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METHODS OF STUDYING THE EFFECT OF ENVIRONMENTAL FACTORS
ON THE FLUCTUATIONS IN THE ABUNDANCE OF THE AZOV ANCHOVY

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faktorov na chislennost azovskoi khamsy

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Prior to the controlling of the run-off from rivers into the Azov Sea the catches of Azov anchovy comprised about 40% of the total catch in the basin of the Azov and Black seas. However, the catches of anchovy varied greatly from year to year. Thus the largest catch of anchovy for the last 23 years was made in 1938. It exceeded by several times the catches for 1935, 1944 and 1945, not to mention the smallest catch in 1954-1955.

The main fishing for anchovy is carried out in the straits of Kerch at the time when the anchovy leave the sea of Azov for winter quarters in the Black Sea.

Table I. The age composition of anchovy (according to the survey material of the Azcherniro expeditions, processed by V.P. Kornilova and others).

Years	Under-yearlings	2-yr. olds	3-yr olds	4-yr olds	Catch in % towards 1932
1932	<u>75,0</u> ¹	11,3	13,7	--	100
1933	33,6	<u>58,1</u>	8,3	--	118
1934	55,8	19,2	<u>24,8</u>	0,2	158
1935	88,1	7,5	4,0	<u>0,4</u>	38
1936	80,7	16,9	2,2	0,2	107
1937	<u>67,6</u>	25,0	7,1	0,3	172
1938	34,7	<u>52,4</u>	12,3	0,6	257
1939	45,0	32,2	<u>21,3</u>	1,5	198
1940	33,5	27,4	33,7	<u>5,4</u>	227
1941	33,6	42,6	21,9	1,9	71
1945	43,6	33,6	21,6	1,2	71
1946	<u>80,2</u>	6,0	12,5	1,3	99
1947	23,8	<u>68,1</u>	8,3	--	155
1948	31,0	29,0	<u>39,0</u>	1,0	150
1949	64,4	17,0	18,0	0,6	241
1950	<u>78,0</u>	12,5	6,1	3,4	126
1951	17,0	<u>69,2</u>	11,0	2,8	245
1952	31,0	20,1	<u>48,1</u>	0,7	175
1953	<u>61,1</u>	18,4	16,6	3,9	124

¹The strong year-classes are underscored

It was assumed that the success of the fishing depended upon the hydrological conditions that developed during the short fishing season in fall. It was also assumed that the fishing touched only

on a small part of the Azov anchovy and that the state of its stocks does not restrict the expansion of the fishing industry.

An analysis of the observations over many years showed that the fluctuations in the catches of anchovy, in many cases, depended upon changes to which its stocks are subject. A comparison of the relative strength of a year-class (according to the age-composition) with the size of the catch, shown in Table I, confirms these conclusions.

The data in Table I indicate the "presence"--during the period under study--of five strong year-classes (1932, 1937, 1946, 1950 and 1953) and five average-crop year-classes (1936, 1938, 1943, 1944 and 1947) in the commercial stocks of anchovy. The estimate of the relative stock strengths according to Mayski and Kornilova) indicates that the year-classes of 1935 and 1949 are also to be numbered among the strong year-classes. However, these year-classes in view of the poor condition of the underyearlings could not, so it seems, endure the severe conditions of wintering that were observed in 1935-1936 and 1949-1950 and perished. This accounts for the considerable reduction in the numbers of the indicated year-class in the catches of subsequent years (1936, 1937, 1950 and 1951).

The commercial age-groups of anchovy are comprised primarily of 2- and 3-year olds. If the significance of these groups in the commercial stocks of anchovy is compared with the catches in the corresponding years a direct dependence between the size of the generation and the catches can be observed. The war years are an exception when a shortage of fishing boats brought about a reduction in the catches.

The dependence between the relative numerical strength of the 2- and 3-year olds and the catches of Azov anchovy is shown by Figure 1. The figure shows that the abundant year-class of 1932 brought about an increase in the catches in 1933 and 1934. The year-classes of 1936, 1937 and 1938 ensured an increase in the catches in 1937-1940; the year-classes of 1946 and 1947--in 1947 and 1948 and, finally, the year-class of 1950--in 1951 and 1952.

The poor year-classes of 1931, 1934, 1935, 1945, 1951 and 1952 reduced the catches in 1932, 1935, 1936, 1940, 1946, 1952 and 1953. Only in two cases was a discrepancy observed between the numerical strength of the year-classes and the catches: 1) As a result of less intensive fishing during the war, and 2) as a result of the enormous mortality among the fry "born" in 1949 during wintering.

Up to 1/3 of the large catch of anchovy in 1949 was comprised of underyearlings. Their numbers were so large that at a relative estimate of the size of the year-classes by the age-composition

the specific weight of the preceding year-classes (1948 and 1947) appeared to be underestimated or conservative.

Thus, not denying the effect of the hydrometeorological conditions and of other factors upon the result of the fall catches of anchovy one may conclude: 1) that the stocks of anchovy vary considerably over the years; 2) the fluctuations in the stocks are brought about, first of all, by the different strength of the year-classes; 3) the fluctuations in the stocks of anchovy are reflected noticeably by the size of the catches.

With regard to relative strength, one year-class of anchovy exceeds the other 4-5 times; this cannot but affect the results of the catches. Therefore, in the case of the smallest stocks one must estimate the possible yield of fall anchovy accordingly.

As early as 1949 V.N. Mayski pointed out the large fluctuations in the stocks of anchovy and the effect of these fluctuations upon the catches. V.N. Mayski regards the natural factors and not the intensity of fishing as the cause for the great diminishing in the stocks of anchovy.

In connection with the above it is clear how necessary it is to know the causes of the fluctuations in the stocks of anchovy and in time to explain and estimate possible changes in its catches, improving the methods for forecasting these catches.

The fluctuations in the stocks of anchovy, first of all, are brought about by the varying strength of the year-classes. For this reason we undertook a complex study of all the factors upon which the reproduction, the development or growth and survival of the fry of anchovy depend.

Those participating in the conference on fishing problems in December of 1951 came to the conclusion that for most species the cause for the fluctuations in the stocks of commercial fish are the conditions for reproduction and the survival of the fry in the early stages of development. The main task of the research in recent years has been to establish the laws that bring about the "best" survival.

If there are any data in the relationship of anadromous and migratory fish that characterize the adaptive qualities of the species and its requirements with regard to the conditions for reproduction and the growth of the fry, we know almost nothing about what causes or determines the survival of the young of marine fish except for the general idea regarding the degree of the food supply for the fry at the moment of the transition of the larvae to active feeding.

Together with the expansion of fishing with regard to most

species of fish the need arises for the introduction of a rational control of fishing which would be based upon a study of the specificity of the species and its adaptive qualities with regard to the reproduction and the survival of the population. Depending on the pace at which the new technique of catching, which facilitates the expansion of fishing, will be put to practical use the need for this kind of knowledge is growing rapidly. The abrupt fluctuations in the numerical strength of marine fish compels us to reckon with this factor also when studying the behaviour and the distribution of the fish and to reflect this when compiling maps for commercial fishing. E.N. Pavlovski observes that the maps for commercial fishing should include the extreme limits or ranges of the dynamics of the accumulations of the stocks of fish in the "aquatorial" as well as "calendar" respect.

All this compels one to begin the study of the conditions for the reproduction and the survival of the fry of marine fish and first of all to develop methods for this study. This will be more complicated with regard to the open sea than for inland bodies of water.

Thus the research carried out by us with regard to the Azov anchovy aims at evolving methods for the kind of work indicated. At the same time work was started to study the conditions for the survival of the Black Sea anchovy as well as of the herring of the Baltic Sea. The methodological importance of the selected species consists in the fact that these marine fish differ from one another in the different dynamics of the stocks in the structure of the spawning populations and the biology of reproduction. The roe of the anchovy is pelagic whereas that of the Baltic herring is demersal. A comparison of the results will help to "uncover" new laws that govern the numerical strength of both species. The results of the research regarding the Azov anchovy are presented in this work.

Research Methods

Much work has been "dedicated" to the problems of the study of the conditions of the reproduction and development or growth of the Azov anchovy. This work was carried out as direct observations on the sea or under experimental conditions. The attitude of the anchovy to the factors of the outside medium, the development of the embryos during the various stages, the food of adult anchovy and its fry, the food interrelations of the anchovy with other fish (for instance, with the "tyulka"--sardelle), the aquatorial (Russian writers regard the mass of waters of a sea or part of a sea as an "aquatorium" Tr.) distribution of their larvae and their numerical strength per unit volume of water and other

questions were studied.

However, all these efforts failed to establish the causes for the change--in one or the other year--in the numerical strength of recruits for the anchovy stocks. On the one hand little attention was allotted to this problem for it was assumed that the size of the year-classes is determined in winter, at the time when the Azov anchovy winter in the Black Sea. On the other hand, it was assumed--without any particular proof-- that good years with regard to food (a "high" biomass of plankton) produced a high recruitment, i.e., ensured the greatest or highest survival of the year-class. However, even with a most cursory comparison it was seen that during the poorest years--with regard to food--(1948, 1950) the best year-classes-- with regard to numerical strength--were produced.

Our research was of a complex nature and was carried out simultaneously on the sea and under experimental conditions. The research differed from other work in that the vital processes were studied directly on the sea and by means of material that was being collected under varying conditions (in different years, months, days and hours of the day during the entire reproduction period of the anchovy). Observations were made every 3 to 4 days. In connection with this, samples were taken to determine the salinity and the oxygen content. At the same time observations were made of the temperature of the water, the velocity or force and direction of the wind, the cloudiness, the condition of the sea and the transparency of the water. Zooplankton as well as phytoplankton and also ichthyoplankton were collected with a roe-net. At night a net and a ring-trawl with a diameter of 1,13 m of a caprone(?) section with a mesh of 3 to 4 mm were used.

The samples were taken at the surface and also at a depth of 4 to 5 m. The obtained material was fixed on the spot, but partly was studied while still alive. The collected samples were processed at once. This helped us to watch directly the spawning of the anchovy and the development of the embryos under various conditions as well as the growth, the distribution, food and strength of the larvae at the early stages of development. The time and nature of further collecting were planned depending on the results obtained.

A study of the collected material made it possible:

- 1) To establish the beginning, the peak and the end of the spawning period under the "concrete" conditions of the given year;
- 2) to establish the density of the distribution of live eggs and larvae at various depths during the entire period of the reproduction of the anchovy under varying conditions;

3) to determine the percentage of the loss of eggs at various stages of development during a 24-hour period and under various conditions of the gas, temperature, salt and winds regime(?) at a varying degree of illumination and condition or state of the sea;

4) to determine the growth of the larvae and nature of their food relations to the food phyto- and zooplankton bearing in mind the changes in the biomass of the predominant forms of plankton at various stages of development;

5) to establish the relative percentage of the loss of eggs to the extruded amount of eggs and the relative numerical strength of the larvae.

