



FINAL REPORT

Project: NAVIDIV

I. Project identification

Project title: Inland navigation infrastructures and biodiversity: impacts and opportunities for waterwayscape management

[FR] Titre du projet: Infrastructures de navigation fluviale et biodiversité : impacts et opportunités pour la gestion du paysage navigable

Acronym: NAVIDIV

Co-funding organization (if relevant): ITTECOP

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Starting date of the project: Nov 2021

Finishing date of the project: Oct 2024

Scientific summary of project (maximum of 300 words characters, spaces included)

Facing global change, inland navigation transport is considered as one of the most promising, sustainable transport alternatives to help operate the world ecological transition and achieve climate neutrality. Waterways thus must develop their infrastructures to promote green transport alternatives. However, ecomorphological modifications of rivers will affect biodiversity status and resilience. With the stated objective to sustainable management of waterways, the question therefore remains: what are the impacts of inland navigation on biodiversity, and how to mitigate them?

Cues currently available to solve this question rely on scattered case studies whose results are highly context- and scale-dependent. In addition, our knowledge of the processes driving navigation-biodiversity relationships is still limited and requires further research. To address this gap, we need an evidence-based synthesis that covers various contexts and allows upscaling local-scale conclusions. We thus realised a synthesis project to study the relationships between navigation activity, the associated Inland Navigation Infrastructures (INIs), and biodiversity across different contexts and scales.

Our specific aims are to:

- (i) Quantify and hierarchize the **effects of navigation and INIs** on taxonomic and functional biodiversity;
- (ii) Evaluate the **context-dependency** and **scale-dependency** of the INIs-biodiversity relationships;
- (iii) Assess the potential of **restoration** plans in mitigating navigation pressures.

We use two complementary approaches of synthesis to address our aims:

- A synthesis of the existing knowledge based on two global scale literature reviews and one meta-analysis for all taxonomic groups;
- Syntheses and analyses of empirical observations at the pan-European scale for two taxonomic groups (fish and invertebrates) that have different interactions of the river and riverscape.

This work provides impact assessment and synthetic knowledge, offering guidelines on how to prioritize management and restoration actions depending on the context and on which scales to conceive policies that ensure consistency across territories.

[FR] Résumé scientifique du projet (maximum de 300 mots caractères, espaces inclus)

Face aux changements globaux, la navigation fluviale est considérée comme une alternative de transport prometteuse pour accompagner la transition écologique. Les infrastructures vont donc devoir se développer pour favoriser ces alternatives durables de transport. Toutefois, les modifications éco-morphologiques associées à un tel développement risquent d'affecter la biodiversité et la résilience des écosystèmes aquatiques.

Un enjeu majeur pour une gestion durable des voies navigables est de déterminer les impacts de la navigation et des infrastructures associées sur la biodiversité, et comment les atténuer.

Les pistes actuelles pour résoudre cette question reposent sur des études éparées et locales dont il est difficile de tirer des généralités, notamment du fait de la forte dépendance des conclusions au contexte et à l'échelle spatiale de ces évaluations.

Nous proposons donc un projet de synthèse pour étudier les relations entre les activités de navigation, les infrastructures de navigation fluviale associées (INIs), visant à :

- (i) Quantifier, hiérarchiser et comprendre les effets de la navigation et des INIs sur la biodiversité taxonomique et fonctionnelle ;
- (ii) Evaluer la contexte-dépendance et l'échelle-dépendance des relations INIs-biodiversité ;
- (iii) Déterminer le potentiel des stratégies de restauration dans la remédiation des pressions liées à la navigation.

Pour ce faire, nous adoptons deux approches complémentaires :

- Une synthèse des connaissances existantes sur la base d'une revue exhaustive de la littérature et de méta-analyses à l'échelle mondiale, pour tous les groupes taxonomiques;
- Synthèses et analyses de données d'observations à l'échelle pan-européenne pour deux groupes taxonomiques (poissons et invertébrés aquatiques) qui ont des interactions différentes avec les cours d'eau et le paysage fluvial.

Ce travail fournit une base de connaissances solide et des recommandations pour prioriser et adapter les mesures de gestion selon les contextes et identifier les échelles auxquelles concevoir les mesures pour assurer leur cohérence à travers différents territoires.

Key words (5): Freshwater shipping, Inland Navigation Infrastructure (INI), Biodiversity, Landscape, Context-dependence, Scales

Context and objectives (around 1,500 characters including spaces)

Inland navigation transport is considered as one of the most promising and sustainable alternatives to support the ecological transition and achieve climate neutrality. For instance, the EU Green Deal plans important waterway developments to promote green shipping and improve navigability conditions, by restoring or creating new Inland Navigation Infrastructures (INIs), such as canals, dams, locks, and harbours. However, the inland navigation system may affect the underneath freshwater ecosystems, and biodiversity.

As we intensify navigation and develop INIs, we need to understand how the related environmental modifications (i.e. water flow, habitat, connectivity, and species invasions) influence biodiversity in order to

know how to effectively mitigate their impacts. Until now, most studies on the topic are local case studies addressing different INI types, taxa, contexts, and scales, which challenges our ability to draw general conclusions.

Our aims are to:

- (i) Quantify and hierarchize the **effects of navigation and INIs** on taxonomic and functional biodiversity;
- (ii) Evaluate the **context-dependency** and **scale-dependency** of the INIs-biodiversity relationships;
- (iii) Assess the potential of **restoration** plans to mitigate navigation pressures.

From an operational perspective, this work will help identify priorities to guide waterway management, customize management solutions to specific territories, and identify at which scale(s) is most relevant to address and remedy INIs impacts on biodiversity.

[FR] Contexte et objectifs (environ 1 500 caractères espaces inclus)

Face aux changements globaux, le transport fluvial est une alternative prometteuse pour accompagner la transition écologique et atteindre la neutralité climatique. Le Pacte vert pour l'Europe prévoit des développements significatifs des voies navigables pour promouvoir le transport fluvial. Or le développement des infrastructures nécessaires (p. ex. canaux, écluses, ports) modifie les caractéristiques éco-morphologiques des cours d'eau avec des impacts potentiellement forts sur leur biodiversité.

Dans ce contexte, il est donc crucial de mieux comprendre les impacts directs et indirects de la navigation et des infrastructures associées sur la biodiversité afin de produire des recommandations pertinentes pour une gestion durable et adaptée des voies navigables. Ce défi est relevé par un groupe de 12 chercheurs/ses d'instituts européens spécialistes du sujet navigation-biodiversité à travers la poursuite de trois objectifs :

- (i) Quantifier et hiérarchiser les effets de la navigation et des INIs sur la biodiversité taxonomique et fonctionnelle ;
- (ii) Evaluer la contexte-dépendance et l'échelle-dépendance des relations INIs-biodiversité ;
- (iii) Déterminer le potentiel des stratégies de restauration dans la remédiation des pressions liées à la navigation.

Le projet NAVIDIV fournit *in fine* des connaissances synthétiques et des recommandations utiles à la priorisation des actions de gestion et de restauration des paysages navigables.

II. Project participants

List and attendance of project participants

Please indicate if any project participants were unable to attend a meeting, but were active remotely by using an asterisk (*).

	Name	Affiliation	Country	WS 1	WS 2	WS 3	WS 4	WS 5
PI 1	Aliénor JELIAZKOV	INRAE, UR HYCAR	France	X	X	X		X
PI 2	Jean-Nicolas BEISEL	ENGEES, CNRS, University of Strasbourg	France	X	X	X	X	X
Post-doc	Aaron SEXTON	CESAB-FRB / ENGEES / INRAE	France		X	X	X	X
1	Cybill STAENTZEL	ENGEES, CNRS, University of Strasbourg	France	X	X*	X	X	
2	Evelyne TALES	INRAE, UR HYCAR	France	X	X*	X	X	
3	Christian WOLTER	Leibniz-Institute of Freshwater Ecology and Inland Fisheries	Germany	X	X	X	X	X
4	Sonja JÄHNIG	Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Humboldt-Universität zu Berlin	Germany	X*	X*	X		
5	Karl M. WANTZEN	UNESCO, University of Tours	France	X*	X*	X		
6	Vanesa MARTÍNEZ FERNÁNDEZ	National Museum of Natural Sciences, CSIC	Spain	X*	X	X	X	X*
7	Carlos GARCIA DE LEANIZ	Swansea University, CSAR	UK	X	X*	X*	X	X
8	Tom BUIJSE	Deltares	Netherlands		X	X	X	X
9	Astrid SCHMIDT-KLOIBER	University of Natural Resources and Life Sciences, BOKU	Austria	X*	X*	X*		X*

Please list any additional invitees similarly, and identify their category: i.e. students, postdocs or visiting experts

	Name	Lab	Country	WS1	WS2	WS3	WS4	WS5
1	Eric TABACCHI, Guillaume FRIED & the BRIDGE group	(several)	France	X*				X
2	Erica RIEVRS	FRB-cesab	France			X		X
3	Nicolas CASAJUS	FRB-cesab	France	X	X	X	X	X

Comment: Nicolas CASAJUS (CESAB) participated to all of our workshops over specific sessions on data analyses. On WS1, we met with the BRIDGE group (other CESAB project) during two hours to exchange on our respective projects, aims and planned directions. On WS3, Erica RIEVRS, the postdoc of the BRIDGE project, spent half a day with us to show us her progress on the BRIDGE project and to discuss potential ideas of future collaboration between NAVIDIV and BRIDGE groups. On WS5 (final meeting), we met with Eric and Erica to discuss the progress of our respective projects, about our collaborative paper on the role of transport linear infrastructures in climate migrations, and the future prospects of our groups.

