Northland REGIONAL COUNCIL
Te Kaunihera ā rohe o Te Taitokerau

State of the Environment

Northland Freshwater Fish Monitoring 2023/24

Technical report

State of the Environment Northland Freshwater Fish Monitoring 2023/24 Technical Report

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Executive Summary

The *State of the Environment Northland Freshwater Fish Monitoring 2023/24 Technical Report* presents the observations from the annual freshwater fish monitoring conducted by Northland Regional Council (NRC) between November 2023 and February 2024. The fish monitoring was conducted at 23 fish monitoring sites across the region's River Water Quality and Ecology Monitoring Network (RWQMN). This SOE Fish report informs stakeholders, including scientist and regional freshwater policies, about the state of freshwater fish community as a component in river health assessments in Northland region.

In total, 11 native fish species were recorded during the SOE Freshwater Fish Monitoring 2023/24 in Northland. The fish species are shortfin eel (*Anguilla australis*), longfin eel (*Anguilla dieffenbachia*), banded kōkopu (*Galaxias fasciatus*), inanga (*Galaxias maculatus*), kōaro (*Galaxias brevipinnis*), bluegill bully (*Gobiomorphus hubbsi*), common bully (*Gobiomorphus cotidianus*), Cran's bully (*Gobiomorphus basalis*), redfin bully (*Gobiomorphus huttoni)*, common smelt (*Retropinna retropinna*), torrentfish (*Cheimarrichthys fosteri*).

The threatened (at-risk) fish species found were bluegill bully, inanga, kōaro, longfin eel and torrentfish. This is the second consecutive year that bluegill bully was found at the Punaruku site.

Adult is prevalent in native fish population in the region. Dominance of adults in fish population can be an indicator of disrupted juvenile fish recruitments, in the region, likely driven by downstream fish passage barriers.

Sites with high fish abundances are mostly located at low elevation and near coasts, e.g. at Ngunguru site, which allow fishes easy inland penetrations. In other words, low fish abundance in upper catchments (which often provide better spawning habitats) reiterates the possible impacts of migration barriers in the region.

Northland's freshwater fish monitoring uses a nationally consistent protocol, as required in the NPSFM for SOE reporting and as planned in Northland's River Water Quality and Ecology Monitoring Plan (RWQEMP). Fish IBI - the fish-related NPSFM attribute – is estimated from data collected during monitoring by using a Fish IBI calculator, developed for Northland region. The calculator is used for its robustness in integrating a range of national, regional and local features that influence fish community.

Overall, the measured IBI scores has shown very good ecological integrity for fish in the region. This, however, requires cautious interpretations. This is because most of the monitored sites are in pastoral catchments with degraded water quality and ecosystem health and possibly impacted fish communities (Graham & Greenwood, 2023). Yet, the IBI values are indicating healthy fish habitats in Northland region. For example, the downstream reaches of Peria and Victoria sites flow through highly modified agricultural landscapes, which likely affect fish migration; yet, both sites are in band A. Similarly, the Pukenui site is in band A despite a fish-barrier downstream and a very low fish abundance.

Interestingly, the highest species richness was measured at Tangowahine site which is located on a modified catchment (mostly pasture). The riparian buffer that created a shaded stream condition at that site may explain the species richness and demonstrates the benefit of riparian restorations for fish habitats in modified catchments.

Several sites in Northland have shown consistency in IBI scores over monitoring years. However, observations also suggest IBI varies in Northland rivers spatially and temporally. While variations in

Fish IBI can be expected, according to literature, the drivers remain unknown. Drivers of Fish IBI can range from changes in fish monitoring techniques, changes in catchment land use changes to climate changes. A clear understanding of the Fish IBI drivers will be necessary for the resource management plans in the region in future.

This report recommends:

- **Consistent annual monitoring at same locations** in order to establish long-term fish database.
- **Expand the current fish monitoring network to all FMUs** and distribute the total fishing efforts to the stream habitats in FMUs proportionally.
- **Use innovative monitoring tools,** such as eDNA, for resource efficient and improved fish monitoring.
- **Add lakes to freshwater fish monitoring network** as habitats for nationally threatened freshwater fish species, including Northland mudfish and dune lake galaxiids (DLG), that are mostly confined to lake-based, closed freshwater ecosystems.
- **Assess the representativeness of the reference sites on the RWQEMP,** from the perspectives of the natural condition for freshwater fish in the region.

In addition, this report highlights the following needs to enhance our understanding and facilitate fish and associated habitat management in Northland:

- **Comprehensive fish passage barrier database** in the region, at least for the fish monitoring sites. A reliable record of fish passage barriers in Northland waterways is currently underdeveloped. This knowledge gap affects fish recruitments efforts in the region.
- **Integrated catchment studies** on land use change, land management practices, fish habitat types and environmental variables that affect fish community.
- **Investigation into Fish IBI drivers** for clear understandings of pressures and drivers that affect freshwater fish health in the region.

List of Abbreviations

DLG	Dune Lake Galaxiids
EF	Electrofishing
FMU	Freshwater Management Unit
GMT	Gee minnow trap
IBI	Index of Biotic Integrity
NPSFM	National Policy Statement for Freshwater Management
RWQEMP	Northland's River Water Quality and Ecology Monitoring Plan
RWQMN	River Water Quality Monitoring Network
SOE	State of Environment
TL	Total length

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Waikoromiko stream at AH Reed Memorial Park, Whangārei, Northland

1 Background

Native fish fauna is a key indicator of freshwater ecosystem health, habitat heterogeneity and connectivity. But many New Zealand (NZ) native fish species are increasingly at risk (Joy et al., 2019). Northland Regional Council (NRC) has been monitoring freshwater fish in the region since 2012. A more nationally consistent monitoring approach was adopted by NRC, in 2021, for State of the Environment (SOE) reporting on freshwater fish in Northland. As an outcome, the *State of the Environment Northland Freshwater Fish Monitoring Report 2023/24* is the third in the SOE technical report series, that communicates annual freshwater fish survey results conducted by NRC in Northland region.

Northland is home to 23 of NZ's approx. 60 native freshwater fish species (Dunn et al., 2018) (Appendix 1). The nationally threatened fish species that are found in Northland include shortjaw kōkopu (*Galaxias postvectis*), lamprey (*Geotria australis*), and Northland mudfish (*Neochanna heleios;* confined to lakes) (Dunn et al., 2018). Most fish species in Northland region are diadromous, which requires migration between freshwater and the sea at certain life stages. This feature highlights the importance barrier-free waterways for a thriving fish population in the region. Fish passage barriers can be physical - both natural (e.g., waterfalls) and man-made (e.g., culverts, ford crossings) – as well as chemical. For example, disappearance of an established adult species, driven by habitat destruction, can mean loss of chemical cue release from adults that guides juveniles, returning from sea, towards safe stream habitats. Such disruption can interrupt juvenile recruitment and can lead to fish population decline (Baker, 2003). Fish communities are also affected by changes in landcover and land use, associated poor water quality, pest fish and climate change (Goodman, 2018; Joy et al., 2019; Lowe et al., 2015; Williams et al., 2017).

Monitoring of native fish is necessary to identify shifts in local fish community and address the regional drivers and pressures. A region-wide and consistent fish monitoring is essential for comprehensive fish database and to inform stakeholders, including communities, resource managers, scientists and freshwater policies, at regional and national levels (Jowett & Richardson, 1996; Rowe et al., 1999).

Shortjaw kōkopu (*Galaxias postvectis*) (on left), and bluegill bully (*Gobiomorphus hubbsi*) (on right) are two nationally threatened (at-risk) fish species found in Northland.

1.1 State of Environment (SOE) freshwater fish monitoring

Northland's State of the Environment (SOE) Freshwater Fish Monitoring will be referred to as SOE Fish Monitoring, from hereon, and is designed for SOE reporting which is a requirement in the Resource Management Act 1991 (RMA) and in the National Policy Statement for Freshwater Management 2020 (NPSFM) (MfE, 2024). The SOE Fish Monitoring surveys fish community as a biophysical component of freshwater ecosystems. The survey is used to measure Fish Index of Biotic Integrity (Fish IBI). The Fish IBI, the only fish-related NPSFM attribute, is used assess the biological integrity of freshwater ecosystems health and inform relevant regional policies.

Fish IBI was developed to account for unique attributes of NZ freshwater fish, e.g. low species diversity and high proportion of migratory species. The calculation of Fish IBI takes into consideration 1) the site-related properties, e.g. site elevation and distance from coast, and 2) fish-related matrices, including the followings:

- native fish abundance,
- habitat index sensitive to changes in stream geomorphology,
- number of stream-degradation-sensitive species,
- proportion of native to invasive species.

Fish IBI scores range from 0 indicating "no fish" (likely at highly human-impacted catchments) to 60 indicating "high native fish abundance" (likely at sites in pristine conditions). See Appendix 2 for a description of Fish IBI.

In 2020, a region-wide monitoring network review identified potential river monitoring sites to assess river water quality and ecology in Northland. From the identified river monitoring sites, 26 sites were recommended for the freshwater fish monitoring network by the Northland River Water Quality & Ecology Monitoring Plan (RWQEMP) in 2021. Based on the RWQEMP, nationally consistent SOE Fish Monitoring began in Northland in summer 2021/22 and is conducted annually by NRC staff. Prior to that, regional fish reporting was sporadic. Some key findings from major freshwater fish reports in Northland are summarized in the following section.

1.2 Northland fish observations 2012-23

1.2.1 Northland Region Freshwater Fish Monitoring 2012

- In 2012, Mahurangi Technical Institute conducted an initial study for NRC that investigated freshwater fish species in the river catchments of Waiarohia Stream, Hāatea River, Mangahahuru Stream, Waitangi River, Mangamuka Stream, Mangakahia River, Waipoua River, and Kaihu River (O'Brien & Decker, 2012).
- Despite a limited spatial coverage of the region, the survey identified 13 native freshwater fish species, including tuna (shortfin eel and longfin eel), torrentfish (panoko), kōaro, banded kōkopu, shortjaw kōkopu, inanga, lamprey (piharau), Cran's bully, common bully, giant bully, redfin bully, and common smelt.
- An encouraging number of shortjaw kōkopu and kōaro were reported at the Waipoua River site.
- No fish were reported at the Hātea River and Mangahahuru Stream sites, warranting further investigation (O'Brien & Decker, 2012).

