Longitudinal Training Dams (LTDs): An Ecosystem-based Approach to River Management

Barrages Longitudinaux: Une Approche Écosystémique de la Gestion des Rivière

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RÉSUMÉ

Les barrages longitudinaux de la rivière Néerlandaise Wahal sont de nouvelles structures qui protègent les zones littorales des effets néfastes de la navigation, fournissant ainsi de nouveaux habitats pour les macro invertébrés ripicoles et les macrophytes, ainsi que des nourriceries pour les poissons. Les chenaux côtiers des barrages longitudinaux sont des habitats hétérogènes pour différents groupes d'espèces, avec une variété spatiale de type de substrats, de vitesse d'écoulement et de profondeur d'eau. Les ensembles de données ADCP collectés à l'aide d'un navire de surface sans pilote et consistant en des mesures de vitesse d'écoulement effectuées tous les 50cm dans la colonne d'eau d'un chenal côtier d'un barrage longitudinal ont été filtrés afin d'obtenir les vitesses d'écoulement à environ 1m de profondeur d'eau, ainsi que les valeurs minimales et maximales. Nous avons utilisé ces données de surveillance explicites spatialement et les distributions de sensibilité des espèces (SSD) pour prédire l'adéquation entre différents groupes d'espèces et leurs habitats en fonction des conditions abiotiques ambiantes en tant que fraction potentiellement présente dans le bassin d'espèces régionales. Les zones centrale et littorale du chenal côtier des barrages longitudinaux ont fourni les habitats les plus appropriés pour tous les groupes d'espèces étudiés en raison des conditions de vitesses d'écoulements faibles. Les habitats naturels étaient propices aux espèces d'éphémères, de plécoptères, de phryganes, de moules et de macrophytes, ainsi que des poissons à différentes étapes de vie.

ABSTRACT

Longitudinal training dams (LTDs) in the river Waal are novel structures that protect the littoral zone from the adverse effects of navigation, thus providing new habitats for riverine macroinvertebrates, macrophytes and nurseries for fish. The LTDs shore channels are heterogeneous habitats for different species groups with spatial variability in substrate type, flow velocity and water depth. ADCP datasets collected with an unmanned surface vehicle and consisting of flow velocity measurements performed every 50 cm in the water column of a LTD shore channel were filtered to obtain the flow velocities at about 1 m water depth, minimum and maximum values. We used this spatially explicit monitoring data and species sensitivity distributions (SSDs) to predict habitat suitability for different species groups based on the ambient abiotic conditions as the potentially occurring fraction (POF) of the regional species pool. The centre and littoral zones of the LTD shore channel provided the most suitable habitats for all species groups assessed due to low flow velocity conditions. The habitats were suitable for species of mayflies, stoneflies, caddisflies, mussels and macrophytes, as well as for different life stages of fish.

KEYWORDS

ADCP, Habitat mapping, Flow velocity, River Rhine

1 INTRODUCTION

Longitudinal training dams (LTDs; Fig. 1) are novel ecosystem-based river training structures that fulfil many different functions including securing water levels for navigation in the main channel, flood safety, ice formation protection, minimizing maintenance and making habitats available in sheltered shore channels. The LTDs are dams parallel to the river shore constructed of basalt boulders that separate the river into the main channel and a protected shore channel. Each shore channel has an outflow and inflow, and lowered sections that connect them to the main channel (Collas et al., 2018). In the river Waal, tree LTDs were constructed along the towns of Wamel, Dreumel and Ophemert. The LTDs shore channels are heterogeneous habitats to different species groups with spatial variability in substrate, flow velocity and water depth (Collas et al., 2018; Flores et al., 2021). Diverse monitoring data is available from the Directorate-General for Public Works and Water Management of the Netherlands (Rijkswaterstaat; RWS), including bathymetry (multibeam echosounder; MBES) and flow velocity datasets (Acoutic Doppler Current Profilers; ADCPs). Additionally, side-scan sonar (SSS) data has been collected which allows for the mapping of substrate types in the shore channels (Flores et al., 2021). Combining these spatial datasets with species sensitivity distributions (SSDs) allows quantification and identification of the suitability of habitats in the LTD shore channels for different species groups. SSDs are statistical models that describe the sensitivity of a species group to an abiotic parameter, such as flow velocity. These models are derived by using either laboratory or field data on the occurrence of species. SSDs enable the prediction of habitat suitability in the form of the potentially occurring fraction (POF) or the fraction of a regional species pool that could occur based on the ambient abiotic conditions (Koopman et al., 2018; Flores et al., 2021). In this study, we focus on mapping and determining habitat suitability based on flow velocity in the Dreumel shore channel for several riverine species groups. We hypothesise that the shore channels offers suitable and heterogeneous habitats based on flow velocity for aquatic fauna.

