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Witch Flounder Biomass Estimates in Divisions 3LNO and Their Possible Relation to Water Temperature From Russian 1980-1994 Research Surveys

by

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Abstract

Witch flounder biomass estimates in Divisions 3LNO from Russian 1980-1994 research surveys are presented. The largest biomass estimates registered in 1984 and 1985 in Div. 3L and in 1988 and 1991 in Divs. 3NO at water pre-bottom temperature about 0.2°C and 0.6-1.2°C, correspondingly.

A dense relation (R^2 > 57%) between pre-bottom temperature and biomass estimates in all Divisions has been revealed, however a dependence characters differed from each other greatly.

Introduction

During long-term fishery, witch stock size and their catch in the area of the Grand Newfoundland Bank were objected to sufficient fluctuations. The largest catches were obtained in early 1970-ies and mid-1980-ies. Because of the sharp decrease of witch stock after 1991, this species has lost its commercial importance, and NAFO Scientific Council recommended to suspend this species fishery since 1995.

One of the possible reasons influencing the stock assessment and character of its distribution is changes of hydrological regime in witch habitats on slopes of Great Newfoundland Bank.

An attempt to analyse a relation between changes in witch biomass estimates and water temperature from 1980 to 1994 from Russian research surveys in the area of the Grand Newfoundland Bank is made in the paper.

Materials and Methods

To obtains comparable long-term biomass estimates, data of trawl surveys carried out annually in spring/summer down to 800-850 m depths in Divs. *3LNO were used*. A standard fish-counting bottom trawl 31.2/27.3 with small mesh size insertion in the codend (a = 8-12 mm) was used.

Surveys were carried out by stratified-random pattern (Doubleday, 1981). A method of their conducting had been presented in detail earlier (Bulatova, Chumakov, 1986); Kuzmin, 1992).

Witch biomass estimates for 1980-1993 were revised. Calculations repeated the estimates, presented earlier, excluding 1991 and 1993, when recalculated values turned out to be slightly higher than those by calculations done in previous years.

To characterize environmental conditions, long-term data on water temperature along the hydrological section 6-A, obtained in October-November, 1980-1992, as well as on the bottom water temperature in Divs. 3L, 3N, 3O in 1980-1994, were used. Water temperatures were measured during trawl surveys just before or after trawlings. In 1992, no trawl surveys were carried out in the area of the Grand Newfoundland Bank.

Geographical location of 6-A section is presented in Figure 1. Method of calculation and temperature data series are presented in papers (Borovkov and Tava, 1988; 1992).

Results and Discussion

Managing of witch stock in the area of the Grand Newfoundland Bank is carried out by singling out of some TAC for the north-eastern slope of the bank (together with Divs. 2J + 3K) and southern slopes (Divs. 3NO). From the point of view of fisheries, they are unequal in importance, since from the early of 1980-ies the total catch in Divs. 3NO (especially 3O) was noticably higher than in 2J + 3KL (Fig. 2). The Hamilton Bank is considered the northern bounder of witch distribution. Hydrological regime near the northern bounder is characterized in average by lower water temperature in the pre-bottom layer compared to that on the southern slopes on the Grand

Newfoundland Bank. In some years temperature difference can reach 2.5°C (Fig. 3). Although witch is a eurythermal species and occured in catches at water temperature of -1 to +10°C, it is considered that its temperature optimum is about 3°C, therefore the dwelling conditions in Divs. 3NO are evidently more favourable.

Estimations of witch biomass from Russian surveys fluctuated in 1980-1994 sufficiently (Fig. 4, Tables 1, 2, 3). The largest numbers in Div. 3L were obtained in 1984 and 1985 at mean water temperature near bottom about 0.2°C. In Divs. 3NO the heightened estimates of biomass were registered at water temperature of 0.6-1.2°C in 1982, 1985, 1986, 1988 and 1991. The analogous estimates from Canadian studies showed in many cases the similar tendency of stock changes, however, values were as a rule higher (Bowering et al., 1994).

The possible reason of high biomass estimates in the mentioned years is short-period shifts of witch within the area of the Great Newfoundland Bank and their re-distribution into high density concentrations in some areas of strata, relatively big in square. This can lead to heightened biomass estimates in some strata in consequence of a number of trawlings unrepresentative for this year in these strata and, in general, for the whole Division. Typical examples of such heightened estimates can be biomass values in strata 345 and 346 for Div. 3L in 1984 and 1985, as well as in strata 336 and 354 for Div. 3O in 1991.

An attempt to determine quantitatively the possible correlation between water temperature on the S-A section and witch biomass in the area of the Grand Newfoundland Bank turned out to have no success. Back relation of mean strength (correlation coefficient is 0.58) was registered between water temperature averaged in 50-200 m layer in parts AB and witch biomass estimates in Div. 3L, obtained a year after doing of hydrological section S-A (Fig. 5, 6, Table 4).

To learn a measure of relation between water temperature in the pre-bottom layer and witch biomass estimates aimed at decreasing of short-period fluctuations, the indices smoothed by 7 terms with the help of sliding averaging were used. Results of an regressional analysis justify on a high measure of relation between smoothed characteristics defined by the determination coefficients of 82.14 %, 57.30 % and 79.93 % for Divs. 3L, N and O, correspondingly (Tables 5, 6, 7). Relation beetween water temperature and biomass estimates is specific for each of Divisions and expressed by a parabolic dependance for Div. 3L and linear models with opposite sign coefficients of slope of a regressional straight line for Divs. 3N and 3O (Fig. 7, 8, 9).