1.2.2 Northland Freshwater Fish Monitoring 2021-2022

- The 2021/22 SOE Fish Monitoring identified 11 native fish species at 20 sites. Surveying all RWQEMP-recommended 26 sites was not possible due to ongoing iwi engagements at several locations (Ruehle, 2022).
- Three sites were in band B, two in band C and one in band D (see Appendix 2). The remaining sites were in band A, resulting in an overall good Fish IBI score for the regional monitoring network.

- Site evaluation solely based on Fish IBI-based NPSFM-bands was criticised for its limitation to account for fish passage barriers, for example. Pukenui site was presented as an example. A high IBI score of 32 (band B) at that site, likely driven by banded kōkopu availability (the species has a high IBI score; Appendix 1) and high site elevation, failed to reflect the low fish abundance (n=2) likely due to the presence of the Whau valley dam located downstream. The report suggested inclusion of site-contexts in IBI score interpretations.
- As the first fish survey conducted within the SOE monitoring network, the 2021/22 Fish Monitoring was an opportunity to assess and learn about the monitoring sites. Several site limitations were identified, for example-
    - Several sites were found too wide that contradicted the site selection criteria in the national freshwater fish sampling protocol (Joy et al., 2013), recommended by NPSFM.
    - Disproportionate representation of the region in the monitoring network risked misrepresenting the region's fish community. For example, large number of the sites, in the monitoring network, were at low elevations and near coasts with potentials to over-represent poor climbers in the region. In contrary, low number of monitoring sites along native bush streams were likely to under-detect the climbing fish species (e.g., shortjaw kōkopu, kōaro).

1.2.3 Northland Freshwater Fish Monitoring 2022/2023

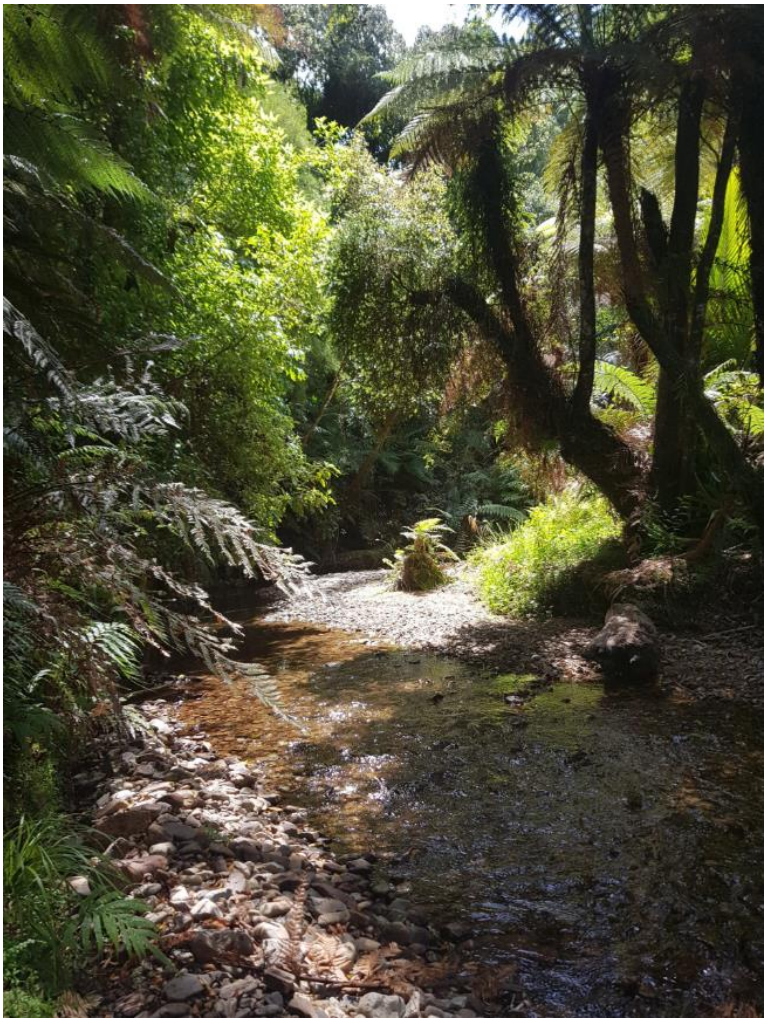
- Several previously observed site limitations were addressed during the SOE Fish Monitoring in 2022/23 by relocating five sites to tributaries upstream from the original locations. Additionally, three new small and native bush streams were added to the monitoring network, bringing the total number of fish monitoring sites to 22 (Ruehle, 2023).
- Revisiting the site plan may had improved fish survey outcomes as the proportion of climbers increased from 19% in 2021/22 to 52% in 2022/23. Shortjaw kōkopu (*Galaxias postvectis)* was found at the Waikohatu and bluegill bully (*Gobiomorphus hubbsi*) were recorded at the Punaruku sites – that were two of the three new sites added that monitoring year.
- A total of 13 fish species were recorded at 22 sites during summer 2022/23, compared to 11 species the previous year.
- Four of these sites were classified in NPSFM band B and one in band C. The remaining sites were in band A, resulting in an overall good Fish IBI score for the regional monitoring network.
- The fish monitoring network was still considered limited for comprehensive fish database.

1.3 Scope of the report

The aim of the Northland's SOE Freshwater Fish Monitoring is to assess and report on the current state of fish community as a biophysical component of freshwater ecosystem health, as listed in Appendix-1A of NPSFM, and inform associated regional policies. Northland's SOE Fish Monitoring has following objectives:

- To measure Fish Index of Biotic Integrity, as listed on Table 13 in Appendix 2B on NPSFM, according to Northland's RWQEMP, and report on the State of the Environment.

- To assess shifts in freshwater fish community structure and population of taonga species in the region.
- To inform baseline state and target state for NPSFM fish attributes for developing regional freshwater policy.



Opapao stream site at Forest Road in Northland

2 Methods

Northland's SOE Fish Monitoring uses a nationally consistent methodology by following the NZ freshwater fish sampling protocol (Joy et al., 2013), as recommended in NPSFM and in RWQEMP. For monitoring purpose, the protocol recommends fish sampling at 150m reaches in wadable streams, where at least 90% of the river is ≤0.6m deep and has a mean wetted width of ≤12m in summer months, between December and April (Joy et al., 2013). The NRC fish monitoring team comprises of three to four staff, including two electrofishing-certified personnel.

2.1 Reconnaissance survey

Prior to fish monitoring season every year, a reconnaissance survey is conducted. The reconnaissance survey uses desktop assessments (including GIS) and field visits to review previous fishing experiences and site alterations caused by natural/anthropogenic events in previous years. Using these approaches, the reconnaissance survey (1) re-assesses site-suitability, site-specific fishing techniques, associated health and safety strategies; and (2) adjusts the monitoring plan, if needed, while keeping the fish survey aligned with the SOE Fish Monitoring objectives and the RWQEMP. A reconnaissance survey was conducted between October and November in 2023, and a list of fishing sites was finalised for the 2023/24 Fish Monitoring.

2.2 Fish monitoring sites

The SOE Fish Monitoring 2023/24 surveyed in total 23 sites (listed in Table 1, Figure 1) between the end of November 2023 and February 2024. Most of the sites were also monitored in the preceding years (Ruehle, 2022, 2023). The Tapapa, Opaopao, Peria, Punaruku, Pukenui and Waikohatu are recognised as r*eference sites* on RWQEMP. The reference sites drain through forested catchments and are intended to represent near-pristine natural conditions of Northland. However, it should be noted that fish communities at some of these reference sites are likely impacted by land use modifications (e.g. pastural land cover) in catchments located downstream. Dominant catchment land use and fish barriers at monitoring sites are listed in Table 3.

The SOE Fish Monitoring sampling strategy aims to fish at same locations every year and close to the nearest river water quality monitoring (RWQMN) site, if available. The strategy scopes future research on the relationships between fish community and water quality properties, based on data available from nearby RWQMN sites. However, guided by the reconnaissance survey:

- the Opouteke site was relocated further upstream from their previous monitored locations in the 2023/24 Fish Monitoring.
- The Hakaru stream was surveyed at slightly different locations in three monitored years (2021/22, 2022/23 and 2023/24).
- The Ngunguru site was surveyed at slightly different locations in 2023/24 and in 2021/22 but could not be surveyed in 2022/23 due to logistical reason.

Table 1 List of 23 fish monitoring sites surveyed during the SOE Fish Monitoring 2023/24 conducted by Northland Regional Council between Nov 2023 – Feb 2024. The sites were recommended in the River Water Quality and Ecology Monitoring Plan (RWQEMP) and supporting memos. Green boxes indicate reference sites on RWQEMP.

