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Sites of Significance for Aquatic Biodiversity in the Manawatu-Wanganui Region :

Technical Report to Support Policy Development

horizons regional council

one plan
MO TE ITI MO TE RAHI

Sites of Significance for Aquatic Biodiversity in the Manawatu-Wanganui Region : Technical Report to Support Policy Development

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regional council

May 2007

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EXECUTIVE SUMMARY

Under the purposes and principles of the Resource Management Act (1991) the maintenance and enhancement of aquatic ecosystems is a matter of national importance. Through the development of the One Plan, Sites of Significance for Aquatic biodiversity (SOS-A) within the Manawatu-Wanganui Region have been identified.

This report summarises current knowledge of the state of aquatic biodiversity in the Manawatu-Wanganui Region, highlights the distribution and diversity of fish and aquatic invertebrates within the regional setting and includes a description of the characteristics of the native fish, blue duck and invertebrate faunas.

National patterns of fish community diversity, described extensively in the New Zealand literature, are not reflected in the Region. Nationally, lowland reaches of waterways have been found to contain the highest abundance and diversity of fish species because of the diadromous (migratory) nature of many native fish. However, loss of suitable lowland habitat, barriers to migration, degraded water quality and the presence of introduced taxa has reduced the number of fish species commonly found in lowland areas.

Many of the rare and threatened fish species that remain are highly vulnerable to regional decline or extinction due to poor inland penetration or non-migratory, small, or sparsely distributed populations and a lack of suitable, accessible habitat. Identification of the critical habitat requirements and protection of the remaining sites and reaches where these species are present is an important first step in halting the decline of aquatic biodiversity in the Manawatu-Wanganui Region.

A regional list of rare and threatened species has been developed and used to determine significant sites for protection under the One Plan. The regional list incorporates information from established threat classification systems and lists, data from the New Zealand National Freshwater Fish Database and regional expert knowledge.

Ten aquatic species (nine fish and the blue duck) are considered regionally rare and threatened. The definition of 149 Sites of Significance Aquatic (SOS-A), based on the recorded presence of one or more regionally rare and threatened species and an additional habitat buffer, is recommended.

Although inanga are not listed as a regionally rare and threatened species, they are an important component of lowland fish communities and are recognised for their significance to the recreational and cultural value of whitebait fisheries. Native Fish Spawning (NFS) is identified as a separate value from SOS-A because inanga spawning does not overlap with the spawning sites of rare and threatened fish. Therefore a separate value (NFS) is determined by the location of inanga spawning sites.

The critical habitat requirements and recommendations for Sites of Significance – Aquatic (defined by the rare and threatened taxa) and Native Fish (inanga) Spawning are defined. Sites acknowledged for these values are identified and mapped regionally and a summary of the current research on native fish and known barriers to fish migration is included.

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1. Introduction and Scope

1.1 Background

Horizons Regional Council, in a State of the Environment Report (Phillips & Joy, 2002) documented the results of an extensive survey of the Region's native fish communities. Phillips and Joy (2002) found that while there were some healthy fish communities in rivers and streams draining the Tararua Ranges, in general native fish communities were degraded throughout much of the Region's modified landscape.

In addition to native fish communities, the Manawatu-Wanganui Region is home to some of the last remaining populations of blue duck (whio) in New Zealand. Although blue duck critical habitat requirements and threats have been identified as an aspect of aquatic biodiversity within this report, species management of blue duck is undertaken by the Department of Conservation.

1.2 Planning context

Historically, native fish have been given scant regard within Horizons' Plans. Whitebait fisheries, trout fisheries, inanga and trout spawning sites or reaches have had specific policies and rules relating to their protection within the current suite of Regional Plans. However, aquatic biodiversity and the habitat requirements of rare and threatened native fish species have never been specifically dealt with.

This document is part of a series of water-resource focused technical reports prepared to support the development of new water management policy (Figure 1). This policy will be incorporated into Horizons' second-generation plan and combined Regional Plan and Policy Statement (the One Plan).

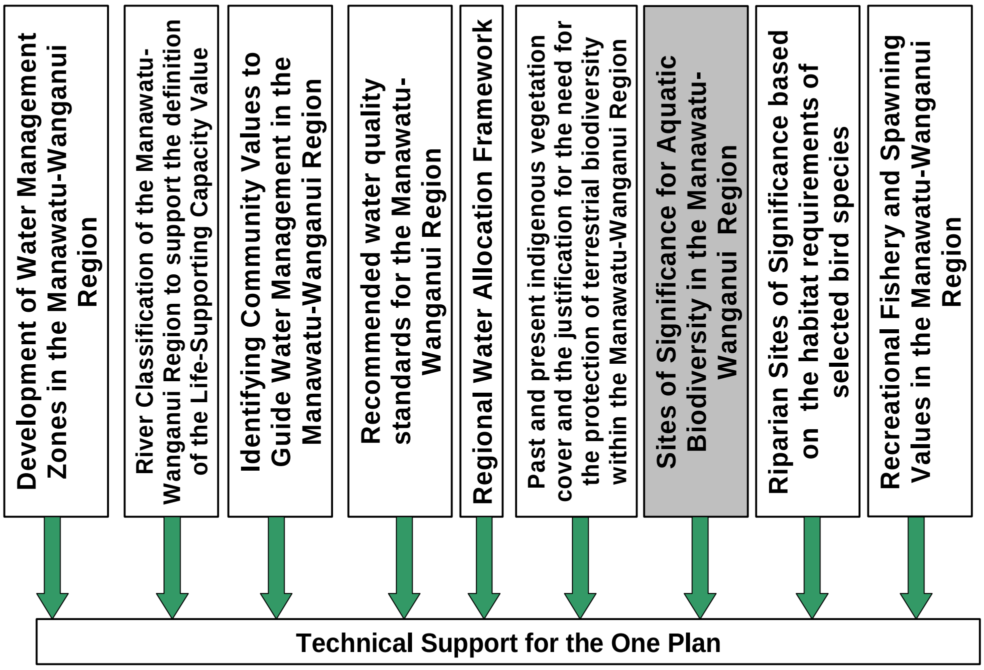


Figure 1. Planning context of the Sites of Significance for Aquatic Biodiversity report in relation to the water and biodiversity technical reports supporting the One Plan

Identification of the specific Sites of Significance – Aquatic (SOS-A) follows on from work to define aquatic biodiversity values in the Region's waterways using criteria developed by Ausseil and Clark (2007a) as follows:

- the presence of one or several rare and threatened species (at a national or regional level);
- the presence of living communities that are more biologically diverse than expected – 'biodiversity hotspots'; or
- the presence of a rare or threatened aquatic habitat.

For the purposes of this report and the proposed schedule of SOS-A sites, only the first criterion has been applied. Further monitoring and research will enable the future use of criteria 2 and 3 for a more ecologically relevant definition of SOS-A, and will assess the need for the inclusion of genetic diversity as a defining criterion.

1.2.1 Scope

Aquatic biodiversity encompasses the community of species that inhabit the Region's rivers, wetlands and lakes. While these ecosystems contain diverse assemblages of plants, birds, invertebrates, fish and micro-organisms, this report focuses on freshwater native fish communities and populations, reflecting their higher trophic status and use as indicators of the life-supporting capacity of the Region's aquatic ecosystems.

As background for the identification of Sites of Significance – Aquatic the first section of this report describes the current state of native fish communities regionally. This material highlights the key issues regarding the distribution and diversity of fish, blue duck and aquatic invertebrates within the regional setting, and creates a knowledge base for future utilisation of the additional criteria (see above) to characterise the SOS-A value in future, namely ‘biodiversity hotspots’ and rare or threatened aquatic habitat types.

The second section of this report relates directly to policy development for the One Plan and lists the rare and threatened aquatic species used to define sites of significance for aquatic biodiversity in the Region, outlines the critical habitat requirements of those species, and provides recommendations for maintaining fish communities through protecting sites of significance.

Using a species-and-site based approach to maintaining aquatic biodiversity applies an environmental bottom line, which although not the most desirable way forward, provides some immediate protection of the current state in order to buy time for further development of a long-term strategy which incorporates ‘biodiversity hotspots’ and rare and threatened habitat types.

This report does not identify or recommend water quality standards for the protection of aquatic biodiversity. Water quality standards have been developed to maintain and enhance the Life-Supporting Capacity (LSC value) of the Region’s waterways and specific reference to these standards can be found in Ausseil & Clark (2007b).

Horizons also recognises the value of native fish for cultural and recreational purposes, and as such a whitebait fishery value is included in the policy framework for the Region’s rivers. The criteria developed under the values framework within the One Plan also allows for the future identification of other native fisheries, such as tuna (eel), koura (freshwater crayfish) or kakahi (freshwater mussels). However, at the time of writing the location of native fisheries for other species had not been identified through the public consultation process.

Little discussion is included in this report on the development or location of the native fishery (NF) and native fish (inanga) spawning (NFS) values regionally (see Ausseil & Clark, 2007a); however the critical habitat requirements and recommendations regarding the protection of inanga spawning habitat has been included in this report for reference purposes.

1.2.2 Key questions

The key questions addressed in this report are:

(Chapters 2 and 3)

- What is the state of aquatic biodiversity in the Region?
- What are the distributional patterns of aquatic biodiversity regionally?
- What are the critical habitat requirements of aquatic species?
- Where are the knowledge gaps and what future research is needed?

(Chapters 4–6)

- What taxa are nationally and/or regionally rare and threatened?
- How were the sites of aquatic significance defined?

- Where do the sites of aquatic significance occur regionally?
- What are the policy recommendations for maintaining fish communities at sites of significance?
- Where do inanga spawn in the region?
- What are the policy recommendations for the protection of inanga spawning habitat?

1.3 Peer review

This report has benefited significantly from the comments of a number of people. External review was undertaken by Russell Death, Freshwater Ecologist – Massey University; Roger Young, Freshwater Ecologist – Cawthron Institute and Dave Rowe, Freshwater Fish Group Manager – NIWA. Specific comment raised through the review process is contained in appendices.

2. The state of aquatic biodiversity in the Manawatu-Wanganui Region

2.1 Components of aquatic biodiversity in the Region

Aquatic ecosystems, although little understood due to their 'out of sight - out of mind' status, are complex systems, existing on a generally microcosmic scale. Macrophytes (aquatic plants), bryophytes (liverworts and mosses), filamentous algae, diatoms and cyanobacteria (blue-green algae) grow within rivers, streams and lakes and are the primary productive base of the food web in aquatic systems (Winterbourn, 2004).

Aquatic macroinvertebrates are the main primary consumers (aquatic 'herbivores'), particularly insects, molluscs, crustaceans and worms. Secondary consumers (predators of the primary consumers) are principally fish and larval insects; however birds such as blue duck and black stilt prey almost exclusively on aquatic insects. The more aggressive predatory fish such as trout, perch and mature eels can be considered tertiary consumers as they often feed on other fish. Aquatic decomposition by fungi and bacteria breaks down instream and allocthonous material, such as fallen leaves, with help from detritivorous insects (Winterbourn, 2004).

Many healthy, functioning aquatic ecosystems have more complex food webs and sometimes greater biodiversity as a result. The replacement of indigenous vegetation with pasture and urban landscapes has a homogenising effect on aquatic habitats, reducing differences among communities and thereby reducing aquatic biodiversity at national and regional scales (Winterbourn, 2004).

2.2 Regional distribution and habitat requirements of native fish

The Manawatu-Wanganui Region covers a vast land area totaling 22,215 km^2 and spans the west to east coasts of the central and lower North Island. The Region is dominated by four major river systems: Manawatu, Rangitikei Whangaehu and Whanganui. There are also a number of moderately-sized catchments (such as the Akitio, Turakina and Ohau Rivers) and many other smaller, coastal catchments.

A number of the Region's rivers have extensive estuarine ecosystems; however many have been highly modified over time. Despite widespread habitat degradation of the Lower Manawatu River catchment, the Manawatu Estuary has been listed as a RAMSAR site of international significance for migrant wading birds and there is significant community interest in the state of the estuarine ecosystem.

In addition to the major rivers, a unique system of coastal dune lakes is found on the west coast extending from the Horowhenua in the south to the northern Wanganui district. Many of these lake and coastal wetland systems were historically connected to the sea and to each other. Like the rivers and estuaries, these ecosystems have also been under tremendous pressure from population expansion, forestry and agricultural development.

The native freshwater fish fauna in the Manawatu-Wanganui Region comprises 19 species and approximately half a dozen estuarine and marine wanderers. This report focuses on the 19 species in the Region that inhabit freshwater for at least one phase in their life history. The distribution of each of these species is mapped below, relative to elevation above sea level. The lighter portion of the land area represents all river reaches <150 m above sea level and indicates habitat at which, given national distribution patterns (Jowett & Richardson, 1996), greatest fish diversity would be expected. All maps show presence/absence data only and do not indicate abundance or frequency of recorded species over time.

Location points have been extracted from the New Zealand National Freshwater Fish Database (NFFBD) from records collected between 1991 and 2006 in order to represent the relatively 'current' known distributions of fish in the Region. Species recommended for protection through the definition of Sites of Significance – Aquatic (SOS-A) (see Chapter 4) have the recommended reaches for SOS-A highlighted within the maps below.

Banded kokopu

Photo: Alton Perrie, Greater Wellington

Banded kokopu are a migratory galaxiid fish with reasonable climbing ability and good migratory drive. Like most galaxiid species they are largely nocturnal. They tend to occupy lower elevation streams draining coastal hills but can penetrate far inland in lower gradient river systems as has occurred in the Whanganui and Manawatu Rivers (Map 1).

Their basic habitat requirements include rivers and streams with forested riparian margins, abundant pools, backwaters and instream cover; however they have also been found to inhabit swamps at the base of lowland podocarp forest and acid, humic forest streams.

Adults take several years to mature, and spawning occurs on river margins with overhead cover amongst the litter and debris adjacent to pools or backwaters of the adult habitat. The timing of spawning is heavily influenced by the occurrence of autumnal river freshes that enable adult fish to reach riparian margins when flows are bank-full and can take place between early autumn to winter (Charteris *et al.,* 2003). Eggs develop amongst the litter (which takes 2-3 weeks) and hatch during freshes. Larval fish are washed downstream and ultimately out to sea by bank-full freshes where they undergo development into ‘whitebait’. The juvenile ‘whitebait’ return during October and move into rivers during mid-season whitebait runs.

The greatest threats to habitat and spawning success are loss of riparian indigenous vegetation, loss of bankside and instream cover and debris, reduction in pool and backwater habitat and control of bank-full freshes during autumn and early winter.

Giant kokopu

Photo: Stephen Moore, Landcare Research

Giant kokopu are diadromous galaxiid fish that do not have good climbing ability or migratory drive and tend to inhabit lowland, slow-flowing streams, lakes and wetlands. They are the largest galaxiid fish but are seldom seen due to their nocturnal nature. They tend not to coexist with trout and are negatively impacted by brown trout in particular (McDowall, 1990; McDowall, 2006).

Giant kokopu are not well distributed in the Region. Having only been found in two locations since 1991 (Map 2), they are one of the rarest fish species in the Region. Growth is slow and giant kokopu are long-lived, taking several years to reach maturity. Spawning is not well studied but it is thought to occur in the margins of adult habitat in late autumn to early winter. Juveniles are washed out to sea and return late in the whitebait run (early November) (McDowall, 2006).

Critical threats to habitat and spawning success are the loss of lowland forested streams, lakes and wetlands, loss of connectivity between adult habitat and the sea (fish barriers), reduction in instream and riparian cover, loss of pool habitat, presence of brown trout and flow regulation.

Due to their limited distribution (only two known sites), lack of lowland habitat, poor swimming and climbing ability and slow maturation, giant kokopu are at high risk of regional extinction.

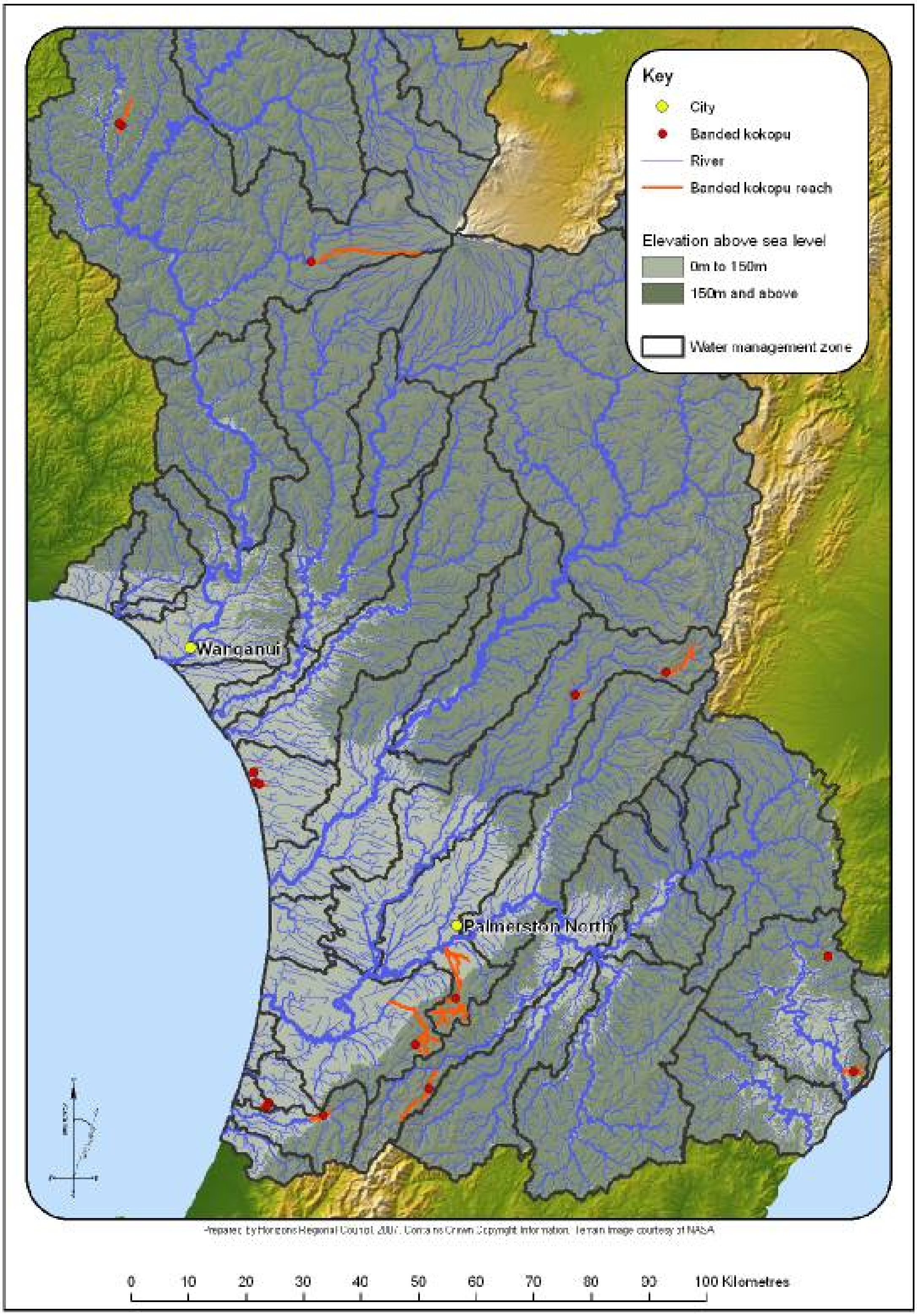
Shortjaw kokopu

Shortjaw kokopu are diadromous galaxiid fish with good climbing ability and inland penetration. The remaining populations in the region are distributed in hill country streams, especially in the Tararua Ranges, with some populations in tributaries of the Whanganui catchment (Map 3).

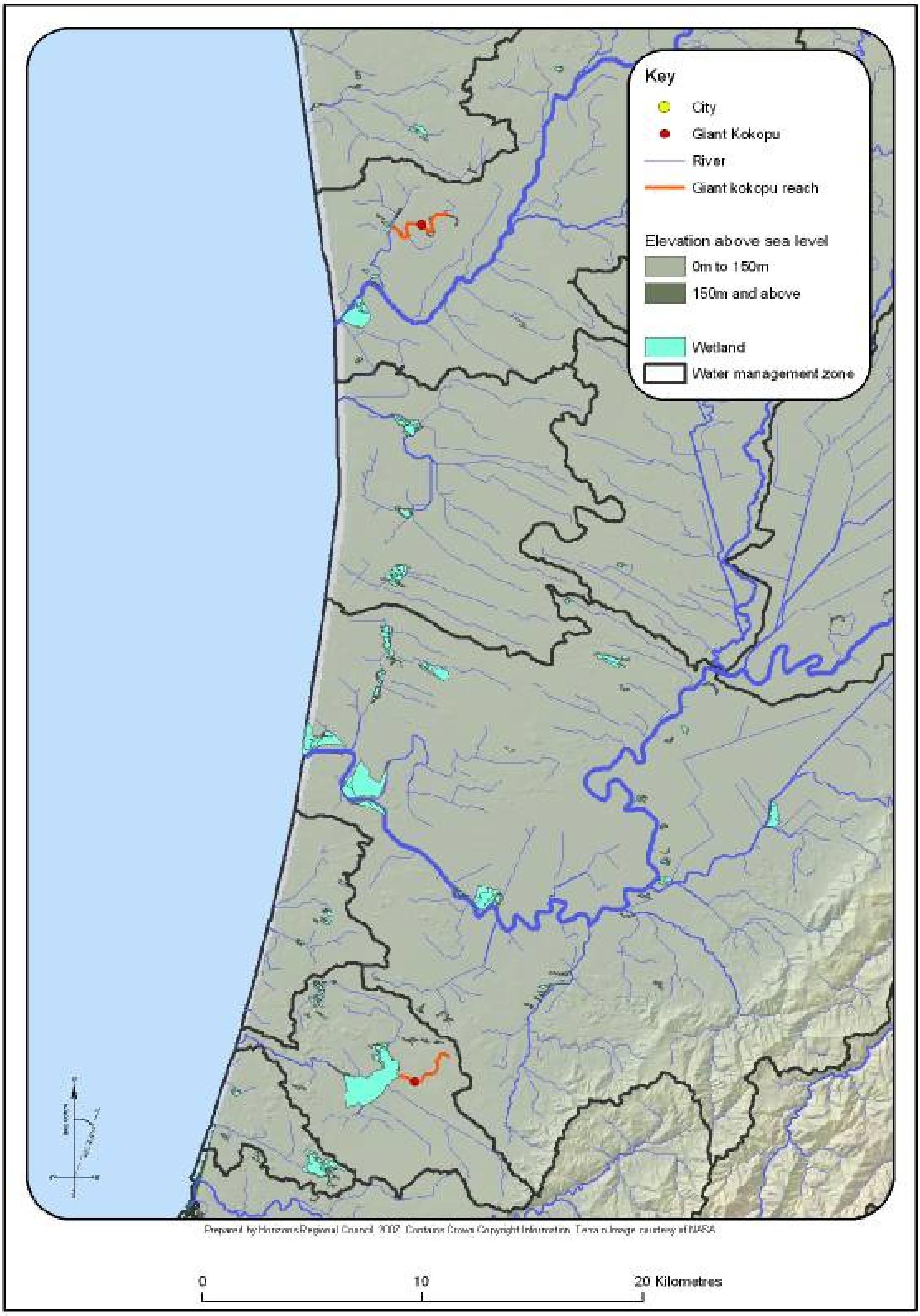
Shortjaw kokopu are also nocturnal and generally inhabit small streams in pools with thick over-hanging riparian vegetation and good instream cover. They feed on a mixture of benthic and terrestrial invertebrates (McDowall, 2006). Spawning occurs on riparian margins with good overhead cover, gravel, debris and leaf litter, alongside pools and backwaters in adult habitat, during bank-full freshes. Egg development occurs in damp spaces amongst the riparian litter and debris and may take 2-3 weeks (though eggs can remain viable in damp terrestrial environments for up to two months) (Charteris *et al.,* 2003). Larvae are washed out to sea, returning in whitebait runs in the spring.

The critical threats to adult habitat and spawning success are deforestation of streams, particularly loss of streams with podocarp/broadleaf forested margins (McDowall, 2006). Reductions in pool habitat, instream woody debris, control of overbank freshes and reductions in the quality of aquatic macroinvertebrates can negatively affect shortjaw kokopu.