The highest witch biomass estimates were as a rule registered in years with moderately warm and normal water heating in pre-bottom layers (1985-1988). In the northern part of the area, influenced by cold water masses in the greatest measure compared to other areas, the temperature optimum during fish concentrating is mostly expressed: from 0.3 to 0.7°C. At temperature higher or lower these values, biomass estimates decrease. In Div. 3N, water temperature increase is followed by the correspondent in time biomass estimates increase, whereas in Div. 3O - by decrease.

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Table 1 Witch flounder biomass estimates (MT) from stratified-random cruises in Div. 3L, 1980-1994.

No of stratum	Depth range,m	Area of stratum sq.miles	Years													
			1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1993	1994
363	57-91	1780		201.2	46.4											
372	57-91	2460		155.1												
350	57-91	2071					34.5									
371	57-91	1121					24.9									
384	57-91	1120	26.8													
364	93-183	2817		67.4	116.3											
370	93-183	1320		14.3												
390	93-183	1481	35.4	16.1	312.3			63.1								
385	93-183	2356			430.2			430.5								
365	93-183	1041			52											
349	93-183	2114	68.9													
348	93-183	2120	341.1													
347	184-274	983	25.6			14.6	228.2									
366	184-274	1394	15.1	45.5	712.1		733.1	199.6	98.1	69.7		12.4		48.5		
369	184-274	961	68.9		300.8		653.1	1466.4	2854.5	294.2	49.3	994.9	37.2			
386	184-274	983	70.5		83.3		61.9	405.3	609.8	25.5	95.3	608		51.3	55.6	
389	184-274	821	72.8	80.2	88.3		36.5	42.6	39.5	53.2		15.2	11.5			
391	184-274	282	11.2	8	23.3		38.3	16.7		8.4	2.7	11.8				4.9
345	275-366	1432	305.1			701.9	1852.8	3337.8	259.9	63.6	36.5					
346	275-366	865		146.7	154.2	136.7	2234	2428.4	472	469.9	22.1	303.3	143.2			
368	275-366	334		13.8	40.7		3.7	98.1	112.2	47.8	8.5	106.4	20.5	56.6		8.7
387	275-366	718	109.3		227.9	168.9	801.8	469.8		127.6	27.2	210.6	70.1	103	12.5	
388	275-366	361		4.7	60.4	15.6	570.5	69.5	34.8	25.8		227.3	92.9			94.2
392	275-366	145		0.5	82.2	6.4	46.9	8.3	4.6	22.6	5.5	18.6			8.2	
729	367-549	186	20.8		29.9		99.3	33.8	55.1	32.9	39.6	19.6	4.8		38	29.9
731	367-549	216	303.3	121.5		20.9	277.6	332.5		136.1	10.7	9	31.1	170.2	41.3	28.2
733	367-549	468	16.3		337.2	46.2		332.8	581.6	395.2	90.7	2.9	51.4	660.1	333.1	123.5
735	367-549	272	50.4	7.1	104.7	8.3	72.7	55.7	219.7	238.2	82.4	74.1	61	320.6		167.9
730	550-731	170		25.1	61.7		59.9	121	38.3	78.3	48.4	47.8			66.1	37.7
732	550-731	231	146.6	6.1		32.7	62.6	191.6	149.1	468.9	173.2	34.8		320.2	112.5	
734	550-731	228				38.7		7.5	109.4	506.1	43.8		38	255.8	310.3	141.8
736	550-731	175	41.5	7.6		11.2	39.1	28.4	37.2	410.7	81.2	26.5	83.2	104.6		121.7
741	732-914	223		48.9												
*	Total		1729.5	938.9	3313.3	1202.1	7931.5	10139.6	5675.8	3474.7	817.2	1823.1	644.8	2007.2	977.5	758.4

Note: data for 1992 are absent.

Table 2 Witch flounder biomass estimates (MT) from stratified-random cruises in Div. 3N, 1980-1993

No of stratum	Depth range,m	Area of stratum sq.miles	Years												
			1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1993
376	>56	1499		113	48.9										
360	57-91	2992	2189.8	156.1	2510.7	398.9	354.6	360.9				14.1		78	65
361	57-91	1853	173.2										42.9		
362	57-91	2520		32.9									39.5		
359	93-183	421	233.1	40.3	158.3	35.6	73.6	1059.5	25				1.3		124.5
377	93-183	100		28	32.8	1.9	73.3	3.7							
382	93-183	647	73.1	4.2			25.6								
358	185-274	225	120.8	55.4	235.8		4	121.3	117	50.3	57.2	128.5	8.4	10.8	94.2
378	185-274	139	97.2	52.3	33.2	15.4	8.9	23.2	4.1	26.8	5.3			3.6	
381	185-274	182	198.1		20		26.5	26.2				1.7			
357	275-366	164			6.1	1.8		30.7	72.3	187.1	110.3	141.5	2.7	4.3	7.8
379	275-366	106		17.3		5.9	62	18.8	10.2	50.8	22.1	27.9		4.6	
380	275-366	116		26.5		21.7	48.8	4.9	2.3	3.4	7.5	28.4			
723	367-549	155	258.8		67.7	21		254.2	18.8	502.9	104	108.4	47.4	147.6	174.2
725	367-549		4.8	11.2	19.2	14.3	135.9	78.8	63.5	119.3	186.9	191.3	13.2	28.3	43.4
727	367-549		9.4	50.8	112.7	24.9	227.3	47.4	73.1	103.5	183.4	254.6	35.1	2.8	
724	550-731	124				13.5	19.9	23	48.4	31.5	79	55.1		86.8	
726	550-731	72				63.2	9.6		58.7	82.7	38.6	67.7	87.3	167.3	
728	550-731	156					302	84		90.5	248.9	192.1		80.9	
760	732-914	154													23.4
*	Total		3358.3	587.8	3245.3	618	1371.9	2136.5	553.3	1248.8	1943.7	1327	588.1	623	532.6

Note: data for 1992 are absent.

