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Use of mangrove habitat by banded rail (*Gallirallus philippensis assimilis*)

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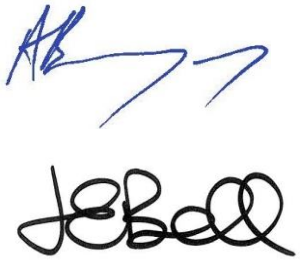
Use of mangrove habitat by Banded Rail (Gallirallus philippensis assimilis)

Literature Review
Prepared for Waikato Regional Council

Document Quality Assurance

Prepared by:	Andrew Blayney Senior Ecologist Boffa Miskell Limited Jacqui Bell Senior Ecologist Boffa Miskell Limited	
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Executive Summary

Banded rail are a cryptic and difficult to monitor bird found along both coasts of the Waikato region. They were common throughout the North and South Island before the 1930s; occurring in both freshwater and estuarine wetlands. Habitat loss and the introduction of mammalian predators now means they occur only in top half of the North Island, in large unmodified saltmarshes in the Nelson-Marlborough region and on offshore islands. They are found predominately in northern habitats that contain both saltmarsh and mangroves and are rarely found in saltmarshes that do not adjoin mangroves.

They spend a large proportion of their time foraging under mangroves which provide cover from aerial predators as well as providing corridors for dispersal and travel between roosting and foraging areas. Within the North Island (where 80-90% of the population of banded rail occur), banded rail are now dependant on mangroves habitats for their continued survival. This dependency on mangroves appears to be a recent phenomenon and banded rail in the past likely utilised a greater range of habitats in the North Island which are now either no longer available or unsuitable due to introduced predator pressure.

This dependency and wide scale use of mangrove habitats for foraging and as corridors by banded rail means that mangrove removal, while not having been fully quantified, is likely to have severe detrimental impacts on banded rail populations where it occurs. It will likely reduce suitable foraging habitat availability and, where no other shoreline vegetation exists, reduce opportunities for dispersal and exploitation of now disconnected habitats. There are possible opportunities for mitigation of these effects but there are too many gaps in our knowledge on banded rail and their use/dependency on mangrove habitats to effectively and reliably implement or quantify this mitigation.

The review identified many gaps in our current understanding of this issue and also identified many authors who have previously identified missing information. All of these gaps have focused around these questions:

- What is the distribution of banded rail in the Waikato region and New Zealand?
- How can we monitor their distribution, abundance, survival, and fecundity effectively?
- What are the current limitations on banded rail populations?
- What are the abundance patterns of banded rail across different habitat types/characteristics?
- What is the impact of mangrove removal on banded rail abundance, distribution, behaviour, health, survival, fecundity, and productivity?
- If we continue to remove mangroves can we effectively mitigate for the loss of banded rail habitat?

We provide a prioritised list of research steps to begin answering these questions and enable us to understand this interaction between mangroves and banded rail. While also enabling the conservation of banded rail and their habitats into the future in a wider catchment management and ecosystem restoration framework.

Current monitoring regimes are sufficient to detect the presence of banded rail throughout the year but we currently lack the tools and/or methodology to begin assessing banded rail densities or even compare indices between sites. There has been a significant amount of

research on the monitoring of cryptic bird species which can help provide a knowledge base for further work into developing appropriate monitoring tools and techniques for banded rail. This will require further refinement of current techniques and continued research into the opportunities new technologies provide for banded rail monitoring.

1.0 Introduction

This review outlines the use of mangrove habitat by banded rail throughout New Zealand and within the Waikato regional context. It provides an overview of the current information on the degree of dependency, purpose of use, important characteristics, seasonality and connectivity between habitats. This review is a standalone report of the wider review of the use of mangrove habitats by *Threatened* or *At Risk* bird species (Bell and Blayney, 2017) and should be read as a contributing part of the wider report.

The review has drawn on a range of literature including peer reviewed scientific journal articles, technical reports, evidence, grey literature (including data collected for Council monitoring, consultant's reports and theses), books and discussions with technical experts.

The report begins with a broad overview of the ecology of both banded rail in New Zealand (Section 2.0) and mangroves (Section 3.0). This is followed by a summary of the use and dependency of banded rail on mangroves (Section 4.0) and the impact of mangrove removal on this species (5.0). Recommendations for future research (Section 6.0) and monitoring (Section 7.0) have been made based on current gaps in knowledge (Section 6.0) and the assessment will be used by Waikato Regional Council (WRC) to inform the review of the Regional Coastal Plan and future science and policy work on mangrove management.

2.0 Banded Rail - moho-pererū (*Gallirallus philippensis assimilis*)

Banded rail (*Gallirallus philippensis assimilis*) is an endemic New Zealand subspecies which has a threat classification of At Risk; with the Data Poor and Range Restricted qualifiers (Robertson et al., 2017).

