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Winter flounder

by

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Distribution, Biology and Management

The winter flounder, blackback, or lemon sole, *Pseudopleuronectes americanus*, is a demersal flatfish distributed in the Northwest Atlantic from Labrador to Georgia. Important U.S. commercial and recreational fisheries exist from the Gulf of Maine to the the Mid-Atlantic Bight. In USA waters, the resource is assessed and managed as three stocks: Gulf of Maine, Southern New England/Mid-Atlantic Bight (SNE/MAB), and Georges Bank (Figure 11.1). Winter flounder generally occur in inshore bays and estuaries during the winter, and move to deeper water in the summer. Spawning occurs during the winter and spring months (Pereira et al. 1999). Growth and maturity vary by stock; Georges Bank fish have the fastest growth and reach the largest size, and reach maturity at the earliest age and smallest size. Gulf of Maine fish grow the slowest and reach the smallest size, and reach maturity at the oldest age and largest size (O'Brien et al. 1993). Winter flounder may grow up to 58 cm in total length and attain 15-20 years of age (Pentilla et al. 1989, Pereira et al. 1999).

U.S. commercial and recreational fisheries for winter flounder are managed in federal waters under the New England Fishery Management Council's Northeast Multispecies Fishery Management Plan (FMP), and in state waters under Atlantic States Marine Fisheries Commission's Fishery Management Plan for Inshore Stocks of Winter Flounder. FMP provisions include restrictions on commercial permits, limits on commercial fishery days-at-sea, commercial and recreational fishery time-area closures, commercial fishery mesh sizes, commercial and recreational fishery fish size limits, and commercial and recreational fishery possession limits. The information provided herein reflects the results of the most recent peer-reviewed assessments for the Gulf of Maine, Georges Bank, and Southern New England winter flounder stocks (Mayo and Terceiro 2005).

GULF OF MAINE WINTER FLOUNDER

The Fishery

Commercial landings from the Gulf of Maine (GOM) winter flounder stock increased from an annual average of about 1,000 mt during 1964 to 1975 to nearly 3,000 mt in 1982 (Figure 11.2). Commercial landings have since declined to 300 mt in 2005. Otter trawls accounted for about 95% of the GOM commercial winter flounder landings during 1964-1985, but their percentage declined to 75% between 1986 and 2001 because of increased landings from gillnets (average of 20% from 1986-2001). Since 2001, gillnets have accounted for 15% of the landings. The recreational rod-and-reel fishery historically harvested a significant proportion of the total landings, but recreational catches have sharply declined over the last decade from over 2,500 mt in the early 1980s to less than 100 mt during 1997-2005 (Table 11.1).

GOM winter flounder landings in numbers have generally been dominated by age 3-5 fish (Figure 11.3). The proportion of ages 2 and 3 winter flounder in the commercial and recreational landings has been greatly reduced by the effects of increasing minimum landing sizes and increasing minimum trawl mesh size in the commercial fishery since the late-1990s.

Research Vessel Survey Indices

Bottom trawl survey biomass indices from the Massachusetts Division of Marine Fisheries (MADMF) spring and fall surveys declined after 1983. The fall survey attained a record low in 1986 while the spring reached a record-low in 1994. Between 1996 and 2000, both survey indices increased. The 2000 spring index was the highest on record and the 2000 fall index was the 2nd highest in the 28-year time series (Figure 11.4). However, subsequently the indices have declined. As stock biomass declined in the late 1980s, the age structure of the winter flounder population became truncated, with a low proportion of fish at ages 5 and older (Figure 11.5). The age structure has expanded slightly since the mid 1990s.

Assessment Results

The assessment for GOM winter flounder was last updated at the Groundfish Assessment Review Meeting (GARM) in 2005 (NEFSC 2005). Average fishing mortality (ages 5-6, unweighted) varied between 0.5 and 2.1 during the 1980s and mid 1990s, but declined to a record low of 0.13 in 2004 (Figures 11.6). Spawning stock biomass declined from 4,800 mt in 1982 to 500 mt in 1996 and then increased to 3,400 mt by 2004 (Figure 11.7). Recruitment at age 1 declined from 12 million fish in 1982 to 3 million fish in 1993, (Figure 11.7) but has since increased to 18 million in 2005. Over the 1982-2004 time period, geometric mean recruitment was 5 million fish.

Biological Reference Points

Biological reference points (Figure 11.8) were last reviewed by SARC 36 (NEFSC 2002) and the values are presented in Table 11.2. The relationship between spawning stock biomass and recruitment for winter flounder over the period covering the 1982-2004 year classes is illustrated in Figure 11.9. The stock-recruitment trajectory suggests that increases in recent SSB have been accompanied by improvement in recruitment. The solid horizontal line indicates the geometric mean recruitment over the same period. Survival ratios, recruits per unit of spawning biomass (Figure 11.10), illustrate a general increasing trend in the survival rate over time.

Summary

Spawning stock biomass in 2004 was 3,400 mt or about 84% of $B_{MSY} = 4,100$ mt. Fishing mortality in 2004 was 0.13 or about 30% of $F_{MSY} = 0.43$. Thus, the stock is not in a overfished condition and overfishing is not occurring.

Table 11.1 Recreational and commercial landings of GOM winter flounder (thousand metric tons).

Category	1986-95 Average	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
U. S. Recreational	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	1.0	0.6	0.6	0.6	0.3	0.4	0.6	0.6	0.7	0.5	0.3
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total Nominal Catch	1.4	0.6	0.6	0.6	0.3	0.4	0.6	0.6	0.7	0.5	0.3

Table 11.2 Yield and SSB per Recruit and MSY Based Reference Points for GOM winter flounder.

Yield and SSB per Recruit-based Reference Points

$$F_{0.1} = 0.26$$

$$F_{max} = 0.69$$

$$F_{40\%} = 0.26$$

MSY-based Reference Points

$$F_{MSY} = 0.43$$

$$MSY = 1,500 \text{ mt}$$

$$B_{MSY} = 4,100 \text{ mt}$$

GEORGES BANK WINTER FLOUNDER

The Fishery

Commercial landings of Georges Bank winter flounder are predominately from U.S. fisheries, but a small percentage (< 12% during most years) is from Canadian fisheries (Table 11.3, Figure 11.11). Canadian landings gradually increased after 1993, reached a peak of 500 mt in 2001, and subsequently declined to 200 mt in 2004. During 1965-1977, the USSR also landed winter flounder from Georges Bank, with Soviet landings accounting for 23% to 38% of the total harvest during 1971-1973. Recreational landings of winter flounder from Georges Bank are insignificant.

After reaching a peak of 4,500 mt in 1972, total landings of Georges Bank winter flounder declined to 1,900 mt in 1976. During 1977-1984, total landings ranged between 3,000 and 4,000 mt, but thereafter declined to a record low (800 mt) in 1995. Total landings increased between 1995 and 2003 then declined to 2,200 mt in 2005.

Discarding of Georges Bank winter flounder occurs in the Northeast multispecies bottom trawl fishery and the sea scallop dredge fishery. However, data from the Fisheries Observer Program and Vessel Trip Report databases have been insufficient to produce reliable estimates of the magnitude or size and age composition of these discards (NEFSC 2002a).

Research Vessel Survey Indices

Autumn relative abundance and biomass indices declined between 1976 and 1991 to reach a record low (Figure 11.12). Thereafter, biomass increased through 2002, then declined to a level near the time series average in 2005.

Assessment Results

The assessment of Georges Bank winter flounder was last updated in 2005 using a surplus production model (Mayo and Terceiro 2005). Model estimates of relative total biomass (B_t/B_{MSY}) and fishing mortality rates (F_t/F_{MSY}) are utilized because they more precisely estimated than absolute values (Prager 1994).

Relative fishing mortality rates (F_t/F_{MSY}) were highest during 1983-1993, declined sharply during 1996-1999, but have since increased to above F_{MSY} during 2000-2004 (Figure 11.13). During 1977-1994, relative biomass indices consistently declined reaching a record low in 1994. Subsequently, relative biomass increased through 2003, but has since declined to a level just below the threshold in 2005 (Figure 11.13).

Biological Reference Points

MSY-based reference points for Georges Bank winter flounder (Table 11.4) were estimated in the 2001 assessment using a surplus production model (NEFSC 2002a) and the reference points implemented in May of 2004 (NEFMC 2003). The MSY estimate (3,000 mt) does not include discards. $F_{MSY} = 0.32$ and $B_{MSY} = 9,400$ mt. Stock status is determined by comparing relative estimates of biomass and fishing mortality with a relative biomass threshold (50% of B_{MSY}) of 0.5 and a relative fishing mortality rate threshold (F_{MSY}) of 1.0 because these relative metrics are more precise than the absolute estimates of fishing mortality rate and biomass (Mayo and Terceiro 2005).

Summary

Relative fishing mortality has exceeded F_{MSY} since 2000 and was 1.86 in 2004. Relative biomass exceeded the threshold level in 2004 but declined below the threshold, to 0.46, in 2005. Therefore, in 2004, the stock was not overfished but overfishing was occurring (Mayo and Terceiro 2005).

Table 11.3 Recreational and commercial landings of Georges Bank winter flounder (thousand metric tons).

Category	1986-95 Average	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
U. S. Recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	1.9	1.3	1.3	1.2	0.9	1.7	1.6	2.1	2.8	2.9	2.1
Canada	<0.1	0.1	0.1	0.1	0.1	0.2	0.5	0.2	0.3	0.2	0.1
Other	-	-	-	-	-	-	-	-	-	-	-
Total Nominal Catch	1.9	1.4	1.4	1.3	1.0	1.9	2.1	2.3	3.1	3.1	2.2

Table 11.4 MSY-based reference points for Georges Bank winter flounder.

MSY-based Reference Points

MSY	=	3,000 mt
B _{MSY}	=	9,400 mt
F _{MSY}	=	0.32

SOUTHERN NEW ENGLAND/MID-ATLANTIC BIGHT WINTER FLOUNDER

The Fishery

U.S. commercial landings of SNE/MAB winter flounder peaked at 12,000 mt in 1966, declined through the 1970s, and then peaked again at over 11,000 mt in 1981 (Figure 11.14). Commercial landings subsequently declined during the 1980s and early 1990s, falling to 2,200 mt in 1994. Commercial landings then increased to 4,700 mt in 2001 but have since declined to 1,200 mt in 2005, a record low (Table 11.5, Figure 11.14). The principal gear used in the SNE/MAB winter flounder fishery is the otter trawl. The recreational rod-and-reel fishery for winter flounder historically harvested a significant proportion of the total catch, but recreational landings have markedly declined during the last decade. After peaking at 5,800 mt in 1984, recreational landings of winter flounder averaged 1,600 mt annually during 1986-1995, but have since declined to 120 mt in 2005 (Table 11.5).

