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Mean weight and growth of Atlantic mackerel (Scomber scombrus) in the Subarea 4 Canadian fishery (1973)

by

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INTRODUCTION

The Canadian fishery for Atlantic mackerel in Subarea 4 extends from the Gulf of St. Lawrence along the Atlantic coast of Nova Scotia and into the Bay of Fundy. Inshore fixed gears and a fleet of small purse seiners and multiple-use vessels contributed to a total Canadian catch of almost 17,000 metric tons in the 1973 season (Stobo and Hunt, 1974). Activity of the fishery is restricted by the arrival and departure of fish from the area during their annual spring and fall migration (Sette, 1950; Stobo and Hunt, 1974; MacKay, 1967).

The history of the fishery and a summary of biological parameters relating to Canadian catches in Subarea 4 was presented by Stobo and Hunt (1974). In this report essentially the same data base (1973) was re-examined to obtain observed weights at age and length by month and ICNAF Division.

MATERIALS AND METHODS

A total of 3,793 fish were examined for weight, fork length and age from samples of fixed and mobile gears collected in the 1973 season. These detailed samples were stratified from the random length frequency samples by selecting two fish from each half-centimeter length group and were generally frozen for later examination.

Estimates of age were made from otoliths by counting hyaline (winter) growth zones using a technique similar to that described for herring by Hunt et al (1973). Year class is thus defined as the year sampled minus the age. The nucleus was excluded from counts and fish caught in the same year in which they were spawned were placed in the 0-group and assigned to the appropriate year class. This is in contrast to the method used by Stobo and Hunt (1974) in which the nucleus was counted but comparison of age estimates can be made by a simple subtraction. While fish were aged to as old an age as possible, for the purpose of this report all fish judged to be 13 or older have been combined into the 1960+ year class.

Summaries of length, weight and age were compiled on a monthly

basis (June to October) for ICNAF Divisions 4T, 4V-W and 4X and for Subarea 4. Seasonal summaries were also completed for each of the above areas.

Weight-length regression parameters for the equation

$$\text{weight} = a\ \text{length}^{b}$$

for each area were calculated from seasonal estimates of weight at length. Curves for each area were plotted using calculated weight at length values from the above equation.

Mean annual weights at age were used to determine constants of the generalized Von Bertalanffy growth equation by giving equal weight to each observed value of weight at age following the method described by Allen (1966). Curves were constructed for each area from equations of the form

$$W_t = W_{max}\ [1 - e^{-k(t-t_o)}]^{n}$$

where W_t = weight at time t, W_{max} = theoretical maximum weight, k and t_o = constant and n = b of the length-weight relationship.

RESULTS AND DISCUSSION

(i) Length-weight relationship

Observed mean weights by centimeter length groups are presented in Table 7 for each of the areas under discussion on a seasonal basis. Calculated mean weight at length are summarized by curves for each area in Figure 1.

In Table 7, it is apparent that the length range for each area is not the same and in particular that fish less than 24 cms. are not represented in area 4T. However, as Stobo and Hunt (1974) suggest, this may be due to selective fishing and size-segregated movement of fish through respective areas. In adequately represented length groups, good agreement in mean weight at length is obtained with the exception of fish over 37 cms. in area 4T. These appear to have a significantly lower mean weight at length than either of the other two areas. Since weight in this case refers to total weight, it is expected that the representation of maturity stages in samples is significant, especially if the proportion of stages varies with season and area. Immediately prior to spawning, gonad weight may account for in excess of 20% of total weight, particularly in large fish, and consequently the ratio of "full" to "spent" fish in samples is an influencing factor in determining mean weight. In addition, Sette (1943) found that large fish tend to spawn earlier within the same area. The four broad ranges to which maturities have been assigned (Sette, 1943) does not allow a detailed breakdown of the representation of "full" and "spent" fish in each area but Stobo and Hunt (1974) did find some general differences between areas. They suggest a tendency for early spawning in area 4T followed by summer-fall spawning in the other two areas and, considering sampling totals by month (Tables 1-5), it is probable that the proportion of "spent" fish collected in area 4T exceeds that of areas 4V-W and 4X.

