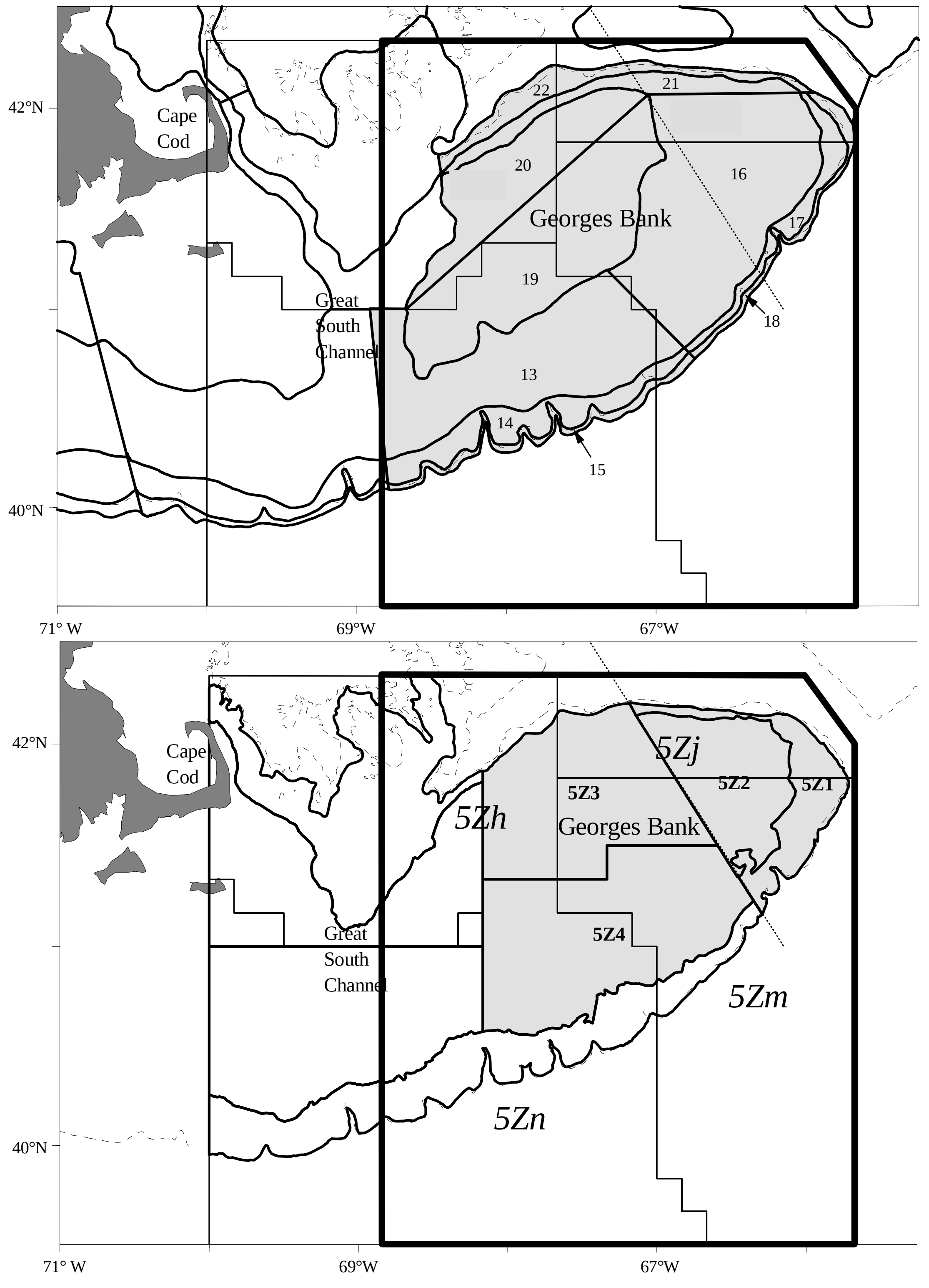



Fig. 21. NMFS (top) and DFO (bottom) strata used to derive research survey abundance indices for Georges Bank groundfish surveys. Note NMFS stratum 22 is not used in assessment.

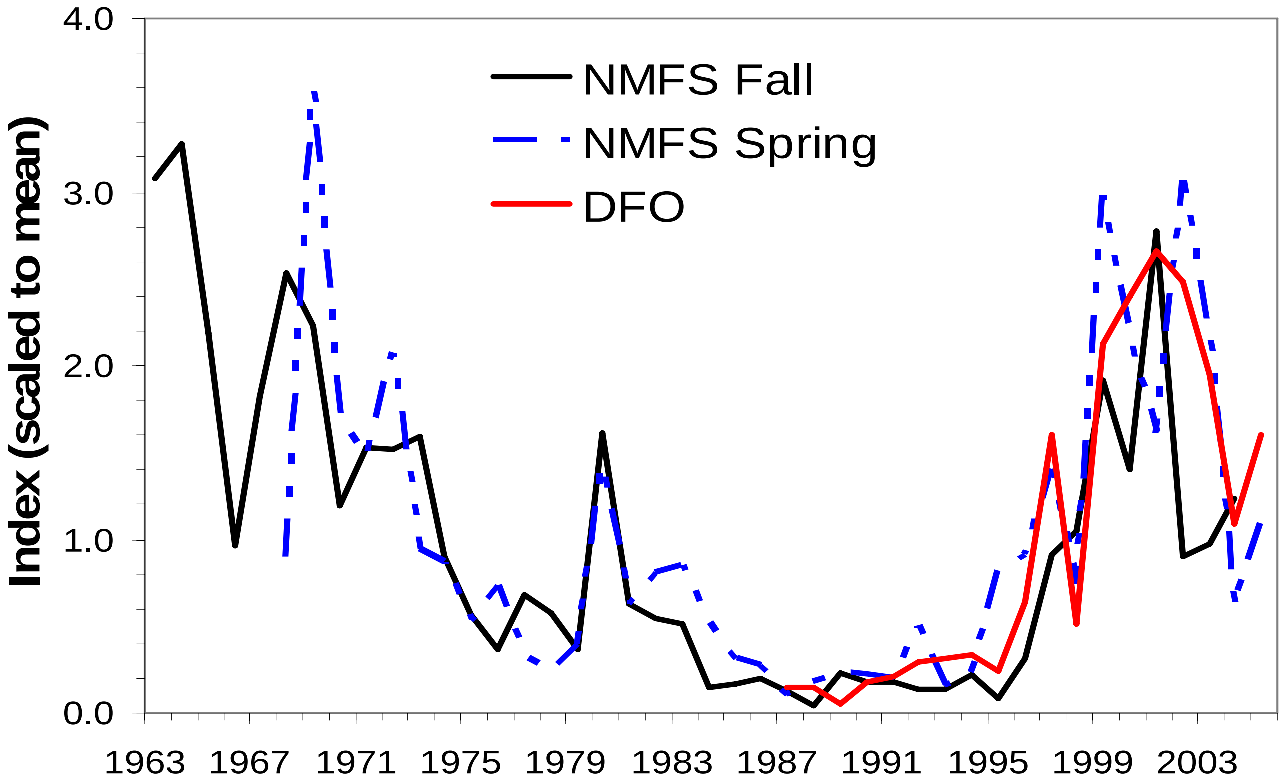



Fig. 22. NMFS and DFO spring and NMFS fall survey biomass indices for yellowtail flounder on Georges Bank.

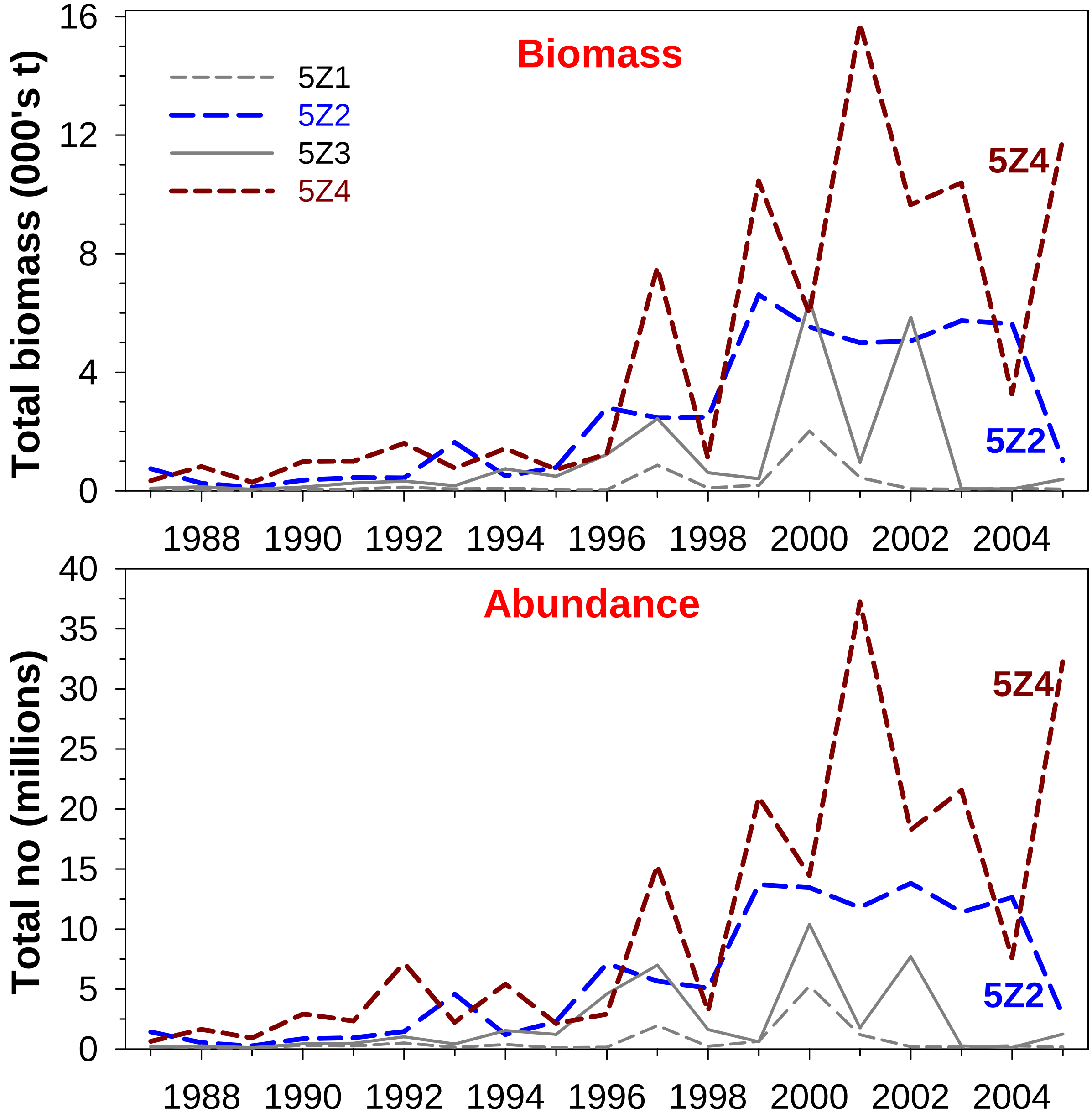



Fig. 23. DFO spring survey estimates of total biomass (top panel) and total number (bottom panel) by stratum area for yellowtail flounder on Georges Bank, 1987-2005.