SNE/MAB winter flounder landings in numbers have generally been dominated by age 2-4 fish (Figure 11.15). Since the mid-1990s, the proportion of ages 1 and 2 fish in the commercial and recreational landings has been greatly reduced by the effects of increasing minimum landed sizes and increases in the minimum trawl mesh size in the commercial fishery.

Research Vessel Survey Indices

NEFSC spring and autumn biomass indices for SNE/MAB winter flounder indicate peaks in abundance during the mid-1960s, early 1980s, and late 1990s, and have exhibited a declining

trend since 1999 (Figure 11.16). As stock biomass declined, the age structure of the winter flounder population became truncated, with a low proportion of fish at ages 5 and older (Figure 11.17).

Assessment Results

The assessment for SNE/MAB winter flounder was last updated at the Groundfish Assessment Review Meeting (GARM) in 2005 (NEFSC 2005). Average fishing mortality (F, ages 4-5, unweighted) ranged between 0.5 and 1.5 during the 1980s and mid 1990s, but has steadily declined since 1997 and in 2004 was $F = 0.4$, a record low (Figures 11.18). Spawning stock biomass declined from 14,800 mt in 1983 to 2,700 mt in 1994, slowly increased to 5,000 mt in 2001, and has since stabilized at about 4,000 mt (Figure 11.19). Since 1982, recruitment at age 1 has ranged from 57 million fish (1982 year class in 1983) to 4 million fish (2001 year class in 2002) (Figure 11.19). Over the 1982-2004 period, the geometric mean recruitment was 16 million fish.

Biological Reference Points

Biological reference points (Figure 11.20) were last calculated by the 2002 Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002a) and are presented in Table 11.6. The relationship between spawning stock biomass and recruitment for winter flounder over the period covering the 1981-2004 year classes is illustrated in Figure 11.21. The stock-recruitment trajectory shows that recent levels of SSB and recruitment occur on the lower-left side of the plot. The solid horizontal line indicates the geometric mean recruitment (16 million fish at age 1) over the same period. Survival ratios (Figure 11.22), illustrate fluctuating survival over time.

Summary

Spawning stock biomass of SNE/MAB winter flounder in 2004 was 3,900 mt, about 13% of B_{MSY} (30,100 mt). Fishing mortality was 0.40 in 2004, 25% above $F_{MSY} = 0.32$. Thus, the stock in 2004 was in an overfished condition and overfishing continues to occur.

Table 11.5 Recreational and commercial landings of SNE/MAB winter flounder (thousand metric tons).

Category	1986-95 Average	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
U. S. Recreational	1.6	0.7	0.6	0.3	0.3	0.8	0.5	0.3	0.6	0.2	0.1
Commercial											
United States	3.9	2.8	3.4	3.2	3.4	3.8	4.7	3.1	2.4	1.5	1.2
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total Nominal Catch	5.5	3.5	4.0	3.5	3.7	4.6	5.2	3.4	3.0	1.7	1.3

Table 11.6 Yield and SSB per Recruit and MSY Based Reference Points for SNE/MAB winter flounder.

Yield and SSB per Recruit-based Reference Points

$$F_{0.1} = 0.25$$

$$F_{\max} = 0.48$$

$$F_{40\%} = 0.21$$

MSY-based Reference Points

$$F_{\text{MSY}} = 0.32$$

$$\text{MSY} = 10,600 \text{ mt}$$

$$B_{\text{MSY}} = 30,100 \text{ mt}$$

For further information

Mayo, R. K. and M. Terceiro. 2005. Assessment of 19 Northeast groundfish stocks through 2004. 2005 Groundfish Assessment Review Meeting (2005 GARM), Northeast Fisheries Science Center, Woods Hole, Massachusetts, 15-19 August 2005. U.S. Dep. Commer., Northeast Fish. Sci. Cent. Ref. Doc. 05-13, 499 p.

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NEFSC [Northeast Fisheries Science Center]. 2002b. Final Report of the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. Northeast Fish. Sci. Cent. Ref. Doc. 02-04, 249 p.

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O'Brien, L., J. Burnett, and R.K. Mayo. 1993. Maturation of nineteen species of finfish off the northeast coast of the United States, 1985-1990. NOAA Tech. Report. NMFS 113, 66 p.

- Pereira, J.J., R. Goldberg, J.J. Ziskowski, P.L. Berrien, W.W. Morse, and D.L. Johnson. 1999. Essential fish habitat source document: winter flounder, *Pseudopleuronectes americanus*, life history and habitat characteristics. NOAA Tech. Mem. NMFS-NE-138, 39 p.
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- Prager, M. H. 1994. A suite of extensions to a nonequilibrium surplus-production model. Fish. Bull. 92: 374–389.

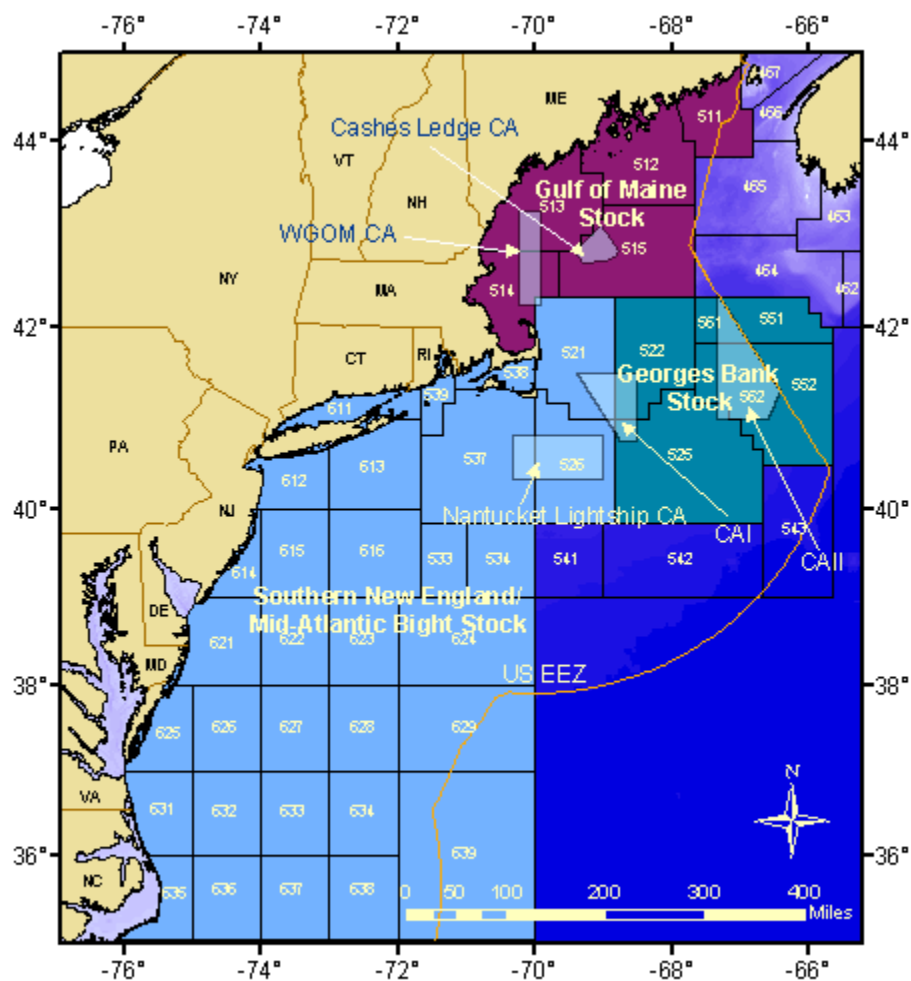


Figure 11.1. Statistical areas used to define the Gulf of Maine, Georges Bank, and Southern New England/Mid-Atlantic Bight winter flounder stocks.

GOM Winter Flounder Commercial Landings

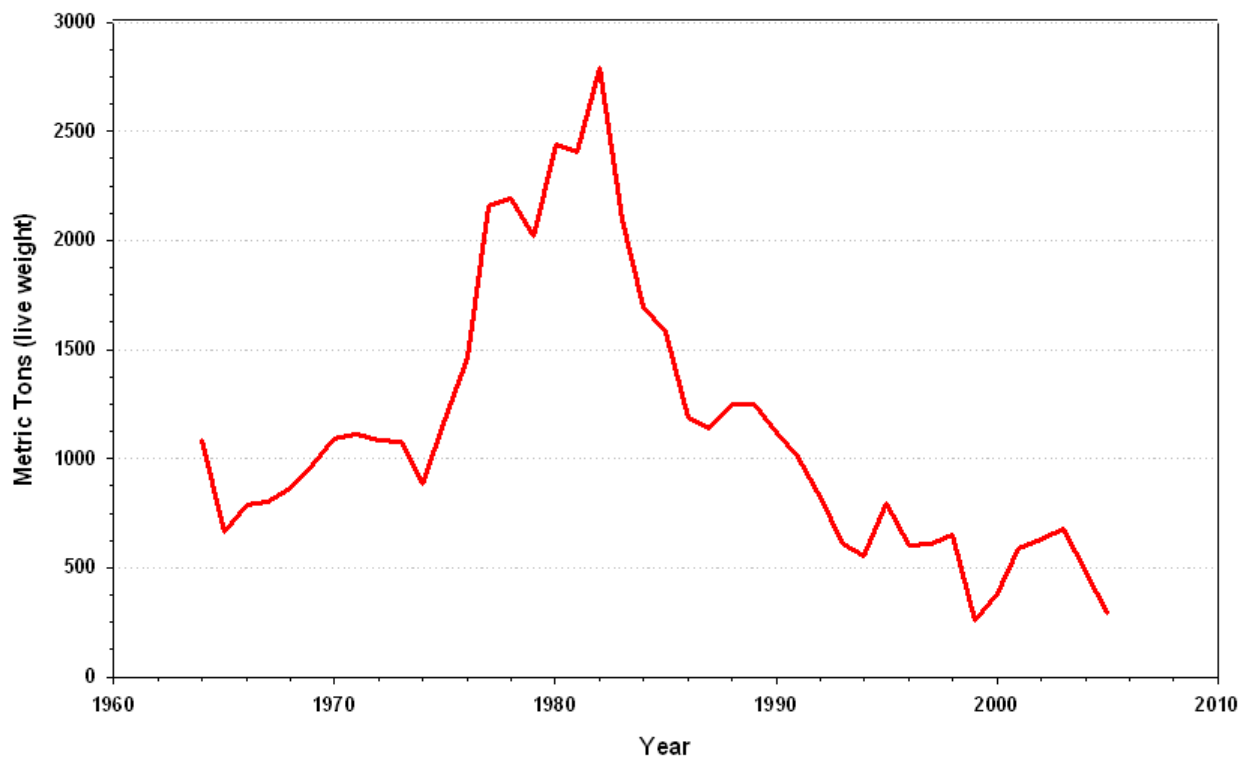


Figure 11.2. Commercial landings of GOM winter flounder, 1964-2005.