Table 3 Witch flounder biomass estimates (MT) from stratified-random cruises in Div. 3 o, 1980-1993.

No of stratum	Depth range,m	Area of stratum sq.miles	Years												
			1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1993
330	57-91	2089	445	208.9	59		139.3								
331	57-91	456		7.9		213.4	96.8	24.8			61.5				
338	57-91	1898	334.2	633.8	276.4		246	543.6	951.3	988.8	1230	573.6	56.2	1633,9	255.8
340	57-91	1716			141.8		25.4		181.1			9.1	38.1		
351	57-91	2520			657.4			619.7							
352	57-91	2580	260.8		827.3	267.6	271.4	47.8			206.1	293	151.1		459.9
353	57-91	1282	33.4	582.5	1655.4	448.4	307.7	249.3	554		1013.2	605.4	132.8	629.8	
332	93-183	1047	545.4	88.8	457.9	92.3	224.9	71.3	1997.1	1374.7	679.5	281.1	765.4	2389	696.5
337	93-183	948	71.4		183.4		66.7	904.2	1779	498.6	2736.1	402		853.2	371
339	93-183	585				151.7	1037.1	28.9							30.5
354	93-183	474	793.4	194.4	708.9	105.2	43.3	663.6	400.3	112.4	271	46.5	20.9	2052.6	240.4
329	93-183	1721						46.7		25.5					583.6
336	185-274	121	2.9	11.8			7.2		11.4	151.2	225.2	15.1	8.8	2673	15.2
355	185-274	103	151.7	5.6	13.2			29.4	3.3	16	44.1	107	1213.9	9	29
333	185-274	151	35.2	14.4	6.4	1.7	5.6	0.7		30.6	54	9.4	15.8	298.3	18.5
334	275-366	96		1.5	0.8			0.9			23.1	0.5	55.1	104.8	8.3
335	275-366	58		1.9			4.3	4	7.2	8.6	39.2	22.6	6	531.4	31.4
356	275-366	61		4.5	8			11	4.8	115.5	4.5	241.3	181.6		23.6
717	367-549	166	1.4	1.4	6.9			13.5		0.7	2.5	0.5		109.7	32.7
719	367-549	76							2.4	3.8	53.7	4.3	5.2	53.9	12.9
721	367-549	76				2.1	5.2	43.3	4.9	475.3	139.6	294.7	61.2	146.7	31.5
718	550-731	134					12	1.1		19.3	4.4	13.7			24.5
720	550-731	105					6	9.8		8.2	25.3	2.8	1.9	4.6	12.8
722	550-731	93				1	8.3	44.8		29.6	8.2	20.9	32.9	7.3	20.2
*	Total		2674.9	1757.4	5002.9	1283.7	2507.2	3355.5	5896.7	3858.6	6830.4	2943.7	2748.1	11497.1	2898.3

Note: data for 1992 are absent.

Table 4. Analysis of variance results from linear regression model relating witch flounder stock biomass and water temperature in 50-200 m layer on section 8-A (parts AB) in Div. 3L, 1980-1994 (time series of stock assessments is shifted on 1 year).

Regression analysis - linear model: Y = a + bx

Parameter	Estimate	St. error	T-value	Prob. level
Intercept	4.37420	0.92865	4.71026	.00115
Slope	-3.89289	1.81186	-2.14879	.05015

Analysis of variance

Source	Sum of squares	DF	Mean Square	F-ratio	Prob. level
Model	34.12849	1	34.12849	4.61731	.05015
Error	66.51897	9	7.39100		

Correlation coefficient = -0.58230 R^2 = 33.91 %

Table 5. Analysis of variance results from parabolic regression model relating witch flounder stock and water temperature near the bottom in Div. 3L, 1980-1994.

Model fitting results Y = A*x^2 + B*x + C

	Estimate	St. error	ratio
A	-11865.0471	1742.73887	-6.80828
B	12014.0503	1690.00523	7.10888
C	1254.8227	322.09338	3.89521

Analysis of variance for the full regression

Source	Sum of squares	Df	Mean square	Ratio
Model	1.3702E8	3	4.5674E7	1.0521E2
Error	4775503.8	11	434136.7	

R^2 = 82.14 %

Table 6. Analysis of variance results from linear regression model relating witch flounder stock biomass and water temperature near the bottom in Div. 3N, 1980-1993.

Regression analysis - linear model: Y = a + bx

Parameter	Estimate	St. error	T-value	Prob. level
Intercept	-72.3165	358.128	-0.20192	.84310
Slope	1580.75	373.718	4.17629	.00109

Analysis of variance

Source	Sum of squares	Df	Mean square	F-ratio	Prob. lev.
Model	4808757.4	1	4808757.4	17	.00109
Error	3584218.2	13	275709.1		

Correlation coefficient = 0.85693 R^2 = 57.30 %

Table 7. Analysis of variance results from linear regression model relating witch flounder stock biomass and water temperature near the bottom in Div. 3O, 1980-1993.

