The Growth of the Turbot in the North Sea

by

R. Kändler and Tekin Mengi

The turbot belongs to the most appreciated and highly payed marine food fishes. In spite of its economic importance only very few publications deal with the growth of this species. This may be caused partly by its high price preventing the investigation of larger samples. From the attempts made until now to establish the growth rate of the turbot, it may be suggested that the annual rings in the otoliths and bones do not allow exact age determinations. As is well known, scales are absent in this species.

In order to complete our knowledge on the biology of the turbot, the second-named author was charged with age determinations by means of otoliths. The material used was collected from trawl catches by R.V. "Uthörn" in 1956-60 and from landings at the Bremerhaven fish market in May 1959 and September 1960. We are much obliged to Dr. Kotthaus for handing over the otoliths taken during the survey of the stock of plaice in the south-eastern North Sea.

Former investigations.

T.W. Fulton (1906) estimated the growth of the turbot by means of the maxima observed in the length distribution. H.M. Kyle (1926) tried to determine the age from the zones on the operculum of 28 specimens. Their results are tabled below.

Table 1. The size of the turbot in the different years of life.

age	T.W. Fulton (1906)	H.M. Kyle (1926)
1 year	7,5-10,5 cm	5,5 cm
2 "	13 "	7-13 "
3 "	13 -17 "	13-15 "
4 "	18 -22 "	16-18 "
5 "	22 -26 "	abt. 24 "
6 "	27 -31 "	26-30 "
7 "	31 -35 "	31-39 "
8 "	35 -41 "	32-49 "
9 "	42 -46 "	35-55 "
10 "	46 -52 "	40-56 "
11 "		60 "
16 "		68 "

E. Ehrenbaum (1936) stated the age of the turbot at its first maturity to be 5 years (males from 28 cm, females from 35 cm in length) in contrast to A.C.Johansen (1915) who read from the otoliths 3 years for a mature male 27.5 cm in length, and 4 years for a mature female 34.3 cm in length. Further on two unpublished drawings of the opercula of turbot exist which Fr. Heincke considered as 3 years (30 cm) and 6 years (44 cm) old, unfortunately without giving the sex (R. Kändler 1949).

A.C. Johansen (1915) has published numerous measurements of young turbot caught in 1905-13 at the coast of Jütland they are grouped according to the month of capture in Table 2.

In the spring two length groups occur representing the age-group I (6-11 cm) and II (19-23 cm). In July the O-group (2-3 cm) appears in the catches. The length distribution in August shows two maxima at 3 cm and 13 cm, advancing to 4-5 cm and 14-16 cm respective in September. They belong to the age-groups O and I the average length of which differ by 10 cm. At the end of the first year of life, the young turbot vary very much in size as the length range of the O-group in October extends from 2 to about 12 cm. In November only few small specimens of the first year-class were still present near the coast, as the larger and older fish had migrated into deeper waters.

At the beginning of the winter, the average length of the 0-group may be estimated at least to 8 cm, of the I-group to 18 cm which fairly correspond with the values obtained in the spring (Table 2).

Own results of otolith readings.

The otolith of the turbot proved to be well readable and can be obtained and prepared for reading by less trouble and expense than the bones. The annual zones are quite similar to those in the otoliths of the plaice. They can be well recognized even at older fish, and the age determination could be carried out reliably up to the age-group XIV.

According to the origin the material is divided in 3 groups:

1. 201 specimens from biological catches in the years 1948-60 (June/July and September),

2. 580 specimens from commercial landings in September 1960 (central North Sea), separated according to sex,

3. 517 specimens from commercial landings in May 1959 (southern North Sea), without separating the sex.

The length range in the biological catches varied from 15 to 54 cm for males, from 17 to 68 cm for females, in the commercial samples from 26 to 57 cm for males, to 70 cm for females.

