Chapter 17
Impact of Gidrometerogical Conditions on Smelt Spawning Migration and Catch Fluctuations in the Rivers of Curonian Lagoon Basin

Anna Burbakh and Sergey Shibaev

Abstract Smelt together with dwarf smelt (resident form) are the most important fishing targets in Kaliningrad oblast in the spring. At the beginning of the twentieth century, their catches reached up to 9 thousand tons (Germany—USSR); currently, the catches do not exceed a thousand tons. Until 2010, the fishing was performed directly in the Curonian Lagoon, since 2011 the role of the Curonian Lagoon-Neman River transit system in fishery statistics has been increasing. The transit system includes the lower course of the Neman River (the Skirvite arm, the Vitine and Atmata rivers) and the Matrosovka River. The restructuring of the fishery system was affected by climatic factors and changes in the legislative regulation of smelt fisheries. The climatic factors, first, the ice regime, determined the new dislocation of the fishery. Changes in fishery legislation in 2011 were accompanied by engagement of a larger number of fishing enterprises and fishermen in smelt fishing and an increase in the fishing efficiency. At the same time, the problem of accurately predicting the allowable volume of catches still exists, because smelt is a species that is very susceptible to the environmental impact. We analyzed the dynamics of spawning migration and catches depending on hydrometeorological factors, such as water temperature during different periods of spawning migration, the rate of water warming, the day of fish migration to the rivers (length of daylight), wind regime. According to the data obtained, it can be concluded that the migration pattern and the volume of catches depend on the rate of water heating and photoperiod, the earlier the migration starts and more gradually water heating occurs, the higher the total catch will be.

Keywords Smelt · Dwarf smelt · Curonian Lagoon · Neman River · Catch · Water temperature · Migration duration · Wind regime

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17.1 Introduction

The smelt is an anadromous species that is very susceptible to environmental effects (Repečka and Gerulaitis 1994). Numerous studies of Russian and foreign researchers have been devoted to the smelt biology as an important commercial species (Gaigalas 1980; Manyukas 1959; Shibaev et al. 2012). Despite the more or less studied biology of the species, the problem of accurately predicting the allowable volume of catches still exists (Ryabchun et al. 2020), i.e. it can be concluded that the smelt fishery is affected rather not by the population size, but by hydrometeorological factors that can affect the spawning migration of smelt, and, accordingly, its yield. This issue was considered only in the work of the Lithuanian researcher in regard to the catches in the Curonian Lagoon (Svagždys 2009).

Table 17.1. Both smelt (*Osmerus eperlanus eperlanus* L.) which lives in the Baltic Sea, and its resident freshwater form (*Osmerus eperlanus eperlanus morpha spirinchus* L.) play an import role in commercial fisheries; they together belong to the family Osmeridae and in the fishery statics, their total catches are usually reported. Fishery is conducted on spawning routes, namely in the Curonian Lagoon and in the Curonian Lagoon-Neman River transit zone, which includes the lower course of the Neman River (the Skirvite arm, the Vitine and Atmata rivers) and the Matrosovka River. The fishery in the transit zone was not sufficiently developed until 2011 for several reasons. First, the fisheries regulation based on the system of the total allowable catch did not allow a large number of commercial enterprises and fishermen to perform fishing, since the quota was distributed among four fishing collective farms according to the historical principle. This approach often led to an underutilization of the quota, especially in years when the ice breakup in the lagoon occurs later, and it was impossible to use set gillnets in the lagoon for the

Table 17.1 Temperature regime during the spawning migration of smelt, 2012–2020 (prepared by the authors)

Year	Migration start date	Duration, days	Water temperature at the start of migration, °C	Water temperature during high speed of migration, °C	Water temperature at the end of migration, °C
2012	20 March	8	0.7	3.8	3.8
2013	6 April	13	1.4	3.5	3.8
2014	11 March	15	1.0	3.9	4.3
2015	27 February	22	1.0	2.0	2.1
2016	27 February	28	2.0	3.0	3.4
2017	03 March	23	0.3	3.0	3.8
2018	25 March	24	1.0	3.0	5.9
2019	03 March	20	2.0	4.0	5.8
2020	27 February	28	2.0	3.2	4.2

quota utilization, and therefore smelt migrated to rivers where commercial fishermen were ready to fish, but their quotas were insufficient for large volumes of catches. Second, the lack of a sufficient number of fishing sites on the rivers, since after the collapse of the USSR, the main fishing sites on the rivers of the Curonian Lagoon basin became part the Lithuanian territory. Russian fishermen were traditionally fishing in the lower reaches of the river, mainly in the Skirvite arm. But in 2012, the possible recommended catch (RC/PC) became an alternative to the system of fishery regulation based on total allowable catch (TAC) which made it possible to develop fisheries in rivers (Anuryeva et al. 2015; Burbakh et al. 2019; Burbach 2021).

