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Assessment of Winter
Flounder Populations
in the Gulf of Maine**

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A Report of the 21st Northeast Regional Stock Assessment Workshop

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This report is a product of the 21st Northeast Regional Stock Assessment Workshop (21st SAW). Proceedings and products of the 21st SAW are scheduled to be documented and released as subissues (denoted by a lower case letter) of *Northeast Fisheries Science Center Reference Document* 96-05 (e.g., 96-05a). Tentative titles for the 21st SAW are:

An index-based assessment of winter flounder populations in the Gulf of Maine

Assessment of winter flounder in Southern New England and the Mid-Atlantic

Influence of temperature and depth on the distribution and catches of yellowtail flounder, Atlantic cod, and haddock in the NEFSC bottom trawl survey

Predicting spawning stock biomass for Georges Bank and Gulf of Maine Atlantic cod stocks with research vessel survey data

Preliminary results of a spatial analysis of haddock distribution applying a generalized additive model

Report of the 21st Northeast Regional Stock Assessment Workshop (21st SAW): Public Review Workshop

Report of the 21st Northeast Regional Stock Assessment Workshop (21st SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments

Stock assessment of northern shortfin squid in the Northwest Atlantic during 1993

The Lorenz curve method applied to NEFSC bottom trawl survey data

INTRODUCTION

Winter flounder (*Pleuronectes americanus*) is a demersal flatfish species commonly found in estuaries and on the continental shelf out to 30 fathoms. The species is distributed between the Gulf of St. Lawrence and North Carolina, although it is not abundant south of Delaware Bay. Winter flounder undergo seasonal migrations in and out of coastal estuaries where spawning occurs in the spring of the year. Winter flounder reach a maximum size of around 2.25 kg (5 pounds; Bigelow and Schroeder, 1953) and 65 cm, with the exception of Georges Bank where growth rate is higher and fish may reach a maximum weight up to 3.6 kg (8 pounds).

Current fishery management for winter flounder is controlled by the Atlantic States Marine Fisheries Commission (ASMFC) in state waters and the New England Fishery Management Council (NEFMC) in federal waters. Previous assessments have been confined to local populations in state waters and the results were the basis for the current ASMFC Fishery Management Plan (FMP).

Management Summary

Winter flounder fisheries in state waters are managed by Interstate Agreement under the auspices of the Atlantic States Marine Fisheries Commission's FMP for Inshore Stocks of Winter Flounder since approval in May, 1992. The plan includes states from Delaware to Maine, with Delaware granted *de minimus* status (habitat regulations applicable but fishery management not required). The Plan's goal is to rebuild spawning stock abundance and achieve a fishing mortality-based management target of F_{40} (fishing rate that preserves 40% MSP) in three steps; F_{25} in 1993, F_{30} in 1995, and F_{40} in 1999 through implementation of compatible, state-specific regulations.

Coastal states from New Jersey to New Hampshire, inclusive, are currently in compliance with the Plan, having promulgated a broad suite of indirect catch and effort controls. State agencies have set or increased minimum size limits for recreationally and commercially landed flounder (10"-12" and 12", respectively); enacted limited recreational closures and bag limits; and instituted seasonal, areal, or state-wide commercial landings/ gear restrictions. Minimum codend mesh regulations have been promulgated in directed winter flounder fisheries: 5" in NJ and NY, 5.5" in CT, 5" in RI, and 6" in MA. In Massachusetts, several regulations preceded the Plan and, in general, the suite of regulations are the most restrictive.

Winter flounder in the Exclusive Economic Zone are managed under the Northeast Multispecies Fishery FMP developed by the New England Fishery Management Council. This was an appropriate grouping for management purposes because the principal catch of winter flounder occurs as bycatch in directed demersal fisheries for Atlantic cod, haddock, and yellowtail flounder primarily of the northeast EEZ. The management unit encompasses the multispecies finfish fishery that operates from eastern Maine through Southern New England

(72°30'). At least one offshore stock, on Georges Bank, has been identified. The Plan extends authority over vessels permitted under the Plan even while fishing in state waters if federal regulations are more restrictive than the state regulations.

The Multispecies Plan was implemented in September, 1986, imposing a codend minimum mesh size of 5.5" (previously 5.1") in the large-mesh regulatory area of Georges Bank and the offshore portion of Gulf of Maine. There were closed areas and seasons for haddock and yellowtail flounder. In the inner Gulf of Maine, vessels were required to enroll in an Exempted Fisheries Program in order to target small-mesh species such as shrimp, dogfish, or whiting. The by-catch restrictions specified area and season and limited groundfish bycatch to 25% of trip and 10% for the reporting period. In southern New England waters, the groundfish bycatch on vessels fishing with small mesh was not constrained but there was a 11" minimum size for winter flounder which corresponded with the length at first capture for 5.5" diamond mesh. Though the Plan was amended four times by 1991, it was widely recognized that many stocks, including winter flounder, were being overfished.