Behaviour, breeding and diet

Banded rail are a medium-sized rail which is a strong but reluctant flier, capable of travelling long distances, generally at night (Bellingham, 2013). In New Zealand, current estimates of home ranges are 4 ha/pair in mangrove forest (*Avicennia marina var. australasica*) in Northland and 1.5ha/pair in Nelson saltmarshes (Bellingham, 2013).

Banded rail feed under cover and rarely venture more than 10m into the open (Beauchamp, 2015; Botha, 2011). They are generally diurnal and crepuscular foragers, but have been recorded foraging at night (Beauchamp, 2012; Botha, 2011; Elliot, 1987). Banded rail roost in dense saltmarsh habitat during high tide and at night (Botha, 2011).

Breeding between monogamous pairs occurs during spring and summer, when they construct nest platforms made of rush and reed up to 0.5m above ground (Bellingham, 2013; Bouma, 2016; Marchant, Higgins, Davies, & Considine, 1993, p. 501). Clutches comprise 4 to 6 eggs and are incubated for approximately 3 weeks. Chicks are capable of leaving the nest within 24 hours of hatching, and are fully grown and able to fly after 2 months (Bellingham, 2013;

Marchant et al., 1993). During spring, banded rail call frequency can increase from 1-2 calls per hour to once per minute during periods exceeding 10 minutes (Beauchamp, 2015).

Moult regimes are poorly known and it is suggested that banded rail exhibit cryptic behaviour when flightless while moulting flight feathers; explaining why so few observations and skins displaying moulting have been recorded (Marchant et al., 1993). They are likely to have two adult moults per year, one of those being a complete post-breeding adult moult during which they are potentially without the ability to fly for 30+ days (Marchant et al., 1993). Based on New Zealand observations in captivity, this flightless period would occur sometime between early January and April (Marchant et al., 1993).

The banded rail's diet can consist of a range of snails, crabs, insects, worms, and spiders but can also include scavenged fish, seeds and fruit (Bouma, 2016). The majority component of the diet is crabs and estuarine snails (Botha, 2011).

Distribution and habitat

Once common throughout New Zealand, banded rail had declined by the 1930s due to habitat loss and the introduction of mammalian predators (Beauchamp, 2015; Botha, 2011; Bouma, 2016; Wildland Consultants, 2012). Its distribution in the North Island is now limited to Northland, Auckland, Waikato and Bay of Plenty regions (including the Three Kings, Poor Knights and Great Barrier islands) (Beauchamp, 2015; Botha, 2011; Bouma, 2016). In the South Island, it is limited to the coastal regions of Nelson-Golden Bay, Marlborough Sounds and offshore Islands around Stewart Island (Botha, 2011; Wildland Consultants, 2012).

Approximately 80-90% of the New Zealand population of banded rail occur in the estuaries and harbours of the North Island (Bellingham, 2013), generally restricted to mixed patches of saltmarsh and mangrove habitat (Beauchamp, 2015; Botha, 2011). Banded rail have been recorded to use freshwater wetlands in the North Island, but this use remains poorly investigated (Beauchamp, 2015). In the South Island, banded rail are confined to unmodified saltmarshes (Beauchamp, 2015; Wildland Consultants, 2012). On offshore islands where mammalian predation pressure is reduced, banded rail are recorded as being more terrestrial in their habitat use and seen more often in the open (Baird, 2015; Beauchamp, 2015; Bellingham, 2013), making use of forested habitat as well as saltmarsh (Botha, 2011). This may be reflective of the original mainland habitats and behaviour of banded rail prior to the introduction of mammalian predators (Bellingham, 2013).

Suitable banded rail habitat also appears to be restricted by access to freshwater; Elliot (1989) noted that in areas where saltmarsh habitat where there is no regular supply of freshwater (streams or rivers flowing through them), banded rail were not observed. The explanation for this distribution pattern of banded rail was speculated to be caused by either a metabolic dependence on freshwater or a requirement to have *Potamopyrgus estuarinus* (which is confined to habitats of brackish water) in their diet. This requirement for freshwater and subsequent associated distributional pattern is not observed in other banded rail subspecies outside of New Zealand (Marchant et al., 1993).

Banded rail distribution in Waikato

Inventory information for some sites is incomplete for cryptic birds such as banded rail in the Waikato (Dowding, 2013). Banded rail is recorded as present at a wide range of sites identified as important to coastal and estuarine birds on the east coast of the Waikato (Dowding, 2013); a summarised inventory of this information is provided in Appendix A. Additionally associated with

mangrove removal resource consent applications there has been considerable survey and summarisation of banded rail distributions in the Tairua and Whangamata Harbours (Wildland Consultants, 2012, 2015d, 2015c, 2015b, 2015a, 2016a, 2016b). However, the west coast and inland freshwater wetlands either lack survey effort or accessible records on the distribution of cryptic bird species including banded rail.

