

# Draft National Plan in favour of Migratory Diadromous Species (PNMA)

Version of 11 February 2022





## **Disclaimer**

This document is the product of collegial work by stakeholders involved in the PNMA, the content of which is not binding upon the French Authorities. It is also an intermediate production in the context of development of the PNMA.

This document does not reflect the French Authorities' position, and they cannot be held responsible for the views and information presented in the document.

This document was drafted with the help of funding from the European Union in the context of the International Year of the Salmon

# **Table of contents**

CHAPTER	1: INTRODUCTION	1
A.	GENESIS OF THE NATIONAL PLAN IN FAVOUR OF MIGRATORY DIADROMOUS SPECIES	1
В.	ECOLOGICAL, SOCIAL AND ECONOMIC ISSUES	3
C.	DURATION AND AREA OF APPLICATION OF THE PLAN	8
CHAPTER	2: SITUATION AND PROTECTION	9
A. M	IIGRATORY DIADROMOUS SPECIES: DESCRIPTION AND SYSTEMATICS	9
1.	What are migratory diadromous species?	9
2.	Systematics of France's migratory diadromous species	.11
a	Metropolitan France	. 11
b	Overseas France	. 12
В.	POPULATION STATUSES AND TRENDS	.16
C.	Knowledge gaps	.21
1.	Biology and ecology of diadromous species	.21
2.	Monitoring of abundance and characteristics of diadromous species	.23
D.	REGULATORY PROTECTION STATUS INCLUDING PROTECTION OF HABITATS	.24
1.	At international level	.31
2.	At European level	.32
3.	At national level	.33
	Tools for implementation of the Framework Water Directive (FWD) and the Marine Strategy Framework	k
	Directive (MSFD)	. 33
	Tools for implementation of the "Flora-Fauna-Habitat" Directive (FFHD)	. 33
	Other French tools contributing to protection of species	. 34
	Tools contributing to protection of species specific to Overseas France	. 38
CHAPTER	3: PRESSURES ON MIGRATORY SPECIES	40
A.	PRESSURES CONNECTED WITH QUALITY OF ENVIRONMENTS AND HABITATS	.40
a	Margins for improvement identified	. 40
b	Recent advances	. 43
В.	PRESSURES RELATING TO ECOLOGICAL CONTINUITY	.46
a	Margins for improvement identified	. 46
b	Recent advances	. 49
C.	PRESSURES RELATING TO FISHING	.51
D.	PRESSURES RELATING TO REPOPULATION OPERATIONS AND AQUACULTURE	.56
a	Fish farms	. 56
b	Transfers and repopulation	. 58
E.	Pressures relating to poaching	.60

	F.	PRESSURES RELATING TO PREDATION AND EXOTIC SPECIES	61
	a	. Metropolitan France	62
	b	. Overseas France	65
	G.	Pressures relating to diseases	67
	a	. Viruses	68
	t	. Parasites	71
	c	. Pathogenic bacteria	73
	Н.	PRESSURES RELATING TO CLIMATE CHANGE	74
	l.	SUMMARY OF PRESSURES BASED ON ISSUES IDENTIFIED	79
СНА	PTER	4: ACTIONS	82
	A.	PARTNERS AND THEIR ROLES	82
	В.	ACTIONS TO BE IMPLEMENTED.	83
	1.	Theme: Land-sea link	84
	2.	Theme: Fishing	86
	3.	Theme: Continental habitats and ecological continuity	87
	4.	Theme: Fish farming and repopulation	90
	5.	Theme: Monitoring, assessments and outlook	92
	6.	Theme: Communication, awareness-raising and training	94
	C.	SUMMARY TABLE OF PROPOSED ACTIONS AND DETAILED ACTION SHEETS	96
	1.	Summary table of proposed actions	96
	2.	Detailed Action Sheets	101
	a	. Theme: Land-sea link	103
	b	. Theme: Fishing	110
	c	. Theme: Habitats and ecological continuity	114
	c	. Theme: Fish farming and repopulation	122
	e	Theme: Monitoring, assessments and outlook	124
	f	Theme: Communication, awareness-raising and training	130
	D.	TIMETABLE FOR IMPLEMENTATION OF THE PLAN AND FINANCIAL ESTIMATE	138
СНА	PTER	5: GOVERNANCE, MONITORING AND ASSESSMENT	139
	A.	THE STEERING COMMITTEE	141
	1.	Missions	141
	2.	Composition	141
	В.	INVOLVEMENT OF EXPERTS	143
	1.	Missions	143
	2.	Composition	143
	C.	THEMATIC GROUPS	143
	D.	MONITORING AND ASSESSMENT	144

1.	Impact indicators	144
2.	Annual Reviews	145
3.	Midterm Assessment	145
4.	Final Assessment	145
	Technical and Financial Review drawn up by the Technical Operator	145
	Assessment by an external body	146
INDEX OF	ABBREVIATIONS AND ACRONYMS	147
LIST OF F	IGURES	150
LIST OF T	ABLES	150
RIRLINGE	RAPHY	152
BIBLIOGR	METIT	132
APPENDI	X 1: LIST OF PLANNING DOCUMENTS DEALING WITH DIADROMOUS SPECIES IN FR	ANCE 169
A.	AT NATIONAL LEVEL	169
В.	AT LOCAL LEVEL	169
Ass	essments of Migratory Fish Management Plans (PLAGEPOMIs) by Migratory Fish I	Management
Committees	(COGEPOMIs)	169
Mig	ratory fish Management Plans (PLAGEPOMIs)	170
Sea	Basin Strategy Documents (DSFs)	170
Wa	ter Development and Management Master Plans (SDAGEs)	170
APPENDI	X 2: LEGAL PROTECTION STATUS INCLUDING PROTECTION OF HABITATS	172
A.	International	172
В.	AT EUROPEAN LEVEL	174
1.	European Directives	174
2.	European regulations	177
C.	AT NATIONAL LEVEL	177
1.	French laws	177
2.	The Environmental Code	178
	MANAGEMENT OF MIGRATORY DIADROMOUS SPECIES	178
	WATERCOURSES	179
3.	National Orders	180
4.	National Strategies	181

# **CHAPTER 1: INTRODUCTION**

# A. GENESIS OF THE NATIONAL PLAN IN FAVOUR OF MIGRATORY DIADROMOUS Species

Watercourses in Metropolitan and Overseas France are frequented by several migratory diadromous species that live alternately in fresh water and salt water in order to complete their lifecycle. Their special lifecycles require them to migrate in order to make successive use of various different habitats (sea, estuaries, rivers, etc.). Metropolitan France hosts 12 species of migratory diadromous fish, including such emblematic species as the Atlantic salmon (*Salmo salar*) and the European eel (*Anguilla anguilla*). On Overseas French islands, most freshwater fish are diadromous, and they also host several species of diadromous macrocrustaceans, including "ouassous" (shrimps of the genus *Macrobrachium*). In the French West Indies, fish species include the Martinique-bachling (*Anablepsoides cryptocallus*), which is an endemic species, the Mozambique eel (*Anguilla mossambica*) and the short-finned eel (*Anguilla bicolor*). In French Guiana, 15 of the 400 and more fish species identified are considered to be diadromous.

Diadromous species are of major ecological, (cultural and natural) heritage and economic importance, and their presence is essential to maintenance of proper balance and functionality of aquatic environments. They can be thought of as "umbrella" species, as by protecting them we also conserve habitats suited to other species. They are also "crossroad" species, bearing witness to good water status, an objective of the Framework Water Directive (FWD) and the Marine Strategy Framework Directive (MSFD) alike.

Once abundant, most populations of migratory diadromous species are currently regarded as threatened. Since the 20<sup>th</sup> century, there has been a major decline in Metropolitan French species, which are now included on the Red List issued by the International Union for Conservation of Nature (IUCN) for Metropolitan France as "vulnerable" or "endangered, and, for the allis shad, European eel and European sturgeon, "critically endangered" (UICN Comité français et al., 2019).

Large-scale actions in favour of diadromous fish began in the 1970s with the first "Salmon Plan" adopted in France in 1976. Such actions focusing on the Atlantic salmon, an emblematic animal whose

behaviour reveals deficiencies in watercourses, spurred a process aiming to repopulate rivers with large migratory species, which was continued and extended to all Metropolitan French diadromous species by the "Migrator Plans" adopted in 1981 and 1986 (five-year plans). These plans encompassed shad, lampreys and the European eel. In 1994, Decree no.94-157 of 16 February 1994, known as the "décret amphihalin" (Diadromous Decree), established the basic principles governing management of diadromous fish species. However, the Decree did not cover the flounder, the thin-lipped grey mullet, the smelt, or Overseas France's diadromous species. Nor was the European sturgeon included, as the Decree targeted "fishing of migratory species", although fishing this particular species had already been prohibited at national level since 1982. The Decree provided for creation of a Comité de gestion des poissons migrateurs (COGEPOMI - Migratory Fish Management Committee) for each large drainage basin, responsible for drawing up Plans de gestion des poissons migrateurs (PLAGEPOMIs – Migratory Fish Management Plans). In 2010, a Stratégie nationale pour la gestion des poissons migrateurs (STRANAPOMI – National Migratory Fish Management Strategy) was published by the Ministry of Ecology and Sustainable Development. It enabled exchanges between professional and amateur fishermen, hydro-electricians, nature conservation associations and public bodies. It established the framework for protecting these species and its guidelines were intended to be expressed in concrete measures, drawing on PLAGEPOMIs and Schémas directeurs d'aménagement et de gestion de l'eau (SDAGEs – Water Development and Management Master Plans).

The Plan national en faveur des migrateurs amphihalins (PNMA – National Plan in favour of Migratory Diadromous Species) is intended to complement existing tools: PLAGEPOMIs, SDAGEs, DSFs, etc. With no limitations on its scope, it aims to increase mobilisation and cooperation of actors with access to levers for action, and facilitate their actions on behalf of sustainable management and long-term conservation of migratory diadromous species. By taking account of Metropolitan France's 12 migratory diadromous species and all such species in Overseas France, the PNMA is fully in line with the 2018 Biodiversity Plan, pooling human and financial resources on a multispecies National Action Plan (NAP) model and facilitating implementation of efficient operational actions. As the European sturgeon is already the subject of a NAP and the eel of a National Management Plan (Plan de Gestion Anguille – PGA ), this Plan focuses on the other species concerned while drawing on the results of plans underway, in particular the "Salmon Plan" (a French plan covering the emblematic species and implementing NASCO's 2019-2024 recommendations), whose actions will benefit all species .

The PNMA also draws on other existing action plans that affect migratory diadromous species' situation, including the Plan d'action pour une politique apaisée de restauration de la continuité écologique

(PARPARCE – Action Plan for a Conciliatory Policy on Restoration of Ecological Continuity (2018) and the Plan de progrès pour la pisciculture (PPP – Fish-farming Progress Plan (2015).

Its drafting benefited from the impetus of work preparatory to the future Stratégie nationale pour la biodiversité (SNB – National Biodiversity Strategy). As an operational expression of this strategy over the next 10 years, the PNMA's objective is to bring about far-reaching changes in society with a view to reducing pressures on biodiversity in France and restoring ecosystems and ecosystemic services, while highlighting the ways in which biodiversity benefits humankind and society. Hence, implementation of the various actions adopted will be based on appropriate case-by-case cost-benefit analyses.

# B. ECOLOGICAL, SOCIAL AND ECONOMIC ISSUES

Like water itself (Petit, 2017), aquatic biological resources have always been of key importance to humankind; provided by nature and its ecosystems, they contributed to territorial economic development and gradually became natural capital requiring preservation as the effects of human beings' activity on their environment became increasingly evident. Humankind and society have gradually become aware of the intrinsic value of living things, above and beyond the many benefits provided by nature and essential to human life, which we now refer to as ecosystemic services (FAO, 2021; MEA, 2005; IPBES, 2019; MAES, 2020; EFESE, 2020). Consequently, models of governance and management of "biological resources" need to evolve.

Water, fauna and flora are now regarded as common natural heritage. The notion of "common heritage", along with "environmental legacy" (Hoffmann, 1996), incorporates connection with the long term and implies transmission over the course of time. Acknowledgment that there is a legacy to be passed on to future generations, whether it is tangible or intangible, inert or living, is the key principle underlying patrimonialisation (Barbe et al., 2012; Bouisset & Degrémont, 2013; Veschambre, 2007). As regards biological resources, this environmental legacy is indisputably passed down by conservation and preservation (Belaidi & Euzen, 2009).

Hence, resources can be exploited, but sustainably so for future generations; consequently sustainable use of resources and their protection are indissociable (Belaidi & Euzen, 2009). Finally, this common heritage, whether "natural" or "ecological", cannot be divided up in accordance with regions and borders established by humankind (Belaidi & Euzen, 2009). These have no biological or ecological meaning, even less so for mobile, migratory species. Management must be on greater or lesser scales,

depending on species and their population dynamics,. On a "small scale" such as a drainage basin, management in mixed transition areas and immediate coastal waters involves specific forms of mobilisation of the various actors and regulations. The environment, ecology and conservation of species cannot be addressed in compartmentalised or fragmented fashion, and management of this common natural heritage requires a collective approach, which would seem to be "the only sure way of reconciling the many expectations of all users with the regulatory requirements and financial capacities locally available over the medium and long term." (Germaine & Barraud, 2013).

Many migratory fish species have become emblematic over the course of history, due to the various ways they are made use of, above all for human consumption and recreational and sports fishing. We can cite a number of examples illustrating their economic importance in Metropolitan and Overseas France.

In the early 20th century, sturgeon fishing and caviar production were a major industry, while at the beginning of the 21st century, the eel was the species with the highest market value (Briand et al., 2008; Castelnaud, 2011; Ringuet et al., 2002). In addition, at the end of the 20<sup>th</sup> century, 75% of total revenue from inshore commercial fishing in Metropolitan France came from landing diadromous fish (Boisneau & Mennesson-Boisneau, 2001; Champion & Perraudeau, 1999). On Overseas French islands, fishing for the postlarvae and alevins of amphidromous fish from the Gobiidae and Eleotridae families – known as "bichique", "pissiette" or "titiri" depending on geographical region (Indian Ocean or French West Indies) – has the greatest economic value in addition to its traditional importance. Massively fished during their upstream migration, these fish were a major source of income for fishermen, of food for populations and of bonding between people over the course of the history of these island territories. In Guadeloupe, for example, the titiri acted as currency for trade between the riverside dwellers who caught them and the mountain dwellers who grew yams; even today, titiri fishing still provides opportunities for bonding and exchanges between individuals, as traditionally it is a collective affair (Glandor, 2019). Finally, this species is emblematic of these islands' festive and cultural occasions insofar as the time of year in which postlarvae migrate upstream, which is consequently the fishing season, corresponds to the festive season. In addition, despite the decline in numbers over the last few years, the species is still very much sought after and selling prices have increased sharply, leading it to be nicknamed "grey gold" and "péi caviar", while the European eel's alevins, known as elvers, are nicknamed "white gold". As it is becoming increasingly scarce, this latter resource is now sold at very high prices and is the subject of widespread illegal trafficking. Historically, major consumption was a culinary tradition typical of the southwest of France and the Iberian peninsula in the 1950s and 1960s. Over the last few decades, stock depletion and management plans have directly modified the socioeconomic fabric of the basins concerned by such fisheries (Danto, 2018). They revealed the existence of a fragile balance between ecosystem preservation and maintenance of local socioeconomic ties, highlighting the need for sustainable management of these different issues (Danto, 2018).

With regard to recreational fishing, there is considerable interest in diadromous fish and macrocrustaceans. Consequently, there are significant economic and cultural aspects to such activities. Salmonids, for example, are especially popular right across the world. As regards the Atlantic salmon, the species is a target of recreational fishing throughout its range, making it one of the world's largest non-professional fisheries (Verspoor et al., 2007). On Overseas French islands, the most sought-after species are macrocrustaceans, crayfish in particular. In Martinique, for example, despite regulatory prohibition of fishing due to Chlordecone, river fishing continues among the island's inhabitants (Morandi et al., 2015). It is justified by a determination to maintain the historically strong bond between the inhabitants and their rivers, evidencing a major heritage and cultural aspect to their recreational fishing practices (Morandi et al., 2018).

In the final analysis, diadromous species not only have significant market value, they also have cultural, recreational and territorial value. Their territorial value is all the greater for the twaite shad and the allis shad, given that their market value may decrease due to depletion of the resource (Baglinière et al., 2003), but this phenomenon is not applicable to all diadromous species. These species are closely connected with the history of drainage basins and constitute a legacy or heritage characteristic of a territory and a cultural landscape (Drouineau et al., 2018).

These species evolve in hydrographic landscapes with socioeconomic and cultural histories. France has a great many large rivers and watercourses that have been developed over the centuries, first of all with mills and then, starting in and throughout the 20<sup>th</sup> century, with hydropower plants. Historically, hydropower forms part of France's landscape, and is of major past and present importance in the context of the fight against climate change (Ministère de la Transition écologique, 2021). It is France's second source of electricity production and its leading source of renewable energy. Small facilities (less than 1 MW) account for 67% of all plants but only 2% of total power. Conversely, facilities of over 10 MW are less numerous (11% of plants) but account for 91% of hydropower. The main challenge these days is ensuring the fleet's modernisation and compatibility, in particular from an environmental point of view, while also ensuring integrated implementation of ecological and energy transition policies.

Due to their major ecological, economic and cultural value, some diadromous species are regarded as "key cultural species", in other words, "culturally important species that shape a society's cultural identity to a significant extent" (Garibaldi & Turner, 2004). Owing to their sensitivity to the quality and fragmentation of their habitats, diadromous species have established themselves as natural indicators of the good ecological status of watercourses, and are even regarded as "umbrella species" (Simberloff, 1998). Protecting these species also means preserving the quality of the environment, water and habitats as well as preserving the balance of an entire biotope and a biocoenosis. Conversely, their depletion indicates degradation of the integrity and functionality of the environments they frequent, and, more generally, the malfunctioning of an entire system. One out of every five freshwater fish species in Metropolitan France is currently endangered, a proportion that increases to six species out of eleven for migratory fish species<sup>1</sup>. This being so, since operations began on "restoration" of ecosystems and, more specifically, ecological continuity of watercourses 2, migratory species have figured prominently in continental water management policies (Germaine & Barraud, 2013; Thomas & Germaine, 2018). These diadromous species are used in communications targeting elected representatives, the general public and, more broadly, all stakeholders, with a view to raising their awareness of the need for ecological restoration actions. In other words, diadromous species are emblematic of environmental policies on rivers. They belong to an entire ecosystem, and when they are at issue, the focus should be on the whole watercourse, the transition area and the marine environment. As Thomas & Germaine (2018) put it, "Behind the ambition of restoring salmon populations lies the question of the future of watercourse, thought of as socio-natural entities, and, more broadly, our uses of nature (Larrère & Larrère, 2009), which it would seem necessary to ask ourselves".

It is also what makes management and conservation of migratory diadromous species a complex subject, as it combines social, cultural, economic and ecological concerns. Moreover, these various concerns often come into conflict with each other due to their different levels. Ecological concerns generally come into play at national and even international level. On the other hand, socioeconomic concerns – which may be to do with maintenance of this or that professional activity or of territorial attractiveness – are often local realities, but may take on national significance in cases of energy production or achievement of food self-sufficiency. As Germaine & Barraud (2013) point out, for example, there is a wide variety of hydraulic works, rivers and valleys in the northwest of France, a fact that suggests

<sup>&</sup>lt;sup>1</sup> https://ofb.gouv.fr/actualites/declin-inquietant-des-poissons-migrateurs

<sup>&</sup>lt;sup>2</sup> Loi sur l'Eau et les Milieux Aquatiques (LEMA – Water and Aquatic Environment Act) no.2006-1772

account should be taken of territorial specificities, landscape trajectories and local expectations (Barraud, 2011; Germaine et al., 2012). The same holds true for the fish resource per se, as perception of its availability in particular is highly variable and depends on people's individual and collective history, which often has a cultural aspect to it, the use to which it is put and ease of access to it (Thomas & Germaine, 2018). Given the findings made at different levels as to the status of the resource, and the many past and present alerts and crises, these species and restoration of their environments must be managed comprehensively and collectively. In this respect, "ecological communication" is of key importance but is sorely lacking in some areas, in particular on small coastal streams and rivers, as such communication is often "focused on the largest basins, heirs to a history and images that no longer comply with the contemporary reality of fishery potentials" (Thomas & Germaine, 2018). However, a recent study, carried out as part of the Diode's project<sup>3</sup>, highlights the importance that small coastal watercourses can have in strategies on conservation of certain diadromous species (Copp et al., 2021).

The restoration, conservation and management of migratory species and, more broadly, the resulting ecological restoration, involve modifications, adaptations and sometimes restrictions of use of the resource, whether direct – through fishing – or indirect – via use of water, sediments, etc., and, more broadly, their habitats.

Some for these uses meet essential human needs, however: physiological need of water, food, energy, etc. In addition, fishing and water use, with the existence of hydraulic works for example, may be of great value culturally, in terms of heritage (such as the mills of bygone days), and economically in certain drainage basins (Fox et al., 2016). This illustrates the existence of a significant ecological, cultural and socioeconomic reality connected with aquatic resources. Consideration of this reality requires a balance between an anthropocentric vision – based on societal and cultural values, associated with amenities and their past and present uses, and with usually major economic aspects – and an ecocentric vision dictated by a model of idealised nature (Germaine & Barraud, 2013). Consequently, socioeconomic and ecological issues must be considered, weighted and taken account of by stakeholders and managed by the public authorities with a view to reconciling them while taking the special context of global change into consideration along with the issues connected with the ecological and energy transitions.

The DiadES (*Diadromous fish and Ecosystem Services*; <a href="https://diades.eu/">https://diades.eu/</a>) European project is overseen by INRAE and seeks to improve transnational cooperation with a view to better preserving diadromous species. The project aims to assess and reinforce the ecosystemic services provided by these species while taking account of possible changes in their geographical distribution brought about by climate change (Irstea, 2019).

# C. DURATION AND AREA OF APPLICATION OF THE PLAN

The Plan is set to last 10 years as from its approval. The objective is to produce a practical, operational and costed plan, in the context of the National Biodiversity Strategy (SNB)(2021-2031).

These ten years will enable creation of links with the PLAGEPOMIs (6-year plans), the SDAGEs, and the Sea Basin Strategy Documents (DSFs) 2028-2033.

Assessments of 2022-2027 PLAGEPOMIs will enable a midterm assessment of the Plan. PLAGEPOMIs may also integrate advances made at national level.

The French Plan's area of application covers Metropolitan France and Overseas France (Guadeloupe, Martinique, French Guiana, Reunion Island and Mayotte,).

# **CHAPTER 2: SITUATION AND PROTECTION**

## A. MIGRATORY DIADROMOUS SPECIES: DESCRIPTION AND SYSTEMATICS

#### 1. What are migratory diadromous species?

Migratory diadromous species are aquatic species (fish and macrocrustaceans) that live alternately in fresh water, in continental areas, and in salt water, in coastal areas or in the open sea. This alternation, which is essential to completion of their lifecycle, is achieved through regular predictable migrations, carried out at specific life stages, a phenomenon known as diadromy (McDowall, 1992; G. S. Myers, 1949). Three life-history strategies are defined, depending on direction of migration and location of breeding and grow-out grounds (Figure 1):

- Catadromous species spend most of their lifecycle in fresh water and migrate to the sea in order to breed there. The best-known such fish in Metropolitan and Overseas France are eels: the European eel (Anguilla anguilla) for Metropolitan France, the American eel (Anguilla rostrata) for the French West Indies, and the short-finned eel (Anguilla bicolor) for Overseas French Islands in the Indian Ocean.
- Anadromous species spend most of their lives in the sea and migrate to continental fresh waters to spawn. The most emblematic such species in Metropolitan France is the Atlantic salmon (Salmo salar).
- As for amphidromous species, their migrations between fresh water and salt water are unconnected with breeding events. This is the most widespread life strategy among all diadromous species (Augspurger et al., 2017). Freshwater amphidromy and marine amphidromy both exist: in the former, larvae migrate to a marine environment after hatching for larval growth, but return to fresh water at the alevin stage to become juveniles, then adults, and finally to breed; for marine amphidromy, the reverse is the case. Amphidromy is particularly widespread in tropical insular systems, accounting for the lifecycles of 90% of diadromous species in French Overseas islands (Abdou et al., 2015; Keith, 2003). On Overseas French Islands in the Indian Ocean (Reunion Island & Mayotte), the best-known species are *Sicyopterus lagocephalus* and *Cotylopus acutipinnis*, both known locally as the cabot

bouche ronde or "bichique" for postlarvae. In the French West Indies (Martinique & Guadeloupe), the endemic fish is the "Martinique-bachling" *Anablepsoides cryptocallus*).

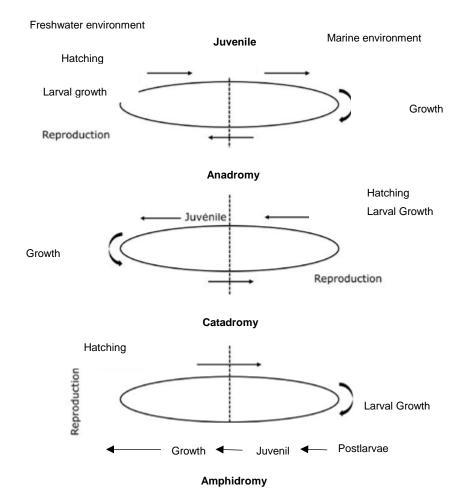


Figure 1: Schematic representation of diadromous life strategies (C. Thomas, 2017).

Migrations have highly variable natural durations depending on species, lasting from a few days to several months or even years. However, they also depend on parameters external to species, which may be biotic, abiotic or anthropic.

Migratory diadromous species are of high ecological, societal and economic importance. These heritage species are also regarded as good indicators of environment quality. However, most migratory fish populations have been seriously depleted over the last few decades. The causes of this depletion are relatively well understood these days and are essentially anthropic: disturbance and destruction of habitats (hydromorphological modifications, various forms of pollution, etc.), rupture of ecological

continuity (obstacles to migration, water and sediment retention), introduction of potentially invasive exotic species (with impacts in terms of predation, introduction of pathogenic organisms, trophic competition, etc.), poaching and overfishing. These causes are all exacerbated by climate change.

# 2. Systematics of France's migratory diadromous species

#### a. Metropolitan France

Metropolitan France hosts 12 species of migratory diadromous fish (Table 1). All these species belong to the kingdom Animalia, the phylum Chordata and the subphylum Vertebrata. It is at the infraphylum taxonomic rank that some species are distinguished from others. Such is the case with lamprey, which are agnatha, i.e. jawless fish, whereas all the others species are gnathostoma, fish with jaws. These latter also differ at family level.

Table 1: Phylogenetic classification of Metropolitan France's 12 migratory diadromous species (Species < Family < Class < Infraphylum < Subphylum). Source: World Register of Marine Species (WoRMS)

Common name	Species	Family	Class	Infraphylum	Subphylum		
European sturgeon	Acipenser sturio	Acispenseridae					
European eel	Anguilla anguilla	Anguillidae					
Thin-lipped grey mullet	Chelon ramada	Mugilidae		_ _ _ _	<del>_</del>		
Smelt	Osmerus eperlanus	Osmeridae					
Flounder	Platichthys flesus	Pleuronectidae					
Allis shad	Alosa alosa						
Atlantic-English Channel twaite shad	Alosa fallax	Clupeidae			Vertebrata		
Mediterranean twaite shad	Alosa agone	_					
Atlantic salmon	Salmo salar	Calmanida a	_				
Sea trout	Salmo trutta	<ul> <li>Salmonidae</li> </ul>					
Sea lamprey	Petromyzon marinus						
River lamprey	Lampetra fluviatilis	<ul> <li>Petromyzontidae</li> </ul>	Petromyzonti	Agnatha	/		

#### b. Overseas France

Overseas France hosts numerous species of fish and crustaceans identified as being diadromous. They are listed in Table 2 for French Guiana, in Table 3 for the French West Indies and in Table 4 for the Indian Ocean Islands. All these species belong to the kingdom Animalia, but two subphyla are represented, with Vertebrata on one side and Crustacea on the other. In addition, several fish families are to be found throughout Overseas France, including Eleotridae and Gobiidae. Finally, as regards Crustacea, the Atyidae s and Palaemonidae families have been identified in all four Overseas French Islands.

Table 2: Phylogenetic classification of French Guiana's diadromous fish (Species < Family < Class < infraphylum < Subphylum).

Common name	Species	Family	Class	Infraphylum	Subphylum
Goby	Dormitator maculatus				
Goby	Eleotris pisonis	_			
Large-scaled spinycheek sleeper	Eleotris amblyopsis	Eleotridae -			
Bigmouth sleeper	Gobiomorus dormitor	_			
-	Guavina guavina		_		
Violet goby	Awaous flavus				
-	Awaous tajasica	_	Actinopterygii	Gnathostomata	Vertebrata
Lyre goby	Evorthodus lyricus	_	7,0		
Violet goby	Gobioides broussonnetii	Gobiidae			
-	Gobioides grahamae	_			
-	Ctenogobius shufeldti	_			
Sperm goby	Ctenogobius thoropsis	_			
Atlantic tarpon	Megalops atlanticus *	Megalopidae	_		
-	Microphis lineatus	Syngnathidae	_		

<sup>\*</sup> sporadic, vicariant species (lack of knowledge on species biology)

Table 3: Phylogenetic classification of the French West Indies' diadromous fish (Species < Family < Class < infraphylum < Subphylum) and specific occurrence depending on island territory (Martinique/Guadeloupe).

Common and Creole name(s)	Species	Family	Class	Infraphylum	Subphylum	Presence	e/absence
Common and create name(s)	Species	- Continue	Ciass	ппарпушт	Suspriyidiri	Martinique	Guadeloupe
American eel, Z'anguille	Anguilla rostrata	Anguillidae				•	•
Martinique-bachling, Rivulus bleu	Anablepsoides cryptocallus§	Cyprinidae				•	
Sleeper goby, Ti-nèg	Dormitator maculatus	_				•	•
Fat sleeper, Flèche, Ptit dormè	Eleotris amblyopsis	_					•
Smallscaled spinycheek sleeper, Dormé, Pitit dormè	Eleotris perniger	Eleotridae				•	•
Bigmouth sleeper	Gobiomorus dormitor	-				•	•
Sleeper goby	Guavina guavina					•	
Padded clingfish, Macouba	Arcos (Gobiesox) nudus	Gobiesocidae	Actinopterygii	Gnathostomata	Vertebrata	•	•
River goby, Loche	Awaous banana	_				•	•
-	Ctenogobius pseudofasciatus	- Gobiidae				•	
Sirajo goby, Loche, Pissiettes (postlarvae)	Sicydium plumieri	Gobildae				•	•
Spotted alae-eating goby, Loche, Pissiettes (postlarvae)	Sicydium punctatum					•	•
Atlantic tarpon	Megalops atlanticus *	Megalopidae				•	•
Mountain mullet, Milet	Dajaus (Agonostomus) monticola	Mugilidae				•	•
Opossum pipefish, Short-tailed pipefish	Microphis lineatus*	Syngnathidae				•	•
Basket shrimp, Cacador, Bouc, Grand bouc	Atya innocous	_				•	•
Basket shrimp, Cacador, Bouc, Grand bouc	Atya scabra	_				•	•
Estuarine tiny basket shrimp, Petit bouc	Jonga serrei						•
Estuarine tiny basket shrimp, Petit bouc	Micratya poeyi	- Atyidae				•	•
Estuarine tiny basket shrimp, Petit bouc	Potimirim glabra						•
Estuarine tiny basket shrimp, Petit bouc	Potimirim potimirim	_				•	•
Cinnamon river shrimp, Chevrette, Bouquet cannelle	Macrobrachium acanthurus		Malacostraca	-	Crustacea	•	•
Big-claw river shrimp, Z'habitant	Macrobrachium carcinus					•	•
Striped river shrimp, Queue rouge, Queue de madras	Macrobrachium crenulatum	– – Palaemonidae				•	•
Caribbean longarm shrimp, Gros mordant	Macrobrachium faustinum					•	•
Cascade River prawn, Grand bras	Macrobrachium heterochirus	_				•	•
American grass shrimp, Bouquet potitinga	Palaemon pandaliformis					•	•
Yellow-nosed shrimp, Pissette	Xiphocaris elongata	Xiphocarididae				•	•

 $<sup>\</sup>hbox{* sporadic, vicariant species (lack of knowledge on species biology)}\\$ 

<sup>§</sup> endemic species

Table 4: Phylogenetic classification of diadromous fish on Overseas French Islands in the Indian Ocean (Species < Family < Class < infraphylum < Subphylum) and specific occurrence depending on Island (Reunion Island/Mayotte).

	Consider		-1			Presence/	absence
Common and Creole name(s)	Species	Family	Class	Infraphylum	Subphylum	Reunion Island	Mayotte
Indian mottled eel, Z'anguille, Z'amab	Anguilla bengalensis					•	•
Short-finned eel, Z'anguille, Z'amab,	Anguilla bicolor	- Anguillidae				•	•
Giant mottled eel, Congre, Z'anguille, Z'amab	Anguilla marmorata	Anguillidae				•	•
African longfin eel, Z'anguille, Z'amab	Anguilla mossambica	-	_			•	•
Dusky sleeper	Eleotris fusca		_			•	•
Dusky sleeper	Eleotris klunzingerii	<u>-</u>				•	•
Dusky sleeper	Butis butis	<u>-</u>				•	•
Dusky sleeper	Eleotris acanthopomus	Eleotridae				•	•
Snakehead gudgeon	Giuris margaritacea (Ophieleotris cf. aporo)	-					•
Tropical carp-gudgeon	Hypseleotris cyprinoides	="				•	•
Northern mud gudgeon, Makanbale latet ron	Ophiocara porocephala	-	_				•
Commerson's freshwater goby, Loche des sables, Loche, Cabot	Awaous commersoni		_			•	•
Common dab, Cabot de cascade (adult), Bichique (postlarvae)	Cotylopus acutipinnis <sup>§</sup>	<u>-</u>	Actinopterygii	Gnathostomata	Vertebrata	•	
Cotylope à nageoires rouges	Cotylopus rubripinnis						•
River goby	Glossogobius callidus	<u>-</u>					•
Tank goby, Loche, Gobie giurus	Glossogobius giuris	<u>-</u>				•	•
Koragu tank goby, Gobie kokou, Loche, Cabot	Glossogobius kokius⁵	Gobiidae				•	
Chequered mangrove goby, Gobi milet	Mugilogobius mertoni	-					•
Rhinohorn goby	Redigobius balteatus	_					•
Speckled goby	Redigobius bikolanus	_					•
Red-tailed goby, Cabot bouche ronde, Bichique	Sicyopterus lagocephalus	_				•	•
Chinestripe goby	Stenogobius polyzona	= 				•	•
Rock flagtail, Poisson plat, Kuhlie des rochers, Double de roche, Carpe	Kuhlia rupestris	Kulhiidae	_			•	•
Double de roche, Poisson plat	Kuhlia sauvagii					•	•

						Presence,	/absence
Common and Creole name(s)	Species	Family	Class	Infraphylum	Subphylum	Reunion Island	Mayotte
			_				
Indo-Pacific tarpon	Megalops cyprinoides*	Megalopidae	_			•	•
Comoro mullet	Agonostomus catalai	_					•
Fairy mullet, Chitte	Agonostomus telfairii	_ Mugilidae				•	•
Bluetail mullet, milé	Crenimugil buchanani (Valamugil buchanani)		_				•
Flat-nosed pipefish	Microphis argulus*	- C + h : -l				•	•
Opossum pipefish	Microphis lineatus*	- Syngnathidae				•	
Crevette bouledogue, Chevaquine	Atyoida serrata					•	•
Short-nose algae shrimp, Chevaquine	Caridina longirostris	- ^*					•
Ninja shrimp, Chevaquine, Secret tas blan	Caridina serratirostris	- Atyidae				•	•
Australian Amano shrimp, Chevaquine	Caridina typus	_				•	•
Koua river prawn, Chevrette, Grand-bras, Chevrette songe	Macrobrachium australe		_			•	•
Rough river prawn, Camaron tacheté, Kanmaron	Macrobrachium equidens	_					•
Chevrette des Mascarins, Chevrette lecroc, Bouquet malais	Macrobrachium hirtimanus⁵	_	Malacostraca	-	Crustacea	•	
Tahitian prawn, Chevrette, Camaron, Bouquet singe, Kanmaron gran lebra	Macrobrachium lar	Palaemonidae				•	•
Madagascar scale prawn, Bétangue	Macrobrachium lepidactylus	_				•	•
Mangrove prawn, Chevrette	Palaemon concinnus	_	_			•	
Sesarmid crab, Crabe de rivière	Sesarmops impressus (Sesarma impressus)	Sesarmidae	=				•
River swimming crab, Crabe d'eau douce, Crabe de rivière, Crabe lisible	Varuna litterata	Varunidae	-			•	•

<sup>\*</sup> sporadic, vicariant species (lack of knowledge on species biology) § endemic species

#### **B.** POPULATION STATUSES AND TRENDS

The IUCN Red List is a tool that uses an assessment system based on precise, stable categories and criteria<sup>4</sup>, enabling measurement and comparison of degrees of threat to species. The List, which is compiled by an expert committee whose membership is adapted in accordance with species and country, is a reference for global, national and sometimes regional assessments of population statuses. Lists are revised on a regular basis; for example, the Red List for Reunion Island was revised at the end of 7 years (2010-2017), and Metropolitan France's at the end of 9 years (2010-2019), which may result in some delay in taking account of actual population statuses.

It should be noted that the IUCN makes it clear that a change of category in the Red List may in no case be connected with a regulatory response involving suspension of activities or trade. Therefore, the tool in and of itself may not be a factor in decision-making.

Several IUCN national and regional Red Lists concerning Metropolitan France and some of Overseas French territories have recently been updated,<sup>5</sup> enabling assessments of present populations of diadromous species at territorial level (Metropolitan France: Table 5; Martinique: Table 6; Reunion Island: Table 7). When data were available and in order to provide complementary information, Table 5 also includes Metropolitan France's hydrographic basins (n=9) in which species and their generation time are to be found.

Out of the ten migratory fish species present in Metropolitan France and for which a population status could be established (flounder and smelt being excluded), five (i.e. 50%) are endangered<sup>6</sup> and there is a downward trend in the evolution of the populations of eight of them (i.e. 80%). As regards Overseas French Islands in the Indian Ocean, an IUCN Red List is only available for Reunion Island. Only 17 of the thirty or so diadromous species described on the island have had their statuses established. Out of the 17 species assessed, 12 are endangered (i.e. 71%) and one is assumed to be extinct. For the French West Indies, only the IUCN Red List for Martinique is currently available, providing information on the present

<sup>&</sup>lt;sup>4</sup>The IUCN Red List's categories and criteria (Version 3.1 Second editions): https://uicn.fr/wp-content/uploads/2016/06/UICN 2012 Categories et criteres Liste rouge.pdf

<sup>&</sup>lt;sup>5</sup> Martinique in 2020, Metropolitan France in 2019 and Reunion Island in 2017.

<sup>&</sup>lt;sup>6</sup> Vulnerable (VU), Endangered (EN) and Critically Endangered (CR) IUCN categories.

status of populations of some twenty diadromous species out of the 25 identified on the island. It was only possible to assess population evolution trends for 4 species, all classified as vulnerable or endangered, and which are currently endangered. For French Guiana, there is an IUCN Red List for vertebrate fauna (2017). Even though numerous freshwater fish are included on it, no diadromous fish are listed.

Although a decline in numbers of diadromous fish is widespread across French territory, there are still contrasts depending on countries, drainage basins and territories (Legrand et al., 2020; Merg et al., 2020). There may also be significant differences between a species' status at national and international level. For example, the Atlantic salmon has "Least Concern" (LC) status at international level, "Near Threatened" (NT) status at national level, and "Vulnerable" (VU) status for the Allier Basin; the allis shad and short-finned eel have "Least Concern" (LC) and "Near Threatened" (NT) statuses respectively on the IUCN's International Red List, while they are both "Critically Endangered (CR) on the Red Lists for Metropolitan France and Reunion Island. It is of particular importance to monitor migratory species across all their ranges in order to appreciate a species' overall situation. As pointed out by Legrand (2021), current management of diadromous fish in Metropolitan France largely focuses on drainage basins. At national level, there are also national plans for the European eel, the European sturgeon and the Atlantic salmon. A number of these species are organised into metapopulations, as populations can feed among and even support each other, requiring analyses at the level of such species' ranges (Hasselman et al., 2010; Jones, 2006; Legrand-Hoffmann, 2021; Waldman et al., 2016). Legrand (2021) provides an indicator based on the ratio between populations in good, growing and constant state, and populations in poor state, i.e. in decline. The author also suggests monitoring the ratio retrospectively in order to reconstruct a history enabling assessment of a species' susceptibility faced with the risk of extinction over time.

In parallel to actual population status, predictive studies anticipate changes in migratory fishes' continental ranges due to global change (Lassalle et al., 2008; Lassalle & Rochard, 2009). Hence, basins colonised yesterday by certain taxa, cold water species in particular, could well become unsuitable for them tomorrow. As Merg et al. (2020) state, "Historical occurrences of diadromous species should be considered as indicators of potential recovery and not as fixed lists of species strictly defining future restoration goals". For effective long-term management that is also realistic, "a compromise between preservation of biodiversity and humankind's use of natural resources must be sought" (Dudgeon et al.,

2006). Certain socioeconomic, political and usage aspects, as regards water in particular, are indissociable from aquatic biodiversity management policies.

Table 5: State and status of migratory diadromous species in Metropolitan France. Presence (+) or absence (-) in French hydrographic basins (?: occurrence not defined): Artois-Picardy (AP), Seine-Normandy (SN), Rhine-Meuse (RMs), Brittany (Br), Loire (Lo), Garonne-Dordogne (GD), Adour (Ad), Rhone-Mediterranean (RMd), Corsica (C). Classification in the IUCN France Red List's categories (Cat) (2019): Data Deficient (DD); Least Concern (LC); Near Threatened (NT); Vulnerable (VU); Endangered (EN); Critically endangered (CR). Population evolution trend (Ted): increasing (↗); stable (→); decreasing (↘); unknown (?). Sources: OFB, INRAE, MNHN, IUCN

_		Metropolitan France's hydrographic basins									Population statuses		Generation
Common name	Scientific name	R Ms	АР	SN	Br	Lo	GD	Ad	R Md	С	Cat	Ted	time (years)
European eel	Anguilla anguilla	+	+	+	+	+	+	+	+	+	CR	Я	14
Sea lamprey	Petromyzon marinus	+	+	+	+	+	+	+	+	-	EN	Я	7
River lamprey	Lampetra fluviatilis	+	+	+	+	+	+	+	-	-	VU	Я	6
Atlantic salmon	Salmo salar	+	+	+	+	+	+	+	-	-	NT	Я	3
Sea trout	Salmo trutta	+	+	+	+	+	+	+	+	+	LC	И	3
Thin-lipped grey mullet	Chelon ramada	-	+	+	+	+	+	+	+	+	LC	71	6
Flounder	Platichthys flesus	-	+	+	+	+	+	+	+	-	DD	?	3
Allis shad	Alosa alosa	+	+	+	+	+	+	+	-	-	CR	И	5
Atlantic-English Channel twaite shad	Alosa fallax	-	+	+	-	+	+	+	-	-	NT	И	4
Mediterranean twaite shad	Alosa agone	-	-	-	-	-	-	-	+	+	NT	<b>→</b>	4
European sturgeon	Acipenser sturio	-	-	-	-	-	+	-	-	-	CR	И	19
Smelt	Osmerus eperlanus	+	+	+	+	+	-	-	-	-	NT	?	3

Table 6: State and status of diadromous species in Martinique. Classification in the IUCN Martinique Red List's categories (Cat) (2020): Data Deficient (DD); Least Concern (LC); Near Threatened (NT); Vulnerable (VU); Endangered (EN); Critically endangered (CR). Population evolution trend (Ted): decreasing (\(\Delta\)); unknown (?). NM: species not mentioned on the list. Sources: OFB, INRAE, MNHN, IUCN

Species	Common and Creole name(s)	Populatio	on statuses
	common and create name(s)	Cat	Ted
Anguilla rostrata	American eel, Z'anguille	EN	R
Anablepsoides cryptocallus	Martinique-bachling, Rivulus bleu	VU	R
Dormitator maculatus	Sleeper goby, Ti-nèg	NT	?
Eleotris perniger	Smallscaled spinycheek sleeper, Dormé, Pitit dormè	LC	?
Gobiomorus dormitor	Bigmouth sleeper	LC	?
Guavina guavina	Sleeper goby	DD	?
Arcos (Gobiesox) nudus	Padded clingfish, Macouba	NT	?
Awaous banana	River goby, Loche	VU	Я
Ctenogobius pseudofasciatus	-	DD	?
Sicydium plumieri	Sirajo goby, Loche, Pissiettes (postlarvae)	LC	?
Sicydium punctatum	Spotted alae-eating goby, Loche, Pissiettes (postlarvae)	LC	?
Megalops atlanticus	Atlantic tarpon	N	IM
Dajaus (Agonostomus) monticola	Mountain mullet, Milet	LC	?
Microphis lineatus	Opossum pipefish, Short-tailed pipefish	DD	?
Atya innocous	Basket shrimp, Cacador, Bouc, Grand bouc	LC	?
Atya scabra	Basket shrimp, Cacador, Bouc, Grand bouc	LC	?
Micratya poeyi	Estuarine tiny basket shrimp, Petit bouc	LC	?
Potimirim potimirim	Estuarine tiny basket shrimp, Petit bouc	DD	?
Macrobrachium acanthurus	Cinnamon river shrimp, Chevrette, Bouquet cannelle	LC	?
Macrobrachium carcinus	Big-claw river shrimp, Z'habitant	LC	?
Macrobrachium crenulatum	Striped river shrimp, Queue rouge, Queue de madras	LC	?
Macrobrachium faustinum	Caribbean longarm shrimp, Gros mordant	LC	?
Macrobrachium heterochirus	Cascade River prawn, Grand bras	LC	?
Palaemon pandaliformis	American grass shrimp, Bouquet potitinga	VU	И
Xiphocaris elongata	Yellow-nosed shrimp, Pissette	LC	?

