Migratory Fish Research Strategy 2022

Critical research needed to help four native migratory species thrive

September 2022

Department of Conservation
Te Papa Atawhai

New Zealand Government

Cover:

TOP – left to right: Īnanga (*Photo: Sjaan Bowie*); Longfin eel (*Photo: Alan Cressler*).

BOTTOM – left to right: Lamprey (*Photo: Stephen Moore*); Shortjaw kōkopu (*Photo: Angus McIntosh, Uni. of Canterbury*)

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Photo: Shortjaw kōkopu (Credit: A. McIntosh, Uni. Of Canterbury)

1 Introduction

The Department of Conservation (the Department) has a core responsibility to protect and enhance the indigenous ecosystems and species of Aotearoa New Zealand. As the country faces a major biodiversity crisis across its terrestrial and aquatic ecosystems, coupled with increasing anthropogenic pressures and threats, this task is as challenging as it is essential.

In freshwater ecosystems, over two-thirds of New Zealand's native fish species are classified as 'Threatened' with or 'At Risk' of extinction (Dunn et al. 2018). The pressures they face include habitat degradation and loss, altered flow regimes, and interference from introduced species.

Many native freshwater fish are diadromous, undertaking at least one major migration between sea and freshwater habitats to complete their life cycles. There is currently no conservation strategy that encompasses the full range of ecosystems required to accommodate such life requirements. The Department is prioritising migratory freshwater species to acknowledge their particular management needs. In 2022, this programme targets four species: īnanga *Galaxias maculatus*, shortjaw kōkopu *Galaxias postvectis*, kanakana/piharau/lamprey *Geotria australis* and tuna/longfin eel *Anguilla dieffenbachii*. All are taonga species as well as mahinga kai for tangata whenua.

Gaps in our knowledge of these species and their habitats across different life stages can hinder conservation efforts at the local, regional, and national scales. In addition, we need cost-effective approaches and tools to manage populations, ki uta ki tai, from mountains to sea. The Migratory Fish Research Strategy (the Strategy) provides research priorities for the Department to help achieve conservation objectives for migratory freshwater species.

This Strategy is a living document, designed to open and foster discussion, and to provide the space, opportunity, and support for Māori-led research initiatives. Taonga and mahinga kai species warrant an integrative and inclusive approach to their conservation. In this regard, the Department will reach out to whānau, hapū, iwi and Māori organisations to understand their views, interests, and priorities.

2 General background

2.1 Strategy purpose

The Migratory Fish Research Strategy provides strategic research direction for migratory freshwater species.

It aims to help drive, influence and support research endeavours within the Department and in other organisations such as government agencies, research institutes, universities, and community groups.

Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy 2020 provides the overall strategic direction for the protection, restoration, and sustainable use of indigenous biodiversity in Aotearoa New Zealand, from 2020 to 2050. Within this framework, the Migratory Fish Research Strategy:

- Identifies priority research areas that contribute to the development of annual migratory fish research plans
- Supports discussions on collaborative research investment opportunities
- Ensures migratory fish research is being delivered in-line with current research needs
- Contributes knowledge, tools and methods that will help secure populations of migratory fish species in the medium and long terms.

Our work on migratory freshwater species occurs alongside other work undertaken by the Department (Figure 1). For example, outputs from the programme can help inform restoration projects conducted under the catchment restoration programme Ngā Awa or contribute to fish passage delivery work. Conversely, actions undertaken in other programmes might answer critical research questions about migratory species.

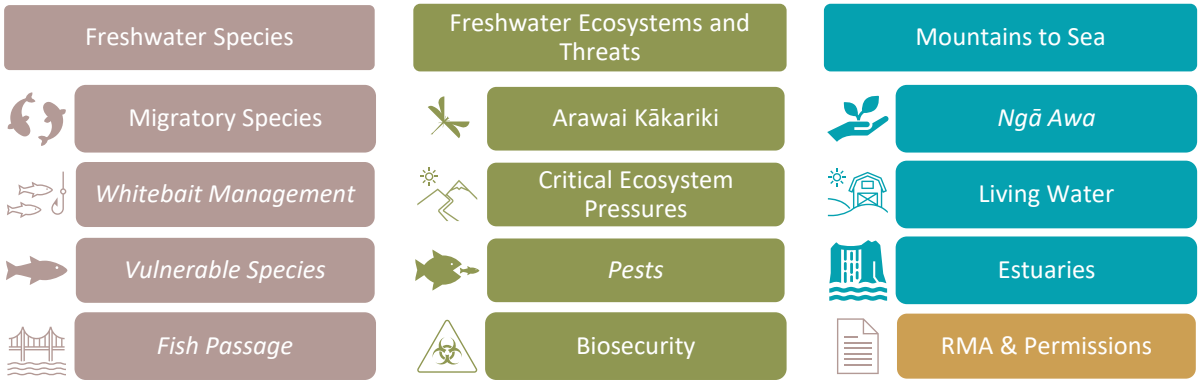


Figure 1. Examples of areas of work in the Department in 2022 with freshwater components. Areas of work with existing functional links with the Migratory Freshwater Species Programme are italicised.

Photo: Longfin eels (Credit: A. Siciliano)

2.2 Strategy development

The Strategy is a framework designed to improve the state of knowledge required to help deliver conservation outcomes for migratory species.

For its development, we completed an internal review of the scientific and technical literature, concentrating either on the focal species (e.g. Williams et al. 2017; Pierre, Dykes, and West 2014; Goodman 2018) or on management, conservation and restoration methods relevant to these species (e.g., Franklin et al. 2018).

This process led us to identify the main requirements to support the conservation of migratory species, which are:

- to comprehensively assess the current state of our focal migratory fish species and their habitats
- to gain a better understanding of the ecological drivers of population demographics at the local, regional, and national scales
- to gain a better understanding of the causes and mechanisms leading to the decline of migratory fish populations
- to assess current conservation and management strategies, tools, and methods, and to identify means of improvement
- to develop and share this knowledge gained to help inform the strategic deployment of operational resources.

