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Predicting asp and pikeperch recruitment in a riverine reservoir

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ABSTRACT

Fish recruitment in riverine reservoirs is not fully understood because the long-term data series required for standard stock–recruitment models are often lacking. In this study, two unrelated piscivorous species with different ecologies, asp (*Leuciscus aspius*) and pikeperch (*Sander lucioperca*), were investigated over a 14-year period in a reservoir in the Czech Republic using a novel informative statistical approach based on dimension reduction methods. This method is useful for situations in which potential predictors are equal to, or exceed, the length of the time series. Recruitment of asp fry was affected by zooplankton abundance, predator density and temperature. Recruitment of pikeperch fry measured with seine and trawls was only affected by the number of predators, while recruitment of pikeperch fry estimated with gillnet data was also affected by temperature and water level fluctuation. Although gillnets are commonly used sampling method, it seems to be inappropriate for developing fry predicting model. This research also highlights the use of a novel approach to dimension reduction for analysis of factors affecting recruitment using shorter time series (in our case 13 years).

1. Introduction

Assessment of fish populations is a key issue in fisheries and plays a prominent role in the evaluation of habitat quality in water bodies in many countries (CWA, 2006; EC, 2000). One of the most important indicators of habitat quality is the recruitment of new individuals to an existing population (Gassner et al., 2003). The relationship between spawning stock, *i.e.*, the total number or biomass of reproducing individuals, and their production of offspring is fundamental to fisheries science (Quinn and Deriso, 1999). Standard methods to estimate stock–recruitment relationships require long time series usually collected through routine sampling programs (*e.g.*, Quinn and Deriso, 1999) and often perform poorly when applied to new datasets (Hansen et al., 2015). This is because fish recruitment is driven by a multitude of environmental factors such as water quality and the presence of spawning habitats (Gassner et al., 2003; Hansen et al., 2015), but their importance differs between species and populations.

Variability of year-class strength (YCS) can be driven not only by numerous environmental factors but also by the timing of these factors, which further hampers the estimation of the stock–recruitment relationship. Critical periods in early life history of fish such as spawning, larval and early juvenile survival can all affect YCS (Bone and Moore, 2008). The starting point of a cohort is spawning, which is dependent on the condition of the parental stock (Worm et al., 2009) and on spawning substrate availability (Paulovits et al., 2007). Water temperature affects not only spawning but also hatching, metabolic rate and growth (Jonsson and Jonsson, 2009). However, the positive effect of water temperature is not sufficient to achieve a successful year-class if the food supply is limited (Hjort, 1914). During the switch from endogenous to exogenous feeding, both the amount and composition of food are important (Cushing, 1990). During the early ontogeny, fish change their temperature and food requirements as they switch between habitats (Bone and Moore, 2008). Last but not least, predation is an important source of mortality and can reduce the survival of a cohort at all critical periods (Bailey and Houde, 1989).

The assessment of YCS can also vary due to the timing or selectivity of the sampling method. In species without parental care after hatching, the larvae and juveniles can either spread over the whole water body or select a particular habitat (Bone and Moore,

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2008). For sampling of juvenile fish, numerous methods have been developed, such as seining and electrofishing in littoral zones, and trawling and purse seining in pelagic zones (Bonar et al., 2009). Some methods are routinely used for standard fish surveys, but the use for sampling 0+ fish is questionable (such as the European gillnet sampling, European Standard EN 14 757, 2005). Species associated with a particular habitat are relatively easy to sample with an appropriate method, while species with random distribution and species that migrate between habitats require sampling of all habitats and integration of the data to get the true picture of YCS (Kubečka et al., 2009). All these issues may contribute to uncertainty in the data and hence less reliable estimates of the stock–recruitment relationship for a given population.

This study focused on two common predatory fish with pronounced differences in early life-history ecology and scientific knowledge. Asp (*Leuciscus aspius*) is a cyprinid species that spawns in rivers relatively early in spring (Hladík and Kubečka, 2003) and inhabits only littoral areas during its juvenile phase (Grift et al., 2003; Jůza et al., 2014). Pikeperch (*Sander lucioperca*) is a percid species that spawns later than asp. Males build nests in shallow areas and stay there until the larvae hatch but do not provide care thereafter (Lappalainen et al., 2003). In large water bodies, pikeperch larvae and juveniles spread to all suitable habitats including littoral and pelagic zones (Frankiewicz et al., 1996; Grift et al., 2003; Kovalev, 1976). While little attention has been dedicated to study asp, pikeperch is a commercially important species in western Eurasia that has been extensively studied (Froese and Pauly, 2014). However, pikeperch recruitment in riverine reservoirs is not well understood.