GOM Winter Flounder Total Fishery Landings by Age

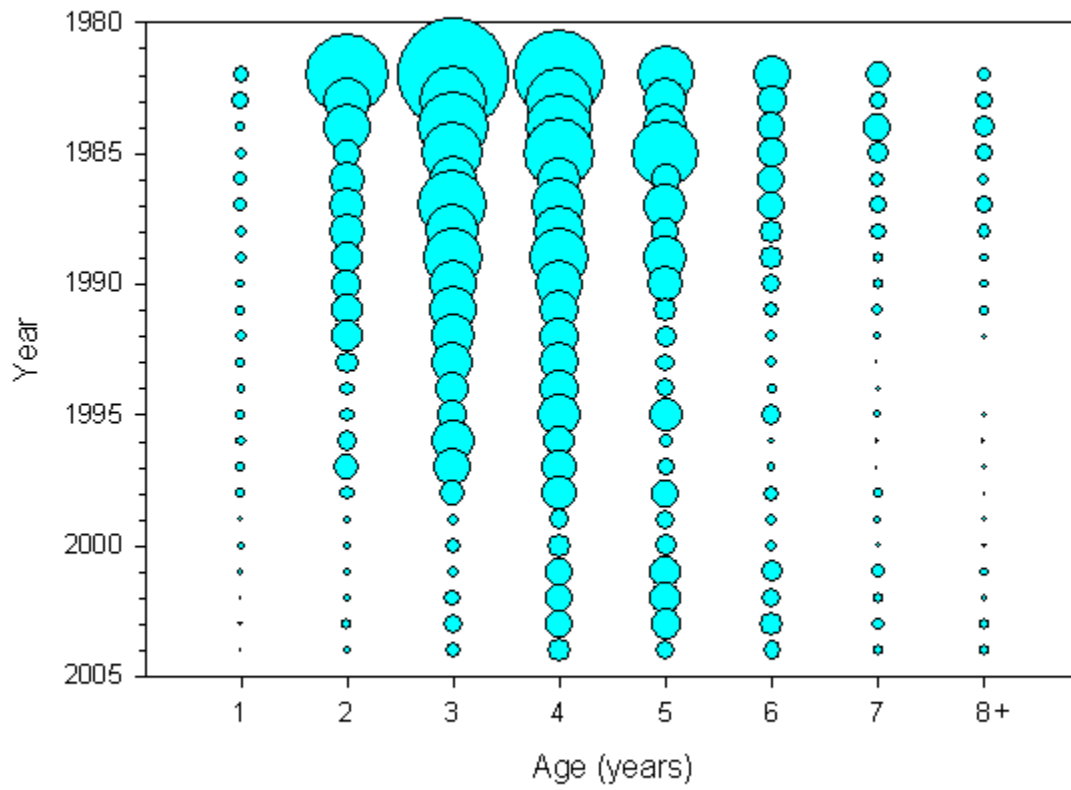


Figure 11.3. Age structure of GOM winter flounder landings, 1982-2004.

GOM Winter Flounder MDMF Spring and Autumn Biomass Indices

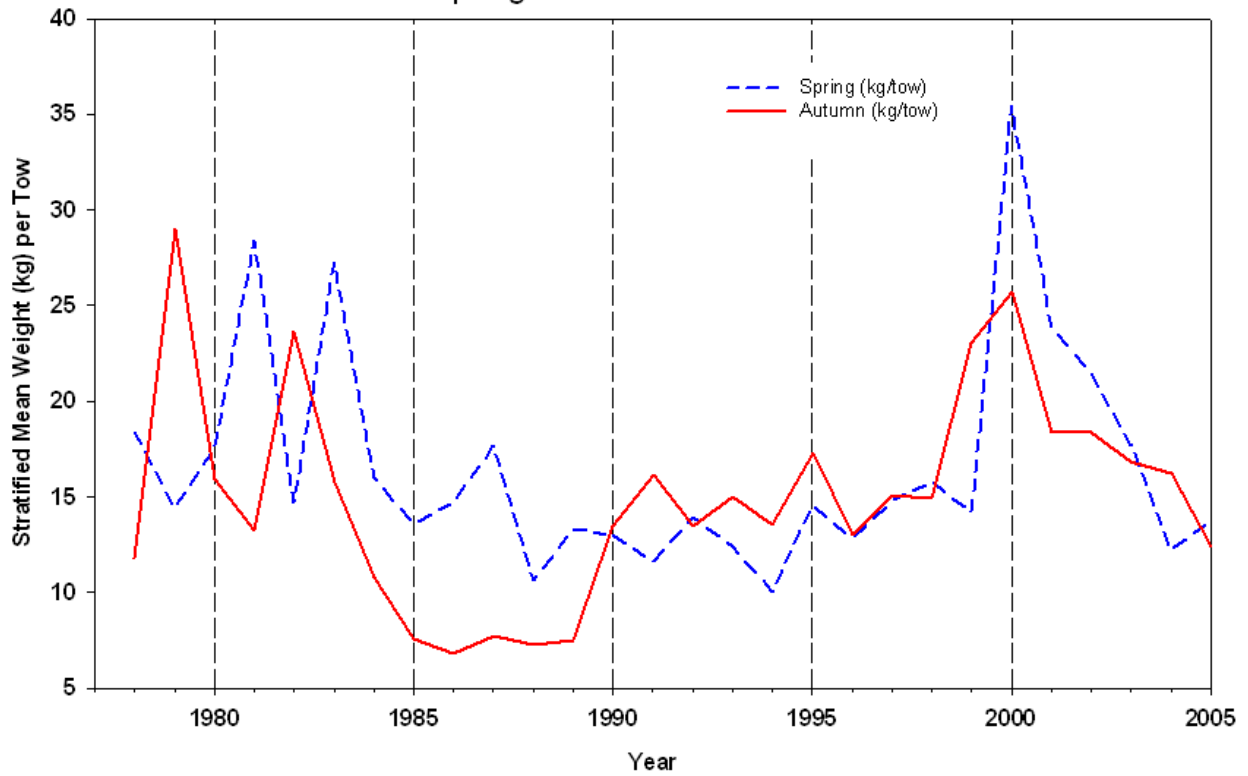


Figure 11.4. Biomass indices (stratified mean weight per tow) for GOM winter flounder from MADMF research vessel surveys.

GOM Winter Flounder Spring DMF Survey Indices by Age

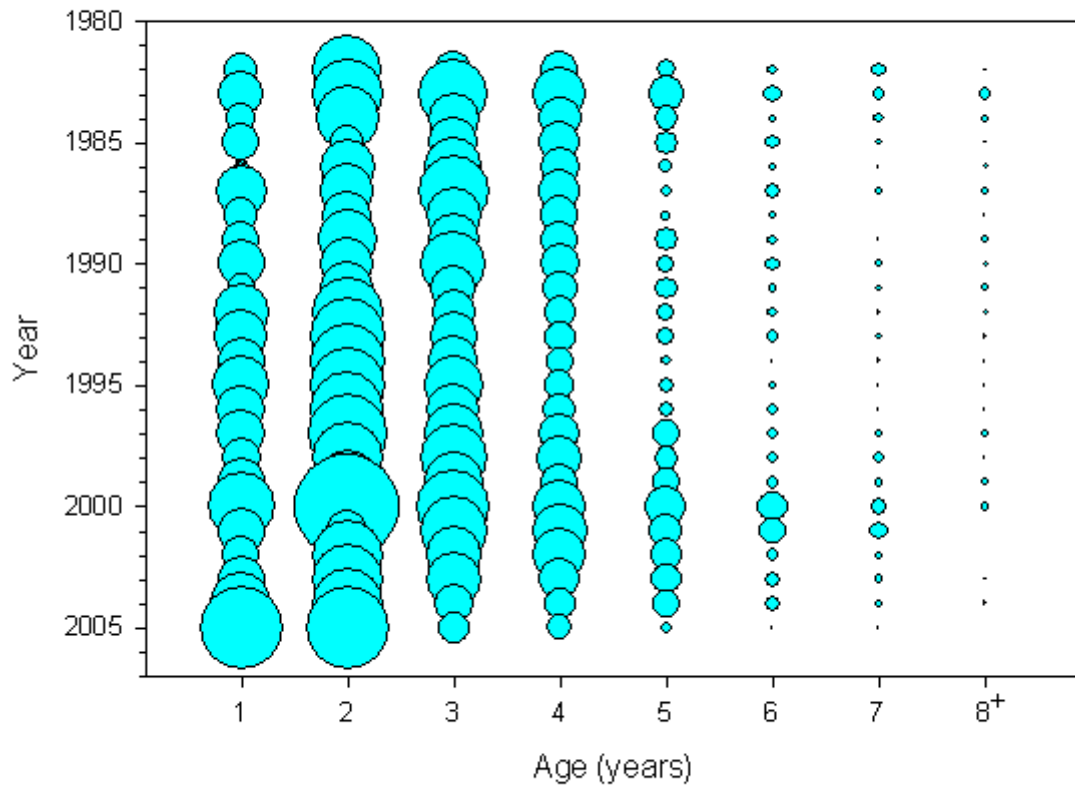


Figure 11.5. Age structure of the GOM winter flounder population, 1980-2004.

