



PROGRAMME de RECHERCHE BRIDGES

FISHRUN – Making the invisible visible: non-commercial fisheries in ecosystem-based and maritime uses management in La Réunion

BRIDGES Grappe de thèses 1

Mots clefs : Small scale fisheries, non commercial fishing, marine socio-ecosystem, scenario co-construction, Fisheries management

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Ecole doctorale de rattachement : Gaia (Montpellier)

Résumé

A ce jour, la gestion des pêcheries à La Réunion ne prend pas en compte l'impact des pêches récréatives et informelles, pourtant reconnues comme pression majeure pour certaines espèces. Il est donc urgent d'avoir des outils pour proposer des mesures de gestion intégrant ces pêches non professionnelles. En 2023, on comptait 323 pêcheurs professionnels et près de dix fois plus de pêcheurs récréatifs pratiquant depuis un bateau ou à partir du rivage. De plus, les enquêtes cadres indiquent que la pêche récréative continue de se développer et exerce une pression au moins comparable à celle de la pêche commerciale sur les écosystèmes marins côtiers et pélagiques de l'île. Malgré cela, seules les activités de pêche professionnelle font actuellement l'objet d'un suivi et d'une réglementation et sont utilisées pour évaluer l'état des stocks halieutiques et définir des mesures de gestion. Par ailleurs, si certaines pratiques illégales persistent, leur impact sur le socio-écosystème reste incertain, en particulier dans le contexte de la dégradation progressive des récifs coralliens induite par le changement climatique et de multiples facteurs de stress locaux. Les axes de travail de cette thèse seront : 1) une description des pratiques et une quantification des captures des pêches récréatives et informelles à La Réunion à partir de l'ensemble des observations et enquêtes disponibles; 2) l'analyse de leurs impacts sur les écosystèmes marins, ainsi que sur d'autres usages maritimes – en particulier la pêche commerciale – et sur les services rendus à la société en utilisant un outil de modélisation de dynamique de pêcherie; 3) co-concevoir avec les acteurs des scénarios de gestion réalistes et les évaluer afin de garantir la durabilité des pêcheries et la résilience du socio-écosystème marin de La Réunion.

Compétences attendues : halieutique ou en écologie quantitative ou statistiques/mathématiques appliquées avec un fort intérêt pour les applications en sciences de l'environnement. Expérience des approches de modélisation statistique (GLMM/GAM/RandomForest/Réseaux de neurones...) et mécaniste (par ex. modèles d'évaluation des ressources, ISIS-Fish...). Programmation en R, JAVA, Git. Une bonne maîtrise de l'anglais. La connaissance du créole réunionnais serait un plus.

Abstract

Fishing provides food and, in island countries, produces more than half of animal protein. The different sectoral patterns in the Indian Ocean compared with other ocean basins are likely to be due to the region's high dependence on small-scale fisheries. Small-scale coastal fisheries present a wide variety of situations and practices, most of which are poorly understood and not included in assessment and management processes. However, they can represent a significant proportion of practitioners, fishing effort and catches. Regardless of the motivations and status of these fisheries (recreational, subsistence / formal, informal), it is essential to take them into account in order to manage the resources they exploit sustainably. However, integrating these previously overlooked activities into management processes faces several challenges due to a lack of knowledge about these activities and the risk of stakeholders not accepting new rules. In La Réunion island, where in 2023, 323 commercial fishers were recorded the number of recreational fishers was estimated between 30 000 to 40 000, either fishing from a boat or from the shore. Despite this, only commercial fishing activities are currently monitored and regulated. Furthermore, assessment of fish stock status and the selection of management measures for commercial fisheries in La Réunion rely exclusively on data derived from the commercial sector. However, numerous studies indicate that recreational fishing continues to expand and exerts at least comparable pressure to commercial fishing on the island's coastal and pelagic marine ecosystems. Furthermore, while some long-standing illegal practices, such as explosive fishing have been eradicated, others persist and their impact on the socio-ecosystem remain unclear, particularly in the context of the gradual degradation of coral reefs driven by climate change and multiple local stressors. These trends support the need to incorporate non-commercial fisheries into 1) a more precise characterisation of fishing practices in La Réunion and 2) the analysis of their impacts on marine ecosystems together with other marine uses - especially commercial fishing, - and the services provided to society, in order to 3) design and assess realistic management scenarios to ensure the sustainability of fisheries and the resilience of La Réunion's marine socio-ecosystem.