III. Activity report

Describe the main stages of advancement of the project, its main results, and their importance for this particular field of research. Please include some key illustrations and figures (**300dpi, 10 x 10cm minimum with legends and reference in the text**). Approximately 8 to 10 pages, with guidelines for the size of sub-sections. You can add documents as Appendices if necessary.

III.1 Description of the work conducted and scientific results obtained: for the scientific reader.

We propose to guide you across the NAVIDIV results through the scientific questions that we addressed. First questions focus on the assessment of the different impacts of navigation on river ecosystems (direct and indirect, mid-term and long-term impacts). The next set of questions strives to identify the solutions to remedy or mitigate these impacts. The final set of questions explores perspectives related to navigation. Each question is developed below, along with a brief overview of the methods applied and a summary of the results, accompanied by a figure.

QUESTION 1. WHAT IS THE CURRENT STATE-OF-THE ART OF OUR KNOWLEDGE REGARDING THE EFFECTS OF NAVIGATION ON RIVER ECOSYSTEMS?

Inland navigation is one of the most sustainable transport alternatives to help decarbonise the world economy. However, the likely impacts of intensifying inland navigation on freshwater ecosystems are difficult to predict. A global map of knowledge that considers both abiotic and biotic responses to increasing shipping traffic and developing infrastructures is lacking. Deriving general evidence-based assessments is challenging, because most studies on inland navigation impacts are merely descriptive and either consist of local case studies or address single navigation stressors or specific taxa only.

We conducted a systematic mapping of the published literature (1908-2021) to provide a global synthesis of the effects of inland navigation on the biotic and abiotic components of freshwater ecosystems. Our findings indicate that only half of the reported navigation-related impacts were statistically tested. Navigation itself (vessel operation) had mainly negative effects on native taxa (57%), followed by waterway management (40%), and navigation infrastructures (35%) (**Fig. 1**). Navigation causes direct negative impacts through physical disturbances such as vessel-induced waves, and indirect impacts by facilitating the spread of aquatic invasive species and altering the abiotic habitat conditions. Thirty percent of the tested relationships showed non-significant impacts on the biotic environment, while in 10% of cases impacts were context-dependent. We identified the main gaps of knowledge, namely (i) impacts of waterway management on communities, (ii) underlying processes of navigation impacts on river ecosystems; and (iii) interactions between multiple navigation factors and cascading effects on multi-taxa responses. These future research directions should improve the diagnosis, mitigate the negative impacts of navigation on rivers, and provide guidelines for improving navigated river management.

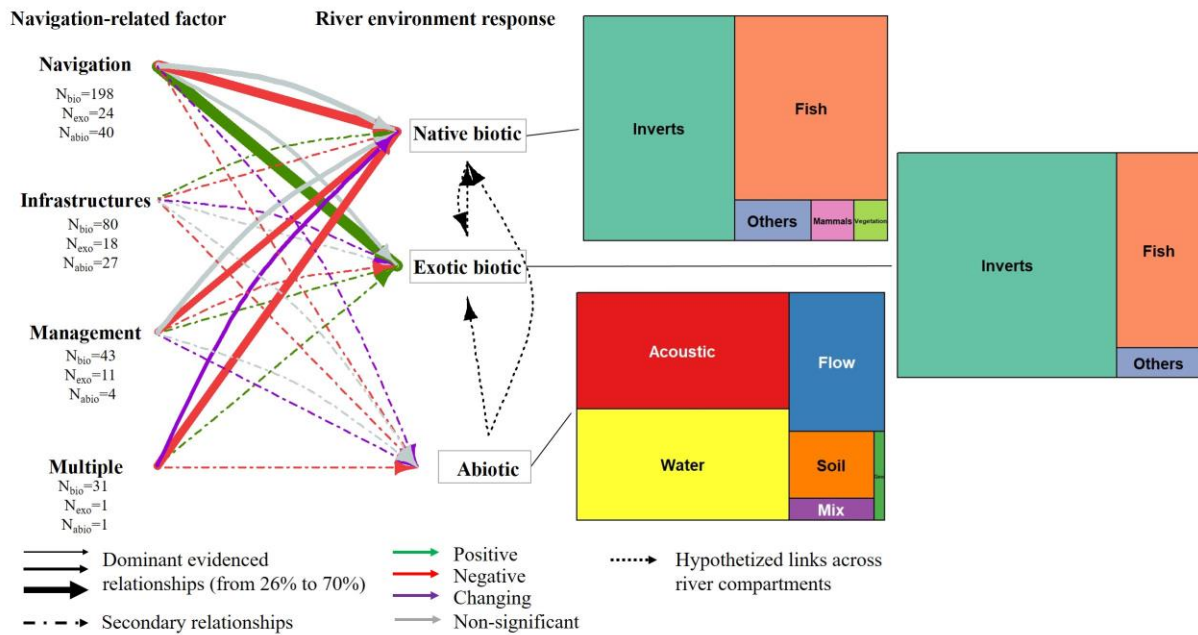


Figure 1. Evidence-based causal map of knowledge of navigation-related factors effects on river environment. Left panel: The dominant relationships (i.e. the ones showing significant imbalance from proportion analyses) are represented with plain arrows. The secondary relationships (i.e. the ones showing no significant imbalance from proportions analyses for the biotic component, and not testable for the abiotic component) are represented with dot-dashed arrows. Thickness of the arrows is proportional to the percentages revealed by the proportion analysis and colour of the arrows indicate the sign of the relationship. Right panel: treemaps showing the relative representativeness of the main taxa and the types of abiotic responses into the map of knowledge. (Jeliazkov et al. 2024, JEM)

QUESTION 2. FOCUS: WHAT WERE THE GREAT HISTORICAL ERAS OF INLAND NAVIGATION IN EUROPE?

Rivers have a long history of human uses and local interventions. This study focuses on inland navigation as one of the oldest uses that became the main driver for river engineering and landscape transformation into waterways in the 19th century (**Fig. 4**). By analyzing historical maps and literature from two usually separated disciplines, river engineering and fisheries, this study aimed to quantify habitat losses related to river regulation and characterize their impacts on fish and fisheries. The systematic engineering of rivers into waterways resulted in significant hydromorphological changes and large-scale habitat loss: on average 22%, 79%, and 84% of their length, braided sections, and islands were lost, respectively. These modifications resulted in depth incision, landscape draining, reduced lateral connectivity and significant losses of shallow habitat areas. Consequently, riverine fishes, especially migratory species declined and disappeared, followed by fisheries after certain lag-time. Riverbed incision and the large-scale loss of multi-thread sections impact the rivers' resilience against climate change, with consequences for riverine biota, but also surrounding land use. Therefore, river management has to account for the incompatibility of certain uses and actively prioritize ecological improvement in all waterways of limited inland navigation transport.

