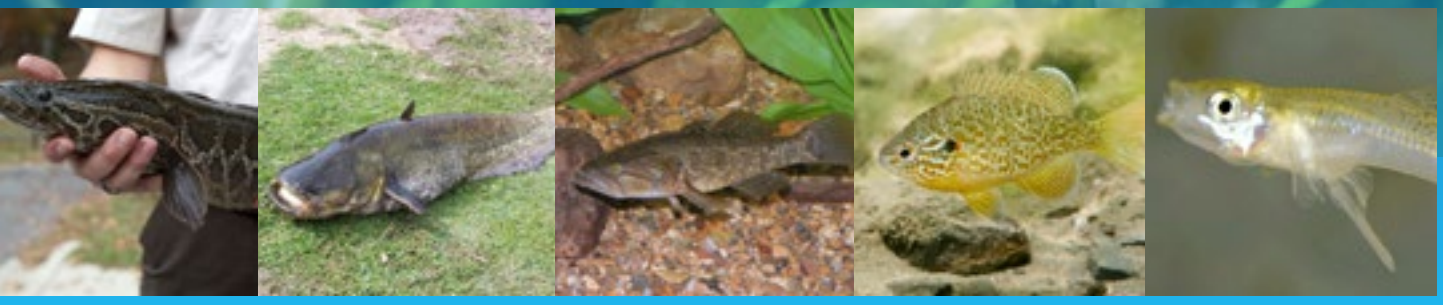
STRATEGIC RECOMMENDATIONS FOR THE TRANSNATIONAL MANAGEMENT OF INVASIVE ALIEN FISH IN IBERIAN INLAND WATERS



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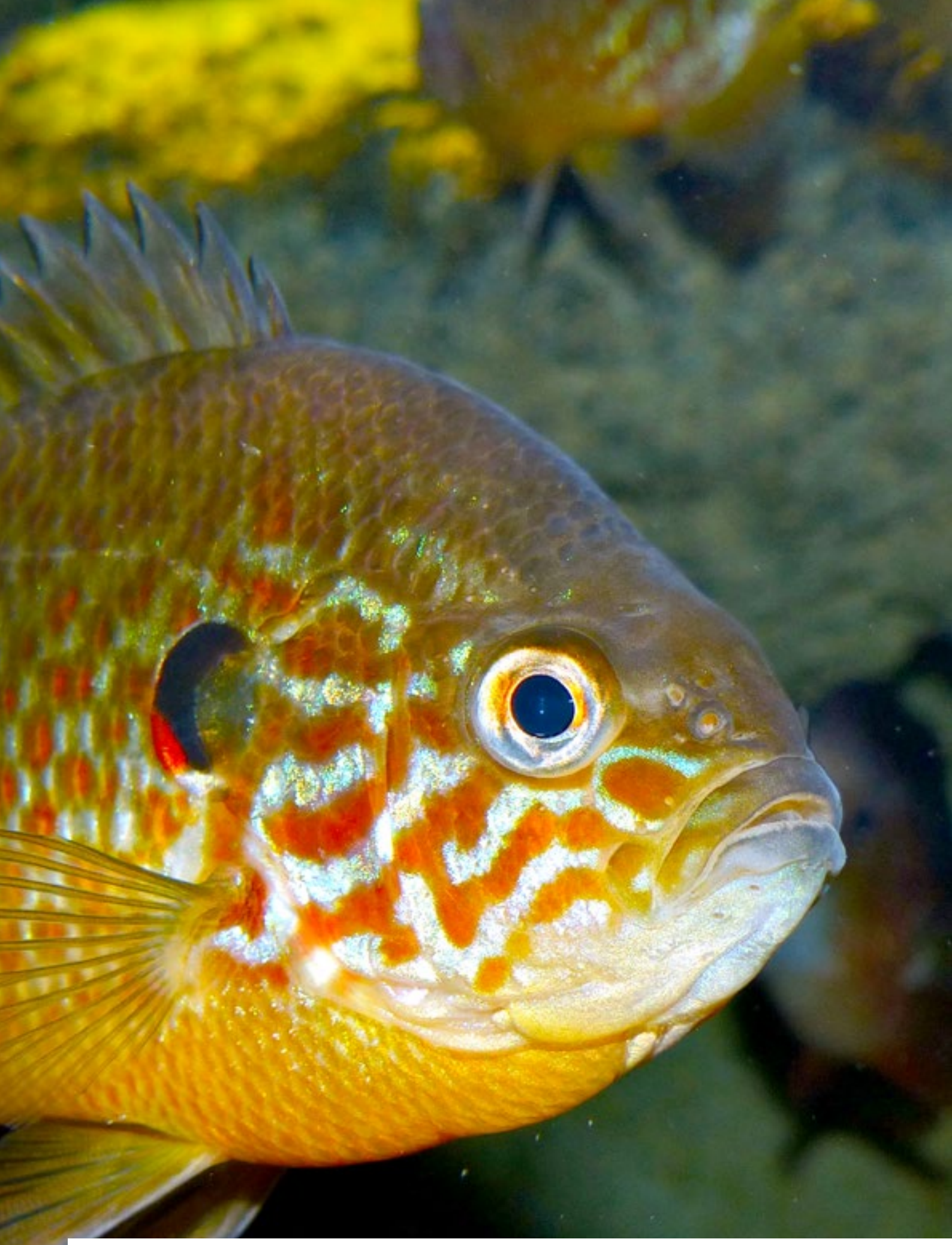


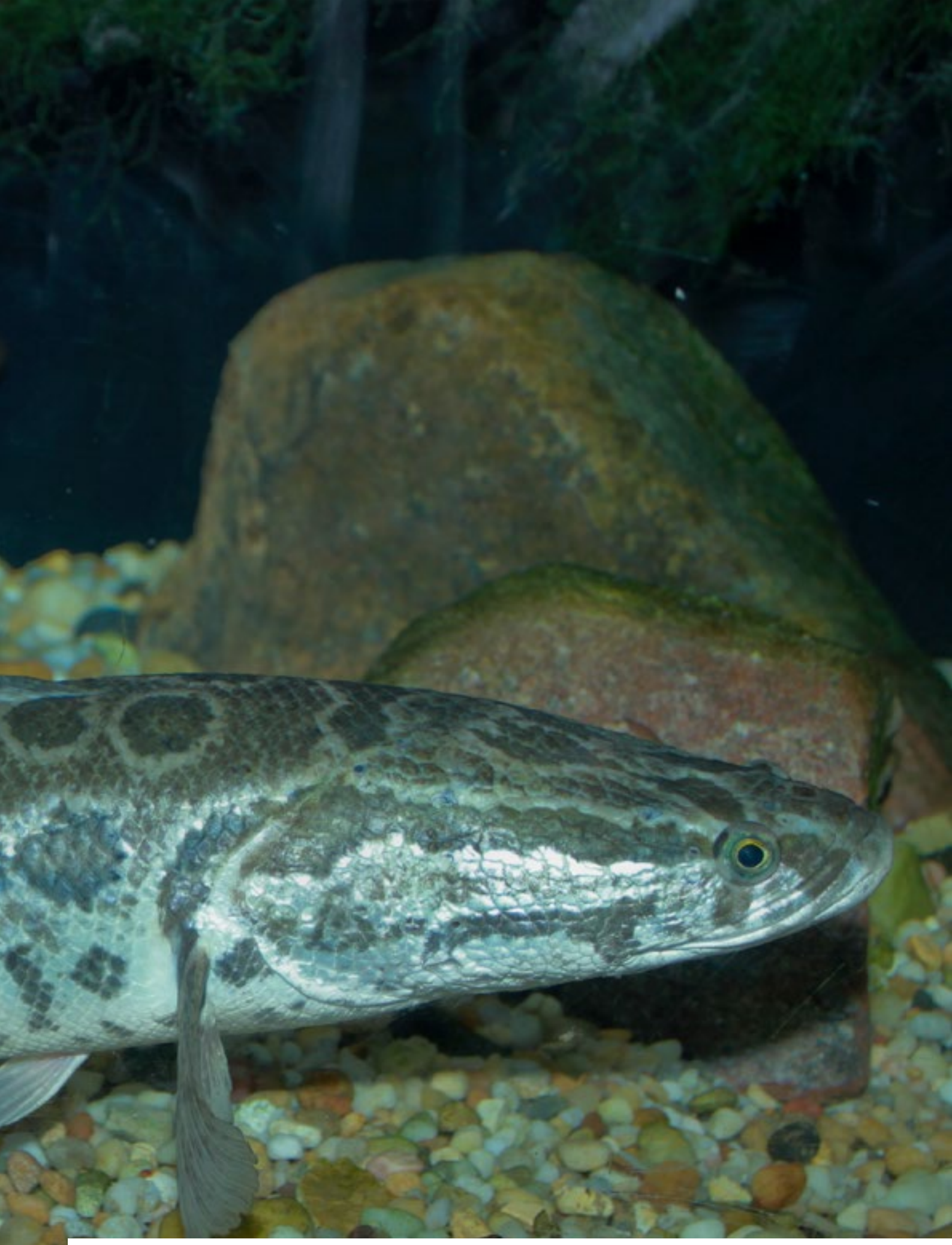
Pumpkinseed (*Lepomis gibbosus*)

STRATEGIC RECOMMENDATIONS FOR THE TRANSNATIONAL MANAGEMENT OF INVASIVE ALIEN FISH IN IBERIAN INLAND WATERS

Authors

Oliva-Paterna F.J., Oficialdegui F.J., Sánchez-González J.R., Zamora-Marín J.M., Casals F., Ribeiro F., Torralva M., Miranda R., Guerreiro P.M., Almeida D., Alexandre C.M., Benejam L., Clavero M., Cobo F., Doadrio I., Fernández-Delgado C., García-Berthou E., Godinho F.N., González G., Magalhães M.F., Morcillo F., Perdices A., Pou-Rovira Q., Santos J.M., Vila-Gispert A. & L. Zamora

LIFE INVASAQUA – TECHNICAL REPORT



Snakehead (*Channa argus*) © Brian Gratwicke. CC BY 2.0

LIFE INVASAQUA - Aquatic Invasive Alien Species of Freshwater and Estuarine Systems: Awareness and Prevention in the Iberian Peninsula.

LIFE17 GIE/ES/000515

This publication is a Technical report by the European Project **LIFE INVASAQUA (LIFE17 GIE/ES/000515)**. It has been drafted in collaboration with a team of experts within the framework of the **Society of Iberian Ichthyology (SIBIC)** and shared for improvement with national authorities of both countries (**Dirección General de Biodiversidad, Bosques y Desertificación, MITERD**, Spain; **Instituto da Conservação da Natureza e das Florestas, ICNF**, Portugal; **Dirección General del Agua, MITERD**, Spain; **Agência Portuguesa do Ambiente, APA**, Portugal; **Conselho Nacional da Água, CNA**, Portugal). It aims to provide evidence-based scientific support to the European policy-making process. The scientific output expressed does not imply a policy position of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use that might be made of this publication.

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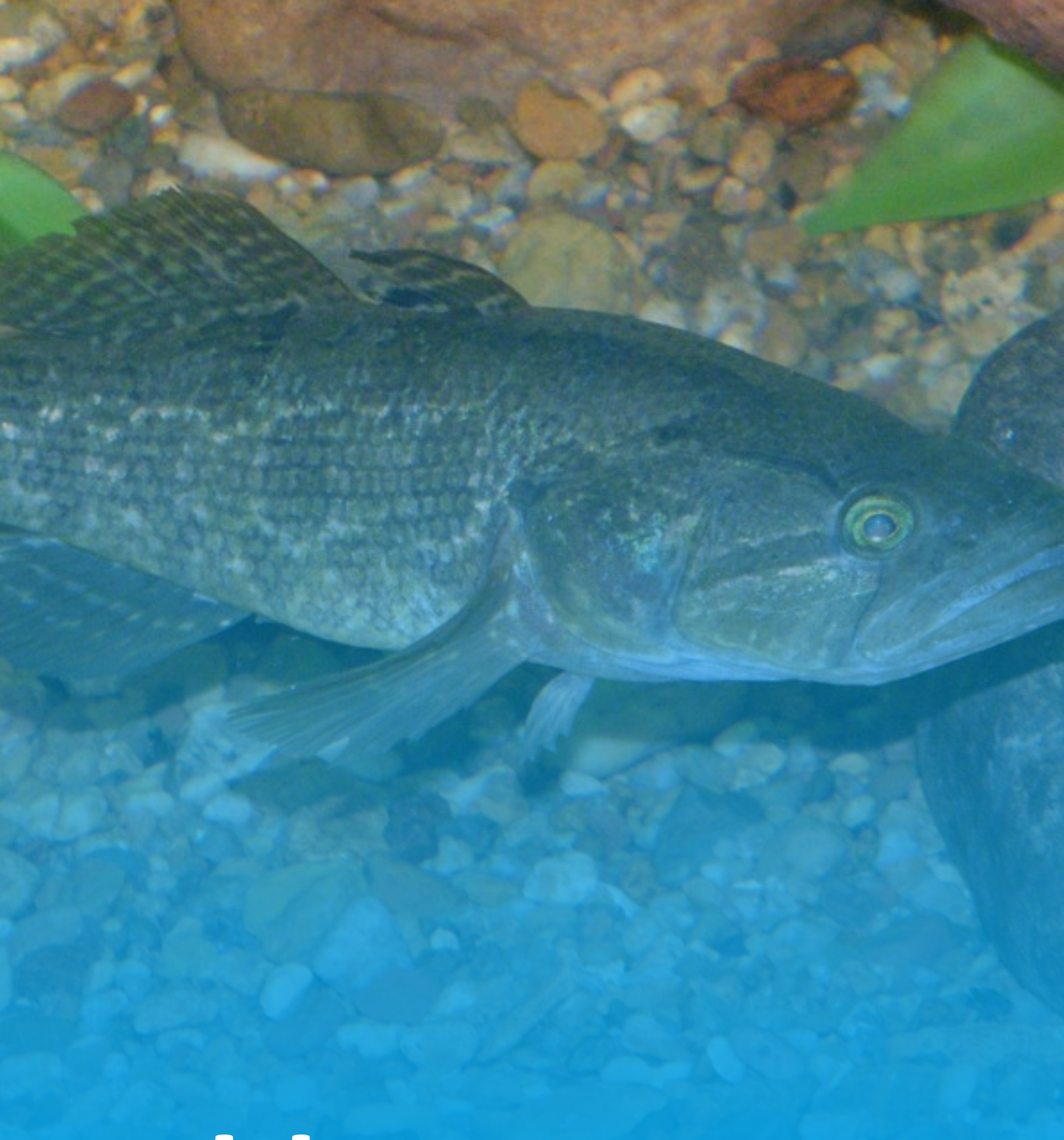
Abstract:

An important goal of LIFE INVASAQUA is to develop tools that will improve management and increase the efficiency of the Early Warning and Rapid Response framework for Invasive Alien Species (IAS) in the Iberian Peninsula. In coordination with the Society of Iberian Ichthyology (SIBIC), we developed a participative process with experts in order to obtain Strategic Recommendations for the transnational management of invasive alien fish in inland waters of Spain and Portugal. The recommendations promote the coordinated management between Spain and Portugal, in order to facilitate implementation of international commitments and best practices and to support development of policies and targets on invasive fish management. The recommendations were designed to serve as a guiding tool seeking to identify a strategic direction for the Spanish and Portuguese governance that is already being developed. The resulting Strategic Recommendations are important tools supporting the implementation of the IAS EU Regulation. Ultimately, the information included can be used for achieving the target of the EU Biodiversity Strategy to 2030 for dealing with IAS, and also for implementing of other EU policies with requirements on alien species, such as the Birds and Habitats Directives, and the Marine Strategy and Water Framework Directives.