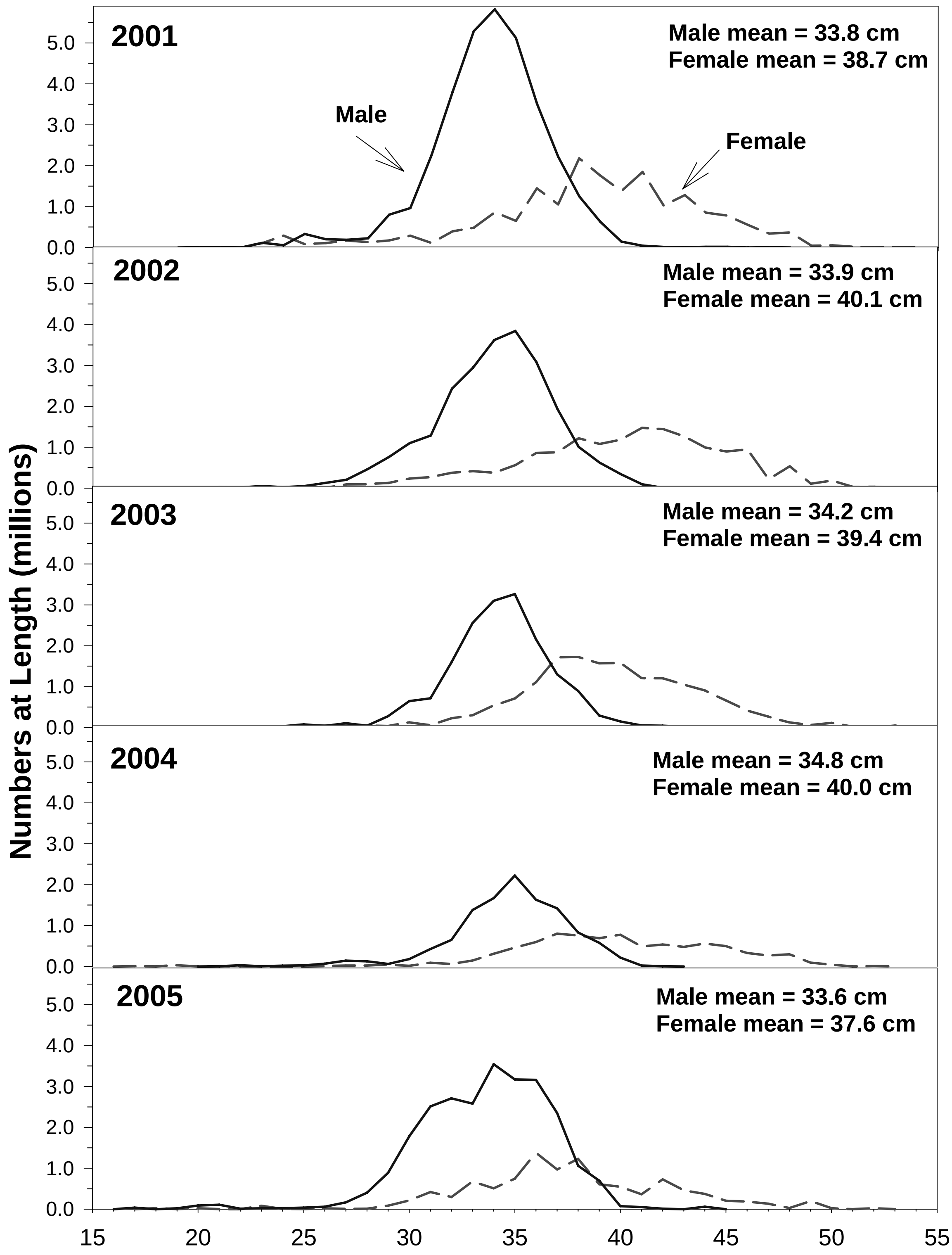



Fig. 24. Comparison of yellowtail flounder length composition in DFO spring surveys on Georges Bank, 2001-2005.

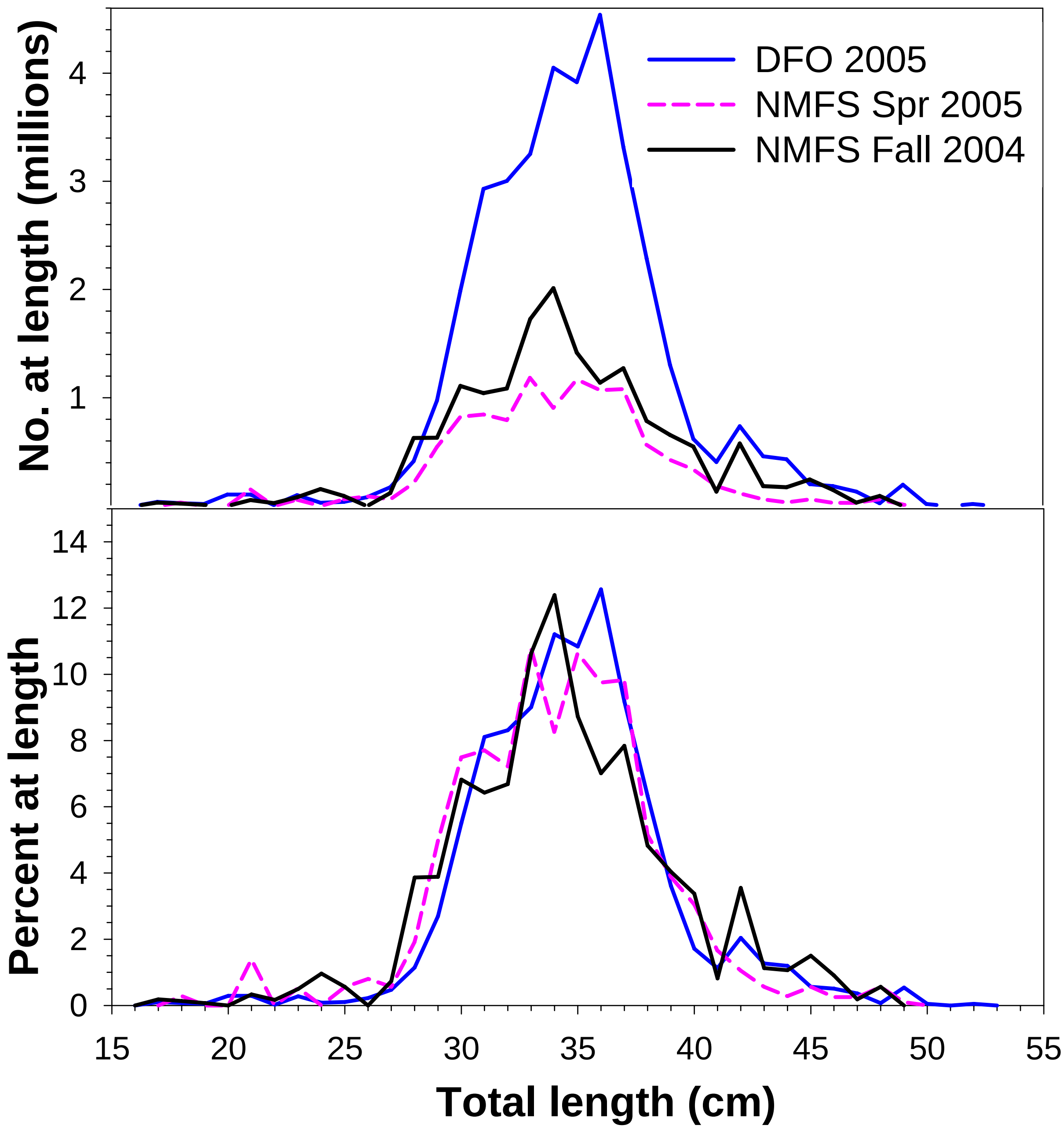



Fig. 25. Comparison of yellowtail flounder catch at length (upper panel) and proportion at length (lower panel) from the 2005 DFO, 2005 NMFS spring and 2004 NMFS fall surveys.

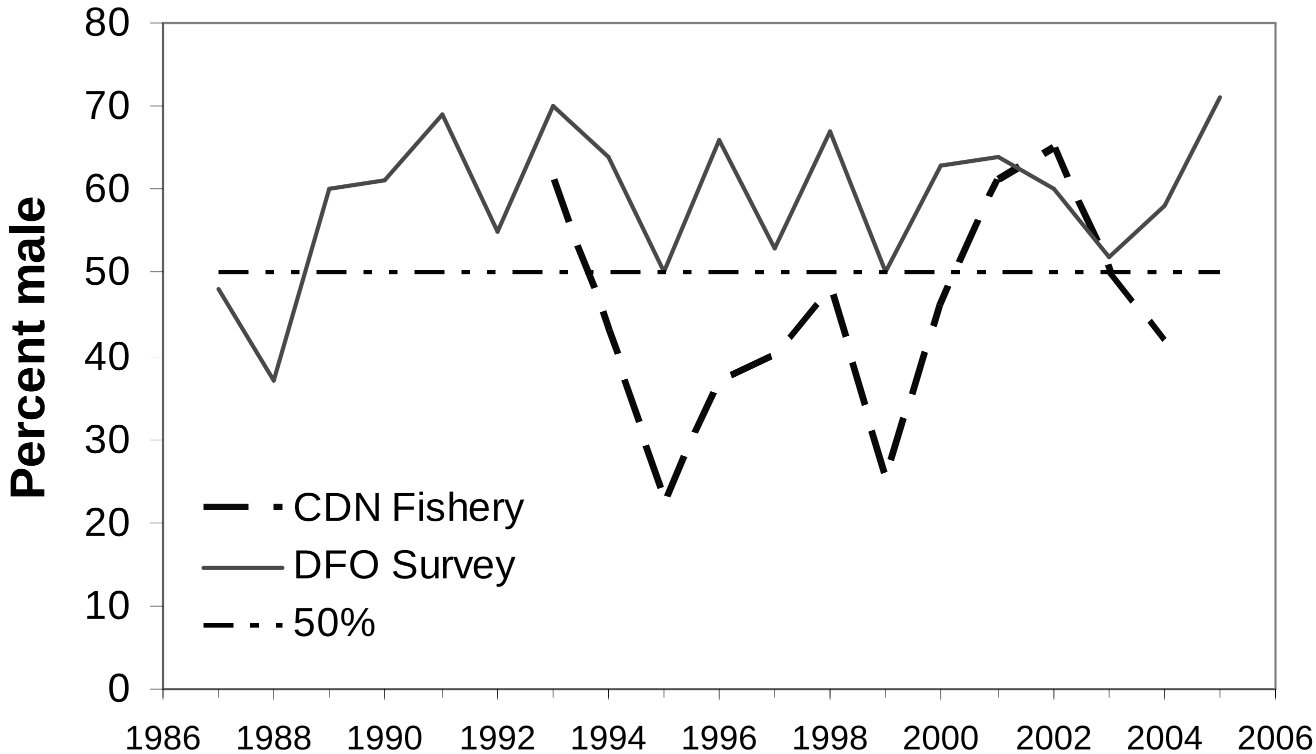



Fig 26. Percentage of male yellowtail flounder in the Canadian fishery (1993-2004) and DFO surveys (1987-2005).