The aim of this paper is twofold: (i) to compare YCS estimates of asp and pikeperch based on specifically designed fry and commonly used standard fish sampling methods and (ii) to determine the critical factors in the early life-history of the two species in a riverine reservoir as a case study.

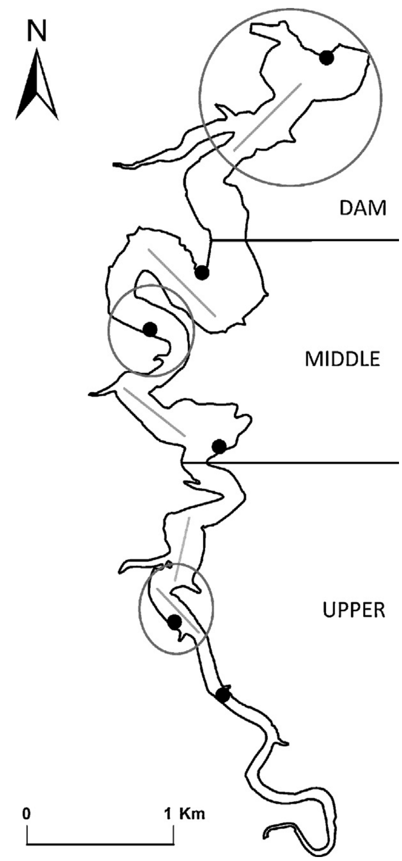

Fig. 1. Map of the Římov Reservoir divided into three parts. Localities sampled by beach seine are symbolized by black dots, the trajectory of trawling is symbolized by gray line and areas where gillnets were installed are in ellipses.

2. Methods

2.1. Study site

The study was conducted in the Římov reservoir, 170 km south of Prague (48°50′8″N, 14°28′55″E), Czech Republic. The reservoir (length 12 km, maximum depth 45 m, average depth 16 m, surface area 210 ha, volume 33.1×10^6 m^3) was built in 1978 mainly for water storage on the Malše river, which is its only large inflow. The reservoir is dimictic with well-developed thermal stratification during the summer. It is moderately eutrophic to eutrophic. A long-term biomanipulation project has been conducted in the reservoir and predatory fish have been propagated since 1985 (Říha et al., 2009) with asp and pikeperch being the main predators in the reservoir (Prchalová et al., 2009a). Despite stocking, the proportion of piscivorous fish in the Římov reservoir remains low compared to other Czech reservoirs (Vašek et al., 2013).

2.2. Fish data

Age-0 fish were collected in August from 1999 to 2012, with the exception of 2002 when extreme flooding prevented fish sampling. Fish were sampled using a beach seine in littoral habitats, a trawl in pelagic habitats and gillnets in both benthic and pelagic habitats at three localities in the reservoir (Fig. 1).

Seining and trawling were conducted at night. The beach seine was 10 m long and 2 m high, with a mesh size of 1.7 mm. The volume of a seine haul was approximately 80 m^3, depending on the slope of the littoral habitat and the area sampled when drawing the seine towards the shore (Kratochvíl et al., 2012). A fixed-frame trawl, with a mouth opening of 3 × 3 m, a length of 5.4 m and a mesh size of 6 mm in the belly and 3 mm in the cod end, was used for trawling. Trawling was performed in localities across the longitudinal gradient with sufficient depth to sample two surface water layers, 0–3 and 3–6 m, since 0+ fish do not occur deeper (Jůza et al., 2009). Pelagic trawling was performed by towing the trawl for a specific time (usually 10 min) at a speed of 1 m s^{-1}, and based on these data, the exact trawled volume was calculated. To obtain a precise abundance estimate for the whole reservoir, catch from both methods was standardised per 1000 m^3 and integrated over the three parts of the reservoir (dam, middle and upper parts). The volume in each part of the reservoir was calculated from a digital three-dimensional bathymetric model in ArcMap 10.0. (ESRI Inc., 2010) for layers 0–2 m in the littoral zone, and 0–3 and 3–6 m in the pelagic zone (Table 1). Finally, the standardized catch was multiplied by the specific volume and summed for all parts of the reservoir.

From 1999 to 2003, 25 m long single mesh size gillnets, with mesh sizes corresponding to the European standard norm EN 14 757 (5; 6.25; 8; 10; 12.5; 15.5; 19.5; 24; 29; 35; 43 and 55 mm) were used. In subsequent years, European standard multi-mesh

Table 1
Ratios of water volume in sampled habitats of Římov Reservoirs.

Habitat	Littoral	Benthic habitat	Pelagic habitat	
Depth layer	0–2	0–5	0–3	0–5
Dam	43	22	58	59
Middle	30	43	24	24
Upper	27	35	18	17
Volume in 1000 m^3	125	854	4796	7140