1. Description scientifique du projet de thèse

1.1) Contexte scientifique, état de l'art

Marine ecosystems in La Réunion, particularly coral reefs and coastal habitats, are increasingly affected by global change, including ocean warming, coral bleaching, coastal development, and intensified human use. These pressures alter community structure and ecosystem functioning. Fisheries play a central

role by influencing biomass, functional diversity, and key ecological processes, making integrated management across all fishing sectors essential to strengthen socio-ecosystem resilience.

In the Indian Ocean, fisheries knowledge remains uneven, with reliable monitoring largely limited to tuna and pelagic stocks (Moustahfid et al., 2019; Heidrich et al., 2022). In the SWIO, 78% of fisheries are small-scale, 9% industrial, and 13% recreational (Groeneveld et al., 2022), yet most countries lack sufficient data to characterize small-scale fleets. In La Réunion, monitoring has focused mainly on commercial fisheries, while non-commercial activities—recreational, informal, and subsistence—remain poorly quantified despite their coexistence with IUU fishing (Zeller et al., 2023). Commercial small-scale fisheries are relatively well documented, targeting mainly pelagic species (>70% of landings), with average annual landings of ~350 tons since 2010 and two overfished stocks among twelve assessed species (Guyader, 2026).

Non-commercial fisheries (shore-based, recreational boat fishing, spearfishing, drone-assisted fishing) are diverse and spatially concentrated near sensitive coastal habitats, including within or close to the RNMR. Existing data are heterogeneous and have never been jointly analyzed. Catch reconstructions extrapolated from commercial data (Le Manach et al., 2010 ; Roos et al., 1998) likely underestimate their magnitude and ecological effects, as these fisheries use distinct techniques and target more reef-associated species (Roos et al., 1998; Garnier et al., 2021). Earlier estimates suggested recreational catches may reach 80–120% of commercial landings (Biais and Taquet, 1991; Roos et al., 1998; Le Manach, 2010), while the recreational fleet has increased by ~40% since 2010 (Guyader, 2026). Shore-based fishing involves up to 6% of the population (Garnier et al., 2021).

Enforcement reveals strong asymmetries between commercial and non-commercial sectors within the marine reserve, and management measures targeting recreational fishing remain socially contested (Tessier, 2025).

In this context, the availability of underexploited long-term datasets on both commercial and non-commercial fisheries, combined with fisheries-independent reef surveys, offers a unique opportunity to quantify their respective impacts and develop evidence-based sustainability scenarios to inform decision-making.

1.2) Objectifs scientifiques et question(s) de recherche, originalité du sujet

This thesis responds to the urgent need for integrated fisheries management that accounts for all fishing sectors and their cumulative ecological impacts. Non-commercial fisheries, largely absent from official monitoring, may constitute a substantial yet poorly quantified source of pressure on coastal and reef ecosystems. **The central objective** is to rigorously characterize, quantify, and incorporate these activities into ecosystem-based management frameworks to enhance the resilience of marine socio-ecosystems under global change, while ensuring the approach remains transferable to other regions. The research is structured around **four key questions**: (1) What are the magnitude, spatial distribution, and long-term dynamics of non-commercial fisheries over the past three decades? (2) How do commercial and non-commercial fisheries

differentially affect species, functional groups, and ecosystem functioning? (3) What are their respective contributions to overall fishing pressure and socio-ecosystem dynamics? (4) How can co-constructed, scenario-based modelling support adaptive management pathways that reconcile ecological sustainability with socio-economic objectives? **The project's originality** lies in explicitly integrating non-commercial fisheries into a unified ecosystem-based framework that combines long-term data reconstruction, trait-based functional ecology, and mechanistic socio-ecosystem modelling. It advances a participatory, decision-oriented approach that quantitatively evaluates co-developed management scenarios and is designed for application beyond the focal study area.

