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Maturity of female cod in 2J3KL

by

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Abstract

This study extends the time series for estimates of proportion mature at age for 2J3KL female cod to Jan. 1 1996, as well as presenting the observed proportion mature at age in each year for each Division. The proportion of mature fish at age has been increasing in all Divisions and in the stock as a whole, with the increase being greatest since the early 1990's. As a result, the estimated age at 50% maturity has decreased from over 6 to a low of 4.86 in the most recent 2 years. A comparison of proportion mature at age and length in the surveyed area in Div. 3L in fall 1995 with data from western Trinity Bay does not show a significant difference between the two areas.

Résumé

La présente étude prolonge jusqu'au 1er janvier 1996 la série chronologique d'estimations du pourcentage de morues femelles adultes selon l'âge dans 2J3KL, et fournit le pourcentage observé chaque année d'individus matures selon l'âge en fonction de la division. Le pourcentage d'individus matures est à la hausse dans toutes les divisions et dans le stock en général, cette hausse étant plus marquée depuis le début des années 1990. Par conséquent, l'âge estimatif où 50 % des individus ont atteint la maturité a baissé, passant de plus de 6 ans à un 4,86 pendant les deux dernières années. Une comparaison du pourcentage d'individus adultes, selon l'âge et la longueur, dans le secteur de la division 3L reconnu à l'automne 1995 et de données sur le secteur ouest de la baie de la Trinité ne révèle pas une différence significative entre ces deux secteurs.

Introduction

The spawning biomass of a stock is a function of the biomass at each age and the proportion of the fish at each age that are mature and will spawn. In recent years there has been an increase in the proportion of mature fish at age in the 2J3KL cod stock as a whole, as well as within each Division separately (Morgan and Shelton, MS 1995; Morgan et al. 1994; Xu et al. MS 1991). Knife-edge estimates of age at maturity do not take such trends into account. Even small differences in age at maturity can have a significant impact on the estimation of potential yield of a fishery and of population growth rate (Welch and Foucher, 1988). Therefore, the best estimates of proportion mature at age should be incorporated into spawning stock biomass estimates. Further, there is a potential for changes in age at maturity to be an indicator of stress in a population so that an examination of the trends themselves may be important (Trippel, 1995).

This study extends the time series for estimates of proportion mature at age for 2J3KL female cod to Jan. 1 1996, as well as presenting the observed proportion mature at age in each year for each Division. Also, the proportions mature at age and size for females from the fall bottom trawl survey in 3L are compared to those observed in a similar time period from three fjords in western Trinity Bay.

Methods

Maturity data from autumn surveys in Div. 2J3KL from 1981 to 1995 were used in the analyses with the exception of Div. 3L in 1984 when the survey ended 2 months before the starting date in any other year. Fish were assigned to the category 'mature' or 'immature' based on the criteria of Templeman et al. (1978). The first stage in this scheme is classed as immature and all other stages show some evidence of maturing to spawn or of having spawned and are classed as mature in this study. The 'other' or 'unknown' category was excluded from analyses. Because of the length stratified collection of otoliths, the calculation of proportion mature at age included a weighting by the female population number at length (Morgan and Hoenig, MS 1993). Estimates of proportion mature at age and of age at 50% maturity (A_{50}) were produced for each year using Probit analyses with a logit link function (SAS Institute Inc. 1989). Since the fish sampled in the fall will not spawn until the following year, the proportion mature at age was assumed to be for Jan. 1 of the year following the survey (eg. Jan. 1, 1996 for the fall 1995 survey) and a year was added to each age (eg. age 5 fish in the fall survey become age 6).

Two studies were conducted in the southwest arm area of western Trinity Bay, the first in December 1995 and the second in April 1996. Fish were assigned to mature and immature categories as above. For the December study, ages were available and the observed proportion mature at age was calculated. These data were not collected in a length stratified manner so there was no weighting by the length frequency. For the April study, only lengths were available and proportion mature at length was calculated. The effect of area (western Trinity Bay vs. bottom trawl survey in 3L) on proportion mature at age and length was examined using a generalized linear model with a binomial error distribution and a logit link function, to determine if the addition of an area term significantly decreased the deviance of the model (McCullagh and Nelder, 1983; SAS Institute Inc.,1993).

Results and Discussion

The annual observed proportion mature at each age in each NAFO Division from 1982 to 1996 is shown in Tables 1 to 3. Each Division shows an increase in observed proportion mature at age for younger ages in recent years, particularly age 5 and 6. In the early portion of the time series, less than 10% of the fish at age 5 were mature. In most recent years, 40 to 85 % of age 5 fish have been mature. The proportion mature at age 6 has increased from 30 to 50% in the first years of the time series to nearly 100% in recent years.