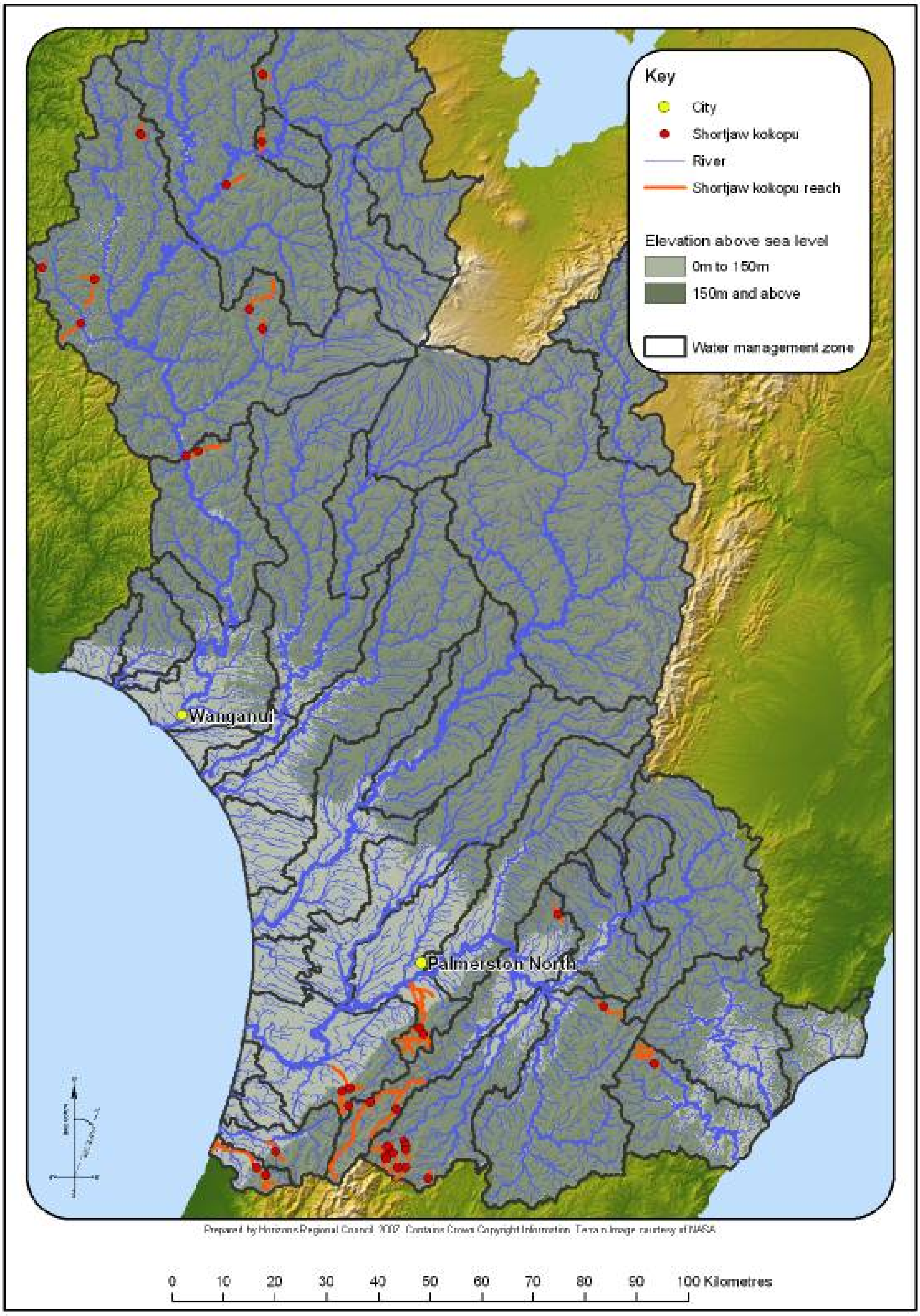
The limited distribution of shortjaw kokopu in the Region and the lack of any record of these fish in the Rangitikei River catchment leaves them vulnerable to further decline regionally.



Map 1. Recorded surveys of banded kokopu between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database) and recommended reaches for Sites of Significance – Aquatic in the Manawatu-Wanganui Region



Map 2. Recorded surveys of giant kokopu between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database) and recommended reaches for Sites of Significance – Aquatic in the Manawatu-Wanganui Region



Map 3. Recorded surveys of shortjaw kokopu between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database) and recommended reaches for Sites of Significance – Aquatic in the Manawatu-Wanganui Region

Dwarf galaxias

Photo: Mike Joy, Massey University

Dwarf galaxias are small, non-migratory fish that are distributed in sparse populations throughout central New Zealand. They are usually found in gravel or stony, stable foothill streams in riffle habitat with some rocky cover. They do not coexist well with brown trout and abundance is known to be enhanced above trout exclusion barriers (Hopkins, 1971; McDowall, 2006).

In the Manawatu-Wanganui Region dwarf galaxias are found in the south-eastern tributaries of the upper Manawatu River, the upper Mangahao River and a small number of upper Rangitikei River tributaries (Map 4). They feed mainly on benthic macroinvertebrates in streambed gravels.

Spawning can occur anywhere between September and January and fry can be seen in marginal shallows during this time and into late March. Spawning habitat is most likely within gravel substrates or under stones in adult habitat (Hopkins, 1971).

Critical threats to adult habitat, spawning success and juvenile recruitment include disturbance or excavation of riverbed and beach gravels, particularly during September to December (spawning and juvenile development phases), sedimentation of gravel substrate, loss of riffle and marginal slow-flowing waters in foothill streams, and the presence of high densities of brown trout.

Dwarf galaxias are at high risk of being lost from the native fish fauna without specific protection of their known habitats because of their sparse distribution in the Manawatu-Wanganui Region, their non-migratory nature, and lack of ability to recolonise after habitat disturbance.

Brown mudfish

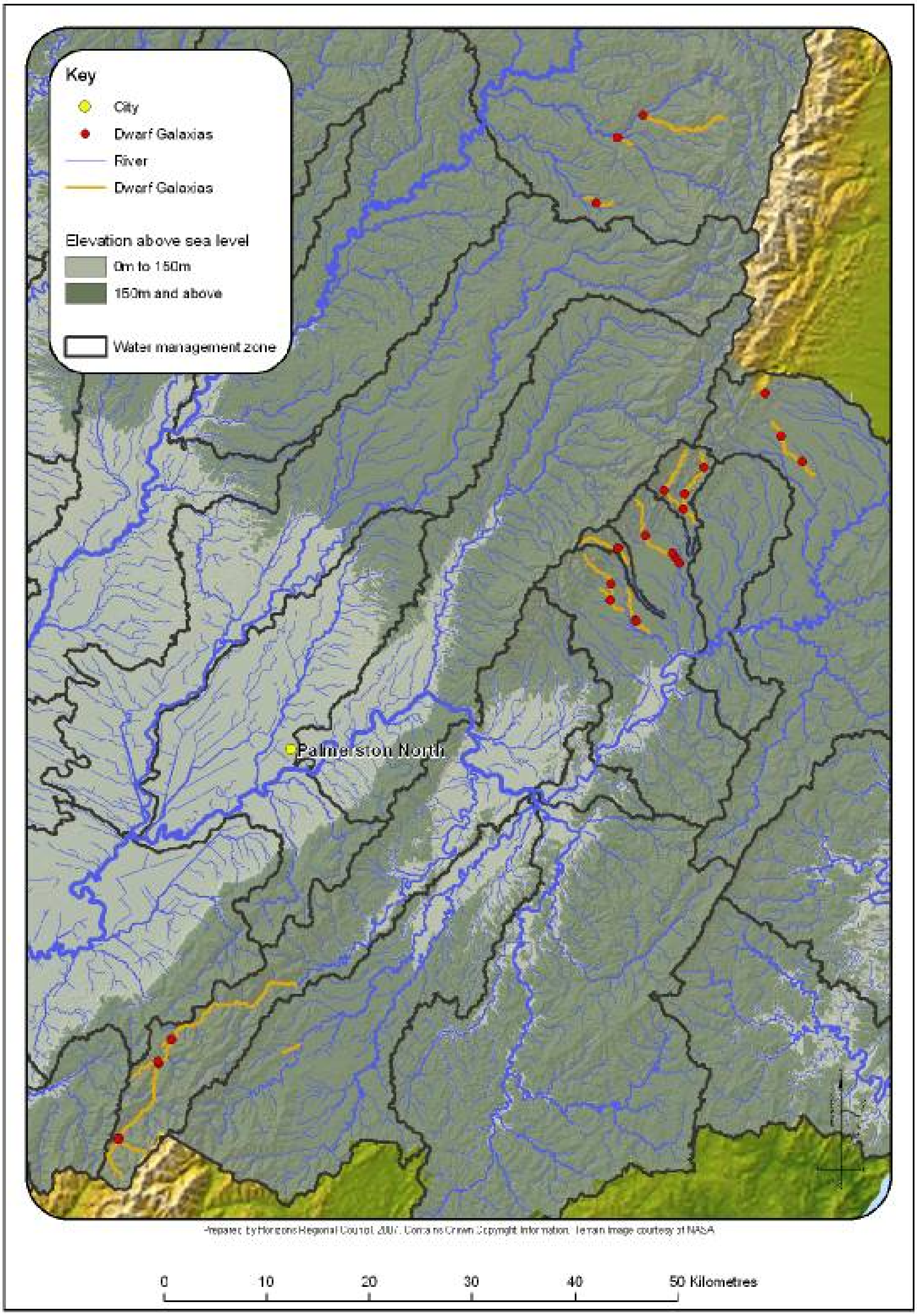
Brown mudfish are non-migratory, which poses significant risk to the remaining populations in the Region. They have only been recorded at eight sites (Map 5) and are monitored by the Department of Conservation at three sites under the Mudfish Recovery programme.

Mudfish inhabit wetland margins, weedy springs, boggy creeks and less frequently maintained drainage systems, mainly at low elevations. The adult fish are nocturnal forage feeders and have a high requirement for woody debris and cover, hiding amongst old root holes or under logs. During dry periods mudfish are known to burrow down into the substrate (hence the name mudfish) where they enter a state similar to aestivation. Mudfish spawn during the first wet period between February and April and lay eggs within old root holes or under woody debris.

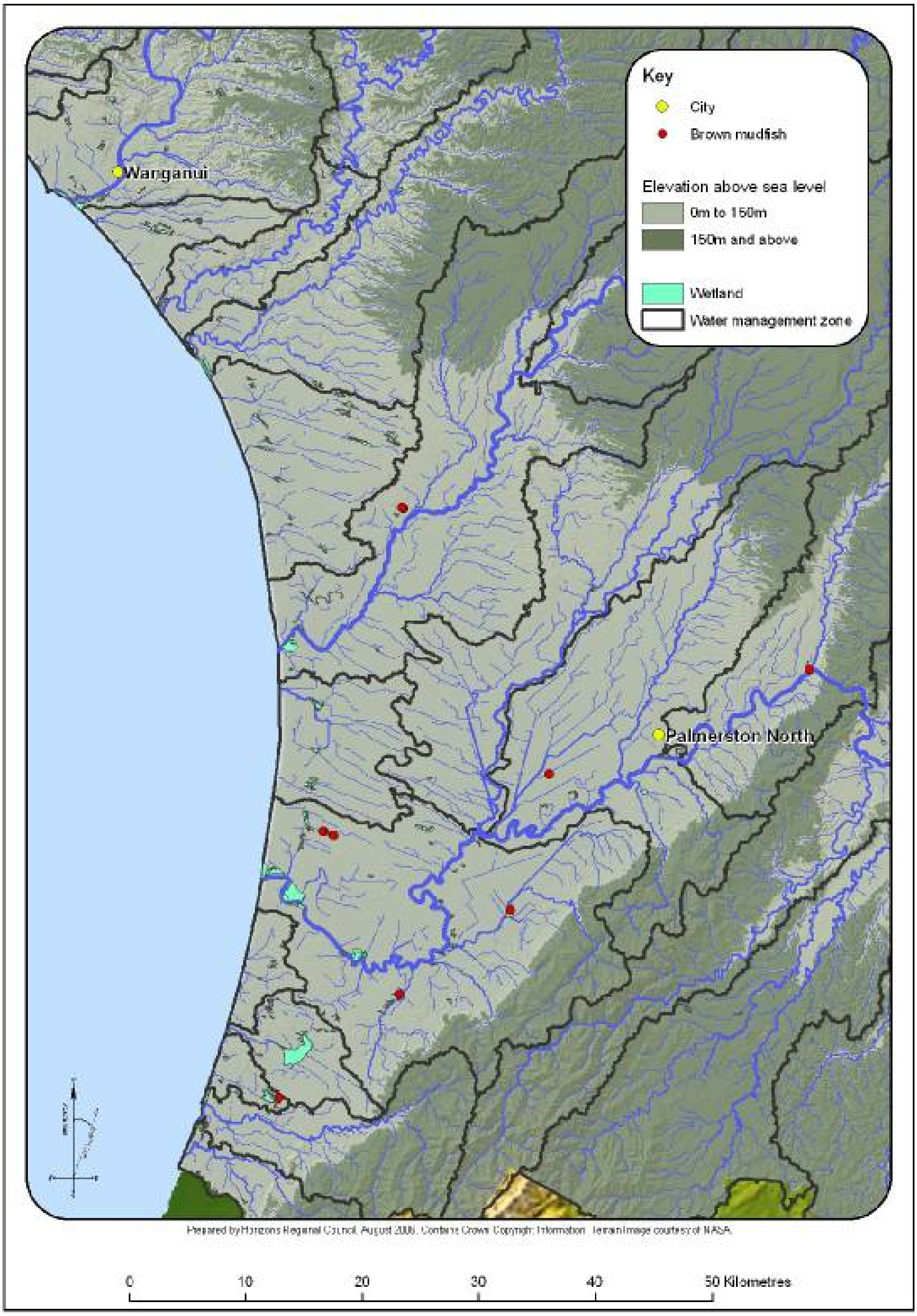
Critical threats to mudfish habitat and spawning and recruitment success are drain clearance (either mechanical or chemical) and loss of woody debris particularly during aestivation, spawning or juvenile development (February-May), lowering of wetland or drain water tables during autumn, drought and loss of wetland habitat in general.

Due to their cryptic nature, aestivation habit and isolated wetland populations, brown mudfish are vulnerable to regional extinction from adverse impacts to existing populations.

Photo: Ashhurst Domain Wetland, known mudfish site - Horizons Regional Council



Map 4. Recorded surveys of dwarf galaxias between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database) and recommended reaches for Sites of Significance – Aquatic in the Manawatu-Wanganui Region



Map 5. Recorded surveys of brown mudfish between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database) and recommended reaches for Sites of Significance – Aquatic in the Manawatu-Wanganui Region

Redfin bully

Redfin bullies are a migratory fish generally found at lower elevations (<150 m above sea level) but are occasionally found inland and have the capability to climb some barriers. They are one of the few regionally rare and threatened species that are still found in the Region’s lowland waterways (Map 6). Nationally, redfin bullies are declining due to habitat loss and water quality degradation (McDowall, 1990).

Spawning occurs between July and November on the underside of large rocks upstream of adult habitat; male fish defend nest sites. Hatching is stimulated by high flow events and juveniles are washed downstream to the sea returning to freshwater throughout the summer (from November). Redfin bullies are particularly susceptible to sedimentation of the streambed. The main adverse effect of sedimentation is on the availability of large invertebrates as food for adult fish.

Critical threats to adult habitat, spawning and recruitment success include physical disturbance of spawning sites during July–November, sedimentation of the streambed during spawning, and suspended sediment during upstream migration of juveniles.

Due to increased sedimentation and degrading water quality in many of the Region’s rivers, redfin bullies are vulnerable to regional decline.

Bluegill bully

The bluegill bully is the smallest of the New Zealand bullies and like most native fish is cryptic, possibly nocturnal and seldom seen. Typical habitats are swift-flowing rivers with gravel substrate and in other regions they commonly occur with torrentfish. However, there are only two recorded sites in the NFFDB between 1991 and 2006 (Map 7). Anecdotal evidence suggests that these fish are regionally rare because of biogeographical constraints in their juvenile population distribution (M. Joy *pers comm.*).

Bluegill bullies feed mainly on benthic invertebrates in rapids and riffles. Male and female adult fish appear to have somewhat separate populations, males most often inhabiting lower reaches of rivers and streams and females more commonly found in upper reaches. Spawning habitat is unknown but because of possible habitat separation between the sexes, fish of at least one sex may have to migrate for spawning. Fish passage throughout bluegill bully habitat may therefore be essential for successful reproduction (D. Rowe *pers comm*.).

Newly hatched larvae are most likely washed out to sea. Juvenile bluegill bullies are known to migrate into freshwaters during spring and autumn, suggesting a dual spawning season (McDowall, 1990).

Lamprey

Photo: Mike Joy, Massey University

Lamprey are migratory fish that are long-lived and very secretive. They have particular significance as a food source to Maori, and anecdotal evidence suggests lamprey were once abundant in all major rivers in the Region, but are seldom seen today. Only four records of adult lamprey exist in the NFFDB since 1991 (Map 8). Lamprey can penetrate far inland and have a reasonable ability to negotiate barriers, leaving the water to move across land in a similar manner to eels.

Adult lamprey spawn in forested headwater streams and larval ammocoetes spend 4-5 years before metamorphosis into macrophthalmia which then migrate to sea where they live and mature for 3-4 years. During the ammocoete stage they are filter feeders, consuming aquatic microorganisms and inhabiting shallow muddy or sandy backwaters along river margins. They migrate to sea from late winter to early spring in the early hours of the night, mid-river, during freshes.

Having matured at sea, macrophthalmia return to freshwater from late winter to early spring as adult lamprey. Inward migration is greatest at times of elevated flow and turbidity. Adults do not feed as they slowly migrate for up to 16 months into small, upland streams to spawn. These migrations occur at night during dark phases of the moon. During the day adult lamprey hide beneath overhanging banks and in holes. Spawning occurs in shallow nests in streambed gravels. It is likely adults die after spawning.

Due to their distinct habitat utilisation at different life stages, protection of lamprey habitat is difficult. However, the sites at which lamprey have been recorded are small hill country streams and the lamprey are likely to have been spawning adults.

Critical threats to lamprey include loss of upland riparian vegetation, loss of riparian and instream cover in all waterways, loss of slow-flowing backwaters, physical disturbance of spawning streams and closure of flood gates during spawning migrations.

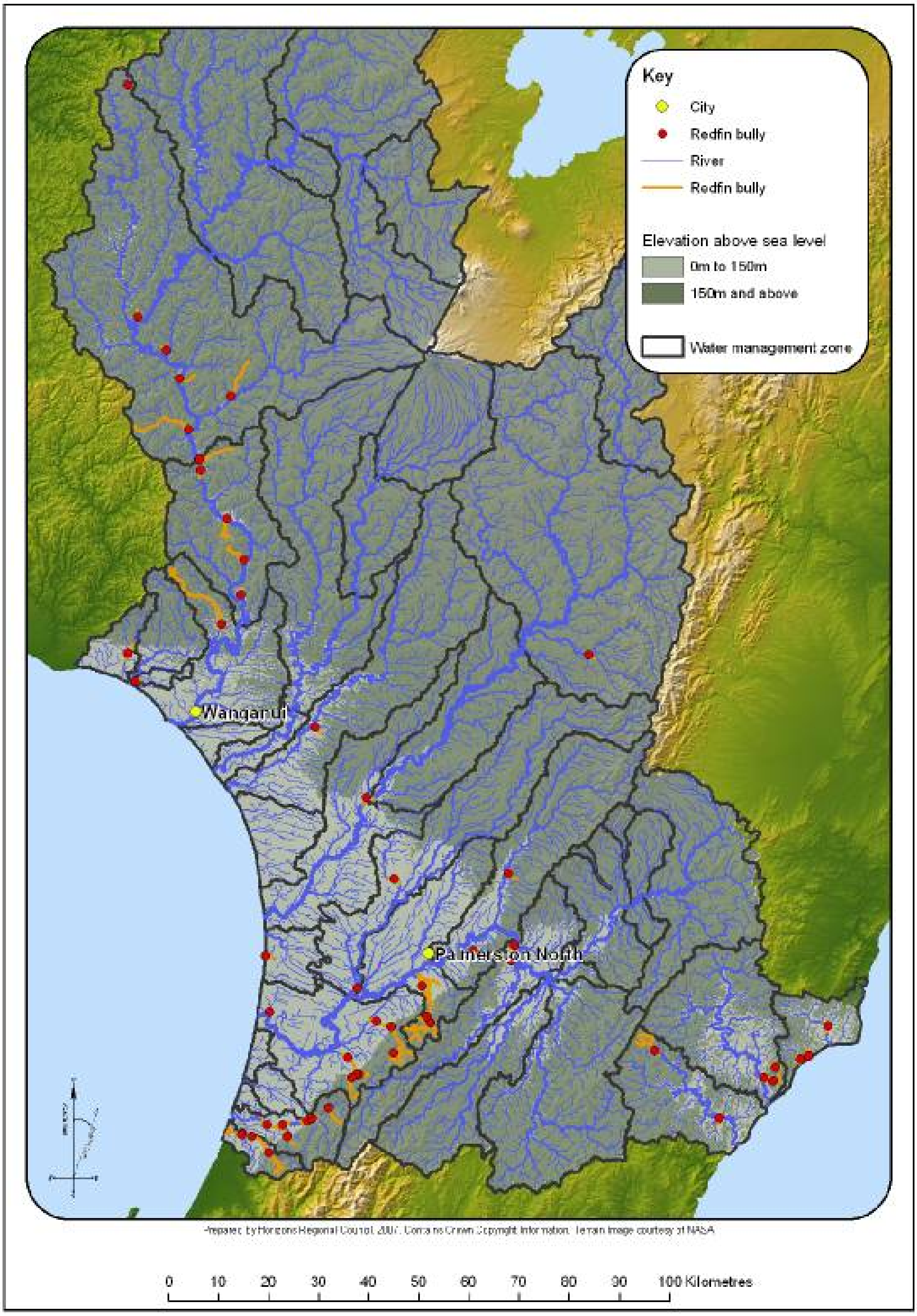
Koaro

Photo: Stephen Moore, Landcare Research

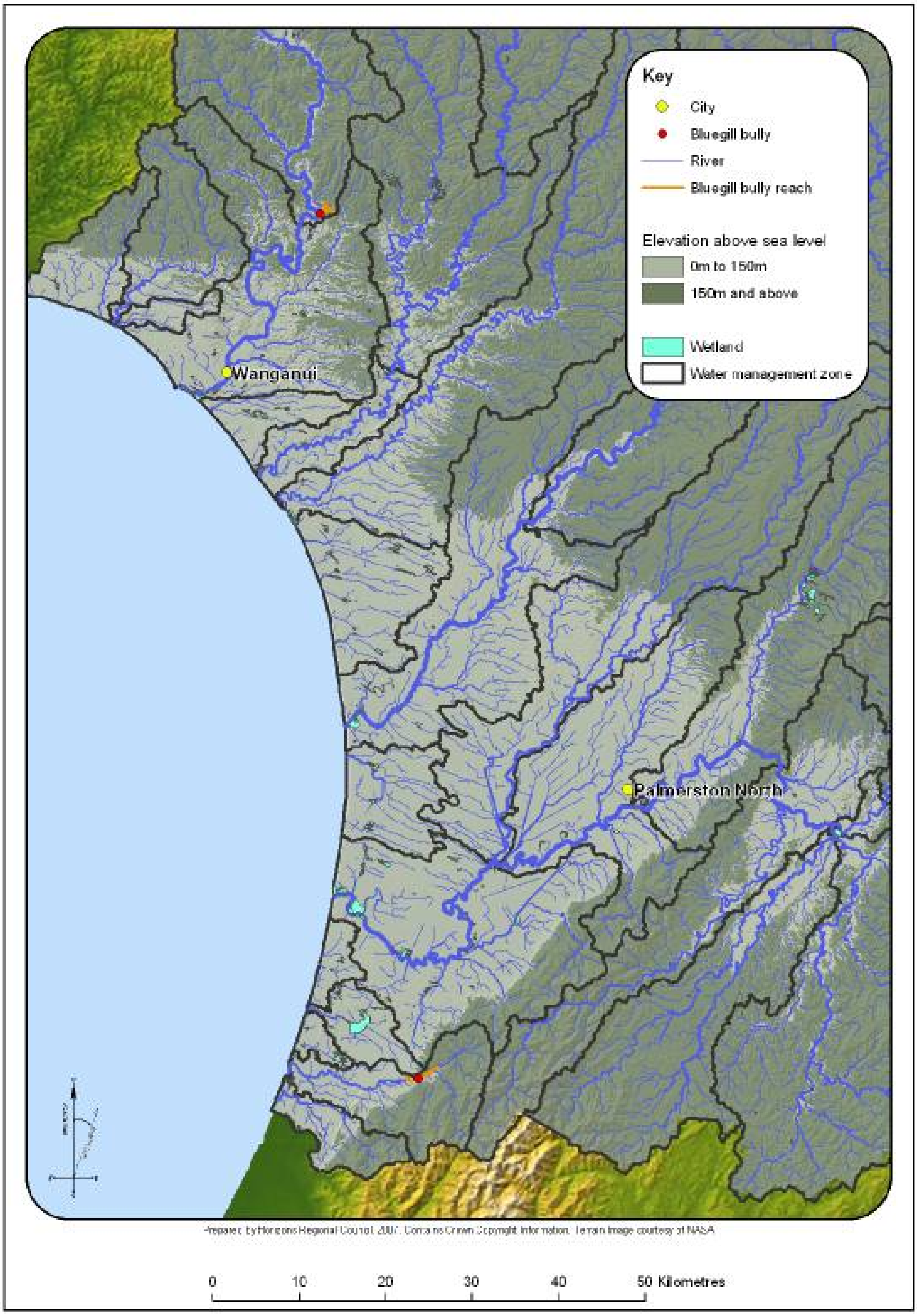
Koaro probably have the best climbing ability of all the diadromous Galaxiid fish. They penetrate well inland and inhabit steep gully streams with heavily forested margins. Their distribution in the Manawatu-Wanganui Region tends to be in hill country streams within forest park boundaries (Map 9). Nationally, koaro are the second most common species in the whitebait catch, although this has not been verified for this Region. Further, given the low occurrence of this species they may not be as proportionately significant in whitebait runs in the Manawatu-Wanganui Region.

The critical habitat requirements of koaro are cold, clear, high velocity, heavily vegetated, upland streams with good instream cover and bouldery substrate. Spawning occurs in autumn to early winter, in the marginal gravels of adult habitat during fresh events. Juveniles are washed out to sea, returning in early whitebait runs in September and October. Instream whitebait migration occurs on the tail of freshes while the water is still turbid.