This led to a register of research projects currently underway and potential future research topics. We amended this register following discussions with subject matter experts, including some external to the Department. We also ensured that the register was consistent with strategic documents such as the Biodiversity Conservation Science Prospectus (Department of Conservation, 2020).

We intend this Strategy to be adaptable, responsive, and representative of the aspirations and needs of relevant stakeholders, including central government agencies, regional authorities, local communities, and Māori (refers to Section 4-Delivering outcome-focused research). In addition, it will be reviewed and updated annually.

3 Current state of knowledge and critical research needs

There are strong differences in the state of knowledge across the four species in this programme. Īnanga and longfin eel have benefited from more scrutiny, leading to a relatively more comprehensive understanding of their ecology. For the more cryptic lamprey and shortjaw kōkopu, further knowledge is required to inform targeted management and conservation measures.

For all four species, knowledge gaps exist regarding the status and trends of species distributions, stocks, population structure, as well as critical habitat availability across their distribution range. Key questions also remain about their ecological requirements, particularly around critical life stages. The timing and triggers of major life cycle events, notably spawning and upstream/downstream migrations, are only partially understood.

In addition, populations responses to their environment are not fully understood, both under normal circumstances and under changing environmental conditions, especially where multiple pressures are combined. In a similar vein, responses to existing management strategies, protection and restoration measures, and recovery plans warrant further scrutiny.

Finally, conservation interventions hinge on accurate data, tools, management systems and databases. The assessment, improvement and development of tools and methods should be an important research and development focus in the short and medium terms.

Therefore, we describe below potential priority research areas for migratory freshwater species conservation, according to the following interrelated themes:

❶ Species and Populations

This theme deals with fundamental biological and ecological questions. It involves assessing the status and trends of populations at different spatial scales; understanding the ecological requirements of migratory species across all life stages; and exploring species relationships to their environment.

❷ Critical Habitats

This theme encompasses questions relative to habitats occupied by vulnerable life stages or used for critical moments of a species' life cycle (e.g., spawning). It includes habitat distribution as well as current state of habitat conservation.

❸ Pressures and Threats

This theme explores populations responses to anthropogenic pressures and threats. It hinges on understanding the relationships between species and their environment.

❹ Tools and Methods for Recovery and Management

This theme deals with the research and development of standards, methods and tools that can inform intervention strategies. It includes applied research on fish passage.

Photo: Lamprey juvenile (Credit: N. Petrove)

3.1 Theme 1: Species and populations

3.1.1 Understanding species conservation status and population trends

A strong focus on increasing survey efforts nationwide of known populations is necessary to obtain and maintain accurate data on each species' distribution status and understand population trends.

Spatially explicit records for freshwater species in Aotearoa New Zealand date back to the 1920s, however for many catchments records are outdated, inadequate, or lack any meaningful spatial extent (e.g., point records, presence-only records). This issue is salient for migratory species, for which local populations are naturally subjected to high spatiotemporal fluctuations that can be further exacerbated by human activities.

Spatial and temporal coverage of periodic survey programmes must be improved to understand recruitment dynamics and population trends at the catchment, regional and national scales. Understanding demographic trends would also contribute to fill some key gaps regarding species ecology and life history.

This body of work requires a high degree of data standardisation and quality. Current survey and monitoring protocols should be reviewed, evaluated, and improved to ensure data that reflect the state of populations at the appropriate scale.

3.1.2 Understanding life histories and ecological requirements to target conservation efforts on key life stages

To improve existing management practices and develop effective conservation strategies, we must better understand life histories, demographics, and dynamics of local populations and their relationships to environmental conditions.

Our focal species are all characterised by complex life histories in which movement between sea and freshwater is pivotal. While life cycles are broadly understood, some species-specific modalities are still under scrutiny. As oceanic life stages are seldom investigated, approaches to species management, habitat restoration, connectivity improvement and, more generally, threat mitigation, focus on freshwater life stages. These approaches often rely on incomplete information and guidance. Notably, important knowledge gaps exist around the timing, triggers, and success of major life cycle events, such as spawning and upstream/downstream migrations.

Īnanga and shortjaw kōkopu are amphidromous: adults mature and spawn in freshwater, while larval growth occurs at sea. Harvest of the species targets freshwater juvenile recruits (whitebait stage) while they start moving up freshwater systems. For both species, recruitment patterns and links to freshwater populations should be thoroughly investigated. Important research gaps on various aspects of reproduction should also be addressed, including spawning behaviour, timing and spatiotemporal variability of spawning events across catchments, ecological triggers and factors affecting spawning success.

Longfin eels are catadromous: mature adults undertake a once-in-a-lifetime migration to oceanic spawning grounds. Larvae hatch at sea and spend a few months migrating back to freshwater where they recruit as glass eels. Juvenile eels (elvers) move upstream to their foraging grounds, where they will spend up to several decades to reach maturity and metamorphose into silver eels (migrant adults). For this species, research is underway to better understand freshwater recruitment dynamics in a few selected catchments. This research should extend across multiple bioregions.

Lampreys are anadromous. Juveniles spend several years at sea feeding parasitically on other fish. They enter freshwater as immature adults and spend months reaching sexual maturity and migrating upstream small, hard-bottomed streams where they spawn and die. Larvae spend around 4 years as filter feeders in freshwater buried in fine sediments before metamorphosing into miniature adults that then move downstream to their oceanic life. There are many unknowns in the species' ecological requirements. Current research efforts target freshwater habitats for spawning and larval rearing, stream selection processes and characterisation of upstream and downstream migrations.

3.2 Theme 2: Identifying, mapping, and evaluating the status of critical habitats

Locating and assessing the quality of freshwater habitats where the focal species are found is key to develop adequate management strategies and target conservation efforts at an appropriate scale.

