AGE-LENGTH-WEIGHT RELATIONSHIP IN THE SOUTHERN BALTIC
SPRAT POPULATIONS IN 1974-76.

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The sprat weight-age and weight-length ratio expressed in numerical values is an important factor of fish stock analyses when it is used for the VPA, as it serves to calculate quantity into population biomass.

1. Material

The basic material for this paper was collected in the Gdansk and Bornholm areas in the years 1974-1976. The following number of fish were examined:

Table 1. Number of sprat examined /measured and weighed/
in the Gdansk and Bornholm areas in the years
1974 - 1976.

| Years | Quarters | Gdansk region | | Bornholm area | |
		Number of samples	Number of fish examined	Number of samples	Number of fish examined
1974	I	8	3.666	5	8.261
	II+III	5	2.284	7	5.177
	IV	6	1.078	3	4.177
1975	I	8	3.755	4	6.985
	II+III	3	2.419	5	6.143
	IV	4	2.629	1	860
1976	I	9	4.941	3	2.856
	II+III	5	1.753	6	5.980
	IV	8	2.124	3	3.355
Total	I	25	12.362	12	18.102
	II+III	13	6.456	18	17.300
	IV	18	5.831	7	8.392

2. Method.

The sprat weight-length ratio was generalized by means
of the Lagler formula:

$$W = c \cdot l^n$$

The following log formula: $\log W = \log c + n \cdot \log l$
served to calculate the coefficients c and n and to inter-
prete the results in graphic form.
The weight-age ratio was generalized by means of the
v. Bertalanffy formula: $W_t = W_\infty \cdot \left[1 - e^{-K(t-t_o)} \right]$

3. Weight – length.

The dependence between the weight and the length of the
sprat and also weight changes in the Gdansk and Bornholm
areas over an annual cycle are shown in Table 2 and illus-
trated in Figs. 1 and 2.

Table 2. Weight changes in sprat from the Gdansk and Bornholm areas depending on length, over the period of one year / data based on observations/ are denoted: - no data, questionable values are given in brackets.

Length classes /cm/	Gdansk region Quarters				Bornholm region Quarters			
	I Wintering	II+III Spawning	IV End of feeding	For whole year	I Wintering	II+III Spawning	IV End of feeding	For whole year
	Mean weight of one fish calculated for the years 1974-1976 /g/							
7,0	2,50	-	2,89	2,69	-	-	-	-
7,5	2,62	/2,00/	3,07	2,61	-	-	-	-
8,0	3,00	2,71	3,74	3,22	/2,50/	-	-	/2,50/
8,5	3,75	3,55	4,36	3;95	3,48	3,60	4,50	3,74
9,0	4,39	4,50	5,04	4,67	4,18	4,34	4,97	4,49
9,5	5,40	5,73	6,09	5,64	5,05	5,14	5,88	5,36
10,0	5,44	6,68	6,74	6,58	5,96	6,27	6,61	6,28
10,5	7,08	7,60	8,12	7,60	6,89	7,55	8,07	7,50
11,0	8,71	7,99	9,79	8,83	8,02	8,77	9,42	8,61
11,5	9,63	9,85	11,08	10,19	9,44	9,86	10,76	9,86
12,0	10,86	11,07	12,25	11,39	10,96	11,23	11,66	11,28
12,5	12,14	12,37	13,55	12,69	12,68	12,87	14,01	13,18
13,0	13,99	13,74	14,43	14,05	14,01	14,34	15,60	14,65
13,5	15,01	15,27	16,53	15,61	15,64	15,89	17,15	16,22
14,0	16,72	17,10	19,08	17,63	17,24	17,79	19,01	18,01
14,5	18,02	18,28	20,19	18,83	19,34	19,78	20,70	19,94
15,0	/21,73/	20,15	20,73	20,85	21,31	22,09	22,39	21,93
15,5	20,48	-	22,00	/20,74/	23,45	23,70	24,12	23,87
16,0	-	-	-	-	23,92	26,28	25,91	25,37
16,5	-	-	-	-	27,29	/32,08/	29,37	/31,06/
17,0	-	-	-	-	30,00	-	-	30,00
W̄/g/				11,00				14,50

Table 3. Comparative specification of parameters in the
Lagler equation for sprat from the Gdansk and
Bornholm areas.