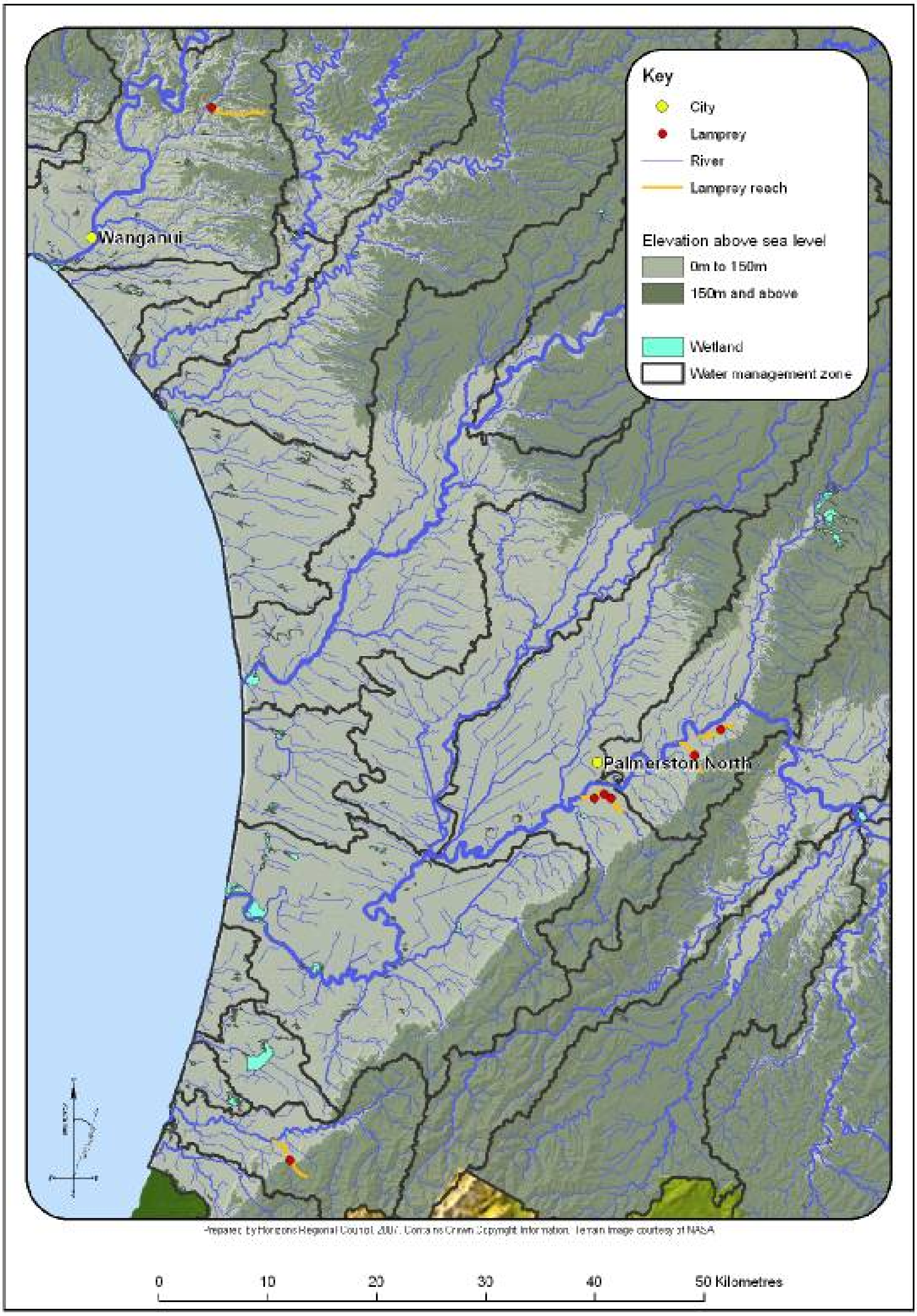
Critical threats to adult habitat, spawning and recruitment success include deforestation and the opening up of vegetated, hill country gully streams; low pH and high water temperature during upstream juvenile migration; flow regulation of turbulent upland streams, and possibly the timing of lowland flood gate operation during the tails of spring floods.



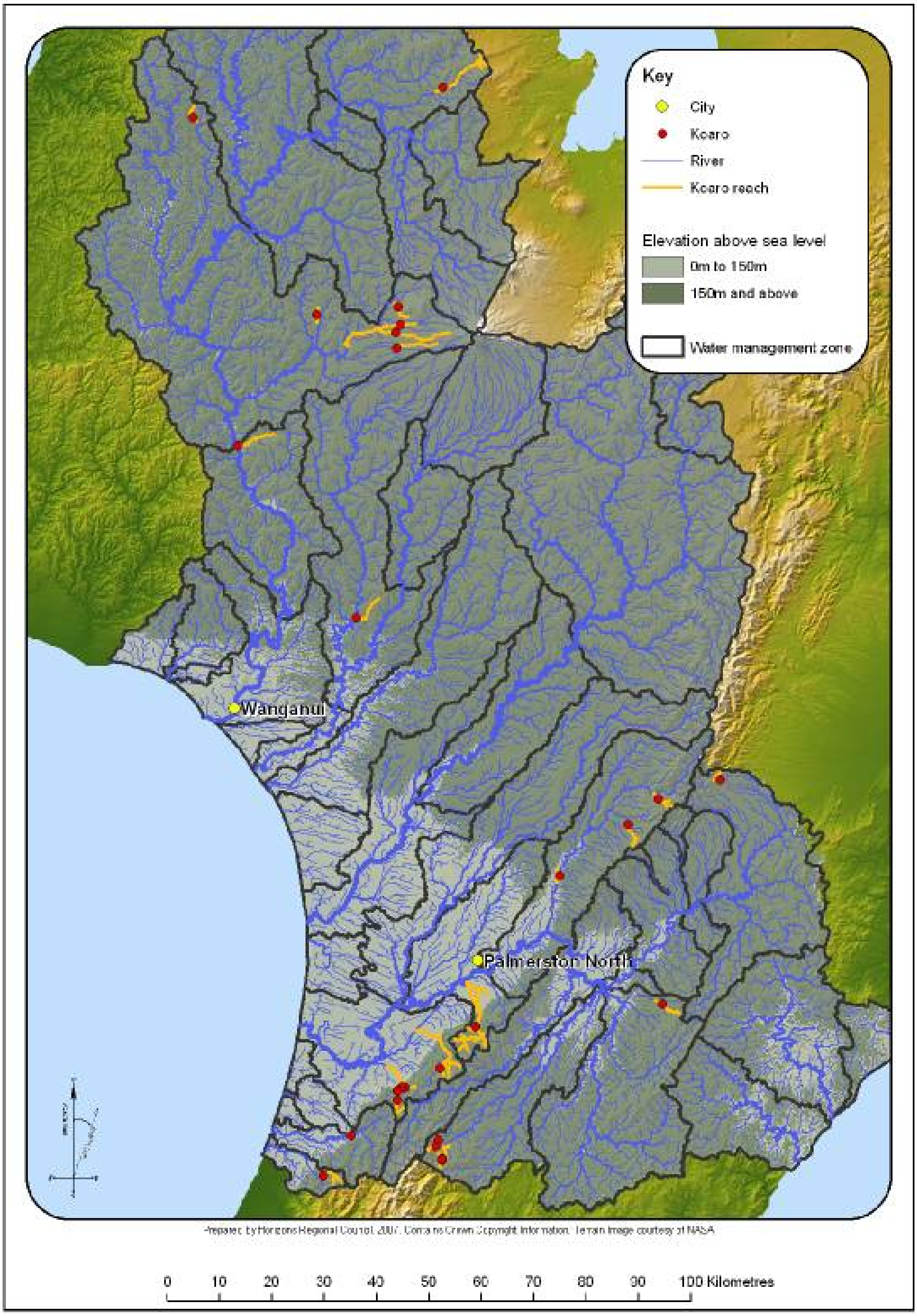
Map 6. Recorded surveys of redfin bullies between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database) and recommended reaches for Sites of Significance – Aquatic in the Manawatu-Wanganui Region



Map 7. Recorded surveys of bluegill bullies between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database) and recommended reaches for Sites of Significance – Aquatic in the Manawatu-Wanganui Region



Map 8. Recorded surveys of lamprey between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database) and recommended reaches for Sites of Significance – Aquatic in the Manawatu-Wanganui Region



Map 9. Recorded surveys of koaro between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database) and recommended reaches for Sites of Significance – Aquatic in the Manawatu-Wanganui Region

Non-migratory bullies

The two species of non-migratory bullies in the Region (Cran's and upland bullies) are widely distributed throughout the mid to upper elevation waterways of the Region (Map 10). Often these two species are lumped together in fish studies due to their non-migratory habit, similar habitat requirements (McDowall, 1990), and the fact that differences in distribution are related more to biogeography than habitat preference (Joy & Death, 2002).

Because these species do not require access to the sea as part of their life history, inhabiting mid to upper reaches of rivers and streams, they tend to comprise an integral aspect of the fish community at sites greater than 150 m above sea level.

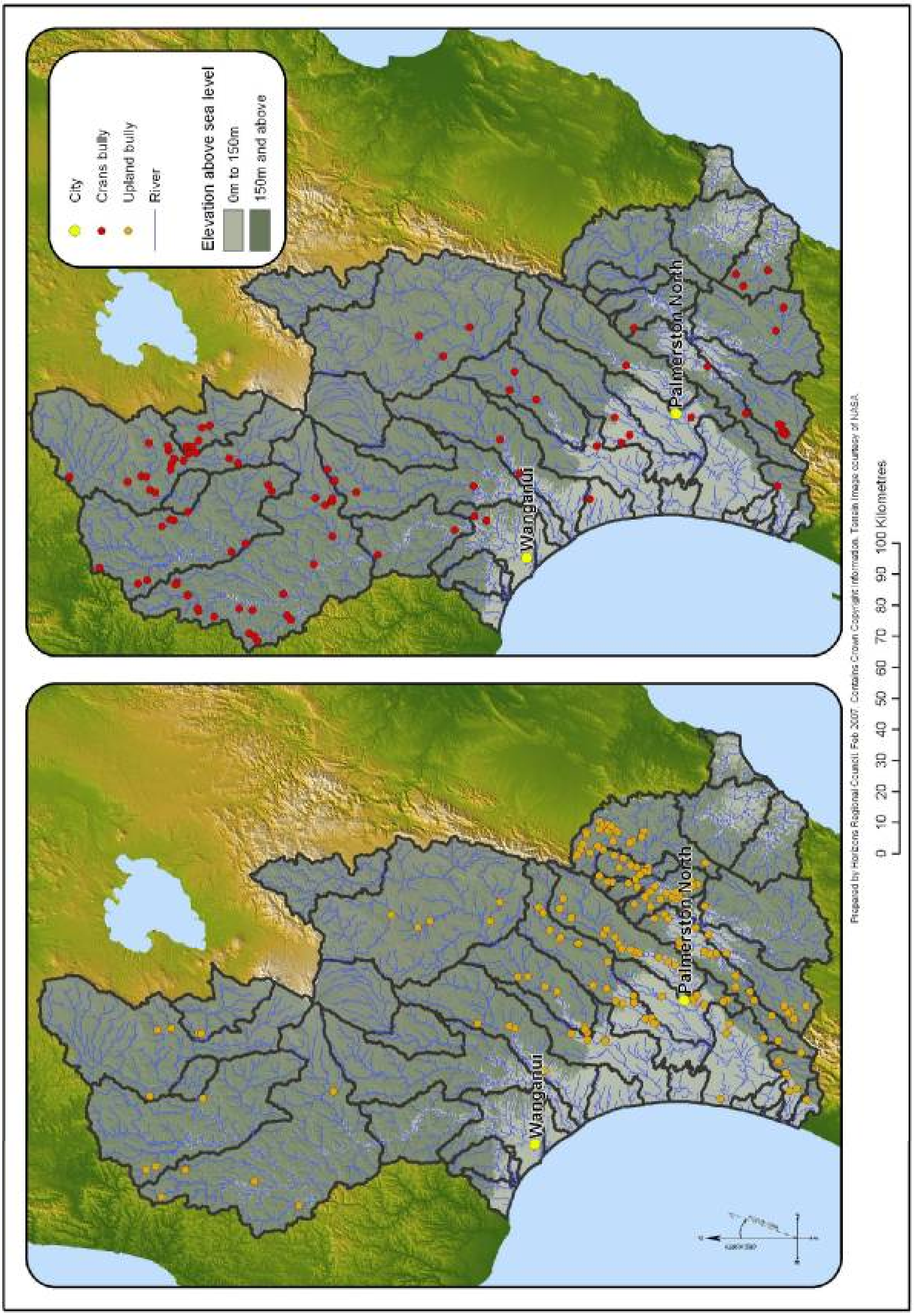
Common bully

The migratory bully fauna comprises bluegill, giant and common bullies. Common bullies are most abundant and have the widest distribution in the Region; they tend to be found in lower elevation rivers and streams due to their inability to climb barriers or negotiate swift flows (Map 11). They are relatively tolerant to higher water temperatures and semi-degraded water quality. Often in poor quality sites common bullies are the only fish species present. Regionally they are found within the 150 m above sea level waterways, including far inland on the low gradient Whanganui River system.

Giant bully

Giant bullies are difficult to survey using electro fishing because they tend to inhabit deep pools and high conductivity coastal and estuarine waterways. They are cryptic fish and tend to utilise instream cover. There are very few records of this species in surveys between 1991 and 2006 (Map 12).

Further work is needed to identify whether giant bullies are rare (because of biogeographical constraints or poor survey success) or threatened (by human activities) and to define their critical habitat requirements. Future consideration should be given to designating giant bullies as significant native fish because of the regional rarity of this species.



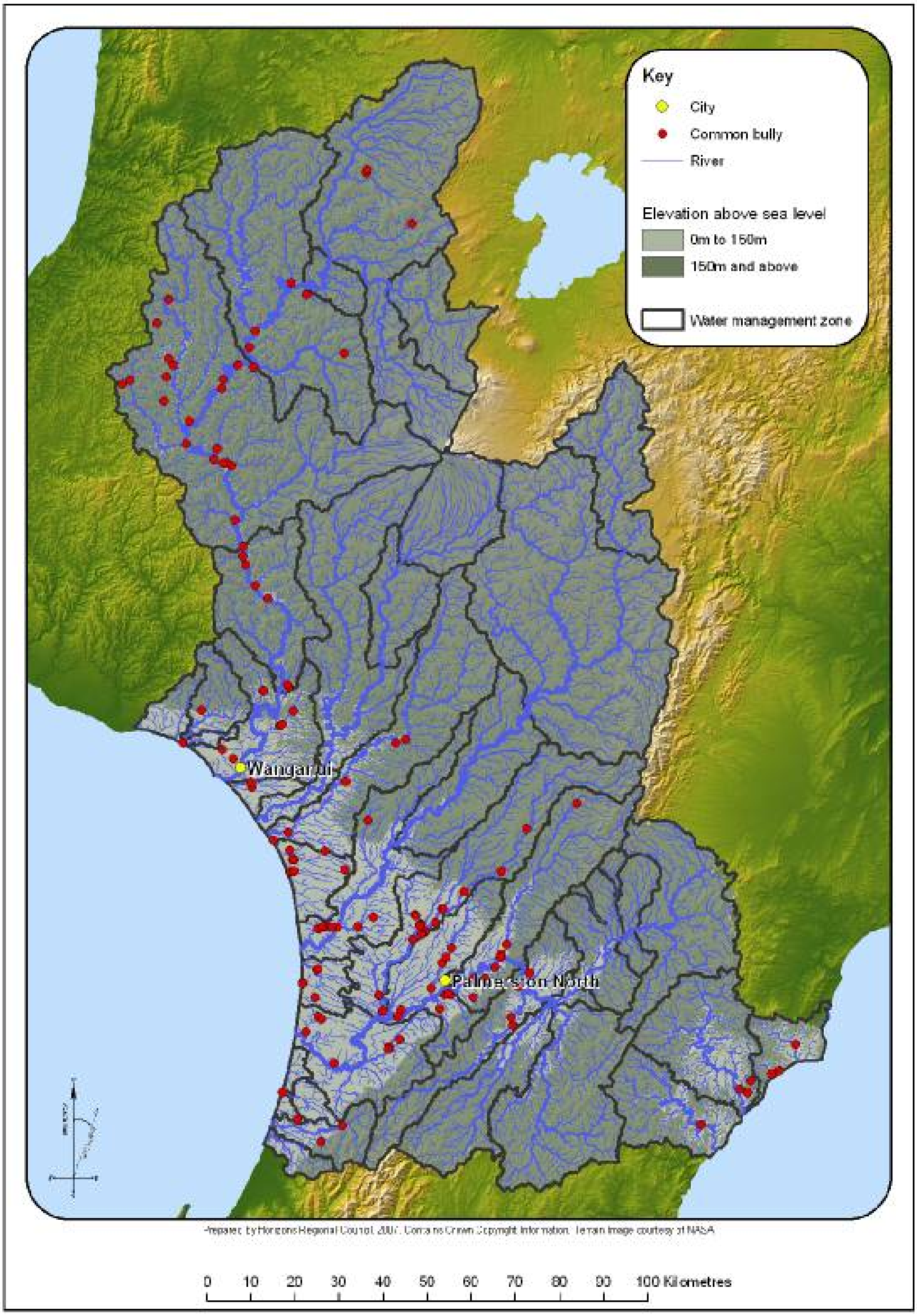
Map 10. Distribution of non-migratory bullies (Cran's and upland) in the Manawatu-Wanganui Region between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database)

Black flounder

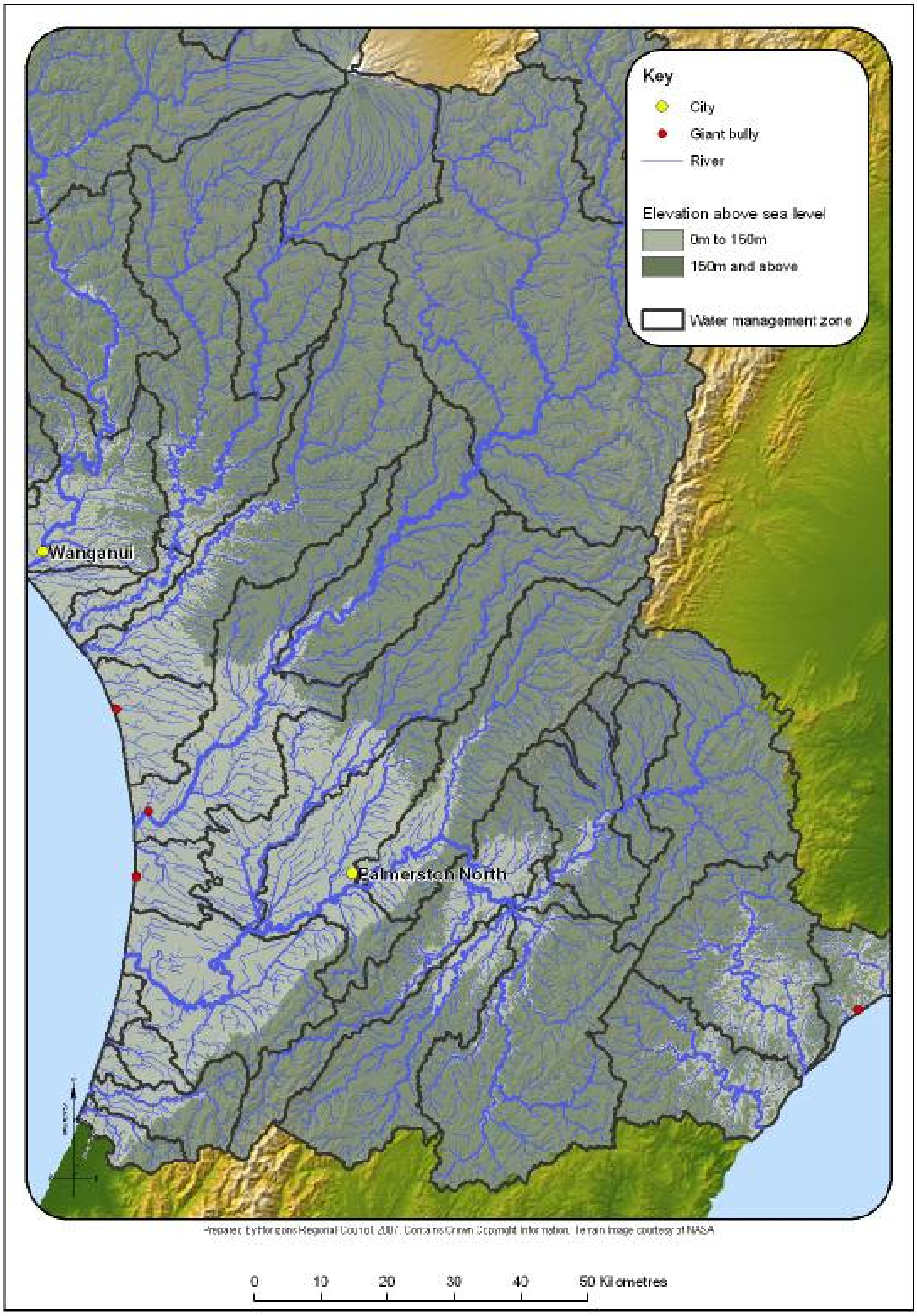
Black flounder are another little-known species in the Region. They have been found at two sites between 1991 and 2006 according to the NFFDB; one in the Turakina River catchment and the other in a tributary of the Rangitikei River (Map 13). Adult black flounder are most commonly found in the lower and estuarine reaches of rivers; however they often venture far inland into freshwaters and can penetrate long distances upstream through swift, gravely rapids (McDowall, 1990). They have been known to venture as far inland as the Manawatu Gorge and the Ohura River in the Whanganui catchment.

Little is known about the spawning habits or breeding biology of black flounder other than they are a diadromous fish, which may spawn at sea with juveniles returning to freshwater after metamorphosis (McDowall, 1990). The absence of winter records for adult fish in the NFFDB supports the suggestion that they make a spawning migration into marine waters prior to the return of juveniles in the spring.

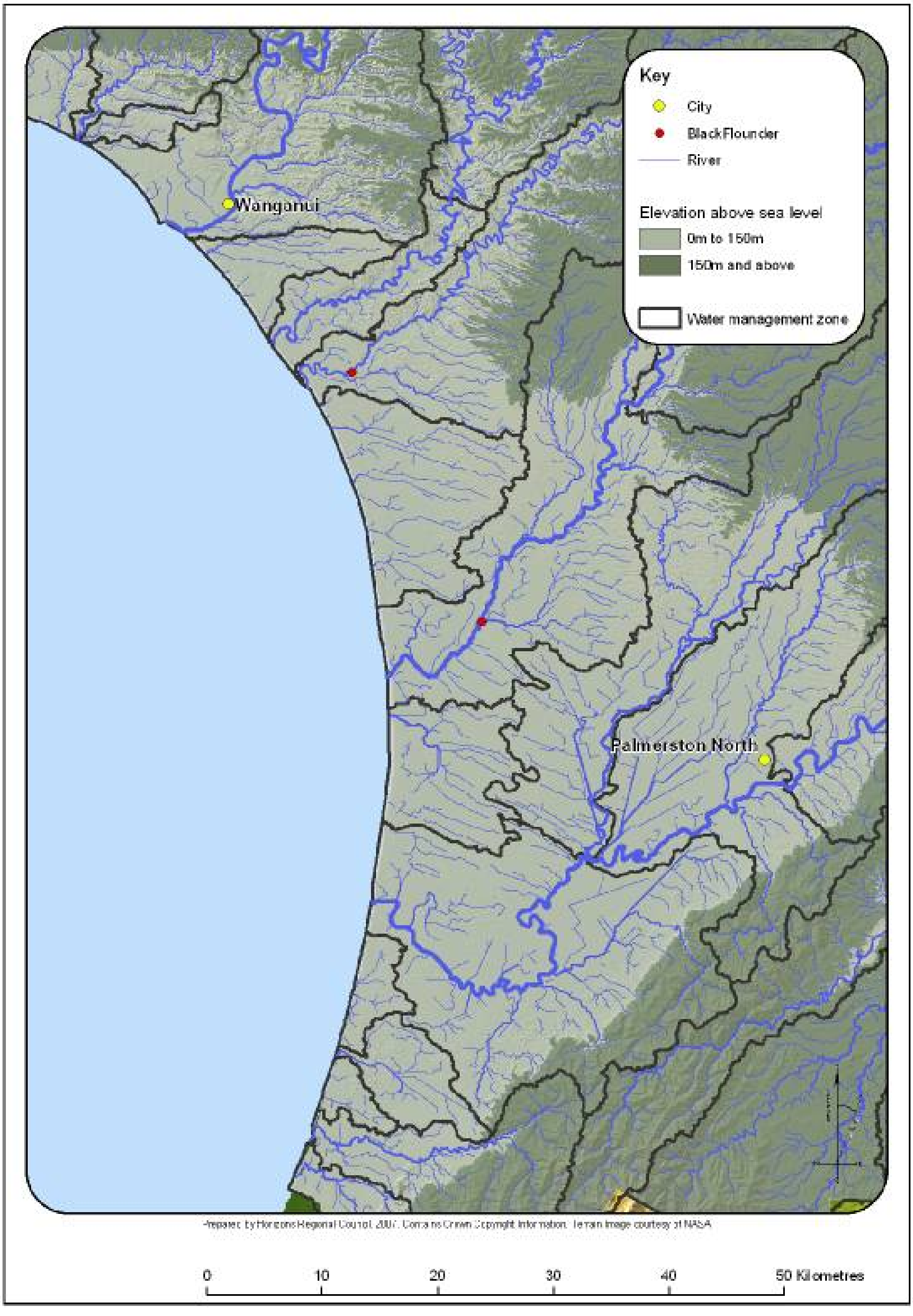
Although records are rare for this fish over the last 15 years, like the giant bully their habitat preferences do not lend themselves to ease of survey or identification, especially in the lower reaches and estuaries of larger river systems. Further work to identify the threat status and critical habitat requirements of this species (and other coastal and estuarine fishes) is required. Again, future consideration, in the light of better knowledge, should be given to whether black flounder should be considered a regionally significant aquatic species.