1.3) Contribution aux défis scientifiques de BRIDGES

This thesis contributes to BRIDGES by addressing a topic and applying methods not initially planned, and in line with FAIR principles. The project integrates heterogeneous datasets across temporal scales, combining fisheries monitoring with benthic and fish community surveys (Challenges 1.1 and 1.3). It models interactions between fishing practices and coastal ecosystems to assess socio-ecosystem dynamics (Challenge 2.1) and develops contrasting trajectories under alternative scenarios to identify risks and sustainable pathways for non-commercial fisheries (Challenge 3.2). Scenarios will be co-developed with stakeholders (Challenge 4.2), supporting scenario-based tools to evaluate management impacts and promote more inclusive, multisectoral fisheries governance (Challenge 5.3).

1.4) Mise en œuvre du projet

1.4.1) Méthodes

Step 1 – Definition and dynamics of non-commercial fisheries: This step involves collecting, standardizing, and structuring data from studies on non-commercial fishing (boat-based, spearfishing, shore fishing), as well as landing surveys, logbooks, and records of illegal fishing. The use of the RNMR is also monitored through aerial and drone observations. The objective is to quantify fishing effort, catches, and their spatial and seasonal patterns, and to compare them with commercial artisanal fisheries. Identifying target species, their population dynamics, and ecological roles will support the development of a typology of non-commercial fisheries, useful for monitoring and for integrating these activities into next steps (modelling).

Step 2 – Trait-based functional ecology analyses: Species differ in their contributions to ecosystem functioning and in their vulnerability to fishing. Integrating functional traits helps link fishing pressure to community changes (response traits) and assess impacts on ecosystem functioning (effect traits). Building a multidimensional functional space makes it possible to identify which ecological functions are affected and to detect threatened species with unique roles, thereby guiding modeling and conservation priorities.

Step 3 - Mechanistic modelling approach: this stage aims to develop an operational model to describe the dynamics of La Réunion's coastal marine fisheries socio-ecosystem and to evaluate management scenarios integrating small-scale commercial and non-commercial fisheries. The work will rely on the ISIS-Fish modelling framework (Mahévas & Pelletier, 2004), which integrates species population dynamics and fishing activities, and can be implemented in spatially explicit or aggregate form depending on data availability (Hopkins et al., 2024; Vajas et al., 2025). Beyond quantitative analysis, ISIS-Fish also functions as a participatory decision-support tool, facilitating stakeholder dialogue and scenario co-construction (Mahévas et al., 2024). Model parameterization will combine biological data, existing stock assessments, SIH-IFREMER datasets for commercial fisheries, and results from Step 1 for non-commercial fisheries. Hindcast simulations with uncertainty analysis will assess the relative contributions of commercial and non-commercial fisheries to pressure on key species.

Step 4: Scenario-based approach to resource management: the final stage adopts a scenario-based approach to support adaptive and participatory fisheries management. After reviewing existing measures, additional scenarios will be co-constructed through stakeholder workshops (Chevalier et al., 2024), informed by evolutionary governance theory (Losen et al., 2025). Scenarios will include regulatory measures (e.g., effort or catch limits, spatial closures) and broader socio-ecological drivers linked to global change (Chevalier et al., 2025). All scenarios will be simulated using ISIS-Fish to generate quantitative indicators for target species and fishing groups, enabling assessment of ecological and socio-economic trade-offs. The results will support management recommendations linking regulatory options to ecosystem and sectoral outcomes.

1.4.2) Site(s) concerné(s) ou applicabilité aux sites si thèse méthodologique

La Réunion island. This proposed methodology might be applicable to other sites. For example, similar challenges exist in Mayotte, where subsistence fisheries also need to be considered.

1.4.3) Calendrier de la thèse

- **Sept–Oct 2026:** Familiarization with the topic, literature review, exploration of available data, formation of the fisheries stakeholder group, and presentation of the thesis project to fishery stakeholders.
- **Nov 2026–Jan 2027:** Characterization of fisheries, definition of indicators, analysis of gaps or weaknesses in current monitoring systems, and feedback of results to stakeholders.
 - **March 2027:** Drafting of paper on the typology of non-commercial fisheries.
- **Apr–Jun 2027:** Assessment of functional group impacts using an established method; evaluate the effects of recreational fisheries on the ecosystem based on effort and catch data using a functional trait approach, with feedback to stakeholders.
 - **Sept 2027:** Drafting of paper on threatened species.
- **Oct 2027–May 2028:** Parameterization of the ISIS-Fish model, hindcast simulations, and diagnosis of the effects of commercial and non-commercial fishing activities.