Good agreement between observed and calculated mean weights at length were obtained from regression parameters as illustrated by Figure 1. Curves are almost co-incident at the lower end of the length range but become somewhat divergent above 36 cms. which is in agreement with observed data. Again this divergence may be attributed to the proportion of maturity stages in samples.

Comparison of regression parameter reported here indicates reasonable agreement with those reported by Anderson (1973) and those derived from the data of Isakov (1973). These parameters are summarized as follows:

	a	b	Calculated weight at 32 cms.
Hunt	0.0068	3.1144	331.2
Anderson	0.0033	3.3194	327.1
Isakov	0.0161	2.8701	336.3

Differences in these parameters may be attributed, at least partially, to varying sampling periods which in this case range from spring-summer to fall-winter. Isakov and Anderson (1973) base their results on data collected in late fall-early winter for, presumably, post-spawning fish and thus gonadal weight is not reflected to the same degree in their results. Even with this consideration, it is significant to note that estimates of mean weight at length are close, suggesting that the length-weight relationship is consistent between Subarea 4 and Subarea 5.

(ii) Mean weight at age and growth

Monthly summaries of mean weight by year class and area are presented in Tables 1-5 and a seasonal summary in Table 6. Von Bertalanffy parameters and resultant curves derived from the data of Table 6 are presented in Figure 2.

Considerable variation in mean weight is apparent both between year classes in successive months in the same area, and between year classes in the same month but different areas. However, since weight is subject to negative as well as positive changes, it is difficult to assess the difference without considering the effect of sampling. As previously mentioned, it is felt that the representation of maturity stages in samples from respective areas is the main influencing factor in the variation in mean weight. If the time and duration of spawning in these areas do not coincide, then the seasonal distribution of samples may introduce some bias. Arnold (1970) and Sette (1950) conclude that mackerel spawning in Subarea 4 occurs over a relatively narrow period from mid-June to mid-July but their results were based on data from area 4T. Stobo and Hunt (1974) reach the same conclusion for area 4T but their results suggest a more prolonged season, particularly in areas 4V-W and 4X. On a seasonal basis it is apparent that the majority of samples were collected in August or later which implies that area 4T is represented by mostly post-spawning fish while areas 4V-W and 4X are represented by mostly pre-spawning fish. The general lower mean weight at age in area 4T tends to support this conclusion. Direct comparison of weight at age between areas is thus complicated but presumably the influence of maturity stages is minimized when all areas are combined to obtain a seasonal mean weight at age for Subarea 4.

Von Bertalanffy growth curves provided reasonably good fits to observed data for each area and comparison of curves again shows some degree of divergence between area 4T and areas 4V-W and 4X. While maturity stage is an influencing factor, Stobo and Hunt (1974) found similar differences between areas for growth in length which suggests a possible real difference in growth rates between areas. Geographical separation of areas and associated differences in environment may explain this variation in growth rates but differing stock compositions cannot be ruled out. Additional information on migration and stock associations awaits the results of an intensive Canadian tagging program to be carried out in 1974.

Growth parameters derived from the combined 1973 Subarea 4 data yield the equation

$$W_t = 752.3 \ [1 - e^{-0.250(t + 1.651)}]^{3.114}$$

which is probably the best representation of growth in weight for mackerel in the Canadian fishery. This equation is comparable with that reported by Isakov (1973) for the winter fishery in Subarea 5 and may suggest a close association between fish in this area in winter and those in Subarea 4 in summer.