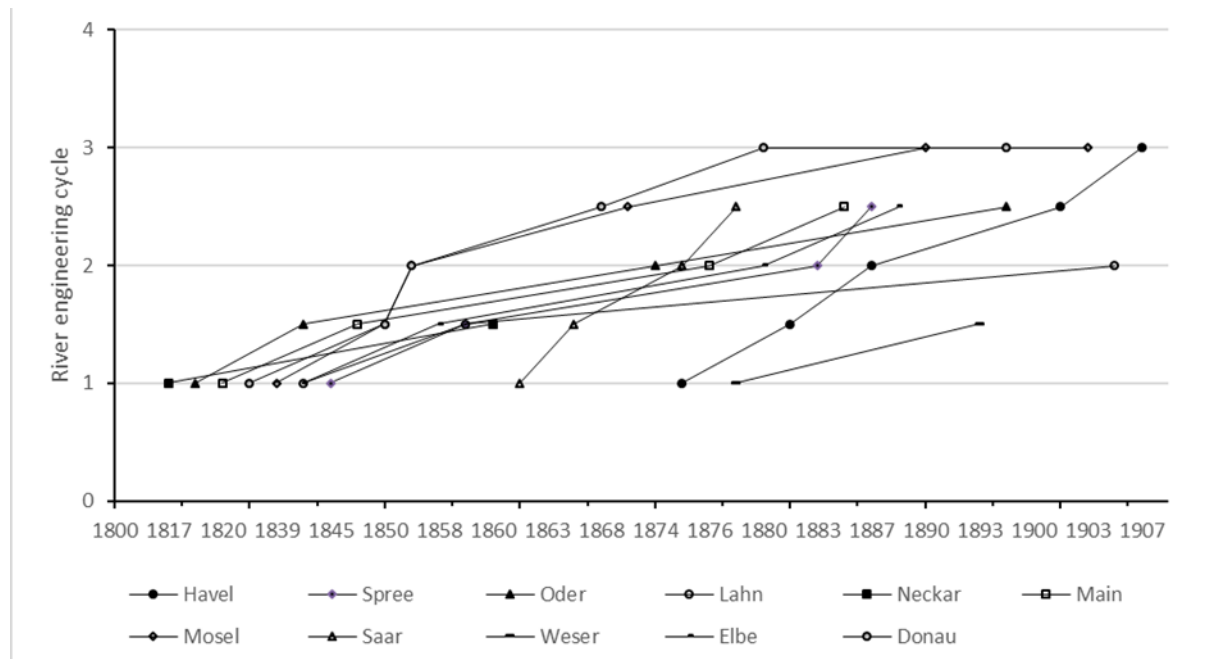


Figure 4. Periods of large-scale river regulation works in various European rivers: 1= beginning of the first regulation phase, known as the “mean water regulation”, 2= beginning of the second phase, so-called low water regulation, 3= beginning of the third regulation wave, which often included dam construction. (Wolter et al. *in prep.*)

QUESTION 3. WHAT ARE THE QUANTITATIVE EFFECTS OF NAVIGATION ON BIODIVERSITY AND THEIR CONTEXT-DEPENDENCE?

Inland navigation in Europe is proposed to increase in the coming years, being promoted as a low-carbon form of transport. However, we currently lack sufficient knowledge on how this would impact biodiversity at large scales and interact with existing stressors. Here we addressed this knowledge gap by analysing fish and macroinvertebrate community time series across large European rivers comprising 19,592 observations from 4,049 sampling sites spanning the past 32 years (**Fig. 2 - left panel**). We found ship traffic to be associated with biodiversity declines, that is, loss of fish and macroinvertebrate taxonomic richness, diversity and trait richness. Ship traffic was also associated with increases in taxonomic evenness, which, in concert with richness decreases, was attributed to losses in rare taxa. Ship traffic was especially harmful for benthic taxa and those preferring slow flows. These effects often depended on local land use and riparian degradation. In fish, negative impacts of shipping were highest in urban and agricultural landscapes (**Fig. 2 - right panel e**). Regarding navigation infrastructure, the negative impact of channelization on macroinvertebrates was evident only when riparian degradation was also high (**Fig. 2 - right panel f**). Our results demonstrate the risk that increasing inland navigation poses to freshwater biodiversity. An integrative waterway management accounting for riparian habitats and landscape characteristics could help to mitigate these impacts.

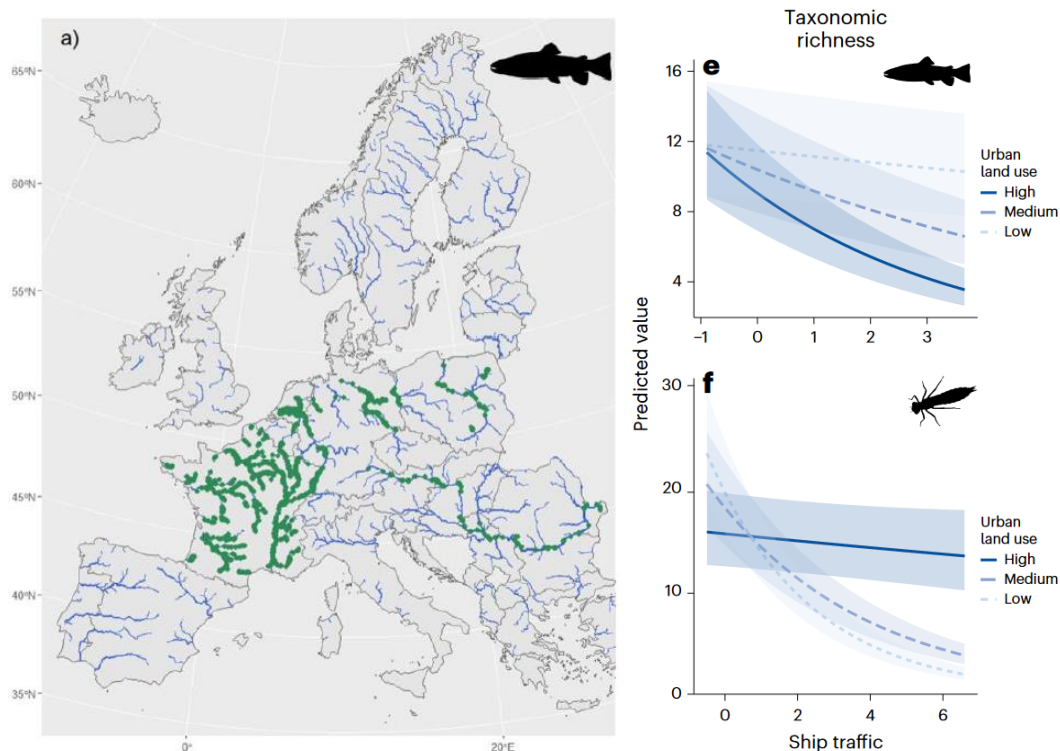


Figure 2. Left panel: Example of data map: Locations of fish biodiversity data used in our analyses (green dots) ($n = 2,381$). Large rivers and navigated canals are shown in blue lines. Right panel: Plots visualizing the changes in the marginal effect of ship traffic at specific levels of urbanization (high, medium and low levels of urban land use, with medium representing the average level of urbanization and high and low representing the maximum and minimum values) by showing the predicted values of taxonomic richness for fish (e) and macroinvertebrate communities (f) as ship traffic increases in across different land use situations. (Sexton et al. 2024 NEE)

QUESTION 4. DOES NAVIGATION FAVOUR INVASIVE SPECIES? AND IF SO, AT WHAT SCALES?

Invasive species are among the most important drivers of native species declines and cause serious economic and ecological costs. Globally, Europe is a hotspot for freshwater non-native species, especially among macroinvertebrates and fish, and inland navigation is thought to be a major driver of their spread. However, the degree to which different aspects of navigation (i.e. ship traffic vs. infrastructures) contribute to the spread, establishment, and distribution of non-native species has not yet been quantified. Our study aims to determine the role that navigation plays in the distribution of European freshwater established non-native species, and which aspects of navigation are most responsible. Additionally, we sought to identify the spatial scale at which these navigation pressures operate, and what ecological characteristics may influence species' response to navigation.

To this aim, we extracted data from the Global Biodiversity Information Facility (GBIF) to identify occurrences of established non-native species in Europe from the past 30 years (**Fig. 3 - upper panel**). Using over 500,000 occurrences, we mapped the coverage of more than 250 established non-native species and paired this with pan-European data on inland ship traffic, navigation infrastructure, and environmental factors.

We found that the greatest predictor of non-native species richness and occurrences was the presence of a shipping canal in the subcatchment (**Fig. 3 - lower panel**). This held true for both fish and macroinvertebrates at fine and large spatial scales. Temperature was also an important predictor of invasive species distribution. We found these positive associations to be strongest for generalist fish species, molluscs, and crustaceans.

Freshwater navigation, especially in canals, are important vectors for non-native species establishment, and highlights the need for frequent monitoring and mitigation. Given that increased temperatures are associated with greater establishment success, climate change may also play an increased role in non-native species dispersal.

