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# Effect of longitudinal training dams on environmental conditions and fish density in the littoral zones of the river Rhine

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## Introduction

Biodiversity and functioning of rivers is increasingly threatened by hydraulic engineering facilitating navigation (e.g., channelization, dredging and protection of embankments). These changes reduce channel sinuosity and habitat diversity. In addition, navigation causes water displacements, increased wave action and changes in, shear stress, flow velocity and underwater sound.

The decreased habitat diversity due to navigation deteriorates spawning and nursery habitats and affects diversity and productivity of migratory and riverine fishes (Wolter and Arlinghaus 2003). Embankments and groynes are often constructed using basalt stones and other rocks serving as habitat for several alien species (Leuven et al. 2009).

With the implementation of the Water Framework Directive the focus of river management changed from technology based to taking ecological values into account. This vision culminated in the Netherlands in the 'Room for the River' programme. As part of this programme existing groynes structures were removed and replaced with longitudinal training dams (LTDs) along a 10 km stretch in the river Waal.

LTDs are novel river training structures placed parallel to the river bank thereby protecting the littoral zones from navigation induced impacts (Collas et al. 2018). The LTDs in the river Waal serve multiple functions: 1) to increase and maintain water depth for navigation, 2) to increase discharge capacity for improved flood safety, 3) to facilitate the safe discharge of ice to protect hydraulic infrastructure and river dikes, 4) to reduce fairway maintenance costs (dredging), and 5) to increase habitat diversity and stability by creating sheltered shore channels (Eerden, 2013).

The objective of the present research is to assess the effects of the LTD on abiotic conditions and fish density in the river Waal.

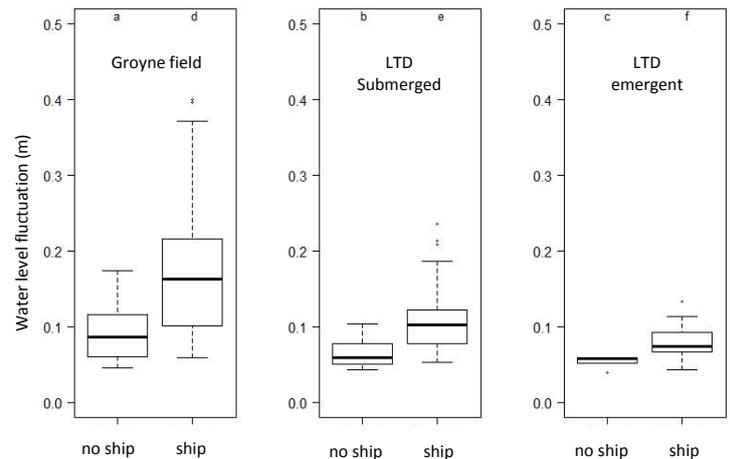


Figure 2. Whisker plots of range of water level fluctuations in the groyne field location, submerged lowered LTD location and emergent lowered LTD location during periods with and without ship passages. Different letters depict significant differences.

## Method

Monitoring was performed in the river Waal in several traditional groyne fields and behind the novel LTDs. Separate monitoring campaigns were performed in order to assess the effect on 1) abiotic conditions and 2) fish density and diversity.

Several abiotic measurements related to navigation induced effects were performed (e.g., flow velocity, water level fluctuation, flow stability and underwater sound level). Measurements were repeated at various water levels.

Fish sampling was undertaken in July in 2016 and 2017 after sunset in the littoral zone using seine nets targeting small-bodied fishes. Sampling locations were grouped into three categories: 1) groyne field, 2) shore channel behind a sheltered LTD section, and 3) shore channel near a dynamic LTD section. Fish assemblages near the stony substrate of the LTD were analysed using boat mounted electrofishing equipment. Transects of 50 m were sampled at regular intervals of 200 m along the entire LTD (total length: 4 km).

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The acquired abiotic data was analysed using generalized linear mixed effect models using R statistics. Fish densities were analysed using anova models and fish diversity was assessed using permutational multivariate analyses of variance.

### Results and discussion

Water level fluctuation during the passage of ships was significantly lower behind the LTD compared to the traditional groyne fields (Figure 2). The effect of navigation on flow velocity did not significantly differ between groyne fields and the LTD, though the variation in flow velocity fluctuation was higher in the groyne field than in the shore channel. Flow stability was significantly higher in the shore channel compared to groyne fields, indicating that conditions in the littoral zones of the shore channel are less dynamic compared to groyne fields. Underwater sound frequency and intensity was strongly reduced in the shore channel compared to the groyne fields further decreasing ship induced stressors in groyne fields. The LTD significantly mitigates abiotic effects of navigation in the littoral zones in intensively used rivers like the river Rhine. Improved hydrodynamic conditions will reduce energy expenditure in relation to swimming and reduced the risk of wash-out for fishes (Schiemer et al. 2003; Trinci et al. 2017).