The aim of the work is to identify the main hydrometeorological factors that affect the dynamics of the spawning migration and smelt fisheries in the Curonian Lagoon-the Neman River transit system.

17.2 Materials and Methods

This work is based on the data of monitoring surveys at fishing sites in the period from 2012 to 2020. Fish sampling was conducted in different sections of the Curonian Lagoon-Neman River transit system, depending on the tasks: in the lower reaches of the Neman River, in the Matrosovka River outflowing the Neman River downstream of the city of Sovetsk, and in the Deyma River (2020) near the fishing sites of fishing brigades in the current year (see Fig. 17.1).

All data on temperature and water level fluctuations in the transit system were obtained directly by the authors.

17.3 Results

The maximum historical catch of smelt was 8.8 thousand tons in 1935 (Osadchiy 2000), in the modern period such a value has never been achieved. The Russian catches after the collapse of the USSR range from 24 to 541 tons, averaging 188 tons.

The year of 2010 is a turning point in the history of smelt fishery. That year, the winter was very cold and prolonged, the lagoon was covered with ice for a long time, therefore, fishing with set gillnets was impossible. As a result, the total catch in 2010 amounted to 23 tons; it is the minimum value for the last 30 years.

Since 2011, there was a tendency in Russia to relocate fisheries to the rivers of the Curonian Lagoon basin, which has become possible for several reasons. First, in some years the ice breakup starts late in the lagoon. Second, the fishing regulations changed. Thus, in 2012, smelt was transferred to the category of aquatic biological resources, for which the total allowable catch (TAC) was not established, but the recommended (possible) catch (RC/PC) was defined. As a result of the transition to the system of the recommended catch (RC/PC), all interested fishing enterprises

Fig. 17.1 Map of the fishing brigades locations and smelt migration ways (compiled by the authors)

and fishermen receive fishing permits for the use of aquatic biological resources, and fishing is carried out according to the "Olympic system". The new regulatory system has made it possible to increase the efficiency of fishing. The allowable volume of catches increased from 38 to 81% (Fig. 17.2).

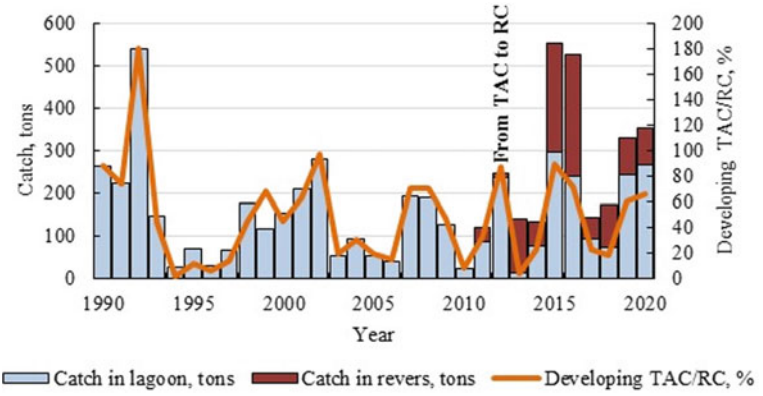

Fig. 17.2 Long-term dynamics of commercial catches of smelt and developing of the allowed volume of production