3.0 Mangroves (*Avicennia marina var. australasica*)

Mangroves (*Avicennia marina var. australasica*) are specialist woody trees or shrubs, adapted for growth within the intertidal zone of low energy coastal and estuarine environments (Morrisey, Beard, Morrison, Craggs, & Lowe, 2007). Typically, mangroves prefer to inhabit a soft muddy substratum and the gradual infilling of estuaries (concurrent with changes in land use) provides a suitable habitat for their establishment and growth (Morrisey et al., 2007). These fringing habitats form a buffer to the land from natural hazards such as tsunami and storm surge, while their dense root system form mats that stabilise sediment and protect the coastline from erosion (Nicholls & Ellis, 2002).

In New Zealand, mangrove habitat is indigenous to the northern coastlines of the North Island. The latitudinal range of mangrove habitat is limited by a number of factors including microclimate, currents and suitable coastlines. Presently the southernmost limit of mangrove habitat in New Zealand is Ohiwa Harbour (38º 03'S) on the east coast and Kawhia Harbour (38º 05'S) on the west coast (de Lange & de Lange, 1994; Morrisey et al., 2007).

Mangroves form an important link in the coastal vegetation sequence between seagrass and saltmarsh habitat (Harty, 2009; Saintilan, Hossain, & Mazumder, 2007). They are one of the most productive forest types in New Zealand and provide a key source of organic material and nutrients to the estuarine food web (De Luca, 2013; Woodroffe, 1982). Branches and roots provide protection from predation for native fish and birds, as well as a substrate within which both mobile and sessile invertebrates and plants can directly or indirectly inhabit. These benthic invertebrates in turn provide an important food source for the fish and birds that also inhabit mangroves (Morrisey et al., 2010).

4.0 Banded rail use of, and dependency on, mangrove habitat

Mangrove habitat use

Mangrove habitats have been identified as providing foraging habitat for banded rail (Baird, 2015; Botha, 2011; Bouma, 2016; Giles, 2014; Wildland Consultants, 2012, 2014, 2015a, 2015d, 2015b, 2015c, 2016a, 2016b; Bellingham, 2013; Beauchamp, 2012, 2015; Boffa Miskell Ltd, 2015; Brian T. Coffey and Associates Ltd, 2012). Within the Waikato region, banded rail are described as the bird species most closely associated with mangrove habitats in the Tairua

Harbour (Wildland Consultants, 2015a) and are found throughout the region where mangroves occur adjacent to saltmarsh (Dowding, 2013; Wildland Consultants, 2015d). In the North Island, banded rail are considered restricted to saltmarshes with adjacent mangroves (Beauchamp, 2015; Bellingham, 2013).

Botha (2011) observed that banded rail reluctantly left their saltmarsh roosting habitat cover to feed on the open mudflats, and only up to a maximum distance of 6m (but an average of 1m) from the saltmarsh edge. In contrast, it was observed that where mangroves provided seaward vegetation cover adjacent to the saltmarsh roosting habitat, banded rail would venture to the seaward edge of the mangroves up to 280m from the saltmarsh edge (Botha, 2011). This finding is consistent with monitoring results in Whangamata Harbour which indicate banded rail use mangroves 300m or more from the saltmarsh edge (Wildland Consultants, 2014). In addition to this increased foraging distance from roosting habitat, Botha (2011) found three times as many footprints along open drains and flow paths within mangrove habitats than those within saltmarsh habitats indicating a clear preference for mangrove habitats for foraging. The increased travel distances and time spent under the mangrove cover has been hypothesised to be a result of poor feeding habitat quality under mangrove habitats (Dr Dumbell cited in Baird (2015)). However Botha (2011) found that food was not limiting under mangroves, with preferred prey (*Austrohelice crassa*) being more abundant within mangrove habitats. The reason for banded rail preferring to forage in mangrove habitats appears to be related to their need for protection from aerial predators which mangroves provide (Botha, 2011; Wildland Consultants, 2012). Mangroves may also provide dispersal corridors for banded rail in areas lacking indigenous vegetation landward of mangroves (Giles, 2014; Wildland Consultants, 2012).

While not recorded in the literature, there have been observations of potential roosting by banded rail in mangrove canopy (T. Beauchamp, Technical Advisor Threats - Department of Conservation, personal communication, February 27, 2017). This observation may point to the possibility that non-breeding birds (as it is assumed nesting cannot occur in the mangrove canopy) could use mangrove habitats that are not adjacent to saltmarsh habitats.