Quarters /in 1974-1976/	Gdansk region		Bornholm region	
	c	n	c	n
I/wintering/	0,006632	2,9656	0,004234	3,1457
II+III /spawning/	0,005887	3,0158	0,004307	3,1587
IV/end of /feeding/	0,011062	2,8061	0,008428	2,9162
Total annual cycle	0,008609	2,8776	0,004682	3,1258

The coefficients of the Lagler equation given in Table 3 change
their values over the period of a year depending on the sprat
life-cycle. Besides this the difference between the values c and
n depends on the region the sprat inhabits. In length classes
from 8.5 to 11.5 cm the weight of the sprat from the Bornholm
area is a little lower than that from Gdansk area, which would
indicate that conditions for growth of smaller fishes in the
Bornholm area are probably slightly worse than in the Gdansk
area / mainly in the Gulf of Gdansk/. The situation changes
beginning from the 12 cm length class. Sprat of this length from
the Bornholm area have a distinctly greater weight as compared
with sprat from the Gdansk area / Table 2, Figures 1 and 2/. As
Figure 2 and Table 2 show the sprat weight-length ratio changes
over the year. The lowest weight is found at the end of the win-
ter and beginning of the spring /March-April-May/. The highest
weight is found in the fourth quarter following the post-spawning
feeding period.

4. Weight-age.

The weight in successive age groups of sprat from the Gdansk
and Bornholm areas is presented in Table 4 and Fig. 3, the values
of parameters in the v. Bertalanffy equation are shown in Table 5.
These parameters were calculated by the least squares method using
the weights of the individual age groups.

Table 4. Weight in successive age groups of sprat in the Gdansk and Bornholm regions in the years 1974-76 /empirical data/;questionable values are given in brackets, - no data

Age groups	Gdansk region				Elwertowski 1953-1954	Bornholm region				Elwertowski 1953-1954	The difference in mean weight of one fish between sprat from the Gdansk and Bornholm regions	
	Quarters			whole year		Quarters			whole year			
	I wintering	II+III spawning	IV end of feeding			I wintering	II+III spawning	IV end of feeding			in g	in %
0	-	-	3,81	3,81	-	-	-	5,66	5,66	-	1,85	48,6
I	3,88	5,51	6,16	5,18	5,6	5,62	7,68	8,72	7,34	7,7	2,16	41,7
II	10,47	10,32	11,20	10,67	11,5	11,76	14,24	14,15	13,38	11,8	2,71	25,4
III	12,06	11,83	13,10	12,33	13,0	15,24	15,32	17,80	16,12	14,3	3,79	30,7
IV	13,36	12,88	14,48	13,57	14,1	16,50	16,81	19,74	17,69	17,6	4,12	30,4
V	15,17	13,65	15,45	15,38	14,9	17,46	17,64	/22,39/	19,16	18,1	3,78	24,6
VI	16,35	14,89	/15,03/	15,42	-	18,14	/18,81/	20,85	19,27	-	3,85	24,9
VII+	16,96	15,14	17,26	16,45	-	19,35	18,78	/19,19/	19,37	-	2,83	17,1
$\overline{W}$ /g/	12,61	12,03	12,30	12,32	-	14,87	15,61	16,16	15,55	Mean values	3,58	34,8

This table presents the mean weights of one fish calculated for 1974-1976 in g.

The mean weight of the Gdansk sprat in a quarter and age group is always less by about 3.5 g i.e. 35% than that of the Bornholm sprat.

Table 5. Values of the parameters in the v.Bertalanffy equation, showing the weight increment of sprat from the Gdansk and Bornholm regions.