This work was carried out in 1952 and 1953. Quite accidentally it was learned that these differed radically with regard to hydrometeorological conditions--as well as with regard to the hydrobiological regime of the sea. This made it possible to make a comparison of the phenomena observed in nature under various conditions and to come to conclusions regarding those conditions that are required for anchovy to ensure the "best" survival of the fry at the early stages of their development.

The conclusions arrived at were compared with the results of the experimental research that was carried out during the same period to determine the dates of the development of the embryos and to establish the optimal conditions of the temperature and salt regimes that ensure the "greatest" survival of the fry. A.S. Leshchinskaya conducted this research in 1952. Besides the results of this work, the data by previous researchers were also used.

In 1953, as a result of the experimental work by V.P. Kornilova, the age of the larval stages at the various stages of development from the moment of hatching to an age of 7 days was established. The further pace of the growth of the larvae was established by the dynamics of the variation curves built on the length of the larvae and then on fry that were caught every day or within short intervals of time.

Simultaneously with the research indicated, constant observation was maintained with regards to the dynamics of the stock of the breeders of anchovy and its age and sex composition. Depending on the "portsionnost" (perhaps "batches") in the extrusion of roe, the nature and size of the eggs, the number of breeders, their fecundity, growth and belonging to one or the other biological groups the effectiveness of the extrusion of roe and the results of the survival of the year-class were also studied. For this purpose biological analyses were made of

anchovy caught in poundnets that were set close to the places from which the observations were made. As a rule fish from the morning and evening catches were analyzed. The composition and the size of the average catches in the pound nets during the years under observation indicated the difference in the numerical strength of the stock. The data obtained were checked according to the estimate of the relative size of the stocks of anchovy, which is determined in the fall during the survey trip or voyage. The results of the effectiveness of the reproduction were also estimated and checked according to the survey of the underyearling made during this voyage.

For a general description of the regime of the body of water in 1952-1953 and in previous years for which data on the results of the reproduction of anchovy exist, sources in the literature which deal with the productivity of the Sea of Azov were used. Use was made also of the hydrometeorological data gathered on the basis of daily observations carried out by the stations of the "Gidrometsluzhba" (Hydrometeorological Service) in the region of our work.

Furthermore, an analysis was made of the importance of competitive food relations with respect to other consumers of plankton, namely, of adult fish as well as of their fry.

A review or consideration of all the enumerated factors made it possible for us to regard the research carried out as thorough and directed at disclosing the main leading factors.

An area or region adjoining the Kazantip peninsula in the SW part of the Azov Sea was chosen for our observations. The hydrological and hydrobiological regime of this region does not differ from the entire SW and W regions of the Azov Sea. The great depths (10-11 meters) that are characteristic of the Azov Sea proper extend almost right up to the northern and western tips of the peninsula. According to the data of A.N. Smirnov the main bulk or body of anchovy upon entering the Azov Sea proceeds to the western half of it. The main spawning grounds are to the SW, W and NE.

The greatest plankton production in the western regions and the constancy of the hydrological regime or conditions create normal conditions for the feeding and spawning of the anchovy. The southern, the southeastern and central parts of the sea are known for the instability of the hydrological conditions of the medium in spring (low oxygen-content in the layers near the bottom and a lower temperature of the water). The plankton production of these regions is lower than that of the western regions. Thus, the western regions of the sea to which the region of the Kazantip peninsula belongs are more favorable for the feeding and spawning of anchovy.

According to the data by V.P. Kornilova concerning the

distribution of adult anchovy, their fry, larvae and eggs one can also assume that the southwestern and the western regions are the most characteristic spawning grounds of the anchovy. All these data provide a reason to assume that the material obtained suffices for a description of the entire western part of the sea. This was confirmed later on when a comparison of the quantitative indicators of the abundance for 1952 and 1953 on the fall survey voyages was made.

The material was collected and the observations were made at a distance of $1\frac{1}{2}$ miles from the shore, outside the shallow Russkaya Bay, three quarters of which is protected from the winds (where somewhat different hydrological conditions than in the sea were observed).

The work was carried out under the direction of the author together with V.P. Kornilova, a senior scientific co-worker from Azcherniro, and N.K. Lukonina, E.I. Arsenyeva and E.G. Petrova, a group of co-workers from VNIRO. G.N. Kurytsina and L.N. Domanevski, students at the "Mosrybvtuz" (some sort of "Fisheries Institute" Tr.), as well as M. Butlerova and N. Chashina, students of the University of Perm, also participated in this work.

The use of the survey or count of live and dead eggs to determine the percentage of the survival of embryos should be mentioned as one of the peculiarities of the methods used in the processing of the material collected.

N.M. Knipovich also noted that there are many dead eggs in the roe of the Azov anchovy (Elizarova, 1936). In our catches there were always, without fail, dead eggs among the live roe. The eggs had died just shortly before they were caught. The eggs that had died earlier usually do not remain suspended in the water and settle on the bottom or disintegrate.

Live eggs can easily be told from dead eggs. The latter are characterized by a perfectly transparent perivitelline space. A live embryo is clearly outlined, is of a regular form. In dead eggs the embryo is deformed and has the appearance of a wrinkled strip during the second stage of development. During the subsequent stages the embryo is better developed. But its outlines are vague, the entire egg appears to be "cloudy" (Figure 2).

At first it was assumed that the damage to the egg occurred when it was being caught and fixed. But special experiments proved that the egg perishes while still in the sea and that no mechanical damage is inflicted during fixing and catching. The live and dead eggs were counted parallel by using the live and the fixed material. The horizontal catching or fishing with

a roe net was carried out twice in one and the same place: One haul of 5-minutes duration and the second one of 10-minutes duration. The percentage of live eggs was the same in both cases. Therefore the increase in the time spent in catching did not cause the death of more eggs.

All these data point out that the percentage of the dead eggs is due to natural causes. Therefore, this indicator can be used in determining the optimal conditions necessary for the survival of embryos.

Thus, on the basis of the percentage of the live eggs contained in the sample one can judge the degree of survival at the given stage of the development under one or the other conditions.

Similar observations were conducted also with regard to the larvae. By knowing the time for development of embryos and larvae at the given temperature it was possible to watch the development or growth of each generation by the number of the embryos that had survived and by the corresponding group of larvae depending upon their size and growth. The comparison was made on the basis of the numerical preponderance of one or the other group according to the stages of development.

Having determined the age of each group in keeping with the stages of development it was possible to determine the time when these larvae were hatched and, therefore, also those conditions that "accompanied" their survival and the development of the embryos.

In this way we established definite laws or regularities with regard to the distribution of the eggs and of the larvae in the sea.

As stated above some of the conclusions reached are based upon experimental research, in particular upon the determination of optimal temperatures at which the survival of the largest number was observed and upon determining the rate of the growth of the larvae.

Prior to describing the effectiveness of the spawning of anchovy the stock of the breeders that participated in the spawning in 1952 and 1953 should be described.

It is known that the Azov anchovy is a typical marine pelagic schooling fish which cannot survive a temperature below 6 degrees. The anchovy spend the summer in the Azov Sea, where

they spawn and feed and fatten.

In spring (in April-May) the anchovy every year perform migrations through the Kerch straits from the Black Sea into the Azov Sea. In the fall as the temperature of the water drops (in October-November, depending on the nature of the fall cooling off) the anchovy return from the Sea of Azov to the Black Sea.

The life-span of the anchovy is brief: During the second summer of their life, i.e., when one year old, the anchovy reach sexual maturity and spawn. The main commercial ages are 2- and 3-year olds. During the fourth year there are usually individual specimens. But in the case of strong year-classes the number of 4-year-olds in a stock is quite noticeable.

The anchovy occupy an important place in the general cycle of the organic substance in the Azov Sea. Seeing that together with the "sardelle" they are the chief consumers of plankton, the anchovy in turn represent an essential component of the food of predatory fish (mainly of perch-pike, Lucioperca sp.). However, bearing in mind the small significance of the predators, especially of perch-pike, with regard to the total stocks of anchovy the loss inflicted upon the anchovy by this fish is insignificant.

Replenishment and Remnant of the Total Stocks

The stocks of the Azov anchovy are subject to abrupt fluctuations. These fluctuations are of short duration; but their amplitude can be very large. The type of the dynamics of the numerical strength is determined by the rapid tempo of the renewal of the stock or school. This is brought about by the early maturing and the short life-cycle. The replenishment in the composition of a spawning school of anchovy consists of one age-group--of year-olds that mature simultaneously. The significance or importance of the replenishment is shown by the curves of the distribution of anchovy according to body-length during their spring migrations from the Black Sea into the Azov Sea (Figure 3).

The analysis of the age-composition of the spawning school or stock of anchovy from 1946-1952 shows that the replenishment comprises, on the average, 52,3% of the total numerical strength of the school.

In most cases the replenishment is larger than the remnant. Due to this feature, the spawning population of the anchovy can be assigned to the second type on the basis of the determination given by G.N. Monastyrski. However, V.N. Mayski suggested assignment or classification of the anchovy as the transitory type of

spawning population, seeing that the predominance of the remnant in the spawning school of the anchovy, in his view, is very frequent and noticeable. Considerable fluctuations in the replenishment must be taken into consideration when estimating the size of the commercial stock or school of anchovy. The total stocks of the Azov anchovy in 1952 and 1953 were relatively small, in particular in 1953. The year-class of 1950, the strength of which by 1953 was already considerably reduced, was of primary importance during this period. The next two year-classes (1951 and 1952) were "weak". In connection with this, the stocks in 1953 were exceptionally poor. This was also reflected by the harvest.

As pointed out (see Table I) the harvest in 1953 comprised 124% of the harvest of 1932 and in 1952--175%, whereas in 1951 the harvest reached 245% (the basis of this harvest or catch was provided by the strong year-class of 1950, which had just entered the commercial stock). The replenishment in 1952 was particularly poor for the last 5 years (27,2%), which could not but affect the decrease of the catch in 1953.

The dynamics of the replenishment and of the remnant in the stocks of anchovy in recent years are represented also on the basis of the data of the fall survey voyages conducted by Azcherniro (perhaps: Azov and Black Seas Institute of Fisheries and Oceanography Tr.)

Years	Stocks in thousands of centners	
	of fry	of large fish
1950	550	260
1951	220	4000
1952	250	2250
1953	500	800

The stocks of anchovy in 1953 were reduced--in comparison with 1952--by almost one half. The numbers of large anchovy, i.e., the breeders, were almost three times smaller.

