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Relative Year-class Strengths of Capelin (Mallotus villosus) in NAFO Div. 3L

by

J. E. Carscadden, B. S. Nakashima, and D. S. Miller

Department of Fisheries and Oceans, Science Branch
P.O. Box 5667, St. John's, Newfoundland, Canada A1C 5X1

Introduction

During the 1980's, indices of capelin abundance in Div. 3L have been derived by Canadian researchers from data collected during offshore acoustic surveys and from catch rate data from logbooks maintained by fishermen operating in inshore Newfoundland waters. Biomass estimates and estimates of year-class strength are usually reported from the acoustic surveys (see eg. Miller 1986 and Miller 1985 for explanation of methods). While these estimates are usually used as a basis for projections, they are not always comparable from year-to-year because of different survey coverage. For example, the coverage by the spring Canadian surveys has varied between 34,900 and 73,500 km^2 between 1982 and 1987. On the other hand, the catch rate data from the inshore fishery provide indices of abundance but have not been used to provide information on the strengths of year-classes in the fishery.

The purpose of this paper is to provide standardized indices of abundance by year-class derived from the offshore acoustic surveys and the inshore fishery in Div. 3L.

Methods

Offshore Acoustic Surveys

Canadian acoustic surveys for capelin have been conducted in Div. 3L since 1981. Two series of surveys have been conducted, a spring survey which started in 1982 and has been conducted annually since then, and a summer survey which began in 1981 but which was discontinued in 1985. Details of the design of the survey and collection and analysis of the data are given in Miller (1985). Miller (1986) noted one change in the analysis of the data in that a new estimate of α, the attenuation coefficient, was now appropriate. All results presented here use the new attenuation coefficient.

As part of the integration process, a density estimate ($gm.m^{-2}$) has been estimated for each survey block. Normally a biomass estimate is then calculated for each survey block by areal expansion. However, in this analysis, the density estimate for each block is partitioned into a density estimate for each age group by applying the age composition for that block. A survey density estimate per age group was then calculated by weighting survey block estimates by area of the survey blocks.

Inshore Catch Rates

Catch rates for the period 1981-86 are available for purse seines and trap nets (see eg. Nakashima and Harnum 1987). Two catch rate series for each gear type are available - catch per day which includes capelin that are kept as well as those that are dumped dead or released alive and landings per day, which includes only those capelin kept and landed.

An annual effort value for each gear type was derived by dividing the landings of that gear by the corresponding gear catch rate. A catch rate per age was then calculated by dividing the catch numbers at age by the appropriate effort index.

Results

Offshore Acoustic Surveys

Details of the mean densities and area by survey block and relevant age composition by survey block are given in Tables 1 and 2. The weighted densities at age for spring and summer surveys are given in Table 3 along with the estimates of abundance (billions of fish) presented in Miller (1986). In some years the surveys occurred at times when both mature and immature fish occur in the same area. Thus, in the present analysis, two-year-olds are of primary interest since they are immature at the time of the surveys and represent recruitment into the fishery. In both the spring and summer series, the 1983 year-class was much stronger as two-year-olds than any of the other year-classes while the 1981 year-class was the weakest.

The densities and abundance at age 2 were standardized (Fig. 1); both series exhibit the same trends. The standardized densities of the weaker year-classes are somewhat higher when compared to the 1983 year-class than the standardized abundances. The spring and summer surveys exhibit the same trends except for the 1982 year-class which appeared relatively stronger in the summer surveys.

Inshore Catch Rates

The landings, catch rates and calculated effort by gear type are given in Table 4 while the age compositions and catch at age by gear type are given in Table 5. The resulting catch rates at age are given in Table 6.

When considering only age 3, the 1983 year-class was strongest for purse seine catch rates. For trap catch rates, the 1979 year-class was strongest for landings/day while the 1982 year-class was strongest for catch/day. In the four catch rate series, there was no clear trend concerning the strong year-classes but in all series, the 1978 and 1981 year-classes were consistently the weakest.

Most capelin mature at age 3 or 4 and the spawning population is usually dominated by these ages (Table 5). The relative contribution of a single year-class at age 3 or 4 is dependent on maturation rate. Maturation rates by age and year-class are not available but by summing the catch rates for ages 3 and 4 of each year-class, the problem of annual differences in maturation rates can be overcome and an index of abundance for each year-class can be constructed (Table 7). Again there are no clear indications of which year-class was strongest although it appears that the 1979, 1980 and 1982 year-classes were relatively strong compared to the 1978 and 1981 year-classes.