Quarters 1974-1976	Gdansk region			Bornholm region		
	W_{∞} /g/	K	t_o	W_{∞} /g/	K	t_o
I	22.71	0.1516	-2.1202	19.55	0.5224	0.1291
II+III	17.04	0.2520	-1.7216	20.62	0.2535	-2.7751
IV	15.87	0.6957	0.5099	21.21	0.6495	0.0583
Whole year	16.27	0.6031	0.5923	19.67	0.6574	0.2243

The best parameters were those of the v.Bertalanffy equation calculated for the whole year /Table 5/ and can thus be used for further mathematical models.

Comparing sprat from the Gdansk and Bornholm region it was found that the annual asymptotic weight /W_{∞}/ calculated for the sprat from the Gdansk region was more than 3 g less, as compared with the sprat from the Bornholm area. This confirms the conclusion drawn from Table 4. The coefficient of catabolism /K/ is also somewhat lower for the Gdansk sprat. O.Rechlin conducted in - vestigations on the weight of the Gotland sprat /1975/. He calculated the following parameters of weight increment:
W_{∞} = 20.423 g K= 0.270 t_o= -2.576. These parameters vary considerably from those presented in Table 5 /calculated by the author for the whole year/. The reason for these differences was the fact that O. Rechlin used data on the length and weight of fishes belonging to a greater number of age groups. Therefore older fish had a decisive influence on the parameters.

The annual variability of the visible in Table 5 parameters in the v.Bertalanffy equation should be explained in the future among other things by comparing these parameters obtained from sprat weight data calculated from back reckoning from otoliths, with corresponding parameters calculated for empirical data.

Table 6. The theoretical weight in successive age groups of the
Gdansk and Bornholm sprat calculated from the v.Bertalanffy
equation is denoted: X — incalculable values from data
for a given quarter and age group; questionable values
are given in brackets.

Age groups	Gdansk region				Bornholm region			
	Quarters in 1974-1976			Whole year	Quarters in 1974-1976			Whole year
	I	II+III	IV		I	II+III	IV	
	mean weight in.g							
0	X	X	X	X	X	X	/7.23/	5.28
I	8.56	8.46	/4.58/	/3.55/	7.15	/12.70/	9.70	7.86
II	10.55	10.37	10.24	9.51	12.20	14.47	15.20	13.55
III	12.26	11.85	13.06	12.86	15.19	15.85	18.07	16.49
IV	13.73	13.01	14.47	14.19	16.96	16.92	19.57	18.02
V	14.99	13.91	15.17	15.13	18.02	17.75	20.35	18.81
VI	16.08	14.60	15.52	15.65	18.64	18.39	20.76	19.22
VII	17.01	15.15	15.69	15.93	19.01	18.89	20.98	19.44

The theoretical values of the sprat weight were calculated
from the v. Bertalanffy equation in age groups from II to
VII + in respective quarters of the years 1974-1976 and
also in the areas investigated. They are generally equal
to the weight values obtained from calculations from empi-
rical data /Table 4/. The divergencies in 0/I age groups
between empirical and theoretical values of the sprat weight
result from the absence of small fish, which due to the
selectivity of fishing gear were not caught and could not
therefore be examined.

5. Conclusions.

5.1. The weight-length ratio calculated from Lagler's equation
for the whole annual cycle for the sprat in Southern Baltic
is as follows: a/ in the Bornholm region:
$$W = 0.004682 \cdot L^{3.1258}$$
b/ in the Gdansk region:
$$W = 0.008609 \cdot L^{2.8776}$$

5.2. The annual rate of sprat weight increment expressed
by the v.Bertalanffy equation is:

a/ in the Bornholm region:
$$W_t = 19.67 \ /g/ \cdot \left[1 - e^{-0.6574} \cdot /t - 0.2243/\right]$$

b/ in the Gdansk region:
$$W_t = 16.27 \ /g/ \cdot \left[1 - e^{-0.6031} \cdot /t - 0.5923/\right]$$

5.3. The Bornholm sprat has a higher rate of weight increment
as compared with the Gdansk sprat; this difference,
taking into account the age group, amounts on average
3.5 g i.e. about 35% of the weight of the respective
age groups.