For the stock as a whole, estimated proportion mature at age has also shown an increase over the time period (Table 4, Figure 1). This increase has been particularly evident since the early 1990's. As a result, the age at 50% maturity has declined from over 6 to less than 5.

The observed proportion mature at length and age for western Trinity Bay and the surveyed area of 3L are shown in Tables 5 and 6. Although it appears that proportion mature at length increases more steeply in the survey, the addition of an area term to the model did not significantly decrease the deviance over a model including the effect of length alone (Table 7). The same result was seen for proportion mature at age (Table 8). These results do not indicate that the maturity schedule in the two areas in the 1995/96 spawning season are different.

These estimates of proportion mature depend on an accurate classification of cod as juvenile or adult fish. In the southwest arm region of western Trinity Bay in April 1996, several large (> 60 cm) fish were sampled which had gonads that appeared to be immature. An alternative explanation is that these fish were adults but were going to skip this spawning season. Non-spawning adult cod have been observed previously, and hypothesized to be fish that were not in good condition (Walsh et al., 1986). It may be possible to distinguish such fish from juveniles by examining the otoliths for spawning checks and/or by histological examination of the gonad (Walsh et al., 1986; Kjesbu, 1991).

Another important consideration with respect to the maturity categories used in the Newfoundland region is the accurate determination of the location and timing of spawning. Cod are batch spawners and will not move sequentially through the maturity categories devised by Templeman et al. (1978). Rather, they will cycle between MatBP (up to 50% clear eggs) and MatAP (eggs visible to the naked eye but no clear eggs) as each batch is hydrated and released (Kjesbu, 1989; 1991; pers. com.). MatCP (50% or more clear eggs) probably represents the formation of the last batch to be spawned for that fish in a season. It is unclear where the partly spent (PSP) category (ovary not as full as MatCP) fits in this cycle but the fish are definitely spawning. This means that all fish which have any clear eggs in the ovary are spawning, as well as some fish which appear to be in the MatAP stage. This MatAP stage must be verified by the careful examination of the oviduct and the inside of the ovary for the presence of a few clear eggs from a previous batch which would indicate spawning (Kjesbu, 1991). A 'spawning' category would include MatBP, MatCP, PSP and any MatAP with clear eggs and this 'spawning' category is what should be used to determine spawning time and location.

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Table 1. Observed proportion mature at age for female cod on Jan. 1 in NAFO Div. 2J. A dot indicates that an age was not sampled in that year.

AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
2	.	0	0	0	0	0	0	0	0	0	0	.	.	.	0
3	0	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0
4	0	0	0	0	0.03	0	0	0	0	0	0	0.02	0	0.14	0.01
5	0	0.03	0.06	0.07	0.03	0	0.11	0	0.09	0.3	0.25	0.33	0.82	0.73	0.74
6	0.3	0.5	0.49	0.71	0.49	0.52	0.49	0.52	0.58	0.52	0.64	0.75	1	1	0.95
7	0.83	0.88	0.85	0.96	0.93	0.9	1	0.9	1	0.95	1	1	1	1	1
8	0.91	1	0.9	1	1	1	0.9	0.96	1	1	0.93	1	1	1	.
9	0.99	1	1	1	1	1	1	1	1	1	1	.	.	.	.
10	1	1	1	0.98	1	1	1	1	1	1	1	.	.	.	.
11	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.
12	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.
13	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.
14	1	1	1	1	.	1	1	1	.	1	.	.	.	.	.
15	1	1	1	.	.	1	1	1	.	.	.	.	.	.	.

Table 2. Observed proportion mature at age for female cod on Jan. 1 in NAFO Div. 3K. A dot indicates that no fish at that age were sampled in that year.

AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.
2	0	0	0	0	.	0	0	0	0	0	0	0	.	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0.02
5	0	0.02	0.06	0.08	0.06	0.06	0.17	0.12	0.12	0.15	0.36	0.53	0.57	0.43	0.49
6	0.61	0.36	0.55	0.7	0.56	0.53	0.48	0.75	0.74	0.54	0.77	0.92	1	1	0.82
7	0.96	0.98	0.85	0.93	0.97	0.95	0.76	0.9	0.85	0.88	0.97	0.93	1	1	.
8	1	0.96	1	1	1	1	1	1	1	0.94	1	1	1	1	.
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.
10	1	1	1	1	1	1	1	1	1	1	1	1	.	.	.
11	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.
12	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.
13	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.
14	1	1	.	1	1	1	1	.	1	.	1	.	.	.	.
15	1	1	1	1	1	.	1	1	1	.	.	.	.	.	.