Several species distribution models have been developed, that rely on survey data and macro-habitat distribution (e.g., Canning 2018; Leathwick et al. 2005). While this approach can be useful at the national and regional scales, local implementation requires to know the extent, integrity, and rate of change of mesohabitats, in relation with associated life stages. Currently this information is mostly lacking, except in a few locations. Identification and mapping of the distribution of high quality mesohabitat, in association with up-to-date distribution data, would help identify population strongholds and geographically target conservation efforts. In that regard, we stress the urgency of identifying and assessing the conservation status of spawning habitats for īnanga, shortjaw kōkopu and lamprey.

This body of work closely relates to the 'Species and Populations' theme, as it requires to understand what makes a high-quality habitat for a given species or for a given life stage, i.e., its ecological requirements. It also requires standardised protocols for habitat survey, quality assessment and monitoring. As an example, the Department is currently developing standardised methods for mapping īnanga spawning habitat; however, these methods have yet to be adopted and implemented nationwide. There currently are no national standards of habitat characterisation for other migratory species.

Photo: Īnanga juvenile (Credit: S. Bowie)

3.3 Theme 3: Identifying the extent and effects of anthropogenic pressures and threats

This theme focuses on understanding the ways in which human activities affect migratory species and their habitats.

All focal species are vulnerable to human-driven pressures ranging from habitat degradation and loss, reduced connectivity and impediment of free movement within catchments, to changes in water quantity, water quality, introduced species and harvest (Figure 2). To some extent, however, the degree of impact of those human-driven pressures is largely unknown. Further research on species' responses to pressures and threats at various spatial and temporal scales is therefore required. Another high priority in recent years has been to understand the impacts of man-made structures and reduced connectivity on migration patterns and life history.

In the medium term, we believe that the effects of cumulative and interactive pressures along environmental gradients on populations and habitats should garner interest in the research community. Impacts of other species, particularly introduced species, parasites, and pathogens, should also be considered in that regard.

We also estimate that predicting the effects of climate change and the incidence, scale and causes of mass mortality events should be an important research focus.

3.4 Theme 4: Assessing and developing standards, tools and methods for the recovery and management of species and habitat

To address threats and pressures, we are implementing practical solutions to improve stocks, distribution, and species resilience. This theme provides tools and methods to support that work.

As highlighted in the previous sections, there is a need for nationwide standards in data acquisition, management, and quality control. We estimate that the upgrade or, where needed, the development of standard protocols, field and desktop tools, data collection and management systems should be a high priority in the short and medium terms.

Current strategies and methods seeking to restore habitat and connectivity should be reviewed in relation to their effects on migratory species. Part of the research efforts must also be allocated to their improvement and to the development and trial of novel approaches to mitigate, reduce or eliminate adverse effects in the New Zealand context.

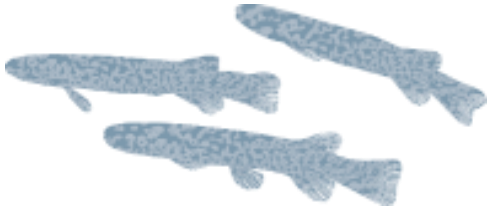
Figure 2. Summary of pressures and threats affecting shortjaw kōkopu, īnanga, longfin eel and lamprey

			Main impacted life stages per species		
	Affects distribution, abundance, dynamics, behaviours	**All species**	*Galaxias spp.*	*A. dieffenbachii*	*G. australis*
Freshwater habitat degradation/loss					
	Foraging habitat	↺			
	Spawning habitat		★●		★●
	Larval habitat				●
Reduced habitat connectivity, instream structures	*Disrupt or impede habitat shaping processes, life cycles and migration patterns*				
	Upstream migration		↺	▲✦	✦★
	Downstream movement		↺	★	●▲
Harvest	*Directly depletes populations, affects population structure and community composition*				
	Commercial		▲	▲✦	
	Recreational		▲	▲✦	
	Customary		▲	▲✦	✦★
Pests and introduced species	*Impact ecology, abundance, habitat quality*				
	Predation		↺	▲✦	↺
	Competition	↺			
	Habitat degradation (e.g., invasive macrophytes), cyanobacterial blooms	↺			
Emergent threats	*Various potential impacts on physiology, fecundity and reproductive success, behaviour, habitat availability and quality*				
	Climate change	↺			
	Parasites and pathogens	↺			

Legend

- ■ *Galaxias spp.* - Whitebait species, īnanga and shortjaw kōkopu
- ■ *A. dieffenbachii* - Longfin eel
- ■ *G. australis* - Lamprey

- ● Eggs, larvae
- ▲ Juveniles
- ✦ Immature adults
- ★ Adults
- ↺ All or multiple stages



3.5 General summary of priority research areas

Below are the Department's priority research areas categorised by theme for the four focal migratory fish species. These broad domains encompass species- and habitat-specific lines of enquiry.

1. Species and Populations
   - 1.1 Status and trends of species and populations
   - 1.2 Ecological drivers of community composition and population demographics
2. Critical Habitats
   - 2.1 Distribution, integrity, and security status of high quality mesohabitats
   - 2.2 Distribution, extent, and accessibility of habitats for critical life stages
3. Pressures and Threats
   - 3.1 Impacts of human activities on species and habitats
   - 3.2 Cumulative and interactive effects of pressures on species and habitats
   - 3.3 Biosecurity: Impacts of introduced species, parasites and pathogens
   - 3.4 Predicting the impacts of climate change on migratory species and their critical habitats
4. Tools and Methods for Recovery and Management
   - 4.1 Desktop tools, data management systems and databases used in species management
   - 4.2 Tools, methods and standards to assess, survey and monitor populations, habitats and pressures
   - 4.3 Tools and methods to mitigate, reduce or eliminate adverse effects of human activities on populations or habitats
   - 4.4 Tools and methods to mitigate, reduce or eliminate adverse effects of man-made structures on migration

3.6 Species-specific research priorities in the short-term

The following diagrams illustrate critical knowledge gaps for each theme in relation to life cycle stages, periods, or habitats for each species that make up the Migratory Species Programme.