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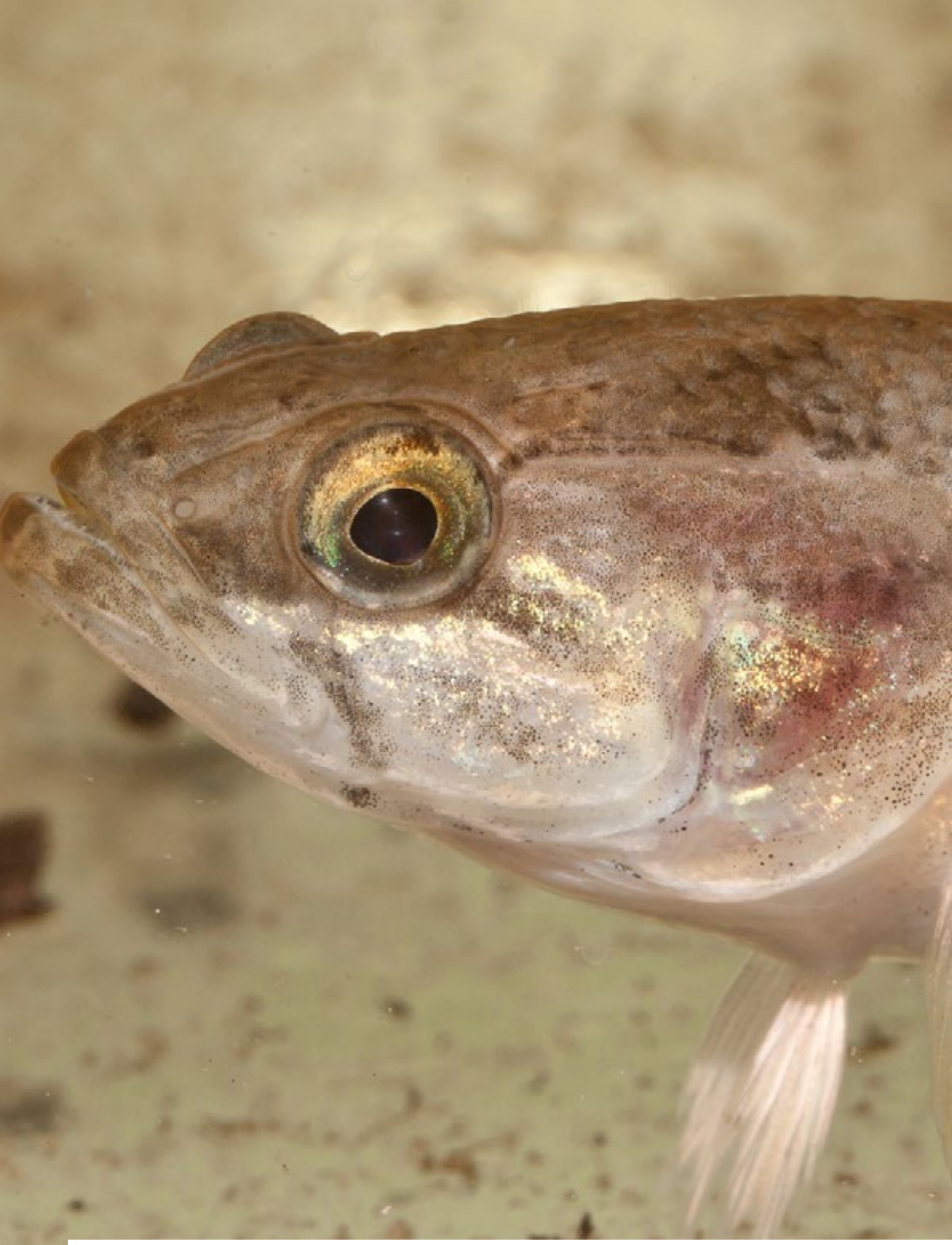

Amur sleeper (*Perccottus glenii*)

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Contributors

SIBIC - IBERIAN SOCIETY OF ICHTHYOLOGY

SIBIC aims to promote the study and conservation of native fishes of inland and marine aquatic ecosystems of the Iberian Peninsula. The board of the SIBIC facilitated the participation of experts in the elaboration process.

Coordination members and beneficiaries of the LIFE INVASAQUA contributed by facilitating logistics in some of the events and workshops.

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We would like to thank all Member States competent authorities, Societies, NGOs, scientists and managers which have contributed to the scope of this report, for their active collaboration and the supply of information. We are particularly indebted to the Fundación Biodiversidad (Government of Spain) and the Government of Navarre for their economic and logistical support for the SIBIC actions into the LIFE INVASAQUA.

The Project team would also like to gratefully acknowledge the experts and managers who contributed to the participatory methodology developed by LIFE INVASAQUA, particularly by participation in several events of the process and through the personal communications, with useful information, comments and insights. Among them, special thanks to: Ricardo Gómez Calmaestra (Dirección General de Biodiversidad, Bosques y Desertificación, MITERD, Spain), Paulo Carmo (Instituto para a Conservação da Natureza e das Florestas, Portugal), Fernando Magdaleno Mas (Dirección General de Biodiversidad, Bosques y Desertificación, MITERD, Spain), Portugal), Miguel Domingues (Instituto da Conservação da Natureza e das Florestas, Portugal), Concha Durán Lalaguna (Dirección General del Agua, Grupo de trabajo de Organismos de cuenca sobre EEI, Spain), Francisco J. Sánchez Martínez (Dirección General del Agua, MITERD, Spain), Maria Helena Alves (Agência Portuguesa do Ambiente, Portugal) y Francisco N. Godinho (in representation of Conselho Nacional da Água, Portugal).

Acronyms and short-names

EASIN: European Alien Species Information Network.

EU: European Union.

EWRR: Early Warning and Rapid Response framework.

IAF: Invasive Alien Fish.

IAF-WG: Iberian working-group for IAF.

IAS: Invasive Alien Species.

IAS EU Regulation: Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species.

IAS – Office: Transnational IAS coordination office.

LIFE: Financial Instrument for the Environment.

MS: Member State of the European Union.

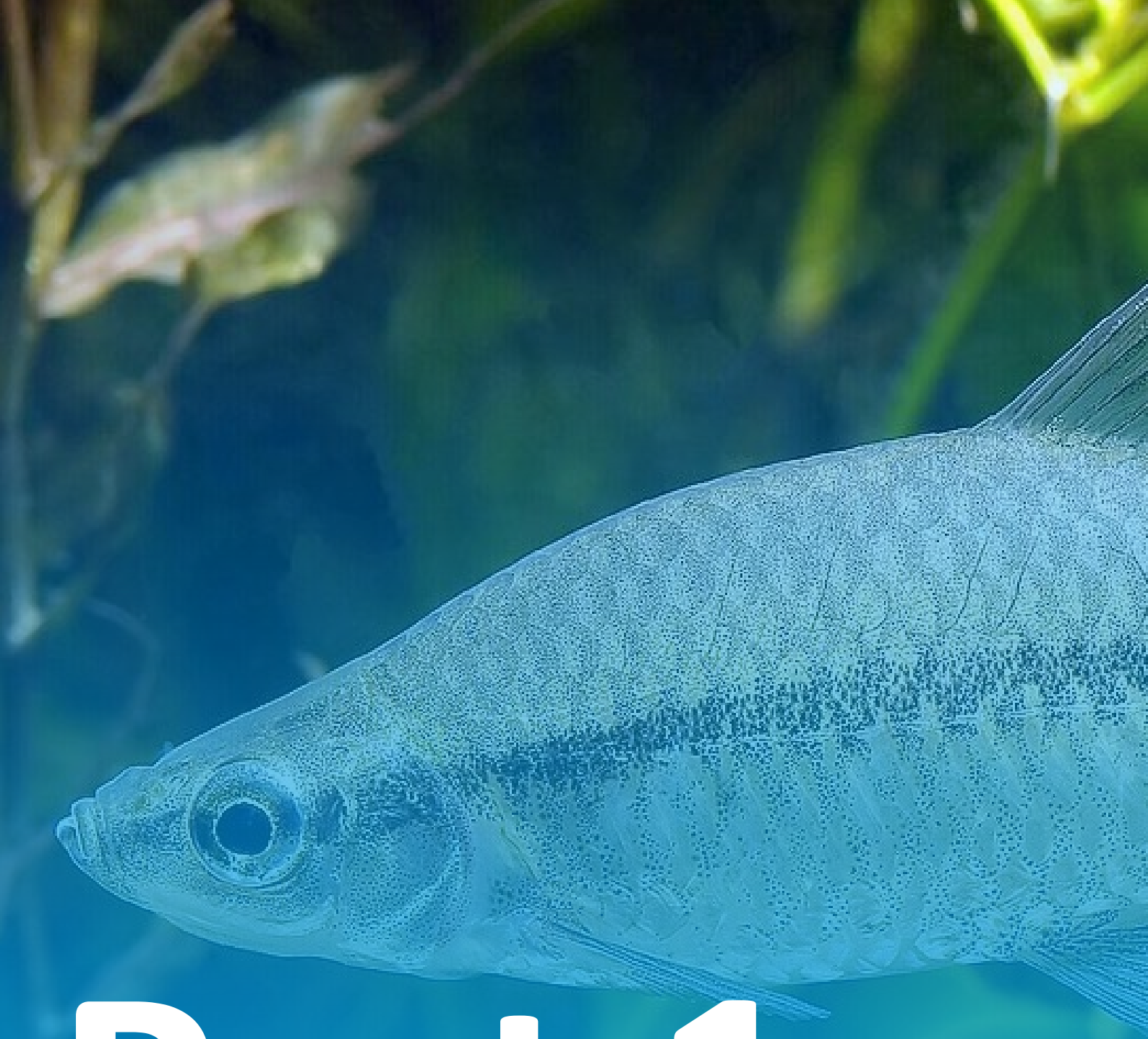
NGOs: Non-governmental organisations.

Portuguese National List of IAS: The National List of Invasive Species (Annex II, Decreto-Lei 92/2019).

SIBIC: Iberian Society of Ichthyology.

Spanish Allochthonous List: List of non-native species capable of competing with native wild species, altering their genetic purity or ecological balances (related to R.D. 570/2020).

Spanish IAS Catalogue: The Spanish Catalogue of Invasive Alien Species (Annex, R.D. 630/2013).



Part 1
Introduction & scope

Invasive Alien Species (IAS) are animals and plants that are introduced accidentally or deliberately into a natural environment where they are not normally found, with serious negative consequences for their new environment. They represent a major threat to native plants and animals in Europe, causing damage worth billions of Euros to the European economy every year. As invasive alien species do not respect borders, coordinated action at the European level will be more effective than individual actions at the Member State level.

European Commission website (December 2022)

Invasive alien species: a priority for the EU biodiversity policy

The Invasive Alien Species (IAS) are defined as species whose introduction and spread outside their natural ecological range poses a real threat to biodiversity and the economy (European Comission)[1]. IAS can upset ecosystems and are one of the main anthropogenic global drivers of species extinction, originating high economic costs[2]. Although alien species have been entering Europe for centuries, their numbers have risen exponentially in the last 50 years, principally as a result of increased trade and travel, and the established IAS are unlikely to decrease in the near future[3].

Thus, the current spread of IAS around Europe is creating complex challenges that threaten both its biodiversity and the well-being of its citizens. Although the problem is continental, the nature and severity of the impacts on natural heritage, society and the economy are unevenly distributed across MS and biogeographic regions. In fact, some aspects of the problem require solutions tailored to the specific values, needs and priorities of each MS, while others require consolidated EU action. Preventing international movements of IAS and coordinating an effective response to invasions will require cooperation and collaboration among governments, economic sectors, NGOs and other organisations.

The *European Strategy on Invasive Alien Species*[4] developed under the Bern Convention, already highlighted the need for implementing coordinated measures among European states, to prevent or minimise the adverse effects of IAS. Recognising this need, the European Parliament and Council adopted the Regulation (EU) No 1143/2014 (hereafter referred to as the IAS EU Regulation) (BOX 1), aiming to establish common measures among MS to prevent the entry and spread of IAS within the EU territory.

