



DATA ARTICLE OPEN ACCESS

# GFID: A Global Fish Invasion Database

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**Keywords:** aquatic ecosystems | biogeography | biological invasion | global database | invasive species

## ABSTRACT

Aquatic ecosystems are experiencing significant threats globally due to the widespread establishment of non-native fishes introduced via diverse anthropogenic pathways. Despite the recognition of their ecological, economic, and social impacts, a harmonized global resource focusing solely on established fish species has been lacking. We introduce a standardized global database encompassing 1538 established non-native fish species across 193 countries (5495 total occurrence records), integrating comprehensive metadata on introduction pathways (such as Escape from confinement, Release in nature, Transport as contaminant or stowaway, and Corridors; subcategories include Aquaculture, Ornamental trade, Fishery stocking, and Ballast water), habitat types (freshwater, marine, and freshwater–marine), native biogeographic realms (Nearctic, Neotropical, Palaearctic, Afrotropical, Indo-Malayan, Australasian, and mixed/cryptogenic), impacts, and first record timelines. Impacts are classified into environmental, economic, and social dimensions, with detailed mechanistic coding (e.g., competition, hybridization, disease transmission, predation). This database, curated from GBIF, *FishBase*, GRIIS, the SInAS workflow, and primary literature, is presented as a data paper and offers an essential foundation for invasion ecology, conservation planning, and biosecurity policy. The metadata is available in MetaCat in JaLTER at <https://jalter.diasjp.net/data/ERDP-2025-06>.

J. Robert Britton and Elizabeta Briski shared senior authorship.

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## 1 | Introduction

Biological invasions are among the leading drivers of biodiversity change worldwide and pose considerable risks to ecosystem functioning, native species persistence, and human well-being (Vilà and Hulme 2017). Aquatic ecosystems are particularly vulnerable to invasions due to their ecological sensitivity and the numerous pathways through which aquatic species can be introduced, whether deliberately or accidentally (Britton et al. 2023; Carpenter et al. 2011). The widespread establishment of non-native fish species represents a significant and ongoing transformation of aquatic biodiversity (Moi et al. 2021). While some introductions are deliberate and seemingly economically motivated, many result in unintended and irreversible consequences for ecosystems and human communities (Gozlan et al. 2010). Moreover, fishes are one of the most frequently introduced vertebrate groups, often translocated across continents for aquaculture, sport fishing, biocontrol, ornamental purposes, or inadvertently via global trade, shipping, and canal networks (Bernery et al. 2022, 2024; Briski et al. 2024). While not all introduced species become established, those that do establish self-sustaining populations can exert disproportionately high ecological effects (Soto et al. 2024). These effects include competition with native species, predation, habitat alteration, and disease transmission (Tsirintanis et al. 2022). Additionally, established non-native fishes can disrupt ecosystem services and cause severe socio-economic impacts, affecting fisheries, aquaculture, recreational water use, and even cultural practices (Charles and Dukes 2007; Galanidi et al. 2018; Haubrock et al. 2022, 2025). The persistence and spread of these species are often facilitated by high propagule pressure (i.e., the quantity, frequency, and quality of individuals introduced), climate compatibility, and a suite of traits that confer competitive advantages, especially under human-altered conditions (Bernery et al. 2023; Daly et al. 2023).

As the global footprint of human activity expands and climate change alters the ranges of species and their environmental filters (Gallardo et al. 2015; Hulme 2017), biological invasions will potentially become more frequent and complex. This is especially true for fish biological invasions, where despite increasing scientific and policy interest, efforts to systematically document established non-native fish species on a global scale have been fragmented and incomplete. Previous attempts at establishing a comprehensive database on invasive fishes are often limited to a single invasion facet (e.g., ecological impacts) or not openly accessible (Bernery et al. 2024). Moreover, many resources fail to link presence data with essential metadata and merge casual occurrences (i.e., recorded but not self-sustaining populations) with established populations. This then makes it difficult to assess invasion dynamics, prioritize species for management, or understand long-term ecological outcomes (Jarnevich et al. 2021). To fill this critical knowledge gap, we introduce the Global Fish Invasions Database (GFID), the most comprehensive and global effort to document and contextualize established non-native fish to date. This database includes specific information on 1536 species across 193 countries. This information covers their invasion pathways, native biogeographic realms, habitat types occupied, introduction pathways, first records, and impact mechanisms.