Regression analysis - linear model: Y = a + bx

Parameter	Estimate	St. error	T-value	Prob. level
Intercept	6791.54	398.999	17.10720	.00000
Slope	-2208.48	306.917	-7.19583	.00001

Analysis of variance

Source	Sum of squares	Df	Mean square	F-ratio	Prob level
Model	13957035	1	13957035	5.178E1	.00001
Error	3594285.4	13	269560.4		

Correlation coefficient = -0.894042 R^2 = 79.93 %

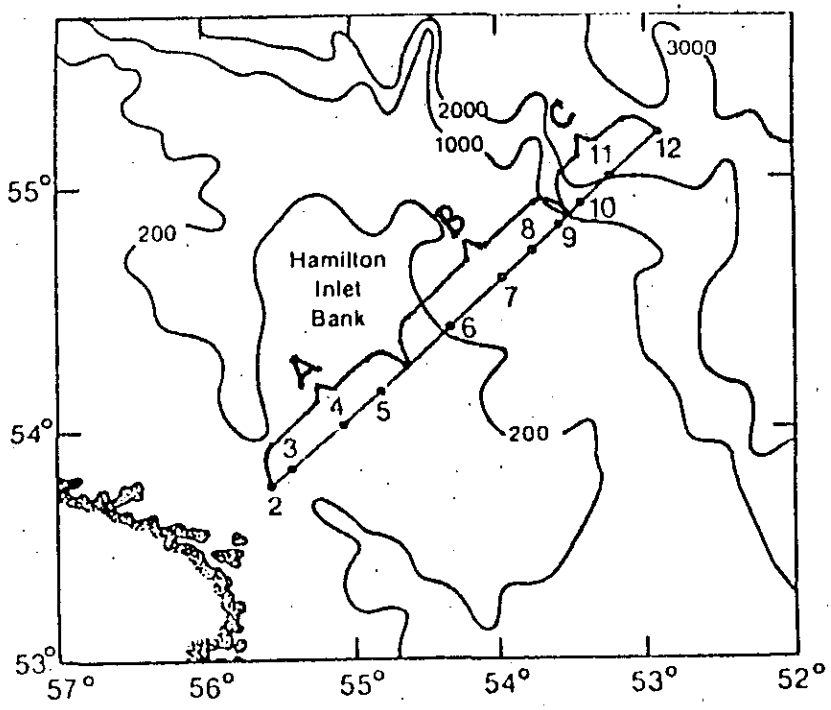

Fig. 1. Location of oceanographic stations on hydrological Section 8-A (parts A,B,C).