Table 7: Status and state of diadromous species on Reunion Island Classification in the IUCN Reunion Island Red List's categories (Cat) (2017): Data Deficient (DD); Least Concern (LC); Near Threatened (NT); Vulnerable (VU); Endangered (EN); Critically endangered (CR) NM: species not mentioned on the list. Sources: OFB, INRAE, MNHN, IUCN

Species	Common and Creole name(s)	Population statuses Cat
Anguilla bengalensis	Indian mottled eel, Z'anguille, Z'amab	NE
Anguilla bicolor	Short-finned eel, Z'anguille, Z'amab,	CR
Anguilla marmorata	Giant mottled eel, Congre, Z'anguille, Z'amab	CR
Anguilla mossambica	African longfin eel, Z'anguille, Z'amab	CR
Eleotris fusca / Eleotris klunzingerii	Dusky sleeper	LC
Butis butis	Dusky sleeper	NE
Eleotris acanthopomus	Dusky sleeper	VU
Hypseleotris cyprinoides	Tropical carp-gudgeon	NE
Awaous commersoni	Commerson's freshwater goby, Loche des sables, Loche, Cabot	VU
Cotylopus acutipinnis	Common dab, Cabot de cascade (adult), Bichique (postlarvae)	EN
Glossogobius giuris	Tank goby, Loche, Gobie giurus	NE
Glossogobius kokius	Koragu tank goby, Gobie kokou, Loche, Cabot	NE
Sicyopterus lagocephalus	Red-tailed goby, Cabot bouche ronde, Bichique	NT
Stenogobius polyzona	Chinestripe goby	NE
Kuhlia rupestris	Rock flagtail, Poisson plat, Kuhlie des rochers, Double de roche, Carpe	VU
Kuhlia sauvagii	Double de roche, Poisson plat	VU
Megalops cyprinoides	Indo-Pacific tarpon	NM
Agonostomus telfairii	Fairy mullet, Chitte	EN
Microphis argulus	Flat-nosed pipefish	NE
Microphis lineatus	Opossum pipefish	NE
Atyoida serrata	Crevette bouledogue, Chevaquine	NT
Caridina longirostris	Short-nose algae shrimp, Chevaquine	NM
Caridina serratirostris	Ninja shrimp, Chevaquine, Secret tas blan	VU
Caridina typus	Australian Amano shrimp, Chevaquine	VU
Macrobrachium australe	Koua river prawn, Chevrette, Grand-bras, Chevrette songe	NT
Macrobrachium hirtimanus	Chevrette des Mascarins, Chevrette lecroc, Chevrette gros crocs, Bouquet malais	RE?
Macrobrachium lar	Tahitian prawn, Chevrette, Camaron, Bouquet singe, Kanmaron gran lebra	VU
Macrobrachium lepidactylus	Madagascar scale prawn, Bétangue	NM
Palaemon concinnus	Mangrove prawn, Chevrette	NE
Varuna litterata	River swimming crab, Crabe d'eau douce, Crabe de rivière, Crabe lisible	NE

# C. KNOWLEDGE GAPS

### 1. Biology and ecology of diadromous species

There is a degree of heterogeneity in available data and knowledge, both as regards diadromous species themselves and France's various territories.

In Overseas France, there is a major lack of information on species' migration phases and migratory calendars, larval dispersion and marine life phases, recruitment of individuals, reproduction and behaviour in freshwater habitats. More generally, there are gaps in knowledge on diadromous species' life histories as a whole. Nor are numbers or population evolution trends known. Due to the wealth of diadromous species to be found in these hydrosystems, work on inventorying and describing species and revising their taxonomy is substantial and continually evolving, in particular with the new methods provided by molecular biology.

Creation of the most exhaustive list possible of the aquatic fauna present in these territories, along with identification of areas frequented by species, would seem essential if they are to be monitored and managed effectively (pers. com. Keith, 2021). By extension, study of the impact of anthropic activities and global change on these species, for example, is out of the question without possession of elementary data on species' biology and ecology. Hence, acquisition of such data and improvement of the present state of knowledge are essential to conservation and management of fish and macrocrustaceans in these Overseas territories. This is also a challenge given the size of the task in question. Implementation of innovative methods may help meet the challenge, but prioritisation in acquisition of knowledge will still be crucial.

In Metropolitan France, even though the state of knowledge is a good deal more advanced, a number of questions are yet to be answered, such as philopatry among sea lamprey, the impact of modifications to the trophic chain (including predation) on migratory diadromous species, partly due to invasive exotic species (IES) and the impact of contaminants. Marine causes that play a part in population dynamics are yet to be fully identified and little information is currently available on this life phase. Data on food, existence of nurseries, length of stays, the osmoregulation process, distribution and migratory patterns (routes and behaviours) is very fragmentary and heterogeneous from one species to another (Table 8; Baglinière & Acou, 2019). Individual survival rates during this key phase are not always known, and only in general terms.

Table 8: Present state of knowledge on the ecology of the marine phase of Metropolitan France's migratory diadromous species. Well-documented subject (green), partially documented (orange) or totally unknown (red). According to Baglinière & Acou (2019)

Species	Food	Duration (%)	Adaptation	Adaptation Distribution	
Salmo salar					
Salmo trutta					
Alosa alosa					
Alosa fallax					
Acipenser sturio					
Petromyzon marinus					
Lampetra fluviatilis					
Osmerus eperlanus					
Chelon ramada					
Platichtys flesus					
Anguilla anguilla					

An R&D operation on migratory diadromous species in the sea (for Metropolitan France's species) was recently carried out by Pôle MIAME<sup>7</sup> with a view to studying the marine phase on the basis of available data. It should enable improvement of knowledge on the ecology of species in the sea and on assessment of species' sensitivity to the main anthropic pressures during this life phase, such as by-catches (Elliott et al., 2020). An initial article was recently published on distribution of lamprey in the sea and their biometric characteristics (Elliott et al., 2021). This leads us to anticipate future publication of long-awaited, highly interesting data on the part of a number of actors, focusing on this marine phase, about which little is yet known for all Metropolitan France's diadromous species.

<sup>&</sup>lt;sup>7</sup> Pôle OFB-INRAE-Agrocampus Ouest-UPPA for management of MIgrateurs AMphihalins dans leur Environnement (MIAME – Migratory Diadromous Species in their Environment).

#### 2. Monitoring of abundance and characteristics of diadromous species

There are currently several methods of monitoring and describing migratory fish populations, including video counting, telemetry, observation *in situ* (reproduction, monitoring of juveniles, etc.), catches (professional and recreational fishing), scientific catches, trapping and hydroacoustics (acoustic cameras and sonar). All these techniques have advantages and disadvantages (Table 9) and some are more commonly used than others. Over recent years, there have been major advances in hydroacoustics methods, enabling obtainment of invaluable information where other traditionally employed methods have reached their limits (Martignac et al., 2018), without however calling into question the interest and use of field observations on the part of experienced specialists.

Table 9: Comparison of the advantages and limitations of tools and methods used for describing migratory fish populations in rivers, (Martignac et al., 2015). Ed.: Non-exhaustive table

	Hydroacoustics	Video counting	telemetric monitoring	Catches
Minimisation of the impact on fishes' physical integrity	+++	+++	-	-
Description of natural migration behaviour	+++	+	++	-
Accuracy of fishes' morphological description	+	++	+++	+++
Identification of species	+	++	+++	+++
Estimation of population abundance	+	+++	-	-
Study of life history traits (genetics, scalimetry, etc.)	-	-	+++	+++
Independence of environmental conditions	+++	+	++	+
Minimisation of material cost	-	-	+	+++
Minimisation of human cost	+++	+	+	-
Transferability	+++	-	+++	+++

In general, these various methodological tools are complementary and enable acquisition of essential data on population abundance and characteristics (biometry, sexual maturity, age, health status, genetics and even geographical origin). Such data are essential to the study of population dynamics and identification of certain migratory species' life stages that may be sensitive or critical to a greater or lesser extent. Available technical tools do not always enable appropriate specific sampling, in particular with

regard to lamprey and river herring larvae. When tools exist, they are not always used or usable everywhere due to technical or financial constraints.

Potentially colonisable routes are gradually increasing in number with restoration of ecological continuity, which is modifying the colonisation front as well as access to some historical spawning grounds for anadromous species.

As monitoring of abundance is quite costly, monitoring campaigns cannot always be carried out in certain sub-basins or for certain species, due to lack of human and financial resources. Consequently, much scientific, empirical and technical information is missing (field data, observation and monitoring data, etc.).

#### D. REGULATORY PROTECTION STATUS INCLUDING PROTECTION OF HABITATS

Table 10 lists the main texts on conservation of migratory diadromous species in Metropolitan France. Degrees of protection provided by these texts are specified in line with the various management compartments: exploitation of populations (fishing), maintenance and restoration of their migration conditions (continuity), preservation and restoration of breeding areas (spawning grounds), and food and growth (habitat). Various levels of protection were considered:

- Very high (XXX), the text provides for regulatory prohibitions;
- High (XX), the text provides for regulatory binding requirements;
- Low (X), the text does not provide for regulatory requirements.

The species concerned are listed in Table 11. Certain texts connected with international conventions such as Regulation R (EC) 338/97 transcribing the Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES into European law, have strong automatic regulatory implications at national level (sturgeon and eel). Others, such as Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, known as the "Fauna-Flora-Habitat Directive" (FFHD), require transposition into national law. The eel, which is not included in this Directive's appendices, was the subject of a special European Regulation that was applied in French law by decrees and orders and implemented via the National Management Plan. These provisions complemented those bearing on other

migratory fish (shad, lamprey, salmon and sea trout), which continue to be taken into account by COGEPOMIs. Strict measures can sometimes be taken at local level, such as prohibition of salmon and sea-trout fishing on the Loire or a moratorium on allis shad fishing in the Garonne-Dordogne-Charente-Seudre-Leyre COGEPOMI area. In addition, integration of the provisions of the FWD, MSFD and the Maritime Spatial Planning Directive (MSPD) into French law now provides management tools (SDAGEs and programmes of measures for example) contributing to better account-taking of diadromous species' requirements. Descriptions of texts listed below are available in Appendix 2.

Table 10: Main texts on conservation of Metropolitan France's migratory diadromous species. Sources: OFB, INRAE, MNHN, INPN Spawni Continuity **TEXTS** Geographical area concerned Degree of protection Fishing ng Habitat grounds CITES World XX XXX Х Barcelona Convention Mediterranean Sea Х XXX XXX (Appendix 1) (Appendix 1) **Bonn Convention** World Χ Χ Χ X (Appendix 2) X (Appendix INTERNATIONAL CONVENTIONS 2) Berne Convention World Х Х Х Χ FAO Law of the Sea World - maritime species NASCO North Atlantic Ocean international waters Х Х Х Χ Х **OSPAR** Northeast Atlantic marine environment Χ Х Χ Х Regional fisheries management General Fisheries Commission Mediterranean Sea (Eel Management Plan Х organisation Mediterranean (GFCM) GFCM/42/2018/1) FFHD (Directive 92/43/EC) - Appendix II and/or V Europe - Metropolitan France XX XX XX XX XX Europe - Metropolitan France FFHD (Directive 92/43/EC) - Appendix IV XXX XX XX XXX Europe - Metropolitan France's hydrographic FWD (Directive 2000/60/EC) basins: coastal water bodies and continental XX XX XX XX transition water bodies **European DIRECTIVES AND** Europe – Metropolitan French coastal waters up to **REGULATIONS** MSFD (Directive 2008/56/EC) Χ Χ 200 miles Regulation (EC) no.338/97 - bearing on protection Europe of wild species of fauna and flora by regulating XX XXX trade therein Eel Regulation (R(EC) 1100/2007) XX XX Χ Χ Europe Order of 8 December 1988 (list of protected fish Metropolitan French watercourses Χ Х Χ species across the national territory) Order of 15 September 1993 (instituting a common licencing system for fishing in estuaries and fishing North Sea, English Channel and Atlantic Ocean XX XX of migratory fish along the North Sea, English coastlines Channel and Atlantic Ocean coastlines) French REGULATORY TEXTS Order of 1999 (list of protected endangered Metropolitan France XXX XXX XXX XXX vertebrate species) Order of 2004 (protection of the species Acipenser Metropolitan France XXX XXX XXX XXX

	<b>Order of 26 October 2012</b> (establishing the minimum catch size or weight for fish and other marine life in the context of recreational sea fishing)	Metropolitan France	xx	xx			
	Order of 28 January 2013 (establishing the minimum catch and landing size or weight for fish and other marine life for professional fishing)	Metropolitan France	xx	XX			
	Order of 6 January 2020 (establishing the list of protected animal and plant species whose removal from which is only possible following an opinion by the Conseil national de la protection de la nature (CNPN – National Council for Nature Protection)	France	xx				
	CE R436 -18 immediate return to the water after their capture, depending on length	Metropolitan France	X	XX			
	EC R436-45 ff. PLAGEPOMI COGEPOMI	Metropolitan French watercourses	X	XX	Х	Х	Х
	EC L214-17 / Classifications of watercourses (Lists 1 and 2)	Metropolitan French watercourses	X		XX		XX
OTHER French REGULATORY TEXTS	EC L214-18 / Minimum residual flow	Metropolitan French watercourses	X		XX	XX	XX
	EC R432-3/ Spawning grounds and feeding and growth areas	Metropolitan France's hydrographic basins	x			xx	xx

CITES: Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora. Barcelona Convention: Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean, adopted in Barcelona on 10 June 1995 (based on the Barcelona Convention of 16 February 1976). Bonn Convention: Convention on Conservation of Migratory Species of Wild Animals (Bonn Convention – CMS). Berne Convention: Convention on the Conservation of European Wildlife and Natural Habitats. FAO Law of the Sea: United Nations Convention on the Law of the Sea (UNCLOS). NASCO: North Atlantic Salmon Conservation Organisation (NASCO). OSPAR: Convention on Protection of the Northeast Atlantic Marine Environment FFHD: inclusion of the species in Appendices to the "Fauna-Flora-Habitat" Directive (92/43/EEC). FWD: Framework Water Directive. MSFD: Marine Strategy Framework Directive. CE: Environmental Code.

Table 11: Overview of legal protection status (national, European and international) of Metropolitan France's migratory diadromous species. Sources: OFB, INRAE, MNHN, INPN Atlantic-English European Allis Mediterranea Sea River Sea Flou **TEXTS** European eel Channel twaite Atlantic salmon Mullet Smelt sturgeon shad n twaite shad lamprey lamprey trout nder shad INTERNATIONAL **CITES** Appendix I Appendix II CONVENTIONS Appendix Appendix Barcelona Convention Appendix II Appendix III Appendix III Appendix III Appendix III Ш Ш **Appendices Bonn Convention** Appendix II 11 and I Appendix **Appendix** Berne Convention Appendix II Appendix III Appendix III Appendix III Appendix III Ш Χ Χ Χ Χ Χ Χ FAO Law of the Sea Χ Χ Χ Χ Χ Χ NASCO Χ Appendix OSPAR Appendix V Appendix V Appendix V Appendix V Appendix Appendix II, **European DIRECTIVES** Appendix II, Appendix II, Appendix II, ΙΙ, Appendix II, Appendix FFHD (Directive 92/43/EC) Appendix Appendix I AND REGULATIONS Appendix V Appendix V Appendix V Appendix IV\* FWD (Directive 2000/60/EC) Х Χ Χ Χ Χ Χ Χ Χ Χ Χ Χ Χ MSFD (Directive 2008/56/EC) Χ Χ Χ Χ Χ Χ Χ Χ Χ Χ Χ Χ Regulation (EC) no.338/97 bearing on protection of wild Х Χ species of fauna and flora by regulating trade therein Regulation (EC) no.338/97 bearing on protection of wild Χ Χ species of fauna and flora by regulating trade therein Eel Regulation (R(EC) 1100/2007) Order of 8 December 1988 (list of Χ Χ Χ Χ Χ Х Χ French REGULATORY protected fish species across the **TEXTS** national territory) Order of 15 September 1993 (instituting a common licencing system for fishing in estuaries and Х Χ Х Χ Х Χ Χ fishing of migratory fish along the North Sea, English Channel and Atlantic Ocean coastlines) Order of 1999 (list of protected endangered vertebrate species) Χ Order of 2004 (protection of the

ľ	species Acipenser sturio												
	Order of 26 October 2012 (establishing the minimum catch size or weight for fish and other marine life in the context of recreational sea fishing)			Х	Х	х			х	Х	х	х	
	Order of 28 January 2013 (establishing the minimum catch and landing size or weight for fish and other marine life for professional fishing)			Х	X	х			x	Х	Х	х	
	Order of 6 January 2020 (establishing the list of protected animal and plant species whose removal from which is only possible following an opinion by the Conseil national de la protection de la nature (CNPN – National Council for Nature Protection)			Appendix I			Appendix I		Appendix I				
	CE R436-18 immediate return to the water after their capture, depending on length						Х	Х		Х	Х		
	CE R436-45 ff. PLAGEPOMI COGEPOMI, etc.		X	Х	×	x	Х	Х	x	Х			
	EC L214-17 / Classifications of watercourses (Lists 1 and 2)	х	X	Х	х	х	х	х	х	х	х	х	x
	EC L214-18 / Minimum residual flow	Х	Х	х	Х	Х	Х	Х	х	Х	Х	Х	Х
	CE R432-3 / Spawning grounds and feeding and growth areas	list 1		list 2	list 2	list 2	list 1	list 1	list 1	list 1			
PLAN		National Action Plan (Berne Convention, 2007)	Eel Management Plan (at.2-3 Regulation (EC) no.1100/2007)						Salmon Plan (NASCO recommendations, 2018)				

CITES: Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora. **Barcelona Convention**: Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean, adopted in Barcelona on 10 June 1995 (based on the Barcelona Convention of 16 February 1976). Bonn **Convention**: Convention on Conservation of Migratory Species of Wild Animals (Bonn Convention – CMS). Berne **Convention**: Convention on the Conservation of European Wildlife and Natural Habitats. FAO **Law of the Sea**: United Nations Convention on the Law of the Sea (UNCLOS). **OSPAR**: Convention on Protection of the Northeast Atlantic Marine Environment **NASCO**: North Atlantic Salmon Conservation Organisation (NASCO). **FFHD**: inclusion of the species in Appendices to the "Fauna-Flora-Habitat" Directive (92/43/EEC). **FWD**: Framework Water Directive. **MSFD**: Marine Strategy Framework Directive. **CE**: Environmental Code. **Plan**: species covered by a National Plan.

Appendix I: endangered species that are or could be affected by trade

Appendix II: species not currently endangered but which might become so if trade in specimens is not strictly regulated

Appendix A: of the EU Regulation includes all CITES Appendix I species as well as all species (whether or not listed in CITES Appendices II and III) that are or could become subject to trade in the European Union or at international level and which are endangered or so rare that any trade in them would compromise their survival

#### **Barcelona Convention:**

Appendix II: list of endangered and threatened species Appendix III: list of species whose exploitation is regulated

#### **Bonn Convention:**

Appendix I: lists endangered species, i.e. species whose ranges might disappear and any other endangered species.

Appendix II: species with unfavourable conservation status.

#### Berne Convention:

Appendix II: strictly protected species of fauna

Appendix III: protected species of fauna

Appendix III\*: this Appendix's provisions do not apply to salmon in marine waters

#### OSPAR:

Appendix V: "protection and conservation of maritime ecosystems and biological diversity"

#### FFHD:

Appendix II: "Animal and plant species of Community interest whose conservation requires the designation of special areas of conservation" (\*priority species)

Appendix IV: "Animal and plant species of Community interest that require strict protection"

Appendix V: "Animal and plant species of Community interest whose taking in the wild and exploitation may be subject to management measures"

#### List of protected species - National Council opinion:

Appendix I: the list of animal and plant species, provided for in Article R. 411-13-1 of the Environmental Code, whose protection can only be removed following an opinion by the National Council for Nature Protection, is appended to this Order.

#### CE R432-3 / Spawning grounds and growth and feeding areas:

List 1: fish species whose breeding is highly dependent on the granulometry of the bottom of a watercourse's ordinary riverbed.

List 2: fish species and crustacean species whose breeding depends on a plurality of factors.

In addition to the regulatory texts referenced in Tables 10 and 11 and in Appendix 2, there are other tools benefiting migratory diadromous species, in particular local regulatory texts complementing the protection already established at higher levels (Prefectural Biotype Protection Order (APPB), Precautionary Approach to Fisheries, etc.).

#### 1. At international level

At international level, different territories have their own statuses. Management measures are implemented to the benefit of migratory diadromous species completing parts of their lifecycles on these sites.

#### RAMSAR sites: wetlands of international importance

The Ramsar Convention was signed in 1971. France ratified the Treaty in 1986 and has since been internationally committed to preservation of its territory's wetlands. France numbers 51 Ramsar<sup>8</sup> sites on which migratory diadromous species complete a part of their lifecycle. The label aims to ensure international recognition of wetland natural heritage and of actions already implemented by territorial actors to ensure conservation and sustainable management of such sites and their resources.

#### Sites inscribed on the UNESCO World Heritage List

The 1972 Convention recognises the interaction between human beings and nature and the fundamental need to preserve the balance between the two. By signing the Convention, each country undertakes to ensure proper conservation of World Heritage Sites on their territory<sup>9</sup> and protect their national heritage. States Parties are encouraged to integrate protection of cultural and natural heritage into regional planning programmes. Such sites include the Loire Valley site between Sully-sur-Loire and Chalonnes and the Mont Saint-Michel site and its bay.

<sup>9</sup> The list of French sites inscribed on UNESCO's World Heritage List can be consulted at the following address: <a href="https://www.culture.gouv.fr/Sites-thematiques/Monuments-Sites/Monuments-historiques-sites-patrimoniaux/Les-biens-français-inscrits-sur-la-liste-du-Patrimoine-mondial-de-Lunesco">https://www.culture.gouv.fr/Sites-thematiques/Monuments-Sites/Monuments-historiques-sites-patrimoniaux/Les-biens-français-inscrits-sur-la-liste-du-Patrimoine-mondial-de-Lunesco</a>

<sup>&</sup>lt;sup>8</sup> The list of sites can be consulted at the following address: <a href="http://www.zones-humides.org/entre-terre-et-eau/ou-les-trouve-t-on/les-sites-reconnus/les-sites-ramsar-en-france">http://www.zones-humides.org/entre-terre-et-eau/ou-les-trouve-t-on/les-sites-reconnus/les-sites-ramsar-en-france</a>

# **Biosphere Reserves**

This is a dynamic, interactive global network of the Man And Biosphere programme's <sup>10</sup>sites of excellence. It comprises a global network of model sites for study and demonstration of approaches to conservation of natural resources and sustainable development. It includes the Camargue site, the Iroise Islands and Sea, the Guadeloupe archipelago and the Dordogne Basin.

# 2. At European level

#### Natura 2000 Network

The FFHD provides that Natura 2000 sites may be designated when species listed in Appendix II are identified on them. Natura 2000 sites aim to protect a number of species representative of European biodiversity. Each State has to submit a list of sites, stating the types of natural habitats targeted by Appendix I and the indigenous species targeted by Appendix II that they accommodate. It should be noted that, as regards aquatic species occupying extensive territories, Article 4 provides that such sites are only submitted if it is possible to determine an area possessing physical and biological features essential to their lives and reproduction. If the site is selected, the State designates it as a Special Area of Conservation (SAC) and must take all necessary measures to ensure prevention of deterioration of natural habitats and habitats of species therein, along with disturbances affecting the species for which the area was designated. In addition, Article 10 aims to ensure continuity between these sites in order to improve the Natura 2000 Network's ecological coherence. Hence, through their land-use planning and development policies, States must endeavour "encourage the management of features of the landscape which are of major importance for wild fauna and flora. Such features are those which, by virtue of their linear and continuous structure or their function as stepping stones are essential for the migration, dispersal and genetic exchange of wild species". Although there are no areas designated solely for a diadromous species, they are listed alongside other Appendix II species on a number of sites.

<sup>&</sup>lt;sup>10</sup> The list of sites can be consulted on <a href="https://unesdoc.unesco.org/ark:/48223/pf0000371003">https://unesdoc.unesco.org/ark:/48223/pf0000371003</a>

# 3. At national level

Tools for implementation of the Framework Water Directive (FWD) and the Marine Strategy Framework Directive (MSFD)

# **Water Development and Management Master Plans (SDAGEs)**

Each 6-year SDAGE is drawn up for a given hydrographic basin. It is a tool for implementation of the FWD. It takes account of such concerns as wetland preservation and maintaining good status of rivers; migratory diadromous species are taken into consideration via general guidelines or more specifically. SDAGEs may come in the form of Schémas d'Aménagement et de Gestion des Eaux (SAGEs – Water Development and Management Plans), which are planning documents at more local level, taking account of an area's specificities.

# Sea Basin Strategy Documents (DSFs)

DSFs (Art. R. 219-1-7 of the Environmental Code) are adopted for 6 years by Sea Basin Coordinator Prefects. They are planning documents applying to coastlines, integrating the Directive cadre de planification de l'espace maritime (DCPEM - Maritime Spatial Planning Directive) and the DCSMM to ensure integrated maritime policies.

In order to best coordinate the two Directives (DCE and DCSMM), administrations responsible for planning documents are asked to implement a common timetable so as to make the two drafting procedures compatible and consistent. The same goes for the Plan de gestion des risques d'inondation (PGRI – Flood Risk Management Plan), a planning document in compliance with the Flood Directive.

Tools for implementation of the "Flora-Fauna-Habitat" Directive (FFHD)

# **National Action Plans (NAPs)**

NAPs are non-enforceable guidance documents aiming to define the actions necessary to conservation and restoration of the most endangered species so as to make sure of their good conservation status. Hence, they meet the requirements set out in the FFHD, which is committed to maintenance and restoration of species of Community interest in good conservation status.

The Environmental Code provides for protection of various species of wild fauna and flora, in particular through Articles L.411-1 and L.411-2, which establish strict protection of species included in lists drawn up by Interministerial Orders. In addition, Article L.411-3 provides for implementation of National Action Plans on "conservation or re-establishment of the species targeted by Articles L.411-1 and L.411-2 as well as pollinating insect species". In practice, decisions may sometimes be made to implement NAPs for endangered species not yet protected within the meaning of Articles L.411-1 and L.411-2. So far, two such NAPs concern freshwater fish species: the Rhone Apron (Zingel Asper) NAP and the Sturgeon NAP, which is of particular concern to us.

# → 2020-2029 National Action Plans in favour of the sturgeon, *Acipenser sturio* (Berne Convention, Appendix II and Article L. 411-1 of the Environmental Code), coordinated by Nouvelle Aquitaine's Direction régionale de l'environnement, de l'aménagement et du logement (DREAL – Regional Directorate for Environment, Planning and Housing)

Following the International Plan, France adopted its own 5-year NAP in favour of the European sturgeon. A second plan is currently underway up until 2028. This NAP would seem essential as, despite its having protected species status in France since 1982 and in Europe since 1998 and its inclusion in several international conventions on biodiversity conservation (see *above*), the European sturgeon's situation has continued to deteriorate. France has a major part to play in its conservation as it hosts Europe's last population, and the two successive NAPs complement the legal and regulatory mechanisms rolled out for protection of the species (Ministry for the Ecological and Inclusive Transition, 2020).

Other French tools contributing to protection of species

# **Other National Plans**

→ The national European Eel Management Plan (in application of European Regulation R(EC) no.1100/2007 of the Council of 18 September 2007), approved by the European Commission in 2010.

France's Plan de gestion anguille (PGA – Eel Management Plan) came into effect in 2010. The Plan is fully in line with the goal of replenishing European eel stocks set by the European Regulation. Il is made up of measures designed to reduce the main mortality factors that can be influenced, and for which results are evident over the medium and long term due to the species' lifecycle. However, these measures can only lead to stock replenishment if environmental quality (water, sediment and habitats) is improved. Furthermore, reduction of mortality connected with anthropic factors other than fishing is one of the aims of programmes of measures implemented (provided for by the Framework Water Directive) and an ambitious action plan for restoration of ecological continuity in watercourses (ONEMA, 2018). Stock productivity is conditional upon our ability to activate the various levers for reduction of pressures.

# → The French Plan for implementation of NASCO's 2019-2024 recommendations

France adopted its 5-year Atlantic salmon management implementation plan in 2020, developed and co-piloted by the Ministry of Ecological Transition (Water and Biodiversity Directorate) and the Ministry responsible for fisheries (Maritime Fisheries and Aquaculture Directorate) with technical support from the OFB.

Actions targeting restoration of ecological continuity and restoration of watercourses' physical characteristics, along with implementation of effective fishing management measures, are essential levers for replenishment of populations.

# **Protected areas**

Protected areas in Metropolitan and Overseas France account for 23.5% of national territory and waters under jurisdiction. Due to the quality of the ecosystemic services they provide, protected areas are put to a great many professional and recreational uses. France's protected areas help preserve and promote its territories' natural and cultural heritage. They include national parks, marine nature parks, regional nature parks, nature reserves, classified and listed sites, conservatories of natural areas,

biological reserves;, the Natura 2000 European network, and Conservatoire du littoral et des rivages lacustres (CELRL – Coastal and Lakeside Conservatory) sites There are also prefectural orders on biotope protection as well as the Zones prioritaires pour la biodiversité (ZPBs – Priority Zones for Biodiversity) and Zones de conservation halieutiques (ZCHs- Fishery Conservation Zones) created by Act no.2016-1087 of 8 August for the restoration of biodiversity, nature and landscapes.

# → Prefectural Biotype Protection Orders

Biotype Protection Orders aim to preserve the natural environments necessary to feeding, rest, breeding and survival on the part of legally protected animal and plant species. Such Orders are governed by Articles L 411-1 and L. 411-2 of the Environmental Code and the Circular of 27 July 1990 on protection of biotopes necessary to species living in aquatic environments. They specify possibilities for authorisation, limitation and even prohibition of certain activities.

# → Priority Zones for Biodiversity (ZPBs)

ZPBs, created by Decree no.2017-176 of 13 February 2017, are areas in which restoration or maintenance of protected species' habitats is required. Following consultation with local actors, the Prefect establishes an action programme for such areas with regard to farming practices, specifying the actions that owners and farmers are encouraged to implement, in line with the protected species for which the Priority Zone has been defined.

# → Fishery Conservation Zones (ZCHs)

ZCHs, referenced in Articles R924-1 to R924-7 of the Rural and Sea-Fishing Code and created by Decree no.2017-568 of 19 April 2017, are protected areas in a maritime area of special interest with regard to breeding, growth and/or feeding on the part of a fishery resource that must be preserved. The designated administrative authority draws up all necessary conservation measures, in particular any prohibitory or regulatory measures required for achievement of the objectives set, taking account of the socioeconomic impact of such measures on the actions and activities concerned. A monitoring plan is implemented with a view to establishing the scientific protocol to deploy in order to assess the effectiveness of the conservation measures adopted.

# The Trame verte et bleu (TVB – Green and Blue Belt network)

The 2010 Grenelle II Act created the TVB, which is a network of terrestrial and aquatic reservoirs of biodiversity and ecological corridors identified by Schémas régionaux de cohérence écologique (SRCEs – Regional Ecological Coherence Schemes). Setup of Green and Blue Belts involves action at three levels: national level, responsible for the drafting of national guidelines for preservation and restoration of ecological continuities; regional level, which collaborates with the State in drafting the SRCE, itself integrated into the Schéma régional d'aménagement, de développement durable et d'égalité des territoires (SRADDET – Regional Plan for Sustainable Development and for the Equality of Territories) since 2016; and local level, which takes account of the SRCE in planning documents (Schéma de cohérence territoriale (SCOT – Territorial Coherence Scheme); Plan local d'urbanisme (PLU – Local Urban Planning Plan) and municipal maps). Blue Belts are partly implemented via the watercourse classifications provided for by the Law on Water and Aquatic Environments (LEMA).

In addition, the Schéma d'aménagement régional (SAR – Regional Development Plan), referred to in Articles L. 4433-7 to L. 4433-11 of the General Local Authorities Code drawn up in Overseas France, is the equivalent of an SRCE and must include a separate chapter on the TVB.

# The "Prevent – Reduce – Offset" (PRO) sequence

The PRO sequence was introduced by the 1976 law on protection of nature. It aims to prevent environmental damage, further reduce damage that has not been adequately reduced, and offset any residual impacts. To begin with, the best way of preserving natural environments is to prevent anything impacting them. When it has proved impossible to completely prevent negative impacts on the environment at a reasonable cost, appropriate technical solutions must be applied in order to reduce consequent degradation. As a last resort, compensatory measures must be taken to offset any persisting negative impacts. Such measures aim to ensure overall conservation of habitats' environmental quality.

Since 2016 and the Act for restoration of biodiversity, the PRO sequence has aimed for zero net loss of biodiversity in the design and implementation of territorial development plans, programmes and projects. It is one of the key actions of the Ministry for the Ecological and Inclusive Transition's "Biodiversité. Tous vivants" (Biodiversity. All Alive) Plan.

Tools contributing to protection of species specific to Overseas France

Freshwater fish populations on Overseas French Islands are mostly composed of migratory diadromous species (fish and macrocrustaceans). Different from Metropolitan France's species, their lifecycles are mostly amphidromous and are still poorly understood. They are not identified in the Environmental Code and do not benefit from all the national measures implemented for protection and conservation of diadromous species.

# Indian Ocean

Reunion Island's Comité de l'eau et de la biodiversité (CEB – Water and Biodiversity Committee) has established a "Diadromous" Commission in order to ensure appropriate governance for the protection and conservation of these species, draft a protection strategy in consultation with all actors concerned, and bring about the national regulatory changes required to complement existing protection tools.

# → Master Plan for conservation of Commerson's freshwater goby (Awaous commersoni), on Reunion Island and Mayotte

Commerson's freshwater goby (*A. commersoni*) was classified as "Vulnerable" (VU) on the Red List of endangered species on Reunion Island according to IUCN criteria. Despite the Commerson's freshwater goby's ineligibility for creation of a NAP in accordance with the selection criteria defined in the 2017 Ministry Note, Reunion Island's direction de l'environnement, de l'aménagement et du logement (DEAL – Environment, Development and Housing Directorate) wished to maintain an action plan on conservation of the species on Reunion Island and Mayotte. In this regard, the draft NAP was turned into a "Conservation Master Plan" for the goby (Valade et al., 2018a).

# → Conservation Master Plan in favour of Anguillidae on Reunion Island 2018-2027

Populations of the main eel species exploited are all in sharp decline due to overfishing and degradation of environments. Reunion Island's Conservation Master Plan in favour of Anguillidae aims to prioritise preservation actions for each species on the basis of existing knowledge. Like the "Conservation Master Plan" for the goby, it can act as a decision-aid tool for local authorities, but is mainly intended for managers of natural resources and has no legal value (Valade et al., 2018b).

# French West Indies

The Cartagena Convention (1983)<sup>11</sup> applies to the Gulf of Mexico's marine environment, the Caribbean Sea and adjacent areas of the Atlantic Ocean. The Convention and its related protocols are designed to foster protected areas' resilience, with implementation of actions contributing to conservation of coral reefs and countering ocean acidification.

<sup>&</sup>lt;sup>11</sup> Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (WCR) – Cartagena Convention: https://www.milieumarinfrance.fr/Nos-rubriques/Cadre-reglementaire/Conventions-des-mers-regionales/Convention-de-Carthagene

# **CHAPTER 3: PRESSURES ON MIGRATORY SPECIES**

According to the IPBES (Intergovernmental Science-Policy on Biodiversity and Ecosystem Services), "The rate of global change in nature during the past 50 years is unprecedented in human history. The direct drivers of change in nature with the largest global impact have been (starting with those with most impact): changes in land and sea use; direct exploitation of organisms; climate change; pollution; and invasion of alien species." (IPBES, 2019).

# A. Pressures connected with quality of environments and habitats

# a. Margins for improvement identified

Habitat quality is a major parameter with a strong influence on diadromous species and their dynamics. Fish are highly sensitive members of river ecosystems and react significantly to the quasi-quality of disturbances of anthropic origin: eutrophication, acidification, chemical pollution, hydromorphological disturbances of watercourses and habitat fragmentation (Limburg & Waldman, 2009; Ormerod, 2003).

Habitat availability, accessibility and functionality are three connected fundamental criteria for restoration and management of these species, and efforts must be made to ensure that they are met. Information is communicated on operations carried out in the various territories so that they can serve as examples (see below, Chapter Chap.3. A.b.).

Chemical and ecological status<sup>12</sup> of surface water bodies. In 2015, 44.2% of water bodies were of good or very good ecological status (very good: 8.2%; good: 36%) as against 41.5% in 2009 (very good: 6.5%; good: 34.9%) (SDES & OFB, 2020). Even though the general status of all surface water bodies<sup>13</sup> is not deteriorating, nor is it showing any significant improvement. It should be noted that this is not due to lack of effort and genuine reductions in the various pressures, but rather to a problem connected with the

<sup>&</sup>lt;sup>12</sup> Established on the basis of three parameters calculated in accordance with information on (i) physicochemical quality (temperature, nutriments, dissolved oxygen, etc.) (ii) biological quality (fauna/flora indices) and (iii) hydromorphological quality (state of banks, variations in bed width, presence of obstacles, etc.).

<sup>&</sup>lt;sup>13</sup> Watercourses, waterbodies, lagoons, estuaries and coastal seas (11,414 bodies of water in 2015).

"one out-all out" rule for assessment of water-body status, which requires that a single indicator of less than good status leads to the whole water body being classified as being of less than good status.

As regards the chemical and physicochemical status of surface waters, numerous chemical and organic substances (pesticides, micropollutants, nitrates, phosphates, etc.) from industrial, domestic and agricultural activities find their way into watercourses and waterbodies via direct discharge and atmospheric deposition, and impact ecosystems. This is one of the main causes of water degradation (Nõges et al., 2016). In particular, increases in concentrations of organic matter and algal blooms lead to hypoxia in environments (Teichert et al., 2016). The occurrence of this phenomenon in a number of rivers and a few waterbodies is referred to repeatedly in assessments of COGEPOMIs. Eutrophication is due to excessive presence of nitrates and/or orthophosphates<sup>14</sup>, concentrations of which observed over the last 15 years have not decreased in surface waters and sometimes even increased in a number of sub-basins (SDES & OFB, 2020).

Finally, as regards micropollutants resulting from industrial, agricultural and domestic activities (mainly polycyclic aromatic hydrocarbons (PAHs) and metals-metalloids), they are still very much present in French watercourses: in 2018, 70,000 of the 586,000 analyses carried out in Metropolitan France highlighted the presence of at least one micropollutant, i.e. in 12% of samples (SDES & OFB, 2020). Their concentrations have remained stable over the last 15 years. In 2015, 25.9% of surface water bodies assessed in the context of the FWD were of poor chemical status (SDES & OFB, 2020). Poor water status and contamination of environments have been identified as having an impact on migratory species (Le Pichon et al., 2020; Bourillon, 2021).

**Biological status of watercourses**<sup>15</sup>. Three main pressures impacting the biological quality of France's watercourses – land use, hydromorphological modifications and physicochemical impairment – have been studied by Villeneuve et al. (2015). These authors showed that nutrient and organic matter loading had a predominant effect on the three biological compartments considered and used as indicators (fish,

41

<sup>&</sup>lt;sup>14</sup>"The simplest and most common form of phosphorus dissolved in water. Phosphorus materials originate almost equally from soil erosion, agricultural activity (phosphate fertilisers), industry and urban waste, with the use of detergents." (https://www.insee.fr/fr/metadonnees/definition/c2206).

<sup>15</sup> Part of ecological status according to the FWD

microalgae and invertebrates)<sup>16</sup>. In addition, land use, and above all its artificialisation and exploitation for conventional agriculture, puts pressure on rivers. As regards the River Fish Index (RFI), parameters in connection with hydromorphology, such as risk of clogging of substrates by fine sediments and rupture of ecological continuity *lato sensu*, also impact it negatively.

Status of habitats of Community interest. In the context of the FFHD, Member States must carry out assessments of the conservation of habitats of species of Community interest every 6 years (known as "FFHD reporting"); the most recent was carried out for the 2013-2018 period (UMS PatriNAt, 2019). In 2020, this enabled the Ministry for the Ecological and Inclusive Transition's General Commission for Sustainable Development to make the following assessment: since 2007, few improvements have been observed and degradation trends are still a matter of concern (SDES & UMS PatriNAt, 2020). Only one in every five assessments concluded that the habitats in question were of favourable status. As migratory diadromous species are concerned by several aquatic compartments (continental, transition, coastal and marine waters), they are all impacted by their degradation. Coastal ecosystems are the most degraded and fresh waters (wetlands, lakes and watercourses) belong to the least well conserved ecosystems: only 15% are classified as being of "favourable status"; (SDES & UMS PatriNAt, 2020).

**Transition habitats**. Estuaries, which are mandatory crossing points for migratory fish, which stay in them for durations that vary depending on species and environmental conditions, are often subject to heavy pressures. Deterioration of the quality of the intertidal zone and transition waters can restrict migration of spawners and juveniles (Lepareur & Aish, 2012). In addition, poor oxygen and turbidity conditions (mud plugs) can result in high mortality rates during migration among certain taxa (Acou et al., 2013).

Transition habitats (natural harbours, bays and estuaries) and their quality should be considered as essential for migratory species (Acou et al., 2013). A recent study carried out in the Picardy Estuaries and Opal Sea Regional Nature Park (PNM-EPMO) demonstrated the importance of estuaries for migratory fish, medium- and small-sized estuaries largely undisturbed by human activity in particular (Denis et al., 2021).

.

<sup>&</sup>lt;sup>16</sup> By using the following three indexes: River Fish Index (RFI), Biological Diatom Index (BDI) and the Multimetric Invertebrate Index (I2M2).

The study illustrates the effect of poor water quality on diversity and abundance of fauna, with low abundances observed in the Somme Bay – a highly anthropised estuary.

As regards Overseas France, no study has yet been made of their characteristic transition environments, the mangroves, and their role and impact on diadromous fish and macrocrustaceans. Given the present state of knowledge, however, it would seem reasonable to think that these special ecosystems have their own major issues requiring resolution.

**Special case of Overseas France.** According to bodies involved in the management of migratory diadromous species in Overseas France <sup>17</sup>, these species suffer from major pressures of urban and agricultural origin (Tabouret, 2012, 2013). Territorial development, due in particular to population growth, <sup>18</sup>can be detrimental to biodiversity.

There are several pressures weighing on these habitats, including artificialisation, soil sealing, erosion, modification of land and watercourse use, pollution, deforestation and degradation of riverbanks and shorelines. All such pressures, connected with urbanisation, absence of wastewater treatment, and conventional monoculture systems, degrade habitats and water quality. Their impact is yet to be assessed in Overseas France. A balance therefore needs to be found between socioeconomic development of France's Overseas Territories and preservation of habitats, which are often described as *biodiversity* hotspots.

# b. Recent advances

**Chemical status of surface waters.** Environment restoration operations, carried out in the context of successive SDAGEs and designed to ensure that waterbodies enjoy good ecological status, have helped improve habitats, as have programmes of measures taken under SDAGEs. Although not all objectives have been achieved, major efforts have already been made and the PNMA must help keep up the momentum.

18 To cite just one example, Mayotte's population increased from 94,410 inhabitants in 1991 to 256,518 in 2017 (+172%) (Said & Desprats, 2021).

<sup>&</sup>lt;sup>17</sup> DEALs, the OFB, National Parks, Basin Committees, Water Agencies, Fédérations départementales des Associations Agréées pour la Pêche et la Protection du Milieu Aquatique (FDAAPPMAs – Départemental Federations of Approved Associations for Fishing and Protection of the Aquatic Environment), the Service Mixte de Police de l'Environnement (SMPE – Joint Environmental Police Service), the Direction de la Mer Sud Océan Indien (DMSOI – Southern Indian Ocean Sea Directorate), and Martinique's Water Observatory.

While physical barriers are widely known to have played a significant role in the decline of migratory species' populations, chemical barriers have also become major sources of impact, a fact that was recently highlighted by Le Pichon et al. (2020) in their study of the Seine Basin in the 1970s. In those years of rapid industrialisation, over half the wastewater produced in the Paris Basin was discharged into the Seine untreated. Water quality deteriorated to such an extent that the great river's desertion by Atlantic salmon, shad and sea lamprey was considered to be irreversible and the idea of equipping dams with fish passes was abandoned. The Water Law of 16 December 1964, which organised water management by basin with creation of Water Agencies and Basin Committees, enabled significant improvements to be made in the 1990s with regard to wastewater treatment. These have led to substantial improvement in water quality over the last few decades (Romero et al., 2016; Le Pichon et al., 2020). Alongside work carried out on ecological continuity, improvement of water quality enabled recolonisation of Atlantic salmon in the Seine in the late 2000s (Perrier et al., 2010). Over twenty consecutive years, from 1998 to 2018, there was a threefold reduction in emissions of organic matter and metals into water by urban wastewater treatment plants (UWWTPs) and industrial concerns (SDES & OFB, 2020). Similarly, since 2008, there has been a drop of around 20% in the level of chronic watercourse contamination by phytopharmaceutical products (pesticides) in 77% of French sub-basins... Finally, the percentage of surface waterbodies assessed as being of good chemical status increased from 43.1% to 62.9% between 2009 and 2015 (SDES & OFB, 2020).

Functional areas favourable to migratory diadromous species. A number of basins have undertaken identification and recognition of sectors favourable to species by drawing up inventories of spawning grounds, watercourse classifications, etc. As regards salmonids in particular, identification of favourable sectors via consideration of riffles-rapids equivalents (RRE) was carried out in numerous areas. This type of work is regularly updated and provides reasonably accurate estimations of basins' and sub-basins' capacities.

Over the course of time, several methods have been proposed for assessment of spawning ground quality in connection with nature of sediments, clogging level, oxygenation, etc.: McNeil sampling method (McNeil & Ahnell, 1964 cryogenic coring method (Stocker & Williams, 1972), wooden stake method (Marmonier et al., 2004), and Archambaud method (Archambaud et al., 2005). The first two methods are destructive, onerous and expensive, while the latter two, which are the most commonly used, are more

economical and easier to implement, but are based on qualitative criteria and remain subjective. Another method, promoted by Datry (Datry & Donor, 2010), is simple to use and based on hydraulic conductivity; it would appear to be of interest for assessment of granulometric quality of breeding grounds, enabling discrimination between them (Coll, 2016). Finally, the study of survival rates of embryos and larvae emerging from eggs buried in gravels (Massa et al., 2000) is another method employed in order to assess substrate quality (clogging, hypoxia, production of composites toxic to eggs, etc.). The existence of these standardised operational protocols enables objective analyses in time and space (e.g. the study of "survival of salmon eggs under gravels" carried out by the Logrami Association in several production areas and watercourses in the Loire-Allier Basin in 2016; Bach et al., 2016). This experimental protocol could be applied on a broader scale, on behalf of freshwater anadromous and amphidromous species in France's various basins.

Finally, the National Action Plan in favour of Wetlands (2014-2018), which is currently undergoing revision, devotes its Action 49 to knowledge and assessment of coastal environments' potential for reception of such fish populations as the European eel.

# B. Pressures relating to ecological continuity

# a. Margins for improvement identified

River continuity —" barrier" effect. There are currently a great many obstacles to journeys made by migratory species, and river fragmentation is still one of the main threats for their populations (Merg et al., 2020). In 2020, a work considered as an obstacle to flow (i.e. dam, sill, bridge, fish farm, etc.) was present every 5 km in France (SDES & OFB, 2020). Such amenities are generally well identified at basin level and some constitute obstacles to migration as diadromous species either cannot get across them or can only do so with difficulty. Consequences of obstructing upstream migration include forced reproduction by spawners in unsuitable areas and delayed migration not enabling individuals to reach the best habitats in good time.

As regards Overseas France, special attention must be paid to ecological continuity due to the growing demand for energy and potable water and the large number of migratory species (Tabouret, 2013). In a context of climate change and human population growth, needs tend to increase and projects implemented (water intakes, hydroelectric dams, reservoirs, etc.) will be subject to prior environmental assessment in line with all identified concerns, which should enable limitation of their impacts.

Obstacles, even those of low height, result in a fragmentation of the hydrographic network that causes several problems

- whose cumulative effects have significant impacts on success of migration, reproduction and survival
  of individuals (delays, exhaustion, injuries, and death) (Baudoin et al., 2014; Merg et al., 2020).
- They tend to encourage individuals to group together, either at the bases of dams or at fish passes, so increasing predation risks (Agostinho et al., 2012), in particular from such opportunist species as the catfish (Boulêtreau et al., 2018, 2021) (see below, Chapter. 3, Part F., subsection a.).

River continuity – "retention" effect. River continuity is referred to in Appendix V of the Framework Water Directive (Directive 2000/60/EC). It is a factor in river quality. The notion of "ecological continuity" introduced by the FWD (2000) includes "river continuity" as a whole, with natural hydro-sedimentary operation (bed load, morphogenic floods).

