

A shift in the regional climate regime strongly affects Peipsi fish

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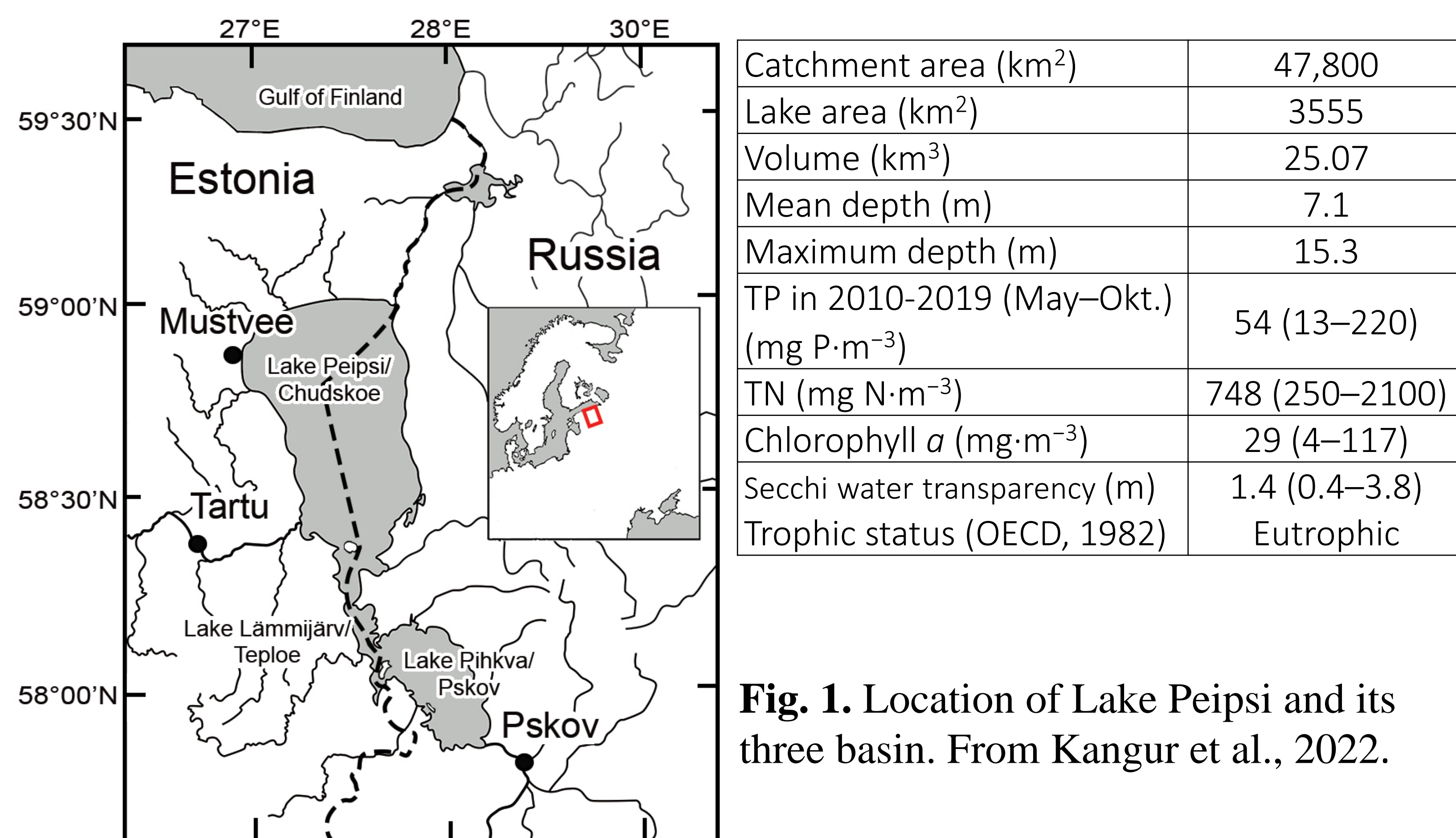


Fig. 1. Location of Lake Peipsi and its three basin. From Kangur et al., 2022.

Introduction Fish populations in northern latitude lakes are strongly impacted by climate warming. This is particularly evident in L. Peipsi (Fig. 1), as climate change favour warm-water species such as pikeperch (*Sander lucioperca*) or bream (*Abramis brama*), and inhibit the survival of cool-water species such as vendace (*Coregonus albula*), Peipsi whitefish (*C. lavaretus maraenoides*) and burbot (*Lota lota*). At the turn of the 1980-1990 decade, a significant shift in the Peipsi fish community took place (Fig. 2), which coincided with a recorded shift in the regional climate regime in Europe, including Estonia (Jaagus et al., 2017).

