Decadal trends in native and non-native fish assemblages in a large floodplain river in the Pacific Northwest, USA

Tendances décennales des assemblages de poissons indigènes et non indigènes dans une grande rivière inondable du nord-ouest du Pacifique, États-Unis

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RÉSUMÉ

Des déclins et des pertes majeurs de biodiversité se produisent à l'échelle mondiale, et les données sur les assemblages de poissons indigènes et non indigènes dans les eaux douces, en particulier les grands fleuves, sont limitées. Nous avons évalué l'assemblage complet de 41 poissons sur 240 km de la rivière Willamette, une rivière de 11ème ordre dans l'Oregon, aux États-Unis, en utilisant des méthodes normalisées de pêche électrique en bateau et sac à dos sur deux décennies. L'abondance et la richesse des espèces de poissons indigènes ont diminué longitudinalement en aval, et l'abondance et la richesse des poissons non indigènes ont augmenté en aval. L'abondance des poissons non indigènes était significativement plus élevée au cours de la période 2021-2023 par rapport à la décennie précédente, et l'augmentation était plus importante dans les tronçons en aval de la rivière. L'abondance des poissons indigènes était significativement plus faible au cours de la période 2021-2023, mais les différences étaient faibles. Les distributions de certaines espèces se sont étendues ou contractées. Des efforts de restauration accélérés dans la rivière Willamette et les rivières du monde entier sont essentiels pour protéger et rétablir leurs assemblages de poissons indigènes. De nombreux programmes de restauration visent à corriger les problèmes causés par l'utilisation passée des terres et la dégradation de l'environnement. Notre succès dans la restauration des rivières et le rétablissement des populations de poissons indigènes pourrait être limité si nous ne comprenons pas les processus en cours et ne parvenons pas à anticiper l'avenir des rivières.

ABSTRACT

Major declines and losses in biodiversity are occurring globally, and data for native and non-native fish assemblages in freshwaters, especially large rivers, are limited. We assessed the complete assemblage of 41 fishes along 240 km of the Willamette River, an 11th order river in Oregon, USA using consistent boat and backpack electrofishing methods over two decades. Abundance and species richness of native fish decreased longitudinally downstream, and abundance and richness of non-native fish increased downstream. The abundance of non-native fish was significantly greater in the period of 2021-2023 as compared to the previous decade, and the increase was greater in the downstream reaches of the river. Abundance of native fish was significantly lower in the period from 2021-2023, but the differences were small. Distributions of some species expanded or contracted. Accelerated restoration efforts in the Willamette River and rivers throughout the world are essential to protect and recover their native fish assemblages. Many restoration programs are focused on correcting the problems caused by past land uses and environmental degradation. Our success in restoring rivers and recovering native fish assemblages may be limited if we do not understand the processes that are changing and fail to anticipate the future river.

KEYWORDS

Biodiversity, Distribution, Native Fish, Non-Native Fish, Monitoring

Biodiversité, Distribution, Poisson Indigène, Poisson Non Indigène, Surveillance

1 INTRODUCTION

Major declines and losses in biodiversity are occurring globally, and data for native and non-native fish assemblages in freshwaters, especially large rivers, are limited. Globally, large rivers face overexploitation, water pollution, flow modification, habitat degradation, non-native species (Dudgeon et al. 2006, Reid et al. 2019), and loss of connectivity (Tickner et al. 2020). One of the major challenges for restoring and conserving native fishes is inadequate monitoring of fish assemblages, especially large rivers. Climate change and biological invasions accelerate shifts in fish assemblages in large rivers over shorter timeframes than previous periods. Distributions typically contract and population abundances decline before species are extirpated or become extinct. Management interventions may be successful if such changes are detected early through accurate and repeatable monitoring.

2 METHODS

We sampled fish populations in the 240-km mainstem Willamette River from its upstream confluence with the McKenzie River down to Willamette Falls in three summers in 2011–2013 and 2021–2023, using the floodplain slices spatial framework (Hulse and Gregory 2004) and consistent sampling methods (Williams et al. 2024). To account for differences in effort, we created an "equal effort" dataset of 108 slices for each decade. We sampled fish from early May to early October, restricted to times of water temperature <18°C because of state and federal permit restrictions. At each 1-km slice, fish were captured with boat and backpack electrofishing. Each boat electrofishing survey was 200 m in length sampled in a downstream direction. Mainstem sampling consisted of four boat electrofishing surveys per 1-km slice, and off-channel sampling consisted of three boat electrofishing surveys per slice. Four backpack electrofishing surveys for mainstem and off-channel slices represented the variety of shallow habitats. We identified captured fishes ≥30 mm to species, except for juvenile lamprey, recorded as "lamprey spp." Permit restrictions did not allow us to capture adult salmon or steelhead.