Some research addressing these gaps is already underway and will continue in subsequent years. We expect however priorities to shift and evolve as the work progresses and we receive feedback from collaborators and partners.

Figure 3. Priority research areas 2020-2023 for īnanga

Species and Populations

- a Species distribution and conservation status update
- b Ecological triggers, timing and spatiotemporal variability of spawning activity
- c Spatiotemporal patterns of freshwater recruitment
- d Links between recruitment and freshwater populations
- e Extent of facultative diadromy and implications for species conservation

Critical Habitats

- f Distribution and conservation status of spawning habitat

Pressures and Threats

- g Effects of environmental instability on spawning success and egg survival
- h Impact of human pressures on spawning success
- i Impacts of climate change on spawning habitat distribution and quality

Tools and Methods for Recovery and Management

- j Geospatial databases for spawning habitat mapping
- k Standards and methods for spawning habitat monitoring
- l Tools and methods for spawning habitat restoration and protection

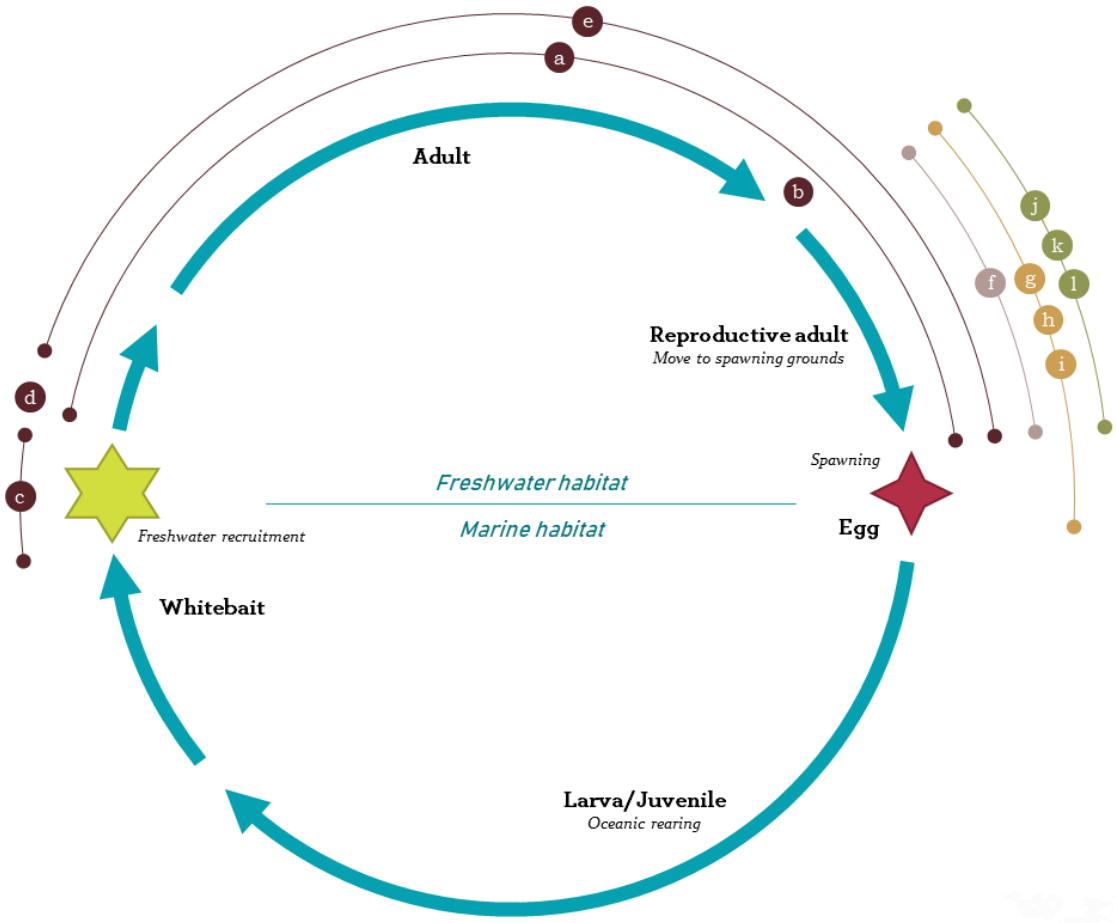


Figure 4. Priority research areas 2020-2023 for shortjaw kōkopu

Species and Populations

- a Species distribution and conservation status update
- b Biological and ecological characteristics of spawning activity
- c Patterns of freshwater recruitment
- d Upstream migration abilities across different size classes

Critical Habitats

- e Characterisation of high quality mesohabitat
- f Distribution and conservation status of spawning habitat

Pressures and Threats

- g Effects of environmental instability on spawning success and egg survival

Tools and Methods for Recovery and Management

- h Geospatial databases for habitat mapping

Figure 5. Priority research areas 2020-2023 for tuna/longfin eel

Species and Populations

- a Species distribution and conservation status update
- b Population structure in priority sites
- c Timing and triggers of downstream migration
- d Patterns in freshwater recruitment
- e Oceanic migration patterns for larvae
- f Oceanic migration patterns for reproductive adults

Pressures and Threats

- g Impacts of in-stream barriers to downstream migration
- h Incidence, scale and causes of mortality events in freshwater habitats
- i Effects of introduced predators throughout freshwater life history

Tools and Methods for Recovery and Management

- j Effects of habitat restoration measures on population structure and abundance
- k Technical solutions to in-stream barriers to upstream and downstream migration