The standardized catch rates for all gears and ages exhibit the same trends (Fig. 2 and 3).

Discussion

The trends in standardized densities from the offshore surveys were not in complete agreement with the trends in standardized inshore catch rates. In all series, the 1983 year-class was strong and the 1981 year-class was weak. However, the inshore indices indicated that the 1980 and 1982 year-classes were relatively strong while the offshore densities indicated these year-classes were weak. The analysis of densities presented here assumes that the densities from the surveys are representative of the population as a whole. It is possible that this assumption was violated in both 1982 and 1984 (1980 and 1982 year-classes). In the spring survey of 1982, overall coverage was good (75,000 km^2) but extensive concentrations of capelin were under the ice and this may have biased down the density estimates. Lilly and Carscadden (1986) reported that on the basis of capelin catches in spring groundfish surveys and capelin in cod stomachs from the same surveys, capelin were distributed in the central and eastern areas of the Grand Bank, including strata outside and

overlapping the 200-mile limit. The summer 1982 survey was not affected by ice but the overall coverage was relatively poor (39,000 km^2) and thus, some areas of high capelin concentration may have been missed. In the spring of 1984, coverage was poor (43,000 km^2) and influenced by ice. In the summer survey, coverage was good (63,000 km^2) and the survey was not affected by ice. The relative densities were higher for this survey than for the spring survey and higher than for both the 1980 and 1981 year-classes. Survey coverage and timing are probably not the only parameters affecting the offshore indices of abundance but this comparison does suggest that these factors could be eliminated by good survey coverage and proper timing. On the basis of their examination of capelin catches in groundfish surveys and capelin in cod stomachs, Lilly and Carscadden (1986) reported that there was no consistent pattern of capelin distribution during the spring within the 200-mile zone, further emphasizing the need for good survey coverage. This has been addressed in that starting in 1986, the Canadian spring and summer surveys were combined into one extensive survey (1986 coverage = 73,000 km^2) at a time when ice should not be a problem. This comparison also assumes that the insnore indices of abundance are tracking relative year-class strengths accurately. Undoubtedly these indices have their own sources of variation such as market demand for different sized fish, the extent of discarding, differential annual mortality rates, and slight differences in timing of the fishery by the two gear types (purse seines catch fish in deeper water before they would have moved inshore where they would be available to traps).

References

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Table 1. Mean densities and area by survey block for spring and summer offshore acoustic surveys in NAFO Div. 3L, 1981-87.

Date and trip	Block	Mean density ($gm.m^{-2}$)	Area (km^2)
GADUS 52 June 1981	A	15.74	23,337
	B	25.39	46,380
	C	4.61	23,076
			92,793
GADUS 64 April 1982	A	2.31	9,483
	B	16.73	19,002
	C	1.49	20,854
	D	3.57	26,398
			75,737
GADUS 66 June 1982	A	1.31	8,645
	B	3.16	13,745
	C	7.27	16,741
			39,131
GADUS 77 April 1983	B	1.25	12,279
	C	.86	12,685
	D	5.90	9,960
			34,924
GADUS 80 June 1983	B	4.74	17,242
	C	1.75	18,828
	E	5.35	12,425
			48,495
GADUS 93 April/May 1984	A	15.87	18,080
	B	2.68	25,220
			43,300
GADUS 96 June/July 1984	A	9.84	9,032
	B	11.20	16,361
	C	3.57	12,512
	D	5.59	25,488
			63,393
GADUS 109 May 1985	A	63.8	5,162
	B	153.8	4,662
	C	215.2	5,464
	D	43.6	6,817
	E	28.4	23,345
	F	24.1	10,770
			56,220
GADUS 111 June 1985	A	27.5	10,433
	B	22.3	18,542
	C	10.7	19,468
	D	3.3	24,788
			73,231
GADUS 124 May 1986	A	139.7	10,715
	B	36.5	19,686
	C	37.4	33,812
	D	23.8	9,106
			73,319
GADUS 137 May-June 1987	A	35.6	10,715
	B	13.8	19,686
	C	44.0	33,812
	D	46.9	9,255
			73,468

Table 2. Age composition of capelin by survey block in acoustic surveys in NAFO Div. 3L, 1981-87.