Time-specific stock rebuilding schedules were a part of Amendment #5 which took effect in May, 1994. The rebuilding target for winter flounder, a so-called "large-mesh" species, was $F_{20\%}$ within 10 years. Along with a moratorium on issuance of additional vessel permits, the cornerstone of Amendment #5 was an effort reduction program that required "large-mesh" groundfish vessels to limit days at sea, which would be reduced each year; however, there was an exemption from effort reduction requirements for groundfishing vessels < 45' and for "day boats" (from 2:1 layover day ratio requirement). Dragger vessels retaining more than the "possession limit" of groundfish (10%, by weight, up to 500 lbs) were required to fish with either 5.5" diamond or square mesh in Southern New England or 6" throughout the net in the regulated mesh area of Georges Bank / Gulf of Maine, respectively. The possession limit was allowed when using small mesh within the inner Gulf of Maine (except Jeffrey's Ledge and Stellwagon Bank) and in Southern New England. Those boats fishing in EEZ West of 72° 30' (longitude of Shinnecock Inlet, NY) were required to abide by 5.5" diamond or 6" square codend mesh size restriction consistent with the Summer Flounder FMP. The minimum landed size of winter flounder was increased to 12" consistent with the increased mesh size and to reduce discards. There were many additional rules including time/area closures for sink gillnet vessels, seasonal netting closures of prime fishing areas on Georges Bank (Areas I and II), and on Nantucket Shoals to protect juvenile yellowtail flounder.

At the end of 1994, the Council reacted to collapsed stocks of Atlantic cod, haddock, and yellowtail flounder on Georges Bank by voting a number of emergency actions to tighten existing regulations reducing fishing mortality. Prime fishing areas on Georges Bank (Areas I & II), and the Nantucket Lightship Area were closed. The Council also addressed expected re-direction of fishing effort into Gulf of Maine and Southern New England while, at the same time, developing Amendment # 7 to the FMP. Days-at-sea controls were extended. Currently, any fishing by an EEZ-permitted vessel must be conducted with not less than 6"

diamond or square mesh in Southern New England east of 72° 30'. Winter flounder less than 12" in length may not be retained.

STOCK STRUCTURE

Although stock groups consist of an assemblage of adjacent estuarine spawning units, the ASMFC Fishery Management Plan defined three coastal management units based on similar growth, maturity and seasonal movement patterns: Gulf of Maine, Southern New England and the Mid-Atlantic. In the initial phase of the assessment, the criteria for separation of the Southern New England and Mid-Atlantic stock boundaries were reconsidered in light of recent data available since the original stock designations.

Boundaries for four stock units were originally defined in the ASMFC management plan (Howell et al., 1992):

Gulf of Maine: Coastal Maine, New Hampshire, and Massachusetts north of Cape Cod

Southern New England: Coastal Massachusetts east and south of Cape Cod, including Nantucket Sound, Vineyard Sound, Buzzards Bay, Narragansett Bay, Block Island Sound, Rhode Island Sound, Rhode Island coastal ponds and eastern Long Island Sound to the Connecticut River, including Fishers Island Sound, NY.

Mid-Atlantic: Long Island Sound west of the Connecticut River to Montauk Point, NY, including Gardiners and Peconic Bays, coastal Long Island, NY, coastal New Jersey and Delaware.

Georges Bank

The SARC retained a definition of a separate Gulf of Maine complex, based on results of tagging studies, and large differences in growth rates consistent with discrete oceanographic regimes between the Gulf of Maine and Southern New England (Howe and Coates, 1975). Additional analyses of life history characteristics and mixing within the Gulf of Maine may lead to refinement of the complex's definition within the Gulf of Maine.

DATA SOURCES

Fishery Data

Landings

Gulf of Maine winter flounder are distributed from Cape Cod to Nova Scotia, in estuaries and coastal waters out to 30 fathoms (Bigelow and Schroeder 1953). Annual commercial landings of winter flounder in the Gulf of Maine were approximately 1,000 mt in the 1960s and early 1970s, gradually increased to a maximum of 2,793 mt in 1982, and subsequently decreased to a record low 596 mt in 1993 (Table 1). From 1979 to 1989, 13%

of commercial landings were taken in state territorial waters, and 87% from the EEZ (Howell et al. 1992, NEFSC 1992). The landings analysis reported by Howell et al. (1992) and NEFSC (1992) involved assumptions concerning the proportion of Massachusetts landings in the Gulf of Maine and are slightly different than the data reported here, which were analyzed by statistical area.

Recreational landings of winter flounder in the Gulf of Maine peaked at 2,330 in 1980, and have since declined to 100 mt. From 1979 to 1989, 75% of recreational Gulf of Maine landings were taken in Massachusetts, 16% in Maine, and 9% in New Hampshire (Howell et al. 1992). Recreational landings in 1994 were 97.1 mt. Total winter flounder landings precipitously declined from 4,767 mt in 1980 to 727 mt in 1993 (Figure 1).

Recreational LPUE

As an index of winter flounder abundance, mean recreational landings per angler per trip (LPUE) from 1981-1994 was calculated. LPUE declined steadily from a high of 7.09 fish per angler per trip in 1981 to 2.68 fish per angler per trip in 1994 (Figure 2). However, increasing state management restrictions, such as bag limits, has likely affected the catch rate over this period.

Stock Abundance and Biomass Indices

Fishery-Independent Indices

Several bottom trawl surveys measure winter flounder abundance and biomass in the Gulf of Maine (Table 2 and 3). The Northeast Fisheries Science Center (NEFSC) has conducted autumn surveys since 1963 and spring surveys since 1968 (Grosslein 1969). NEFSC surveys in the Gulf of Maine prior to spring 1979 were not conducted in inshore strata. The Massachusetts Division of Marine Fisheries (MADMF) has operated inshore research surveys in spring and autumn since 1978 (Howe 1989). Normandeau Associates (1994) sampled demersal fishes at three fixed coastal stations off Hampton Seabrook Harbor, four times each month, since 1976. Although autumn data from the Normandeau Seabrook survey may be useful, the series may be biased because sampling was sporadic from August to November in recent years due to avoidance of lobster gear.

