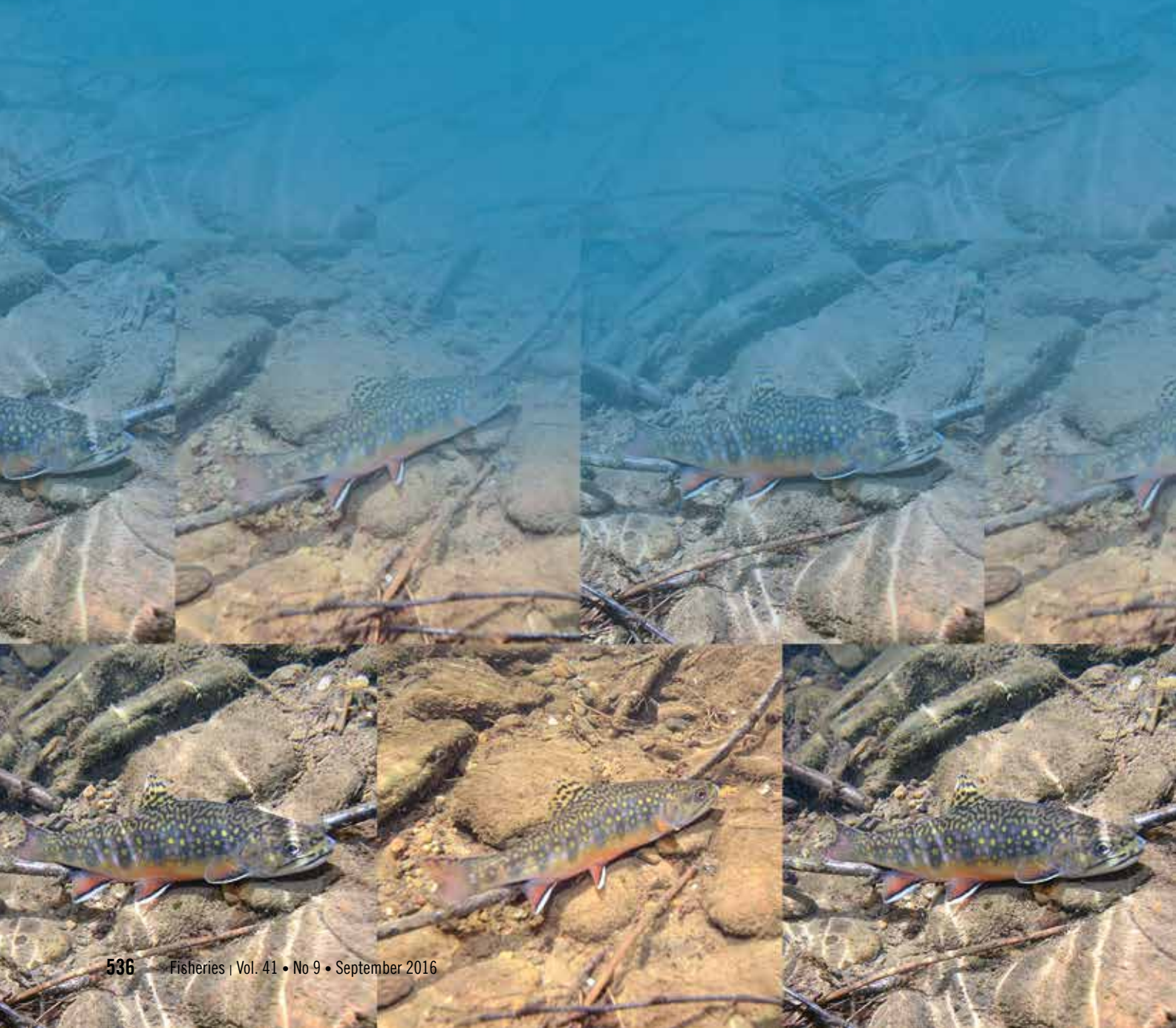


Transboundary Fisheries Science:

Meeting the Challenges of Inland Fisheries
Management in the 21st Century



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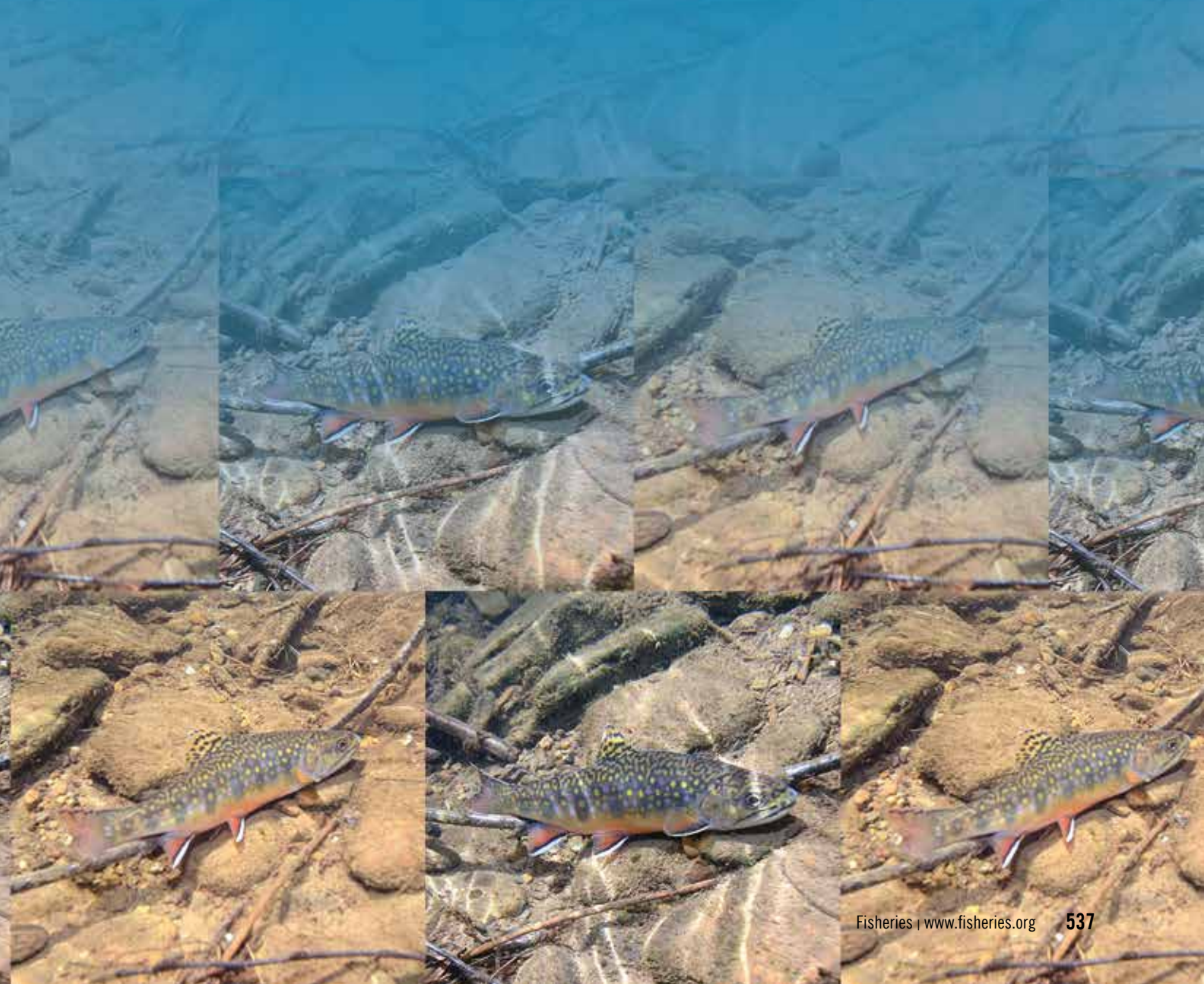
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Managing inland fisheries in the 21st century presents several obstacles, including the need to view fisheries from multiple spatial and temporal scales, which usually involves populations and resources spanning sociopolitical boundaries. Though collaboration is not new to fisheries science, inland aquatic systems have historically been managed at local scales and present different challenges than in marine or large freshwater systems like the Laurentian Great Lakes. Therefore, we outline a flexible strategy that highlights organization, cooperation, analytics, and implementation as building blocks toward effectively addressing transboundary fisheries issues. Additionally, we discuss the use of Bayesian hierarchical models (within the analytical stage), due to their flexibility in dealing with the variability present in data from multiple scales. With growing recognition of both ecological drivers that span spatial and temporal scales and the subsequent need for collaboration to effectively manage heterogeneous resources, we expect implementation of transboundary approaches to become increasingly critical for effective inland fisheries management.