Date and Trip	Block	Age 1	2	3	4	5	6
GADUS 52 June 1981	A	29.3	54.0	15.5	0.7	0.4	0.1
	B	49.4	14.1	28.0	6.7	1.6	0.1
	C	0.1	3.5	79.3	14.2	2.8	0.1
GADUS 64 April 1982	A		40.7	50.0	6.8	1.9	0.5
	B		40.7	50.0	6.8	1.9	0.5
	C		1.4	80.9	13.6	3.4	0.7
	D		1.9	77.0	14.7	5.2	1.2
GADUS 66 June 1982	A	3.7	34.9	57.4	3.2	0.7	0.1
	B	32.3	63.7	3.4	0.6		
	C	79.6	10.9	8.9	0.3		
GADUS 77 April 1983	B		57.8	30.4	10.4	1.2	0.1
	C	0	2.4	48.6	44.5	3.8	0.8
	D	0.9	61.4	28.1	9.0	0.5	0.1
GADUS 80 June 1983	B	88.3	6.2	4.2	1.3		
	C	98.2	0.2	1.3	0.3		
	E	93.4	3.4	2.2	0.9		
GADUS 93 April/May 1984	A	0.4	73.9	16.3	8.1	1.2	
	B		14.0	50.3	31.1	4.5	
GADUS 96 June/July 1984	A	6.2	36.3	28.5	26.5	2.4	
	B	3.6	77.8	11.6	6.3	0.6	
	C	54.7	41.8	2.4	1.0	0.1	
	D	79.0	18.8	0.5	0.8	0.2	
GADUS 109 May 1985	A		90.0	8.2	1.1	0.5	
	B		82.8	16.8	0.2	0.2	
	C		82.4	17.0	0.6	0.1	
	D	0.1	89.3	10.3	0.3	0.1	
	E		69.5	27.6	2.1	0.7	
	F		35.7	51.3	8.7	4.2	0.1
GADUS 111 June 1985	A	0.3	74.0	23.3	1.8	0.6	
	B	0.6	83.6	15.6	0.1	0.0	0.1
	C	9.4	85.7	4.5	0.1		
	D	7.8	61.4	29.8	0.8	0.2	
GADUS 124 May 1986	A		26.0	62.7	10.6	0.4	0.3
	B		23.4	73.0	3.4	0.1	0.1
	C		26.8	63.8	9.0	0.2	0.1
	D		6.6	72.3	20.2	0.7	0.3
GADUS 137 May-June 1987	A	0.2	0.3	11.5	7.0	10.6	0.4
	B	0.1	64.2	13.1	20.2	2.3	0.1
	C	0.3	69.9	10.7	17.2	1.9	<0.1
	D		9.9	25.0	58.4	6.5	0.1

Table 3. Weighted densities-at-age and estimated abundances of capelin from NAFO Div. 3L spring and summer acoustic surveys, 1981-87.

	Year	Age 1	2	3	4	5	6
Weighted densities ($gm.m^{-2}$)							
Spring surveys	1982		1.85	3.53	0.55	0.17	0.04
	1983	0.02	1.31	0.77	0.34	0.03	0.01
	1984	0.03	5.15	1.87	1.02	0.15	
	1985	0.01	47.69	12.38	0.88	0.36	
	1986		12.55	33.38	4.68	0.15	0.10
	1987	0.08	17.12	4.68	11.63	1.40	0.30
Summer surveys	1981	7.43	3.96	5.08	1.04	0.25	0.02
	1982	2.86	1.15	0.48	0.03		
	1983	2.32	0.08	0.06	0.02		
	1984	2.35	3.48	0.76	0.58	0.06	
	1985	0.41	10.68	2.23	0.09	0.02	0.01
Abundance (Nos. in billions)							
Spring surveys	1982	<0.1	9.9	16.0	2.4	0.7	0.2
	1983	<0.1	3.5	1.9	0.7	<0.1	<0.1
	1984	0.1	21.0	6.1	3.2	0.5	<0.1
	1985	<0.1	367.4	82.0	4.8	1.8	<0.1
	1986	0	63.7	168.1	22.6	0.8	0.4
	1987	0.2	87.6	18.6	38.4	4.4	0.1
Summer surveys	1981	61.8	19.7	34.9	8.2	1.9	<0.1
	1982	23.1	4.1	4.3	0.2	<0.1	<0.1
	1983	57.5	2.3	1.7	0.7	<0.1	0
	1984	47.5	28.9	3.8	2.8	0.4	<0.1
	1985	3.7	84.5	16.3	0.6	0.2	<0.1

Table 4. Annual landings, catch rates and effort by gear type for capelin in NAFO Div. 3L (L/D = landings (t)/day, C/D = catch (t)/day).