50,086 individual fishes were captured and used in the analyses. We divided the river into three sections based on hydrogeomorphic characteristics (lower middle river - slices 42–72, middle river - slices 73–151, upper river - slices 152–216). We did not include the lower river (slices 0-41) in this analysis because we were not permitted to sample in all years. We compared losses or gains in fish abundances and distributions between decades for the Willamette River and each river section, using a linear mixed model with square-root transformation.

3 RESULTS

In the original survey on 2011-2013, we found that abundance and richness of native fishes decreased longitudinally downstream, while abundance and richness of non-native fishes increased downstream (Figure 1). More than 93% of the individual fish captured in the initial survey were native species. The five most abundant species by number in 2011-2013 were redside shiner (*Richardsonius balteatus*), largescale sucker (*Catostomus macrocheilus*), reticulate sculpin (*Cottus perplexus*), northern pikeminnow (*Ptychocheilus oregonensis*), and speckled dace (*Rhinichthys osculus*). The five most abundant non-native species by number were largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), bluegill (*Lepomis macrochirus*), and common carp (*Cyprinus carpio*). Based on biomass, 80% of the fish captured in 2011-2013 were native species. The five most abundant species by biomass in 2011-2013 were largescale sucker, northern pikeminnow, cutthroat trout (*Oncorhynchus clarkii*), redside shiner, and chiselmouth (*Acrocheilus alutaceus*). The five most abundant non-native species by number were common carp, smallmouth bass, largemouth bass, bluegill, and yellow perch. The Willamette River basin contains 36 native fish species and 34 non-native fish species; 21 native fish species were captured in the mainstem river during these surveys and 20 non-native species.

Abundance of native fishes declined slightly between decades in the mainstem Willamette River, whereas non-native fishes increased in abundance over that same timeframe, especially downriver (Figure 1). Native and non-native fish abundances did not change substantially between decades in the upper reach change, but non-native fish abundance increased significantly in the lower middle river. Richness of native fish species did not differ between decades throughout the mainstem Willamette River or in any reach. Non-native fish species richness increased significantly in the lower middle river between decades, but no change in non-native richness was observed un the upper reach. Distributions of non-native fish species expanded in 2021–2023 compared to 2011–2013 (Williams et al. 2024).

4 DISCUSSION AND CONCLUSION

Past studies of fish assemblages recorded the introduction and successful establishment of non-native fish populations in the mainstem Willamette River (Dimick and Merryfield 1945; Hughes and Gammon 1987). The earliest survey of fish in the Willamette did not capture any non-native fish species (Snyder 1908), even though many non-native fishes were known to be introduced and established in the latter half of the 19^{th} century (Lampman 1946). Severe water pollution and habitat degradation throughout the mainstem were documented in the early 1900s. Water quality in the upper river currently is excellent and the water quality in the lower river has improved significantly over the last 40 years.

While slight decreases in abundance of native fish in the Willamette River were observed between 2011-2013 and 2021-2023, non-native fish abundance and richness increased significantly in the lower and middle reaches of the river. The lack of change in fish richness and only slight change in abundance of native and non-native fishes in the upper river reflects the higher water quality and habitat complexity in the upper river. One of the additional trends of concern in non-native fishes was the greater distribution of several major non-native fish species in 2021–2023 compared to 2011–2013. Smallmouth bass were captured farther upstream to the upper extent of the mainstem river in the second survey (White et al. 2023). The relative magnitude of the changes in fish occurrence or distribution in the Willamette River over the last decade has been relatively small, which highlights the importance of early detection and management responses to address challenges to aquatic biodiversity. Importantly, this study demonstrates that a decade is sufficient time to detect biodiversity shifts and potentially implement management decisions to protect native fish populations.

Warming river temperatures in recent years has exacerbated the longer-term consequences of flow modification, habitat degradation, and reduced connectivity, and may have contributed to the declines in native fish abundance and increases in non-native fishes we observed over the decade between our surveys. The changes in the water quality and habitat conditions in the Willamette River over the past 200 years reflect patterns in large rivers worldwide (Gregory et al. 2019; Flitcroft et al. 2023, Dudgeon et al. 2006, Tickner et al. 2020). Efforts to restore habitat and water quality frequently are outpaced by actions that simplify habitats and degrade water quality (Bilby et al. 2024). Restoration actions commonly require years, decades, or even centuries to attain their intended function, while habitat degradation is immediate. The illusion restoration actions immediately counteraction degradation actions lead to a ratcheting effect and continual and sometimes gradual reduction in the potential productivity of the riverine ecosystem (Gregory 2007). Accelerated restoration efforts in the Willamette River and other rivers throughout the world are essential to protect and recover their native fish assemblages. Many of these restoration programs are focused on correcting the problems caused by past land uses and environmental degradation. Our success in restoring rivers and recovering native fish assemblages may be limited if we do not understand the processes that are changing and fail to anticipate the future river.