**Sedimentary transport.** Transport of sediments is a natural process that seems to have been largely neglected in restoration efforts made in a good many territories, where the focus has been more on the "barrier" effect, i.e. the effect of obstacles on ichthyofauna movement. However, it is of particular importance for certain life and breeding phases in diadromous species' lifecycles, and more generally for the functionality of aquatic environments. Granulometric quality of spawning grounds is an essential parameter that often continues to deteriorate, due in particular to a deficit of sediment transport and an increase in fine fractions. It should be noted that not all amenities have a significant sedimentary impact(Collins et al., 2020): those of limited height ( $\leq 2 - 3$  metres) usually do little to disturb transport (Peeters et al., 2020). The authors warn of cumulative effects that can be highly significant in the event of numerous works being constructed on a watercourse. Such effects are further exacerbated when the works in question are not or only poorly maintained (i.e. without regular opening of floodgates and locks).

**River and flow morphology.** Flows on stretches of water or watercourses may naturally vary considerably from one year to the next, in particular with climate change, and may modify some sectors' morphology. Works are regulated by Article L214-18 of the Environmental Code, which provides for maintenance of a minimum flow "permanently ensuring the life, movement and reproduction of species".

**Fish passes and maintenance.** A number of fish passes were constructed a good many years ago and were not sized for all the migratory species making use of the routes under consideration, and will therefore have to be adapted or replaced. The often high number of works on such routes requires implementation of efficient crossing systems in order to ensure that significant numbers of fish reach the most functional habitats. Although fish pass efficiency percentages can be as high as 90% (and sometimes, in a few rare cases, up to 100%) for salmon, they are significantly lower for shad, and are considered good if they reach 50% (Larinier & Travade, 2002).

Crossing systems must be sized on a case-by-case basis, taking a cost-effective approach and taking account of regulatory obligations, target species present (established during watercourse classifications), positions of works on the route in relation to functional habitats, the number of works on the route, etc.

Regular maintenance of systems is of the utmost importance, but is by no means cost neutral and is sometimes lacking. A study carried out on the Loire basin by Logrami shows that 60% of the basin's

crossing systems are poorly maintained (Boucault, 2007). In Normandy, it was found that almost half the passes were not guaranteed, 33% of them due to lack of maintenance or inadequate hydraulic management (Gaberel, 2005). 65% of passes on the River III are poorly maintained, and 35% are inefficient due to the presence of numerous logiams (Association Saumon-Rhin, 2010).

**Outmigration mortalities.** Over the last 20 years, numerous studies have been carried out on migratory species' outmigration conditions as regards obstacles and routes. Such studies have focused on salmon and eels, largely due to the national and international plans implemented in their favour and their high sensitivity to impacts generated by obstacles along migration routes.

New techniques have been developed, including the so-called "ichtyophilic" turbines and "ichtyocompatible" water intakes (Courret et al., 2008). Efficiency tests on "ichtyocompatible" water intakes carried out by the OFB over recent years have shown high levels of efficiency, between 88% and almost 100% depending on site and species (Tomanova et al., 2018; Frey et al., 2020). Outmigration of juvenile shad and lamprey has generally not been tackled, however, because of the technical difficulties and high costs involved due to the size of these species' juveniles.

Ensuring compliance of large works has proved to be particularly difficult, usually for technical and/or financial reasons. Nonetheless, such works, in particular those located on the middle and downstream sections of routes, are all too likely to have major impacts on species and are a concern of prime importance.

**Watercourse classification.** Classification Orders for watercourses on List 1 and List 2 pursuant to Article L.214-17 of the Environmental Code were mostly issued between 2012 and 2015 for Metropolitan and Overseas France, and enabled a substantial increase in actions designed to restore ecological continuity.

The legal framework is evolving, with amendment of 2° of I of Article L. 214-17 of the Environmental Code, introduction of Article L 214-18-1 and, more recently, the Act of 22 August 2021 on combating climate change and strengthening resilience to its effects.

Due in particular to the large number of obstacles that have to be brought into compliance, an Action Plan for a Conciliatory Policy on Restoration of Ecological Continuity (PARPARCE) was put forward by the Comité national de l'eau (CNE – National Water Committee) in 2018 and adopted via a Technical

Note from the Ministry for the Ecological and Inclusive Transition in 2019. It enables prioritisation of actions and short-term concentration of resources on a smaller number of works.

**Construction work.** In watercourses travelled by diadromous species, construction work may impact populations when it is carried out near breeding areas or during migration periods. As this is true of many types of such work, including construction, repair, demolition and development of an amenity, and any other nearby worksite that might disturb a river's normal operation, It would seem necessary to take account of the migratory calendar of species present, in particular in the context of Authorisation Orders, and to adapt their implementation as far as possible so as to limit consequent disturbances impacting these species.

### b. Recent advances

**Knowledge of obstacles to flow.** Inventorying of obstacles to flow has been stepped up over the course of the last decade, due to the Référentiel national des obstacles à l'écoulement (ROE – National Repository of Obstacles to Flow). In 2020, over 104, 459 transverse structures were inventoried, including more than 103,219 in Metropolitan France, 554 in French Guiana, 382 in Martinique, 133 on Reunion Island, 113 in Guadeloupe and 58 in Mayotte (Sources: OFB, OIEau).

Restoration and maintenance of continuity. According to assessments of PLAGEPOMIs and SDAGEs in 2021, major work has been carried out on restoration of ecological continuity in most territories, accounting for around 80% of the resources employed in the various drainage basins for management of migratory fish. Implementation of watercourse classification pursuant to Article L214-17 of the Environmental Code, in 2012-2013 for Metropolitan France and in 2014-2015 for Corsica and Overseas France, has speeded up restoration actions. Solutions are implemented on a case-by-case basis (maintenance, management, equipment, levelling, etc.); levelling and removal operations are concentrated on basins of major concern as regards diadromous species, but are less numerous at national level than creations of fish passes. A good many systems have now been adapted to numerous species, which is of particular importance in a context of climate change.

**Crossing systems.** New techniques have been developed over recent years, enabling increased efficiency. In particular, during upstream migration, increased introduction of so-called "natural" systems (Larinier

et al., 2006) now enables numerous species to make their way across and limits maintenance constraints. For outmigration, introduction of "ichtyocompatible" water intakes (Courret & Larinier, 2008) at hydropower plants has led to significant reduction of impacts. A number of large dams have started reducing or stopping turbining in order to enable eels to pass unharmed.

Diagnosis of obstacle passability. In 2014, Baudoin et al. published a method for diagnosing passability of works in accordance with a standardised protocol (ICE method, standing for "Informations sur la Continuité Ecologique"), accompanied by a practical guide to its implementation (Burgun et al., 2015). Even though it does not apply to assessment of impacts of works on outmigration (which requires ad-hoc expert appraisal), the work provides an almost exhaustive list of the various barriers impacting upstream migration and, for the first time in France, makes a harmonised, shared method available to all actors concerned. The document also specifies the main criteria for sizing crossing systems for all the species populating Metropolitan France's watercourses.

The ICE method has recently been adapted for the fish and macrocrustaceans of French Overseas island départements (Kreutzenberger et *al.*, 2019).

Maintenance of systems. Maintenance of fish passes is often a major problem in many territories. Two basins (Seine-Normandy and Rhine-Meuse) have taken action to improve the situation. In Seine-Normandy, there has been an increase in numbers of inspections carried by the water police services. In the Rhine-Meuse basin, work undertaken by the Saumon Rhin Association has helped raise awareness among managers.

In the Loire basin, the Logrami Association has developed GPAP, a mobile application dedicated to the monitoring and maintenance of works, with a view to assisting their owners and managers: in just a few clicks, it enables the user to check a system's status directly on the ground, tells them what to look out for on the type of system concerned, and facilitates reporting of actions.

# C. Pressures relating to fishing

Migratory Fish Management Committee. There is a COGEPOMI for each of Metropolitan France's <sup>19</sup>main river basins. COGEPOMIs develop 6-year Migratory Fish Management Plans (PLAGEPOMIs) for their respective basins. Such plans establish (1) measures useful to reproduction, development, conservation and movement of migratory fish, (2) methods for estimation of stocks and of quantities that can be fished each year, (3) fish nursery plans and population support programmes, (4) the conditions under which periods when fishing is permitted are set, (5) methods for possible limitation of fishing, which can be adapted in accordance with the specific characteristics of professional fishing and recreational fishing, and (6) the conditions under which fishermen's logbooks are delivered and kept, subject to the provisions of Article R436-64 [of the Environmental Code]<sup>20</sup>. PLAGEPOMIs also incorporate local versions of national and even international plans on some species (eel and salmon). The European sturgeon is not statutorily included in PLAGEPOMIs.

Created in the wake of Decree no.94-157 of 1994 "on fishing of fish belonging to species living alternately in fresh water and salt water", COGEPOMIs are organisations dedicated to management of river fishing in Metropolitan French waterways occupied by diadromous species. Absence of such organisational entities in Overseas France, and of any equivalent alternative organisation or regulation, makes management and preservation of diadromous species more difficult in Overseas territories, in particular in view of local fishing practices (see *below*, "special case of Overseas France").

**Special entities governing fishing.** The systematic or mandatory existence, of associations or professional bodies for professional fishermen (National Committee for Professional Freshwater Fishing (CONAPPED), National Committee / Regional Committees / Interdépartemental Committees for Marine Fisheries and Sea Farming (CNPMEM / CRPMEMs / CIDPMEMs)<sup>21</sup>, and producers' organisations for professional sea fishermen) and amateurs (National Federation of Fishing in France (FNPF) / départemental fishing federations, and recreational sea-fishing associations and federations) enables monitoring of fishing

<sup>&</sup>lt;sup>19</sup> Artois-Picardy; Seine-Normandy; Rhine-Meuse; Brittany; Loire; Garonne, Dordogne; Adour; Rhone-Mediterranean; Corsica (Article R436-47 of

<sup>&</sup>lt;sup>20</sup> Article R436-45 of the Environmental Code

<sup>&</sup>lt;sup>21</sup> Article L.912-1 of the Rural and Sea Fishing Code

activities and obtainment of information on types of practices employed and species targeted. Such entities also enable organisation of exchanges between fishermen, their representatives, scientists, and State departments.

However, such organisations are largely absent in Overseas French inland waterways. Reunion Island is the only French Overseas Département with a Fédération départementale de pêche et de protection du milieu aquatique (FDPPMA 974 – Départemental Federation for Fishing and Protection of Aquatic Environments). The absence of any dedicated interlocutors in Overseas France for recreational river fishing makes it more difficult to organise exchanges between the various actors concerned by migratory fish.

In the maritime domain, although recreational sea-fishing federations and associations exist, there is no legal membership requirement.

**Data from fisheries.** Data from fisheries are invaluable for estimation of the pressure that this activity exerts on diadromous species, providing information on the presence of a given species in a given place and time, and estimating the size of species' populations (in particular by calculating the number of catches per unit effort (CPUE)), determining their characteristics and, more generally, providing information on their population status. In addition, catch reports help ensure management of fishing activities and assess the effectiveness of the regulatory measures implemented.

However, methods for reporting catches differ from one area to another. Fisheries are all required to report their catches in the same way, as current fishing regulations are established in accordance with salt water demarcation lines. River fishing regulations differ from sea fishing regulations, as do types of fishing authorised, reporting methods, related pressures and available data, depending on the area in question. Articles R.436-44 to R.436-68 of the Environmental Code attenuate these differences, however, by establishing harmonised management and fishing rules for certain migratory fish species, between salt water demarcation lines and the maritime lateral limit.

Report quality and completeness are major issues. Knowledge of the characteristics of individuals caught and methods used (size / weight and stage of maturity / age group, exact place of catch,

origin/population, presence of pathologies/lesions, etc.) is essential for assessment of pressure on species and obtainment of knowledge on populations. Sampling of individuals can also prove useful in this regard.

Adjustments to fishing activities and fishing grounds. In accordance with species' situations, efforts to reduce fishing-related pressures have been made following international and national decisions – such as fishing quotas and decommissioning plans – and local decisions at drainage basin level under the aegis of COGEPOMIs (quota, moratorium, technical measures, fishing season, etc.). In a context of species depletion, it is worth mentioning a few examples of management measures such as the moratorium on allis shad fishing in the Garonne-Dordogne-Charente-Seudre-Leyre COGEPOMI area, the prohibition of salmon and sea trout fishing on the Loire<sup>22</sup> and the prohibition of fishing and using bottom-set and fixed nets in certain sectors of the Seine-Normandy basin<sup>23</sup>.

Allowing fishing in areas identified as being residual zones for species or in sectors with high concentrations of individuals creates pressure on the resource. Logically, this is true upstream and downstream of obstacles (see *above*, Chapter3, Part B, subsection a, "River continuity – barrier effect") and on spawning grounds, as well as along coastlines and in estuaries, all the more so during upstream migration of spawners and outmigration of juveniles (and vice-versa for the eel). Such areas are transit sectors, and also act as stabling zones, sometimes for long periods, for individuals in recognition and acclimation phases (Acou et *al.*, 2013; Morandeau & Caill-Milly, 2011). The importance of these coastal areas is demonstrated, for example, by accidental catches of shad on Natura 2000 sites located in the Bay of Biscay, between the Loire and Gironde estuaries, (Lepareur & Aish, 2012) and of salmon in shallow waters near fresh water (estuaries and streams) on the Landes coast (Morandeau & Caill-Milly, 2011).

Hence, adjustment of fishing regulations (closing, or prohibition of non-selective fishing techniques) in certain important areas and at certain crucial periods in fishes' lifecycles may prove necessary, two examples being the seasonal confinement area introduced on the Landes coast in favour of salmon and the prohibition on landing allis shad in the Gironde and Charente-Maritime seaports. France

<sup>23</sup> Order no.81/2020 regulating the fishing of migratory species in the maritime sections of estuaries, watercourses and canals in Normandy for the 2020-2021 period

<sup>&</sup>lt;sup>22</sup> Order no.262/2009 prohibiting professional and recreational Atlantic salmon (Salmo salar) and sea trout (Salmo trutta, f. trutta.) fishing, by any means whatsoever upstream of the Loire-Brittany basin's salt water demarcation line in the départements of Loire-Atlantique and Vendée and up to the limit of the Pays de la Loire Region's territorial waters

implements such regulatory tools as setup of fishing reserves (Articles L. 436-12 and R.436-69 of the Environmental Code) and Fish Conservation Zones (Articles L.924-1 to L.924-6 and R924-1 to R924-7 of the Rural and Sea Fishing Code).

Coherent management of the land-sea continuum. Diadromous species are symbolic of the land-sea continuum, as they evolve in fresh and salt water alike. This highlights the need for regulatory consistency in fishing management within the continuum. Although Articles R.436-44 to R.436-68 of the Environmental Code are good illustrations of such consistency, other initiatives also exist. One example of coherent fishing management in the land-sea continuum is to be found in Mont-Saint-Michel Bay in the Seine-Normandy basin. In 2017, regulations governing salmon catches were harmonised between inland waterways and the maritime domain. The move was the result of major consultations between users and was the subject of a communication campaign targeting the actors concerned.

Special case of Overseas France. Section 3 of Chapter VI of Title III of Book IV of the Environmental Code, entitled, "Management and fishing of fish belonging to species living alternately in fresh water and salt water" sets out the management and fishing rules applying between the salt water demarcation line and the marine lateral limit and concerning migratory fish, enabling harmonisation of such rules between inland waterways and the maritime domain in this limited area. Article R.436-44 of the Environmental Code specifies the territorial limits and the species concerned. It only mentions Metropolitan France's diadromous species. Nor is Overseas France included on the list of France's major hydrographic basins, as the 9 currently identified are all in Metropolitan France. Hence, special knowledge and measures are required for management of migratory fish and crustaceans present in Overseas France.

**French West Indies.** River fishing is totally prohibited in Martinique<sup>24</sup> and much of Guadeloupe<sup>25</sup>, mainly for health reasons to do with Chlordecone contamination. Professional sea fishing is also totally or partially prohibited in Guadeloupe in areas contaminated by Chlordecone, in compliance with the Order

<sup>24</sup> Prefectoral Order no.R02-2017-12-28-003 on prohibition of fishing and marketing of fish and crustaceans caught in rivers on Martinique's territory.

<sup>25</sup> DAAF/Direction (Directorate for Food Agriculture and Forestry) Order of 29 July 2016 regulating the fishing of fish, crustaceans and molluscs in certain permanent watercourses in Guadeloupe.

of 26 June 2013<sup>26</sup>. Traditional forms of recreational fishing are practiced in the estuaries, mainly targeting "pissiettes" (Guadeloupe) and "titiris" (Martinique), local names for the juveniles of amphidromous fish of the genera *Sicydium* (for the most part) and *Eleotris*, which are recolonising the rivers (Tabouret, 2012). This is a further impediment to recruitment, colonisation and reinforcement of stocks of these species.

Indian Ocean. Eels are not fished in Mayotte as they are a "taboo" fish, and fishing mainly focuses on crustaceans of the genus Macrobrachium (chevrettes and crayfish) (Tabouret, 2012). On Reunion Island, all fish species are concerned by fishing. It is prohibited to fish for 7 of the 15 diadromous species to be found on the island and whose conservation is deemed to be of priority concern<sup>27</sup>, and numbers of catches are limited for the other 8 (authorised period, minimum catch size, number of catches per day, etc.)<sup>28</sup>) (DEAL Réunion et al., 2019). When it was found that the "bichique" resource was becoming seriously depleted, a measure prohibiting its fishing between March and September was adopted on Reunion Island in 2020. The new regulatory measure also defined no-fishing zones in rivers and on the sea, in particular in free channels (breeding channels), and prohibited fishing on the right side of the 12 main permanent rivers' estuaries (Bonnefoy, 2021). In parallel, use of end lines for eel fishing has been reduced over recent years and prohibited on a number of rivers. This was done with a view to encouraging fishermen to use the "à la tâte" fishing technique that enables release of catches that are too small and of eel species whose fishing is prohibited (DEAL Réunion et al., 2019). Implementation of Reunion Island's new fishing regulations will assign fishing rights in accordance with fishermen's status and whether or not they can sell the results of their activities; it will also enable obtainment of information on numbers of fishermen, quantities caught, times of year, etc.

**French Guiana.** In French Guiana, the only diadromous species subject to small-scale professional coastal fishing is the tarpon, *Megalops atlanticus*. However, traditional non-selective fishing methods are used, such as pêche à la nivrée (ichtyotoxic plants-based fishing) and "Chinese barrier" fishing), which may

<sup>&</sup>lt;sup>26</sup> Dynamic mapping of no-fishing zones in bays and the sea, in force in Martinique: <a href="https://cartes.observatoire-eau-martinique.fr/adws/app/83f52cae-8825-11e7-bae5-dd76fc4678e9/index.html">https://cartes.observatoire-eau-martinique.fr/adws/app/83f52cae-8825-11e7-bae5-dd76fc4678e9/index.html</a>

Regulations governing coastal sea fishing in the waters of the Département of Guadeloupe: <a href="http://www.dm.guadeloupe.developpement-durable.gouv.fr/reglementation-regionale-r75.html">http://www.dm.guadeloupe.developpement-durable.gouv.fr/reglementation-regionale-r75.html</a>

<sup>&</sup>lt;sup>27</sup> Corresponding to species classified as Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR) and assumed extinct on the IUCN's most recent Red List for Reunion Island (see Table 7).

<sup>&</sup>lt;sup>28</sup> Regulation of freshwater fishing under Prefectural Order no.2017-2806/SG/DRCEV of 27 December 2017

affect other diadromous species (Tabouret, 2013). Furthermore, there is no Départemental Fishing Federation in French Guiana, which limits regulation of river fishing. The impact of fishing on diadromous fish is yet to be determined in this territory.

# D. Pressures relating to repopulation operations and aquaculture

# a. Fish farms

There are 521 fish production companies, including 280 marine fish farms in Metropolitan France according to the 2020 Aquaculture Survey carried out by the Ministry of Agriculture and Food's Statistics and Forward Planning Department. According to the Comité interprofessionnel des produits de l'aquaculture (CIPA – Interprofessional Committee for Aquaculture Products), over 96% of national production is represented by salmonids, 28% of which are released for repopulation purposes. This is an important sector in France, creating jobs in rural areas and promoted by populations ever more desirous of consuming local, environmentally respectful products (Communication from the Ministry of Agriculture and Food on the Charter of Commitment for Sustainable Development and French Aquaculture, 2017). Like any other anthropic activity, fish farms have impacts on the aquatic environment and wild fauna. They are therefore governed by strict regulations designed to protect aquatic environments, and, depending on location and size, are subject to authorisations based on the Water Law, using the nomenclature IOTA (Installations, Ouvrages, Travaux et Activités), referring to facilities, works, undertakings and activities impacting water and aquatic environments, and/or Installations Classées pour la Protection de l'Environnement (ICPEs – Facilities Classified for the Protection of the Environment) requiring an environmental authorisation pursuant to Article L181-1 of the Environmental Code. This regulatory framework mainly focuses on measurement and respect of flows (instream and bypass) in watercourses tapped to supply fish farms, measurement and respect of the quality of water exiting fish farms, and respect of ecological continuity. The technical rules that continental fish farms must comply with are specified in the Order of 1 April 2008, which includes the following obligations

• Tapped water flow is set in the individual authorisations issued by the administration, and fish farms must be able to measure the incoming flow at any time. There is also an instream flow to be respected in tapped watercourses.

- Fish farms must have systems for preventing fish from escaping into the environment and ways of maintaining them.
- The quality of effluents discharged by fish farms must comply with minimum and maximum concentrations/values, in particular with regard to temperature, pH, oxygen, suspended matter, NH<sub>4</sub><sup>+</sup>, NO<sub>2</sub><sup>-</sup>, PO<sub>4</sub><sup>3-</sup> and BOD5.
- Supervision of ways of using, storing and eliminating products for treating/cleaning/disinfecting animals and facilities.

Supervision of fish farms' main impacts on the aquatic environment is complemented by the animal health accreditation delivered and monitored by Government offices, which regulates the health risks to farmed fish and conditions for use of products for treatment/disinfection/ healthcare of fish and facilities, in order to prevent transmission and spread of diseases between fish farms and the natural environment, and within a fish farm.

These main authorisations and the obligations that they include (delivered and monitored by Government offices) help meet aquatic environment managers' main concerns.

They committed fish-farmers to sustainable development of the fish-farming sector in 2011. They were followed by a progress plan, signed in 2015, designed to assist professionals integrate regulatory environmental requirements into their farms. Reconciliation of the fish-farming sector's economic development and compliance with environmental requirements is of major importance, as has been emphasised by the Ministries responsible for Agriculture, Fishing and the Environment. In the 2014-2020 Plan stratégique national pluriannuel de développement aquacole (PSNPDA – Multiannual National Plan for the Development of Sustainable Aquaculture), the environmental aspect is stressed and highlighted via the emergence of so-called "controlled" and "integrated" farms (PSNPDA, 2015). The same provisions are included in the 2021-2027 Plan d'aquacultures d'avenir (P2A – Future Aquaculture Plan).

<sup>&</sup>lt;sup>29</sup> Modes of closed-loop production, a sustainable approach to production with such accreditations as Aquitaine's AquaREA Charter.

<sup>&</sup>lt;sup>30</sup> Organic aquaculture, integrated multi-trophic aquaculture (IMTA) and aquaponics.

# b. Transfers and repopulation

Release of migratory diadromous and other fish species is a commonly practiced management measure in France (Daupagne et *al.*, 2019; Cucherousset, 2017; Cucherousset et *al.*, 2021). In Metropolitan France, fish stocking operations are carried out by 88.6% of Associations agréées de pêche et de protection des milieux aquatiques (AAPPMAs – Approved Associations for Fishing and Protection of the Aquatic Environment) at a substantial economic cost, accounting for an average of 65% of such organisations' annual budgets (Cucherousset, 2017; Cucherousset et *al.*, 2021). Several thousand tonnes of fish are used every year for repopulation, over half of which are salmonids<sup>31</sup>.

The introduction of non-native species can also upset the environment's natural balance, at trophic-chain level by introducing new species that prey on migratory fish as well as at health level via introduction of new diseases and parasites (Cucherousset & Olden, 2020; Daupagne et *al.*, 2019; Spalinger et *al.*, 2018).

Two different fish restocking strategies are implemented in France. The first consists of releasing fish with a view to their being fished within a short period of time, no more than a few days. This is done with fish of so-called "serving size" or sometimes larger. Such fish are not intended to stay in the river in order to breed, but rather to be caught by fishing enthusiasts. Consequently, the strategy generally has a limited spatiotemporal impact. The second strategy consists of introducing individuals at early physiological stages of their development (i.e. elvers and troutlings) in the context of repopulation schemes. The aim here is to enable juvenile individuals to settle in the environment, develop to adulthood and breed. For this type of repopulation, AAPPMAs usually prefer to use local strains genetically adapted to their environments. Such repopulation operations also take account of watercourses' reception capacities. Transfer operations aiming to repopulate environments do not always appear to be well suited to their purpose, taking account of such scientific, biological and/or health data as genetic adaptation, quantities of fish transferred depending on the environment's reception capacity, and how well suited a release area is for establishing a given species (Cucherousset, 2017). A number of COGEPOMIs and

<sup>&</sup>lt;sup>31</sup> Salmonids account for the great majority of repopulations carried out in watercourses compared with such operations carried out in waterbodies, the most commonly released species being the rainbow trout, *Oncorhynchus mykiss*, a non-native species (Cucherousset et al., 2021).

migratory fish associations state that they take these factors into consideration, watercourse reception capacity in particular, although there is still little scientific literature on this subject.

COGEPOMIs also take account of the existence of operational natural spawning grounds as they can disturb reproduction of alevins. It is worth noting that existence of past spawning grounds (n-1) may also be taken into consideration provided that mapping is regularly updated by the competent departments.

As yet, no shared rigorous specifications exist governing fish releases for whatever purpose, including in enclosed waters and in the private domain, where there are risks of non-native species escaping during floods. Production of a "best repopulation practices" guide would therefore seem necessary, as well as supervision of the practices involved. In general, there is little monitoring of repopulation and transfer operations (Cucherousset, 2017; Dekker & Beaulaton, 2016) when they have not been identified in PLAGEPOMIs. Several studies show that the effectiveness of repopulation practices varies considerably and is highly dependent on context (Cucherousset et al., 2007; Lorenzen et al., 2012; Roques et al., 2018). While circumscribed repopulation operations may be of interest to fishing enthusiasts in that they result in more catches, studies suggest that those undertaken in order to support wild populations alongside natural recruitment are of vey variable effectiveness. (Baer & Brinker, 2010; Johnston et al., 2018; Lorenzen et al., 2012). As a variety of factors contribute to the effectiveness of repopulation actions, depending on hydrographic basin and the environment's reception conditions, studies show that results can vary greatly. For example, according to the literature on the subject, actions carried out on the Gave de Pau and the Couesnon's drainage basin, watercourses with extremely favourable reception conditions for Atlantic salmon, seem to have been effective.

Hence it would still seem necessary to improve quantitative estimations of such repopulation practices at national level, as well as in other countries, in order to better understand the biological and economic impacts of such activities, whatever their purpose (Cucherousset et *al.*, 2021).

It would also seem necessary to couple these actions with restoration of habitats and watercourses. Without access to quality habitats, restoration by alevin stocking will not work (Cuinat, 1971).

Finally, such operations should be seen as compensatory measures designed to counterbalance anthropic impacts and meet the demand for fishery products (Cucherousset, 2017; Daupagne et *al.*, 2019).

The aims of such operations have varied over the last few centuries: increase the intra-basin fish biomass and create a food reservoir, meet the demand for fishery products, and lend support to existing wild populations on the point of extinction or in decline, in order to restore biodiversity (Cucherousset, 2017; Dekker & Beaulaton, 2016). These days, it would seem necessary to ensure that the purposes of repopulation operations carried out on French soil are explained, fully assumed and shared, and that their interest and limitations are clearly outlined.

# E. Pressures relating to poaching

By definition, resources removed in the context of undetected illegal fishing activities (known as IUU fishing, standing for "illegal, unreported and unregulated") are hard to quantify. According to the UN Food and Agriculture Organisation (FAO, 2015), catches in the context of IUU fishing were estimated as 20% of all catches worldwide; after demersal white fish, migratory species (salmon, trout and smelt) account for the highest percentage (45%) of illegal or unreported catches in the open sea (Agnew et *al.*, 2009). There is a significant connection between a country's governance<sup>32</sup> and the prevalence of IUU fishing. Such activities are mainly carried out in regions of the world where developing countries are located, often neighbouring Overseas French territories, and where few if any controls are carried out and regulation is almost non-existent. This highlights the importance of a country's governance.

In Metropolitan and Overseas France, poaching comes in a variety of forms and may be divided into two main categories, "small-scale" and "large-scale" poaching (Valade, 2018): the first includes use of authorised techniques but without a fishing licence, fishing during closed season periods, and accidental catches of unauthorised species by anglers poorly informed of the regulations; the second includes fishing by poisoning the water, watercourse diversion, use of prohibited fishing gear and, more generally, organised targeted fishing, often on a massive scale, of a species for commercial purposes (such as elvers, Atlantic salmon, bichique, pisquettes, titiris and chevaquines) (Association Normandie Grands Migrateurs, 2018; Tabouret, 2012; Valade, 2018). Some poaching techniques are particularly damaging

32 Via use of the World Bank Institute's Worldwide Governance Indicators (WGI) (https://info.worldbank.org/governance/wgi/).

60

to biotopes and biocoenoses, including discharge of chemical products in order to poison rivers, diversion of channels and dewatering of river arms, and use of mosquito nets.

Consequently, countermeasures differ depending on type of poaching. In the first case, communication, awareness-raising and prevention are all of importance, while in the second case, strategic targeted controls in time and space along with appropriate dissuasive penalties are required.

Putting the necessary pressure on poachers requires organisation of field operations along with coordination and mobilisation of the various administrations concerned via interdepartmental operations. Among others, the Division of Ocean Affairs, the fisheries police, the gendarmerie, the Office central de lutte contre les atteintes à l'environnement et à la santé publique (OCLAESP – Central Office against Environmental and Public Health Crime), the OFB, fishery committees and fishing federations are all concerned.

Combating such practices helps preserve resources.

In the French West Indies, in addition to the problems that some poaching practices cause with regard to preservation of species, IUU fishing also causes real health problems, as waters are sometimes contaminated.

Finally, in Metropolitan France, with major demand on the black market and very high prices (€100-€150/kg for wild salmon and €350-€420/kg for elvers fresh off the boat; OFB, 2020), poaching is a control priority in all basins and territories. Combating poaching involves the whole sector, from catch to marketing to final purchase.

# F. Pressures relating to predation and exotic species

According to IPBES (2019), introduction of IES is the 5<sup>th</sup> cause of biodiversity loss worldwide. Several Conventions and regulatory tools exist at international, European and French levels alike<sup>33</sup>. European Regulation no.1143/2014 of the European Parliament and Council of 22 October 2014 on the

<sup>33</sup> https://www.ecologie.gouv.fr/especes-exotiques-envahissantes

prevention and management of the introduction and spread of invasive alien species was adopted in the context of the Berne Convention. Following its enactment, a national strategy on IES, covering Metropolitan and Overseas France, was approved in 2016. It aims to protect marine, fresh water and terrestrial ecosystems, fauna and flora from risks and impacts associated with biological invasions, and is coordinated with already existing local strategies.

# a. Metropolitan France

The wels catfish, *Silurus glanis*. First introduced in the mid-19th century, the species was also released into rivers in the 1970s and 1980s to meet recreational fishing needs (GT IBMA, 2016b). Since then, the catfish has been included on the list of species of fish, crustaceans and frogs present in the waters referred to in Article L.431-3 of the Environmental Code, prohibiting the introduction of these individuals without authorisation. Due to the variety of feeding strategies that these catfish have developed, along with their opportunism and capacities for adaptation, their impact on the ecosystem's species richness are a focus of discussion (Copp et *al.*, 2009; Guillerault et *al.*, 2015; Vejřík et *al.*, 2017). Several recent studies show that there may well be significant predation pressure on migratory fish from catfish (Boulêtreau et *al.*, 2018, 2020, 2021; Belhamiti et Boisneau, 2015). Impacts on species are aggravated by the presence of obstacles that slow down migrations and result in accumulations. Predation at crossing systems has also been observed in some areas. Recent studies have shown how sensitive the sea lamprey is to predation by catfish (Boulêtreau et *al.*, 2020). Shad are also sensitive during spawning, in particular on forced spawning grounds downstream of obstacles, due to the catfish's predation strategy: nocturnal predation based on water vibrations (Carol et *al.*, 2007; Cucherousset et *al.*, 2012; Pohlmann et *al.*, 2004).

The signal crayfish, *Pacifastacus leniusculus*. This decapod crustacean is a freshwater IES present in a great many of France's watercourses (INPN, 2017). The European Commission has included it on the list of invasive exotic species of concern to the European Union, in compliance with Regulation (EU) no.1143/2014<sup>34</sup>. It seems to have a significant impact on salmonids and, more generally, on benthic fish and crustaceans, as it interferes at several levels. It preys upon salmonid eggs and alevins (Edmonds et *al.*,

<sup>34</sup> https://eur-lex.europa.eu/legal-content/FR/TXT/PDF/?uri=CELEX:32016R1141&from=FR

2011; Findlay et *al.*, 2015). It also competes for shelters with benthic fish (including salmonids) and macrocrustaceans and is capable of dislodging them from sheltered areas (Griffiths et *al.*, 2004). And finally, it modifies the habitat's sedimentary nature, fostering the formation of fine sediments, which can have a negative impact on the survival of salmonid eggs and alevins in breeding grounds (Harvey et *al.*, 2011).

The sea walnut, *Mnemiopsis leidyi*. This transparent pelagic ctenophore is an ES that has been present on all Metropolitan France's coasts since the 2000s if not before (Antajan et *al.*, 2014; Pôle-relais lagunes, 2021). As a euryhaline eurytherm able to make its way up estuaries, it is a threat to all fish species. This carnivorous species is reputed to be highly voracious and feeds on zooplankton and above all on fish eggs and larvae (Ziemski & Maran, 2020). Over recent years, Mediterranean eel fishermen have reported major damage caused by this cnidarian, which clogs up nets and mutilates catches (Marchessaux, 2019). More recently, its major presence in a number of Brittany's watercourses has been highlighted by the Bretagne Grands Migrateurs Association. Known to have contributed to the collapse of stocks of anchovies and horse mackerel in the Black Sea following its introduction in the early 1980s (Ivanov et *al.*, 2000), this species generates socioeconomic problems as well as causing ecological damage, in particular by upsetting the trophic network (Pôle-relais lagunes, 2021). Its direct impact on migratory fish is yet to be studied, but a close eye needs to be kept on it if its density continues to increase in watercourses.

The topmouth gudgeon, *Pseudorasbora parva*. This fish, originally from Asia, is an IES introduced into Central Europe in the 1960s via carp intended for aquaculture (GT IBMA, 2016a) and introduced into France some ten years later. These days, the topmouth gudgeon is to be found in all the country's large basins (Gozlan, 2019; Poulet, 2020) as its biology provides it with good capacities for growth, colonisation and establishment in all freshwater aquatic environments (see references in Gozlan, 2019). The European Commission has included it on the list of invasive exotic species of concern to the European Union, in compliance with Regulation (EU) no.1143/2014<sup>39</sup>. This fish poses a threat to endemic fish species as it is a healthy carrier of the parasite *Sphaerothecum destruens*, better known as the "rosette agent". This parasite affects a wide range of hosts (cyprinids, percids and salmonids alike), leading to high mortality rates that can have significant consequences on the rapid decline of fish populations (Gozlan, 2019; GT IBMA, 2016a) (*see below*, Chapter 3, Part G, subsection b). Gozlan also (2019) points out that the

continued presence of a healthy carrier such as the topmouth gudgeon maintains high levels of virulence on the part of the pathogenic organism.

Zebra mussel, *Dreissena polymorpha*. The zebra mussel is an ES with widespread presence in Europe and North America. It was first reported in France in the late 19<sup>th</sup> century (Lamand, 2015). Classified as an engineer species, the zebra mussel adapts the environment in which it lives, modifying its habitat by doing so. Studies carried out in the United States have shown that modifications at primary production level caused by *D. polymorpha* are harmful to "open-water" fish such as shad (*Alosa* spp.) (Higgins & Zanden, 2010; Strayer et *al.*, 2004). More recently, Schultz et *al.* (2019) have confirmed the fact that zebra mussels significantly impair the trophic chain and reduce availability of prey essential to the American shad's juvenile stages. These authors assume that this has probably contributed to reductions in recruitment of shad. Two further additions might well be made to the list of invasive exotic species.

# Corbicula fluminea and corbicula fluminalis,, two distinct species both commonly known as Asian clams.

Corbicula are bivalve molluscs, the world's most widespread aquatic IES<sup>35</sup> (Sousa et *al.*, 2008). They started colonising France's drainage basins in the 1980s and 1990s and can be found in high densities (Brancotte & Vincent, 2002). Like the zebra mussel, corbicula are not regulated, and are defined as an engineer species as they modify their environment and have an impact on their habitat. Where they are abundant, their high filtering capacity leads to a steep drop in phytoplanktonic biomass and consequently of primary production (Vohmann et *al.*, 2010), which impacts zooplanktonic biomass in its turn (Pigneur et *al.*, 2014). Hence, invasion by these filtering organisms and their impact on plankton have a negative impact on ecosystem processes and productivity overall. However, there are very few studies available on these invasive bivalves' influence on upper trophic levels, as most of them have focused on the zebra mussel. One study measured the *C. fluminea* clam's influence on various epibenthic fish, including the European eel and the sea trout (Ilarri et *al.*, 2014). These authors state that these two migratory fish are to be found in greater abundance where there are high densities of corbicula. In view of such studies, it would be helpful to acquire more knowledge on each of these IES bivalves, as the phenomena connected with their

 $<sup>^{35}</sup>$  Most international studies have also focused on *C. fluminea* rather than *C. fluminalis*.

impacts are complex and depend on a range of ecological factors, which are themselves closely connected with the environmental context (Ilarri et *al.*, 2014; Strayer et *al.*, 2004).

# b. Overseas France

In 2011, the number of identified fish species introduced into Overseas French rivers and estuaries stood at 4 in Guadeloupe, 5 in Martinique, 1 in Mayotte and 13 on Reunion Island (Tabouret, 2012). Exotic species are introduced by various means, some more deliberate than others, the main reasons being aquaculture, aquariology and (anti-mosquito) vector control. Consequences can be more harmful in island environments (N. Myers et *al.*, 2000). This is not always true, however, as not all exotic species are invasive.

French West Indies. Species introduced into Guadeloupe and Martinique include the Mozambique tilapia, *Oreochromis mossambicus*, which is one of the world's 100 most invasive species that disturb ecosystems the most (Lowe et *al.*, 2000). Reared on fish farms, its introduction is subject to Regulation (EC) 708/2007 of the Council of 11 June 2007 on use in aquaculture of exotic species and locally absent species. Fish farms in Overseas France are subject to the same authorisation systems as in Metropolitan France (see Part D point a of this document). Also present, the guppy, *Poecilia reticulata*, was introduced for vector control purposes. The exact impact that these species have on indigenous ichthyofauna is yet to be measured on these islands. Nonetheless, several studies carried out in other parts of the worlds have highlighted the threat they represent for endemic species: competition for ecological and trophic niches, predation of eggs and juveniles, hosts of pathogenic organisms, etc. (see references in Tabouret, 2012). Furthermore, according to Terrigeol & Gigot (2019), it seems that the Martinique-bachling, *Anablepsoides cryptocallus*, an increasingly rare species endemic to Martinique, is threatened in general by pollution and urbanisation as well as by competition with fish that have been introduced onto the island.

In the context of work currently being carried out on IES in Martinique (thesis by Thomas Baudry underway), the Australian red claw crayfish, *Cherax quadricarinatus*, which was introduced in 2004 and seems to have colonised many of the island's watercourses quite quickly (Baudry et *al.*, 2020) appears particularly sensitive. The exact impact that this species has on Martinique's ecosystem is unknown, although several studies across the world have already shown the effects that allochthonous crayfish have on the trophic chain and indigenous species richness (see references in Baudry et *al.*, 2020); mention is

also made of probable competition on the part of *C. quadricarinatus* for ecological niches vis-à-vis prawn species belonging to the genus *Macrobrachium*. The Pleco<sup>36</sup> has also been observed very recently and described as being an IES according to the criteria established by the IUCN (Dubreuil, 2021; UICN, 2015). Although the exact impact that this species has on Martinique's ecosystem is unknown, its introduction into a number of countries has had significant and quite well documented socioeconomic and environmental impacts (see references in Dubreuil, 2021).

Indian Ocean. On Reunion Island and Mayotte, the guppy, *P. reticulata*, also known as the million fish, is an introduced species. In other countries where they have been introduced, Poeciliidae are suspected of preying on fish eggs and of being responsible for the depletion of indigenous species (Soubeyran, 2008). Among other recent introductions on Reunion Island due to aquariology, two carnivorous fish from the Cichlidae family seem to pose a threat: the jaguar cichlid, *Parachromis managuensis*, and the convict cichlid, *Amatitlania nigrofasciata*. The real impact of these two species has not been specifically studied, but several authors highlight the potential impact of their presence on indigenous fauna (OCEA, 2011). It seems that the jaguar cichlid is extremely aggressive, both intra- and inter-specifically, as is the convict cichlid due to its territorial behaviour which may have an impact in terms of competition with and predation on indigenous species (Richarson & Valade, 2008). IES seem to be present in high concentrations in ponds and downstream sections of watercourses that correspond to transit zones for migratory species' juveniles (Valade, 2018).

**French Guiana.** French Guiana seems to be largely unaffected by biological invasions. Nonetheless, information is still sporadic and few data are available (Tabouret, 2013). According to Soubeyran (2008), following the development of aquariology, exotic fish were able to colonise a number of fragile sites, including the marshes along the département's east coast, downwards from Suriname, as is also the case, for example, with the Mozambique tilapia, *O. mossambicus*<sup>37</sup>, which was introduced into the country in 1955. In the rivers and canals where this fish is to be found, its presence has led to major reduction of species diversity, prevailing over the common snook, *Centropomus undecimalis*, the mullet, *Mugil* 

<sup>36</sup> Common name for several species of catfish belonging to the Loricariidae family, and including Hypostomus robinii.

<sup>&</sup>lt;sup>37</sup> It should be borne in mind that this fish is one of the world's most invasive species and that it causes significant disruptions to the ecosystems it is introduced into (Lowe et al., 2000).

cephalus and Mugil curema, and the tarpon (Tabouret, 2013). It would appear that other species may have been introduced accidentally, but the impact on indigenous species is yet to be documented (Mol, 2012).

When fauna inventories are made in French Overseas territories particularly affected by IES, they are often found in high densities. As their impacts on indigenous ichthyofauna are yet to be measured, no conclusions can be put forward. The same is true for Metropolitan France, where characterisation and assessment of impacts and the evolution of colonisation of watercourses by IES are not well documented.

# G. Pressures relating to diseases

Microorganisms are a part of biological diversity and play an essential role in the operation of ecosystems and ecological balance, whether or not they are pathogenic. Like all living species, they possess evolutive ecological methods of interaction with their environment, as well as with their hosts. Development of a disease depends on this triangular interaction between pathogenic agent, host and environmental conditions: the conceptual model of the "Disease Triangle" (McNew, 1960). Diseases are usually part of a process due to some kind of natural imbalance, but such imbalances are often aggravated or even directly caused by human beings' action on the environment and biocoenoses (Scholthof, 2007). Increases in population densities in limited spaces, facilitation of contacts between individuals, whether or not of the same species, climate change and modifications of environments' physicochemical parameters are all factors that foster emergence, or re-emergence of infectious diseases (Blanc et al., 2017).

The World Organisation for Animal Health (OIE) (the former Office International des Epizooties) was established in order to provide worldwide management of diseases affecting land and water animals. Among other things, it identifies diseases that may have health impacts and those that pose a threat to aquaculture, fishing and natural populations. It issues guidelines that are then expressed in national or international regulations. In this particular case, diseases regulated within the EU are specified in Implementing Regulation (EU) no.2018/1882 of the European Commission: only VHS, IHN and ISA (and, to a lesser extent, KHV) are regulated. Some are not present in France or are of minor concern, while

others emerge sporadically and are monitored, above all in fish farms; such is the case with VHS and IHN<sup>38</sup>. There are other up-and-coming pathogenic organisms, however, which do not appear on this list but which are no less harmful. These pathogens' epidemiological processes on populations are often little known and should at minimum be monitored. Yet biodiversity diagnostics often overlook the role played by pathogenic organisms and infectious diseases in the decline of fish populations, even though aquacultural history has already seen various species nearly wiped out by major epizooties caused by allochthonous diseases (Combe & Gozlan, 2018; Gozlan, 2019). However, it should be borne in mind that fish released into rivers by French fish farms are not allochthonous species.

The viruses, parasites and bacteria referred to below are responsible for the main diseases discussed in the literature on "natural" threats to migratory diadromous species. Consequently, this section is not intended to be in any way exhaustive with regard to diseases so far identified.

#### a. Viruses

**IHN & VHS.** IHN and VHS are two viral diseases caused by rhabdoviruses and affecting salmonids in particular. Many other fish species have also proved sensitive, however, including the arctic grayling, the northern pike, the flounder and the river lamprey (EFSA, 2008). These diseases may lead to particularly high mortality rates in fish farms and natural environments alike, as juveniles are especially sensitive (OIE, 2019c, 2019b). The main problems with these virus are (i) horizontal transmission through water may be spread for several kilometres by the current, secretions (mucus, sexual fluids, and faeces), and (ii) they may linger in the environment – water and sediments – for up to a month under the right conditions (low temperature and wealth of organic matter). Fish farms have been monitored for these two diseases since the 1990s, in particular in order to detect any outbreak early on. Such monitoring is based on two measures, one mandatory and the other voluntary. The mandatory measure provides for culling of all the fish farm's fish if either of these diseases is detected; the voluntary system is described below.

A Programme National d'Eradication et de Surveillance (PNES – National Eradication and Control Programme) for IHN and VHS has been in effect since 2018, with the aim of eradicating them throughout

<sup>38</sup> As diseases regulated under the FWD (Directive 2006/88/EC) are the subject of a Programme National d'Eradication et de Surveillance (PNES – National Eradication and Control Programme) in the context of the Ministry of Agriculture and Food's "Fish Health Plan 2020".

68

Metropolitan France, although it is up to fish farmers to decide whether or not they wish to participate in it. Nonetheless, it has enabled increasing numbers of fish farms to be officially recognised as being free from these diseases, which is of importance given transfers of animals or farms for release and repopulation operations. In addition, the role played by affected fish farms in the direct dissemination of these viruses in the natural environment and contamination of wild populations and vice versa is yet to be demonstrated.

*Eel-Virus-European-X* (EVEX). The EVEX virus is the main rhabdovirus infecting eel populations and is very widespread, particularly in Europe (Jorgensen et *al.*, 1994; van Ginneken et *al.*, 2004). The virus indirectly affects infected individuals' breeding success as it has a negative effect during sustained swimming (van Ginneken et *al.*, 2005). These authors showed that infected eels developed haemorrhages and anaemia during a simulated migration and ended up dying prematurely. They also state that the spread of the virus, with transfers and aquaculture, in countries where it is practiced (as is the case in France), has certainly contributed to the decline in eel populations. In addition, it seems that the EVEX virus can also infect and be fatal to juvenile rainbow trout (van Beurden et *al.*, 2012).