By improving access to structured, verified, and reproducible data on global fish invasions, this work provides the necessary baseline to track invasion trajectories, anticipate emerging risks, and

inform timely, evidence-based interventions. Our compilation, therefore, addresses a range of previously unmet needs. It standardizes species-level data across freshwater and marine habitats, harmonizes information on introduction pathways and connects records with the native biogeographic realm and the year of first report. Importantly, it also maps the impact landscape, providing detailed records of ecological, social, and economic consequences, as well as the mechanisms driving those impacts. This database thus serves as a foundational resource for stakeholders at multiple levels—including researchers modeling invasion risk, policymakers developing management strategies, and conservation practitioners monitoring vulnerable ecosystems. It also highlights key knowledge gaps, such as underreporting in low-income regions, the lack of impact data for many established species, and the urgent need for better taxonomic resolution and continuous data curation. Future updates and community contributions will ensure that this database remains a living resource in the effort to manage one of the most pressing environmental challenges of our time. Finally, this resource is designed to support diverse research applications, from invasion science and conservation biology to biosecurity policy and socioeconomic planning, and offers a foundational tool for comparative and predictive analyses of biological invasions in aquatic systems. As such, this article is presented as a data paper describing the development, structure, and content of GFID.

## 2 | Data Description

### 2.1 | Identifier

ERDP-2025-06.

### 2.2 | Contributor

#### 2.2.1 | Dataset Owners

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## 2.3 | Project Title

Global Fish Invasions Database (GFID): Established Species, Locations, Pathways, Origins, and Impacts.

## 2.4 | Geographical Coverage

The dataset has global geographical coverage. It includes records from 193 countries across all inhabited continents and encompasses a wide range of freshwater, marine, and brackish ecosystems. Species occurrences are linked to countries and continents. Native origin data are mapped to major biogeographic realms (e.g., Nearctic, Neotropical, Palaearctic, Afrotropical, Indo-Malayan, and Australasian), enabling assessments of invasion asymmetry and cross-realm introductions. Biogeography is based on Miklos Udvardy's system (Udvardy 1975).

## 2.5 | Temporal Coverage

We note that while our compilation of temporal records spans over three centuries of introduction events (from 1696 to present), the database itself represents a recent synthesis assembled in 2024–2025 and does not constitute a time series of systematic sampling. First-record data are included for each species-country combination where available, allowing users to analyze the historical progression of fish introductions at national, continental, and global scales.

## 2.6 | Taxonomic Coverage

The taxonomic scope is restricted to ray-finned fishes (Actinopterygii) and includes 1538 established species belonging to 195 families. Taxonomic metadata (such as scientific name, family, and class) is harmonized using FishBase and GBIF to ensure consistency and reliability. Cosmopolitan species are excluded.

## 2.7 | Methods

### 2.7.1 | Data Compilation

We compiled a global dataset of established non-native fish species (Actinopterygii), which are defined as species forming self-sustaining populations across at least one non-native region without ongoing human-mediated propagule pressure (*sensu* Soto et al. 2024). The core dataset was sourced from Briski et al. (2024) and refined using data from the *Global Biodiversity Information Facility* (GBIF; Telenius 2011), FishBase

(Froese and Pauly 2024), the *Standardized Alien Species workflow* (SInAS; Seebens et al. 2020, 2021), the *Global Register of Introduced and Invasive Species* (GRIIS; Pagad et al. 2018), the CABI Compendium (CABI 2025), the *Global Impacts Dataset of Invasive Alien Species* (GIDIAS; Bacher et al. 2025) and supplementary literature and web searches. Species that were classified as “casual” or “absent” in Darwin Core terms (degreeOfEstablishment, occurrenceStatus; Groom et al. 2019) were excluded. Entries were manually verified, with species names validated against FishBase and GBIF, and all country-level records were cross-referenced for accuracy. Any discrepancies or uncertain data were checked further using open-access sources, such as Google Scholar. The final dataset includes 1535 species and 5413 records, spanning 193 countries (Figure 1). The Overall\_data sheet provides species-country combinations along with taxonomy (species, family, class), habitat (freshwater, marine, both), establishment status, introduction pathways (main category, subcategory, and intentionality), native biogeographic realm (e.g., Palaearctic, Nearctic), year of first record, and source provenance. Data were primarily sourced from:

- Briski et al. (2024)
- Global Biodiversity Information Facility (GBIF) (Svenningsen and Schigel 2024)
- Global Register of Introduced and Invasive Species (GRIIS) (Pagad et al. 2018)
- FishBase ([www.fishbase.com](http://www.fishbase.com); Froese and Pauly 2024)
- The Standardized Alien Species (SInAS) workflow (Seebens et al. 2020, 2021)
- CABI Compendium (CABI 2025)
- Global Alien First Records Database (Seebens et al. 2017)
- Global Impacts Dataset of Invasive Alien Species (GIDIAS) (Bacher et al. 2025)
- Other scientific literature
- Manual verification via Google Scholar and open-access references

### 2.7.2 | Habitat Classification

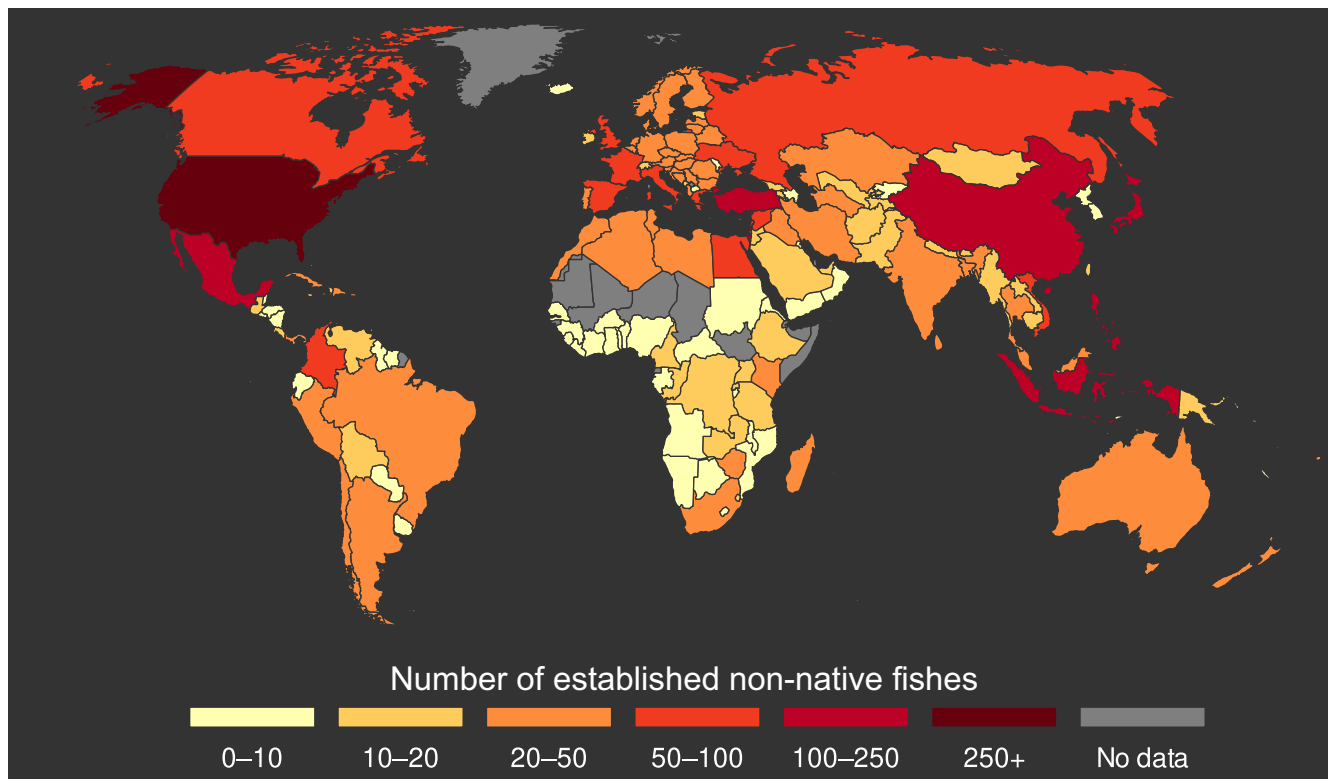
Habitat classifications follow GRIIS and the Venice System (1958), with manual validation where needed.

