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THE SPAWNING OF THE SPRAT, *SPRATTUS SPRATTUS* (L.) IN THE KVARNER REGION AND RIJEKA BAY

MRIJEŠTENJE PAPALINE, *SPRATTUS SPRATTUS* (L.) U KVARNERU I RIJEČKOM ZALJEVU

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As the spawning places of sprat in Kvarner — Rijeka Region were not established with certainly to this day, we performed examination of presence of the planktonic eggs of this species once in a month, on 12 stations, in spawning period 1972—1973.

There was established that this species of fish spawns on the whole examined region from November until May. The most intensive spawning of sprat was attained in December with totally 1161 eggs.

INTRODUCTION

The sprat, *Sprattus sprattus* (L.) is a typical representative of the boreal species. The sprat is widespread along the coast of Great Britain, in the British channel and along the European coasts of the Atlantic. It is also found in the Mediterranean, in the areas of lower salinity and temperature, i. e., mainly the regions of the Adriatic, the Black Sea, and the Gulf of Lion. In the Adriatic it usually exists in the area of the Gulf of Venice, Kvarner, Kvarnerić, the Velebit channel and in the channels of the middle Dalmatia. In the Black Sea the sprat is widespread along the coats of Turkey, Bulgaria, Rumania and Russia. It also lives in the area of Bospor and in the Marble Sea.

In the North Adriatic the sprat is one of the most frequent representatives of the small blue fish. First data on biology, morphology and etymology were reported by Canestrini (1972), Stossich (1880), Graeffe (1888) and Kišpatić (1893).

Later, Fage (1920) comparing the material from various locations of the Mediterranean concluded, that the Adriatic sprat is in fact a special species of the sprat *Clupea sprattus* L.

More recent investigations revealed that the North Adriatic sprat belongs to the subspecies *Sprattus sprattus phalericus*. However, there exists differences which point at two subpopulations of the sprat in this area (D. Zavodnik and N. Zavodnik, 1967).

It ist known that the fish migrates which is determined by the location of spawning places and by its nutrition. In summer the sprat stays in the open waters west of the Istrian coast and from there goes to Kvarner at the end of autumn (D. Zavodnik, 1968). The other part of the sprat population remains along the Italian coast and never reaches southern of Rimini (Varagnolo, 1964). Past investigations revealed that the sprat spawns in the area west of the Istria, between the Italian and our coast and very probably in Kvarner (Štirn, 1969). It spawns in the colder period of year and its maximum of spawning continues from October until December. In that period, in the open sea west off the Limski channel 441 eggs under 1 m^2 of sea surface were counted (N. Zavodnik, 1969).

The spawning period of fish as well as the locality and dynamics of spawning place depend on many environmental factors, as e. g., the sea depth, temperature and salinity. The sprat, compared to some authors (Arslanova, 1954; Svetovidov, 1964) spawns in the temperature range 5°C—19°C, and in the Adriatic between 8.8°C—14°C (Zavodnik D., 1970). The spawning period is different in the area of its distribution (Furnestin, 1948). In the northern seas it continues for about 6 months and it take place in the summer period, while in the Mediterranean basin the spawning period is shorter and occurs in winter.

With regard to salinity, the sprat inhabits areas of lower salinity, which in our area means the North Adriatic — the Gulf of Venice, the region of Kvarner, Rijeka Bay and the Velebit channel to the Novigrad Sea. Compared to results of investigations in the last ten years, the sprat spawns in the Adriatic at the salinity 36—37.9‰ (D. Zavodnik, 1970).

It is considered, that the sprat is the species on whose horizontal disposition salinity has a significant influence, the same as depth is a limited factor for its horizontal spreading (R. Mužinić, 1973).

It is evident that on the formation of spawning all environmental factors, biotic and abiotic, and with reciprocal interactions have an influence. The investigations, which to date have been carried out periodically in Kvarner (Štirn, 1969) could not give an answer to the question, whether the sprat stays in this area during the whole winter period, in what quality and whether it spawns here, when, where and which is the intensity of the spawning.

To find the answers to these questions we started the investigations that are the subject of this work.