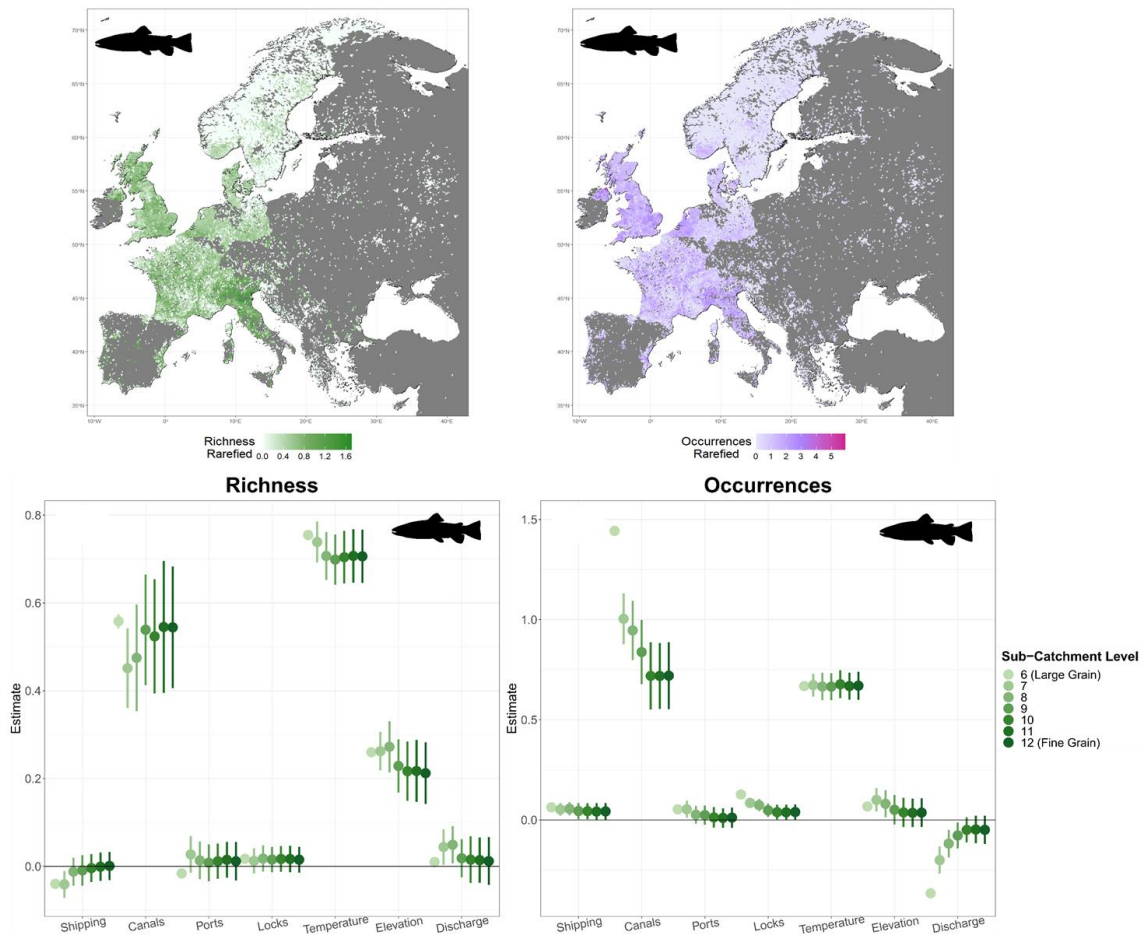


Figure 3. Upper panels: Maps of freshwater invasive fish distributions: left panel shows the invasive species rarefied richness in our subcatchments at the finest spatial grain – Pfafstetter level 12; right panel shows the rarefied number of invasive species occurrences (values are rarefied via the Menhinick diversity metric, and have been square root converted for improved visualization). Grey subcatchments indicate no data. Lower panels: Model estimates of how navigation and environmental variables predict the richness and occurrences of fish invasive species. Dots represent the average model estimate for each term and bars represent the standard deviation of model estimates across the 999 iterations of the models with invasive species richness (panels on the left) or occurrences (panels on the right). Dot and line color represent the spatial grain the model was run at, from a large grain (Pfafstetter level 6) in pale green to a fine/small grain (Pfafstetter level 12) in dark green. (Sexton et al. *major rev. in GEB*)

QUESTION 5. WHAT IS THE CURRENT STATUS OF OUR KNOWLEDGE REGARDING RESTORATION ACTIONS IN NAVIGATED RIVERS?

As discussed above, vessel traffic, transport infrastructure, and waterway management impose significant costs on biodiversity. It is therefore crucial to identify ways to mitigate these negative impacts to support this low-emission form of transport. We reviewed 61 studies across 16 countries and conducted word analysis to illustrate the relationships between impacts and mitigation measures. Most studies have focused on optimizing the functioning of existing infrastructure (54%),

followed by restoration measures (34.5%), and impact avoidance strategies (11.5%) (Fig. 5). The most common restoration actions to mitigate the impacts of inland navigation include channel division, the creation of river islands, and the restoration of natural banks to enhance lateral connectivity and reconnect the channel with the floodplain through integrated water level management. Measures to avoid or reduce impacts at the source (66% of actions) are diverse and often involved innovative solutions, such as the installation of flap on the barge stern to reduce wave energy, water injection dredging as an ecologically sensitive alternative to traditional dredging, and the management of sluice gates to allow the migration of fish. Our findings underscore the importance of legislation to implement solutions, such as the prohibition of TBT-base anti-fouling paints, the European Regulation on fuel quality used by boats, or the Ballast Water Exchange regulations for transoceanic vessels to prevent the transfer of invasive species. This analysis is an aid to decision-making in a context of increasing river transport activity and the construction of new waterways.

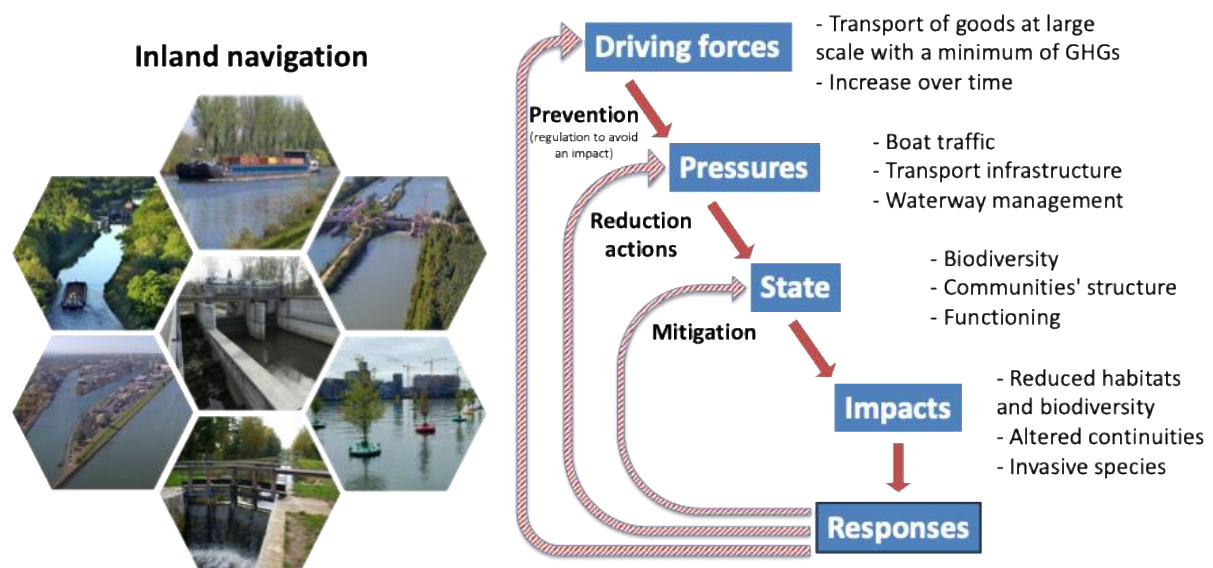


Figure 5. Inland navigation impact on freshwater ecosystems and mitigation / restoration solutions seen through the prism of the DPSIR framework.

QUESTION 6. IS RESTORATION OF NAVIGATED RIVERS EFFECTIVELY SUCCESSFUL?

Active restoration in navigated rivers mainly relies on hydromorphological restoration measures, such as bank renaturalization, floodplain reconnection, and dam removal. Among restoration projects, there is a high variability in the success of restoring biodiversity and ecosystem functioning. The outputs of restoration often depend on the river type, for instance, natural headwater rivers vs. large and highly anthropized rivers such as navigated rivers have very different functioning. Results also depend on the restoration aims, the restoration measures, the target, either biotic or abiotic, the geographical location, the landscape context, etc. We do not know to which extent restoration works in navigated rivers. From scattered results of river restoration projects across various river types, it is difficult to derive an accurate assessment and understanding of restoration success for navigated rivers specifically. In addition, conclusions can vary depending on the methodology used for restoration assessment, and in particular, what baseline is used to assess the success of a restoration project (e.g. whether compared to degraded rivers or reference rivers).

We urgently need an assessment of restoration success in navigated rivers, because they are important for society (bring many ecosystem services to humans, e.g. regulation, food, recreation, transportation, etc.). This assessment is of particularly high importance because navigation is going to increase in the coming decades due to the emergence of transport greening strategies in the face

of climate change. So, we need to know how to avoid or mitigate adverse effects of navigation on river ecosystems. In addition, in the context of the UN restoration decade, it is particularly timely to gain knowledge, and provide recommendations to support future restoration policies and adapt restoration strategies to highly anthropized rivers.