5.4. During the year the weight of the sprat undergoes cycli-
cal changes; it is the lowest in March-April-May and
the highest in the fourth quarter. This confirms the
results of earlier investigations on the sprat carried
out by P.F. Moyer., B.Dixon., F.W. Morawa, J.Elwertowski,
O.Rechlin and others.

5.5. In view of the divergencies in the sprat weight between
data from observations and those calculated theoretically
from the v.Bertalanffy equation, it would seem to be
worth while to investigate the problem of sprat growth
based on back-reckoning from the otoliths.

Acknowledgments

B i b l i o g r a p h y

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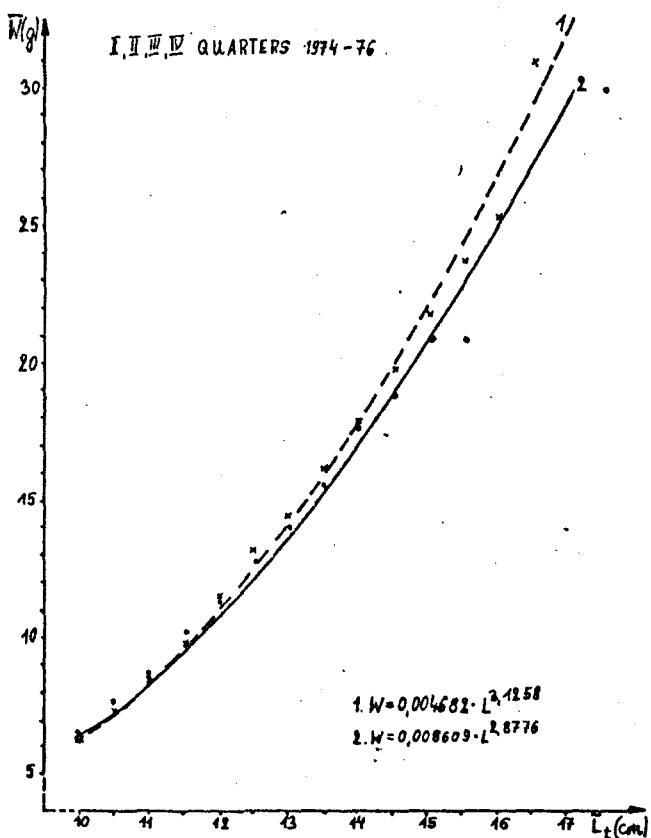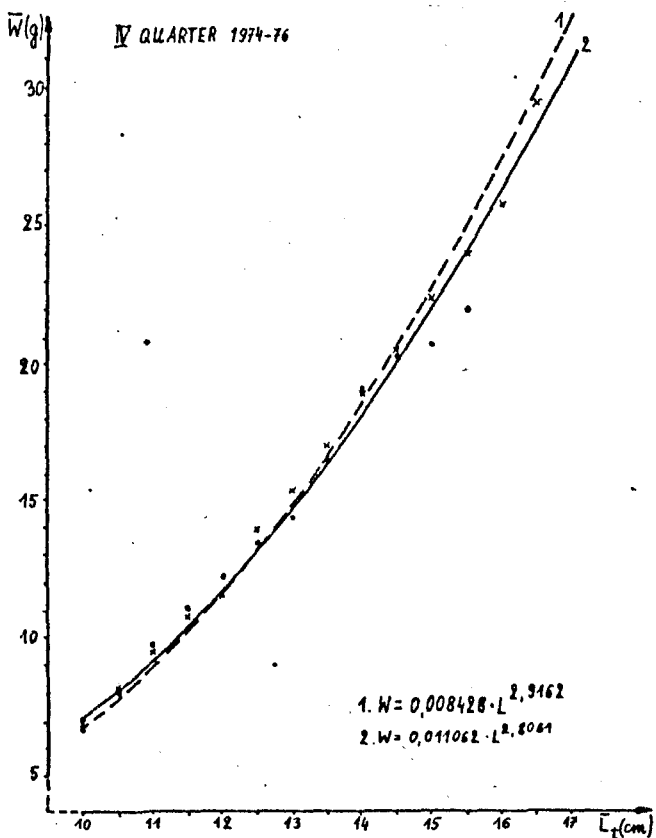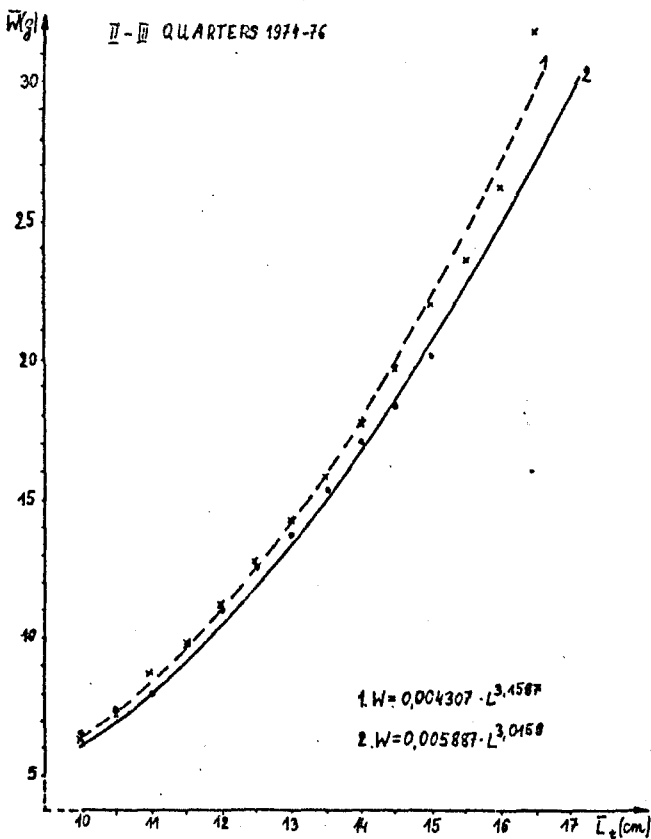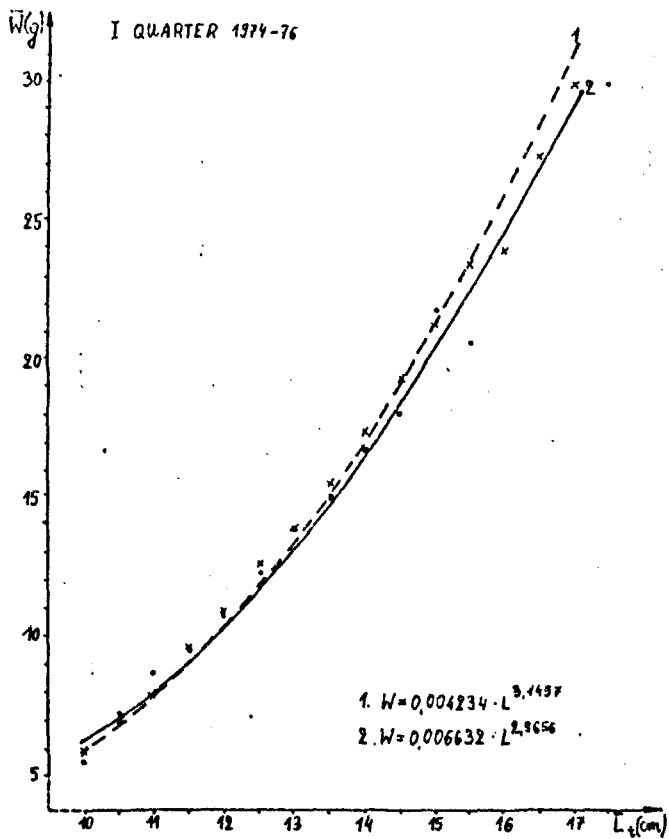
Fig.1 The relationship between the length and weight of sprat
from the following regions:
1. Bornholm /x-empirical data, ------ data calculated theoreti-
cally/