MATERIAL AND METHODS

In the region of Kvarner and Rijeka Bay measurements of some environmental factors were carried out, and samples of plankton were taken at 12 stations, 5—7 n. m. apart one from another (Fig. 1.). The observations were

undertaken during the season of the sprat — spawning in 1972—1973, during the day, once or twice a month, on the research vessel »Vila Velebita«, of the Center for Marine Research at Rovinj.

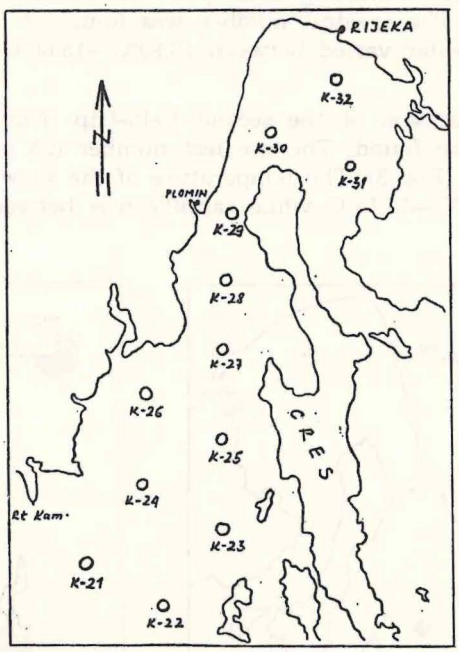

Fig. 1. Investigated area

At each station, the temperature was measured and the samples of seawater for determining salinity were collected on the surface and at the depths of 10, 30 and 50 m. The seawater was taken using Nansen — type water-bottles with mounted Richter and Wiese reversed thermometers. The salinity of the seawater was determined titrimentrically in the laboratory using Mohr and Knudsen method. Temperature conditions in a continuous water-column from the surface down to 5—10 m from the bottom, examined also with the Wallace and Tierman FA bathythermograph at 0—60 m.

For plankton sampling a modified Helgoland-type net with an opening of 0.5 m^2 was used. The net was drawn vertically from at least 5 m above the bottom, to the surface, with a constant speed of 0.5 m/s. To achieve more accurate results, two vertical samplings were performed at each station. The plankton was preserved with 2.5% neutralized formaldehyde in glass bottles of 2000 ml. After sedimentation, the plankton-sample was decanted on the ship into the bottles of 500 ml, and then once again in the laboratory, where further treatment of samples was performed.

RESULTS

Our field investigations began with the first cruise on November 17—18, 1972. Then, the greatest number of sprat eggs was found at stations south of imaginated line connecting Crna punta and Pernat corner on the island of Cres (Fig. 2.). The greatest number was found at Station K—21. The temperature of seawater varied between 13.90°C—15.60°C and salinity was between 35.43—38.68‰.

On the occasion of the second field-trip (November 27—28, 1972) more sprat eggs were found. The greatest number (96 eggs/m^2) was discovered at Station K—26 (Fig. 3). The temperature of the seawater was lower and varied between 10.68°C—14.13°C while salinity was between 34.31—37.83‰.