In France, there are no data on this virus' prevalence among wild populations or the existence of potential virus-free areas. Nonetheless, it would appear that a substantial number of the elvers monitored over the last 40 years and more are EVEX carriers (Rigaud et *al.*, 2015). Hence, current elver transfer operations carried out as part of the Eel Management Plan help spread the virus, which is already present among elvers in the sea, and may pose a risk to virus-free populations and sectors.

Anguillid herpesvirus 1 (AngHV1). The eel herpes virus is a host-specific virus affecting the European eel, *A. anguilla*, the Japanese eel, *Anguilla japonica* and the American eel, *A. rostrata* (Kempter et *al.*, 2014; van Beurden et *al.*, 2012). This virus is one of the eel's main pathogenic agents and its involvement in the decline of stocks has been suggested on several occasions (Haenen et *al.*, 2012; van Beurden et *al.*, 2012). Like the EVEX virus, it is commonly found among eels bred on fish farms, in countries where such breeding is practiced (which is not the case in France), and can cause significant numbers of deaths. It is also present among wild eels in several European countries, including Germany, Belgium and the Netherlands (Philippart, 2019; van Beurden et *al.*, 2012). The herpes virus can be latent, so healthy carriers exist. Stress on individuals and increases in the environment's temperature are major factors that reactivate the virus and make it virulent, and also increase individuals' sensitivity to secondary infections (Haenen et *al.*, 2012;

van Beurden et *al.*, 2012). A positive correlation has been observed between AngHV1's viral load and Anguillicola crassus' *parasite load*, which has proved to be a major stress factor for eels (see *below*, subsection b) (Kullmann et *al.*, 2017).

Little is yet known about the prevalence, pathogenicity and mortality caused by AngHV1 in wild populations in France and Europe. Special attention should nonetheless be paid to these concerns in the context of global change, increase in stress conditions and increase in water temperatures. The absence of any regulatory obligations as to transferred elvers' and eels' health status does not help encourage investigations, although anthropic propagation of AngHV1 by eel repopulation is a reality (Kullmann et al., 2017) and a number of authors have raised the alarm on the risk to wild populations, in particular as long-term consequences remain unknown (Haenen et al., 2012; Kullmann et al., 2017).

Infectious pancreatic necrosis (IPN). This infectious disease is caused by a birnavirus and affects several fish species, most of them in the salmonid family (salmon, trout, arctic char and lake whitefish). Many other freshwater and saltwater species (fish, molluscs and crustaceans) can be carriers and are regarded as reservoirs (De Kinkelin et *al.*, 2018; MPO, 2017). The IPN virus is highly stable in the environment and is widely spread horizontally and vertically (MPO, 2017; Wallace et *al.*, 2008). It can cause substantial losses in fish farms and is ranked just behind IHN in terms of animal health risks for farmed fish (ANSES, 2015; De Kinkelin et *al.*, 2018). Due to its worldwide distribution, this disease is no longer included on the OIE's list of fish diseases, which has led to abandonment of control measures including regulatory restrictions on movement and mandatory elimination policies (MPO, 2017). Although it is regularly monitored in hatcheries, where it poses problems, no data are available as to this virus' prevalence in wild populations or its potential impact on their health. A study carried out in Scotland, in the maritime domain, has shown that fish farms are responsible for a slight increase in its prevalence among wild salmon present in their surroundings, by maintaining transmission of the virus (Wallace et *al.*, 2008). It should be borne in mind that Scottish production (200,000 tonnes in 2019) cannot be compared with French production, which is much lower.

#### b. Parasites

Anisakis spp. Anisakiasis is a cosmopolitan zoonotic disease<sup>39</sup> caused by a roundworm. Its lifecycle can involve several hosts, including crustaceans and fish<sup>40</sup> (EFSA, 2010). It is very widespread in the seas and oceans, infesting fish that live in them (anchovies, hake, whiting, horse mackerel and mackerel) as well as those that are simply passing through, such as migratory diadromous species (ANSES, 2017; Orain, 2010). Infestations are usually found in fishes' abdominal cavities and muscles, in very variable intensities (Gay et al., 2019). No information on its prevalence or potential harmful effects on migratory fish populations is available to date. A recent meta-analysis shows that parasitism intensity per Anisakis per fish has increased 283-fold over the last 50 years (Fiorenza et al., 2020). Hence, apart from the health aspect, the question arises of this parasite's impact on the health of fish already in fragile situations.

Gyrodactylus salaris. A parasitic flatworm particularly harmful to many salmonid species, it is included on the OIE's list of fish diseases as a "notifiable pathogen" causing a "significant disease". This parasite is present in much of Europe and its dissemination is mainly linked to rainbow trout movements between countries (Paladini et al., 2021; Peeler et al., 2006). In addition, the fact that hosts can be infected for long periods without showing any obvious clinical signs increases their role as sources of infection for other sensitive fish (Paladini et al., 2021). Its pathogenicity has been demonstrated for Atlantic salmon and trout (Bakke, 1991; Bakke et al., 2004). The mortality rates observed among Atlantic salmon alevins and parr can be particularly high (85-100%) in fish farms and natural environments alike (CORDIS, 2001; OIE, 2019a; Paladini et al., 2021). Although this parasite is not present in France, it is one of the main parasites identified with regard to health risks causing the most problems among farmed fish (ANSES, 2015). Its occurrence in European countries, whether bordering France or otherwise, makes it clear that health controls need to be carried out when salmonids are transferred (Lautraite et al., 1999; Paladini et al., 2021).

.

<sup>&</sup>lt;sup>39</sup> Zoonotic diseases are diseases that can be transmitted from vertebrate animals to human beings and vice versa (the best known being salmonellosis and listeriosis; <a href="https://agriculture.gouv.fr/les-zoonoses-ces-maladies-transmissibles-entre-lhomme-et-lanimal">https://agriculture.gouv.fr/les-zoonoses-ces-maladies-transmissibles-entre-lhomme-et-lanimal</a>).

<sup>&</sup>lt;sup>40</sup> They are paratenic intermediate hosts, whereas human beings are regarded as "accidental" hosts (among whom infestation can cause major reactions).

Anguillicola crassus. Anguillicolosis is caused by a widespread polyxenous parasitic nematode now present throughout the northern hemisphere, with high prevalences in France (Elie & Girard, 2009; ISC, 2019). The eel is A. crassus' permanent host, with the parasite infesting its swim bladder and causing severe pathologies (inflammation, lesions, haemorrhages and fibroses) (Lefebvre et al., 2012). It has a major impact on the population, reducing swimming efficiency and consequent migratory capacities (Palstra et al., 2007). According to these authors, it has contributed to the European eel's rapid decline, by preventing parasitised individuals from reaching spawning grounds. There are major prevalences in France and eel transfers have played a significant part in this parasite's expansion over the last few decades (Elie & Girard, 2009; Rigaud et al., 2015).

**Tetracapsuloides bryosalmonae.** This myxozoan parasite has a complex lifecycle that includes infestation of bryozoans; it causes polycystic kidney disease (PKD) among many salmonid taxa (Canning et *al.*, 1999). This disease, which poses a serious threat to salmonids, is known to result in high mortality rates in aquaculture and wild populations alike across Europe and North America (Hedrick et *al.*, 1993; Sudhagar et *al.*, 2020). In addition, rising water temperatures caused by climate change seem to accelerate the spread of this parasite. *For example, T. bryosalmonae* has been identified as one of the main causes of the decline of natural populations of Alpine brown trout (Borsuk et *al.*, 2006; Gorgoglione et *al.*, 2016). This has aroused the scientific community's interest, and the parasite's presence in wild salmonid populations has been researched and confirmed in several European countries close to France (Germany, Switzerland and the United Kingdom among others). Although few data exist on wild populations in French watercourses, this parasite has nonetheless already been detected in rainbow trout bred in fish farms in several regions (Henderson & Okamura, 2004; Sudhagar et *al.*, 2020).

**Sphaerothecum destruens.** This pathogenic agent, commonly known as the "rosette agent" and introduced at the same time as the topmouth gudgeon (see *above*), is a half-animal half-fungal parasite that can infect a large number of fish species and is fatal for most of them (Gozlan, 2019). It has major negative ecological and economic consequences in some areas, in fish farms and natural environments alike. For example, it only took a few years for the introduction of the topmouth gudgeon into Turkey's southeast drainage basin, and consequent spread of *S. destruens*, to cause a decline of over 80% in local fish populations (Ercan et *al.*, 2015). It was also responsible for sometimes chronic diseases leading to variable mortality rates among chinook salmon and Atlantic salmon (Arkush et *al.*, 1998, 2003). This

pathogenic organism is to be found in several areas of Metropolitan France, although some sectors are still exempt and deserve special protection (Gozlan, 2019). It would seem necessary to control transfers of fish that have come into contact with topmouth gudgeon, pursuant to the European regulation on prevention and management of the introduction and spread of IES (see Ministerial Orders of 14 February 2018<sup>41</sup>) (Poulet, 2020). In conclusion, this pathogenic agent has been identified as a real threat to fish biodiversity, in particular as it is maintained within a population of healthy carriers, alongside populations that are sensitive to it.

#### c. Pathogenic bacteria

In view of the number of fish farms affected and their persistence in the environment, pathogenic bacteria can be problematic for farmed and wild fish populations alike. They are the least monitored pathogenic agents: diseases not listed by the OIE, no mandatory reporting, and unregulated (Order of 29 July 2013).

The main harmful bacteria causing diseases among farmed and wild fish belong to the genus *Aeromonas* and the Flavobacteriaceae family (Barnes & Brown, 2011; Starliper, 2011).

The best known species of *Aeromonas* is *Aeromonas salmonicida* sub *salmonicida*. It causes furunculosis, a disease mainly found in salmon farms. This disease has been reasonably well controlled so far, but an upsurge in cases and recurring episodes have been reported. In some (non-EU) countries, massive use of antibiotics in fish farms over the years has resulted in major forms of antibiotic resistance (Hayatgheib et *al.*, 2021; Romero et *al.*, 2012). This is not the case in France, whose fish-farming sector records the lowest consumption of antibiotics. Antibiotic resistance among pathogenic bacteria is therefore much less of a concern (ANSES, 2020<sup>42</sup>)

<sup>41</sup> http://especes-exotiques-envahissantes.fr/base-documentaire/reglementation/#1541429061298-98684be8-7a60

<sup>42</sup> https://www.anses.fr/fr/system/files/ANMV-Ra-Antibiotiques2020.pdf

As regards Flavobacteriia, and more specifically the freshwater species *Flavobacterium psychrophilum,* they are responsible for flavobacterioses<sup>43</sup>, which affect salmonids<sup>44</sup>, causing haemorrhagic septicaemia among alevins. Controlling the disease is particularly problematic given the bacteria's horizontal and vertical modes of transmission (Kumagai & Nawata, 2010; Madsen & Dalsgaard, 2008) along with its persistence in environments and resistance to disinfection methods (Madetoja et *al.*, 2003; Starliper, 2011). Consequently, these bacteria, which are naturally present in upstream and downstream stretches of watercourses, are to be found in higher concentrations in rivers, sediments and biofilms receiving waters discharged from infected fish farms (Fujiwara-Nagata et *al.*, 2013; Starliper, 2011). These bacteria are not among the pathogenic organisms monitored during repopulation operations.

## H. Pressures relating to climate change

Global change, more often referred to as climate change, is now generally agreed to be a scientific reality. Attributable to humankind, it is having unprecedented consequences on the environment. However, the scientific community is still a long way from measuring or estimating all its past, present and future impacts on all ecosystems. Climate change is happening on a worldwide level that appears complex to study comprehensively, all the more so when you are trying to measure its impact on migratory aquatic animals which evolve in seas and rivers. However, it has already been shown that migratory species are especially sensitive to such ecosystemic changes taking place in their habitats, as well as along their migration routes (Lin et al., 2017; Robinson et al., 2009).

In the face of these significant changes, organisms have four possibilities, Beever et *al.* (2017): move, adapt, acclimate or die. As extinction is the ultimate outcome for a species, it must start by trying the first three alternatives. Species' major ecological responses to climate change come about via three main changes as regards: (i) physiology and phenology, (ii) distribution and range, and (iii) species

<sup>43</sup> The best known flavobacteriosis caused by *Flavobacterium psychrophilum* is commonly called *Cold Water Disease* and affects a wide range of host species of fish living in cold freshwater environments (Starliper, 2011).

<sup>&</sup>lt;sup>44</sup> Flavobacterium psychrophilum has also been detected among sea lampreys in Canada and among European eels in France and Spain (Starliper, 2011).

assembly and spatial synchrony of populations (Buisson, 2009; Hughes, 2000; Lassalle, 2008; Legrand-Hoffmann, 2021; Parmesan & Yohe, 2003; Rougier, 2014). Many authors also state that we need to consider the fact that modifications observed among animals may be the result of the joint effect of multiple anthropic pressures, acting at local level, and climate change, acting at global level (Almodóvar et *al.*, 2020; Legrand-Hoffmann, 2021; Mendoza, 2014). In addition, due to a complex lifecycle shared between freshwater and marine environments, diadromous species are vulnerable to a range of stress factors in a hierarchy of varied spatial levels (Limburg & Waldman, 2009). Transition from one stage of development to another, usually corresponding to different environments, results in the effects of climate change being heterogeneous and felt at varying intensities depending on development stage.

Physiology – growth and maturation. The decrease in the average size of individuals is now a well-known consequence of climate change (Daufresne et *al.*, 2009; Gardner et *al.*, 2011; Sheridan & Bickford, 2011). For Atlantic salmon, for example, a significant reduction in the size of spawners travelling up French rivers has been observed over the last 30 years (Bal et *al.*, 2017). These authors state that temporal similarities in variations of life histories between regions may be attributed to a common change in environmental conditions in the sea. This would appear to be explained by modifications of ocean conditions, making them difficult and unconducive to animals' successful marine growth, which may have a significant effect on the risk of extinction of populations (Piou & Prévost, 2013).

**Distribution and ranges.** Due to global change and modification of such climatic variables as temperature and rainfall, several studies have shown proof of changes in diadromous fishes' continental ranges, mainly in the form of their movement northwards and contraction (Lassalle et *al.*, 2008; Lassalle & Rochard, 2009; Rochard & Lassalle, 2011). Migratory species are extremely sensitive to environmental modifications and water temperature, and movement northwards of certain Metropolitan French migratory fishes' ranges has already been observed. For example, the smelt has gradually disappeared from the Garonne basin over the last 20 years, and the Loire has become the southern limit of its range (Pasquaud, 2006; Pronier & Rochard, 1998). The flounder has seen its range move by an average 1.4° latitude north since the 1970s (Nicolas et *al.*, 2011); its abundance in Gironde decreased between 1979 and 2005, whereas it increased between 1981 and 2002 in the Bristol Channel (Severn estuary, Celtic Sea) (Delpech, 2007; Genner et *al.*, 2004). As regards the thin-lipped grey mullet, a warm-water species, it has been increasingly observed at northern latitudes in Scotland, Denmark and southern Sweden since the

late 2000s; in France, it now regularly colonises watercourses further to the north (in Normandy, for example), as does the allis shad (Lassalle, 2008; Rochard & Lassalle, 2011). The twaite shad (*A. fallax*) is recorded more often in the Baltic Sea, with occurrences in the Gulf of Riga (Latvia/Estonia), with the northern limit of its range marked by the River Neman (Lithuania) (Aprahamian et *al.*, 2003; Thiel et *al.*, 2008).

In conclusion, even though it would seem difficult to measure the movement of a migratory species' entire range (as it requires very large-scale studies with data covering several seas, oceans and continents), the first consequences of climate change are already observable among a number of diadromous species. A good many authors specify that, due to its past present and future direct and indirect impact, climate change represents a real supplementary pressure on species.

Phenology – beginning and duration of migration. Many recent studies have shown a change in the phenology of land and water species' migration in response to climate change. Their main results highlight earlier springtime events than was previously the case for most species (Parmesan & Yohe, 2003; Root et al., 2003). This is partly due to the fact that migration of species, fish in particular, requires a great deal of energy and is therefore carried out when the best possible conditions obtain for the animals concerned (Visser & Both, 2005). This being so, any environmental change, such as water flow or temperature, can result in modification of the timing of fish migration (Anderson et al., 2013). A very recent study focused on the migration periods of diadromous species in Metropolitan France over the last 30 years (Legrand et al., 2021). Its authors observed significant modification of these species' migration chronology (apart from elvers) upstream, with expected arrival in basins an average of 2.3 days earlier per decade (i.e. around 7 days earlier in 30 years). The greatest time shift was observed among shad, with extension of the migration period (see Table 12). In 1985, 95% of individuals migrated in  $\approx$  5 days as against  $\approx$  20 days in 2015. The final day of migration has not varied much, but arrival of the first spawners has been observed a good deal earlier, a little less than 3 weeks. Migration durations are stable overall for other species: eel (elver) ≈ 8 days, young ("yellow") European eel ≈ 18 days, sea lamprey ≈ 14 days, salmon and trout ≈ 30 days.

Table 12: Migration timing of 5 taxa studied by Legrand et *al.* (2021) and variations observed by these authors between 1985 and 2015. Data are rounded out and simplified; values in grey are not significantly different. *Note*: the median day corresponds to the day of the year on which half of all individuals have migrated.

	Median day	of the year		n migration median in days)
Taxa studied	1985	2015	by decade	over 30 years
Alosa spp.	148	137	<b>—</b> 3.7	— 11.1
Anguilla anguilla (elver)	166	166	0,1	0,2
Anguilla anguilla (yellow eel)	178	172	<b>— 1.9</b>	<b>—</b> 5.7
Petromyzon marinus	139	138	<b>—</b> 0.2	<b>—</b> 0.6
Salmo salar	166	157	<b>—</b> 2.9	<b>—</b> 8.7
Salmo trutta	176	168	<b>—</b> 2.6	<b>—</b> 7.8
Average	161.4	154.6	<b>— 2.3</b>	<b>- 6.8</b>

In addition, Legrand et al. (2021) have shown that a number of parameters, including the North Atlantic Oscillation (NAO) Index), Sea Surface Temperature (SST)), air temperature and river flow influence timing, emphasising the importance of factors at work on a variety of spatial levels. Consequently, such changes must be taken into account in management of migratory species, in particular as regards obstacles to their movement.

**Spatial synchrony.** A fundamental concept in aquatic ecology is that a predator's evolutionary advantage – its *fitness* – depends on its spatial and temporal synchrony with the presence and production of its prey (Cushing, 1974). Hence, a change in a species' ecology, even when only indirectly connected with another species, may involve changes in cascade and, in extreme cases, a species' extinction may lead to chains of extinction (Brook et *al.*, 2008).

In parallel, it may become problematic when it concerns synchronisation of populations of one and the same species organised into metapopulations. When members of a species' populations synchronise under the effect of environmental parameters, it can increase the risk of the species' extinction; it seems that this may be one of the consequences of climate change (Chevalier et *al.*, 2015; Legrand-Hoffmann, 2021; Olmos et *al.*, 2020; Ong et *al.*, 2016).

In the case of species organised into metapopulations<sup>45</sup>, spatial correlation is of interest as an indicator of far-reaching change in populations, such as a decline in numbers. This is why, in the present context of climate change, several authors suggest monitoring this coefficient and, more generally, synchrony of population dynamics (Dakos et *al.*, 2010; Legrand-Hoffmann, 2021).

Hydrological conditions. Climate change is leading to ever more extreme and frequent meteorological events: storms, heatwaves, floods, droughts, etc. (National Observatory on the Effects of Global Warming (ONERC), 2019). Such major variations in rainfall and extreme pluviometric events have a significant impact on drainage basins. Rainfall influences intensity of watercourse flows, which affect diadromous species' population dynamics in their turn. According to Piou & Prévost (2013), a major variation of flows between summer and winter can become more problematic for maintenance of salmon populations in France's small coastal rivers than an increase in the water's overall temperature. These authors state that, unlike poor growth conditions in oceans, which pose a threat to populations but which seem impossible to manage directly, management of river flows may be the only potential means of action contributing to local limitation of population extinction risks. In the present context it is more than ever necessary to give thought to methods of adaptation and modifications to be made to management methods.

Management and conservation. In order to ensure coherent management and conservation of migratory species, ongoing and future global changes must be taken fully into account. It would therefore seem irrational to make reestablishment of historical occurrences of species our goal. A habitat favourable to a species in 1900 will most certainly not be favourable to it in 2100 (Rochard & Lassalle, 2011). Hence, these authors state that, in order to ensure reasonable conservation of targeted species, measures and action plans must be implemented that above all take hydrographic basins into consideration, as they currently provide conditions favourable to these species, and should continue to do so in a century. In this context, balanced management of water uses and their reconciliation must be adapted in accordance with territorial resiliencies.

<sup>&</sup>lt;sup>45</sup> As is the case with a number of anadromous species such as shad and salmonids (Hasselman et al., 2010; Jones, 2006; Randon, 2016; Waldman et al., 2016).

## I. SUMMARY OF PRESSURES BASED ON ISSUES IDENTIFIED

Migratory diadromous species have been suffering particularly significant declines in their populations for several decades now (Deinet et *al.*, 2020; Limburg & Waldman, 2009; Merg et *al.*, 2020; Nieto et *al.*, 2015; SDES & UMS PatriNAt, 2020; UMS PatriNAt, 2019). Relative abundances of these diadromous animals have declined to historically unprecedented levels, numerous taxa continue to survive at very low levels, and many of these species are now threatened with extinction (IUCN et *al.*, 2019, 2020). The causes of this "group" decline are now well identified, and are mostly of anthropic origin: fragmentation and destruction of habitats, overfishing, pollution and degradation of environments, climate change, introduction of invasive exotic species, and aquaculture (Limburg & Waldman, 2009; Figure 2).

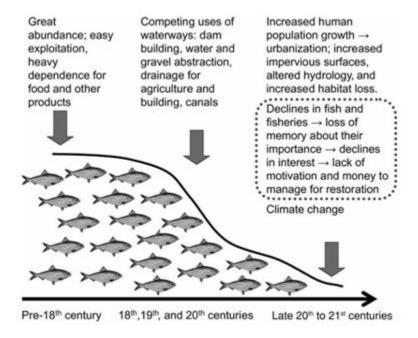


Figure 2: Conceptual diagram of the general history of and factors leading to the decline of diadromous species in the North Atlantic. Most species were heavily exploited before industrialisation and physical alteration of watercourses; other alterations to drainage basins due to human population expansion and climate change have aggravated loss of habitat. (Limburg & Waldman, 2009)

One of the main causes of the depletion of stocks of migratory species is fragmentation and loss of habitats (Limburg & Waldman, 2009; Merg et *al.*, 2020). By modifying watercourse hydromorphology, degrading riverbeds and preventing fish from accessing spawning grounds, development and construction

of obstacles to flow have significantly reduced habitats favourable to diadromous species' growth and reproduction.

Another major cause of these migratory species' decline is their overexploitation. Due to the high market value of certain taxa, some diadromous fish have been and continue to be subjected to major pressure from fishing and poaching that is hard to quantify. Overfishing is also a major factor in the disappearance of the European sturgeon and is partly responsible for the significant decline in European eel populations (Dekker, 2019; Limburg & Waldman, 2009; Williot et *al.*, 2002).

Degradation of environment quality is also one of the main factors involved in depletion of stocks. Unfavourable physicochemical conditions – pollution, eutrophication, turbidity, anoxia, etc. – have significant negative consequences on migratory behaviour and the animals' survival (reproduction, development of alevins, growth to adulthood, etc.) (Acou et *al.*, 2013; Lepareur & Aish, 2012; Limburg & Waldman, 2009; Villeneuve et *al.*, 2015). As previously stated (see *above*, Chapter 3, Part A), quality of environments is a key criterion for migratory diadromous species, and availability, accessibility and functionality of habitats are essential parameters for maintenance and restoration of populations. Yet habitats continue to degrade, losing their reception capacities as they do so, above all in middle and downstream sections of basins.

All in all, throughout their lives, migratory diadromous species are confronted with multiple direct and indirect pressures that threaten their survival and the sustainability of their populations. Nonetheless, the various stress factors involved have not all been accorded the same attention over the years by the actors concerned, some having emerged more recently than others. For example, over the last few decades, a great deal of work has been done on the impact of habitat fragmentation on migratory populations, whereas there are fewer studies on the consequences of climate change (although more have been published over the last few years).

As a result, the real influence and impact that the various pressures may have on migratory species and their life stages are not yet all well documented. Consequently, it is difficult to hierarchise them, all the more so when they act simultaneously and often result in "multi-stress" (Nõges et *al.*, 2016; Schinegger et *al.*, 2016; Teichert et *al.*, 2016). We need to adopt a holistic approach to the subject of

management and preservation of populations of migratory diadromous species, working simultaneously on the various sources of pressure and improve knowledge on points that are still poorly understood.

## **CHAPTER 4: ACTIONS**

## A. PARTNERS AND THEIR ROLES

The Ministry for the Ecological Transition's (MTE) Direction de l'eau et de la biodiversité (DEB – Water and Biodiversity Directorate) and the Ministry of Food and Agriculture's (MAA) Direction des pêches maritimes et de l'aquaculture (DPMA – Directorate for Sea Fisheries and Aquaculture) are the Plan's co-pilots, with support from the Ministry for the Sea. They approved the drafting of the Plan and designated the OFB as its coordinator

With technical support from the Institut national de recherche pour l'agriculture, l'alimentation et l'environnement (INRAE – National Research Institute for Agriculture, Food and the Environment), the OFB is the Plan's coordinating body and facilitator. It is responsible for:

- Centralising and summarising information from action supervisors;
- Facilitating the Plan's implementation and preparing the annual review of the Plan's actions;
- Acting as Secretariat to the Steering Committee and Thematic Groups (drawing up minutes of meetings, dissemination of annual reviews, etc.)

**Deconcentrated Government** departments (DREAL, DEAL, DIRM, etc.) are responsible for ensuring that the PNMA's orientations and measures are taken into account in the polices adopted across the territory.

As "frontrunners", Regional Councils have been responsible for coordinating local authorities' common action on protection of biodiversity since 2014. They also possess such amenities as Regional Nature Reserves and Regional Nature Parks and manage various European funds that finance actions on behalf of biodiversity. They are involved in the drafting and implementation of the Plan.

**Nature protection associations.** These include migratory diadromous species associations such as the Loire Grands Migrateurs Association, which represents all migratory species associations active on the Atlantic and English Channel seaboard and in the Rhine-Meuse basin during Steering Committee (SC) meetings, and the Migrateurs Rhône Méditerranée Association, which attends SC meetings as it has

special expertise on lagoon environments. They are involved in the drafting and implementation of PLAGEPOMIs. Associations can contribute to the PNMA through facilitation of their networks and implementation of various of the Plan's actions

**All partners** participate in implementing the Plan's actions. Partners may be public institutions, local authorities, socioprofessional actors (companies, professional unions, etc.), nature protection associations, user associations, or scientific bodies.

These actors' roles are specified in Action Sheets.

For each action, one or more partners are designated as action supervisor or co-supervisors.

## B. ACTIONS TO BE IMPLEMENTED



## 1. Theme: Land-sea link



The term "land-sea link" refers to the interdependence of the terrestrial and marine phases of diadromous species' lifecycles. It enables measurement of the impacts and pressures of human activities in one environment on the other, which may accumulate and have a major impact on populations.

It should be borne in mind that this theme does not cover quantitative management of stocks (see "Fishing" theme), offshore installations or protection of habitats via creation of protected areas (see "Continental habitats and ecological continuity" theme).

The challenge is to better organise management of marine and freshwater environments on behalf of migratory diadromous species.

## ➤ Orientation 1: Improve knowledge of diadromous species in marine environments

Although increasing numbers of studies are being published on movements of migratory fish through estuaries and lagoons, the marine phase of migratory diadromous species' lifecycles is still poorly understood due to the very low density of these species in the sea and a resulting paucity of data.

The PNMA aims to make best use of available knowledge and acquire further data in order to characterise functional maritime and transition areas.

As human activities in marine and coastal areas (fishing in and outside coastal areas, marine renewable energies, port infrastructures, offshore installations, etc.) have potentially major impacts, pressure reduction goals have already been identified in DSFs, in particular with regard to accidental and targeted catches and land-sea continuity. Nonetheless, lack of knowledge is still particularly detrimental to these species as far as adoption of effective, sustainable management measures is concerned.

The PNMA therefore aims to better understand pressures on migratory diadromous species, whether originating on land or at sea, as well as their health status, and hierarchise the impacts of such pressures.

# Orientation 2: Make better use of the possibilities provided by regulations and stepping up all forms of cooperation on the land-sea continuum

Some coastal watercourses either do not have maritime lateral limits or salt water demarcation lines or only inexact ones. Regulation of fishing of migratory diadromous species is directly or indirectly based on these demarcations. Their absence results in regulation enforcement and water policing problems.

Furthermore, the notion of estuary, on which regulations on fishing of migratory diadromous species may be based, is not clearly defined from a legal point of view.

The PNMA therefore aims to draw up an inventory of existing maritime lateral limits and salt water demarcation lines, in order to implement coherent actions, in particular with regard to fishing management.

# Orientation 3: Strengthen coherence of governance and policies regarding the land-sea interface

Management of migratory diadromous species draws on numerous legal texts, including the FFHD, the FWD, the MSFD and such national strategies as the SNB and the Stratégie nationale pour les aires protégées (SNAP – National Protected Areas Strategy)... The PNMA aims to improve the coherence of public action at the land-sea interface.

## > Orientation 4: Others: international cooperation

Numerous international conventions make reference to migratory diadromous species. The PNMA aims to further incorporate consideration of their provisions into international exchanges.

Orientation 1.	Orientation 2.	Orientation 3.	Orientation 4.
Improve knowledge of diadromous species in marine environments	Make better use of the possibilities provided by regulations and step up all forms of cooperation on the land-sea continuum	Strengthen coherence of governance and policies regarding the land-sea interface	International cooperation

Reference documents

- STRANAPOMI
- Sea Basin Strategy Documents (DSFs)
- SDAGEs and PLAGEPOMIs
- PMA Management Plans

### **DIADES & SAMARCH Interreg projects**



## 2. Theme: Fishing

This theme is dedicated to responsible professional and recreational fishing of migratory diadromous species in continental waters (fresh water, estuaries and lagoons) and maritime waters. Fishing is a direct cause of mortality but also contributes to the heritage and economic development of our aquatic biodiversity (see above, Chapter 3, Part C). There are stringent fishing regulations for some species (salmonids and eels in particular) while others are not subject to any special regulations.

The challenge here is to be able to reconcile fishing activities with issues regarding preservation and restoration of migratory diadromous species.

# Orientation 1: Improve knowledge on fisheries and catches at sea and in continental waters

Professionals are obliged to report their catches. As regards recreational fishing in the sea and in continental waters, levels of knowledge on catches of migratory diadromous species differ from one fishery to another due to the existence or otherwise of (mandatory or voluntary) reporting systems. Furthermore, data on catches are not automatically made available to the various actors concerned (difficulty in accessing data, difficulties in analysing them, etc.).

The PNMA aims to improve knowledge on fisheries and catches at sea and in continental waters through actions relating to catch reports.

## Orientation 2: Mobilise fishermen's knowledge

Economic activities and protection of species are not mutually exclusive. As fishermen are on the water almost all the time and their activity's sustainability depends on their ability to understand the ecology of the species they target and their environments, they have empirical knowledge of species.

The PNMA aims to mobilise and make best use of such knowledge.

	Orientation 1.	Orientation 2.
	Improve knowledge on fisheries and catches at sea and in continental waters	Mobilise fishermen's knowledge
Reference documents	<ul> <li>European sturgeon NAP</li> <li>Salmon Plan</li> <li>Eel Management Plan</li> <li>PLAGEPOMIs</li> <li>Data collection framework</li> </ul>	

## 3. Theme: Continental habitats and ecological continuity



Proper operation of continental habitats is a complex subject as it depends on a great many parameters, including a watercourse's hydrology, morphology and physicochemical quality. Continental habitats are migratory diadromous species' living environments on which it has proven possible to take medium- and short-term action and obtain noticeable results very quickly.

For several decades now, development of new uses of watercourses has resulted in the deterioration of habitat functionality (see above, Chapter 3B), aggravated by climate change, and even in the disappearance of certain habitats. In a number of territories, risks of the current situation deteriorating further have emerged due to development of anthropic activities, while most species find themselves in particularly problematic states of conservation. In addition, a number of estuaries suffer from turbidity maximums that can act as chemical obstacles during key stages in migration.

Physical and sometimes chemical barriers prevent fish from reaching better quality habitats. They also result in delays in migration and sometimes even deaths, by forcing individuals to stop in sectors whose quality is incompatible with species' requirements.

As regards obstacles to flow, there are currently over 100,000 transverse structures identified on France's watercourses. Although chronological prioritisation of actions designed to restore ecological continuity has recently been established in France's various basins (Action Plan for a Conciliatory Policy on Restoration of Ecological Continuity), there are still a great many works that need to be made compliant and regulatory deadlines for so doing are short.

Certain sections of watercourses used as routes, sometimes extensively so, are of major concern to the future of migratory fish as they are under the influence of large dams that have been disrupting their functionality for decades. Some of the dams in question have major impacts on these species' movements as they control access to the best habitats, watercourse hydrology (instream flow and lockage water) and/or transit of sediments. Technical solutions are often difficult to implement, for administrative, technical and/or financial reasons (see above, Chapter 3).

The challenge is to reconcile protection of migratory diadromous species with uses made of watercourses (irrigation, hydropower, recreational activities, etc.), in particular in the context of the energy transition policy.

Orientation 1: In high-stakes areas especially resistant to climate change, ensure high levels of protection and restoration of environment functionality and ecological continuity in line with energy and ecological transition policies

By basing itself on work to be carried out in the basins and facilitating its harmonisation at national level, the PNMA aims to improve the protection provided in various high-stakes areas especially resistant to climate change and reduce the impacts that a number of "key" works have on the future of migratory species, by seeking to mobilise the necessary resources collectively, better understanding the effects of various water intakes on species, and improving the functionality of certain areas suffering from major hydromorphological or chemical constraints.

The notion of resistance is introduced here in order to highlight the need to reduce extinction risks by reducing impacts.

Orientation 2: Improve knowledge on habitats and restore their functionalities in highstakes areas Many areas colonised by migratory species suffer from serious problems connected with watercourse morphology (extraction of aggregates, dams, agriculture, etc.). As yet, there is no reference technical document that might help us choose actions that would solve such problems. The PNMA aims to share technical recommendations on management/restoration of diadromous species' habitats.

Exchanges are currently taking place in most of France's large basins, with regard to predation of migratory fish by catfish, cormorants and other species. Studies carried out implement various, sometimes ill-suited protocols whose results are not always shared. The PNMA aims to carry out an assessment of such studies, ensure harmonised monitoring at national level and, when necessary, facilitate implementation of appropriate actions enabling reduction of impacts observed and monitoring of their effectiveness on species.

Orientation 3: Assist owners with monitoring and maintenance of functionality of fish crossing systems, in order to improve such systems' efficacy.

Recurrent problems with maintenance of fish crossing systems have been observed on many of France's watercourses. They may have major consequences for migrators, by preventing all or some individuals from continuing their journeys upstream to the best habitats, by delaying migration, by forcing individuals to stop in degraded territories, and by causing deaths during outmigration.

Independently of the regulatory obligations incumbent upon owners and control operations organised on watercourses, the PNMA aims to help owners to monitor and maintain their crossing systems.

#### Orientation 1. Orientation 2. Orientation 3. In high-stakes areas especially Improve knowledge on habitats Assist owners with monitoring and restore their functionalities resistant to climate change, ensure and maintenance of in high-stakes areas functionality of fish crossing high levels of protection and restoration of environment systems, in order to improve functionality and ecological such systems' efficacy continuity in line with energy and ecological transition policies

Reference documents

- STRANAPOMI
- MTES Note, 30 April 2019
- Sturgeon NAP, Eel Management Plan, Salmon Plan
- SDAGEs and PLAGEPOMIs

## 4. Theme: Fish farming and repopulation



Aquaculture for consumption (trout, sturgeon, etc.) can have direct and indirect impacts on migratory fish (see *above*, Chapter3, Parts D and G), both in terms of health and ecology (rupture of ecological continuity, effect on water quality, etc.).

Repopulation would seem to be one of the solutions to restoration of populations. However, several studies show that it can have counterproductive effects, including competition with wild populations (removal of spawners, competition among juveniles), undesirable genetic effects (introgression), and spread of parasites. Another question arises: Should we continue to prioritise maintenance of numbers rather than focusing more on restoration of environment quality?

In some basins, populations (of salmon for the most part) are maintained by repopulation operations in accordance with strategies defined in PLAGEPOMIs. One example is the implementation of an ambitious repopulation programme in the Loire basin with the Conservatoire National du Saumon Sauvage (CNSS – National Conservatory of Wild Salmon) in Chanteuges and, at national level, creation of ARA France (Association Repeuplement Anguilles France), which has implemented an innovative programme of eel repopulation actions overseen by professional fishermen, the DEB and the DPMA, with scientific and technical support from the National Museum of Natural History (MNHN) and the OFB. INRAE has also been carrying out operations focusing on the European sturgeon since 2003.

The challenge is to identify the purposes of repopulation operations carried out on French soil, and ensure that they are explained, fully assumed and shared, and that their interest and limitations are clearly outlined in a national context.

## Orientation 1: Establish a decision framework for repopulation programmes

It is necessary to establish and share a common reference framework on repopulation, with the aim of ensuring the good health of aquatic ecosystems.

The PNMA aims to establish such a reference framework of recommendations on virtuous repopulation operations collectively, with a view to maintaining numbers and restocking fisheries alike, based on experience feedback and analysis of the scientific literature concerned.

	Orientation 1- Establish a decision framework for repopulation programmes
Reference documents	<ul> <li>European sturgeon NAP</li> <li>Salmon Plan</li> <li>Eel Management Plan</li> <li>PLAGEPOMIs</li> <li>Fish-farming Progress Plan (PPP)</li> </ul>

## 5. Theme: Monitoring, assessments and outlook



Efficient implementation of the PNMA requires setup of governance bodies dedicated to the project, with each member knowing their role and assuming their responsibilities. In order to ensure facilitation of the Plan, monitoring of the implementation of its various actions, and its assessment. Such national facilitators responsible for monitoring the Plan could well be complemented by actions making best use of existing tools.

# Orientation 1: Set up a national facilitation responsible for monitoring implementation of the PNMA

An action plan's goal is to maintain or re-establish favourable conservation status of habitats and species through mobilisation of all actors concerned. In order to ensure that such mobilisation is maintained throughout the PNMA's duration, national facilitation bodies are to be created, facilitating dialogue between the Plan's partners and with the entities involved in management of migratory species.

# Orientation 2: Make best use of existing tools, define new tools and share them across territories

A good many monitoring operations have been carried out over the last 20 years and more, in particular by associations for protection and management of migratory diadromous species. Without such operations, data on migratory fish populations in France would be fragmentary or almost non-existent. Even so, they lack visibility as to the sustainability of their actions. For example, maintenance of the open-source STACOMI software developed by the Vilaine Etablissement Public Territorial de Bassin (EPTB - Basin Public Territorial Establishment) with support from the Conseil supérieur de la pêche (CSP — High Council for Fisheries), and then from the Office national de l'eau et des milieux aquatiques (ONEMA — National Office for Water and Aquatic Environments), which enabled unification of collection of data from most partners, is by no means ensured.

The PNMA therefore aims to make best use of existing tools in support of implementation of new common tools.

In addition, new threats are emerging such as climate change, whose effects are still poorly understood. Hence, through this orientation, it would seem advisable to ensure that migratory diadromous species are integrated into the various forward-planning studies carried out on French soil.

#### Orientation 1-

## Orientation 2-

Set up a national facilitation body responsible for monitoring implementation of the PNMA

Make best use of existing tools, define new tools and share them across territories

**Reference documents** 

- European sturgeon NAP
- Other examples of NAPs
- Salmon Plan
- Eel Management Plan
- STRANAPOMI
- Associations' various dashboards



## 6. Theme: Communication, awareness-raising and training

Numerous actions over the last few years have focused on communication, awareness-raising and training on migratory diadromous species. It would nonetheless seem necessary to provide territorial actors, elected representatives and the general public with better explanations of why they should be interested in migratory fish.

The challenge is to get them to better understand that these species are subject to numerous constraints and pressures across a wide variety of environments, and that by acting to preserve them, they are also acting to preserve the environments that accommodate them and the other species that live in such environments.

Orientation 1: Draw up a shared lexicon and a series of arguments on migratory diadromous species

A great many actors work on behalf of diadromous species. They must pool their efforts and come up with a common argument in order to mobilise the public.

Orientation 2: Improve the section dedicated to migratory diadromous species at the
 CDR Cours d'eau (Watercourse Resource Centre)

There are resources centres similar to the one set up by the OFB as a tool for information and facilitation of a community of interests on watercourse ecology, and which needs to be promoted much more widely.

As regards Wetlands Resource Centres (RCs), for example, (there are 5 such "Pôles relais zones humides" altogether), work is being done on improving knowledge, with web conferences, MOOCs, and training courses underway (fishery continuity in costal marshes) for managers of natural areas (associations & local authorities). The Watercourse RC has been identified as the most relevant RC for provisioning of the "migratory diadromous species" section.

# Orientation 3: Define targeted actions that are consistent with each other and adapted to each of the audiences concerned, elected representatives and professionals

Communication actions have been carried out for many years, but there has not been enough pooling of knowledge up until now. Lack of knowledge on issues and solutions, often accompanied by dissemination of erroneous or biased information, has led to a lack of commitment, and even when knowledge is acquired, people seem to find it hard to actually take the necessary action. This being so, the PNMA aims to develop and strengthen partnerships with the press through this orientation, and raise awareness and communicate on migratory diadromous species and the threats to their conservation among various groups of actors.

# > Orientation 4: Set up training programmes dedicated to migratory diadromous species

There are a good many existing training programmes focusing on biodiversity.

The PNMA aims to include questions on migratory diadromous species in them, on the basis of an inventory of courses that might by concerned.

Orientation 1- Draw up a shared lexicon and a series of arguments on migratory diadromous species	Orientation 2- Improve the section dedicated to migratory diadromous species at the CDR Cours d'eau (Watercourse Resource Centre)	Orientation 3- Define targeted actions that are consistent with each other and adapted to each of the audiences concerned, elected repre- sentatives and profession- als	Orientation 4- Set up training programmes dedicated to migratory diadromous species
---	---	--	---

**Reference documents** 

- STRANAPOMI
- PGA and European Sturgeon NAP
- Salmon Preservation Plan
- PLAGEPOMIs currently underway
- International, national and local communication and awareness-raising campaigns targeting the actors concerned.

## C. SUMMARY TABLE OF PROPOSED ACTIONS AND DETAILED ACTION SHEETS

# 1. Summary table of proposed actions

The table below summarises the various actions proposed by theme. Il is followed by Action Sheets.

Theme: Land-sea li	Fheme: Land-sea link			
Action number	Title	Prospective supervisor(s)	Partners	
LO1-1.1	Make best use of available knowledge on the various species in order to identify migration corridors and functional marine zones	MNHN-BOREA	Metropolitan France: OFB University of Perpignan Overseas France: UMR 7205 ISYEB (UA)	
LO1-1.2	Acquire further data in order to characterise such functional zones in the sea and in transition areas	MNHN-BOREA	Metropolitan France: OFB, University of Perpignan Overseas France: DGTM French Guiana, UMR 7205 ISYEB (UA)	
LO1-1.3	Assess the health status (detection of contaminants, parasitic status, life history in transition areas, etc.) of migratory diadromous species populations	OFB	Metropolitan France: MNHN-BOREA University of Perpignan DROM: UMR 7205 ISYEB (UA) MNHN-BOREA	
LO1-2	Identify, assess and quantify the strongest pressures in Metropolitan and Overseas France	MNHN-BOREA	Overseas France: UMR 7205 ISYEB (UA)	
LO2.1	Draw up an inventory of marine lateral limits and salt water demarcation lines, in particular for fishing management purposes.	OFB	CNIG and MTE	
LO3.1	Help coordinate consultations between bodies focusing on inland issues (COGEPOMIs and Basin Committees) and those focusing on the sea (Comités maritimes de façade (CMFs – Sea Basin Committees), Natura 2000 site SCs) in Metropolitan and Overseas France		Metropolitan France: MNHN-BOREA, FHE Overseas France: UMR 7205 ISYEB (UA)	
LO4.1	Facilitate international exchanges	MTE and MAA (DPMA)	Metropolitan France: MNHN-BOREA, OFB, University of Perpignan Overseas France: UMR 7205 ISYEB (UA)	
Theme: Fishing				
FO1-1.1	Improve the catch records provided by professional fishermen on continental waters and at sea in order to increase knowledge on fisheries.	CNPMEM, CONAPPED with support from the MAA (DPMA), MTE and OFB (for compliance with the rules of statistical secrecy in respect of stakeholders)	CRPMEM, CIDPMEM in Metropolitan France, AAPPED, University of Perpignan	
FO1-1.2	Implement a national tool for monitoring catches by recreational fishermen at sea and in continental waters, integrating bycatches	MAA (DPMA), FNPF and MTE (DEB)	OFB, University of Perpignan	
FO1-1.3	Coordinate and centralise methods for calculating indicators from fisheries	CNPMEM and CONAPPED	OFB, Migratory fish associations, University of Perpignan CRPMEM and CIDPMEM in Metropolitan France + AAPPED	
FO2-1	Make best use of fishermen's knowledge and knowhow in the context of responsible exploitation of diadromous species	CNPMEM and CONAPPED	MNHN-BOREA, University of Perpignan	

Theme: Habitat	ts and ecological continuity		
HO1-1.1	Harmonise identification of high-stakes areas especially resistant to climate change at national level, with the specific aim of strengthening their protection	Metropolitan France: OFB, MTE with support from DREALs (national harmonisation DEB/OFB) Overseas France: MNHN and OFB	Metropolitan France: MNHN, EDF, FHE Overseas France: UMR 7205 ISYEB (UA)
HO1-1.2	Facilitate implementation of appropriate (financial, technical and/or administrative) means enabling limitation of impacts by key works identified across the national territory	For identification of works:  EDF and other volunteer hydropower companies, DEB (and deconcentrated departments), DGEC, OFB For determination of impacts by works, identification of solutions and implementation of actions on "pilot" sites: each owner/ manager	Metropolitan France: FHE, MNHN-BOREA Overseas France: UMR 7205 ISYEB (UA)
HO1-1.3	Determine and reduce impacts during outmigration resulting from the various water intakes (watercourses and estuaries) in line with energy and ecological transition policies	For summaries of studies: OFB For studies to be launched (call for projects) and implementation of appropriate solutions: each owner / manager	Metropolitan France: EDF CNR Overseas France: Reunion Island OE MNHN-BOREA, UMR 7205 ISYEB (UA)
HO1-1.4	Identify the territories most impacted by hydromorphological and/or chemical problems, by major basin and COGEPOMI and with national harmonisation, with a view to improving their functionality		Metropolitan France: MNHN-BOREA EDF, CIPA, OFB Overseas France: UMR 7205 ISYEB (UA)
HO2-1	Create a technical guide to management/ restoration of diadromous species' habitats	OFB	Metropolitan France: EDF, CNR, FHE Overseas France: MNHN-BOREA, Hydreco Guyane UMR 7205 ISYEB (UA)
HO2-2	2- Characterise the impacts of predation and/or competition by various species, including IES, on migratory diadromous species populations	CONAPPED, MNHN- BOREA and OFB	Metropolitan France: EDF, CNR, FNPF, APPEND GIRONDE, COGEPOMI DREAL, Syndicats de marais (Marshland Syndicates) - Forum des marais Atlantique (FMA – Atlantic Wetlands Forum)  Overseas France: Hydreco Guyane, UMR 7205 ISYEB (UA)
HO2-3	Coordinate and lend support to drainage basins with a view to diagnosing the functionalities of main spawning grounds (shad, lamprey, salmon and sea trout) and improving them if necessary	OFB	EDF, FNPF, Migratory fish associations
HO3-1	Develop an assistance strategy on monitoring and maintenance of the functionality of fish crossing systems, and facilitate its rollout across the territories concerned	OFB and the MTE's departments, and managers of works	Metropolitan France: FNPF, FHE, Migratory fish associations, Overseas France: Hydreco Guyane
Theme: Fish far	ming and repopulation		
RO1-1	Share knowledge and experience feedback	OFB, DPMA	FNPF, CIPA, Migratory fish associations

RO1-2	Draw up a national guide to repopulation	OFB, DPMA	MNHN-BOREA, CNPMEM, CONAPPED, FNPF, CIPA, Migratory fish associations
			ARA France

Theme: Monito	ring, assessments and outlook		
MO1-1	Equip the PNMA with a dashboard for monitoring actions	OFB	PNMA action supervisors
MO1-2	Develop a medium- and long-term funding strategy for the PNMA's actions, excluding local actions provided for in PLAGEPOMIs	OFB	Action supervisor and financers
MO1-3	Bring the PNMA's results to the attention of the authorities responsible for planning documents	OFB	Basin DREALs and DIRMs
MO2-1	Centralise population monitoring data at national level	OFB (with regard to the information system) and Migratory fish associations	Metropolitan France: MNHN-BOREA, CNPMEM (CRPMEM and CDPMEM), CONAPPED (APPEED), FNPF, Overseas France: UMR 7205 ISYEB (UA)
MO2-2	Coordinate implementation of shared conservation objectives for all species in Metropolitan and Overseas France	CNPMEM - CONAPPED - FNPF	Metropolitan France: MNHN-BOREA, University of Perpignan, Migratory fish associations Overseas France: UMR 7205 ISYEB (UA) MNHN-BOREA
MO2-3	Ensure that migratory diadromous species are included in forward-planning studies	OFB	MNHN-BOREA, Migratory fish associations, INRAE
Theme: Commu	unication, awareness-raising and training		
CO1-1	Consolidate content of communication intended for the various audiences in Metropolitan France and to be adapted in Overseas Territories	OFB, Migratory fish associations	Action supervisors
CO2-1.1	Consolidate the section dedicated to migratory fish in the Watercourse RC and ensure that it is visible to the actors concerned (in particular for the marine environment)	OFB	PNMA action supervisors
CO2-1.2	Create a communication toolbox on migratory diadromous species	OFB, Migratory fish associations	
CO3-1.1	Develop and strengthen partnerships with the press	OFB	MTE
CO3-1.2	Make use of all possible communication channels and of existing events	OFB	MNHN-BOREA: Depending on territory
CO3-1.3	Communicate to the general public and elected representatives on restoration of ecological continuity for migratory diadromous species	OFB	MNHN-BOREA, Water Agencies
CO3-1.4	Raise awareness among and communicate to users on diadromous species	OFB at national level, Migratory fish associations	Metropolitan France: MNHN  Overseas France: French Guiana DGTM, University of Perpignan
CO4-1	Integrate issues identified in the PNMA into the various training courses focusing on biodiversity and other professional training programmes connected with activities that may interact with migratory diadromous species	OFB	Metropolitan France: EDF, Overseas France: French Guiana DGTM

## 2. Detailed Action Sheets

Each action is the subject of a descriptive sheet (hereunder) containing the following information: theme, action number and title, deadline, geographical areas concerned, action supervisor and partners, objectives to be achieved, context, description of action, indicators, available funding, estimated budget, and connection with other actions. At this stage, Action Sheets are drafts that may well evolve in 2022.