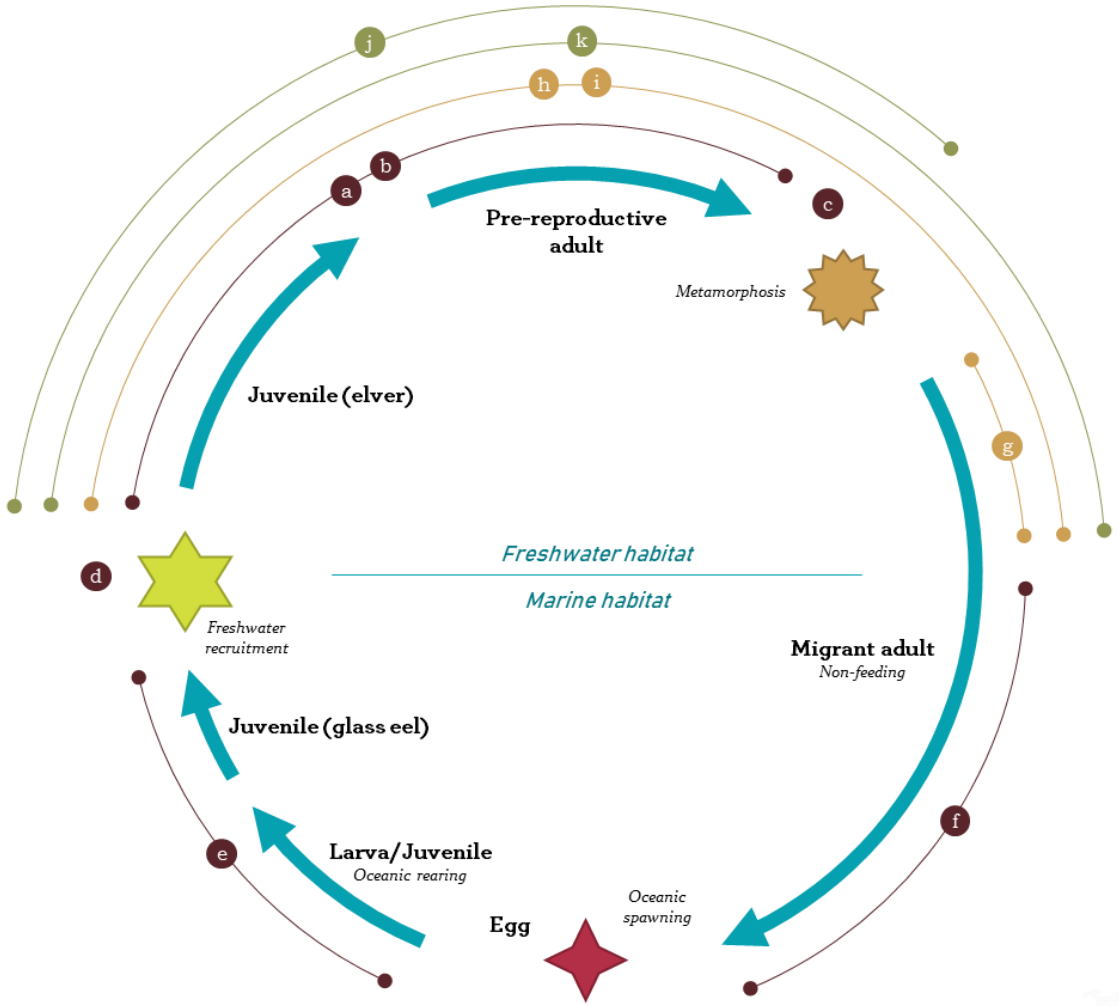


Figure 6. Priority research areas 2020-2023 for kanakana/piharau/lamprey

Species and Populations

- a Species distribution and conservation status
- b Duration, range and ecology of oceanic life
- c Stream selection processes by migrant adults
- d Timing and modalities of upstream migration
- e Biological and ecological characteristics of spawning activity
- f Larval habitat selection
- g Timing and modalities of downstream migration

Critical Habitats

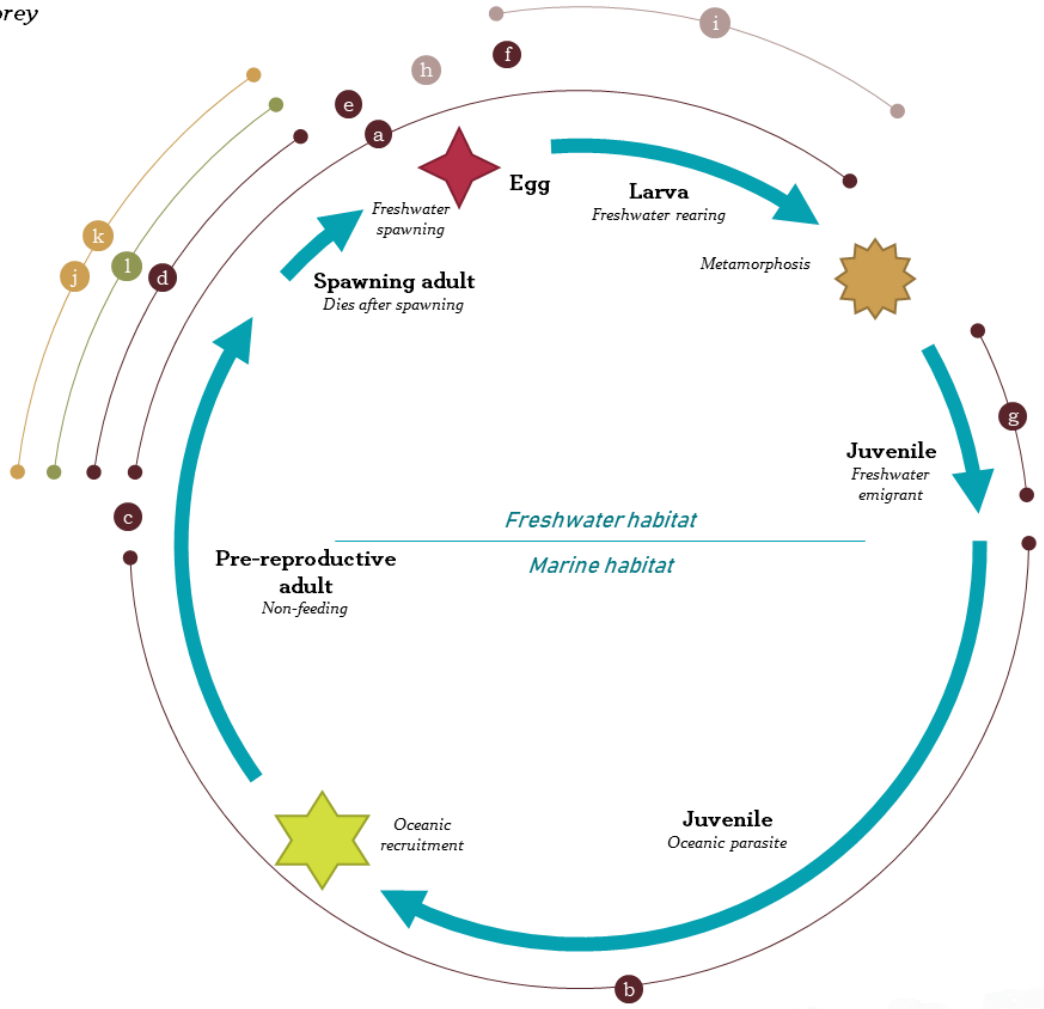
- h Distribution and conservation status of spawning habitat
- i Distribution and conservation status of larval habitat