Research survey indices reflect the pattern in landings: survey catch rates were generally below the time series average in the 1960s and early 1970s, increased to well above average in the late 1970s and early 1980s, and decreased to below average in recent years (Figures 3 and 4). The NEFSC spring indices are significantly correlated with all other survey indices, except the MADMF autumn indices - which were correlated with no other indices (Table 4).

Bottom trawl surveys indicate a gradual truncation in size distribution. Mean weight per fish in the NEFSC spring survey series decreased from approximately 0.9 kg in the late

1960s to 0.3 in recent years (Figure 5). Length frequency distributions from NEFSC autumn surveys show few fish larger than 40 cm in recent years (Figure 6).

Mortality Estimates

Fishing Mortality

The only information available on age composition of Gulf of Maine winter flounder is from the MADMF spring survey, aged cooperatively by the MADMF and NEFSC (Table 5). Estimates of instantaneous fishing mortality were derived as log catch ratios of cohort catches at age minus natural mortality (0.2). From 1978-1993, estimates of fishing mortality fluctuated around a mean of 1.21, which is similar to earlier results, and exceeds previously estimated biological reference points ($F_{msy} = 0.60$, $F_{25\% MSP} = 0.79$) (Howell et al. 1992, NEFSC 1992).

Conclusions

Excessive fishing mortality rates indicate that the Gulf of Maine winter flounder stock is overexploited. Record low landings, low survey indices, and few large fish in recent years support the conclusion that the stock is overexploited.

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Table 1. Winter flounder landings (mt) in the Gulf of Maine.

Year	Commercial	Recreational	Total
1964	1081		
1965	665		
1966	785		
1967	803		
1968	864		
1969	975		
1970	1092		
1971	1113		
1972	1085		
1973	1080		
1974	885		
1975	1181		
1976	1465		
1977	2161		
1978	2194		
1979	2021	1389	3410
1980	2437	2330	4767
1981	2406	2586	4992
1982	2793	1823	4616
1983	2096	848	2944
1984	1698	1103	2801
1985	1584	1775	3359
1986	1188	523	1711
1987	1142	1713	2855
1988	1252	559	1811
1989	1267	631	1898
1990	1085	369	1454
1991	981	101	1082
1992	806	93	899
1993	596	131	727
1994		97	

Table 2. Research Trawl Survey indices of biomass and abundance of Gulf of Maine winter flounder, in stratified mean weight (kg) per tow and stratified mean number per tow.

Year	NEFSC Spring				NEFSC Autumn				MADMF		MADMF		Seabrook
	Offshore		Inshore-Offshore		Offshore		Inshore-Offshore		Spring		Autumn		Spring
	wt	#	wt	#	wt	#	wt	#	wt	#	wt	#	#
1963					0.25	0.60							
1964					0.12	0.17							
1965					1.16	1.04							
1966					0.17	0.17							
1967					0.07	0.08							
1968	0.54	0.60			0.32	0.28							
1969	0.44	0.63			--	---							
1970	0.54	0.57			0.38	0.36							
1971	0.32	0.42			0.13	0.31							
1972	0.71	1.14			0.33	0.82							
1973	0.17	0.36			0.18	0.32							
1974	0.24	0.53			0.63	1.34							
1975	0.02	0.05			0.03	0.04							
1976	0.35	0.50			0.25	0.36							1.5
1977	0.63	1.14			0.81	1.80							3.6
1978	0.16	0.37			0.22	0.38			18.37	86.78	9.89	43.36	5.5
1979	0.62	1.29	0.95	2.65	0.18	0.32	0.80	1.84	14.62	64.93	28.98	116.07	6.9
1980	0.78	1.75	1.91	4.29	0.87	0.90	1.95	3.89	17.49	66.23	15.94	74.68	8.9
1981	0.87	1.74	2.57	6.56	0.86	1.17	0.89	1.31	28.37	100.56	13.23	47.34	14.9
1982	0.48	0.99	0.95	2.34	0.26	0.43	0.63	1.53	14.69	60.68	23.64	106.05	5.1
1983	1.28	2.31	1.79	3.94	0.46	1.43	1.09	3.17	28.51	112.20	15.77	88.14	6.3
1984	0.36	0.68	0.60	1.52	0.57	1.02	0.96	2.31	15.98	66.20	10.82	35.96	3.8
1985	0.22	0.45	0.43	1.04	0.19	0.42	0.90	3.16	13.06	47.81	7.38	44.56	2.5
1986	0.23	0.38	0.30	0.71	0.10	0.25	0.29	0.76	14.96	63.94	6.60	41.91	3.8
1987	0.34	0.72	0.47	1.79	0.04	0.22	0.21	0.69	17.65	82.91	6.99	48.68	4.5
1988	0.20	0.59	0.68	3.23	0.09	0.17	0.26	0.76	10.62	52.70	9.87	43.14	3.9
1989	0.37	1.05	0.37	1.05	0.36	1.23	0.59	1.89	13.32	63.61	9.28	55.46	7.2
1990	0.48	0.94	0.61	1.36	0.04	0.15	0.30	0.76	12.97	74.00	13.45	67.87	4.3
1991	0.23	0.56	0.39	1.04	0.03	0.10	0.43	2.07	11.59	49.22	15.47	88.77	5.8
1992	0.29	0.81	0.36	1.13	0.10	0.33	0.81	2.77	13.94	68.69	12.43	75.25	2.1
1993	0.06	0.20	0.07	0.28	0.03	0.20	0.56	2.28	12.39	79.85	14.97	92.4	4.3
1994	0.16	0.46	0.25	0.88	0.06	0.16	0.26	0.82	10.04	69.39	13.56	67.3	2.3

Table 3. Research Trawl Survey average weight (kg) per fish of Gulf of Maine winter flounder.