During the spawning period in early summer the males predominated by 59% (biological catches), whereas in the autumn the females were more frequent (59% in biological catches, 61% in commercial catches). After spawning the turbot leave the coastal region and migrate to deeper water. Therefore the biological catches from the German Bight in late spring contain more larger fish (56% 40 cm and more in length) than in the autumn (12%).

Biological catches.

The results of the age determination for males and females are given in Tables 3 and 4. At first sight one finds a much more rapid growth of the females than of males, compared with the results for other species of flatfish. The difference in the mean sizes of the age-groups increases with increasing age, from 2 cm in the third year of life to 7-8 cm for fish more than 10 years old.

A great number of age-groups is included in the biological material from the spawning period. The III- and IV-groups are most frequent (more than 20%), the following V-IX-groups are represented by 6-10%, and the fish more than 10 years old amount to 17.5%. In the autumn catches the number of older fish is low (only 12% for age-group V+), and the II-group dominates by 52%.

Commercial samples.

The material taken at the Bremerhaven fish market is far richer comprising about 1100 turbot. For May and September it must be dealt with separately as only in the latter sample the sex was determined. The relationship between length, age and sex in the sample from September 1960 are presented in Table 4. Due to the large numbers even in the higher age-groups, the calculated average length for males and females is fairly reliable up to the XIV-group which shows a difference in size by 8.7 cm in favour of the females.

According to net selection and demand of commerce, the length range comprises fish from 32 cm and age-group III upwards. The most frequent age-groups are VIII (11.9%) and IX (11.2%), followed by V (9.6%), VII (8.9%), and XI (8.2%). Up to the age-group XIII the percentage is above 5%, only for XIV-group and the youngest age-groups III and IV it is around 4%. The collective group XV+ contributes 12.2% to the catch, an astonishing high part of which the males account for 3.4% (maximum length 57 cm) and females for 8.8% (maximum length 68 cm).

The length-age-analysis of the commercial samples taken in May/1959 is given in Table 5. The length varies from 26 to 70 cm, but the smaller fish up to 31 cm are rare. The length distribution in the age-group IV and older ones shows a striking phenomenon: instead of a nearly normal distribution two maxima occur in a distance of about 6-8 cm. Obviously they are caused by the differences in the growth rate of males and females. For example we find in the age-group IV maxima at 35 and 41 cm; they increase to 40 and 46 cm in the VI-group, and to 46 and 51 cm in the VIII-group. Looking at Table 4 we find that these values lie near the mean values for males and females in the

preceding age-group from the autumn. In age-group X and older the sex is clearly separated in the length range by a gap of 2-3 cm. Therefore the average length for males and females can be calculated easily without sex determination, as was done in Table 5.

In the commercial catches from May, i.e. before spawning the age-group V dominates by 20.7%. The oldest group XV+ (9.1%) maintains the fourth place after the age-group IV (11.6%) and VI-group (9.7%). This age analysis shows also that the turbot fishery is based on many age-groups.

The average length of all age-groups obtained by biological and commercial catches in May/July and September was plotted in a diagram to draw growth curves for males and females (Figure 1).

Thereby the problem of the growth rate of the turbot in the North Sea, as yet unknown, seems to be solved in a satisfactory way. Further investigations are necessary to obtain knowledge of the size and age composition of commercial catches from different parts of the North Sea. From the results presented in this paper, the conclusion may be drawn that many age-groups are included in the landings. Many turbot reach a considerable size and high age. This may be explained by the fact that the exploitation of the turbot stock is limited by its scarcity and the wide dispersion over a large area.

References

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Table 2. Length distribution in catches of young turbot caught in April-November 1905-1913 in coastal waters of Jutland.

