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THE DEATH OF REDLIP MULLET (OR HAARDER) *LIZA HAEMATOCHEILUS* (TEMMINCK & SCHLEGEL, 1845) IN TILIGUL LIMAN IN WINTER 2014

The mass mortality of older age groups (age 2 + – 5 +) of Redlip Mullet (Haarder) *Liza haematocheilus* (Temminck & Schlegel, 1845) was observed at the end of January 2014 in Tiligulskyi Liman. The environmental factors that caused the death of fish were analyzed. Assessment of the loss scale of Redlip Mullet (at least 335 m in a limited area of the estuary) allows revising the idea of the volume of Redlip Mullet`s population in Tiligulskyi Liman. It was assumed that the complex of meteorological conditions (sharp fall of temperature with gale winds, intense convection of water masses at low temperatures and significant salinity) was the most likely reason of death of fish. Significant differences of size-age structure of Redlip Mullet herds in Tiligulskyi and Hadzibeevsky Limans were revealed. The recommendations on Tiligul Liman fishery improvement have been provided.

Keywords: Tiligulskyi Liman, Redlip Mullet, wintering, death of fish

Tiligul Liman is located on the border of Odessa and Nikolaev regions of Ukraine, and is extended from north to south periodically connected with the Black sea (Fig. 1). The length of the estuary is about 60 km, the width is 0,2–4,5 km. An average area of water body is 160 km^2. The average depth does not exceed 3.0 m, maximum – 23.0 m [1, 2]. At present the liman is separated from the sea by the sand-spit, which length is about 3.8 km and width 7.0 km. The sand-spit is covered with salt marshes with numerous shallow (10-15 cm depth) channels and shallow

salty lakes. The water level, area of water body of the estuary and its hydrological and hydrochemical regime firstly depends on climatic factors, the Tiligul River flow and other ephemeral channels, as well as on the functioning of the canal connecting the estuary with the sea [1, 3].

Historically, salinity in the Liman changed in a very wide range – from 0,5 to 28,0 ‰. According to data obtained, at the beginning of the last century in connection with the extended dry season salinity was high and marine fish complex dominated in the liman [2]. In 1932-1934 the increased river flow has played a crucial role in the formation of the hydrological regime of the water masses. As a result of the powerful floods, there was a sharp increase in water level of the estuary, freshening of its waters, breakthrough of the sand-spit and connection with the sea through a natural channel up to 20 m width. The salinity of the water in this period decreased to 0,5-5,5 ‰, the brackish and freshwater species of fish appeared in the estuary [4]. Up to the middle of last century, despite the fact that the channel sea-estuary periodically was covered with sand during the autumn storms, salinity stayed unchanged, its value was determined by the river discharge. In period from 1959 to 1968 the liman was always connected with the sea by means of an artificial fishery channel. However, at this time, work on the regulation of rivers and the extensive use of river water for household needs began. As a result, the volume of the spring flood was reduced by 2.5 times, and the value of river flow to Tiligul Estuary ceased to play a leading role [2]. The salinity of the water began to rise gradually. In 1968 the channel estuary-sea was filled up with sand and was not restored for a long time. Salinization of the estuary has continued. As a result in the 1980 the freshwater fish complex was replaced by brackish and marine species again. In 1994-1995 salinity of the water has reached its critical values 19,0-23,0 ‰, which led to a complete loss of freshwater species of fish [5]. In recent years, the connecting channel of Tiligul Liman has been very much silted and functioned only sporadically. The river flow has stopped almost completely, and there are no prospects for its increase. The average salinity in the estuary exceeded the value of 26,0 ‰ and continues to rise gradually [6]. The

water exchange with the sea is extremely insignificant, the level of water in the estuary (0.5-1 m below sea level) reduced greatly.

In the context of major changes in the environment of the estuary a steady successions in ichthyocenoses has been observed. During the long years of isolation of the estuary from the sea fish catches were sharply reduced, and many species (both marine and freshwater) disappeared completely [2, 4]. Lonstanding research has shown that the connection with the sea has the main influence on the formation of structural and functional characteristics of the fish fauna of Tiligul Liman.

Nowadays, the main commercial species in the estuary are gobies, Black Sea mullet, mostly golden mullet *Liza aurata* (Risso, 1810) and silverside *Atherina pontica* (Eichwald, 1838) [6]. Successfully acclimatized invader – redlip mullet *Liza haematocheilus* (Temminck & Schlegel, 1845) is very important in the fisheries of the estuary.