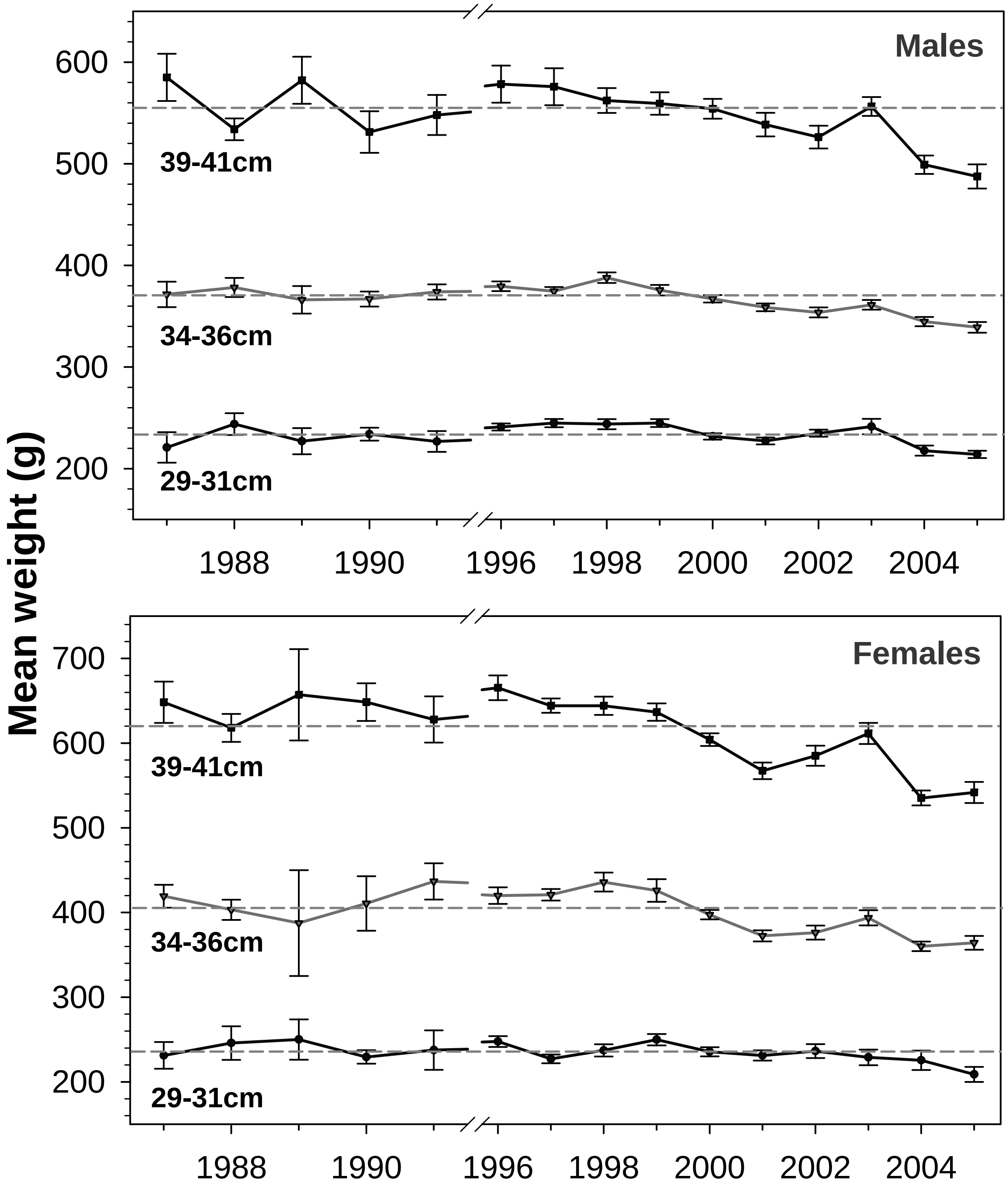



Fig 27. Trends in mean weight at 29-31cm, 34-36cm and 39-41cm cm TL for male and female yellowtail flounder sampled during February bottom trawl surveys conducted by DFO during 1987-1991 and 1996-2005. The dashed line is the long term mean for each series. Vertical bars represent ± 1SE.

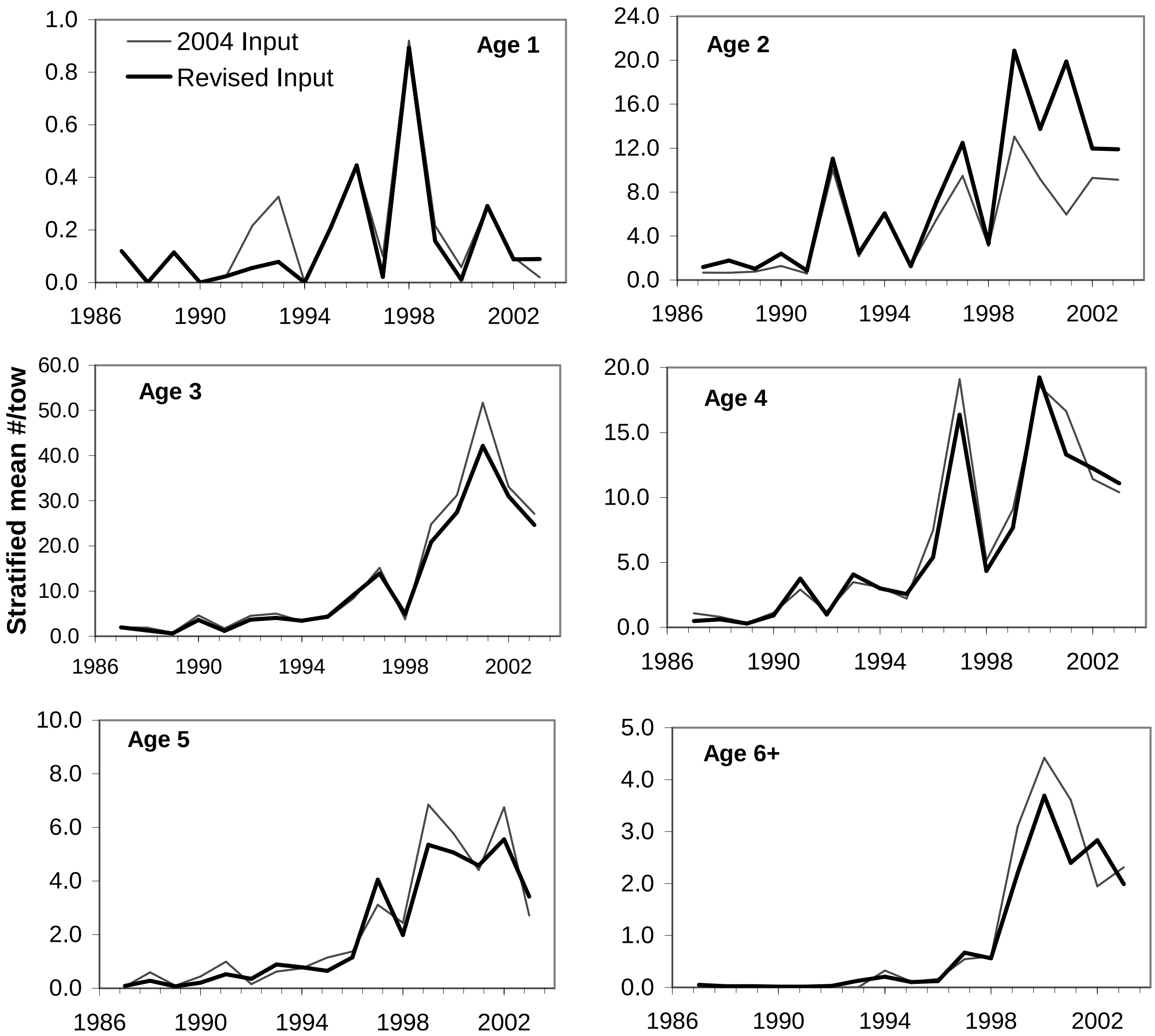



Fig. 28. Comparison of 1987-2003 DFO survey age-specific indices of abundance generated using borrowed age length keys from NMFS spring surveys only (2004 Assessment Input) and enhanced age length keys with additional ages from half 1 US port and observer samples (Revised Input).