Mangrove habitat preference characteristics

Connectivity of mangroves to saltmarsh habitats appears to be the key characteristic influencing the use of mangroves by banded rail as they require saltmarsh habitats for roosting and nesting (Beauchamp, 2012, 2015; Botha, 2011; Giles, 2014). The size of saltmarsh habitat connecting to the mangroves does not appear to be a limiting factor as banded rail have been recorded in saltmarsh sites of 0.01ha in size which are connected to mangrove habitat (Beauchamp, 2015).

Linked to the direct connectivity of mangroves to saltmarsh habitats; mangroves act as a 'long-shore corridors' providing connectivity between patches of saltmarsh and other terrestrial vegetation. This appears to also be a key characteristic, especially where mangroves form the only estuarine edge vegetation, in determining banded rail use (Baird, 2015; Giles, 2014; Wildland Consultants, 2012). Banded rail are likely to use these long-shore corridors for dispersal and travel between foraging, roosting, and/or nesting sites (Baird, 2015; Giles, 2014; Wildland Consultants, 2012).

The combination of mangroves high structural complexity above ground and low structural complexity at ground level provides cover from aerial predators in conjunction with unimpeded access to ground level foraging habitat (Botha, 2011; Giles, 2014; Marchant et al., 1993; Wildland Consultants, 2012). This preference of banded rail for aerial cover and unimpeded access at ground level is also observed outside of mangroves distribution. Banded rail prefer *Juncus kraussii* subsp. *australiensis* habitats as the culms are held at an angle providing aerial

cover while retaining clear access at ground level, compared to other rush habitats which grow vertically and provide less cover while also restricting ground level access (Elliot, 1987). Therefore, this habitat preference exists independent of mangrove presence.

There is no information in the literature that completely assesses whether the size, density, or age of mangroves are characteristics that influence use by banded rail. Botha (2011) reported that banded rail used scattered, spatially separated and small mangroves in preference to open mudflat areas. Whether these scattered mangroves provided equal quality foraging habitat to older, denser mangroves was not quantified. This finding does suggest that mangroves of any size and distribution are able to provide the foraging cover required by banded rail, even at small sizes and scattered distributions such as those often found on the lower tidal limit of mangrove stands (Botha, 2011; Elliot, 1987).

Mangrove habitat extent into the seaward edge of estuaries and their distribution lower down the shore may have an impact on its value for banded rail foraging habitats. Elliot (1987) found that banded rail activity is highest amongst saltmarsh vegetation that is inundated by the tide more often and consequently where a greater abundance of food is available; a finding further supported by Botha (2011) within mangrove habitats. This may also further explain the preference of mangroves over saltmarsh for foraging in areas where mangroves occur (Botha, 2011).

Seasonality of mangrove habitat use

Though little information exists, there appears to be no seasonal influence in the use of mangroves by banded rails observed in the several monitoring reports and studies (Beauchamp, 2012, 2015, Wildland Consultants, 2014, 2014, 2015a, 2015b, 2015d, 2016a, 2016b). This would suggest banded rail use mangroves year round in the Waikato Region and throughout the North Island.

Seasonal variation in the probability of detecting banded rail in bird count monitoring has been reported, primarily due to differences in call frequency during and outside of the breeding season (Beauchamp, 2012, 2015).

There is limited literature that describes different life history and diet requirements of banded rail which could lead to seasonal variations of mangrove habitat use:

- Elliot (1987; 1989) identified seasonal changes in banded rail diet in the South Island, identifying banded rail switching from their preferred food of mud crab (*Austrohelice crassa*) to the snails *Amphibola crenata* and *Potamopyrgus estuarinus* during winter when the mud crab were scarce. Botha (2011) found higher abundances of mud crab in mangroves but lower abundances of *P. estuarinus* when compared to mudflats. How this impacts on banded rail use of mangroves in the North Island has not been explored but remains the only information that might influence a seasonal component of banded rail use of mangroves based on diet.
- Life history stages such as during the pre-breeding adult moult when birds are flightless (Marchant et al., 1993), when they are nesting in spring and summer, or when they are raising chicks in the 2-month period before fledgling (Bellingham, 2013; Marchant et al., 1993).

There has been no investigation on whether these life history stages drive a requirement for certain times of year when undisturbed access to mangrove habitats may be more important to banded rail.