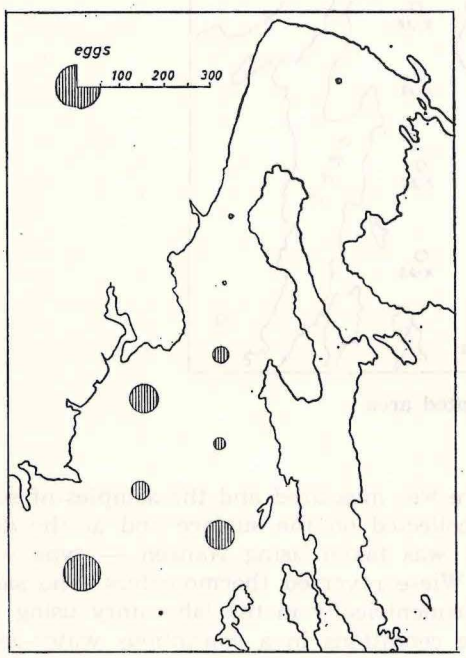

Fig. 2. Distribution of sprat eggs in November 17—19, 1972

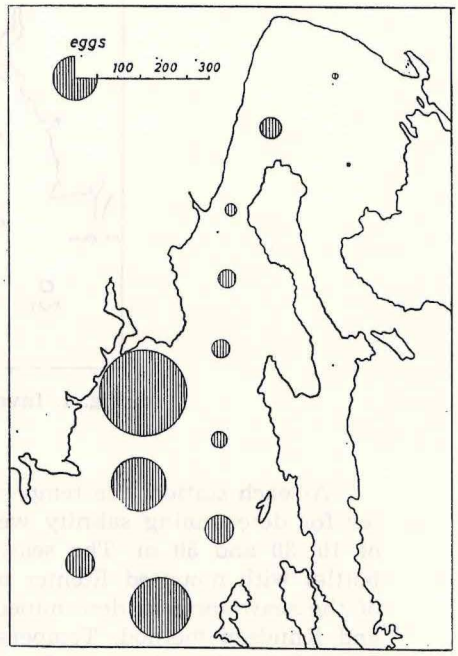

Fig. 3. Distribution of sprat eggs in November 27—28, 1972

During the third field-trip (December 14—15, 1972) the number of sprat eggs found was even greater. The maximum number of sprat eggs was found at Station K—24 (274 eggl/m^2). As it is evident from Fig. 4, there were more eggs in the southern than in the northern part. The seawater temperature was lower than the previous month and varied between 11.90°C—13.65°C. The salinity was within the range 36.17—38.08‰.

At the beginning of January (January 8—9, 1973) the number of sprat eggs found was high in the whole area. The greatest number of sprat eggs

was found in the northern part at Station K—30 (111 eggs/m^2) (Fig. 5). The temperature was again lower and varied between 10.50°C—11.10°C while salinity was 37.30—37.83‰.

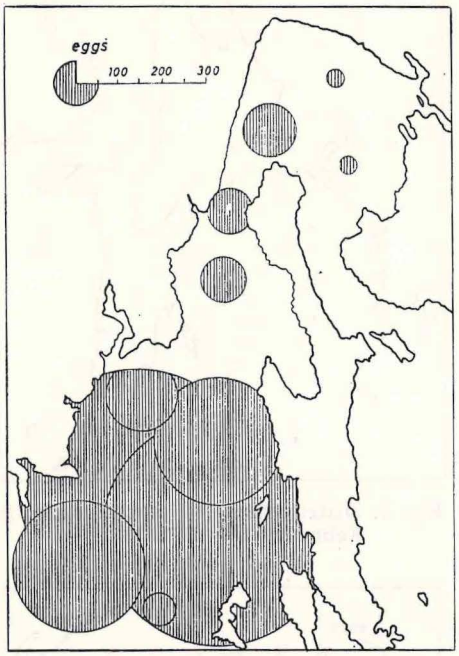

Fig. 4. Distribution of sprat eggs in December 14—15, 1972

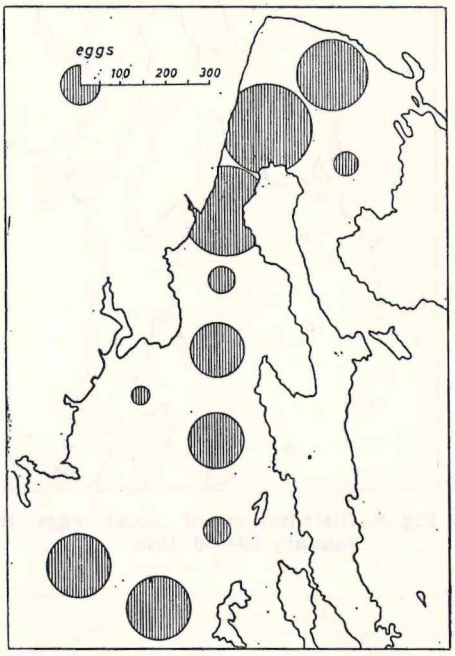

Fig. 5. Distribution of sprat eggs in January 8—9, 1973

At the end of the same month (January 29—30, 1973) the quantity of sprat eggs was considerably lower. At that time the eggs (only 9) were found at Station K—31 (Fig. 6). The temperature of the sea was within 9.50°C——10.32°C. The salinity did not show greater differences than the last time and it was 37.38—37.83‰.