The commercial catches of the Mysovskaya MRS (fishing station? in the area of the Kazantip peninsula), made with one and the same number of gill nets indicate the reduction in the strength of the anchovy in 1953 in comparison with 1952, namely (in centners):

	<u>1952</u>	<u>1953</u>
May	4225	1628
June	7572,14	257,23
July	1017,5	75,0

Growth of Adult Anchovy

The anchovy use the entire Azov Sea for the "nagul" (feeding) and a considerable part of the Taganrog bay. When comparing the maps of the distribution or occurrence of anchovy on the basis of the July survey of the Azov Sea it was established in 1952 and 1953 that the anchovy are scattered over the entire sea and that individual accumulations were due to the concentrations of food organisms.

In view of the availability of a large feeding area and the great plasticity in selecting the food, the rate of the growth of the anchovy changes very little over the years. But in the case of yearlings the differences in the growth are more pronounced. Thus, according to the data by V.P. Kornilova, the increase in the length and the weight of the body is expressed, on the average, by the following figures (1948-1952).

	Increase	
	<u>in body-length in mm</u>	<u>in weight in g</u>
Yearlings	59,1	2,0
2-year olds	22,0	3,6
3-year olds	7,0	1,0

The most rapid growth of the anchovy occurs in the first summer; but the maximal increase in the weight occurs during the second year of their life. In the third year the rate of growth and the increase in body-weight are radically reduced.

During the feeding or fattening period the anchovy grow most rapidly in June and July. It was found that the anchovy in the fall samples, on the average, had a shorter body-length and weighed less. V.P. Kornilova explains this by saying that the heavier anchovy had already passed through the straits into the Black Sea and that the skinny fish continued their feeding in the Azov Sea.

The largest increase in the growth of all the age-groups was observed in 1952 and partly in 1949 and in 1951 and the smallest-- in 1950 and 1953. Thus in the year 1953 the conditions for the growth of the anchovy were less favorable than in 1952. This is also reflected in the data on the condition of the anchovy in Table II.

Table II. Average weight of anchovy according to size in g (according to data of V.P. Kornilova).

Year and Month	Size of Anchovy in mm											
	55 - 60	60 - 65	65 - 70	70 - 75	75 - 80	80 - 85	85 - 90	90 - 95	95 - 100	100 - 105	105 - 110	
1952												
August	1,6	2,0	2,5	3,2	4,7	5,5	6,3	6,7	7,8	8,7	9,1	
1953												
August	1,3	1,7	2,2	2,7	3,7	4,7	5,5	6,3	7,0	7,8	8,4	

The same interrelations between the length and the weight of the anchovy were observed during the other months.

On the basis of the data on the body-length of the anchovies during the period of their reproduction one can judge about the biological characteristics of the breeders that had spawned in the region of our observations. Thus on Figure 4 the growth of the yearlings and of the 2-year olds of the anchovy from June 1 to July 20, 1952, is shown. This curve shows that the initial rapid growth of the fish stopped or slowed down in the latter part of June. Later on it was even "reduced". Such a phenomenon can be explained by the approach of a group of breeders--of smaller sizes than the previous--to the spawning grounds.

Conditions for Spawning, Fecundity and the "Portsiionnost" (batches) of the Egg-Extrusion

The conditions for the spawning of the anchovy in the Azov Sea are very unstable. In connection with this, one of the adaptive peculiarities of the anchovy to conserve or protect their numbers is the drawn out spawning period and the "portsionnost" of the egg-extrusion. Chugunova and Petrova (two women Tr.) also noted that the "portsionnost" of the reproduction makes the latter more successful seeing that the "accidental death" of one batch of extruded roe is compensated by other batches. In the case of batch-spawning the fecundity of the fish is increased in comparison with fish of the same sizes that have only one extrusion of eggs. In the case of gradual hatching the food or feeding of the larvae is better safeguarded.

The Azov Sea anchovy, in comparison with the Black Sea anchovy, according to the same data, display a greater fecundity. Thus the average fecundity of an Azov Sea anchovy measuring 9-10 cm is "comprised" of 21,000 eggs and a Black Sea anchovy of the same length will produce 18,600 eggs.

According to the data by V.P. Kornilova the average fecundity of the Azov Sea anchovy 9 to 10 cm long in 1952-1953 "comprised"

17,100-18,600 eggs, i.e., it hardly differed from the fecundity of the anchovy in the Black Sea. The "feeding" time in the Azov Sea is shorter than in the Black Sea. In view of this Chugunova and Petrova assume that the extrusion of the first batch of eggs in the Azov Sea must be earlier and more abundant.

The 2-year olds and the 3-year olds, the older age-groups are the first to spawn. The recruit spawners enter the spawning not before June. In the years when the spring is early and warm the spawning begins in the first 10-day period of May and comes to an end in the latter part of July. In the years when the spring is late or drawn out and cold the spawning does not begin before June and is continued till the end of August.

The spring in 1952 was drawn out and cold, whereas in 1953 the spring was early and warm. Depending upon this the spawning of the anchovy in 1952 in the southern part of the Azov Sea began during the third 10-day period in May and was finished in August. The larvae did not appear till about the 9th June. This indicated that the beginning of the spawning was of little effect.

Mass-spawning was observed during the days of June in 1953. The anchovy that comprised the recruit spawners began to spawn during the second 10-day period in June. At the time when they extruded their first batch of eggs the older specimens were already extruding the second batch. The mass-extrusion of the second batch took place in the second half of June. According to the data by V.P. Kornilova the second batch contains considerably fewer eggs. The weight of the gonads at this time comprises only up to 16-20% of the weight of the body. The third batch was extruded in the early part of the second half of July. This batch contains the smallest number of eggs.

In 1952 the older specimens began to extrude the first batch 10-14 days later than usually. The second batch was extruded during the period from June 26 to July 19 and the third batch-- from July 19 till the end of the month. The mass-spawning in the western part of the sea was finished by the end of July, whereas in the eastern part of the sea the spawning continued during the first and second 10-day periods in August.

It should be said that the dates of the extrusion of the three separate batches are not delimited or marked. They show only the main periods of the extrusion of one or the other batch. According to the data by V.P. Kornilova and G.N. Kuritsyna, who examined the size-composition of the oocytes of 3-year olds the extrusion of roe can occur four times and even oftener.

Furthermore, another peculiarity has been noted regarding the dates of the extrusion of roe: Due to the more intensive warming up of the water in June as observed in 1953, the dates or

the intervals between each batch were shortened and occurred earlier than under other (different) conditions.

These qualities of the spawning stock of the anchovy ensure the high reproductive capacity of this fish which makes it possible even during the years with unfavorable conditions for the survival of the fry to maintain a relatively high numerical strength in the population.

Differences in the Composition of the Populations in 1952 and in 1953

Our observations with regard to the composition of the breeders were made of altogether different--with regard to biological qualities and numerical strength--populations, the spawning of which occurred also under various conditions. Thus the spawning population of the anchovy in 1953, as already mentioned, was considerably less in numbers than in 1952. The older age groups (the remnant) predominated in their composition. The growth of the anchovy this year was considerably poorer, the spawning occurred at earlier dates to which the dates of the extrusion of the separate batches corresponded, etc.

A Study of the Conditions that determine the Survival of the Embryos of the Azov Anchovy

In order to study the most favorable conditions that are required by the fry of anchovy for the "best" survival the abiotic and biotic factors in their direct interrelation were analyzed. We studied the conditions of the salt, temperature and gas regime of the sea, the physical effect of the heaving or swell of the sea, illumination, the supply of food for the larvae during the early stages of development, the importance of predators and so forth.

Salinity

The Azov anchovy thrive when the salinity ranges from 9 to 19‰. The experimental work of T.E. Morozova and of N.M. Karakash showed that the Azov anchovy can reproduce when the salinity varies from 10 to 17‰.

Seventy-75% of the hatched larvae developed normally in the water of the Kerch straits. A salinity of 11.7 to 11.9‰ is most suitable for the development of the eggs and the larvae that were hatched.

According to the data by Leshchinskaya a salinity of 14 to 19‰ is the optimal one for the fertilization and development of the eggs of the Azov anchovy. The larvae "lived in these salinities" until the resorption of the yolk sac. Thus, the proposed increase

in the salinity of the Azov Sea will not affect the conditions for the reproduction of anchovy adversely. This question is treated or discussed in the work by V.P. Kornilova. It should be said that the changes in the contemporary salt regime in the southern part of the sea are insignificant and have no effect upon the fluctuations in the numerical strength of separate year-classes. The changes in the salinity were registered by us only for the purpose of determining the direction of the currents around the Kazantip peninsula; for with the change of the wind to the SE point of the compass the Black Sea current became of primary importance. This current brought with it waters with a greater salinity (Figure 5). This raises or increases the salinity by about 0,5‰.

A survey of the direction of the currents was necessary in order to determine the drift of the larvae.

The differences in the salinity of the waters on the surface, in between, and near the bottom were insignificant in view of the small depth (9-11 m) and there was intermixing of the waters from top to bottom when heavy winds blew. This circumstance also made it possible not to stop at the salinity in this and not to regard it as the decisive factor upon which the survival of the fry depends since the existing fluctuations in the salinity correspond to the level of the development of the anchovy. Only in the case of a radical and persistent change in the salt regime can the total numerical strength of the anchovy-populations change.

The Temperature Factor

Among the many factors that affect the development of the anchovy the temperature is of importance; for its effect is manifested either directly or indirectly.

A.N. Smirnov already came to the conclusion that a high temperature of the water in June had a beneficial effect upon the survival of the eggs and the larvae of the anchovy. T.E. Morozova studied the effect of the temperature upon the development of the eggs and the larvae of anchovy. Experiments showed that a drop in the temperature brought about a sharp prolongation of the incubation period. If at a temperature of 22° the development lasted 31 to 34 hours the incubation period at a temperature of 17° was prolonged to 57 hours. A temperature of 16° stretched the period to 68 hours. In this case the mortality of eggs and larvae reached as high as 52%. S.G. Kryzhanovski, N.N. Disler and E.N. Smirnova attach much importance to the effect of a lowered temperature upon the development of the embryo. According to their data, embryos of perch usually reproduced at a temperature of 10 to 15° when placed in water that is cooled to a temperature

of 3° and then returned to the normal temperature yielded abnormal forms which perished.

T.I. Privol'nev observes that during the formation-period the embryo is particularly sensitive with regard to temperature. When the temperature is lowered the mortality rate of the eggs reaches 85%. The remaining 10 to 15% produce, in most cases, misshapen embryos the development of which, usually, does not reach the stage of hatching.