BOX 1. EU Regulation 1143/2014 on Invasive Alien Species

Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species (the IAS Regulation) entered into force on 1 January 2015. It aims to: (i) prevent, minimise and mitigate the adverse impacts of IAS on biodiversity and ecosystem services; and (ii) limit social and economic damage.

The adoption of the IAS EU Regulation was a major step forward in developing the EU's biodiversity policy, adopting it fulfilled both: (1) Action 16 of Target 5 of the EU biodiversity strategy to 2020; and (2) Aichi Target 9 of the strategic plan for biodiversity 2011-2020 under the Convention on Biological Diversity.

The core of the IAS Regulation is the **list of invasive alien species of Union concern** (the Union list), together with a set of measures on these to be taken across the EU. Three types of measures are foreseen, following an internationally agreed hierarchical approach to combat IAS:

(1) Prevention
(2) Early detection and rapid eradication (EWRR)
(3) Management

1. European Commission. 2017. *Invasive alien species: a European Union response*. Directorate-General for Environment. Publications Office.
2. Diagne C., Leroy B., Vaissière A.C., Gozlan R.E., Roiz D., Jarić I., Salles J.M., Bradshaw C.J.A. and F. Courchamp. 2021. High and rising economic costs of biological invasions worldwide. Nature, 592, 571-576.
3. Seebens H., Bacher S., Blackburn T.M., Capinha C., Dawson W., Dullinger S., Genovesi P., Hulme P.E., van Kleunen M., Kühn I., Jeschke J.M., Lenzner B., Liebhold A.M., Pattison Z., Pergl J., Pyšek P., Winter M. and F. Essl. 2021. Projecting the continental accumulation of alien species through to 2050. Global Change Biology. 27, 970-982.
4. Genovesi P. & C. Shine. 2011. *European Strategy on Invasive Alien Species.* Nature and Environment, No. 161. Council of Europe.

Why Strategic Recommendations for the transnational management?

Because IAS are a global problem, unilateral action by a few states is not enough to prevent new introductions and to mitigate their impacts. Cooperation at international, regional and transboundary levels is essential to develop compatible approaches. Thus, the need for regional approaches at biogeographical levels has long been recognised by EU institutions.

Under the EU IAS Regulation, Spain and Portugal must prevent the entry of alien species, contain their spread within their territories, implement effective EWRR mechanisms to detect new introductions and adopt management measures for IAS that are already established. The EU IAS Regulation has been transposed into Spanish and Portuguese legislations and is implemented by each national administration, with the Spanish IAS catalogue and the Portuguese National List of IAS being pivots in this Regulation (BOX 2). However, collaboration and partnership between administrative agencies, NGOs and other stakeholders in both MS should be encouraged and enhanced to achieve the objectives of the EU IAS Regulation.

Spain and Portugal face similar constraints in their IAS management efforts. These may include:

- Low public awareness and opposition to government intervention.
- Poor coordination between administrative agencies and other stakeholders.
- Absence of common and agreed priorities for action.
- Non-harmonized legal frameworks.
- Inadequate monitoring capacity.
- Lack of effective rapid response measures.
- Shortage and inaccessibility of scientific and technical information.

The present *Strategic Recommendations for the Transnational Management* (hereafter referred to as the Strategic Recommendations) addresses some of these constraints. Their aim is to promote the coordinated management between Spain and Portugal, in order to facilitate implementation of international commitments and best practices and to support development of policies, measures and targets on IAS management.

BOX 2. Relevant normative in Spanish and Portuguese IAS Regulations

SPAIN
- Law No. 42/2007 on Natural Heritage and Biodiversity.
- Royal Decree No. 630/2013 that developed the Spanish Catalogue of IAS, and subsequent updates.
- Royal Decree No. 570/2020 regulating the administrative procedure for the prior authorisation of the importation into the national territory of allochthonous species in order to preserve Spanish native biodiversity, which developed the Spanish Allochthonous list.

PORTUGAL
- Law No. 50/2006 as amended, on Environmental Administrative Offences.
- Resolution of the Council of Ministers No. 55/2018 that approved the National Strategy for Nature Conservation and Biodiversity for 2030 (ENCNB 2030).
- Decree-Law 92/2019 that developed the National List of Invasive Species.

Objectives of the Technical report

This technical report is designed to serve as a guiding tool to identify a strategic direction for the Spanish and Portuguese IAS governance that is already being developed at the regional and national level. Its geographical scope encompasses the continental areas of the two EU Member States, Spain and Portugal.

The Strategic Recommendations could be useful to improve the transnational response capacity to deal with invasive alien fish (IAF) in the freshwater and estuarine waters of the Iberian Peninsula. The majority of the vertebrates introduced and established in Iberian inland waters are fish, with 42 taxa registered in the updated *List of Aquatic Alien Species of the Iberian Peninsula*, many of them prioritised in a black list developed by LIFE INVASAQUA (Appendix A). Additionally, 90 taxa were included in the list of potential taxa that have not yet recorded in the inland waters of the Iberian Peninsula but at high risk of invasion, in this case prioritised in an alert list (Appendix B).

Therefore, the Strategic Recommendations are primarily aimed at improving EWRR systems to deal with IAF in complement to the existing IAS management framework, by providing guidance to help Spain and Portugal in their effort to:

- Strengthen transnational capacity and cooperation on IAF issues.
- Prioritise and identify key actions.
- Prevent new invasions and spread of IAF.
- Mitigate the adverse impacts and restoration of habitats as a mean of controlling IAF.
- Develop applied research on IAF.
- Increase awareness and information on IAF issues and ways to tackle them.

The technical report must be a dynamic tool that would evolve over time according to new situations or scenarios. It is also designed for a participatory process with agency managers and other stakeholders. Finally, it should be noted that one of the objectives of LIFE INVASAQUA, and thus of their technical reports, is to promote collaboration with decision-makers and stakeholders and ensure information sharing and exchange.

Who is the Strategic Recommendations for?

The technical report is a guiding tool mainly addressed to nature conservation administrative agencies and other sectorial agencies with responsibility on IAS issues. It is recognised that many aspects of implementation should be delivered through existing administrative agencies which have long-standing expertise in particular management areas. The Strategic Recommendations also seeks to engage the general public and stakeholders (BOX 3) involved in the introduction, movement, use and management of alien fish and to build on the expertise and commitment of non-governmental organisations and research institutions. Many of the recommendations call for joint or complementary initiatives by both private and public stakeholders.

BOX 3. Public and private stakeholders.

Stakeholders are individuals, groups and organizations that are actively involved in the IAS issues or whose interests may be affected by the IAS management. The involvement of stakeholders is critical for ensuring the management success and for the synthesis of evidence on what works, where, and for whom, providing key benefits.Examples of public and private stakeholders involved in IAS are:

- Administrative agencies: wildlife managers, protected area managers, surveillance agents, customs and quarantine services, wildlife trade personnel, water resource managers, and other government departments (national and regional) responsible for agriculture and forestry.
- Professional associations for aquaculture/mariculture, recreational fishing, commercial fishing, pet and animal retailers, ornamental fish and aquarium trade, bird breeding, tourism/travel, shipping, water sports, forestry, horticulture, botanic gardens, zoological parks and aquariums.
- Universities and research institutes.
- Environmental NGOs.
- Environmental educators and journalists.

Topmouth gudgeon or stone moroko *Pseudorasbora parva* (Temminck & Schlegel, 1842)

The topmouth gudgeon is a small freshwater fish which typically inhabits small ponds and streams with good vegetation cover, but sometimes larger rivers, as well as disturbed habitats. It is native to the eastern Asia, including Siberia, China and Japan, having been introduced to several regions in Europe and Asia. In the EU it was initially introduced in Romania, in 1961, and now there are established populations in almost all Member States including Spain but with the current exception of Portugal. It can quickly dominate new water bodies, causing the loss of native cyprinid fish because competes for food and exert high grazing pressure, which in turn may alter ecosystem function and habitat quality. This species has also an important role in the spread of parasites and diseases, this may also have a negative impact on aquaculture and fishing activities. This species has been included in the European List of Invasive Alien Species, and also in the Spanish IAS Catalogue and in the Portuguese National List of IAS, ranking among the top in the black list developed by LIFE INVASAQUA.

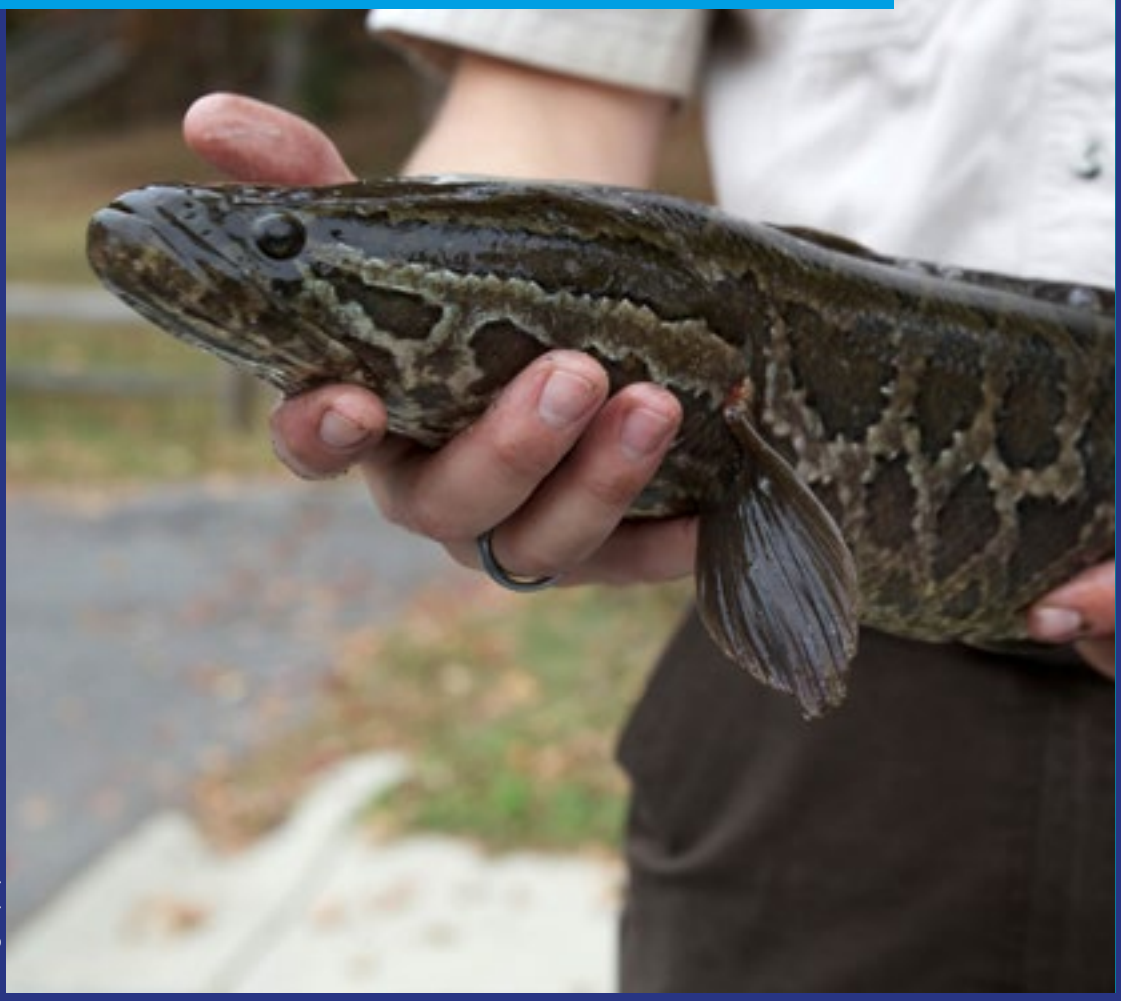
European catfish
Silurus glanis Linnaeus, 1758

The European catfish is established in four of the largest river drainages of the Iberian Peninsula (Ebro, Duero, Tagus and Guadalquivir) and in other smaller drainages in the Northeastern and Eastern areas. The European catfish was initially detected in the lower Ebro in 1974, being posteriorly introduced in upper Tagus (1998) and in Catalonian rivers (2000). It also occurs in the Duero river and, more recently (2013), occurring in Guadalquivir river in two different locations. This catfish is the third largest freshwater fish attaining 2.8 m long and up to 120 kg of weight, being considered a top-predatory fish. The impacts to local biodiversity are probably high given their predatory habits, where the smaller catfish (<1 meter) eat predominantely crustaceans (crayfish and shrimp) and fishes, while the larger fish (>1m) eat almost exclusively fish. There is a bulk of evidence that this invasive fish targets spawning areas of shads, sea-lamprey and native barbels, potentially causing high population declines of these species and loss of income to professional fishermen. Also, the large catfish aggregations observed (shoals of 60 of large individuals) in several reservoirs could create high concentrations of nitrogen and reduce water quality of drinking water. Little is known about pathogen transmission of the catfish to native fishes. The species was included among the top in the balck list of harmful invasive taxa in Iberian inland waters developed by LIFE INVASAQUA.

Amur sleeper
Perccottus glenii Dybowski, 1877

The Amur sleeper is considered one of the most widespread and harmful alien fish in European inland waters. Native to East of Asia, since its first introduction in Europe (European part of Russia), non native populations have been identified in more than fifteen countries in the central and easthern areas. Amur sleeper is a voracious predator fish which represents a serious threat to aquatic fauna as it forages on a wide range of preys including invertebrates, fish and amphibians. Thus, it can significantly affect the trophic structure of some water bodies and even lead to local extinction of native species. It can rapidly spread through canals and it was also accidentally introduced as contamination of stocked fish. Amur slepper is also kept in aquaria and used as live bait, activities that could be additional reasons for uncontrolled introductions. Considering its widespread and rapid invasion in Europe and its impact on native biota it has been assigned to the European List of Invasive Alien Species. Previosly, Amur slepper has been listed as one of the top 27 animal IAS introduced in Europe for aquaculture and related activities, which includes species that cause serious threat to biodiversity. It was included among the top in the alert list of potential aquatic species with high risk of invasion in Iberian inland waters developed by LIFE INVASAQUA.