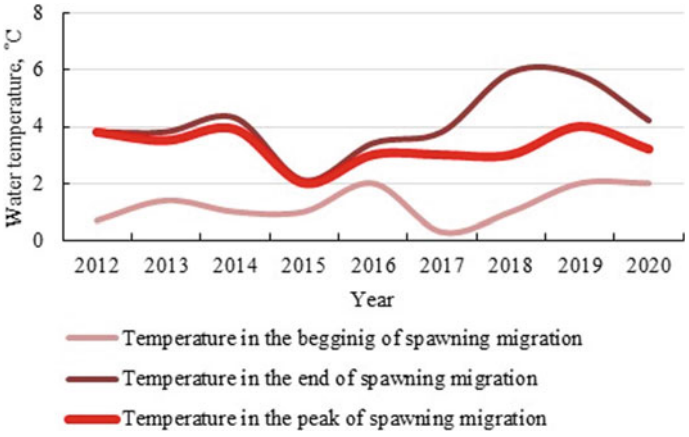

Fig. 17.3 Temperature regime during spawning migration of smelt to the rivers of the Curonian Lagoon basin (compiled by the authors)

In some years, the catch volume exceeds the recommended one, but this fact does not have a negative impact on the smelt stock.

We paid attention to the main hydrological factors that can affect the dynamics of the spawning migration and catches such as water temperature during different periods of spawning migration, rate of water warming, the day fish enter the rivers (the length of daylight), wind regime.

During the research period, smelt enters the Curonian Lagoon-Neman River transit zone in different periods, usually at the end of February or early March, less often at the end of March or mid-April, usually at a temperature of 1.0–1.5 °C, only in 2016 it was recorded at a temperature of 2 °C. The spawning migration ends at a water temperature of about 4–6 °C, i.e. at spawning temperatures, the period of intensive migration is observed at a temperature of 3–4 °C (see Table 17.1, Fig. 17.3).

When comparing the data on catches in the rivers with the average water temperature during the period of intensive migration, when the maximum catches are recorded, it is found that the temperature affects rather not the amount of total catch and the duration of migration, but the time of entry and termination of migration, this in turn determines the results of fishing. Thus, in 2012, when the average temperature was 3.5 °C during the period of intensive migration, the yield in the rivers was 252 tons, and in 2014, at the same temperature, the yield was 54 tons. At an average temperature of 3 °C during the intensive migration, the catches differ, amounting to 275 and 50 tons in 2016 and 2017, respectively (see Fig. 17.4).

Another important factor determining spawning migration is the rate of water warming. At slow water warming, the spawning migration is gradual and long. Accordingly, the catches per effort are low, but the total catch is higher than in years when warming period is short. The most durable migrations were recorded in 2015 and 2016 (23 and 30 days, respectively); at that time the catches in the rivers were maximal and amounted to 257 (2015) and 286 tons (2016) (see Fig. 17.5).

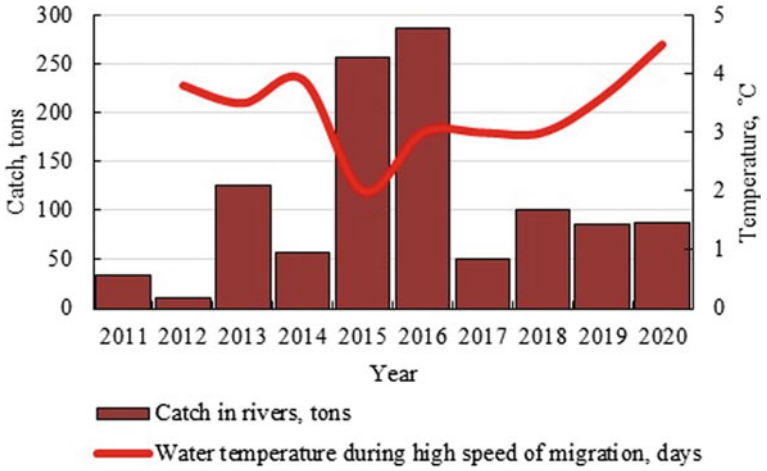

Fig. 17.4 Temperature regime during spawning migration and its impact on smelt catches in rivers (compiled by the authors)