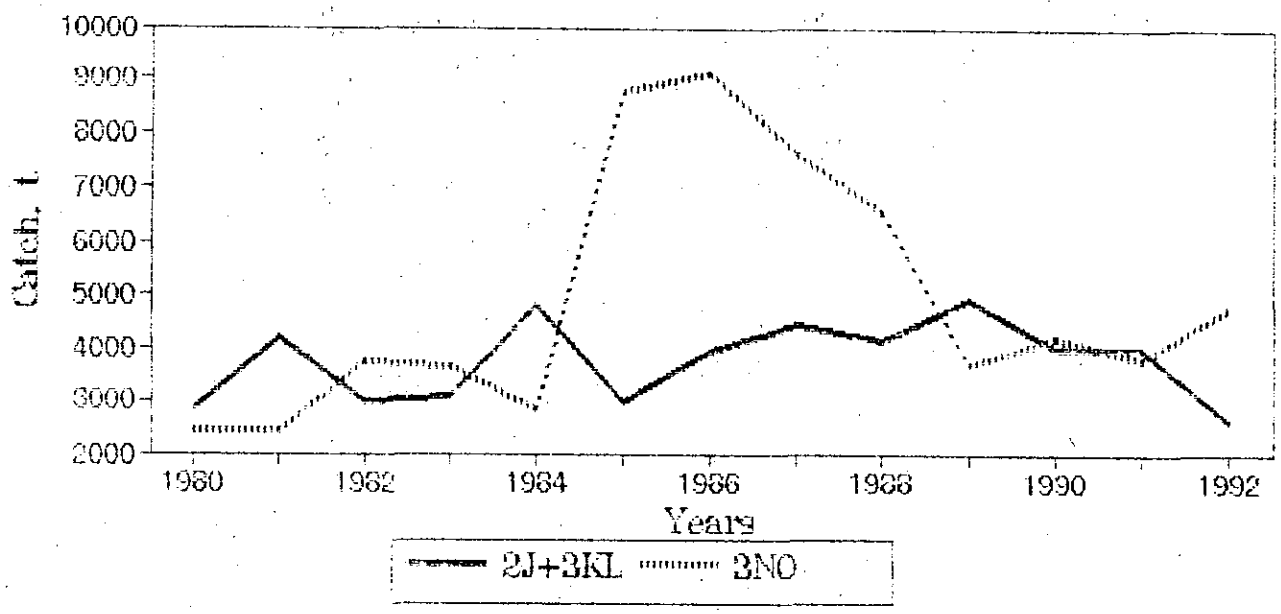

Fig. 2. Witch flounder catches in Divs. 2J+3KL and 3NO in 1980–1992

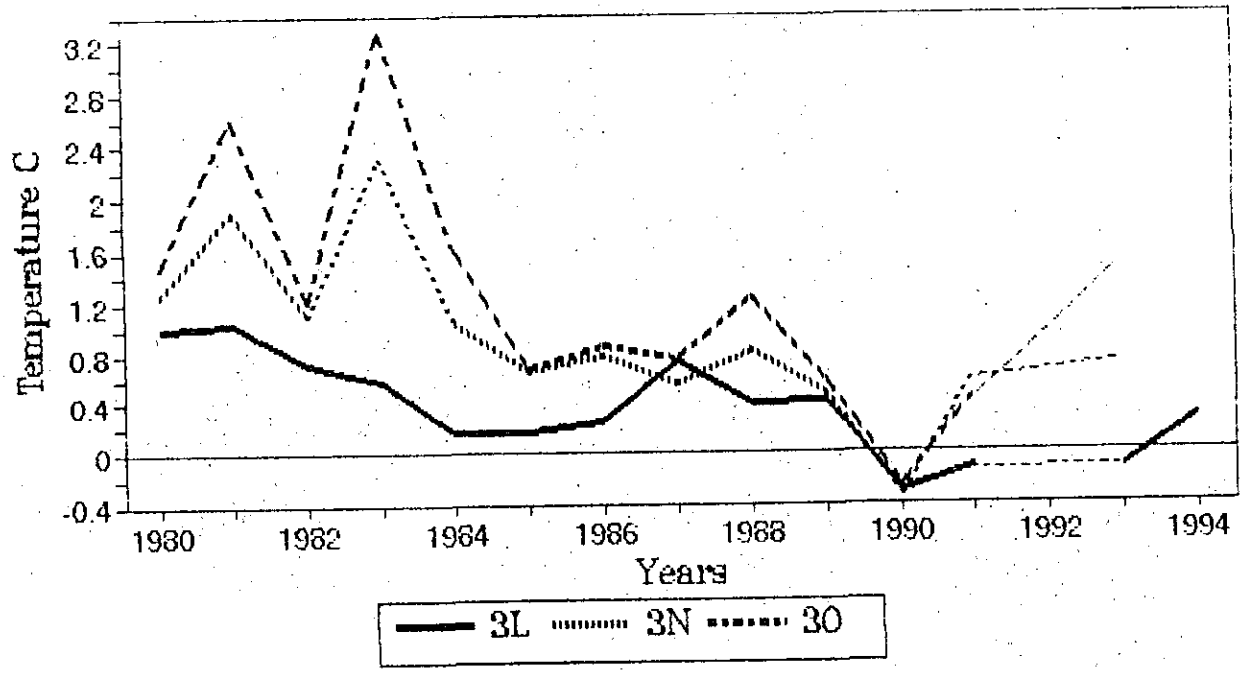

Fig.3 . Temperature of water near the bottom in Divs. 3L,N,O 1980-1994

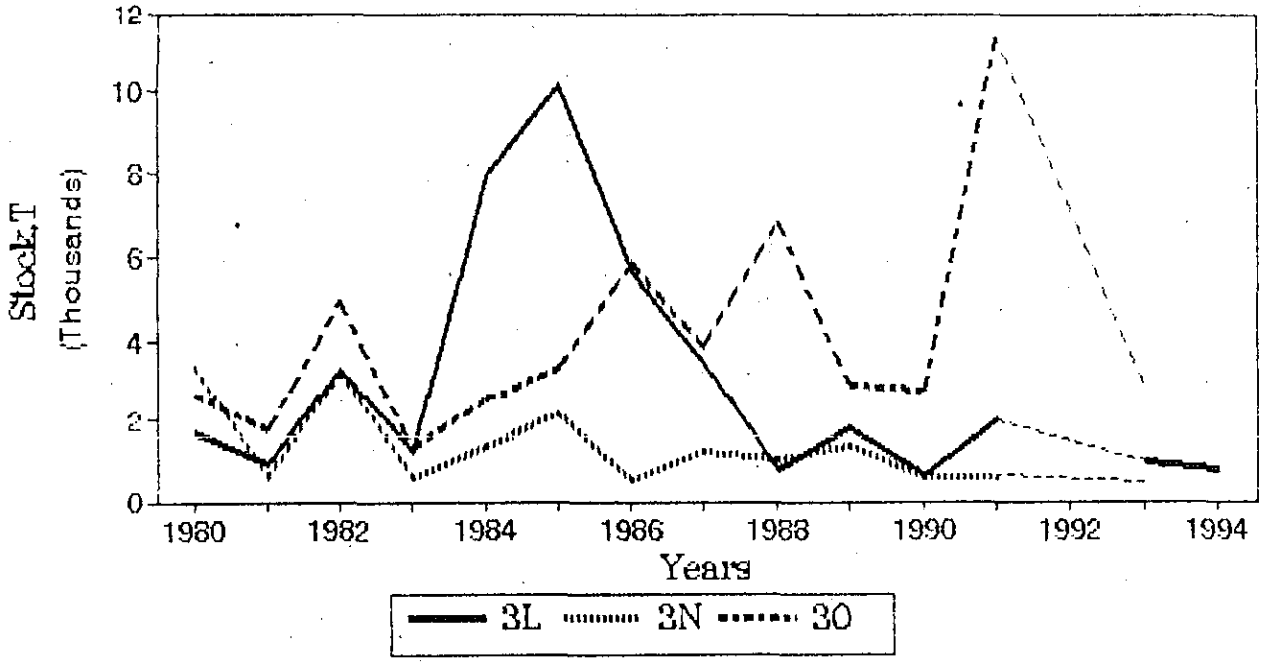

Fig.4 . Stock assessments of Witch flounder in Divs. 3L,N,O 1980-1994

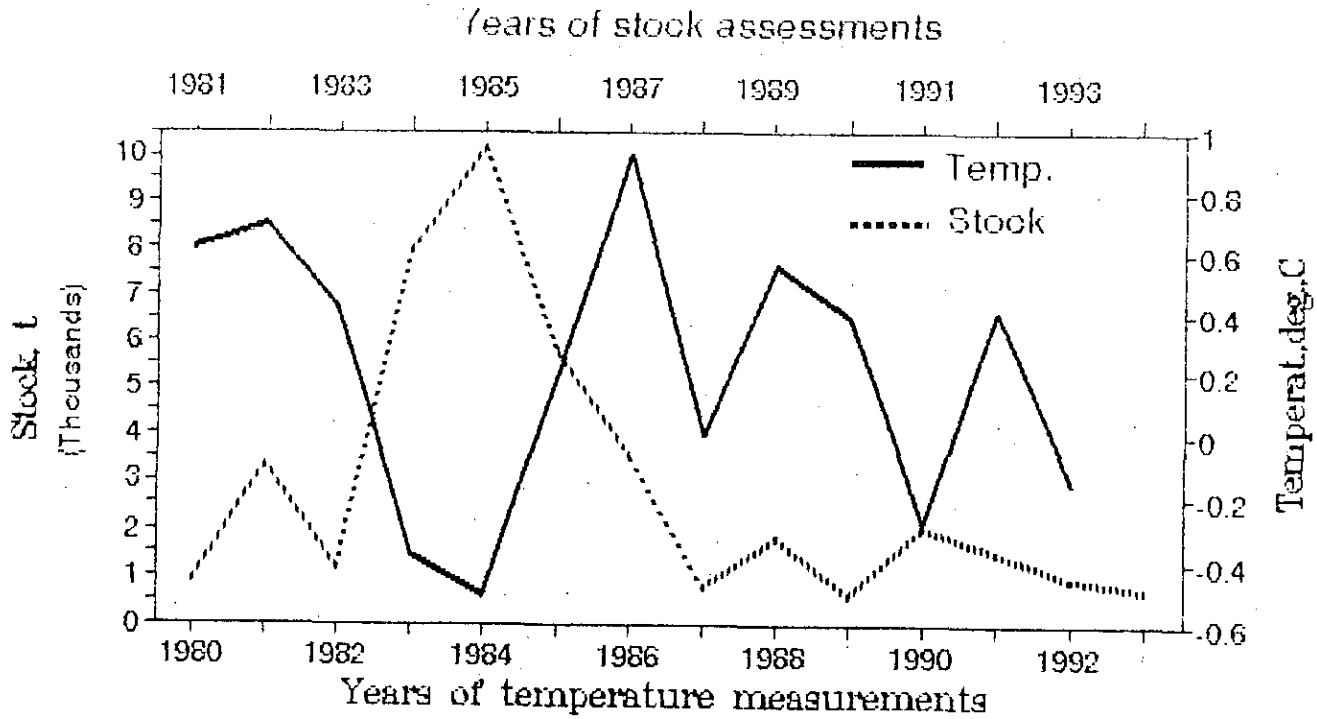