Pressures and Threats

- j Impacts and sustainability of customary harvest
- k Environmental triggers of Lamprey Reddening Syndrome

Tools and Methods for Recovery and Management

- l Tools and methods to mitigate/reduce incidences of Lamprey Reddening Syndrome



4 Delivering outcome-focused research

We developed a framework to assess and loosely prioritise research projects which may contribute to one or more priority research areas (Figure 7).

This framework is necessary considering our limited resources. We identified nine criteria specifically in the context of this species-centric programme, some considered "essential" (e.g., the usefulness of the research outputs for the conservation of the focal species) and others "important". Criteria embed the principles of the Treaty of Waitangi in the decision-making process. Other aspects, such as project costs, delivery timeframe, and associated risks (e.g., additional resources requirements) are to be considered as individual project scopes are narrowed.

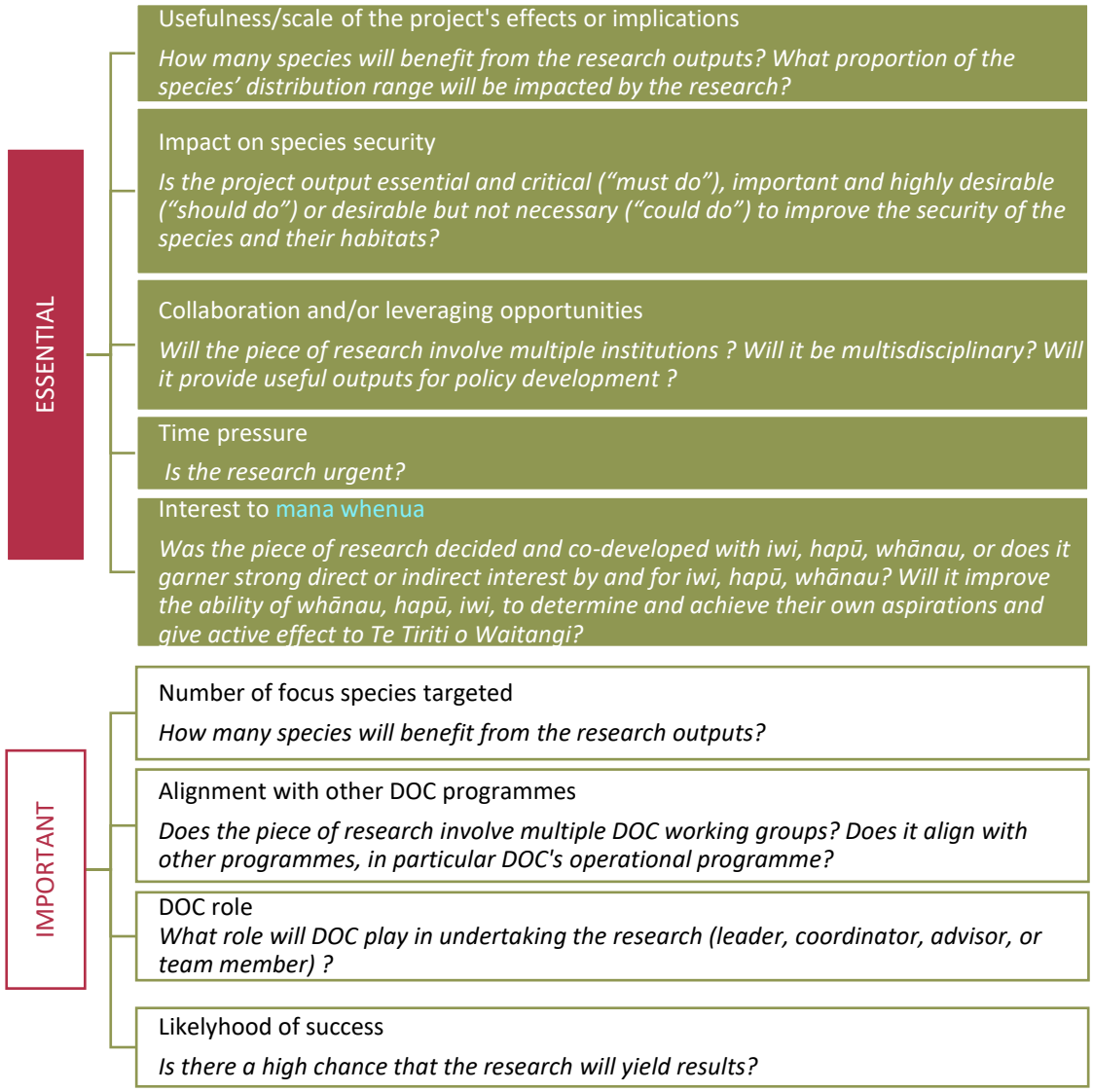


Figure 7. Set of criteria used to prioritise research in the Migratory Freshwater Species programme