Snakehead
Channa argus (Cantor, 1842)



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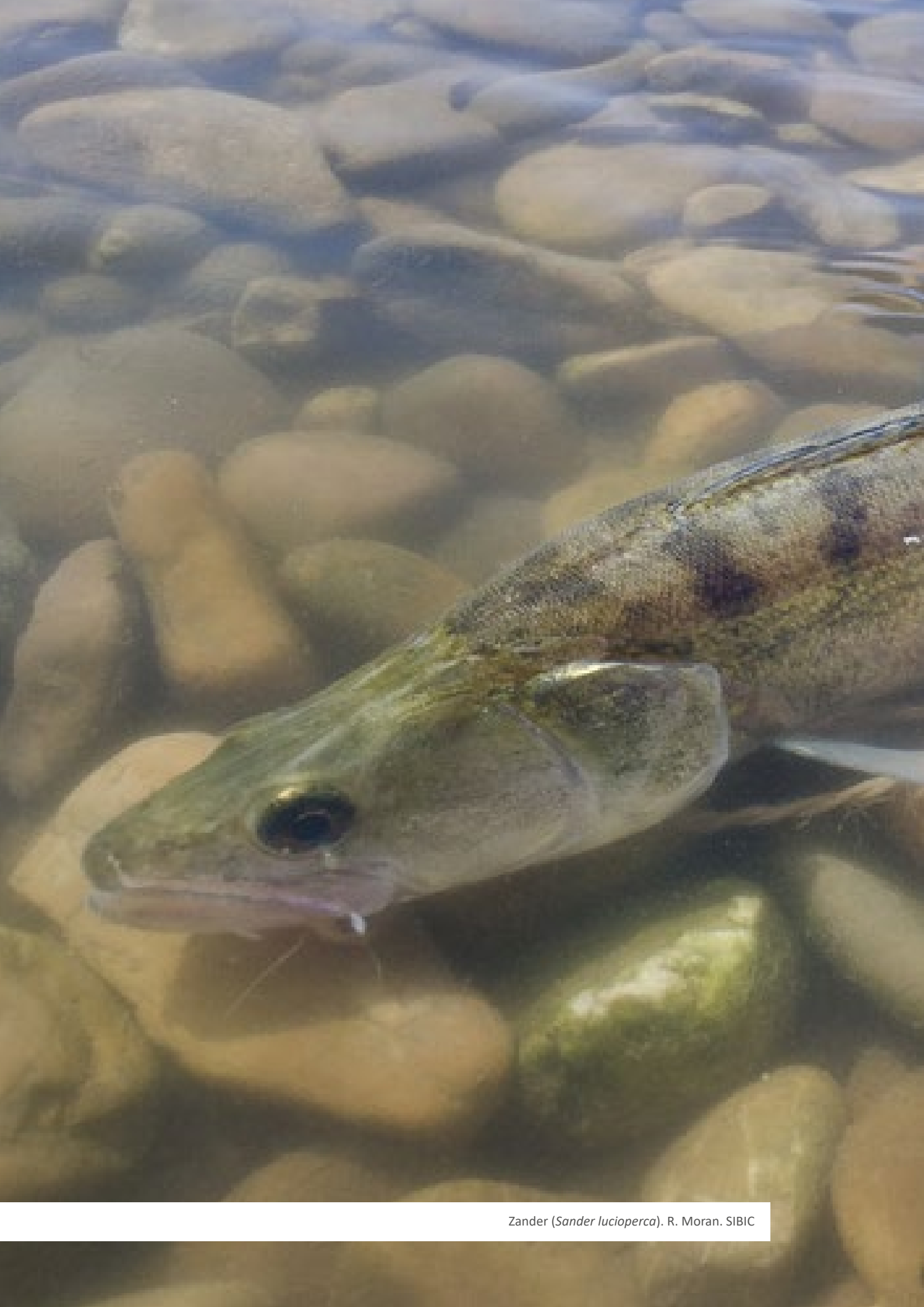
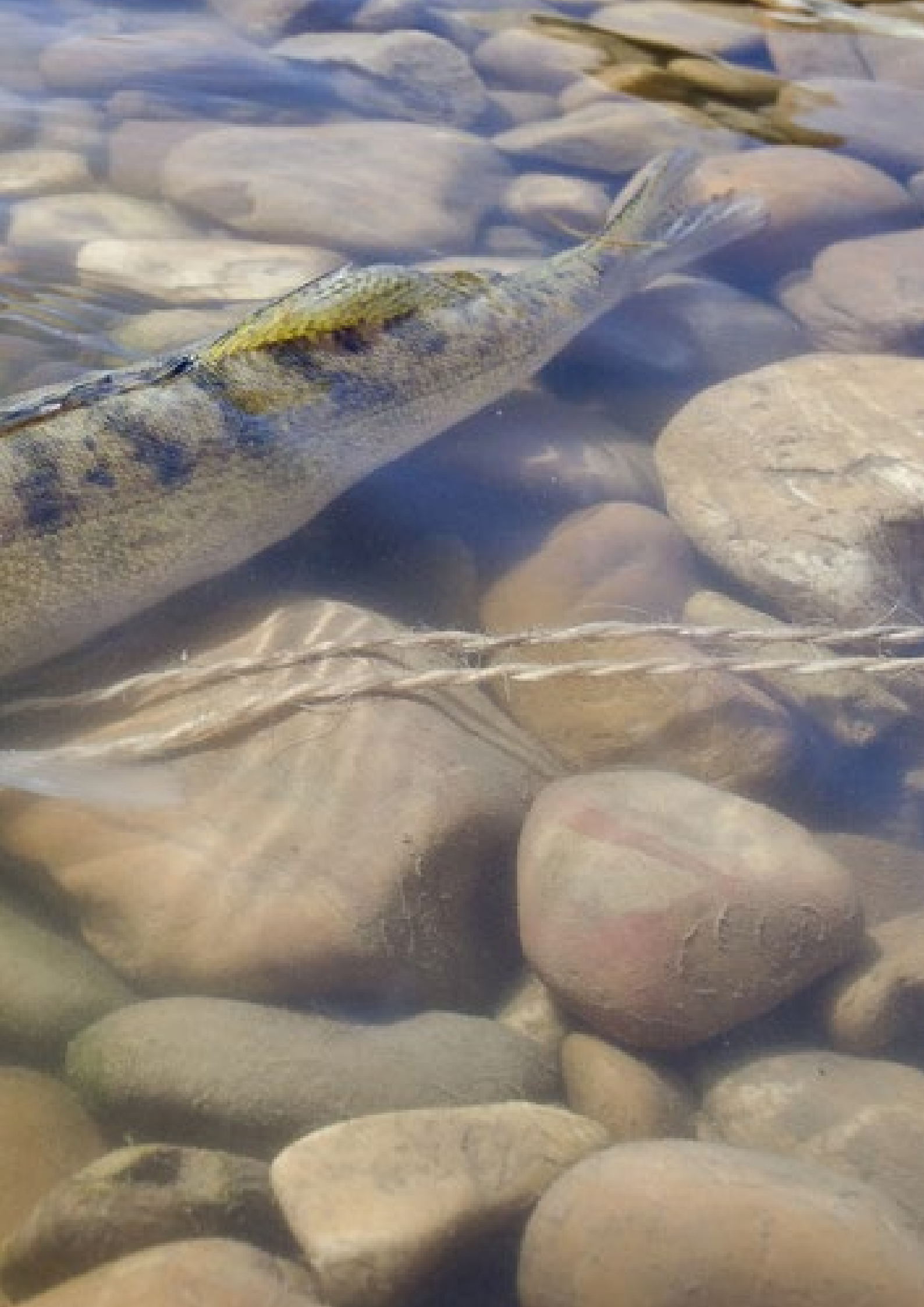
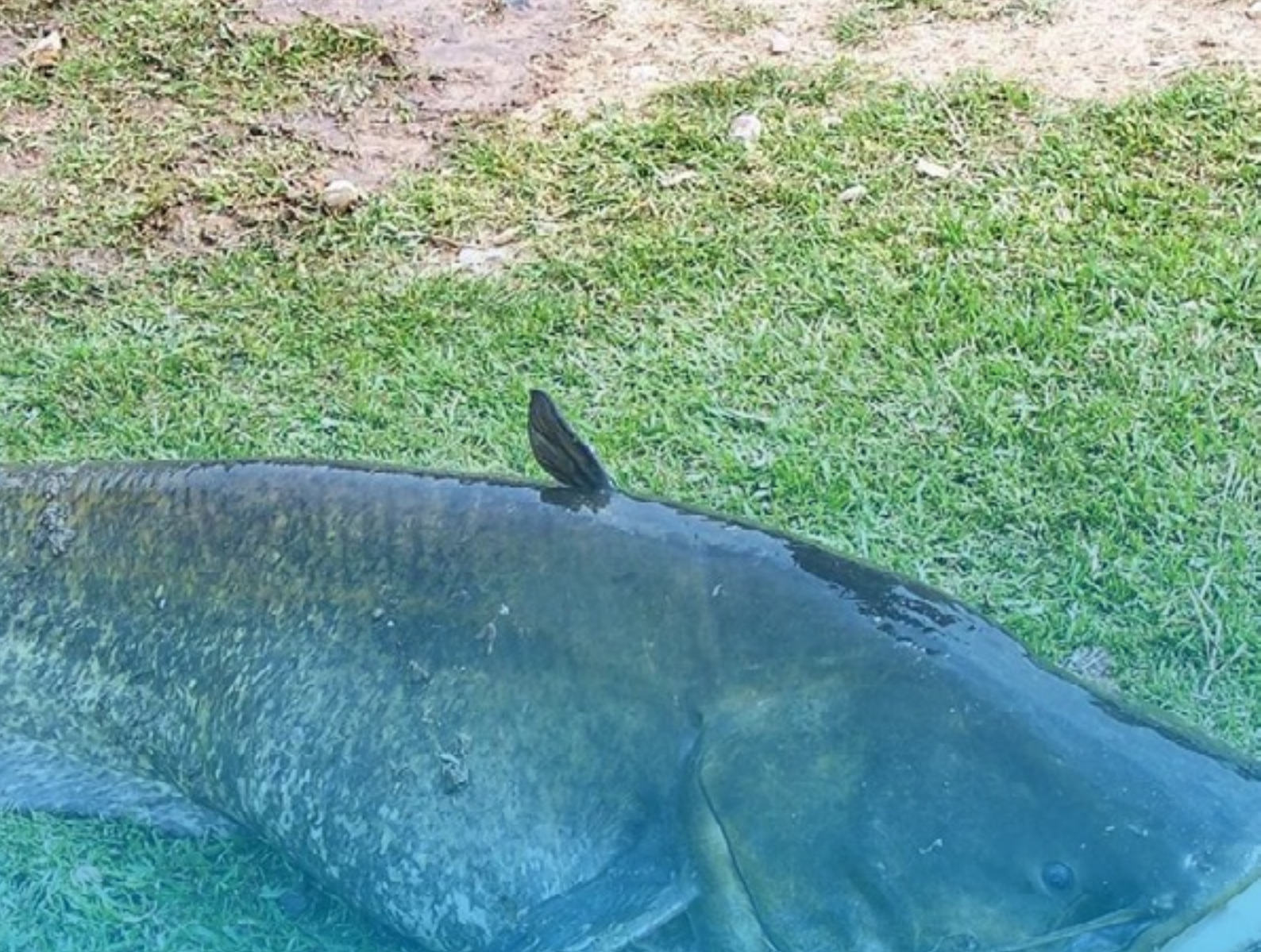
The snakehead is native from southern and eastern China and was introduced to Japan in the early 1900s. The species can survive out of water for up to three or four days and commonly escapes from ponds where it has been introduced to, dispersing into new areas and establishing populations relatively quickly in new water bodies. The snakehead inhabits shallow, marshy ponds and wetlands and is an ambush predator that wait for its prey on the bottom affecting native fauna. It is widely distributed in USA and, at least, three countries in Europe have shown records. The species is not involved in the aquarium fish trade but is sold aquaculture and in live food fish markets as a food fish. The most likely pathway in Europe is the introduction by escape from aquiculture or perhaps in relation to angling. The genera *Channa* is included in the Spanish IAS catalog and in the Portuguese National List of IAS. The species was included by LIFE INVASAQUA in an alert list of potential aquatic species with high risk of invasion in Iberian inland waters.



Zander (*Sander lucioperca*). R. Moran. SIBIC





Part 2
Strategic recommendations Lines of action

The Strategic Recommendations that are key in terms of time and feasibility of implementation are structured in seven lines of action that are not present any order of priority.

The lines of action are broadly similar to those included in the *European Strategy on Invasive Alien Species* by the Council of Europe. Moreover, as a whole, the lines share several principles: Scientific basis; Synergy and partnerships; Capacity, procedural streamlining and long-term commitment; and Awareness, communication and education.

Line of Action 1.
STRENGTHENING INSTITUTIONAL AND LEGAL FRAMEWORKS FOR TRANSNATIONAL COOPERATION.

Line of Action 2.
UPDATING, SHARING AND TRANSFER OF INFORMATION.

Line of Action 3.
PREVENTION, SURVEILLANCE, EARLY WARNING AND RAPID RESPONSE.

Line of Action 4.
MONITORING, CONTAINMENT, CONTROL AND ERADICATION.

Line of Action 5.
ENVIRONMENTAL RESTORATION AND HABITAT MANAGEMENT.

Line of Action 6.
APPLIED RESEARCH TO IMPROVE MANAGEMENT CAPACITY.

Line of Action 7.
ENGAGEMENT OF STAKEHOLDERS AND AWARENESS OF THE GENERAL PUBLIC.

Line of Action 1
STRENGTHENING INSTITUTIONAL AND LEGAL FRAMEWORKS FOR TRANSNATIONAL COOPERATION

Aim & Objectives.

Improve the legal and institutional framework by coordinating and unifying efforts among IAF stakeholders to develop and strengthen relationships and to promote more effective management and governance strategies at the transnational level.