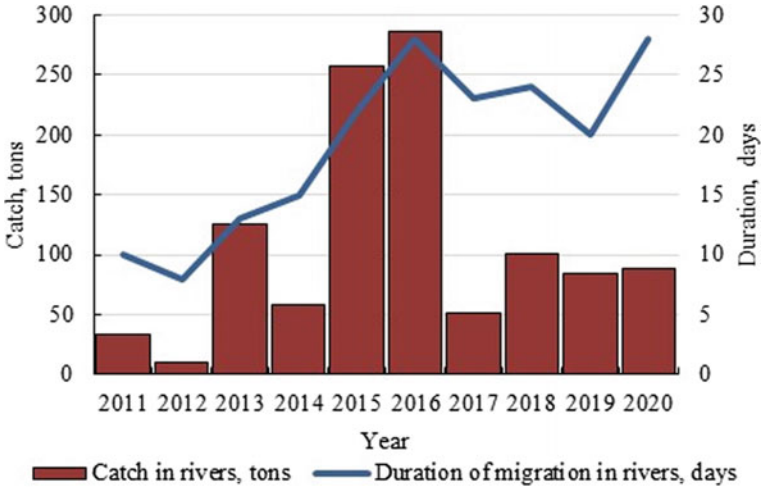

Fig. 17.5 Relationship between smelt catches in rivers and duration of spawning migration (compiled by the authors)

At the same time, the rate of warming has an impact in combination with other hydrometeorological factors, which does not allow conducting the direct correlation analysis. Thus, in 2018, the duration of the spawning migration was 22 days, and the yield was low (100 tons).

The study of the temporal dynamics of the spawning migration showed that the date of its beginning is not always correlated with the water temperature, but has its own deterministic period. It was found that at an earlier migration into rivers, the yield

is higher (the correlation coefficient is 0.7, which indicates a strong dependence). Conversely, the later the water temperature reaches the optimum for the beginning of the spawning migration, the smaller the catch value is (see Figs. 17.6 and 17.7).

The water level during the spawning migration varied between 1.9 and 3.4 m. The average fluctuation of the level during the spawning migration of smelt in the Skirvite River is 10–15 cm. The dependence of the water level on the daily dynamics of catches was not found (see Fig. 17.8). The effect of the water level on the total catch in the rivers was not also found (see Fig. 17.9).

The wind regime is an important factor during the spawning migration. It should be mentioned that, an important condition for smelt to enter the Neman River is "silence", i.e. when the ice breaks or the wind is strong, the fish cannot enter the rivers because they are deterrent factors. The depth of the Skirvite River in the

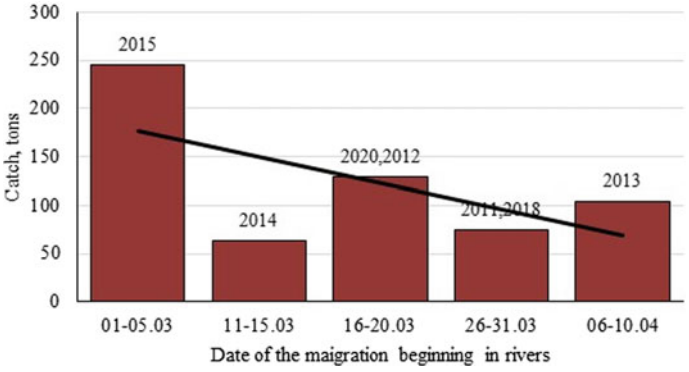

Fig. 17.6 Relationship between smelt catch in the rivers and the day of entry into the rivers of the Curonian Lagoon basin by years (compiled by the authors)

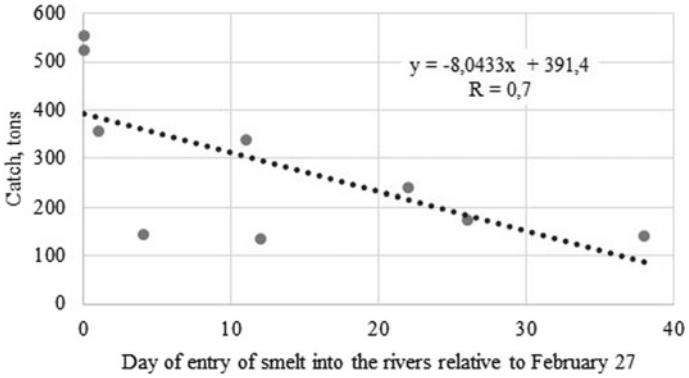

Fig. 17.7 Relationship between the catch of smelt in the rivers of the Curonian Lagoon basin and the day of entry into the rivers relative to the date of the earliest start of spawning migration (compiled by the authors) (x-day of entry of smelt into the rivers relative to February 27, y-catch)