## **Explanatory Sheet**

Theme: Among the 6 themes previously described			
Orientation: Title of previously described Orientation			
Action No.  Action title: Action name			
Action No.	Deadline: To be set on the Plan's duration	Geographical areas concerned: Actions at regional or national level concerning Metropolitan and/or Overseas France	
Action supervisors:	<ul> <li>Action supervisors coordinate and oversee other contributors (partners).</li> <li>They decide on what means to deploy (meetings, studies, implementation of measures, etc.) in order to achieve the action's objective in compliance with the timetable defined in the PNMA. They report on actions to the SCs concerned.</li> <li>Supervisors are responsible for actions. They are in charge of their monitoring and implementation.</li> <li>Perhaps the action's financer (to prioritise) but not necessarily so.</li> </ul>		
Objectives to be achieved:	Objective(s) targeted by the action		
Context:	Reminder of the context that has led to	o this action being proposed	
Description of the action:	Action content		
Output indicator:	Refers to the content of the action and enables verification that it has actually been implemented, and monitoring of how well it is keeping to the provisional timetable. Among other things, this indicator helps SCs fully understand the point of the action.		
Means indicator:	FTE, material means, etc. To define in 2022		
	Partner(s) to involve no.1:		
	- They help the supervisor achieve the action's objectives Prospective partners can contribute to implementation of the action in a variety of ways (providing data, expertise and field materials, administrative support, etc.)	Partners (s) to involve no.2:	
Available funding: Indication of types of local, national and European funding that may be available	Estimated budget: - costs arising from facilitation / studies: To be budgeted on a number of days (approve a cost per day), - costs arising from management work / investments, etc. : Give an indicative range of costs when it is possible and relevant.	Connection with other actions: Orientation and number of the action concerned.	

## a. Theme: Land-sea link



Theme: Land-sea link			
Orientation: L-O1- Improve knowledge of diadromous species in marine environments			
Action No. LO1-1.1	Action title: 1- Improve knowledge of diadromous species, in particular in the marine environment and transition waters (in Metropolitan and Overseas France)		
	<b>Sub-action title:</b> 1.1- Make best use of available knowledge on the various species in order to identify migration corridors and functional marine zones		
	Deadline: Geographical areas concerned:  To be set on the Plan's duration Metropolitan and Overseas France		
Prospective action supervisor:	MNHN-BOREA		
Objectives to be achieved:	Identify functional zones and key periods as well as migratory diadromous species' migration areas in the sea and in international areas.		
	Benefit: Knowledge of migration corridors in order to improve management		
Context:	Identification of migration corridors and functional zones is a prerequisite for management of these species in the sea.		
Description of the action:	- Summary of all species' migratory calendars - Mapping of migration corridors and functional zones in known transition zones and in the sea		
Output indicators:	Further numbers of species whose migratory areas and functional zones are known.		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved:  Metropolitan France: OFB, University of Perpignan Overseas France: UMR 7205 ISYEB (UA)		
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget: To define in 2022	Connection with other actions: LO1-1.2 FO2-1 MO2-1 MO2-2	

	Theme: Land-sea link			
Orientation: L-O1- Improve knowledge of diadromous species in marine environments				
Action No. LO1-1.2	<b>Action title:</b> 1- Improve knowledge of diadromous species, in particular in the marine environment and transition waters (in Metropolitan and Overseas France)			
	<b>Sub-action title:</b> 1.2- Acquire further data in order to characterise functional zones in the sea and in transition areas			
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France		
Prospective action supervisor:	MNHN-BOREA			
Objectives to be achieved:	Identify functional zones and key periods as well as migratory diadromous species' migration areas in the sea and in international areas.  Benefit: Knowledge of migration corridors in order to improve management			
Context:	Identification and definition of migration corridors and functional zones is a prerequisite for management of these species in the sea. In addition, in a context of global change, functional zones are likely to evolve.			
Description of the action:	<ul> <li>Acquisition of knowledge, in particular via new technologies (telemetry, popup archival tags, environmental tracers, etc.)</li> <li>Fishing campaigns in pre-identified corridors during the season identified</li> </ul>			
Output indicators:	Further numbers of species whose migratory areas and functional zones are known.			
Means indicator:	FTE, material means, etc To define in 2022			
	Partner(s) involved:  Metropolitan France: OFB, University of Perpignan Overseas France: DGTM French Guiana, UMR 7205 ISYEB (UA)			
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget: To define in 2022	Connection with other actions: LO1-1.1 HO1-1.1 MO2-1		

Theme: Land-sea link			
Orientation: L-O1- Improve knowledge of diadromous species in marine environments			
Action No. LO1-1.3	<b>Action title:</b> 1- Improve knowledge of diadromous species, in particular in the marine environment and transition waters (in Metropolitan and Overseas France)		
	<b>Sub-action title:</b> 1.3- Assess the health status (detection of contaminants, parasitic status, life history in transition areas, etc.) of migratory diadromous species populations		
	<b>Deadline:</b> To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France	
Prospective action supervisor:	OFB		
Objectives to be achieved:	A comprehensive study of the health status of populations, already undertaken in a few large sub-basins.		
	<b>Benefit:</b> Assessment of health statuse	<u> </u>	
Context:	We need to have a better understanding of the health status of populations currently in decline, in particular in order to provision the pressure impact dashboard.		
Description of the action:	Acquire knowledge and store it in a national database.		
Output indicators:	- Number of species for which a health status assessment exists		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved:  Metropolitan France: MNHN-BOREA, University of Perpignan Overseas France: UMR 7205 ISYEB (UA), MNHN-BOREA		
Available funding: Indication of types of local, national and European funding that may be available.  To define in 2022	Estimated budget: To define in 2022	Connection with other actions: MO2-1 MO2-2	

Theme: Land-sea link		
Orientation: L-O1- Improve knowledge of diadromous species in marine environments		
Action No. LO1-2	Action title: 2- Identify, assess and quantify the strongest pressures in Metropolitan and Overseas France	
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	MNHN-BOREA	
Objectives to be achieved:	Identification of main pressures.  Benefit: Main pressures identified and dealt with	
Context:	Species are subjected to a range of pressures. As it stands, it is complicated to hierarchise their impacts. Nonetheless, it would seem important to work together to identify the pressures with the greatest impact on these species' dynamics, drawing in particular on assessments of DSFs and SDAGEs.	
Description of the action:	<ul> <li>Set up a national workgroup to identify pressures regarded as major on marine and transition environments.</li> <li>Develop a methodology enabling identification and hierarchisation of the effects that the various pressures have.</li> </ul>	
Output indicators:	The greatest pressures are identified collectively by 2024	
Means indicator:	FTE, material means, etc To define in 2022	
	Partner(s) involved:  Overseas France: UMR 7205 ISYEB (UA)	
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget: To define in 2022	Connection with other actions: MO2-1 MO2-2 CO2-1.1

#### Theme: Land-sea link

Orientation: L-O2 - Make better use of the possibilities provided by regulations and step up all forms of cooperation

	on the land-sea continuum	
Action No. LO2-1	<b>Action title:</b> 1- Draw up an inventory of marine lateral limits and salt water demarcation lines, in particular for fishing management purposes	
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	OFB	
Objectives to be achieved:	Improve the clarity of regulations governing the fishing of migratory diadromous species, by drawing up an inventory of missing marine lateral limits and salt water demarcation lines and clarify the notion of estuary in legal terms.  Benefit: Easier application of regulations and protection of migratory diadromous species	
Context:	Some coastal watercourses do not have marine lateral limits or salt water demarcation lines, or only inexact ones. Regulation of fishing of migratory diadromous species is directly or indirectly based on these demarcations. The absence of such limits leads to problems in applying regulations. Furthermore, the notion of estuary, on which regulations on fishing of migratory diadromous species may be based, is not clearly defined from a legal point of view.	
Description of the action:	<ul> <li>- Draw up a list of missing, inexact and inadequate marine lateral limits and salt water demarcation lines</li> <li>- Map the various limits and related regulations.</li> <li>- Drawing on this diagnosis, propose solutions (Decrees, etc.) ensuring better management of fishing whose regulation is based on these limits.</li> <li>- Work on finding a legal definition of the term "estuary".</li> </ul>	
Output indicators:	- Percentage of estuaries for which limits have been clarified for fishing diadromous species (out of the total number of "problematic" estuaries)	
Means indicator:	FTE, material means, etc. To define in 2022	
	Partner(s) involved: CNIG and MTE	
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget: To define in 2022	Connection with other actions: FO1-1.1 FO1-1.2

	Theme: Land-sea link		
Orientation: L-O3 - Stren	gthen coherence of governance and polici	ies regarding the land-sea interface	
Action No. LO3-1	Action title: 1- Help coordinate consultations between bodies focusing on inland issues (COGEPOMIs and Basin Committees) and those focusing on the sea (Comités maritimes de façade (CMFs – Sea Basin Committees), Natura 2000 site SCs, etc.) in Metropolitan and Overseas France		
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France	
Prospective action supervisor:	Joint supervision: MTE and MAA (DPI	MA), via COGEPOMI DREALs and DIRMs	
Objectives to be achieved:	species in the sea and in continental v Land-Sea actors.  Benefit: Make compliance with regula diadromous species more efficient, in	Ensure better governance of the management of migratory diadromous species in the sea and in continental waters, and improve exchanges between	
Context:	There are a good many different policies governing management of migratory diadromous species, including the Fauna-Flora-Habitat Directive, the Framework Water Directive, the Marine Strategy Framework Directive, and such national strategies as the SNB and SNAP. This action aims to improve consistency between actions implemented under these various public policies.		
Description of the action:	Organise technical days between actors in the marine environment and actors in continental waters, with focuses on problems common to both environments with regard to diadromous species (e.g. ecological continuity, offshore windfarms, recreational and professional fishing at sea and in estuaries, mud plugs in estuaries, etc. )		
Output indicators:	Perception indicator: Questionnaires at start and end of Plan:  - How would you rank the quality of land-sea consultations on the subject of migratory diadromous species?  - Have land-sea relations been enhanced by this PNMA action?  - Number of technical days organised		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved:  Metropolitan France: MNHN-BOREA, FHE Overseas France: UMR 7205 ISYEB (UA)		
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget: To define in 2022	Connection with other actions: MO1-3	

Theme: Land-sea link		
Orientation: L-O4- Others: international cooperation		
Action No. LO4-1	Action title: 1- Facilitate international exchanges	
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	Joint supervision: MTE and MAA	
Objectives to be achieved:	Take advantage of international meetings to give thought to protection of migratory diadromous species in Metropolitan and Overseas France.  Benefit: Protection of areas essential to migratory diadromous species.	
Context:	Numerous international conventions make reference to migratory diadromous species. The PNMA should enable greater focus on this subject during various international exchanges (CITES, OSPAR, etc.).  This action in particular (but not only) concerns the functional zones identified in international waters for the European eel and Atlantic salmon.	
Description of the action:	Ensure that France takes part in ad hoc <i>workgroups</i> in order to promote implementation of spatial protection for certain species in international waters.	
Output indicators:	<ul> <li>Number of functional zones identified in international waters</li> <li>Number of international exchanges in which reference is made to migratory diadromous species</li> <li>Number of exchanges of data in the context of international exchanges</li> </ul>	
Means indicator:	FTE, material means, etc To define in 2022	
Available funding:	Partner(s) involved:  Metropolitan France: OFB, MNHN-BOREA, University of Perpignan Overseas France: UMR 7205 ISYEB (UA)	
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget: To define in 2022	Connection with other actions: MO1-3 CO1-1





Theme: Fishing			
Orientation: F-O1- Improve knowledge on fisheries and catches at sea and in continental waters			
Action No. FO1-1.1	Action title: 1.1- Improve the catch records provided by professional fishermen on continental waters and at sea in order to increase knowledge on fisheries.		
	<b>Deadline:</b> To be set on the Plan's duration	<b>Geographical areas concerned:</b> Metropolitan and Overseas France	
Prospective action supervisor:	Joint supervision: CNPMEM, CONAPPED With support from the MAA (DPMA), MTE and OFB (for compliance with the rules of statistical secrecy in respect of stakeholders))		
Objectives to be achieved:	Objectives to be achieved 1: Know how to quantify catches and fishing of migratory diadromous species by all categories of professional fishermen in all environments.  Objectives to be achieved 2: Develop a relationship of trust between fishermen and the administration in order to improve data quality and bring about a shared vision.  Benefit: better knowledge of the fishing pressure' impact		
Context:	Professional fishermen are obliged to report their catches. Improvements have recently been made to these tools (CESMIA). However:  - The absence of mandatory reports for some fisheries prevents accurate estimation of catches.  - Data on catches are not automatically made available to the various actors concerned.  - Some of these synthesised data are required in the context of various regulations (MSFD, PGA, DCF, etc.).  In the context of the PNMA, we will need to obtain report data, to be complemented via surveys (CRPMEM) and Ifremer data in order to ensure that information provided is reliable and enable everybody's commitment.  An action of this sort requires that a trusting relationship be established with fishermen.		
Description of the action:	- Use report data in order to estimate catches of migratory diadromous species - Improve report quality, These actions must be carried out in collaboration with socioprofessional actors in Metropolitan and Overseas French fishing sectors. This will require agreement on use of data in order to remove any barriers.		
Output indicators:	- Number of stocks already assessed that have been the subject of a consensus between actors		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved: CRPMEM, CIDPMEM, AAPPED, University of Perpignan		
Available funding: Indication of types of local, national and European funding that may be available.	Estimated budget: To define in 2022	Connection with other actions: MO2-1 MO2-2	
To define in 2022			

Theme: Fishing		
Orientation: F-O1- Improve knowledge on fisheries and catches at sea and in continental waters		
Action No. FO1-1.2	Action title: 1.2- Implement a national tool for monitoring catches by recreational fishermen at sea and in continental waters, integrating bycatches	
	<b>Deadline:</b> To be set on the Plan's duration	Geographical areas concerned: Metropolitan France
Prospective action supervisor:	MAA (DPMA) and FNPF / MTE (DEB)	
Objectives to be achieved:	Be able to quantify catches and fishing of migratory diadromous species by all categories of recreational fishermen in all environments.  Benefit: Better knowledge of the fishing pressure's impact	
Context:	Levels of knowledge on catches of migratory diadromous species vary from one fishery to another due to reports being voluntary, even though, with regard to some species, recreational fishing is responsible for a very significant number of catches.  The FNPF is implementing a sea trout project covering freshwater fisheries.	
Description of the action:	Design a system taking account of what already exists (existing obligations, data that can be exploited to varying degrees) in relation to species and categories of fishermen.  An initial experiment could be carried out targeting a few species at issue, such as sea trout.	
Output indicators:	- Number of tools implemented	
Means indicator:	FTE, material means, etc To define in 2022	
	Partner(s) involved: MTE, OFB, University of Perpignan	
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget: To define in 2022	Connection with other actions: MO2-1 MO2-2

Theme: Fishing		
Orientation: F-O1- Improve knowledge on fisheries and catches at sea and in continental waters		
Action No. FO1-1.3	Action title: 1.3- Coordinate and centralise methods for calculating indicators from fisheries	
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	Joint supervision: CNPMEM and CONA	APPED
Objectives to be achieved:	Produce indicators for certain migratory diadromous species, resulting from data from various (recreational and professional) fisheries.  Benefit: better use of the data acquired	
Context:	Catch data is sometimes exploited at local level, which is usually the most relevant procedure. Methods are not necessarily shared, however, and there is a need to centralise such indicators' results.  Need to reach agreement on use of indicators  Calculation methods will have to fully integrate data acquisition conditions, which are just as important as the data themselves.	
Description of the action:	<ul> <li>Assess species and fisheries for which such work can be carried out over the medium and long term.</li> <li>Implement an exploitation rate, taking account of work already carried out by COGEPOMIs.</li> <li>These actions must be implemented in collaboration with socioprofessional actors in recreational fishing, amateur fishing with fixed and mobile gear, and professional fishing</li> <li>This action is to be implemented following actions FO1-1.1 and FO-1.2</li> </ul>	
Output indicators:	- Number of indicator series established	
Means indicator:	FTE, material means, etc To define in 2022	
	Partner(s) involved:  OFB, Migratory fish associations, University of Perpignan  CRPMEM and CIDPMEM in Metropolitan France + AAPPED	
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget: To define in 2022	Connection with other actions: FO1-1.1 and FO-1.2 SO2-1

Theme: Fishing			
Orientation: P-O2 - Mobilise fishermen's knowledge			
Action No. FO2-1	Action title: 1- Make best use of fishermen's knowledge and knowhow in the context of responsible exploitation of diadromous species		
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan France	
Prospective action supervisor:	Joint supervision: CNPMEM - 0	CONAPPED	
Objectives to be achieved:	Give thought to ways of making use of fishermen's expertise and knowhow (e.g. Charts, etc.) in implementation of actions on knowledge and management of diadromous species  Benefit: acquisition of further knowledge		
Context:	Economic activities and protection of species are not mutually exclusive. As fishermen spend a great deal of time on the water, they have age-old empirical knowledge of species that it is important to make use of.  Citizen science and participatory research/action tools must also be mobilised. In other words, fishermen, scientists and managers work together to develop a shared vision of the knowledge and management measures to implement on behalf of migratory fish.  Get amateur fishermen with gear and nets (PAEFs) involved in actions (sampling, etc.), in particular in sectors where no professional fishing takes place.		
Description of the action:	Design a tool enabling better account to be taken of fishermen's expertise and knowhow.		
Output indicators:	- Tool created		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved: MNHN-BOREA and University of Perpignan		
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget: To define in 2022	Connection with other actions: MO2-2, MO2-3 CO1-1, CO3-1.4, CO4-1	

#### c. Theme: Habitats and ecological continuity



#### Theme: Habitats and ecological continuity Orientation: H-O1 -In high-stakes areas especially resistant to climate change, ensure high levels of protection and restoration of environment functionality and ecological continuity in line with energy and ecological transition policies Action title: 1- In high-stakes areas especially resistant to climate change, ensure high levels of protection and restoration of environment functionality and ecological continuity Action No. HO1-1.1 in Metropolitan and Overseas France **Sub-action title:** 1- Harmonise identification of high-stakes areas especially resistant to Deadline: Geographical areas concerned: To be set on the Plan's duration Metropolitan and Overseas France Overseas France: MNHN and OFB Metropolitan France: OFB and MTE with support from DREALs (with national Prospective action supervisor: harmonisation DEB/OFB) Have a national map of identified territories available and implement strong protective measures in Metropolitan and Overseas France. Objectives to be achieved: Benefit: non-degradation of environment functionality Many territories (continental and marine alike) of major importance to the future of migratory species and with high resistance to climate change are seeing their (migration, reproduction and growth) habitats deteriorate while anthropic pressures increase. Context: The National Protected Areas Strategy sets objectives in terms of creation and management of protected areas. - Use shared criteria to harmonise – at national level and by large drainage basin – methods for identifying territories, drawing on the various reference documents available (SDAGEs, SAGEs, forward-planning studies, etc.) If necessary, conduct complementary analyses in order to refine the work carried out. Description of the action: - Identify territories already provided with protection systems and assess such systems' effectiveness - Propose stepping up protection in relation to issues identified in the territories in question (nature reserves, biotope protection areas, fishery conservation areas, etc.) - Mapping of territories' identified - Lengths of watercourses concerned Output indicators: - Protection systems implemented by territory FTE, material means, etc. Means indicator: To define in 2022 Partner(s) involved: Metropolitan France: MNHN, EDF, FHE Overseas France: UMR 7205 ISYEB (UA) Connection with other actions: Available funding: Estimated budget: Indication of types of local, national To define in 2022 LO1-1.2 and European funding that may be CO2-1.1, CO2-1.3, CO3-1.3, CO4-1 available.

To define in 2022

#### Theme: Habitats and ecological continuity

**Orientation:** H-O1 -In high-stakes areas especially resistant to climate change, ensure high levels of protection and restoration of environment functionality and ecological continuity in line with energy and ecological transition policies

Action No. HO1-1.2	Action title: 1- In high-stakes areas especially resistant to climate change, ensure high levels of protection and restoration of environment functionality and ecological continuity in Metropolitan and Overseas France  Sub-action title: 1.2- Facilitate implementation of appropriate (financial, technical and/or administrative) means enabling limitation of impacts by key works identified across national territory		
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France	
Prospective action supervisor:	For identification of works:  EDF and other volunteer hydropower companies, DEB (and deconcentrated departments), DGEC, OFB		
Trospective action supervisor.	For determination of impacts by works, identification of solutions and implementa actions on "pilot" sites:  Each owner/manager		
	Reduce certain key works' impac climate change.	ts on the future of migratory species, in a context of	
Objectives to be achieved:	<b>Benefit:</b> Access to numerous functional habitats and/or improvement of functionality and resistance of strategic territories for migratory species in a context of climate change		
Context:	By controlling access to habitats and disturbing their hydrology and/or sedimentary transit, a number of key works have major impacts on migrations and environment functionality, and can single-handedly undermine the effectiveness of the preservation / restoration actions undertaken. Reduction of these works' impacts often requires "special" (administrative and/or technical and/or financial) means that are often difficult to implement at local level alone. In addition to the regulatory obligations incumbent upon some of them, special (financial, technical and/or administrative) means are required in order to facilitate implementation of adapted versions of action plans.		
Description of the action:	- Use a national approach to identifying such key works for each large drainage basin (works on List 2 and works for which pressures are identified in planning, inventory and assessment documents (SDAGEs, SAGEs, PLAGEPOMIs, etc.)).  - Making use of harmonised methodology, determine these key works' main impacts (fish movement, hydrology, sediments, and physicochemistry) and identify solutions (reproducible if possible) to implement in order to reduce them  - For a number of "pilot" works to be identified among these key works, implement appropriate actions (making use of financial, technical and/or administrative means) that will provide experience feedback		
Output indicators:	- Number, main characteristics and mapping of key works identified - Number of works whose impacts have been understood, and for which solutions to implement in order to limit them have been identified - Number of pilot sites established		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved: Metropolitan France: MNHN-BOREA, FHE Overseas France: UMR 7205 ISYEB (UA)		
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget:  To define in 2022  HO1-1.4  MO1-2  CO2-1.1, CO2-1.3, CO3-1.3, CO4-1		

#### Theme: Habitats and ecological continuity Orientation: H-O1 -In high-stakes areas especially resistant to climate change, ensure high levels of protection and restoration of environment functionality and ecological continuity in line with energy and ecological transition policies Action title: 1- In high-stakes areas especially resistant to climate change, ensure high levels of protection and restoration of environment functionality and ecological Action No. HO1-1.3 continuity in Metropolitan and Overseas France **Sub-action title:** 1.3- Determine and reduce impacts during outmigration resulting from the various water intakes (watercourses and estuaries) in line with energy and ecological transition policies Deadline: Geographical areas concerned: To be set on the Plan's duration Metropolitan and Overseas France For study summaries: OFB For studies to be launched (call for projects) and implementation of appropriate Prospective action supervisor: solutions: each owner / manager For the various species at stake, determine numbers of deaths caused by water intakes (irrigation, drinking water, hydroelectricity and nuclear power) and, if necessary, Objectives to be achieved: propose actions designed to reduce them. Benefit: reduction of numbers of deaths at life stages often strategic to species' future In this case, it is not a matter of determining what impacts works have in order to prioritise interventions, as full protection of migratory species must be guaranteed on listed watercourses within the meaning of Article L214-17 of the Environmental Code. There are numerous water intakes along watercourses, and they may well have major impacts (direct and later deaths, latenesses, etc.) on migratory species, often at very Context: important life stages. Studies focusing on hydropower have been carried out in numerous basins but no summary of their findings is currently available. Some areas have not been the subject of investigation. The impacts of some water intakes likely to have significant impacts (certain nuclear power plants, for example) are either unknown or poorly documented. - Draw up a summary of the various studies carried out in France. - Launch a call for projects intended to: i) determine poorly documented water intakes' impacts that are likely to be significant, making use of nationally harmonised methods ii) propose appropriate solutions Description of the action: enabling reduction of impacts - Draw on existing studies to make an assessment of the cumulative impacts of the various water intakes concerned - Disseminate/ make best use of studies in the "Watercourse" RC - Production of a summary document on the various studies carried out - Number, characteristic and mapping of water intakes selected for the call for projects Output indicators: - Number of action plans drawn up and level of engagement FTE, material means, etc... Means indicator: To define in 2022 Partner(s) involved: Metropolitan France: EDF, CNR Overseas France: La Réunion OE, MNHN-BOREA, UMR 7205 ISYEB (UA) Available funding: Connection with other actions: Estimated budget:

To define in 2022

HO1-1.2,

CO2-1.1, CO2-1.3, CO3-1.3, CO4-1

MO1-2

Indication of types of local, national

and European funding that may be

available

To define in 2022

	Theme: Habitats and ecological contin	nuity	
_	areas especially resistant to climate cha tionality and ecological continuity in line policies	nge, ensure high levels of protection and e with energy and ecological transition	
Action No. HO1-1.4	Action title: 1- In high-stakes areas especially resistant to climate change, ensure high levels of protection and restoration of environment functionality and ecological continuity in Metropolitan and Overseas France		
	<b>Sub-action title:</b> 1.4- Identify the territories most impacted by hydromorphological and/or chemical problems, by major basin and COGEPOMI and with national harmonisation, with a view to improving their functionality		
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France	
Prospective action supervisor:	COGEPOMI DREALs with support from and STBs)	STBs (subject to agreement by DREALs	
Objectives to be achieved:	Characterise the difficulties encountered by migratory species and identify improvement needs		
	Benefit: improvement of habitats' functionality and resilience		
Context:	In a context of climate change, many territories (watercourses and, estuaries) suffer from environmental conditions that disrupt species' lives, migration and/or reproduction. A number of such territories are monitored, and some of them have been for quite some time.		
Description of the action:	- Identify the most problematic strategic territories  - Produce a summary of available knowledge on these territories  - Implement restoration actions, drawing on results from pilot territories if necessary  - Where it proves useful, carry out appropriate monitoring operations on specific territories with a view to characterising problems, identifying main causes and proposing appropriate solutions		
Output indicators:	- Number of territories identified, surfaces and lengths of related watercourses, mapping - Number, characteristics and locations of restoration actions - Number, characteristics and locations of territories that have been the subject of expert appraisals and proposals for implementation of appropriate solutions		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved:		
	Metropolitan France: MNHN-BOREA, EDF, CIPA, OFB Overseas France: UMR 7205 ISYEB (UA)		
Available funding:	Estimated budget:	Connection with other actions:	

HO1-1.2, SO1-2

CO2-1.1, CO2-1.3, CO4-1

To define in 2022

Indication of types of local, national and European funding

that may be available.

To define in 2022

Theme: Habitats and ecological continuity		
Orientation: H-O2- Improve knowledge on habitats and restore their functionalities in high-stakes areas		
Action No. HO2-1	Action title: 1- Create a technical guide to management/ restoration of diadromous species' habitats	
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	OFB	
Objectives to be achieved:	Possession of a national reference document (1 for Metropolitan France and 1 for Overseas France) for habitat restoration work.  Benefit: harmonisation of practices, improvement of the effectiveness of actions undertaken; improvement of environment functionality	
Context:	Numerous territories suffer from major problems relating to watercourse morphology (extraction of aggregates, dams, agriculture, bank stabilisation, etc.).  Such problems are likely to have strong impacts on migratory species' various life stages (survival of eggs and juveniles, growth and reproduction).  There is no reference technical document covering the restoration actions undertaken.  There is little sharing of experience feedback on migratory species.	
Description of the action:	- Draw up an assessment of operations carried out - Create a technical guide to be shared with actors, in order to help project leaders and research departments, drawing on the various documents and initiatives that already exist (e.g. Life Dordogne) Organise a seminar presenting work carried out	
Output indicators:	Production of a national reference document (1 for Metropolitan France and 1 for Overseas France) for habitat restoration work, integrating available experience feedback.  - Organisation of a presentation seminar	
Means indicator:	FTE, material means, etc To define in 2022	
Available funding:	Partner(s) involved:  Metropolitan France: EDF, CNR, FHE Overseas France: MNHN-BOREA, Hydreco Guyane, UMR 7205 ISYEB (UA)	
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget:  To define in 2022	Connection with other actions: SO1-2, SO2-1 CO2-1.1

Theme: Habitats and ecological continuity		
Orientation: H-O2- Improve knowledge on habitats and restore their functionalities in high-stakes areas		
Action No. HO2-2	Action title: 2- Characterise the impacts of predation and/or competition by various species, including IES, on migratory diadromous species populations	
	<b>Deadline:</b> To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	Joint supervision CONAPPED / MNHN-	- BOREA/ OFB
Objectives to be achieved:	Objective to be achieved 1: In accordance with appropriate protocols harmonised at national level, understand the impacts of various predators (catfish, cormorants, seals, etc.) on sensitive areas in Metropolitan France  Objective to be achieved 2: Better understand competition by certain species (Hypostomus robinii, Cherax quadricarinatus, etc.) present in Overseas French watercourses.  Benefit: objectification of impacts, improvement of knowledge in order to implement appropriate actions	
Context:	Discussions are currently taking place in most of France's major basins with regard to predation of migratory species by catfish and exotic species. Studies have been carried out in accordance with a variety of protocols and do not always enable comparison between situations, objectification of realities and implementation of the most appropriate actions.	
Description of the action:	- Draw up a summary of available studies on the subject  - Compare the impacts of the species studied with other pressures  - Set up appropriate monitoring operations harmonised at national level  - When necessary, implement actions enabling reduction of impacts and measure their effects in terms of population dynamics	
Output indicators:	<ul> <li>Publication of a summary report on studies carried out</li> <li>Production of a document enabling comparison of the impacts of targeted species with those of all other types of pressures</li> <li>Number, characteristics and locations of monitoring operations carried out</li> <li>Number, characteristics, locations and effectiveness of actions implemented to limit impacts</li> </ul>	
Means indicator:	FTE, material means, etc To define in 2022	
Available funding:	Partner(s) involved:  Metropolitan France: EDF, CNR, FNPF, APPED GIRONDE COGEPOMI DREALs Syndicats de marais (Marshland Syndicates) - Forum des marais Atlantique (FMA – Atlantic Wetlands Forum) Overseas France: Hydreco Guyane, UMR 7205 ISYEB (UA)  Estimated budget:  Connection with other actions:	
Indication of types of local, national and European funding that may be available. To define in 2022	To define in 2022	FO3-1 HO2-1, HO2-3 MO1-3 CO3-1.4

	Theme: Habitats and ecological conti	nuity
Orientation: H-O2- Improve knowledge on habitats and restore their functionalities in high-stakes areas		
Action No. HO2-3	Action title: 3- Coordinate and lend support to drainage basins with a view to diagnosing the functionalities of main spawning grounds (shad, lamprey, salmon and sea trout) and improving them if necessary	
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan France
Prospective action supervisor:	OFB	
Objectives to be achieved:	Identify spawning grounds regarded as strategic from a quality point of view for each major basin and COGEPOMI, and share the information at national level; characterise their functionality and improve it if necessary.  Benefit: improvement of spawning ground functionality /resistance in the face of climate change; improved survival of eggs and juveniles; short-term targeting of means on the most strategic sites.	
Context:	Spawning ground functionality (survival of eggs and juveniles in particular) is of major importance to the future of migratory species in a context of climate change.  Their functionality may have been impaired following large-scale extractions of materials from minor beds carried out up until the 1980s, presence of obstacles, agricultural practices, bank stabilisation, etc.	
Description of the action:	<ul> <li>Making use of a nationally harmonised method identify the main colonised and colonisable spawning grounds in each large drainage basin.</li> <li>Use a harmonised protocol to describe environmental conditions (sediments, thermal conditions, physicochemistry, and trophic network) and relate them to species' needs.</li> <li>Propose and implement actions designed to improve environment functionality</li> </ul>	
Output indicators:	- Number, surface, characteristics and locations of sectors identified - Number, surface, characteristics and locations of sectors diagnosed - Number of actions undertaken and surfaces concerned	
Means indicator:	FTE, material means, etc To define in 2022	
	Partner(s) involved: EDF, FNPF, Migratory fish associations	
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget:  To define in 2022	Connection with other actions:

Theme: Habitats and ecological continuity		
<b>Orientation:</b> H-O3 - Assist owners with monitoring and maintenance of functionality of fish crossing systems, in		
Action No. HO3-1	order to improve such systems' efficacy.  Action title: 1-Develop an assistance strategy on monitoring and maintenance of the functionality of fish crossing systems, and facilitate its rollout across the territories concerned	
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	OFB and the MTE's departments, manager	s of works to be identified
Objectives to be achieved:	Make sure that crossing systems (for upstream migration and outmigration) are properly maintained and function correctly, in particular during main migration periods.  Benefit: Reduction of delays in migration, reduction of deaths, easier access	
	to the most functional habitats	
Context:	Numerous crossing systems are poorly maintained, creating problems likely to disrupt movement of species.  There are procedures and tools implemented in a number of territories that it may well be useful to draw on.	
Description of the action:	- Define monitoring needs (main periods, frequency, etc.) by territory and related issues - Establish and share a simplified method for analysis of crossing system functionality - Organise technical exchanges with territorial actors (owners, local authorities, syndicates, EPTBs, etc.) with a view to raising awareness on functionality objectives and the obligations connected with crossing systems, and developing a maintenance assistance tool - Facilitate coordination of monitoring actions - Set up/develop networks for each basin	
Output indicators:	- Number, frequency, characteristics and locations of monitored systems - Lengths of watercourses concerned - Number and characteristics of systems in which malfunctions were observed - Preparation of a maintenance assistance tool	
Means indicator:	FTE, material means, etc To define in 2022	
	Partner(s) involved: Metropolitan France: FNPF, FHE, Migratory fish associations, Overseas France: Hydreco Guyane	
Available funding: Indication of types of local, national and European funding that may be available.	Estimated budget:  To define in 2022	Connection with other actions: HO2-1 CO2-1.1, CO2-1.3, CO3-1.3
To define in 2022		



### d. Theme: Fish farming and repopulation

	Theme: Fish farming and repopula	tion	
Orientation: R-	O1- Establish a decision framework for r	epopulation programmes	
Action No. RO1-1	Action title: 1- Share knowledge and experience feedback		
	<b>Deadline:</b> To be set on the Plan's duration	Geographical areas concerned: Metropolitan France	
Prospective action supervisor:	OFB, DPMA		
Objectives to be achieved:	Share knowledge acquired in France assessment.  Benefit: Pooling of updated knowledge	Share knowledge acquired in France and abroad and make a shared assessment.	
Context:	Need to share available experience feedback in order to share the interest and limitations of such operations		
Description of the action:	<ul> <li>- Draw up a document summarising current knowledge</li> <li>- Propose a "fish-farming and repopulation" section in an existing RC</li> <li>- Provision the RC</li> </ul>		
Output indicators:	<ul><li>Dissemination of a summary document</li><li>Creation of a "fish-farming and repopulation" in a RC</li><li>Number of exchange meetings</li></ul>		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved: FNPF, CIPA, Migratory fish associations		
Available funding:  Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget:  To define in 2022	Connection with other actions: SO1-3, CO2-1.1	

Theme: Fish farming and repopulation		
Orientation: R-O1- Establish a decision framework for repopulation programmes		
Action No. RO1-2	Action title: 2- Draw up a national guide to repopulation	
	<b>Deadline:</b> To be set on the Plan's duration	Geographical areas concerned: Metropolitan France
Prospective action supervisor:	OFB, DPMA	
Objectives to be achieved:	Draw up a national guide to repopulation operations  Benefit: Harmonised practices	
Context:	Repopulation operations must be based on a shared national document specifying conditions for implementation or continuation of actions as well as the main technical factors to take into consideration.	
Description of the action:	- Set up a national editorial committee. - Draw up a national guide.	
Output indicators:	- Number of editorial committee meetings - Dissemination of the national guide	
Means indicator:	FTE, material means, etc To define in 2022	
	Partner(s) involved: MNHN-BOREA, CNPMEM, CONAPPED, FNPF, CIPA, Migratory fish associations, ARA France	
Available funding:  Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget:  To define in 2022	Connection with other actions: SO1-3, CO2-1.1



# e. Theme: Monitoring, assessments and outlook

	Theme: Monitoring, Assessments and C	utlook	
Orientation: M-O1- Set up a national facilitation body responsible for monitoring implementation of the PNMA			
Action No. MO1-1	Action title: 1- Equip the PNMA with a dashboard for monitoring actions		
	Deadline: To be set on the Plan's duration		
Prospective action supervisor:	OFB		
Objectives to be achieved:	<ul> <li>Monitor the PNMA's progress.</li> <li>Monitoring of policies connected with the PNMA (Ministries and OFB).</li> </ul> Benefit: ability to monitor actions connected with migratory diadromous species in organised fashion		
Context:	The PNMA dashboard will ensure consistency of the Plan's actions at national level: the various supervisors of its actions will report on their evolution and the SC will take note (accountability).		
Description of the action:	- Set up a dashboard in order to ensure the PNMA's facilitation and assess and disseminate actions implemented Organise annual meetings		
Output indicators:	<ul><li>Creation of the dashboard</li><li>Number of actions implemented</li><li>Minutes of Steering Committee meetings</li></ul>		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved: PNMA action supervisors		
Available funding:  Indication of types of local, national and European funding that may be available.  To define in 2022	Estimated budget:  To define in 2022	Connection with other actions:	

	Theme: Monitoring, Assessments and	l Outlook	
Orientation: M-O1- Set up a n	ational facilitation body responsible for	monitoring implementation of the PNMA	
Action No. MO1-2	Action title: 2- Develop a medium- and long-term funding strategy for the PNMA's actions, excluding local actions provided for in PLAGEPOMIs		
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France	
Prospective action supervisor:	OFB		
Objectives to be achieved:	achievement of the population rest PNMA's actions.	Objective to be achieved 2: Initiate thought on implementation of appropriate	
Context:	The various financing channels are known but remain difficult to control and correlate.  Financial engineering is called for by all project leaders and it would need to be long-term. PNMA actions are not duplications of local actions. Hence, the PNMA's financial strategy does not impinge upon the funding of actions carried out in basins.		
Description of the action:	<ul> <li>Set up a "financial" workgroup incorporating potential financers.</li> <li>Facilitate and create communication tools on funding the PNMA</li> <li>Ensure financial monitoring by the dedicated workgroup</li> </ul>		
Output indicators:	- Number of financial WG meetings  - Number of actions funded <i>via</i> the PNMA  - Number of tools dedicated to the financial strategy  - Financial strategy successful		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved: Action supervisors and financers	· ·	
Available funding:  Indication of types of local, national and European funding that may be available.  To define in 2022	Estimated budget:  To define in 2022	Connection with other actions: All actions funded <i>via</i> the PNMA	

	Theme: Monitoring, Assessments and C	Outlook
Orientation: M-O1- Set up a nati	onal facilitation body responsible for m	nonitoring implementation of the PNMA
Action No. MO1-3	Action title: 3- Bring the PNMA's results to the attention of the authorities responsible for planning documents	
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	OFB	
Objectives to be achieved:	- Identify PNMA provisions to bring attention to - Analyse regulatory texts and tools that might be modified as a result.  Benefit: Ensure consistency of PNMA actions in the various regulatory and planning tools	
Context:	Amendments to legal texts have always been extremely powerful levers for protection of areas and species. They are real springboards for implementation of concrete solutions across the territories and are gladly taken up by managers (e.g. inclusion on List 1 or List 2, Decree on reports for removal of works and no further authorisations, etc.) in order to improve watercourse and migratory fish population statuses.	
Description of the action:	- Set up a WG (major need for lawyers and specialists in environmental law), possibly attached to the CNE and CNML - Propose amendments to regulatory texts to Ministries, along with provision of assistance as experts on the subject - Propose contributions to planning documents in a spirit of coordination	
Output indicators:	- Number of monitoring WG meetings - Number of PNMA proposals taken into account in planning documents	
Means indicator:	FTE, material means, etc To define in 2022	
	Partner(s) involved: Basin DREALs and DIRMs	
Available funding: Indication of types of local, national and European funding that may be available. To define in 2022	Estimated budget:  To define in 2022	Connection with other actions: LO3.1, LO4-1 HO2-2 R01-1, R01-2

Theme: Monitoring, Assessments and Outlook			
Orientation: M-O2- Make best use of existing tools, define new tools and share them across territories			
Action No. MO2-1	Action title: 1- Centralise population monitoring data at national level		
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France	
Prospective action supervisor:	Joint supervisor: OFB (with regard to the inf	ormation system) and Migratory fish associations	
Objectives to be achieved:	Objective to be achieved 1: Have a National (data) Observatory on migratory diadromous species (taking account of DATAPOMI and PONAPOMI) and observation of migratory fish associations, incorporating socioeconomic aspects while continuing to develop existing tools Benefit: data continuity ensured  Objective to be achieved 2: At national level, and for each management unit where necessary, define population status indicators for each species, along with main pressure indicators.  Benefit: acquisition of further knowledge		
Context:	A good many monitoring operations have been carried out over the last 20 years and more, in particular by associations dedicated to migratory species Such data, which are usually acquired in fish passes that may be located a very long way from the sea, are necessary but far from sufficient to enable understanding of the status of populations of major migratory species in hydrographic basins.  Without these operations, data on migratory fish populations in France would be even more fragmentary.  Development of Stations de Contrôle des Migrations (STACOMIs – Migration Control Stations) has enabled unified collection of most partners' data. It must be maintained.  Indicators in greater or lesser states of finalisation exist for each species. Efforts must be made to finalise them all by monitoring their evolution, and identify gaps. Without contrasting local and national indicators, indicators must be developed in such a way as to take account of all		
Description of the action:	impacts and populations, and must define their field of use clearly.  - Set up a "data" WG with a point of contact from the consortium of migratory fish associations - Develop data exchange (definition of needs, exchange scenario, technical development of update method based on remote servers). Among other things, we need to obtain a metadata catalogue in order to know where data are located.  Regarding indicators: - Identify existing and missing indicators and those we have need of		
Output indicators:	- Establish indicators for monitoring conservation status of and pressures on these species  - Creation of the post of consortium of migratory fish associations' point of contact, with a view to pooling observatories and data  - Creation of the National (Data) Observatory on migratory diadromous species  - Number of population status indicators and main pressure indicators obtained		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved: Metropolitan France: MNHN-BOREA, CNPMEM (CRPMEM and CDPMEM), CONAPPED (APPEED), FNPF Overseas France: UMR 7205 ISYEB (UA)		
Available funding:  Indication of types of local, national and European funding that may be available.  To define in 2022	Estimated budget:  To define in 2022	Connection with other actions: LO1-1.1, LO1-1.2, LO1-1.3, LO1-2 FO1-1.1, FO1-1.2, FO1-1.3 HO2-1	

	Theme: Monitoring, Assessments an	d Outlook
Orientation: M-O2- Make best use of existing tools, define new tools and share them across territories		
Action No. MO2-2	<b>Action title:</b> 2- Coordinate implementation of shared conservation objectives for all species in Metropolitan and Overseas France	
	Deadline:  To be set on the Plan's duration  Geographical areas concerned:  Metropolitan and Overseas France	
Prospective action supervisor:	Joint supervision: CNPMEM - CONAPPE	ED - FNPF
Objectives to be achieved:	Share and reach agreement on concepts of conservation limits, responsible fishing and sustainable fishing.	
	Benefit: Increase in populations.	
	Sustainable fishing seeks to minimise its environmental impact over the long term while maximising the economic and social utility of fish caught in the sea and continental waters. The questions are: What impact on biodiversity do we accept? What level of biodiversity do we choose? As regards sustainable fishing, the environmental pillar is a prerequisite: if stocks and ecosystems are no longer functional, there is no point in focusing on other pillars. The priority is environmental but the objective is economic and social.	
Context:	Fishing can only be sustainable if the continental, estuary, coastal and near-shore environments that make up its areas of exploitation are respected by other actors in energy, agriculture, urbanisation, tourism, etc. and their impacts are taken into account.  The IUCN's Red Lists must act as guides to thought on actions relating to protection of diadromous species.	
	In Overseas France, such actions must be carried out in collaboration with socioprofessional actors in recreational fishing, amateur traditional fishing and professional fishing. Species targeted bichique, inaa, titiri and eels.	
Description of the action:	- Develop a national methodology for species with homing (scientific expertise and consultation) - Implement in management units and for relevant species (rolled out by COGEPOMIs on each coastline) or on a broader scale if necessary for widely distributed species	
Output indicators:	- Production of the document summarising concepts	
Means indicator:	FTE, material means, etc To define in 2022	
	Partner(s) involved:	
	Metropolitan France: MNHN-BOREA, University of Perpignan, Migratory fish associations Overseas France: MNHN-BOREA, UMR 7205 ISYEB (UA)	
Available funding: Indication of types of local, national and European funding that may be available.	Estimated budget:  To define in 2022	Connection with other actions: LO1-1.1, LO1-1.3 FO1-1.1, FO1-1.2, FO2-1
To define in 2022		

Theme: Monitoring, Assessments and Outlook		
Orientation: M-O2- Make best use of existing tools, define new tools and share them across territories		
Action No. MO2-3	<b>Action title:</b> 3- Ensure that migratory diadromous species are included in forward-planning studies	
	<b>Deadline:</b> To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	OFB	
Objectives to be achieved:	Forward-planning studies take account of migratory diadromous species.	
Context:	The emergence of new threats such as global change has effects that are still poorly understood. As a number of watercourses that have already undergone restorations (of ecological continuity, etc.), and which have major reception potential, have not provided the desired results, other of the pressure factors previously referred to could be responsible.	
Description of the action:	- Anticipate upcoming changes/threats to migratory diadromous species - Identify methods for such studies at national level	
Output indicators:	- Number of studies in which migratory diadromous species are taken into consideration	
Means indicator:	FTE, material means, etc To define in 2022	
	Partner(s) involved: MNHN-BOREA, Migratory fish associations INRAE	
Available funding: Indication of types of local, national and European funding that may be available.  To define in 2022	Estimated budget:  To define in 2022	Connection with other actions: FO2-1





Theme: Communication, awareness-raising and training		
Orientation: C-O1- Draw up a shared lexicon and a series of arguments on migratory diadromous species		
Action No. CO1-1	Action title: 1- Consolidate content of communication intended for the various audiences in Metropolitan France and to be adapted in Overseas Territories	
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	Joint supervision: OFB and Migratory fish associations	
Objectives to be achieved:	Have communication content available intended for the various audiences concerned and shared by all PNMA actors.  Benefit: Provide migratory diadromous species with greater visibility.	
Context:	Although a great many actors work on behalf of diadromous species, their efforts must be pooled in order to come up with a common argument if we are to get the general public actively involved.	
Description of the action:	- Draw up a lexicon/ glossary to be shared by PNMA actors Share comprehensive communication content that: (1) explains why we should be interested in migratory diadromous species, and (2) explains the issues involved in restoration of ecological continuity  Communication content will draw on scientific knowledge and objective data in order to counter misconceptions	
Output indicators:	- Creation of the lexicon/ glossary to be shared by PNMA actors Number of communication tools designed for the various publics concerned	
Means indicator:	FTE, material means, etc To define in 2022	
Available funding: Indication of types of local, national and European funding that may be available  To define in 2022	Partner(s) involved: Action supervisors Estimated budget:  To define in 2022	Connection with other actions: LO4-1 FO2-1 CO2-1.2 CO3-1.4

Theme: Communication, awareness-raising and training			
Orientation: C-O2- Improve the section dedicated to migratory diadromous species			
at	at the CDR Cours d'eau (Watercourse Resource Centre)  Action title: 1- Improve the section dedicated to migratory diadromous species at		
Action No. CO2-1.1	the CDR Cours d'eau (Watercourse Resource Centre)		
	<b>Sub-action title:</b> 1.1- Consolidate the section dedicated to migratory fish in the Watercourse RC and ensure that it is visible to the actors concerned (in particular for the marine environment)		
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France	
Prospective action supervisor:	OFB		
Objectives to be achieved:	Objective to be achieved 1: Consolidate the section dedicated to migratory fish in the Watercourse RC and ensure that it is visible to the actors concerned (in particular for the marine environment)  Objective to be achieved 2: Provision the Resource Centre by contributions from all professionals concerned and make relevant content available to professionals, elected representatives and the general public using the centre, in particular via crosscutting communication through SC members		
Context:	The OFB is responsible for several RCs: facilitation of networks of actors (needs assessment, organisation of technical exchange days, project coordination, etc.); technical support (advice, training, etc.); production and provision of resources (methods, technical and scientific tools, experience feedback, news, etc.). The Watercourse RC has been identified as the most relevant RC for provisioning of the "migratory diadromous species" section.		
Description of the action:	<ul> <li>- Analyse the Watercourse Resource Centre's borders and porosities with the 8 other RCs</li> <li>- Maintain the connection between the Watercourse RC's facilitation service and the PNMA's facilitator</li> <li>- Ensure that bridgeways are developed between the various resource centres on subjects to do with migratory diadromous species</li> <li>- Organise Watercourse RC's technical days on migratory diadromous species and in particular on restoration of ecological continuity, in connection with other RCs</li> </ul>		
Output indicators:	<ul> <li>Number of resources provisioned</li> <li>Status report on information available, in particular in the Watercourse RC</li> <li>Number of meetings between RCs in order to highlight information connected with migratory diadromous species</li> <li>Number of technical days held, to distinguish between in terms of themes covered</li> </ul>		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved:		
Available funding:	Action supervisors  Estimated budget:	Connection with other actions:	
Indication of types of local, national and European funding that may be available To define in 2022	To define in 2022	LO1-2 HO1-1.1, HO1-1.2, HO1-1.3, HO1-1.4, HO2-1, HO3-1 RO1-1, RO1-2	

Theme: Communication, awareness-raising and training			
Orientation: C-O2- Improve the section dedicated to migratory diadromous species at the CDR Cours d'eau			
	(Watercourse Resource Centre)		
Action No. CO2-1.2	Action title: 1- Improve the section dedicated to migratory diadromous species		
ACTION NO. CO2-1.2	at the CDR Cours d'eau (Watercourse Resource Centre)		
	Sub-action title:1.2- Create a communication toolbox on migratory diadromous		
	species		
	Deadline: Geographical areas concerned :		
	To be set on the Plan's duration	Metropolitan and Overseas France	
Prospective action supervisor:	OFB and migratory fish associations		
	Objectives to be achieved 1: Help actors to communicate on migratory		
	diadromous species		
Objectives to be achieved:	<b>Objectives to be achieved 2</b> : Better knowledge on and concern for migratory diadromous species		
	Benefit: Commitment on the part of actors and the general public.		
Cartant	Although a great many actors work on behalf of diadromous species, their efforts must be pooled in order to come up with a common argument if we are		
Context:	to get the general public actively involved.		
	- Establish a protocol for provision and verification of content.		
	- Use Action C-O1-1 so as to have detailed arguments available to incorporate into communication tools, in line with the subjects broached - Share models for press releases/kits - Share photo and video resources with appropriate rights of use - Share existing territorial communication tools		
Description of the action:			
	- Produce shareable communication tools (content and media lending libraries)		
	- Creation of the Toolbox		
Output indicators:	- Number of articles / reports/ documentaries		
	FTE, material means, etc		
Means indicator:	To define in 2022		
	Partner(s) involved:		
Available funding:	Estimated budget:	Connection with other actions:	
Indication of types of local,		CO1-1	
national and European funding	To define in 2022	CO3-1.1	
that may be available		CO3-1.2 CO3-1.4	
To define in 2022		1.7	

Theme: Communication, awareness-raising and training			
<b>Orientation:</b> C-O3- Define targeted actions that are consistent with each other and adapted to each of the audiences concerned, elected representatives and professionals			
Action No. CO3-1.1	<b>Action title:</b> 1- Raise awareness on migratory diadromous species by carrying out consistent targeted actions appropriate to the various sectors of the public concerned		
	Sub-action title: 1.1- Develop and strengthen partnerships with the press		
	Deadline:  To be set on the Plan's duration  Geographical areas concerned:  Metropolitan and Overseas France		
Prospective action supervisor:	OFB		
Objectives to be achieved:	Mobilise potential press partners  Benefit: More media coverage of migratory diadromous species		
Context:	Advantage must be taken of existing monitoring units, using them to highlight information and news on diadromous species.  Such communication will not be a substitute for territorial communication, but aims to be complementary to it with a national vision.		
Description of the action:	Help actors develop and strengthen relations with the press by providing them with various tools:  - Make use of the toolbox provided for in C-O2-1.2  - Organise national communication campaigns and actions targeting the press and coordinated with territorial actions		
Output indicators:	- Number of communication campaigns - Number of press releases		
Means indicator:	FTE, material means, etc To define in 2022		
	Partner(s) involved: MTE		
Available funding: Indication of types of local, national and European funding that may be available  To define in 2022	Estimated budget:  To define in 2022	Connection C-O2-1.2	on with other actions:

Theme: Communication, awareness-raising and training		
_	eted actions that are consistent with e concerned, elected representatives ar	
Action No. CO3-1.2	<b>Action title:</b> 1- Raise awareness on migratory diadromous species by carrying out consistent targeted actions appropriate to the various sectors of the public concerned	
	<b>Sub-action title:</b> 1.2 - Make use of all possible communication channels and of existing events	
	<b>Deadline:</b> To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	OFB	
Objectives to be achieved:	Disseminate subjects on migratory diadromous species more widely.  Benefit: Provide migratory diadromous species with greater visibility	
Context:	Communication actions have been carried out for many years, but there has not been enough pooling of knowledge up until now. Lack of knowledge on issues has led to a lack of commitment Some groups defend their interests on the basis of erroneous explanatory data	
Description of the action:	- Create a benchmark for existing communication channels and events.  - Select the most interesting public events and technical partners so as to be able to integrate issues to do with migratory diadromous species.  - Make use of other channels, including social networks.	
Output indicators:	Number of posts/shares on social networks Number of events concerned	
Means indicator:	FTE, material means, etc To define in 2022	
	Partner(s) involved: MNHN-BOREA	
Available funding: Indication of types of local, national and European funding that may be available  To define in 2022	Estimated budget:  To define in 2022	Connection with other actions:

Them	e: Communication, awareness-raising a	nd training
	eted actions that are consistent with ea	·
audiences concerned, elected representatives and professionals		
A-41 No. 603.4.3	-	gratory diadromous species by carrying
Action No. CO3-1.3	out consistent targeted actions appropriate to the various sectors of the public concerned	
	Sub-action title: 1.3- Communicate to the general public and elected	
	representatives on restoration of ecological continuity for migratory	
	diadromous species	
	Deadline: Geographical areas concerned:	
	To be set on the Plan's duration	Metropolitan and Overseas France
Prospective action supervisor:	OFB	
	Objectives to be achieved 1: Develop major communication actions on	
		tended for the general public and elected
	representatives (in order to counter disinformation).	
	<b>Objectives to be achieved 2:</b> Conduct communication campaigns designed to	
Objectives to be achieved:	combat misconceptions.  Benefits:	
	- better acceptance of projects and initiatives on restoration of ecological	
	continuity - a more balanced public opinion	
	Restoration of ecological continuity, a key factor in improvement of migratory	
	fishes' population status, is a subject the general public still knows relatively	
Context:	little about. It is often belittled and there is a great deal of misinformation	
	about. An awareness-raising campaign on restoration of ecological continuity	
	with Water Agencies and the OFB is in the pipeline.  Launch of a national communication campaign on the proven usefulness and	
	benefits of restoration of ecological continuity (possible combination with the	
Description of the action:	"extraordinary" aspects of species benefiting from it = playing upon people's	
	sympathies).	
	- Number of communication actions targeting the general public	
Output indicators:	- Number of communication actions t	argeting elected representatives
·	- Number of favourable opinions	
	FTE, material means, etc	
Means indicator:	To define in 2022	
	Partner(s) involved:	
	MNHN-BOREA	
	Water Agencies	
Available funding:	Estimated budget:	Connection with other actions:
Indication of types of local,	T 16	HO1-1.1, HO1-1.2, HO1-1.3, HO3-1
national and European funding	To define in 2022	
that may be available		
To define in 2022		

Them	ne: Communication, awareness-raising a	and training
Orientation: C-O3- Define targeted actions that are consistent with each other and adapted to each of the audiences		
con	cerned, elected representatives and pro	
Action No. CO3- 1.4	<b>Action title:</b> 1- Raise awareness on migratory diadromous species by carrying out consistent targeted actions appropriate to the various sectors of the public concerned	
	<b>Sub-action title:</b> 1.4- Raise awareness among and communicate to users on diadromous species	
	<b>Deadline:</b> To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	OFB at national level Migratory fish associations	
Objectives to be achieved:	Better account taking by users of issues regarding migratory diadromous species and the potential impacts of their activities.	
	Benefit: Commitment by users	
Context:	A number of migratory fish populations are subject to pressures connected with leisure activities. Such pressures can vary in kind depending on season and environment. For example: recreational fishing for shad in areas of population concentration, and kayaking in salmon juvenile growth areas  This action can be linked with the "Engagée pour la nature" (Committed to Nature) initiative promoted by the MTE with support from the OFB.	
Description of the action:	<ul> <li>Develop information mediums/ tools on the consequences of such activities depending on times of year and areas concerned.</li> <li>Propose more responsible practices with less impact on diadromous fish populations.</li> </ul>	
Output indicators:	- Number of actions carried out by category of targeted user	
Means indicator:	FTE, material means, etc To define in 2022	
	Partner(s) involved: Metropolitan France: MNHN Overseas France: French Guiana DGTM and University of Perpignan	
Available funding: Indication of types of local, national and European funding that may be available  To define in 2022	Estimated budget:  To define in 2022	Connection with other actions: CO1-1, CO2-1.2

Theme: Communication, awareness-raising and training		
Orientation: C-O4- Set up training programmes on migratory diadromous species		
Action No. CO4-1	Action title: 1- Integrate issues identified in the PNMA into the various training courses focusing on biodiversity and other professional training programmes connected with activities that may interact with migratory diadromous species	
	Deadline: To be set on the Plan's duration	Geographical areas concerned: Metropolitan and Overseas France
Prospective action supervisor:	OFB	,
Objectives to be achieved:	Objective to be achieved 1: Integrate issues identified in the PNMA into training programmes designed for the general public and professionals.  Objective to be achieved 2: Integrate species' biological requirements into studies and projects by research departments and watercourse managers via training courses. Such courses will be no substitute for mobilisation of experts and implementation of studies, but they will make the actors concerned aware of all the factors that have to be taken into account on the subject during development of territorial projects.	
	<b>Benefit:</b> Better account-taking of migratory diadromous species by the actors concerned (biodiversity professionals and others)	
Context:	There are a good many existing training programmes focusing on biodiversity; we need to ensure that issues identified in the PNMA are included in them. Numerous training programmes are delivered by the OFB and other actors. However, assessment needs to be made of the current situation in order to know which of them include training on issues connected with migratory diadromous species.	
Description of the action:	1- Work in consultation with actors concerned to ensure inclusion of training on migratory diadromous species in programmes.  - Benchmark existing courses  - Identify the importance of modules on restoration of ecological continuity enabling establishment of common bases  - Create a module that can be reused in targeted biodiversity training courses.  2- Propose courses by group and by subject, at national level, in particular in the form of free online classes (MOOCs).	
Output indicators:	<ul> <li>Number of partnerships with continuing and initial training institutions</li> <li>Number of training courses / MOOCs that include training on migratory diadromous species</li> <li>Number of modules created for training purposes</li> </ul>	
Means indicator:	FTE, material means, etc To define in 2022	
Available funding: Indication of types of local, national and European funding that may be available To define in 2022	Partner(s) involved:  Metropolitan France: EDF  Overseas France: French Guiana DGTN  Estimated budget:  To define in 2022	Connection with other actions: FO2-1 HO1-1.1 HO1-1.2 HO1-1.3 HO1-1.4

# D. TIMETABLE FOR IMPLEMENTATION OF THE PLAN AND FINANCIAL ESTIMATE

A financial estimate for the Plan is not possible at this time. 2022 will see operational organisation of adopted actions, enabling an estimate of implementation costs, along with identification of financial partners. The financial strategy for implementation of the Plan should include the mounting of a "traditional" LIFE project in the context of the "Nature and Biodiversity" sub-programme of the European Union's LIFE 2021-2027 programme, LIFE being a European Commission financial instrument entirely dedicated to supporting projects in the fields of the environment and the climate. The project will itself be connected with two other projects led by the OFB: an integrated LIFE project entitled "LIFE Stratégique Nature" with restoration of environments as its main focus, and a "traditional" LIFE project entitled "LIFE espèces mobiles", aiming to meet the MSFD's environmental goals promoted by France.

## **CHAPTER 5: GOVERNANCE, MONITORING AND ASSESSMENT**

Organisation and governance are essential factors in guaranteeing effective and efficient implementation of the Plan. The proposed organisational framework is presented below (Figure 3).

The Steering Committee (SC) is the main body responsible for monitoring and orientating the Plan. It intervenes in the implementation phase and must be as operational as possible. In order to provide the SC with technical and scientific support, thematic groups will be set up for each of the PNMA's themes. Scientific experts will be consulted when necessary in order to inform the SC's deliberations. Finally, a "financial" workgroup, incorporating potential financers will be created in order to facilitate development of projects and guarantee their funding.

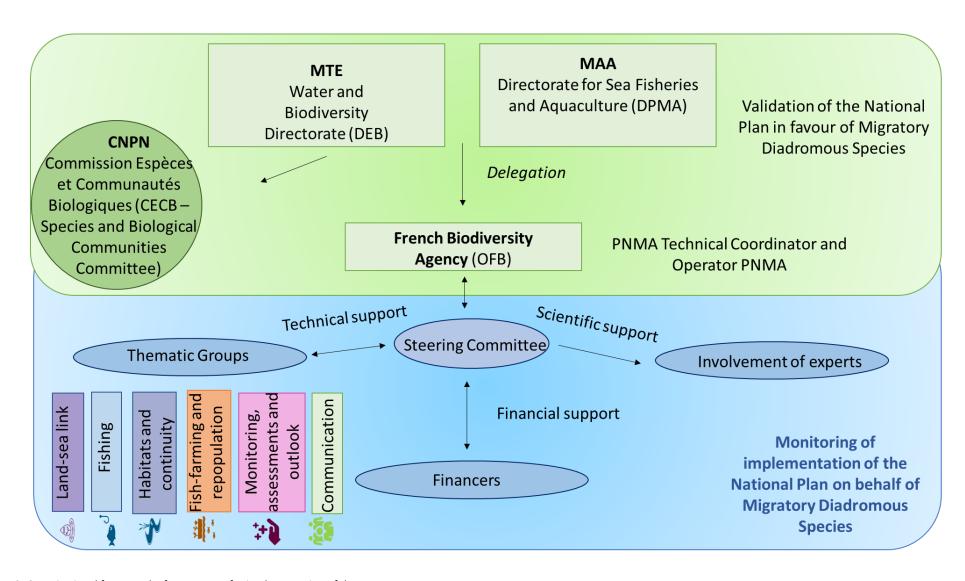


Figure 3: Organisational framework of governance for implementation of the PNMA.

# A. THE STEERING COMMITTEE

# 1. Missions

The SC's missions are as follows:

- Monitoring and assessing implementation of actions;
- Proposing establishment or modification of actions defined in the Pan;
- Define and approve output and result indicators proposed by action initiators.

The Steering Committee's composition may be enlarged if need be, and if its members agree. However, its size must remain compatible with its operational character. If necessary and depending on the agenda, stakeholders may occasionally be invited to take part in meetings.

It meets at least once a year.

# 2. Composition

So that the PNMA's drafting and implementation results from consultation with stakeholders, the Plan's SC, in addition to action supervisors, includes representatives of users sitting on COGEPOMIs (recreational fishing, professional freshwater fishing, professional sea fishing, fish farming, hydropower, agriculture, etc.), organisations responsible for monitoring, such as migratory fish associations (of a scientific character) and the administrations concerned (DREALs, DIRMs, etc.), under the joint authority of the DEB and the DPMA (Table 13). The SC was open to all interested stakeholders and includes all actors partnering actions.

Table 13: Entities called upon in the context of an enlarged SC.

	Entity
	Ministry for the Ecological Transition (Water and Biodiversity
State  Environmental protection associations	Directorate)
	Ministry of Agriculture and Food' (Maritime Fisheries and Aquaculture
	Directorate)
	Ministry for Overseas France
	Ministry for the Sea
	French Biodiversity Agency
	COGEPOMI Secretariats
	DSF Technical Secretariats
	Water Agencies
	International Union for Conservation of Nature
	France Nature Environnement
	Fund for the Conservation of Wild Rivers (FCRS)
Hydropower actors	Electricité De France (EDF)
	Compagnie Nationale du Rhône (CNR)
	France Hydro Electricité (FHE)
	National Committee for Marine Fisheries and Marine Farming
Fishing operators	(CNPMEM)
	National Committee for Professional Freshwater Fishing (CONAPPED)
	National Federation of Fishing in France (FNPF)
Aquaculture operators	Interprofessional Committee for Aquaculture Products (CIPA)
Other users	French Federation of Canoe Kayak and Paddle Sports (FFCK)
	Voies Navigables de France (VNF)
	French Federation of Associations for the Protection of Mills (FFAM)
	Federation of Mills of France (FDMF)
	Association des Riverains de France (ARF)
Local Authorities	National Federation of Licensing Authorities (FNCCR)
	National Association of River Basin Elected Representatives (ANEB)
	Régions de France (RdF)
Managers of Natural Areas	Regional Nature Parks
	Marine Protected Area Network (MPAN)
	Coastal Conservatory (CDL)
Research actors	National Research Institute for Agriculture, Food, and Environment
	(INRAE)
	National Museum of Natural History (MNHN)
	University of Perpignan
	National Institute for Ocean Science (IFREMER)
Associations for management and protection of migratory species	Loire Grands Migrateurs (LOGRAMI – representing associations for
	management and protection of migratory species)
	Migrateurs Rhône-Méditerranée Association (expertise on lagoon
	environments)

# **B.** INVOLVEMENT OF EXPERTS

### 1. Missions

Experts will be consulted in order to provide opinions and inform the SC on actions to promote in line with scientific knowledge on conservation of species.

A member can be designated from among the experts involved and invited to Steering Committee meetings as a rapporteur.

# 2. Composition

The SC will call upon experts as required, depending on the action or subject on which an opinion is needed. They will have to have a reputation for impartiality.

# C. THEMATIC GROUPS

Thematic Groups (Figure 4) will be formed in order to monitor and, if required, adapt the actions overseen by the various supervisors. They will provide the Steering Committee with opinions.

In order to ensure they work efficiently, Thematic Groups will have limited numbers of members. Their composition will be set by the Steering Committee. Lists of participants can be adapted by the SC as needed. Each workgroup will be led by an expert on the theme concerned.



Figure 4: Thematic Groups for the National Plan in favour of Migratory Diadromous Species (PNMA).

# **D. MONITORING AND ASSESSMENT**

# 1. Impact indicators

Implementation of the Plan will be assessed throughout its duration, making use of a system whose first level is based on one or more indicators measuring the Plan's impact. Upon completion of the Plan and at midterm, these indicators must enable us to answer the question: how are populations of migratory diadromous species evolving?

One possible indicator has already been implemented by the National Observatory on Biodiversity, entitled "Proportion of species of migratory diadromous fish in Metropolitan France classified as extinct or threatened on the national Red List", which is based on the classifications in the Red List published by the IUCN. As this indicator only concerns species in Metropolitan France, it would be useful to modify it by including regional Red Lists from Overseas France. Other indicators can be suggested.

# 2. Annual Reviews

The Steering Committee will meet at least once a year to ensure that the PNMA is properly monitored and assessed.

In order to prepare for the meeting, an annual Technical and Financial Report will be drawn up by the PNMA Coordinator, centralising and summarising information provided by the action supervisors involved. This document will enable the Steering Committee to set strategic orientations for the following year.

For each action, the Report presents:

- A review of actions carried out, indicating their state of progress and any difficulties encountered (planned actions not undertaken, problems encountered during the launch or funding of actions, information on developments that may have impacted species, etc.) as well as output indicators;
- A financial statement and an assessment of the human resources mobilised, in the light of means indicators;
- A costed scheduling proposal for the following year.

# 3. Midterm Assessment

The Plan will be assessed at midterm in order to draw up an interim review and be able to adapt actions to be carried out in the following years in accordance with the impact indicator and results obtained.

The midterm assessment will adopt the methodology set for the final assessment (see below).

# 4. Final Assessment

Technical and Financial Review drawn up by the Technical Operator

The Plan Coordinator will draw up a Technical and Financial Review which they will submit to the SC and which will present:

- A summary of operations carried out;
- The state of progress, the financial statement, and human resources mobilised;

• An update of Chapters 3 and 4 of the Plan.

Assessment by an external body

The PNMA will be assessed by an external body following its period of implementation. The aim of such assessment is to provide a comprehensive review of the PNMA and define any future action that might be taken.

The assessment will take stock of results in terms of conservation and knowledge acquired. The Plan's effectiveness will be measured in the light of species' conservation statuses at the beginning and end of the Plan and knowledge acquired, in particular via the impact indicator.

Actors' roles and positionings will be analysed. Special attention will be paid to synergies between national actors, cooperation with management bodies, and awareness-raising among and communication to the general public, all of which are major factors to take into consideration in order to estimate how successful the Plan has been and highlight any shortcomings. A financial statement will also be drawn up.

The review of the Plan's various objectives and summary of the assessment's essential points will provide avenues for thought on prolongation of the Plan or possible drafting of a new action plan, if a need for one has been demonstrated.

The Interim and Final Assessments and the Annual Report are releasable public documents.

# INDEX OF ABBREVIATIONS AND ACRONYMS

#### Α

AAPPMA · Association agréée de pêche et de protection des milieux aquatiques (Approved Association for Fishing and Protection of the Aquatic Environment) AngHV1 · Anquillid herpesvirus 1

#### В

**BGM** · Association Bretagne grands migrateurs (Brittany Migratory Fish Association)

# C

CEB · Comité de l'eau et de la biodiversité (Water and Biodiversity Committee)

CDR · Centre De Ressource / RC Resource Centre

CIPA · Comité interprofessionnel des produits de l'aquaculture (Interprofessional Committee for Aquaculture Products)

CITES · Convention on International Trade in Endangered Species of Wild Fauna and Flora

CNPMEM/CRPMEM · Comité national/régional des pêches maritimes et des élevages marins (National Committee / Regional Committees Committee for Marine Fisheries and Sea Farming

COGEPOMI · Comité de gestion des poissons migrateurs (Migratory Fish Management Committee)

CONAPPED · Comité national de la pêche professionnelle en eau douce (National Committee for Professional Freshwater Fishing)

CPUE · Catches per Unit Effort

#### D

DCE · Directive-cadre sur l'eau / FWD Framework Water Directive

DCPEM · Directive-cadre pour la planification de l'espace maritime / MSPD Maritime Spatial Planning Directive

DCSMM · Directive-cadre stratégie pour le milieu marin / MSFD Marine Strategy Framework Directive

DEAL · Direction de l'environnement, de l'aménagement et du logement (Environment, Development and Housing Directorate)

DHFF · Directive habitats faune flore / FFHD Fauna-Flora-Habitat Directive

DiadES · Diadromous Fish and Ecosystem Services

DMB · Débit minimum biologique / MRF Minimum Residual Flow

DMSOI · Direction de la mer sud océan indien (Southern Indian Ocean Sea Directorate)

DREAL · Direction régionale de l'environnement, de l'aménagement et du logement (Regional Directorate for Environment, Planning and Housing)

DROM · Départements et régions d'outre-mer (Overseas France)

DSF · Documents stratégiques de façades (Sea Basin Strategy Documents)

#### Ε

EE · Espèce exotique / ES Exotic Species

EEE · Espèce exotique envahissante / IES Invasive Exotic Species

ERC · Eviter, réduire, compenser / PRO Prevent – Reduce – Offset

ERR · Equivalent radier/rapide / RRE riffles-rapids equivalent

EVEX · Eel virus European X

#### F

FDPPMA · Fédération départementale de pêche et de protection du milieu aquatique (Départemental Federation for Fishing and Protection of Aquatic Environments)

FNPF · Fédération nationale de la pêche en France (National Federation of Fishing in France)

#### н

HAP · Hydrocarbure aromatique polycyclique / PAH Polycyclic aromatic hydrocarbon

#### ı

I2M2 · Indice invertébrés multimétrique (Multimetric Invertebrate Index)

IBD · Indice biologique diatomées / BDI Biological Diatom Index

ICE · Informations sur la continuité écologique (Information on ecological continuity)

INN · Illicite non déclarée et non réglementée / IUU illegal, unreported and unregulated

IPBES · Intergovernmental science-policy platform on biodiversity and ecosystem services

IPR · Indice poisson rivière / FBI Fish Biotic Index

### L

- LEMA · Loi sur l'eau et les milieux aquatiques (Water and Aquatic Environment Act)
- LSE · Limite de salure des eaux (Salt water demarcation line)
- LTM · Limite transversale de la mer (Maritime lateral limit)

#### M

- MAA · Ministère de l'Agriculture et de l'Alimentation (Ministry of Agriculture and Food)
- MTE · Ministère de la Transition écologique (Ministry for the Ecological Transition)
- MTES · Ministère de la Transition écologique et solidaire (Ministry for the Ecological and Inclusive Transition)

## Ν

- NHI · Nécrose hématopoïétique infectieuse / IHN Infectious Haematopoietic Necrosis
- NOA · North Atlantic Oscillation
- NPI · Nécrose pancréatique infectieuse / IPN Infectious pancreatic necrosis

#### 0

- OCLAESP · Office central de lutte contre les atteintes à l'environnement et à la santé publique (Central Office against Environmental and Public Health Crime)
- OCSAN · Organisation de conservation du saumon de l'Atlantique Nord / NASCO North Atlantic Salmon Conservation Organisation)
- OE · Obstacle à l'écoulement (Obstacle to flow)
- OFB · Office français de la biodiversité (French Biodiversity Agency)
- OIE · World Organisation for Animal Health (Office international des épizooties)
- ONB · Observatoire national de la biodiversité (National Observatory on Biodiversity)
- ONEMA · Office national de l'eau et des milieux aquatiques (National Office for Water and Aquatic Environments)

#### P

- PGA · Plan de gestion anguille (Eel Management Plan)
- PGRI · Plan de gestion des risques d'inondation (Flood Risk Management Plan)
- PKD · Polycystic kidney disease
- PLAGEPOMI · Plan de gestion des poissons migrateurs (Migratory fish management plan)
- PLU · Plan local d'urbanisme (Local Urban Planning Plan)
- PNA · Plan national d'action / NAP National Action Plan

- PNES · Programme national d'éradication et de surveillance (National Eradication and Control Programme)
- PNMA · Plan national en faveur des migrateurs amphihalins (National Plan in favour of Migratory Diadromous Species)
- PNM-EPMO · Parc naturel marin des estuaires picards et de la mer d'opale (Picardy Estuaries and Opal Sea Regional Nature Park)
- PSNPDA · Plan stratégique national pluriannuel de développement aquacole (Multiannual National Plan for the Development of Sustainable Aquaculture)

#### R

- RCE · Restauration de la continuité écologique (Restoration of ecological continuity)
- ROE · Référentiel national des obstacles à l'écoulement (National Repository of Obstacles to Flow)

#### S

- SAGE · Schéma d'aménagement et de gestion des eaux (Water Development and Management Plan)
- SAR · Schéma d'aménagement régional (Regional Development Plan)
- SCOT · Schéma de cohérence territoriale (Territorial Coherence Scheme)
- SDAGE · Schéma directeur d'aménagement et de gestion des eaux (Water Development and Management Master Plan)
- SHV · Septicémie hémorragique virale / VHS Viral haemorrhagic septicaemia
- SNB · Stratégie nationale pour la biodiversité (National Biodiversity Strategy)
- SRADDET · Schéma régional d'aménagement, de développement durable et d'égalité des territoires (Regional Plan for Sustainable Development and for the Equality of Territories)
- SRCE · Schémas régionaux de cohérence écologique (Regional Ecological Coherence Schemes)
- SST · Sea surface temperature
- STB: Secrétariat technique de bassin (Basin Technical Secretariat)
- STACOMI · Station de Contrôle des Migrations (Migration Control Station)
- STEU · Station d'épuration des eaux usées / WWTP Wastewater Treatment Plant
- STRANAPOMI · Stratégie nationale pour la gestion des poissons migrateurs (National Migratory Fish Management Strategy)

TVB · Trame verte et bleu (Green and Blue Belt network)

U

UICN · Union internationale pour la conservation de la nature / IUCN International Union for Conservation of Nature

UNESCO · United Nations Educational, Scientific and Cultural Organisation

W

WGI · Worldwide Governance Indicators WoRMS · World Register of Marine Species

Ζ

ZCH · Zone de conservation halieutique (Fishery Conservation Zone)

ZPB · Zone prioritaire pour la biodiversité (Priority Zone for Biodiversity)

ZSC · Zone spéciale de conservation / SAC Special Area of Conservation

# **LIST OF FIGURES**

Figure 1: Schematic representation of diadromous life strategies (C. Thomas, 2017).

Figure 2: Conceptual diagram of the general history of and factors leading to the decline of diadromous species in the North Atlantic. Most species were heavily exploited before industrialisation and physical alteration of watercourses; other alterations to drainage basins due to human population expansion and climate change have aggravated loss of habitat. (Limburg & Waldman, 2009).

Figure 3: Organisational framework of governance for implementation of the PNMA.

Figure 4: Thematic Groups for the National Plan in favour of Migratory Diadromous Species (PNMA)..

# **LIST OF TABLES**

Table 1: Phylogenetic classification of Metropolitan France's 12 migratory diadromous species (Species < Family < Class < Infraphylum < Subphylum). Source: World Register of Marine Species (WoRMS)

Table 2: Phylogenetic classification of French Guiana's diadromous fish (Species < Family < Class < infraphylum < Subphylum).

Table 3: Phylogenetic classification of the French West Indies' diadromous fish (Species < Family < Class < infraphylum < Subphylum) and specific occurrence depending on island territory (Martinique/Guadeloupe).

Table 4: Phylogenetic classification of diadromous fish on Overseas French Islands in the Indian Ocean (Species < Family < Class < infraphylum < Subphylum) and specific occurrence depending on island territory (Reunion Island/Mayotte).

Table 5: State and status of migratory diadromous species in Metropolitan France Presence (+) or absence (-) in French hydrographic basins (?: occurrence not defined): Artois-Picardy (AP), Seine-Normandy (SN), Rhine-Meuse (RMs), Brittany (Br), Loire (Lo), Garonne-Dordogne (GD), Adour (Ad), Rhone-Mediterranean (RMd), Corsica (C). Classification in the IUCN France Red List's categories (Cat) (2019): Data Deficient (DD); Least Concern (LC); Near Threatened (NT); Vulnerable (VU); Endangered (EN); Critically endangered (CR) Population evolution trend (Ted): increasing (¬); stable (→); decreasing (¬); unknown (?). Sources: OFB, INRAE, MNHN, IUCN.

Table 6: State and status of diadromous species in Martinique. Classification in the IUCN Martinique Red List's categories (Cat) (2020): Data Deficient (DD); Least Concern (LC); Near Threatened (NT); Vulnerable (VU); Endangered

(EN); Critically endangered (CR). Population evolution trend (Ted): decreasing (১); unknown (?). NM: species not mentioned on the list. Sources: OFB, INRAE, MNHN, IUCN.

Table 7: Status and state of diadromous species on Reunion Island Classification in the IUCN Reunion Island Red List's categories (Cat) (2017): Data Deficient (DD); Least Concern (LC); Near Threatened (NT); Vulnerable (VU); Endangered (EN); Critically endangered (CR) NM: species not mentioned on the list. Sources: OFB, INRAE, MNHN, IUCN.

Table 8: Present state of knowledge on the ecology of the marine phase of Metropolitan France's migratory diadromous species. Well-documented subject (green), partially documented (orange) or totally unknown (red). Based on Baglinière & Acou (2019).

Table 9: Comparison of the advantages and limitations of tools and methods used to describe migratory fish populations in rivers (Martignac et *al.*, 2015).

Table 10: Main texts on conservation of Metropolitan France's migratory diadromous species.

Table 11: Overview of legal protection status (national, European and international) of Metropolitan France's migratory diadromous species.

Table 12: Migration timing of 5 taxa studied by Legrand et *al.* (2021) and variations observed by these authors between 1985 and 2015. Data are rounded out and simplified; values in grey are not significantly different. *Note*: the median day corresponds to the day of the year on which half of all individuals have migrated.

Table 13: Entities called upon in the context of an enlarged SC.

# **BIBLIOGRAPHY**

- Abdou, A., Keith, P., & Galzin, R. (2015). Freshwater neritids (Mollusca: Gastropoda) of tropical islands, amphidromy as a life cycle, a review. *Revue d'écologie (Terre et Vie)*, 70(4), 12.
- Acou, A., Lasne, E., Reveillac, E., Robinet, T., & Feunteun, E. (2013). Programme de connaissances « Amphihalins Natura2000 en mer ». Evaluation de la suffisance du réseau Natura2000 en mer pour les espèces amphihalines et éléments de réponse aux recommandations émises en zone atlantique. 25. https://doi.org/10.13140/RG.2.1.1841.1921
- Agnew, D. J., Pearce, J., Pramod, G., Peatman, T., Watson, R., Beddington, J. R., & Pitcher, T. J. (2009). Estimating the Worldwide Extent of Illegal Fishing. *PLOS ONE*, *4*(2), e4570. https://doi.org/10.1371/journal.pone.0004570
- Agostinho, A. A., Agostinho, C. S., Pelicice, F. M., & Marques, E. E. (2012). Fish ladders: Safe fish passage or hotspot for predation? *Neotropical Ichthyology*, 10(4), 687\_696. https://doi.org/10.1590/S1679-62252012000400001
- Almodóvar, A., Leal, S., Nicola, G., Hórreo, J., García-Vázquez, E., & Elvira, B. (2020). Long-term stocking practices threaten the original genetic diversity of the southernmost European populations of Atlantic salmon *Salmo salar*. *Endangered Species Research*, *41*, 303\_317. https://doi.org/10.3354/esr01029
- Anderson, J. J., Gurarie, E., Bracis, C., Burke, B. J., & Laidre, K. L. (2013). Modeling climate change impacts on phenology and population dynamics of migratory marine species. *Ecological Modelling*, *264*, 83\_97. https://doi.org/10.1016/j.ecolmodel.2013.03.009
- ANSES. (2015). Hiérarchisation des Dangers Sanitaires Exotiques ou Présents en France Métropolitaine Chez les Poissons D'élevage (Saisine n°2013-SA-0049). https://www.anses.fr/fr/system/files/SANT2013sa0049-05.pdf
- ANSES. (2017). Fiche de description de danger biologique transmissible par les aliments—Caractéristiques et sources d'Anisakis spp. Et Pseudoterranova spp. https://www.anses.fr/fr/system/files/BIORISK2016SA0071Fi.pdf
- Antajan, E., Bastian, T., Raud, T., Brylinski, J.-M., Hoffman, S., Breton, G., Cornille, V., Delegrange, A., & Vincent, D. (2014). The invasive ctenophore *Mnemiopsis leidyi* A. Agassiz, 1865 along the English Channel and the North Sea French coasts: Another introduction pathway in northern European waters? *Aquatic Invasions*, *9*(2), 167\_173. https://doi.org/10.3391/ai.2014.9.2.05
- Aprahamian, M. V., Aprahamian, C. D., Baglinière, J. L., Sabatié, R., & Alexandrino, P. (2003). *Alosa alosa and Alosa fallax spp: Literature review and bibliography* (R&D Technical Report N° W1-014/TR; p. 374). INRA, CIBIO, ENSAR.
- Archambaud, G., Giordano, L., & Dumont, B. (2005). *Description du substrat minéral et du colmatage* (p. 7). CEMAGREF UR Hydrobiologie.
- Arkush, K. D., Frasca, S., & Hedrick, R. P. (1998). Pathology Associated with the Rosette Agent, A Systemic Protist Infecting Salmonid Fishes. *Journal of Aquatic Animal Health*, 10(1), 1\_11. https://doi.org/10.1577/1548-8667(1998)010<0001: PAWTRA>2.0. CO; 2
- Arkush, K. D., Mendoza, L., Adkison, M. A., & Hedrick, R. P. (2003). Observations on the Life Stages of *Sphaerothecum destruens* n. G., n. Sp., a Mesomycetozoean Fish Pathogen Formally Referred to as the Rosette Agent. *Journal of Eukaryotic Microbiology*, *50*(6), 430\_438. https://doi.org/10.1111/j.1550-7408.2003.tb00269.x
- Arrêté du 26 octobre 2012 déterminant la taille minimale ou le poids minimal de capture des poissons et autres organismes marins (pour une espèce donnée ou pour une zone géographique donnée) effectuée dans le cadre de la pêche maritime de loisir—Légifrance. (s.d.). Consulté 5 octobre 2021, à l'adresse https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000026582115
- Article L214-17—Code de l'environnement—Légifrance. (s.d.). Consulté 5 octobre 2021, à l'adresse https://www.legifrance.gouv.fr/codes/article\_lc/LEGIARTI000033034927/
- Article L214-18—Code de l'environnement—Légifrance. (2006).

  https://www.legifrance.gouv.fr/codes/article\_lc/LEGIARTI000006833152/

- Article L432-3—Code de l'environnement—Légifrance. (2013). https://www.legifrance.gouv.fr/codes/article\_lc/LEGIARTI000025144585/
- Association Normandie Grands Migrateurs. (2018). Rivières vivantes de Normandie—La lettre de l'association Normandie Grands Migrateurs n°5. <a href="http://normandiegrandsmigrateurs.fr/wp-content/uploads/2018/03/NGM">http://normandiegrandsmigrateurs.fr/wp-content/uploads/2018/03/NGM</a> RVN 5 VF HD.pdf
- Association Saumon-Rhin. (2010). Brèves... En quelques chiffres. Vol 14: 6. Saumon Rhin Infos.
- Augspurger, J. M., Warburton, M., & Closs, G. P. (2017). Life-history plasticity in amphidromous and catadromous fishes:

  A continuum of strategies. *Reviews in Fish Biology and Fisheries*, *27*(1), 177\_192. <a href="https://doi.org/10.1007/s11160-016-9463-9">https://doi.org/10.1007/s11160-016-9463-9</a>
- Bach, J. M., Parouty, T., Leon, C., Senecal, A., Portafaix, P., Barault, A., Rautureau, C., Rimbert, L., Duperray, A., & Baisez, A. (2016). *Volet scientifique: Suivis biologiques des populations de poissons grands migrateurs, année 2016. Rapport d'activité du programme de recherches appliquées en faveur des poissons migrateurs.* Association LOGRAMI. https://www.logrami.fr/telechargement/nos-publications/rapports/recueil/Rapport-RECUEIL-2016-VF\_enligne.pdf
- Baer, J., & Brinker, A. (2010). The response of a brown trout stocks and perception of anglers to cessation of brown trout stocking. *Fisheries Management and Ecology*, 17(2), 157\_164. https://doi.org/10.1111/j.1365-2400.2009.00713.x
- Baglinière, J.-L., & Acou, A. (2019). *Vie océanique chez les poissons diadromes : Connaissances et lacunes, rôle de cette phase dans le cycle biologique*. Rencontres migrateurs de Loire, Nantes, France. https://www.logrami.fr/download/vie-oceanique-chez-les-poissons-diadromes-connaissances-et-lacunes/?wpdmdl=3634&refresh=607e7a643c8331618901604
- Bakke, T. A. (1991). A review of the inter and intraspecific variability in salmonid hosts to laboratory infections with *Gyrodactylus salaris* Malmberg. *Aquaculture*, *98*(1), 303\_310. https://doi.org/10.1016/0044-8486(91)90394-M
- Bakke, T. A., Harris, P. D., Hansen, H., Cable, J., & Hansen, L. P. (2004). Susceptibility of Baltic and East Atlantic salmon *Salmo salar* stocks to *Gyrodactylus salaris* (Monogenea). *Diseases of Aquatic Organims*, *58*, 171\_177. https://doi.org/10.3354/dao058171
- Bal, G., Montorio, L., Rivot, E., Prévost, E., Baglinière, J.-L., & Nevoux, M. (2017). Evidence for long-term change in length, mass and migration phenology of anadromous spawners in French Atlantic salmon *Salmo salar*: Changing *s. salar* size and phenology. *Journal of Fish Biology*, *90*(6), 2375\_2393. https://doi.org/10.1111/jfb.13314
- Baran, P., Longuevergne, L., Ombredane, D., Dufour, S., & Dupont, N. (2015). *Débit Minimum Biologique (DMB) et gestion quantitative de la ressource en eau* (p. 124). Centre de ressources et d'expertise scientifique sur l'eau de Bretagne (Creseb). https://www.gesteau.fr/sites/default/files/creseb-guidedmb.pdf
- Barbe, N., Chauliac, M., & Tornatore, J.-L. (2012). Le patrimoine culturel immatériel au risque de la délibération publique. Culture et recherche, Paris : Ministère de la Culture et de la Communication, 127, 41.
- Barnes, M. E., & Brown, M. L. (2011). A Review of *Flavobacterium Psychrophilum* Biology, Clinical Signs, and Bacterial Cold Water Disease Prevention and Treatment. *The Open Fish Science Journal*, 4, 40\_48. https://doi.org/10.2174/1874401X01104010040
- Barraud, R. (2011). Rivières de l'Ouest de la France : Préférences paysagères, usages et choix de gestion. *Cahiers nantais*, 2, 13.
- Baudoin, J.-M., Burgun, V., Chanseau, M., Larinier, M., Ovidio, M., Sremski, W., Steinbach, P., & Voegtle, B. (2014). *Informations sur la Continuité Ecologique (ICE). Evaluer le franchissement des obstacles par les poissons. Principes et méthodes.* Onema. https://www.documentation.eauetbiodiversite.fr/notice/evaluer-le-franchissement-des-obstacles-par-les-poissons-principes-et-methodes-informations-sur-la-c0
- Baudry, T., Becking, T., Goût, J.-P., Arqué, A., Gan, H. M., Austin, C. M., Delaunay, C., Smith-Ravin, J., Roques, J. A. C., & Grandjean, F. (2020). Invasion and distribution of the redclaw crayfish, *Cherax quadricarinatus*, in Martinique. *Knowledge & Management of Aquatic Ecosystems*, 421, 50. https://doi.org/10.1051/kmae/2020041