Length cm	April/June	July	August	September	October	November
2	-	6	77	6	5	-
4	-	10	275	120	31	2
6	1	1	31	95	44	14
8	1	3	8	22	33	8
10	1	3	49	4	74	1
12	2	3	55	4	27	-
14	-	-	59	9	12	-
16	-	1	39	8	14	-
18	-	2	25	4	8	-
20	2	1	10	3	15	-
22	3	5	8	-	2	-
24	1	3	1	2	3	-
26	-	1	-	-	1	-
28	-	2	-	1	1	-
Number	11	41	637	278	270	25
Mean 0-group	-	3.1	3.3	4.8	8.0	6.7
Length, I-group	9.5	9.7	13.5	15.1	17.5	-
cm, II-group	21.2	22.2	21.5	25.2	-	-

Length (cm)	II ♂	II ♀	III ♂	III ♀	IV ♂	IV ♀	V ♂	V ♀	VI ♂	VI ♀	VII ♂	VII ♀	VIII ♂	VIII ♀	IX ♂	IX ♀	X ♂	X ♀	XI ♂	XI ♀	XII ♂	XII ♀	XIII ♂	XIII ♀	XIV ♂	XIV ♀	XV+ ♂	XV+ ♀	Total ♂	Total ♀
24	2	1																											2	1
26		2																											-	2
28		2	2																										2	2
30			7																										7	-
32			5	2																									5	2
34			5	2																									5	2
36			1	3	6	-																							7	3
38				3	7	2	1	-																					8	5
40				1	5	1	3	-																					8	2
42						3	1	1	1	-																			2	4
44						1	2	-	3	-	1	-																	6	1
46						2	1	-	2	-	2	-	2	-															7	2
48						1	-	1	1	-	1	1	3	1	3	-	1	-											9	4
50							-	2	-	2	-	2	1	1	1	-	1	-	1	-			1	-					5	5
52											1		-	2	-	2	-	-	-	-	3	◄	2	-	3	-			8	5
54												1	-	2	-	3	-						1	-	1	-	1	-	3	6
56														1		1			-	1	-	-							-	3
58																1			-	2	-	1							-	4
60																			-	1	-	1							-	2
62																									-	1			-	1
64																													-	-
66																											-	1	-	1
68																											-	2	-	2
Number	2	5	2o	11	18	1o	8	2	7	2	4	5	6	7	4	7	2	-	1	4	3	2	4	-	4	1	1	3	84	59
♂ + ♀	7		31		28		1o		9		9		13		11		2		5		5		4		5		4		143	
%	4.9		21.7		19.6		7.o		6.3		6.3		9.1		7.7		1.4		3.5		3.5		2.8		3.5		2.8		1oo.1	
Mean length ♂	24.o		31.5		37.8		41.9		44.6		46.3		47.7		48.3		49.5		5o.5		51.8		52.o		52.3		53.5			
" " ♀	26.7		35.7		42.9		45.o		5o.5		5o.7		52.4		54.1		-		57.8		59.5		-		61.5		67.8			

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Table 4. Length and age distribution in biological catches of turbot, in the south-eastern North Sea (September)

Length (cm)	I ♂	I ♀	II ♂	II ♀	III ♂	III ♀	older ♂	older ♀	Total ♂	Total ♀
16	1	-							1	-
18	2	3							2	3
20	2	3							2	3
22	2	3							2	3
24			4	1					4	1
26			2	3					2	3
28			-	6					-	6
30			8	2					3	2
32				6	1	-			1	6
34				3	1	-			1	3
36					2	-			2	-
38					-	1			-	1
40							V		1	-
42							V		1	-
44							V		1	-
>50							XIII, IX, XIII XV+		1	3
Number	7	9	9	21	4	1	4	3	24	34
♂ + ♀	16		30		5		7		58	
%	27.6		52.2		8.6		11.6		100.0	
Mean length cm ♂	19.5		26.4		34.3					
♀	20.2		29.6		38.5					

Table 5. Length and age distribution in commercial catches of turbot, September 1960