Year	NEFSC Spring		NEFSC Autumn		MADMF	MADMF
	Offshore	Inshore- Offshore	Offshore	Inshore- Offshore	Spring	Autumn
1963			0.25			
1964			0.12			
1965			1.16			
1966			0.17			
1967			0.07			
1968	0.90		0.32			
1969	0.70		----			
1970	0.95		0.38			
1971	0.78		0.13			
1972	0.62		0.33			
1973	0.47		0.18			
1974	0.46		0.63			
1975	0.41		0.03			
1976	0.70		0.25			
1977	0.55		0.81			
1978	0.45		0.22		0.21	0.23
1979	0.50	0.36	0.39	0.80	0.23	0.25
1980	0.40	0.45	0.71	1.95	0.26	0.21
1981	1.05	0.39	0.66	0.89	0.28	0.28
1982	0.41	0.40	0.61	0.63	0.24	0.22
1983	0.55	0.45	0.53	1.09	0.25	0.18
1984	0.74	0.40	0.72	0.96	0.24	0.30
1985	0.51	0.42	0.46	0.90	0.27	0.17
1986	0.55	0.42	0.42	0.29	0.23	0.16
1987	0.31	0.26	0.19	0.21	0.21	0.14
1988	0.36	0.21	0.78	0.26	0.20	0.23
1989	0.28	0.35	0.47	0.59	0.21	0.17
1990	0.50	0.45	0.36	0.30	0.18	0.20
1991	0.53	0.37	0.36	0.43	0.24	0.17
1992	0.56	0.32	0.31	0.81	0.20	0.17
1993	0.27	0.27	0.18	0.56	0.16	0.16
1994	0.33	0.28	0.35	0.26	0.14	0.20

Table 4. Correlations of Gulf of Maine winter flounder research trawl survey indices.
 * indicates correlation is statistically significant at the 95% probability level.

Mean weight per tow

	<u>NEFSC-S</u>	<u>NEFSC-F</u>	<u>MADMF-S</u>	<u>MADMF-F</u>
NEFSC-S	1.00	0.67*	0.77*	0.30
NEFSC-F	0.67*	1.00	0.39	0.28
MADMF-S	0.77*	0.39	1.00	0.03
MADMF-F	0.30	0.28	0.03	1.00

Mean number per tow

	<u>NEFSC-S</u>	<u>NEFSC-F</u>	<u>MADMF-S</u>	<u>MADMF-F</u>	<u>Seabrook</u>
NEFSC-S	1.00	0.40*	0.42*	0.05	0.80*
NEFSC-F	0.40*	1.00	0.05	0.31	0.16
MADMF-S	0.42*	0.05	1.00	0.00	0.45
MADMF-F	0.05	0.31	0.00	1.00	0.04
Seabrook	0.80*	0.16	0.45	0.04	1.00

Table 5. Stratified mean number per tow at age of winter flounder from the Massachusetts inshore bottom trawl survey and derived instantaneous mortality.

Year	Age								
	1	2	3	4	5	6	7	8	9+
1978	21.58	23.98	23.39	12.18	3.25	0.91	0.49	0.16	0.84
1979	10.87	21.77	16.84	11.15	2.80	0.68	0.27	0.16	0.39
1980	6.40	19.32	20.21	15.15	3.62	0.81	0.40	0.13	0.19
1981	11.62	24.68	30.27	24.30	6.82	1.58	0.54	0.22	0.53
1982	8.14	19.11	18.65	9.53	3.23	1.00	0.57	0.16	0.29
1983	15.13	25.87	41.03	21.01	5.69	1.47	0.90	0.46	0.64
1984	5.65	21.72	22.24	11.15	3.54	0.97	0.38	0.17	0.38
1985	9.01	8.33	14.36	11.28	3.19	0.88	0.41	0.17	0.18
1986	10.78	18.73	24.06	8.26	1.65	0.27	0.07	0.05	0.07
1987	15.30	20.18	28.50	14.67	2.82	0.68	0.37	0.16	0.23
1988	8.74	17.12	17.17	7.80	1.31	0.27	0.11	0.05	0.13
1989	10.35	22.76	16.78	9.44	2.97	0.60	0.25	0.16	0.30
1990	14.27	18.33	27.47	10.04	2.04	1.35	0.34	0.02	0.14
1991	4.82	19.21	13.00	7.84	3.17	0.50	0.24	0.17	0.27
1992	14.55	32.12	12.31	6.70	1.97	0.69	0.16	0.07	0.12
1993	17.86	37.10	15.09	6.46	2.03	1.09	0.15	0.00	0.07
1994	12.00	36.11	15.44	4.66	0.79	0.12	0.17	0.08	0.02

