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Ecological Peculiarities of Reproduction of Fishes with Pelagic Eggs

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Zoogeographical peculiarities of the Baltic, and changeable regime associated with the boundaries of two climatical zones going throughout the sea (Izhevski, 1964) caused spatial and seasonal heterogeneity in living conditions of marine fishes.

The basis of pelagic ichthyofauna in the Baltic is composed by the representatives of two zoogeographical complexes: atlanto-boreal (sprat, four-bearded rockling, turbot, plaice) and arcto-boreal (cod, flounder, dab). Some common ecological regularities become apparent in the distribution of these fishes and in the peculiarities of their reproduction.

Sprat spawns throughout the sea in near-bottom (in spring) and in the surface layers (in summer). Sprat eggs and larvae development occurs at water temperature 4-16° and salinity 5-20°/oo. The most intensive spawning is observed at temperature from 10-15°.

Cod, flounder, and four-bearded rockling are more particular to water salinity, and their spawning ranges are limited by near-

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bottom layers of deep-sea depths.Their eggs develop normally at salinity not less than I0-II°/oo and water temperature 4-7°.

Being more particular to the salinity(not less than I3-I4°/oo), plaice and dab reproduct in South-Western regions.As a rule, their eggs occur to the east off Bornholm Island.(Lindblom, I973).

The spawning of cod and flounder(fishes of arcto-boreal origin)occurs at temperatures lower(5-6°)than that of sprat and four-bearded rockling(7-I5°).

The duration of spawning season decreases by I-2 months when movimg northwards from Bornholm and Gdansk regions(Middle and Northern Gotland),and mass spawning shifts to the later terms:flounder spawns within 2-3 months;March being the peak of spawning in Southern regions of the sea,April-in Northern.Four-bearded rockling reproducts within 2 months in the North,and 4-5 months in the South;mass spawning being observed in May-June.Mass spawning of cod is noted in April-May(South-western regions)and in May or June(in North-Eastern regions).(Table I).

Unlike the fishes mentioned the duration and spawning terms of sprat differ a little by regions.Reproducting in different layers,it has two spawning maximums:in May at temperature 5-7° (for near-bottom layers);in June or July at temperature I0-I6° (for surface layers).

Sprat eggs dominate in ichthyoplankton from March-July in all regions(Table I)that is caused by high sprat abundance,as well as by its good acclimation to different ecosystem conditions(near-bottom and surface).

Species composition of ichthyoplankton differ by regions

and months.The largest abundance of eggs below Im^2 and percentage of live eggs is observed in Bornholm; the smallest one- in Northern Gotland(Table I).Bornholm spawning ground is notable for higher salinity and temperature,and better water exchange, that results in lasser eggs mortality, and fish migration to this area from other regions(Lablaika,Lishev,I964;Biryukov, I97I).

Maximum larvae abundance of the fishes studied is marked throughout all regions in May and June,when their mass emergence occurs.Bornholm region is considered to be the first from the point of view of eggs abundance,and from the point of view of larvae abundance paramount position is taken by Gdansk spawning ground(Table 2),though the eggs are lesser in number in the particular region.

Sprat larvae abundance below Im^2,as well as its eggs,surpass the summary quantity of the other larvae in all regions, except Northern Gotland(Table 2).The index "The number of larvae in % against the quantity of eggs" for all the fishes mentioned increases from the south-west to the north-east(Table 3). For example,in April sprat larvae percentage is the lowest in Bornholm and reaches the maximum in the Southern part of Gotland where the number of larvae does not correspond with the number of eggs(Table I,2);in May larvae percentage increases in Middle and Northern parts of Gotland.

Average length of sprat and flounder in Northern regions is larger than that of the Southern(Table 4),though water temperature in the North is lower and spawning begins later.It is essential that in one and the same period the majority of larvae in the North is on later stages of their development than those in

the South.The increase in larvae percentage(Table 3) and discrepancy of their sizes to the terms of spawning and conditions of development may be explained by the presence of distinctly marked larval drift in the Baltic in North and North-eastern directions.Large abundance of eggs in southern parts and the dis repancy between the little number of eggs and high quantity of young fishes in Northern areas may serve as a confirmation for the phenomenon.

