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Kristensen, Martin Lykke; Birnie-Gauvin, Kim; Aarestrup, Kim; Sivebæk, Finn

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Sea trout behaviour in the Limfjord - a fascinating display of the adaptability of the species?

Almost all surviving acoustically tagged sea trout smolts and kelts left a Danish fjord system using a similar 120 km long route. They also left with the highest recorded progression speed ever reported for sea trout in the literature. The repeatability of the behaviour and the geographical history of the Limfjord suggest that the sea trout are adapted to the specific conditions found in the area.

The Limfjord is the longest fjord in Denmark, crossing the entire width of the Jutland peninsula. Some of the most important Danish sea trout rivers exit into the fjord. To complete their marine stage, the fish can remain within the fjord, or migrate to sea. If they migrate to sea, the fish can exit the fjord through both a Western exit into the North Sea and an Eastern exit into the Kattegat Sea. Two recent studies have investigated the migration of smolts and kelts from two of the largest rivers exiting into the central part of the fjord, with the aim of exploring their behaviour and survival in the fjord. Is the Limfjord home to some 'fjord residents'? If not, which exit will the fish use?

The results were obtained by tagging 101 smolts and 160 kelts from River Karup and River Simested with acoustic tags, and following their migration with Automatic Listening Stations strategically placed throughout the fjord. The fish from the two river systems behaved similarly in the fjord despite the river outlets being located roughly 35 km apart. Survival in the fjord was low. After a short period of residency near the river mouths, the vast majority (98 %) of the surviving fish migrated the 120 km to the Kattegat Sea through the Eastern exit within a narrow window of time. Only 2 % of kelts ($n = 2$) stayed in the fjord (none of the smolts did so), and no fish left the fjord using the 110 km long (and thus shorter) western route to the North Sea. Notably, this route has only existed since 1825, when a storm opened the Limfjord to the North Sea. The kelts spent a mean of 4.5 days (range: 2.8 – 11.6 days) migrating through the final 103 km of the fjord, with mean progression rates increasing to 43.6 km d⁻¹ (range: 10 - 86 km d⁻¹) in the narrow final 29 km before reaching the sea. This is the highest linear progression rates ever reported for sea trout in the scientific literature.

The observed sea trout-behaviour in the Limfjord system is unique compared to observations in fjord systems elsewhere. Sea trout have been documented to stay close to the river mouth throughout their

marine period in several other systems, but the Limfjord could be a dangerous place to exhibit this strategy. Our results reveal that only 20 % of the smolts had survived their trip through the Limfjord, and 64 % of the kelts that entered the Limfjord ended up dying or being lost in it. The cost of residing in the Limfjord therefore appears high. The relatively constant, fast and highly directed movement recorded for both smolts and kelts from the two different river systems in our study could reflect important local adaptations to survive in this dangerous fjord. Previous studies with genetic methods have documented that non-native sea trout stocked in the region during the 20th century failed to survive in the Limfjord, possibly as a consequence of them not being adapted to these unique local conditions the way that wild fish are.

Our results therefore highlight the potential adaptability and behavioural flexibility of sea trout in marine environments, and further demonstrate the importance of conditions in the marine environment for the survival and behaviour of sea trout.

Smolt behaviour and survival in the Limfjord

Kelt behaviour and survival in the Limfjord

Af Martin Lykke Kristensen, Kim Birnie-Gauvin, Kim Aarestrup and Finn Sivebæk, DTU Aqua, Institut for Akvatiske Ressourcer.

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