Year	Purse seine (PS) Trap (T)	Landings (t)	Catch rate L/D	C/D	Effort (days) L	C
1981	PS	15,210	6.9	9.4	2204	1618
	T	7,917	2.2	2.9	3599	2730
1982	PS	17,692	13.5	16.4	1311	1079
	T	8,845	2.7	3.1	3276	2853
1983	PS	13,713	10.4	18.8	1319	729
	T	10,487	2.4	3.4	4370	3084
1984	PS	17,075	12.3	14.3	1388	1194
	T	15,205	2.6	2.9	5848	5243
1985	PS	8876	10.5	16.4	845	541
	T	15,682	2.9	4.6	5408	3409
1986	PS	20,481	14.4	19.0	1422	1078
	T	26,524	3.2	4.6	8289	5766

Table 5. Annual age compositions and catch at age for capelin by gear type, NAFO Div. 3L, 1981-86.

	Year	Age 1	2	3	4	5	6
Age compositions							
Purse seine	1981	5.4	2.8	39.1	30.6	21.1	1.0
	1982	0.2	1.4	80.9	12.6	3.9	0.9
	1983		4.5	60.4	33.2	1.7	0.1
	1984		0.9	36.0	57.6	5.2	0.1
	1985		13.3	59.3	19.9	7.0	0.4
	1986		0.2	64.5	32.3	2.4	0.6
Trap	1981		4.2	38.4	34.4	21.7	1.2
	1982		1.3	86.4	9.5	2.3	0.5
	1983		4.8	61.0	32.6	1.5	0.1
	1984		2.4	42.8	50.2	4.4	0.2
	1985		12.2	62.4	20.0	5.1	0.3
	1986		0.4	60.2	36.1	2.6	0.7
Catch at age ($x10^{-3}$)							
Purse seine	1981	35625	18615	258353	202178	139081	6526
	1982	1165	7240	422572	65959	20289	4813
	1983	12	21189	283915	155972	8192	467
	1984		4852	185439	296573	26973	738
	1985		47940	213053	71552	25177	1568
	1986		1181	503527	252406	18956	4839
Trap	1981	126	12202	111120	99448	62853	3560
	1982		3624	246487	27085	6699	1478
	1983	13	16472	207968	111114	5091	252
	1984		11991	214639	252096	22153	888
	1985		71940	369247	118585	30125	1932
	1986		3077	519603	312163	22600	6245

Table 6. Catch rates at age for capelin from purse seines and traps, NAFO Div. 3L, 1981-86.

	Year	Age 2	3	4	5	6
Purse seine						
Landings/day	1981	8.4	117.2	91.7	63.1	3.0
	1982	5.5	322.3	50.3	15.5	3.7
	1983	16.1	215.3	118.3	6.2	0.4
	1984	3.5	133.6	213.7	19.4	0.5
	1985	56.7	252.1	84.7	29.8	1.9
	1986	0.8	354.1	177.5	13.3	3.4
Catch/day	1981	11.5	159.7	125.0	86.0	4.0
	1982	6.7	391.6	61.1	18.8	4.5
	1983	29.1	389.5	214.0	11.2	0.6
	1984	4.1	155.3	248.4	22.6	0.6
	1985	88.6	393.8	132.3	46.5	2.9
	1986	1.1	467.1	234.1	17.6	4.5
Trap						
Landings/day	1981	3.4	30.9	27.6	17.5	1.0
	1982	1.1	75.2	8.3	2.0	0.5
	1983	3.8	47.6	25.4	1.2	0.1
	1984	2.1	36.7	43.1	3.8	0.2
	1985	13.3	68.3	21.9	5.6	0.4
	1986	0.4	62.7	37.7	2.7	0.8
Catch/day	1981	4.7	40.7	36.4	23.0	1.3
	1982	1.3	86.4	9.5	2.3	0.5
	1983	5.3	67.4	36.0	1.7	0.1
	1984	2.3	40.9	48.1	4.2	0.2
	1985	21.1	108.3	34.8	8.8	0.6
	1986	0.5	90.1	54.1	3.9	1.1

Table 7. Catch rate at age indices for age 3 and 4 capelin combined, NAFO Div. 3L, year-classes 1978-82.

