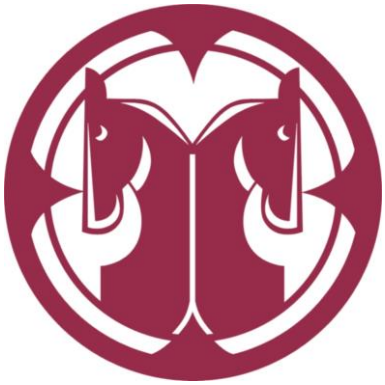
UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN

FACULTY OF ANIMAL BIOENGINEERING



Adam Marcin Lejk, M.Sc. B.Sc.

BIOLOGICAL AND MANAGEMENT DETERMINANTS OF SEA TROUT *SALMO TRUTTA* M. *TRUTTA* L. SPAWNING STOCK DYNAMICS IN THE ŁEBA RIVER BASIN

Doctoral dissertation conducted
under the direction
Piotr Gomułka, PhD., associate Professor

Olsztyn, 2022

Summary

Biological and management determinants of sea trout
Salmo trutta m. *trutta* L. spawning stock dynamics in the Łeba River basin

Adam Marcin Lejk, M.Sc. B.Sc.

Brown trout, *Salmo trutta* L., is a member of the family Salmonidae. Since the species is highly plastic, it has evolved into a number of ecological forms that inhabit various ecosystems. The life cycle of the anadromous form of brown trout, *Salmo trutta* m. *trutta*, is divided into two stages that inhabit two different habitats. This species spends its early juvenile life-history stage in the upper reaches of rivers and streams, while it spends its adult life-history stage in the sea. The sea phase is marked by migration in search of suitable feeding grounds depending on its life strategy. In the marine environment, sea trout feed and grow intensively. Most often, after one or two years in the sea, some individuals mature sexually and begin the spawning migration to their natal rivers where they were born or into which they were released. This phenomenon, known as the homing instinct, means that each river has a specific stock of fish characterized by certain genetic features and adaptations to local conditions. Sea trout reproduce in the fall and winter, and spawn in rivers and their tributaries. During spawning, female sea trouts lay their eggs on a gravel bed, building a so-called redds. The young sea trouts hatch in spring, from March to May. Juvenile sea trout most often spend from one to four years in rivers, after which they smoltify, which is the process of physiologically adapting to life in a marine environment, and then they migrate to the sea.

Migratory salmonids are excellent bioindicators of changes occurring in the natural environment. The complexity of their life cycle and their high sensitivity to low oxygen concentrations, high water temperatures, and hydrotechnical barriers in streams mean that their population abundance and range of occurrence are continuously changing. This species is of great economic value and natural importance, which is why sea trout smolts, summer fry, and larvae are stocked into Polish rivers annually. Thanks to these measures, the population abundance of this species is being maintained at a satisfactory level. Identifying the origin of individuals is possible by applying marking methods that are appropriate for different life-history stages of this fish. Marking makes

it possible to evaluate the effects of the stocking carried out and their impact on the recruitment of the spawning stock. Being able to discriminate fish that were stocked from those that were spawned naturally facilitates managing stocks accordingly from the juvenile through to the adult stages.

In the past, the sea trout population in the Łeba River basin was not the subject of intense study. While data regarding selected aspects of the ecology and biology of this species are available, they do not form a coherent whole. As part of the present study, field work and laboratory analyses were conducted that permitted characterizing the sea trout spawning stock from the Łeba River basin and following changes in the stock over the course of a decade. Additionally, an attempt was made to estimate the influence stocking had on the formation of spawning stocks. Simultaneously, the selected Łeba River tributaries that are currently being used in the stocking management model in the Łeba River basin were evaluated for their suitability as sites in which juvenile sea trout can develop.

Field work was conducted in Słowiński National Park in 2007–2016 with the aim of characterizing the structure of the sea trout spawning stock in the Łeba River basin. Biological material collected from adult sea trout individuals was used to determine the biological parameters of the spawning stock. Identifying individuals originating from stocking was done on two levels. Stocked smolts had been marked externally with adipose fin clipping that permitted identifying them immediately among adult individuals. For anatomical reasons and associated limitations, in the 2010-2013 period prior to release as larvae, sea trout were marked at the Fish Farm in Żelkówko by immersion in a fluorochrome solution of alizarin red S. This substance forms stable complex compounds with calcium ions thanks to which it is deposited as a red band on fish otoliths. Individuals that originated from stocked fry were identified from among those that had clipped adipose fins, and otoliths were collected exclusively from these individuals for examination.