Ciencia pesquera transfronteriza: enfrentando los retos del manejo de pesquerías continentales en el siglo 21

El manejo de las pesquerías de aguas interiores en el siglo 21 presenta varios obstáculos que incluyen la necesidad de analizar las pesquerías desde distintas escalas espaciales y temporales, lo cual normalmente implica poblaciones y recursos que rebasan las fronteras sociopolíticas. Si bien la colaboración no es algo nuevo en la ciencia pesquera, los sistemas acuáticos continentales han sido históricamente manejados a nivel local y entrañan retos que son diferentes a los del medio marino y a los de grandes sistemas de agua dulce como Los Grandes Lagos. Por lo tanto, se propone una estrategia flexible que considera a la organización, cooperación, análisis e implementación como piezas fundamentales para abordar de forma efectiva los asuntos relativos a las pesquerías transfronterizas. Adicionalmente se discute el uso de modelos jerárquicos bayesianos (dentro de la etapa analítica) debido a su flexibilidad en cuanto al tratamiento de la variabilidad de los datos en múltiples escalas. Tomando en cuenta la creciente aceptación tanto de los forzantes ecológicos, en las dimensiones espacial y temporal, y la subsecuente necesidad de colaboración para manejar eficientemente recursos heterogéneos, se espera que la implementación de enfoques transfronterizos se vuelva cada vez más importante para un manejo efectivo de las pesquerías en aguas interiores.

Sciences halieutiques transfrontalières: relever les défis de la gestion des pêches continentales au 21e siècle

La gestion des pêches continentales au 21e siècle présente plusieurs obstacles, y compris la nécessité de considérer la pêche à partir de multiples échelles spatiales et temporelles, ce qui implique généralement des populations et des ressources réparties sur plusieurs frontières sociopolitiques. Bien que la collaboration ne soit pas quelque chose de nouveau pour la science de la pêche, les systèmes aquatiques continentaux ont toujours été gérés à l'échelle locale et présentent des défis différents des grands systèmes d'eau douce ou marins comme les Grands Lacs laurentiens. Par conséquent, nous présentons une stratégie souple qui met en évidence l'organisation, la coopération, l'analyse et la mise en œuvre en tant que blocs de construction afin de traiter efficacement les questions de pêche transfrontières. De plus, nous discutons de l'utilisation de modèles hiérarchiques bayésiens (au sein de la phase d'analyse), en raison de leur flexibilité dans le traitement de la variabilité présente dans les données de plusieurs échelles. Avec la reconnaissance croissante des facteurs écologiques qui couvrent des échelles spatiales et temporelles, et la nécessité d'une collaboration ultérieure pour gérer efficacement les ressources hétérogènes, nous nous attendons à ce que la mise en œuvre d'approches transfrontalières devienne de plus en plus critique pour une gestion efficace de la pêche continentale.

INTRODUCTION

Inland fisheries managers often work at relatively small spatial scales (e.g., a single lake or watershed) corresponding to their local or regional authorities. Local influences, objectives, regulations, and enforcement have traditionally guided protection, enhancement, and sustainability of fish populations within an individual water body, stream reach, or watershed. Likewise, management objectives often have a brief temporal window (e.g., months or years). Correspondingly, applied inland fisheries research has predominantly attempted to reduce uncertainties at these small spatial and temporal scales. Many issues can be addressed at spatial and temporal scales consistent with local management objectives—such as harvest rates and fishing effort. Other critical questions are untenable or misleading at small scales. For this suite of issues, a broader spatial or temporal approach is needed. For example, large-scale processes, such as climate and land-use change, can alter physiochemical and biological properties of aquatic and terrestrial ecosystems and shift linkages among habitat types (Frissell et al. 1986; Fausch et al. 2002; Soranno et al. 2009). Elucidating links between multi-scale phenomena is critical for integration of existing data to inform management of resources that respond to both local and large-scale influences.

Fisheries (and ecological) research has been generally expanding to include larger-scale questions coincident with a greater appreciation that natural resources are sensitive to large-scale phenomena via complex and dynamic pathways (e.g., Wenger et al. 2011; Pépino et al. 2012; Muhlfeld et al. 2014). Although the appreciation of large-scale dynamics in fisheries is not new (e.g., Frissell et al. 1986), common challenges remain in addressing research questions across multiple spatial and temporal scales and diverse inland fisheries. In particular, reducing large-scale uncertainties often requires data from multiple and disparate sources. As such, efforts based on collaboration and coordination of data across jurisdictional management boundaries are increasingly important in fisheries management, within the contexts of several key issues (e.g., barriers to migration, habitat loss, and climate change).

Recent scientific and management efforts emphasize a growing focus on interdisciplinary and holistic approaches for understanding and managing ecosystems across broad scales. Among notable examples are the U.S. Fish and Wildlife Service (USFWS) Landscape Conservation Cooperatives (fws.gov/landscape-conservation/lcc.html), U.S. Department of Interior Climate Science Centers (doi.gov/Csc/index.cfm), the National Fish Habitat Action Plan (fishhabitat.org), and associated