On the occasion of the next field-trip (February 15—16, 1973) the same quantity of sprat eggs was found. The maximum of 12 eggs/m^2 was found at Sattion K—29 (Fig. 7). The temperature of seawater varied between 9.42°C—10.96°C and salinity 35.79—38.06‰.

During the following field-trip (March 15—16, 1973) still less sprat eggs werefound, maximum 6 eggs/m^2 at Station K—30 (Fig. 8). The temperature of seawater was 8.70°C—10.75°C in the whole region. The salinity did not show greater variations and varied between 37.43—38.28‰.

The number of sprat eggs was lower (April 12—13, 1973) and the maximum of 4 eggs/m^2 was found at Station K—23 (Fig. 9). The temperature of water was slightly higher, between 9.30—11.70‰. The salinity was lower than earlier and varied between 37.07—38.17‰.

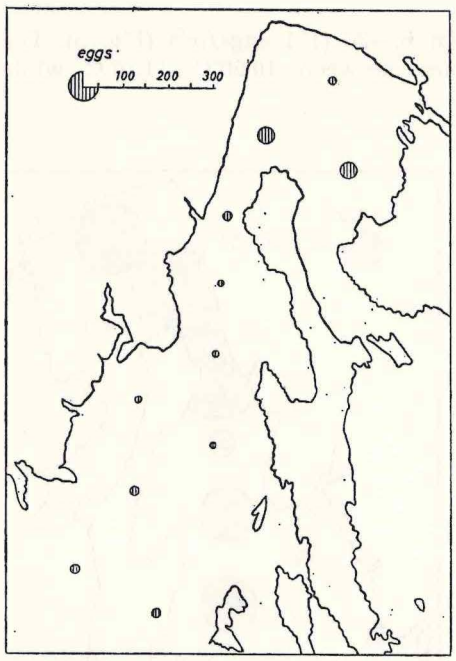

Fig. 6. Distribution of sprat eggs in January 29—30, 1973

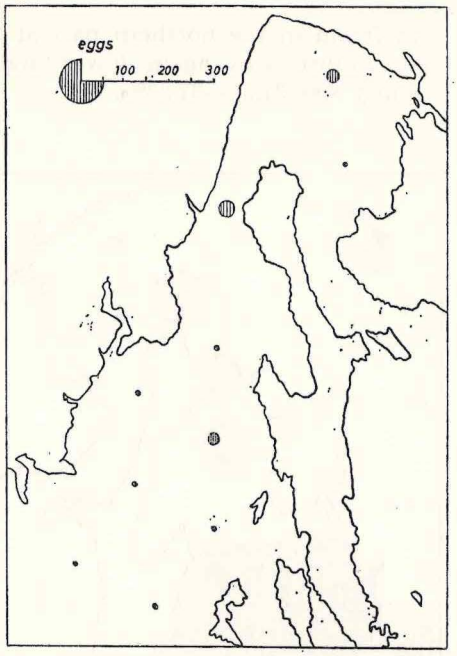

Fig. 7. Distribution of sprat eggs in February 15—16, 1973

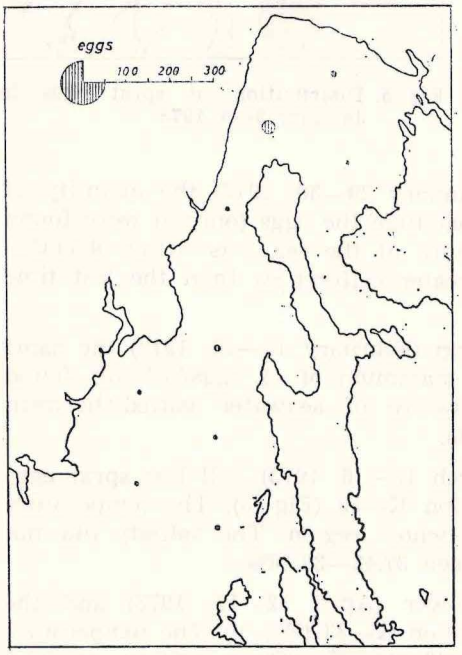

Fig. 8. Distribution of sprat eggs in March 16—17, 1973

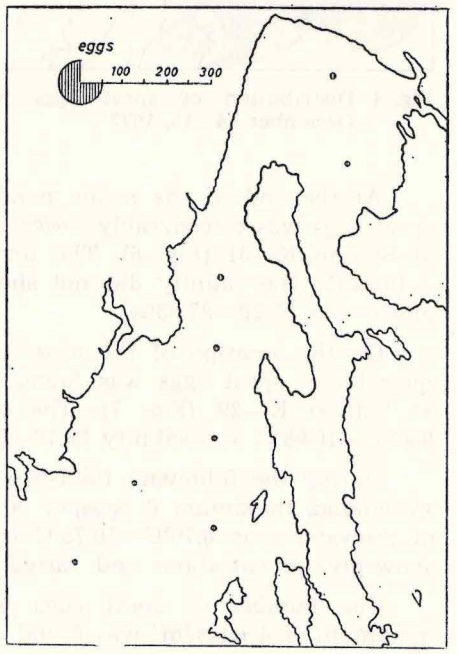

Fig. 9. Distribution of sprat eggs in April 12—13, 1973

However, the sprat eggs considerably decreased in number and on the ninth cruise, May 14—15, 1973, most of the eggs (3 eggs/m^2) were found at Station K—22 (Fig. 10). The temperature of seawater was successively higher, in the range 9.40°C—17.70°C. The salinity in the whole area varied between 35.88—38.17‰.

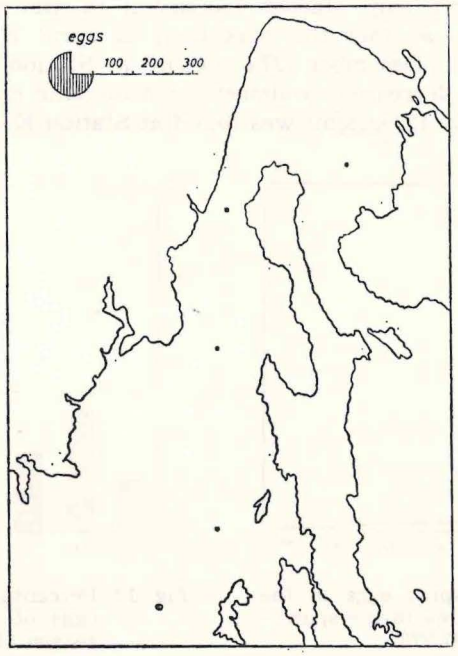

Fig. 10. Distribution of sprat eggs in May 14—15, 1973