The first attempt of redlip mullet invasion in Tiligul Estuary was undertaken in 1973-1974. 1330 examples of this species was set free into the liman, but at this stage the experiment did not give positive results and the formation of population of haarder did not occur [7]. The acclimatization of this species of fish in the Tiligul Liman took place in the 1990s during the penetration of different ages of haarder through the connection channel with the Black Sea. In subsequent years haarder, as a species with high ecological plasticity, spread to the waters of the entire estuary, its population has increased significantly. In August 1998 the first catches of haarder were noted in Tiligul estuary. According to ichthyological surveys of YugNIRO, individuals in age (1+), average length 26.5 cm and a weight 290 g were predominant in the catches. The state of gametes of some individuals led to the conclusion that there is possible spawning process of this species of fish in the estuary. In 2002, larvae of haarder were found in the catches of ichthyoplankton and thus its natural spawning in Tiligul Estuary was proven. Since 2002 annually slight, but constant catch of haarder was registered in the estuary [6].

Over the past 15 years haarder successfully wintered in Tiligul Liman. However, according to the survey of fishermen and reports of employees of Tiligul Regional Landscape Park, in winter for the last 5 years, almost every year in the estuary death of haarder has been observed. This process was much less massive than for two-year-native species of mullet that could not leave the estuary through the channel in autumn. At the end of January 2014 in the estuary the mass death of the older age groups of haarder were first registered. Thus the aim of this paper is to assess the extent of death of haarder in Tiligul Liman in winter 2014, to analyze the consequences of this phenomenon and make recommendations on sustainable fishery use of the reservoir were the aim of the present work.

Material and methods

The material was collected in the course of hydrological work, visual observation and survey with local people conducted on Tiligul Liman near Chervonoukrainka and Lubopol in the period from February, 6 till April, 4, 2014. Archive, published and statistical data provided by the Basin Administration "Zahchorriboohorona" were also used in the paper. Meteorological data are presented according to the data of Ochakov meteostation (http://meteopost.com/papapap./city/6968.html). Sampling was performed using standard techniques [8-10]. Water temperature and salinity were determined by mercury thermometers and express Salimeters «Atago» in the field, and more precisely via conductometer MC 226 (Toledo 44 M). Coordinates were determined by navigation device Garmin GPS-12. Visual observations were carried out on a reservoir, on ice in the place of detection of dead fish (Fig. 1) and with diving equipment during underwater observations. Diving operations were carried out at a depth of 3.0 to 8.0 m in two transects about 3 m width and at least 500 m length each (№ 1 and № 2). The area of the survey made approximately 2.0 km^2 (square calculations were made using the program Google Earth). The complete biological analysis by standard ichthyological methods was provided [11]. In total 42 specimens of haarder were analyzed from a representative sample.

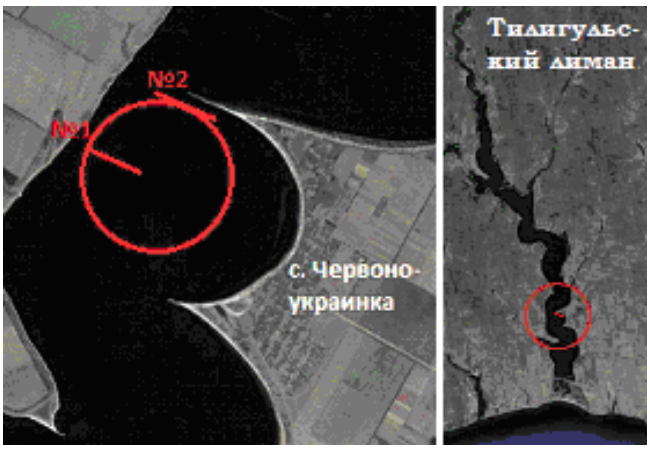

Fig. 1. Tiligul Liman. Area of detection of dead individuals of haarder. Transect number 1 and number 2 of underwater visual observations

Results and discussion

According to the weather report of Ochakov meteostation in the III-rd decade in January 2014 a sharp decrease in temperature up to -17°C together with strengthening of the northwest squally wind (speed reached up to 27 m/s) in the study area was observed. Continuous wind storm and cold snap led to intense mixing of water masses, sharp and significant decrease of water temperature both on the surface and in the bottom layers, formation of sludge, and then a sharp formation of a powerful ice thicker than 30 cm over the entire area of the estuary. In late January 2014, after stormy weather, and the formation of ice on the estuary near Chervonoukrainka (Mykolaiv region) and Lyubopol (Odessa region) significant accumulation of dead fish of haarder frozen in the ice was observed (Fig. 2). Local people began to extract the fish, cutting down the ice with the help of axes and chainsaws.

According to our observations and to a survey of local people every day from January, 30 till February, 15, 2014 up to 200 people caught the haarder from ice. During daylight hours on average 10 kg of fish were extracted per 1 person. According to various estimates over 2,5 weeks on Tiligul Liman near Chervonoukrainka from 35 to 90 tons of haarder were produced.