Year	Total Instantaneous Mortality				Weighted		Fishing Mortality	
	4	Age 5	6	7	Mean	Mean	Mean	Mean
1978	1.47	1.56	1.22	1.12	1.34	1.46	1.14	1.26
1979	1.12	1.24	0.53	0.73	0.91	1.11	0.71	0.91
1980	0.80	0.83	0.41	0.60	0.66	0.78	0.46	0.58
1981	2.02	1.92	1.02	1.22	1.54	1.94	1.34	1.74
1982	0.52	0.79	0.11	0.21	0.41	0.54	0.21	0.34
1983	1.78	1.77	1.35	1.67	1.64	1.75	1.44	1.55
1984	1.25	1.39	0.86	0.80	1.08	1.25	0.88	1.87
1985	1.92	2.47	2.53	2.10	2.26	2.07	2.06	1.84
1986	1.07	0.89	*	*	0.98	1.04	0.78	0.79
1987	2.42	2.35	1.82	2.00	2.15	2.38	1.95	2.18
1988	0.97	0.78	0.08	*	0.61	0.91	0.41	0.71
1989	1.53	0.79	0.57	2.53	1.35	1.34	1.15	1.14
1990	1.15	1.41	1.73	0.69	1.24	1.24	1.04	1.04
1991	1.38	1.52	1.14	1.23	1.32	1.41	1.12	1.21
1992	1.19	0.59	1.53	**	1.10	1.09	0.90	0.89
1993	2.10	2.83	1.86	0.63	1.85	2.20	1.65	2.00
Mean	1.42	1.45	1.12	1.19	1.28	1.41	1.08	1.21

* negative estimate

** no age-8 catch in 1993

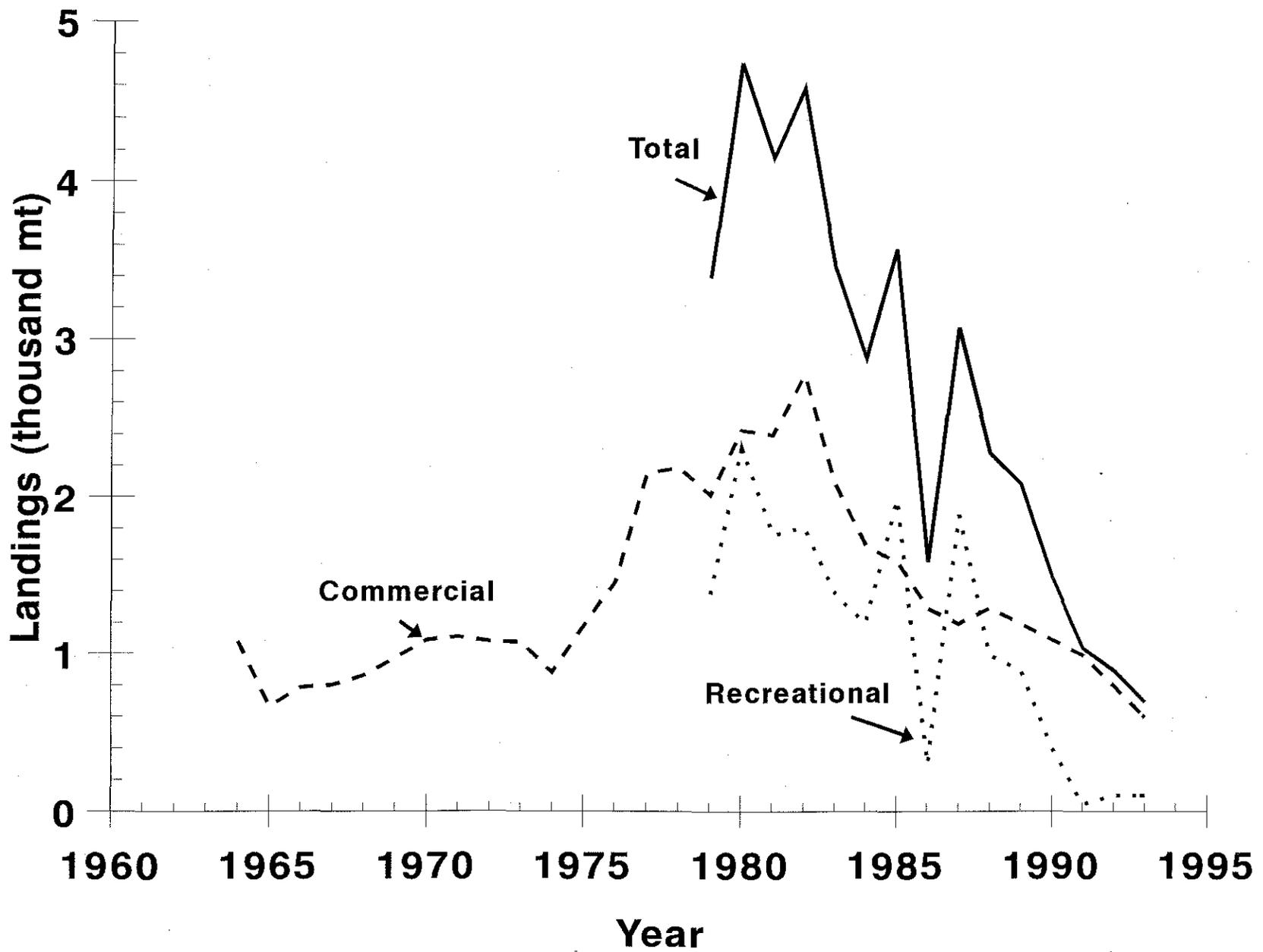


Figure 1. Winter flounder landings in the Gulf of Maine.