Table 3. Observed proportion mature for female cod on Jan. 1 in NAFO Div. 3L. Data for 1985 are not included as the fall 1984 survey was several months early.
A dot indicates that no fish of an age were sampled in that year.

AGE	1982	1983	1984	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0	0	0	.	.	.	.	.	.	.	.	.	.	.
2	0	0	0	0	0	0	0	.	.	0	.	.	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0.02	0	0	0	0.02	0.05	0.11	0
5	0.03	0.09	0.03	0.03	0	0	0.12	0.12	0.07	0.11	0.26	0.51	0.61	0.85
6	0.43	0.55	0.4	0.29	0.16	0.17	0.73	0.65	0.31	0.23	0.83	0.87	1	0.84
7	0.78	0.96	0.78	0.63	0.67	0.8	0.9	0.98	0.87	0.51	0.82	0.97	1	0.77
8	1	1	0.91	1	0.75	1	1	0.93	1	0.95	1	1	.	1
9	1	1	1	1	0.92	1	1	1	1	1	1	1	.	.
10	1	1	1	1	1	1	1	1	1	1	1	.	.	.
11	1	1	1	1	1	1	1	1	0.69	1	1	1	.	.
12	1	1	1	1	1	1	1	1	1	1	1	.	.	.
13	1	1	1	1	1	1	1	1	1	1	.	.	.	.
14	1	1	1	1	1	1	1	1	1	1	.	.	.	.
15	.	1	1	1	1	1	1	1	1	.	.	.	.	.

Table 4. Estimated proportion mature at age for female cod in NAFO Div. 2J3KL on Jan. 1. No estimate was produced for 1985 because of the timing of the fall survey in 3L in 1984. Age at 50% maturity for the population is also given for each year. A dot indicates that an age was not sampled in that year. n is the number of otoliths examined.

AGE	1982	1983	1984	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0	0	0	.	.	.	.	0	.	.	.	.	.	0
2	0	0	0	0	0	0	0	0	0.001	0.003	0.001	.	0	0
3	0.001	0	0.001	0	0.001	0.001	0.002	0.001	0.006	0.013	0.007	0.006	0.002	0.001
4	0.005	0.004	0.009	0.004	0.007	0.008	0.016	0.011	0.03	0.059	0.053	0.073	0.051	0.046
5	0.051	0.052	0.075	0.049	0.066	0.07	0.123	0.118	0.13	0.24	0.292	0.494	0.612	0.625
6	0.35	0.45	0.428	0.381	0.401	0.409	0.551	0.615	0.423	0.611	0.753	0.924	0.979	0.983
7	0.844	0.924	0.873	0.88	0.864	0.864	0.915	0.95	0.782	0.887	0.958	0.993	0.999	1
8	0.982	0.995	0.984	0.989	0.984	0.983	0.989	0.996	0.946	0.975	0.994	0.999	1	1
9	0.998	1	0.998	0.999	0.998	0.998	0.999	1	0.989	0.995	0.999	1	1	.
10	1	1	1	1	1	1	1	1	0.998	0.999	1	.	.	.
11	1	1	1	1	1	1	1	1	1	1	1	1	.	.
12	1	1	1	1	1	1	1	1	1	1	1	.	.	.
13	1	1	1	1	1	1	1	1	1	1	.	.	.	.
14	1	1	1	1	1	1	1	1	1	1	.	.	.	.
15	1	1	1	1	1	1	1	1	1	.	.	.	.	.
A50	6.27	6.07	6.13	6.2	6.18	6.16	5.91	5.81	6.19	5.72	5.44	5.01	4.86	4.86
n	1028	1354	1202	1260	1037	1146	1386	1422	1361	1045	697	489	139	561

Table 5. Proportion mature at length from Shamook 252 and 1995 fall survey in 3L. Adjacent 3cm length categories have been combined to increase sample size.

Length		Shamook		Survey	
14.5		.		0	
20.5		0		0	
26.5		0		0	
32.5		0		0	
38.5		0.06		0	
44.5		0.2		0.23	
50.5		0.76		0.91	
56.5		0.87		0.8	
62.5		0.85		1	
68.5		0.78		1	
74.5		0.95		.	
80.5		0.67		.	
85		1		.	
97		1		.	
130		1		.	

Table 6. Proportion mature at age from Shamook 250 and 1995 fall survey in 3L. Ages are as of Jan. 1.

Age		Shamook		Survey	
2		.		0	
3		.		0	
4		0.2		0	
5		0.56		0.85	
6		0.81		0.84	
7		0.88		0.77	
8		1		1	
9		1		.	