Length (cm)	III ♂	III ♀	IV ♂	IV ♀	V ♂	V ♀	VI ♂	VI ♀	VII ♂	VII ♀	VIII ♂	VIII ♀	IX ♂	IX ♀	X ♂	X ♀	XI ♂	XI ♀	XII ♂	XII ♀	XIII ♂	XIII ♀	XIV ♂	XIV ♀	XV+ ♂	XV+ ♀	Total ♂	Total ♀
32		1																									-	1
34	2	-																									2	-
36	3	1	3	-																							6	1
38	3	1	1	-	2	-																					6	1
40	2	8	7	-	4	-																					13	8
42	-	2	7	-	7	-	5	-																			19	2
44	-	1	-	1	8	1	2	-	1	-																	11	3
46			-	2	6	11	9	3	11	-	2	-	1	-													29	16
48			-	1	-	15	-	6	5	1	7	-	10	-	7	-	3	-	1	-							33	23
50					-	2	-	13	-	18	1	5	9	-	13	-	15	-	8	-	3	-	1	-			50	38
52							-	1	-	12	-	31	-	8	-	-	4	-	8	-	5	-	4	-	2	-	23	52
54									-	4	-	17	-	13	-	-	-	-	3	-	7	-	2	-	5	-	17	34
56											-	6		24	-	10	-	4	-	-	1	-	3	-	7	-	11	44
58															-	9	- 13		-	7	-	2	-	-	6	-	6	31
60																	-	2	-	13	-	8	-	3	-	3	-	29
62																		1	-	4	-	7	-	7	-	15	-	34
64																			-	1	-	2	-	15			-	18
66																					-	1	-	16			-	17
68																							-	2			-	2
Number	10	14	18	4	27	29	16	23	17	35	10	59	20	45	20	19	22	20	20	24	16	18	10	13	20	51	226	354
♂ + ♀	24		22		56		39		52		69		65		39		42		44		34		23		71		580	
%	4.1		3.8		9.7		6.7		9.0		11.9		11.2		6.7		7.2		7.6		5.9		4.0		12.2		100.0	
Mean length (cm) ♂	36.7		40.1		42.8		44.5		46.9		47.8		49.0		49.4		50.2		51.4		52.9		53.5		55.2		47.86	
♀	39.4		46.2		47.3		49.1		51.2		52.7		54.8		57.2		58.2		59.7		61.0		62.2		63.5		52.66	

Table 6. Length and age distribution in commercial catches of turbot, May 1959.