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TABLE 1. Mean weight (gms) at age for mackerel in June by area

AREA	YEAR CLASS														
	'73	'72	'71	'70	'69	'68	'67	'66	'65	'64	'63	'62	'61	'60+	N
4T	-	-	-	309.6	426.7	429.2	477.3	539.2	593.3	638.7	586.9	727.7	745.6	667.8	
N				1	2	16	35	19	9	5	4	4	1	4	100
4V-W	-	172.3	198.0	405.5	389.9	435.9	465.3	537.4	584.2	536.0	681.7	776.1	753.1	851.6	
N		1	11	5	7	14	14	14	10	3	2	1	1	2	85
4X	-	-	238.7	377.5	381.5	503.9	496.7	548.8	571.9	684.4	736.7	730.4	718.7	723.1	
N			3	17	14	23	46	25	11	8	8	3	3	2	163
Combined		172.3	206.7	380.6	388.0	463.4	484.9	542.9	582.4	642.3	686.1	734.8	730.9	727.5	348

TABLE 2. Mean weight (gms) at age for mackerel in July by area

AREA	YEAR CLASS														
	'73	'72	'71	'70	'69	'68	'67	'66	'65	'64	'63	'62	'61	'60+	N
4T	-	218.7	265.7	324.9	404.8	429.1	453.1	492.4	547.6	601.7	607.7	554.4	613.5	689.2	
N		1	31	21	31	76	135	44	15	6	6	2	1	5	374
4V-W	-	135.5	225.5	311.9	373.1	418.3	435.8	486.7	503.8	637.0	695.9	709.0	-	747.1	
N		177	275	105	60	52	46	8	8	2	1	4		1	739
4X	-	95.3	282.8	367.3	381.7	462.2	407.9	-	472.6	-	-	-	-	-	
N		27	2	2	6	7	2		1						47
Combined	-	130.6	229.9	314.9	383.8	426.7	448.3	491.5	531.4	610.5	620.3	657.4	613.5	698.9	1160

TABLE 3. Mean weight (gms) at age for mackerel in August by area

AREA	YEAR CLASS														
	'73	'72	'71	'70	'69	'68	'67	'66	'65	'64	'63	'62	'61	'60+	N
4T	-	175.8	265.7	315.3	395.3	438.8	455.0	501.5	540.4	564.7	602.7	711.6	692.4	620.2	
N		1	31	21	31	76	135	44	15	6	6	2	1	5	679
4V-W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
N															
4X	-	127.5	252.9	288.8	393.1	444.6	477.5	514.7	532.4	516.8	535.5	-	-	-	
N		54	20	6	14	15	14	8	2	1	1				135
Combined		130.0	264.1	313.9	394.9	439.7	456.7	502.8	539.6	559.3	589.2	711.6	692.4	620.2	814

TABLE 4. Mean weight (gms) at age for mackerel in September by area

AREA	YEAR CLASS														
	'73	'72	'71	'70	'69	'68	'67	'66	'65	'64	'63	'62	'61	'60+	N
4T	-	189.5	282.5	338.2	416.6	461.6	435.9	474.4	549.2	-	645.1	-	-	-	
N		9	84	39	25	43	45	20	12		1				278
4V-W	74.6	179.4	289.2	372.3	433.3	469.8	501.3	538.9	627.7	654.6	819.5	-	-	-	
N	28	79	118	35	42	34	36	11	4	1	1				389
4X	-	117.5	250.2	350.6	400.4	454.4	480.6	522.6	670.7	610.8	451.1	-	-	-	
N		39	13	8	23	14	28	10	4	1	1				141
Combined	74.6	161.1	284.2	354.0	420.3	463.6	469.0	503.4	589.2	632.7	638.5	-	-	-	808

Table 5. Mean weight (gms) at age for mackerel in October by area

AREA	YEAR CLASS														
	'73	'72	'71	'70	'69	'68	'67	'66	'65	'64	'63	'62	'61	'60+	N
4T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
N															-
4V-W	-	185.4	293.4	368.4	447.6	476.0	517.3	579.9	679.2	751.4	673.9	700.3	812.2	785.7	
N		34	116	24	48	57	56	24	9	8	2	2	1	2	383
4X	-	151.1	285.4	363.4	417.5	436.8	448.7	517.5	471.9	679.8	589.6	-	608.3		
N		30	29	21	48	23	31	15	3	5	1		1		207
Combined	-	169.4	291.8	366.1	432.5	464.8	492.9	554.0	627.4	723.9	645.8	700.3	710.2	785.7	590