Dependency on mangrove habitats

The geographic range of banded rail extends beyond that of mangroves current distribution, inhabiting saltmarsh habitats in the coastal regions of Nelson-Golden Bay and Marlborough Sounds, offshore Islands around Stewart Island (Botha, 2011; Wildland Consultants, 2012) and in a range of non-mangrove habitats on Great Barrier Island (Beauchamp, 2015; Botha, 2011; Bouma, 2016). Thus, while banded rail do not have a natural obligate dependency on mangrove habitats, outside of the distribution of mangroves they are now confined to large unmodified saltmarshes (Botha, 2011; Wildland Consultants, 2012) or offshore islands which are either entirely mammalian predator free or in other cases lack just mustelid predators (Baird, 2015; Beauchamp, 2015; Bellingham, 2013; Department of Conservation, 2012). Therefore, this understanding that banded rail are not dependent on mangrove habitats across their entire range is not appropriate to apply to the current modified landscape of most of the New Zealand mainland; particularly the North Island where it is estimated that 80-90% of the banded rail population is now found (Bellingham, 2013).

In the North Island there has been considerable loss of freshwater and estuarine wetland habitats to farming, coastal development and other human disturbances as well as increased predation pressure with a range of introduced mammalian predators present (Baird, 2015; Beauchamp, 2015; Botha, 2011; Bouma, 2016; Wildland Consultants, 2012). Both this habitat loss and increased predation pressure have contributed to banded rail declining by the 1930s to being restricted to, outside of occasional records, north of a line of between Kawhia and Opotiki (Baird, 2015; Beauchamp, 2015; Botha, 2011; Bouma, 2016; Marchant et al., 1993; Wildland Consultants, 2012) which matches the current distribution of mangroves (de Lange & de Lange, 1994; Morrisey et al., 2007). Within this present North Island distribution of banded rail there is a range of evidence for banded rails use and reliance on mangroves as foraging areas (Botha, 2011) and restriction to saltmarsh habitats that are close to mangrove habitats (Beauchamp, 2015). This distribution pattern of occurring only where mangroves occur is also observed within the Waikato region (Dowding, 2013; Wildland Consultants, 2012, 2015d, 2016b).

Due to a combination of habitat loss and introduction of mammalian pests (at least within the North Island), banded rail are dependent on mangrove habitat for their continued survival (Baird, 2015; Beauchamp, 2012), requiring mangroves to provide cover from aerial predators while foraging close to their preferred saltmarsh roosting and breeding habitats (Beauchamp, 2012; Bellingham, 2013; Botha, 2011). Research is required to further quantify this dependency and whether supplementation with alternative habitats and pest control can mitigate the dependency of banded rail on mangrove habitats.

5.0 Impact of mangrove removal on banded rail

Throughout this review no study or survey was found to provide conclusive information or quantify the effect of mangrove removal on banded rail (Bouma, 2016). Surveys in the Waikato have focused on call counts, visual surveys, and footprint surveys to determine the presence of banded rail before and after mangrove removal. These surveys have confirmed both presence of banded rail before and after partial mangrove removal, but reported their absence in some areas were complete mangrove removal occurred (Wildland Consultants, 2014, 2015a, 2015d, 2015c, 2015b, 2016a, 2016b). These survey methodologies currently cannot be used to

determine densities of banded rail (Beauchamp, 2015). To fully understand the impact of mangrove removal on banded rail, long and short term surveys would be required to quantify rail density, changes in feeding behaviours, abundance, fecundity, survival, and dispersal.

Without quantitative information on the effects of mangrove removal on banded rail, we are still able to assess the likely effect based on the recorded and researched habitat preferences and foraging behaviour. As banded rail are restricted to saltmarsh and mangrove habitats in the North Island (Baird, 2015; Beauchamp, 2012, 2015; Bellingham, 2013), the removal of mangroves would detrimentally alter the available foraging habitat as it removes their cover from aerial predators (Botha, 2011; Giles, 2014; Morrisey et al., 2007; Wildland Consultants, 2015a). Additionally the removal of mangroves is associated with significant impacts on benthic macrofauna communities (Lundquist, Hailes, Cartner, Carter, & Gibbs, 2012), further reducing the suitability for banded rail foraging habitat.

The scale of mangrove removal is likely to be important contributing factor in the impact on banded rail. Greater areas of mangrove removal will cause greater loss of foraging habitat; this impact may be proportional but if removal impacts on identified preferred habitat characteristics it could be greater than expected for the area of foraging habitat removed. Known factors that could contribute to these greater impacts of are:

- Removing all mangroves that are adjacent to a patch of saltmarsh habitat may contribute to making the saltmarsh habitat unsuitable for banded rail as occupancy of saltmarsh habitats has found to be dependent on mangrove connectivity in the North Island (Beauchamp, 2015).
- The removal of mangroves in areas where there is no intact marine to terrestrial vegetation sequence could also limit the ability of banded rail to disperse and move between nesting and foraging sites, or to unexploited habitat (Giles, 2014; Wildland Consultants, 2012).
- Reducing the mangrove's seaward extent could reduce the value of foraging habitat for banded rail as banded rail prefer vegetation that is inundated by the tide more often and where there is a consequently greater abundance of food (Botha, 2011; Elliot, 1987).