We have referred here only to a small part of all the works that are devoted to this question. But it suffices to convince one to regard the study of the influence or effect of the temperature upon the survival of the embryos as a matter of primary importance.

We used the classification by T.S. Rassa according to which there are four stages of development in the egg-stage to determine the development stages of the anchovy. First stage--the "breaking down" of the blastomeres and the "overgrowing" of the yolk with the embryonic layer or shield(?). The second stage--is the stage of the embryonic shield. At this time the eyes are formed as well as the tail-bud. Towards the end of this stage the tail begins to separate from the yolk. At the stage where the tail separated the heart is formed and it begins to pulsate or beat. The third stage is the stage of the unformed embryo after the heart has started to pulsate. The fourth stage is the stage of the formed embryo when the final differentiation of all the organs of the embryo takes place.

Table IIa shows the duration of the embryonic development of the Azov anchovy at different temperatures (according to the data by Leshchinskaya).

Table IIa. Duration of the embryonic development of the anchovy in hours and minutes at various temperatures.

Stages	18°	20°	22°	24°	26°
First	4.05	3.50	3.40	3.00	2.10
Second	13.30	13.30	13.00	12.00	12.00
Third	30.00	28.00	27.00	26.00	24.00
Fourth	40.00	39.00	38.00	36.00	34.00
Pre-larval stage	110.00	107.00	101.00	95.00	80.00
Larval stage	120.00	115.00	110.00	108.00	95.00

The development of the eggs and of the larvae of the Azov anchovy takes place at a temperature of 18 to 26°. A temperature of the water from 22,5 to 24° represents the optimal conditions for fertilization and development. At this temperature, Leshchinskaya points out, the largest percentage of surviving

embryos and of larvae is observed under experimental conditions.

The anchovy spawn during the evening hours. At the beginning of the spawning period the eggs are extruded at an earlier hour of the day than in the middle and at the end of the period. Thus in the middle of June, 1953, at 2200 hours the sample contained eggs that had just been extruded (in the breaking-up stage) and in the stage of the unformed embryo. In the first half of July at the same hour only eggs in the third stage were encountered. The eggs in the samples taken from 1 to 3 o'clock in the morning were in the breaking-up stage. However, these data are based upon separate or isolated observations and are regarded as tentative. There is a difference of opinion on the question of the nature of the distribution of the eggs in the entire layer of the water. A.N. Smirnov and S.S. Elizarova find that the largest number of eggs is encountered in the upper layers. Malyatski, on the other hand, maintains that the largest number of eggs occur at a depth of 5 meters. Our observations showed that the distribution of the eggs in the entire layer of water depends upon many factors, among other things, upon the velocity and the direction of the wind and the development-stage. In calm weather the spawning is more intensive in the upper layers of the water. This affects also the distribution of the roe: In calm weather there are more eggs in the surface layers; but when there is a swell of 3 to 4 points there are more eggs in the lower layers.

The data on the distribution of the eggs and the larvae of the anchovy in the water according to the results of the research in 1952 are shown on Table III.

Table III. The vertical distribution of the eggs of the anchovy depending upon the wind (according to the data by Domanevski).

No. of Stat.	Date of haul (1952)	Swell in Points	No. of eggs in 10 min. of fishing at depths		Ratio of the No. of eggs in the upper layers to the No. of eggs in the lower layers in %
			0-1 m	5-6 m	
4	4/VI	0-1	7 520	2 420	31,5
5	4/VI	0-1	2 224	1 440	64,8
6	4/VI	0-1	2 700	1 040	38,7
18	16/VI	5-7	972	4 432	444,0
19	16/VI	3-4	9 968	10 128	101,0
20	16/VI	1-2	12 484	8 260	66,0
38	14/VII	4	1 060	2 884	274,0
39	14/VII	4	2 108	4 270	202,0
40	14/VII	4	532	1 316	248,0

L.N. Domanevski observes that the difference in the distribution of the number of eggs at station No. 18 was especially indicative; for the observation or survey was made when there was

a heavy swell, whereas station No. 20 is located in a relatively sheltered place beyond the peninsula. At the first station more eggs were encountered in the lower layers of water than in the upper layers. At the second station it was the opposite. Hence, one may conclude that in calm weather the spawning is more intense in the upper layers and in windy weather (a swell up to 4-5 points) it is more intense in the lower layers of the water. When a high wind blows for a long time from the same direction the intensity of spawning drops rapidly.

It is possible that this is also related to a drop in the temperature which is always observed in these cases. A drop in the temperature can cause the death of the embryos and delay the spawning. When calm weather sets in and the water warms up the quantity of the eggs and of the planktonic organisms increases rapidly.

It was also possible in 1953 to trace the dependence of the distribution of live eggs and the intensity of the spawning on the condition or state of the sea, the force and direction of the wind (Table IV).

These data show that in the case of steady but light winds (9/VI) the largest number of eggs was encountered in the surface layers. Only half as many eggs were present at a depth of 4 to 5 meters, but the survival was the same. The next day (10/VI) when a 4-point wind was blowing the amount of eggs in the surface layer was only half as large. During the next period of steady light winds (19/VI) the eggs of the anchovy were distributed more or less evenly in the surface and intermediate layers of the water.

The following observation confirms the view that the distribution of the eggs depends upon the swell: At two "stations made on June 27, 1953, as well as in 1952" in a sheltered zone the eggs were distributed evenly. But in the region to the north of the peninsula where the swell after the storm had not yet subsided there were one-third as many eggs in the surface layers as there were at a depth of 4 to 5 meters. There were also considerably fewer live eggs on the surface. This could have been due to the rather high temperature at that time.

Table IV. Distribution of the eggs (at the embryo-forming stage) and of the larvae in June, 1953. (Horizontal fishing was carried out with a roe-net for 10 minutes during the second half of the day).

Date of Research	9/VI		10/VI			27/VI			
	0	4-5	0	4-5	0	0 ¹	4-5 ¹	0 ²	4-5 ²
Fishing depth in meters									
Strength & direction of wind	Slight changes in the wind.		4 Points		1-2 Points	Calm after a heavy NE wind			
Quantity of eggs	7,4	3,9	4,2	13,1	12,9	6,5	7,7	3,6	10
% of live eggs	37,0	38,3	38,5	65,6	65,0	65,7	66,6	13,8	51
Quantity of larvae	54	24	72	88	490	1352	4440	292	360
Temp. of water in degrees	23,3	23,3	24,1	24,4	24,3	24,7	23,6	26,5	24,4
O ₂ - content	5,8	6,2	--	5,1	6,3	--	--	8,1	6,7

¹To the west of the peninsula

²To the north of the peninsula

At the earlier stages of development, i.e., during the period when the yolk is being overgrown with the embryonic shield (9-12 o'clock in the morning) the eggs concentrate more in the surface layers than in the intermediate layers (Table V). However, there are more live eggs as well as larvae at a depth of 4 to 5 meters, at this stage of the development, than on the surface. Towards the afternoon or "second half of the day" the percentage of live eggs increases relatively; for the mortality rate of the embryos at the earlier stages of development is considerably higher than in the subsequent stages. At the moment when the embryo breaks through the membrane of the eggs there remain about 20 to 25% of all the eggs caught during the morning hours. In 1952, according to the figures by L. Domanevski, there remained only about 10%.

These indicators do not remain steady or stable for the entire period of the development. The differences in them should indicate which conditions are most conducive to the survival of the largest number of embryos.

Table V. Distribution and quantity of larvae and of eggs at the stage when the yolk is being overgrown with the embryonic shield (1953).

Date of Research	8/VI		16/VI		17/VI		17/VI		2/VII		6/VII	
Depth in Meters	0	4-5	0	4-5	0 ¹	4-5 ¹	0 ²	4-5 ²	0	4-5	0	4-5
Force and direction of wind	Slight changes in Wind											
Quantity of eggs in thousands	35,0	27,0	28,3	17,3	57,5	26,1	29,5	5,2	0,6	1,4	0,5	7,6
% of live eggs	1,2	3,6	8,7	41,5	1,0	18,9	20,0	29,0	0,7	1,2	0	0,9
Quantity of larvae	575	3000	272	1608	40	1600	144	532	588	345	28	104
Temp. of water in degrees	21	21	23,5	23,6	23,4	22,8	24,4	24,4	22,6	22,8	24,0	23,6
O ₂ content	5,7	5,7	5,3	6,3	5,9	6,2			5,9	5,8	5,2	5,5

¹To the north of the peninsula

²To the west of the peninsula

A summary of all the material showed that there exists a definite relation between the changes in the temperature regime and the quantity of the live embryos. Figure 6 shows the schematic distribution of the live and the dead eggs at the various stages of development (at various hours of the day and the night) and under various temperature conditions on the surface of the sea and in the layer of the water.

Only those samples that were taken at a temperature of 22 to 24°--for the largest percentage of live embryos corresponds to them--are mentioned in the chart. However, the general amplitude of the temperature level at which the development of the anchovy is possible equals 15 to 26°.

R.M. Pavlovskaya also points out that a water temperature of 20 to 24° is the most suitable for the development and survival of the eggs of the Black Sea anchovy.

However, even within the range of 22 to 24° regular changes

are observed in the quantity of live embryos dependent upon the greater or lesser warming up of the waters. This leads us to believe that there exists a direct relationship between these factors. This relationship is understood as an adaptation of the anchovy-- in their development--to a certain temperature level.

The chart on Figure 6 shows that: 1) At a lower temperature at one and the same stage of development the percentage of live eggs is several times less than at a temperature of 23 to 24°. 2) During the second stage of the development the quantity of the eggs is larger than in the hours that follow, but the percentage of live eggs is smaller. 3) The layer of water from top to bottom contains more eggs than the surface of the water.

On the basis of the data obtained a curve of the survival of the embryos was constructed relative to the stages of development during a 24-hour period at an optimal temperature of 23 to 24° (Figure 7).

This curve shows that the mortality rate of eggs at the early stages is quite considerable. Towards the transition to the gastrulation-stage the curve rises again somewhat. The mortality rate of the embryos is drastically reduced at the third stage and prior to breaking through the membrane it reaches 10 to 12%. These data show the relative sensitivity of the embryo at various stages of development to the temperature that is most conducive to the survival of the eggs. Figure 8 also indicates the effect of the temperature factor upon the mortality rate of the embryos giving the number of embryos that perished at the stages of gastrulation and embryo formation under various temperature conditions that were encountered during the observation-period in 1953. This curve shows the direct relationship between the temperature and the percentage of the eggs that had perished. However, at a temperature of 25 to 26° the number of live eggs goes down sharply. These data, that were obtained directly on the sea, confirm the conclusions or deductions on the basis of the experimental work about the most favorable temperature conditions that are necessary for the development of the anchovy embryo.