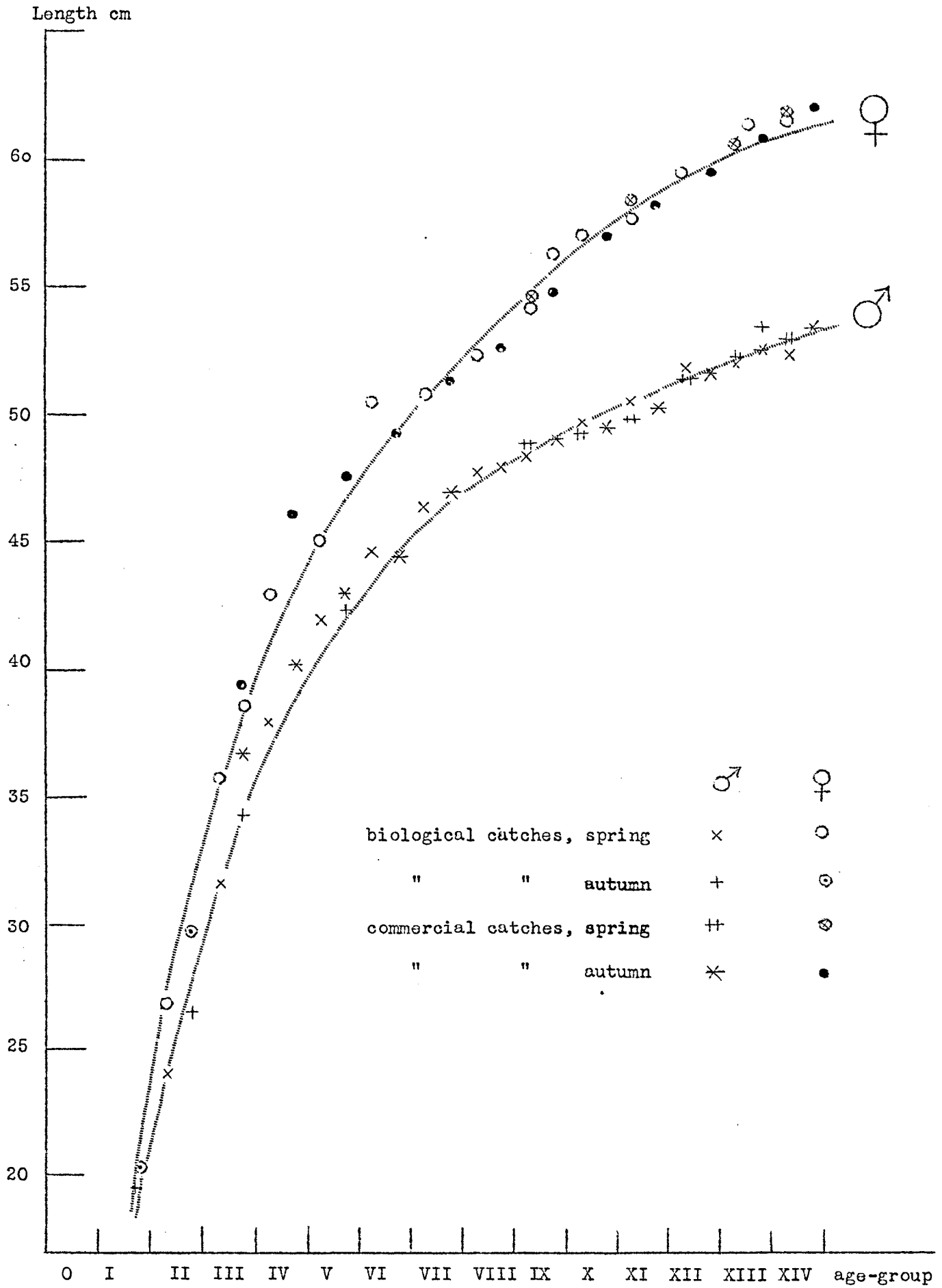| Length (cm)	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV+	Total
						A g e g r o u p s								
26	3													3
28	6													6
3o	6													6
32	9	4	3											17
34	3	9	13											25
36		15	28	1										44
38		8	13	7										28
4o		6	16	9	1									32
42		11	22	6	4									43
44		5	8	4	7	3								27
46		1	4	13	5	7	3							33
48				8	11	7	8	4	3					36
5o				2	5	4	9	7	4	4	2			37
52					3	7	4	-	2	5	8	3	1	33
54						3	8	2	-	1	3	3	3	23
56							9	4	3	-	-	2	7	25
58							1	6	7	3	2	-	2	21
6o								2	3	1o	7	5	1	28
62										2	7	4	3	16
64											1	2	7	1o
66												1	14	15
68													7	7
7o													2	2
Number	27	6o	1o7	5o	36	31	37	25	22	25	3o	2o	47	517
%	5.2	11.6	2o.7	9.7	7.o	6.o	7.1	4.8	4.3	4.8	5.8	3.9	9.1	1oo.o
Mean length ♂+♀ (cm)	3o.3	38.o	38.7	43.5	46.7	49.o	52.3	53.6	54.7	56.5	57.1	58.5	63.6	
♂						46.8	48.9	49.2	49.8	51.4	52.2	53.o	55.6	
♀						52.o	54.5	57.o	58.1	59.5	6o.7	61.7	66.7	

Length cm

Figure 1. Growth curves of the turbot in the North Sea.