	Year-class	L/D	C/D
Purse seines	1978	167.5	218.8
	1979	440.6	605.6
	1980	429.0	637.9
	1981	218.3	287.6
	1982	429.6	627.9
Traps	1978	39.2	50.2
	1979	100.6	122.4
	1980	90.7	115.5
	1981	58.6	75.7
	1982	106.0	162.4

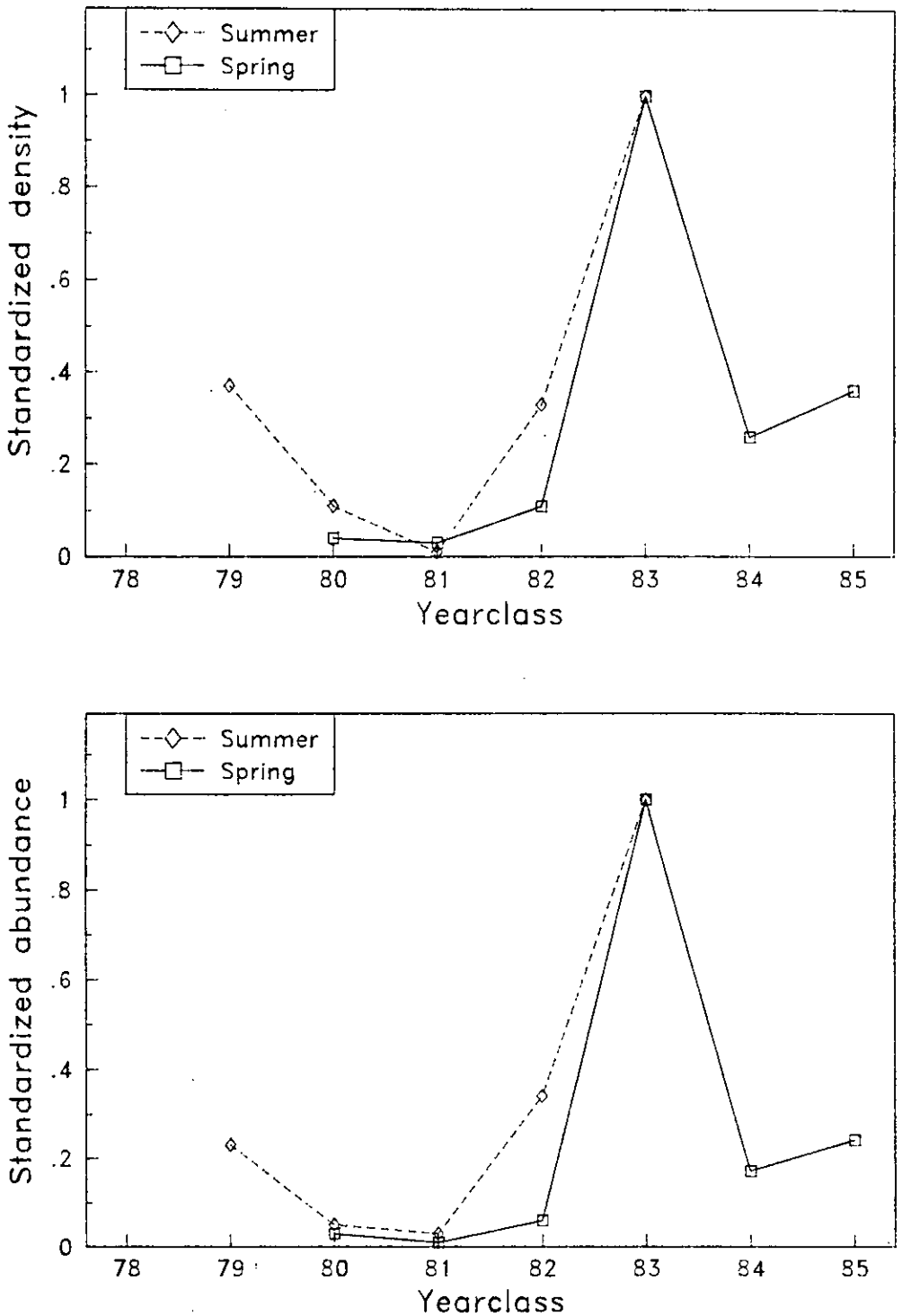
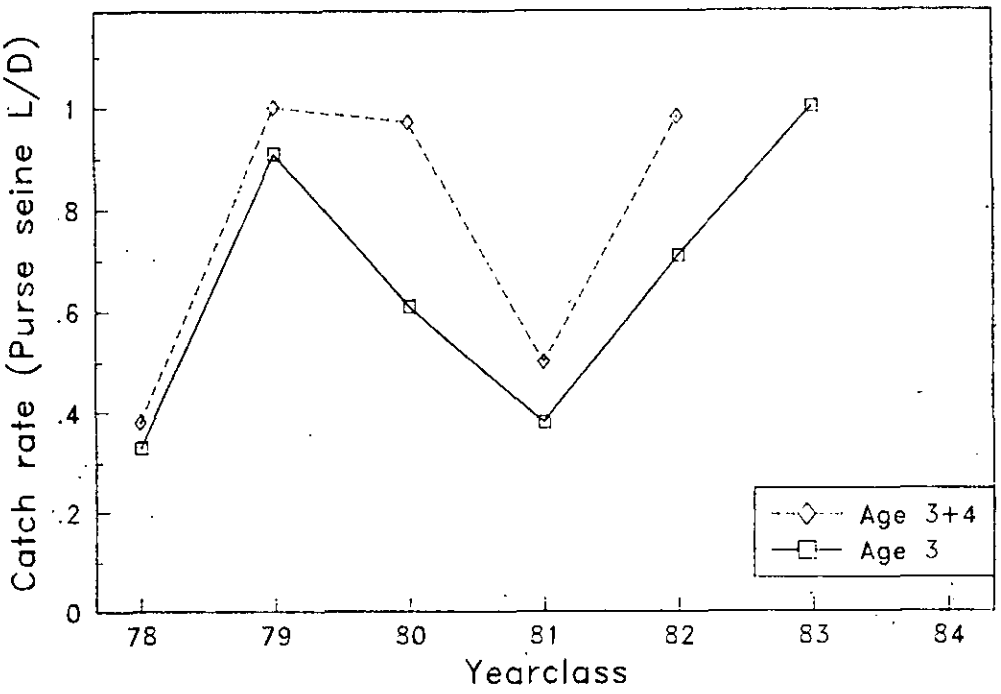