Fig. 2. Catch of haarder on Tiligul Liman on February, 6, 2014

Underwater observations in the same area of the Tiligul Liman on March, 4, 2014 at two transects at a depth of 3,0-8,0 m showed numerous dead individuals of haarder (Fig. 3). The density of distribution of dead fish throughout the study bottom transects was practically homogenous, as well as in visual observations during the extraction of fish from the ice on February, 6, 2014, and made 3-4 individuals per 10 m^2. At the same time in the area only a few other species of fish were noticed dead (goby *Zosterisessor ophiocephalus* (Pallas, 1814) – 2 individuals, pipefish *Syngnathus abaster* (Risso, 1827) – 2 individuals). Thus, according to our calculations, 600-800 thousands individuals of dead haarder with total mass of about 300 tons appeared concentrated in the study area of about 2.0 km^2. Considering seized fish from ice by fishermen and locals, it can be assumed that only in this part of the estuary at least 335 tonnes of haarder was lost.

Fig. 3. Killed individuals of haarder in the result of suffocation on the studied bottom areas in Tiligul Liman on March, 4, 2014.

Observations in February have shown that in most cases, the deceased fish was completely frozen into the ice mass at an angle to the upper edge, sometimes almost vertically, or frozen by its side or back to its lower edge. This arrangement of dead fish indicates that her death occurred at the time of the formation of ice on January 22-24, 2014. This assumption was also confirmed by the oral reports of fishermen who watched fish alive floating in the surface layer of water among the ice slush before ice formation on estuary.

According to scientific data, in spite of its eurythermal and euryhaline features haarder is predominantly marine thermophilic fish. It tends to form winter accumulation on the freshened parts of the reservoir and lies at a depth of 6 to 10 m. It is known that during the winter it can tolerate significant short-term lowering of water temperature. Juveniles of haarder accumulates separately from the mature specimens in a freshened areas, mainly in the estuaries and lower reaches of rivers, and much worse tolerate harsh thermal conditions [12].

Analysis of the water samples taken during the study period from February, 6 til March, 4, 2014 in Tiligul Liman did not reveal any significant abnormality. The pH made 7,58-8,25; salinity reached 27,1 ‰. The water temperature in this period varied between -0,8 – -1,0°C. Obviously, forced occurrence in such a cold water was the cause of the mass death of fish. Pass of haarder from bottom places of winter bedding with warmer water to the surface was probably caused by a complex of hydrological and meteorological conditions formed in the end of January 2014 (prolonged cold snap and the gale force winds cause intense convection of water masses characterized with such salinity significantly negative temperatures).

It should be noted that, in more freshwater (salinity up to 7,0 ‰) and less deep Khadzhibey Liman under similar weather conditions similar death of haarder in winter 2014 and in previous years was not observed.

According to the results in a sample from February, 6, 2014 individuals aged 2+ dominated (40.5% of the total number of analyzed fish). The proportion of individuals of older age groups was less significant (Table 1), and individuals of

haarder aged 0+ and 1+, as well as native species of the Black Sea mullets (golden mullet and gray mullet), among the dead fish were not observed.

Table 1

Size and weight parameters of dead individuals of haarder in the study area of Tiligul Liman (February, 6, 2014)

Parameter	Age, years			
	2+	3+	4+	5+
Length (l), cm	27,1±1,3	35,6±1,8	47,4±0,7	53,0±0,5
Mass, g	382,6±12,4	537,3±10,0	1542,0±28,9	2076,0±87,5
Abundance, ind./%	17/40,5	10/23,8	8/19,0	7/16,7

Obviously, in the Tiligul Liman (as well as in other water bodies, according to B. N. Kazanskyi [12]) juveniles of haarder and Black Sea mullet go to wintering places apart from the mature specimens in other more freshened areas, the location of which yet to be determined.

The average commercial length and mass of more numerous individuals (age 2+) was 27,1 ± 1,3 cm and 382,6 ± 12,4 g, respectively, at the lowest values 26.3 cm and 320 g (Table 1). Maximum length and weight of fish found did not exceed 54.0 cm 2.24 kg, respectively. According to the survey, among the dead fish were occasionally observed individuals weighing 4-5 kg. However, it was not possible to verify the accuracy of these data.

The scale of the death of haarder Tiligul estuary in winter 2014 significantly change the current understanding of the state of commercial fish fauna of this water body established on the basis of catch statistics.

According to Basin Administration "Zahchorriboohorona" basic catches in Tiligul Liman recently consisted of silversides and gobies. The catch of mullet (mostly golden mullet) and haarder was insignificant. In 2013, catches of fish species accounted for 0.74 and 0.06 t, respectively (Table 2).