- **Sept 2028:** Drafting of paper on the relative impacts of commercial and non-commercial activities on targeted species.
- **Jun 2028–Apr 2029:** Inventory of existing management scenarios and co-construction of additional scenarios, scenario simulations with the model, diagnostics on target species and commercial/non-commercial fishing groups, and formulation of management recommendations.
- **Aug 2029:** Drafting of paper on scenarios and management recommendations for fishing activities.
- **Apr–July 2029:** Final writing of the thesis document based on the prepared papers.
- **Sept 2029 :** Defense

1.5) Résultats attendus

- 1) **A Characterization of recreational and informal fisheries**, analysis of gaps and weaknesses in current monitoring.
- 2) **An assessment of the impacts of these fisheries** on the most affected functional traits by fishing activity type, and evaluation of consequences for ecosystem functioning.
- 3) **The development of an operational modeling tool** for La Réunion's coastal marine fisheries socio-ecosystem.
- 4) **Diagnostics of co-constructed management scenarios** for exploited species, integrating all types of fisheries.
- 5) **A trust-based stakeholder network** to support integrated fisheries and maritime-use management,

1.6) Valorisations académique et sociétale

As outlined in the detailed thesis timeline, four scientific articles will be produced, along with presentations to stakeholders at each stage of the project

1.7) Risques potentiels et moyens mis en œuvre pour les éviter

The data have already been acquired. Nevertheless, there remains the possibility of rerunning the models (steps 2 and 3) using data collected during the course of the thesis as part of related projects. This is a project with strong territorial roots, ensuring a realistic definition of the issues, while providing a novel conceptual contribution (modeling) that allows for addressing questions of impacts and trajectories of socio-ecosystems.

1.8) Références bibliographiques

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2. Moyens mis à disposition par l'équipe encadrante pour la bonne réalisation de la thèse

Main location in Réunion (EMR SantéCo - UMR Entropie) with Thomas Claverie and Erwann Lagabrielle and from October 2027 to May 2028 in Sète (Marbec) with Stéphanie Mahévas and Emmanuel Tessier.

The student will receive support from the ISIS-Fish community for model parameterisation, and will have access to a computer and Ifremer's computers (Datarmor) for modelling.

Emulations with other students, including those from Bridges, access to weekly seminars (bioecotrop). In December 2027, participation in the annual meetings of the Mexico modelling network.

The doctoral student will be supervised by a multidisciplinary team at two levels: a close-knit team (mainly academic) with regular meetings, and a broader team (academic and non-academic) with occasional meetings with the doctoral student.

| Nom, UMR, Lieu, Rôle | Discipline | Compétences |
|---|----------------------|---|
| Mahévas Stéphanie - IFREMER, MARBEC Sète (HDR, Directrice et PI PC3) | Modélisation | Dynamique spatio-temporelle des pêcheries ISIS-Fish Scenarios Co-construction Incertitude |
| Thomas Claverie université de La Réunion, EMR SANTECO, UMR ENTROPIE (Co-encadrant, PC2-PC4) | Ecologue, biologiste | Functional analysis, Fish communities |
| Erwann Lagabrielle université de La Réunion(Co-encadrant) | Géographe | Expert of spatial planning, evolutive gouvernance and littoral and coastal uses |
| Emmanuel Tessier - IFREMER, MARBEC Sète (Co-encadrant, PC4) | Biologiste | Gestion des pêches et environnement, Halieutique |

Key contacts outside the immediate management team: Stock assessment (David Roos et Erwan Saulnier, Ifremer stock assessment manager in Réunion), CRPME (professional fishing representative David Guyomard), Marine Reserve (Anne-Laure Techer-Clément), non-professional fishing representatives (e.g. "La mer, notre liberté" association)