In 1953 the peak of the spawning was reached in the middle of June. This is confirmed by the largest quantity of eggs extruded during the second to fourth 5-day periods in June (Table 6).

The data of Table 6 show that the survival rate of the embryos at varying temperature conditions during the second and the fourth 5-day period in June when the quantity of the extruded roe was about the same is considerably higher at a higher temperature.

Thus the extent to which the water is warmed determines the intensity, dates and effectiveness of the spawning. The spawning usually begins when the temperature of the water is 15°; but in that case no pre-larvae and larvae are encountered in the catches with

a roe-net for a long time. This is explained by the prevalence of low temperatures, at which a minimal quantity of embryos, perhaps not fertilized (as pointed out by S.G. Kryzhanovski) and rapidly perishing is produced. During this period there are no results from the spawning. This happened in 1952 during the second 5-day period in June. In 1953, however, the spawning had already reached its peak at this time.

Table VI. Average quantity of eggs by thousands during a 10-minute haul with a roe-net.

Depth of tow in meters	Time when catch was made	5-day periods in June				5-day periods in July		
		2	3	4	6	1	2	3
0-1	9-12	35,0	--	37,7	--	0,6	0,5	--
4-5	9-12	27,0	--	26,1	--	1,4	7,6	--
0-1	17-21	7,4	4,2	13,1	5,0	5,1	2,6	--
4-5	17-21	3,9	--	12,9	9,2	--	--	0,1
The live eggs among them in %								
0-1	9-12	1,2	--	9,9	--	0,7	0,0	--
4-5	9-12	3,6	--	18,9	--	1,2	0,9	--
0-1	17-21	37,2	38,3	65,5	40,3	44,3	58,0	--
4-5	17-21	38,6	--	65,0	58,7	--	--	66,0
Mean temperature of water in degrees		21,0	--	23,6 - 24,4		--	22,6	24,0

The Importance of the Gas Regime

The temperature of the water is of decisive importance at the beginning of the spawning. But later on, after the temperature has reached the optimal level the oxygen content of the water exerts a relatively stronger influence upon the survival of the embryos.

The content and distribution of oxygen in the water of the Azov Sea results from the interaction of a number of various factors. For this reason the oxygen content in the water of the Azov Sea belongs to the most unstable hydrological elements. According to the data by E.G. Vinogradova the oxygen content ranges from a high degree of over saturation to traces of it (or it is lacking altogether). The vertical distribution of oxygen may be fairly uniform or characterized by a sharply pronounced stratification, especially in summer during the blooming of the phytoplankton.

F.D. Mordukai-Boltovski observes that regardless of the extreme shallowness of the sea and the heavy intermixing of the waters

caused by winds, the gas regime of the sea is extremely unfavorable. Each storm above 6 to 7 points saturates the entire layer of water with oxygen. But during the summer months the consumption of oxygen is so rapid and so "energetic" that a few days after a storm the oxygen in the layers of the water near the bottom begins to disappear again. At the same time, at the surface there may be an over-saturation of the water with oxygen due to the blooming of the phytoplankton.

The influence of the blooming upon the gas regime of the sea can vary depending upon the hydrometeorological conditions which are the most important factor with regard to the oxygen regime of the sea. It has been established that there is no connection between the Don (in general of rivers) River run off, the phytoplankton and the oxygen regime. Neither is there any connection between the run off and the severity of the mortality of fish due to the lack of oxygen.

The oxygen regime is related directly to the wind regime. Thus E.G. Vinogradova cites the following data on the velocity or force of the wind--in points--over the Azov Sea in July in 1952 and 1953 (in % from the total number of observations):

Year	Points	
	0-1-2	3-4 and above
1952	38	60
1953	26	74

According to her data the lowest values of oxygen saturation in the surface layers of the waters of the Azov Sea were observed in the summer of 1952.

Below follow the data about the number of cases when the water of the Azov Sea was saturated with oxygen (in %).

Oxygen saturation	1951	1952	1953
150-120	42	7	2
120-100	37	18	36
100- 90	21	75	62

According to our data the oxygen content in the water in 1953 was also higher than in 1952. Furthermore, the bottom layers (4-5 meters) contained more oxygen than the surface layers. However, in these layers a relatively large quantity of larvae and of live embryos was observed.

S.G. Kryzhanovski points out that the eggs of all pelagic fish are usually lacking pigment and when there is a lack of oxygen they usually die earlier than the demersal eggs. The eggs of the anchovy are also transparent and also lack the pigment. This indicates good respiratory conditions and a small oxygen consumption.

However, there is an enormous amount of embryos in the sea which, together with other organisms needs oxygen for its development. Thus the total need for consumption of oxygen is considerable and the occurring fluctuations in the content of dissolved oxygen affect the survival of the embryos. Thus, with one and the same temperature, the largest quantity of live embryos or larvae was encountered in the layers that had an increased oxygen content.

The largest quantity of live embryos and larvae is usually observed during the period of an intensive warming up of the waters after prolonged and heavy winds, which enrich all the layers of the water with oxygen. In 1953 such periods occurred from May 30 to June 2, on June 9 to 12, 23 and 25 to 27. These dates were characterized by the largest number of surviving fry.

About the Effect of Light Upon the Survival of the Embryos

A.S. Leshchinskaya assumes that the largest loss in eggs is encountered in bright sunny weather. In murky weather the survival of the embryos takes an upward swing.

Our observations with regard to the development of the embryos of the anchovy in the sea failed to confirm this. On bright sunny days we observed cases of heavy and light losses of roe. However, if the warming of the water--heightened by bright sunlight exceeded the temperature that is optimal for the development of the anchovy, i.e., if it reaches 26° , then the loss of eggs increased.

L.N. Domanevski, in his work in 1952, also failed to establish a direct relation between the intensity of solar illumination and the number of surviving eggs. According to his data the loss of eggs under unfavorable conditions was the same on murky as well as on sunny days. The conclusions at which A.S. Leshchinskaya arrived with regard to the higher mortality rate of anchovy embryos in sunlight are not confirmed or supported when the data used by the author are analyzed more closely. Thus, the relationship between the percentage of the live eggs and the cloudy weather has not been established. The reduction of the percentage of the live roe in the middle of July is connected with the fact that the spawning comes to an end at this time. This is confirmed by the fact that on cloudy days towards the end of July the survival of the embryos did not increase. The peak of the spawning occurred in June when the fate of the year-class was also decided. However, A.S. Leshchinskaya did not conduct similar observations at this time. Furthermore, the material was collected in a "half-closed" bay, where the absence of swells was conducive to an increase in the percentage of live eggs. Therefore, on the basis of this material, one cannot judge the region as a whole.

At the same time it is known that the development of the eggs of the Salmonidae, which occurs in the bottom, proceeds better in the

dark. Light has a retarding effect upon the development of their roe. On the other hand, pelagic eggs develop more successfully in the light and the cutting out of light leads to a retardation in their development.

A Comparison of the Numerical Strength
of Live Embryos in 1952 and in 1953

On the basis of observations it was established that in 1953 the percentage of the surviving embryos was considerably higher than in 1952. This also explains the fact that the relative number of eggs per unit of catch in 1953 was usually larger than in 1952, regardless of the fact that the numbers of the breeders and subsequently, the actually extruded roe in 1952 were four times larger.

Table 7 carries the comparative data on the quantity of the extruded and the live eggs in 1952 and 1953.

Table VII. Average number of eggs caught during 10-minutes of fishing with a roe net during the entire observation period.

Hours when the catch was made	Depths at which catch was made in meters	Number of Eggs in thousands			
				Among them the live eggs in %	
		1952	1953	1952	1953
9-12	0-1	6,1	15,8	15,9	
9-12	5-4	5,3	13,0	24,3	11,0
17-20	0-5	2,0	8,2	28,0	52,0
21-22	0-1	--	5,2	--	62,0
TOTAL . . .		5,5	10,4	22,7	38,5

The Importance of Biotic Factors

On the Survival of the Embryos and Larvae of the Anchovy

When surveying the conditions or circumstances that determine the amount or size of the surviving embryos only the abiotic factors, which are of basic importance, were studied. The role of the biotic factors with regard to the mortality of the embryos of the Azov anchovy is insignificant, so it seems. In the main spawning area, i.e., in the central, western and southern parts of the Azov Sea, where the roe of the anchovy predominate, other fish hardly ever spawn. On the other hand, the adult anchovy feed upon the larvae to an amount that is directly proportional to their numbers. In years with the largest amount of larvae their numbers in the stomachs of adult anchovy, according to the data by V.P. Kornilova,

reached 56%. But regardless of this the generation of 1950 was rather abundant. For 3 years it held the leading position in the catches (up to the age of 4 years inclusive).

In the Black Sea numerous sagittae and medusae, which are enemies of the anchovy-larvae appear, but are absent in the Azov Sea. Thus the anchovy-fry in the Azov Sea are not faced by a large number of enemies.

But the nature of the development of food organisms at the stage of the transition of the larvae to active feeding, and the food-relations with the other consumers or users of these organisms are of great importance in the survival of the larvae.

The Food Supply of the Larvae of the Azov Anchovy and the Extent of their Survival under Varying Food-Conditions

Determination of the age and of the growth of the larvae

In order to determine the food requirements of the larvae with regard to various organisms as well as to determine how great the survival of these larvae is with regard to the numerical strength of the embryos it is necessary to know the size and the age of the larvae. We watched the increase in length of the predominant number of larvae by days. On the basis of these data we could determine their rate of growth as long as they can still be caught with a roe net or a ring-trawl (113 cm in diameter).

In connection with the nocturnal migrations of the ichthyoplankton towards the surface the horizontal fishing with a net and a ring-trawl, carried out at night-fall, yielded abundant and variegated material.

The larvae were larger, by comparison, than those that were caught during the day. The further growth of the young was observed on the fry or fingerlings in 1953 that were caught in a stake or gill net in large numbers. Daily measurements made it possible to learn the growth rate of these fry during the main feeding or fattening period.

It was also possible to determine separate biological groups of anchovy that were "born" at various times and that differed from one another in average length. It was possible to compare the relative numerical strength of the fry--according to the catches or yields of other years--by the dynamics of the average catches with a gill-net and by the percentage of the content of fry in the catches.

In order to determine the age of the larvae V.P. Kornilova conducted experiments on the incubation of eggs and also on the

raising of pre-larvae and of larvae on an experimental basis. The temperature conditions of the experiments were about the same as the warming up of the waters of the sea during the observation period.