Map 11. Distribution of common bully in the Manawatu-Wanganui Region between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database)



Map 12. Distribution of giant bully in the Manawatu-Wanganui Region between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database)



Map 13. Distribution of black flounder in the Manawatu-Wanganui Region between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database)

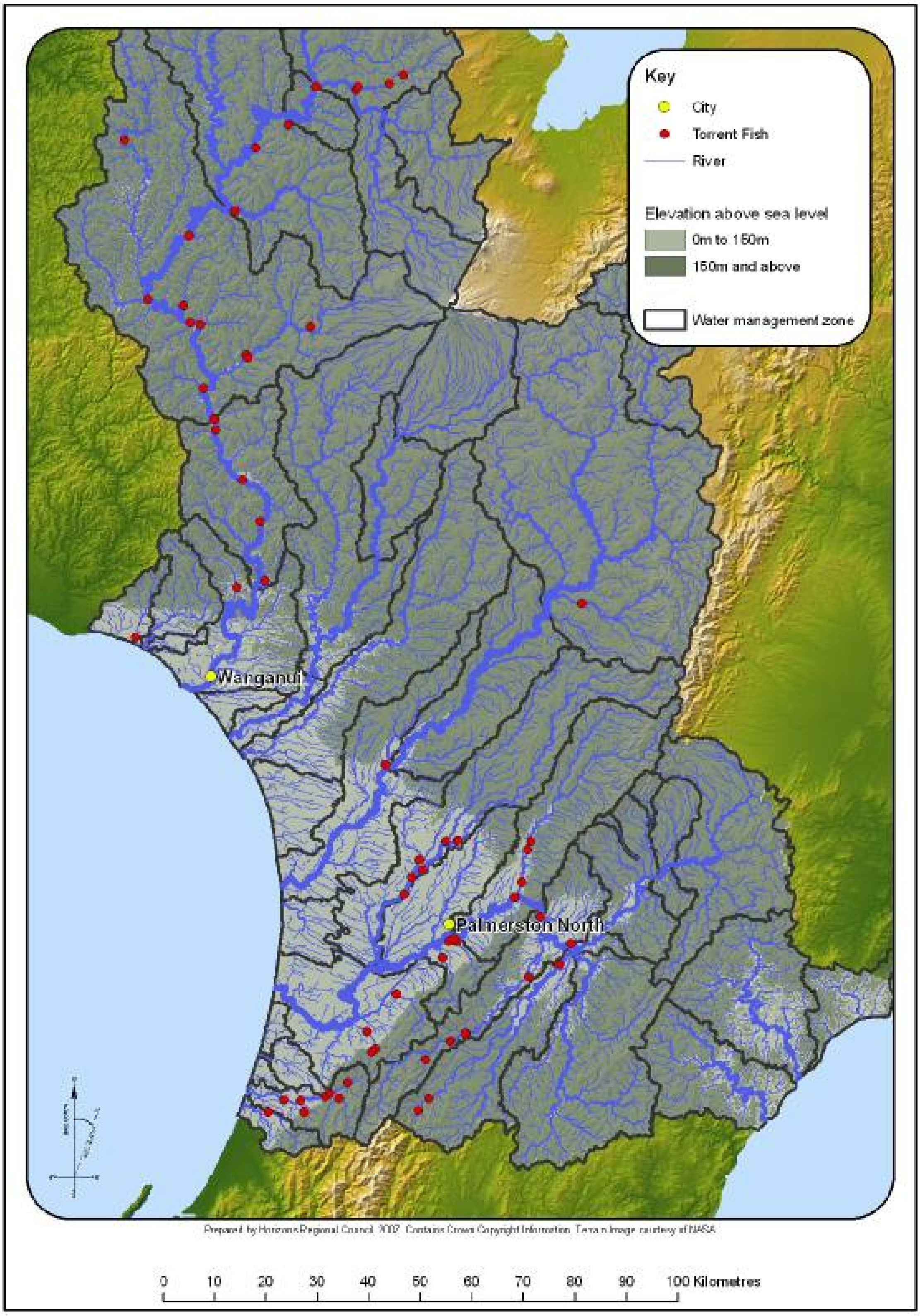
Torrentfish

Torrentfish are diadromous migrants that move long distances up and down rivers throughout their lives. Due to their swift-water swimming ability they tend to inhabit the mid to upper reaches of fast-flowing rivers and streams and are able to negotiate their way upstream through large rapids (such as the Manawatu Gorge). As their name suggests they are often found in rapids or 'torrents' and their regional distribution is closely associated with swift-flowing, open rivers with gravel or bouldery substrate (Map 15).

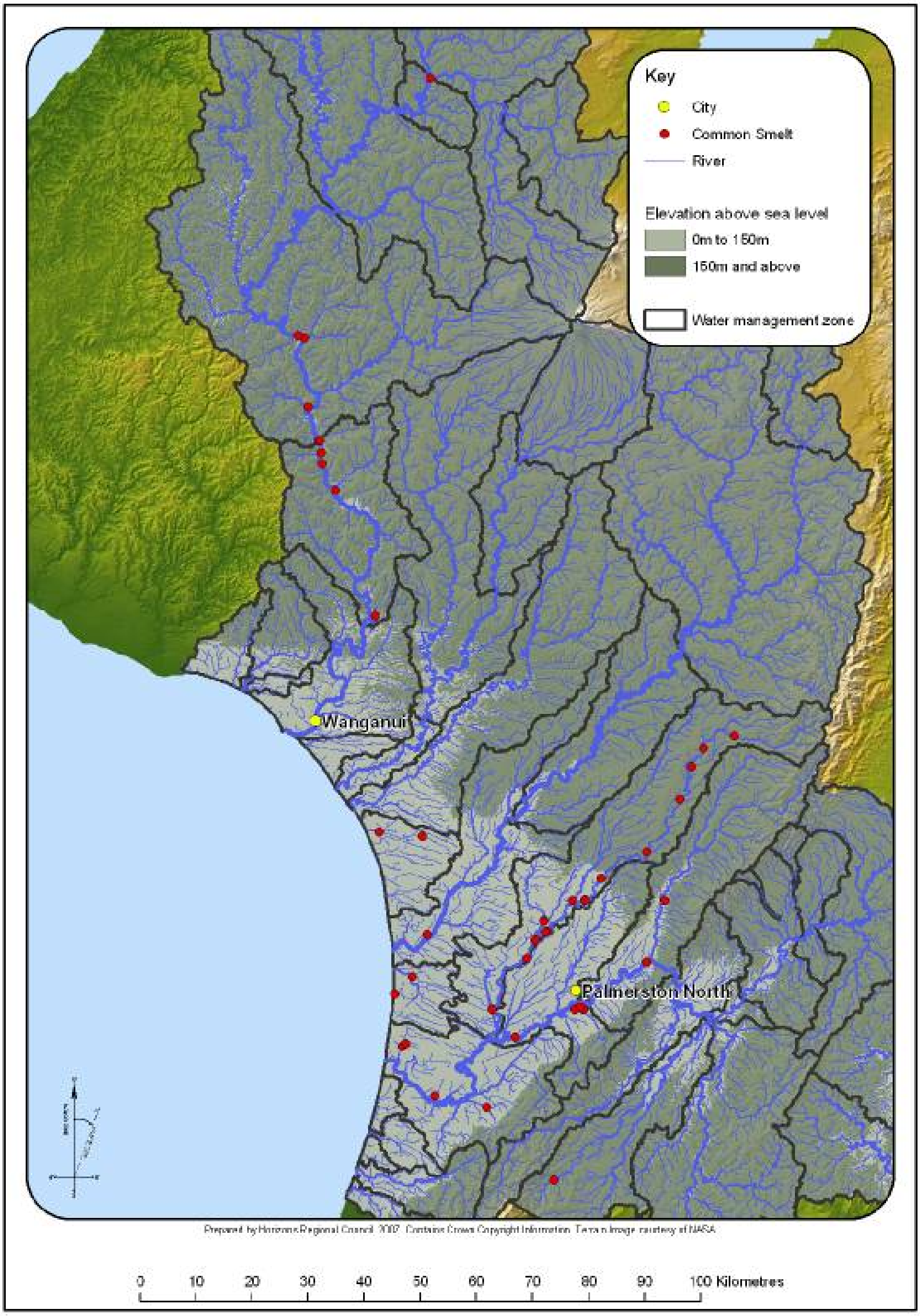
Adult torrentfish spawning habitat is unknown but is likely to be in substrate gravels. Males generally occur in the lower reaches of rivers and females upstream, so a spawning migration is clearly required for at least one of the sexes. Spawning can occur several times in one season from late spring to early autumn, peaking in February. Larvae are washed downstream after hatching and return to estuaries to migrate instream in spring and autumn.

Common smelt

Like inanga, common smelt shoal in low elevation coastal rivers, estuaries, lakes and sea waters. They prefer gentle flows and can form lake-locked populations. Adult smelt migrate upstream to spawn on submerged sand bars in large shoals from late spring to autumn and die after spawning. Common smelt are distributed throughout the lowland lakes and rivers of the Manawatu-Wanganui Region (Map 15).



Map 14. Distribution of torrentfish in the Manawatu-Wanganui Region between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database)



Map 15. Distribution of common smelt in the Manawatu-Wanganui Region between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database)

Inanga

Photo: Stephen Moore, Landcare Research

Juvenile inanga inward migration (whitebait run) occurs during the first river freshes of spring. Adult inanga have a shoaling habit which is unusual in galaxiid fishes. They are generally found in low elevation rivers and streams (<20 m above sea level) close to the sea (<10 km inland) (Map 16), however inanga have been found far up the Oroua and Whanganui River catchments, outside their known inland range (Baker *et al.,* 2003).

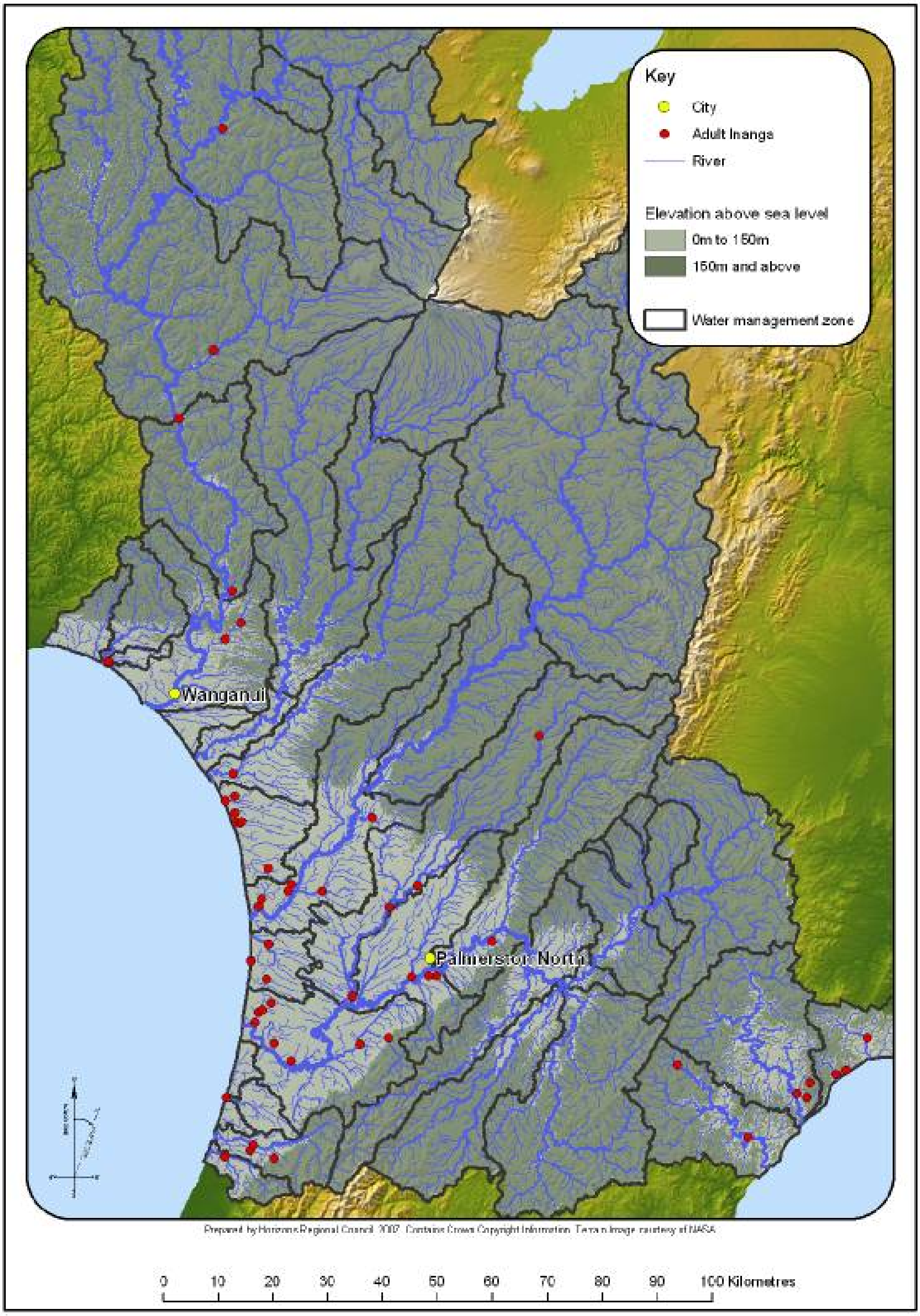
Records of adult inanga in the Manawatu-Wanganui Region from the NFFDB show only 60 records out of the 892 between 1991 and 2006. Loss of lowland, coastal habitat with slow-flowing pools and backwaters, through river channelisation and wetland drainage, in combination with the presence of downstream fish barriers, are likely to be the greatest contributing factors causing decline in inanga throughout the Region (Richardson & Taylor, 2002).

Further information on the critical habitat requirements and distribution of inanga spawning in the Region can be found below (Chapter 6). Inanga spawning habitat is recognised as a separate value from the SOS-A value within the One Plan because of the physical separation between spawning and adult fish habitat requirements.

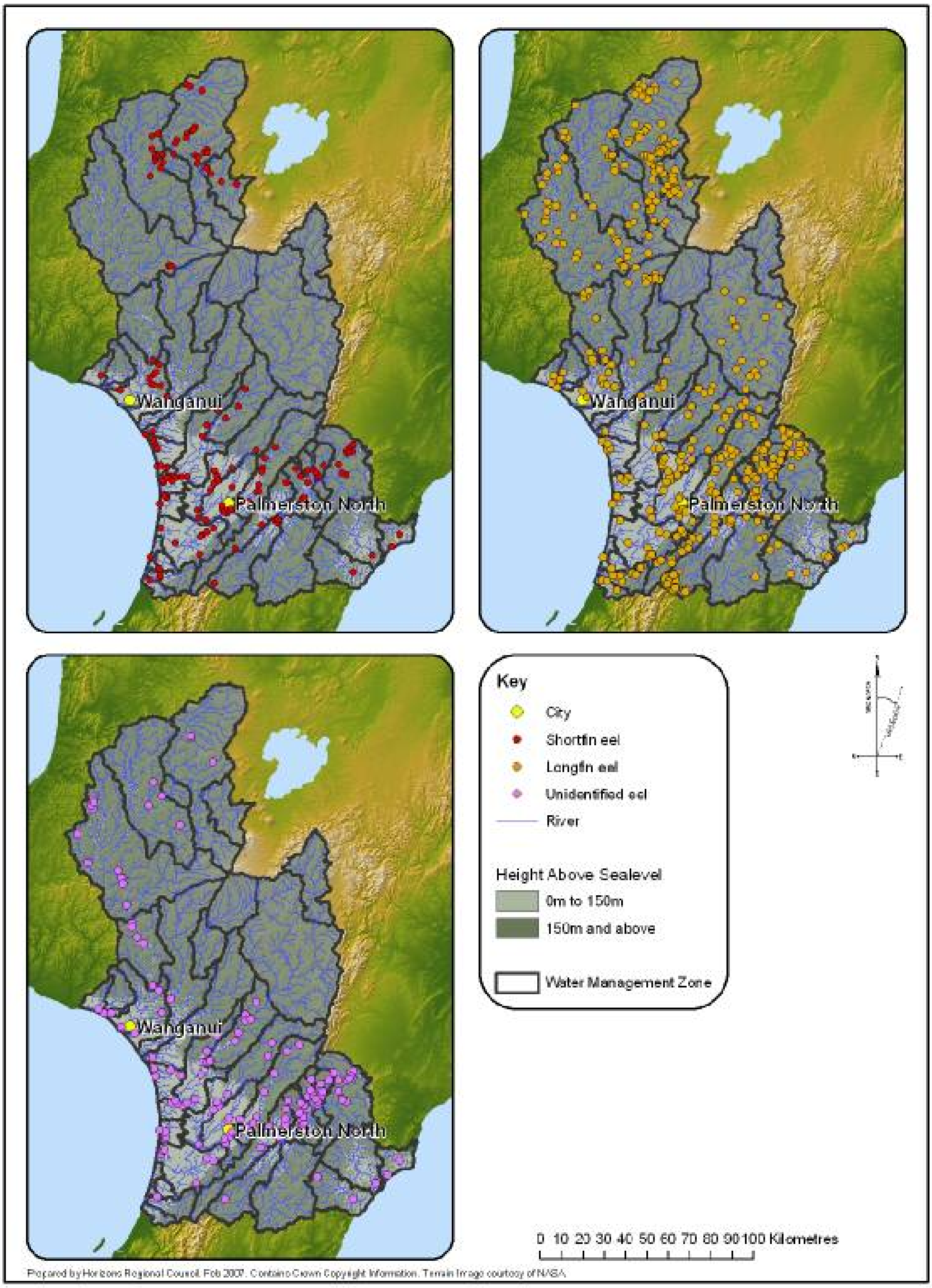
Eels

Longfin eels are endemic to New Zealand and along with the shortfin eel they comprise an important component of aquatic biodiversity. Under the life-supporting capacity value (see Ausseil & Clark, 2007a) which applies to all waterbodies in the Region, both long and shortfin eel species will be afforded the same environmental bottom line protection by way of water quality standards under the One Plan.

Apart from large hydroelectric and water supply dams which can prevent eel access to extensive areas of riverine habitat above them, the harvest of eels is the main threat to eel populations in New Zealand and is likely to have the greatest population impact on these fish as harvested eels will never mature to breed. Statutory control over the harvest of eels is not within the responsibilities of the Regional Council and therefore Horizons has little influence over the protection of longfin eels from this threat. Other adverse impacts can include the loss of instream cover in pools, severe water quality degradation and high summer temperatures (McDowall, 1990).



Map 16. Distribution of adult inanga in the Manawatu-Wanganui Region between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database)



Map 17. Distribution of eels in the Manawatu-Wanganui Region between 1991 and 2006 (*Source:* New Zealand National Freshwater Fish Database)

2.3 Characteristics of the freshwater fish fauna

Native fish exhibit a number of interesting features in their behavioural and life-history characteristics including diadromy (migration between freshwater and marine environments) and climbing ability. Many native species are nocturnal or cryptic (Table 1), meaning they either only come out at night or are exceptionally retiring, usually well-camouflaged and seldom seen. These species have a high requirement for instream cover and overhanging riparian shelter and shade.

Table 1. Characteristics of native freshwater fish in the Manawatu-Wanganui Region

Species	Cryptic	Riparian spawners	Ability to penetrate upstream	Diadromous (migratory)
giant kokopu (*Galaxias argenteus*)	ü	ü	X	ü
inanga (*Galaxias maculatus*)	–	ü	X	ü
koaro (*Galaxias brevipinnis*)	ü	ü	ü	ü
shortjaw kokopu (*Galaxias postvectis*)	ü	ü	ü	ü
banded kokopu (*Galaxias fasciatus*)	ü	ü	ü	ü
brown mudfish (*Neochanna apoda*)	ü	–	X	X
shortfin eel (*Anguilla australis*)	ü	X	ü	ü
longfin eel *(Anguilla dieffenbachii)*	ü	X	ü	ü
lamprey *(Geotria australis)*	ü	X	ü	ü
dwarf galaxias (*Galaxias divergens*)	ü	X	X	X
bluegill bully (*Gobiomorphus hubbsi*)	ü	X	ü	ü
giant bully (*Gobiomorphus gobioides*)	ü	–	X	ü
Cran's bully (*Gobiomorphus basalis*)	ü	X	X	X
upland bully (*Gobiomorphus breviceps*)	ü	X	X	X
common bully (*Gobiomorphus cotidianus*)	ü	X	X	ü
redfin bully (*Gobiomorphus huttoni*)	ü	X	ü	ü
black flounder (*Rhombosolea retiaria*)	ü	X	ü	ü
common smelt (*Retropinna retropinna*)	–	X	X	ü
torrentfish (*Cheimarrichthys fosteri*)	ü	–	ü	ü

Note: (ü) = species definitely possesses this characteristic;
(X) = species definitely does not possess this characteristic; and
(–) = either this characteristic is not applicable to this species or more information is required.

2.3.1 The requirements of diadromous fish

Of the 19 native freshwater fish found in the Region, 15 are diadromous, meaning they require access to and from the sea to complete part of their life-history. The larvae of many diadromous fishes are washed out to sea; juveniles develop in marine environments and return to freshwater as whitebait in runs, before migrating upstream to complete their maturation to adulthood.

However there are exceptions to the rule for some diadromous fishes. Lamprey larvae (known as ammocoetes) spawned in headwater streams mature into juveniles (macrophthalmia) for 4-5 years, moving slowly down river before going to sea. They then migrate back into freshwater as adults to spawn after 3-4 years. Both long and shortfin adult eels migrate far into the South Pacific Ocean to spawn; only the glass eels ever return to freshwater habitats and move upstream as maturing elvers (McDowall, 1990).

Due to the high proportion of diadromous fish in the freshwater fauna, access between marine and fresh waters, distance inland, barriers to migration and elevation/altitude all play influential roles in the distribution, abundance and diversity of native fish (McDowall, 1993; Jowett & Richardson, 1996; Joy & Death, 2002).

Of the 15 diadromous fish found in the Manawatu-Wanganui, roughly half have good climbing skills and can negotiate some upstream barriers to penetrate inland. However, chemical, flow, velocity, impoundment and physical barriers can still prohibit access upstream (and downstream in the case of migrating adult eels), even to the most determined climbing species.

2.3.2 The requirements of lowland fish

Diadromous fish with poor climbing ability are generally restricted to coastal lowland rivers, streams and lakes with sea outlets; making the value of these habitat types, and lowland habitats in general, disproportionately more important for aquatic biodiversity. Unfortunately this value often conflicts with the high value of lowland productive pasture, forestry and coastal urban development.

Several of the lowland dwelling freshwater fish utilise wetland and lake habitats. Throughout the Region (and nationally) this habitat type is extremely sparse due to human modification - slightly over 3% of the Region's pre-human wetland habitat remains (Maseyk, 2007). Consequently, species that are poor climbers and/or wetland species, such as the giant kokopu (*Galaxias argenteus*) and brown mudfish (*Neochanna apoda*) are considered Chronically Threatened (Hitchmough *et al.,* 2007).

Inanga (*Galaxias maculatus*) are the most important whitebait species, making up 95% of the whitebait catch. They tend to inhabit lowland rivers and require vegetated estuarine habitat in which to spawn, and access to the sea for outward larval and inward whitebait migrations. Although these fish are still relatively common and are not considered nationally threatened (Hitchmough *et al.,* 2007), there does appear to be a decline in available adult habitat in the

Manawatu catchment (Baker *et al.,* 2003) for incoming juveniles to mature and breed.

2.3.3 The requirements of climbing and non-migratory upland fish

For species that have some climbing ability, or do not migrate from their adult habitat, is the future any brighter? Fish that live further inland either permanently (non-migratory species), or have high ability to penetrate habitats at higher elevation, still have to contend with loss of adult and spawning habitat, as well as predation and competition from exotic fish species and water quality and habitat disturbance.

Several of the galaxiid species spawn on bankside, riparian vegetation when the first river freshes of the year occur in autumn and early winter. Eggs develop in the leaf litter, rank grasses or beach gravels (or in the case of inanga eggs, on estuarine vegetation) and then larvae are washed downstream and out to sea when river levels rise again. Loss of forested headwater and riparian river margins (Charteris *et al.,* 2003) in conjunction with control of river floodways, has reduced the opportunity for successful spawning of species like the shortjaw kokopu (*Galaxias postvectis*) which is considered nationally At Risk (Hitchmough *et al.,* 2007), the banded kokopu (*Galaxias fasciatus*), and koaro (*Galaxias brevipinnis*) both of which are considered regionally rare (R. Death *pers comm.*).

Photo: Koaro climbing – Alton Perrie, Greater Wellington

Substrate spawners like the redfin (*Gobiomorphus huttoni*), upland (*Gobiomorphus breviceps*) and Cran's (*Gobiomorphus basalis*) bullies tend to lay eggs on the underside of large rocks within the flowing channel. Disturbance of the substrate, embeddedness through sedimentation, and loss of habitat diversity in gravel streams can adversely affect the success of these species. Habitat disturbance is further exacerbated by poor water quality and sedimentation. The redfin bully is particularly sensitive to poor water quality and sedimentation of the substrate (Rowe, 2007).

The situation is even more serious for the non-migratory dwarf galaxias (*Galaxias divergens*) which is considered chronically threatened (Hitchmough *et al.,* 2007). If dwarf galaxias habitat is disturbed to the point where fish are displaced and populations suffer (either large scale or frequent disturbance), their non-migratory habit means these fish are unable to recolonise lost habitats through juvenile recruitment during post-disturbance phases. The sparse range and non-migratory habitat of dwarf galaxias also has implication for the long-term genetic viability of their populations (Allibone, 2002).