From 2010 to 2013, larval sea trout marked with alizarin red S were released into selected streams each spring, and each September from 2010 to 2013 monitoring catches of young-of-the-year sea trout were made at sites that were each 50 m long. The catch results were supplemented with temperature data at the sites throughout the juvenile sea trout growth periods to identify the interactions between stream temperatures and early stage fish growth. Full hydrographic data was also collected at the monitoring stations.

The results of the study showed the variability of growth parameters over ten years of observation, which applied to both sexes. Currently, smolts aged 1 year dominate the sea trout population in the Łeba River basin, and, depending on their origin, 72.1% are wild, while 98.9% are cultivated. Among the wild fish, 27.7% are two-year-old smolts, while only 0.2% are three-year-old smolts. Just 1.1% of stocked smolts do not migrate to the sea and instead spend another winter in freshwater streams. Studies indicate that the sea age of the spawning stock is dominated by individuals that have inhabited the sea for either one or two years, and seasonal differences were observed between these age groups. The cumulative share of one-year-old individuals (62%) indicated that younger fish dominated the spawning stock, while approximately 36% of the individuals inhabited the sea for two years. In comparison with historical results, the population age structure has changed significantly over the last 70 years, and the share of sea trout individuals that smoltified after the first year wintering in streams has increased. Moreover, a decrease was noted in the share of older individuals in the spawning stock, which could have been caused by the negative effects of excessive fishing pressure. Similar observations pertained to fish growth; the mean sea trout body length decreased from 65.9 cm in the 1950s to 59.9 cm in the current study.

One important aspect of managing sea trout resources in the Łeba River basin was determining the share of fish from stocked larvae and smolts and from natural spawning, which was done through observations. On average, over 61% of adult sea trout originated from stocked smolts. Among the remaining sea trout, 77.7% originated from natural spawning. Alizarin red S marks were found in 22.3% of the fish, which confirmed their origin from stocked larvae. The results of marking larvae with alizarin red S are noteworthy since these are the first results of their kind to confirm that individuals released as larvae are now contributing to the formation of spawning sea trout stocks in the Łeba River basin.

The results of the current study indicated the strong influence stocking with sea trout smolts had on spawning sea trout stock dynamics in the Łeba River basin. The differences observed between wild and hatchery-reared individuals pertained to various population aspects, ranging from basic growth parameters, such as spawner length and body weight, to age structure models, and variable condition. Only in female fertility were no differences noted, but this must be verified on a larger number

of individuals. Moreover, the origin of the individuals determined periods of intensifying spawning migrations, which indirectly affected differences in stock age and sex structures.

The current study indicated the suitability of the streams selected for stocking larval sea trout for growth into juvenile sea trout. Over the four-year observation period differences were noted among the various sites, and these were also reflected in differences in condition. The density of juvenile sea trout in the 0+ age group at the sites monitored ranged from 22–130 indiv./100 m^2, while juvenile sea trout marked with alizarin red S were identified at all the sites monitored in all seasons of the study (2010–2013). The shares of marked fish were from 30 do 100% throughout the study period at an average of 85.4%. The thermal regime in the selected streams strongly affected the fish that originated from stocked alevins. The total number of degree days had a significant, positive affect on juvenile sea trout growth. Simultaneously, the maximum values for mean 7-day water temperatures in July had a significant, negative affect on growth in a given season. These relationships were not noted in juvenile sea trout originating from natural spawning. This is an important observation in light of the ongoing climate change and for making possible changes to stocking strategies in the future.

The results of this work permit concluding that stocking tributaries in the Łeba River basin with sea trout alevins had a positive effect on spawning stocks. Moreover, the dominance of individuals originating from stocked smolts indicated the great importance of stocking itself in the management of this population. In addition to the stocked fish, individuals from natural spawning were an important component of the stocks. To optimize the effects of stocking with younger sea trout stages while simultaneously enhancing the importance of natural reproduction, stocking should be performed in tributaries that lack natural spawning grounds or in stream segments located upstream from artificial barriers. The negative impact fishing pressure has on spawning stock structure by eliminating larger, older individuals is a worrying phenomenon.

Key words: age structure, fecundity, fry growth, fish marking, stocking effectiveness