On the last cruise (June 13—14, 1973), when the temperature was between 10.10°C—22.95°C and salinity 36.83—37.97‰ no sprat eggs were found.

DISCUSSION

Among the first who investigated the period of reproduction of sea organisms in the Adriatic Sea was Graeffe (1888) who studied the time of appearence and spawning of many kinds of animals starting from the most important systematical groups that inhabit the Gulf cd Trieste. At that time and later some data on the sprat, its form and eggs size were known (Raffaele, 1888; D'Ancona, 1931), but very little was known about its spawning place.

The first data which refer to the sprat spawning area in the Gulf of Venice, especially the west Istrian area, are more recent data (Gamulin and D. Zavodnik, 1961), but permanent spawning sites in this area have not been located to date.

The previous investigations established that the sprat spawns in the west Istrian area and very probably in Kvarner too. The sprat spawns in the colder period of year with maximum reaching from October till December (N. Zavodnik, 1969).

The sprat spawning in Kvarner in 1973 continued till June, when no more eggs were found in the plankton (Table I). Compared to our results, the number of sprat eggs started increasing in the investigated area in November (Fig. 11), so that the maximum of sprat eggs under 1 m^2 sea surface was found in December (274 eggs/m^2 at Station K—22). In Jannuary the number rapidly decreased to almost inconsiderable quantities. In February the maximum of only 12 eggs/m^2 was found at Station K--29.