Figure 1. Standardized density and abundance at age 2, for 1979–85 yearclasses of capelin from spring and summer acoustic cruises in NAFO division 3L



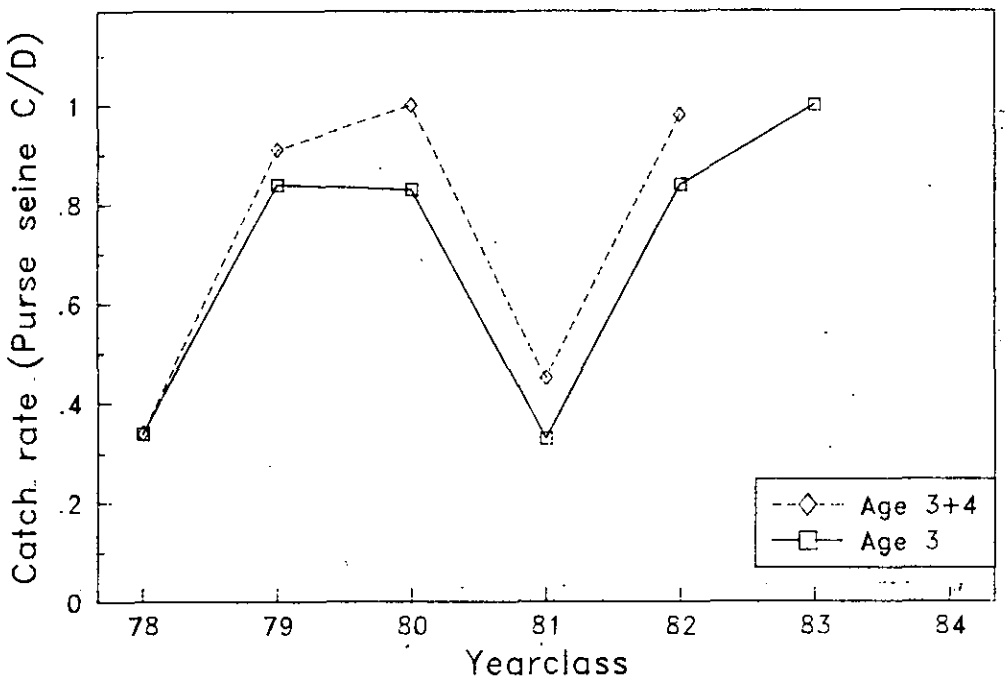


Figure 2. Standardized catch rates at age from purse seines, for NAFO division 3L capelin, 1978–83 yearclasses