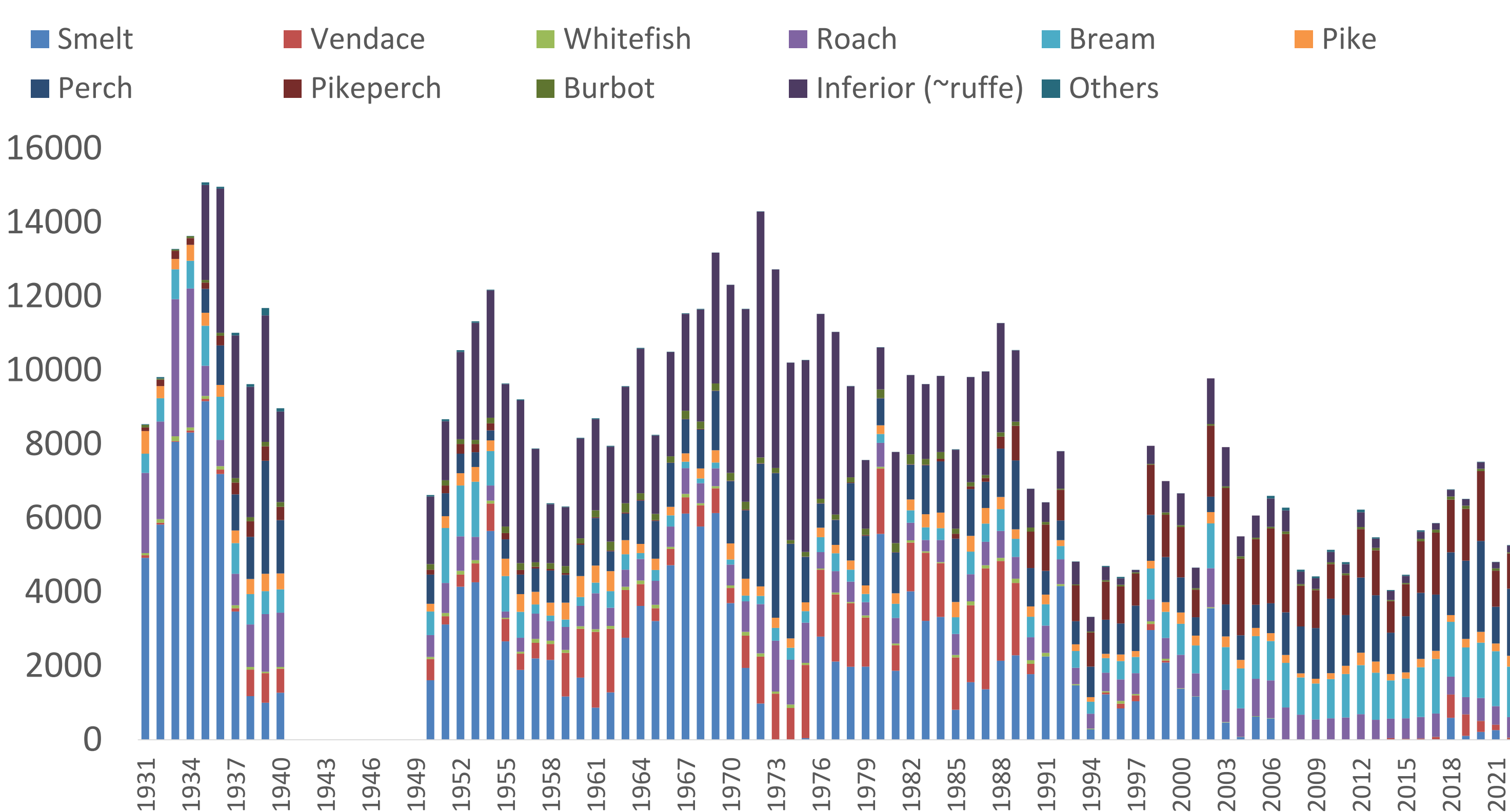


Fig. 2. Catch statistics by species (tons) on L. Peipsi 1931-2022.

Methods We applied the first time the “mean temperature of the catch” (MTC) concept (Cheung et al., 2013) to freshwater species. The MTC index was computed from the preferred temperature of the fish species caught from the lake and the size of their catch by species in the years 1931-2022. The preferred temperature of each of the ten target fish species was obtained from the literature. The analysis of the MTC time series thus obtained with a segmented regression yielded two trend lines (Fig. 3).



References

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- Jaagus, J., Sepp, M., Tamm, T., Järvet, A., Mõisja, K. (2017). Trends and regime shifts in climatic conditions and river runoff in Estonia during 1951–2015. *Earth System Dynamics*, 8, 963–976. <https://doi.org/10.5194/esd-8-963-2017>
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Results We found that up to 1986, the MTC oscillated around 14.5 °C, while from 1987 onwards it increased strongly - 0.85 °C per decade. This makes the MTC for entire periods resemble the hockey-stick figure typical of global warming studies.