- Strengthening and promoting a Spanish-Portuguese strategy towards consensual decision-making through transnational agreements and coordination figures among administrative agencies.
- Identifying gaps and inconsistencies in legal framework by promoting the participation of administrative agencies and stakeholders in the improvement of legislation providing more flexible and adaptive context-dependence solutions.
- Harmonising regulation and lines of action related to IAF management between national and regional administrative agencies.
- Identifying, clarifying and coordinating competencies, roles and responsibilities among government authorities and administrative agencies directly involved in IAF management (i.e. environmental and wildlife management). In turn, encouraging coordination among agencies with responsibility in human and animal health, transport, tourism, trade, aquaculture and fishing, protected areas, urban water supply, irrigation and agriculture, and other fields relevant to management of IAF.
- Update regulation and standards in pet/aquaria shops and e-commerce, fostering enforcement of normative and prevention of the trade of alien fish.
- Safeguarding areas of biodiversity conservation interest (e.g. protected areas) with specific measures and regional policies, to prevent the arrival and control IAF populations.

Recommended actions.

1.1. Collaboration among administrative agencies responsible for environmental and wildlife management, through a consultative process, for the development of a **Transnational Action Plan of IAF (IAF-TAP)** (BOX 4) to be incorporated into National and European Biodiversity Strategies and other relevant policies.

1.2. Developing a **Transnational IAS coordination office (IAS-Office)** for coordinating national IAS-related authorities, as well as supervising the efforts of administrative agencies to facilitate decision-making. An I**berian Working-Group for IAF (IAF-WG)** should be key for advising the IAS-Office (BOX 5).

1.3. Establishing a **transnational organogram of roles and responsibilities**, by the IAS-Office, to clearly assign the administrative agencies involved in the enforcement and implementation of the IAF-TAP. **Regular work-meetings** among agencies will be essential.

1.4. Promoting **cross-sectorial collaboration** among administrative agencies to establish linkages between any transnational programme and focal points on the IAS management. For instance, **cooperation programmes** between the agencies that manage the main pathways and vectors of IAF in the Iberian Peninsula (e.g. recreational fishing, aquarium trade, aquaculture).

1.5. **Identify key stakeholders** (e.g. NGOs, scientific groups, recreational and professional fishermen, aquaculture farmers) **and promote their participation** in, for instance, looking for a consensual set of inter-administrative regulations for IAF in order to avoid obstacles or contradictions across legal and administrative boundaries.

1.6. Initiate a t**ransnational review of existing measures and non-statutory procedures to manage the transport, trade and possession of IAF**, in order to produce practical recommendations and help administrative agencies set priorities. The r**eview of regulatory transnational measures at the border-cross level** for human activities with potential for introduction of IAF (e.g. aquarium trade, aquaculture, recreational and commercial fishing) should be priority.

1.7. Develop and enforce coordinated **action sub-plans for protected areas in cross-border regions** (e.g. for special conservation areas) in Spain and Portugal to address IAF, integrating awareness and communication efforts, regulatory measures, prevention aspects, as well as management actions.

BOX 4. General elements of a Transnational Action Plan of IAF.

- Status, trends, and specific problems of IAF in the Iberian Peninsula (Spain and Portugal).
- Main pathways, vectors and particular risks.
- Details of national IAS authority/network.
- Roles and responsibilities of key administrative agencies.
- Relevant legislation, non-statutory measures, and proposals for improved prevention and management.
- Outline of criteria for risk analysis, management planning and mitigation.
- Needs related to monitoring, training, capacity building and funding.
- Specific measures or policies for isolated and/or ecologically sensitive ecosystems (e.g. protected areas).
- Priority list of actions, timelines and lead administrative agencies and stakeholders for implementation, with realistic targets to be achieved.
- Establishment of a mechanism to exchange information and collaborate with other countries.

BOX 5. Possible roles of a Transnational IAS coordination office (IAS-Office).

- Lead and coordinate the development and implementation of strategies and action plans on IAS (e.g. proposed IAF-TAP).
- Lead and coordinate the institutional and legal review process.
- Coordinate input from different administrative agencies to national and European policy making and programmes.
- Consult with competent scientific and technical authorities to obtain technical advice on decision making related to IAF, with the Iberian IAF-WG being a key element.
- Engage with stakeholders and relevant sectors to raise awareness campaigns and encourage best practices.

Line of Action 2
UPDATING, SHARING AND TRANSFER OF INFORMATION

Aim & Objectives.

- Promoting transnational exchange to unify and address information on IAF issues (e.g. biological/ecological data, management techniques) in order to rapidly make available the most up-to-date and effective measures for their management.
- Identifying requirements and strengthening agreements for Spanish-Portuguese exchange of information, promoting use of terminology consistent with the IAS EU Regulation, with a common interpretation of key terms and concepts.
- Engaging and creating synergies between knowledge building and different stakeholders.
- Gathering, centralising and updating information related to the IAF management in each responsible administrative agency (national and regional).
- Encouraging the exchange and sharing of mechanisms for best-practices, eradication techniques and knowledge among national and regional administrative agencies.

Recommended actions.

2.1. Establish a **general procedure for transnational and intra-State information exchange, notification and consultation** (e.g. information-exchange protocols) of the components involved in the IAF-TAP (action 1.1). Transnational documents, web platforms and other mechanisms of information exchange should be in a multilingual format (at least Spanish, Portuguese and English).

2.2. Develop mechanism to strength links between policy makers, administrative agencies, scientific groups from different fields (e.g. ecology, economy, geography, geology, sociology), and other stakeholders. For instance, developing links between **knowledge-exchange programmes** on IAF (action 6.2) and administrative agencies to identify key requirements facilitating the creation of **collaborative networks** (action 6.2) and to encourage synergies, information exchange and share experiences.

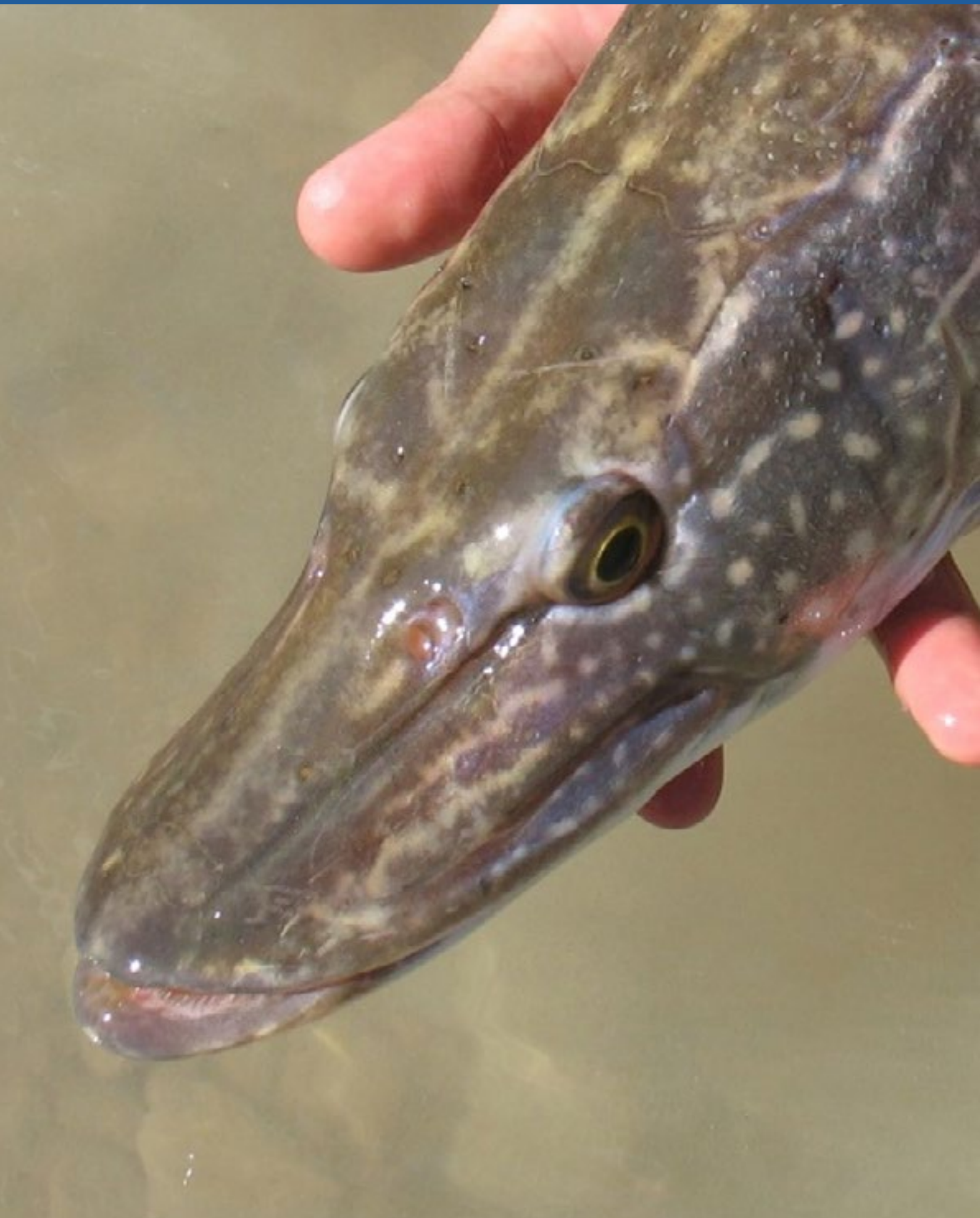
2.3. Organizing periodic **workshops and forums** coordinated by the IAS-Office and IAF-WG in collaboration with scientific societies (e.g. SIBIC -Iberian Society of Ichthyology) to explain concerns about IAF and to discuss solutions among stakeholders.

2.4. Develop and maintain a **user-friendly online platform/website** (e.g. *Aquatic Invasive Alien Species of the Iberian Peninsula platform; IBERMIS platform*) or other system of linked regional, national and transnational information on IAF management (e.g. established and potential species, occurrence in the wild, priority eradication actions, basic guidelines for citizens). This system should set data standards and facilitate the sharing of data in multiple languages (at least in the official languages of Spain and Portugal). **Technical review-reports** (action 6.2) must be available for download in this platform.

2.5. **Reporting innovative, cost-effective and non-invasive sampling protocols** for early detection, eradication and control of IAF. **Workshops and forums** (action 2.3) will assure the transfer of the most up to date methods for IAF management.

2.6. Encouraging the development of **best-practices and codes of conduct to aquarium shops/aquarium trade, aquaculture facilities**, and **recreational fishing associations** for avoiding the risks associated with release and escape of IAF into the wild. These codes of conduct must be designed following the European legislation on animal welfare[5].

5. See review in: Simonin D. and A. Gavinelli. 2019. The European Union legislation on animal welfare: state of play, enforcement and future activities. In: Hild S. & Schweitzer L. (Eds), Animal Welfare: From Science to Law, 2019, pp.59-70.



Pike (*Exos lucius*). F.J.Oliva SIBIC

Line of Action 3
PREVENTION, SURVEILLANCE, EARLY WARNING AND RAPID RESPONSE

Aim & Objectives.

To prevent and minimise the introduction and the spread of IAF through an approach prioritising pathways and vectors of arrival.

- Applying prevention and surveillance efforts to key private stakeholders that generate intentional and unintentional introductions, as well as to high-risk entry sites (e.g. locations next to aquaculture farms in estuaries and rivers) and natural dispersal pathways (e.g. water systems in cross-border regions or shared watersheds).
- Increasing the EWRR system efficiency for surveillance cross-border regions (also in-State themselves) and to conduct rapid response actions. Updating information, maximising the use of existing capacity, disseminating advantages of new technologies, and training field surveillance agents.
- Implementing site-based actions to complement prevention and surveillance targets at spatial scales, from global to regional, and down to specific areas (e.g. protected areas).

Recommended actions.

3.1. The IAF-TAP (action 1.1) must **update and incorporate the information from the national action plans on the pathways of introduction and spread of IAS**[6] considering prevention and surveillance strategies specific for IAF at the Iberian and cross-border levels.

3.2. Developing **contingency sub-plans**, included in the IAF-TAP, ensuring funds, equipment and staff, to prevent the arrival of new IAF. For instance, build agreement and communication strategies between customs at airports and ports and administrative agencies (e.g. IAS-Office) to address weaknesses, to strength control best techniques for detection and to implement staff training and capacity-building programmes.

3.3. Coordinate by IAS-Office, developing and updating a **transnational agreed listing system** (BOX 6) and subsequently propose transfer to the regulatory lists.

3.4. Coordinated by the IAF-WG, **applying a periodically horizon scanning** to guide efforts in rapid risk assessments, to update the **alert list** (BOX 6) for potential new IAF, and to identify new pathways.

3.5. **Adapt licensing rules for prevention and containment facilities** to minimise risk arising from escape and release of IAF. Target facilities may include aquaculture farms, public aquaria, and animal retail establishments.

3.6. Develop **prediction models of spread of established IAF** (or encourage, action 6.4) that can for instance define key sentinel areas and set monitoring for early detection, thus increasing the efficiency of spreading control.

3.7. Establish **cross-border contingency sub-plans** (included in the IAF-TAP) to promote a rapid response in new invaded areas, ensuring funds, equipment and staff. The **creation of national and regional funds** per administrative agencies may be necessary.

3.8. Establishing and monitoring an **early warning and surveillance network on high-risk inland waters** most vulnerable to new invasions of IAF at regional scale (e.g. at watershed level) and also in protected areas (e.g. special areas of conservation). Protocols with standardised sampling techniques are needed to detect first introductions and spread of IAF within and across river basins (e.g. environmental DNA).

3.9. **Training personnel involved** in surveillance, early warning and rapid response to conduct site- and taxa-specific surveys (e.g. courses and practical identification guides for IAF).

3.10. **Enhancing the use of citizen science applications** (e.g. *the Invasive Alien Species in Europe App*[7]) for prevention and surveillance.