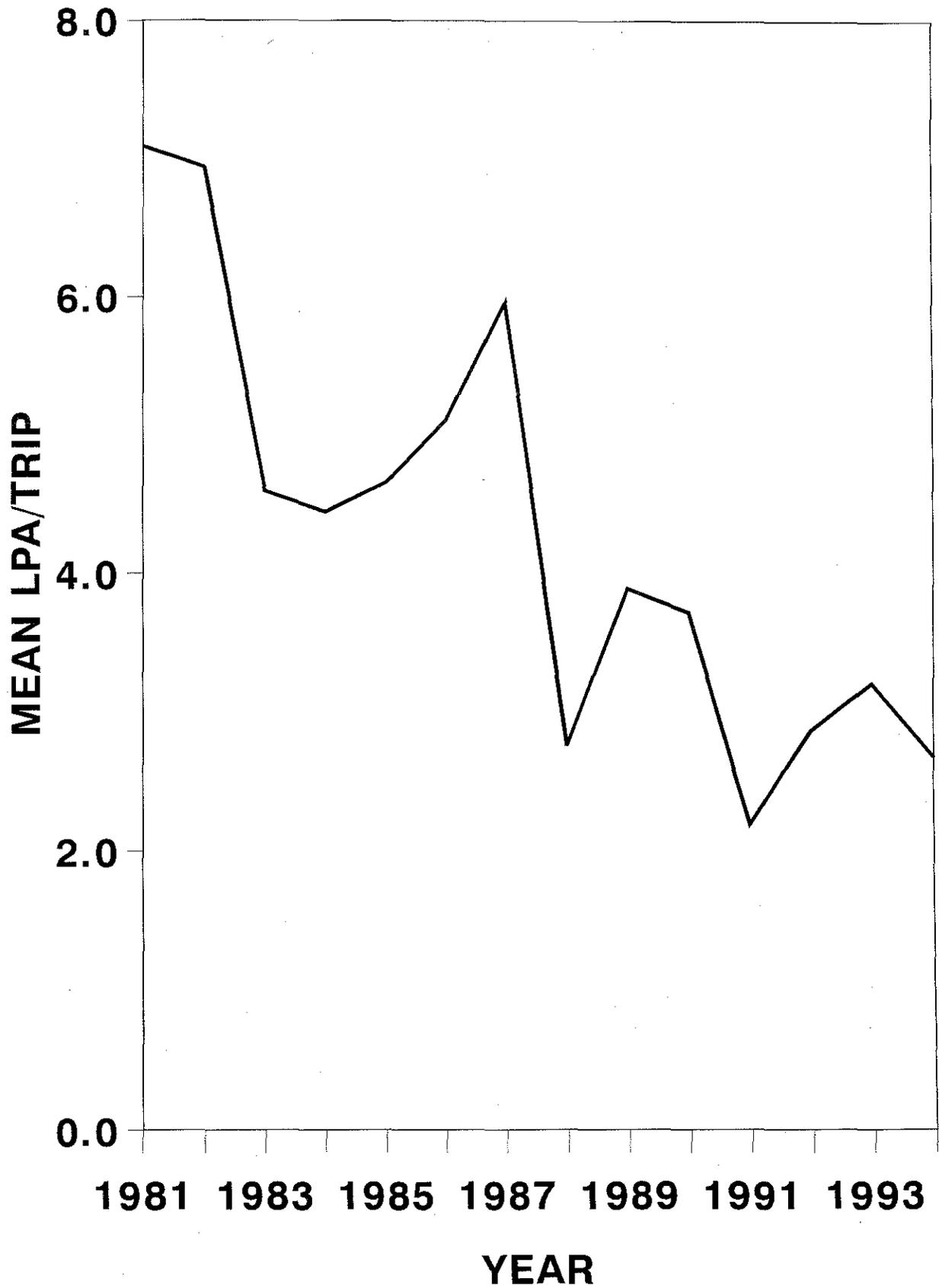


Figure 2. Winter flounder recreational landings per angler per trip from Gulf of Maine, 1981-1994.