FMU	IRIS Fish monitoring site	Site tag	RWQMN / Fish site id	Fishing technique
Awanui	Victoria at Victoria Valley Road	Victoria	LOC.105532	Electrofishing
Bay of Islands	Wairoa Stream UT Kerikeri Inlet Road	Wairoa	LOC.333762	Electrofishing
	Waitangi at Waimate North Road	Waitangi	LOC.103178	Netting
Bream Bay	Ruakākā at Flyger Road	Ruakākā	LOC.105008	Netting
	Tanekaha Track Stream at King Road	Tanekaha	LOC.333761	Electrofishing
Doubtless Bay	Oruaiti at Windust Road	Oruaiti	LOC.304641	Netting
	Peria at 702 Honeymoon Valley Road	Peria	LOC.335340	Electrofishing
Hokianga	Opaopao Stream at Forest Road	Opaopao	LOC.331866	Electrofishing
	Tapapa at SH1	Tapapa	LOC.313165	Electrofishing
Northern Wairoa	Hakaru River UT US at Topuni	Hakaru	LOC.333756	Electrofishing
	Mangahahuru at Main Road	Mangahahuru	LOC.100237	Netting
	Opouteke at Suspension Br	Opouteke	LOC.1046651	Netting
	Tangowahine at Tangowahine Valley Road	Tangowahine	LOC.322490	Electrofishing
Waipoua	Waikohatu Stream at Visitor Centre	Waikohatu	LOC.333758	Electrofishing
	Waimamaku at SH12	Waimamaku	LOC.109098	Electrofishing
Whananaki Coast	Ngunguru at Coalhill Lane	Ngunguru	LOC.110603	Electrofishing
	Punaruku River UT at Punaruku Road	Punaruku	LOC.333760	Electrofishing
Whangārei	Otaika at Otaika Valley Road	Otaika	LOC.110431	Electrofishing
	Waikoromiko at Hātea Confluence	Waikoromiko	LOC. 331834	Electrofishing
	Pukenui at Kanehiana Drive	Pukenui	LOC.312177	Electrofishing
	Raumanga at Bernard Street	Raumanga	LOC.304709	Electrofishing
	Waiarohia at Second Avenue	Waiarohia	LOC.108359	Electrofishing
	Waimahanga Stream UT at Mt Taika Forest	Waimahanga	LOC.335338	Electrofishing

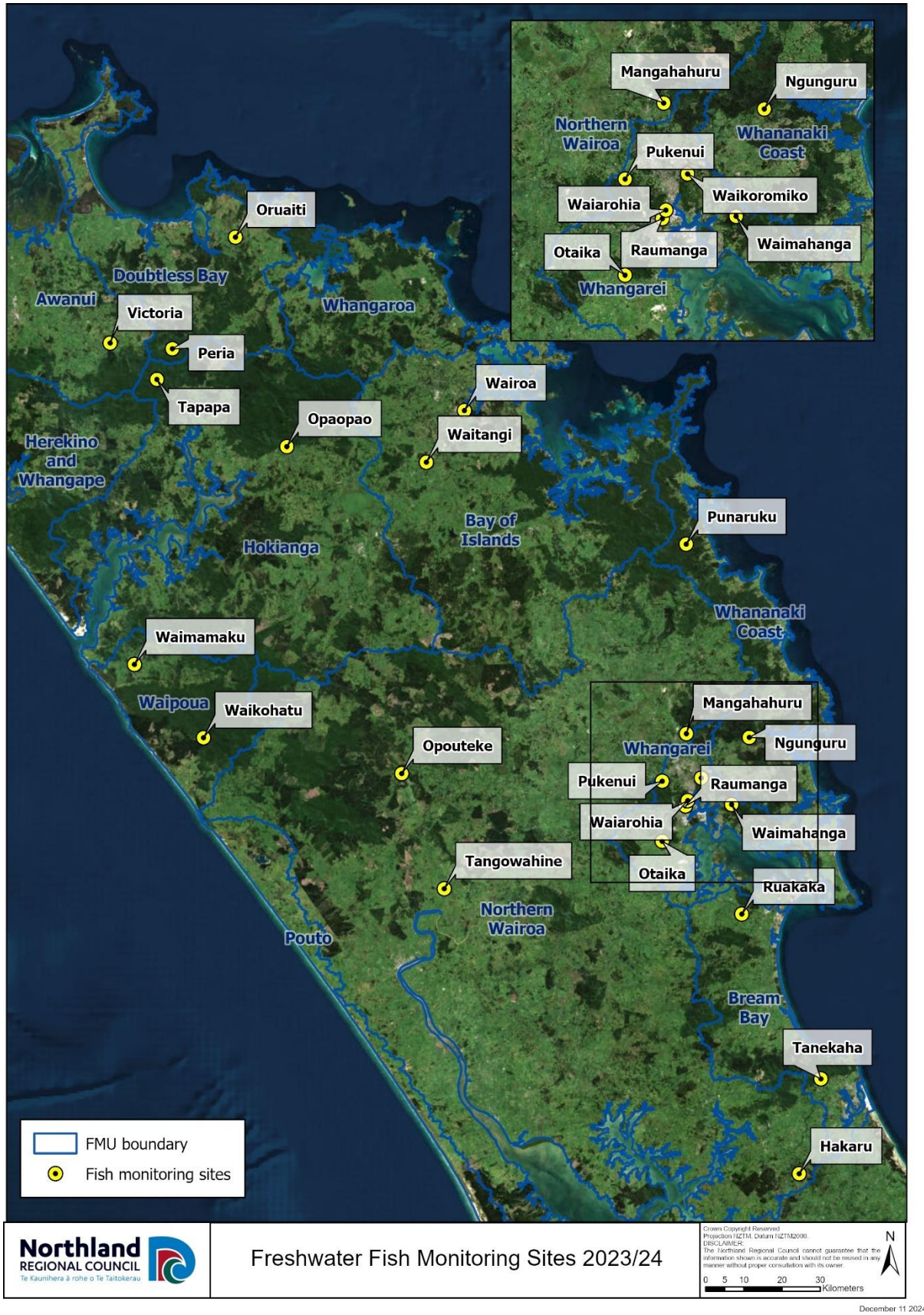


Figure 1 Map shows locations of 23 fish monitoring sites in 9 FMUs across Northland surveyed during the SOE Fish Monitoring 2023/24, conducted by Northland Regional Council between Nov 2023 – Feb 2024.

2.3 Sampling

At each site, a 150 m stream reach was surveyed as suggested in the national freshwater fish sampling protocol (Joy et al., 2013). Following high flow events, two-week stand-down periods were observed before sampling to minimize the effect of the associated habitat disruptions (e.g. due to streambed movement) on local fish communities. The fish survey recorded in-situ environmental and fish-related data by using a Microsoft Excel macro system, on a Toughbook laptop, developed for the Waikato Regional Council.

2.3.1 Water quality properties

At the start of each fish survey, in-situ water quality parameters were measured using a YSI Pro-DSS water meter, which is calibrated daily. The measured parameters included water temperature (°C), dissolved oxygen concentration (DO mg/L), dissolved oxygen percentage saturation (DO%), and conductivity (µS/cm).

2.3.2 Fishing techniques

Electrofishing

Fish survey is conducted using electrofishing techniques at sites where 90% of the stream reach sampled is ≤0.6m deep and has an average wetted width ≤12m. Electrofished sites are indicated in Table 1. A stream site is surveyed at a 150m reach, divided into ten 15m wide sub-reaches starting at the downstream. The sub-reach widths were sampled over net-width distances from one bank to the other (Figure 2). A Smith-Root LR-24 Electrofisher is used for electrofishing. In contrast to the NIWA Kainga EFM360, another commonly used electrofishing equipment, the LR-24 Electrofisher has the flexibility of finer tuning of settings (e.g., voltage adjustments at 5V increments, in contrast to 100V increments in other electrofishers) that allows better control in adapting to fishing conditions.

Electrofishing by NRC monitoring team at Hakaru site in Northland

Fish welfare was kept a priority during sampling. Device settings were selected to minimise detrimental electrofishing impact on fish. The equipment settings were set to create low electric field in the water only adequate to stun fish, within the field, that allowed for in-situ fish investigation and had low-or-no impact on fish swimming ability once the electric field was turned off. Fish swimming condition across all sites were kept consistent. by adjusting device settings. The voltage varied between 100 and 300V, depending on in-situ

conductivity with lower voltages used at higher conductivities. Electrofishing technique is illustrated in Figure 2.

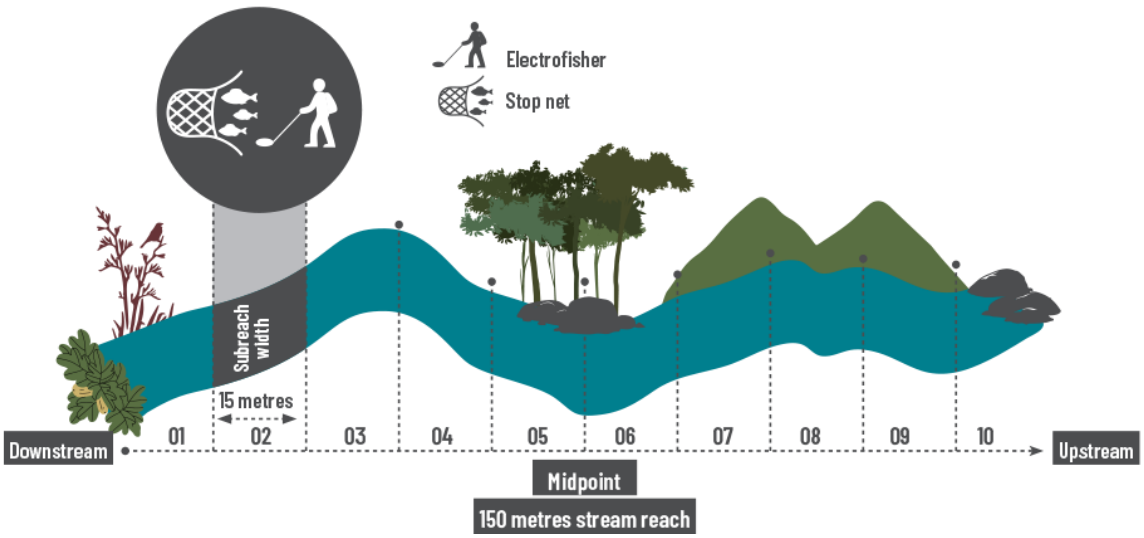


Figure 2 Diagram illustrates the electrofishing approach used during SOE Fish Monitoring. Fish survey is conducted in a 150 m reach, divided into ten 15m long sub-reaches. Starting at the downstream sub-reach, electrofishing is performed over net-width distances, across the stream, from one bank to the other. An LR-24 Electrofisher equipment is used to create an electric field in the water to stun fish, which is caught in a stop-net held 3-5m downstream. The stop-net is hold by a person against the streambed to prevent fish from escaping underneath. The stunned fish is collected from the net for field investigations before being released back into the water. The process is repeated in ten sub-reaches.

At the end of each sub-reach, fish species were identified, total length (TL) was measured and number of fish per species was counted for fish abundance. Fish total length (TL) was measured in millimetres (mm) from the tip of the nose to the tip of the caudal fin. The TL of the first 50 fish of each species were measured and then the TL of first 10 fish per sub-reach of those species were measured. The remaining fish were only counted. Where identification up to the species level was not possible fish was assigned as "unidentified" e.g. unidentified bully, unidentified galaxiid and unidentified eel. Kōura or freshwater crayfish (*Paranephrops sp.*) were not measured but the number of individuals was recorded. Freshwater shrimp (*Parataya sp.*) was counted and placed into 1 of the 5 fish-count

Fish sample collected for field investigation (on the left) are getting measured for fish total length (TL) (on the right) during SOE Fish Monitoring 2023/24.

categories which are: 0, 1-9, 10-99, 100-1000, or over 1000. Additional site-related parameters recorded at each sub-reach included wetted width (distance between the opposite wetted edges at each sub-reach), mid-stream depth (stream-depth in at mid-sub-reach point), and total fishing time (min).