3.11. Complement a **transnational agreed listing system** (action 3.3.) developing a ***white list*** of alien fish (BOX 6) to facilitate screening of permit applications.

3.12. Work on the establishment of monitoring and **filtering systems to reduce movements of IAF throughout water transfers** between watersheds.

3.13. **Work with recreational fishing associations** at regional and national levels to identify and minimise risks associated with the introduction and spread of IAF, for example, advising against the use of live bait for fishing and the release of targeted alien fish.

BOX 6. Possible components of a transnational agreed listing system.

The Spanish and Portuguese IAS Regulation already include lists in normative that can be the basis for a transnational agreed listing system: Spanish IAS Catalogue, Portuguese National List of IAS and Spanish Allochthonous List.

- Alert list: Alien species not yet present in a territory or present only in introduction stage that pose invasion risks to the invaded areas and for which particular prevention, surveillance and monitoring efforts are recommended, in order to enhance prompt response in the case of entry into the wild and spread. The list shall be updated and transferred to the competent authorities.
- Black list: Species whose introduction is strictly regulated, and that according to a specific risk assessment pose risks to the environment, economy or human well-being. Priority should go to: (1) species already identified as highly invasive in MS and species proven to be invasive in other Mediterranean regions; (2) species that are likely to cause problems to several MS and have a high potential of introduction; (3) species that are likely to be a problem in several MS, which are not yet present but are likely to be introduced.
- White list: Species classified as low risk following a specific risk assessment. This list includes exotic taxa known on the basis of stringent criteria to have such a low probability of invasion that they can be commercialized. The use of white lists should not prevent the preferential use of native species of local provenance where appropriate. It is recommended to involve stakeholders in the acceptance of the white list.

The listing system should be dynamic, making it possible to transfer species among lists if justified (e.g. for white-listed species in trade over a long period, the risk should be reassessed if there is new evidence of invasive behaviour). Species listing and decision-making need to be based on scientific criteria that are periodically reviewed.

Terminology adapted from: Genovesi P. and D. Shine. 2011. *European Strategy on Invasive Alien Species.* Nature and Environment, No. 161. Council of Europe; European Environment Agency. 2010. *Towards an early warning and information system for invasive alien species (IAS) threatening biodiversity in Europe.* European Environment Agency, Technical report, No. 5.

6. e.g. *Action Plan on the pathways of introduction and spread of invasive alien species in Spain*. 2021. Coordinated by General Directorate for Biodiversity, Forest and Desertification. Ministry for Ecological Transition and the Demographic Challenge. Spain.

7. Joint Research Center. 2022. *Invasive Alien Species in Europe*. Version 5.1.0. JRC Scientific Information Systems and Databases. European Commision.

Line of Action 4
MONITORING, CONTAINMENT, CONTROL AND ERADICATION

Aim & Objectives.

Improve the management framework providing administrative agencies and stakeholders with best tools for appropriate monitoring and actions to mitigate impacts of established IAF.

- Develop lists of established IAF and priority action sites, as up-to-date and dynamic as possible, with practical guidelines on how to improve management actions.
- Evaluate costs associated with IAF management projects (containment/control/eradication) using both cost benefit and cost effectiveness analyses.
- Engage relevant stakeholders in monitoring and management actions.

Recommended actions.

4.1 Updating lists of priority established IAF to contain, control or eradicate (e.g. **black list**) following the **transnational agreed listing system** (action 3.3) (BOX 6) that contemplates the space-time context necessary to mitigate impacts (e.g. extension of the invaded area) and increase the success of management actions at the population level.

4.2 Establishing **a network of transnational focal sites for management actions** on priority IAF populations, based on potential spread, degree of disturbance, feasibility, and success of measures.

4.3 Implement management **pilot projects in transnational focal sites**, with coordinated aims, appropriate arrangements and if possible with **high visibility** (action 7.3).

4.4 Maximise the **contribution of relevant stakeholders** (e.g. recreational and commercial fishing associations, aquaculture associations) to monitoring and management actions. For instance, extending responsibility to prevent and control spread of IAF (e.g. notification of listed IAF on holdings, farms, and fishing grounds) with backed by incentives.

4.5 **Gathering information on priority IAF containment/control/eradication techniques** to enable site-specific assessments of the type of management to be carried out quickly and efficiently.

4.6 Use of **humane dispatch methods for control and eradication**, which should be dependent on species, habitat, fish numbers and enforcing agent. **Designing or adopting protocols** in concordance with animals' welfare European regulation[8]. Communication plans should ensure public understanding of the need to euthanize IAF.

4.7 Environmental agencies should require **rapid risk assessments of IAF spreading in projects for the construction of canals and water transfers**, especially those connecting watersheds. This should be requested for projects related to water pumping and irrigation systems, or downstream dredging.

4.8 Require adequate **monitoring of results in IAF containment/control/eradication projects.** This should serve both to adaptive management plans against non-containment or re-colonization, and to transfer lessons learned to new projects.

4.9 Provide funding for research (action 6.4) and development **of novel containment/control/eradication methods** (e.g. pilot projects of genetic control, containment devices, and efficient humane dispatching methods).

8. Smith K.G., Nunes A.L., Aegerter J., Baker S.E., Di Silvestre I., Ferreira C.C., Griffith M., Lane J., Muir A., Binding S., Broadway M., Robertson, P., Scalera R., Adriaens T., Åhlén P.A., Aliaga A., Baert K., Bakaloudis D.E., Bertolino S., Briggs L., Cartuyvels E., Dahl F., D'hondt B., Eckert M., Gethöffer F., Gojdičová E., Huysentruyt F., Jelić D., Lešová A., Lužnik M., Moreno, L., Nagy, G., Poledník L., Preda C., Skorupski J., Telnov D., Trichkova T., Verreycken H. and Vucić M. 2022. *A manual for the management of vertebrate invasive alien species of Union concern, incorporating animal welfare*. 1st Edition. Technical report prepared for the European Commission within the framework of the contract no. 07.027746/2019/812504/SER/ENV.D.2.

BOX 7. Several criteria for eradication actions.

The is the complete removal of all individuals in a population of an alien species. When carried out successfully, it is more cost-effective than other management actions (i.e. control, containment, do-nothing).

CONDITIONS FOR ERADICATION

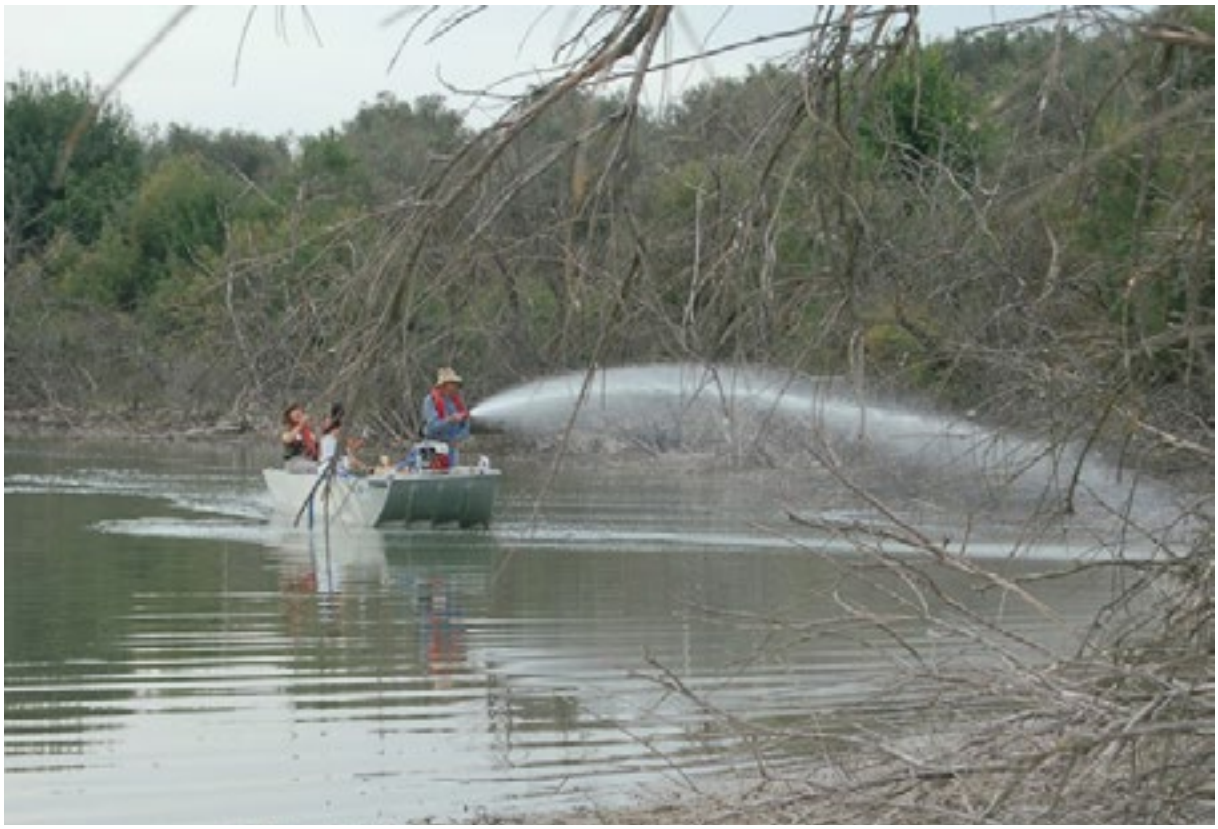
- There are adequate public support, sufficient funding and political commitment.
- The eradication is logistically feasible. Feasibility should be assessed on the basis of relevant biological characteristics of the target IAF, its ecological relationship with the invaded area and socio-economic considerations.

PRIORITY SPECIES FOR ERADICATION

- Newly-arrived alien fish, especially if non-reversible effects are predicted.
- Species representing a major threat to biodiversity.
- Species already established, but whose effects on invaded ecosystems are reversible.
- Species for which eradication is most feasible.

DESIGN OF ERADICATION ACTIONS

- Consider impacts, reversibility of effects and risk of re-invasion of the management area.
- A pilot eradication project can be designed to collect information for the assessment (e.g. risk for non-target species and ways to minimise it), determine the chances of success and address worst case scenarios.
- Select eradication methods primarily on the basis of their efficiency (e.g. methods should be adequate to remove all individuals in the population, methods should reduce population size below the threshold of future viability).
- Methods should be as selective, ethical and humane as possible and comply with applicable regulations (e.g. animal welfare).
- Monitor effort, costs and results to allow for corrections and identify means to prevent future re-invasions.



Carp eradication program with rotenone in the Zoñar lagoon (Spain). C. Fernández-Delgado.

Line of Action 5
ENVIRONMENTAL RESTORATION AND HABITAT MANAGEMENT

Aim & Objectives.

Develop methods for the restoration and rehabilitation of aquatic and riverine habitats that prevent introduction, spread and establishment of IAF and support recovery of the conservation status of invaded areas.

- National policies and strategies for the restoration/rehabilitation of aquatic ecosystems[9] need to take account of invasion risk of IAF and promote ecologically sound practices to minimise their introduction, spread and establishment, reducing the invasibility of ecosystems, and also to remedy their impacts.
- Adequate monitoring of the results of restoration/rehabilitation projects. This should serve both to design adaptive management and to transfer lessons learned, thereby increasing the effectiveness of restoration in the face of new invasions.

Recommended actions.

5.1. Develop integrative and comprehensive **protocols for the diagnosis of the level of impacts of IAF** on biodiversity and ecosystem services **and protocols for the assessment of effectiveness of restoration/rehabilitation measures.**

5.2. **Implement integration mechanisms for stakeholders** (e.g. recreational and commercial fishing associations, aquaculture associations, irrigation associations, staff of other administrative agencies) involved in restoration/rehabilitation projects.

5.3. Encourage the development of **best-practices and codes of conduct to environmental restoration agencies, NGOs or companies** to expose the risk of restoration/rehabilitation procedures in areas invaded by IAF (e.g. inspection and cleaning of machinery) and the need to use native taxa and local materials in projects.

5.4. **Promote adequate environmental flows and recovery of natural flow regimes** in the restoration/rehabilitation projects in fluvial ecosystems to prevent introduction, spread and establishment of IAF.

5.5. **Take account of IAF spread risk at regional level in fluvial connectivity restoration projects**, especially in those involving longitudinal barrier removals.

9. e.g. *National Strategy for River Restoration*. 2010. Ministry of the Environment and Rural and Marine Affairs. Spain.

Line of Action 6
APPLIED RESEARCH TO IMPROVE MANAGEMENT CAPACITY

Aims & Objectives.

To promote and foster scientific knowledge on IAF in order to develop tools that support institutional framework, improve forecasting, and make management more effective in inland and estuarine waters.

- Encouraging integrative, multi- and inter-disciplinary approaches in research applied to the management of IAF (e.g. biological, social, economic sciences).
- Involving academic research institutions and societies on IAS issues, and enhance the creation of collaborative networks at Iberian scale.
- Designing and proposing mechanisms that prioritize research to improve prevention and mitigation of impacts of IAF.
- Fostering innovative techniques for the eradication, control and monitoring of IAF.
- Providing regular updated species inventories at Iberian scale with information on IAS and support the integration of data into the *European Alien Species Information Network* (EASIN)[10].

Recommended actions.

6.1. Incorporating **applied research on IAF management into the scientific-technical priorities** of the national governments operational planning tools (e.g. State Plans for Scientific and Technical Research and Innovation which include funds planned schedule for R&D&I).

6.2. Promoting the development of **knowledge-exchange programmes** on IAF between research institutions and scientific societies including **collaborative networks** (e.g. *InvaNET*) with managers **to develop pilot studies** to improve control and eradication techniques.

6.3. **Technical review-reports** of the status of IAF in the Iberian Peninsula would be advisable periodically, including updated lists of species, occurrence and distribution maps, and scientific-based guidance on management methods.

6.4. **Directing existing research resources**, both national and regional, towards applied approaches addressing priority topics on IAF management (BOX 8). This will be a dynamic process, and will follow updates in data and knowledge.