Particular position is taken by the Gdansk spawning ground where the largest percentage of all the fishes mentioned is recorded.This is explained by the isolation of the Gdansk Bay that is the result of cyclonic stream formation in this area (Soskin,Denisov,1957)hampering the drift of larvae into the other regions.

In the course of growth larvae of flounder,sprat,and four-bearded rockling emerge from near-bottom layers into surface, but cod larvae keep to the deeper layers.Maximum larvae density in upper layer is observed from Bornholm to the Southern Gotland in April-June,and in Middle and Northern Gotland from May -July.

Certain links are outlined between the distribution of young and adult individuals and the duration of larvae stay in the pelagic zone:larvae of spart and flounder occur in surface layers from April - August:and of four-bearded rockling -in June-July:accordingly the area of sprat distribution is wider than that of four-bearded rockling.

The data listed allow to propose that the major part of stocks of fishes with pelagic eggs reproducts in Southern regions;local reproduction in Northern Baltic is of lesser importance

and the stocks of fishes mentioned recruit by the drift from more Southern regions.

Conclusions

I. Distribution of fishes with pelagic eggs in the Baltic Sea is mainly characterized by: sprat and flounder have wider area, including the Gulf of Finland; cod and four-bearded rockling reach the Northern Baltic; plaice, turbot and dab prefer salter South-western regions, and to the East off Bornholm are met rarer.

2. Sprat has the largest spawning area, reproducting in near-bottom, deep-water and surface layers throughout the sea; its eggs and larvae dominate in ichthyoplankton of the Baltic.

3. The duration of spawning season and the terms of its maximum are, accordingly: in flounder-3 months, and March and April: in cod-up to 7 months, April-May - South-Eastern areas, and May-July - in North-Eastern areas; in four-bearded rockling -4 months, and May-June; in sprat-up to 7 months, and maximum in June-July.

4. The largest quantity of eggs below Im^2 in fish examined is noted in Bornholm region, the smallest one-in Northern part of the Gotland Deep.

5. Peculiarities of spawners migrations, terms of spawning, distribution of eggs and larvae development and growth testify to the presence of distinctly expressed larvae drift in the Baltic Sea from Southern regions to Northern ones.

6. Certain connections are outlined between the distribution of areas of young and adult fishes and the duration of larvae

stay in pelagic zone;sprat and flounder larvae occur in upper layers of the sea from April - August;four bearded rockling - in June-July.This provides their wider disperse by the tide over the aquatory of the sea.

7.The major part of the stocks of fishes with pelagic eggs reproducts in Southern areas;in Northern areas local reproduction is of less importance,and the stock increases by the drift of larvae from more Southern regions.

8.Eggs and larvae of pelagic fishes enter different ecosystems depending on regions and seasons:sprat spawns in spring,in deep near-bottom layers;in summer-in surface;flounder and cod reproduct in near-bottom layers;sprat and flounder larvae keep to the surface layer,and cod-in deep-water layer.Thus,the study of year-class formation in fishes with pelagic eggs should be carried out by methods of zoogeographical and ecosystimatical analysis.

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Table I.

Mean Abundance of Eggs Below Im^2 and Eggs Survival by Species in March-August 1971-1973

Region	Fish species	Months III	IV	V	VI	VII	VIII	Mean eggs quan.	Eggs surviv. in %
Bornholm	sprat	46	96	150	521	780	0	313	33
	cod	21	91	57	50	38	6	44	31
	flounder	27	20	4	-	-	-	17	33
	four bearded rockling	-	2	10	9	1	-	6	-
	Total	94	209	221	580	819	8		
Gdansk	sprat	33	132	140	330	226	6	144	35
	cod	5	13	20	17	5	5	11	30
	flounder	4	2	1	-	-	-	2,5	30
	four beard. rockling	-	3	5	3	-	-	3,5	-
	Total	42	150	166	350	231	11		
Southern Gotland	sprat	15	19	85	170	376	3	111	29
	cod	4	11	16	18	14	5	11	26
	flounder	-	6	5	-	-	-	5,5	32
	four beard. fockling	-	5	4	7	2	2	4	-
	Total	19	41	110	195	392	10		
Middle Gotland	sprat	32	30	54	196	130	3	74	24
	cod	-	5	14	16	13	1	10	30
	flounder	-	9	4	-	-	-	6,5	32
	four beard. rockling	-	2	3	4	5	2	3	-
	Total	32	46	75	216	148	6		
Northern Gotland	sprat	3	5	7	66	130	9	37	21
	cod	-	-	2	7	6	2	4	18
	flounder	-	3	2	-	-	-	2,5	19
	four beard. rockling	-	-	6	2	-	-	4	-
	Total	3	8	17	75	136	11		

Table 2.