Netting technique

Netting technique is used for fish sampling at sites that have grater wetted widths and stream reach depths than suitable for electrofishing technique. Netting technique was used in 5 out of the 23 sites (as listed in Table 1) during the 2023/24 Fish Monitoring (Figure 3).

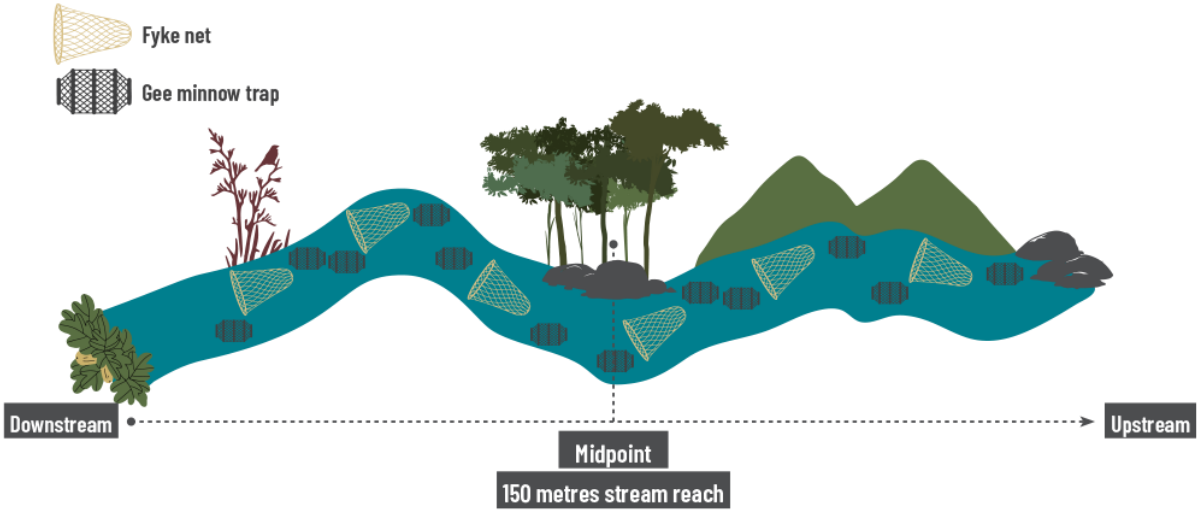
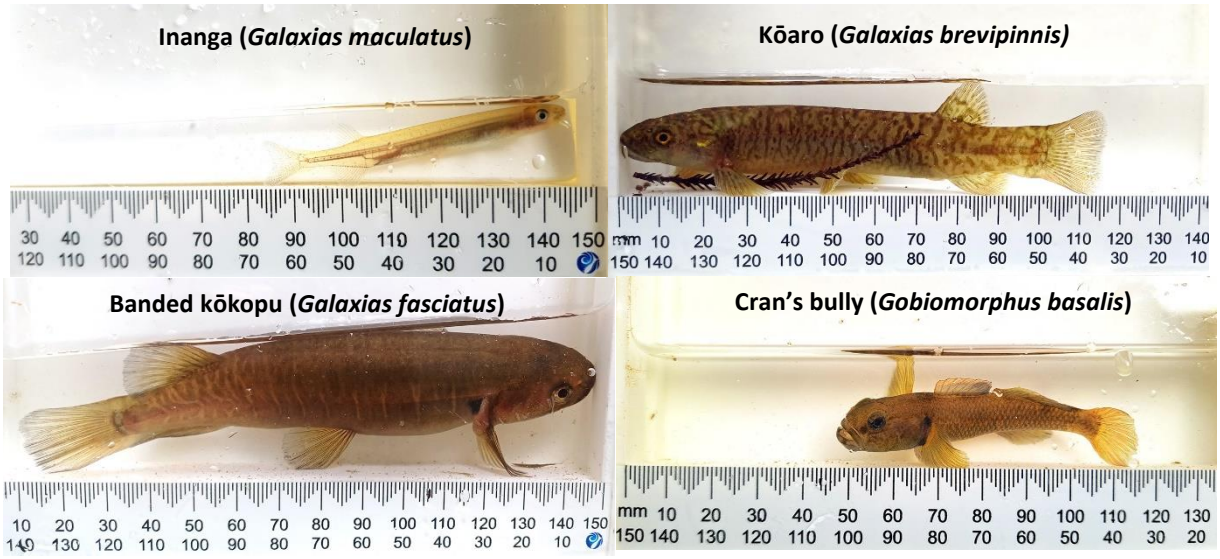


Figure 3 (Top) Diagram illustrates netting technique used in SOE Fish Monitoring. A 150 m long stream reach is marked upstream, midpoint (at 75m) and downstream. Six fyke nets and twelve Gee Minnow Traps (GMT) are set for fish sampling. Three fyke nets are set between upstream and the midpoint, three fyke nets between the midpoint and downstream and two GMT within five metres of each fyke net, with one upstream and the other at downstream of the fyke nets. The nets are left out overnight and recovered the next day, the recovery starts with the most downstream set of nets (i.e., fyke and 2 GMTs). (Photo at bottom) Fyke and Gee minnow nets set in a stream for fishing during the SOE Fish monitoring 2023/24.

Fish sample was counted, identified and measured for total length before being released back into the stream. In-situ measurements and data entry used same procedure as was for electrofishing. The only exception was wetted width and mid-stream depth were not measured at netted sites.



Fish samples from the SOE Freshwater Fish Monitoring 2023/24

2.4 Data analysis

Site-wise statistical analysis was conducted on the measured environmental parameters (water temperature, dissolved oxygen concentration) and site-related parameters (wetted width and depth) for their corresponding mean, median and 90-th percentile values (Appendix 5).

In this report, fish abundance denotes the total number (n) of fish sampled. Species richness denotes the number of fish species sampled.

Fish IBI score was calculated by using Northland's Fish IBI calculator developed by Joy (2019). The Fish IBI calculator uses fish species name, fish abundance (n), site elevation (m) and distance from coast (km) as input and applies the index of biotic integrity methodology to New Zealand freshwater fish communities (Joy & Death, 2004). Data related to the site elevation and distance to coast were extracted from the geospatial database for River Environment Classification (REC2). Fish IBI scores were interpreted using the NPSFM guidelines (Appendix 2) and site integrity class was assigned sites using the technique developed for Northland region (Appendix 3).

Age distribution (e.g. adult, juvenile) in fish sample was assessed based on measured fish total length (TL) values as in Table 2 using the NZ Freshwater Fish size class categories (Joy et al., 2013). Additionally, unidentified fish species were included in the age-distribution analysis by using the most common cut-off TL values for the corresponding fish families in the size class category. Conservation status of the fish samples was assessed using the New Zealand Threat Classification System (NZTCS) (Dunn et al., 2018).

Fish samples were also categorised based on 1) climbing capacities, e.g. climbers and poor-climbers (Appendix 1); and 2) fish families, e.g. bullies, eels, galaxiids, smelts and torrents.

Freshwater crayfish and freshwater shrimp were disregarded in data analysis.

Data analysis in this report was conducted using MS Excel and R program version 2024.04.2 Build 764.

Table 2 Age distribution in fish samples during the SOE Fish Monitoring 2023/24 conducted by Northland Regional Council between Nov 2023 – Feb 2024. Total length (TL) applied was for age distribution according to the size class category for New Zealand Freshwater Fish (Joy et al., 2013).

Common name	Scientific name	Age distribution based on total length (mm)
Banded kōkopu	*Galaxias fasciatus*	Juvenile < 50; Adult ≥ 50
Unidentified bully	*Gobiomorphus sp.*	Juvenile < 20; Adult ≥ 20
Common bully	*Gobiomorphus cotidianus*	Juvenile < 20; Adult ≥ 20
Common smelt	*Retropinna retropinna*	Juvenile < 40; Adult ≥ 40
Cran's bully	*Gobiomorphus basalis*	Juvenile < 20; Adult ≥ 20
Inanga	*Galaxias maculatus*	Juvenile < 40; Adult ≥ 40
Kōaro	*Galaxias brevipinnis*	Juvenile < 50; Adult ≥ 50
Longfin eel	*Anguilla dieffenbachii*	Juvenile < 100; Adult ≥ 100
Redfin bully	*Gobiomorphus huttoni*	Juvenile < 20; Adult ≥ 20
Shortfin eel	*Anguilla australis*	Juvenile < 100; Adult ≥ 100
Torrent fish	*Cheimarrichthys fosteri*	Juvenile < 40; Adult ≥ 40
Unidentified eel	*Anguilla sp.*	Juvenile < 100; Adult ≥ 40
Unidentified galaxiid	*Galaxias sp.*	Juvenile < 50; Adult ≥ 40

3 Results & Discussion

During the SOE Fish Monitoring 2023/24, 11 fish species were identified in total at 23 monitored sites located across 9 freshwater management units (FMU) in Northland region. The fish species found are shortfin eel (*Anguilla australis*), longfin eel (*Anguilla dieffenbachia*), banded kōkopu (*Galaxias fasciatus*), inanga (*Galaxias maculatus*), kōaro (*Galaxias brevipinnis*), bluegill bully (*Gobiomorphus hubbsi*), common bully (*Gobiomorphus cotidianus*), Cran's bully (*Gobiomorphus basalis*), redfin bully (*Gobiomorphus huttoni)*, common smelt (*Retropinna retropinna*) and torrentfish (*Cheimarrichthys fosteri*).

According to the survey, bully (*Gobiomorphus sp*.) is the most common (66%) fish family in the region (Figure 4). Redfin bully (*Gobiomorphus huttoni*) comprises 45% of the total fish abundance and was present at all monitored sites, except at the Mangahahuru, Opouteke, Pukenui and Waimahanga sites (Figure 5). Eels are the next most common fish family (12%) (Figure 4).