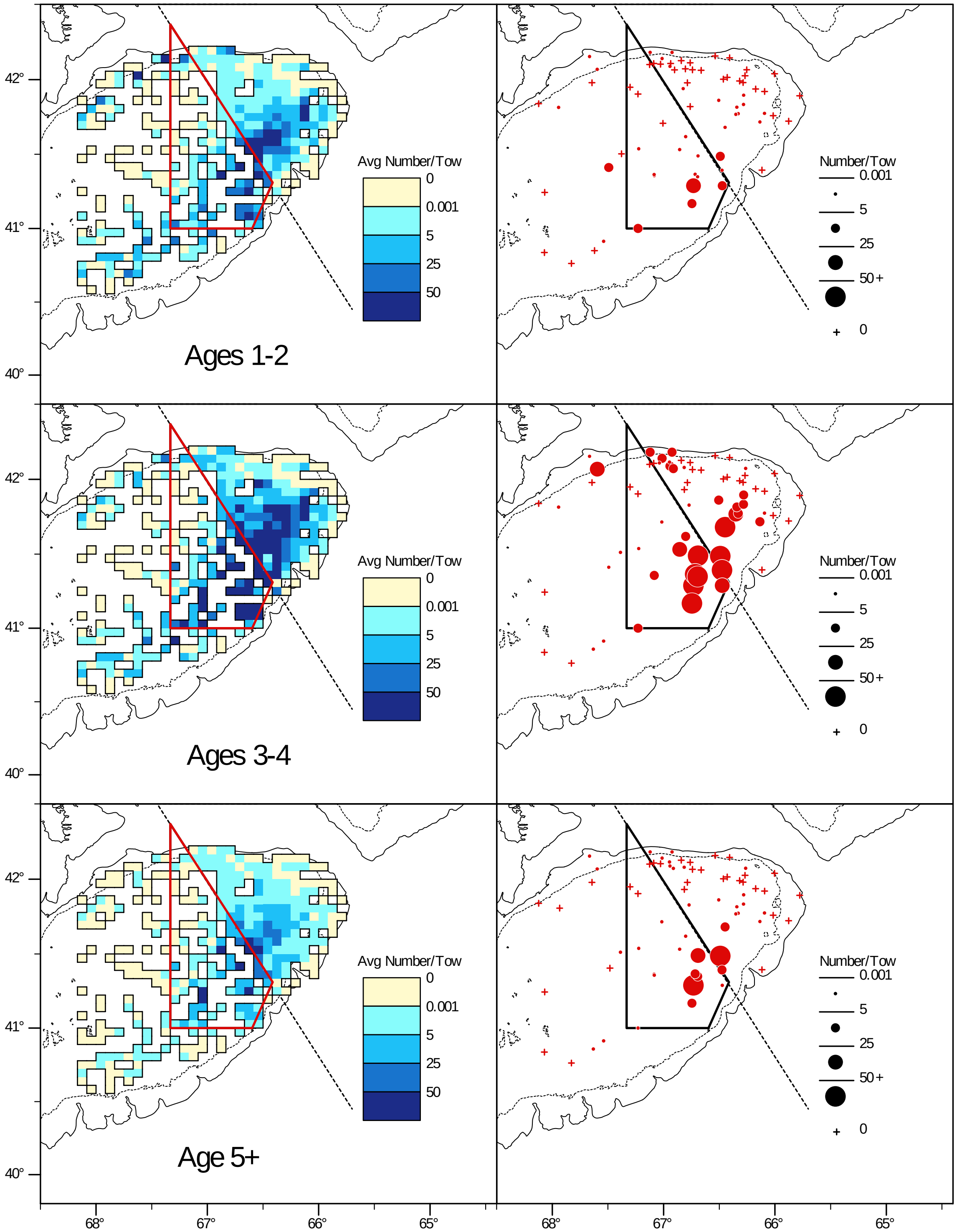



Fig. 29. The distribution of catches (#/tow) of yellowtail flounder (solid circles) in the 2005 DFO survey, compared with the average distribution for 1995-2004 (3x5 minute shaded rectangles) for ages 1-2, 3-4 and 5+. The boundary of Closed Area II is shown in red (left side) and black (right side).

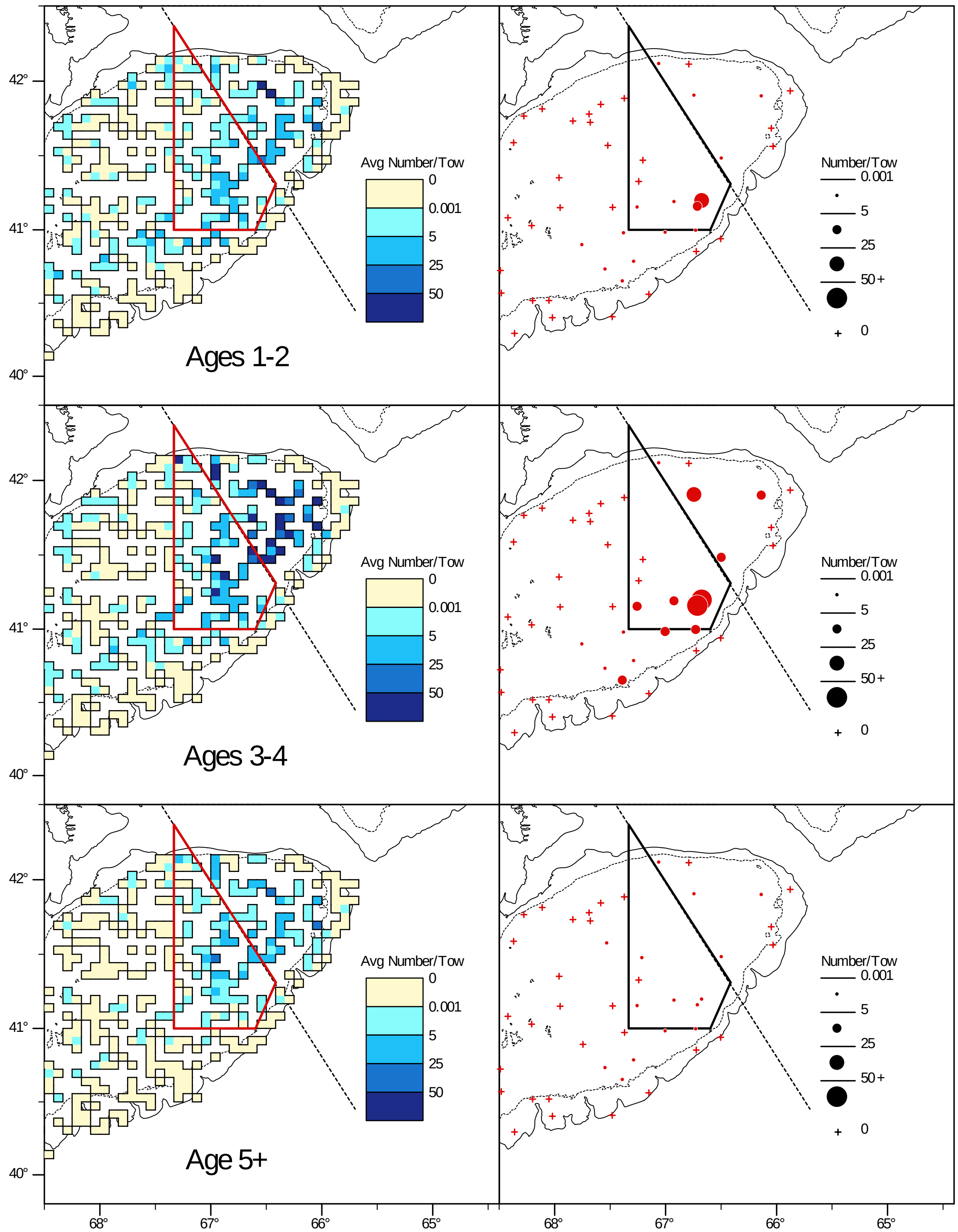



Fig. 30. The distribution of catches (#/tow) of yellowtail flounder (solid circles) in the 2005 NMFS spring survey, compared with the average distribution for 1995-2004 (3x5 minute shaded rectangles) for ages 1-2, 3-4 and 5+. The boundary of Closed Area II is shown in red (left side) and black (right side).

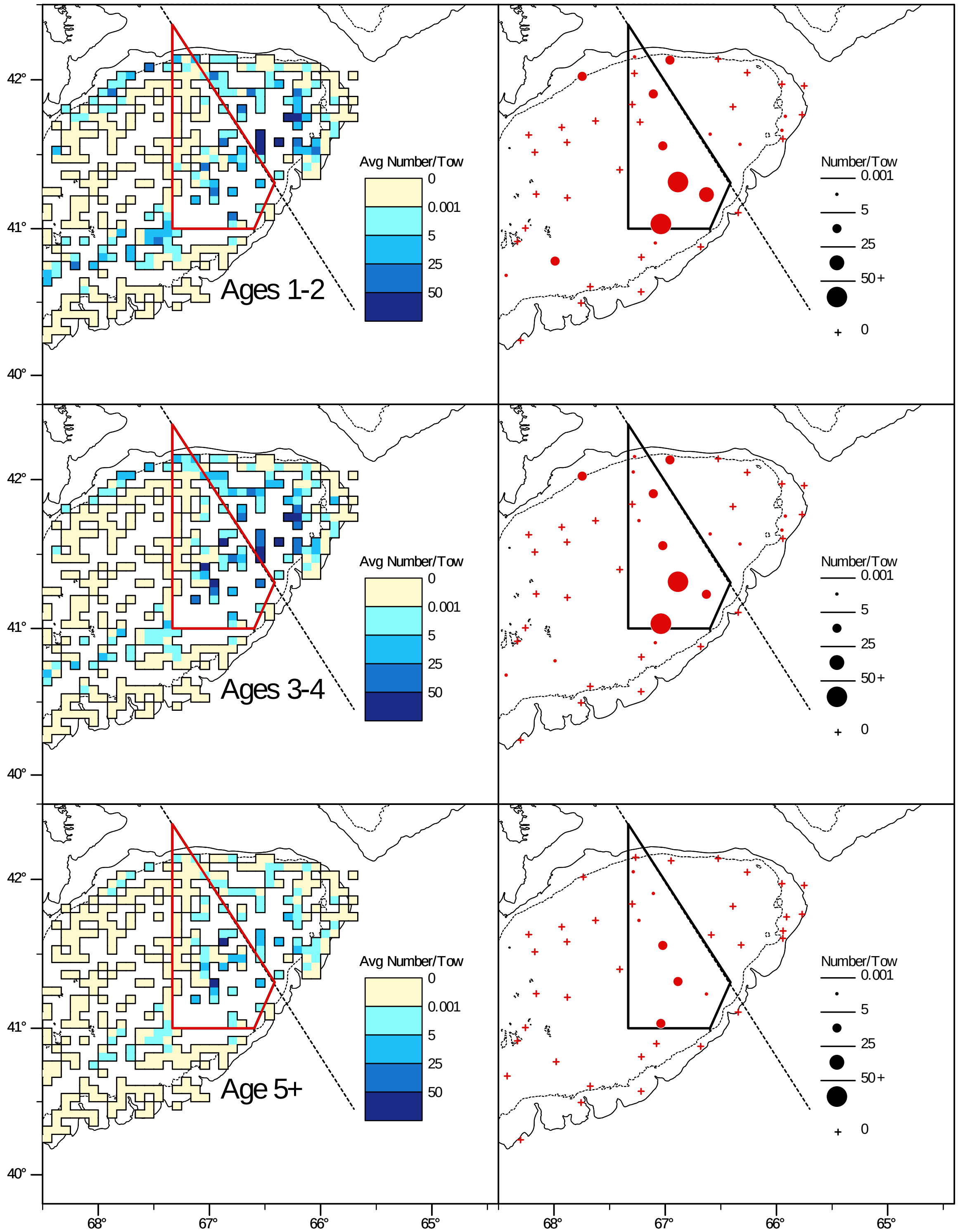



Fig. 31. The distribution of catches (#/tow) of yellowtail flounder (solid circles) in the 2005 NMFS fall survey, compared with the average distribution for 1995-2004 (3x5 minute shaded rectangles) for ages 1-2, 3-4 and 5+. The boundary of Closed Area II is shown in red (left side) and black (right side).