2.4 Aquatic invertebrates


Photo: Stephen Moore, Landcare Research

Although this report concentrates on the fish species that contribute to our regional aquatic biodiversity, it is important that the biodiversity value of aquatic invertebrates is acknowledged and considered. Aquatic invertebrates are excellent bioindicators of aquatic health because of their long life spans – making them good integrators of environmental conditions over time; sedentary nature – which is representative of local conditions; and diversity of form, feeding habit and life-history – which provides a variety of responses to changing environmental conditions (Boothroyd & Stark, 2000).

Invertebrate communities can be assessed in a number of ways to establish the health of aquatic ecosystems. Several methods have been developed using health 'scores' such as the Macroinvertebrate Community Index (MCI) and the quantitative version of this index (QMCI) (Stark, 1985). More recently, predictive models of fish and invertebrate communities have been developed which are directly applicable to the Horizons Region (Joy & Death, 2002; Joy & Death, 2003).

Horizons and Massey University have undertaken regular biomonitoring surveys of the aquatic macroinvertebrates and periphyton since 1999 at approximately 35 sites around the Region. This biomonitoring is annually documented in 'State of the Riverine Environment – invertebrates and periphyton' and has encompassed predictive modeling methods into the analysis since 2002. Work is ongoing with Massey to refine the predictive invertebrate model for wider, more generalised use by Council staff. The recoded distributions of some significant invertebrate species are detailed below.

Regionally significant aquatic invertebrates

Freshwater polychaete

Photo: Reese Fowler

Often the intrinsic biodiversity value of aquatic invertebrate communities is under-appreciated and they are viewed purely as a means for assessing ecosystem health and/or to provide food for 'higher' vertebrate animals, namely fish and birds. Little is known or reported about rare or threatened aquatic invertebrates which may require some form of monitoring or protection.

One invertebrate species listed as nationally 'At Risk' by the Department of Conservation due to sparse populations of this taxon is the freshwater polychaete *Namanereis tiriteae*, commonly known as a paddle worm (Hitchmough *et al.,* 2007). This species was first identified in the Turitea Stream, a tributary of the Manawatu River (Winterbourn, 1969), and has since been occasionally found in a small number of sites in the Manawatu (Map 18), Hawkes Bay and Fiji (I. Henderson *pers comm*.). *Namanereis* is the only river-dwelling polychaete in New Zealand.

Koura

The largest aquatic invertebrate and one of considerable cultural and biodiversity worth is the decapod crustacean *Paranephrops planifrons* commonly known as the freshwater crayfish or koura. Along with 39 other families and genera of aquatic invertebrates, koura have been recorded as occurring at less than 10% of sites monitored by the National Rivers Water Quality Network (Boothroyd, 2000). However, one advantage of koura as the largest aquatic invertebrate is that records of koura are found within the New Zealand National Freshwater Fish Database. Database information for koura suggests koura are widely distributed throughout the Region (Map 18).

Photo: Koura after the 2007 Whangaehu Valley lahar event – Horizons Regional Council

Koura are highly valued as a food source by Maori and have been fished from traditional sites for generations. Koura are a nocturnal, slow-growing crustacea and take 3-4 years to reach breeding maturity. They are found in stony and soft bottomed streams, rivers, lakes, ponds and swampy wetlands, and feed on small invertebrates, organic detritus and macrophytes. Koura are known to be pollution sensitive, adversely affected by predation by trout or birds and the disturbance of macrophyte beds by mechanical removal or chemical spraying. Physical disturbance of stony stream substrates can also negatively affect koura habitat, depending on the scale and frequency.

Being nocturnal, koura also require plenty of instream cover and shade during the day in the form of woody debris, large boulders, undercut/overhanging banks and macrophyte beds. Removal of instream habitat and substrate diversity will also negatively impact koura distribution and breeding success. Koura are especially vulnerable to these impacts whilst moulting or when the females are carrying eggs or young, between April and December (Chapman & Lewis, 1976).

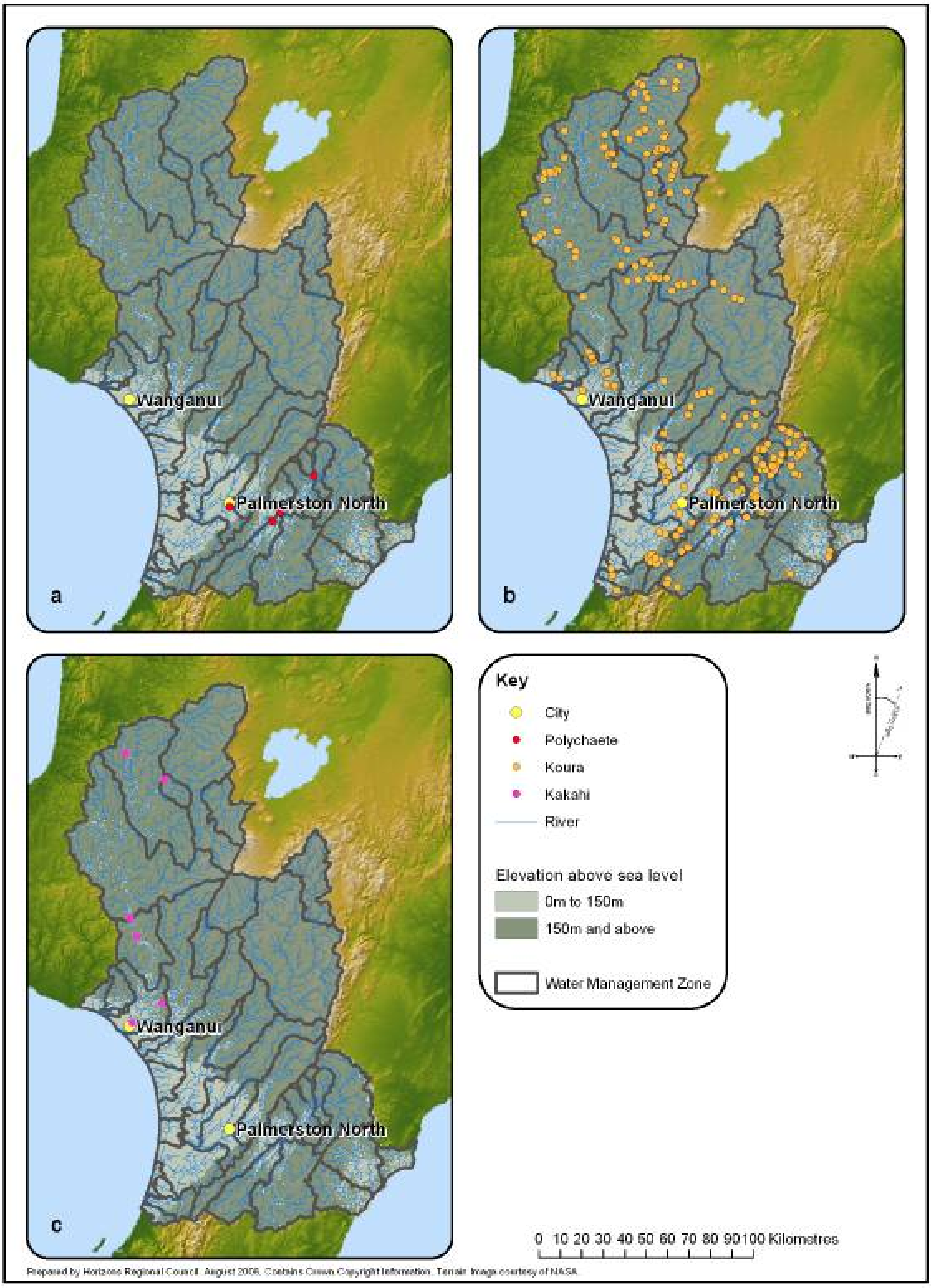
Kakahi

Kakahi (*Hyridella menziesi* or freshwater mussels) are also considered a significant traditional food by Maori, being highly valued as food for the young or infirm. Freshwater mussels are found in lakes, rivers and streams throughout the country, but most of the information on their biology comes from lake or impounded river populations. Anecdotal evidence from the Whanganui River catchment suggests kakahi have been declining since the turn of the 20th century due to declining water quality (Horrox, 1998).

Suitable kakahi habitat can be found in slow-flowing reaches of low gradient rivers (such as the Whanganui River) with unconsolidated geology and soft-bottomed areas in backwaters, or between large boulders and in lakes. Kakahi can grow as large as 10 cm in shell length and are found clustered together in suitable habitats, sometimes buried within river sediments. There has been little study of kakahi populations in the Manawatu-Wanganui Region; however Horrox (1998) measured shell dimension and condition of kakahi at six sites on the Whanganui River (Map 18).

Further research is currently being undertaken by Massey University and more information on the distribution and health of kakahi populations in the Manawatu-Wanganui Region is needed in order to assess the threat status of this freshwater mollusc regionally.

Photos: Hannah Rainforth



Map 18. Recorded distribution of Aquatic Invertebrates (polychaete, koura and kakahi) in the Manawatu-Wanganui Region between 1991 and 2006

2.5 Blue duck

Blue duck or whio (*Hymenolaimus malacorhynchos*) are considered to be an aquatic species for the purposes of this report due to their requirements for water quantity, quality, and riparian habitat, and food sources being somewhat commensurate with the requirements of many of our native fish. However, it should be noted that introduced mammalian predators such as feral cats, dogs, stoats, possums and rats pose significant threats to the breeding success and juvenile recruitment of blue duck. This report only covers the critical requirements and threats relating to the aquatic components of blue duck habitat.

The critical habitat requirements and sites of importance for other significant bird species associated with aquatic ecosystems and riparian margins have been identified in Lambie (2007). Technical support and recommendations for the One Plan associated with these habitats can be found within that report.

Nationally, blue ducks are listed as 'Acutely Threatened – Nationally Endangered' by the Department of Conservation (Hitchmough *et al.,* 2007). The Department of Conservation actively manage the remaining approximately 2,500 blue duck in New Zealand through the blue duck recovery plan; however it is appropriate that reaches of river inhabited by blue duck are considered sites of aquatic significance for regional planning purposes, given the level of threat to this species. Also for consideration is that these ducks cannot be translocated to secure offshore islands as their habitat requirements are for large, fast-flowing rivers with good riparian vegetation; habitats which are not available on small, offshore islands.

Blue duck inhabit fast-flowing, turbulent highland rivers in catchments with dense indigenous vegetation, particularly at the riparian margins, and high water quality. Woody debris at the riparian margin is also important for nesting. The volcanic plateau region of the central North Island provides some ideal riverine habitat with steep gradient, high energy flows and heterogeneous pool riffle habitat complexes (Map 20). The aquatic macroinvertebrate fauna is dominated by large high quality insect species that comprise much of the diet of the blue duck. The Northern Ruahine and Tararua Ranges also have small populations of blue duck remaining.

Nesting can occur between July and December but is usually August to October, and occurs around woody debris in riparian vegetation (Heather & Robertson, 1996). Chicks fledge after 10 weeks; during this time they are very vulnerable to predation or abandonment as a result of disturbance in the habitat of breeding pairs.

Critical threats to blue duck habitat, breeding success and juvenile recruitment include vegetation clearance, particularly of riparian margins; gravel/boulder extraction and general riverbed disturbance (especially during nesting and fledging seasons); the loss of turbulent flows and complexity of flow regime; loss of habitat heterogeneity (through damming and/or channelisation) and predation from introduced mammals. Direct human interference or disturbance of breeding pairs can also have marked impacts on blue duck at any time of year as breeding adults are site specific.

2.6 Introduced species

Sports fish

The Manawatu-Wanganui is home to several species of exotic fish, both sports fish and pest fish. Fish & Game New Zealand has a statutory obligation under the Conservation Act (1987) to manage sports fish in New Zealand. The introduced sports fish of note in the Region are brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*) and perch (*Perca fluviatilis*). Although these species are introduced, they are established in many of the Region's rivers and lakes, with some rivers in the Region providing world class trout fisheries such as the upper Rangitikei and Manganui o te Ao which are covered by National Water Conservation Orders (established for trout fishery, aesthetic and blue duck protection).

Recreational and cultural values associated with trout fisheries and spawning habitat are recognised as values within the One Plan, separate from the aquatic ecosystem values (SOS-A) defined in this report. Critical habitat requirements for trout fishery and spawning can be found in McArthur & Lambie (2007). For further information on waterbody values see Ausseil & Clark (2007a).

Though trout and salmon are held in high esteem by many New Zealanders for their heritage and recreational value, salmonids are also known to have significant adverse effects on galaxiid fish communities in New Zealand (Allibone & McIntosh, 1999) and throughout the Southern hemispheric range of galaxiid fishes (McDowall, 2006). Perch are also known to have serious adverse effects on native fish, particularly in lakes (Rowe, 2007). The juxtaposition of values between sportsfish and native fish can make the management of aquatic habitats for both introduced and native species difficult (McDowall, 2006).

Pest fish

Pest fish are not specifically addressed within this report; however the detrimental effect of these species on native fish and aquatic ecosystems is well documented in New Zealand, particularly in lakes and wetlands (Closs *et al.,* 2004). Horizons continues to support and work with the Department of Conservation in the identification and control of pest fish populations within the Region.

Didymosphenia geminata

At the time of writing the invasive algae *Didymosphenia geminata* (didymo) had not been detected in the North Island. However, more than 30 rivers and lakes in the South Island have been infected. Didymo has the potential to have a significant detrimental impact on aquatic biodiversity, particularly in sites of high biodiversity and trout fishery value, within more 'natural' river systems.

3. Threats to aquatic biodiversity

3.1 Human modification of aquatic habitat

Nationally, research into distributional patterns of fish communities has found that low elevation waterways (less than 150 m above sea level) generally have the highest diversity and abundance of native fish, whereas the mid to upper reaches of rivers are usually dominated by one or two species (Jowett & Richardson, 1996). This pattern is not reflected in the Manawatu-Wanganui Region where nearly half of the native fish are either scarce or absent from lowland waterways.

Photo: Horizons Regional Council

The high suitability of lowland floodplains for agricultural, urban and forestry development has caused extensive modification of these habitats, reducing their ability to support diverse fish communities throughout much of the Region. Although the impacts of land use, instream habitat, distance from the sea and altitude are all thought to influence native fish distribution and abundance, the relative contributions of each of these factors are difficult to separate from each other (Jowett *et al.*, 1996).

A small proportion of the river reaches in the Region are within the lowland elevation class (<150 m above mean sea level). However, the percentage of lowland aquatic habitat with reduced biodiversity potential is disproportionate to the impact on fish diversity because of the high utilisation of lowland habitat during at least one life stage by more than 80% of the regional fish fauna.

The biodiversity value of any remaining, high-quality, lowland, aquatic (and terrestrial) habitat cannot be overstated.

3.1.1 Loss of catchment and riparian vegetation

Although much of the originally forested land area in the Region has been progressively cleared, some large areas of indigenous vegetation remain. Generally these are found in mountain and hill country and often within the public conservation estate. The impacts of land clearance and the resultant scarcity of indigenous lowland vegetation have been substantial on freshwater ecosystems and native fish communities.

Land clearance in the mid to upper reaches of river basins can cause catchment scale habitat degradation and sedimentation from erosion, greater severity of natural flood events, changes to the hydrologic regime and increases in average temperature due to loss of stream shading. It is difficult to establish direct cause and effect relationships between these processes and habitat suitability for fish, due to the long time scales and multiple cumulative effects of catchment deforestation.

The combined impact of lowland, riparian deforestation can be more directly related to reductions in fish community diversity and abundance. Regionally, two thirds of the native fish species are nocturnal or cryptic and require habitat with suitable stream shading and high amounts of woody instream cover (McDowall, 1990). One third of the fauna require specific riparian vegetation for successful bankside or forest-litter spawning (in conjunction with autumnal bank-full flows). The expectation of higher diversity and abundance of fish communities in lowland areas (Jowett & Richardson, 1996) hinges on the availability of suitable instream and riparian habitat, which are absent throughout much of the Region.

3.1.2 Loss of habitat diversity, connectivity and flow regime

In addition to loss of lowland riparian vegetation, modification of aquatic habitat has occurred to protect urban centres and productive lowland floodplains from flood and erosion risk. River and drainage control schemes have had a significant modifying influence on river and wetland habitats and thus the availability of suitable habitat for native fish.

Many of the native fish found in the Manawatu-Wanganui Region utilise slow-flowing, back-water habitats. Channelisation, stopbank construction, bank protection and drainage schemes have caused disconnection between rivers, wetlands and floodplains in lowland waterways, reducing the availability of these habitat types. Channelisation of major rivers can cause fish to rely on tributaries for refuge and habitat (R. Death *pers comm*.) as appears to be the case in the Rangitikei River catchment (Hamer & Lewis, 2004a). However, for poor swimmers like the giant kokopu, this means negotiating the swift-flowing mainstem of larger rivers to find wetland or backwater habitat connected to tributaries.

3.1.3 Morphological diversity and instream habitat

The heterogeneity of instream habitat is closely linked to the morphological diversity of a river channel (Fuller & Smart, 2007). Maintaining or enhancing morphological diversity of river channels can have positive effects on the instream habitat and thereby the opportunities for enhancing aquatic biodiversity. Conversely cumulative and ongoing reductions in morphological diversity, which can occur as a consequence of river engineering, can negatively affect the potential availability of habitats for aquatic species (Hamer & Lewis, 2004a & 2004b).

3.1.4 Fish barriers and flood gates

Loss of connectivity between freshwater and marine environments is one of the major conservation issues for diadromous fishes (McDowall, 2006). Enabling the inward and outward migration of the majority of the Region's native fish species will enhance aquatic biodiversity generally by opening up habitat that previously excluded some or all species, either at critical migration times, or throughout the year.

Further investigation of flood and tide gate timing or the introduction of fish gates within existing structures may increase migration opportunities for many species. Appendix 5 identifies known fish barriers within the region. Further investigation and remedial work is required to reduce the adverse effects of fish barriers on aquatic biodiversity.

Conversely, there is evidence to suggest a positive effect from the exclusion of salmonid fish from upstream indigenous fish habitats through the use of structures which only allow the passage of galaxiid fish but exclude trout or salmon (Allibone & McIntosh, 1999; McDowall, 2006). Further investigation of this topic is required to ascertain whether some vulnerable galaxiid populations (such as the dwarf galaxias in the south-eastern Ruahine tributaries of the Manawatu River) could be enhanced through trout exclusion barriers.

3.1.5 Stock exclusion

Critical phases within the life-history of all species are spawning, nesting or breeding and juvenile development. For success during these critical phases it is necessary to reduce the frequency and scale of disturbance to individuals and habitats. For riparian and bankside spawning fish (Table 1) reducing the physical disturbance of riparian margins will have direct benefits on spawning success. Stock should be permanently excluded from riparian margins utilised for native fish (including inanga) spawning.

Photo: Manawatu River – Horizons Regional Council

For gravel spawners like bullies and dwarf galaxias, reducing any mechanical or stock disturbance to instream gravel substrates during both spawning and juvenile development will have beneficial effects on reproductive success. Additionally the reduction of instream disturbance is likely to reduce sedimentation effects on spawning substrate.

3.1.6 Introduced fish

Competition with or predation by introduced fish species, particularly aggressively competitive salmonid fishes, has had significant impacts on the habitat availability (Allibone & McIntosh, 1999) and juvenile recruitment (McDowall, 1990; McDowall, 2006) of many of New Zealand's native fish. Galaxiid fish of several species have been found to be especially vulnerable to decline as a result of habitat displacement or predation by introduced salmonids, compounded by habitat degradation and other stressors (McDowall, 2006).

It is likely that salmonid fish introductions have had significant predation and displacement impacts on galaxiid fish communities because of the lack of a large predatory fish fauna in New Zealand's aquatic ecosystems prior to salmonid introduction. Galaxiids, having not undergone co-evolutionary processes with large piscivorous fish, have never evolved competitive, defence or escape mechanisms (McDowall, 2006).

Additional flow-on effects, such as genetic and ecological isolation caused by displacement, competition and predation by salmonids, may threaten the long term survival of native fish communities (McDowall, 1990). The introduction of other fishes such as perch (*Perca fluviatilis*), koi carp (*Cyprinus carpio*), rudd

(*Scardinius erythrophthalamus*), tench (*Tinca tinca*) and *Gambusia sp.* (mosquito fish) have also had detrimental impacts on native fish communities either directly through competition and predation or indirectly through reductions in water quality, particularly in lakes (Rowe, 2007).

According to McDowall's (2006) review of the impacts of introduced salmonid fishes on galaxioid communities in the Southern hemisphere "assertive responses to the impacts of invasive species (primarily salmonids) are needed to prevent significant future biodiversity losses."

3.2 Summary of habitat requirements for aquatic species

Maintaining and enhancing aquatic biodiversity in the Manawatu-Wanganui Region relies on a number of key principles:

- Habitat heterogeneity creates opportunity for diverse communities and ecosystems with greater taxonomic richness;
- Connectivity of riverine habitats from sea to source is important to provide for migratory species and life-history variations;
- Connectivity between the riverscape and the landscape, particularly with respect to riparian vegetation and natural flood regimes, is essential for most species;
- Reducing the frequency and scale of physical disturbance (stock, machinery and human disturbance) to spawning and nesting habitats will enhance reproductive success for many aquatic species; and
- Moving towards a habitat-based approach, measured by healthy fish communities and the availability of important habitat types is the best way to maintain and enhance aquatic biodiversity in the long-term.

3.3 Recommendations for further research

Recommendations for habitat improvement, increasing fish community diversity, removal of fish barriers, stock exclusion from significant sites, predictive modelling of fish habitat, lake eutrophication, floodgate passage and drainage programme review have been suggested as outcomes from a summary review of the literature on native fish in the Horizons Region (Appendix 3).

Regional evaluation of the current state of aquatic biodiversity for the development of SOS-A, to support the values framework within the One Plan, is the first step in identifying potential enhancement and/or restoration opportunities for aquatic habitats. Further work to maintain and enhance aquatic biodiversity in the Region should include:

- state of the environment monitoring of SOS–A
- state of the environment native fish monitoring
- top 100 SOS–A protection and restoration programmes
- known fish barrier removal (Appendix)
- further identification of fish barriers regionally
- flood and tide gate timing investigation

- whitebait composition and abundance study
- risk assessment of invasive fish on native fish communities
- polychaete, kakahi and other significant aquatic invertebrate diversity
- macrophyte diversity, distribution and abundance
- adult inanga habitat investigation
- inanga spawning habitat monitoring and restoration

In order to address the multiple requirements and threats to aquatic species, this report recommends the development of a regional strategy for monitoring the state of aquatic biodiversity and determining programmes for the enhancement and restoration of aquatic habitats. This strategy should be focused at moving towards the monitoring and protection of aquatic habitats, rather than species.

4. Sites of Significance – Aquatic: recommendations for the One Plan

Defining species of regional significance

4.1 A species-based approach

This report recommends the use of a species-based approach only as an initial step in the identification of sites of aquatic significance in the Manawatu-Wanganui Region because of the current level of information available. Further work towards using criteria which define sites as significant due to their value as biodiversity hotspots or rare and threatened habitat types is recommended as the next step in a robust framework to address aquatic biodiversity issues within the Region.

4.2 The role of predictive modelling

When faced with the task of securing biodiversity, it is desirable to focus on ecosystems, habitats and communities rather than just species of interest. In doing so, not only is the diversity of species preserved but the integrity of the ecological processes is retained, securing the functionality of the ecosystems and biodiversity in the long term.

Predicting where highly diverse fish communities should exist (in the absence of adverse impacts), based on the suitability of the environmental characteristics of waterbodies, would provide a habitat-based focus for aquatic biodiversity work under the proviso of "if we build it they will come". But, any regulation of activities in areas predicted to have diverse native fish communities would be difficult to defend in the absence of the fish communities in question.

Although predictive modelling provides some information on habitat suitability and the expected locations of high quality fish communities and observed biodiversity hotspots, Joy and Death (2002) found the key factors associated with fish community structure to be at the broad catchment scale.

Catchment scale is not a fine enough resolution from which to apply stringent and specific policies and rules, designed to halt the decline of native fish habitat and communities. In order to preserve the remaining fish communities, policies and rules need to be specific to the critical habitat requirements of the species which make up these depleted communities.

Biodiversity 'hotspots'

The extensive survey work of Mike Joy and Russell Death in developing a predictive model for the Manawatu-Wanganui Region identified some sites that had more diverse observed (actual) fish communities than predicted by the model. Some discrepancies between the location of these sites and data from the NFFDB preclude their immediate use to determine SOS-A.