Figure 1. Map showing the location of the three LTDs (1 Wamel, 2 Dreumel and 3 Ophemert) in the river Waal, the Netherlands. The flow direction is indicated by the white arrow. Aerial photographs source: Environmental Systems Research Institute (ESRI) Nederland, beeldmateriaal.nl. Modified from Flores et al. (2021).

2 METHODS

ADCP datasets collected with an unmanned surface vehicle and consisting of flow velocity measurements performed every 50 cm in the water column of the Dreumel shore channel were filtered to obtain the flow velocity at 1.16 m, minimum and maximum values. The data was then interpolated using kriging fitted to a spherical model in ArcMAP. SSDs available in the scientific literature for the different life stages of fish, macroinvertebrates and macrophyte species occurring in the river Rhine were obtained and their descriptive statistics used to convert the abiotic parameter maps into habitat suitability maps (Flores et al., 2021).

3 RESULTS AND DISCUSSION

The median POF values for the different species groups were equal to 0.48 or higher for all measurements of flow velocity in the shore channel (Fig. 2 and 3). The fish species had the lowest median POF values and EPT species had the highest values. For the four fish life stages assessed the juveniles had the lowest flow velocity POF median values (0.21-0.29) and adults had the highest (0.48-0.60).

Seine net samples have shown that fish densities and diversity in the LTD shore channels are higher than in surrounding groyne fields. (Collas et al., 2018). LTD flow velocities do not pose a major bottleneck for the migratory fish species hence their use as a nursery is feasible and has been documented for some species.

The flow velocities were not very limiting for the species groups in the Dreumel shore channel, with the exception of the inflow and outflow of the channel where the highest flow velocities were present. Macrophytes were also adversely affected by the higher flow velocities recorded near the centre of the shore channel, which could inhibit their establishment in those areas. The most suitable flow velocity conditions for all the species groups were predicted for the recorded minimum flow velocities. These flow velocities were also the most suitable for various life stages of fish. However, the POF for maximum flow velocities of several areas in the Dreumel shore channel also show suitable habitat for the fish life stages assessed, especially in the littoral zones. These results agree with the suggestion that the shore channels offer suitable habitats and refuge areas for the different life stages of fish species as well as habitat for other species groups (Collas et al., 2018, Flores et al., 2021).

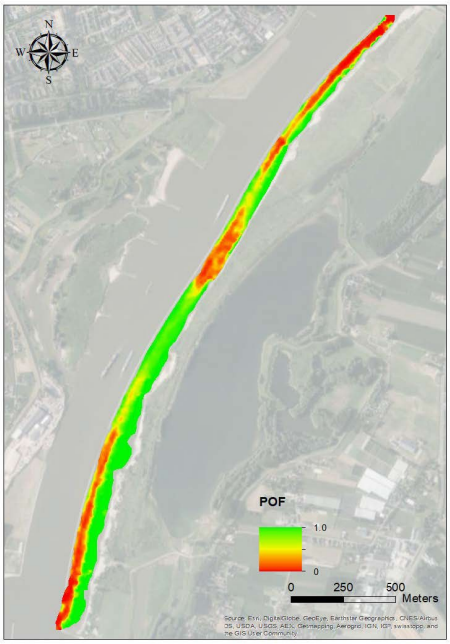

Figure 2. Maximum flow velocity potentially occurring fraction map for macrophyte species. Aerial photographs source: Environmental Systems Research Institute (ESRI), DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

4 CONCLUSION

In the Dreumel shore channel, the centre and littoral zones provided the most suitable habitats for all species groups due to low flow velocity conditions. The inflow, outflow and lowered sections had higher flow velocities and hence could inhibit the establishment of some species at those locations.

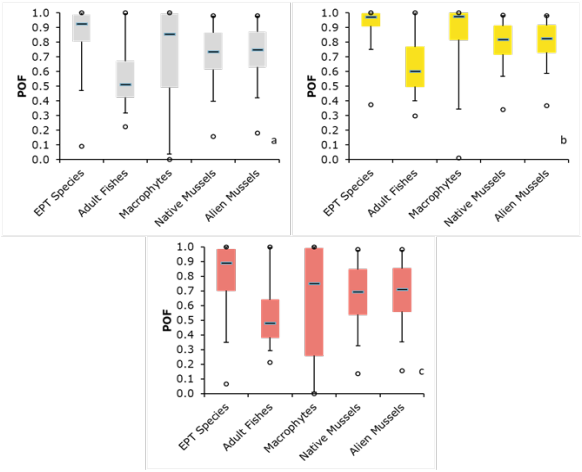

Figure 3. Box plots for the flow velocity POF of the different species groups for the Dreumel shore channel including the (a) flow velocity at 1.16 m water depth, (b) minimum flow velocity, and (c) maximum flow velocity. The lines represent the median values, the edges of the boxes the first and third quartiles, the whiskers the 2.5% and 97.5% percentiles and the points the minimum and maximum values.

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