These habitat factors and the dependency of banded rail of mangroves in the modified habitats of the North Island suggest that mangrove removal is likely to have a severe detrimental impact on banded rail populations. Habitats which would have provided alternatives to mangroves for banded rail in the past have been significantly reduced and impacted by mammalian pests and no longer support banded rail populations (Baird, 2015; Marchant et al., 1993; Wildland Consultants, 2012).

6.0 Current knowledge gaps and research required on the use of mangrove habitats by banded rail

There have been several reports and research that have identified significant gaps in information on banded rail use of mangroves and called for additional research regarding this matter.

Botha (2011):

- Investigate the influence of mangroves have on the reproductive success of banded rail.
- Radio or satellite tracking of banded rail to determine foraging ranges and whether they maintain territories.
- Evaluate the value of mangroves as ecological corridors for banded rail around harbour edges.

Dowding (2013):

- Inventory of banded rail distribution in the Waikato required - several areas on the east coast of the Waikato noted lack of distribution and presence data.

Giles (2014) also referenced and expanded on within Bouma (2016):

- Investigate banded rail behaviour (quantify movement and feeding patterns in saltmarsh and mangrove habitats).
- Territory sizes and whether banded rail are territorial.
- Carrying capacity of habitats and suitability of habitats post mangrove removal.
- The role of predation in population dynamics.
- Lag effects/ long term effects on banded rail fecundity and survival following mangrove removal.

Beauchamp (2015):

- How banded rails are using habitats.
- Can call counts be used to determine banded rail density?
- Using transmitters to assess relationship between presence and calling, habitat use, home range size, and longevity.

Further to the already identified research gaps, we have found additional gaps or incomplete information within the literature that might be pertinent:

- Moult regimes, their behaviour during flightless periods, and how this impacts on the need for undisturbed access to preferred habitats.
- Variation in habitat preference (size, extent and composition) and predation pressure between the North and South Islands, different habitat types, and sites with the same habitat types. This may further explain why banded rail appear restricted to mangroves in the North Island. Providing clues on what pressures and features of habitats are most important in determining banded rail distribution and abundance, and provide information towards what can be done to provide suitable alternative habitats for banded rail in the North Island.
- Potential mitigation strategies of mangrove removal and their effectiveness in providing suitable banded rail habitat.
- Banded rail distribution on the west coast of the Waikato region.

With this review and previous reports, there now exists a relatively complete picture of the current understanding of banded rail and their use of mangrove habitats, as well as the gaps and missing information in this current understanding. To progress from here, a prioritised

approach to further research is needed to begin answering outstanding questions in order to inform future policy documents and decisions relating to mangroves and banded rail.

We consider the outstanding questions to be:

- What is the distribution of banded rail in the Waikato region and New Zealand?
- How can we monitor their distribution, abundance, survival, and fecundity effectively?
- What are the current limitations on banded rail populations?
- What are the abundance patterns of banded rail across different habitat types/characteristics?
- What is the impact of mangrove removal on banded rail abundance, distribution, behaviour, health, survival, fecundity, and productivity?
- If we continue to remove mangroves can we effectively mitigate for the loss of banded rail habitat?

We consider the priority of further research to answer these questions and the justification of this priority to be (listed in order of priority):

1. Presence/non-detection inventory of banded rail distribution with information on habitat use and adjoining habitats throughout the Waikato; where this information is incomplete or missing.
    - Justification: Without inventory information we cannot determine when banded rail should be considered in future decision making regarding potential habitats. Additionally, a clear picture of banded rail habitat use in the Waikato is needed to further determine the importance of mangroves.
2. Research into modifying existing or developing new monitoring techniques in order to develop a standard protocol for monitoring of banded rail that includes the ability to provide estimates of density.
    - Justification: Currently a lack of density-evaluating monitoring techniques limits our ability to determine abundance patterns across New Zealand and the Waikato region (which may point to what factors might limit banded rail populations). Without these techniques the impact of the modification of their habitats by mangrove removal or other habitat disturbance cannot be quantified.
3. Surveys across sites in the Waikato region and New Zealand to determine how density and carrying capacity are impacted by different habitats and their connectivity.
    - Justification: First requiring suitable monitoring techniques; without density information at sites we are unable to determine potential impacts of mangrove removal on banded rail. This information can also begin to further inform banded rail dependence on mangrove habitats, their habitat requirements and increase our predictive power on what effects mangrove removal will have.
4. Research and monitoring on the effect of mangrove removal on banded rail populations in the short and long term. Including measures of banded rail density, survival, fecundity, site occupancy, and use of mangrove removal areas. This could be achieved through comparisons between specific mangrove removal study sites and appropriate control sites where mangroves are not removed.