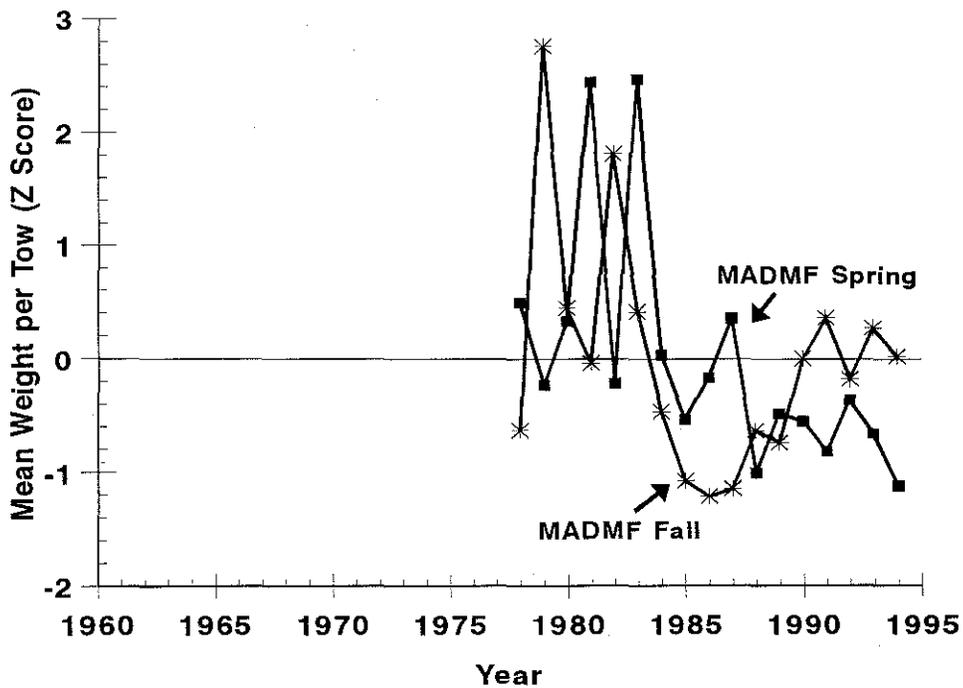
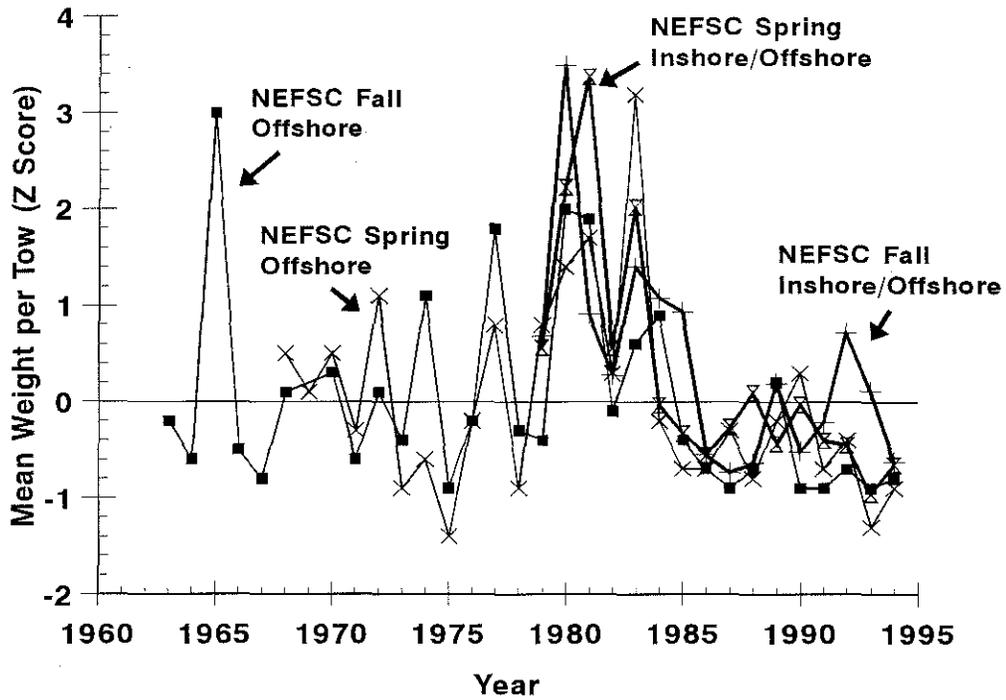


Figure 3. Standardized research trawl indices of Gulf of Maine winter flounder biomass

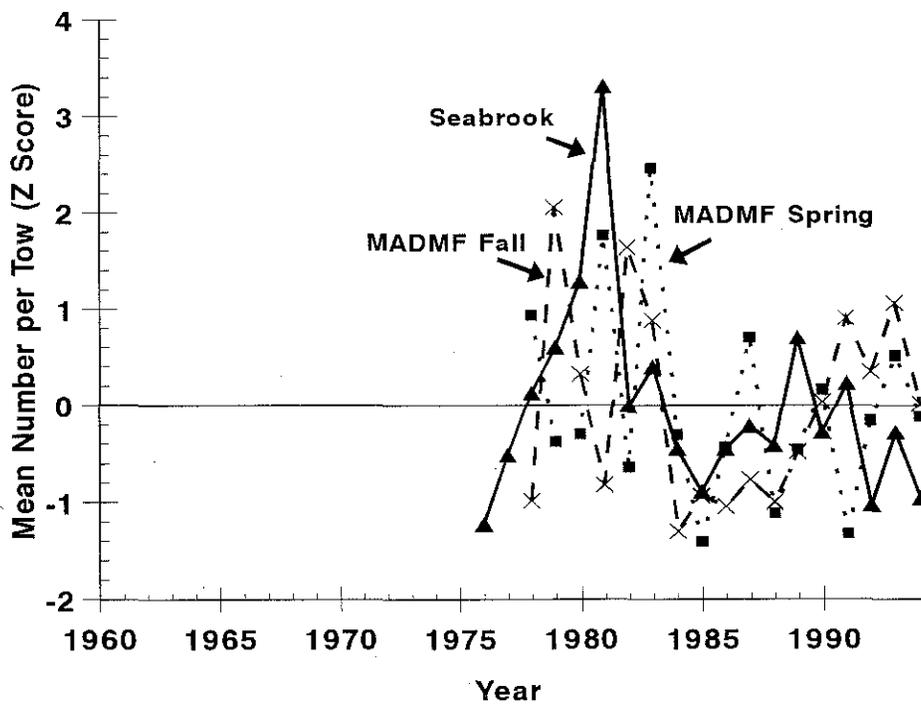
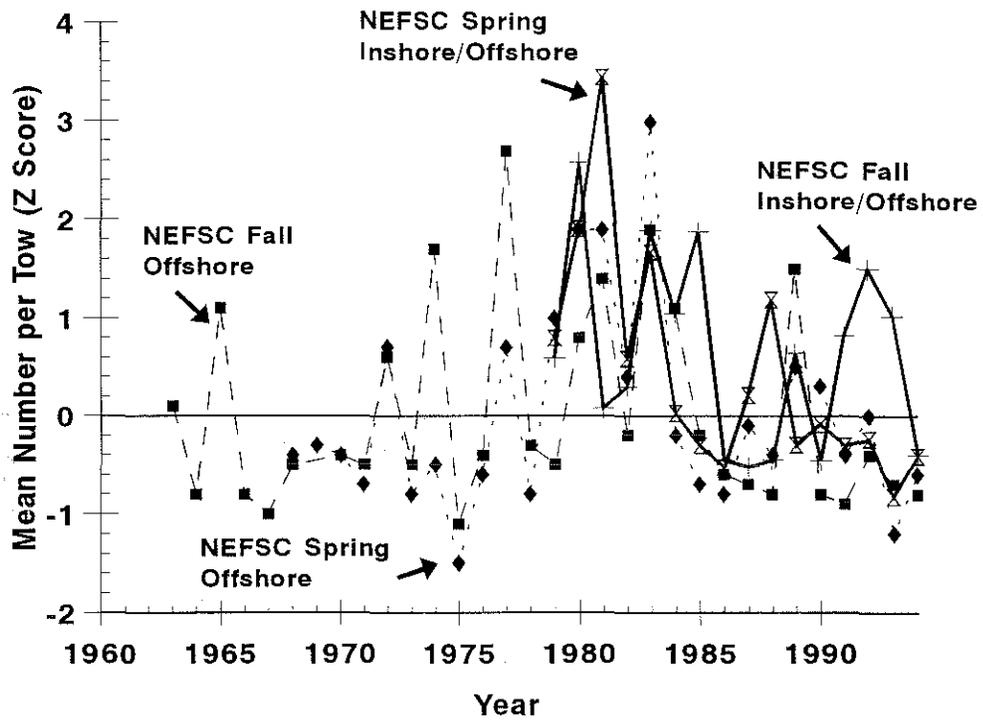