Fig.5 Stock assessments of Witch flounder in Div. 3L in 1981-1994 and water temperature in 50-200 m layer on section 8-A, part AB in 1980-1992

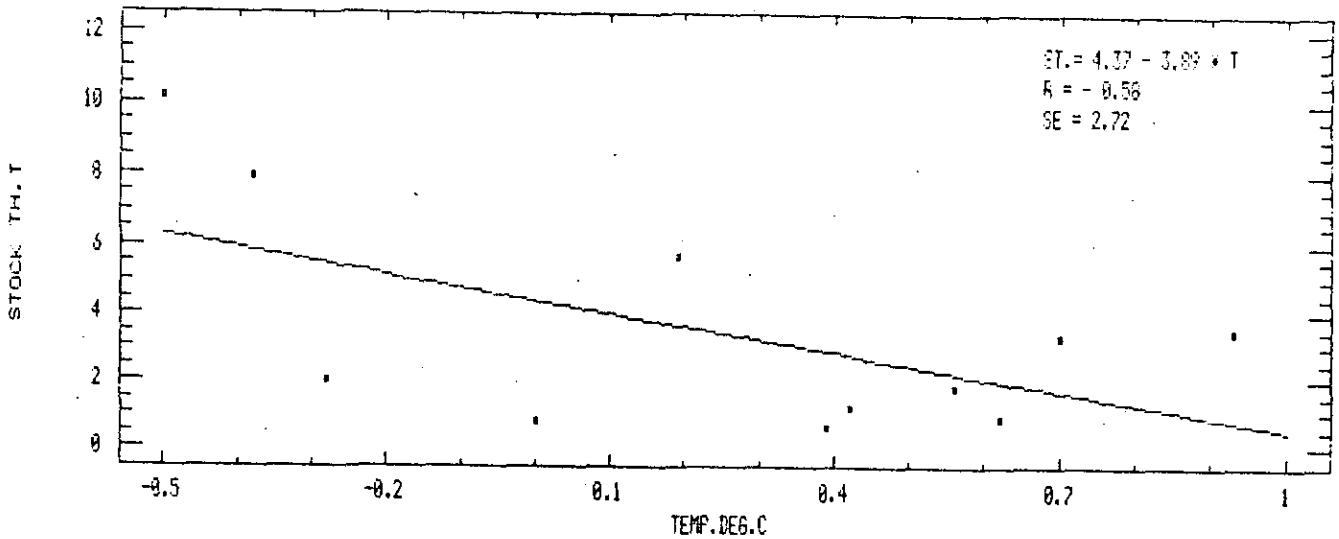

Fig. 6 . The relationship of water temperature in 50-200 m layer on Section 8-A (parts AB) and stock biomass in Div. 3L, 1980-1994 (time series of stock assessments is shifted on 1 year).