Table 6. Mean annual weight (gms) at age for mackerel by area

AREA	YEAR CLASS														
	'73	'72	'71	'70	'69	'68	'67	'66	'65	'64	'63	'62	'61	'60+	N
4T		188.6	271.3	321.9	402.8	439.2	454.1	500.0	553.2	595.8	603.3	686.6	687.2	658.4	
N		13	254	165	118	223	387	154	54	19	15	10	5	14	1431
4V-W	74.6	153.4	254.5	335.2	412.7	452.0	484.1	547.2	597.8	682.0	704.4	716.0	782.6	804.3	
N	28	291	520	169	157	157	152	57	31	14	6	7	2	5	1596
4X		123.8	265.9	359.7	404.6	465.0	485.0	546.6	590.4	668.8	690.8	771.4	701.6	813.2	
N		150	68	56	110	96	146	67	27	19	14	5	5	3	766
ALL AREAS	74.6	144.6	260.5	333.1	407.4	448.6	467.4	520.9	574.5	645.7	655.7	715.2	709.1	712.7	
N	28	454	842	390	385	476	685	278	112	52	35	22	12	22	3793

Table 7. Mean weight (gms) at length (cms) for mackerel for 1973 season by area with regression parameters (weight = a(length^b))

Length Group	AREA							
	4T		4V-W		4X		Combined	
	a=0.0163 b=2.8743		a=0.0040 b=3.2822		a=0.0033 b=3.3244		a=0.0068 b=3.1144	
	Weight	N	Weight	N	Weight	N	Weight	N
10-10.9	-	-	-	-	-	-	-	-
11-11.9	-	-	-	-	-	-	-	-
12-12.9	-	-	-	-	-	-	-	-
13-13.9	-	-	-	-	-	-	-	-
14-14.9	-	-	-	-	-	-	-	-
15-15.9	-	-	-	-	-	-	-	-
16-16.9	-	-	-	-	-	-	-	-
17-17.9	-	-	47.6	2	-	-	47.6	2
18-18.9	-	-	59.4	6	51.7	4	56.3	10
19-19.9	-	-	69.0	15	63.4	8	67.1	23
20-20.9	-	-	83.8	25	76.9	14	81.3	39
21-21.9	-	-	94.7	22	86.2	18	90.9	40
22-22.9	-	-	112.1	28	101.6	20	107.7	48
23-23.9	-	-	123.9	33	123.7	26	123.8	59
24-24.9	144.9	2	140.6	51	137.0	17	139.8	70
25-25.9	168.7	3	161.9	63	158.5	22	161.3	88
26-26.9	194.6	5	183.2	90	187.4	13	184.2	108
27-27.9	217.6	25	208.1	102	206.6	11	209.7	138
28-28.9	241.8	59	232.5	116	227.7	19	234.8	194
29-29.9	267.7	114	262.6	139	263.2	23	264.7	276
30-30.9	295.2	120	292.6	127	289.8	25	293.5	272
31-31.9	330.2	77	327.8	125	343.9	35	331.0	237
32-32.9	373.2	127	368.9	109	385.9	81	375.0	317
33-33.9	409.4	224	405.3	140	414.1	101	409.2	465
34-34.9	447.1	249	448.8	118	456.7	95	449.5	462
35-35.9	490.0	183	487.6	111	508.9	76	493.1	370
36-36.9	531.8	123	535.5	80	540.4	53	534.7	256
37-37.9	572.1	40	586.3	39	585.6	47	581.5	126
38-38.9	592.2	35	662.2	21	664.5	29	634.2	85
39-39.9	642.1	25	720.4	14	716.8	17	684.3	56
40-40.9	710.1	16	765.4	13	773.5	4	739.5	33
41-41.9	808.7	2	847.9	4	877.5	5	854.2	11
42-42.9	875.2	1	835.8	3	777.9	2	823.0	6
43-43.9	-	-	-	-	-	-	-	-
44-44.9	-	-	-	-	727.0	1	727.0	1
45-45.9	593.2	1	-	-	-	-	593.2	1
MEAN	414.0	1431	325.4	1596	393.4	766	372.6	3793