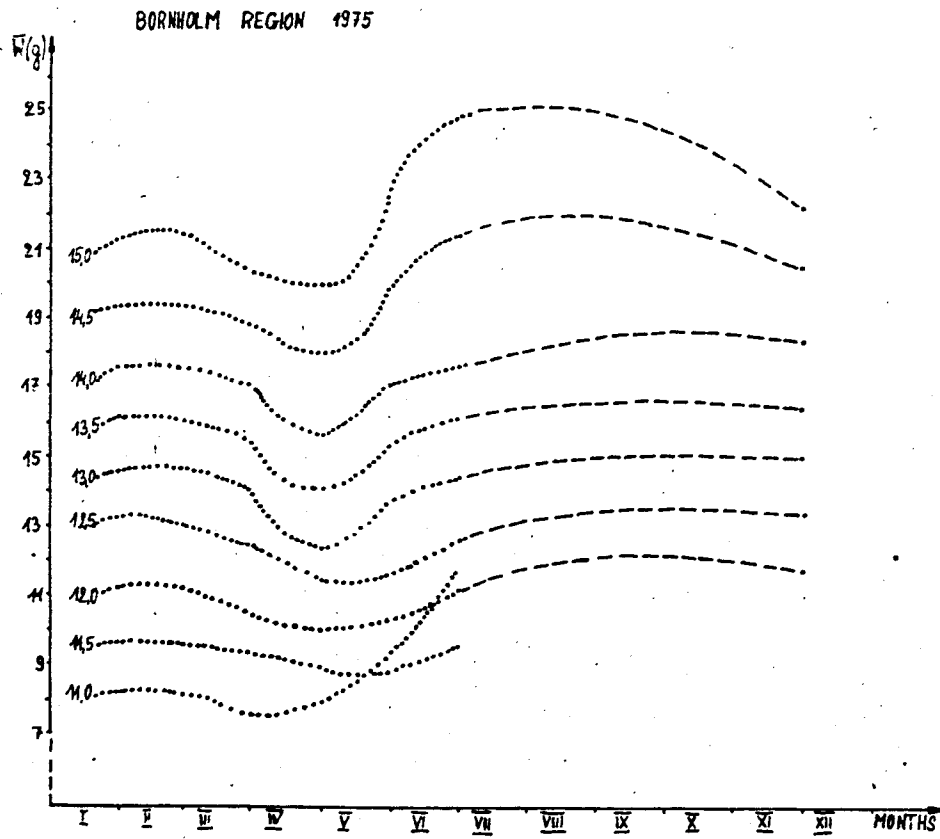2. Gdańsk /.- empirical data, ———— data calculated theoretically/.
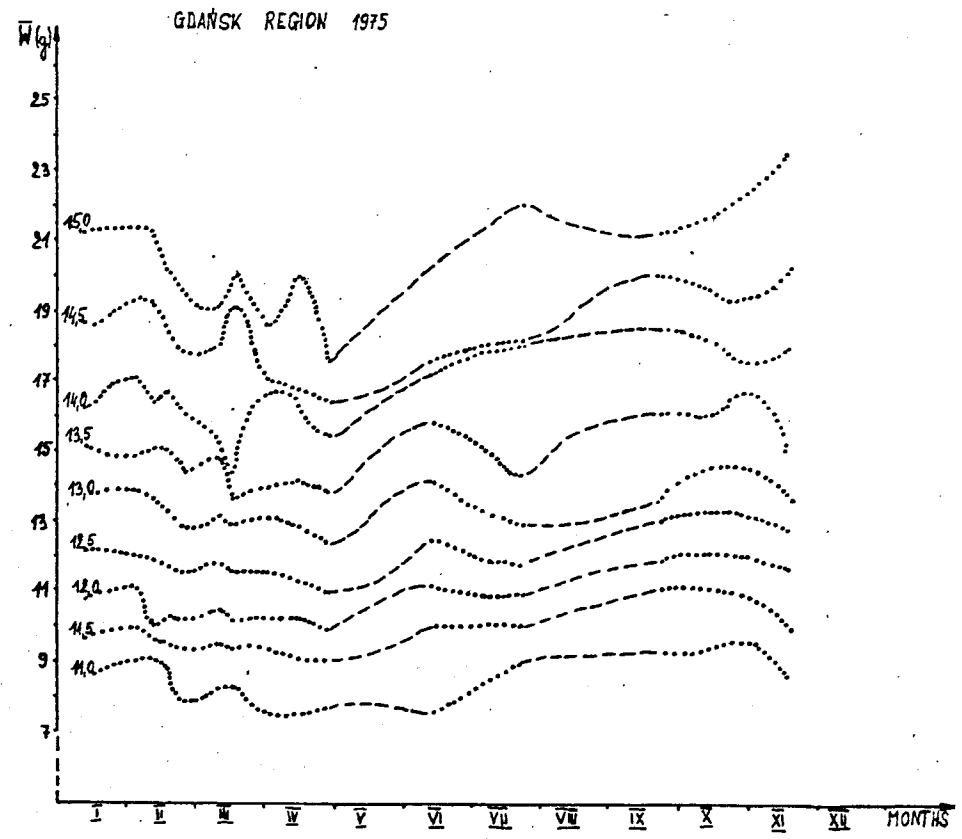
Fig.2 Changes in the weight of the sprat over the year according to length classes /- - - - no data/.
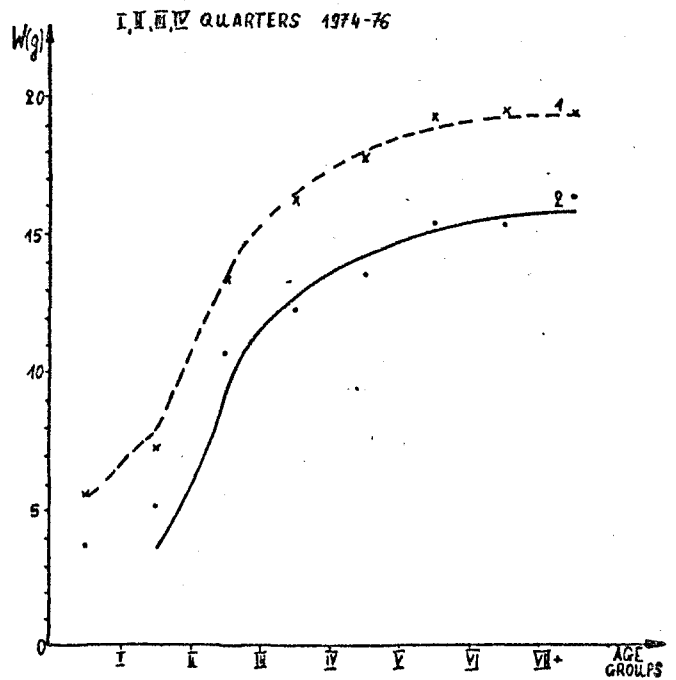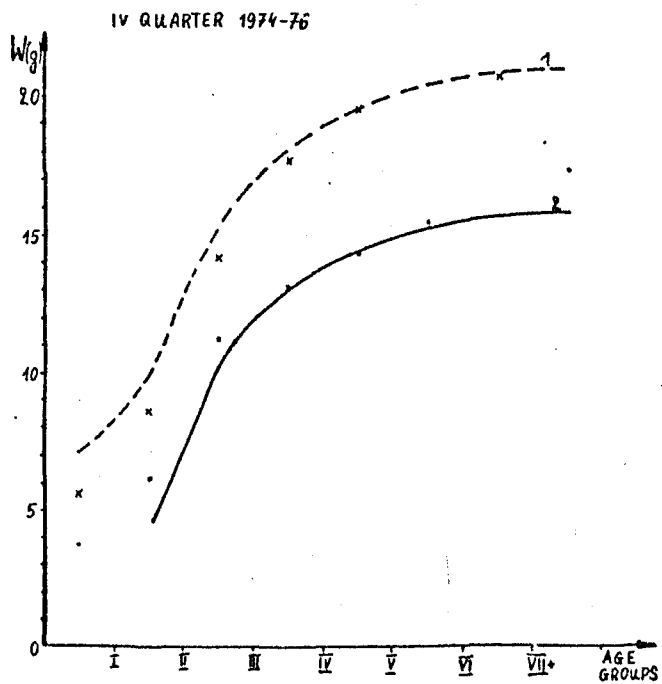