To fill this gap, we here propose a meta-analysis that synthesizes the results of restoration on navigated rivers. In particular, we aim to assess (1) to which extent restoration works in navigated rivers, (2) which types of hydromorphological restoration methodologies work best, (3) for whom, and (4) how the choice of reference influences the outcome of restoration projects.

Based on an exhaustive / systematic literature search focusing on the 64 largest and most navigated rivers worldwide, we found 30 case studies from which we were able to extract the raw data of effect sizes of restoration projects. We applied a meta-analysis on these data and compared the effect sizes across river compartments, taxonomic groups and assessment strategies.

We observed strong improvements from degraded rivers, but not a full return to reference levels (Fig. 6). Restoration greatly and almost systematically improves the situation of rivers that are degraded by navigation. Restoration strategies that work the best are: morphology adaptations, flooding regulation and riparian vegetation management. Almost all taxonomic groups, habitat types, and organization levels benefit from restoration. However, restoration cannot bring navigated rivers back to reference conditions. Overall, rivers do not reach reference level after restoration, probably because rivers initially were too strongly degraded and may have reached a kind of no-return point and/or because the navigation pressure persists. Furthermore, we observed substantial differences between degraded vs. reference analyses. For instance, reference level seems more difficult to reach for population-level objectives than for community-level objectives. This may be because restoration might result in the colonization of new, generalist or non-native species, which leads to a higher diversity and thus, favours the community-level responses.

This study provides recommendations to support future restoration policies and adapt restoration strategies to navigated rivers.

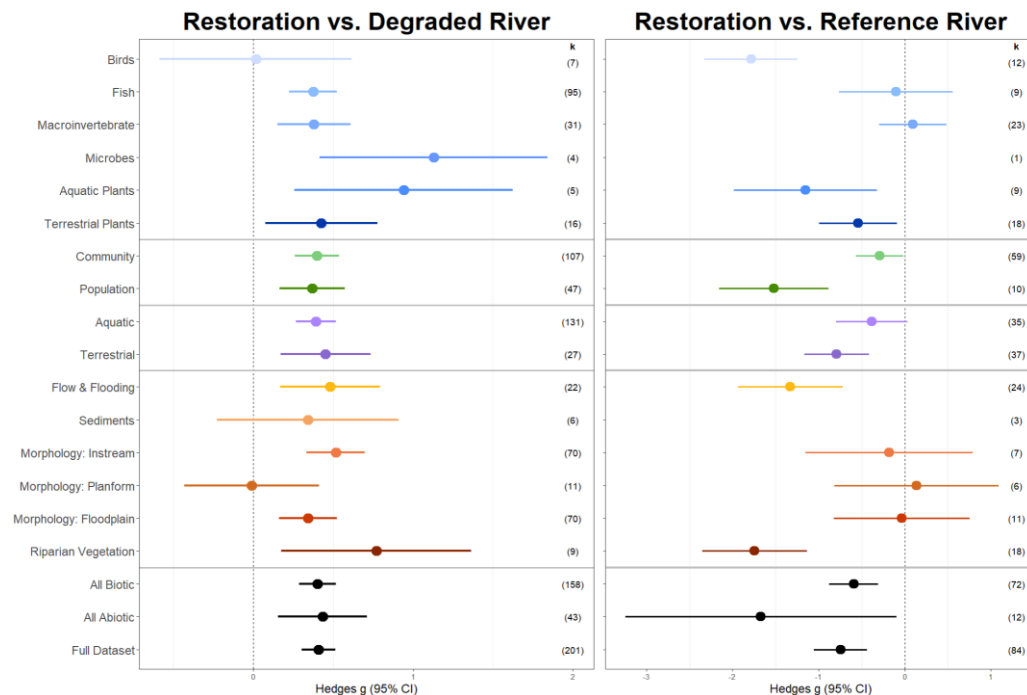


Figure 6. Forest plot showing the effect sizes (Hedge's g) and 95% confidence interval for the overall effect of restoration, and on subset analyses. Left panel represents the effect sizes comparing restorations to a degraded river, and right panel represents a comparison to a reference or "goal"

river. Points represent the mean effect size from the random effects model and bars represent the 95% confidence intervals. The numbers to the right represent the number of data points for each model. In addition to the full models, we also show the subset analyses split by taxa at the top, followed by level of organization, habitat, and restoration methodology. (Sexton et al. *in prep.*)

QUESTION 7. WHAT ARE THE PERSPECTIVES FOR (NAVIGATION) TRANSPORT INFRASTRUCTURES WITH RESPECT TO BIODIVERSITY AND CLIMATE CHANGE ? AN OPINION PIECE ON CLIMATE MIGRATION.

As the climate continues to change, species are expected to shift their distributions to track their preferred temperature and moisture regimes. However, many species will not be able to move fast enough to keep pace with the changing climate, or face barriers preventing their climate migrations. As such, there is a need to identify ways that landscapes can be managed and designed to facilitate climate migrations, whenever possible. We argue that linear infrastructure units (e.g. roads, waterways, railways) could provide a unique opportunity that, to this point, has been overlooked in their potential to facilitate climate migrations. While linear infrastructures are well known to have negative impacts on biodiversity, such as increasing invasive species spread and fragmenting landscapes, they also have the potential to facilitate distributional shifts of native species.

Here we outline potential management and design practices that could favour the dispersal of native populations and therefore enable species to shift their ranges, and open new avenues for climate migrations that would otherwise be impossible. We argue for several evidence-based practices, mostly aiming at increasing habitat quality and landscape connectivity alongside linear infrastructures that could both mitigate their inherently negative impacts on biodiversity and support climate migrations of target species. Additionally, we discuss potential avenues of implementation via funding mechanisms and point towards areas of future research. In this paper, we provide an extensive list of management actions that should make the LIUs suitable opportunities for climate migration, and a graphical summary of the main properties LIU should have in order to facilitate this migration while avoiding the spread from invasive species.

As LIUs are virtually ubiquitous worldwide and will continue to be developed and expanded in the coming decades, it is important we gain a better understanding of how to mitigate their negative impact on the environment while identifying areas where they could have positive impacts. As they often connect otherwise unlinked habitats, we have argued that LIUs could provide an avenue for facilitating climate change-induced range shifts. If they are managed and designed with this in mind, they could support a diversity of species and help species avoid extirpation, or extinction. There is future work needed to fully identify best practices, but there is already a suite of actions that can be applied today to mitigate LIUs negative impacts and enhance their connectivity potential for native species. (Sexton et al. *in prep.*; collaborative paper with the BRIDGE group)

III.2.1 Introduction (around 300 characters including spaces): for large audience

This will be used in the project summary. CESAB-FRB reserves the right to modify the text for publication on its platforms. You will be consulted before publication. As these elements are intended for the general public, be sure to write this text in a way that is easy to understand.

Inland navigation transport is considered as one of the most promising, sustainable transport alternatives to help operate the ecological transition and achieve climate neutrality. However, shipping and the development of navigation infrastructures come with important impacts on river ecosystem and biodiversity.

III.2.2 [FR] Introduction (environ 300 caractères, espaces inclus): pour grand public

Ceci sera utilisé dans la fiche résultat du projet. CESAB-FRB se réserve le droit de modifier le texte pour publication sur ses plateformes. Vous serez consulté avant la publication. Ces éléments étant destinés au grand public, veillez à rédiger ce texte dans une optique de vulgarisation.

Face aux changements globaux, la navigation fluviale est une alternative de transport prometteuse pour accompagner la transition écologique. Or l'intensification du trafic fluvial et le développement des infrastructures nécessaires modifient les caractéristiques éco-morphologiques des cours d'eau avec de sérieux impacts sur leur biodiversité.

III.3.1 Methods and approaches used for your project (around 700 characters including spaces): for large audience

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We studied the relationships between navigation activity, the associated Inland Navigation Infrastructures (INIs), and biodiversity.

We aimed to:

- Understand the **effects of navigation and INIs** on biodiversity;
- Evaluate the effect of the landscape **context** on the INIs-biodiversity relationships;
- Assess the potential of **restoration** plans in mitigating navigation pressures.

We used two complementary synthesis approaches:

- A literature review of the existing knowledge and meta-analysis at the global scale for all taxonomic groups;
- Analyses of empirical observations at the European scale for two taxonomic groups (fish and invertebrates) that have different interactions with the river and riverscape.

III.3.2 [FR] Méthode et approches utilisées pour le projet (environ 700 caractères, espaces inclus): pour grand public

Ceci sera utilisé dans la fiche résultat du projet. CESAB-FRB se réserve le droit de modifier le texte pour publication sur ses plateformes. Vous serez consulté avant la publication. Ces éléments étant destinés au grand public, veillez à rédiger ce texte dans une optique de vulgarisation.