It was possible to follow the development of the larvae only to an age of 7 days; for the experimental base was insufficiently equipped and the raising of larvae was extremely difficult under these conditions.

It is necessary to point out, prior to proceeding with a characterization of the growth of the larvae, the difference in the distribution and the quantity of larvae, which was observed in the Azov Sea in 1952 and 1953 (Table VIII).

The data show--the data on Table VIII--that the quantity of the anchovy-larvae observed in 1953 exceeded many times the quantity of the anchovy-larvae in 1952. Furthermore, it was also observed that in 1953 the quantity of live embryos was considerably larger than that of 1952. However, the relation between the number of embryos that survived and the larvae is not the same each year: The quantity of larvae in 1953 considerably exceeds the quantity of the larvae in 1952, whereas the number of live embryos in 1953 was only twice as large as in 1952.

This discrepancy in the indices of survival so it seems, must be ascribed to the difference in the factors that determine the numerical strength of the embryos and of the larvae as well as to some methodical errors which were inevitable during the first year of observations.

Table VIII. Average quantity of anchovy-larvae in June and in July in 1952 and in 1953 in the region of the Kazantip peninsula.

Year	Depth of the haul in meters	Time when the catch was made	June					July				Mean Total	
			I	II	III	IV	V	I	II	III	IV		
1952	0-1	9-13	0	172	0	10	-	-	-	11	0	32,0	
	5-4	9-13	0	45	0	0	-	-	57	7	18,0		
	0-1	17-19	-	2	-	0	-	-	0	0	0,5		
	5-4	17-19	-	5	-	0	-	-	3	7	4,0		
												TOTAL	15
1953	0-1	9-13	-	600	-	150	-	600	30	-	-	345	
	5-4	9-13	-	3000	-	1230	-	300	100	-	-	1157	
	0-1	17-19	-	600	-	1650	600	1350	500	140	-	805	
	5-4	17-19	-	20	-	640	2380	-	700	140	-	776	
												TOTAL	775

The work also dealt with the data on the frequency of occurrence of the larvae with regard to size and distribution density

at various times of their life. On the basis of these indices the number of the chief spawnings of the anchovy-larvae in 1953 and the rate or pace of their growth were determined (in 1952 there was a shortage of material for such a comparison in view of the small number of larvae).

It was established on the basis of experimental data that at the beginning of the development the pre-larva and the larva grow about 1 mm in a 24-hour period. Similar changes could be traced also under natural conditions. Collections made from June 8 to 10 and from July 2 to 3 showed that the average size of the larvae of the same spawning also increased by one mm per day. Proceeding from this it was possible to determine the growth of the larvae by days. The date of the "birth" of each group was assigned to a range of several days seeing that in the samples the larvae (as well as pre-larvae) varied from 2 to 5 mm in length. This was especially the case at the peak of spawning. This indicated a mass-survival of larvae during several days that were characterized by the same optimal conditions for their development.

During a period of one and a half months it was possible to distinguish the "presence" of several spawned groups of which three were exceptionally numerous. It is possible that subsequently they will also form separate biological groups that are selected for size and other qualitative distinguishing marks.

The confidence that the predominating groups of larvae are relatively stable with regard to their numerical strength is supported by the following data: 1) The same size-composition and relative numerical strength of the larvae was observed on the surface as well as in the layer of the water at any hour of the day or of the night; 2) one and the same size-composition of the larvae (and of the pre-larvae) was observed simultaneously to the north and to the west of the peninsula. This indicates the uniformity of the distribution of the larvae in calm weather over a great area independent of the nature and the direction of the current.

The first group of larvae was "born" during the first days in June (when the temperature of the water was 19-20°). During 3 days these larvae increased gradually in size; for this reason they must be assigned to one and the same group. The absence of smaller larvae among them indicated that the results of the spawning in subsequent days had been negative regardless of the fact that roe had been extruded every day.

Later on, the first-spawned group was encountered in the evening catch on June 17, together with a new, a younger, group. Evidence of the fact that the first group was the older for the given period is the absence of larger larvae in the given sample; for in subsequent samples such larvae were encountered. The longer larvae of the first spawning (30-32 mm) were also encountered in

the catch on July 3.

The next or following stable group belongs to the period of June 9 to 12. Its development took place at a higher temperature of the water (23-24°). What happened to it later on could be traced on June 26 and on July 3, 6 and 10.

The strongest spawned group was encountered at the end of June. Its predominance over the others can easily be seen till the end of the period of observations. Beginning with the first days of July, pre-larvae and larvae of the smallest sizes ceased to appear in large numbers in the samples. It is evident that at this time the spawning of the anchovy had begun to slacken.

Fry, the size of which did not exceed 30 to 35 mm, were caught by roe-net and ring-trawl. Larger specimens were seldom caught. Further observations of the growth of fry were made by means of the "prilov" (literally--caught with the others) of fry in gill nets in which they were being caught, beginning in the latter part of June. Already on July 8, the "prilov" of fry comprised several centners per "srezka"¹ (a colloquial expression which perhaps means a "haul" or every time the net is lifted. Tr), whereas in 1952 there was no "prilov" of fry. This also points to the difference of the numerical strength of the populations that were spawned in 1952 and 1953. The results of the daily measurements of the anchovy-fry are shown on Figure 9.

In 6 days (from July 8-13) the under-yearlings grew 8.7 mm, i.e., they grew on the average 1 to 1.5 mm each day. When comparing all the data on the growth of the larvae and of the fingerlings one may come to the conclusion that at the end of the first 10-day period of July the under-yearlings of the early spawning--of an average length of 40 to 60 mm--that were spawned in the early part of June began to approach the Kazantip Bay in enormous quantities. Later on--by the change in the average length of the body of the under-yearlings--it was also possible to detect the approach of the subsequently spawned groups. After July 20 there appeared the most numerous spawned group which had been hatched during the last 5-day period in June from the first and second batches of roe. The material of the complex July survey of the Azov Sea showed that this spawning group comprised more than 50% of the total number of the under-yearlings that were caught.

It is thought by some that the largest percentage of the normally developing roe comes from the first batch and that the roe of the third batch is possessed of less vitality and that the mortality rate is greater than in the case of the first two batches. Our observations have shown that the largest productions with regard to numbers--resulted from the extrusion of the first batch of the recruit spawners and of the second batch of the remnant of

¹Srezka - a funnel-shaped affair used in fishing. Tr.

the commercial school of anchovy, i.e., at that time when the optimal conditions for the development of the embryos set in.

The survey trip in the fall disclosed that the main bulk of the anchovy-fry by September to October, i.e., at the time of the departure from the Azov Sea, had attained an average length of 56.0 mm. If we compare the nature of the growth of the fry in separate years we will see that the growth of the fry was the worst or poorest in 1953, but their numbers (according to the data of the survey trip) were the largest though the size of the stocks of breeders, i.e., of large anchovy, was small (Table IX).

Table IX. Average size of the fry and the relative stocks of large and small anchovy (data by Azcherniro).

Years	Stocks in thousands of centners		Average size of the Fry by September 1 in mm
	Large Fish	Fry	
1946	550	560	--
1947	3490	410	61,1
1948	1900	600	58,0
1949	1900	1400	63,0
1950	260	550	56,0
1951	4000	220	62,0
1952	2250	250	61,5
1953	800	500	54,5

The fry in 1950 and in 1948 were distinguished by poor growth and the largest numbers. The strong recruitment of 1949 is an exception. However, its ultimate fate is not clear. Its disappearance from the commercial stock is explained, it seems, by the severe conditions of the first wintering.

The data of the survey voyage in 1952 and 1953 fully confirmed our conclusions about the relative numerical strength of the various spawning groups of these years that were obtained on the basis of observations conducted in the region of the Kazantip peninsula. With regard to the quantity of larvae the harvest of 1953 was many times greater than in 1952; but the stocks of the fry in 1953 was only twice as large (see Tables 8 and 9). Both kinds of survey cannot--methodologically--pretend to a sufficient accuracy with regard to the quantitative proportions in the anchovy-population in the Azov Sea. Furthermore, in 1953, the fry began to leave the Azov Sea rather early and therefore could not be fully surveyed during the fall cruise.

The characteristics of the growth of the fish in a population cannot be dealt with without an evaluation of the food-base, which ensures the survival and the growth of the fish at or during the early stages of development and also during the first summer. This

question is dealt with in the next section.

The Ensuring of Food for the Larvae of the Azov Anchovy when passing on to Active Feeding

The transition to active feeding is one of the decisive stages in the life of the larvae during which the highest mortality rate is observed among them. It was assumed that this cause--in every case--determines the strength of the harvest of fry. This view was based upon experimental research and observations made in the open. N.A. Gerbilski observed in 1954 that the stage of the transition to active feeding is related to the rapid and radical change in the function of the digestive system and that the main reason for the high mortality rate of the larvae is the lack of food that would meet the requirements of the larvae. It has been established that the numerical strength of the Danube herring depends upon the opportuneness of the development of the food objects. Further, the numerical strength of the semi-anadromous Cyprinidae of the Volga River depends upon the density of the distribution of zooplankton in the "poloynaya" (perhaps flood-lands. Tr) system. The opportune development and the density of the food-zooplankton determines also the numerical strength of the "salaka" (Baltic herring) in the Baltic Sea.

Thus the survival of the larvae even under natural conditions at the critical stage--depends upon the accessibility or availability and assimilability of the food. This, in turn, is related to the time of the mass development of the young and the adult forms of the food plankton which changes in keeping with the course of the warming-up and of other seasonal phenomena.

However, many questions regarding the food supply of the generations that were "born" are still unanswered.

In this work we are trying to solve the problem or find an answer to the question pertaining to the food or feeding of the larvae of the Azov-anchovy and its relationship to the size and the composition of the plankton under various conditions of development (in 1952 and 1953). The data obtained by us on the characteristics of the plankton in the Kazantip region were compared with the data by A.N. Novozhilova and G.K. Pitsyk who processed collections of phytoplankton and zooplankton from the entire Azov Sea during these years.

We collected phytoplankton and zooplankton while collecting larvae. The growth and food of the latter were studied during the 2-year observation period. Seeing that only small quantities of phytoplankton were encountered in the intestines of larvae we restricted ourselves to general observations or comments regarding the importance and size of the biomass of the phytoplankton for the duration of the entire season according to the data by G.K. Pitsyk. The statement by D.N. Longvinovich and V.A. Feldman that no phytoplankton had been encountered in the guts of sardelles provided us

with a reason for assuming that phytoplankton is not a part of the diet of the larvae of sardelle and anchovy.

The material on zooplankton was collected and processed according to the methods adopted by VNIRO. The material on the zooplankton and on the food of the larvae was processed by E.I. Arsenyeva, who also compiled the tables used in this work.