- Justification: Current monitoring represents only a relatively short term continuation of banded rail presence post mangrove removal with acknowledgement this does not indicate lack of effect. Without this information effects of mangrove removal on banded rail are largely based on likelihood given the current understanding of banded rail habitat usage and foraging behaviours.

5. Research into the life history factors that may contribute to the impact of mangrove removal on banded rail such as breeding patterns, parental care and moult regimes.
    - Justification: We need to understand whether there are times of the year when banded rail rely on mangroves more to survive and reproduce, so policy and mitigation strategies can attempt to provide for these requirements.
6. Explore and compare the abundance and habitat use distribution patterns of banded rail across New Zealand; what are the different habitats they are using, habitat patch size, predation pressure, connectivity to other habitats, etc.
    - Justification: To determine why banded rail appear currently dependent on mangroves in the North Island we must first find out how they survive and what pressures they face where they do not inhabit mangrove habitats compared to when they do. With this information we can begin to determine what pressures drive the requirement for mangroves in the North Island and begin to understand how to create or enhance alternative habitats for banded rail.
7. Conduct a research trial: design and implement a trial of habitat enhancement/creation based on the previous priority research findings to provide supplementary and alternative habitat for banded rail. With the goal that banded rail in the trial area exhibit habitat use patterns and behaviours more similar to those observed in areas of more intact habitats and less predation pressure such as on offshore islands.
    - Justification: The banded rail dependence on mangrove habitats appears to be a recent phenomenon driven by anthropogenic pressures on populations. The ultimate long term goal of research should be to enable the conservation of banded rail in such a way that while acknowledging mangroves importance as a habitat decreases their dependency on them and provides a greater suite and extent of suitable habitats. This last stage would be an aspirational goal and would likely benefit a wider range of native species and should be conducted as part of wider catchment management and ecosystem restoration.

7.0 Recommendations for effective monitoring of banded rail in mangrove and surrounding habitats

Determining banded rail presence can be done using any of the current monitoring techniques at any time of year (Beauchamp, 2015) and, with appropriate replication and baseline surveys, could be used to compare indices over time. However, variables such as weather, tide, time of day and season would have to be controlled for and relies on an assumption that the

relationship between call/footprint/visual observation frequency and absolute density is linear. As such this is likely to be labour intensive, highly variable and of low statistical power.

To optimise the efficacy of the current available monitoring techniques, certain variables should be considered when they are being employed:

- Call counts: to optimise effectiveness and efficiency call surveys should be done in spring and in the period of 0.5 to 1 hour before sunset when banded rail call more frequently. However there is no time of year where banded rail are considered undetectable (Beauchamp, 2015).
- Footprint surveys: ensure survey planning takes into consideration the ability of the substrate to hold footprints (in sand and dense pneumatophores of mangroves there may be little trace of banded rail footprints or where substrates remain shallowly submerged by the tide (Wildland Consultants, 2015d)) consider using print stations or alternative survey methodology where substrates are unsuitable. Surveys should be timed during a period of time when low tide occurs in the morning when banded rail exhibit a peak of activity (Beauchamp, 2015).
- Audio recorders: ensure that audio recorders are placed close to preferred estuarine margin habitats and at a high enough density to effectively detect banded rail (Stewart, 2016).
- Visual surveys: consider all points above mentioned for footprint and call surveys to increase likelihood of encounter. Should be considered only as an additional/incidental monitoring technique to either call or footprint surveys for presence/absence determination but remains a useful source of habitat use and behavioural observations.

As reviewed in previous sections, there is currently a lack of accepted and effective monitoring techniques for banded rail that have the ability to provide information on density. There have been surveys that used a combination of calls and footprints and spatial separation of greater than 100m to provide estimates of banded rail density (Davis & Bellingham, 1984 cited in Beauchamp, 2015), but this methodology needs research to determine the validity of results as too little is known about banded rail home ranges.