### 2.7.3 | Data on First Records

The year of the first introduction was compiled per country, using the *Global Alien First Records Database* (Seebens et al. 2017) and primary literature. Including these data enables the assessment of cumulative introduction trends over time.

### 2.7.4 | Pathway Information

To analyze introduction pathways, the CBD's standardized classification scheme (CBD 2014) was applied, including six main



**FIGURE 1** | Number of established non-native fishes by country.

introduction pathway categories (release, escape, corridor, stow-away, contaminant, and unaided), 13 subcategories (e.g., aquaculture, ornamental trade, ballast water), and intentionality (intentional, unintentional, unknown). Most known introductions occurred via escape from confinement ( $n = 392$  spp.), corridors ( $n = 136$  spp.), and deliberate release ( $n = 109$  spp.).

### 2.7.5 | Impact Information Compilation

Impact information was derived from multiple sources (GRIIS, CABI, FishBase, peer-reviewed articles), with environmental impacts documented for 419 species, economic impacts for 98, and social impacts for 97 species. Impact mechanisms were identified for 330 species. The most common impact mechanisms were competition (224 species) and predation (194 species), followed by hybridization, disease transmission, rapid growth, and habitat modification. Where possible, mechanisms were linked to original source references and recorded in a standardized binary format. The Species\_spec\_impacts sheet contains impact data (presence of environmental, economic, health, and social impacts) and mechanistic categories (e.g., competition, predation, hybridization, disease transmission, habitat alteration, fouling, poisoning). Mechanisms were compiled from CABI, FishBase, and manual literature reviews.

### 2.7.6 | Notation

It is important to note that our database captures non-native fish establishments at the country level. This information includes both cross-border introductions and intracountry translocations

across distinct biogeographic regions. The information is linked to anthropogenic pathways, such as the pet trade, aquaculture, corridors, and zoological facilities. While GFID represents the most comprehensive compilation of established non-native fish species to date, it is not without limitations (see Haubrock et al. 2025). The database may include uncertainties due to taxonomic revisions, gaps in reporting, and the inherent complexity of biogeographically diverse countries where native ranges span multiple realms, which complicates definitions of non-native status. We acknowledge these challenges and encourage future contributions from regional experts to refine and expand this resource as a living dataset. Moreover, local introductions (e.g., intracountry translocations) and records tied to anthropogenic pathways (including angling, aquaculture, and the pet trade) pose additional classification challenges. We also acknowledge the need for ongoing regional validation to refine these records. By openly publishing this resource, the aim is to facilitate expert engagement to ensure that future iterations of GFID can incorporate improved local data and confidence assessments.

Species were included only if classified as “established”—meaning they form reproducing populations independent of continued human-mediated propagule pressure.

## 2.8 | Database Structure

### 2.8.1 | Data Files and Variable Definitions

The data file is named “GFID\_A\_GLOBAL\_FISH\_INVASION\_DATABASE” and consists of two core sheets (Table 1, Supporting Information). The first, “Overall\_data” (5495 rows

×23 columns), records species-country occurrences along with rich associated metadata, including taxonomy (species, family, class), habitat type (marine, freshwater, or both), establishment status and source database, and detailed introduction pathway information—capturing the main category (e.g., escape from confinement, release in nature), subcategory (e.g., aquaculture, aquarium trade), and intentionality. It also documents the native

biogeographic realm (e.g., Neotropical, Palaearctic), the first recorded year of introduction in each country, and the verification source (e.g., GBIF, literature). A comprehensive description of each column is provided in Table 2. The second sheet, “Species\_spec\_impacts” (1536 rows × 18 columns), summarizes the impact data at the species level, indicating the presence of environmental, economic, and social impacts. It details the specific

**TABLE 1** | Summary of the structure and content of the two main datasets compiled in the Global Fish Invasions Database.

Sheet name	Description	Rows	Columns
Overall_data	Species occurrences with pathway, realm, and time metadata	5495	23
Species_spec_impacts	Impact types and mechanisms per species	1536	18
GBIF Key	Species-key identifiers for the Global Biodiversity Information Facility	1536	2

Note: Each sheet contains standardized, species-level records with associated ecological, geographical, and impact metadata.