BOX 8. Examples of research priorities

- Risk analysis to assess species and identify management tools to prevent and reduce their entry and dispersal through specific pathways and vectors (e.g. aquarium trade, water transfers, canalization).
- Models to predict the distribution and spread of target IAF (e.g. distribution models based on species occurrences and environmental variables, including for instance climate projections).
- Effective techniques to detect newly introduced IAF (e.g. environmental DNA).
- New mechanical, chemical and biological approaches in population control and eradication (e.g. biocontrol, genetic control, species-specific toxins, pheromones traps and diseases), to be integrated and combined in management protocols.
- Development of physical and non-physical behavioural barriers for selective fish passage (i.e. allowing passage of native while blocking alien fish) under fluvial connectivity.
- Assessment of the IAF impacts on biodiversity, economy, and public health, as well as their implications for human well-being and society.
- Evaluate and prioritise mitigation measures according to feasibility, effectiveness and cost-benefit.

10. European Commission - Joint Research Centre - European Alien Species Information Network (EASIN).

Line of Action 7
ENGAGEMENT OF STAKEHOLDERS AND AWARENESS OF THE GENERAL PUBLIC

Aims & Objectives.

Build public awareness and commitment of key stakeholders for making IAF a priority issue, leading to greater support of on-going actions and pro-active participation in the solutions.

Identifying the main interests and roles of key stakeholders (e.g. aquaculture associations, recreational and commercial fishing associations, aquarium associations and trade) (BOX 3) to engage them in shared solutions linked to the IAF-TAP (e.g. adoption of best-practices and codes of conduct).
Developing awareness-raising, environmental education, and information campaigns to gain the general support of different audiences, incorporating communication methods that avoid contradictions (e.g. making information easily understandable, and widely accessiblein several languages).

Recommended actions.

7.1. Develop **raise-awareness campaigns directed to key stakeholders** of the aquarium, aquaculture and recreational fishing sectors. Develop partnerships with stakeholders to disseminate information and to implement the use of **best-practices and codes of conduct in the aquarium shops and trade, in the aquaculture facilities, and in the recreational fishing** (action 2.6).

7.2. Implement **raise-awareness campaigns to education and communication groups**. Manuals of best-practices for knowledge multipliers (e.g. museums, aquariums), environmental educators, and environmental journalists, among other groups, are useful tools.

7.3. Use **appropriate pilot management projects on IAF** (action 6.2) **with high visibility** as a basis for raising public awareness, validating investment in specific measures, and building capacity through *learning by doing*.

7.4. Develop and implement **multidisciplinary approaches to prevent and minimise social conflicts** (e.g. with recreational and professional fishermen) so that social support for IAF management is not deteriorated.

7.5. **Enhance the use of citizen science applications** (e.g. *Invasive Alien Species in Europe* App) to informon IAF and to raise awareness in invaded, and severely impacted areas.

7.6. Establish **co-management committees in areas invaded by IAF** where there are associated socio-economic activities, to reach agreements involving stakeholders. For instance, professional fishermen should be involved in the management of target IAF by establishing trade-offs between sustainable exploitation and containment specific measures.

Eastern mosquitofish (*Gambusia holbrooki*). C.González Revelles

Terminology

Administrative agencies: Governance authorities, institutions and services at national, regional or local scales.

Alien Species: Animals, plants, fungi or microorganisms introduced outside their natural ranges; it includes any part, gametes, seeds, eggs or propagules of such species, as well as any hybrids, varieties or breeds that might survive and subsequently reproduce (Regulation (EU) No 1143/2014). Common synonyms for alien species are: exotic, introduced, non-indigenous, or non-native species.

Containment: Actions aiming to limit spread and restrict alien species within regional barriers in a defined area. This action is particularly appropriate where the range of the introduced population is small enough to achieve a significant result. This should be considered a high priority action for IAS that could spread through cross-border areas and- into ecologically vulnerable areas.

Control: Actions aiming to reduce the density and abundance of an alien species population to keep its impact below an acceptable threshold. Effective control should be considered on the basis of cost/benefit analysis and may be achieved through a range of integrated management techniques (e.g. mechanical, chemical and biological).

Early warning and rapid response (EWRR): A framework designed to respond to biological invasions through a coordinated system of surveillance and monitoring actions; diagnosis and assessment of risks; circulation of information; and enforcement of appropriate responses.

Eradication: Complete removal of all individuals of a population of an alien species. Eradication is considered to be feasible in the early stages of invasion when populations are small and localised, and only in areas of manageable size (e.g. small water bodies, isolated small streams,) which should be priority areas for this action.

Invasive Alien Species (IAS): Alien species whose introduction or spread has been found to threaten or adversely impact upon biodiversity and ecosystem services (Regulation (EU) No 1143/2014).

Mitigation: Management actions related to eradication, containment and control of introduced and established alien species.

Potential taxa: Alien taxa not yet present in a territory but already present in transport or introduction invasion stage, or taxa occurring in nearby territories, with a high risk of invasion.

Prevention: Measures that will reduce the risk of arrival and establishment of alien species due to human assisted transport.

Rapid response: Management measures to tackle the potential impacts of alien species and invasive alien species that are implemented within a short period of time.

Risk assessment: Evaluation of the likelihood of introduction, establishment or spread of an alien species/taxon in a given territory, and of the associated potential biological and economic consequences, taking into account possible management options. Risk assessment includes **risk analysis** (process of evaluating biological or other scientific and economic evidence to determine whether an alien species will become invasive) and **risk management** (evaluation and selection of options to reduce the risk of introduction, establishment and spread of an invasive alien species).

Stakeholders: Individuals, groups and organizations that are actively involved in IAS issues or whose interests may be affected by IAS management.

Transnational Action Plan: A plan that addresses priority issues in a coordinated way and promotes Spanish-Portuguese approaches to shared problems. This must develop common frameworks between Spain and Portugal administrative agencies which consider possible management strategies contingent on the species that have or may be introduced or spread in inland and estuarine waters in the Iberian Peninsula. It is recommended that this plan specify the nature of the actions to be implemented, the timeframe, the key groups involved, the costs, and the funding sources.

Transnational strategies/programmes: Spanish-Portuguese strategies and programmes developed and implemented in a coordinated way.

Carp fish (*Cyprinus carpio*). R. Moran. SIBIC

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Appendix A

Alien fish registered in the *List of Aquatic Alien Species of the Iberian Peninsula*[11].

Updated list of introduced fish that have been recorded in the Iberian inland waters where they maintain wild and self-sustaining populations (status = established) or are not clearly established or naturalised (status = uncertain).

Scientific name	Family	Status	Black List[12]
Abramis brama (Linnaeus, 1758)	Cyprinidae	Established	
Acipenser baerii Brandt, 1869	Acipenseridae	Uncertain	Yes
Acipenser naccarii Bonaparte, 1836	Acipenseridae	Uncertain	
Alburnus alburnus (Linnaeus, 1758)	Cyprinidae	Established	Yes
Ameiurus melas (Rafinesque, 1820)	Ictaluridae	Established	Yes
Aphanius fasciatus (Valenciennes, 1821)	Cyprinodontidae	Uncertain	
Australoheros facetus (Jenyns, 1842)	Cichlidae	Established	
Barbatula barbatula (Linnaeus, 1758)	Nemacheilidae	Established	
Blicca bjoerkna (Linnaeus, 1758)	Cyprinidae	Established	Yes
Carassius auratus (Linnaeus, 1758)	Cyprinidae	Established	Yes
Carassius gibelio (Bloch, 1782)	Cyprinidae	Established	
Cobitis bilineata Canestrini, 1865	Cobitidae	Established	
Cynoscion regalis (Bloch & Schneider, 1801)	Sciaenidae	Established	
Cyprinus carpio Linnaeus, 1758	Cyprinidae	Established	Yes
Esox lucius Linnaeus, 1758	Esocidae	Established	Yes
Fundulus heteroclitus (Linnaeus, 1766)	Fundulidae	Established	Yes
Gambusia holbrooki Girard, 1859	Poeciliidae	Established	Yes
Gobio occitaniae Kottelat & Persat, 2005	Cyprinidae	Established	
Hucho hucho (Linnaeus, 1758)	Salmonidae	Uncertain	
Ictalurus punctatus (Rafinesque, 1818)	Ictaluridae	Established	Yes
Lepomis gibbosus (Linnaeus, 1758)	Centrarchidae	Established	Yes
Leuciscus aspius (Linnaeus, 1758)	Cyprinidae	Established	
Leuciscus idus (Linnaeus, 1758)	Cyprinidae	Uncertain	Yes
Micropterus salmoides (Lacepède, 1802)	Centrarchidae	Established	Yes
Misgurnus anguillicaudatus (Cantor, 1842)	Cobitidae	Established	Yes
Oncorhynchus aguabonita (Jordan, 1892)	Salmonidae	Uncertain	

11. Oliva-Paterna F.J., Ribeiro F., Miranda R., Anastácio P.M., García-Murillo P., Cobo F., Gallardo B., García-Berthou E., Boix D., Medina L., Morcillo F., Oscoz J., Guillén A., Arias A., Cuesta J.A., Aguiar F., Almeida D., Ayres C., Banha F., Barca S., Biurrun I., Cabezas M.P., Calero S., Campos J.A., Capdevila-Argüelles L., Capinha C., Carapeto A., Casals F., Chainho P., Cirujano S., Clavero M., Del Toro V., Encarnação J.P., Fernández-Delgado C., Franco J., García-Meseguer A.J., Guareschi S., Guerrero A., Hermoso V., Machordom A., Martelo J., Mellado-Díaz A., Moreno J.C., Oficialdegui F.J., Olivo del Amo R., Otero J.C., Perdices A., Pou-Rovira Q., Rodríguez-Merino A., Ros M., Sánchez-Gullón E., Sánchez M.I., Sánchez-Fernández D., Sánchez-González J.R., Soriano O., Teodósio M.A., Torralva M., Vieira-Lanero R., Zamora-López A. and Zamora-Marín J.M. 2021. *List of Aquatic Alien Species of the Iberian Peninsula (2020)*. Updated list of the aquatic alien species introduced and established in Iberian inland waters. Technical Report prepared by LIFE INVASAQUA (LIFE17 GIE/ES/000515).

12. Oliva-Paterna F.J., Oficialdegui F.J., Anastácio P.M., García-Murillo P., Zamora-Marín J.M., Ribeiro F., Miranda R., Cobo F., Gallardo B., García-Berthou E., Boix D., Medina L., Arias A., Cuesta J.A., Almeida D., Banha F., Barca S., Biurrun I., Cabezas M.P., Calero S., Campos J.A., Capdevila-Argüelles L., Capinha C., Casals F., Clavero M., Encarnação J.P., Fernández-Delgado C., Franco J., Guareschi S., Guillén A., Hermoso V., López-Cañizares C., Machordom A., Martelo J., Mellado-Díaz A., Morcillo F., Olivo del Amo R., Oscoz J., Perdices A., Pou-Rovira Q., Rodríguez-Merino A., Ros M., Ruiz-Navarro A., Sánchez-Gullón E., Sánchez M.I., Sánchez-Fernández D., Sánchez-González J.R., Teodósio M.A., Torralva M., Vieira-Lanero R. 2022. *Black list and Alert list of the Aquatic Invasive Alien Species of the Iberian Peninsula*. Horizon scanning exercise focused on the high-risk aquatic invasive alien species for the Iberian inland waters. Technical Report prepared by LIFE INVASAQUA (LIFE17 GIE/ES/000515).

Scientific name	Family	Status	Black List
Oncorhynchus kisutch (Walbaum, 1792)	Salmonidae	Established	
Oncorhynchus mykiss (Walbaum, 1792)	Salmonidae	Uncertain	Yes
Paramisgurnus dabryanus Dabry de Thiersant, 1872	Cobitidae	Established	
Perca fluviatilis Linnaeus, 1758	Percidae	Established	Yes
Phoxinus septimaniae Kottelat, 2007	Cyprinidae	Established	
Phoxinus sp1 Hermann, 1804	Cyprinidae	Uncertain	
Poecilia reticulata Peters, 1859	Poeciliidae	Established	
Pseudorasbora parva (Temminck & Schlegel, 1846)	Cyprinidae	Established	Yes
Rutilus rutilus (Linnaeus, 1758)	Cyprinidae	Established	Yes
Salvelinus fontinalis (Mitchill, 1814)	Salmonidae	Established	Yes
Salvelinus umbla (Linnaeus, 1758)	Salmonidae	Established	
Sander lucioperca (Linnaeus, 1758)	Percidae	Established	Yes
Scardinius erythrophthalmus (Linnaeus, 1758)	Cyprinidae	Established	Yes
Silurus glanis Linnaeus, 1758	Siluridae	Established	Yes
Tinca tinca (Linnaeus, 1758)	Cyprinidae	Established	
Xiphophorus maculatus (Günther, 1866)	Poeciliidae	Established	

Appendix B

Alien fish registered in the *List of Potential Aquatic Alien Species of the Iberian Peninsula*[13]**.**

Updated list of invasive alien fish that have not yet recorded in the Iberian inland waters but with high risk of invasion in those aquatic systems (status = potential).