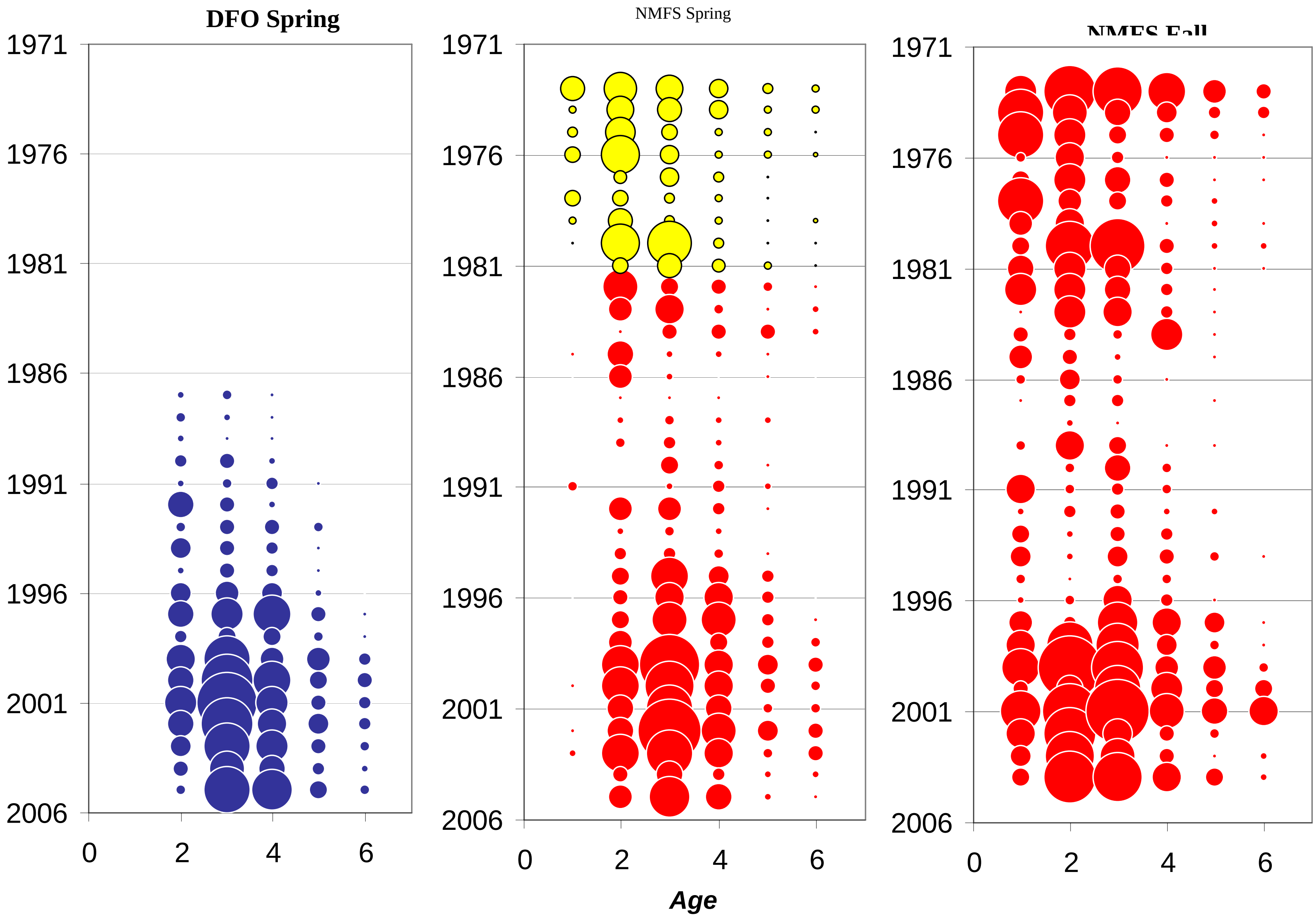



Fig. 32. Age specific indices of abundance for the DFO spring (1987-2005), NMFS spring (1968-2005), and NMFS fall (1963-2004) surveys (bubble is proportional to the magnitude) The yellow symbols in the NMFS spring series denote the period when the Yankee 41 net was used. Refer to Tables 8, 9 and 10 for the absolute value of the indices.

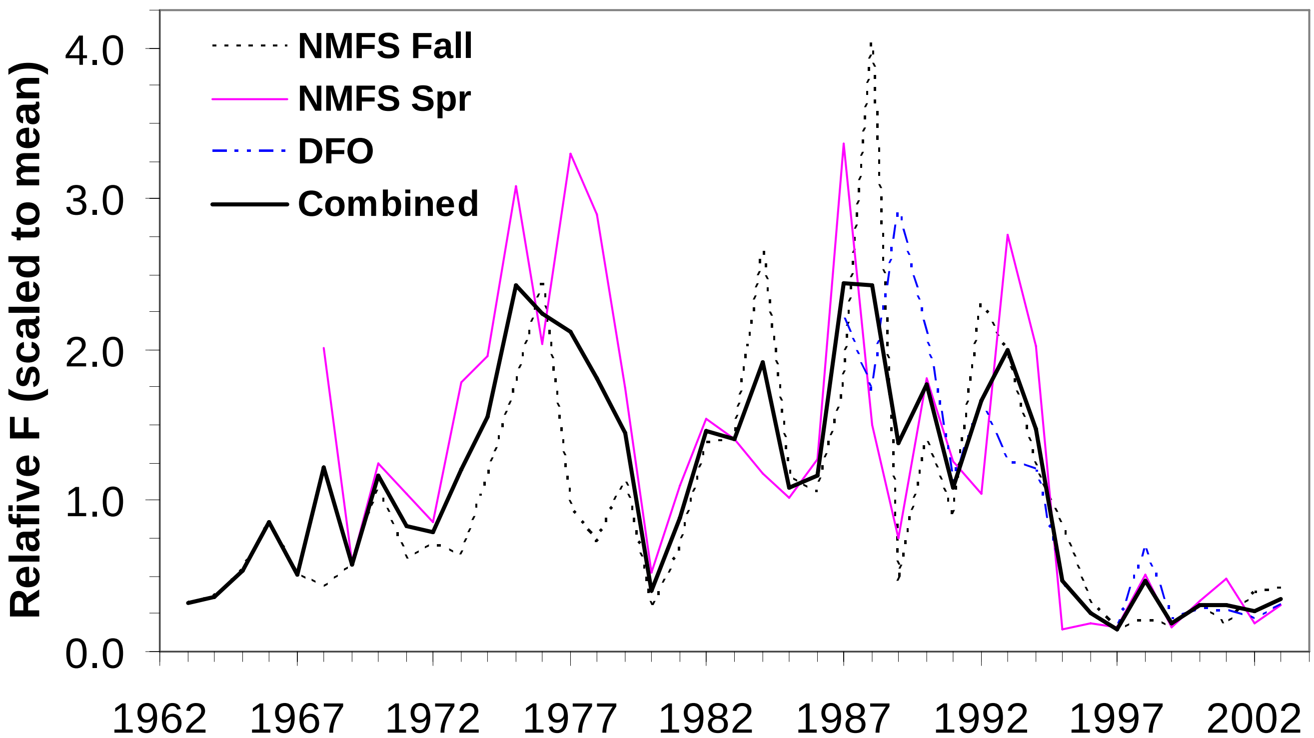



Fig. 33. Trends in relative fishing mortality (catch biomass/survey biomass), standardized to the mean for 1987-2004.

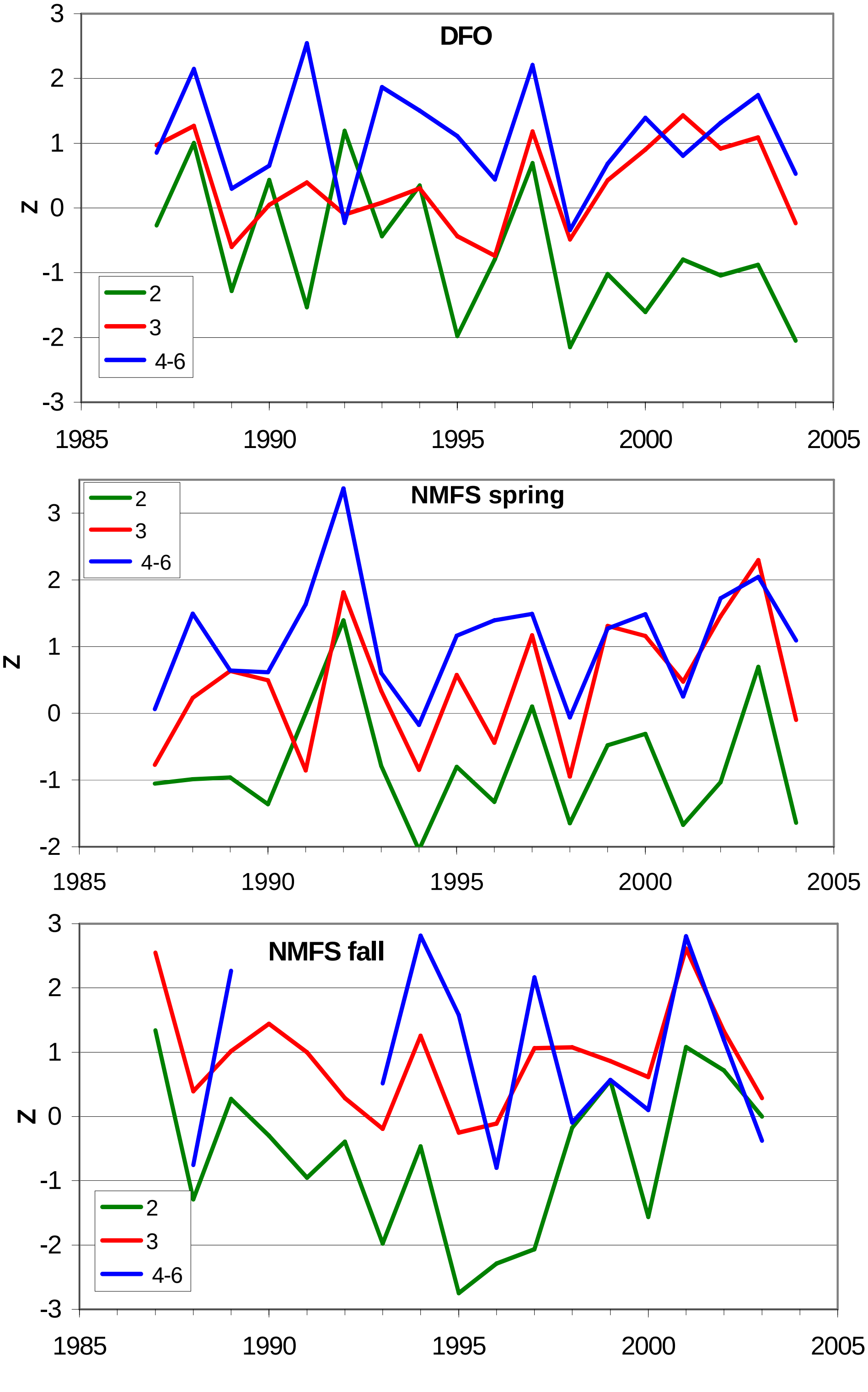



Fig. 34. Trends in total mortality (Z) for ages 2, 3, and 4-6 from DFO, NMFS Spring and NMFS Fall bottom trawl surveys, 1987-2003/2004.