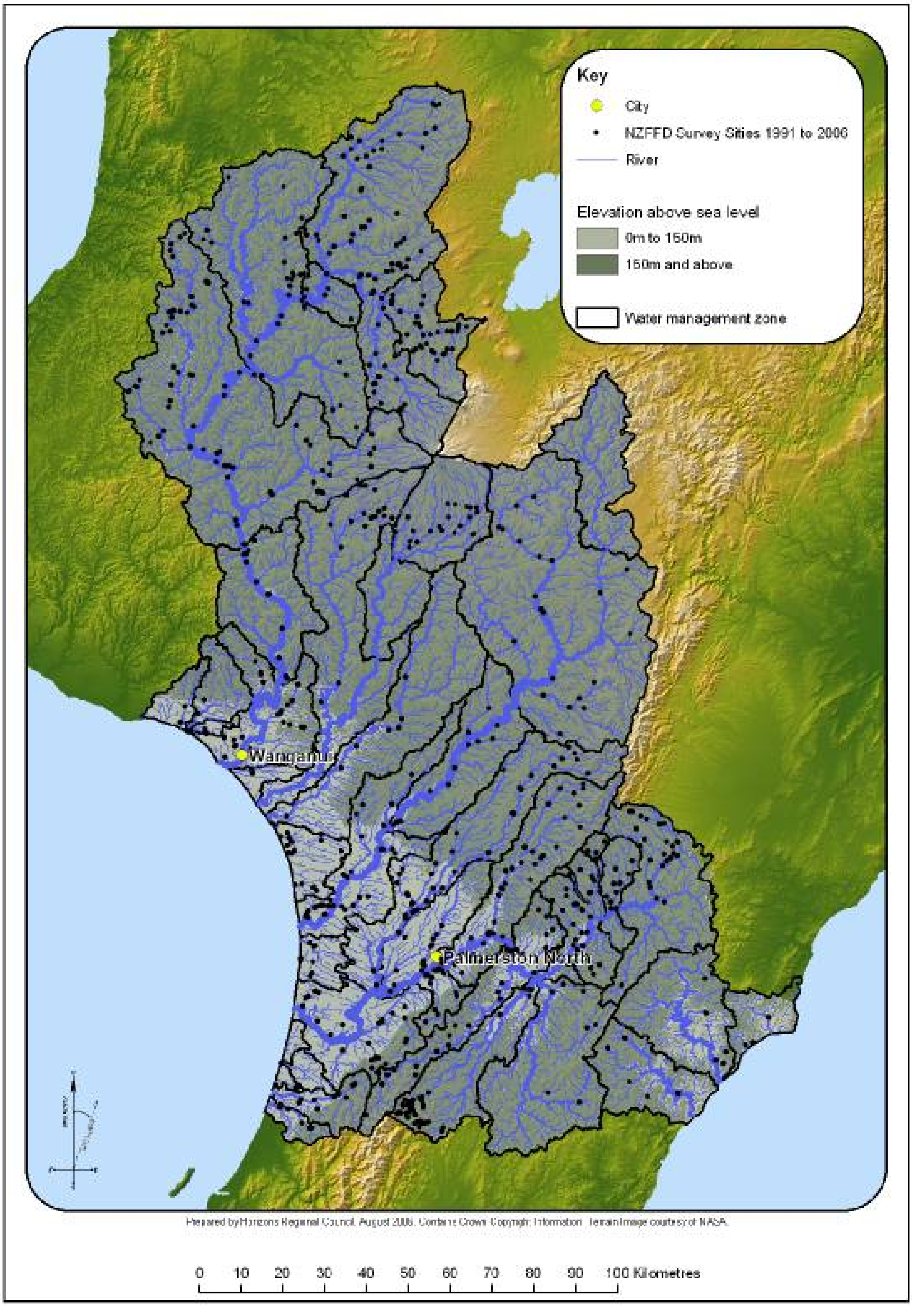
However, many of the sites identified by predictive modelling as biodiversity hotspots are identified as SOS-A due to the presence of rare and threatened species. Sites with an observed over-expected ratio of 1.1 that are not already included as SOS-aquatic are recommended for investigation through the aquatic biodiversity strategy for their potential value as biodiversity hot spots (Wright, 1995; Joy & Death, 2002).

4.3 New Zealand National Freshwater Fish Database records

Within the Manawatu-Wanganui Region there have been over 3300 records entered into the New Zealand National Freshwater Fish Database (NFFDB), dating back to 1918. Despite this, the knowledge of native freshwater fish was extremely sparse prior to the late 1990's. Much of the information before this time (apart from a small number of targeted surveys) was collected by Fish & Game Councils (formerly Acclimatisation Societies) or the former Ministry of Agriculture and Fisheries, and was targeted at introduced sports fish.

Since the late 1990s researchers and students from Massey University's Ecology Group have added substantially to the knowledge base on native fish in the Region's rivers and lakes (Appendix 3). Research Institutes, such as NIWA and Cawthron Institute, have occasionally been commissioned to undertake additional fish survey work on behalf of local authorities or resource consent applicants.

In order to reflect the relatively 'current' state of freshwater fish distribution and abundance this report has used 892 records between 1991 and 2006 from the NFFDB (Map 19) and all reported survey information from Massey University, NIWA and Cawthron Institute collected independently or on behalf of Horizons, DoC, PNCC or Fish & Game NZ since 1995. Although there are some gaps in the coverage of NFFDB surveys, Map 19 shows a reasonable degree of coverage across the Region.



Map 19. Map of all New Zealand National Freshwater Fish Database (NFFDB) records in the Manawatu-Wanganui Region between 1991 and 2006

The NFFDB is the most widely accepted source of fish distribution data in New Zealand. Record entries are able to be traced back to the source of survey data collection. Using information from the NFFDB to map species distributions allows for direct comparisons between national and regional patterns in fish presence/absence and enables the robust definition of regionally rare and threatened species. Identification of the species which are nationally and/or regionally rare and threatened from the NFFDB has been undertaken in conjunction with further advice from experts in the fields of aquatic biodiversity and fish communities.

4.4 International threatened species classification

The IUCN Red List (2006) is a global approach to evaluating conservation status of plant and animal species for the purposes of identifying those species most in need of conservation attention if global extinction rates are to be reduced and to provide a global index of the state of biodiversity degeneration (IUCN, 2006).

Five aquatic species listed on the IUCN Red List (2006) are found within the Manawatu-Wanganui Region:

- blue duck – listed as endangered;
- giant kokopu – listed as vulnerable;
- shortjaw kokopu – listed as vulnerable;
- dwarf galaxias – listed as vulnerable; and
- brown mudfish – listed as near threatened.

Given the recognition of the threat to these species at an international level, any Regional Plan, policy or rule for the protection of aquatic biodiversity should recognise these species as significant within the regional as well as international context.

4.5 National threatened species classification

The Department of Conservation has developed a Threat Classification System for all native and endemic species (both plants and animals) in New Zealand to determine the threat of extinction of each species. The latest classifications for aquatic species in the Region are listed below (**Error! Reference source not found.**) after Hitchmough *et al.* (2007). The classifications are nationally applicable with the justification set out in Molloy *et al.* (2002).

Table 2. National Species Threat Classification System in relation to freshwater aquatic organisms – Department of Conservation, after Hitchmough *et al.* (2007)

Threat Classification	Species	Threat definition
Acutely Threatened – Nationally endangered	blue duck / whio (*Hymenolaimus malachorhynchos*)	Taxa within this group are facing a very high risk of extinction in the wild due to: - small population size - small area of occupancy - decline in habitat area - fragmented populations - declining total population
Chronically Threatened – Gradual decline	giant kokopu (*Galaxias argenteus*) dwarf galaxias (*Galaxias divergens*) brown mudfish (*Neochanna apoda*) longfin eel (*Anguilla dieffenbachii*)	Taxa within this group are considered to be facing extinction but are buffered slightly by: - a large total population, or - slow rate of decline
At Risk – Sparse	Lamprey (*Geotria australis*) shortjaw kokopu (*Galaxias postvectis*) freshwater polychaete (*Namanereis tiriteae*)	Taxa within this group are not considered to be currently in decline, although their population characteristics (restricted range or scattered sub-populations) mean a new threat could rapidly deplete their population/s.

Although this classification system is limited to identifying the status of species in relation to their threat of extinction at a national level, it does not necessarily encompass all species or communities of aquatic organisms of significance in the Manawatu-Wanganui Region.

Two species noted within the National Species Threat Classification (Hitchmough *et al*., 2007) which are not currently recommended as significant species in the Manawatu-Wanganui Region are longfin eels and freshwater polychaetes.

Longfin eel

Although longfin eels are defined as Chronically Threatened - in Gradual Decline (Hitchmough *et al.,* 2007), longfin eels are able to utilise a diverse range of aquatic habitats, have strong inland penetration, and are not sensitive to poor water quality, relative to other native freshwater fish species (McDowall, 1990). Additionally eels are widely distributed throughout the Region (recorded in 512 out of 892 records in the NFFDB, see (Map 16) making stringent protection of all recorded eel sites unnecessary.

Additionally, as eels commonly co-occur with other freshwater fishes, the protection of 'significant' fish (as defined below) will afford an umbrella of habitat protection which will also benefit eels of both species.

Freshwater polycheate

Despite much of the sparse distribution of freshwater polychaete occurring within the Manawatu-Wanganui Region, little is known about the critical habitat requirements of this species and thus specific protection under rules and policies within the One Plan is not recommended without better knowledge of these requirements.

4.6 Regionally rare, threatened and significant species

Local expertise in freshwater fish, and presence/absence data from NFFDB records were used to identify regionally rare and threatened species. The following species are proposed as 'significant' indicator species for definition of sites of aquatic significance (SOS-A) in the One Plan (Table 3).

In considering the number of records for each species listed in Table 3 it should be noted that many of the records were collected from reference sites with relatively unimpacted habitat and as part of survey work directed at finding native freshwater fish. The fact that so few have been found in the last 16 years supports the extensive reported evidence (Appendix 3) that the Region's fish communities are in a degraded state.

Table 3. Classification and justification of aquatic bird and freshwater fish species to define Sites of Significance – Aquatic (SOS-A) and Native Fish (inanga) Spawning (NFS) values

Aquatic Species	Value Classification	Justification	NFFDB Regional Records
blue duck / whio (*Hymenolaimus malachorhynchos*)	Sites of Significance – Aquatic	IUCN Red List 2006 Nationally endangered Regionally threatened	(approx. North Island population 1,000)
giant kokopu (*Galaxias argenteus*)	Sites of Significance – Aquatic	IUCN Red List 2006 Nationally chronically threatened Regionally threatened	2 records*
dwarf galaxias (*Galaxias divergens*)	Sites of Significance – Aquatic	IUCN Red List 2006 Nationally chronically threatened Regionally threatened	26 records*
koaro (*Galaxias brevipinnis)*	Sites of Significance – Aquatic	Regionally rare	35 records*
banded kokopu (*Galaxias fasciatus*)	Sites of Significance – Aquatic	Regionally rare	17 records*
brown mudfish (*Neochanna apoda*)	Sites of Significance – Aquatic	IUCN Red List 2006 Nationally chronically threatened Regionally threatened	20 records*

Aquatic Species	Value Classification	Justification	NFFDB Regional Records
shortjaw kokopu (*Galaxias postvectis*)	Sites of Significance – Aquatic	IUCN Red List 2006 Nationally at risk Regionally threatened	45 records*
lamprey (*Geotria australis*)	Sites of Significance – Aquatic	Nationally at risk Regionally threatened	7 records*
redfin bully (*Gobiomorphus huttoni*)	Sites of Significance – Aquatic	Regionally rare	68 records*
bluegill bully (*Gobiomorphus hubbsi*)	Sites of Significance – Aquatic	Regionally rare	2 records*
inanga (*Galaxias maculatus*)	Native Fish (inanga) Spawning	Whitebait fishery (recreational/cultural)	60 records*

* New Zealand National Freshwater Fish Database – all Manawatu-Wanganui records between 1991 and 2006.

5. Identification of Sites of Significance – Aquatic (SOS-A)

5.1 Defining site locations and habitat buffers

After determining the species to be used for the identification of Sites of Significance – Aquatic, data on the distribution of regionally 'significant' taxa was collated in order to establish known locations for each species. Sites at which significant species have been surveyed and recorded were defined and buffer zones were determined for the application of policies and rules within the One Plan. Each Site of Significance – Aquatic (SOS-A) encompasses the known survey point of one or more significant aquatic species and the buffer zones around each survey point.

5.1.1 Blue duck SOS-A

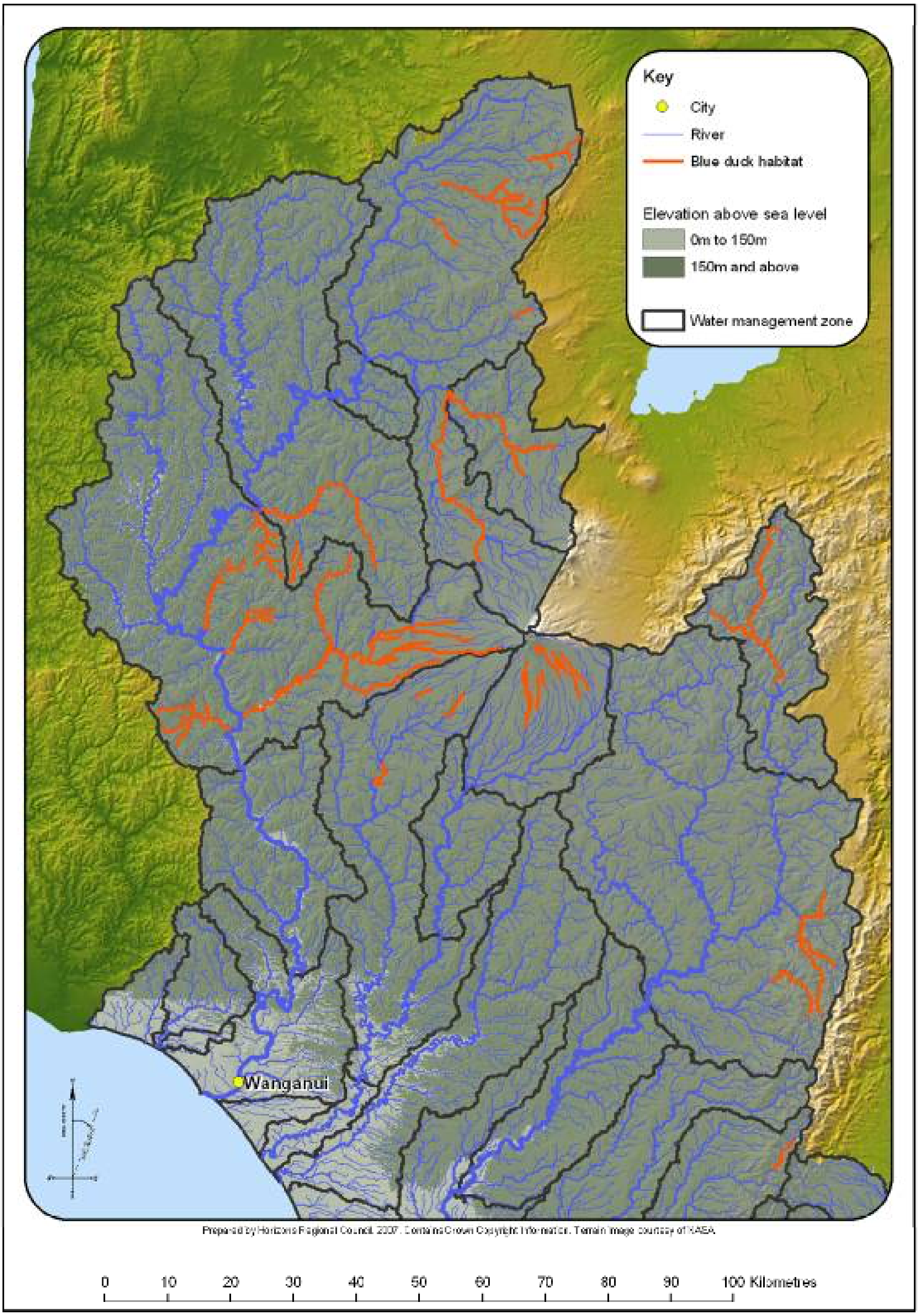
The location of potential blue duck distribution in the Region was based on maps provided by the Ornithological Society of New Zealand Inc. (OSNZ) using provisional unpublished atlas data from a national survey of bird distribution (1999-2004). Survey data points identified the presence of birds within 10 km grid squares, based on thousands of hours of volunteer observations between December 1999 and November 2004. It is important to note that the coarse scale of the atlas grids contributes a spatial error of +/- 5 km to the analysis.

Using the Horizons modified River Environment Classification (Ausseil & Clark, 2007c) GIS layer to depict the Region's rivers, all river reaches falling within the OSNZ 10 km grid squares were selected as being potential sites of significance – aquatic for blue ducks (Map 20).

Blue duck point data from DoC observations held on Bioweb were used to vet river reaches selected in the Waikato Conservancy (B. Taylor and G. Dennis *pers. comm.*). Data from Etheridge *et al.* (2005) was used to vet records from the Taupo/Tongariro Conservancy. Maps of blue duck reaches within the Wanganui DoC Conservancy were scrutinised by Nick Peet, Jim Campbell and Vivienne McGlynn for Wanganui and Ruahine populations.

Additionally, all tributaries under the National Water Conservation Order (1988) Manganui o te Ao were included to give effect to the protection of blue duck habitat under the Conservation Order. One outlying observation point on the Mangawhero River had an arbitrary 1 km upstream and downstream buffer applied in consultation with Wanganui DoC Conservancy.

All reaches identified through the above process are recommended as SOS-A for blue duck habitat (Map 20).



Map 20. Identified Sites of Significance – Aquatic as defined by the presence of blue duck in the Manawatu-Wanganui Region

5.1.2 Fish SOS-A

Lake and wetland habitats

Under the living heritage policies for the protection of terrestrial biodiversity in the One Plan, all wetlands (including lakes) of likely significance to native fish in the region are protected by their status as rare/threatened habitat types. Wetlands which are known to contain significant species such as brown mudfish or giant kokopu are dually protected under policies for terrestrial biodiversity and sites of significance-aquatic.

Records from the NFFDB define only the survey point at which the fish species was found. In the case of most of the brown mudfish sites and one of the giant kokopu sites this intercept point delineated a wetland and was therefore a discrete habitat unit. In order to meet the critical habitat requirements of brown mudfish in wetland sites, especially requirements for marginal wetland vegetation and nearby drainage systems, a buffer zone of 200 m from the wetland edge is recommended for the application of rules to protect these sites. This buffer zone should also apply to any other wetland sites designated as SOS-A for freshwater fish.

River and stream reaches

Riverine fish (particularly diadromous species) can utilise large reaches of rivers and streams. A ‘habitat buffer zone’ is recommended for each fish record to provide aquatic habitat for the identified species at that location. In the absence of ecologically relevant information on fish habitat utilisation at each site, an arbitrary buffer zone of 2 km upstream and 2 km downstream of the survey point is recommended.

Due to the arbitrary nature of this designated ‘buffer’ reach, the following exceptions to the 2 km upstream and downstream rule apply:

- If the river or stream in question reaches a major confluence with another waterway, in which case the define SOS-A reach ends at that confluence;
- If the reach intersects with or becomes (in the case of upland rivers) a reach valued for Natural State (Ausseil & Clark, 2007a), in which case the SOS-A extends to the source of the river in question within the Natural State area;
- If several reaches scheduled as SOS-A are in close proximity, in which case they are linked to form a larger, ecologically significant SOS-A reach (i.e. the Waikawa River and Kahuterawa Stream mainstems); or
- If SOS-A habitat for diadromous species is in close proximity to the sea the reach can be extended to the coastal boundary in recognition of the habitat value of marine access for rare and threatened migratory species.

Riparian margins

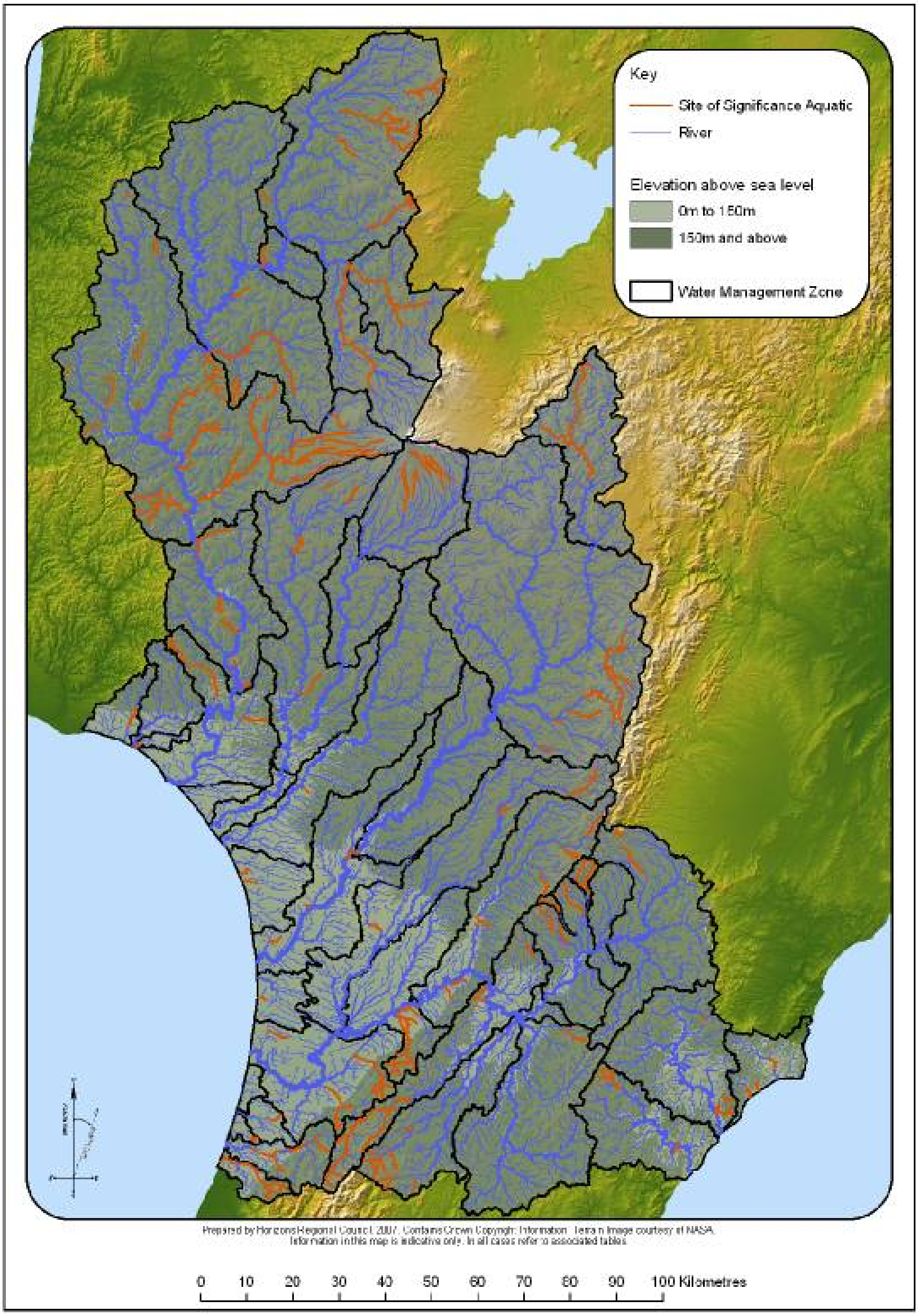
Additionally a 20 m landward riparian buffer zone has been applied from the bank edge of SOS-A to recognize the critical nature of riparian vegetation to the survival of rare and threatened fish species (particularly riparian spawners).

5.1.3 Fish passage recommendations

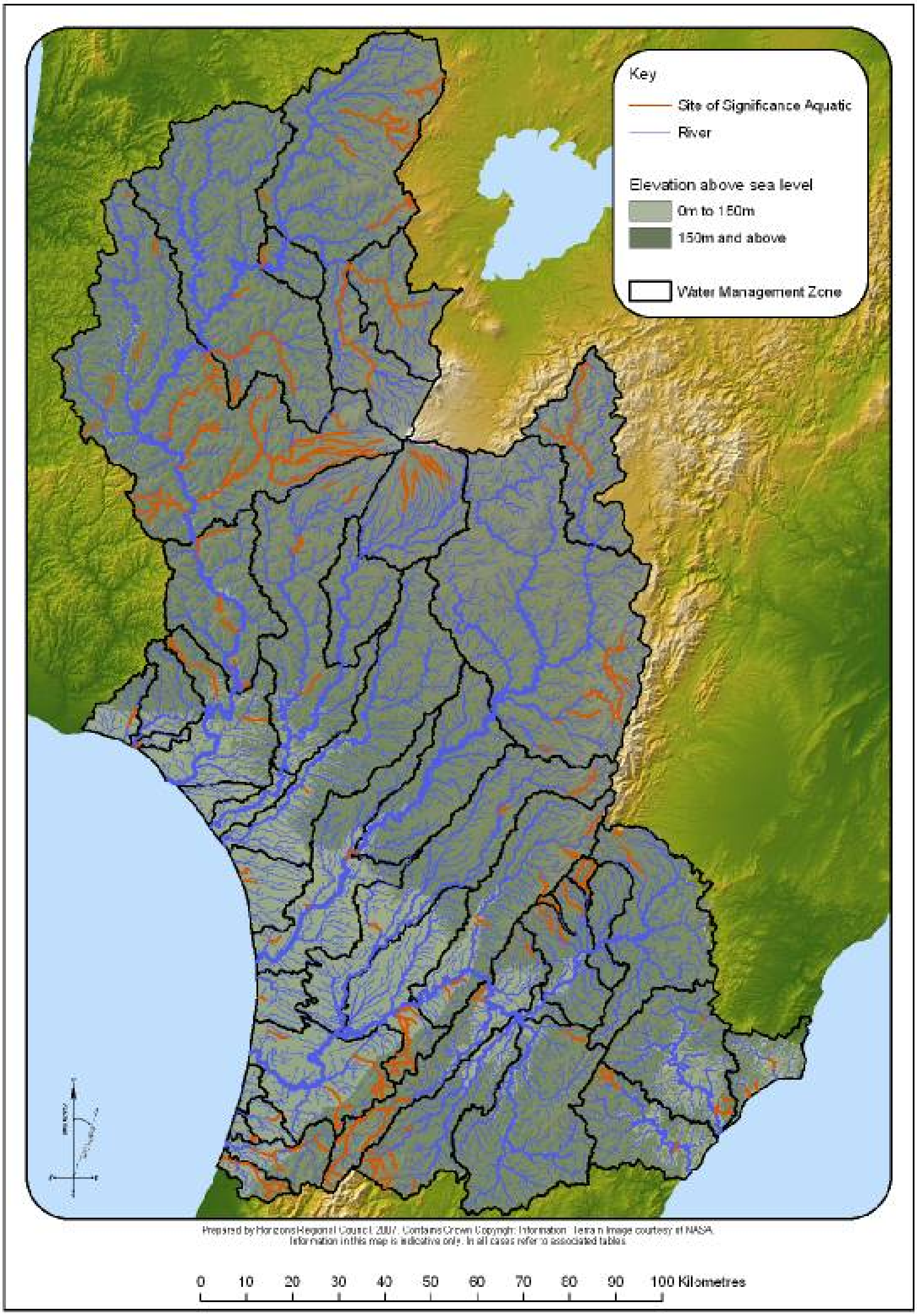
Permitted activity thresholds for activities in the beds of rivers and lakes include provision for fish passage past any works or structures. Without such provision for fish passage any activity will be deemed discretionary, in which case consideration should be given to the presence of diadromous fish upstream of any proposed fish barrier to ensure migratory routes of significant fish are not reduced.