Table 2

Dinamics of fish catches in Tiligul Liman (t)

Species	Year											
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Glossa	-	-	0,14	0,08	0,01	0,02	0,14	0,08	0,15	0,04	-	-
Silverside	102,8	142,7	256,3	147,2	301,4	252,2	163,2	280,6	315,5	371,3	380,6	481,6
Gobies	36,5	48,4	37,7	37,0	22,8	24,7	25,4	26,5	25,7	20,0	0,8	1,28
Golden mullet	0,01	0,30	7,92	18,53	15,03	0,04	0,4	-	4,08	20,60	0,40	0,74
Anchovy	2,0		-	-	-	-	-	1,0	-	-	10,7	-
Haarder	0,9	1,7	-	1,34	0,40	0,13	0,80	1,02	2,74	3,34	-	0,06
Shrimps	-	-	-	0,02	-	-	0,06	0,15	0,39	-	-	-
In total:	142,2	193,1	302,2	204,2	339,7	277,1	190,0	309,3	351,7	415,4	392,5	483,7

The total catches of haarder in Tiligul Liman for 12 years of fishing from 2002 to 2013 amounted to 12.4 tons, on average 1.0 ton per year, and on the base of present research it appears that the stock of this species of fish could be ten times more.

For example, in the neighboring Khadzhibey Liman where except nets the twin trawl is used to catch haarder, annual production in 2005-2013 was on average 426 tons. In 2013, in Khadzhibey Liman record number haarder – 905.1 tons – was caught. In the catch individuals aged 2-3 years (82.9%) dominated. The maximum size of the caught fish does not exceed 39.0 cm (900 g weight). Individuals of older age groups have not been found in the catches from 2011 to the present time. That is the evidence of their low relative abundance and, according to our estimates, is the result of intensive fishing [6]. Despite these catch volumes and absence of older age groups in the catches, the stock of haarder in Khadzhibey Liman is constantly regenerated through effective spawning and high fertility of this species of fish. According to Yu. V. Pryakhin [13], fertility of females of haarder in the Azov Sea weighing 0.9 kg at the age of 3+ averaged 0.55 million eggs (maximum – 6.0 million eggs). With such a high fertility in

conditions of effective natural spawning even a small number of mature individuals of haarder able to quickly replenish their stocks.

In comparison with Khadzhibey Liman size-age structure of the haarder population in Tiligul Liman is significantly different. Much higher relative abundance of mature individuals in Tiligul population (at least, until the mass death during winter 2014) testifies its extremely high reproductive potential. In this regard, it is clear that all the recommendations, proposed previously [14-16], for seeding the Tiligul Liman by haarder especially on a large scale, lose its relevance.

Forecast of the abundance of commercial stocks of haarder in Tiligul Liman in the long run depends on two questions: what part of its producers died in January 2014? How successful was wintering of fish aged 0+ and 1+?

Conclusions and recommendations

1. In Tiligul Liman large self-reproducing isolated population of haarder, which includes individuals of at least 6 age groups, is formed. The data from the catches of fishing gear used on the estuary (fyke nets and gill nets), do not allow to make representative assessment of stocks of this species of fish. The actual size of the population according to the observations of the winter 2014 was much higher than expected.

2. Meteorological and hydrological conditions (prolonged cold snap and gale force winds, intense convection of water masses at low temperatures and significant salinity) led to the death of mature individuals of haarder in the moment of ice formation on the estuary (at least 335 t).

At the same time and under the same conditions, the death of young haarder and native species of the Black Sea mullet did not registered.

3. Fishing gear (set nets) used on Tiligul Liman, do not provide effective fishery stocks of *L. haematocheilus*.

In connection with the above mentioned the introduction of these fishery activities is recommended:

- to use active gears (purse seine) for fisheries of haarder, except the ineffective fixed nets;

- the volumes of haarder production have to be corrected annually according to results of the catch;

- to reliable assess the status of haarder population in Tiligul Liman it is necessary to conduct monitoring ichthyological studies to analyze age and gender, size and mass structure of the population, spawning efficiency, determination of stock of *L. haematocheilus*. It is necessary to identify and map all potential winteringof adults and juveniles of haarder;

- to prevent the loss of Tiligul Liman as a fishery water body and turning it into hypersaline liman as Kuyalnik Liman, it is recommended to immediately begin dredge and deepening of channel connecting the estuary with the sea.

Normal functioning of the channel will contribute to the overall stabilization of the ecosystem, increase its productivity and fishery. Only in condition of sufficient water exchange and with the depth channel of at least 1.5 m will be available in autumn output Black Sea species of mullet and haarder of the estuary to the sea, which will continue to avoid undue death of fish in the Tiligul Liman in winter.

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