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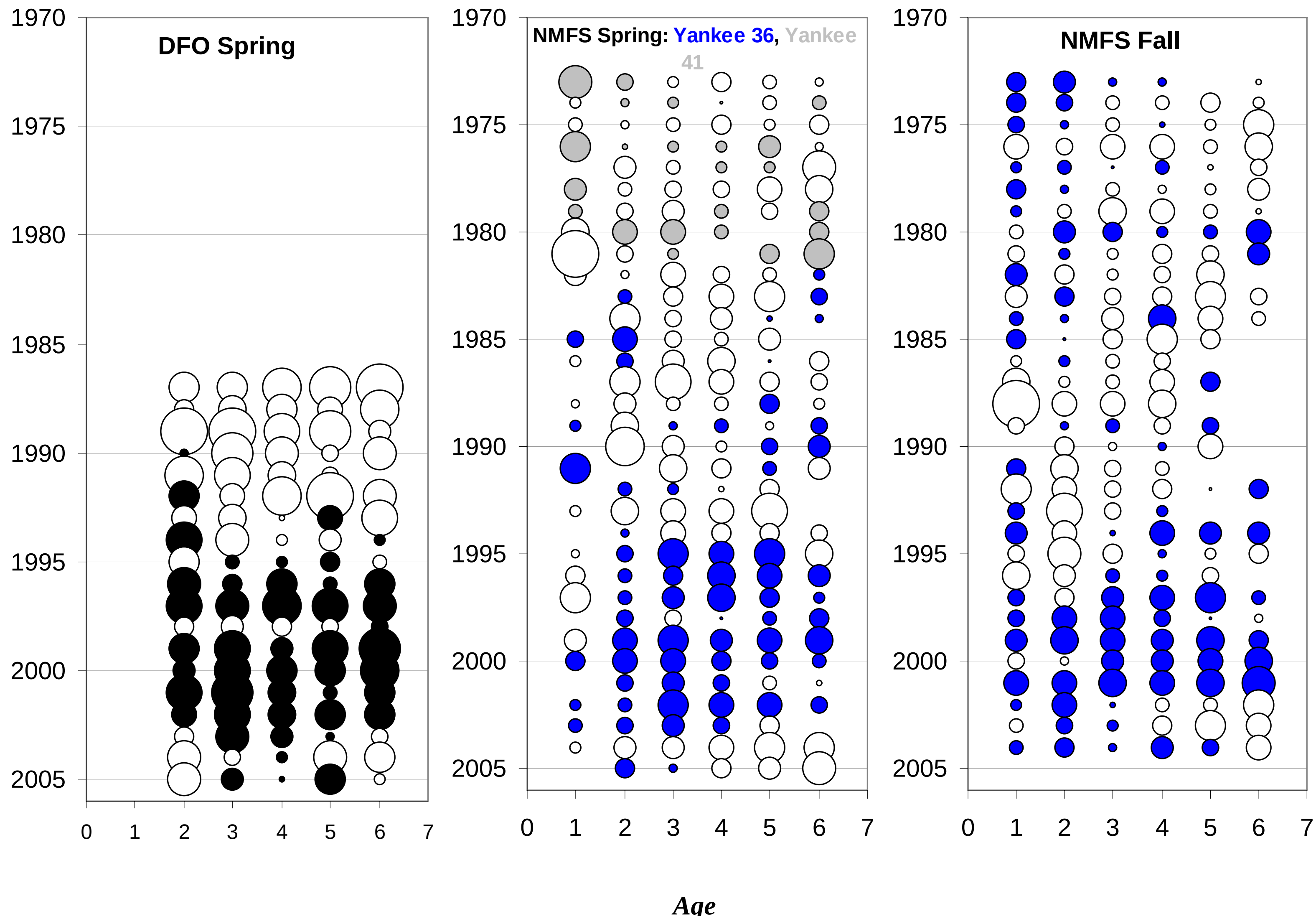



Fig. 35. Age by age residuals from the Base VPA model formulation for the relationships between *ln* abundance index versus *ln* population numbers, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The grey shaded symbols in the NMFS spring series denote the period when the Yankee 41 net was used. The open symbols denote negative residuals, and closed symbols denote positive residuals.

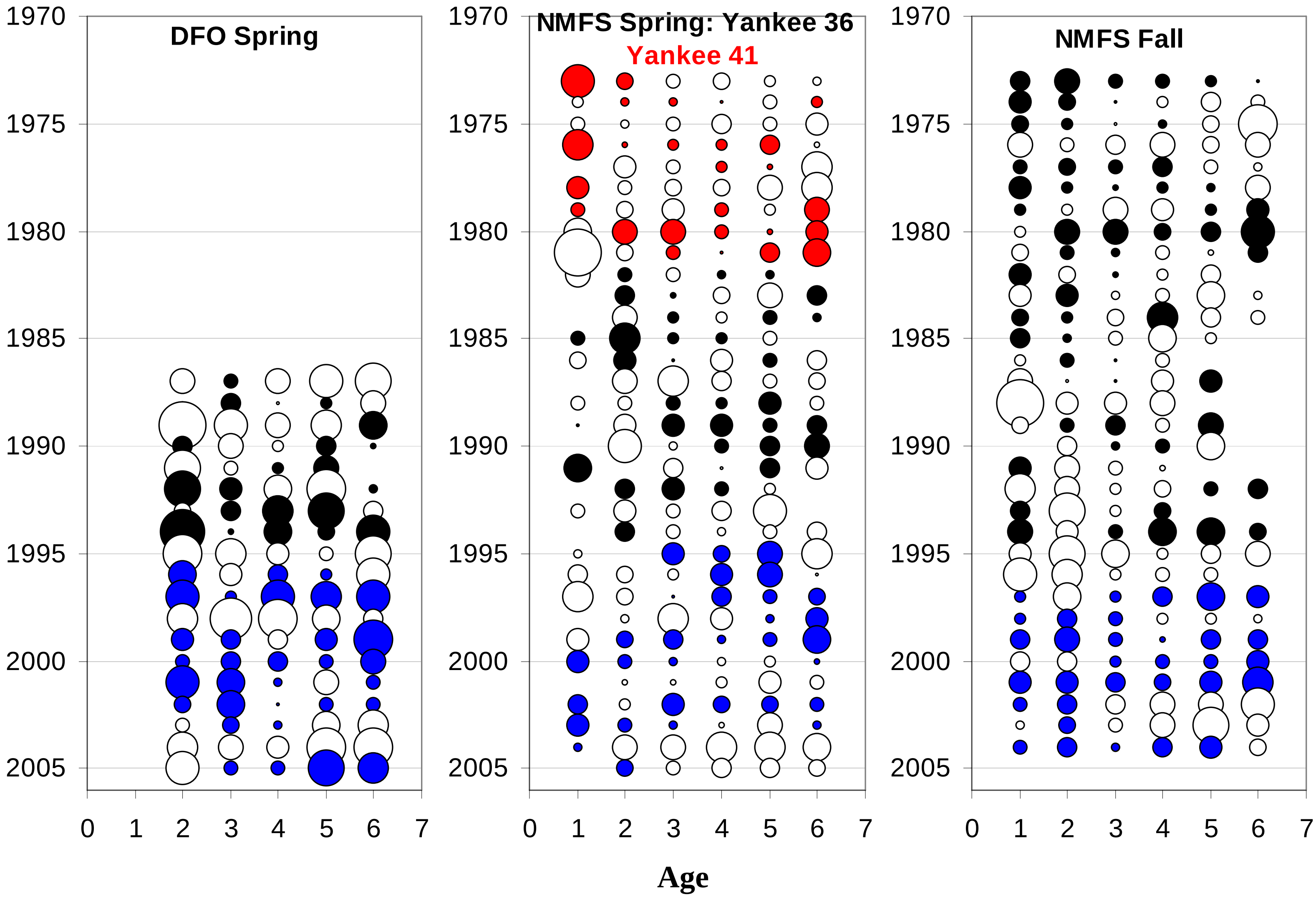



Fig. 36. Age by age residuals from the major change VPA formulation for the relationships between *ln* abundance index versus *ln* population numbers, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The red shaded symbols in the NMFS spring series denote the period when the Yankee 41 net was used. The open symbols denote negative residuals, and closed symbols denote positive residuals.