It is the recommendation of this report that no barrier to fish passage should be consented downstream of a site of aquatic significance for migratory fish, in recognition of the poor state of the Region's native fish fauna. The only exception should be in circumstances where a barrier may enhance native fish diversity or protect a population at risk by excluding introduced fish predators from the site.

5.2 Regional identification of Sites of Significance – Aquatic (SOS-A)



Map 21 shows the river reaches and wetlands defined by the presence of significant freshwater fish species, blue duck habitat, and the habitat buffer zones. Appendix 2 defines the legal description of each of the sites of significance and identifies the species by which each site is defined.



Map 21. Sites of Significance – Aquatic (SOS-A) in the Manawatu-Wanganui Region

6. Native Fish (inanga) Spawning Value

The low number of NFFDB records of adult inanga in the region between 1991 and 2006 (60 records) is of particular concern, considering the importance of inanga to the whitebait fishery and the common assumption that inanga are one of the most abundant native fish. Survey work by NIWA in the Manawatu catchment (Baker *et al.,* 2003) found inanga to be abundant in only one site, common in one site, and occasional in four sites out of thirty sampled in 2003. Surprisingly, the highest abundance of inanga was found in the lower Mangaone Stream, a stream with extremely degraded habitat and water quality.

As discussed above, inanga spawning habitat does not overlap with the spawning habitats of other native fish species. Maintenance and enhancement of inanga populations is required for aquatic biodiversity and recreational and cultural values. Protection of inanga spawning sites is important to ensure the long-term viability of inanga populations in the Region; the process of identifying these sites is documented in Ausseil & Clark (2007a) and information on the native (whitebait) fishery value can be found in McArthur & Lambie (2007). The critical habitat requirements for the protection of inanga spawning through the Native Fish Spawning (NFS) value are outlined below.

Inanga spawning habitat

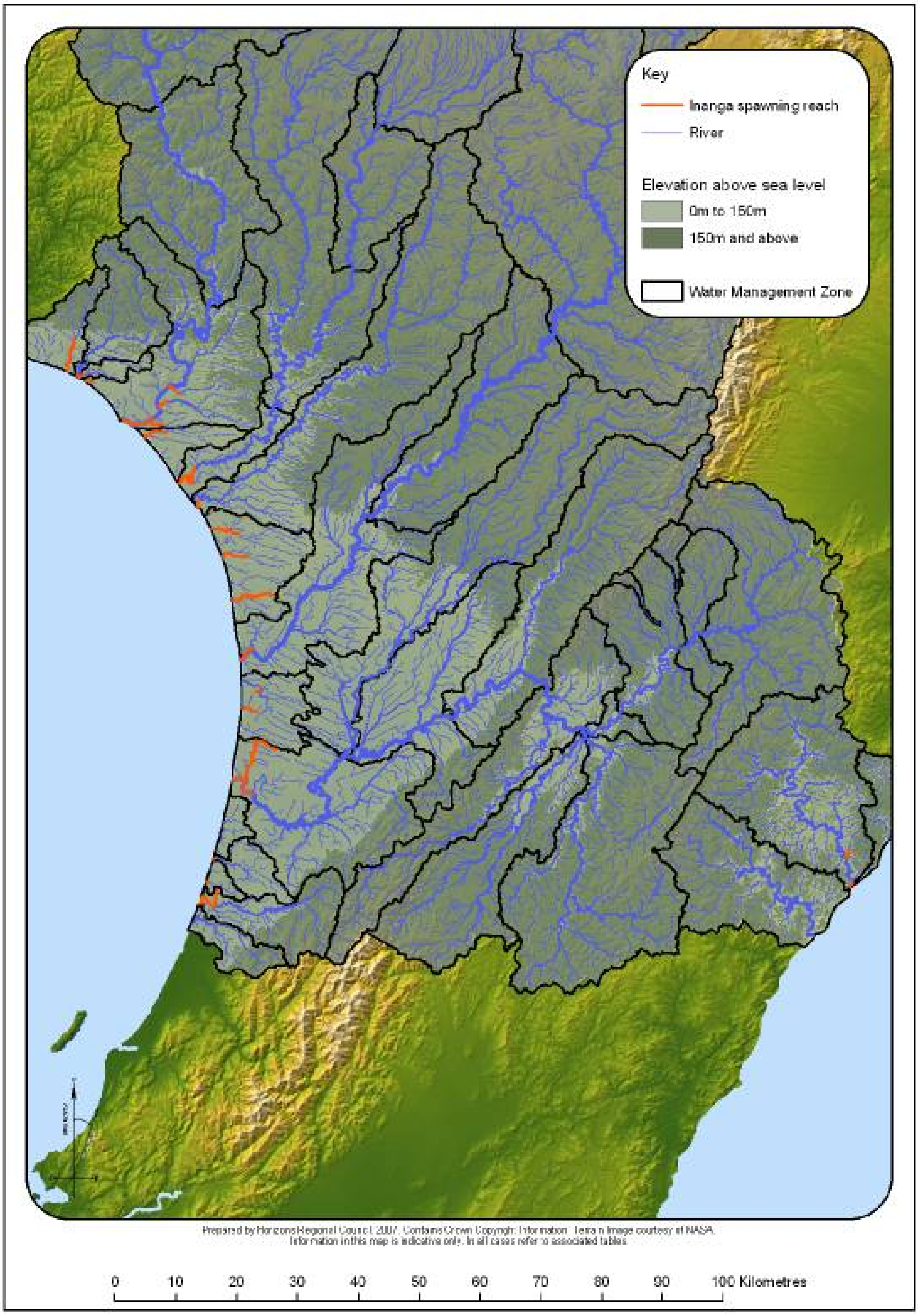
Inanga spawn in estuaries on high tides (generally spring tides on the new or full moon) in autumn. Although they are well distributed nationally, inanga habitat have been adversely affected by urban and rural coastal development. Many coastal wetlands now no longer support adult populations or suitable spawning sites (Richardson & Taylor, 2002). Spawning occurs amongst riparian vegetation with the greatest spawning density near the upper limit of the high-tide, salt-water wedge (Map 22). The same spawning sites are used year after year and inanga do not survive spawning. Many sites may need continuous management to ensure vegetation remains suitable for egg development.

The critical habitat requirements for the long-term sustainability of inanga spawning and in the Region are:

- unimpeded access (without fish barriers, perched culverts or floodgates) to lowland rivers and coastal lakes;
- estuarine and lowland riparian vegetation;
- stock exclusion from spawning areas to enhance riparian vegetation and reduce direct disturbance during spawning and egg development;
- inundation of spawning vegetation by autumnal freshes; and
- slow moving run, pool and back-water habitat within lower reaches of rivers and streams with overhanging or instream cover for adult fish and juvenile development (Richardson and Taylor 2002).

Baker *et al.* (2003) also identified invasive aquatic weeds as potentially reducing adult inanga habitat utilisation and there is some anecdotal evidence to suggest predator control during egg development may enhance spawning habitat management, although this has not been strongly established (D. Rowe, *pers comm.*)

Direct disturbance of inanga spawning sites is best avoided between 1 February and 1 May; ideally stock would be excluded from these sites to encourage desirable riparian vegetation.



Map 22. Sites identified for Native Fish (inanga) Spawning in the Manawatu-Wanganui Region

7. Summary

Most of the lowland river and wetland habitat in the Manawatu-Wanganui Region is not reaching its biodiversity potential when compared to national patterns in fish diversity. However, the persistence of some rare and threatened species over the last 15 years at some sites is a positive indication that halting further loss of aquatic biodiversity through habitat protection (via the introduction of new regulatory policies and rules in the One Plan) is both justified and needed.

Photo: Galaxiid fish egg – Stephen Moore, Landcare Research

Activities that have the potential to cause an adverse effect on species and/or habitats within Sites of Significance – Aquatic and their respective buffer zones are recommended for regulation as non-complying activities under the One Plan. However, addressing and providing for the critical habitat requirements of the rare and threatened species at each site through the resource consent process allows for the avoidance, remedy or mitigation of potential adverse effects on rare and threatened aquatic species and their habitats.

Further work is required to identify biodiversity hotspots and rare and threatened aquatic habitats, and for active participation in enhancement and restoration of these habitats in order to protect more than the status quo for aquatic biodiversity in the Region in the long term.

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Appendix 1

Summary of critical habitat requirements of significant aquatic species in the Manawatu-Wanganui Region

Species	Critical Habitat Threats	Critical Spawning Threats	Timing
banded kokopu (*Galaxias fasciatus*) (migratory)	Loss of forested riparian margin Loss of pool/backwater habitat	Bankside and riparian disturbance in adult habitat - particularly adjacent to backwaters and pools High requirement for bankside vegetation, debris and overhead cover for spawning Regulation/loss of overbank flow during autumn freshes	Pool, backwater and forested margin loss – year round Spawning: 1 April – 1 July
giant kokopu (*Galaxias argenteus*) (migratory)	Instream barriers Loss of forested riparian margin Loss of slow flowing / pool habitat in lowland waterways Disconnection / loss of forested wetland habitat Loss of instream woody debris Presence of brown trout	Margin disturbance in adult habitat Regulation/loss of overbank flow during autumn freshes	Upstream barriers to juvenile migration (migrates later than other whitebait (Nov) – Spring and Summer Spawning: 1 May – 31 August
shortjaw kokopu (*Galaxias postvectis*) (migratory)	Loss of podocarp/broadleaf riparian forest and over-hanging cover Loss of instream woody debris Loss of pool/backwater habitat Loss of high quality aquatic invertebrates	Bankside and riparian disturbance in adult habitat – particularly adjacent to backwaters and pools High requirements for overhead cover, vegetation and debris for riparian spawning Regulation/loss of overbank flow during autumn freshes	Pool, backwater and forested margin loss – year round Spawning: 1 April – 1 July
koaro (*Galaxias brevipinnis*) (migratory)	Forest clearance Opening up of gullies Disturbance of substrate invertebrates Loss of flow in upland streams	Riparian and instream disturbance Loss of cobble/boulder substrate on river margins Barriers to juvenile migration (flood gates)	Spawning: 1 March – 1 July Juvenile migration September – October (inclusive)
dwarf galaxias (*Galaxias divergens*) (non-migratory)	Presence of trout Disturbance of substrate Loss of upper tributary habitat heterogeneity Loss of high quality aquatic invertebrates	Instream and riparian disturbance in adult habitat Sedimentation (suspended and settled during spawning and juvenile development)	Spawning: 1 September – 1 March (peaking in November/December) Juvenile development 1 November – 31 March (peaking in December/January)
brown mudfish (*Neochanna apoda*) (non-migratory)	Wetland drainage Forest swamp clearance Drain clearance and road grading Lowered water table	Drain maintenance and loss of woody cover in drains during spawning Lowering of water table during/post spawning	February – April (during first heavy rains after dry season)

Species	Critical Habitat Threats	Critical Spawning Threats	Timing
lamprey (*Geotria australis*) (migratory)	Loss of riparian and instream cover Loss of habitat and flow heterogeneity Disturbance/loss of sandy shallow backwaters	Loss of riparian cover	June – September – inward adult migration August – September – outward juvenile migration
redfin bully (*Gobiomorphus huttoni*) (migratory)	Water quality degradation Loss of high quality aquatic invertebrates Loss of habitat heterogeneity	Instream disturbance or embedding of cobble spawning substrates Sedimentation (suspended and on spawning substrate) – particularly during juvenile migration	July – December Juvenile migration November - February
bluegill bully (*Gobiomorphus hubbsi*)	Water quality degradation Loss of high quality aquatic invertebrates Loss of habitat heterogeneity	Instream barriers Instream disturbance or embedding of cobble spawning substrates	Juvenile migration Spring and Autumn
inanga spawning (*Galaxias maculatus*) (NFS value)	Physical disturbance of spawning habitat and sedimentation Loss of overbank flows from autumnal freshes and high tides	Loss of estuarine and lower river riparian vegetation Disconnection of lower river channels from estuarine flood plains	1 February – 1 May (inclusive) on high tides during full and new moons
blue duck / whio (*Hymenolaimus malachorhynchos*)	Introduced mammalian predators Loss of indigenous riparian forest Loss of flow and habitat heterogeneity Regulation of turbulent flows Loss of high quality aquatic invertebrates Human or physical disturbance within known territories	Disturbance of breeding pairs Disturbance of nesting sites Disturbance of family groups with chicks Predation Grazing of riparian vegetation used for nesting	Breeding adults are site-specific and can be affected by disturbance at any time of the year Nesting July – December (peaking August – October) Juvenile development October – January

Appendix 2

Sites and species of aquatic significance (SOS-A) in the Manawatu-Wanganui Region

Management Zone	Sub-zone	Site	Species	Map Ref
Upper Manawatu	Upper Manawatu	Manawatu River and tributaries	koaro and dwarf galaxias	From confluence with the Manawatu River at approx NZMS 260 U23:780-258 to source
	Mangatewainui	Mangatewainui River	dwarf galaxias	From NZMS 260 U23:828-177 to U23:785-231
Upper Tamaki	Upper Tamaki	Tamaki River including East and West Branches	dwarf galaxias	From approx NZMS 260 U23:710-131 to source
Upper Kumeti	Upper Kumeti	Kumeti/Mangapuaka Stream	dwarf galaxias	From approx NZMS 260 T23:646-091 to source
Tamaki – Hopelands	Lower Tamaki	Rokaiwhana Stream	dwarf galaxias	From confluence with the Tamaki River at approx NZMS 260 T23:697-091 to source
	Oruakeretaki	Mangapukakakahu Stream	dwarf galaxias	From confluence with the Oruakeretaki River at approx NZMS 260 T23:666-023 to source
		Oruakeretaki Stream	dwarf galaxias	From approx NZMS 260 T23:642-045 to T23:618-067
		Oruakeretaki tributary	dwarf galaxias	From confluence with the Oruakeretaki Stream at approx NZMS 260 T23:628-058 to source
Tiraumea	Lower Tiraumea	Makairo Stream	shortjaw kokopu and koaro	From approx NZMS 260 T24:655-833 to source
Mangatainoka	Upper Mangatainoka	Mangatainoka tributary	shortjaw kokopu and koaro	From confluence with the Mangatainoka River at approx NZMS 260 S25:249-535 to source
		Ngamaia Stream tributary	koaro	From confluence with the Ngamaia Stream at approx NZMS 260 S25:243-568 to source
		Mangatainoka River	shortjaw kokopu and koaro	From approx NZMS 260 S25:262-562 to source
		Mangatainoka tributary	shortjaw kokopu	From confluence with the Mangatainoka River at NZMS 260 S25:252-555 to source
		Rawnsley Stream	shortjaw kokopu	From confluence with the Mangatainoka River at approx NZMS 260 S25:259-555 to source
		Makotukutuku Stream	shortjaw kokopu	From confluence with the Mangatainoka River at approx NZMS 260 S25:279-576 to source

Management Zone	Sub-zone	Site	Species	Map Ref
	Middle Mangatainoka	Tramway Creek	dwarf galaxias	From confluence with the Mangatainoka River at approx NZMS 260 T25:326-625 to source
	Makakahi	Bruce Stream tributary	shortjaw kokopu	From confluence with the Bruce Stream at approx NZMS 260 T25:332-510 to source
		Makakahi River tributary	shortjaw kokopu	From confluence with the Makakahi River from approx NZMS 260 S25:286-514 to source
		Makakahi River	shortjaw kokopu	From the confluence with a tributary at approx NZMS 260 S25:286-514 to source
Upper Gorge	Upper Gorge	Manawatu River tributary	redfin bully	From confluence with the Manawatu River at approx NZMS 260 T24:486-899 to source
		Manawatu River Tributary	redfin bully	From confluence with the Manawatu River at approx NZMS 260 T24:490-928 to source
	Mangaatua	Mangaatua Stream	shortjaw kokopu	From approx NZMS 260 T24:590-992 to approx NZMS 260 T23:574-023
	Lower Mangahao	Mangahao tributary	dwarf galaxias	From confluence with the Mangahao River at approx NZMS260 S25:150-532 to source
		Mangahao River	dwarf galaxias and shortjaw kokopu	From approx NZMS 260 T25:324-679 To source
		Roaring Creek	dwarf galaxias	From confluence with the Mangahao River at approx NZMS 260 S25:190-606 to source
		Ngapuketurua Stream	banded kokopu and shortjaw kokopu	From confluence with the Mangahao River at approx NZMS 260 S25:278-660 to source
Middle Manawatu	Middle Manawatu	Manawatu River tributary	lamprey	From confluence with the Manawatu River at approx NZMS 260 T24:410-937 to T24:444-940
		Manawatu River tributary	lamprey	From confluence with the Manawatu River at approx NZMS 260 T24:392-929 to T24:413-902
	Upper Pohangina	Pohangina tributary	koaro	From confluence with the Pohangina River at approx NZMS 260 T23:652-233 to source
		Pohangina River	whio	From NZMS 260 U23:705-256 to approx NZMS 260 U23:708-303
		Makawakawa Stream tributary	koaro	From approx NZMS 260 T23:606-173 to source

Management Zone	Sub-zone	Site	Species	Map Ref
	Middle Pohangina	Pohangina River	koaro	From approx NZMS 260 T23:468-058 to NZMS 260 T23:469-086
		Waitokanui Stream	redfin bully	From confluence with the Pohangina River at approx NZMS 260 T23:474-069 to source
	Lower Pohangina	Ashhurst Domain	brown mudfish	At approx NZMS 260 T24:446-967 to NZMS 260 T24:444-940
Lower Manawatu	Turitea	Turitea Stream	Lamprey	From confluence with the Manawatu River at approx NZMS 260 T24:302-880 to approx NZMS 260 T24:341-866
	Kahuterawa	Kahuterawa Stream and tributaries	banded kokopu, shortjaw kokopu and redfin bully	From confluence with the Manawatu River at approx NZMS 260 S24:293-870 to source
	Main Drain	Unnamed Wetland	brown mudfish	At approx NZMS 260 S24:223-877
Oroua	Upper Oroua	Mangapikopiko Stream	banded kokopu	From confluence with the Oroua River at NZMS 260 T22:515-307 to approx T22:538-317
		Oroua River	banded kokopu	From approx NZMS 260 T22:667-349 to source
	Makino	Mangaone West Stream	redfin bully	From approx NZMS 260 S23:258-050 to approx NMZS 260 S23:236-064
Coastal Manawatu	Coastal Manawatu	Round Bush Scenic Reserve and tributary	brown mudfish	From approx NZMS 260 S24:013-835 to source at approx S24:058-819
	Upper Tokomaru	Tokomaru River tributary	redfin bully, koaro and banded kokopu	From confluence with the Tokomaru River at approx NZMS 260 S24:243-705 to source
		Tokomaru River tributary	redfin bully, koaro and banded kokopu	From confluence with the Tokomaru River at approx NZMS 260 S24:255-720 to source
		Tokomaru River tributary	redfin bully, koaro and banded kokopu	From confluence with the Tokomaru River at approx NZMS 260 S24:259-734 to source
	Upper and Lower Tokomaru	Tokomaru River	redfin bully koaro and banded kokopu	From approx NZMS 260 S24:198-776 to approx S25:240-698
	Lower Tokomaru	Makuera Swamp Wildlife Management Reserve	brown mudfish	At approx NZMS 260 S24:190-760
	Mangaore	Mangaore Stream	shortjaw kokopu, redfin bully and koaro	From approx NZMS 260 S24:142-711 to source at approx S24:177-635

Management Zone	Sub-zone	Site	Species	Map Ref
		Mangatangi Stream	shortjaw kokopu, redfin bully and koaro	From confluence with the Mangaore Stream at approx NZMS 260 S25:173-670 to source
		Mangaore Stream tributary	koaro	From confluence with the Mangaore Stream at approx NZMS 260 S25:161-648 To source
	Koputaroa	Perawitis Wetland	brown mudfish	At approx NZMS 260 S25:094-688 and S25:095-688
Upper Rangitikei	Upper Rangitikei	Rangitikei River	whio	From approx NZMS 260 U20:707-031 to approx NZMS 260 U19:716-274
		Mangamarie River	whio	From confluence with the Rangitikei River at approx NZMS 260 T20:691-090 to approx NZMS 260 T20:699-102
		Otamatenui Stream	whio	From confluence with the Rangitikei River at approx NZMS 260 T20:672-107 to approx NZMS 260 T20:603-146
Middle Rangitikei	Pukeokahu - Mangaweka	Mangatera River	whio	From confluence with the Maropea River at approx NZMS 260 U21:749-655 to Lake Colenso at approx U21:781-660
		Waiokotore Stream	whio	From confluence with the Mangatera River at approx NZMS 260 U21:770-659 to U21: 789-697
		Maropea River	whio	From confluence with the Mangatera River at approx NZMS 260 U21:749-655 to U22:803-580
		Kawhatau River	whio	From the confluence with Hikurangi Stream at approx NZMS 260 U22:700-557 to approx U22:760-499
		Waikakamaka River	whio	From confluence with the Maropea River at approx NZMS 260 U21:748-622 to approx U22:782-502
		Porangaki River	dwarf galaxias and redfin bully	From confluence with the Mangakukeke Stream at approx NZMS 260 T22:635-507 to approx T22:651-499
		Hikurangi Stream	dwarf galaxias	From confluence with the Kawhatau River at approx NZMS 260 T22:661-530 to source
		Mangawharariki River	shortjaw kokopu	From approx NZMS 260 T22:602-449 to approx NZMS 260 T22:632-444

Management Zone	Sub-zone	Site	Species	Map Ref
Lower Rangitikei and Coastal Rangitikei	Lower Rangitikei and Coastal Rangitikei	Rangitikei River	redfin bully	From approx NZMS 260 S23:184-206 to approx S23:210-222
Coastal Rangitikei	Tutaenui	Tutaenui Stream tributary	brown mudfish	From confluence with the Tutaenui Stream at approx NZMS 260 S23:104-104 to source
	Coastal Rangitikei	Forest Road Wetland	giant kokopu	From approx NZMS 260 S23:016-028 to approx S23:040-034
Upper Whanganui	Upper Whanganui	Mangatepopo Stream	whio	From confluence with the Whanganui River at approx NZMS 260 S19:289-405 to T19:308-360
Upper Whanganui and Cherry Grove	Upper Whanganui and Cherry Grove	Whanganui River	whio	From confluence with the Whakapapa River at approx NZMS 260 S19:188-495 to source
Cherry Grove	Upper and Lower Whakapapa	Whakapapa River and Whakapapiti Stream	whio	From confluence with the Whanganui River at approx NZMS 260 S19:188-495 to approx S19:237-224 (SH47 Bridge)
	Pungapunga	Pungapunga River	whio	From approx NZMS 260 S18:291-612 to source
		Pungapunga River	koaro	From approx NZMS 260 S18:234-573 to source
	Upper Ongarue	Ongarue River and tributaries	whio	From NZMS 260 T17:314-864 to source
		Mangatukutuku Stream	whio	NZMS 260 S18:166-770 to S18:204-729
		Maramataha River	whio	From NZMS 260 S17:176-825 to source
		Piropiro Stream	whio	From confluence with the Maramataha River at approx NZMS 260 S17:251-804 to source
		Paupangonui Stream	whio	From confluence with the Piropiro River at approx NZMS 260 S17:265-819 to source
		Totara Stream	whio	From confluence with the Maramataha River at approx NZMS 260 S18:271-796 to source
		Unnamed Maramataha River tributary	whio	From confluence with the Maramataha River at approx NZMS 260 S18:273-793 to source
	Lower Ongarue	Opotiki Stream	shortjaw kokopu	From approx NZMS 260 S18:022-633 to source
Te Maire	Te Maire	Motutara stream	shortjaw kokopu	From confluence with Whanganui River at approx NZMS 260 S19:000-488 to source

Management Zone	Sub-zone	Site	Species	Map Ref
Middle Whanganui	Middle Whanganui	Whanganui River tributary	shortjaw kokopu	From confluence with the Whanganui River at approx NZMS 260 S19:939-422 to source
	Retaruke	Retaruke River	whio	From confluence with the Whanganui River from approx NZMS 260 R19:890-309 to approx NZMS 260 S19:072-213
		Horomea Stream	whio	From approx NZMS 260 S19:947-252 to source
		Morinui Stream	whio	From approx NZMS 260 S19:954-233 to source
Pipiriki	Pipiriki	Mangapurua Stream and tributaries	whio	From approx NZMS 260 R20:800-117 to source
		Mangatiti Stream and tributaries	whio	From approx NZMS 260 R20:832-079 to source
		Kaiwhakauka Stream	whio	From approx NZMS 260 R19:878-305 to source
		Puketapu Stream	redfin bully	From confluence with the Whanganui River at approx NZMS 260 R20:737-180 to source
		Whanganui River tributary	redfin bully	From confluence with the Whanganui River at approx NZMS 260 R20:793-115 to source
		Puwawa Stream	redfin bully	From confluence with the Whanganui River at approx NZMS 260 R20:819-058 to source
		Mangaio Stream and tributaries	whio and redfin bully	From confluence with the Whanganui River at approx NZMS 260 R20:839-955 to source
	Tangarakau	Waitaanga Stream tributary	redfin bully	From confluence with the Waitaanga Stream at approx R18:710-645 to source
		Heao Stream	shortjaw kokopu and koaro	From approx NZMS 260 R18:781-513 To source
		Mangarae Stream	banded kokopu	From confluence with the Mangarae Stream at approx NZMS 260 R19:732-302 to source
		Mangarae Stream tributary	banded kokopu	From approx NZMS 260 R19:728-288 to source
	Whangamomona	Tirohanga Stream	shortjaw kokopu	From confluence with the Whangamomona River at approx NZMS 260 R20:658-157 to source
		Awahou Stream	shortjaw kokopu	From confluence with the Marangae Stream at approx NZMS 260 R19:587-277 to source