**TABLE 2** | Names and definitions of the variables in the data files.

Variable name	Sheet	Variable definition
Location	Overall_data	Country where the non-native fish species have been recorded as established.
LocationID	Overall_data	Internal identifier for each country.
Continent	Overall_data	Continent in which the country is situated.
ContinentID	Overall_data	Internal identifier for each continent.
Taxon	Overall_data	Scientific name of the fish species (base name without authorship).
ScientificName	Overall_data	Full scientific name of the species, including authority.
TaxonID	Overall_data	GBIF identifier.
Family	Overall_data	Taxonomic family of the species.
Class	Overall_data	Taxonomic class (e.g., Actinopterygii).
Phylum	Overall_data	Taxonomic phylum (Chordata).
Habitat	Overall_data	Habitat type where the species occurs: freshwater, marine, or both.
OccurrenceStatus	Overall_data	Indicates whether the species is present or absent.
EstablishmentMeans	Overall_data	Status of the species.
DegreeOfEstablishment	Overall_data	Level of establishment (e.g., established, casual).
OrigDB	Overall_data	Original database where the record was sourced.
OurReference	Overall_data	Internal reference or curation tag.
Impact_GRIIS_old	Overall_data	Historical record of impact presence from GRIIS.
Pathway_main_category	Overall_data	Main introduction pathway category following CBD classification.
Pathway_subcategory	Overall_data	Specific introduction method (e.g., aquaculture, pet trade).
Pathway_intentionality	Overall_data	Whether the introduction was intentional or unintentional.
impact2	Overall_data	Internal tag for additional impact classification.
native_region	Overall_data	Biogeographic realm from which the species originated.
First_record	Overall_data	Year of the first recorded introduction in that country.
Taxon	Species_spec_impacts	Scientific name of the fish species (base name without authorship).
Family	Species_spec_impacts	Taxonomic family of the species.
Impact_economic	Species_spec_impacts	Presence of documented economic impacts (1 = yes).
Impact_environmental_ecol	Species_spec_impacts	Presence of documented ecological/environmental impacts.

(Continues)

TABLE 2 | (Continued)

Variable name	Sheet	Variable definition
impact_social	Species_spec_impacts	Presence of documented social impacts.
Mech_Competition	Species_spec_impacts	Indicates whether competition is an impact mechanism.
Mech_Hybridization	Species_spec_impacts	Indicates whether hybridization is an impact mechanism.
Mech_Interaction	Species_spec_impacts	Indicates other biotic interactions as impact mechanisms.
Mech_disease_transm	Species_spec_impacts	Indicates disease transmission as a mechanism.
Mech_Predation	Species_spec_impacts	Indicates predation as a mechanism of impact.
Mech_Herb_graz	Species_spec_impacts	Indicates grazing/herbivory as a mechanism of impact.
Mech_rapidgrowth	Species_spec_impacts	Indicates rapid growth as an ecological mechanism.
Mech_pathogen/parasite	Species_spec_impacts	Presence of pathogenic or parasitic transmission.
Mech_Habitat_alt	Species_spec_impacts	Indicates habitat alteration by the species.
Mech_Fouling	Species_spec_impacts	Indicates fouling as a documented impact.
Mech_poisoning	Species_spec_impacts	Indicates poisoning or toxin production as an impact.
Source	Species_spec_impacts	Source used to verify and classify impacts.
COMMENT	Species_spec_impacts	Additional notes, links, or references regarding the impact evidence.
Species	GBIF_Key	Full scientific name of the species.
GBIF Key	GBIF_Key	GBIF specific identification key.

mechanisms, including competition, predation, hybridization, disease transmission, fouling, rapid growth, habitat alteration, alongside relevant sources and comments. The third sheet, “GBIF keys” (1536 rows × 2 columns), contains the specific unique species identifier used in GBIF.

## 2.9 | Usage Rights

### 2.9.1 | License

This dataset is provided under a Creative Commons Attribution 4.0 International License (CC BY-NC 4.0; <https://creativecommons.org/licenses/by-nc/4.0/deed.en>).

### 2.9.2 | Location of Storage

The dataset is published on GitHub (<https://github.com/IsmaSA/GFID>) and Zenodo (<https://doi.org/10.5281/zenodo.16286917>), with accompanying metadata documentation on MetaCat in JaLTER at <https://jalter.diasjp.net/data/ERDP-2025-06>.

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### Conflicts of Interest

The authors declare no conflicts of interest.

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### Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** ere70016-sup-0001-Supinfo.zip.