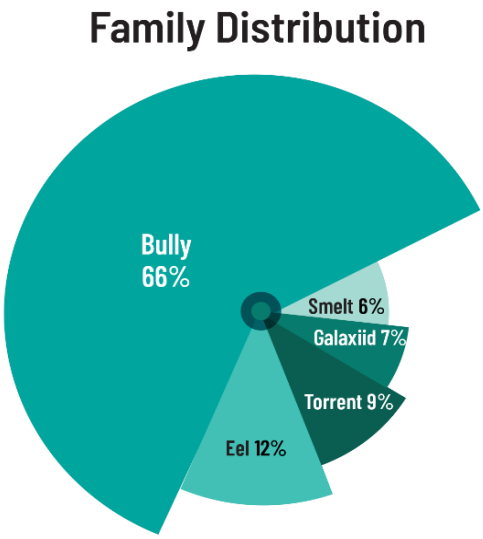


Figure 4 Pie chart shows fish family distribution in fish samples during the SOE Fish Monitoring 2023/24.

3.1 Fish abundance

The largest fish abundance was recorded at Ngunguru (n=654) that accounted for one-fifth of the total fish abundance during the SOE Fish Monitoring 2023/24. Other sites with high fish abundance were Tanekaha (n= 395), Opouteke (n= 371), Punaruku (n= 251) and Raumanga (n= 206) sites (Figure 5).

Several sites showed low abundances despite their drainage though forested catchments which includes the Hakaru, Mangahahuru, Peria, Pukenui and Waikohatu sites, among which the later three sites are reference sites. The low abundances are likely due to barriers on fish migration routes at those sites (Table 3).

The Ngunguru and Punaruku sites, combined, accounted for 25% of the total fish abundance that led to Whananaki Coast ranking at the top of the FMUs that were surveyed in 2023/24. Whananaki Coast also has ranked at top in previous years (Ruehle, 2022). The site proximities to the coast that allow fish easy inland penetration can explain the overall high fish abundances observed in the Whananaki Coast. The same feature can also explain the large occurrence of juveniles at Ngunguru (about 30% of the fish abundance at that site) (Figure 6). Juveniles at Ngunguru were predominantly eels or 'elvers' (n=43) and torrentfish (n=49) (Table 3).

Occurrence of juveniles indicate fish recruitments in stream habitats. Adult fish population were prevalent during the 2023/24 Fish Monitoring (Figure 6). Recruitment of torrentfish – a threatened species (at risk – declining) - was recorded at the Victoria, Tapapa, Tangowahine, Ngunguru and Waiorohia sites (Table 3). The Mangahahuru, Pukenui and Waitangi sites– located above fish passage barriers (ford, dam, waterfalls) – show signs of no recruitment.

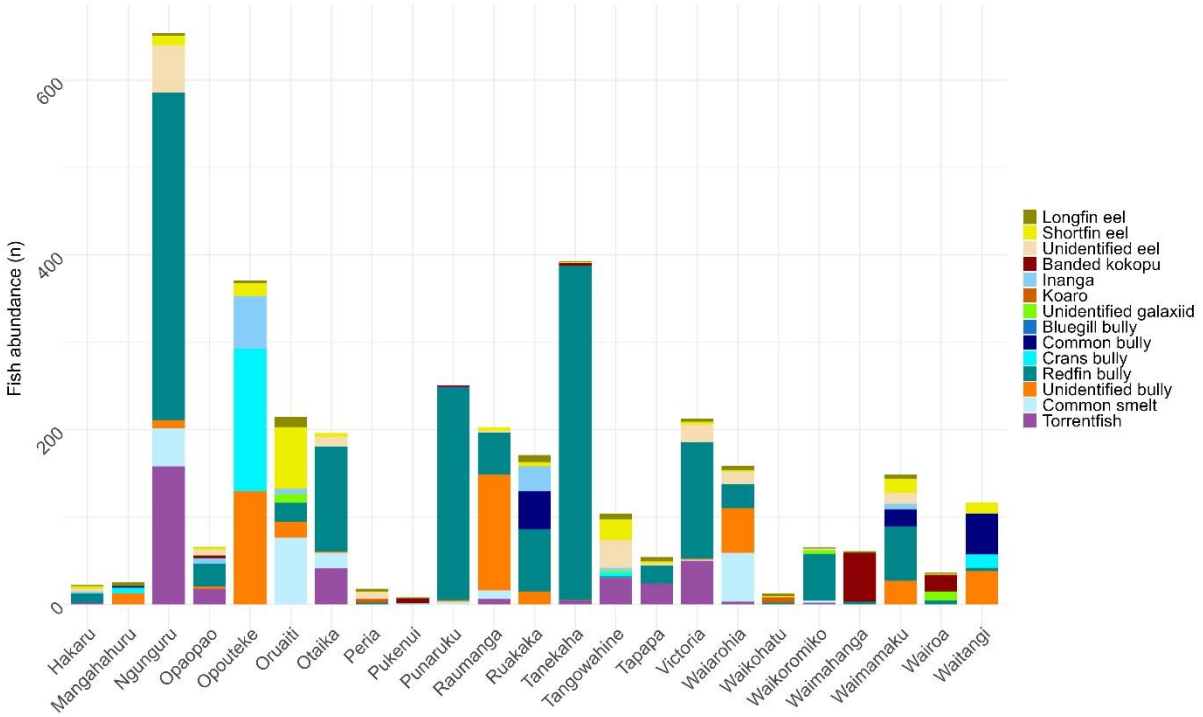


Figure 5 Bar chart shows 11 fish species at 23 sites, surveyed during the SOE Freshwater Fish Monitoring 2023/24 conducted by Northland Regional Council between Nov 2023 – Feb 2024. The largest fish abundance was at the Ngunguru site (n= 654). The highest species richness was at the Tangowahine site (n=7).

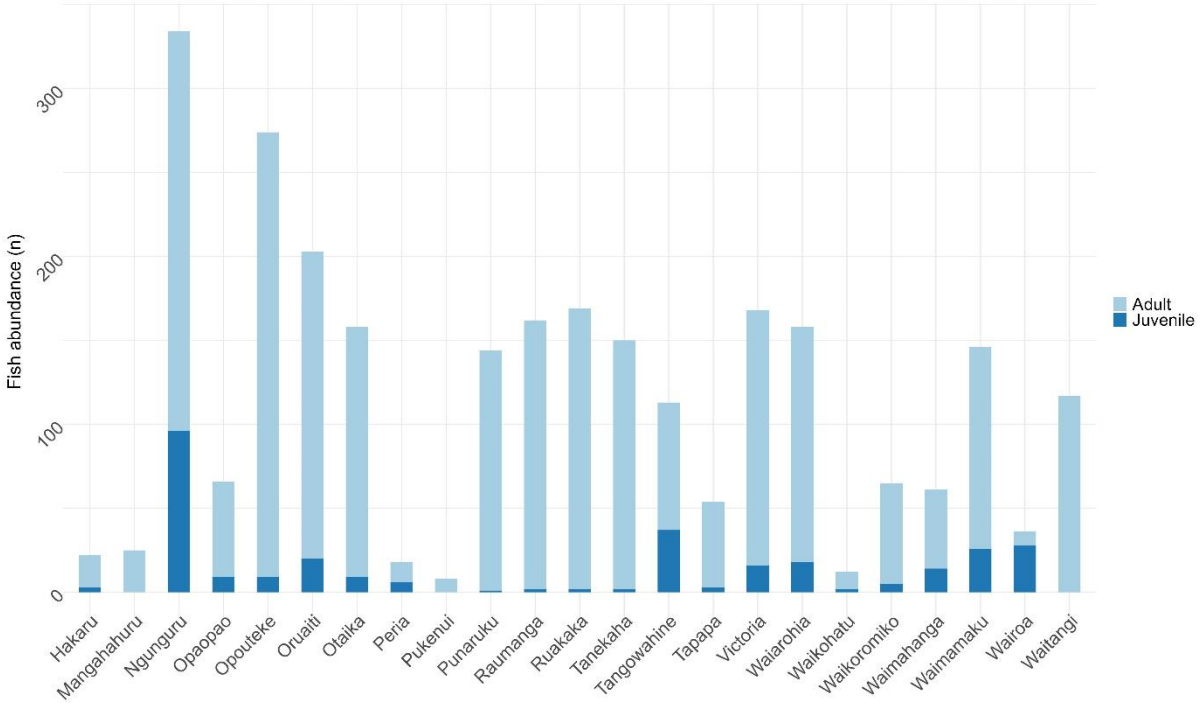


Figure 6 Barchart shows fish age distribution in Northland during the SOE Fish Monitoring 2023/24 conducted by Northland Regional Council between Nov 2023 – Feb 2024. On this plot, the age distribution is based on the sample population that were measured for their total lengths. Juveniles indicate fish recruitments at sites. Ngunguru (n= 92) has the largest juvenile populations, predominantly eels (n=43) and torrentfish (n=49). The Mangahahuru, Pukenui and Waitangi sites – located above fish passage barriers (ford, dam, waterfalls) – show signs of no recruitment.

3.2 Species richness

The Tangowahine site measured the highest species richness (n=7) (Table 3), despite its location at a modified catchment dominated by pastures. The shaded stream habitat and the proximity to the coast is likely driving the high species richness. High species richness values (n = 5-6) were also recorded at inland sites e.g. at the Victoria (pasture-dominated catchment) and the Opaopao (mixed-landuse in the catchment) sites, located >7 km from the coast (Table 3, Figure 5).

3.3 Threatened fish species

Five nationally at-risk species were found in Northland during the 2023/24 fish survey including bluegill bully, inanga, kōaro, longfin eel and torrentfish (Table 3). Their populations are nationally declining (Dunn et al., 2018). No shortjaw kōkopu (*Galaxias postvectis*) – a threatened species - was found this year, compared to one recorded at the Waikohatu site in 2022/23 (Ruehle, 2023).

Bluegill bully (*Gobiomorphus hubbsi*) was recorded at the Punaruku site, located in a forested catchment, for the second consecutive year in 2023/24. Kōaro (*Galaxias brevipinnis*), a climber species, was recorded at the Peria and the Waikohatu sites (both are reference sites in forested catchments). However, the very low fish abundance (n=44) at the Waikohatu site, with a known fish passage barrier downstream, could be a fish barrier impact.