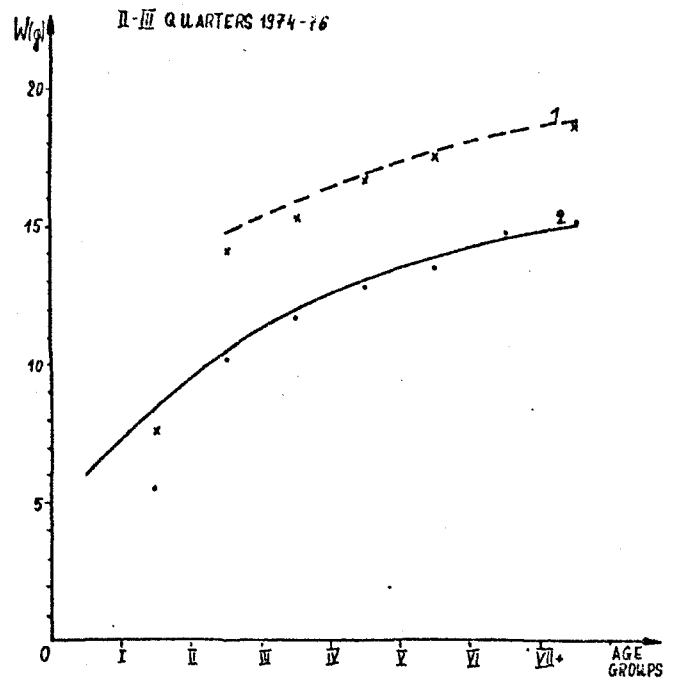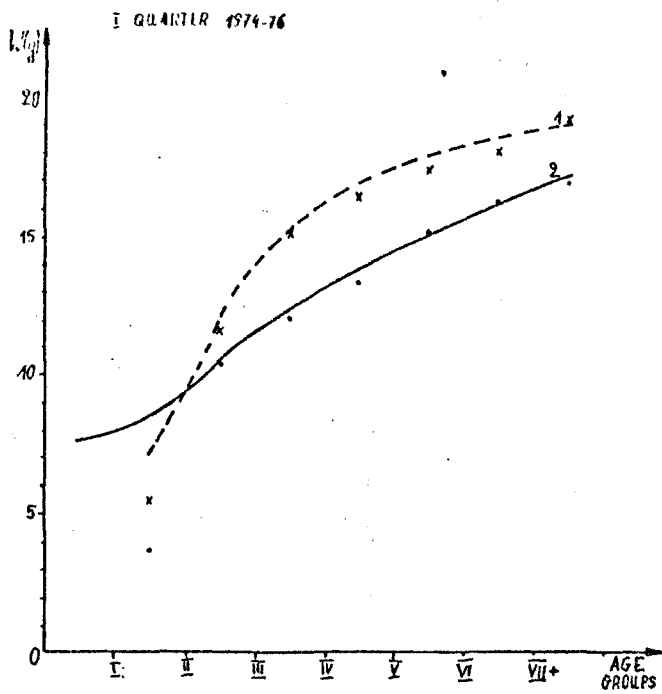
Fig.3. Changes in the weight /W/ of the sprat over the year, in con-
secutive years of its life in:
1. The Bornholm region /x-empirical data, ------- data calculated
theoretically/
2. The Gdansk region /.-empirical data, ——— data calculated
theoretically/.