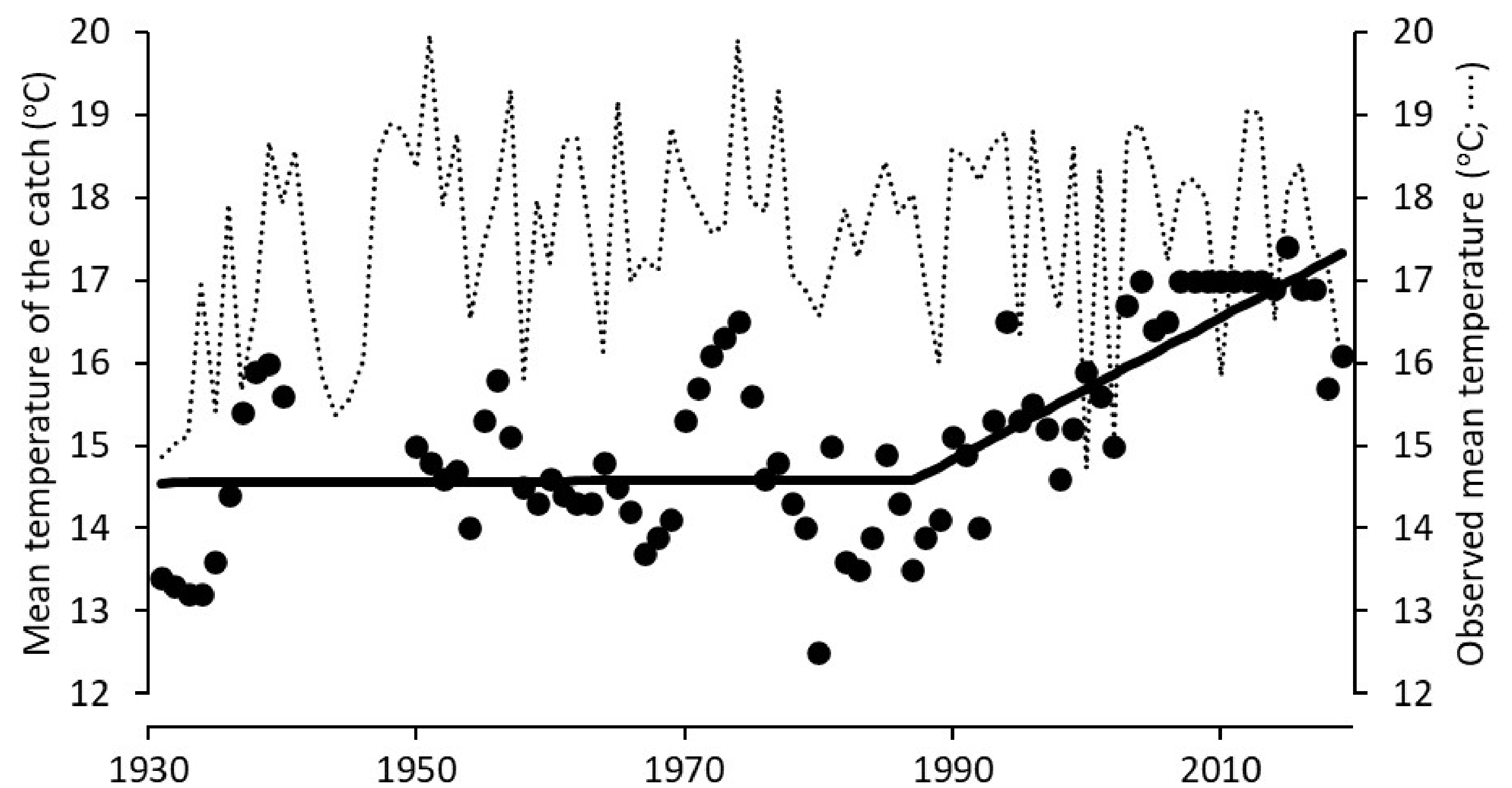


Fig. 3. Segmented regression of the time series of MTC (the horizontal 1931-1986, and the ascending 1987-2019).