Large inanga populations were recorded at Ruakaka, as was expected, and at Opouteke. The Ngunguru site had shown inanga population previously in 2021/22 (Ruehle, 2022), but not in 2023/24.

Overall, threatened fish species has declined in the region from 30% of the surveyed fish population in the 2021/22 fish survey (Ruehle, 2022) to 18% in the 2023/24 fish survey (Figure 7). In addition, compared to their proportion in total fish samples in 2022/23 (52%), climbers were lower in 2023/24 (15%). Differences in sampling reaches between the monitoring years, at several sites, can be an explanation. The higher climber proportion in 2022/23 could also partly be driven by no survey that year at Ngunguru, which predominantly has poor-climbers (as the 2023/24 Fish Monitoring suggests) likely driven by the site proximity to the coast.

Yet, further investigation into climbers in 2023/24 shows longfin eel was present at less number of sites compared to the previous year, when all sites recorded longfin eels (Ruehle, 2023). Among the

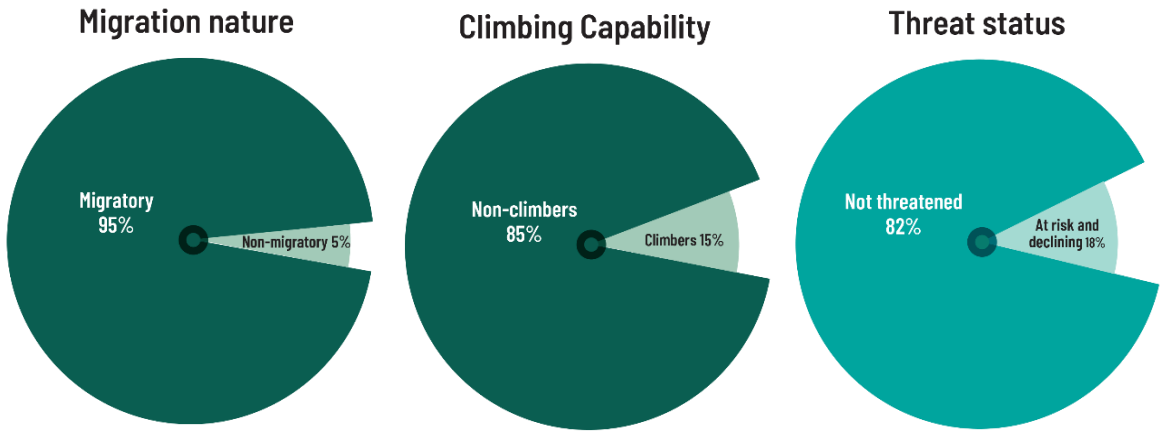


Figure 7 (From left-to-right) Pie charts show Migration nature, Climbing capability and Threat status in fish samples during the SOE Freshwater Fish Monitoring 2023/24 in Northland.

sites monitored in 2023/24, longfin eel was absent at Otaika, Punaruku, Raumanga and Waitangi sites (Figure 5). It should be noted that the Punaruku site is a reference site located in a forested catchment.

In terms of migration accessibility, the occurrence of inanga (poor-climbers) at the Opouteke site is encouraging (Figure 7, Table 3) considering the site location is above a fish passage barrier, at a modified catchment at high altitude and distant from the coast.

3.4 Fish Index of Biotic Integrity (Fish IBI)

Overall, Northland has a very good fish community integrity as IBI scores ranges between 32-54 (with a regional average IBI of 42) according to the 2023/24 Fish Monitoring survey (Table 3, Appendices 3). The current regional average IBI (42), presented on this report, is higher in value compared to the national average (27.9 during 2000-2007) (MfE, 2015).

All but one monitored site was in band A (IBI ≥ 34) during the 2023/24 Fish Monitoring (Table 3). Band A indicates very good to excellent site condition, and healthy fish community, with low habitat degradation and migration accessibility (Appendices 2, 3). The Mangahahuru site was in band B (IBI between 34 and ≤28; Table 3) meaning the site has reduced habitat or limited migratory access (Appendix 2).

Sites with high Fish IBI scores (≥50) were Opaopao (fish passage barrier downstream), Punaruku (reference site), Tanekaha and Tangowahine sites. All these sites receive drainage from forested catchments located upstreams, except the Tangowahine site which is dominated with pastoral landcover.

The Pukenui and the Waikohatu (both reference sites) scored high IBI, despite very low abundances likely driven by migration barriers (Figure 5, Table 3). This observation warns for cautious interpretations of Fish IBI scores in river health assessments. It also calls for reassessment of the representativeness of the reference sites for healthy freshwater fish community assemblages in Northland region, as originally intended on the RWQEMP.

When it comes to IBI scores and associated national bands, several monitoring sites that have shown consistencies, across the monitored years, are the Opaopao, Oruaiti, Otaika, Tapapa, Waimahanga and Victoria sites (Table 3).

In addition, the sites that have improved in terms of NPSFM bands in 2023/24 are the Hakaru, Pukenui, Tangowahine and Waitangi sites (Table 3). The improvements in NPSFM bands can partly be explained by the inherent high sensitivity of Fish IBI calculation technique to certain fish species (e.g. threatened species). For example, occurrence of at-risk species has likely driven band A at Pukenui, despite low fish abundance (Figure 5, Table 3). Another explanation can be the improved connectivity driven by elevated rainfall, during *La Nina,* which has been speculated to improve migratory routes and promote IBI values in some parts in NZ (Paul Fisher *pers. comm.*). However, climate change driven improved water connectivity is less likely to explain the band improvements we observed in Northland this year. The reason is many of the sites (Hakaru, Pukenui, Waitangi sites) with improved NPSFM bands, in Northland in 2023/24, have physical fish passage barriers (presence of barriers indicated on Table 3, Appendix 4) where improved water connectivity is less likely. For instance, the Waitangi site is located

Table 3 Summary from the SOE Fish Monitoring 2023/24 conducted by Northland Regional Council between Nov 2023 – Feb 2024 at 23 sites located in 9 FMUs across Northland. Site names in green boxes are reference sites, considered as in natural state on the RWQEMP. Fishing techniques are indicated with EFM = Electrofishing, Net = Netting technique. Dominant catchment codes: F=forested, P=pasture, M=mixed, U=urban. For fish passage barriers, Y=Yes, N=No, U=Unknown. Fish IBI score ranges 0-60 where Fish IBI 0 indicates native fish absence, equivalent to high human impact while Fish IBI 60 indicates pristine condition at a site. Fish IBI scores were used to assign NPSFM bands where band A≥34 (blue), band B <34 and ≥28 (dark green), band C <28 and ≥18 (orange), band D <18 (red). Site IBI scores from the previous monitoring years, from Ruehle (2022, 2023), are presented for comparisons, where the *marked has slightly different sampling location.

Freshwater Management Unit (FMU)	Site name	Site tag	Fishing technique	Dominant catchment landuse, Fish passage barrier	Site description		Species richness	Fish abundance	Fish IBI score			Fish integrity class in 2023/24	Threatened species (n)	Fish species of Juveniles (n)
					Altitude (m)	Distance from coast (km)			2023/24	2022/23	2021/22			
Awanui	Victoria at Victoria Valley Road	Victoria	EFM	F, U	69	33.05	5	213	48	48	-	Very Good	Longfin eel (4), Torrentfish (50)	Torrentfish (2), Redfin bully (1), Unidentified eel (13)
Bay of Islands	Wairoa Stream UT Kerikeri Inlet Road	Wairoa	EFM	U, U	69	1.38	4	36	42	40	-	Good	Longfin eel (1)	Banded kōkopu (18), Unidentified galaxiid (10)
	Waitangi at Waimate North Road	Waitangi	Net	P, Y	79	21.93	4	117	34	24	24	Fair	None	None
Bream Bay	Ruakaka at Flyger Road	Ruakaka	Net	P, Y	17	2	5	171	40	52	52	Good	Inanga (28), Longfin eel (8)	Unidentified bully (2)
	Tanekaha Track Stream at King Road	Tanekaha	EFM	F, U	87	5.16	5	393	50	48	-	Very Good	Longfin eel (1), Torrentfish (4)	Banded kōkopu (1), Unidentified eel (1)
Doubtless Bay	Oruaiti at Windust Road	Oruaiti	Net	P, U	19	5.56	5	215	46	46	44	Good	Inanga (6), Longfin eel (12)	Common smelt (2), Unidentified bully (14), Unidentified galaxiid (4)
	Peria at 702 Honeymoon Valley Road	Peria	EFM	F, U	79	26.05	4	18	42	46	-	Good	Kōaro (4), Longfin eel (3)	Unidentified eel (6)
Hokianga	Opaopao Stream at Forest Road	Opaopao	EFM	F, Y	29	7.18	6	66	54	54	54	Excellent	Inanga (6), Longfin eel (1), Torrentfish (18)	Banded kōkopu (2), Unidentified eel (7)
	Tapapa at SH1	Tapapa	EFM	F, Y	80	12.1	4	54	38	38	40	Good	Longfin eel (5), Torrentfish (24)	Torrent fish (1), Unidentified eel (2)
Northern Wairoa	Hakaru River UT US at Topuni	Hakaru	EFM	M, Y	26	2.21	5	22	38	32	14	Good	Inanga (3), Longfin eel (1), Torrentfish (2)	Unidentified eel (3)