GOM Winter Flounder Trends in Catch and Fishing Mortality

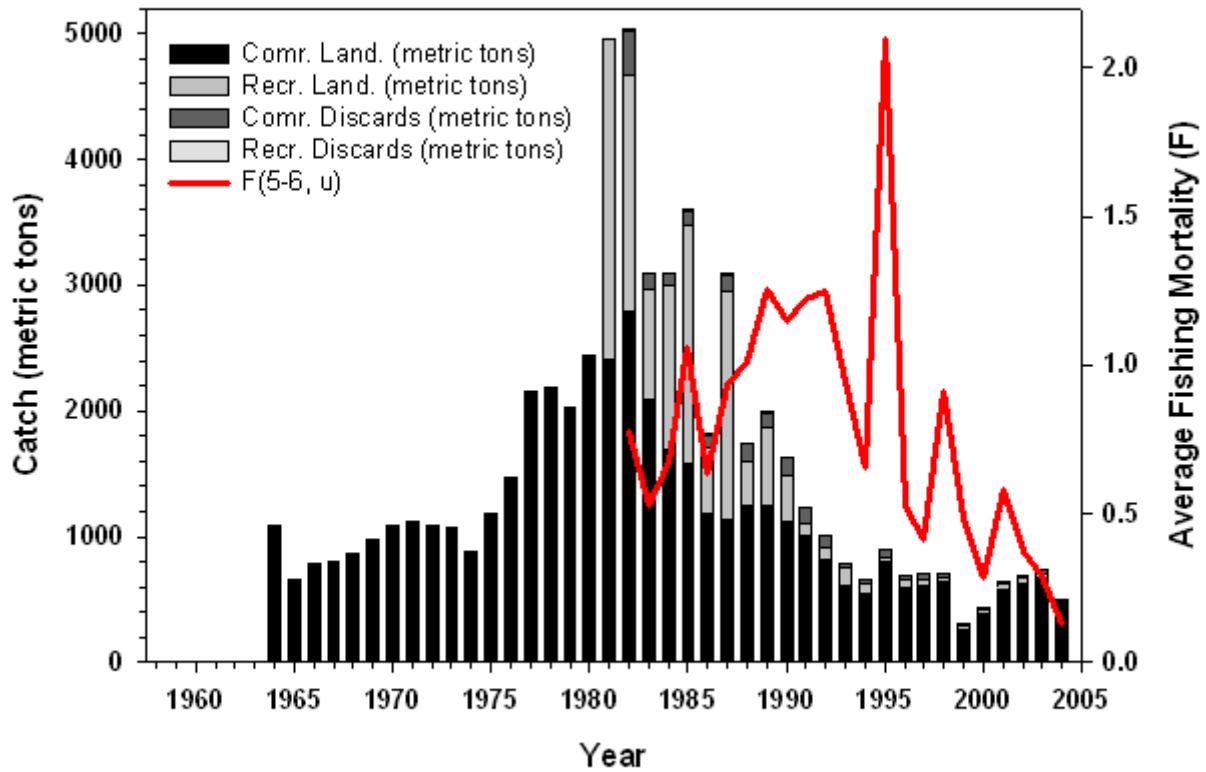


Figure 11.6. Trends in catch and fishing mortality for GOM winter flounder.

GOM Winter Flounder Trends in Recruitment and Spring Stock Biomass

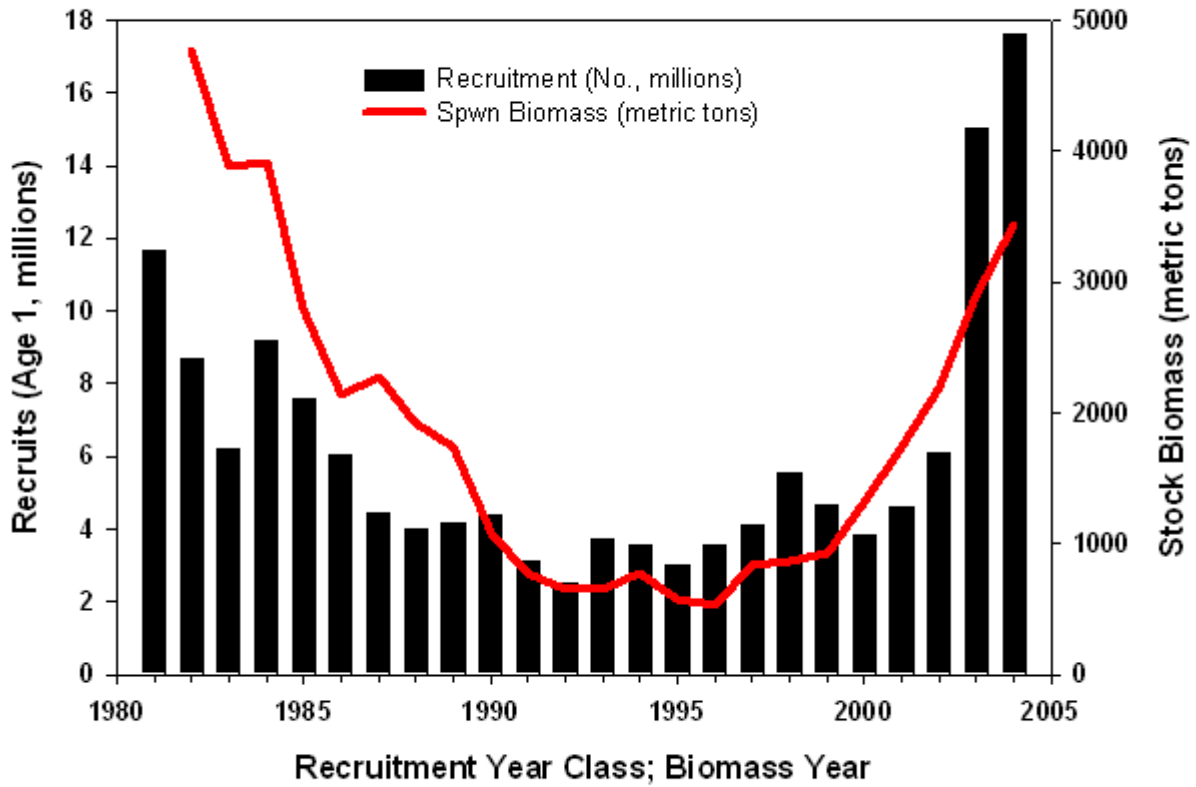


Figure 11.7. Trends in recruitment (age 1) and spring stock biomass for GOM winter flounder.

GOM Winter Flounder Yield and SSB per Recruit

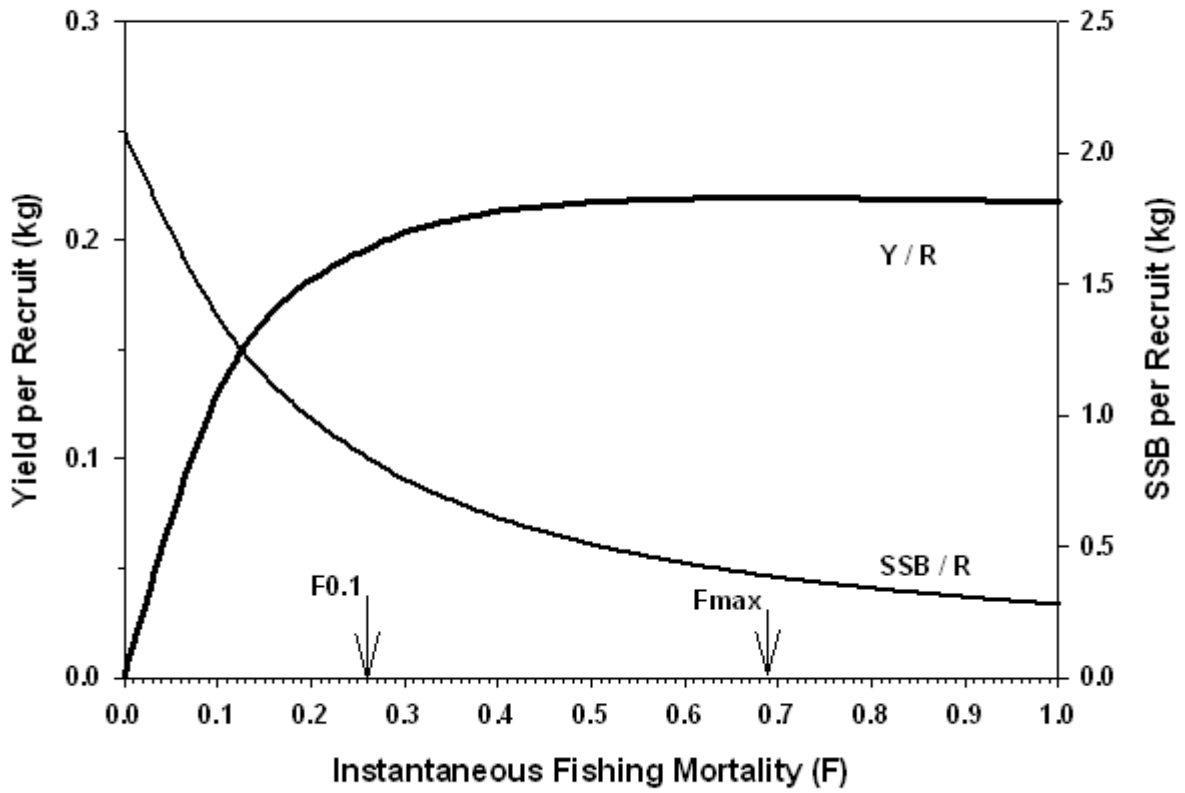


Figure 11.8. Yield and SSB per recruit results for GOM winter flounder.