Scientific name	Family	Status	Alert List
Alburnoides bipunctatus (Bloch, 1782)	Cyprinidae	Potential	
Ameiurus catus (Linnaeus, 1758)	Ictaluridae	Potential	
Ameiurus nebulosus (Lesueur, 1819)	Ictaluridae	Potential	Yes
Astronotus ocellatus (Agassiz, 1831)	Cichlidae	Potential	
Babka gymnotrachelus (Kessler, 1857)	Gobiidae	Potential	
Barbonymus schwanenfeldii (Bleeker, 1853)	Cyprinidae	Potential	
Barbus barbus (Linnaeus, 1758)	Cyprinidae	Potential	
Benthophilus nudus Berg, 1898	Gobidae	Potential	
Carassius carassius (Linnaeus, 1758)	Cyprinidae	Potential	Yes
Catostomus commersonii (Lacepède, 1803)	Catostomidae	Potential	
Channa argus (Cantor, 1842)	Channidae	Potential	
Channa panaw Musikasinthorn, 1998	Channidae	Potential	
Chondrostoma nasus (Linnaeus, 1758)	Cyprinidae	Potential	
Chrosomus eos Cope, 1861	Cyprinidae	Potential	
Clarias batrachus (Linnaeus, 1758)	Clariidae	Potential	Yes
Clarias gariepinus (Burchell, 1822)	Clariidae	Potential	Yes
Coptodon zillii (Gervais, 1848)	Cichlidae	Potential	Yes
Coregonus nasus (Pallas, 1776)	Salmonidae	Potential	
Ctenopharyngodon idella (Valenciennes, 1844)	Cyprinidae	Potential	Yes
Culaea inconstans (Kirtland, 1840)	Gasterosteidae	Potential	
Cynoglossus sinusarabici (Chabanaud, 1931)	Cynoglossidae	Potential	
Cyprinella lutrensis (Baird & Girard, 1853)	Cyprinidae	Potential	
Decapterus russelli (Rüppell, 1830)	Carangidae	Potential	
Gambusia affinis (Baird & Girard, 1853)	Poeciliidae	Potential	Yes
Gobio alverniae Kottelat & Persat, 2005	Cyprinidae	Potential	
Gobio gobio (Linnaeus, 1758)	Cyprinidae	Potential	
Gymnocephalus cernuus (Linnaeus, 1758)	Percidae	Potential	
Hemichromis fasciatus Peters, 1857	Cichlidae	Potential	Yes
Hemichromis letourneauxi Sauvage, 1880	Cichlidae	Potential	
Hypophthalmichthys molitrix (Valenciennes, 1844)	Cyprinidae	Potential	Yes
Hypophthalmichthys nobilis (Richardson, 1845)	Cyprinidae	Potential	
Hypostomus plecostomus (Linnaeus, 1758)	Loricariidae	Potential	
Ictiobus bubalus (Rafinesque, 1818)	Catostomidae	Potential	
Ictiobus cyprinellus (Valenciennes, 1844)	Catostomidae	Potential	
Ictiobus niger (Rafinesque, 1819)	Catostomidae	Potential	
Knipowitschia longecaudata (Kessler, 1877)	Gobiidae	Potential	
Lagocephalus sceleratus (Gmelin, 1789)	Tetraodontidae	Potential	

Scientific name	Family	Status	Alert List
Lates calcarifer (Bloch, 1790)	Latidae	Potential	
Lates niloticus (Linnaeus, 1758)	Latidae	Potential	Yes
Lepisosteus spp. Lacepède, 1802	Lepisosteidae	Potential	
Lepomis cyanellus Rafinesque, 1819	Centrarchidae	Potential	Yes
Leucaspius delineatus (Heckel, 1843)	Cyprinidae	Potential	
Leuciscus leuciscus (Linnaeus, 1758)	Cyprinidae	Potential	Yes
Lota lota (Linnaeus, 1758)	Lotidae	Potential	
Megalobrama terminalis (Richardson, 1846)	Cyprinidae	Potential	
Melanochromis auratus (Boulenger 1897)	Cichlidae	Potential	
Micropercops cinctus (DabrydeThiersant, 1872)	Odontobutidae	Potential	
Micropogonias undulatus (Linnaeus, 1766)	Sciaenidae	Potential	
Micropterus dolomieu Lacepède, 1802	Centrarchidae	Potential	Yes
Misgurnus fossilis (Linnaeus, 1758)	Cobitidae	Potential	
Monopterus albus (Zuiew, 1793)	Synbranchidae	Potential	
Morone americana (Gmelin, 1789)	Moronidae	Potential	Yes
Morone chrysops (Rafinesque, 1820)	Moronidae	Potential	
Morone saxatilis (Walbaum, 1792)	Moronidae	Potential	
Mylopharyngodon piceus (Richardson, 1846)	Cyprinidae	Potential	
Neogobius fluviatilis (Pallas, 1814)	Gobiidae	Potential	
Neogobius melanostomus (Pallas, 1814)	Gobiidae	Potential	Yes
Odontesthes bonariensis (Valenciennes, 1835)	Atherinopsidae	Potential	
Oncorhynchus clarkii (Richardson, 1836)	Salmonidae	Potential	
Oncorhynchus gorbuscha (Walbaum, 1792)	Salmonidae	Potential	Yes
Oncorhynchus nerka (Walbaum, 1792)	Salmonidae	Potential	
Oreochromis aureus (Steindachner, 1864)	Cichlidae	Potential	
Oreochromis mossambicus (Peters, 1852)	Cichlidae	Potential	Yes
Oreochromis niloticus (Linnaeus, 1758)	Cichlidae	Potential	
Oryzias sinensis Chen, Uwa & Chu, 1989	Adrianichthyidae	Potential	
Osmerus mordax (Mitchill, 1814)	Osmeridae	Potential	
Pachychilon pictum (Heckel & Kner, 1858)	Cyprinidae	Potential	
Parabramis pekinensis (Basilewsky, 1855)	Cyprinidae	Potential	
Paralichthys olivaceus (Temminck & Schlegel,1846)	Paralichthyidae	Potential	
Pelmatolapia mariae (Boulenger, 1899)	Cichlidae	Potential	
Perccottus glenii Dybowski, 1877	Odontobutidae	Potential	Yes
Phoxinus phoxinus (Linnaeus, 1758)	Cyprinidae	Potential	
Piaractus brachypomus (Cuvier, 1818)	Serrasalmidae	Potential	
Pimephales promelas Rafinesque, 1820	Cyprinidae	Potential	
Planiliza haematocheila (Temminck & Schlegel, 1845)	Mugilidae	Potential	
Plotosus lineatus (Thunberg, 1787)	Plotosidae	Potential	
Ponticola gorlap (Iljin, 1949)	Gobiidae	Potential	
Ponticola kessleri (Günther, 1861)	Gobiidae	Potential	Yes
Proterorhinus marmoratus (Pallas, 1814)	Gobiidae	Potential	

Scientific name	Family	Status	Alert List
Proterorhinus semilunaris (Heckel, 1837)	Gobiidae	Potential	Yes
Pygocentrus nattereri Kner, 1858	Serrasalmidae	Potential	
Rhodeus amarus (Bloch, 1782)	Cyprinidae	Potential	Yes
Salvelinus alpinus (Linnaeus, 1758)	Salmonidae	Potential	
Salvelinus Namaycush (Walbaum, 1792)	Salmonidae	Potential	
Sander vitreus (Mitchill, 1818)	Percidae	Potential	Yes
Saurida undosquamis (Richardson, 1848)	Synodontidae	Potential	
Squalius cephalus (Linnaeus, 1758)	Cyprinidae	Potential	Yes
Umbra pygmaea (DeKay, 1842)	Umbridae	Potential	
Xiphophorus hellerii Heckel, 1848	Poeciliidae	Potential	Yes

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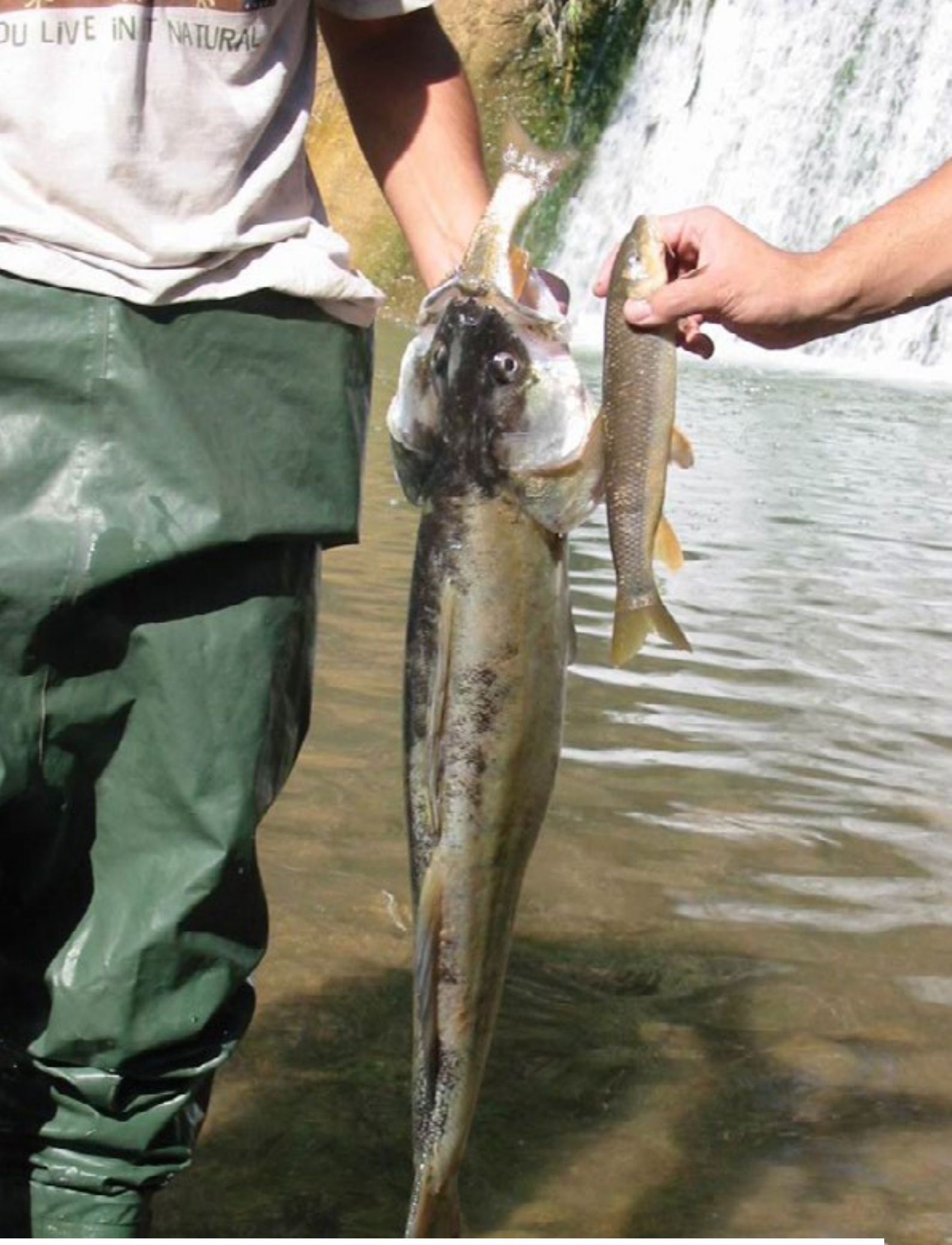
14. Oliva-Paterna F.J., Oficialdegui F.J., Anastácio P.M., García-Murillo P., Zamora-Marín J.M., Ribeiro F., Miranda R., Cobo F., Gallardo B., García-Berthou E., Boix D., Medina L., Arias A., Cuesta J.A., Almeida D., Banha F., Barca S., Biurrun I., Cabezas M.P., Calero S., Campos J.A., Capdevila-Argüelles L., Capinha C., Casals F., Clavero M., Encarnação J.P., Fernández-Delgado C., Franco J., Guareschi S., Guillén A., Hermoso V., López-Cañizares C., Machordom A., Martelo J., Mellado-Díaz A., Morcillo F., Olivo del Amo R., Oscoz J., Perdices A., Pou-Rovira Q., Rodríguez-Merino A., Ros M., Ruiz-Navarro A., Sánchez-Gullón E., Sánchez M.I., Sánchez-Fernández D., Sánchez-González J.R., Teodósio M.A., Torralva M., Vieira-Lanero R. 2022. *Black list and Alert list of the Aquatic Invasive Alien Species of the Iberian Peninsula*. Horizon scanning exercise focused on the high-risk aquatic invasive alien species for the Iberian inland waters. Technical Report prepared by LIFE INVASAQUA (LIFE17 GIE/ES/000515).



Zander (*Sander lucioperca*) and south Iberian barbel (*Luciobarbus sclateri*). F. J. Oliva SIBIC

Chameleon cichlid (*Australoheros facetus*) © CHUCAO CC-BY-SA-3.0


LIFE INVASAQUA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Abstract

An important goal of LIFE INVASAQUA is to develop tools that will improve management and increase the efficiency of the Early Warning and Rapid Response framework for Invasive Alien Species (IAS) in the Iberian Peninsula.

In coordination with the Society of Iberian Ichthyology (SIBIC), we developed a participative process with experts in order to obtain Strategic Recommendations for the transnational management of invasive alien fish in inland waters of Spain and Portugal. The recommendations promote the coordinated management between Spain and Portugal, in order to facilitate implementation of international commitments and best practices and to support development of policies and targets on invasive fish management. The recommendations were designed to serve as a guiding tool seeking to identify a strategic direction for the Spanish and Portuguese governance that is already being developed. The resulting Strategic Recommendations are important tools supporting the implementation of the IAS EU Regulation.

Ultimately, the information included can be used for achieving the target of the EU Biodiversity Strategy to 2030 for dealing with IAS, and also for implementing of other EU policies with requirements on alien species, such as the Birds and Habitats Directives, and the Marine Strategy and Water Framework Directives.

WHAT IS LIFE INVASAQUA?

A European project that seeks to tackle aquatic invasive alien species in Spain and Portugal by increasing public and stakeholder awareness. It will contribute to improve IAS management and reduce their environmental, societal, economic and health impacts through information campaigns and the exchange of successful management solutions and practices.

HOW WILL IT BE ACHIEVED?

Creating priority lists of IAS and strategic management guidelines at the Iberian level to support and facilitate the implementation of the EU Regulation. Implementing training and information campaigns with key stakeholders. Developing communication and awareness activities through volunteering campaigns, citizen science, events with students or travelling exhibits across the Iberian Peninsula.

Coordination

UNIVERSIDAD DE MURCIA

Associated beneficiaries

sibic · USC · UICN · espea · Universidad de Navarra · Universidade de Évora · MARE · EFE Verde · CSIC · mncn

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