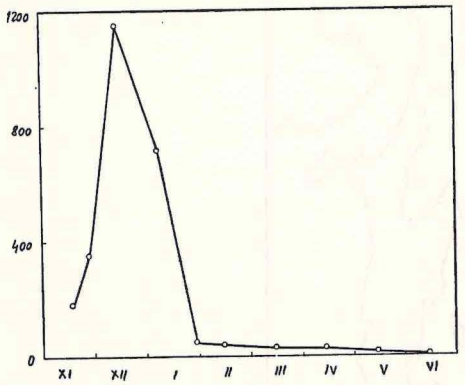

Fig. 11. Quantity of sprat eggs in the investigated area in the spawning seanson 1972/73

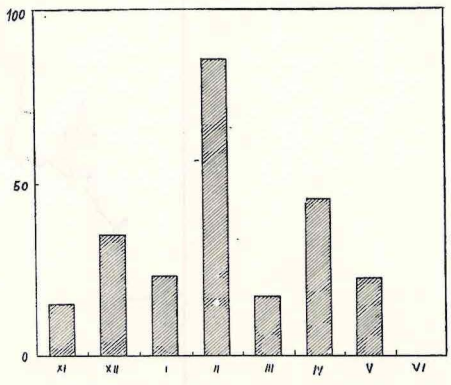

Fig. 12. Percentage of dead planktonic eggs of sprat in the spawning season 1972/73

During the whole spawning season, the maximum of eggs was found in the southern part of the studied area, but never at the same stations.

Considering the maximum of eggs in December it could be said that the most intensive spawning of the sprat takes place in the southern part of Kvarner. It is evident, therefore, that the sprat does not stay at the same place during the whole spawning period.

The sprat from the west Istrian area migrates to Kvarner and spawns in the area of the Kvarner islands, but the spawning place of sprat has not been established yet. With regard to the results obtained it could not be concluded, that the permanent spawning place of sprat is in the Kvarner area, but we could say that the sprat spawns here very intensely.

The total number of sprat eggs was maximal in December (1161 eggs). Also, at the same time, the maximal temperature was 13.95°C at a depth of 30 m. However, the total number of the sprat rapidly decreased in several following months. In January there were 772 eggs and in February 38 eggs only. At the same time the temperature was lower with the minimum in March (8.60°C in the whole water-column). After that an increase in temperature followed again, but the number of sprat eggs still decreased, so that no sprat eggs were found in June.

Table 1. Distribution of fish eggs in the investigated area

Date	K—21		K—22		K—23		K—24		K—25		K—26	
	sprat	fish total	sprat	fish total	sprat	fish total	sprat	fish total	sprat	fish total	sprat	fish total
17.—19. 11. 72	50	171	1	152	35	205	25	44	8	92	44	154
27.—28. 11. 72	33	41	76	190	37	52	62	81	9	28	96	126
14.—15. 12. 72	154	167	33	48	261	300	274	303	149	169	79	127
8.— 9. 01. 73	78	104	77	93	32	54	—	9	75	104	14	31
29.—30. 01. 73	5	19	5	11	—	—	6	14	2	9	1	7
15.—16. 02. 73	1	5	2	77	3	13	4	13	7	25	2	12
15.—16. 03. 73	—	12	—	81	1	6	2	5	1	7	1	4
12.—13. 04. 73	1	99	—	188	4	119	2	17	2	110	—	77
14.—15. 05. 73	—	78	3	70	1	55	—	85	—	57	—	69
13—14. 06. 73	—	268	—	99	—	186	—	61	—	33	—	83

Table 1. (continue)