GOM Winter Flounder Stock-Recruitment Plot

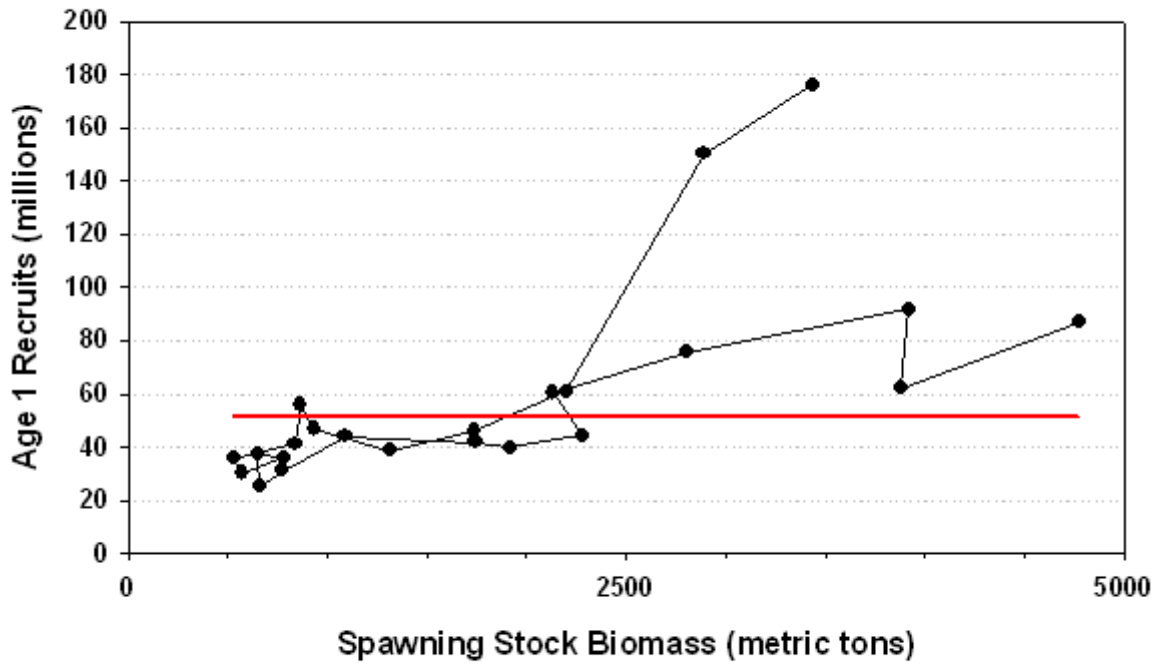


Figure 11.9. Spawning stock-recruitment scatterplot for GOM winter flounder. The solid horizontal line represents the geometric mean recruitment.

GOM Winter Flounder R/SSB Survival Ratios

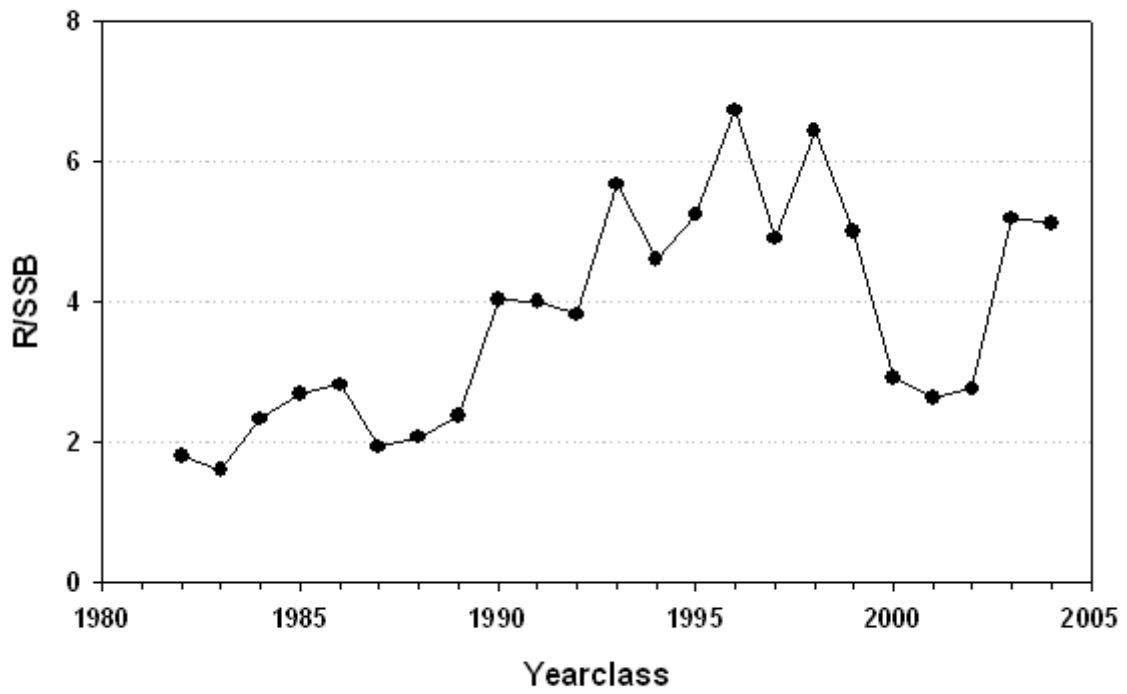


Figure 11.10. Trends in survival ratios (R/SSB) for GOM winter flounder.

Georges Bank Winter Flounder Commercial Landings

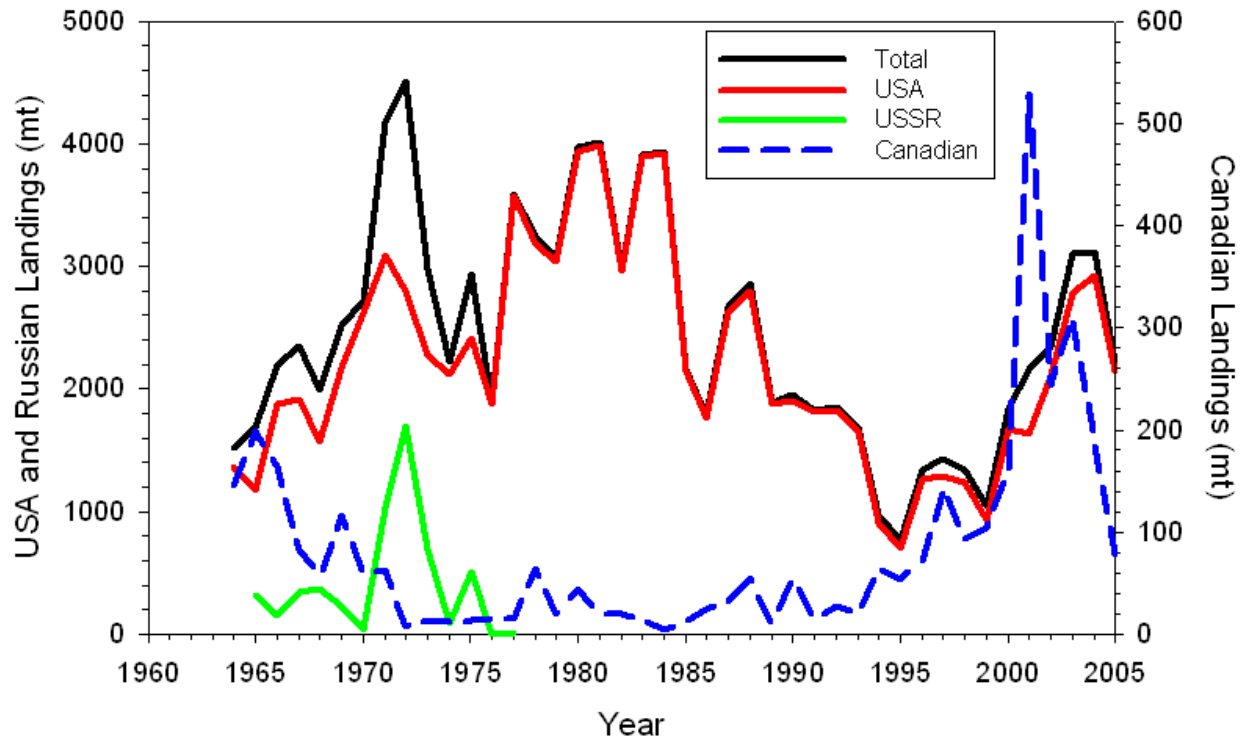


Figure 11.11. Commercial landings of Georges Bank winter flounder.

Georges Bank Winter Flounder NEFSC Survey Indices

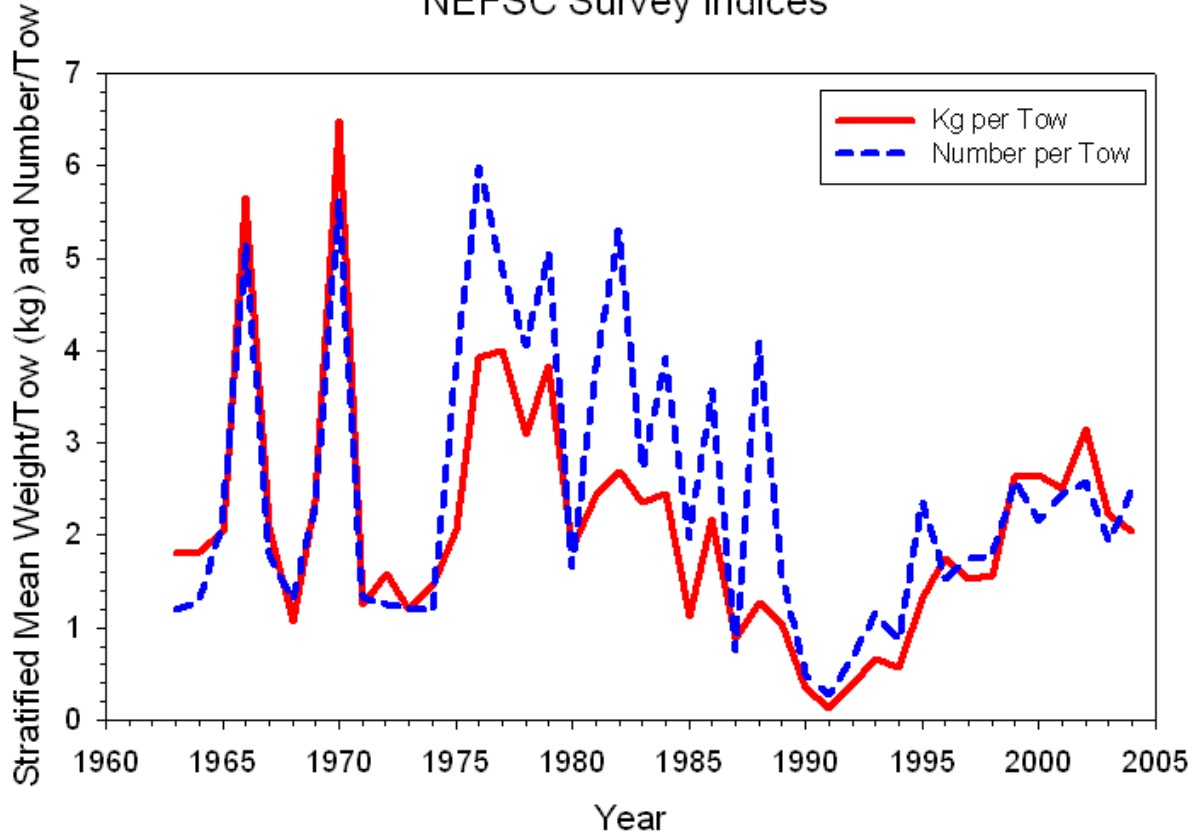


Figure 11.12 Relative abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) indices for Georges Bank winter flounder from NEFSC autumn bottom trawl surveys.