Freshwater Management Unit (FMU)	Site name	Site tag	Fishing technique	Dominant catchment landuse, Fish passage barrier	Site description		Species richness	Fish abundance	Fish IBI score			Fish integrity class in 2023/24	Threatened species (n)	Fish species of Juveniles (n)
					Altitude (m)	Distance from coast (km)			2023/24	2022/23	2021/22			
	Mangahahuru at Main Road	Mangahahuru	Net	F, Y	115	54.28	3	25	32	34	32	Fair	Longfin eel (4)	None
	Opouteke at Suspension Br	Opouteke	Net	P, Y	59	62.1	4	371	34	28*	30*	Fair	Inanga (60), Longfin eel (3)	Unidentified bully (9)
	Tangowahine at Tangowahine Valley Road	Tangowahine	EFM	P, U	19	2.31	7	104	52	32	-	Excellent	Inanga (4), Longfin eel (7), Torrentfish (30)	Shortfin eel (1), Torrentfish (7), Unidentified eel (27), Unidentified galaxiid (2)
Waipoua	Waikohatu Stream at Visitor Centre	Waikohatu	EFM	F, Y	99	12.2	4	12	44	56	-	Good	Kōaro (6), Longfin eel (3)	Kōaro (1), Unidentified eel (1)
	Waimamaku at SH12	Waimamaku	EFM	P, U	19	6.23	5	149	40	38	44	Good	Inanga (6), Longfin eel (5)	Unidentified eel (26)
Whananaki Coast	Ngunguru at Coalhill Lane	Ngunguru	EFM	M, U	45	3.5	5	654	42	-	52*	Good	Longfin eel (3), Torrentfish (158)	Common smelt (3), Redfin bully (1), Torrentfish (49), Unidentified eel (43)
	Punaruku River UT at Punaruku Road	Punaruku	EFM	F, U	21	4.04	3	251	54	48	52	Excellent	Bluegill bully (1)	Banded kōkopu (1)
Whangārei	Otaika at Otaika Valley Road	Otaika	EFM	M, U	20	3.11	4	196	36	46	44	Fair	Torrent (41)	Redfin bully (1), Unidentified eel (8)
	Waikoromiko at Hatea Confluence	Waikoromiko	EFM	M, U	23	2.4	4	65	34	40	54	Fair	Longfin eel (1), Torrentfish (2)	Unidentified eel (1), Unidentified galaxiid (4)
	Pukenui at Kanehiana Drive	Pukenui	EFM	M, Y	162	8.17	3	8	46	32	32	Good	Inanga (1), Longfin eel (1)	None
	Raumanga at Bernard Street	Raumanga	EFM	U, U	19	0.86	4	223	36	38	46	Fair	Torrent (6)	Unidentified eel (1)
	Waiarohia at Second Avenue	Waiarohia	EFM	U, U	20	0.6	5	159	40	54	54	Good	Longfin eel (5), Torrentfish (3)	Common smelt (1), Torrentfish (1), Unidentified bully (2), Unidentified eel (14)
	Waimahanga Stream UT at Mt Taika Forest	Waimahanga	EFM	F, U	160	2.93	3	61	46	46	-	Good	Longfin eel (2)	Banded kōkopu (14)

above a natural waterfall and the Hakaru site has a man-made fish passage barrier downstream (Appendix 4).

3.4.1 Fish IBI variations

Annual variations were observed in Fish IBI scores both when sampled at same location every year and when sampled at slightly different locations. For instance, the Waitangi site (located above a waterfall) was in band C in previous years (Ruehle, 2022, 2023), but in band A in 2023/24. Increase in species richness and fish assemblage may have contributed partly to the Fish IBI variation. Sampling the same location for three consecutive years has shown an increase in species richness and a fluctuation in fish abundance at the Waitangi site. The species richness increased from 3 (abundance=181; band C) in 2021/22 to 4 (fish abundance=93; band C) in 2022/23. In 2023/24, the abundance increased (abundance = 117) but species richness remained consistent (species richness = 4; band A). Additionally, longfin eel was absent but redfin bully (both share similar IBI score as in Appendix 1) giving different fish assemblage in 2023/24.

In contrast, sampling at different locations at the Hakaru site, in last three years, has also yielded annually variable IBI (Ruehle, 2022, 2023). Comparison shows, the Hakaru site was in band D during the 2021/22 Fish Monitoring (species richness=1; abundance=14) and band B (species richness=5; abundance=150) in 2022/23 but improved to band A in 2023/24 (species richness=5; abundance=22) (Table 3) (Ruehle, 2022, 2023). The IBI variation between the monitored years, at the Hakaru site, could be due to differences in sampled stream reaches and species richness and IBI calculator's high sensitivity to certain species. For example, torrentifish has high IBI score (Appendix 1), as a threatened species, and was recorded at Hakaru site that yielded high IBI in 2023/24, despite low fish abundance, compared to the previous monitored years.

Temporal variation in IBI scores is expected (Joy & Death, 2004). The challenge in Northland is the uncertainty around the source of IBI variations. As the above discussion suggests, IBI variation in Northland could be driven by sampling reach differences, changes in fish migration routes, catchment land-use change and/or climate change. Apparently, a clear understanding about the IBI drivers is currently limited in Northland. The limited knowledge can constrain the upscaling the site IBI scores to the region that is necessary for region-wide resource management plans.

To minimise related uncertainties, and to enhance the functionality of the SOE fish monitoring, we recommend:

- Consistently monitor same site locations every year to build long-term fish database. Reliable long-term data is necessary for understanding fish population trend and change in community structure. Monitoring sites at different locations prevents comparison of observations between years.

- Distribute the monitoring effort proportionally to the fish habitats in FMUs across the region. SOE fish monitoring network does not have full coverage to all FMUs; e.g., no fish monitoring sites in Poutō, Whangaroa, Herekino-Whāngāpē, and Aupōri FMUs.

- Identify drivers of fish IBI to increase functionality of site-based IBI for extrapolation to regional scale.

- Improvise current fish monitoring approaches to enable identify drivers (e.g. landuse changes, flow and water quality, environmental events, barriers on fish migration routes) in Northland region that influence fish community - spatially and temporally.

4 Conclusions

The State of Environment (SOE) of freshwater fish in Northland is reported annually in this technical report series to inform stakeholders, including scientists and policy experts, about the river health in the region. The fish monitoring generates information which is necessary to meet the requirements of the RMA and the NPSFM's objective in the Northland region. As the only fish-related NPSFM attribute, Fish IBI score is measured based on fish monitoring data by using a Fish IBI calculator, developed for the Northland region. The calculator is used for its robustness in integrating a range of national, regional and local features that influence fish community.

The SOE Fish Monitoring 2023/24 in Northland identified in total 11 native fish species that include shortfin eel (*Anguilla australis*), longfin eel (*Anguilla dieffenbachia*), banded kōkopu (*Galaxias fasciatus*), inanga (*Galaxias maculatus*), kōaro (*Galaxias brevipinnis*), bluegill bully (*Gobiomorphus hubbsi*), common bully (*Gobiomorphus cotidianus*), Cran's bully (*Gobiomorphus basalis*), redfin bully (*Gobiomorphus huttoni)*, common smelt (*Retropinna retropinna*), torrentfish (*Cheimarrichthys fosteri*).

The threatened (at-risk species) fish species found in Northland were bluegill bully, inanga, kōaro, longfin eel and torrentfish. This is the second consecutive year that bluegill bully was found at the Punaruku site. However, data suggests a possible decline in the proportion of threatened species in the region. Unlike the previous monitored years, longfin eels were absent at several sites this year.

Adult is prevalent in native fish population in the region. Dominance of adults in fish population can be an indicator of disrupted juvenile fish recruitments, in the region, likely driven by downstream fish passage barriers.

Sites with high fish abundances are mostly located at low elevation and near coasts, e.g. at Ngunguru site, which allow fishes easy inland penetrations. In other words, low fish abundance in upper catchments (which often provide better spawning habitats) reiterates the possible impacts of migration barriers in the region.

Overall, the measured IBI scores has shown very good ecological integrity for fish in the region. This, however, requires cautious interpretations. This is because most of the monitored sites are in pastoral catchments with degraded water quality and ecosystem health and possibly impacted fish communities (Graham & Greenwood, 2023). Yet, the IBI values are indicating healthy fish habitats in Northland region. For example, the downstream reaches of Peria and Victoria sites flow through highly modified agricultural landscapes, which likely affect fish migration; yet, both sites are in band A. Similarly, the Pukenui site is in band A despite a fish-barrier downstream that likely has driven the low fish abundance at that site.

Interestingly, Tangowahine site is located on a modified catchment, mostly in pasture, yet the site has measured the highest species richness of all monitored sites. The riparian buffer creating shaded

habitat may explain the high species richness at that site and demonstrates the benefit of riparian restorations for fish habitats in modified catchments.

Several sites in Northland have shown consistency in IBI scores over monitoring years. However, observations also suggest IBI varies in Northland rivers spatially and temporally. While variations in Fish IBI can be expected, according to literature, the drivers remain unknown. Drivers of Fish IBI can range from changes in fish monitoring techniques, changes in catchment land use changes to climate changes. A clear understanding of the Fish IBI drivers will be necessary for the resource management plans in the region in future.

This report recommends:

- **Consistent annual monitoring at same locations** in order to establish long-term fish database.
- **Expand the current fish monitoring network to all FMUs** and distribute the total fishing efforts to the stream habitats in FMUs proportionally.
- **Use innovative monitoring tools,** such as eDNA, for resource efficient and improved fish monitoring.
- **Add lakes to freshwater fish monitoring network** as habitats for nationally threatened freshwater fish species, including Northland mudfish and dune lake galaxiids (DLG), that are mostly confined to lake-based, closed freshwater ecosystems.
- **Assess the representativeness of the reference sites on the RWQEMP,** from the perspectives of the natural condition for freshwater fish in the region.

In addition, this report highlights the following needs to enhance our understanding and facilitate fish and associated habitat management in Northland:

- **Comprehensive fish passage barrier database** in the region, at least for the fish monitoring sites. A reliable record of fish passage barriers in Northland waterways is currently underdeveloped. This knowledge gap affects fish recruitments efforts in the region.
- **Integrated catchment studies** on land use change, land management practices, fish habitat types and environmental variables that affect fish community.
- **Investigation into Fish IBI drivers** for clear understandings of pressures and drivers that affect freshwater fish health in the region.