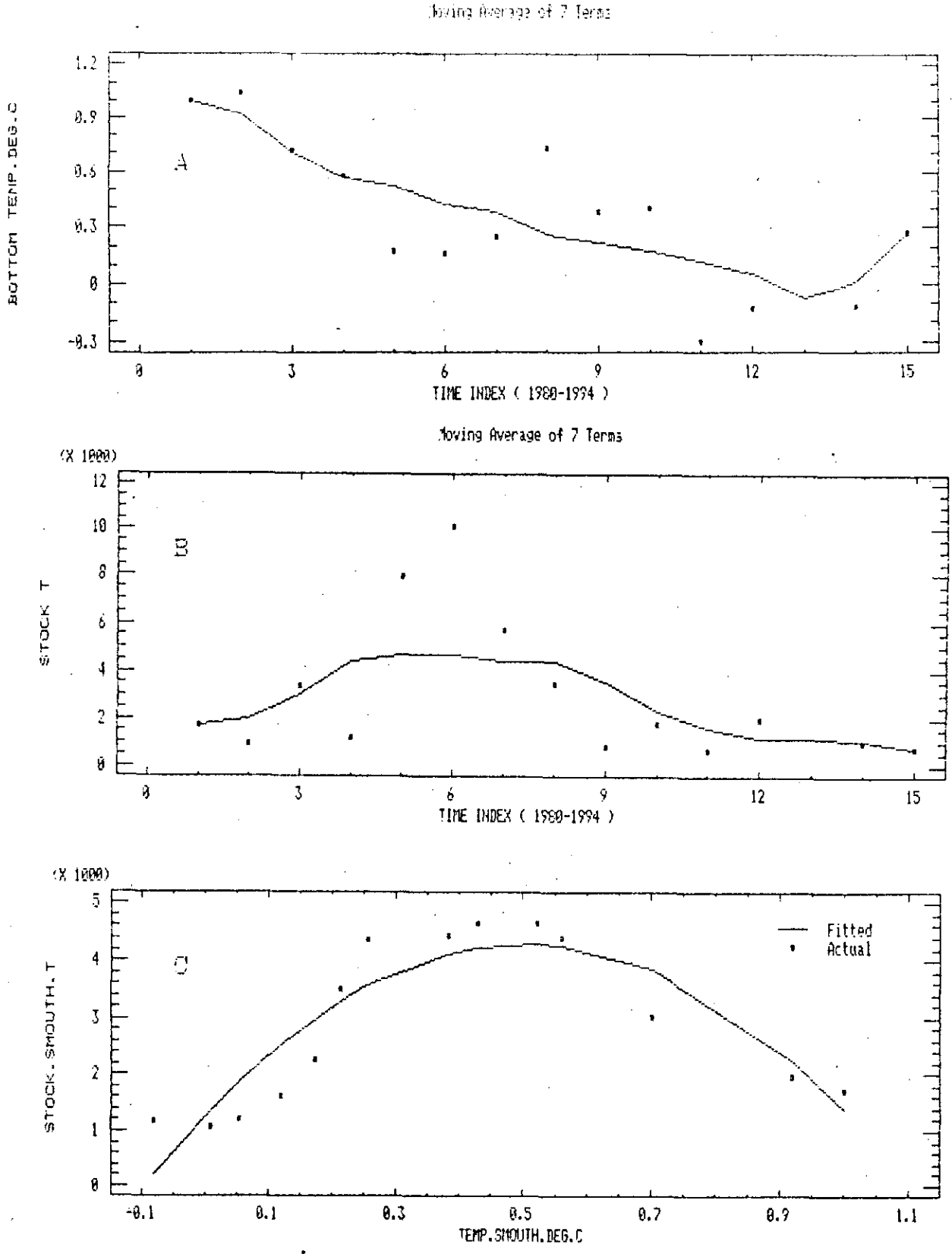

Fig. 7 .Actual and smouthed values of water temperature (A), stock assessments of Witch flounder (B) and their relationship (C) in Div. 3L,1980-1994.