A description of the specific composition of the zooplankton and the change in its biomass in 1952 and 1953 are given on Tables X and XI.

Table X. Titer of the zooplankton in the Russkaya Bay in June to July, 1953.

Organisms	JUNE					JULY			
	5	8	16	17 Even- ing	26 Night	2	6	10 Even- ing	13
Nauplii and copepodal stages	172,3	280,6	279,1	347,6	165,9	438,6	453,4	240,5	222,9
<u>Ac. clausi</u>	322,5	637,7	303,2	208,2	444,9	913,7	874,1	203,8	125,2
<u>Ac. latisetosa</u>	8,4	4,3	6,5	6,1	291,8	263,4	202,7	54,9	4,1
Centropages kroyeri	11,3	15,3	16,9	18,0	90,8	81,65	143,3	91,1	38,9
Calanipeda a.d.	16,7	49,4	46,4	278,8	320,6	1,1	2,3	0,5	--
Mollusca larvae	81,1	24,5	94,9	14,8	12,1	15,6	18,3	5,0	3,7
Synchaeta sp.	1,5	2,0	1,0	0,6	0,6	--	--	--	0,3
Nauplii Balanus	154,1	27,5	10,9	21,6	--	9,8	16,9	3,0	13,5
Cladocera	0,07	1,7	29,8	5,0	--	--	--	--	--
Polychaeta larvae	--	0,1	0,1	0,5	0,3	--	0,02	0,1	0,02
Tintinnoidea	0,02	0,07	1,0	2,7	1,2	0,3	0,3	0,6	--
Varia	3,5	2,2	4,0	5,3	4,2	12,0	12,3	5,7	56,4
TOTAL	771,5	996,0	793,8	969,1	1343,9	1736,15	1723,62	605,1	410,3

Table XI. Titer of the zooplankton in the Russkaya Bay (Kazantip) in June to July, 1952.

Organisms	May	June					July	
	30	4	11	16	17	18	12	14
Ac. cl.+Ac. lat.	73,16	230,7	112,27	156,17	381,68	112,12	333,12	260,87
Centrop.kr.	10,5	11,82	5,14	7,93	21,85	8,78	26,09	13,16
Calanipeda a.d.	23,02	8,76	9,4	28,17	24,36	33,48	3,96	4,67
Lamel. larv.	6,5	86,46	30,71	197,67	--	38,12	1,57	10,68
Synchaeta	16,5	44,45	169,98	243,18	182,0	132,63	119,75	70,03
Nauplii								
Balanus	510,97	459,55	270,24	411,47	263,27	339,55	28,1	26,17
Varia	64,77	33,72	63,51	31,93	8,65	25,88	0,44	7,64
	705,4	875,51	633,51	1076,5	883,15	689,5	513,92	393,22

The composition of the plankton in 1953 differs radically from the plankton in 1952. If, in the plankton in 1952, the Synchaeta sp. and Nauplii Balanus (the latter were even dominant) were of great importance together with Acartia clausi and A. latisetosa, then in the plankton in 1953 Acartia clausi, which determines the size (?) of the entire biomass of plankton, was the basic form. The importance of Synchaeta in the plankton was negligible.

One of the causes that brings about the difference in the composition of the plankton of two spring-summer seasons was the varying course of the warming up of the waters. The temperature of the water in 1952 for almost the entire duration of the reproduction of the anchovy was lower than in 1953 (Figure 10).

It should also be said that in 1953 the largest amount of zooplankton was observed during the last 5-day period in June and the first 5-day period in July, i.e., at the time when the most numerous generation of the anchovy-larvae emerged.

The composition of the food of the larvae that were caught in the surface layer and at a depth of 4 to 5 m was relatively homogeneous.

The material for determining the composition of the food organisms was processed in the following way: The intestines of the larvae were "prepared" under binoculars. The food was removed from the intestines. The composition of the food was determined--down to species if possible--under a microscope. The result from

the examination of the intestines of anchovy is shown on Table XII (Particular (?) indices of the composition of food in the case of the larvae that contained any are indicated in the table).

Table XII. Food of the anchovy larvae in June to July, 1953 (in indices).

Food Components	Size of Larvae in mm									
	3-4	4-5	5-6	6-7	7-8	8-9	Mean Index for sizes 3-9	15-16	16-17	17-18
Synchaeta sp.	6,1	3,2	2,8	--	3,3	--	2,6	--	--	--
Tintinnoidea	1,2	1,2	--	--	--	--	0,4	--	--	--
Coscinodiscus	26,4	8,7	3,0	--	--	--	6,3	--	--	--
Lamel larvae	13,0	0,9	--	--	--	--	2,3	--	--	--
Nauplii										
Copepoda	85,9	19,6	7,3	11,9	--	--	20,7	--	--	--
Copepodite stages	131,0	45,5	60,9	65,3	33,2	--	56,0	--	--	--
<u>Acartia clausi</u>	--	--	89,9	125,5	78,9	89,0	63,9	--	--	67,2
Calanipeda and	--	--	--	--	--	--	--	25,7	52,5	--
General index of filling	263,6	79,1	163,9	202,7	112,1	89,0	152,8	--	--	--
Number of dissected larvae	270	266	273	146	61	34	1050	11	3	4
Number of larvae with food	91	78	73	36	10	2	290	1	1	1
Number of larvae with empty intestines in %	66,3	70,7	73,3	75,3	83,6	94,1	72,4	90,9	66,7	75,0

The data in Table XII show that among the larvae of the Azov anchovy there occurs a large percentage--at every stage of development--of empty intestines. Thus, in the case of the larvae from 8 to 9 mm in length it reaches 94.1%. The general index of "filling" is largest in the case of the larvae of 3 to 4 mm (263.6). This indicates relatively active feeding by the larvae after the resorption of the yolk sac.

The first food of the larvae of the Azov-anchovy--according to our observations--is the small zooplankton (the larvae of the pelecypoda, rotifera, nauplii and the first copepodous stages). As they continue to grow the nature of the food of the larvae changes--the importance of the phytoplankton, of the rotifera and

of the larvae of the pelecypoda dwindle. The following comprise the main food items for larvae from 5 to 10 mm in length: Nauplii, copepodous stages and the adult forms of Acartia clausi. At the later stages (when the larvae measure 15-16 mm) Calanipeda aquae dulcia, Centropages kroyeri and Mysidae are the main food items.

Table XIII shows the composition of the food of the larvae and the composition of the plankton samples from the same place of fishing. Furthermore, the index of the extent to which the stomachs were filled are computed not on the sample in which food was discovered but on all the dissected larvae including even those the intestines of which were empty.

Table XIII. Composition of the food of the larvae of the Azov anchovy and of the zooplankton samples in the region of Kazantip in 1953.

Length of Larvae in mm	4-5		3-4		5-6		5-6	
No. of station and date	No. 3 June 8		No. 9 June 17		No. 16 July 2		No. 20 July 6	
Titer of zooplankton on the stations in mg/cm ³	996,0		1285,9		1736,7		1723,6	
Name of Organisms	Titer of a separate organism	Particular index of the fill of the intestines	Titer of a separate organism	Particular index of the fill of the intestines	Titer of a separate organism	Particular index of the fill of the intestines	Titer of a separate individual	Particular index of the fill of the intestines
Nauplii Copepoda	51,7	15,5	85,6	93,1	100,3	10,4	40,0	--
Copepodite stages	178,2	20,0	417,8	--	338,3	103,0	413,4	75,0
<u>Ac. clausi</u> + <u>Ac. latisetosa</u>	637,7	--	401,4	--	1177,1	--	1076,8	--
<u>Centropag. kroyeri</u>	15,3	--	31,8	--	81,65	--	143,3	--
<u>Calanipeda a.d.</u>	49,4	--	231,2	--	1,1	--	2,3	--
Lamellibranch. larvae	19,0	--	8,4	--	10,6	--	14,6	--
Synchaeta sp.	2,0	5,0	6,6	6,1	--	--	--	--
Coscinodiscus	--	--	--	6,7	--	--	--	--
Varia	42,3	--	103,1	--	27,55	--	33,2	--
General index of the extent to which guts were filled		40,5		105,9		113,4		75,0
Number of larvae that had food in the intestines		5		7		5		6
Total number of dissected larvae		32		25		14		14
Number of larvae with empty guts in %		84,4		72,0		64,3		57,1

When analyzing the data in Tables XIII and XIV a direct relationship between the food of the larvae and the composition of the plankton can be discovered. In the early part of June in 1953 small amounts of Synchaeta were encountered in the plankton; but nauplii and copepodous stages were represented in mass. Later on the rotifera were missing entirely and Acartia clausi in all its development stages was the main form. All this is also reflected in the food of the larvae of the Azov anchovy of the respective sizes.

Thus it can be seen from Table XI that the composition of the plankton in 1952 was altogether different from that in 1953. At that time (1952), rotifera were present in large quantities. Also in the guts together with the copepodous stages, the rotifera (their eggs) were encountered more frequently than in 1953 (Tables XIII and XIV).

The percentage of empty intestines and the general index of the extent to which they were filled were almost the same in 1952 and in 1953. This indicates that the larvae did not starve in 1952, which was regarded as the year when a poor year-class was born.

The data obtained by E.N. Bokova on the food of the larvae in 1952 are quoted in the comparison with the titers of zooplankton (Table XIV).

Table XIV. (see Page 38)

Table XIV, The zooplankton and the food of the larvae of the Azov anchovy in the Kazantiip region in 1952.

Length of Larvae in mm	3 - 4		3,5 - 5,1		4,5 - 4.6	
Station and Date	No. 10	9/VI	No. 19	16/VI	No. 29	18/VI
Titer of zooplankton on the stations in mg/cm ³			1200,9		578,849	
Name of Organisms	Titer of individual organisms	Particular(?) index of the fill of the intestines	Titer of individual organisms	Particular(?) index of the fill of the intestines	Titer of individual organisms	Particular(?) index of the fill of the intestines
<u>Ac. clausi</u> + <u>Ac. latisetosa</u>	--	--	204,9	--	132,2	--
<u>Centropages kroveri</u>	--	--	8,96	--	2,59	--
Calanipeda a.d.	--	--	1,1	--	25,4	--
Lamellibr. larvae	--	77,5	42,83	--	24,4	--
Synchaeta	--	77,6	742,45	35,6	81,86	--
Nauplii Balanus	--	--	189,44	6,8	294,2	--
Copepodite stages	--	271,9	--	--	16,25	--
Coscinodiscus	--	52,7	--	--	--	--
Varia	--	--	11,22	--	--	--
General index of fill	479,3		--		0	
Number of larvae that had food in the intestines	3		6		--	
Total number of dissected larvae	28		17		2	
Number of larvae with empty guts in %	89,3		64,7		100	

Observations with regard to the food of the larvae of the Azov anchovy at various depths and at different hours of the day are shown in Table XV.