Date	K—27		K—28		K—29		K—30		K—31		K—32	
	sprat	fish total	sprat	fish total	sprat	fish total	sprat	fish total	sprat	fish total	sprat	fish total
17.—19. 11. 72.	10	77	2	15	4	66	—	36	—	—	1	47
27.—28. 11. 72.	11	37	16	33	8	30	14	45	2	74	3	21
14.—15. 12. 72	—	31	53	93	58	125	58	123	19	34	23	136
8.— 9. 01. 73	72	103	39	59	109	142	111	143	20	43	94	131
29.—30. 01. 73	3	20	2	9	5	11	8	10	9	21	3	3
15.—16. 02. 73	2	11	—	6	12	19	—	6	2	7	3	10
15.—16. 03. 73	4	11	—	2	1	5	6	9	3	6	4	6
12.—13. 04. 73	2	16	3	15	—	10	—	7	3	10	3	10
14.—15. 05. 73	1	59	—	41	1	27	—	20	2	38	1	21
13.—14. 06. 73	—	46	—	24	—	68	—	42	—	36	—	47

Table 2. The frequency of dead eggs of sprat in the investigated area in the spawning season 1972/73

Date	Sprat eggs				
	total No.	alive No.	alive %	dead No.	dead %
17.—19. 11. 1972	180	160	88.8	20	11.2
27.—28. 11. 1972	367	302	82.2	65	17.8
14.—15. 12. 1972	1161	744	64.0	417	36.0
8.— 9. 1. 1973	721	560	77.6	161	22.4
29.—30. 1. 1973	51	29	56.8	22	43.2
15.—16. 2. 1973	38	5	13.1	33	86.9
15.—16. 3. 1973	23	19	82.6	4	17.4
12.—13. 4. 1973	20	11	55.0	9	45.0
14.—15. 5. 1973	9	7	77.7	2	22.3
13.—14. 6. 1973	—	—	—	—	—
Total	2570	1837	71.5	733	28.5

Based on the above, we could conclude that considering the spawning, the sprat does not depend on temperature variations in the environment, as e. g., sardine (Gamulin and Hure, 1955).

However, there is a problem of the occurrence of dead eggs. The percentage of dead eggs decreases and increases without evident reason, with the highest percentage (86%) registered in February (Fig. 12, Table 2).

We could find no special reasons for relatively high mortality, particularly because meteorological and hydrographical conditions of the environment were favourable in that period.

The collected material indicates (unpub.) that no staion stands out with respect to permanently greater presence of earlier or later developmental stages connected with time. This gives strength to the hypothesis that the eggs are brought into some regions by water currents. It seems, therefore, that the sprat spawns in every region where its eggs are found.

CONCLUSIONS

1. In the season 1972—1973, the sprat spawned in the investigated area from November until May.
2. The sprat spawn was found at the water temperature of 8.60°C——17.70°C and the most intensive spawning took place at a temperature between 12.70°C—12.80°C.
3. On the occasion of our investigations, the sprat eggs were obtained in water having a salinity of 34.31—38.68‰ and the most intensive spawning at a salinity 37.21—37.39‰.
4. The sprat spawns in the whole Kvarner Region including the Gulf of Rijeka, but the most intensive spawning took place in the open areal of south Kvarner.

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MRIJEŠTENJE PAPALINE, *SPRATTUS SPRATTUS* (L.) U KVARNERU I RIJEČKOM ZALJEVU

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KRATAK SADRŽAJ

U Kvarnersko-riječkom području vršena su u sezoni 1972—1973. ispitivanja prisutnosti planktonskih jaja papaline. Terenska opažanja vršena su jednom ili dvaput mjesečno na 12 postaja. Uzorci su uzimani vertikalnim potezima sa modificiranom mrežom helgolandskog tipa sa otvorom od 0.5 m^2 od dubine 30 m prema površini. Materijal je konzerviran u 2.5% neutraliziranom formalinu. Ukupno je obrađeno 2570 jaja papaline.

Prilikom svakog izlaska na teren, na pojedinim postajama uzimani su također neki hidrografski podaci (temperatura i salinitet).

Dobiveni rezultati potvrđuju poznatu činjenicu da se papalina mrijesti u sjevernom Jadranu u periodu od jedanaestog do petog mjeseca. Maksimalne količine jaja papaline dobivene su u istraživanom području u 12-om mjesecu i to ukupno 1161 jaje. Najintenzivnije mriješćenje papaline odvijalo se je u južnom dijelu Kvarnera pri temperaturi između 12.70—12.80°C. Vrijednosti saliniteta prilikom najintenzivnijeg mriještenja iznosile su 37.21—37.39‰.