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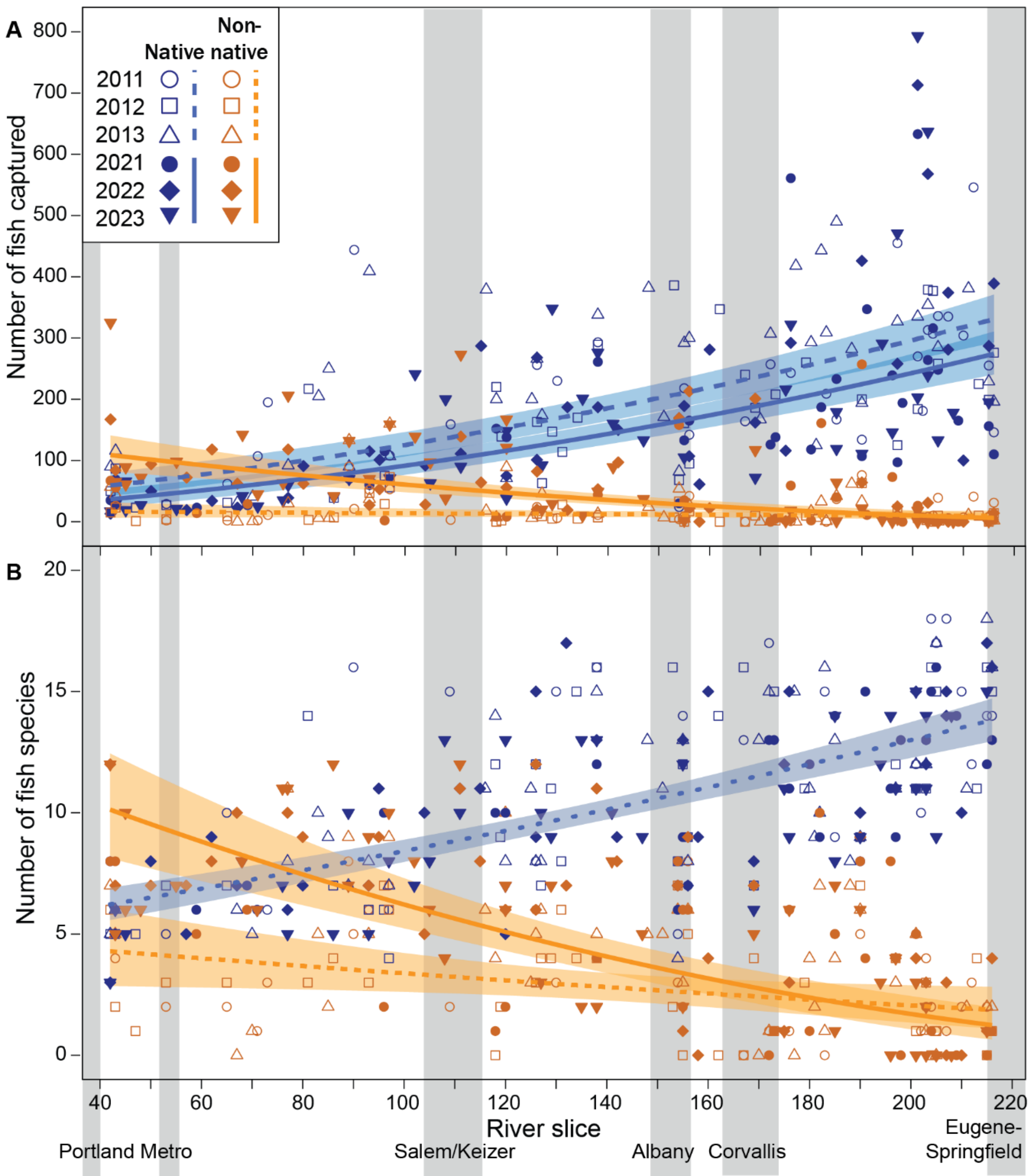

Figure 1. Average number of (blue) and non-native (orange) at each slice by decade presented longitudinally along with 2011-2013 at top and 2021-2023 at bottom.

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