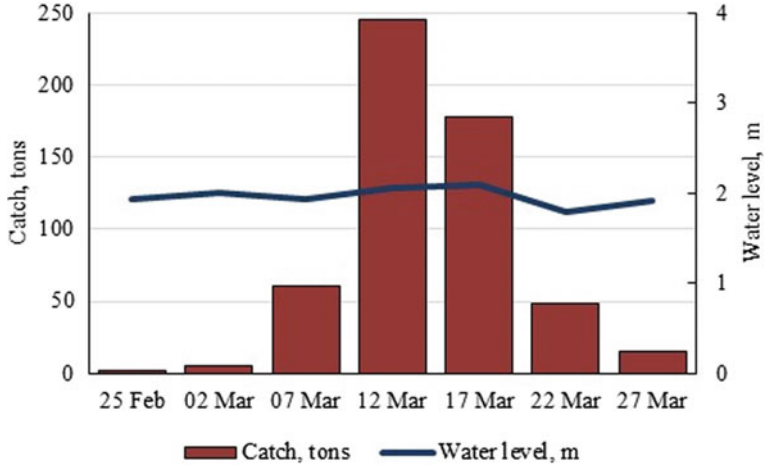

Fig. 17.8 Level regime during the spawning migration period and its impact on the smelt catch by the dates of fishing (compiled by the authors)

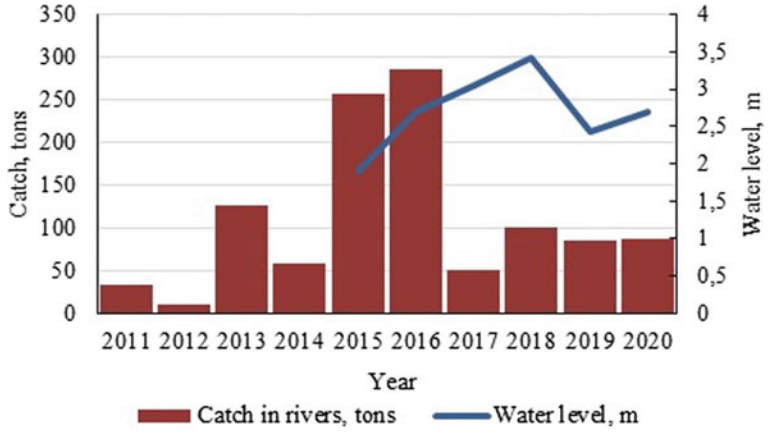

Fig. 17.9 Level regime during spawning migration and its impact on smelt catches in rivers (compiled by the authors)

mouth part during this period is no more than 0.5 m, which makes it impossible for the smelt to descend to avoid the action of the wind. Provided that strong winds blow during the fishing season, the efficiency of fishing also decreases, due to the fact that the "shoal breaks" and the fish move separately.

17.4 Conclusion

In modern conditions, there has been a redistribution of smelt catches between the Curonian Lagoon and the rivers of its basin. In some years, the share of smelt catches in the rivers reaches 90% (2013), on average over the past 10 years, the share of catches in the rivers has been 40–50%. The period of smelt spawning migration in the rivers is at the end of February-beginning of April, and depends on hydrological factors. The beginning of migration is usually timed to water warming to a water temperature of 1.0–1.5 °C, the peak of the migration is observed at a temperature of 3–4 °C, at a higher temperature, solitary specimens are found in catches. The slow water warming and the early beginning of the migration determine the maximum catches of smelt, so in 2014 the spawning migration lasted 15 days and the total catch was 58 tons, whereas in 2016, the catch was 5 times higher for 28 days.

Due to the different fishing modes, set gillnets are used in the lagoon, and beach seine in the rivers, a separate system of fisheries regulation is necessary. The transition from the regulation of smelt fisheries according to the system of the total allowable catch, which is distributed by quotas among fishing enterprises to fisheries according to the "Olympic system", the utilization of the total quota by all fishing enterprises, ensured self-regulation of fishing depending on the intensity of the spawning migration in each particular year.

Due to the fact that intensive spawning migration and smelt fishery lasts 5–7 days, and then stops, the by-catch of related species, with the exception of ruff, corresponds to the concept of an ecosystem approach.

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