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Perspective

A note on fish biology

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The topic of fish reproductive biology has grown quickly during the last five decades, owing to the wide diversity of species and physiologies as well as reproduction-related limitations in aquaculture. This review integrates basic and applied advancements and milestones to present my opinion on the subject over this time period. The failure of farmed fish to ovulate and spawn in captivity was overcome thanks to our basic understanding of the brain-pituitary–gonadal axis, allowing us to conclude the fish life cycle and establish a regular, year-round egg production. The study of the molecular and hormonal systems involved in sex determination and differentiation led to the development of methods for developing higher-performing mono-sex and reproductively-sterile fish.

Key words: Reproduction of fish, fishing culture, farming, ground water, fish production, water sheds

ABOUT THE STUDY

Many discoveries have been made as a result of the growing number of passionate fish biologists, as well as the availability of innovative platforms such as transgenesis and gene editing, as well as new models such as the zebra fish and medaka, which have led to new insights into reproductive biology in higher vertebrates, including humans. As a result, fish are now commonly used as vertebrate reproduction models. The International Symposia on Reproductive Physiology of Fish (ISRPF), which our scientific family has gathered every four years since the field's grandfather, the late Ronald Billard, organised the first meeting in Paimpont, France in 1977, is perhaps the best testament to our discipline's progress. As the one person who has been fortunate enough to attend all of these meetings since their inception, I have witnessed first-hand the astounding evolution of our field as we capitalized on the molecular and biotechnological revolutions in the life sciences, which enabled us to provide a higher resolution of fish reproductive and endocrine processes, answer more questions, and dive into deeper comprehension. Undoubtedly, the next (five) decades will be similarly exciting as we continue to integrate physiology with genomics, basic and translational research, and the small fish models with the aquacultured species. Groundwater pumping for agriculture is a major driver causing declines of global freshwater ecosystems, yet the ecological consequences for stream fish assemblages are rarely quantified. We combined retrospective modeling approaches within a multiscale framework to predict change in Great Plains stream fish assemblages associated with groundwater pumping from the United States High Plains Aquifer. We modeled the relationship between the length of stream receiving water from the High Plains Aquifer and the occurrence of fish's characteristic of small and large streams in the western Great Plains at a regional scale and for six subwatersheds nested within the region. Water development at the regional scale was associated with construction of 154 barriers that fragment stream habitats, increased depth to groundwater and loss of 558 km of stream, and transformation of fish assemblage structure from dominance by large-stream to small-stream fishes. Scaling down to subwatersheds revealed consistent transformations in fish assemblage structure among western subwatersheds with increasing depths to groundwater. Although transformations occurred in the absence of barriers, barriers along Mainstem Rivers isolate depauperate western fish assemblages from relatively intact eastern fish assemblages. Projections to 2060 indicate loss of an additional 286 km of stream across the region, as well as continued replacement of large stream fishes by small-stream fishes where groundwater pumping has increased depth to groundwater. Our work illustrates the shrinking of streams and homogenization of Great Plains stream fish assemblages related to groundwater pumping, and we predict similar transformations worldwide where local and regional aquifer depletions occur. We assessed change in fish assemblage structure at the regional and subwatershed scales using existing historical data from Colorado, Kansas, and Nebraska. We selected species for analysis based on occurrences across 940 collections and retained only those species with at least 30 occurrences for regression analysis. We used annual estimates of the length of stream connected to the aquifer as the

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predictor variable and the occurrence of each retained species in collections taken during that year as the response variable for the period 1950–2010 at the regional and subwatershed scales. Based on projected annual lengths of stream combined with the aquifer, we fitted binomial logistic regression models to each species and utilized these models to forecast capture probability for all years between 1950 and 2060. To show fish assemblage response to spatiotemporal heterogeneity in stream lengths linked with groundwater, we estimated the mean and 95 percent confidence interval for all species classed as small stream or large stream users. Although fish distributions in relation to stream size formed a continuum, we used the designation of first- to third-order streams as “headwaters” to facilitate comparison of how fishes in small and large streams might be affected by groundwater depletion. Fish collection methods were consistent with protocols approved by the Tennessee Technological University Institutional Animal Care.