Fish densities in the littoral zone were significantly higher in the shore channel compared to the groyne field (Figure 3). Native fish densities were also significantly higher in the shore channel compared to the groyne field (Collas et al., 2018). The same effect was found for rheophilic and eurytopic fishes. Fish diversity did not differ between the littoral zone of groyne fields and shore channel. Fish density in and near stony habitats of the LTD increased with increasing distance to dynamic sections. The added value of the shore channel is expected to increase as erosion and sedimentation processes will further increase habitat diversity over the coming years.

### Conclusion

- Abiotic effects of navigation are greatly reduced in the shore channel of LTDs compared to groyne fields.
- Environmental conditions are more stable in the shore channel
- Shore channels provide valuable habitat for juvenile fishes and show
- higher fish densities compared to groyne fields.
- LTDs allow ecological rehabilitation of littoral zones of highly navigated rivers while simultaneously enabling an increased river usage.

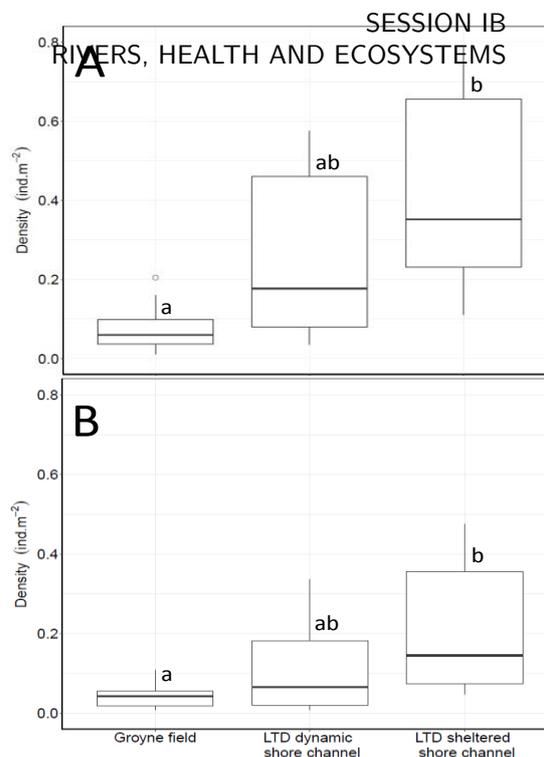


Figure 3. Whisker plots of fish density caught during 2016 with a seine net at the groyne field location, LTD dynamic shore channel location and LTD sheltered shore channel location of (a) all species pooled and (b) native fish species pooled. Different letters depict significant differences.

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### References

- Collas, F.P.L., Buijse, A.D., Van den Heuvel, L., Van Kessel, N., Schoor, M.M., Eerden, H., Leuven, R.S.E.W. 2018. Longitudinal training dams mitigate effects of shipping on environmental conditions and fish density in the littoral zones of the river Rhine. *Science of the Total Environment* 619-620, 1183-1193.
- Eerden, H. 2013. Pilot Langsdammen Waal: Projectplan realisatiefase II monitoren en inregelen – projectfase MIRT4. Concept Projectplan versie 1.0. Ministerie van Infrastructuur en Milieu, RWS Oost Nederland, Arnhem. Bijlage D: Monitoringsplan Pilot Langsdammen Waal versie (in Dutch).
- Leuven, R.S.E.W., Van der Velde, G., Baijens, I., Snijders, J., Van der Zwart, C., Lenders, H.J.R., Bij de Vaate, A. 2009. The river Rhine: a global highway for dispersal of aquatic invasive species. *Biological Invasions* 11, 1989-2008.
- Schiemer, F., Keckeis, H., Kamler, E. 2003. The early life history stages of riverine fish: Ecophysiological and environmental bottlenecks. *Comparative Biochemistry and Physiology Part A* 133, 439-449.
- Trinci, G., Harvey, G.L., Henshaw, A.J., Bertoldi, W., Hölker, F. 2017. Life in turbulent flows: interactions between hydrodynamics and aquatic organisms in rivers. *WIREs Water*, 4:e1213. Doi:10.1002/wat2.1213.
- Wolter, C., Arlinghaus, R. 2003. Navigation impacts on freshwater fish assemblages: the ecological relevance of swimming performance. *Reviews in Fish Biology and Fisheries* 13, 63-89.