Management Zone	Sub-zone	Site	Species	Map Ref
		Kuri Stream	shortjaw kokopu	From approx NZMS 260 R20:666-190 to source
	Upper Manganui o te Ao	Mangaturuturu River and tributaries	banded kokopu and whio	From confluence with the Manganui o te Ao at approx NZMS 260 S20:056-067 to source
		Mangaturuturu River tributary	koaro	From confluence with the Mangaturuturu River at approx NZMS 260 S20:161-083 to source
		Manganui o te Ao River tributary	whio	From confluence with the Manganui o te Ao River at approx NZMS 260 S20:068-099 to source
		Manganui o te Ao River	koaro	From approx NZMS 260 S20:067-085 to source
		Makomiko Stream	koaro	From confluence with the Waimarino Stream at approx NZMS 260 S20:153-168 to source
		Makatote River	koaro and whio	From confluence with the Manganui o te Ao River at approx NZMS 260 S20:128-119 to source
	Upper and Lower Manganui o te Ao	Manganui o te Ao River	whio	From approx NZMS 260 R20:861-980 to source
	Lower Manganui o te Ao	Orautoha	whio	From confluence with Manganui o te Ao at approx NZMS 260 S20:027-067 to source
		Ruatiti Stream	whio and shortjaw kokopu	From confluence with Manganui o te Ao at approx NZMS 260 S20:993-080 to source
		Makino Stream tributary	shortjaw kokopu and koaro	From approx NZMS 260 S20:011-130 to source
		Ohangaia Stream	redfin bully	From confluence with the Manganui o te Ao River at approx NZMS 260 S20:919-021 to source
Paetawa	Paetawa	Kaukore Stream	shortjaw kokopu, redfin bully, koaro	From confluence with the Whanganui River at approx NZMS 260 R21:859-894 to source
		Whanganui River	redfin bully	From approx NZMS 260 R21:861-858 to approx NZMS 260 R21:861-892
		Riripo Stream	redfin bully	From confluence with the Whanganui River at approx NZMS 260 S21:915-777 to source
		Otuporiki Stream	redfin bully	From confluence with the Whanganui River at approx NZMS 260 S21:950-696 to source

Management Zone	Sub-zone	Site	Species	Map Ref
		Taupiri Stream	redfin bully	From confluence with the Whanganui River at approx NZMS 260 S21:942-624 to source
		Whauteihi Stream	bluegill bully	From confluence with Whanganui river at approx NZMS 260 S22:959-577 to source
Lower Whanganui	Lower Whanganui	Kauarapaoa Stream	redfin bully	From approx NZMS 260 S22:900-558 to source
	Upokongaro	Mongotai Stream	lamprey	From confluence with the Upokongaro Stream at approx NZMS 260 S22:958-511 to source
Upper Whangaehu	Upper Whangaehu	Unnamed tributary of the Whangaehu River	whio	From approx NZMS 260 T20:410-019 to source
		Makahikatoa Stream and tributaries	whio	From approx NZMS 260 T20:396-008 to source
		Wahianoa Stream	whio	From approx NZMS 260 T20:365-039 to source
	Tokiahuru	Unnamed tributary of the Tokiahuru Stream	whio	From NZMS 260 T20:341-027 to source
		Unnamed tributary of the Unuunuakapuateariki Stream	whio	From NZMS 260 T20:329-989 to source
		Unuunuakapuateariki stream and tributaries	whio	From NZMS 260 T20:312-960 to source
Lower Whangaehu	Lower Whangaehu	Taukoro Stream	koaro	From confluence with the Mangawhero River at approx NZMS 260 S22:083-566 to source
	Upper Mangawhero	Mangawhero River	whio	From NZMS 260 S20:179-978 (Ohakune) to source
		Taonui Stream	whio	From NZMS 260 S20:135-009 to S20:160-021
	Lower Mangawhero	Mangawhero River	whio	From NZMS 260 S21:067-875 to S20:080-903
Turakina	Upper Turakina	Turakina River tributary	redfin bully	From confluence with the Turakina River at approx NZMS 260 S22:090-361 to approx S22:104-350
Ohau	Upper Ohau	Waiti Stream	redfin bully	From confluence with the Ohau River at approx NZMS 260 S25:118-604 to source
	Upper and Lower Ohau	Ohau River	redfin bully, bluegill bully and banded kokopu	From approx NZMS 260 S25:061-575 to approx NZMS 260 S25:098-588
	Lower Ohau	Ohau River	redfin bully	From approx S25:982-578 to approx S25:039-574
		Makorokio Stream	redfin bully, lamprey and shortjaw kokopu	From confluence with the Ohau River at approx NZMS 260 S25:018-563 to source

Management Zone	Sub-zone	Site	Species	Map Ref
Owahanga	Owahanga	Owahanga River	redfin bully	From approx NZMS 260 U25:902-585 to approx NZMS 260 U25:889-568
		Pongaroa River	redfin bully and shortjaw kokopu	From approx NZMS 260 U24:778-708 to source
East Coast	East Coast	Waimata River	redfin bully	From river mouth at approx NZMS 260 U25:058-691 to approx NZMS 260 U24:051-710
		Papuka Stream	redfin bully	From river mouth at approx NZMS 260 U24:076-705 to approx NZMS 260 U24:072-723
		Wainui River	redfin bully	From approx NZMS 260 V24:112-752 to approx NZMS 260 V24:102-771
Akitio	Upper Akitio	Akitio River tributary	banded kokopu	From confluence with the Akitio River at approx NZMS 260 U24:955-866 to source
	Lower Akitio	Middle Creek	redfin bully and banded kokopu	From the confluence with the Akitio River at approx NZMS 260 U25:986-654 to source
		Wakawaihine Stream	redfin bully	From confluence with the Akitio River at approx NZMS 260 U25:985-657 to approx NZMS 260 U25:990-677
		Wakawaihine Stream tributary	redfin bully	From approx NZMS 260 U25:998-696 to source
Northern Coastal	Northern Coastal	Okehu Stream	redfin bully	From approx NZMS 260 R22:713-495 to approx R22:731-531
Mowhanau	Mowhanau	Mowhanau Stream	redfin bully	From river mouth at approx NZMS 260 R22:726-448 to approx R22:743-462
Southern Wanganui Lakes	Southern Wanganui Lakes	Unnamed Stream Santoft Forest	banded kokopu	From river mouth at approx NZMS 260 S23:954-173 to Lake Koitiata at approx S23:973-185
		Waimahora Stream	banded kokopu	From river mouth at approx NZMS 260 S23:961-153 to approx S23:989-154
Northern Manawatu Lakes	Northern Manawatu Lakes	Kaikokopu Stream	redfin bully	From river mouth at approx NZMS 260 S24:992-905 to approx S24:009-902
Lake Papaitonga	Lake Papaitonga	Lake Papaitonga	brown mudfish	Lake Papaitonga Wetland at approx NZMS 260 S25:991-600
		Lake Papaitonga and tributaries	banded kokopu	From confluence with Lake Papaitonga and Waiwiri stream at approx NZMS 260 S25:977-600 to source

Management Zone	Sub-zone	Site	Species	Map Ref
Waikawa	Waikawa	Panatewaewae Stream	koaro	From confluence with the Waikawa Stream at approx NZMS 260 S25:017-498 to source
		Waikawa Stream	shortjaw kokopu and redfin bully	Waikawa Stream mainstem from mouth to source
Lake Horowhenua	Lake Horowhenua	Patiki Stream	giant kokopu	From confluence with Lake Horowhenua at approx NZMS 260 S25:019-642 to source

Appendix 3

Native Fish (inanga) Spawning Value in the Manawatu-Wanganui Region

Management Zone	Sub-zone	River/Stream Name	Reference
Coastal Manawatu	Coastal Manawatu	Manawatu River	From the river mouth to a point 100 m upstream of the CMA boundary located at the seaward edge of Foxton Loop at approx NZMS 260 S24:010-765
		Whitebait Creek	From confluence with the Manawatu River from approx NZMS 260 S24:982-791 to source
Coastal Rangitikei	Tidal Rangitikei	Rangitikei River	From the river mouth to a point 100 m upstream of the CMA boundary located at the seaward edge of the boat ramp on the true left bank of the river located at approx NZMS 260 S24:009-000
Lower Whanganui	Lower Whanganui	Mateongaonga Stream	From confluence with Whanganui River at approx NZMS 260 R22:873-434 to Kaimatira Road at approx R22:889-422
	Coastal Whanganui	Whanganui River	From the river mouth to a point approx 100 m upstream of the CMA boundary located at the seaward edge of the Cobham Street Bridge at approx NZMS 260 R22:848-381
		Stream opposite Corliss Island	From confluence with Whanganui River at approx NZMS 260 R22:836-374 to State Highway 3 at approx R22:862-370
		Omapu Stream	From the stream mouth to a point 1 km upstream at approx NZMS 260 R22: 750-441
	Matarawa	Matarawa Stream	From confluence with Whanganui River at approx NZMS 260 R22:858-398 to Ikitara Street at approx R22:869-409
Coastal Whangaehu	Coastal Whangaehu	Whangaehu River	From the river mouth to approx NZMS 260 S22:915-300
Turakina	Lower Turakina	Turakina River	From the river mouth to a point located at the continuation of the fence line at approx NZMS 260 S23:918-246
Ohau	Lower Ohau	Ohau River	From the river mouth to a point 5 km upstream at NZMS 260 S25:948-579
		Lake Waitaha Drain	From the confluence with the Ohau River at approx NZMS 260 S25:946-580 to the Lake Waitaha Outlet at approx S25:954-605
Akitio	Lower Akitio	Akitio River	From the river mouth to a point 100 m upstream of the CMA boundary located at the seaward edge of the bridge that crosses the river at NZMS 260 U25:996-619
		Whakawaihine Stream	From the confluence with the Akitio River at approx NZMS 260U25:985-657 to a point approx 2 km upstream at approx U25:989-670

Northern Coastal	Northern Coastal	Okehu Stream	From the stream mouth to intersection with SH3 at approx NZMS 260 R22:717-510
Management Zone	**Sub-zone**	**River/Stream Name**	**Reference**
Kai Iwi	Kai Iwi	Kai Iwi Stream	From the stream mouth to 100 m upstream of the CMA boundary located at the seaward edge of the bridge that crosses the stream at NZMS 260 R22:721-452
Mowhanau	Mowhanau	Mowhanau Stream	From the stream mouth to Rapanui Road at approx NZMS 260 R22: 731-452
Kaitoke Lakes	Kaitoke Lakes	Kaitoke Stream	From the stream mouth to Kaitoke Lake at NZMS 260: R22:869-358
Southern Whanganui Lakes	Southern Whanganui Lakes	Koitiata Stream	From the stream mouth to a point 5 km upstream at approx NZMS 260 S23:987-191
		Waimahora Stream	From the stream mouth to intersection with Santoft Rd at NZMS 260 S23:001-154
		Raumai Range Stream	From the stream mouth to source
Northern Manawatu Lakes	Northern Manawatu Lakes	Kaikokopu Stream	From the stream mouth to Lake Kaikokopu at NZMS 260 S24:019-899
		4 Mile Creek	From the stream mouth to Lake Pukepuke at NZMS 260 S24:024-937
Lake Papaitonga	Lake Papaitonga	Waiwiri Stream	No location defined, assume from stream mouth to a point 500 m upstream at NZMS 260 S25:939-618
Lake Horowhenua	Hokio	Hokio Stream	From the stream mouth to 100 m upstream of the CMA boundary located at the seaward edge of the bridge that crosses the stream at NZMS 260 S25:950-659

Appendix 4

Recent survey/research work on freshwater fish in the Manawatu-Wanganui Region from 1995–2005

Author / Publication	Findings	Recommendations
The distribution and potential enhancement of eels in Mangaone Stream, Manawatu – Report to PNCC, Glova & Bonnett (NIWA) 1995	• Longfin eels were very rare in the survey (only 4% of total eel catch) • Other species found were common bully, koura, brown trout, perch and paratya shrimp • The size-frequency distribution was similar to previous surveys in the Turitea Stream but the proportion of longfin eels was less in the Mangaone • There did not appear to be any sign of commercial fishing impacts – although some harvest pressure on larger eels may have been apparent • Juvenile eels were more abundant and most often found in riffles • Mature eels were less abundant and most often found in pools • Analysis indicated increasing size with increasing depth • Depauperate fish fauna in Mangaone Stream attributed to a lack of riparian shading, sluggish flows and abundant weed and algal growth • Ecologic function and structure severely impaired	Habitat improvement methods included: • Tree planting on lower true right terraces to achieve 30-40% stream shading • Riparian vegetation allowed to establish more through a change in the vegetation clearance methods such as only clearing one bank each year to maintain some shelter for fish – drag line clearance should not be undertaken in any circumstances • Instream cover needs to be increased by strategic placement of boulders, over-hanging banks, well-anchored logs and some areas of weed refuge left (i.e. a 5 m pocket in every 100 m cleared streambed) • Habitat diversity needs increasing through changes in flow to create more pool/riffle complexes by placement of structures instream to deflect flow
Native Fish Diversity in the Oroua River and Tributaries: a contribution to a study of the life supporting capacity of the Oroua River – DoC Report, Mike Joy, 1998	• Tributaries at <150 m asl. had highest diversity • Tributaries higher diversity than mainstem – very important habitat for native fish • Fish diversity was low in the vicinity of Feilding but improved towards the Manawatu confluence • Dominant fish species common smelt • Makino Stream at Kitchener Park – refuge to species during low flows (water temp) • Important for spawning and recruitment of trout • No inanga, redfin bully or koaro found – have been found in the rest of the Manawatu catchment but not in the Oroua in three surveys	• Retirement and riparian planting to increase habitat and thereby fish diversity in tributaries

Author / Publication	Findings	Recommendations
Freshwater Fish Diversity and Distribution in the Ohakune Area: A contribution to a study of the environmental impact of vegetable washing – Horizons Report, Mike Joy, 1998	• Natural barriers (Raukawa Falls and the acidity barrier of the Whangaehu) stop migratory fish from entering the Upper Mangawhero and Whangaehu catchments • Cran's (non-migratory) bullies were only found in the Makara and Makotuku and may be slow to recolonise after lahar events • Low species diversity and abundance was not a result of vegetable washing but a result of barriers to the sea and altitude • Non-point sediment from cultivation on stream margins may also be a factor	• Retirement and riparian planting required to reduce movement of sediment into waterways from cultivation on river margins • This would also restore some of the fish habitat
A Freshwater Fish Survey of the Manawatu Coastal Lakes – DoC Report, Mike Joy, 1999	• Giant kokopu found in Forest Road Wetlands (Parewanui Drains) Crawshaw Property – some fish passage issues in restored/constructed wetland • Presence of perch noted in many Lakes may have a detrimental effect on native fish (by eating small ones) • Sarah Pond has only known lake population of Cran's. bullies in New Zealand • Some reduction in diversity generally but this may be historical anyway due to periodic opening and closing of access between lakes and the sea for diadromous species	• A reduction in grazing pressure on lake edges and inlet/outlet streams by fencing to increase riparian cover and reduce nutrient inputs • Research into the effects of drain clearance on life-supporting capacity of inlet and outlet flows for coastal dune lakes Large table of possible inlet/outlet barriers including (more in document): • Whitebait Creek (access to Foxton No. 1 Lake and others) • No. 2 drain (Rangitikei Drainage scheme) – access to Forest Road Wetlands • Waimahora Stream – access to Waimahora Wetlands and Blind Lake • Koitiata Stream – access to Tunnel Lake, Lakes Heaton and Bernard • Drain from Sextons Lake

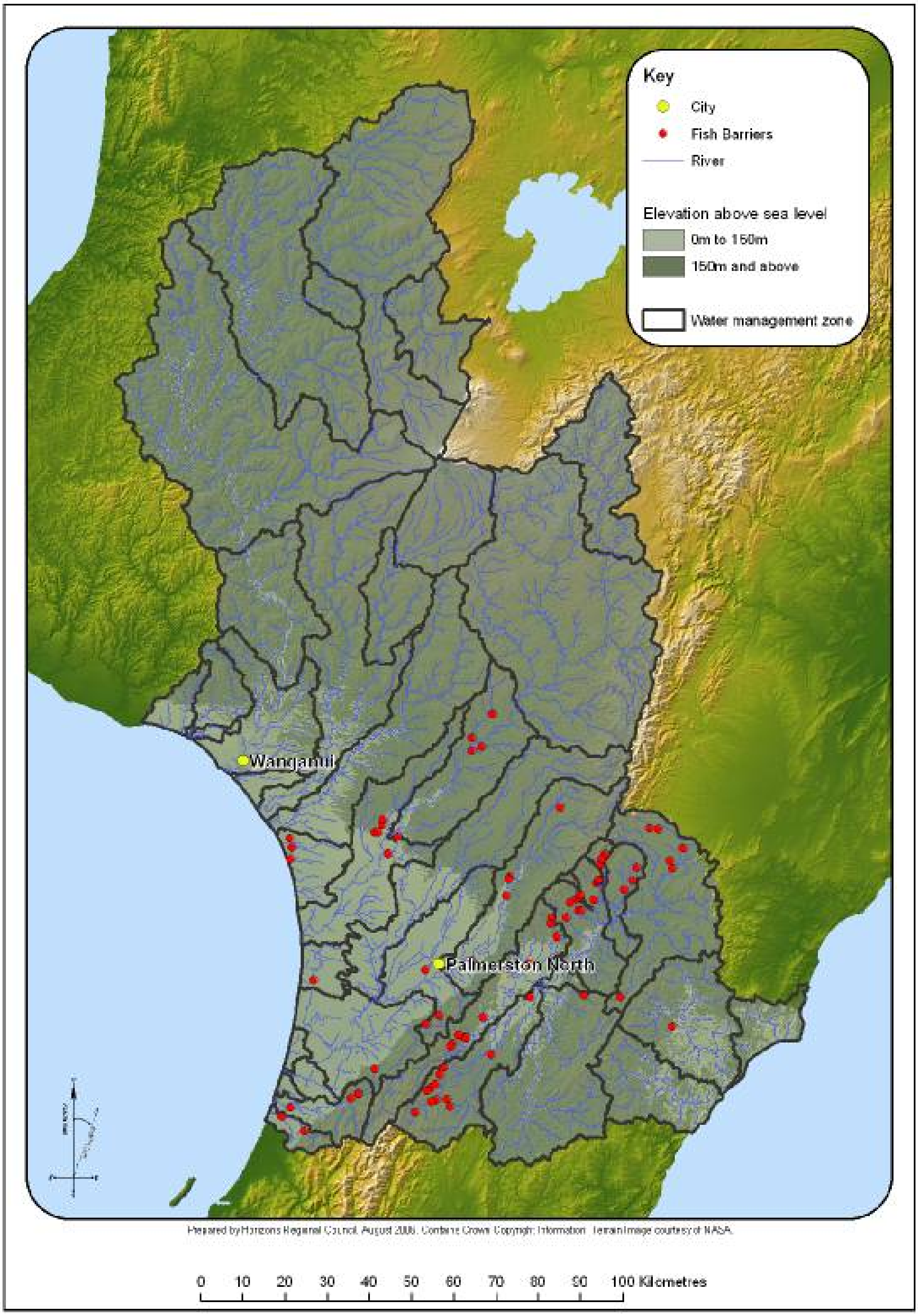
Author / Publication	Findings	Recommendations
Freshwater Fish in tributaries of the South Eastern Upper Manawatu River – Horizons Report, Russell Death and Mike Joy, 2000	• SE Ruahine tributaries have generally higher diversity of native fish than the mainstem of the Manawatu • Dwarf galaxias is only found in central NZ – good populations present in the Tamaki upstream of the water supply weir and Kumeti at Rehunga • High proportion of riffle habitat associated with dwarf galaxias presence • Fish barriers appear to have the greatest influence on fish diversity in the SE Upper Manawatu • Eels dominated below barriers and dwarf galaxias dominated above barriers	
Predictive modelling of freshwater fish as a biomonitoring tool in NZ – Horizons Report, Mike Joy, 2002	• Sites with high O/E ratios (e.g. >1.0) indicate sites with more species than expected which may be sites of high conservation value • Elevation, distance from sea, ecoregion and map coordinates were the most important factors affecting fish community structure at unimpacted (reference) sites • Impacted sites generally showed lower O/E ratios – validating the model	• To use the model in future the same sampling methods will need to be used at the same time of year as the original sampling • The same physical measures need to be taken at the site as in the original survey – these are not onerous however
State of the Environment Report: Native fish in the Manawatu-Wanganui Region – Horizons Report, John Phillips & Mike Joy, 2002	• High-value fish community in forested streams draining the Tararua Ranges and some smaller coastal draining streams • Poor state of native fish health in most other waterways • Problem catchments appear to be the Rangitikei, Whanganui, Upper Manawatu, Pohangina	• Identification of fish barriers regionally • Specific catchment studies in the Rangitikei and Upper Manawatu • Development of better guidelines for the management of waterways for native fish
The effects of landuse on native fish fauna in eight dune lakes along the West Coast, North Island, New Zealand – Horizons Report, Anna Lewis, 2002	• Report found no galaxiid species in any of the lakes surveyed • However identification was likely to be inaccurate • Poor reporting with little survey detail	• Water Quality investigations in lakes recommended to look at sources of eutrophication • Investigations into grazing pressure and landuse especially at Lakes Koitiata, Pauri, Heaton and Dudding • Fencing recommended for Lakes Koitiata, Pauri and Heaton • Investigate ecological status of lakes in terms of water quality, aquatic vegetation and rank the lakes for protection status

Author / Publication	Findings	Recommendations
Survey of Inanga (Galaxias maculatus) within the Manawatu River catchment – Horizons Report (NIWA), Baker *et al.,* 2003	• Lower Mangaone Stream near Manawatu confluence identified as important inanga habitat • Distribution of inanga in the Manawatu catchment appears to be limited so protection of remaining habitat is important • Good inland penetration of inanga into the Upper Oroua River (beyond normal inland limits) • No inanga found in the Manawatu catchment above the Gorge • No inanga found in Pohangina tributaries but may have been as a result of drying of tributaries over summer • Inanga are inhibited in upstream movement by all drops greater than 15 cm	• Removal of oxygen weed from Mangaone Stream may increase habitat value • Flood gates on tributaries of the Mangaone should also be investigated as to whether they are barriers to inanga habitat and on other tributaries of the Lower Manawatu • Investigations into floodgate passage during spring upstream migrations is needed • Habitat enhancement may also be needed
Fish communities of the middle and lower Rangitikei River catchment tributaries – Horizons and Fish & Game Report, Hamer & Lewis, 2004	• Low diversity and abundance of fish in lower (<150 m asl) Rangitikei tributaries when compared to national average – surprising considering distance from the sea and good water quality in mainstem • Average diversity and abundance in middle (>150 m asl) tributaries when compared to national average • Tutaenui had extremely poor fish community with only 1 fish (bully) caught in an upstream site and nothing in the lower sites • Ephemeral nature of the Rangitikei tributaries may be causing low fish diversity – no refuge in summer • Direct discharges to water in many tributaries causing poor water quality may also be an issue • Fish diversity decreased moving upstream from the confluence of tributaries with the mainstem Rangitikei • Makowhai and Pakihikura had highest diversity and abundance and Tutaenui and Burns Road Ford had lowest	• Fish barriers identified in many tributaries – especially Makohine • Monitoring impacts on habitat complexity of river control schemes recommended

Author / Publication	Findings	Recommendations
Fish Communities of the Upper Manawatu River catchment tributaries – Horizons and Fish & Game Report, Hamer & Lewis, 2004	• The Mangaatua Stream had no fish found during the survey • The Rokiawhana Stream had the highest density of dwarf galaxias surveyed, other stream with DG are Tamaki, Oruakeretaki and Mangatewainui • Otamaraho had the highest density of freshwater crayfish (koura) • Generally tributaries at <150 m asl (lower catchment tributaries) had low-average species diversity and abundance when compared to national averages • Tributaries at >150m asl (upper catchment tributaries) had average-high abundance and diversity when compared to national average • Trout were more abundant in lower catchment tributaries	• Table of fish barrier identified at sites – Oruakeretaki identified in report • Some impact noted from eel exploitation though sites not identified • Monitoring impacts on habitat complexity of river control schemes recommended
Manawatu-Wanganui Brown Mudfish Survey – Horizons Report, Jonno Tonkin and Amy MacDonald, 2004	• Whitiki Swamp (6 fish), Lake Herbert (1 fish), and Knottingly Swamp (1 fish) contained brown mudfish in this survey • Heatherlea Park Swamp (3 fish), Te Whanga Swamp (10 fish) and Artillery Swamp (1 fish) all contained banded kokopu	• Undertake a survey of potential drainage habitat for brown mudfish • Te Whanga Swamp identified fish barrier in a southern culvert
Freshwater Fish Survey of the Lowland Manawatu-Wanganui – Horizons Report, Jonno Tonkin, 2005	• No banded kokopu were found in 46 surveyed sites • Redfin bullies were only found at 5 sites out of 46 • Both species react negatively to suspended and/or benthic sedimentation • Foxton Loop had the highest fish diversity • Ohau River fish diversity was also high • Lake Kaikokopu	• Fish barrier identified at Lake Kaikokopu (South Western control weir)

Appendix 5

Identified barriers to fish migration in the Manawatu-Wanganui Region



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