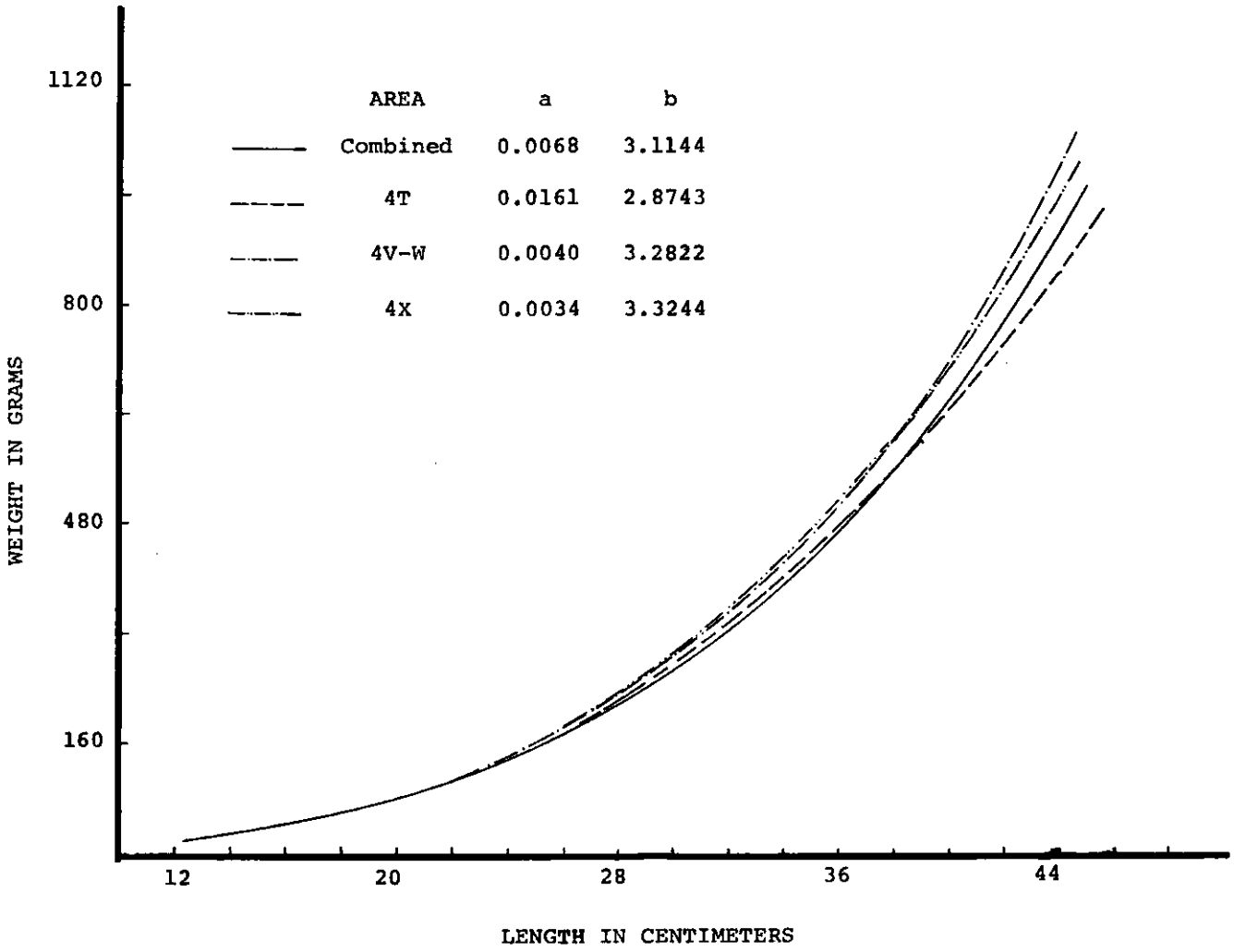

Figure 1. Comparison of length-weight relationship by area on a seasonal basis (weight = a length ^{b}).