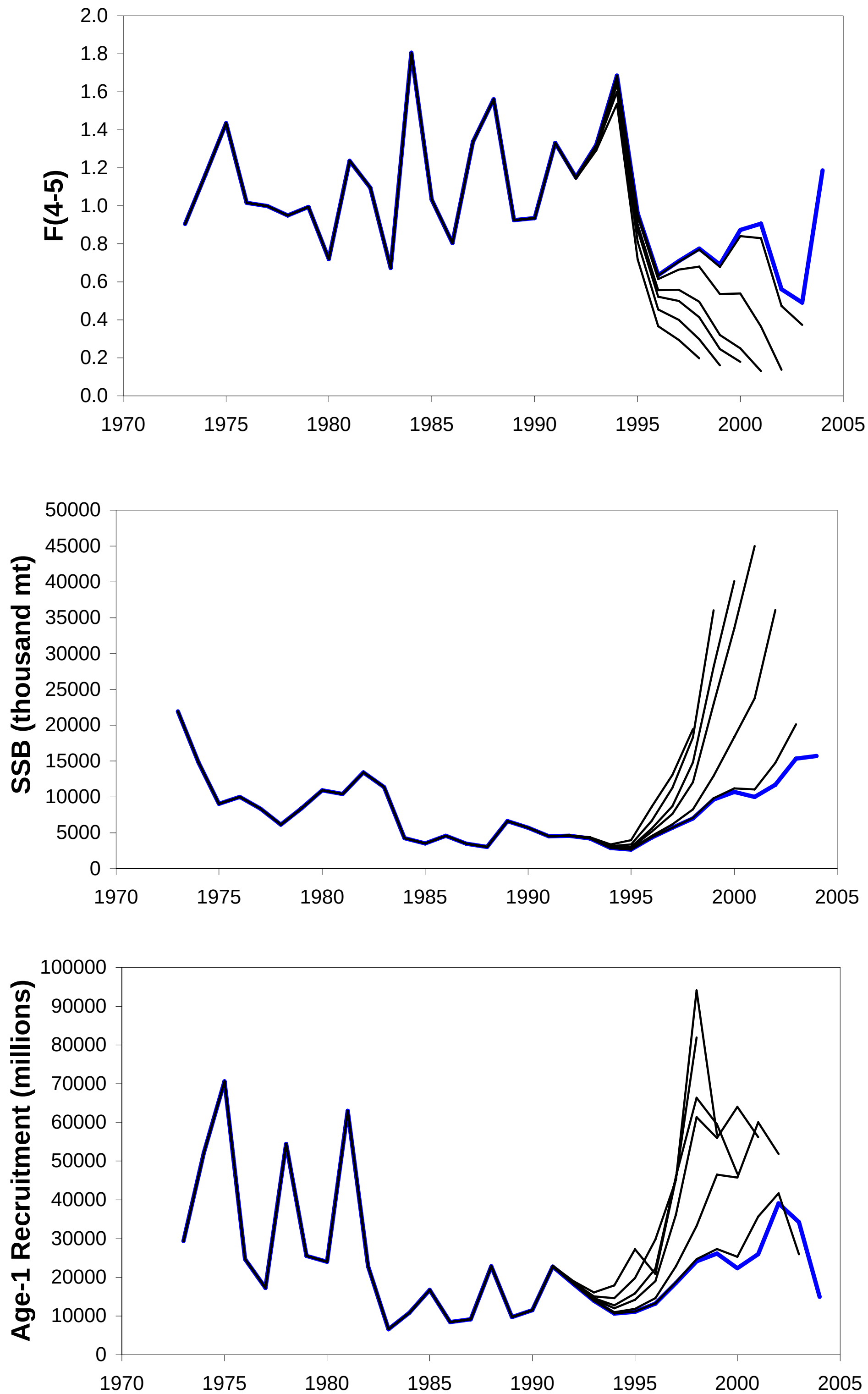



Fig. 37. Retrospective analysis of Georges Bank yellowtail flounder from the BaseVPA for age 4-5 fishing mortality (top panel), age 3+ biomass (middle panel) and age 1 recruits (lower panel) based on US NFT ADAPT software results.

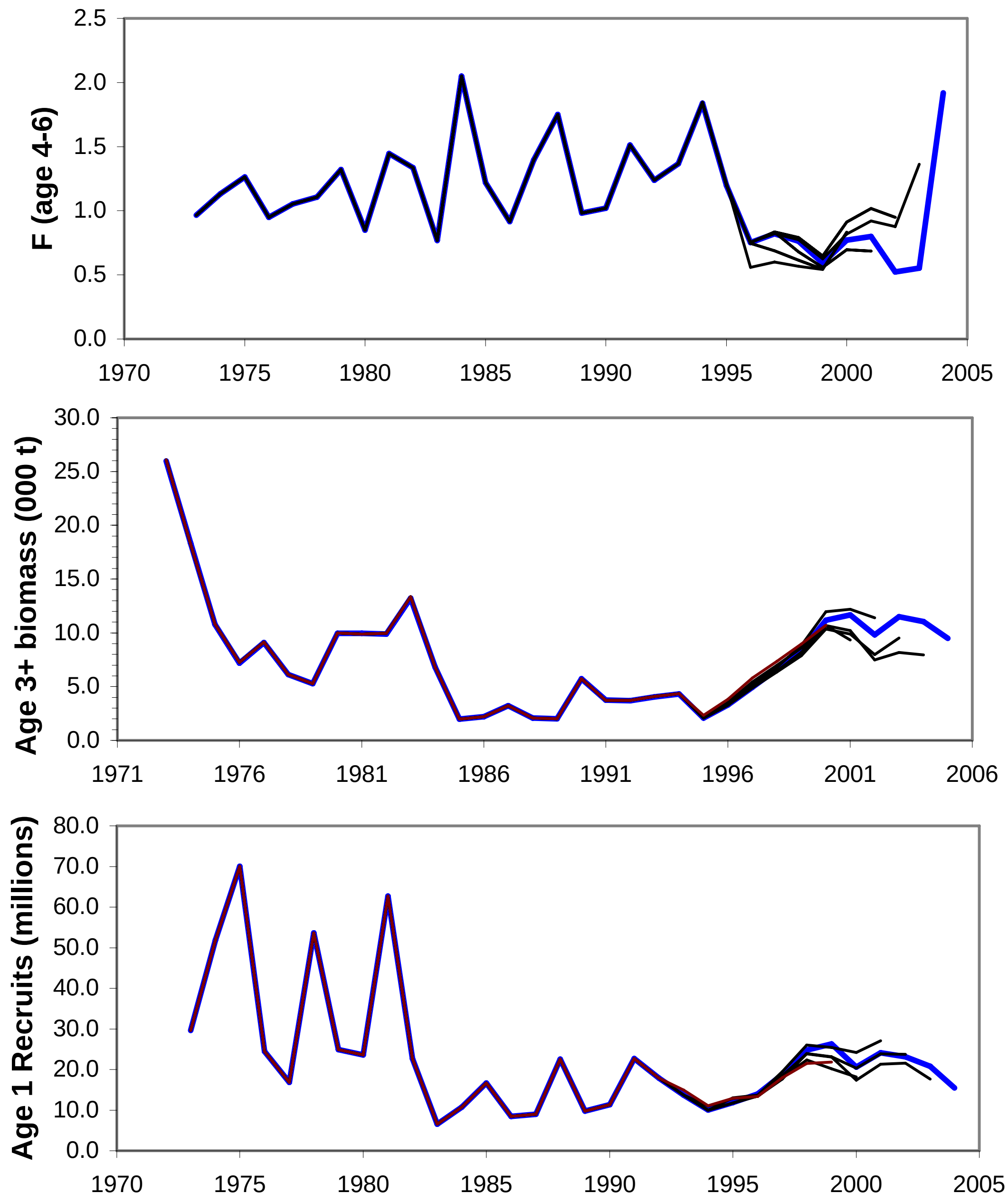



Fig. 38. Retrospective analysis of Georges Bank yellowtail flounder from the Major Change VPA for age 4-6 fishing mortality (top panel), age 3+ biomass (middle panel) and age 1 recruits (lower panel) based on Canadian ADAPT software results.

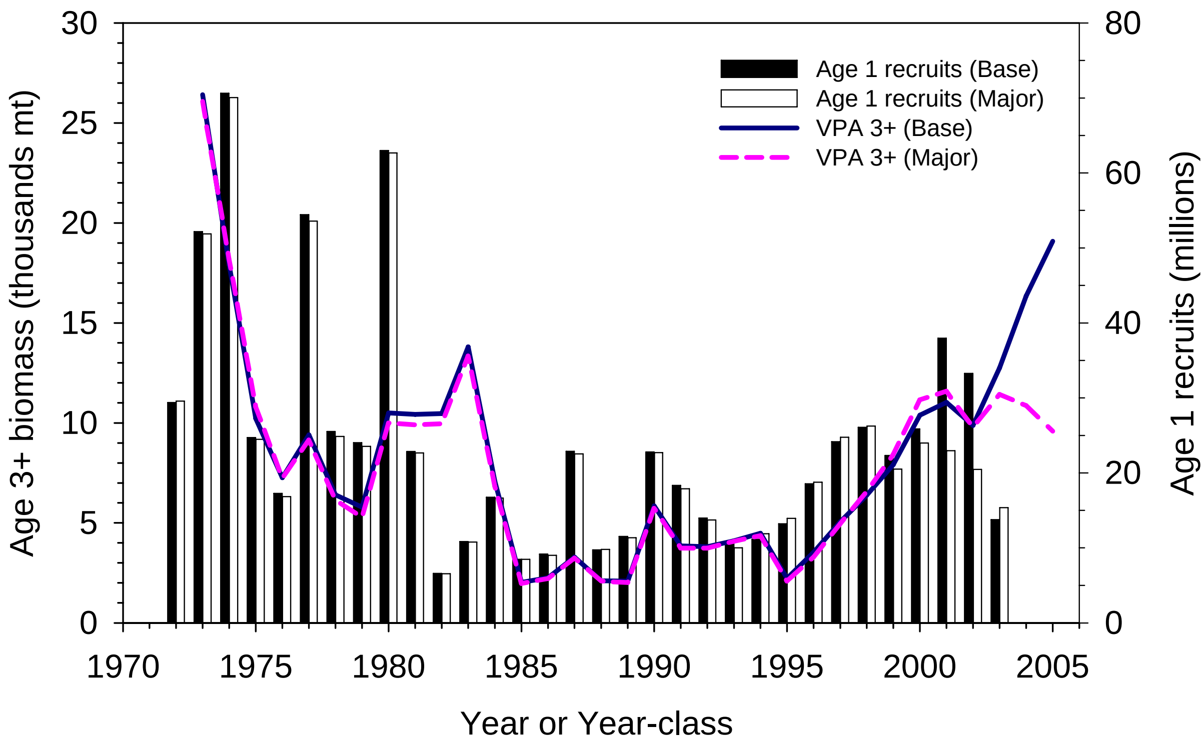
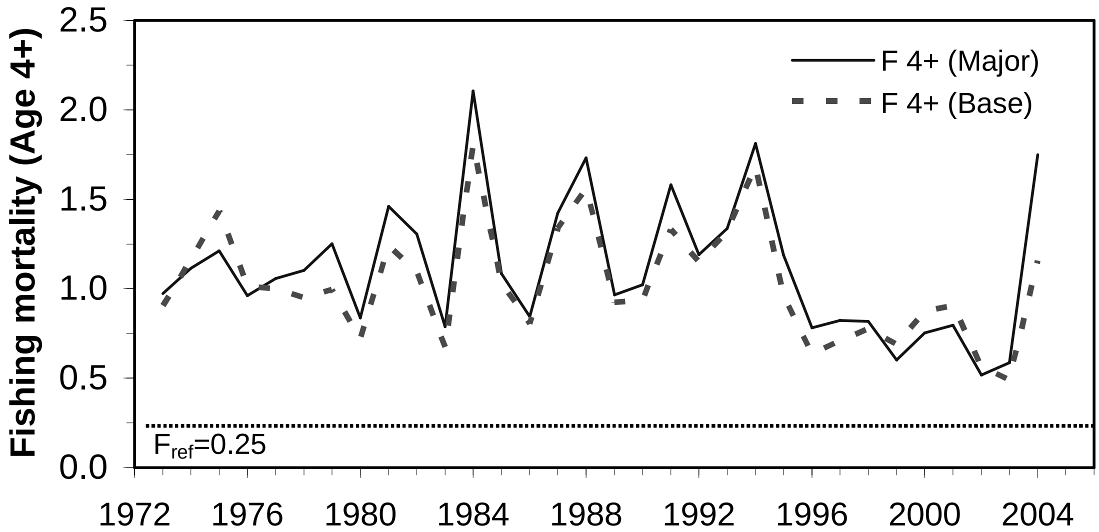



Fig. 39. Trends in and adult (age 3+) beginning of year biomass (000s) and age 1 recruits for Georges Bank yellowtail flounder as indicated from the Canadian ADAPT Base and Major Change VPA model formulations.