Le projet NAVIDIV étudie les relations entre les activités de navigation, les infrastructures de navigation fluviale associées (INIs), et la biodiversité.

Il vise à :

- Comprendre les effets de la navigation et des INIs sur la biodiversité,
- Evaluer l'effet du contexte paysager sur les relations INIs-biodiversité,
- Déterminer le potentiel des stratégies de restauration dans la remédiation des pressions liées à la navigation,

à travers deux approches complémentaires de synthèse :

- Revues exhaustives de la littérature et méta-analyses à l'échelle mondiale, pour tous les groupes taxonomiques;

- Analyses de données d'observations à l'échelle européenne pour deux groupes taxonomiques (poissons et invertébrés aquatiques) qui ont des relations différentes à la rivière et son paysage.

III.4 Access to data

Describe any data and/or databases created or added to during the course of the project, and components of your data management plan:

- (a) the types of data collected and used

Please see below a table extracted from our data management plan (**Table 1**).

Table 1. List of data used for the NAVIDIV project (data type, description, storage location, and formats)

Data type	Description	Storage location	Formats
Collaborative files	<ul style="list-style-type: none"> ▪ PowerPoint presentations at seminars and progress meetings ▪ Bibliography & scientific articles 	OneDrive (private)	pdf., ppt., xls., csv.
Data collected and used	<p><i>Biological data</i></p> <ul style="list-style-type: none"> ▪ Local data from NAVIDIV scientific partners ▪ Biodiversity data extracted from the web <ul style="list-style-type: none"> ○ Observation data from sampling of river fish and macroinvertebrates (relative abundances) (e.g. Large River Database, GBIF) ▪ Ecological trait data (e.g. Tachet et al. 2010) ▪ IUCN red lists <p><i>Environmental data</i></p> <ul style="list-style-type: none"> ▪ Contextual, landscape and territorial data <ul style="list-style-type: none"> ○ Land-use / land-cover data from remote sensing tools (e.g. Copernicus) ○ Topography / hydrography ▪ Physico-chemical and hydroclimatic data (Climate/Hydrology) ▪ Contour and scale data <p><i>Navigation & INIs data</i></p> <ul style="list-style-type: none"> ▪ Navigation and infrastructure data <ul style="list-style-type: none"> ○ Shipping traffic (MarineTraffic) ○ Channels (MarineTraffic) ○ Ports and locks data (UNECE) ○ Types of vessels (MarineTraffic) 	Seafile (private)	csv., shp., xls., gpkg., xml
Data produced by the NAVIDIV group	<ul style="list-style-type: none"> ▪ Transformed files with DOI (provision of metrics used in statistical models) ▪ List of navigation-ecosystem relationships (N=1103) as collected from an exhaustive literature search along with detailed metadata (see the map of knowledge Jeliaskov et al. 2024) ▪ List of invasive macroinvertebrates species informed for each European country (see Sexton et al., major rev. in GEB) ▪ Code used for GBIF data processing (https://github.com/CStaentzel/GBIF-paper) ▪ Meta-analysis dataset from Sexton et al. (in prep.) – sites of all restoration projects in 	<p>Hydroshare (public) for transformed files</p> <p>Access to data in publications</p> <p>Access to our codes in Github (Sexton et al., major.rev in GEB)</p>	csv., pdf, R.script

	navigated rivers, and the measured biodiversity responses with effect sizes (Hedge's <i>g</i>) calculated for each response.		
	<ul style="list-style-type: none"> ▪ Data management plan 		

(b) standards used to document the data

To ensure high standards in data documentation and facilitate data reuse, we adhere to well-established practices recommended by leading journals we selected, such as *Nature Ecology and Evolution*. For metadata, we follow standard protocols to provide comprehensive and precise information about each dataset, including collection dates, methods, and authorship. We aligned our practices with what top-tier publications require to ensure data clarity and transparency. Moreover, we apply consistent file naming and organization conventions, enhancing data accessibility and interpretability. Collaborative files were always named according to the date of the meeting to which they refer, or the title of the task in which they are inserted. For example, we carried out a major bibliographical project to report on the influence of navigation on several biological compartments. For this work, two files were made available on the drive of Aliénor Jeliakov (PI): (i) 4_REVIEW_TABLE (the 4 referring to the version of the working paper) and (ii) Papers_to_review_22122021 (the date referring to the version of the working paper). When relevant, we incorporated controlled vocabularies and ontologies to ensure consistent terminology across datasets. By following these practices, we uphold documentation standards that support data integrity and allow for effective data sharing and understanding across research communities.

(c) policy for access and re-use, short- and long-term storage and management

Our data management policy ensures responsible access, reuse, and storage both in the short and long term. We provide open access to data wherever possible, under licenses that define permitted uses, ensuring compliance with FAIR principles. Some policies varied by data sources:

- Private data we were unable to make public, such as navigation intensity from MarineTraffic, have been stored on at least two computers, each backed up with external hard drives and a private cloud server (SeaFile). These data are made available on a case-by-case basis according to inquires and our ability to respond.
- Public data have been stored on public repositories primarily on HydroShare for transformed files (doi) then GitHub for specific requests of journals. When data are used in published papers, we archive these public repositories on Github to ensure their long-term preservation. All public repositories include meta-data and a "ReadMe" to assist in interpretation. Examples of our public repositories include:
 - https://github.com/aaronsexton/Sextonetal_Navigation_Biodiversity_Supplementals
 - <https://github.com/CStaentzel/GBIF-paper>
- The data from the map of knowledge (Jeliakov et al. 2024) have been made publicly available on the public repository data.gouv.fr: <https://doi.org/10.57745/N6Y6QR>
- **The finalized version of the data management plan is now available via the public link [DMPNAVIDIV_05102024](#) – and has been uploaded to the ITTECOP Google Drive group as requested.**

During the project, data has been securely stored on protected servers with controlled access and version tracking. For long-term preservation. This policy supports the immediate needs of our research while ensuring data remains accessible and useful over time, following best practices recommended by leading journals.

(d) people to contact after the end of the project.

For general purpose:

Aaron Sexton
Alienor Jeliakov
Jean-Nicolas Beisel
Cybill Staentzel

For specific requests regarding data:

Aaron Sexton
Jérôme Belliard
Evelyne Tales
Cybill Staentzel
Christian Wolter
Tom Buisje

III.5 Scientific outcomes of the project

- List of ALL publications (articles, books, book chapters ...) published, submitted or planned (with planned deadlines for submission). **Highlight the 3 most significant in your view.**

Sexton, A. N., Beisel, J.-N., Staentzel, C., Wolter, C., Tales, E., Belliard, J., Buijse, A. D., Martínez Fernández, V., Wantzen, K. M., Jähnig, S. C., Garcia de Leaniz, C., Schmidt-Kloiber, A., (...) Jeliaskov, A. (2024). Inland navigation and land use interact to impact European freshwater biodiversity. *Nature Ecology & Evolution*, 1-11. <https://doi.org/10.1038/s41559-024-02414-8>

Jeliaskov A. *, Martínez-Fernández V. *, Altanov V., Beisel J.-N., Buijse A. D. , Consuegra S., Felin S., Garcia de Leaniz C., Graf W., He F., Jähnig S. C., Leitner P., Schmidt-Kloiber A., Sexton A. N., Staentzel C., Tales E., Wantzen K. M., & Wolter C. A global systematic map of knowledge of inland commercial navigation effects on freshwater ecosystems. *Journal of Environmental Management*, 370, 122474. <https://doi.org/10.1016/j.jenvman.2024.122474>

Sexton A. N., Staentzel C., Jeliaskov A. (...) & Beisel J.-N. Freshwater navigation supports non-native species across spatial scales. Major revision in *Global Ecology and Biogeography*

Beisel J.N., Staentzel, C., Sexton A. N.; Wantzen, K. M., (...) Jeliaskov A. Reducing the impact of inland navigation: a review of mitigation and restoration solutions. Being finalized, submission planned by the end of 2024.

Sexton A.N., Tales E. Beisel J.N. (...), Jeliaskov A.* & Martinez Fernandez V.* Restoration in navigated rivers works, but falls short of reference levels. In prep, submission planned in *Frontiers in Ecology and the Environment* by beginning 2025.

Wolter C., Tales E., Staentzel C., (...), Beisel J.N. & Jeliaskov A. Adjusting rivers to vessels marks the beginning of large-scale river fish declines. Being finalized, submission planned by beginning 2025.

Sexton A.N., Borges E.R., Beisel J.N., Fried G., Jeliaskov A., Tabacchi E. et al. Can linear infrastructures facilitate climate migration? Being finalized, submission planned beginning 2025.