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Appendices

Appendix 1 Freshwater fish species found in Northland (adopted from Ruehle, 2022)

Common name	Scientific name	Family	Native status	Conservation status	Migratory	Climber	Species IBI score
Longfin eel	*Anguilla dieffenbachii*	Anguillidae	Endemic	At Risk - Declining	Yes	Yes	3
Shortfin eel	*Anguilla australis*	Anguillidae	Native	Not Threatened	Yes	Yes	2
Australian Spotted eel	*Anguilla reinhardtii*	Anguillidae	Non-resident Native	Coloniser	Yes	No	N/A
Inanga	*Galaxias maculatus*	Galaxiidae	Native	At Risk - Declining	Yes	No	3
Dune Lake *Galaxias* (Kai Iwi)*	*Galaxias* "dune lakes"	Galaxiidae	Endemic	At Risk – Naturally Uncommon	No	No	3
Dwarf īnanga	*Galaxias gracilis*	Galaxiidae	Endemic	Taxonomically Indistinct	No	No	3
Banded kōkopu	*Galaxias fasciatus*	Galaxiidae	Endemic	Not Threatened	Yes	Yes	4
Shortjaw kōkopu	*Galaxias postvectis*	Galaxiidae	Endemic	Nationally Threatened	Yes	Yes	4
Giant kōkopu	*Galaxias argenteus*	Galaxiidae	Endemic	At Risk - Declining	Yes	Yes	3
Kōaro	*Galaxias brevipinnis*	Galaxiidae	Native	At Risk - Declining	Yes	Yes	4
Northland mudfish*	*Neochanna heleios*	Galaxiidae	Endemic	Nationally Threatened	No	No	3
Black mudfish	*Neochanna diversus*	Galaxiidae	Endemic	At Risk - Declining	No	No	3
Common bully	*Gobiomorphus cotidianus*	Eleotridae	Endemic	Not Threatened	Yes	No	2
Cran's bully	*Gobiomorphus basalis*	Eleotridae	Endemic	Not Threatened	No	No	2
Redfin bully	*Gobiomorphus huttoni*	Eleotridae	Endemic	Not Threatened	Yes	No	3
Bluegill bully	*Gobiomorphus hubbsi*	Eleotridae	Endemic	At Risk - Declining	Yes	No	3
Giant bully	*Gobiomorphus gobioides*	Eleotridae	Endemic	At Risk – Naturally Uncommon	Yes	No	3
Common smelt	*Retropinna retropinna*	Retropinnidae	Endemic	Not Threatened	Yes	No	3
Torrentfish	*Cheimarrichthys fosteri*	Cheimarrichthyidae	Endemic	At Risk - Declining	Yes	No	2
Pouched lamprey	*Geotria australis*	Geotriidae	Native	Nationally Threatened	Yes	Yes	3
Grey mullet	*Mugil cephalus*	Mugilidae	Native	Not Threatened	No	No	2
Dart goby	*Parioglossus marginalis*	Gobiidae	Non-resident Native	Coloniser	No	No	2
Black flounder	*Rhombosolea retiaria*	Rhombosoleidae	Endemic	Not Threatened	Yes	No	3

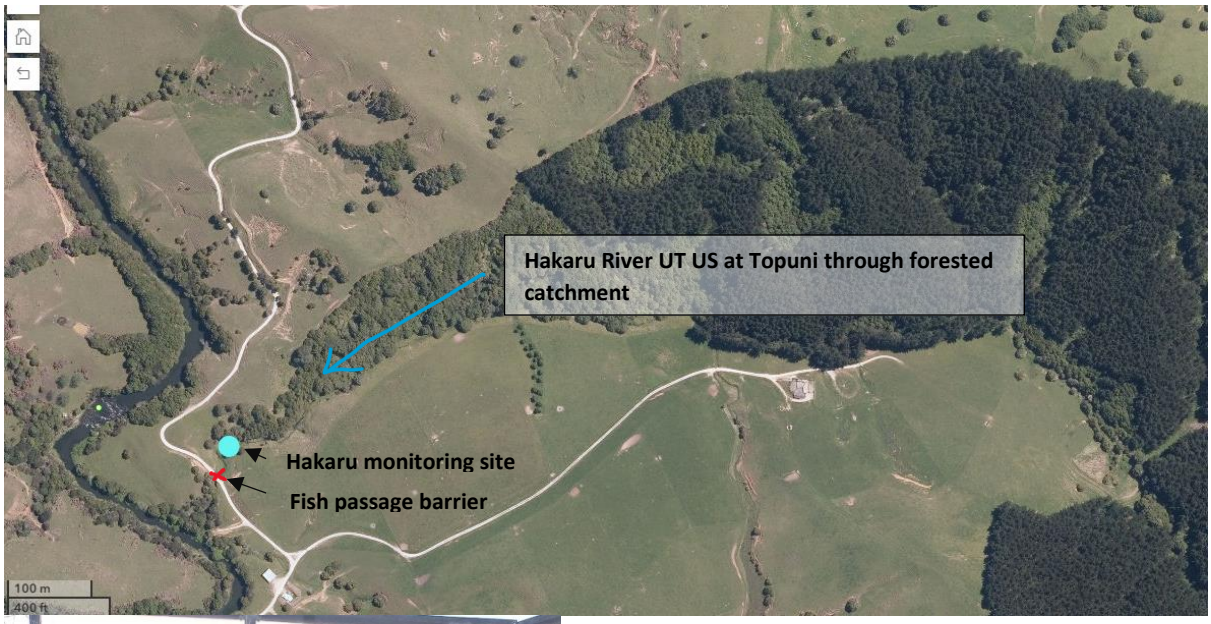
Appendix 2 Description of Fish Index of Biotic Integrity or Fish IBI scores. Fish IBI score is the only NPSFM fish attribute used for river ecosystem health assessments.

Attribute band and description	Fish Index of Biotic Integrity (F-IBI)
Band A High integrity of fish community. Habitat and migratory access have minimal degradation.	≥34
Band B Moderate integrity of fish community. Habitat and/or migratory access are reduced and show some signs of stress.	<34 and ≥28
Band C Low integrity of fish community. Habitat and/or migratory access is considerably impairing and stressing the community.	<28 and ≥18
Band D Severe loss of fish community integrity. There is substantial loss of habitat and/or migratory access, causing a high level of stress on the community.	<18

Appendix 3 Qualitative site integrity class derived from Fish IBI scores are also presented and has been adopted from Joy (2019).

Total IBI score	Integrity class	Attributes
41 – 60	Excellent	Comparable to the best situations without human disturbance; all regionally expected species for the stream position are present. Site is above the 90th percentile of Northland sites
33 – 40	Very good	Site is above the 80th percentile of all Northland sites species richness is slightly less than best for the region
25 – 32	Good	Site is above the 60th percentile of Northland sites but species richness and habitat or migratory access reduced some signs of stress
21 – 24	Fair	Score is just above average, but species richness is significantly reduced habitat and or access impaired
16 – 20	Poor	Site is less than average for Northland region IBI scores, less than the 50th percentile, thus species richness and or habitat are severely impacted
8 – 15	Very poor	Site is impacted or migratory access almost non existent
0	No fish	Site is grossly impacted or access non existent

Appendix 4 Photo shows a fish passage barrier at the downstream of the Hakaru monitoring site in Northland



Appendix 5 In-situ water quality properties and site characteristics of 23 sites monitored during the SOE Fish Monitoring 2023/24 conducted by Northland Regional Council between Nov 2023 – Feb 2024.

FMU	Site names	Site tag	Fishing technique	Temperature (C)	Dissolved oxygen (mg DO/L)	Wetted Width (m)			Mean Depth (m)		
						Mean	Med.	90%	Mean	Med.	90%
Awanui	Victoria at Victoria Valley Road	Victoria	Electrofishing	19.2	9.19	7.3	7.00	10.1	0.29	0.28	0.56
Bay of Islands	Wairoa Stream UT Kerikeri Inlet Road	Wairoa	Electrofishing	20.7	8.4	1.8	1.80	8.75	0.11	0.11	0.35
	Waitangi at Waimate North Road	Waitangi	Netting	NA	NA	-	-	-	-	-	-
Bream Bay	Ruakākā at Flyger Road	Ruakākā	Netting	20.9	7.18	-	-	-	-	-	-
	Tanekaha Track Stream at King Road	Tanekaha	Electrofishing	16.3	9.97	4.0	3.80	5.31	0.14	0.09	.43
Doubtless Bay	Oruaiti at Windust Road	Oruaiti	Netting	22.9	8.56	-	-	-	-	-	-
	Peria at 702 Honeymoon Valley Road	Peria	Electrofishing	18.9	9.24	6.8	6.50	9.2	0.22	0.15	0.58
Hokianga	Opaopao Stream at Forest Road	Opaopao	Electrofishing	14.5	9.39	2.0	2.00	3.4	0.15	0.15	0.39
	Tapapa at SH1	Tapapa	Electrofishing	18	9.93	6.9	6.05	9.6	0.26	0.24	1.1
Northern Wairoa	Hakaru River UT US at Topuni	Hakaru	Electrofishing	16.9	10.22	3.5	3.20	9.7	0.29	0.29	0.53
	Mangahahuru at Main Road	Mangahahuru	Netting	19.5	9.07	-	-	-	-	-	-
	Opouteke at Suspension Br	Opouteke	Netting	22	9.55	-	-	-	-	-	-
	Tangowahine at Tangowahine Valley Road	Tangowahine	Electrofishing	17.8	8.4	6.0	5.85	7.8	0.38	0.28	0.91
Waipoua	Waikohatu Stream at Visitor Centre	Waikohatu	Electrofishing	18.6	9.13	6.3	6.50	7.2	0.15	0.15	0.79
	Waimamaku at SH12	Waimamaku	Electrofishing	21.8	8.13	9.6	10.00	11.50	0.47	0.46	0.64
Whananaki Coast	Ngunguru at Coalhill Lane	Ngunguru	Electrofishing	20.2	7.26	8.6	8.80	13.6	0.28	0.27	0.43
	Punaruku River UT at Punaruku Road	Punaruku	Electrofishing	17.3	8.82	2.9	3.20	4.12	0.14	0.08	0.93
Whangārei	Otaika at Otaika Valley Road	Otaika	Electrofishing	19.7	8.23	5.4	5.70	8.94	0.38	0.30	0.80
	Waikoromiko at Hātea Confluence	Waikoromiko	Electrofishing	15.2	9.78	3.3	3.30	9.9	0.41	0.28	0.8
	Pukenui at Kanehiana Drive	Pukenui	Electrofishing	15.03	9.71	-	-	-	-	-	-
	Raumanga at Bernard Street	Raumanga	Electrofishing	18.6	9.26	3.6	3.20	6.1	0.34	0.28	0.96
	Waiarohia at Second Avenue	Waiarohia	Electrofishing	20	9.05	4.5	4.70	5.7	0.23	0.20	0.55
	Waimahanga Stream UT at Mt Taika Forest	Waimahanga	Electrofishing	16.9	9.24	2.2	1.90	3.2	0.08	0.08	0.2

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