Figure 4. Standardized research trawl indices of Gulf of Maine winter flounder abundance.

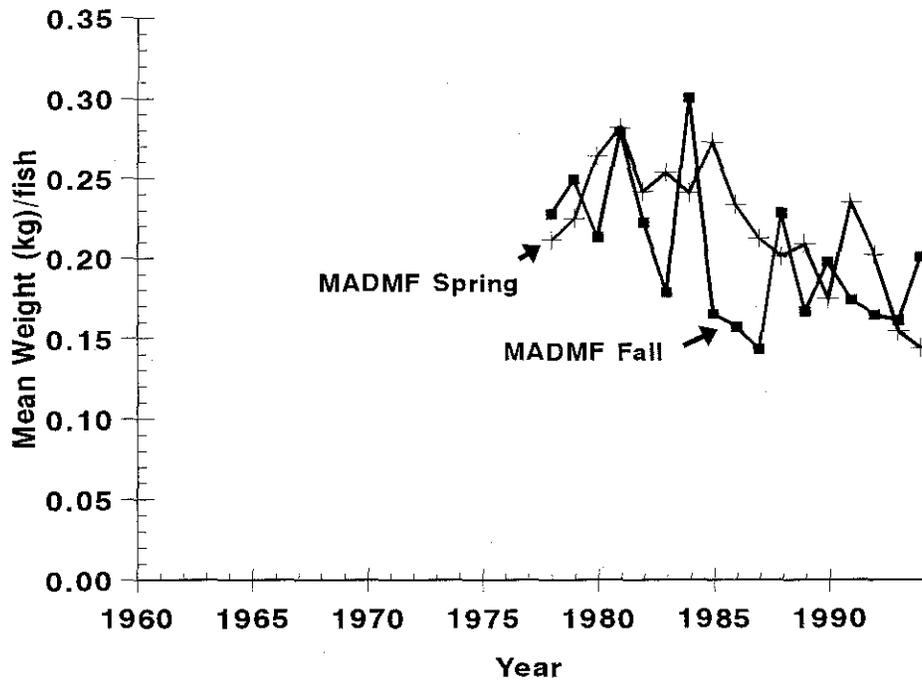
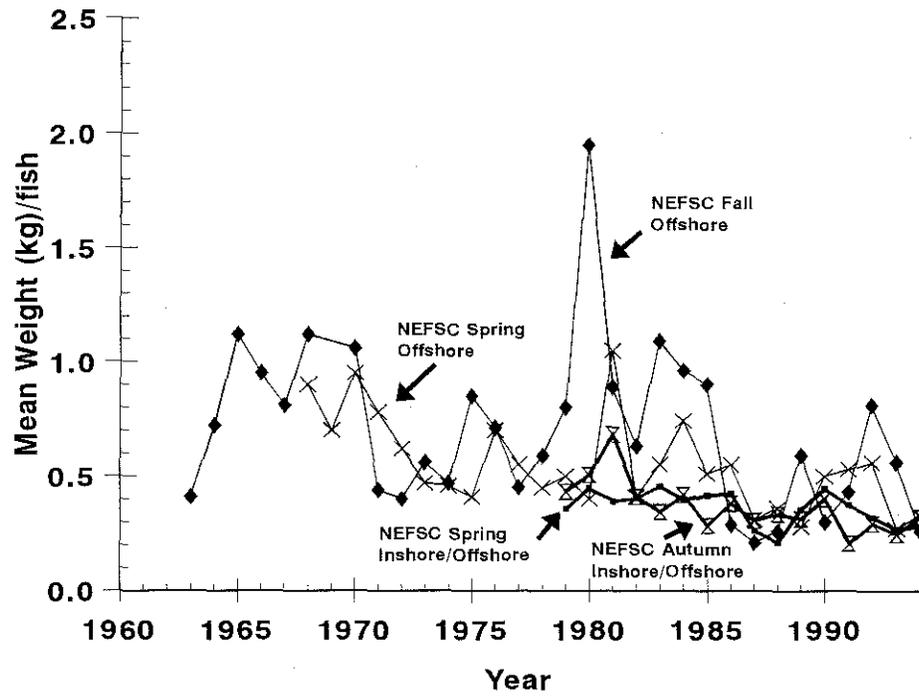


Figure 5. Research trawl indices of Gulf of Maine winter flounder average size.