- List of oral communications and posters in conferences, past or planned (please, give the dates of these conferences)

Aaron N. Sexton, Jean-Nicolas Beisel, Cybill Staentzel, Alienor Jeliaskov. Inland navigation and land use interact to impact European freshwater biodiversity. *British Ecological Society meeting*. Dec 2023. Belfast, Northern Ireland.

Alienor Jeliaskov, Jean-Nicolas Beisel, Aaron N. Sexton. Infrastructures de navigation fluviale et biodiversité : impacts et opportunités pour la gestion du paysage navigable. *Journées webinaires ITTECOP*, ITTECOP, MTE, Sep 2022, Paris, France. [hal-04186250](https://hal.archives-ouvertes.fr/hal-04186250)

Jean-Nicolas Beisel, Aaron N. Sexton, Alienor Jeliaskov. Infrastructures de navigation fluviale et biodiversité : impacts et opportunités pour la gestion du paysage navigable. *Colloque ITTECOP 2022*, Oct 2022, Paris, France. [hal-04186239](https://hal.archives-ouvertes.fr/hal-04186239)

Aaron N. Sexton, Jean-Nicolas Beisel, Alienor Jeliaskov. Context-dependence of navigation effects on biodiversity: a data synthesis across Europe. *SFE² GfÖ EEF Joint meeting, International Conference on Ecological Sciences*, SFE² GfÖ EEF, Nov 2022, Metz, France. [hal-04186185](https://hal.archives-ouvertes.fr/hal-04186185)

Alienor Jeliaskov, Aaron N. Sexton, Jean-Nicolas Beisel, The Navidiv Group. Effects of inland freshwater navigation on river ecosystems. *SEFS13 Symposium for European freshwater sciences*, FBA; EEF, Jun 2023, Newcastle Upon Tyne, United Kingdom. [hal-04186278](https://hal.archives-ouvertes.fr/hal-04186278)

- Other outcomes (databases, software, R-code, web sites, etc).

- 1) JELIAZKOV, Alienor, 2024, "Database for systematic map of inland navigation effects on freshwater biodiversity", <https://doi.org/10.57745/N6Y6QR>, Recherche Data Gouv, V1
- 2) https://github.com/aaronsexton/Sextonetal_Navigation_Biodiversity_Supplementals
- 3) <https://github.com/CStaentzel/GBIF-paper>

- List of grant proposal submitted or planned (with planned deadlines for submission).

- 1) **SYNERGY Call 2022. "Mapping Riparian Forests of High Conservation Interest". Led by Staentzel C. and Sexton A.**

Abstract: In concert with calls from researchers, conservationists, and recent legislation, France has an ambitious goal of preserving 30% of its land for conservation purposes by 2030. The environmental and economic benefits of this goal are clear, however the long-term plan of how to execute said mission are less so. Crucial to this process of protecting France's land, and subsequent biodiversity, is identifying where conservation/protection efforts would be most beneficial. Ecosystems range in their services and plant and animal communities widely across France, and even within ecosystem types the quality of habitats can vary significantly. Riparian forests are an ecosystem that host a disproportionately high degree of France's biodiversity. The connection between aquatic and terrestrial realms allows for unique habitat and resource availabilities that in-turn harbour an extremely high degree of biodiversity. However, their protection across Europe is lacking, with a lower proportion of riparian forests protected than other ecosystem types. As such, we argue that as France pushes to expand its protected areas, there should be a focus on riparian forests. However, as mentioned above, forests can vary in their ecosystem services and habitat quality, so it is important land managers and stakeholders have the tools available to identify forests of highest conservation interest. The RIPARIAN project is focused on creating a novel metric to quantify the conservation interest of France's riparian forests based on a set of spatial and temporal indicators. These indicators, such as forest patch size, age, historical land usage, and connectivity, will be based on publicly available data so that this metric can be reproduced by external research groups and stakeholders. Our metric will be made available in the form of a peer-review publication to detail our methodology, reasoning, and validations, as well as in the form of a white-paper report meant for land managers and conservation practitioners with a focus on implementation and reproducibility. The RIPARIAN project builds on fundamental findings and data collection conducted in the NAVIDIV project. This previous work by the NAVIDIV group allows us to quickly jump-start this project and begin from a well-prepared position. The addition of new group members with strong expertise in riparian ecology and pre-existing datasets will allow us to be efficient and produce tangible results for stakeholders in our timeframe.

Unfortunately not funded.

2) BIODIVERSA+ 2022 Call. "Monitoring Quality of Riparian Forests by Conservation Interest and Multifunctionality for Europe and beyond". Led by Staentzel C. & Sexton A.

Abstract: Several European nations have plans to conserve a certain percentage of their land and water for biodiversity within the next decade (e.g. EU Biodiversity Strategy 2030). How this will be done, and what areas will be prioritised in conservation acquisitions is largely not yet clear, much less so the share of components of such planning (Eros & Banyai 2020). Hence, stakeholders require tools that can help them build a conservation strategy roadmap and focus on habitats that host rich biodiversity and provide abundant ecosystem services. RIPARIAN+ will (i) quantify the conservation interest, focusing on riparian forests explicitly, where we argue conservation efforts would have large returns on value (increased biodiversity and ecosystem services), and (ii) develop a tool to make analysis from monitoring accessible, automatic, and fast. Riparian forests are among the most important ecosystems for the conservation of European biodiversity (Naiman et al. 1993; Van Looy et al., 2013). The boundary between aquatic and terrestrial ecosystems harbours unique species assemblages that cannot otherwise exist, due to the specific interface conditions (Gregory et al., 1991; Naiman et al. 2005). Riparian forest conservation has been shown to have cascading benefits, leading to not only improved terrestrial communities, but even fish and aquatic macroinvertebrate communities (Fig.1, Burdon et al. 2020, Kupilas et al. 2021). Beyond biodiversity, riparian forests provide a range of ecosystem services, including temperature regulation, pollution attenuation, and flood mitigation which are becoming increasingly important in the context of climate change (Riis et al., 2020). However, riparian forests face a range of anthropogenic threats and are disproportionately under-protected compared to other ecosystem types (Nilsson & Berggren, 2000). In the 19th and early 20th centuries, riparian forests were drastically reduced, leaving only slivers of remnant forest patches within the matrices of land use. Contemporary forests reflect these historical and modern pressures with a mosaic of forest patches of varying ages, land-use histories, and consequent conservation values. These legacy effects combined with modern anthropogenic pressures play a central role in the ecosystem function and resilience of European's riparian forests. Research in heavily fragmented environments has shown that narrow and isolated riparian forest patches host reduced species richness and communities composed of predominantly disturbance-tolerant plant species (Nagy et al., 2015). Additional research has documented pronounced species-specific shifts in tree regeneration in riparian forests fragmented by agriculture, indicating lasting legacy effects of disturbances in these forests (Lehvavirt et al., 2014; Aguiar et al., 2018). Vital to future monitoring and conservation efforts is our ability to link spatial and temporal features to the biodiversity and ecological functionality of riparian buffers. While there has been a great deal of high-quality research in riparian corridors

(e.g., OSCAR, CROSSLINK, SABICAS, CONVERGES projects), the influence of temporal, or historical changes, has not yet been fully investigated. However, with the creation of new software and tools, our team plans to build on the knowledge gained from these projects, especially as members of RIPARIAN+ were involved in said previous projects. The RIPARIAN+ project aims to fill the gaps and produce two interoperable and novel metrics of conservation interest, and a tool to aid their calculation which can inform conservation interest.

Unfortunately not funded.

IV. Principal conclusions (publishable)

IV. 1 Principal conclusions (around 1000 characters including spaces): for large audience

Highlight a key outcome with illustration (graph, map, picture, etc.) and let us know its significance.

This will be used in the project summary. CESAB-FRB reserves the right to modify the text for publication on its platforms. You will be consulted before publication. As these elements are intended for the general public, be sure to write this text in a way that is easy to understand.

NAVIDIV demonstrates the adverse effects of inland navigation and infrastructures on river ecosystems and biodiversity at both European and global scales. Ship traffic, causing physical disturbances and habitat alteration, is associated with biodiversity declines, especially in fish and macroinvertebrates, while canals favour the prevalence of non-native species. Moreover, navigation effects are context-dependent and generally worst in rivers that flow in highly anthropized landscapes (agricultural or urban) or those suffering from strong riparian degradation.

These impacts can be avoided, or at least mitigated by optimizing the functioning of existing infrastructures, and active restoration. Restoration strategies that work the best in navigated rivers are river morphology adaptations, flooding regulation and riparian vegetation management. However, restoration cannot bring navigated rivers back to reference level, because these rivers have reached a too high level of degradation and require customized, integrative management policies.