Table 7. Results of analysis of deviance for effect of area on proportion mature at length.

Source	Deviance	DF	Chisquare	P
intercept	382.4994	0	.	.
length	108.2187	1	274.2807	0.0001
area	105.7867	1	2.432	0.1189

Table 8. Results of analysis of deviance for effect of area on proportion mature at age.

Source	Deviance	DF	Chisquare	P
intercept	184.4826	0	.	.
age	38.9732	1	145.5093	0.0001
area	38.7505	1	0.2227	0.637

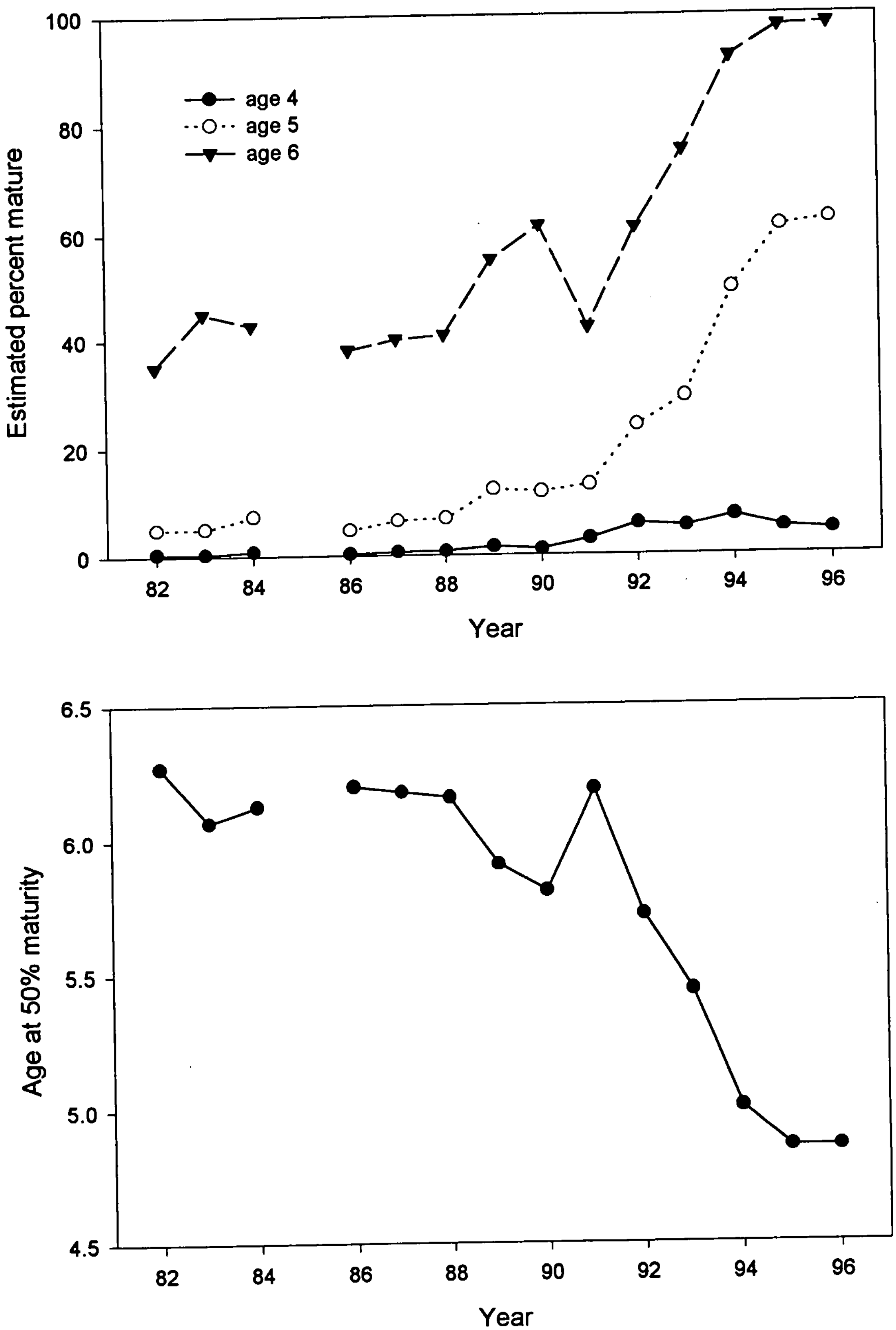

Figure 1. Estimated proportion mature at ages 4, 5 and 6 for female cod in NAFO Div. 2J3KL for Jan. 1 1982 to 1996 (top). Age at 50% maturity over the same time period is shown in the bottom panel.