Table XV. The food or feeding of anchovy-larvae during various hours in a 24-hour period.

Hours when the fishing was done	Catching on the Surface		Catching at a Depth of 4-5 m	
	% of larvae with empty intestines	General mean index of the extent the intestines were filled	% of larvae with empty intestines	General mean index of the extent the intestines were filled
3	100	--	--	--
6-11	77,3	102,9	73,7	78,2
17-19	63,7	100,6	59,2	75,1
22-23	97,5	33,5	100	--

The data in Table XV show that the largest percentage of larvae with empty intestines caught on the surface was observed during the morning hours. When twilight set in and the zooplankton drifted, or rose to the upper layers of the water, the larvae in the upper layers of the water fed somewhat more intensely. It seems that they did not feed during the night.

The same dependence between the size of the larvae and the food objects was also observed on a relatively small quantity of material. It has been established that in keeping with the increase of the size of the larvae the composition of their food also changes (Table XVI).

Table XVI. Dependence between the size of the larvae of the Azov anchovy and their food objects.

Food Objects	Average size of Larvae that feed upon these objects in mm	Number of Larvae that were measured
Coscinodiscus	3,86	36
Tintinnoidea	3,9	25
Nauplii Copepoda	4,2	109
Copepodite stages	5,3	125
<u>Acartia clausi</u>	6,4	27

Besides studying the food of the larvae of the Azov anchovy at the early stages of their development we also observed the increase in the weight of the larvae. The results of these observations are shown in Table XVII in which the average weight of the larvae of various size-groups as well as the increase in weight when passing from one size-group to another are shown.

Table XVII. Increase in the weight of larvae in mg as their size increase.

Size of Larvae in mm	Average Weight of Larvae in mg in 1953	Increase in Weight in 1953	Average Weight of Larvae in mg in 1952	Increase in Weight in 1952
3-5	0,16	0,72	0,17	0,51
5-10	0,88	3,31	0,73	3,5
10-15	4,19	--	4,23	5,77
15-20	--	--	9,27	18,9
20-25	--	--	28,6	29,54
25-30	--	--	58,14	

A comparison of the gain in the weight of the larvae that had just gone over to active feeding showed that in 1952 the tempo of the weight-gain was not slower than in 1953. Therefore, also this indicates that the food conditions for the larvae in 1952 were not worse than in 1953.

CONCLUSIONS

1. In connection with the varying dates of the warming up of the waters in 1952 and 1953 the specific composition of the zooplankton in June to July of these years was different. In the colder year of 1952 a heavy development of the rotifera, the eggs of which were used to a considerable extent by the larvae at the stage of the transition to active feeding, was observed. But in 1953 the rotifera were absent from the plankton as well as from the intestines of the larvae. Instead of them nauplii and the copepodal stages of Acartia clausi, that predominated in the plankton, were consumed in enormous quantities.
2. The food conditions in 1952 to all appearances were worse than in 1953 for large quantities of the larvae of the corn barnacle, little used as food by the anchovy, were observed in the plankton.
3. There were no indications that the food situation for the larvae had worsened or deteriorated in 1952. This is confirmed by the following facts: a) the total biomass of plankton was not below that of 1953; b) the number of non-feeding larvae during these years was almost the same; c) the number of non-feeding larvae was the same with regard to the smallest larvae (3-5 mm) as well as to the larger ones. This does not confirm the opinion or view of the lesser adaptation of the larvae for obtaining food at the early stages of development; d) The general index of the extent of filling is sufficiently large in the case of the larvae that were "born" in 1952; e) The rate of the weight-gain of the larvae of the stage of the transition to active feeding in 1952 was not slower than in 1953.

4. The composition of the food of the larvae corresponds to the composition of the food plankton that grows in the sea. It changes as the size of the larvae increases.
5. All the data cited indicate the plasticity of the anchovy larvae with regard to the food objects used, to the proper sizes. Therefore, they also indicate the greater chance for the survival of the larvae at the stage of the transition to active feeding. This plasticity in the selection of food objects required is an adaptive quality of the anchovy larvae which enables them to escape mass mortality when there is a change in the dates of the growth of one or the other of the food organisms.

The Azov anchovy possess this great plasticity with regard to food by virtue of their biological, morphological, and physiological peculiarities. The fact of an enormous opening in the oral-apparatus makes it possible for the anchovy to have a wide range of food organisms.

6. The transition to active feeding is accompanied by a considerable loss of larvae seeing that this stage is characterized by a rapid and radical change in the function of the digestive system. But it seems, that this loss is in direct proportion to their numerical strength.
7. In most cases the numerical strength of a generation under the conditions of the great feeding capacity of the Azov Sea depends primarily upon the number of the embryos that survived. The food supply of the larvae need not be the cause determining the numerical strength with the exception of those years when the food situation deteriorates radically!
8. The causes that determine the survival of the embryos of the Azov anchovy are the optimal temperature conditions and the supply of oxygen to the layers of water. The optimal temperature limits for the largest survival of anchovy embryos are very narrow (22-24°).

In 1954 to 1955 the productivity of the Azov Sea due to the decrease in the river runoff and the shift of its date was greatly reduced. The conditions for the fattening of the anchovy and the survival of the fry deteriorated considerably in connection with this. As a result of this the size of the stock or school in 1955 was "catastrophically" reduced and the catches dropped sharply.

The narrower the optimal limits of any fluctuating factor are with regard to an organism, the more important grows its role as the regulator of the numerical strength of a given organism. A change in the temperature regime of the water beyond the optimal level lowers the intensity of metabolism. This leads to the death of more individuals than the action or effect of

any other factor; for the adaptation of the anchovy to them has a wider range (the food plasticity of the larvae at the early stages of development).

9. The conclusion regarding the decisive significance of the temperature regime of the water with regard to the survival of the embryos is confirmed also by the fact that the amount of the larvae corresponds to the amount of the live eggs at the stage of the formed embryos. At the same time the periods of the greatest growth of plankton correspond to, and therefore also determine the high degree of the survival of the larvae under otherwise equal conditions.
10. In view of the sharp fluctuations in the numerical strength the adaptation or adjustment for its preservation is expressed-- in the case of the anchovy--by batch--spawning and a prolonged spawning period.
11. The numerical strength of embryos and of larvae in 1952 was small due to the unfavorable conditions for the development of the embryos regardless of the abundance of breeders. In 1953, the number of the breeders was several times smaller but the conditions for the growth of the embryos were more favorable. The "poverty" of the 1952 year-class and, on the other hand, the "mighty strength" of the 1953 year-class were confirmed by the quantitative survey of the under-yearlings in catches with lamparanets and in commercial catches.
12. In preceding years the generations with the highest yielding capacity were observed also at the time when the water was very warm during the reproduction process of the anchovy as, for instance in 1948 and in 1950, when especially strong year-classes emerged. In these years the intensive warming up began as early as May.

It seems that this condition led to most effective spawning. According to the data by V.M. Korovina the eggs or roe of the females which ovulate under optimal temperatures survive the effect of the changes in the thermal regime better than the roe developing under low temperatures. The latter is distinguished by a considerably higher sensitivity towards thermal action.

In years characterized by relatively low temperatures but abounding in food the numerical strength of the year-classes remained low (1951).

13. Independently of the indicators of the biomass of the food plankton a poor growth of the fry of anchovy was observed in 1948, 1950, 1953 (the years of greatest numerical strength). Thus according to the data of A. Novozhilova the total amount of the biomass of zooplankton in 1953 was not smaller than in the preceding years. However, the growth of the anchovy was poorer than ordinarily. The dependence of the nature of the

growth of the anchovy upon their numerical strength is still more emphasized during the years of the abundant year-classes of the sardelles which emerge in August from the Taganrog Bay and spread over the entire sea. During the period of their growth the larvae of the sardelles and of the anchovy occupy different feeding grounds and do not compete with one another.

14. The above laws that determine the best survival of the anchovy at the early stages of growth are specific for the given species. Further research in this direction will aid in disclosing more the regularities of the dynamics of the numerical strength of commercial fish.

In order to establish the causes for the fluctuations in the numerical strength of the fish that reproduce in the sea it is necessary to know the density of the distribution or occurrence of the food plankton with regard to its consumer under natural conditions. For this reason the minimal size or amount of the biomass of the plankton at which the food supply of the larvae is ensured must be determined.

LEGENDS FOR FIGURES

- Figure 1. Interrelation between the numerical strength of the anchovy (with regard to 2- and 3-year olds) and the catches. (1) catches in %; (2) numerical strength of the year classes in %.
(a) Year-classes; (b) Catches.
- Figure 2. Eggs in the stage of the unformed embryo.
(a) Live; (b) Dying.
- Figure 3. Length of anchovy during their spring migration through Kerch straits in 1949-1953 (according to data by V.P. Kornilova). (a) Length in mm.
- Figure 4. Growth of 2-year olds and of yearlings of the Azov Sea anchovy in the Kazantip region in the summer of 1952 (according to data by Kurytsina). Solid line--females; dotted line--males.
- Figure 5. A Schematic map of the stations and the direction of the wind (indicated by arrows), which brings about an increase in the salinity of the water in the Kazantip region. (a) Bay of Kazantip; (b) Stations established in 1952; (c) Stations established in 1953.
- Figure 6. The distribution of the live and dead eggs of anchovy (at various stages of development) in the middle of June of 1953 according to depth. (a) Depth of water in meters; (b) Thousands/% of live eggs; (c) Thousands of eggs; (d) Dead eggs; (e) Live eggs. (The rest is self-explanatory. Tr.)
- Figure 7. Curve of the mortality rate of embryos at various hours of a 24-hour period at a temperature of 22 to 24° in June, 1953. (a) Breaking up; (b) Formation of the embryonic layer or shield; (c) Formation or forming of the embryo until the heart begins to pulsate; (d) Hatching; (e) Mortality rate in %.
- Figure 8. Quantity of the roe that perished at a varying temperature at separate stages of the development of anchovy: (1) Gastrulation; (2) Formation of the embryos. (a) Temperature in degrees.

(continued)

Legends for Figures (continued)

Figure 9. Length of anchovy-fry caught in a gill-net in July, 1953 (according to the data by V.P. Kornilova).
(a) Length in mm.

Figure 10. Mean diurnal temperature of the water during the reproduction period of the anchovy in 1952-1953.
(a) Temperature in degrees; (b) June.