IV. 2 [FR] Principales conclusions (environ 1000 caractères, espaces inclus): pour grand public

Mettez en évidence les résultats à l'aide d'illustrations (graphique, carte, image, etc.) et faites-nous connaître sa signification.

Ceci sera utilisé dans la fiche résultat du projet. CESAB-FRB se réserve le droit de modifier le texte pour publication sur ses plateformes. Vous serez consulté avant la publication. Ces éléments étant destinés au grand public, veillez à rédiger ce texte dans une optique de vulgarisation.

NAVIDIV démontre les impacts de la navigation et des infrastructures associées sur les écosystèmes fluviaux et leur biodiversité à l'échelle européenne et mondiale. Le trafic fluvial, à l'origine de perturbations physiques et d'altération de l'habitat, est associé au déclin de la biodiversité, en particulier des poissons et macroinvertébrés. Les canaux de navigation favorisent l'expansion des espèces non-natives. De plus, les effets de la navigation dépendent du contexte et sont généralement pires dans les rivières coulant en paysages fortement anthropisés (agricole ou urbain) ou dont l'environnement riparien est fortement dégradé. Ces impacts peuvent être évités, ou à défaut, atténués en optimisant le fonctionnement des infrastructures et en restaurant activement les milieux. Les actions de restauration les plus efficaces en milieu navigué sont les adaptations morphologiques du cours d'eau, la régulation des débits et la gestion de la végétation riparienne. Toutefois, la restauration ne parvient pas à ramener les fleuves navigués à un niveau de référence car ces fleuves sont trop dégradés et requièrent des politiques de gestion adaptées et intégratives.

V. Result's impact

V. 1 Anticipated (or actual) impact of these results for science, society, public and private decision making (around 1500 characters including spaces): for large audience

This will be used in the project summary. CESAB-FRB reserves the right to modify the text for publication on its platforms. You will be consulted before publication. As these elements are intended for the general public, be sure to write this text in a way that is easy to understand.

NAVIDIV results demonstrate the risk of increasing inland navigation on freshwater biodiversity and the need for an integrative waterway management.

NAVIDIV brings to the attention of the policy makers and waterway managers the generalised negative impacts of inland navigation on native biodiversity. Inland navigation policies will need to reinforce regulation on boat traffic to limit erosion and nuisances, on lock operations to improve connectivity, and on ballast water to avoid contamination. Waterway management will need to minimize or conceive environment-friendly dredging activities and to apply creative suites of restoration actions to mitigate the impacts of navigation. Waterway policies will have to account for the importance of interactions between multiple navigation impacts by adopting a more integrative view of the river ecosystems. The future inland navigation regulation will further need to adapt to the context of global change where some rivers are and will be increasingly exposed to flow modifications and species invasions. Our research provides policymakers and waterway managers with more evidence-based and large-scale guidance that will help build and coordinate inland navigation management policies and fulfil the objectives of transboundary consistency of inland navigation.

NAVIDIV also reveals to the scientific community that some gaps of knowledge remain, including the indirect effects of navigation pressures on biodiversity through the analysis of abiotic responses that influence biotic outcomes. Addressing these gaps is essential to gain a deeper understanding of the underlying processes of navigation impacts on river ecosystems.

Finally, NAVIDIV's findings are important for society in general by highlighting the trade-off between transporting people and goods and protecting essential functions of the ecosystem and contribute to support more sustainable river ecosystem services.

IV. 2 [FR] Impact pour la science, la société et la décision publique et privé (environ 1500 caractères, espaces inclus): pour grand public

Ceci sera utilisé dans la fiche résultat du projet. CESAB-FRB se réserve le droit de modifier le texte pour publication sur ses plateformes. Vous serez consulté avant la publication. Ces éléments étant destinés au grand public, veillez à rédiger ce texte dans une optique de vulgarisation.

NAVIDIV démontre les risques liés au développement de la navigation intérieure sur la biodiversité aquatique et le besoin urgent d'une gestion intégrée des voies navigables.

NAVIDIV porte à l'attention des politiques publiques et des gestionnaires de voies navigables les effets négatifs généralisés de la navigation sur la biodiversité native. Les réglementations devront se renforcer sur le trafic fluvial pour limiter les nuisances et l'érosion, sur les opérations d'éclusées pour améliorer la connectivité, et sur les ballastages pour éviter les contaminations par des espèces exotiques. Les gestionnaires devront développer des solutions écologiquement responsables pour l'entretien des voies navigables et inventer des mesures de restauration intégratives et adaptées au contexte. Les futures régulations devront par ailleurs s'adapter pour faire face au changement climatique, étant donné que certains fleuves seront de plus en plus exposés aux modifications de débit et aux invasions biologiques. Notre recherche fournit des recommandations à large échelle basées sur des preuves qui permettront de coordonner les politiques de gestion de la navigation entre pays et ainsi répondre aux objectifs de cohérence transfrontalière de la navigation intérieure.

NAVIDIV révèle également des défis de recherche restant à relever, notamment élucider les effets indirects de la navigation sur la biodiversité à travers la quantification des réponses abiotiques et leurs liens avec les réponses biotiques.

Enfin, NAVIDIV a un impact pour la société car il met en lumière les compromis nécessaires entre transport de biens et de personnes et la protection de fonctions écosystémiques essentielles. Il contribue ainsi à la durabilité des services écosystémiques issus des voies navigables.

VI. Outreach and dissemination activities (if relevant)

The FRB strongly encourages the dissemination of results toward various non-academic actors including policy makers. Results of research projects can be disseminated and valued in different ways and through different channels: publications, scientific conferences, posters or scientific syntheses (cf. section III), but also via internet sites, syntheses for policy makers, articles in various media, conferences involving non-academic actors, systems to support decision-making, data bases, etc.

- Please describe any dissemination and knowledge transfer activities that have been conducted toward policy makers, managers, socio-economic actors (or any other stakeholder) in relation to the project.
- Let us know about any media articles, interviews, educational projects, etc. in relation with the research conducted in the project.
- Are there any management or decision-making tools which have been developed as a result of the project (e.g. design/implementation of biodiversity indicators)?
- Are there any activities planned (or that could be planned) to expand the utilization or application of the results?

At the beginning of the NAVIDIV project, we attempted to establish contact with waterway stakeholders (Voies Navigables de France, Cerema, Inland Navigation Europe). We exchanged few emails in order to advertise our project and to invite them to interact. We also tried to draw their attention through some ITTECOP meetings and asked ITTECOP to help us to reach them. However, the exchanges remained scarce, at a superficial level and we did not manage yet to embark them on the project nor to find the appropriate/available/interested interlocutors.

To remedy this, the plan is to organize a meeting with them over the NAVIDIV “CESABAFTER” meeting over Spring 2025 (as proposed by the CESAB; half-funded by the group). This will allow us to show them the final results and main outputs of the NAVIDIV project and to ask them what dissemination means they would find most valuable from a management perspective and to make sure our scientific results will be useful and transferable.

VII. Next steps – the legacy of the CESAB project

Are there any actions planned as a result of the CESAB project? Have you submitted proposals resulting from the work conducted during the course of the CESAB project for further work? If yes, have you been successful? What is the current status of the post-doctoral researcher affiliated with the project?

Aaron SEXTON (the post-doctoral researcher affiliated with NAVIDIV) is currently a post-doctoral researcher at the Technical University of Munich continuing work on anthropogenic ecosystems at the continental scale. In 2025, he will begin a professor position at Cornell University in the School of Integrative Plant Sciences.

VIII. CESAB AFTER

Would you like to consider the organisation of a « CESABAFTER » meeting ?

In such case please list your co-funding opportunities/ideas.

Note that this will be discussed during a scientific assessment meeting that will be held after this report has been submitted; the project would have to be approved by CESAB’s scientific direction.

The plan is to organize a hybrid transdisciplinary meeting in Spring 2025 and invite several stakeholders to participate remotely (from e.g. VNF, OFB, Agences de l’Eau). The core group of NAVIDIV (at least AJ, JNB, CS, AS, CW, TB, & VMF) will come to Montpellier (half of them will fund their travel on their own). The stakeholders will be invited to attend remotely in order to maximize our chance to have them on board. The meeting will last one day, the morning will be dedicated to the presentation and discussion of the scientific results. The afternoon will be used to discuss together about the dissemination means and prepare a potential participation to the I.S.Rivers conference (June 2025, Lyon, France).

IX. Comments on the execution of the project

Please comment on any practical aspects (organization, accommodation etc), difficulties encountered, particular issues related to the management of data, etc.

This project would not have been possible to execute to its full potential without the fantastic assistance of FRB and CESAB - especially Maud CALMET, Nicolas CASAJUS and Nicolas MOUQUET.