Georges Bank Winter Flounder Relative Biomass and Relative Fishing Mortality

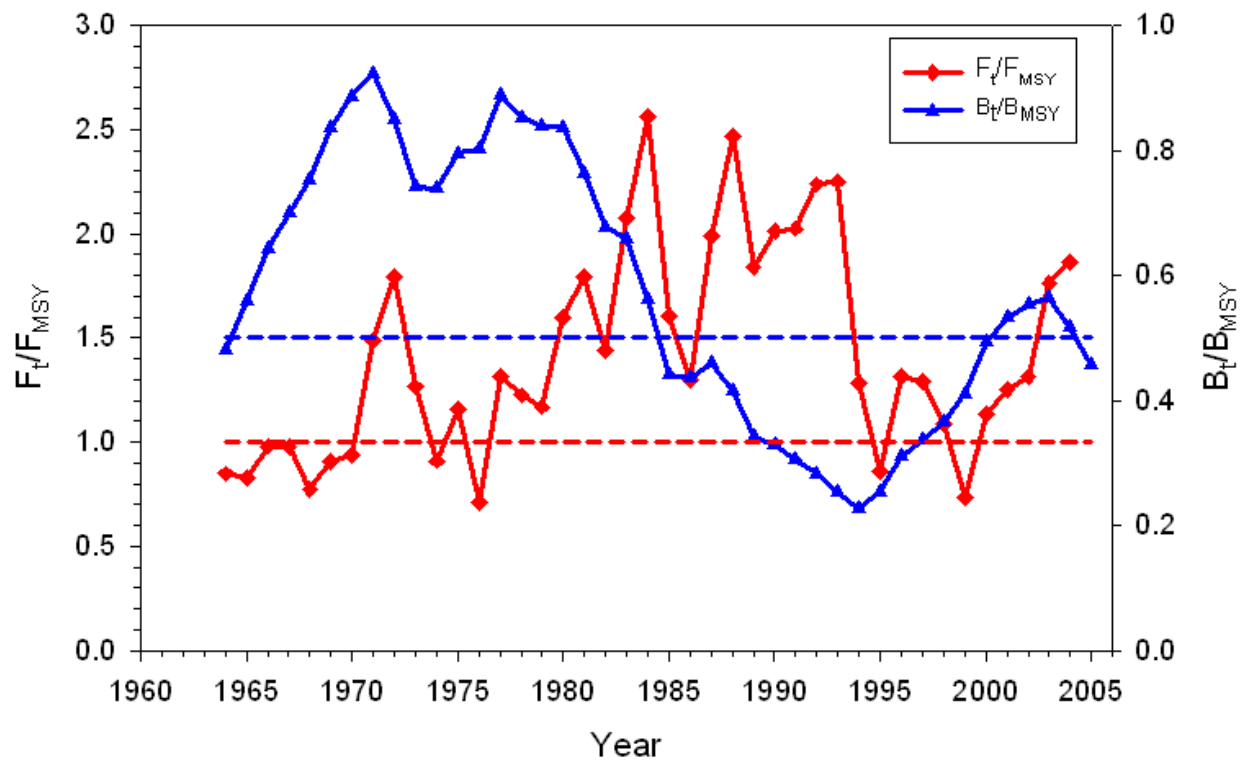


Figure 11.13. Trends in bias-corrected estimates of relative total biomass (B_t/B_{MSY}) and relative fishing mortality rates (F_t/F_{MSY}) for Georges Bank winter flounder. The dashed blue and red lines represent the fishing mortality rate threshold (F_{MSY}) and the biomass threshold (50% of B_{MSY}), respectively.

SNE/MAB Winter Flounder Commercial Landings

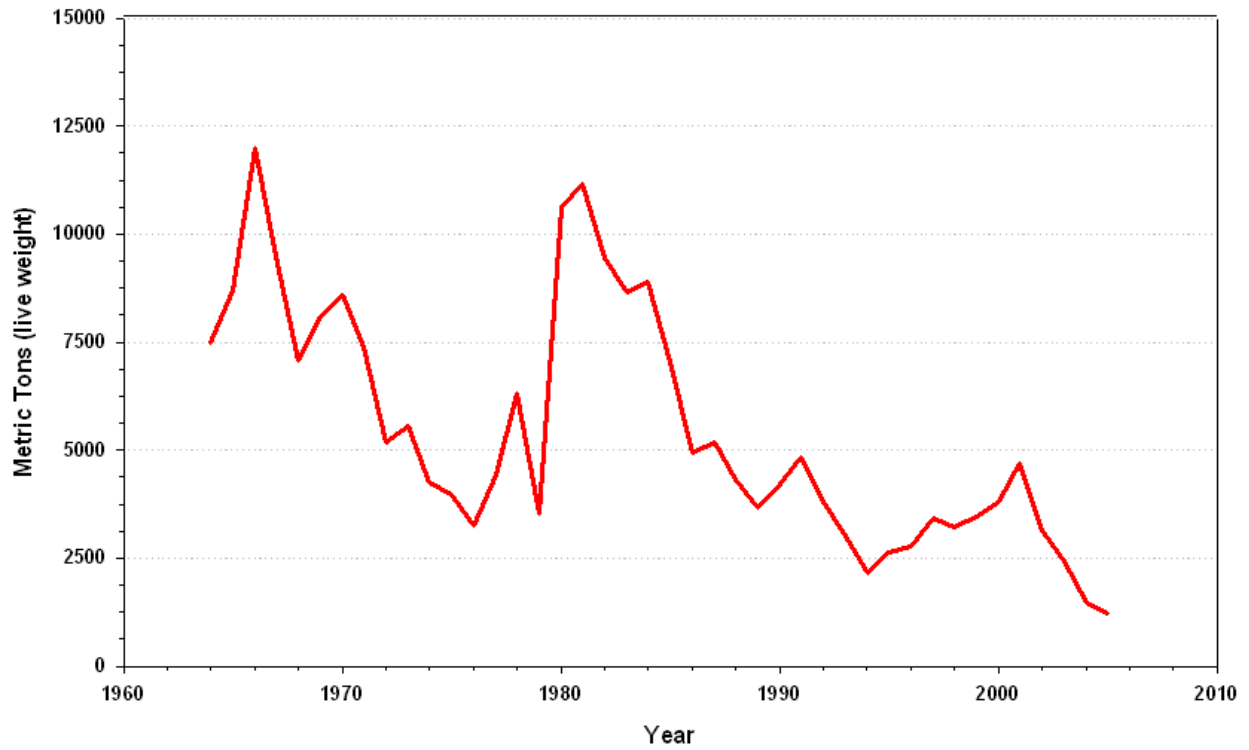


Figure 11.14. Commercial landings of SNE/MAB winter flounder, 1964-2005.

SNE/MAB Winter Flounder Landings by Age

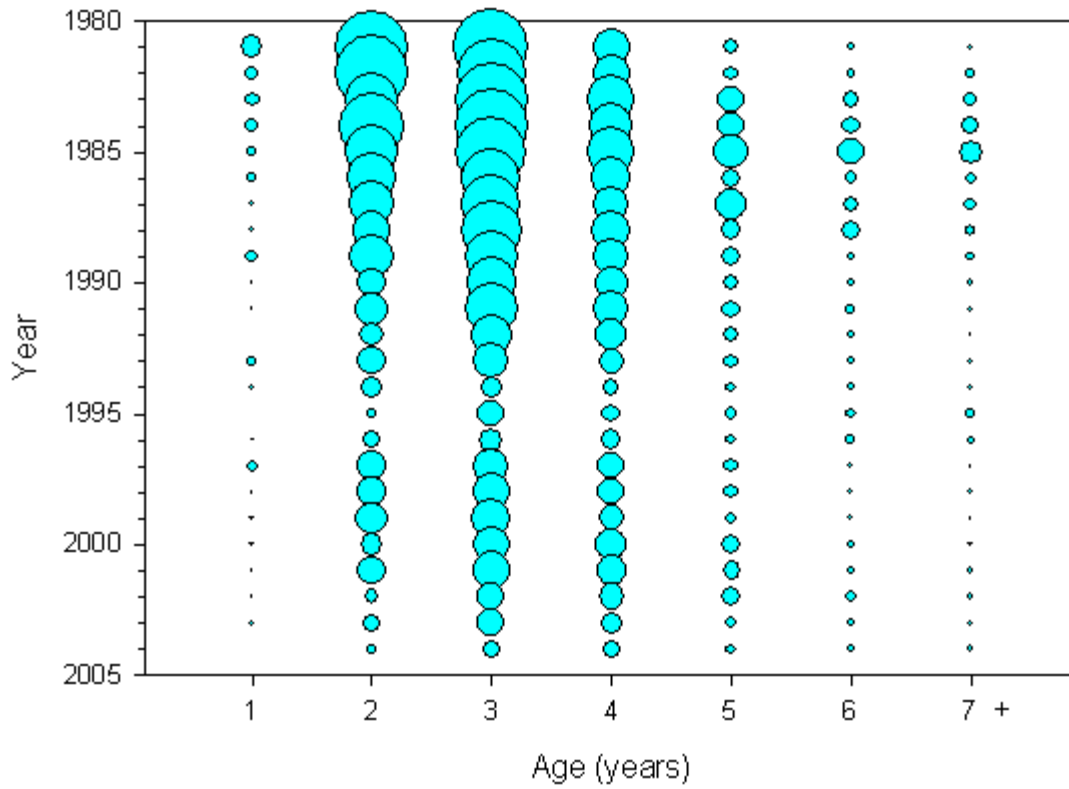


Figure 11.15. Age structure of SNE/MAB winter flounder landings, 1981-2004.