Mean Larvae Abundance Below Im^2 (in pieces) by Species in March-August 1971-1973

Regions	Fish species:	Months						Mean abund.
		III	IV	V	VI	VII	VIII	
Bornholm	Sprat	2	13	8	30	13	1	11.0
	Cod	0	5	3	6	2	0	4.0
	Flounder	2	9	10	4	2	0	5.3
	Four bearded rockling	0	0	7	2	2	1	3.0
	Total	4	27	28	42	19	2	
Gdansk	Sprat	2	24	59	44	10	45	29.0
	Cod	1	2	6	2	2	0	2,6
	Flounder	0	4	9	7	2	0	5.5
	Four bearded rockling	0	3	4	2	1	0	3.5
	Total	3	33	78	55	15	45	
Southern Gotland	Sprat	1	12	11	14	13	1	8.6
	Cod	0	2	5	2	3	0	3.0
	Flounder	2	2.5	5	4	2	0	3.0
	Four bearded rockling	0	2	3	4	2	2	2.6
	Total	3	41	24	24	20	3	
Middle Gotland	Sprat	3	5	17	14	13	3	9.0
	Cod	0	1	5	3	2	0	2.7
	Flounder	0	3	4	5	3	0	4.0
	Four bearded rockling	0	0	3	3	2	3	2.7
	Total	3	9	29	25	20	6	
Northern Gotland	Sprat	0	1	5	3	7	3	4.0
	Cod	0	2	3	0	0	0	2.5
	Flounder	0	2	2	3	2	0	2.2
	Four bearded rockling	0	0	0	0	2	0	2.0
	Total	0	5	10	6	11	3	

Table 3.

Larvae Percentage Against the Abundance of Eggs below Im^2 by Months and Regions in 1971-1973

Fish species	Regions	Months					Mean weigh.
		III	IV	V	VI	VII	
Sprat	Bornholm	4.3	13.5	5.3	5.7	1.6	5.6
	Gdansk	6.0	18.2	42.1	12.3	4.8	22.2
	South Gotland	6.6	63.0	13.0	8.0	8.2	12.8
	Middle Gotland	9.0	16.6	31.0	7.1	10.0	14.7
	North Gotland	-	20.0	71.0	4.8	5.4	25.5
Cod	Bornholm	-	5.4	5.2	12.0	5.3	6.9
	Gdansk	20.0	15.3	30.0	11.8	40.0	15.3
	South Gotland	-	18.0	31.2	11.1	21.4	17.2
	Middle Gotland	-	20.0	35.7	18.7	15.0	19.1
	North Gotland	-	-	150.0	-	-	20.0
Flounder	Bornholm	7.4	45.0	250.0	-	-	50.0
	Gdansk	-	200.0	-	-	-	350.0
	South Gotland	-	33.0	60.0	-	-	50.0
	Middle Gotland	-	33.0	100.0	-	-	100.0
	North Gotland	-	66.0	100.0	-	-	125.0
Four bearded rockling	Bornholm	-	-	70.0	22.0	20.0	31.6
	Gdansk	-	150.0	80.0	60.0	-	44.3
	South Gotland	-	40.0	75.5	57.7	100.0	50.0
	Middle Gotland	-	-	100.0	75.0	40.0	75.0

Table 4.

Mean Length of Sprat and Flounder Larvae(mm) by Regions in the Surface Layer in February-August 1971

Regions	Sprat					Flounder					
	IV	V	VI	VII	VIII	II	III	IV	V	VI	VII
Bornholm			5.6	6.4	14.0	3.7	4.5	4.5	5.0	7.2	10
Gdansk	4.9	5.1	6.2	9.4	16.9	-	-	4.2	5.4	7.0	8.2
South Gotland		5.1	7.5	7.2	14.5	-	4.0	4.5	4.8	8.3	9.0
Middle Gotland	4.5	5.0	7.4	10.1	18.1			4.7	4.3	7.4	8.2
North Gotland	-	5.7	8.5	7.7	22.4			4.2	5.0	7.5	9.0

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