Research required on the effective monitoring of banded rail to support the #2 research priority identified in the above section should include:

- Exploring the use of satellite or radio transmitters to determine home ranges, survival, habitat use patterns and potentially provide information towards the calibration of call frequency and absolute density of banded rail
- Continue to develop and refine methodology for the use of electronic audio recorders to monitor for banded rail and attempt to calibrate these methods with banded rail density. Electronic recorders have been used for banded rail monitoring in Tairua harbour by Wildlands (2016b) but developed protocols and methodology to assess banded rail densities with automatic records is required. UAV placement of audio recorders at study sites could also be explored to avoid disturbance and tracking into habitats (Stewart, 2016)
- Explore the use of remote sensor operated cameras to gather information on habitat use and behaviour and as a monitoring tool to determine density indices

While not directly applicable to banded rail monitoring, there has been significant research on the development of monitoring techniques for cryptic bird species by Williams (2016) with a focus on bittern (*Botaurus poiciloptilus*) using electronic recording devices. There have also

been successful trials within the Waikato region using audio recorders to detect cryptic avifauna (Stewart, 2016). This work should provide an effective research and knowledge base to develop these techniques for banded rail. These techniques are also described within O'Donnell & Williams (2015), with further information on a decision framework for when to use differing monitoring techniques.

8.0 Conclusion

Banded rail are found predominately in North Island habitats that contain both saltmarsh and mangroves and are rarely found in saltmarshes that do not adjoin mangroves. Spending a large proportion of their time foraging under mangroves which provide cover from aerial predators as well as providing corridors for dispersal and travel between roosting and foraging areas. Within the North Island (where 80-90% of the population of banded rail occur), banded rail are now dependant on mangrove habitats for their continued survival. This dependency on mangroves appears to be a recent phenomenon and in the past banded rail likely utilised a greater range of habitats in the North Island which are now either no longer available or unsuitable due to introduced predator pressure.

Mangrove removal, while not having been fully quantified, is likely to have severe detrimental impacts on banded rail populations where it occurs. It will likely reduce suitable foraging habitat availability and, where no other shoreline vegetation exists, reduce opportunities for dispersal and exploitation of now disconnected habitats.

The review identified many gaps in our current understanding of this issue and also identified many authors who have previously identified missing information. We also identified that there are effective monitoring techniques for determining the presence of banded rail but currently lack the methodology or tools to assess factors such as survival, abundance, and fecundity. A prioritised approach to further research is required to further determine and understand the relationship between mangroves and banded rail.

9.0 References

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Appendix A:

Appendix A1: List of areas where there are records of banded rail presence at sites of importance to shorebirds on the east coast of the Waikato Region (Sourced and summarised from Dowding (2013))

Site # used	Site name	Notes regarding banded rail presence (blank = nothing other than presence noted)
01	Firth of Thames west (Kaiaua to Waihou River)	Regular sightings, probably relatively common in parts of the site.
04	Manaia Harbour	
08	Colville Bay	Distribution of banded rail, fernbird and other cryptic species incomplete.
13	Waikawau Bay (including Little Bay)	Present and increasing. Provides map of important habitat for banded rail
15	Whangapoua Harbour, including New Chums Beach, Whangapoua Beach, and Matarangi Spit	Records from 1980s, probably still present
22	Whitianga	Older records, probably still present There are records of bittern, banded rail and fernbird from the upper reaches of the harbour, but there appears to be little recent or site-specific information.
23	Cooks Beach, Purangi Estuary, Cathedral Cove, Hahei Beach	Recorded in Purangi Estuary in 2013
26	Tairua Harbour (including Tairua Ocean Beach, Pauanui Beach and Spit, and Pauanui Waterways)	Widespread in suitable habitat around the harbour. Also extensive monitoring by Wildlands (2012, 2015a, 2016b)
28	Ohui	Old records from small wetland at rear of beach.
29	Opoutere Sandspit and Wharekawa Harbour	Still relatively common, regularly seen around the mouth of Wahitapu Stream, almost certainly occurs elsewhere in the harbour. Information gap: Distribution of banded rail and bittern incomplete. Banded rails are regularly seen at the mouth of Wahitipu Creek, but occur elsewhere.
32	Whangamata Harbour	References Raynor 2011[1] which indicates Banded rail presence in Whangamata Harbour. Also extensive monitoring by Wildlands (2015d, 2015d, 2015c, 2015b, 2016a)

[1] Rayner, M. 2011. Whangamata Harbour Mangrove Removal Assessment: Effects on Avifauna. NIWA Client report AKL2010-038. National Institute of Water and Atmospheric Research. Auckland.

Appendix A2: List of areas where there are identified gaps of information on the presence of banded rail at sites of importance to shorebirds on the east coast in the Waikato Region (Sourced and summarised from (Dowding, 2013))

Site #	Site name	Notes regarding banded rail
06	Coromandel Harbour	Information on presence/distribution of banded rail, fernbird and other cryptic species required.
33	Otahu Estuary	Older data suggest the upper reaches of the estuary could be important for wetland birds, such as bittern, banded rail, and fernbird. Up to date information is required on species, abundance and distribution in the upper estuary.