SNE/MAB Winter Flounder NEFSC Spring and Autumn Biomass Indices

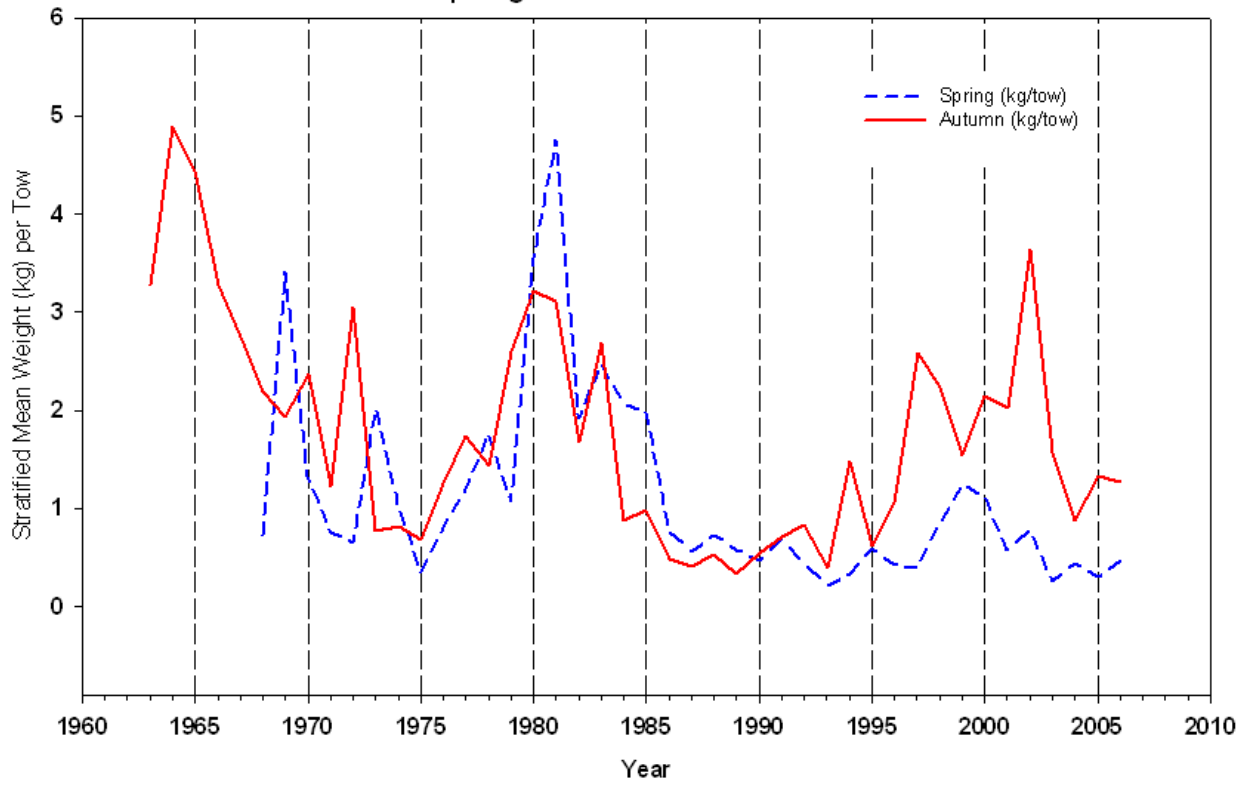


Figure 11.16. Biomass indices (stratified mean weight per tow) for SNE/MAB winter flounder from NEFSC research vessel surveys.

SNE/MAB Winter Flounder Spring Survey Indices by Age

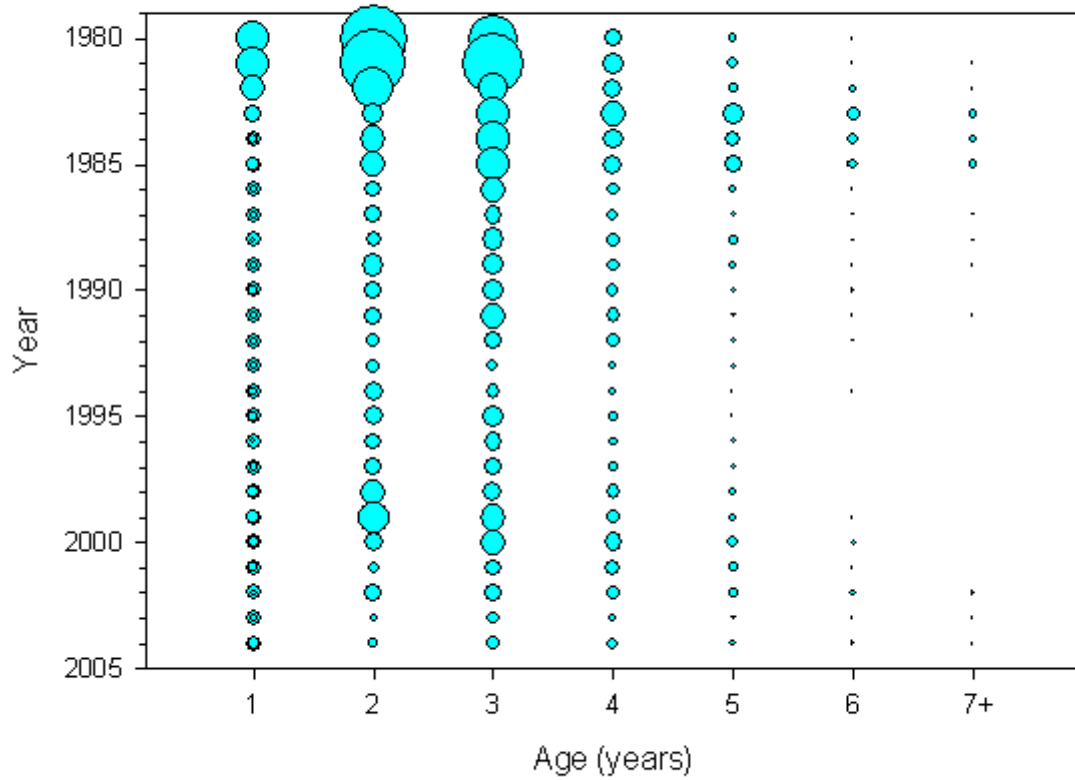


Figure 11.17. Age 1+ structure of the SNE/MAB winter flounder population, 1980-2004.

SNE/MAB Winter Flounder Trends in Catch and Fishing Mortality

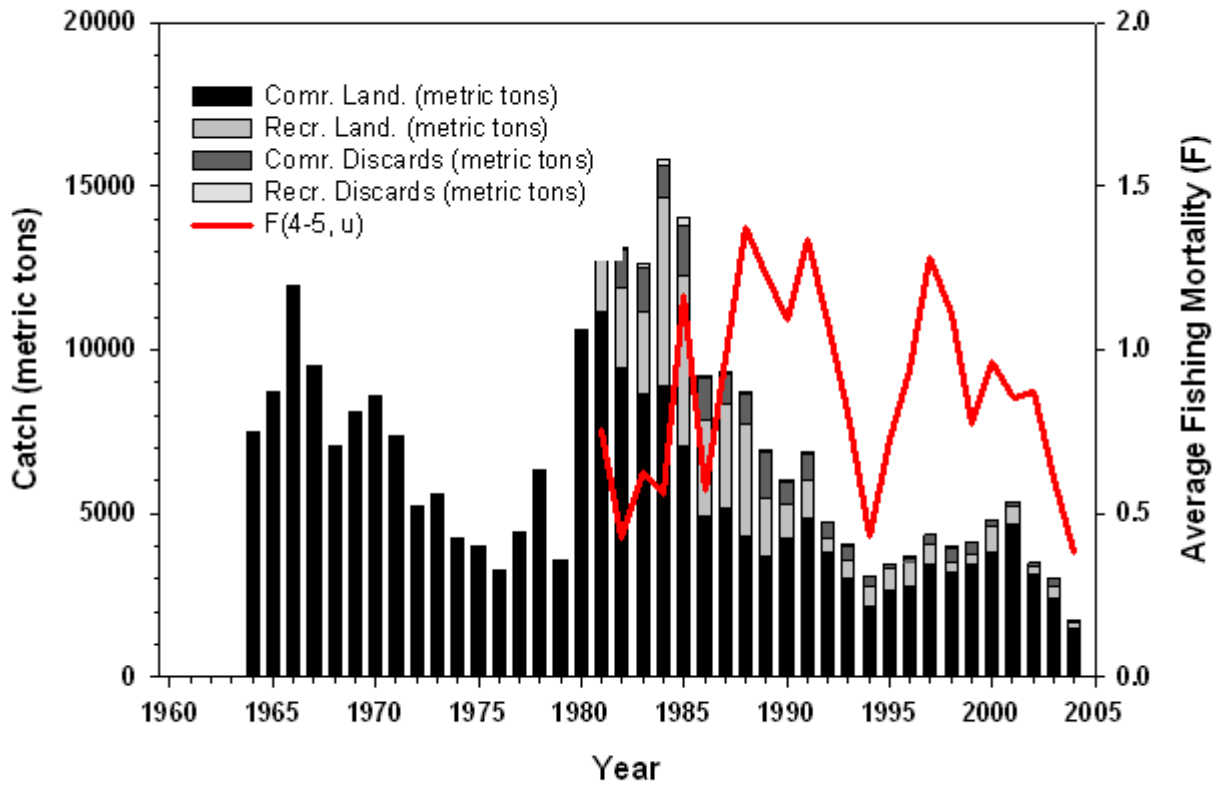


Figure 11.18. Trends in catch and fishing mortality for SNE/MAB winter flounder.