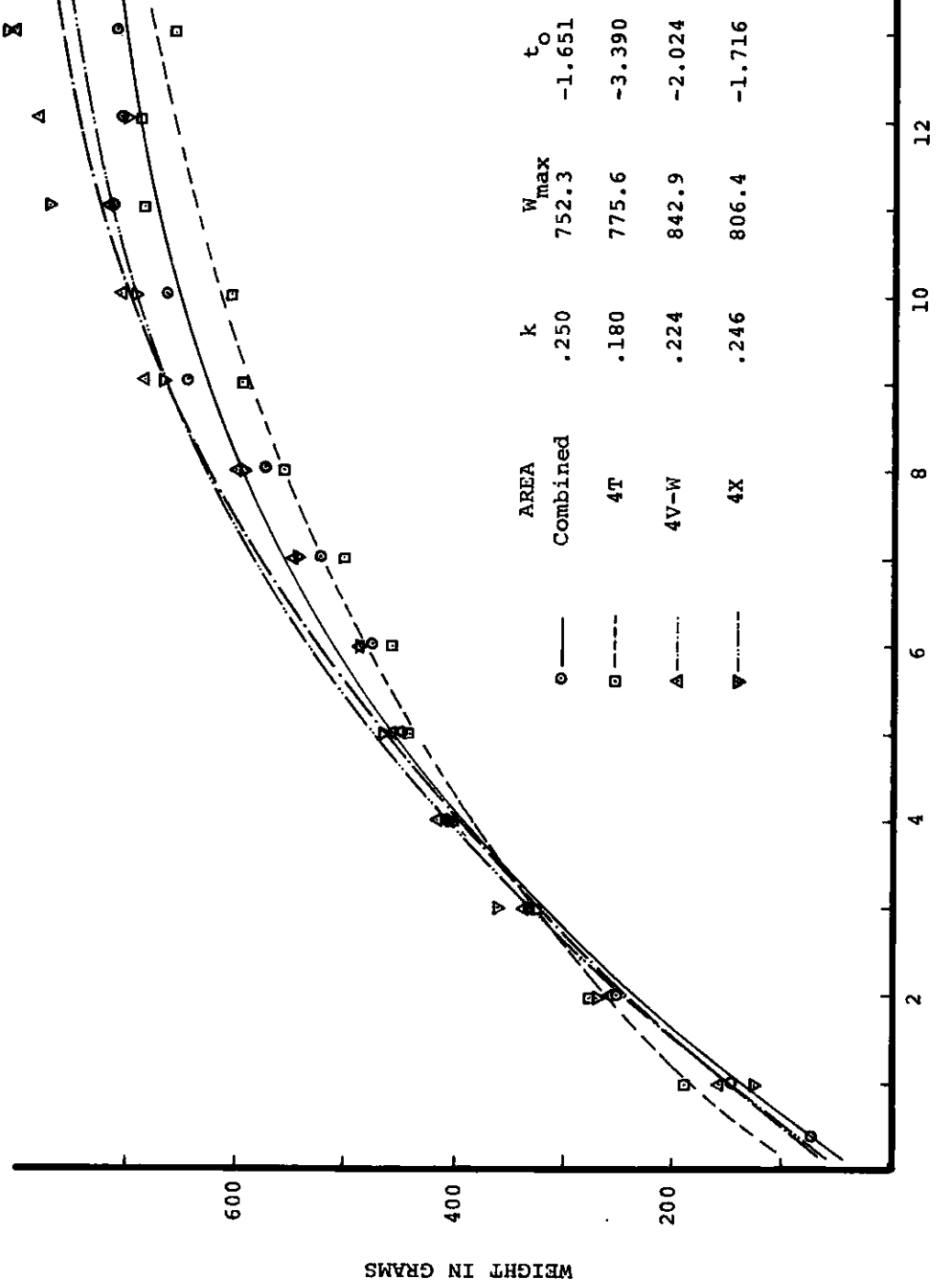

Figure 2. Von Bertalanffy growth curves for observed values of mean weight of mackerel in the 3rd quarter.

$$W_t = W_{max}\ (1 - e^{-k(t-t_o)})n$$