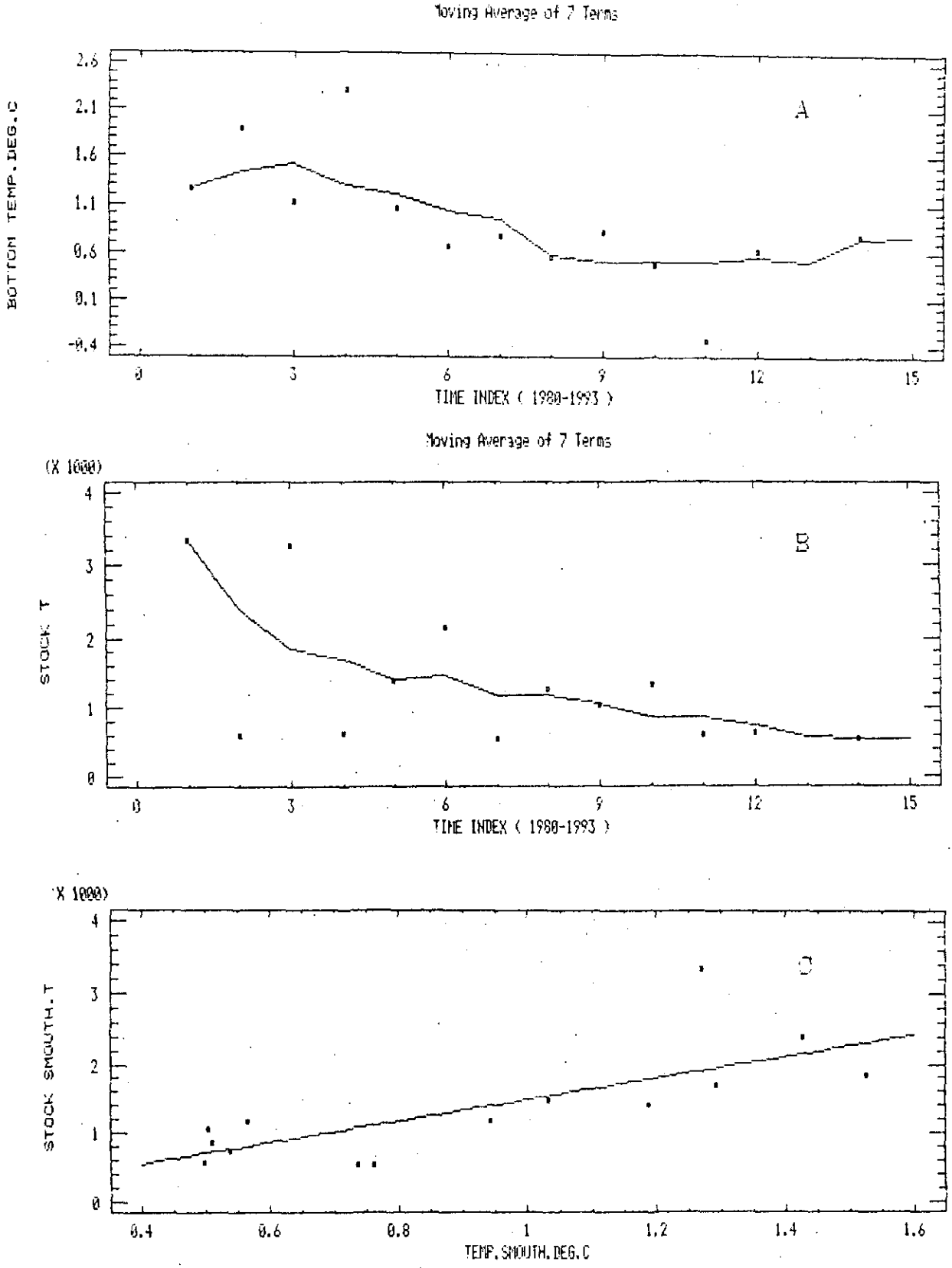

Fig. 8 .Actual and smouthed values of water temperature (A), stock assessments of Witch flounder (B) and their relationship (C) in Div. 3N,1980-1998.

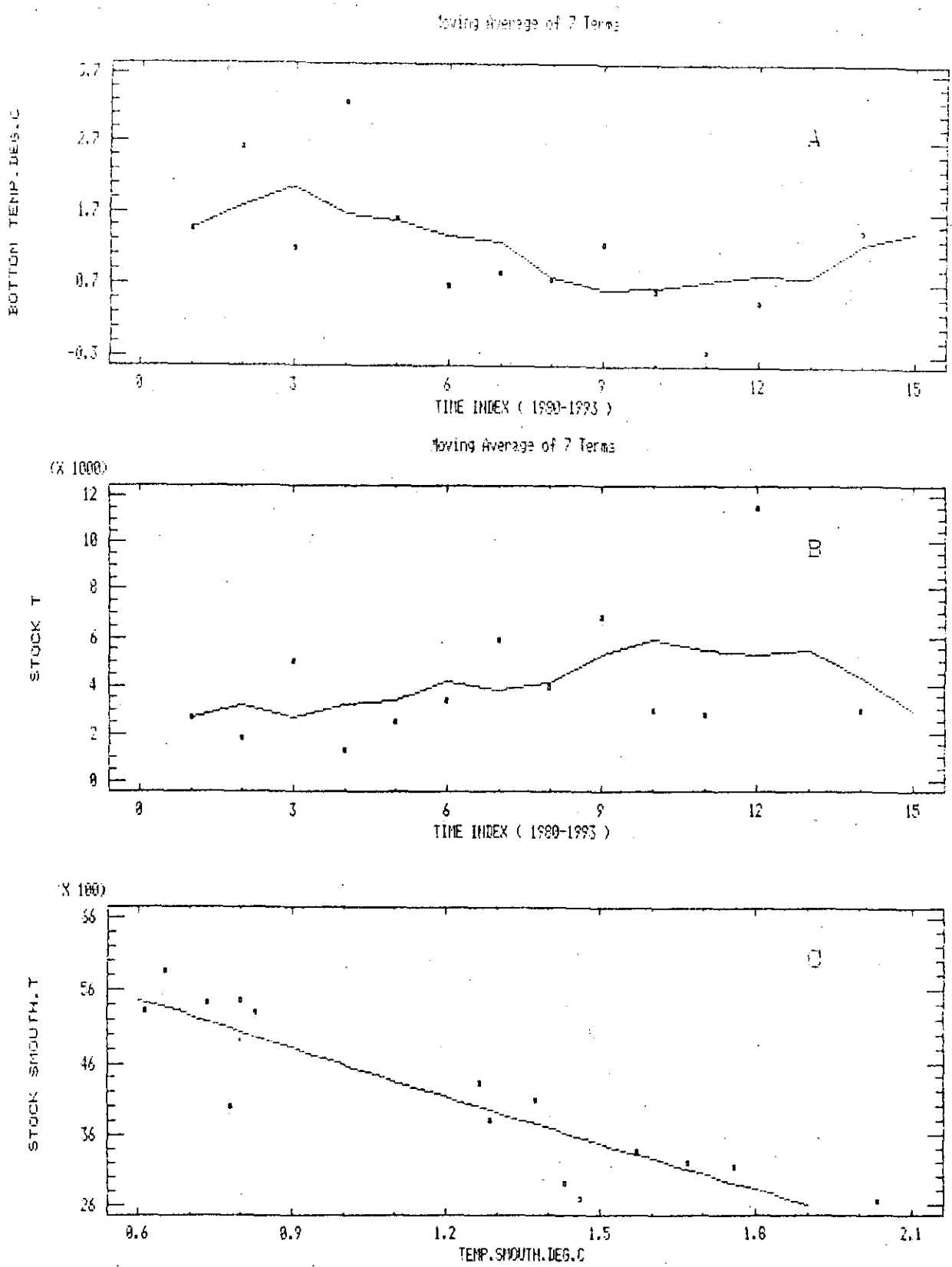

Fig. 9 .Actual and smouthed values of water temperature (A), stock assessments of Witch flounder (B) and their relationship (C) in Div. 3O,1980-1993.