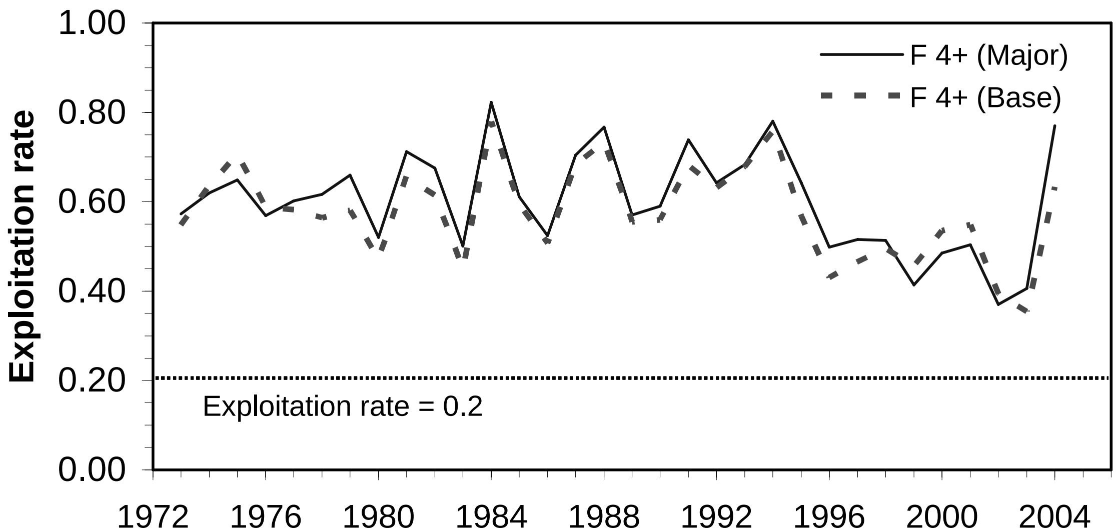




Fig. 40. Trends in fully recruited (age 4+) fishing mortality (upper panel) and exploitation rate (lower panel) for Georges Bank yellowtail flounder as indicated from the Canadian ADAPT Base and Major Change VPA model formulations.

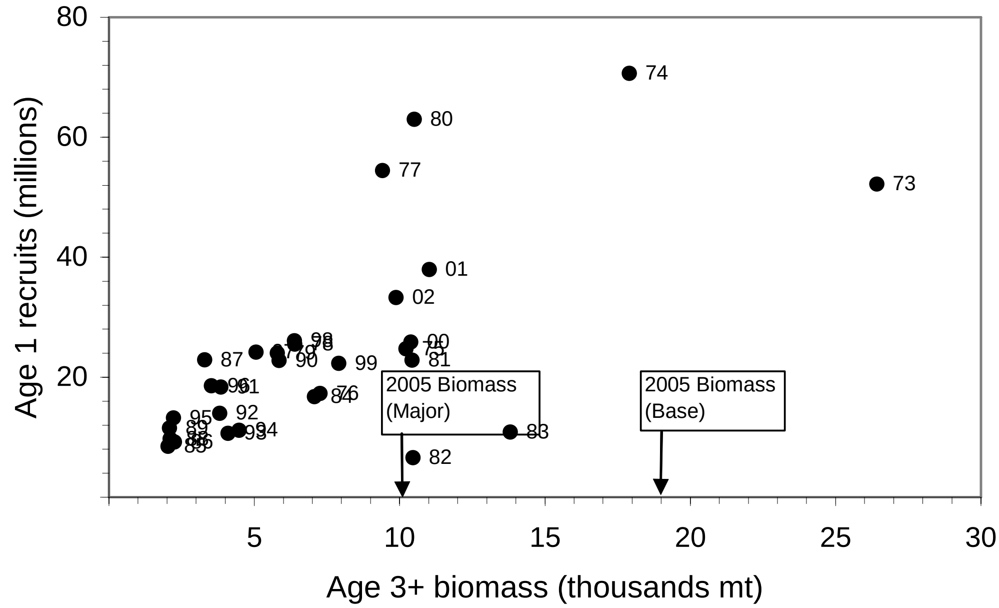



Fig. 41. Age 3+ biomass and age 1 recruitment relationship for Georges Bank yellowtail flounder from the Base VPA formulation. The beginning of year age 3+ biomass for 2005 from the Base VPA and Major Change VPA is also shown.

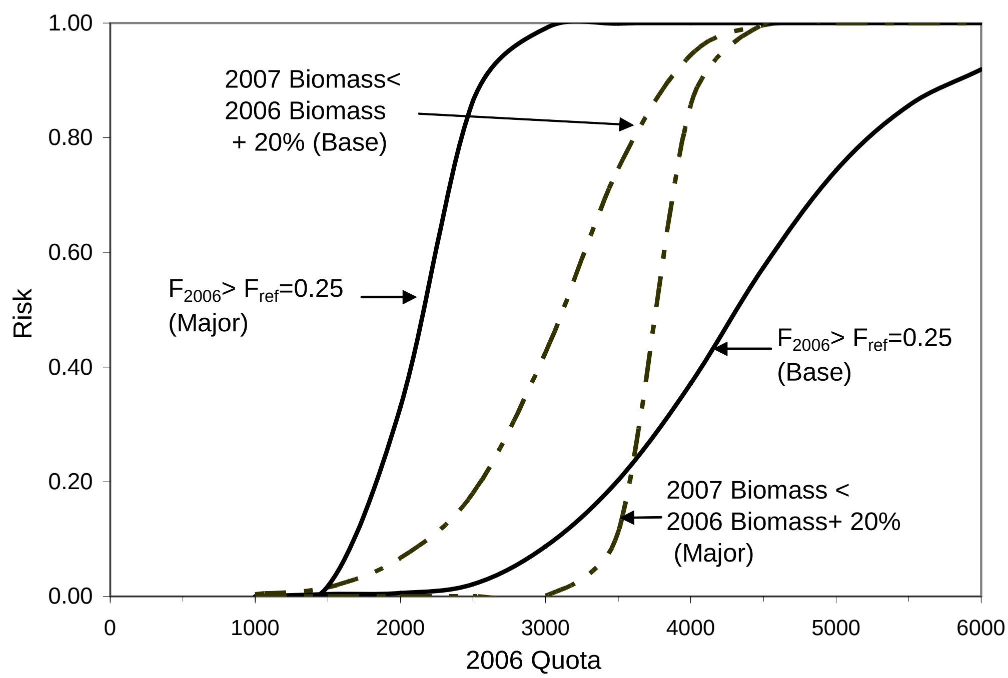



Fig. 42. Risk of exceeding $F_{ref}$ fishing mortality or not achieving increments of age 1+ population biomass growth from the Base VPA and Major Change VPA model formulations, at various quotas for the 2006 fishery for Georges Bank yellowtail flounder.

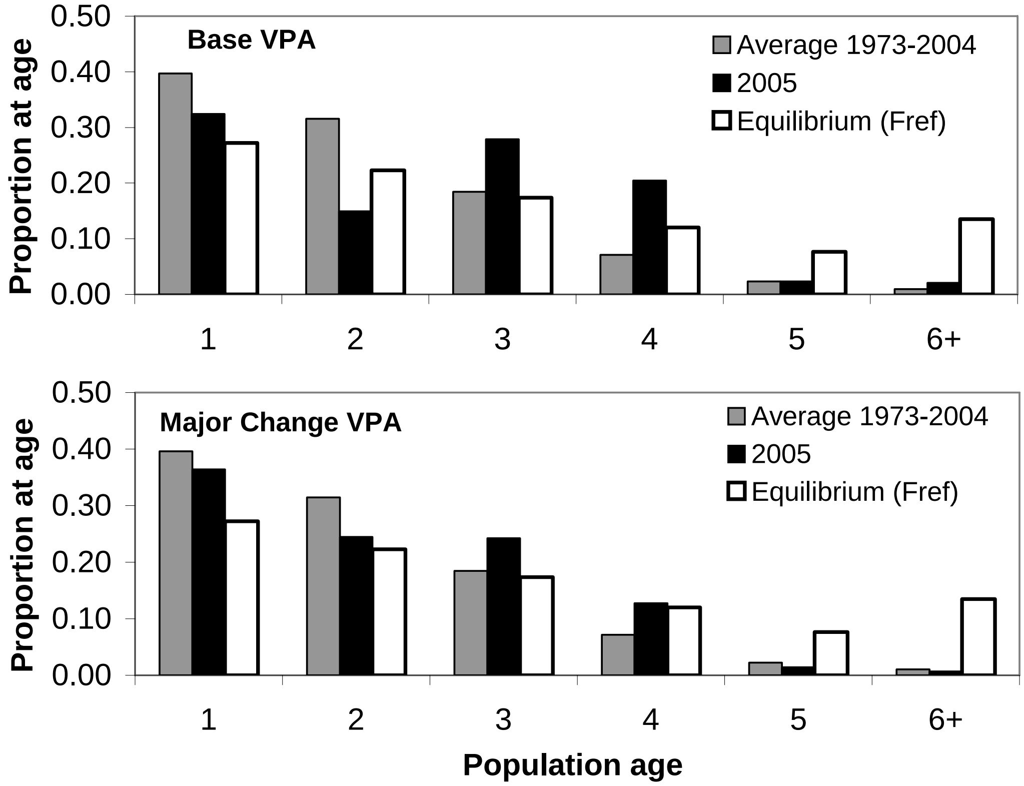



Fig. 43. Proportions at age for the Georges Bank yellowtail flounder population in 2005, for the average of 1973-2004 and when the population is at equilibrium, based on results from the Base VPA (upper panel) and Major Change VPA (lower panel).