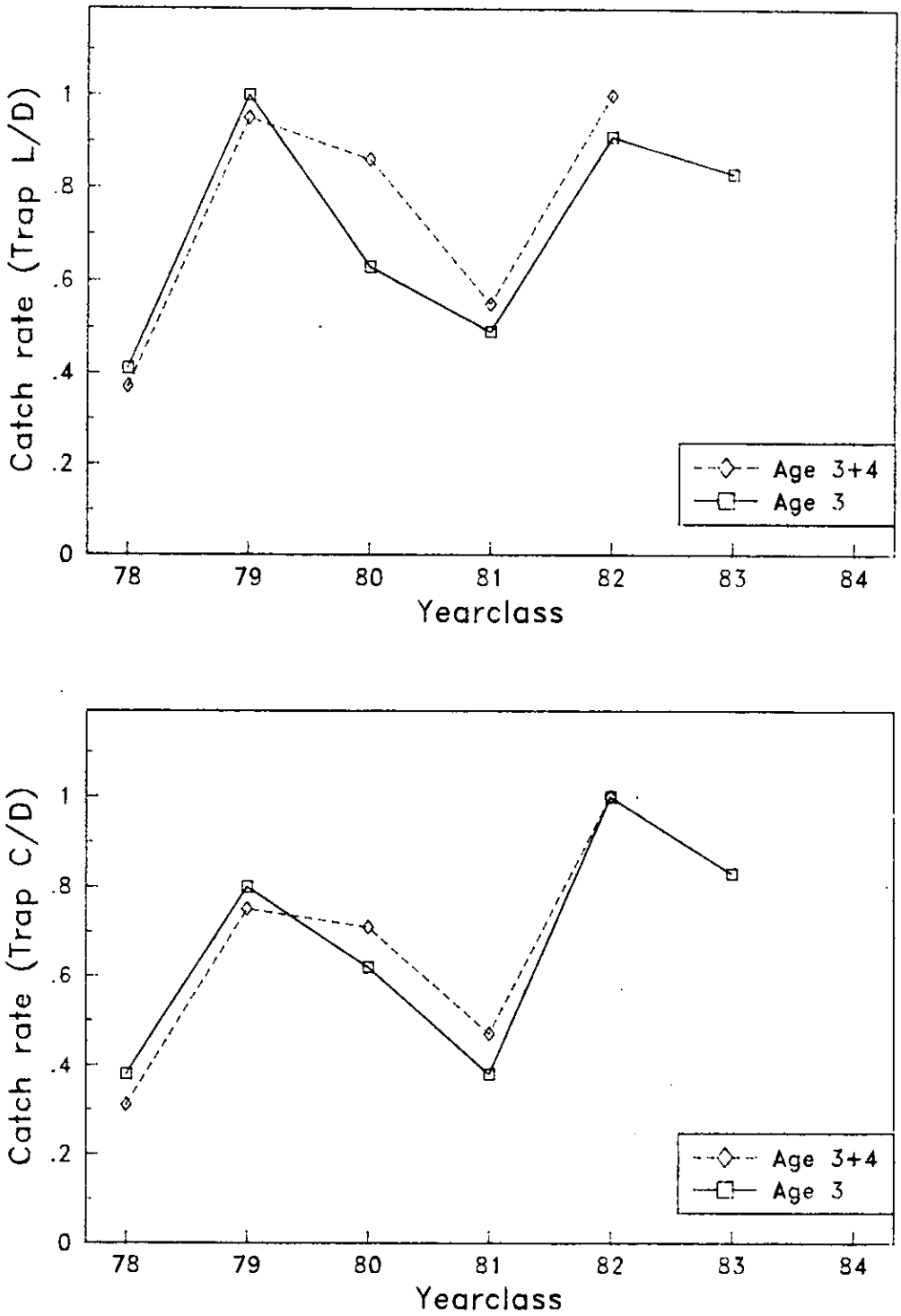


Figure 3. Standardized catch rates at age from trap nets for, NAFO division 3L capelin, 1978-83 yearclasses