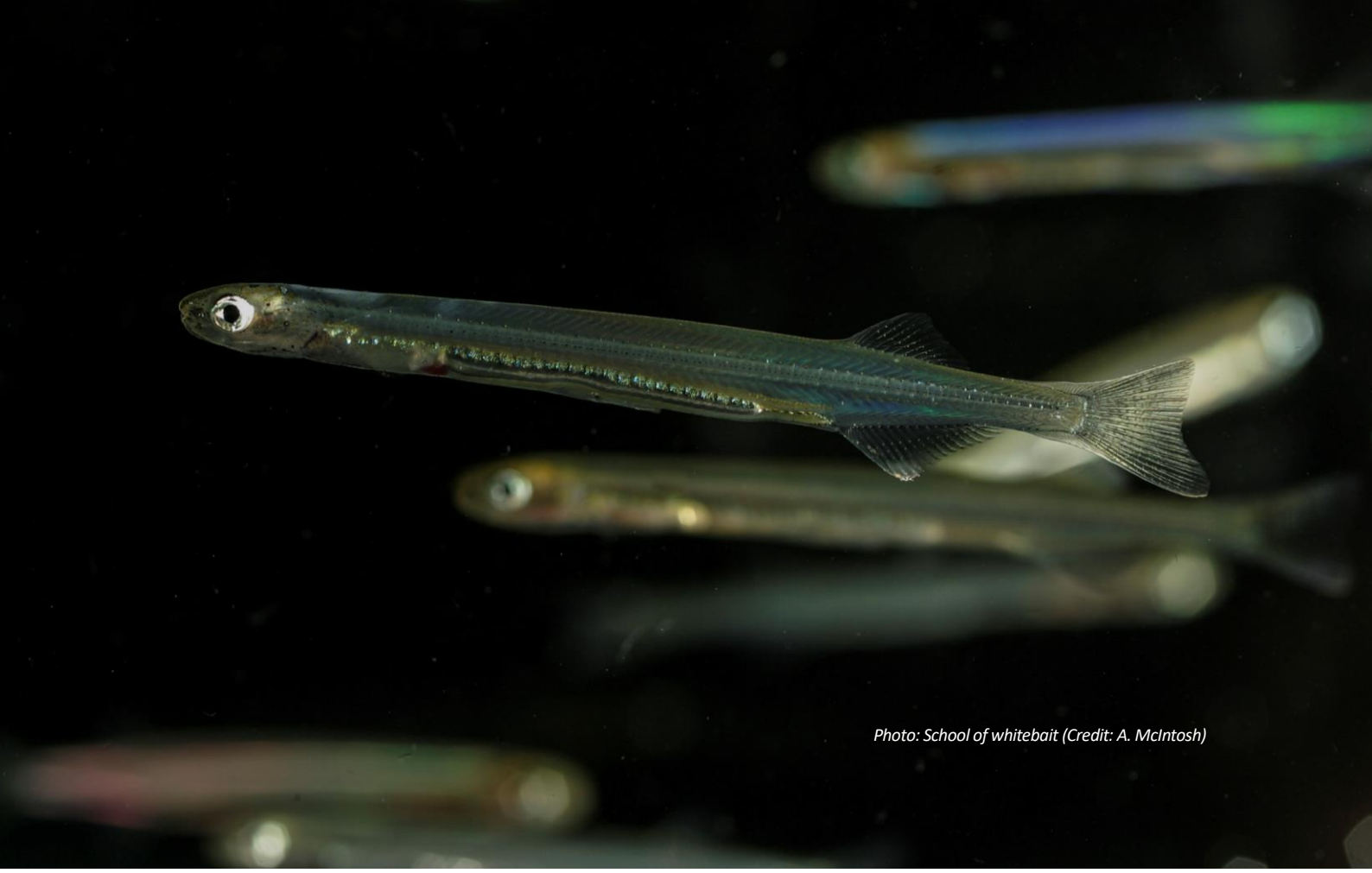


Photo: School of whitebait (Credit: A. McIntosh)

5 Data sovereignty and intellectual property

To deliver positive conservation outcomes, the Department strives for evidence-based, transparent decisions that stem from the best available information, including mātauranga Māori.

Mātauranga Māori may be used to inform and shape site-based research. However, cultural and intellectual property rights of traditional knowledge and the data it generates entirely lie with mana whenua.

While we, as part of our mission as the Department of Conservation, expect to use relevant data and research outputs to build into our relationship with our Te Tiriti partners and improve outcomes for our native migratory species, we do not expect this knowledge to be divulged as part of our reporting requirements and will treat it as confidential, unless explicitly agreed upon.