- Beever, E. A., Hall, L. E., Varner, J., Loosen, A. E., Dunham, J. B., Gahl, M. K., Smith, F. A., & Lawler, J. J. (2017). Behavioral flexibility as a mechanism for coping with climate change. *Frontiers in Ecology and the Environment*, *15*(6), 299\_308. https://doi.org/10.1002/fee.1502
- Belaidi, N., & Euzen, A. (2009). De la chose commune au patrimoine commun. *Mondes en developpement, n° 145*(1), 55–72.
- Belhamiti, N., & Boisneau, C. (s. d.). SILURUS: Étude du silure à l'échelle de la Loire en région Pays de la Loire. 131.
- Blanc, S., Boëtsch, G., Hossaert-McKey, M., & Renaud, F. (2017). Écologie de la santé : Pour une nouvelle lecture de nos maux (CNRS cherche midi). CNRS. http://www2.cnrs.fr/sites/communique/fichier/dp ecologie sante.pdf
- Boisneau, P., & Mennesson-Boisneau, C. (2001). Inland commercial fisheries management in France. *Fisheries Management and Ecology*, 8(4\_5), 303\_310. https://doi.org/10.1111/j.1365-2400.2001.00255.x
- Bonnefoy, A. (2021). *Présentation du projet de réglementation de la pêche des bichiques*. Comité Eau Biodiversité (CEB), La Réunion. http://www.comite-eau-biodiversite-reunion.fr/IMG/pdf/ceb\_reglementation\_bichiques.pdf
- Borsuk, M. E., Reichert, P., Peter, A., Schager, E., & Burkhardt-Holm, P. (2006). Assessing the decline of brown trout (*Salmo trutta*) in Swiss rivers using a Bayesian probability network. *Ecological Modelling*, 192(1), 224\_244. https://doi.org/10.1016/j.ecolmodel.2005.07.006
- Boucault, J. (2007). État des lieux de l'entretien des passes à poissons sur le bassin versant de la Loire [Rapport de stage Master 2]. Université Paul Verlaine de Metz et Université Rennes 1.
- Bouisset, C., & Degrémont, I. (2013). La patrimonialisation de la nature : Un processus en renouvellement. *LEspace geographique*, *Tome 42*(3), 193\_199.
- Bourillon, B. (2021). Variations biogéographiques et temporelles des traits de vie des anguilles argentées (*Anguilla anguilla*) en réponse aux changements environnementaux et à la contamination chimique. Thèse de Doctorat, MNHN Cresco Dinard.
- Boulêtreau, S., Carry, L., Meyer, E., Filloux, D., Menchi, O., Mataix, V., & Santoul, F. (2020). High predation of native sea lamprey during spawning migration. *Scientific Reports*, 10(1), 1\_9. https://doi.org/10.1038/s41598-020-62916-w
- Boulêtreau, S., Fauvel, T., Laventure, M., Delacour, R., Bouyssonnié, W., Azémar, F., & Santoul, F. (2021). "The giants' feast": Predation of the large introduced European catfish on spawning migrating allis shads. *Aquatic Ecology*, 55(1), 75–83. https://doi.org/10.1007/s10452-020-09811-8
- Boulêtreau, S., Gaillagot, A., Carry, L., Tétard, S., Oliveira, E. D., & Santoul, F. (2018). Adult Atlantic salmon have a new freshwater predator. *PLOS ONE*, *13*(4), e0196046. https://doi.org/10.1371/journal.pone.0196046
- Brancotte, V., & Vincent, T. (2002). L'invasion du réseau hydrographique français par les mollusques *Corbicula* spp. Modalité de colonisation et rôle prépondérant des canaux de navigation. *Bulletin Français de la Peche et de la Pisciculture*, 365/366, 325 337.
- Briand, C., Bonhommeau, S., Beaulaton, L., & Castelnaud, G. (2008). *An appraisal of historical glass eel fisheries and markets: Landings, trade routes and future prospect for management*. Proceedings of the Institute of Fisheries Management conference 2007, Wesport, Ireland.
- Brook, B. W., Sodhi, N. S., & Bradshaw, C. J. A. (2008). Synergies among extinction drivers under global change. *Trends in Ecology & Evolution*, 23(8), 453\_460. https://doi.org/10.1016/j.tree.2008.03.011
- Buisson, L. (2009). Poissons des rivières françaises et changement climatique : Impacts sur la distribution des espèces et incertitudes des projections [Thèse de Doctorat, Université de Toulouse]. https://oatao.univ-toulouse.fr/7847/1/buisson.pdf
- Burgun, V., Chanseau, M., Marty, V., Penil, C., Tual, M., & Voegtle, B. (2015). *ICE: Informations sur la continuité écologique. Protocole de terrain pour l'acquisition des données* (p. 88). ONEMA, ECOGEA. https://www.documentation.eauetbiodiversite.fr/notice/ice-informations-sur-la-continuite-ecologique-protocole-de-terrain-pour-l-acquisition-des-donnees0

- Canning, E. U., Curry, A., Feist, S. W., Longshaw, M., & Okamura, B. (1999). *Tetracapsula bryosalmonae* n.sp. For PKX organism, the cause of PKD in Salmonid fish. *Bulletin European Association of Fish Pathologists*, *19*(5), 203.
- Carol, J., Zamora, L., & García-Berthou, E. (2007). Preliminary telemetry data on the movement patterns and habitat use of European catfish (*Silurus glanis*) in a reservoir of the River Ebro, Spain. *Ecology of Freshwater Fish*, *16*(3), 450\_456. https://doi.org/10.1111/j.1600-0633.2007.00225.x
- Castelnaud, G. (2011). Sturgeon Fishing, Landings, and Caviar Production During the Twentieth Century in the Garonne Basin and the Coastal Sea. In P. Williot, E. Rochard, N. Desse-Berset, F. Kirschbaum, & J. Gessner (Éds.), *Biology and Conservation of the European Sturgeon Acipenser sturio L. 1758* (p. 177\_193). Springer. https://doi.org/10.1007/978-3-642-20611-5 13
- Caudron, A., Champigneulle, A., & Large, A. (2004). Evaluation de l'efficacité du repeuplement et comparaison des caractéristiques des truites (Salmo trutta L.) sauvages et introduites dans les rivières de Haute-Savoie—Campagne 2003, étude du stade 0+ sur les bassins versants des Usses, de l'Ugine de Chévenoz, de la Menoge et du Viaison (SHL 248-2004 FDP74.04/02; p. 55). INRA, FDP74.
- Champion, L., & Perraudeau, Y. (1999). Étude socio-économique des pêches professionnelles continentales (p. 91). LEN-CORRAIL; Université de Nantes.
- Chen, X., Samson, E., Tocqueville, A., & Aubin, J. (2015). Environmental assessment of trout farming in France by life cycle assessment: Using bootstrapped principal component analysis to better define system classification. *Journal of Cleaner Production*, 87, 87–95. https://doi.org/10.1016/j.jclepro.2014.09.021
- Chevalier, M., Laffaille, P., Ferdy, J.-B., & Grenouillet, G. (2015). Measurements of spatial population synchrony: Influence of time series transformations. *Oecologia*, 1\_14. https://doi.org/10.1007/s00442-015-3331-5
- CITES. (1973). https://cites.org/fra
- COGEPOMI Rhin-Meuse. (2021). Bilan du PLAGEPOMI Bassin Rhin-Meuse 2016-2021.
- Coll, M. (2016). Evaluation du colmatage du substrat des frayères à salmonidés sur le bassin de la Garonne amont (p. 27) [Mémoire de stage]. Université Toulouse III.
- Collins, M. J., Kelley, A. R., & Lombard, P. J. (2020). River channel response to dam removals on the lower Penobscot River, Maine, United States. *River Research and Applications*, *36*(9), 1778\_1789. https://doi.org/10.1002/rra.3700
- Combe, M., & Gozlan, R. E. (2018). The rise of the rosette agent in Europe: An epidemiological enigma. *Transboundary and Emerging Diseases*, 65(6), 1474–1481. https://doi.org/10.1111/tbed.13001
- Convention on the conservation of European wildlife and natural habitats (Bern Convention). (1979). Convention relative à la conservation de la vie sauvage et du milieu naturel de l'Europe. https://www.coe.int/fr/web/bern-convention/home
- Copp, G. H., Daverat, F., & Bašić, T. (2021). The potential contribution of small coastal streams to the conservation of declining and threatened diadromous fishes, especially the European eel. *River Research and Applications*, *37*(1), 111 115. https://doi.org/10.1002/rra.3746
- Copp, G. H., Robert Britton, J., Cucherousset, J., García-Berthou, E., Kirk, R., Peeler, E., & Stakenas, S. (2009). Voracious invader or benign feline? A review of the environmental biology of European catfish Silurus glanis in its native and introduced ranges\*. Fish and Fisheries, 10(3), 252\_282.
- CORDIS. (2001). Sauver le saumon européen d'un parasite, le Gyrodactylus | Results In Brief | CORDIS | European Commission. https://cordis.europa.eu/article/id/80377-saving-european-salmon-from-gyrodactylus-parasites/fr
- Courret, D., & Larinier, M. (2008). Guide pour la conception de prises d'eau « ichtyocompatibles » pour les petites centrales hydroélectriques (p. 72). GHAAPPE.
- Cucherousset, J. (2017). Enquête sur la gestion des milieux aquatiques continentaux et des populations de poissons d'eau douce en France, synthèse des principaux résultats obtenus. https://www.fichier-pdf.fr/2017/07/04/synthese-resultats-enquete-aappma/

- Cucherousset, J., Boulêtreau, S., Azémar, F., Compin, A., Guillaume, M., & Santoul, F. (2012). "Freshwater Killer Whales": Beaching Behavior of an Alien Fish to Hunt Land Birds. *PLoS ONE*, *7*(12), e50840. https://doi.org/10.1371/journal.pone.0050840
- Cucherousset, J., Horky, P., Slavík, O., Ovidio, M., Arlinghaus, R., Boulêtreau, S., Britton, R., García-Berthou, E., & Santoul, F. (2018). Ecology, behaviour and management of the European catfish. *Reviews in Fish Biology and Fisheries*, *28*(1), 177\_190. https://doi.org/10.1007/s11160-017-9507-9
- Cucherousset, J., Lassus, R., Riepe, C., Millet, P., Santoul, F., Arlinghaus, R., & Buoro, M. (2021). Quantitative estimates of freshwater fish stocking practices by recreational angling clubs in France. *Fisheries Management and Ecology,* n/a(n/a), Article n/a. https://doi.org/10.1111/fme.12471
- Cucherousset, J., & Olden, J. D. (2020). Are domesticated freshwater fish an underappreciated culprit of ecosystem change? *Fish and Fisheries*, *21*(6), 1253 1258. https://doi.org/10.1111/faf.12499
- Cucherousset, J., Paillisson, J.-M., & Roussel, J.-M. (2007). Using PIT technology to study the fate of hatchery-reared YOY northern pike released into shallow vegetated areas. *Fisheries Research*, *85*(1), 159\_164. https://doi.org/10.1016/j.fishres.2007.01.011
- Cuinat, R. (1971). Écologie et repeuplement des cours d'eau à truites (1ère partie). *Bulletin Français de Pisciculture*, 240, 71\_106. https://doi.org/10.1051/kmae:1971007
- Cushing, D. H. (1974). The natural regulation of fish populations. In *Sea fisheries research* (Harden Jones F.R., p. 399\_412). John Wiley and Sons.
- Dakos, V., van Nes, E. H., Donangelo, R., Fort, H., & Scheffer, M. (2010). Spatial correlation as leading indicator of catastrophic shifts. *Theoretical Ecology*, *3*(3), 163\_174. https://doi.org/10.1007/s12080-009-0060-6
- Danto, A. (2018). La pêche à l'anguille (Anguilla anguilla). Regards croisés sur les mutations de pratiques de pêche d'une espèce vulnérable en Atlantique français et Baltique allemande. *Norois. Environnement, aménagement, société, 246,* 75\_92. https://doi.org/10.4000/norois.6363
- Datry, T., & Donon, E. (2010). Colmatage interstitiel des cours d'eau : Développement d'un protocole de mesure standardisé sur les réseaux français. (p. 126). Cemagref Onema.
- Daufresne, M., Lengfellner, K., & Sommer, U. (2009). Global warming benefits the small in aquatic ecosystems. *Proceedings of the National Academy of Sciences*, 106(31), 12788\_12793. https://doi.org/10.1073/pnas.0902080106
- Daupagne, L., Rolan-Meynard, M., Dublon, J., & Argillier, C. (2019). *Enquête sur la gestion piscicole des plans d'eau français* (p. 60) [Rapport de recherche]. Irstea. https://hal.inrae.fr/hal-02609935/document
- De Kinkelin, P., Dorson, M., Benmanour, J., Castric, J., Thiéry, R., Morin, R., & Hedrick, P. (2018). Virus et viroses des poissons. *Santé des poissons*. https://doi.org/10.15454/1.5332127475160718E12
- DEAL Réunion, S., OCEA, & ECO-MED OI. (2019). Étude en vue de la protection des espèces de poissons et de crustacés d'eau douce de La Réunion. (p. 124).
- Décret n° 2014-1195 du 16 octobre 2014 portant publication de l'amendement de la liste des annexes II et III du protocole relatif aux aires spécialement protégées et à la diversité biologique en Méditerranée, signé à Barcelone le 10 juin 1995, adopté à Marrakech le 5 novembre 2009 (1)—Légifrance. (2014). https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000029603513/
- Deinet, S., Scott-Gatty, K., Twardek, W. M., Marconi, V., McRae, L., & et al. (2020). *The Living Planet Index (LPI) for migratory freshwater fish* [Technical Report]. World Fish Migration Foundation. https://worldfishmigrationfoundation.com/wp-content/uploads/2020/07/LPI\_report\_2020.pdf
- Dekker, W. (2019). The history of commercial fisheries for European eel commenced only a century ago. *Fisheries Management and Ecology*, *26*(1), 6\_19. https://doi.org/10.1111/fme.12302
- Dekker, W., & Beaulaton, L. (2016). Faire mieux que la nature ? The History of Eel Restocking in Europe. *Environment and History*, 22(2), 255\_300. https://doi.org/10.3197/096734016X14574329314407

- Delpech, C. (2007). Evolution à long terme de la structure des communautés piscicoles estuariennes. Effet de la variabilité hydrodynamique. [Mémoire de Master 2]. CEMAGREF.
- Denis, J., Rabhi, K., Lheriau, A., Boutin, K., Amara, R., & Gruselle, M.-C. (2021). Suivi des poissons migrateurs amphihalins en zone estuarienne—Inventaire, suivi, état des lieux des populations au niveau du Parc Naturel Marin des Estuaires Picards et de la Mer d'Opale [OFB, ULCO, UMR LOG 8187, AMP, PNM-EPMO]. COPIL n°3, Saint-Étienne-au-Mont.
- Direction de la Mer de Guyane. (2016). *La réglementation des pêches en Guyane française*. http://www.dm.guyane.developpement-durable.gouv.fr/la-reglementation-des-peches-a52.html
- Directive 2000/60/CE du parlement européen et du conseil du 23 octobre 2000 établissant un cadre pour une politique communautaire dans le domaine de l'eau, n° L327/1.
- Drouineau, H., Carter, C., Rambonilaza, M., Beaufaron, G., Bouleau, G., Gassiat, A., Lambert, P., Floch, S. le, Tétard, S., & Oliveira, E. de. (2018). River Continuity Restoration and Diadromous Fishes: Much More than an Ecological Issue. *Environmental Management*, 1\_16. https://doi.org/10.1007/s00267-017-0992-3
- Dubreuil, T. (2021). Caractérisation de Hypostomus robinii comme Espèce Exotique Envahissante des hydrosystèmes d'eau douce martiniquais (p. 89) [Mémoire de fin d'études]. École Supérieure d'Agro-Développement International.
- Dudgeon, D., Arthington, A. H., Gessner, M. O., Kawabata, Z.-I., Knowler, D. J., Lévêque, C., Naiman, R. J., Prieur-Richard, A.-H., Soto, D., Stiassny, M. L. J., & Sullivan, C. A. (2006). Freshwater biodiversity: Importance, threats, status and conservation challenges. *Biological Reviews*, *81*(2), 163\_182. https://doi.org/10.1017/S1464793105006950
- Edmonds, N. J., Riley, W. D., & Maxwell, D. L. (2011). Predation by *Pacifastacus leniusculus* on the intra-gravel embryos and emerging fry of *Salmo salar*. *Fisheries Management and Ecology*, *18*(6), 521\_524. https://doi.org/10.1111/j.1365-2400.2011.00797.x
- EFSA. (2008). Aquatic species susceptible to diseases listed in Directive 2006/88/EC. *EFSA Journal*, *6*(11), 808. https://doi.org/10.2903/j.efsa.2008.808
- EFSA. (2010). Scientific Opinion on risk assessment of parasites in fishery products. *EFSA Journal*, *8*(4), 1543. https://doi.org/10.2903/j.efsa.2010.1543
- Elie, P., & Girard, P. (2009). Effets des micropolluants et des organismes pathogènes chez l'anguille européenne Anguilla anguilla L.1758 (N° 128 ; Étude Cemagref, p. 122). ONEMA.
- Elliott, S., Deleys, N., Rivot, E., Acou, A., Reveillac, E., & Beaulaton, L. (2020). *Report on the ecology of diadromous fish at sea* (p. 34). OFB, INRAE, Agrocampus Ouest, UPPA. https://hal.archives-ouvertes.fr/hal-03233520/document
- Elliott, S., Deleys, N., Rivot, E., Acou, A., Réveillac, E., & Beaulaton, L. (2021). Shedding light on the river and sea lamprey in western European marine waters. *Endangered Species Research*, 44, 409\_419. https://doi.org/10.3354/esr01113
- Ercan, D., Andreou, D., Sana, S., Öntaş, C., Baba, E., Top, N., Karakuş, U., Tarkan, A. S., & Gozlan, R. E. (2015). Evidence of threat to European economy and biodiversity following the introduction of an alien pathogen on the fungal–animal boundary. *Emerging Microbes & Infections*, 4(9), e52. https://doi.org/10.1038/emi.2015.52
- FAO. (2015). *L'accord de lutte contre la pêche non autorisée prend de l'ampleur.* http://www.fao.org/news/story/fr/item/318083/icode/
- FAO. (2021). Services Ecosystémiques & Biodiversité. Food and Agriculture Organization of the United Nations. http://www.fao.org/ecosystem-services-biodiversity/fr/
- FDAAPPMA974, OCEA, & INRA. (2019). Programme d'étude sur la truite arc-en-ciel (Onchorynchus mykiss) présente en milieu naturel à La Réunion. Bilan du suivi des populations 2018-2019 (Axe 1—Phase 2).
- Findlay, J. D. S., Riley, W. D., & Lucas, M. C. (2015). Signal crayfish (*Pacifastacus leniusculus*) predation upon Atlantic salmon (*Salmo salar*) eggs. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 25(2), 250\_258. https://doi.org/10.1002/aqc.2480
- Fiorenza, E. A., Wendt, C. A., Dobkowski, K. A., King, T. L., Pappaionou, M., Rabinowitz, P., Samhouri, J. F., & Wood, C. L. (2020). It's a wormy world: Meta-analysis reveals several decades of change in the global abundance of the parasitic

- nematodes *Anisakis* spp. and *Pseudoterranova* spp. in marine fishes and invertebrates. *Global Change Biology*, *26*(5), 2854\_2866. https://doi.org/10.1111/gcb.15048
- Fox, C. A., Magilligan, F. J., & Sneddon, C. S. (2016). "You kill the dam, you are killing a part of me": Dam removal and the environmental politics of river restoration. *Geoforum*, 70, 93\_104. https://doi.org/10.1016/j.geoforum.2016.02.013
- Frey, A., Tomanova, S., Mercier, O., Richard, S., Courret, D., Tetard, S., Tissot, L., Mataix, V., & Lagarrigue, T. (2020). Étude d'efficacité de prises d'eau ichtyocompatibles pour les smolts de saumon atlantique—Projet EFFIGRI Synthèse des résultats 2017-2018. https://doi.org/10.13140/RG.2.2.12051.40481
- Fujiwara-Nagata, E., Chantry-Darmon, C., Bernardet, J.-F., Eguchi, M., Duchaud, E., & Nicolas, P. (2013). Population structure of the fish pathogen *Flavobacterium psychrophilum* at whole-country and model river levels in Japan. *Veterinary Research*, *44*(1), 34. https://doi.org/10.1186/1297-9716-44-34
- Gaberel, P. (2005). Evaluation de l'état de fonctionnalité des passes à poissons de Basse-Normandie Actualisation de la base de données « ouvrages » de la CATER. Rapport de stage Section STE, Écoles des Métiers de l'Environnement.
- Gardner, J. L., Peters, A., Kearney, M. R., Joseph, L., & Heinsohn, R. (2011). Declining body size: A third universal response to warming? *Trends in Ecology & Evolution*, *26*(6), 285–291. https://doi.org/10.1016/j.tree.2011.03.005
- Garibaldi, A., & Turner, N. (2004). Cultural Keystone Species: Implications for Ecological Conservation and Restoration. *Ecology and Society*, *9*(3). https://doi.org/10.5751/ES-00669-090301
- Gay, M., Lailler, R., Bourgau, O., Rudloff, L., Guillotteau, S., & Midelet, G. (2019). Niveaux d'infestation par les anisakidae chez sept espèces de poisson prélevées au stade de la distribution en France. *Bulletin épidémiologique, Santé animale-alimentation*, 17.
- Gemenne, F., & Denis, M. (2019). *Qu'est-ce que l'Anthropocène ?* Vie publique.fr. https://www.vie-publique.fr/parole-dexpert/271086-terre-climat-quest-ce-que-lanthropocene-ere-geologique
- Genner, M. J., Sims, D. W., Wearmouth, V. J., Southall, E. J., Southward, A. J., Henderson, P. A., & Hawkins, S. J. (2004). Regional climatic warming drives long—term community changes of British marine fish. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, *271*(1539), 655–661. https://doi.org/10.1098/rspb.2003.2651
- Germaine, M.-A., & Barraud, R. (2013). Restauration écologique et processus de patrimonialisation des rivières dans l'Ouest de la France. *VertigO la revue électronique en sciences de l'environnement, Hors-série 16*, Article Hors-série 16. https://doi.org/10.4000/vertigo.13583
- Germaine, M.-A., Lespez, L., & Cador, J.-M. (2012). Le poids des héritages dans la gestion durable des paysages des basses vallées côtières de l'ouest de la France. In L. Lespez (Éd.), *Paysages et Gestion de l'eau : Sept millénaires d'histoire de vallées et de plaines littorales en Basse-Normandie* (p. 273\_302). Bibliothèque du Pôle Rural 3, MRSH Caen. https://hal.parisnanterre.fr//hal-01640644
- Glandor, J.-C. (2019). Présentation du Programme de prévention Titiri—Interview du Président de l'ordre des gardiens du patrimoine de la Guadeloupe [Youtube]. https://www.youtube.com/watch?v=IfsiCSsWH1Y
- Gorgoglione, B., Kotob, M. H., Unfer, G., & El-Matbouli, M. (2016). First Proliferative Kidney Disease outbreak in Austria, linking to the aetiology of Black Trout Syndrome threatening autochthonous trout populations. *Diseases of Aquatic Organisms*, 119(2), 117\_128. https://doi.org/10.3354/dao02993
- Gozlan, R. E. (2019). Détection de l'agent rosette Sphareothecum destruens dans les communautés piscicoles de France (Rosetta) (p. 35). IRD/AFB.
- Griffiths, S. W., Collen, P., & Armstrong, J. D. (2004). Competition for shelter among over-wintering signal crayfish and juvenile Atlantic salmon. *Journal of Fish Biology*, 65(2), 436\_447. https://doi.org/10.1111/j.0022-1112.2004.00460.x
- GT IBMA. (2016a). *Pseudorasbora parva*. Centre de ressources des EEE. http://especes-exotiques-envahissantes.fr/espece/pseudorasbora-parva/

- GT IBMA. (2016b). Silurus glanis. Base d'information sur les invasions biologiques en milieux aquatiques. Groupe de travail national Invasions biologiques en milieux aquatiques. Centre de ressources des EEE. http://especesexotiques-envahissantes.fr/espece/silurus-glanis/
- Guillerault, N., Delmotte, S., Boulêtreau, S., Lauzeral, C., Poulet, N., & Santoul, F. (2015). Does the non-native European catfish *Silurus glanis* threaten French river fish populations? *Freshwater Biology*, *60*(5), 922\_928. https://doi.org/10.1111/fwb.12545
- Guillot, F., & Thinus, Z. (2017). Impact à la dévalaison de l'anguille des centrales hydroélectriques de grande capacité de l'aval de la Seine—Rapport de synthèse. Cerema Normandie-Centre. http://normandiegrandsmigrateurs.fr/wp-content/uploads/2017/04/2017\_ETUDE-DEVALAISON-ANGUILLE-SEINE\_CEREMA-1.pdf
- Haenen, O. L. M., Mladineo, I., Konecny, R., Yoshimizu, M., Groman, D., Munoz, P., Saraiva, A., Bergmann, S. M., & van Beurden, S. J. (2012). Diseases of eels in an international perspective: Workshop on Eel Diseases at the 15th International Conference on Diseases of Fish and Shellfish, Split, Croatia, 2011. *Bulletin of the European Association of Fish Pathologists*, 32(3), 109\_115.
- Harbicht, A. B., Nilsson, P. A., Österling, M., & Calles, O. (2021). Environmental and anthropogenic correlates of migratory speeds among Atlantic salmon smolts. *River Research and Applications*, *37*(3), 358\_372. https://doi.org/10.1002/rra.3760
- Harvey, G. L., Moorhouse, T. P., Clifford, N. J., Henshaw, A. J., Johnson, M. F., Macdonald, D. W., Reid, I., & Rice, S. P. (2011). Evaluating the role of invasive aquatic species as drivers of fine sediment-related river management problems: The case of the signal crayfish (*Pacifastacus leniusculus*). *Progress in Physical Geography: Earth and Environment*, 35(4), 517\_533. https://doi.org/10.1177/0309133311409092
- Hasselman, D. J., Bradford, R. G., & Bentzen, P. (2010). Taking stock: Defining populations of American shad (*Alosa sapidissima*) in Canada using neutral genetic markers. *Canadian Journal of Fisheries and Aquatic Sciences*, *67*(6), 1021\_1039. https://doi.org/10.1139/F10-031
- Hayatgheib, N., Calvez, S., Fournel, C., Pineau, L., Pouliquen, H., & Moreau, E. (2021). Antimicrobial Susceptibility Profiles and Resistance Genes in Genus *Aeromonas* spp. Isolated from the Environment and Rainbow Trout of Two Fish Farms in France. *Microorganisms*, 9(1201), 21. https://doi.org/10.3390/
- Hedrick, R. P., MacConnell, E., & de Kinkelin, P. (1993). Proliferative kidney disease of salmonid fish. *Annual Review of Fish Diseases*, 3, 277 290. https://doi.org/10.1016/0959-8030(93)90039-E
- Henderson, M., & Okamura, B. (2004). The phylogeography of salmonid proliferative kidney disease in Europe and North America. *Proceedings of the Royal Society of London. Series B: Biological Sciences, 271*(1549), 1729\_1736. https://doi.org/10.1098/rspb.2004.2677
- Higgins, S. N., & Zanden, M. J. V. (2010). What a difference a species makes: A meta—analysis of dreissenid mussel impacts on freshwater ecosystems. *Ecological Monographs*, 80(2), 179–196.
- Hoffmann, R. C. (1996). Economic Development and Aquatic Ecosystems in Medieval Europe. *The American Historical Review*, 101(3), 631\_669. https://doi.org/10.2307/2169418
- Hughes, L. (2000). Biological consequences of global warming: Is the signal already apparent? *Trends in Ecology and Evolution*, 15, 56\_61.
- Ilarri, M. I., Souza, A. T., Antunes, C., Guilhermino, L., & Sousa, R. (2014). Influence of the invasive Asian clam *Corbicula fluminea* (Bivalvia: Corbiculidae) on estuarine epibenthic assemblages. *Estuarine, Coastal and Shelf Science, 143*, 12\_19. https://doi.org/10.1016/j.ecss.2014.03.017
- INPN. (2017). Pacifastacus leniusculus (Dana, 1852)—Écrevisse de Californie (L'), Écrevisse signal (L'), Écrevisse du Pacifique (L'). Inventaire National du Patrimoine Naturel. https://inpn.mnhn.fr/espece/cd\_nom/162667
- IPBES. (2019). Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). *IPBES Secretariat*, 1148. https://doi.org/10.5281/zenodo.3831674

- Irstea. (2019). Irstea pilote un projet européen pour la préservation des poissons migrateurs et le maintien des services qu'ils rendent face au changement climatique. https://www.comite-peches.fr/wp-content/uploads/2019/03/CP-Irstea-Diades .pdf
- ISC. (2019). Anguillicoloides crassus. Invasive Species Compendium. https://www.cabi.org/isc/datasheet/93709
- Ivanov, V. P., Kamakin, A. M., Ushivtzev, V. B., Shiganova, T., Zhukova, O., Aladin, N., Wilson, S. I., Harbison, G. R., & Dumont, H. J. (2000). Invasion of the Caspian Sea by the Comb Jellyfish *Mnemiopsis Leidyi* (Ctenophora). *Biological Invasions*, *2*, 255–258.
- Johnston, F. D., Allen, M. S., Beardmore, B., Riepe, C., Pagel, T., Hühn, D., & Arlinghaus, R. (2018). How ecological processes shape the outcomes of stock enhancement and harvest regulations in recreational fisheries. *Ecological Applications: A Publication of the Ecological Society of America*, 28(8), 2033\_2054. https://doi.org/10.1002/eap.1793
- Jones, C. M. (2006). CHAPTER 4—Estuarine and Diadromous Fish Metapopulations. In J. P. Kritzer & P. F. Sale (Éds.), *Marine Metapopulations* (p. 119\_154). Academic Press. https://doi.org/10.1016/B978-012088781-1/50007-8
- Jorgensen, P. E. V., Castric, J., Hill, B., Ljungberg, O., & de Kinkelin, P. (1994). The occurrence of virus infections in elvers and eels (*Anguilla anguilla*) in Europe with particular reference to VHSV and IHNV. *Aquaculture*, 123(1), 11\_19. https://doi.org/10.1016/0044-8486(94)90115-5
- Keith, P. (2003). Biology and ecology of amphidromous Gobiidae of the Indo-Pacific and the Caribbean regions. *Journal of Fish Biology*, *63*(4), 831\_847. https://doi.org/10.1046/j.1095-8649.2003.00197.x
- Kempter, J., Hofsoe, P., Panicz, R., & Bergmann, S. M. (2014). First detection of anguillid herpesvirus 1 (AngHV1) in European eel (*Anguilla anguilla*) and imported American eel (*Anguilla rostrata*) in Poland. *Bulletin European Association of Fish Pathologists*, 34(3), 87–94.
- Kreutzenberger, K., Sagnes, P., Valade, P., & Voegtlé, B. (2019). Évaluer le franchissement des obstacles par les poissons et les macro-crustacés dans les départements insulaires ultramarins. Principes et méthode. OFB. https://professionnels.ofb.fr/node/706
- Kullmann, B., Adamek, M., Steinhagen, D., & Thiel, R. (2017). Anthropogenic spreading of anguillid herpesvirus 1 by stocking of infected farmed European eels, *Anguilla anguilla* (L.), in the Schlei fjord in northern Germany. *Journal of Fish Diseases*, *40*(11), 1695\_1706. https://doi.org/10.1111/jfd.12637
- Kumagai, A., & Nawata, A. (2010). Mode of the intra-ovum infection of *Flavobacterium psychrophilum* in salmonid eggs. *Fish Pathology*, *45*(1), 31 36. https://doi.org/10.3147/jsfp.45.31
- Lamand, F. (2015). *Moule zébrée : Dreissena polymorpha*. ONEMA. http://www.especes-exotiques-envahissantes.fr/wp-content/uploads/2015/04/Dreissena-polymorpha\_Moule-zebree.pdf
- Larinier, M., & Travade, F. (1999). La dévalaison des migrateurs : Problèmes et dispositifs. *Bulletin Français de la Peche et de la Pisciculture*, 353/354, 181 210. https://doi.org/10.1051/kmae:1999012
- Larinier, M., & Travade, F. (2002). The design of fishways for shad. *Bulletin Français de La Pêche et de La Pisciculture,* 364 supplément, 135\_146. https://doi.org/10.1051/kmae/2002098
- Larrère, C., & Larrère, R. (2009). Du bon usage de la nature. Pour une philosophie de l'environnement (Flammarion).
- Lasne, E., Rigaud, C., & Feunteun, E. (2011). Compte-rendu du premier séminaire GRISAM sur la thématique « Poissons migrateurs amphihalins et milieux marins » 22-23 Février 2011, CRESCO, Dinard (p. 34). GRISAM.
- Lassalle, G. (2008). Impacts des changements globaux sur la distribution des poissons migrateurs amphihalins : Une approche par modélisation à l'échelle continentale [Thèse de Doctorat, Université de Bordeaux 1]. http://www.theses.fr/2008BOR13647
- Lassalle, G., Beguer, M., Beaulaton, L., & Rochard, E. (2008). Diadromous fish conservation plans need to consider global warming issues: An approach using biogeographical models. *Biological Conservation*, 141, 1105 1118.

- Lassalle, G., & Rochard, E. (2009). Impact of twenty-first century climate change on diadromous fish spread over Europe, North Africa and the Middle East. *Global Change Biology*, *15*(5), 1072\_1089. https://doi.org/10.1111/j.1365-2486.2008.01794.x
- Lautraite, A., Blanc, G., Thiery, R., Daniel, P., & Vigneulle, M. (1999). Gyrodactylids parasitizing salmonids in Brittany and Western Pyrénées water basins: Epidemiological features of infection and species composition. *Bulletin Français de La Pêche et de La Pisciculture*, 355, 305\_325. https://doi.org/10.1051/kmae:1999001
- Lefebvre, F., Fazio, G., Crivelli, A. J., Woo, P. T. K., & Buchmann, K. (2012). *Anguillicoloides crassus*. In *Fish parasites : Pathobiology and protection*. (p. 310–326).
- Legrand, M., Briand, C., Buisson, L., Artur, G., Azam, D., Baisez, A., Barracou, D., Bourré, N., Carry, L., Caudal, A.-L., Charrier, F., Corre, J., Croguennec, E., Mikaélian, S. D., Josset, Q., Gurun, L. L., Schaeffer, F., & Laffaille, P. (2020). Contrasting trends between species and catchments in diadromous fish counts over the last 30 years in France. *Knowledge & Management of Aquatic Ecosystems*, 421, 7. https://doi.org/10.1051/kmae/2019046
- Legrand, M., Briand, C., Buisson, L., Besse, T., Artur, G., Azam, D., Baisez, A., Barracou, D., Bourré, N., Carry, L., Caudal, A.-L., Corre, J., Croguennec, E., Mikaélian, S. D., Josset, Q., Gurun, L. L., Schaeffer, F., Toussaint, R., & Laffaille, P. (2021). Diadromous fish modified timing of upstream migration over the last 30 years in France. *Freshwater Biology*, 66(2), 286–302. https://doi.org/10.1111/fwb.13638
- Legrand-Hoffmann, M. (2021). Les poissons amphibalins de France face au changement climatique : Évolution des effectifs et modification de la phénologie migratoire [Thèse de Doctorat]. Université de Toulouse.
- Le Pichon, C., Lestel, L., Courson, E., Merg, M.-L., Tales, E., & Belliard, J. (2020). Historical Changes in the Ecological Connectivity of the Seine River for Fish: A Focus on Physical and Chemical Barriers Since the Mid-19th Century. *Water*, *12*(5), 1352. https://doi.org/10.3390/w12051352
- Lepareur, F., & Aish, A. (2012). Note sur l'évaluation de l'état de conservation des espèces marines d'intérêt communautaire et de leurs habitats, à l'échelle d'un site Natura 2000 en mer (p. 36). MNHN.
- Limburg, K. E., & Waldman, J. R. (2009). Dramatic declines in North Atlantic diadromous fishes. *BioScience*, *59*(11), 955\_965. https://doi.org/10.1525/bio.2009.59.11.7
- Lin, H.-Y., Bush, A., Linke, S., Possingham, H. P., & Brown, C. J. (2017). Climate change decouples marine and freshwater habitats of a threatened migratory fish. *Diversity and Distributions*, 23(7), 751\_760. https://doi.org/10.1111/ddi.12570
- Lorenzen, K., Beveridge, M. C. M., & Mangel, M. (2012). Cultured fish: Integrative biology and management of domestication and interactions with wild fish. *Biological Reviews of the Cambridge Philosophical Society*, *87*(3), 639 660. https://doi.org/10.1111/j.1469-185X.2011.00215.x
- Lowe, S., Browne, M., Boudjelas, S., & De Poorter, M. (2000). 100 of the World's Worst Invasive Alien Species: A Selection From The Global Invasive Species Database. In *Encyclopedia of Biological Invasions* (The Invasive SpeciesSpecialist Group (ISSG) a specialistgroup of the Species Survival Commission (SSC) of the WorldConservation Union (IUCN), p. 12). University of California Press. https://doi.org/10.1525/9780520948433-159
- Madetoja, J., Nystedt, S., & Wiklund, T. (2003). Survival and virulence of *Flavobacterium psychrophilum* in water microcosms. *FEMS Microbiology Ecology*, *43*(2), 217\_223. https://doi.org/10.1111/j.1574-6941.2003.tb01061.x
- Madsen, L., & Dalsgaard, I. (2008). Water recirculation and good management: Potential methods to avoid disease outbreaks with *Flavobacterium psychrophilum*. *Journal of Fish Diseases*, *31*(11), 799\_810. https://doi.org/10.1111/j.1365-2761.2008.00971.x
- Marchessaux, G. (2019). Étude de l'anthroposystème emblématique de l'étang de Berre : Approches écosystémique et sociologique de l'impact du cténaire invasif Mnemiopsis leidyi [Thèse de Doctorat]. Université d'Aix-Marseille.
- Marino, C., & Valadou, B. (2018). Les politiques de gestion des poissons amphihalins—État des lieux et perspectives. Rapport final (p. 80). AFB.

- Marmonier, P., Delettre, Y., Lefebvre, S., Guyon, J., & Boulton A.J. (2004). A simple technique using wooden stakes to estimate vertical patterns of interstitial oxygenation in the beds of rivers. *Archiv Für Hydrobiologie*, *160*(1), 133\_143. https://doi.org/10.1127/0003-9136/2004/0160-0133
- Martignac, F., Boulenger, C., & Marchand, F. (2018). *Matériel d'hydroacoustique de nouvelle génération* (p. 31) [Rapport final Inra, AFB].
- Martignac, F., Hémon, A., & Blancher, P. (2015). Hydroacoustique et poissons migrateurs amphihalins : Analyse innovante de leur dynamique migratoire. *Sciences, Eaux et Territoire*, *17*, 18\_23.
- Massa, F., Baglinière, J. L., Prunet, P., & Grimaldi, C. (2000). Survie embryo-larvaire de la truite (*Salmo trutta*) et conditions chimiques dans la frayère. *Cybium*, *24*, 129-140.
- McDowall, R. M. (1992). Diadromy: Origins and Definitions of Terminology. *Copeia*, 1992(1), 248\_251. https://doi.org/10.2307/1446563
- McNeil, W. J., & Ahnell, W. H. (1964). Success of pink salmon spawning relative to size of spawning bed materials. *Special Scientific Report-Fisheries*, 469, 17.
- McNew, G. L. (1960). The nature, origin and evolution of parasitism. In *Plant pathology : An advanced treatise* (Vol. 2, p. 19 69). Academic Press.
- MEA. (2005). *Ecosystem and Human Well-Being: Synthesis*. http://temis.documentation.developpement-durable.gouv.fr/docs/Temis/0066/Temis-0066726/18715.pdf
- Mendoza, G. H. (2014). Identification des risques de perte de biodiversité face aux pressions anthropiques et au changement climatique à l'horizon 2100 : Application de la conservation dynamique au territoire des Alpes-Maritimes [Thèse de Doctorat, École Nationale Supérieure des Mines de Paris]. https://pastel.archives-ouvertes.fr/tel-01123766
- Merg, M.-L., Dézerald, O., Kreutzenberger, K., Demski, S., Reyjol, Y., Usseglio-Polatera, P., & Belliard, J. (2020). Modeling diadromous fish loss from historical data: Identification of anthropogenic drivers and testing of mitigation scenarios. *PLOS ONE*, *15*(7), e0236575. https://doi.org/10.1371/journal.pone.0236575
- Middlemas, S. J., Fryer, R. J., Tulett, D., & Armstrong, J. D. (2013). Relationship between sea lice levels on sea trout and fish farm activity in western Scotland. *Fisheries Management and Ecology*, *20*(1), 68\_74. https://doi.org/10.1111/fme.12010
- Arrêté du 6 janvier 2020 fixant la liste des espèces animales et végétales à la protection desquelles il ne peut être dérogé qu'après avis du Conseil national de la protection de la nature, JORF n°0024 du 29 janvier 2020, NOR : TREL1934322A (2020). https://www.legifrance.gouv.fr/eli/arrete/2020/1/6/TREL1934322A/jo/texte
- Ministère de la Transition écologique et solidaire. (2021). *Hydroélectricité*. https://www.ecologie.gouv.fr/hydroelectricite
- Ministère de la Transition écologique et solidaire coord. DREAL NA. (2020). Plan national d'actions 2020-2029 en faveur de l'esturgeon européen, Acipenser sturio. DREAL Nouvelle-Aquitaine, Ministère de la Transition écologique et solidaire. http://www.nouvelle-aquitaine.developpement-durable.gouv.fr/IMG/pdf/pna-esturgeon-2020-2029-complet-high-quality-v101120.pdf
- Arrêté du 20 décembre 2004 relatif à la protection de l'espèce Acipenser sturio (esturgeon)., NOR : DEVN0540001A (2004). https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000259841/
- Arrêté du 8 décembre 1988 fixant la liste des espèces de poissons protégées sur l'ensemble du territoire national, NOR : PRME8861195A (1988). https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000327373/
- Arrêté du 9 juillet 1999 fixant la liste des espèces de vertébrés protégées menacées d'extinction en France et dont l'aire de répartition excède le territoire d'un département, NOR: ATEN9980224A (1999). https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000396986/

- Ministère de l'Agriculture et de l'Alimentation. (2017). *Pisciculture : Charte d'engagement pour le développement durable de l'aquaculture française*. agriculture.gouv.fr. https://agriculture.gouv.fr/pisciculture-chartedengagement-pour-le-developpement-durable-de-laquaculture-française
- Arrêté du 17 décembre 1985 fixant la liste des espèces de poissons, de crustacés et de grenouilles représentées dans les eaux visées à l'article 413 du code rural—Légifrance, (1985) (testimony of Ministère de l'Environnement). https://www.legifrance.gouv.fr/loda/id/LEGITEXT000006074797/
- Mol, J. H. (2012). The Freshwater Fishes of Suriname (Pp., 737 III. ed., Vol. 2). Brill, Netherlands.
- Morandeau, G., & Caill-Milly, N. (2011). *Note sur les captures de saumons atlantiques en mer au sud de Mimizan* (Comité Local des Pêches Maritimes et des Elevages Marins HGS/LRHA/2011-001). Ifremer. https://salmotierra-salvatierra.com/wp-content/uploads/2020/03/note-de-2011-sur-les-captures-de-saumons-atlantiques-en-mer-au-sud-de-mimizan.pdf
- Morandi, B., Rivière-Honegger, A., & Cottet, M. (2015). Étude en Sciences Humaines et Sociales sur l'Eau et les Milieux Aquatiques en Martinique—Les représentations et les pratiques associées aux cours d'eau (N° 043-12\_2014 ; p. 41). CNRS, ONEMA, ODE, CIRAD, EVS. https://www.observatoire-eau-martinique.fr/images/7-ODE/Actualites/2015/pdf\_Etude\_Martinique\_CNRS\_2015\_synthese.pdf
- Morandi, B., Rivière-Honegger, A., & Cottet, M. (2018). La pêche en rivière en Martinique : Quels sont les enjeux d'une patrimonialisation socio-environnementale? Études caribéennes, 41. https://doi.org/10.4000/etudescaribeennes.13857
- MPO. (2017). Risque résiduel de transmission de la nécrose pancréatique infectieuse lié au transfert de l'omble chevalier en Colombie-Britannique (p. 37). Secrétariat canadien de consultation scientifique du MPO (Pêches et Océans Canada). https://waves-vagues.dfo-mpo.gc.ca/Library/40674976.pdf
- Myers, G. S. (1949). Usage of anadromous, catadromous and allied terms for migratory fishes. Copeia, 89 97.
- Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, 403(6772), 853\_858. https://doi.org/10.1038/35002501
- Nicolas, D., Chaalali, A., Drouineau, H., Lobry, J., Uriarte, A., Borja, A., & Boët, P. (2011). Impact of global warming on European tidal estuaries: Some evidence of northward migration of estuarine fish species. *Regional Environmental Change*, *11*(3), 639\_649. https://doi.org/10.1007/s10113-010-0196-3
- Nieto, A., Ralph, G. M., Comeros-Raynal, M. T., Kemp, J., Garcia Criado, M., & et al. (2015). *European red list of marine fishes*. (Publications Office of the European Union) [Technical Report]. UICN European Regional Office. https://data.europa.eu/doi/10.2779/082723
- Nõges, P., Argillier, C., Borja, Á., Garmendia, J. M., Hanganu, J., Kodeš, V., Pletterbauer, F., Sagouis, A., & Birk, S. (2016). Quantified biotic and abiotic responses to multiple stress in freshwater, marine and ground waters. *Science of The Total Environment*, *540*, 43\_52. https://doi.org/10.1016/j.scitotenv.2015.06.045
- OCEA. (2011). Inventaire et recommandations de gestion pour la préservation de l'ichtyofaune de la zone humide de la zone humide de l'étang du Gol. Campagne d'échantillonnages de mars 2011. Rapport de résultats des inventaires. Rapport Ocea Consult. (p. 21).
- OCEA. (2018). Étude en vue de la protection des espèces de poissons et de crustacés d'eau douce de La Réunion. Commission « amphihalins » du CEB, La Réunion.
- OCSAN. (2009). Directives OCSAN Gestion des pêcheries de saumons. North Atlantic Salmon Conservation Organization (NASCO)/Organisation pour la Conservation du Saumon de l'Atlantique Nord (OCSAN), Édimbourg, Écosse, Royaume-Uni. (p. 12).
- OFB. (2020). *Opération de réintroduction de civelles dans leur milieu naturel*. ofb.gouv.fr. https://ofb.gouv.fr/actualites/operation-de-reintroduction-de-civelles-dans-leur-milieu-naturel
- OIE. (2019a). *Chapter 2.3.3—Infection with Gyrodactylus salaris*. World Organisation for Animal Health. https://www.oie.int/fileadmin/Home/eng/Health\_standards/aahm/current/chapitre\_gyrodactylus\_salaris.pdf

- OIE. (2019b). *Chapter 2.3.4—Infection with infectious haematopoietic necrosis virus*. World Organisation for Animal Health. https://www.oie.int/index.php?id=2439&L=0&htmfile=chapitre ihn.htm
- OIE. (2019c). *Chapter 2.3.10—Viral haemorrhagic septicaemia*. World Organisation for Animal Health. https://www.oie.int/index.php?id=2439&L=0&htmfile=chapitre\_vhs.htm
- OIE. (2021). *Chapitre* 1.3—Maladies listées par l'OIE. https://www.oie.int/fileadmin/Home/fr/Health\_standards/aahc/current/chapitre\_diseases\_listed.pdf
- Olmos, M., Payne, M. R., Nevoux, M., Prévost, E., Chaput, G., Pontavice, H. D., Guitton, J., Sheehan, T., Mills, K., & Rivot, E. (2020). Spatial synchrony in the response of a long range migratory species (*Salmo salar*) to climate change in the North Atlantic Ocean. *Global Change Biology*, *26*(3), 1319\_1337. https://doi.org/10.1111/gcb.14913
- ONEMA. (2010). *Plan de gestion anguille de la France* (p. 118). Ministère de l'Ecologie, de l'Energie, du Développement durable et de l'Emmenagement du territoire ; Ministère de l'Agriculture et de la Pêche. https://www.migrateurs-loire.fr/telechargement/documentation/textes-reglementaires/p\_ang\_volet\_natal070709\_1\_.pdf
- ONERC. (2019). Les événements météorologiques extrêmes dans un contexte de changement climatique : Rapport au Premier ministre et au Parlement (La documentation française). Observatoire National sur les Effets du Réchauffement Climatique.
- Ong, J. J. L., Rountrey, A. N., Zinke, J., Meeuwig, J. J., Grierson, P. F., O'Donnell, A. J., Newman, S. J., Lough, J. M., Trougan, M., & Meekan, M. G. (2016). Evidence for climate-driven synchrony of marine and terrestrial ecosystems in northwest Australia. *Global Change Biology*, 22(8), 2776–2786. https://doi.org/10.1111/gcb.13239
- Orain, D. (2010). Apport de l'histologie dans la détection d'Anisakis simplex et de Kudoa sp. Dans les poissons et les matières premières utilisées dans l'industrie ou dans les produits finis [Thèse de Docteur Vétérinaire]. Université Paul Sabatier Toulouse.
- Ormerod, S. J. (2003). Current issues with fish and fisheries: Editor's overview and introduction. *Journal of Applied Ecology*, 40(2), 204\_213. https://doi.org/10.1046/j.1365-2664.2003.00824.x
- OSPAR Commission. (1992). Commission OSPAR pour la protection du milieu marin de l'Atlantique du Nord-Est Bilan de santé 2000. OSPAR Commission. https://www.ospar.org/convention
- Paladini, G., Shinn, A. P., Taylor, N. G. H., Bron, J. E., & Hansen, H. (2021). Geographical distribution of *Gyrodactylus salaris* Malmberg, 1957 (Monogenea, Gyrodactylidae). *Parasites & Vectors*, 14(1), 34. https://doi.org/10.1186/s13071-020-04504-5
- Palstra, A. P., Heppener, D. F. M., van Ginneken, V. J. T., Székely, C., & van den Thillart, G. E. E. J. M. (2007). Swimming performance of silver eels is severely impaired by the swim-bladder parasite *Anguillicola crassus*. *Journal of Experimental Marine Biology and Ecology*, 352(1), 244\_256. https://doi.org/10.1016/j.jembe.2007.08.003
- Parmesan, C., & Yohe, G. (2003). A globally coherent fingerprint of climate change impacts across natural systems. *Nature*, 421(6918), 37\_42. https://doi.org/10.1038/nature01286
- Pasquaud, S. (2006). Les relations trophiques : Éléments de structuration des peuplements ichtyologiques en milieu estuarien. Application à l'estuaire de la Gironde. [Thèse de Doctorat]. Université de Bordeaux I.
- Peeler, E., Thrush, M., Paisley, L., & Rodgers, C. (2006). An assessment of the risk of spreading the fish parasite *Gyrodactylus salaris* to uninfected territories in the European Union with the movement of live Atlantic salmon (*Salmo salar*) from coastal waters. *Aquaculture*, 258(1), 187\_197. https://doi.org/10.1016/j.aquaculture.2005.07.042
- Peeters, A., Houbrechts, G., Hallot, E., Campenhout, J. V., Gob, F., & Petit, F. (2020). *Can coarse bedload pass through weirs* ? 14.
- Perrier, C. (2010). Structure génétique des populations de saumon Atlantique en France. Thèse de Doctorat, Université de Caen Basse-Normandie.