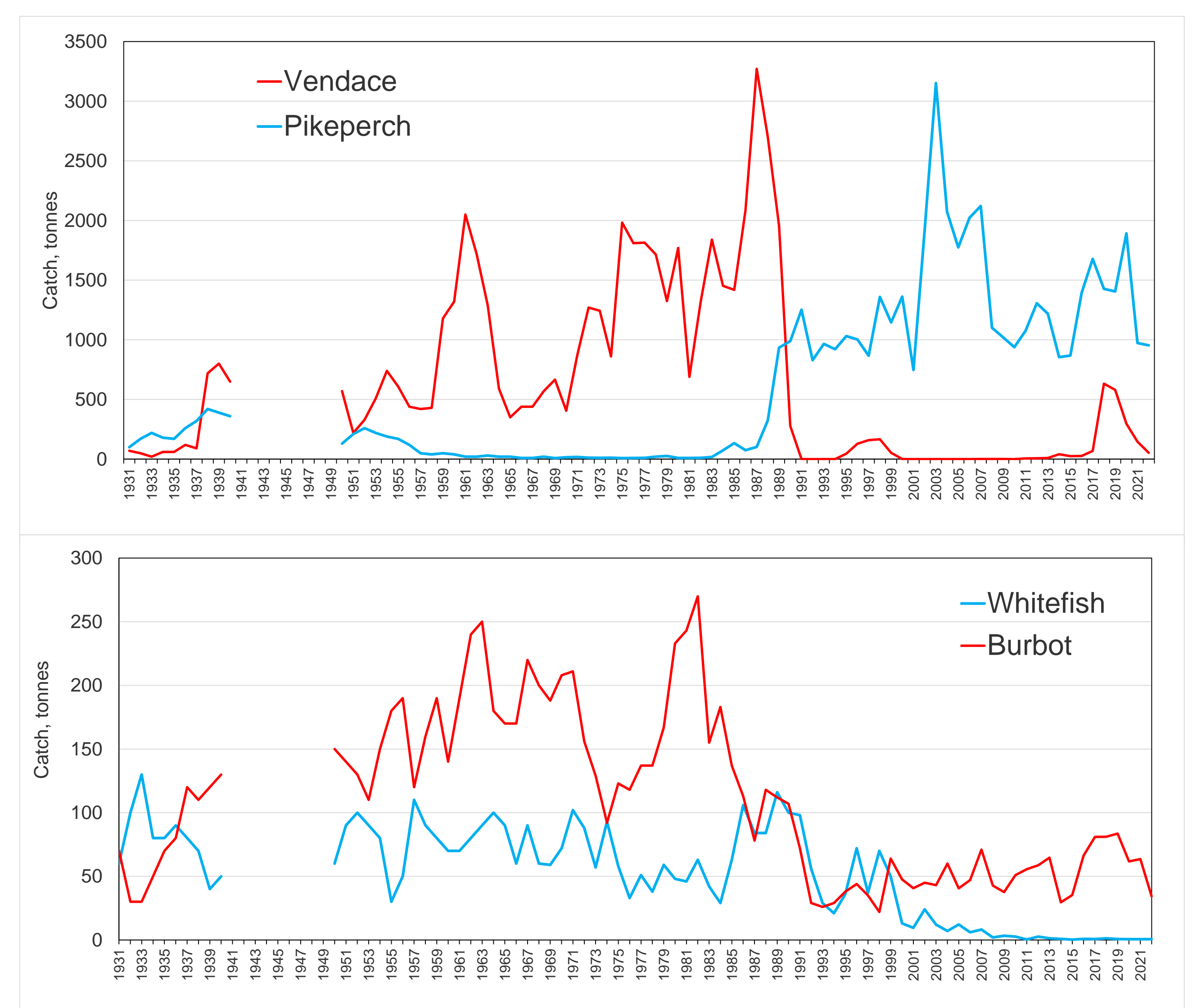


Fig. 4. Annual catches of warm-water pikeperch and cool-water species such as vendace, whitefish and burbot from L. Peipsi.

Fish communities in large shallow lakes such as Peipsi normally respond to short-term extreme climatic events (heat waves, unstable ice cover) rather than to slow rises in average water temperature. Thus, the MTC index reflects the abrupt increase in water temperature recorded at the end of the 1980s, which was linked to the decline of cool-water species and collapse of the vendace population; the hot summer of 1988, which was accompanied by a severe cyanobacterial bloom and extensive fish kill, and the subsequent non-permanent ice cover and early ice-offs in 1989 and 1990, which led to the disappearance of vendace from catches in 1991 (Fig. 4).

These events were determinant for the MTC trend of 0.85°C per decade, which is stronger than the MTC trends we have seen for the world’s Large Marine Ecosystems of 0.19 °C per decade and even for the East China and Yellow Seas, of 0.55°C per decade.

Conclusion

- MTC index can be used for comparing the vulnerability to global changes of freshwater ecosystems.
- Our results show that the fish community of Peipsi reacts more strongly to temperature changes than marine ecosystems so far studied using the MTC.
- Heat waves and erratic winters seems to be the recent overwhelming pressure to fish and fisheries in Lake Peipsi.
- Changes in the fish assemblages of Peipsi indicate that the stability and resilience of the whole ecosystem has weakened.