SNE/MAB Winter Flounder Trends in Recruitment and Spawning Stock Biomass

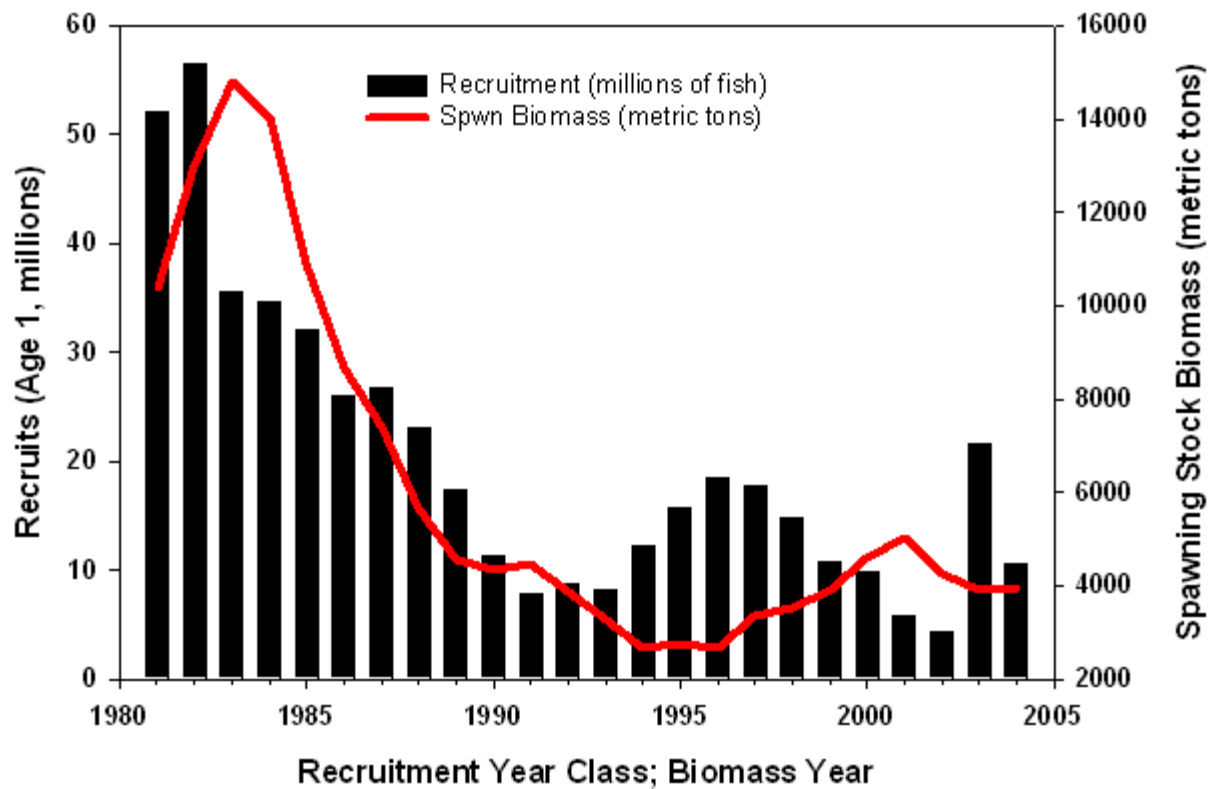


Figure 11.19. Trends in recruitment (age 1) and spawning stock biomass for SNE/MAB winter flounder.

SNE/MAB Winter Flounder Yield and SSB per Recruit

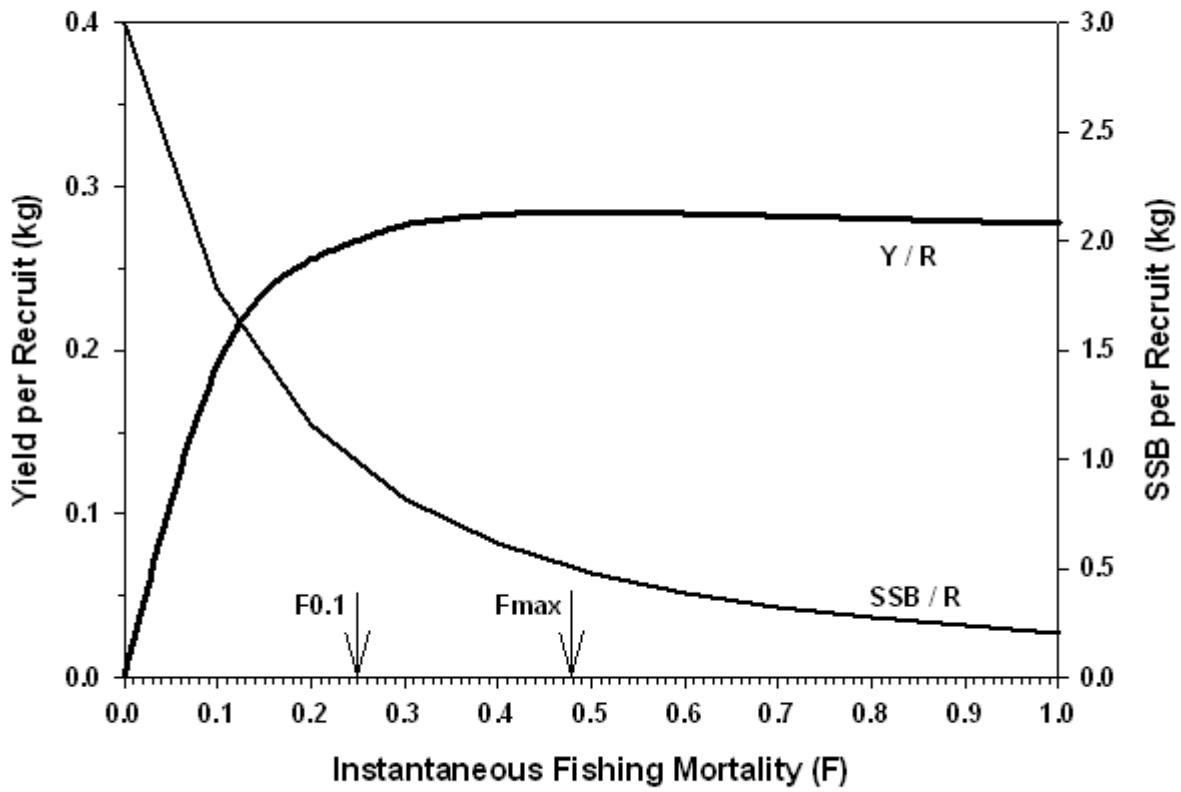


Figure 11.20. Yield and SSB per recruit results for SNE/MAB winter flounder.

SNE/MAB Winter Flounder Stock-Recruitment Plot

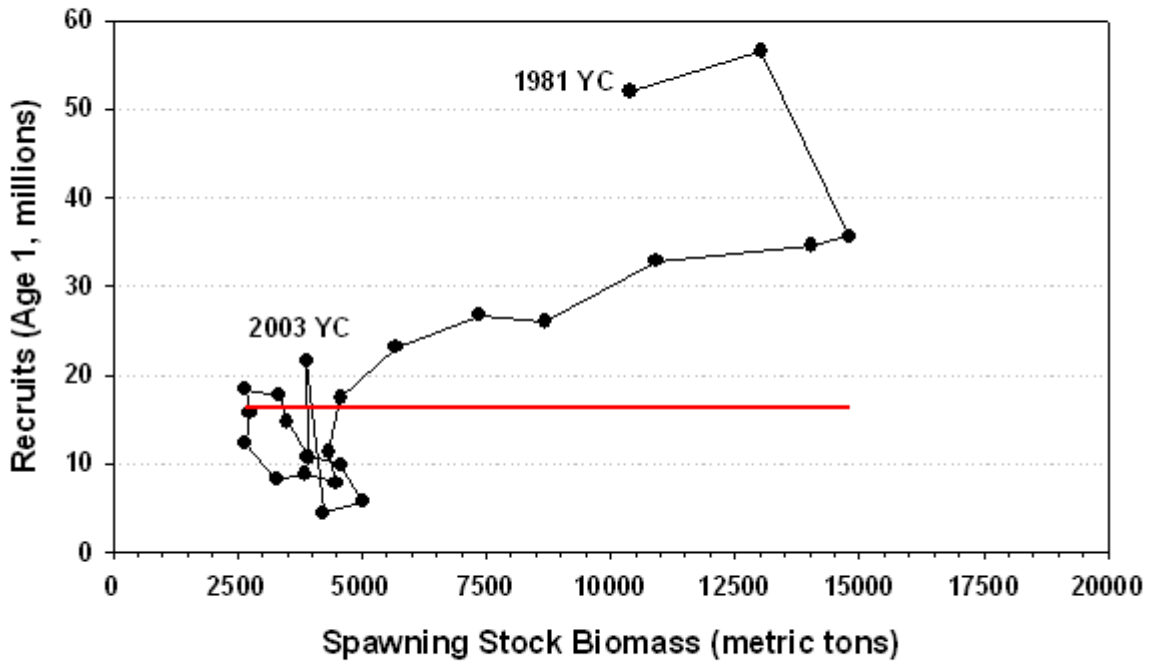


Figure 11.21. Spawning stock-recruitment scatterplot for SNE/MAB winter flounder. The solid horizontal line represents the geometric mean recruitment.

SNE/MAB Winter Flounder R/SSB Survival Ratios

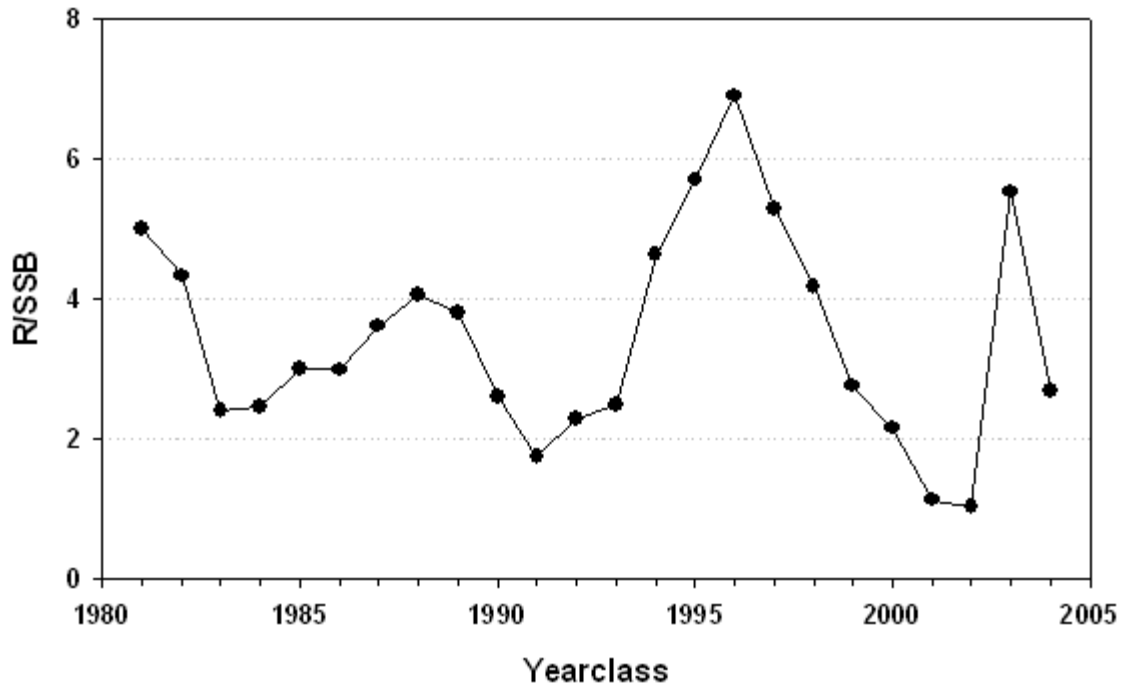


Figure 11.22. Trends in survival ratios (R/SSB) for SNE/MAB winter flounder.