- Petit, S. (2017). « Le Creusot n'a pas d'eau ». Tensions entre développement économique et capital environnemental sur le temps long. *Développement durable et territoires. Économie, géographie, politique, droit, sociologie, Vol. 8, n*°3, Article Vol. 8, n°3. https://doi.org/10.4000/developpementdurable.11876
- Philippart, A. (2019). Étude de la prévalence de l'Anguillid herpesvirus 1 chez l'anguille européenne (Anguilla anguilla) au sein de cours d'eau wallons (p. 51) [Mémoire de fin d'études en Médecine vétérinaire]. Université de Liège.
- Pigneur, L.-M., Falisse, E., Roland, K., Everbecq, E., Deliège, J.-F., Smitz, J. S., Doninck, K. V., & Descy, J.-P. (2014). Impact of invasive Asian clams, *Corbicula* spp., on a large river ecosystem. *Freshwater Biology*, *59*(3), 573\_583. https://doi.org/10.1111/fwb.12286
- Pinter, K., Unfer, G., Lundsgaard-Hansen, B., & Weiss, S. (2017). Besatzwirtschaft in Österreich und mögliche Effekte auf die innerartliche Vielfalt der Bachforellen. Österreichs Fischerei, 70, 15\_33.
- Piou, C., & Prévost, E. (2013). Contrasting effects of climate change in continental vs. Oceanic environments on population persistence and microevolution of Atlantic salmon. *Global Change Biology*, 19(3), 711\_723. https://doi.org/10.1111/gcb.12085
- Pohlmann, K., Atema, J., & Breithaupt, T. (2004). The importance of the lateral line in nocturnal predation of piscivorous catfish. *Journal of Experimental Biology*, 207(17), 2971 2978. https://doi.org/10.1242/jeb.01129
- Pôle-relais lagunes. (2021). Expansion du cténaire invasif Mnemiopsis leidyi dans les lagunes méditerranéennes françaises le long du Golfe du Lion. https://pole-lagunes.org/expansion-du-ctenaire-invasif-mnemiopsis-leidyi-dans-les-lagunes-mediterraneennes-francaises-le-long-du-golfe-du-lion/
- Poulet, N. (2020). Détection de l'agent rosette Sphareothecum destruens dans les communautés piscicoles de France. Centre de ressources des EEE. http://especes-exotiques-envahissantes.fr/detection-agent-rosette-sphareothecum-destruens-communautes-piscicoles-france/
- Pronier, O., & Rochard, E. (1998). Fonctionnement d'une population d'éperlan (*Osmerus eperlanus*, Osmériformes Osmeridae) située en limite méridionale de son aire de répartition, influence de la température. *Bulletin Français de la Pêche et de la Pisciculture*, 350\_351, 479\_497. https://doi.org/10.1051/kmae:1998018
- PSNPDA. (2015). European Maritime and Fisheries Fund—Operational Programme for France 2014-2020. https://ec.europa.eu/oceans-and-fisheries/system/files/2021-04/op-france fr.pdf
- Randon, M. (2016). Using otolith microchemistry within Bayesian reallocation models to explore the allis shad (Alosa alosa) metapopulation functioning [Mémoire de fin d'études, Agrocampus Ouest, Université de Rennes 1]. http://halieutique.agrocampus-ouest.fr/memoires/201625.pdf
- Richarson, M., & Valade, P. (2008). Un point sur les introductions récentes d'espèces animales exotiques dans les eaux douces de la Réunion Observations, traits de vie, menaces pour la biodiversité. CSRPN, Trois Bassins.
- Rigaud, C., Beaulaton, L., Briand, C., Charrier, F., Feunteun, E., Mazel, V., Pozet, F., Prévost, É., Tréguier, A., & Verreault, G. (2015). *Le programme français de repeuplement en civelles—Bilan des trois premières années de transferts* (p. 229). GRISAM.
- Ringuet, S., Muto, F., & Raymakers, C. (2002). Eels, their harvest and trade in Europe and Asia. *Traffic bulletin*, 19(2), 80\_106.
- Robinson, R., Crick, H., Learmonth, J., Maclean, I., Thomas, C., Bairlein, F., Forchhammer, M., Francis, C., Gill, J., Godley, B., Harwood, J., Hays, G., Huntley, B., Hutson, A., Pierce, G., Rehfisch, M., Sims, D., Santos, B., Sparks, T.,... Visser, M. (2009). Travelling through a warming world: Climate change and migratory species. *Endangered Species Research*, 7, 87–99. https://doi.org/10.3354/esr00095
- Rochard, E., & Lassalle, G. (2011). Change in the climate and in the biodiversity-conservation paradigm—The case of diadromous fish. *Sciences Eaux & Territoires*, *3-bis*, 104\_109. https://doi.org/10.14758/SET-REVUE.2011.3BIS.20
- Romero, J., Gloria, C., & Navarrete, P. (2012). Antibiotics in Aquaculture Use, Abuse and Alternatives. In E. Carvalho (Éd.), *Health and Environment in Aquaculture*. InTech. <a href="https://doi.org/10.5772/28157">https://doi.org/10.5772/28157</a>

- Romero, E., Le Gendre, R., Garnier, J., Billen, G., Fisson, C., Silvestre, M., & Riou, P. (2016). Long-term water quality in the lower Seine: Lessons learned over 4 decades of monitoring. *Environmental Science & Policy*, *58*, 141-154. https://doi.org/10.1016/j.envsci.2016.01.016
- Root, T. L., Price, J. T., Hall, K. R., Schneider, S. H., Rosenzweig, C., & Pounds, J. A. (2003). Fingerprints of global warming on wild animals and plants. *Nature*, 421(6918), 57\_60. https://doi.org/10.1038/nature01333
- Roques, S., Berrebi, P., Rochard, E., & Acolas, M. L. (2018). Genetic monitoring for the successful re-stocking of a critically endangered diadromous fish with low diversity. *Biological Conservation*, *221*, 91\_102. https://doi.org/10.1016/j.biocon.2018.02.032
- Rougier, T. (2014). Repositionnement des poissons migrateurs amphihalins européens dans un contexte de changement climatique : Une approche exploratoire par modélisation dynamique mécaniste [Thèse de Doctorat, Université de Bordeaux]. http://www.theses.fr/2014BORD0055
- Said, K., & Desprats, J. (2021). Guide des bonnes pratiques pour limiter l'érosion des terres agricoles à Mayotte. CAPAM, BRGM.
- Schinegger, R., Palt, M., Segurado, P., & Schmutz, S. (2016). Untangling the effects of multiple human stressors and their impacts on fish assemblages in European running waters. *Science of the Total Environment*, *573*, 1079 1088.
- Scholthof, K.-B. G. (2007). The disease triangle: Pathogens, the environment and society. *Nature Reviews Microbiology*, 5(2), 152\_156. https://doi.org/10.1038/nrmicro1596
- Schultz, E. T., Smircich, M. G., & Strayer, D. L. (2019). Changes over three decades in feeding success of young American Shad *Alosa sapidissima* are influenced by invading zebra mussels Dreissena polymorpha. *Marine Ecology Progress Series*, 628, 141\_153. https://doi.org/10.3354/meps13114
- SDES, & OFB. (2020). *Eau et milieux aquatiques—Les chiffres clés—Édition 2020* (p. 128). Ministère de la Transition Ecologique.
- SDES, & UMS PatriNAt. (2020). *Biodiversité rare ou menacée : Peu d'améliorations depuis 2007* (p. 4). Ministère de la Transition Ecologique et Solidaire.
- Sheridan, J. A., & Bickford, D. (2011). Shrinking body size as an ecological response to climate change. *Nature Climate Change*, 1(8), 401\_406. https://doi.org/10.1038/nclimate1259
- Simberloff, D. (1998). Flagships, umbrellas, and keystones: Is single-species management passé in the landscape era? Biological Conservation, 83(3), 247–257.
- Smith, P. J. (1995). Diversité génétique des ressources halieutiques marines—Impacts possibles de la pêche (FAO). http://www.fao.org/3/v4865f/V4865F00.htm#toc
- Soubeyran, Y. (2008). Espèces exotiques envahissantes dans les collectivités françaises d'outre-mer. État des lieux et recommandations. (UICN, Éd.). Comité français de l'UICN.
- Sousa, R., Antunes, C., & Guilhermino, L. (2008). Ecology of the invasive Asian *clam Corbicula fluminea* (Müller, 1774) in aquatic ecosystems: An overview. *Annales de Limnologie International Journal of Limnology*, 44(2), 85\_94. https://doi.org/10.1051/limn:2008017
- Spalinger, L., Dönni, W., Hefti, D., & Vonlanthen, P. (2018). *Repeuplement durable des cours d'eau—Conditions, cadres et principes* (Biodiversité/Pêche, p. 42). Office fédéral de l'environnement (OFEV). http://www.bafu.admin.ch/uw-1823-f
- Starliper, C. E. (2011). Bacterial coldwater disease of fishes caused by *Flavobacterium psychrophilum*. *Journal of Advanced Research*, *2*, 97\_108. https://doi.org/10.1016/j.jare.2010.04.001
- Stocker, Z. S. J., & Williams, D. D. (1972). A Freezing Core Method for Describing the Vertical Distribution of Sediments in a Streambed. *Limnology and Oceanography*, *17*, 136\_138. https://doi.org/10.4319/lo.1972.17.1.0136
- Strayer, D. L., Hattala, K. A., & Kahnle, A. W. (2004). Effects of an invasive bivalve (*Dreissena polymorpha*) on fish in the Hudson River estuary. *Canadian Journal of Fisheries and Aquatic Sciences*, 61(6), 924\_941. https://doi.org/10.1139/f04-043

- Sudhagar, A., Kumar, G., & El-Matbouli, M. (2020). The Malacosporean Myxozoan Parasite *Tetracapsuloides* bryosalmonae: A Threat to Wild Salmonids. *Pathogens*, *9*(1), 16. https://doi.org/10.3390/pathogens9010016
- Tabouret, H. (2012). Les poissons migrateurs amphihalins des départements d'outre-mer : État des lieux. Synthèse générale sur les DOM insulaires (p. 276) [Rapport final]. MNHN, ONEMA.
- Tabouret, H. (2013). Les poissons migrateurs amphihalins des départements d'outre-mer : État des lieux. Partie 1 : Synthèse générale sur la Guyane. Rapport final (p. 110). ONEMA, MNHN.
- Teichert, N., Borja, A., Chust, G., Uriarte, A., & Lepage, M. (2016). Restoring fish ecological quality in estuaries: Implication of interactive and cumulative effects among anthropogenic stressors. *Science of The Total Environment*, 542, 383\_393. https://doi.org/10.1016/j.scitotenv.2015.10.068
- Terrigeol, L., & Gigot, G. (2019). État des lieux des espèces faunistiques prioritaires pour l'action publique dans les DROM [Rapport de synthèse]. UMS Patrinat, AFB/NRS/MNHN.
- Thiel, R., Riel, P., Neumann, R., Winkler, H. M., Böttcher, U., & Gröhsler, T. (2008). Return of twaite shad *Alosa fallax* (Lacépède, 1803) to the Southern Baltic Sea and the transitional area between the Baltic and North Seas. *Hydrobiologia*, 602(1), 161\_177. https://doi.org/10.1007/s10750-008-9293-4
- Thomas, C. (2017). Étude du « bichique » à La Réunion : Du recrutement d'une espèce amphidrome à l'éco-socio-système [Thèse de Doctorat, Université Pierre et Marie Curie Paris VI]. https://tel.archives-ouvertes.fr/tel-01799224
- Thomas, O., & Germaine, M.-A. (2018). De l'enjeu de conservation au projet de territoire : Le saumon atlantique au cœur des débats. *VertigO la revue électronique en sciences de l'environnement*, 18(2), Article Volume 18 numéro 2. https://doi.org/10.4000/vertigo.22259
- Tomanova, S., Courret, D., Alric, A., Oliveira, E. D., Lagarrigue, T., & Tetard, S. (2018). Étude d'efficacité des exutoires associés à des grilles inclinées ou orientées pour la dévalaison des smolts de saumon atlantique. https://doi.org/10.13140/RG.2.2.11387.21283
- UICN. (2015). Les espèces exotiques envahissantes sur les sites d'entreprises. Livret 1 : Connaissances et recommandations générales (p. 40).
- UICN Comité français, MNHN, SFI, & AFB. (2019). La Liste rouge des espèces menacées en France Chapitre Poissons d'eau douce de France métropolitaine. https://uicn.fr/wp-content/uploads/2019/08/liste-rouge-poissons-d-eau-douce-de-france-metropolitaine.pdf
- UICN, MNHN, SFI, & AFB. (2019). Liste rouge des espèces menacées en France—Poissons d'eau douce de France métropolitaine. AFB, MNHN, UICN. https://uicn.fr/wp-content/uploads/2019/08/liste-rouge-poissons-d-eau-douce-de-france-metropolitaine.pdf
- UICN, OFB, & MNHN. (2020). Liste rouge des espèces menacées en France—Faune de Martinique.
- UMS PatriNAt. (2019). *Biodiversité d'intérêt communautaire en France : Un bilan qui reste préoccupant* (Rapportage DHFF). MNHN. https://inpn.mnhn.fr/docs/N2000\_EC/Note\_synthese\_2019\_DHFF.pdf
- Valade, P. (2018). Les espèces de poissons et de crustacés d'eau douce de la Réunion. Biodiversité, origines des espèces et menaces. Comité Eau et Biodiversité (CEB), La Réunion.
- Valade, P., Hoarau, P., & Bonnefoy, A. (2018a). *Plan Directeur de Conservation de la Loche des sables, Awaous commersoni, à l'île de La Réunion et à l'île de Mayotte 2018-2027* (p. 157). DEAL, OCEA Consult'. http://www.reunion.developpement-durable.gouv.fr/IMG/pdf/pdc\_loche\_des\_sables\_v5\_2018\_04\_23web.pdf
- Valade, P., Hoarau, P., & Bonnefoy, A. (2018b). *Plan Directeur de Conservation en faveur des Anguillidae à l'Ile de La Réunion 2018-2027* (p. 206). DEAL, OCEA Consult'. http://www.reunion.developpement-durable.gouv.fr/IMG/pdf/pdc\_anguilles\_reunion\_v4\_2018\_04\_23web.pdf
- van Beurden, S. J., Engelsma, M. Y., Roozenburg, I., VoorbergenLaarman, M. A., van Tulden, P. W., Kerkhoff, S., van Nieuwstadt, A. P., Davidse, A., & Haenen, O. L. M. (2012). Viral diseases of wild and farmed European eel *Anguilla anguilla* with particular reference to the Netherlands. *Diseases of Aquatic Organisms*, 101(1), 69\_86. https://doi.org/10.3354/dao02501

- van Ginneken, V., Ballieux, B., Willemze, R., Coldenhoff, K., Lentjes, E., Antonissen, E., Haenen, O., & van den Thillart, G. (2005). Hematology patterns of migrating European eels and the role of EVEX virus. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, 140, 97 102.
- van Ginneken, V., Haenen, O. L. M., Coldenhoff, K., Willemze, R., Antonissen, E., van Tulden, P. W., Dijkstra, S., Wagenaar, F., & Van Den Thillart, G. (2004). Presence of virus infections in Eel species from various geographic regions. *Bulletin of the European Association of Fish Pathologists*, 24(5), 268\_272.
- Vejřík, L., Vejříková, I., Blabolil, P., Eloranta, A. P., Kočvara, L., Peterka, J., Sajdlová, Z., Chung, S. H. T., Šmejkal, M., Kiljunen, M., & Čech, M. (2017). European catfish (*Silurus glanis*) as a freshwater apex predator drives ecosystem via its diet adaptability. *Scientific Reports*, 7(1), 15970. https://doi.org/10.1038/s41598-017-16169-9
- Verspoor, E., Stradmeyer, L., & Nielsen, J. L. (2007). *The atlantic salmon: Genetics, conservation and management* (Blackwell Publishing Ltd.). Alaska Science Center. https://doi.org/10.1002/9780470995846
- Veschambre, V. (2007). Patrimoine : Un objet révélateur des évolutions de la géographie et de sa place dans les sciences sociales. Annales de geographie,  $n^{\circ}$  656(4), 361\_381.
- Villeneuve, B., Souchon, Y., Usseglio-Polatera, P., Ferréol, M., & Valette, L. (2015). Can we predict biological condition of stream ecosystems? A multi-stressors approach linking three biological indices to physico-chemistry, hydromorphology and land use. *Ecological Indicators*, 48, 88\_98. https://doi.org/10.1016/j.ecolind.2014.07.016
- Visser, M. E., & Both, C. (2005). Shifts in phenology due to global climate change: The need for a yardstick. 9.
- Vohmann, A., Borcherding, J., Kureck, A., bij de Vaate, A., Arndt, H., & Weitere, M. (2010). Strong body mass decrease of the invasive clam *Corbicula fluminea* during summer. *Biological Invasions*, *12*(1), 53\_64. https://doi.org/10.1007/s10530-009-9429-0
- Vonlanthen, P., & Hefti, D. (2016). Génétique et Pêche. Synthèse des études génétiques et recommandations en matière de gestion piscicole. *Connaissance de l'environnement*, *1637*, 90.
- Waldman, J., Wilson, K. A., Mather, M., & Snyder, N. P. (2016). A Resilience Approach Can Improve Anadromous Fish Restoration. *Fisheries*, *41*(3), 116\_126. https://doi.org/10.1080/03632415.2015.1134501
- Wallace, I. S., Gregory, A., Murray, A. G., Munro, E. S., & Raynard, R. S. (2008). Distribution of infectious pancreatic necrosis virus (IPNV) in wild marine fish from Scottish waters with respect to clinically infected aquaculture sites producing Atlantic salmon, *Salmo salar* L. *Journal of Fish Diseases*, *31*(3), 177\_186. https://doi.org/10.1111/j.1365-2761.2007.00886.x
- Williot, P., Rouault, T., Brun, R., Pelard, M., & Mercier, D. (2002). Status of Caught Wild Spawners and Propagation of the Endangered Sturgeon *Acipenser sturio* in France: A Synthesis. *International Review of Hydrobiology, 87*(5\_6), 515\_524. https://doi.org/10.1002/1522-2632(200211)87:5/6<515:: AID-IROH515>3.0. CO; 2-#
- Ziemski, F., & Maran, V. (2020). *Mnémiopsis*. DORIS Données d'Observations pour la Reconnaissance et l'Identification de la faune et la flore Subaquatiques. https://doris.ffessm.fr/Especes/Mnemiopsis-leidyi-Mnemiopsis-234

# APPENDIX 1: LIST OF PLANNING DOCUMENTS DEALING WITH DIADROMOUS SPECIES IN FRANCE

# A. AT NATIONAL LEVEL

MTE, 2017, 2018. Reports on implementation of France's Eel Management Plan la France. Ministry for the Ecological and Inclusive Transition.

MTE, 2010. Migratory diadromous species – the National Migratory Fish Management Strategy's (STRANAPOMI) policy guidelines. Ministry of Ecology, Sustainable Development, Transport and Housing

MTE, MAA, 2010. French Eel Management Plan (PGA). Ministry of Ecology, Energy, Sustainable Development and the Sea, Ministry of Food, Agriculture and Fisheries.

ONEMA, 2011. Implementation of the STRANAPOMI.

MTE, coordination DREAL NA, 2020. National Action Plans 2020-2029 in favour of the European sturgeon, Acipenser sturio. Nouvelle-Aquitaine DREAL, Ministry for the Ecological and Inclusive Transition e

MTE, 2020. French Atlantic Salmon Management Plan, 2020-2024. Ministry for the Ecological and Inclusive Transition

# B. AT LOCAL LEVEL

# Assessments of Migratory Fish Management Plans (PLAGEPOMIs) by Migratory Fish Management Committees (COGEPOMIs)

Rhine-Meuse COGEPOMI, 2021. Assessment of the Rhine-Meuse basin PLAGEPOMI 2016-2021. Grand Est DREAL Seine-Normandy COGEPOMI, 2021. Assessment of the Seine-Normandy basin PLAGEPOMI 2016-2021. Ile-de-France DRIEE

Loire, Sèvre Niortaise and Vendée Coast COGEPOMI, 2020. Assessment of the Loire basin PLAGEPOMI 2014-2019.

Pays de la Loire DREAL & Centre-Val de Loire DREAL

Garonne-Dordogne-Charente-Seudre-Leyre COGEPOMI, 2020. Assessment of the extended Garonne-Dordogne-Charente-Seudre-Leyre PLAGEPOMI 2014-2019. Nouvelle-Aquitaine DREAL

Adour Coastal Region COGEPOMI, 2020. Assessment of the extended Adour coastal watercourses PLAGEPOMI 2014-2019. Nouvelle-Aquitaine DREAL

Rhone-Mediterranean COGEPOMI, 2020. Assessment of the Rhone-Mediterranean basin PLAGEPOMI 2016-2021.

Auvergne-Rhone-Alpes DREAL

# Migratory fish Management Plans (PLAGEPOMIs)

Rhine-Meuse basin PLAGEPOMI 2016-2021

Artois-Picardy basin PLAGEPOMI 2015-2020

Seine-Normandy basin PLAGEPOMI 2016-2021

Breton watercourses PLAGEPOMI 2018-2023

Loire, Sèvre Niortaise and Vendée Coast basins PLAGEPOMI 2014-2019

Garonne, Dordogne, Charente, Seudre, Leyre PLAGEPOMI 2015-2019

Adour and coastal watercourses PLAGEPOMI 2015-2019

Rhone-Mediterranean basin PLAGEPOMI 2016-2021

# Sea Basin Strategy Documents (DSFs)

DIRM-MEMN, 2019. Coastline Strategy – Strategic document for the Eastern English Channel-North Sea coastline.

Direction interrégionale de la Mer Manche Est – Mer du Nord (Interregional Directorate of the Eastern English Channel-North Sea), Préfecture maritime de la Manche et de la mer du Nord (Maritime Prefecture for the English Channel and the North Sea) Ministry for the Ecological and Inclusive Transition

DIRM-NAMO, 20120. Coastline Strategy – Strategic document for the North Atlantic coastline. Direction interrégionale de la Mer Nord Atlantique-Manche Ouest (Interregional Directorate of the North Atlantic - Western English Channel), Préfecture maritime de l'Atlantique (Maritime Prefecture for the Atlantic), Ministry for the Ecological and Inclusive Transition

DIRM Sud-Atlantique, 2019. Strategic document for the South Atlantic coastline. Direction interrégionale de la Mer Sud-Atlantique (Interregional Directorate of the South Atlantic, Ministry for the Ecological and Inclusive Transition DIRM Méditerranée, 2019. Coastline Strategy – Strategic document for the Mediterranean coastline. Direction interrégionale de la mer Méditerranée (Interregional Directorate of the Mediterranean Sea), Ministry for the Ecological and Inclusive Transition

# Water Development and Management Master Plans (SDAGEs)

Water Development and Management Master Plan for the Rhine-Meuse basin 2016-2021. Rhine-Meuse Basin Committee, Rhine-Meuse Water Agency, Lorraine Rhine-Meuse basin DREAL

Water Development and Management Master Plan for the Artois-Picardie basin 2016-2021. Artois-Picardy Basin Committee Artois-Picardy Water Agency, Ministry of the Environment, Energy and the Sea

- Water Development and Management Master Plan for the Seine basin and Normandy's coastal watercourses 2016-2021. Seine Normandy Basin Committee, Seine Normandy Water Agency
- Water Development and Management Master Plan for the Loire-Brittany basin 2016-2021. Loire-Brittany Basin Committee, Loire-Brittany Water Agency, Loire-Brittany basin DREAL
- Water Development and Management Master Plan for the Adour-Garonne basin 2016-2021. Adour Garonne Basin Committee, Adour-Garonne Water Agency, ONEMA Midi-Pyrénées DREAL
- Water Development and Management Master Plan for the Rhone-Mediterranean basin 2016-2021. Rhone-Mediterranean Basin Committee, Rhone Mediterranean Corsica Water Agency, ONEMA, Auvergne-Rhone-Alpes Rhone-Mediterranean DREAL
- Water Development and Management Master Plan for the Corsica basin 2016-2021. Corsica Basin Committee, Corsica Regional Authority, Rhone Mediterranean Corsica Water Agency, Corsica DREAL
- Water Development and Management Master Plan for the hydrographic district comprising Guadeloupe and Saint-Martin 2016-2021. Guadeloupe Basin Committee, Guadeloupe DEAL, Guadeloupe Water Office, ONEMA
- Water Development and Management Master Plan Martinique 2016-2021. Martinique Basin Committee, Martinique Prefecture, Martinique DEAL, Martinique Water Office
- Water Development and Management Master Plan French Guiana basin 2016-2021. French Guiana Basin Committee, French Guiana DEAL, French Guiana Water Office, ONEMA
- Water Development and Management Master Plan Reunion Island basin 2016-2021. Reunion Island Basin Committee, Reunion Region Prefecture
- Water Development and Management Master Plan for Mayotte 2016-2021. Mayotte Basin Committee, Mayotte DEAL

**APPENDIX 2: LEGAL PROTECTION STATUS INCLUDING PROTECTION OF** 

**HABITATS** 

A. INTERNATIONAL

**CITES** 

The Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), regulates trade in these species by making export and import of species listed in Appendices I and II subject to prior delivery and presentation of an export or import licence. The Convention therefore aims to protect such species against overexploitation. The European sturgeon has been listed in Appendix I

since 1983, and the European eel has been listed in Appendix II since 2010 (CITES 1973).

**Barcelona Convention** 

The main objective of the Barcelona Convention for the Protection of the Mediterranean Sea Against Pollution is to "reduce pollution in the Mediterranean zone and protect and improve the marine environment of that zone in order to contribute to sustainable development". Decree no.2014-1195 bears on publication of the amendment to the lists in Appendices II and III of the protocol on specially protected areas and biological diversity in Mediterranean. It was signed in Barcelona in 1995. The European eel, the marine lamprey, the river lamprey, the allis shad and the twaite shad are listed in Appendix III on species whose exploitation is regulated. The European sturgeon is listed in Appendix II of the amendment

concerning endangered and threatened species (Decree no.2014-1195 of 16 October 2014)<sup>46</sup>.

**Bonn Convention**<sup>47</sup>

<sup>&</sup>lt;sup>46</sup> Decree no.2014-1195 of 16 October 2014 bearing on publication of the amendment to the lists in Appendices II and III of the protocol on specially protected areas and biological diversity in the Mediterranean, signed in Barcelona on 10 June 1995, adopted in Marrakech on 5 November 2009 (1)

NOR: MAEJ1423033D; ELI: <a href="https://www.legifrance.gouv.fr/eli/decret/2014/10/16/MAEJ1423033D/jo/texte">https://www.legifrance.gouv.fr/eli/decret/2014/10/16/2014-1195/jo/texte</a>; JORF no.0242 of 18 October 2014 Text no.5

<sup>&</sup>lt;sup>47</sup> https://eur-lex.europa.eu/legal-content/FR/TXT/?uri=LEGISSUM%3Al28051; Convention on the Conservation of Migratory Species of Wild Animals: https://eur-lex.europa.eu/legal-content/FR/TXT/?uri=celex%3A21979A062 %3 %280 %1 %29; 82/461/EEC: Decision of the Council, of

The Bonn Convention on migratory species was adopted in 1979. Its Article 2 provides that "The Parties acknowledge the need to take action to avoid any migratory species becoming endangered". The European sturgeon and the European eel are among the species listed in Appendix II; This implies that the two species are considered as having an unfavourable conservation status requiring the conclusion of international agreements on their conservation and management.

#### **Berne Convention**

The Berne Convention on the Conservation of European Wildlife and Natural Habitats was adopted in 1979. The European sturgeon y is listed in its Appendix II, with twaite shad, allis shad, river lamprey, marine lamprey and Atlantic salmon in Appendix III. The species of wild fauna listed in Appendix III of the Convention must be governed by national regulations in order to ensure their populations do not become endangered. Species listed in Appendix II of the Convention must also be governed by appropriate legal and regulatory provisions in order to ensure their conservation. In 2007, the Berne Convention's Standing Committee adopted the International Action Plan for the Restoration of the European sturgeon. It acts as a guide for the competent national authorities, which must use it as a basis for the drafting of national action plans in favour of the European sturgeon (Convention on the Conservation of European Wildlife and Natural Habitats (Berne Convention), 1979) (Marino & Valadou, 2018).

# United Nations Convention on the Law of the Sea

The Law of the Sea is made up of a set of rules on use of maritime areas, i.e. "freely and naturally connected expanses of salt water", by subjects of international law, foremost among them being the States.

The Law of the Sea first of all provides a legal definition of maritime areas, i.e. internal waters, territorial seas, contiguous zones, exclusive economic zones, continental shelves, high seas, special regimes for straits used for international navigation and archipelagic States. Secondly, it covers States' rights and

<sup>24</sup> June 1982, concerning conclusion of the Convention on the Conservation of Migratory Species of Wild Animals: <a href="https://eurlev.europa.eu/legal-content/FR/TXT/?uri=celex%3A31982D0461">https://eurlev.europa.eu/legal-content/FR/TXT/?uri=celex%3A31982D0461</a>

duties in these areas, in particular those of navigation, exploitation of economic resources, and protection of the marine environment.

#### **NASCO**

The North Atlantic Salmon Conservation Organisation (NASCO) is an intergovernmental organisation whose objective is to contribute to conservation, restoration, development and sustainable management of stocks of Atlantic salmon (*Salmo salar*)in the North Atlantic Ocean, via cooperation between signatories. NASCO was created in 1984 and its Convention sets out the broad policy directions for protection of Atlantic salmon and makes recommendations. NASCO asks each of its contracting parties, including the European Union, to draw up an "Implementation Plan" showing how they are endeavouring to apply its recommendations. Each European Union Member State concerned must meet this obligation by implementing its own plan: France is currently implementing its plan for the 2019/2024 period (NASCO, 2009).

#### **OSPAR Convention**

The Convention on Protection of the Northeast Atlantic Marine Environment, known as the OSPAR (Oslo-Paris) Convention, came into force in 1998. It requires its contracting parties to take "all possible steps to prevent and eliminate pollution and [...] take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected". Efforts made by its contracting parties have had significant results with regard to protection of the Northeast Atlantic Marine Environment. The European sturgeon, marine lamprey, Atlantic salmon, allis shad and European eel are listed in Appendix V, which concerns protection and conservation of the maritime area's ecosystems and biological diversity (OSPAR Commission, 1992).

# B. AT EUROPEAN LEVEL

# 1. European Directives

Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora.

Adopted in 1992, the "Fauna-Flora-Habitat Directive" (FFHD) aims to ensure conservation of natural habits and wild fauna and flora. It refers to diadromous species in several of its Appendices:

- Appendix II designates the European sturgeon, Atlantic salmon, twaite shad, allis shad and the sea
  and river lamprey as species of Community interest whose conservation requires designation of
  special conservation areas.
- Appendix IV designates the European sturgeon as a species of Community interest requiring strict
  protection. This includes prohibition of deliberate capture or killing, deliberate disturbance,
  deliberate destruction or taking of eggs, and deterioration or destruction of breeding sites and
  resting places, as well as keeping, transport and offering for sale or exchange. This provision is an
  implementation of the Council of Europe's Berne Convention on the Conservation of European
  Wildlife and Natural Habitats, and specifically of its Article 6 which provides the same prohibitions
  for the European sturgeon
- And Appendix V designates species whose capture in the wild and exploitation are liable to be subject to management measures as species of Community interest. The Atlantic salmon, twaite shad, allis shad and river lamprey are listed in Appendix V.

Directive 2000/60/EC of the European Parliament and Council, establishing a framework for Community action in the field of water policy<sup>48</sup>

Adopted in 2000, the FWD requires Member States to ensure that water quality does not deteriorate and

to achieve "good water status" by 2015. Achievement of such "good status" is based on assessment of

the chemical and ecological status of watercourses and so contributes to the improvement of diadromous

fishes' habitats. Ecological status comprises physicochemical and biological parameters, including the

diversity and abundance of animal and plant species present in rivers. Diversity and abundance of species

depends on three main parameters in constant interaction: hydrology, physicochemical conditions and

morphological conditions. Member States must ensure that the following actions are carried out for each

of their hydrographic basins: an analysis of characteristics, a study of human impacts on water status, an

economic analysis of water use, and establishment of a register of all areas designated as requiring special

protection under specific Community legislation, a water status monitoring programme, a programme of

measures, and a management plan. The FWD is therefore an important lever for restoration of the

habitats of migratory fish populations, which are both beneficiaries and indicators of good water status.

Directive 2008/56/EC of the European Parliament and Council establishing a framework for Community

action in the field of marine environmental policy.

Adopted in 2008, the Marine Strategy Framework Directive. It establishes a framework for Community

action in the field of marine environmental policy. In this regard, each Member State is required to

develop a strategy designed to achieve or maintain good ecological status, knowing that such good status

includes biological diversity. Hence, States must take the measures required to reduce the impacts of

human activities on the marine environment.

# 2. European regulations

Regulation (EC) no.1100/2007 of the Council establishing measures for the recovery of the stock of European eel.

Regulation (EC) no.1100/2007 of the Council establishing measures for the recovery of the stock of European eels was adopted in 2007. The Regulation establishes a framework for protection and sustainable exploitation of the stock of European eels in Community waters and in Member States' coastal lagoons, estuaries, rivers, streams and internal waters. Pursuant to this Regulation, Member States are required to identify and define the river basins on their territory that constitute the eel's natural habitat and draw up an eel management plan for each of them. The Regulation aims to "reduce anthropogenic mortalities so as to permit [...] the escapement to the sea of at least 40% of the silver eel biomass" relative to the original situation (ONEMA, 2010).

# C. AT NATIONAL LEVEL

#### 1. French laws

At national level, the law on use of **hydraulic energy**, **adopted in 1919**, requires that the specifications operators must comply with include measures concerning "the conservation and free movement of fish".

The **1829 law on river fishing, amended in 1941** (and validated in 1945) defines the organisation of freshwater fishing. Under its provisions, fishing in public waters was no longer free, a fishing tax was introduced in order to fund the monitoring and promotion of the nation's fish heritage, and "approved fishing and fish-farming associations" were instituted.

The Water Law of 1964 organises decentralised management of water by drainage basin. It demarcates six main basins. Mention should also be made of the 1976 Law on the Protection of Nature, which instituted biotope protection orders (arrêtés de biotopes) at local level, ensuring the integrity of areas essential to the successful completion of some species' lifecycles; and of the 1980 Law on Energy Efficiency, which established classification as "reserved watercourses", by which no authorisation or concession will be granted to new hydraulic companies on certain watercourses, the list of which is set by

Council of State decree. Another important piece of legislation is the **1984 law on freshwater fishing and** management of fishery resources and its environmental protection measures, which have gradually enabled reduction of various sources of damage, connected in particular with hydropower facilities.

Then came the new Water and Aquatic Environment Act, (LEMA) which came into force in **2006 and transcribes** the FWD into French law. It modifies methods for classification and designation of watercourses in which migratory transparency is required in order to enable the survival or return of migratory diadromous fish and holobiotic migratory species. The new classification was introduced into the Environmental Code in Article L214-17 and includes two watercourse designations concerning diadromous species (See Article L214-17 below). Once these lists have been finalised, the provisions stemming from them will replace those of previous classifications.

The Act for the restoration of biodiversity, nature and landscapes of 9 August 2016 provided French law with a dynamic new vision of biodiversity.

#### 2. The Environmental Code

**M**ANAGEMENT OF MIGRATORY DIADROMOUS SPECIES

# → Articles R. 436-44 to R. 436-68 of the Environmental Code

Management of diadromous fish is governed by Articles R436-44 à R436-68 of the Environmental Code, which reproduce the provision of the "décret amphihalin" (Diadromous Decree) of 1994. However, these provisions only cover the Atlantic salmon, the allis shad, the twaite shad, the sea lamprey, the river lamprey, the European eel and the sea trout. No provision is made for the European sturgeon, the flounder, the thin-lipped grey mullet or the smelt, or for diadromous species in Overseas France. The provisions of the 1994 "décret amphihalin" include setup of the COGEPOMIs responsible for drawing up PLAGEPOMIs.

The "décret amphihalin" establishes the basic principles for management of diadromous fish species. It provides for creation of a Migratory Fish Management Committee (COGEPOMI) for each major basin, responsible for drawing up Migratory Fish Management Plans (PLAGEPOMIs). COGEPOMIs are consultation bodies focusing specifically on migratory fish issues; they provide Basin Coordinator Prefects with proposals for appropriate measures with regard to exploitation of stocks and management of

environments. The PLAGEPOMIs they draw up are six-year plans providing for measures useful to the reproduction, development, conservation and movement of diadromous fish, methods for estimating stocks and quantities that can be fished each year, fish nursery and population support plans, the conditions under which periods in which fishing is permitted are set, methods for possible limitation of fishing, and the conditions under which fishermen's logbooks are delivered and kept. Composition of COGEPOMIs is governed by Article R436-49 of the Environmental Code.

#### **WATERCOURSES**

## → Article L. 214-17

Two lists for watercourses have been drawn up:

- List 1: Watercourses on which no new facility will be authorised if it constitutes an obstacle to continuity, so as to ensure full protection of diadromous fish,
- List 2: Watercourses on which all works must be managed, maintained and, if necessary, equipped in such a way as to ensure ecological continuity.

The two lists are drawn up by order of the competent administrative authority, after study of the impact of classifications on the various uses of water referred to in Article L. 211-1. Lists are updated during revision of Water Development and Management Master Plans (SDAGEs) in order to take account of issues specific to the various uses and evolution of knowledge (*Article L214-17 – Environmental Code – Légifrance*, s. d., p.21).

Destruction of watermills' water retention structures is explicitly excluded from means enabling reestablishment of free movement of fish.

## → Article L. 214-18

This Article requires that any work built on the bed of a watercourse must incorporate systems maintaining a minimum flow in the bed permanently guaranteeing the lives, movement and reproduction of the species living in the waters concerned at the time the work is installed, and, if required, systems preventing fish from getting into supply channels and tailraces (*Article L214-18 – Environmental Code – Légifrance*, 2006, p.2).

## Article L. 214-18-1

This Article creates an exemption to the provisions of Article L. 214-17, for watermills equipped to produce electricity.

#### → Article L. 432-3

Article L432-3 of the Environmental Code results from the LEMA and reinforces protection of spawning grounds, nursery zones and feeding areas for aquatic life, and provides that destruction of such areas without prior authorisation is a criminal offence. Prefectural Orders on spawning grounds were issued in several French départements in the wake of this Article, (*Article L432-3 – Environmental Code – Légifrance*, 2013, p. 43)

## 3. National Orders

# → Order of 8 December 1988 establishing the list of protected species across the entire national territory

Lampreys, shad and salmonids are designated by the Order of 8 December 1988 establishing the list of protected species of fish across the entire national territory, Article 1 of which states that "The destruction or removal of eggs and the alteration or degradation of the specific environments, breeding grounds in particular, designated by Prefectural Order are prohibited on the national territory at all times" (Order of 8 December 1988 establishing the list of protected species of fish across the entire national territory).

# → Order of 9 July 1999 establishing the list of endangered vertebrate species in France whose range extends beyond a single département

The Order establishes the list of endangered vertebrate species in France whose range extends beyond a single département.

The European sturgeon is a protected species under Article L.211-1 of Environmental Code and an endangered species in France due to already observed or anticipated low population numbers. For this species, exemptions from destruction of protected species are granted by the Minister responsible for

protection of nature and not by Prefects (Order of 9 July 1999 establishing the list of endangered vertebrate species in France whose range extends beyond a single département).

→ Order of 20 December 2004 on protection of the species Acipenser sturio (sturgeon)

Article 12 of the FFHD requires Member States to take the measures required for institution of a strict protection system for the species listed in Appendix IV, which include the European sturgeon. The Order of 20 December 2004 on protection of the species Acipenser sturio extends protection of the sturgeon to the species' specific habitats (Order of 20 December 2004 on protection of the species Acipenser sturio (sturgeon)).

It is also worth mentioning the Ministerial Order of 25 January 1982 prohibiting fishing for European sturgeon in France.

- → Order of 26 October 2012 setting the minimum catch size or weight of fish and other marine life (for a given species or geographical area) in the context of recreational sea fishing
- → Order of 28 January 2013 establishing the minim catch and landing sizes of fish and other marine life for professional fishing
- → Order of 6 January 2020 establishing the list of animal and plant species which can only be exempted from protection following an opinion from the National Council for Nature Protection (CNPN)<sup>49</sup>

The sea lamprey, river lamprey, Atlantic salmon and allis shad are included in Appendix I.

# 4. National Strategies

**National Biodiversity Strategy (SNB)** 

<sup>&</sup>lt;sup>49</sup> Order of 6 January 2020 establishing the list of animal and plant species which can only be exempted from protection following an opinion from the National Council for Nature Protection; NOR: TREL1934322A ELI: <a href="https://www.legifrance.gouv.fr/eli/arrete/2020/1/6/TREL1934322A/jo/texte">https://www.legifrance.gouv.fr/eli/arrete/2020/1/6/TREL1934322A/jo/texte</a>; JORF no.0024 of 29 January 2020 Text no.12

The first National Biodiversity Strategy was rolled out in 2004 with the aim of providing better responses to biodiversity restoration, conservation and protection issues in France. The Strategy was revised in 2011 in order to strengthen actors' commitment and integrate biodiversity into all public activities and policies, local and national alike. An assessment of SNB2 was carried out in late 2020. It assessed implementation and effects of the initiatives deployed in order to prepare the new National Biodiversity Strategy.

SNB3, which is currently being drafted, will set national objectives for biodiversity over the next 10years and actions for the next 3 years. The National Plan in favour of Migratory Diadromous species will contribute to the new Strategy's implementation.

## **Biodiversity Plan**

The 2018 Biodiversity Plan aims to speed up implementation of SNB2; its Action 42 provides that "multispecies and multi-habitat national action plans will be drawn up for the most endangered species" by 2020.

# National Protected Areas Strategy 2030 (SNAP)

For the first time, France has provided itself with a unified strategy for Metropolitan and Overseas France that recognises the obvious connection between land and sea issues, covers all statutory types of protected areas, and focuses on their creation as much as their management. It aims to protect 3 of the national natural areas by 2030, including 10% under enhanced protection: objectives that are now included in the 2021 Law on Climate and Resilience.

Currently, only 1.8% of such areas are under enhanced protection The SNAP seeks to be more territorially anchored so as to ensure greater involvement on the part of the actors concerned. In this respect, it relies on the commitment of a great many local and national partners. In addition to creation of protected areas, the new Strategy also assigns a key role to management of such areas, through 7 objectives and 18 measures. Each measure is designed to address one of the Strategy's concerns over the next 10 years. Their implementation will be via 3-year action plans. An initial National Action Plan will cover the 2021-2023 period. In each territory (Regions, coastlines and sea basins, competent Overseas communities, etc.), local action plans will be drawn up in order to implement the Strategy (OFB, 2021).

# **National Migratory Fish Management Strategy (STRANAPOMI)**

The STRANAPOMI, which was adopted in 2010, promoted consistency of policies likely to have an impact on migratory fish management by setting out policy guidelines, including for Overseas France; it was deployed between 2013 and 2015. Its drafting provided an opportunity for exchanges between professional and amateur fishermen, hydro-electricians, nature conservation associations and public bodies. It established the framework for protecting these species and its guidelines were intended to be expressed in concrete measures, drawing on PLAGEPOMIs and Water Development and Management Master Plans (SDAGEs).

Technical Note of 30 April 2019 on implementation of the Action Plan for a Conciliatory Policy on Restoration of Ecological Continuity (PARPARCE).

Restoration of watercourses' ecological continuity is at the crossroads of a number of public policies whose concerns can be reconciled. The Technical Note aimed to: – disseminate the PARPARCE, specifying the context and spirit in which it was drafted – give instructions on its implementation by State departments and public institutions of parts of the plan that fell within their competence, in particular with regard to prioritisation of interventions, interdepartmental coordination, weighting of issues and dialogue with stakeholders.