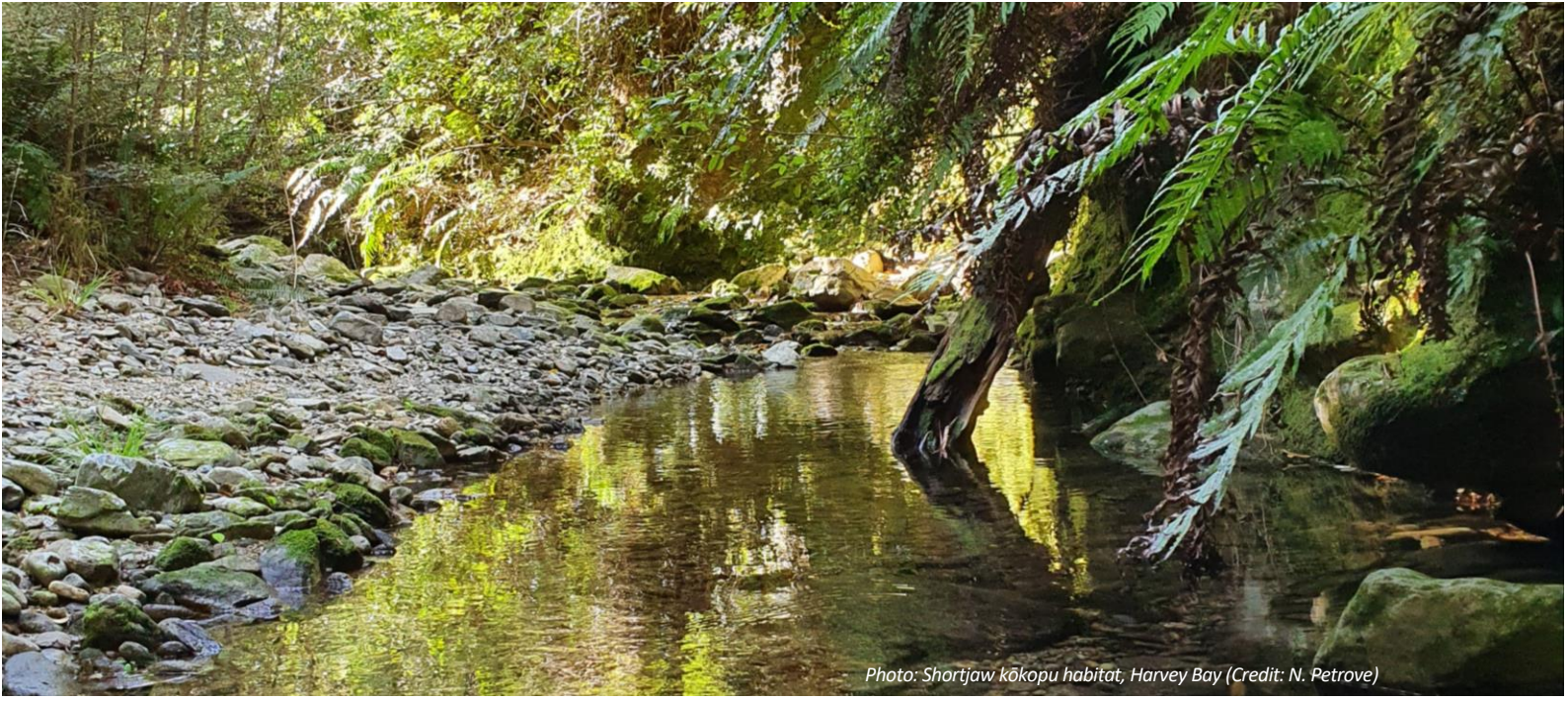


Photo: Shortjaw kōkopu habitat, Harvey Bay (Credit: N. Petrove)

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7 Glossary

KEY TE REO TERMS

Hapū - Kinship group, clan, tribe, subtribe.

Iwi – Extended kinship group, tribe, nation.

Ki uta ki tai – From mountains to sea. This concept refers to a whole-system approach in sustainable freshwater management.

Mahinga kai – Food-gathering place.

Mana whenua – Territorial rights, authority over land or territory.

Tangata whenua – People of the land; the indigenous people of New Zealand. In relation to a particular area, it means the iwi or hapū that holds mana whenua over that area.

Taonga – Treasure, anything prized – applied to anything considered to be of value including socially or culturally valuable objects, resources, phenomena, ideas and techniques.

Te reo – The [Māori] language.

Whānau – Extended family, family group.

KEY TECHNICAL TERMS

Bioregion – Geographic area defined by characteristics of the natural environment. For migratory species, bioregions correspond to areas with similar geography and freshwater ecosystems associated with prevailing large-scale ocean currents.

Catchment – Area of land in which rainfall drains towards a common water body (lake, stream, river or estuary).

Connectivity - Degree to which organisms (and matter) can move among spatially defined units in a natural system. In a river system, connectivity relates to the longitudinal (*i.e.* upstream/downstream continuum), lateral, and vertical dimensions within the river corridor and the catchment over diverse temporal and spatial scales.

Ecosystem – Community or group of organisms (microorganisms, plants, animals) that live and interact with each other and their physical environment.

Diadromous – refers to organisms that migrate between marine and freshwater. All species in the Migratory Freshwater Species programme are diadromous.

- Amphidromous species migrate between fresh and salt water at some stage of their life cycle, not for reproduction purposes.
- Anadromous species migrate from the sea to freshwater to reproduce.
- Catadromous species migrate from fresh to salt water to reproduce.

Introduced species (synonym: exotic species) – Plant or animal species that have been brought to a certain area by humans, either by accident or design.

Mesohabitat – Habitat of medium scale. In freshwater systems, refers to spatially distinct patches of relatively homogeneous surface flow and substrate, such as pools and rapids.

Migratory species – A species that moves from one habitat to another to complete its life cycle.

Native (synonym: indigenous) – naturally occurring at a specific place.

Population – group of individuals of the same species that occupy a specific area at a given time.

Population structure – Umbrella term referring to several aspects of population ecology, including:

- Age class structure – Age ranges of individuals that compose a population and their proportion
- Population density – Measurement of population per unit area
- Population dynamics – Changes in the size and structure of populations over time. Important factors in population dynamics include rates of reproduction, death, and migration; type of mathematics used to model and study these parameters
- Population size – Number of individual organisms in a population.

Recruitment – process by which new individuals are added to a population, whether by birth and maturation or by immigration. In this document, recruits are young individuals that undergo juvenile settlement and become part of the adult population.

Species – group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding.