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Sewage discharges from boats in the Waikato region

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Te Kaunihera ā Rohe o Waikato

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Report Number: 2016-07

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1 Executive summary

The discharge of sewage from boats in the Waikato Region is currently regulated in accordance with the default requirements of the Resource Management (Marine Pollution) Regulations 1998. Waikato Regional Council are considering whether they should continue to use the default regulations or whether more stringent measures should be provided in their Coastal Plan. In order to make an informed decision, Waikato Regional Council require scientific information on the magnitude and impacts of discharged sewage on the marine environment and its users. The aims of this project were to:

- provide a concise comparison of the sewage discharge rules used by other Regional and District Councils, and the methods they used to determine those rules;
- review the international literature for information on the potential impacts of boat sewage discharges on the environment;
- assess the available information on the potential impacts of boat sewage discharges in the Waikato Region; and,
- identify knowledge gaps and provide recommendations as to how they could be filled.

Nine Regional and District councils are using the default marine pollution regulations, five councils have strengthened the regulations, and two councils have stronger regulations in their Proposed Plans. Bay of Plenty Regional Council, Gisborne District Council and Marlborough District Council (pending acceptance of the proposed Plan) have uniformly extended the no-discharge zones to 1–2 km. Bay of Plenty and Gisborne have also banned discharges in specific harbours. Northland Regional Council, Hawkes Bay District Council, Greater Wellington and Auckland Council (pending acceptance of the proposed Auckland Unitary Plan) have increased discharge restrictions to cover specific areas. Northland Regional Council are also proposing to make holding tanks compulsory for boats staying overnight in restricted areas, and to limit boat stays in restricted areas. Increases to the regulations set by various councils appear to be largely based on advocacy from tangata whenua and community groups, rather than any scientific evidence documenting faecal contamination from boat sewage. In some instances, areas deemed to be special or highly sensitive have been given larger no-discharge zones as a means of extra protection.

A review of the international literature shows that the discharge of untreated boat sewage can cause conditions that are unsuitable for shellfish harvesting or recreational water use, particularly in enclosed water bodies or areas of high boat usage. Evidence to suggest that boat sewage is the cause of faecal contamination in some areas include:

- high faecal bacteria concentrations in marinas, with concentrations decreasing with increasing distance from the boats;
- peak faecal bacterial concentrations in popular boating destinations and marinas during holiday weekends; and,
- positive correlations between faecal bacteria concentrations and the number of boats present in popular anchorages.

Very limited information is available on recreational boating and sewage discharge practices in the Waikato Region. The peak boating densities in popular anchorages and the degree of compliance with current sewage discharge regulations are unknown. Sewage pump-out facilities are provided at Whitianga, Whangamata, Pauanui and Tairua, but they are almost never used. The majority of public do not have shore-based toilet facilities within 500 m of the ramps. The lack of use of pump-out facilities and the unavailability of public toilets suggests that the majority of people must discharge their sewage at sea.

A review of the coastal water quality in the Waikato Region showed that water quality at most monitored sites is generally good to excellent. The majority of exceedances in Enterococci concentrations occurred in estuaries or near freshwater discharges, and are most likely to be affected by contaminated land run-off. This conclusion is supported by the fact that many exceedances coincided with periods of heavy rainfall. Exceedances at some popular boating locations in Coromandel Harbour, Whitianga and Whangamata were not correlated to rainfall, and boat sewage may be a potential source of contamination. However, all of these sites are potentially affected by multiple sources of faecal contamination (e.g., livestock, septic tanks, boats, freshwater discharges), and consequently, it cannot be ascertained from the existing water quality data whether boat sewage is the primary source.

Critical knowledge gaps in the assessment of the boat sewage discharge in the Waikato Region include:

1. Boat sewage discharge practices and preferences of the boating sector;
2. Live-aboard boat usage of the Waikato region (times, densities, areas);
3. Evidence for compliance with current regulations;
4. Evidence for adverse effects caused by current sewage discharge practices; and,
5. What size should no-discharge zones be to minimise adverse impacts on human health, cultural values and enjoyment of the coast, and effects on the environment?

Auckland Council's recent experience with their proposed changes to sewage discharge regulations highlight the importance of stakeholder consultation and the need for rigorous scientific evidence to support any proposed changes. Outlined below is a recommended process to determine whether changes to the sewage discharge regulations in the Waikato Region are necessary, and if so, the appropriate extent of discharge buffers.

1. Develop an engagement plan that identifies the best methods to gather information on boat sewage disposal perceptions, practices and preferences. The drafting of this plan should include input from a representative group of boat owners to ensure that a high level of stakeholder support is achieved.
2. Gather information on the discharge perceptions, practices and preferences on the boating sector to ascertain:
    a. their perceptions about whether sewage discharge from boats is currently a problem and the reasons for those concerns (e.g. health concerns, cultural concerns and/or impacts on their enjoyment of the coast);
    b. the proportion of boats that stay at sea overnight (e.g. where, when, how often, average stay length);

c. the proportion of boats with holding tanks;

d. sewage pump-out/disposal practices for boats with and without holding tanks (e.g. how, where and when do they discharge);

e. impediments to the use of marina pump-out facilities;

f. familiarity with the discharge regulations;

g. whether discharges should be prohibited in specific areas where shellfish such as scallops are gathered and/or from high-use recreation areas;

h. whether there are additional areas where the discharge of sewage should be prohibited;

i. preferences on the size of no-discharge zones.

3. Conduct aerial surveys to estimate live-aboard boat usage of the region (areas, boat densities, boat types, times).
4. Conduct water quality testing to assess the level of compliance with current regulations. Testing should be conducted:
    a. at popular anchorages before, during and after peak usage;
    b. at popular fishing spots that are within 500 m from marine farms before, during and after peak usage;
    c. during fine weather and in locations that are unlikely to be contaminated by other faecal sources;
    d. at increasing distances away from boats to assess the scale and magnitude of effects.
5. Conduct water quality testing to assess whether the current regulations are sufficient. Testing should be conducted in areas where sewage discharge is permitted including:
    a. just outside the 500 m boundary of popular anchorages during high use periods;
    b. in areas where sewage is frequently discharged (as identified by the boating sector);
    c. in areas where shellfish are harvested, particularly in areas where discharges are currently permitted (e.g., scallop beds and > 500 m from marine farms).
6. If it is ascertained in the steps above that the majority of people are complying with current sewage discharge regulations, but faecal contamination from boat sewage is still a health or environmental risk, then an increase in the no-discharge zone is recommended. The most robust method of determining the appropriate size of no-discharge zones is likely to involve a Quantitative Microbial Risk Assessment, coupled with community consultation on acceptable levels of risk.

2 Background

Untreated or partially treated sewage that is discharged into the marine environment poses a health risk to humans through direct water contact or the consumption of contaminated seafood. The discharge of large volumes of sewage into the marine environment may also lead to high nutrient concentrations and low dissolved oxygen concentrations, particularly in enclosed areas that have poor water circulation (Leon & Warnken 2008). The discharge of sewage from boats in New Zealand is currently regulated by the Resource Management (Marine Pollution) Regulations 1998 (MPR). These regulations stipulate that:

- Untreated sewage cannot be discharged into the marine environment:
  - within 500 m of land (mean high water spring (MHWS));
  - in water less than 5 m deep;
  - within 500 m of a marine farm or mataitai (traditional food collection) reserve;
  - within 200 m of a marine reserve; or,
  - within areas prohibited under rules in a Regional Coastal Plan.
- Grade A treated sewage (defined in Schedule 6 of the Regulation) cannot be discharged into the marine environment:
  - within 100 m of a marine farm; or,
  - within the internal waters of Fiordland.
- Grade B treated sewage (defined in Schedule 7 of the Regulation) cannot be discharged into the marine environment:
  - within 500 m of a marine farm or mataitai (traditional food collection) reserve; or,
  - within areas prohibited under rules in a Regional Coastal Plan.

Territorial authorities have the authority to extend the default MPR restrictions in their Regional Coastal Plan. Waikato Regional Council (WRC) are currently considering whether they should continue to use the default MPR, or whether they should define different rules in their Coastal Plan. In order to make an informed decision, WRC require scientific information on the magnitude and impacts of discharged sewage on the marine environment and its users. The aims of this project were to:

- provide a concise comparison of the sewage discharge rules used by other Regional and District Councils, and the methods they used to determine the rules;
- review the international literature for the potential impacts of boat sewage discharge on the environment;
- assess the available information on potential boat sewage discharge impacts in the Waikato Region; and,
- identify any knowledge gaps and provide recommendations as to how they can be filled.

2.1 Key stakeholders

The discharge of untreated sewage into coastal waterways potentially affects numerous people. Table 1 lists the key stakeholders and the potential impacts that boat sewage discharge may have on their use of coastal waters.

Table 1: Potential impacts of boat sewage discharge on key stakeholders.

Key stakeholders	Potential impacts
Recreational water users	▪ Illnesses from water contact ▪ Unenjoyable experiences
Marine farmers	▪ Harvest closures ▪ Loss of income ▪ Loss of 'clean, green' reputation
Shellfish harvesters	▪ Illness from consuming contaminated shellfish
Tangata whenua	▪ Illness from consuming contaminated shellfish ▪ Loss or degradation of Mauri (life force) through the discharge of sewage into water
Tourism operators	▪ Loss of 'clean, green' reputation ▪ Unenjoyable experiences for customers ▪ Loss of business
Conservation groups	▪ Degradation of the environment ▪ Adverse impacts on ecosystem function
Regulatory authorities (Councils, DOC, District Health Boards, MPI, MfE)	▪ Breach of duty – regulatory authorities have a duty to protect the environment and/or people's health.

3 Comparison of New Zealand boat sewage regulations

Sixteen regional and unitary consent authorities were contacted about their boat sewage discharge policies, and asked the following four questions:

1. Have you extended the MPR restrictions on the discharge of untreated sewage in your Coastal Plan?
2. If yes, was it to specify particular areas or add a larger buffer from the coast?
3. What evidential basis did your Council use to support your case?
4. Can you share your data or reports?

Nine regional and district councils are currently using the default regulations, five councils have strengthened the regulations, and two councils proposed to strengthen the regulations in their proposed Plans (Table 2). Bay of Plenty Regional Council has uniformly extended the no-discharge zones to 2 km, while Gisborne District Council and Marlborough District Council (pending acceptance of the proposed Plan) have uniformly extended the no-discharge zones to 1 km. Bay of Plenty and

Gisborne Councils have also banned discharge in specific harbours. Northland Regional Council, Hawkes Bay District Council and Auckland Council (pending acceptance of the proposed Plan) have increased discharge restrictions to cover specific areas. Northland Regional Council have also proposed to make holding tanks compulsory for boats staying overnight in restricted areas, and to limit boat stays in restricted areas. Greater Wellington has only increased the default MPR restrictions for vessels over 500 tonnes within Wellington Harbour.

Environment Southland has not strengthened the default MPR restrictions in their Coastal Plan because the council believes that Coastal Plan changes are not an effective or efficient method of managing the effects of sewage discharges from boats. Environment Southland's policies (that strongly discourage the discharge of sewage into coastal waters) are provided on their website and are circulated to stakeholders. Environment Southland will be reviewing and evaluating the effectiveness of these policies in the next plan review cycle, which is due to start in 2017.

3.1 Basis for current approaches to setting no-discharge zones

Increases to the MPR restrictions set by various councils are based on:

- advocacy from tangata whenua and community groups;
- engagement from statutory consultation processes related to Coastal Plan Change Processes;
- iwi and hapu management plans; and,
- values and scientific data that have been used to identify and protect areas of geological, ecological and cultural significance.

There is very limited evidence documenting faecal contamination caused by boat sewage in New Zealand (Faire & Kelly 2012). In some instances, areas deemed to be special or highly sensitive have been given larger no-discharge zones as a means of extra protection. There appears to be no evidence for the selection of the size increase of the no-discharge zones (Table 2 & Faire & Kelly 2012).

Table 2: Comparison of boat sewage discharge regulations among New Zealand's different regulatory authorities.

Council	Changed default MPR?	No discharge rules (changes to MPR)	Evidential basis to support rule changes
Northland	Yes	In the operative Coastal Plan: ▪ most harbours and specific areas in the Bay of Islands are no-discharge zones. In the proposed Coastal Plan: ▪ boats must have holding tank or other means of holding sewage if anchored overnight in a sewage restriction area; ▪ maximum stay of 5 consecutive nights in a restricted area before a vessel must move into waters where sewage discharge is permitted; ▪ maximum stay of 14 nights in one harbour (in the Bay of Islands and Whangaroa Harbour this limit applies to a bay or inlet, not the entire harbour).	▪ Public advocacy ▪ Discussion and general support from Yachting NZ ▪ Section 32 report[1]
Auckland	Yes[2]	▪ specific harbours and special areas are protected in the proposed Unitary Plan.	▪ Public concern ▪ Anecdotal evidence of non-compliance ▪ Section 32 report
Waikato	No		
Bay of Plenty (Toi Moana)	Yes	▪ within 2 km of land for ships < 300 gross tonnage; ▪ within 10 km of land for ships ≥ 300 gross tonnage; ▪ area-based extensions to cover all of Ōhiwa and Tauranga Harbours.	▪ The offshore extensions were driven by Councillors looking to the Auckland Unitary Plan provisions, and pressure from tangata whenua and some community groups to increase no-discharge zones, particularly in areas were kai moana is collected.

[1] Section 32 report will be publicly available when the Plan is notified.
[2] Operative Plan is currently the default regulations, changes to the discharge regulations are in the Proposed Plan.

Council	Changed default MPR?	No discharge rules (changes to MPR)	Evidential basis to support rule changes
			▪ Extensive feedback from engagement on the Coastal Plan. ▪ Iwi and hapu management plans ▪ The difference in boat sizes was based on advice from the harbour master to differentiate recreational boats from commercial vessels (that should have adequate facilities on board to store or treat sewage). ▪ Area-based restriction means that implementation and enforcement is simpler and more effective.
Gisborne	Yes	▪ within 1 km seaward of mean high water springs in the internal waters of Poverty Bay (4.5.7A). ▪ Except as provided for in the Marine Pollution Regulations 1998 and Rule 4.5.7A, any discharge of human sewage into the CMA is a: a) discretionary activity when the discharge occurs more than 1 km offshore from MHWS. b) non-complying activity where the discharge occurs in an estuary or inlet, or within 1 km from the shoreline (MHWS) (4.5.7G).	
Hawkes Bay	Yes	▪ within the Porangahau Estuary; ▪ in or within 500 m of Pania Reef; ▪ in or within 500 m of Te Angiangi Marine Reserve; ▪ within 500 m of the seaward extent of the banks of, the Wairoa River, Whangawehi Harbour or Waikokopu Harbour; ▪ in or within 500 m of an Aquaculture Management Area; ▪ in or within 500 m of the Port Management Area; ▪ in or within 500 m of the Harbour Management Area.	▪ Documentation on the sensitivities of special areas (high geological, ecological or cultural values).

Council	Changed default MPR?	No discharge rules (changes to MPR)	Evidential basis to support rule changes
Taranaki	No		
Horizons	No		
Greater Wellington	Yes	▪ within Wellington Harbour and its pilotage limits for vessels > 500 tonnes.	▪ Public advocacy to clean up the harbour identified in public consultation for proposed plan change. ▪ Water quality concerns for the harbour. ▪ Catchment-based planning focus for the region has highlighted cleaning up the harbour as a priority.
Tasman	No		
Nelson	No		
Marlborough	Yes[2]	▪ within 1 km of MHWS or a marine farm is proposed in the Resource Management Plan to be effective from 2022.	▪ Section 32 report
Canterbury	No		
West Coast	No		
Otago	No[3]		
Southland	No		

[3] Currently under review

3.2 Case study: Auckland Council's proposed approach to boat sewage discharge regulations

In 2013, Auckland Council proposed to increase their boat sewage discharge restrictions to 2 km from MHWS in their Proposed Auckland Unitary Plan (PAUP). This decision followed research on discharge options (Faire & Kelly 2012) and limited consultation with members of the recreational boating sector. However, the decision was challenged by the recreational boating sector through a hearing process, and as a result, the council amended the sewage restrictions in the PAUP to:

- not allow sewage discharge in specific harbours and bays; and,
- revert to the default 500 m from MHWS elsewhere (Dey 2015).

A summary of the key points that arose from the hearing are given below.

- There was support for the increase in the no-discharge zone to 2 km from key environmental groups and the aquaculture industry.
- Local boating representatives[4] provided useful insights into current practices and safety issues for smaller boats. The group highlighted the lack of data to support a causal effect to public health or amenity values. Auckland Health Board highlighted their concern about health issues but did not have the evidence to support their concerns. The examples they raised relating to contamination of oyster farms could also have been the result of septic tank leakage or sewage system failures.
- Through the meditation process, the recreational boat owners identified that they did not have collective evidence of compliance with the current regulations within their sector, but believed that there was a high level of compliance. They also stated that, in general, they discharged sewage when underway, at greater depth and distance than the current rules, but had no evidence to prove that this was a common practice.
- Boat owners provided comment on how holding tanks are designed and used, and stated that many boat owners are unlikely to use sewage pump-out facilities due to the design of holding tanks that cannot connect with pump-outs, and difficulties with waiting for and using existing pump-out facilities at marinas. Boat owners prefer to discharge while returning to Auckland, and the proposed extension removed this option because it excluded much of the waterway between Waiheke Island and the mainland.
- Evidence presented by one stakeholder suggested that sewage that was discharged in certain channels may be retained within the channel rather than dispersed. However, there was no rigorous scientific evidence to support this claim and it was refuted by the boating sector. Boat owners highlighted that there is no documented evidence of adverse effects from discharges while a vessel is underway, due to the high degree of dilution and difficulties in monitoring.
- Boat owners identified particular bays where sewage discharge is currently permitted in small areas because they were >500 m from the shore. They suggested that these small areas could

[4] Submissions were made by Yachting New Zealand, Auckland Boating Association and several individual boat owners.

be included in site-specific sewage restrictions. There was good support for this approach among the boating sector.

- There was a general willingness by boat owners to explore non-regulatory solutions. Boat owners agreed that further exclusions should be included if there is sufficient evidence.
- It is important to note that all parties valued good water quality and health of the coastal marine environment. Boat owners argued that they are unlikely to discharge while a boat is moored because of the potential adverse effects on their own amenity values.

Key lessons learnt from this process include:

- engagement with a wider range of stakeholders, mana whenua and the general public would have provided valuable contextual information;
- there is no reliable data on compliance with the current regulations;
- it is very difficult to monitor compliance or enforce boat sewage discharge rules;
- effective rule changes require support from the majority of stakeholders; and,
- there is a lack of scientific evidence on any adverse environmental effects of current sewage discharge practices in New Zealand.

4 Literature review on boat sewage discharge

Faecal contamination of water is typically assessed by measuring the concentrations of faecal indicator bacteria, e.g., faecal coliforms, *Escherichia coli* and Enterococci. These indicator organisms are prevalent in human and animal intestines, and are used as proxy measures for microbial pathogens[5]. Faecal coliform bacteria was the most common indicator organism measured in early research on boat sewage contamination. However, faecal coliforms do not survive for long in the marine environment (Ministry for the Environment 2003; Campos et al. 2013). *Enterococcus* bacteria are the currently recommended indicator bacteria for monitoring sewage contamination in the marine environment because they can survive in saline conditions (Ministry for the Environment 2003; Layton et al. 2010). It should be noted that both faecal coliforms and Enterococci can also originate from animals.

There are numerous sources of faecal microbial contamination to the marine environment including untreated or poorly treated wastewater, poorly functioning septic tanks, boat sewage, and urban and rural stormwater run-off (particularly around areas where stock are held near waterways). Consequently, it is difficult to quantify the percentage contribution of boat sewage to the faecal bacterial load of the marine environment. However, there is a small body of circumstantial evidence that indicates that boat sewage is the most likely source of faecal contamination in certain overseas areas. These include studies that show that:

- marinas had high faecal bacteria concentrations, with concentrations decreasing with increasing distance from the boats (Sobsey et al. 2003);

[5] Faecal indicator bacteria are a poor proxy for enteric viruses (Campos et al. 2013).

- faecal bacterial concentrations in popular boating destinations and marinas were highest during holiday weekends, when the number of boats increased dramatically (Faust 1982; Guillon-Cotard et al. 1998; Sobsey et al. 2003);
- faecal bacterial concentrations were positively correlated to the number of boats present (Faust 1982).

Faecal coliform concentrations were found to be positively correlated ($r = 0.76$) to the number of boats present in a shallow (1.5 m mean depth), brackish sub-estuary of Chesapeake Bay. Faecal coliform concentrations increased from 3 coliforms/100 mL prior to the arrival of boats, to a maximum of 28 coliforms/100 mL, which coincided with the presence of 40 boats in the bay. Faecal coliform concentrations decreased rapidly once all the boats had left the bay (Faust 1982).

Similarly, faecal coliform concentrations in two marinas were found to exceed safe recreational limits. Sobsey et al. (2003) sampled water for faecal coliform bacteria within an open-water and enclosed marina during a six day period that encompassed a 3-day holiday weekend. For both marinas, faecal coliform concentrations and boat occupancy increased over the holiday weekend to over 1000 coliforms/100 mL. Faecal coliforms were also significantly higher at stations directly adjacent to boats compared to stations that were 305 m away from the nearest boat ($p < 0.05$). The enclosed marina had higher faecal coliform concentrations than the open marina, and a larger difference between the boat and non-boat stations. These differences were attributed to the lack of mixing and dispersal with oceanic waters, and the higher percentage of live-aboard boats that were occupied in the enclosed marina.

In a more recent study, Mallin et al. (2010) used multiple indicators to demonstrate that faecal contamination present around a resort area in North Carolina was most likely the result of boat sewage. Polymerase chain reaction (PCR) fingerprinting of *Bacteroides–Prevotella* bacteria showed that the vast majority of bacteria in the water were of human origin. Local wastewater treatment plants were ruled out as a source of contamination by testing the water samples for the presence of optical brighteners (from laundry detergents), and by examining the integrity of the wastewater pipes using cameras. The authors concluded that boat sewage was the most likely source of faecal bacterial contamination. As a result of the study, the town made a successful application to the U.S. Environmental Protection Agency to declare a 3 nautical mile no-discharge zone around the town.

In a few cases, the discharge of sewage from boats have been implicated in human illnesses:

- Several outbreaks of gastroenteritis in people who had consumed raw oysters have been traced back to infected oyster harvesters who disposed of their faeces and vomit overboard in the vicinity of the oyster beds. Patients and oysters tested positive for the Norwalk-like viruses, and four oyster harvesters had high levels of IgA antibody to Norwalk-like virus, suggesting recent infection (Kohn et al. 1995; Berg et al. 2000).
- An outbreak of Norwalk-like virus in people who had consumed raw oysters from a Waiheke farm was thought to be the result of recreational boat sewage discharge. Infected oysters were traced back to the farm, and oysters present on the farm tested positive for the virus. However, there was no conclusive evidence that the virus was introduced to the region by boat sewage (Simmons et al. 2001).

The detection and quantification of the faecal contamination at a particular time and location is relatively easy. However, it much more difficult to quantify the annual faecal load and the safe carrying capacity of the environment[6], as these are affected by numerous factors including currents and dispersal rates, water volume, survival rate of infectious organisms, boat density, number of people on board, the incidence of pathogens in the boating population; and the percentage of boats that use holding tanks. The annual sewage discharge from 20 popular anchorages in eastern Moreton Bay, Australia was estimated using aerial survey data to develop predictive models based on multiple linear regression (Leon & Warnken 2008). The models estimated that 59,000 vessel[7] nights were spent in the area, which resulted in the discharge of 22.2 ± 13.3 t of faecal matter, 102.1 ± 13.3 t of urine and 1.17 ± 0.38 t of nitrogen (from sewage) per annum[8]. Contamination loads were particularly high during summer and holiday weekends. For example, the Christmas/New Year's period (10 days) accounted for 11% of the annual sewage discharge, demonstrating that health risks to recreational water users and shellfish harvesters are much higher during holiday periods.

In summary, a review of the international literature shows that the discharge of untreated boat sewage can sometimes cause conditions that are unsuitable for shellfish harvesting or recreational water use, particularly in enclosed water bodies or areas of high boat usage. It should be noted that all of the above studies assumed that boats did not use holding tanks and that raw sewage was discharged when boats were moored.

5 Boat sewage discharge in the Waikato Region: a review of available data

The Waikato Region spans the width of the North Island. For simplicity in this report, the coastline on the Tasman Sea side of the region is referred to as the western zone, and both sides of the coastline of the Coromandel Peninsula is referred to as the eastern zone.

5.1 Recreational boating in the Waikato Region

5.1.1 Magnitude of recreational boating in the region

Recreational boating in New Zealand has increased by four fold over the past 20 years, with approximately 960,000 recreational vessels present in New Zealand in 2014 (Figure 1), of which, 128,000 boats (13%) are likely to be suitable for living aboard (> 6 m length).

Boats visiting the Waikato Region are likely to originate from Auckland, Waikato and the Bay of Plenty. In 2014, approximately 223,200 people from Auckland, 83,700 people from Waikato and 65,100 people from the Bay of Plenty participated in recreational boating. This represented 24%, 9% and 7% of the country's recreational boating sector, respectively (Kalafatelis et al. 2014). Specific information on the number and types of boats present in the Waikato Region is not available. If we assume that boat numbers and types of boats in the Waikato Region is proportional to participation, there would be approximately 86,400 boats in the Waikato Region, of which, around 11,500 would be suitable for living aboard (> 6 m) (Table 3). Alternatively, we can estimate the number of large boats based in the

[6] Below the safe guidelines for shellfish harvesting and recreational water use.
[7] Vessels that were > 6 m in length
[8] Estimates were based on the assumption that there were two people/boat and that no holding tanks were used.

region based on the number of available berths and moorings. There are around 845 berths and 743 currently consented moorings in the Waikato Region (Table 4), providing a total of 1588 potential berths/moorings for large, live-aboard boats to be held. There is a large difference in the number of berthing/mooring spaces and the estimated number of large boats in the region based on Kalafatelis et al's (2014) data. There are a number of potential reasons for the difference, but a prevalence of boats from other regions (particularly Auckland) is likely to be a key factor. Other reasons could include:

- the presence of numerous unconsented moorings in the region;
- boat ownership (number and type) in the Waikato region is not proportional to national ownership; and/or,
- inaccurate estimation of boating participation and ownership.

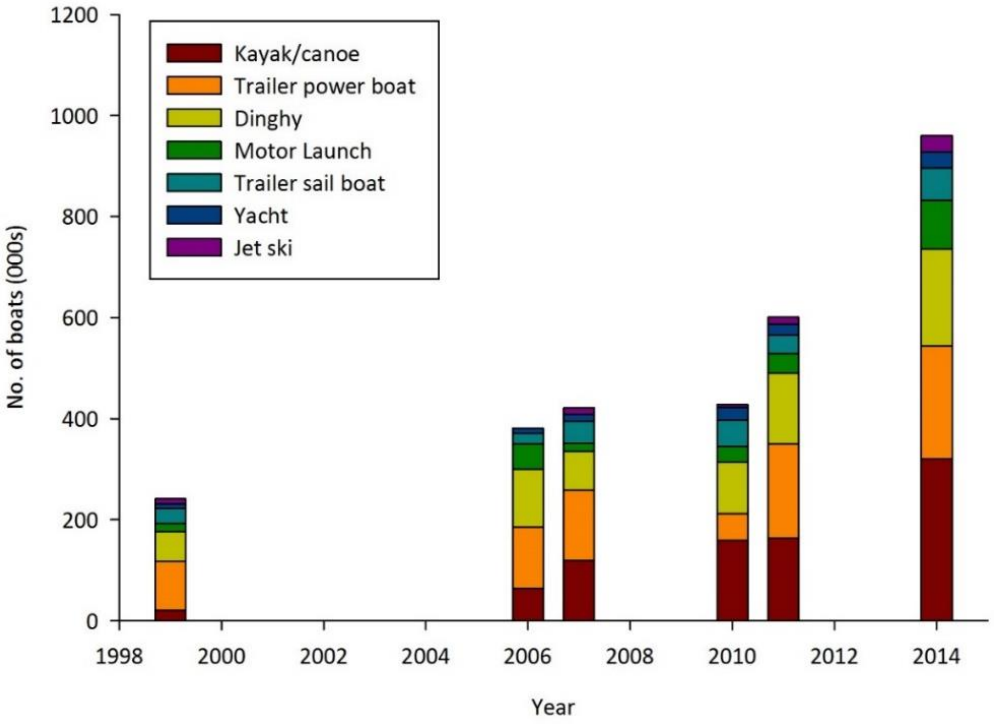

Figure 1: Estimated number of recreational vessels owned in New Zealand between 1999 and 2014. (Data from Maritime Safety Authority 1999; Colmar Brunton 2011; Kalafatelis et al. 2014).

Table 3: National vessel ownership percentage and estimated number of recreational vessels owned in the Waikato Region. Estimates assume the vessel type ownership in Waikato is proportional to nationwide vessel type ownership.

Vessel type	National vessel ownership (%) (Kalafatelis et al. 2014)	Estimated no. of vessels in Waikato
Kayaks/canoes	33	28,800
Power boats < 6 m	23	20,160
Dinghies	20	17,280
Power boats > 6 m	10	8,640
Sail boats < 6 m	7	5760
Sail boats > 6 m	3	2880
Jetskis	3	2,880
TOTAL		**86,400**

Table 4: Capacity of marinas and currently consented moorings present in the Waikato Region (marine areas only). (Mooring data from WRC).

Region	Marina	No. of berths	No. of moorings
Kawhia			23
Raglan			9
Coromandel Harbour			243
Whangapoua			9
Whitianga	Whitianga Marina	191	118
	Whitianga Waterways	~150[9]	
Tairua	Tairua Marina	95	86
	Pauanui Waterways	~200[9]	
Whangamata		209	109
Other			146
TOTAL		**845**	**743**

[9]There will be eventually space for 500 addition berths in Whitianga and Pauanui Waterways over the next 15–20 years (G. Hopper, Hopper Development Ltd, pers. comm.).

5.1.2 Popular boating areas in the Waikato Region

The vast majority of boats in the Waikato Region are small recreational fishing boats (Hartill et al. 2011; Parker 2011; Hartill et al. 2013; Kalafatelis et al. 2014). Most of these boats are used for day excursions and are unlikely to have a built-in toilet onboard. Aerial surveys of recreational fishing boats show that almost the entire Coromandel Peninsula is used by recreational fishers (Figure 2). The most popular area in the eastern zone is the western coastline of the Coromandel Peninsula between Te Mata and Motumakareta Island, with hotspots having densities of between 16 and 64 boats/km^2. Other popular areas are the islands off the eastern Coromandel coast (Great Mercury, Ohinau, Slipper and Shoe Islands), and the region between Kuaotunu and Mercury Bay (Figure 2B & Hartill et al. 2013). Recreational boating intensity in the western zone is much lower than the eastern zone, and is concentrated around the three harbours (Raglan, Kawhia and Aotea) (Figure 2A). The vast majority of recreational fishing boats in the western zone were trailer boats. Yachts and launches only accounted for 3.2% each of the total number of fishing boats present during summer weekends (Hartill et al. 2011).

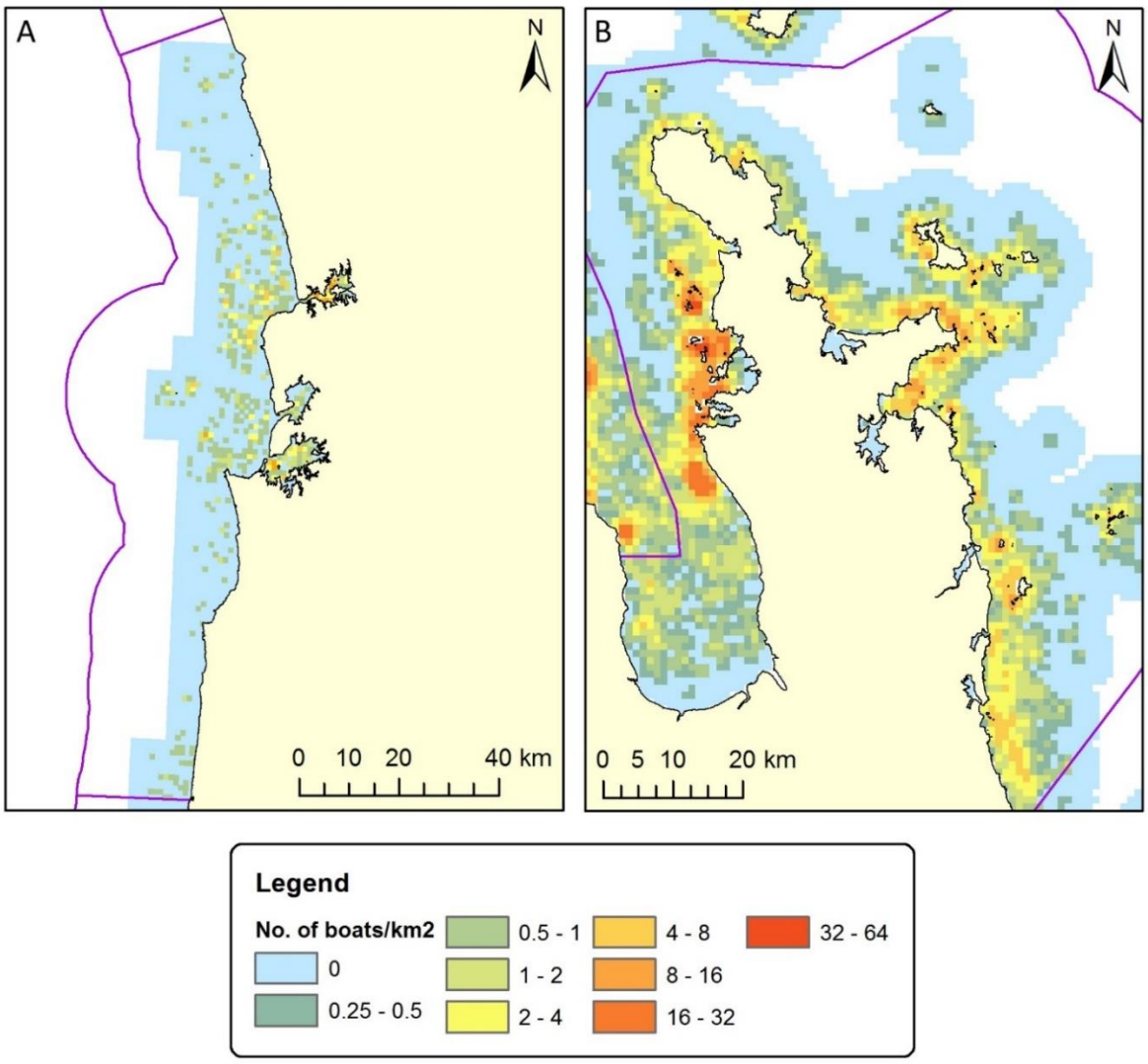

Figure 2: Estimated number of recreational fishing boats observed during aerial surveys in the A) western zone in 2006–2007, and B) eastern zone in 2011–2012 (data from Hartill et al. 2011; Hartill et al. 2013).

Popular and safe anchorages and high use recreational areas in the eastern zone of the Waikato Region were identified as part of the SeaChange project (http://www.seachange.org.nz) (Figure 3 and Figure 4). High use recreational areas includes all types of marine recreation (e.g., swimming, surfing, kayaking, boating, fishing). Densities of live-aboard boats at popular anchorages and high use areas are unknown, but they are likely to be greatest during the Christmas period (20 Dec–15 Jan), public holiday weekends, Easter and event weekends e.g., fishing competitions (Ormiston Associates Ltd 2004). Three marinas are present in the Waikato Region at Whitianga, Tairua and Whangamata. In addition, Whitianga Waterways and Pauanui Waterways provide areas for residents to construct their own private berthing areas (Figure 3).

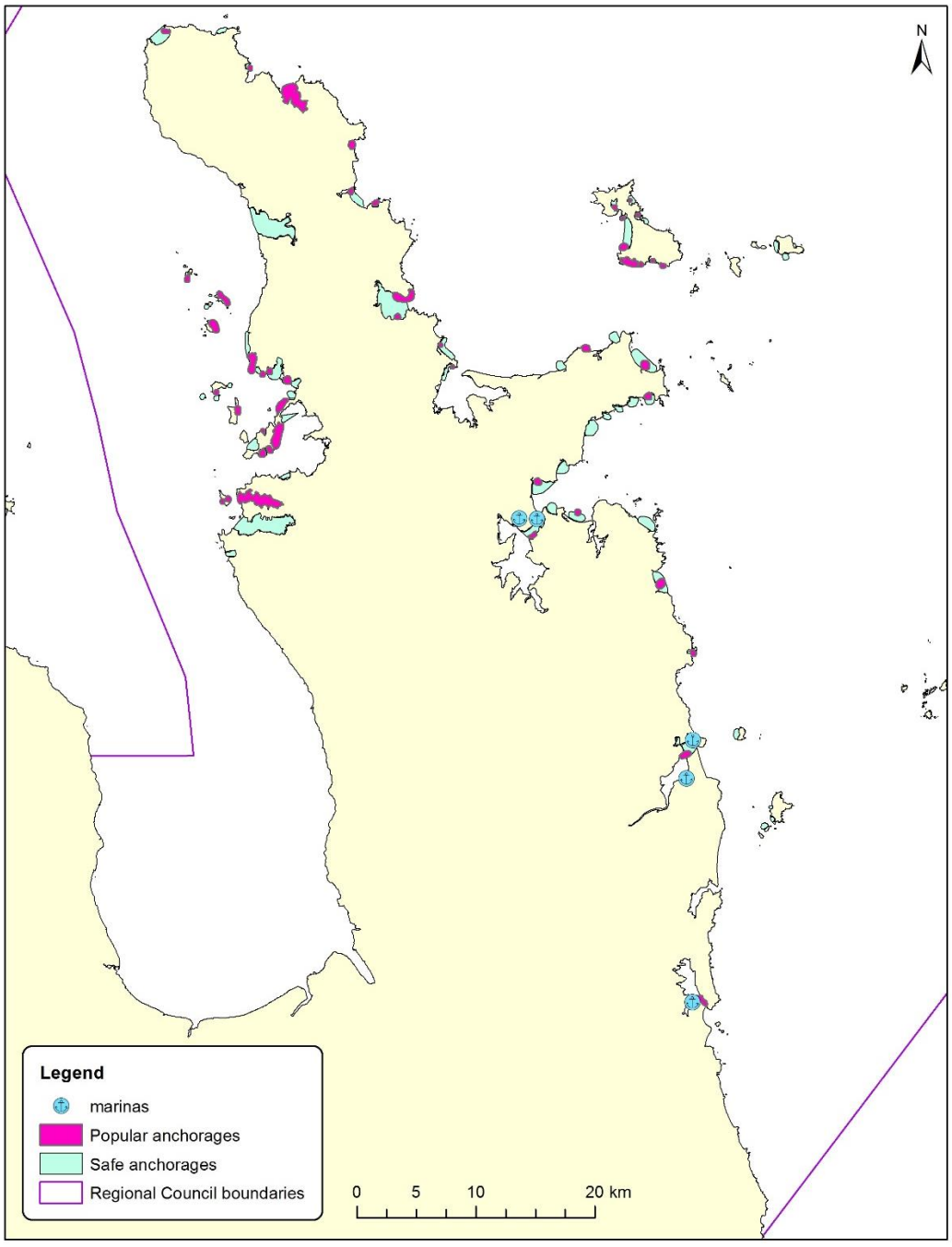

Figure 3: Popular and safe anchorages and marinas in the eastern zone of the Waikato Region. (Anchorage data from WRC, Auckland Council and the Department of Conservation).

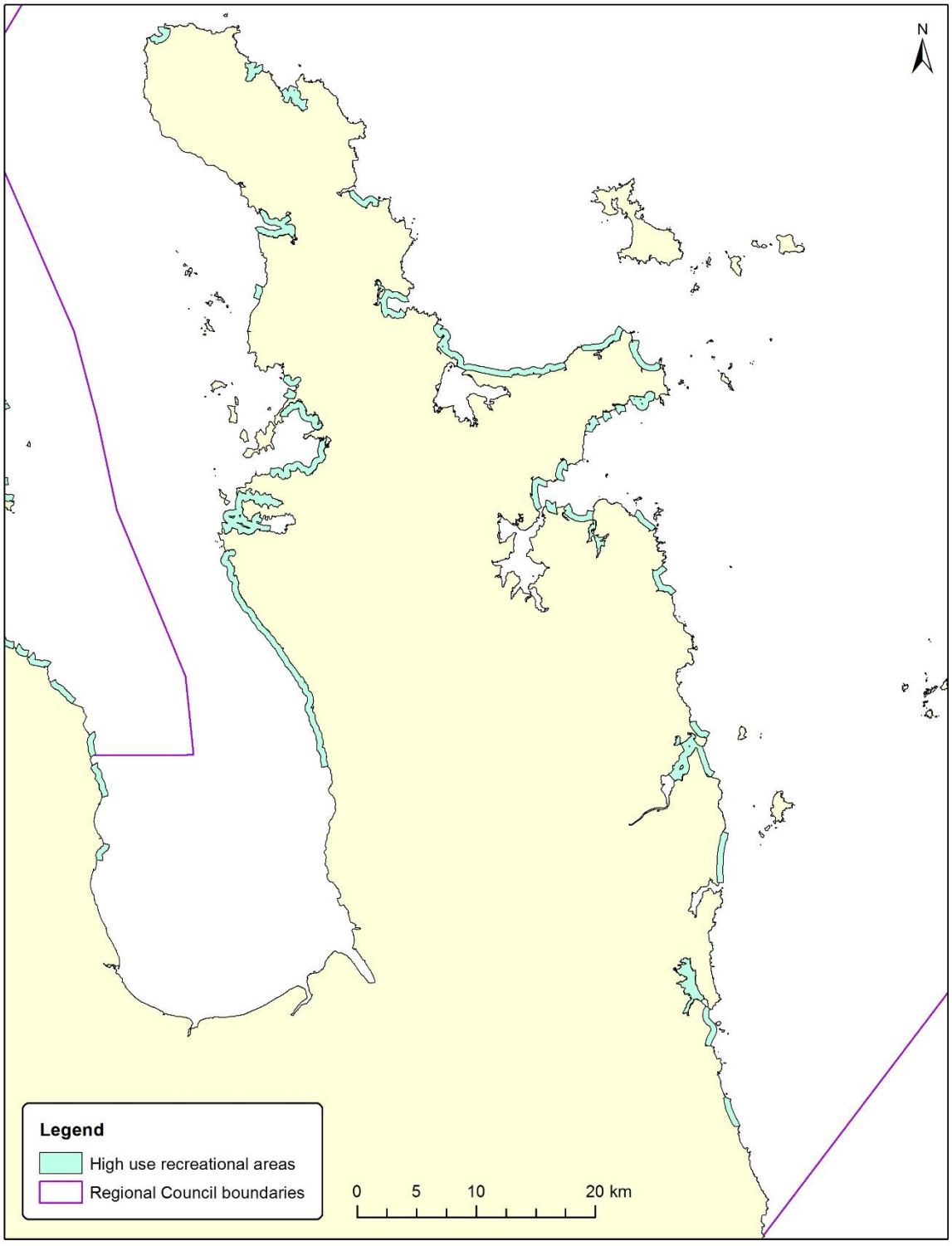

Figure 4: High use recreational areas in the eastern zone of the Waikato Region. (Data from WRC, Auckland Council and the Department of Conservation).

5.2 Compliance with current sewage discharge regulations

Compliance rates with current sewage discharge regulations in New Zealand are not known. Nor are the number of boats currently fitted with holding tanks or onboard sewage treatment systems. Ormiston Associates Ltd (2004) attempted to survey the sewage discharge practices of members of two Auckland yacht clubs, but they only received one completed survey form. It is very difficult to prove that boats have been illegally discharging sewage, and fines for illegal sewage discharge in New Zealand are rare (Faire & Kelly 2012).

5.3 Availability of pump-out facilities and shore-based toilets

All three marinas in the Waikato Region provided shore-based toilets and sewage pump-out facilities. The Pauanui and Whitianga Waterways, which are housing developments with private mooring areas, also provide sewage pump-out facilities. We contacted the three marinas and two Waterways and asked them about the usage of their pump-out facilities.

Whitianga Marina has had a sewage pump out facility for 15 years that is located by the fuel pump. There is no charge for using the facility and it is available for use by the general public (not just members). Use of the pump-out facility is very low, with an estimated usage of one boat per week (D. Smith, pers. comm.). Whitianga Marina permits up to six live-aboards in the marina but the marina requires that the toilet discharge valve of all live-aboard boats is locked off.

Whangamata Marina has had a sewage pump-out facility for six years and in that time only one boat has used it (J. Gilloly, pers. comm.). There is no charge for using the facility and it is available for use by the general public. There is also a land-based dump station in the carpark, but this is mostly used by campervans. Whangamata Marina does not permit live-aboards in the marina and also discourages the discharge of all greywater e.g., kitchen sink water, within the marina.

Tairua Marina has had a sewage pump out facility for two years. There is no charge for using the facility and it is available for use by the general public. The marina informed us that not a single boat has used their pump out facility since it was installed (C. Wightman, pers. comm.). Tairua Marina does not permit live-aboards in their marina.

Pauanui and Whitianga Waterways provide sewage pump out facilities for their residents. Use of these facilities is very minimal. Most of the boats berthed in the Waterways are only used for daily excursions, and all residents have access to their house toilets. During holiday periods, there may be live-aboards on a few boats in the Waterways (G. Hopper, pers. comm.).

Most of the boat ramps in the Waikato Region do not have nearby public toilets. Of the 34 boat ramps in the region, only seven had public toilets within 500 m of the ramp (Figure 5 & Figure 6). It should be noted that these figures may not be accurate because the public toilet data that was provided by the Council appears to be out-of-date and missing several public toilets (WRC, pers. comm.).

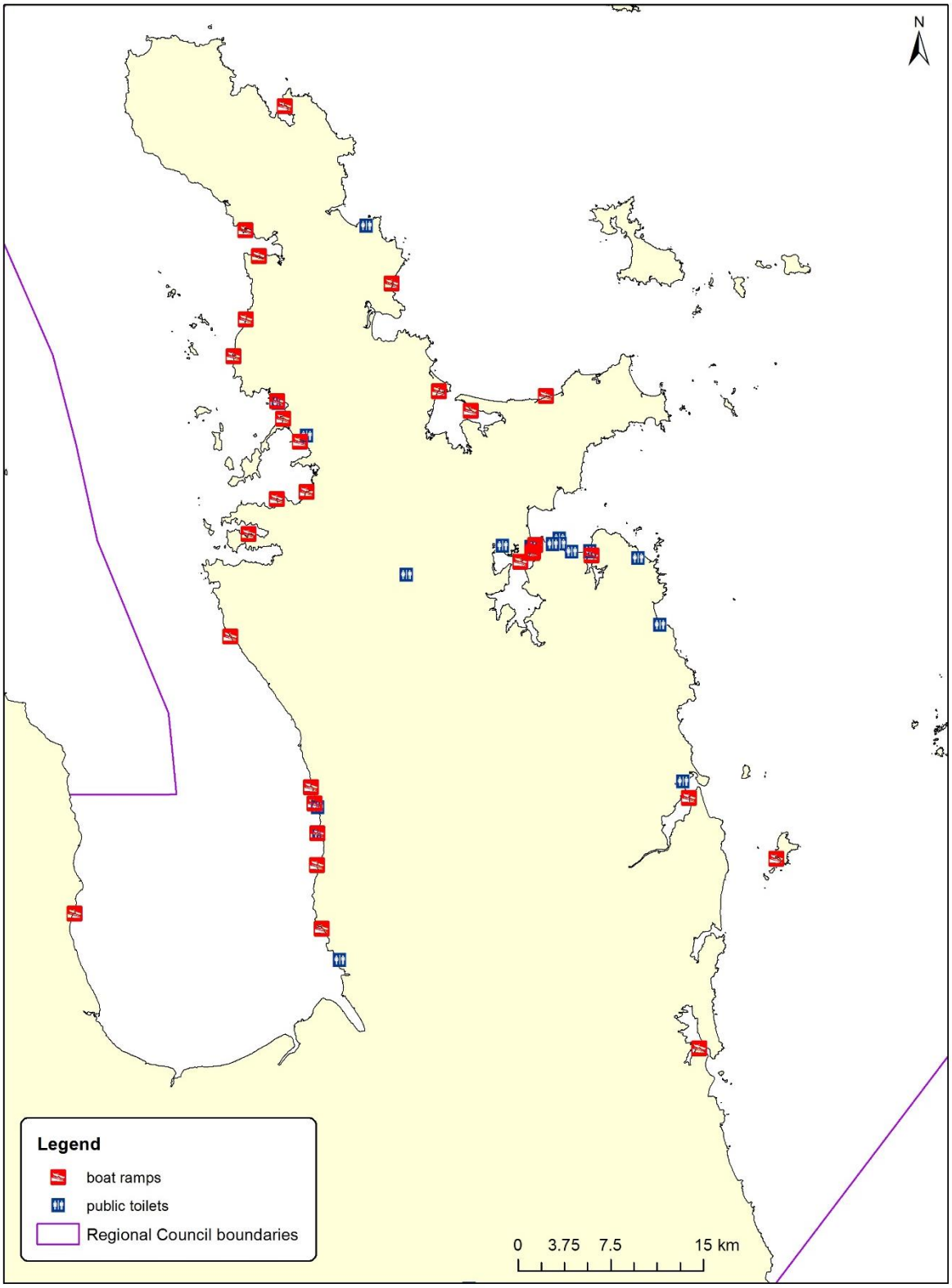

Figure 5: Location of public toilets and boat ramps in the eastern zone of the Waikato Region (boat ramp data from LINZ; toilet data from WRC). Note that the public toilet data may be missing some toilets.

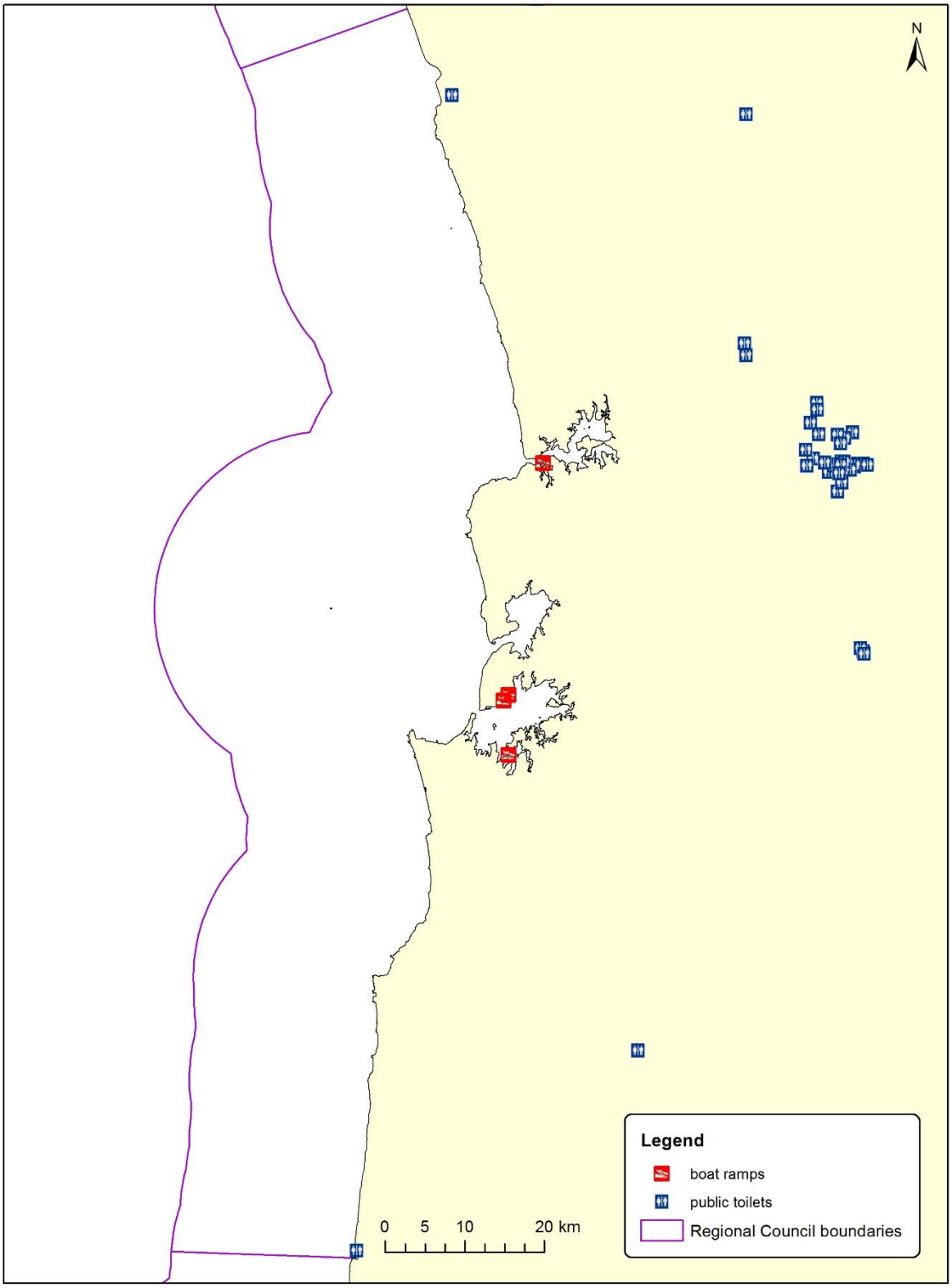

Figure 6: Location of public toilets and boat ramps in the western zone of the Waikato Region (boat ramp data from LINZ; toilet data from WRC). Note that the public toilet data may be missing some toilets.

6 Marine water quality in the Waikato Region

The Ministry for the Environment (MfE) microbiological water quality guidelines (Ministry for the Environment 2003) state that:

- marine bathing water must have less than 280 Enterococci/100 mL (red alert), and should have less than 140 Enterococci/100 mL (amber alert);
- shellfish growing areas should have:
    - a median faecal coliform concentration of less than 14 Most Probable Number (MPN)/100 mL; and,
    - less 10% of the samples with faecal coliform concentrations above 43 MPN/ 100 mL.

Coastal water quality has been monitored by the WRC at various locations and for varying durations and frequencies. Recent Enterococci monitoring data (post-2000) is available for 68 locations, with long term (>10 years) monitoring data available for 24 locations (Figure 7). Few of these sites coincide with popular anchorages.

Overall, three percent of readings since 2000 (n = 103) exceeded the red alert level. These exceedances occurred at twenty eight sites, comprising seven sites in Raglan Harbour, two sites in the inner Firth of Thames, two sites in Coromandel Harbour, five sites around Whangapoua Harbour, seven sites around Whitianga, one site in Tairua, and four sites in Whangamata (Figure 8 & Figure 9). The data for these sites were examined in more detail to assess whether boat sewage is a possible cause of faecal contamination to nearshore regions (< 500 m of shore) (Table 5).

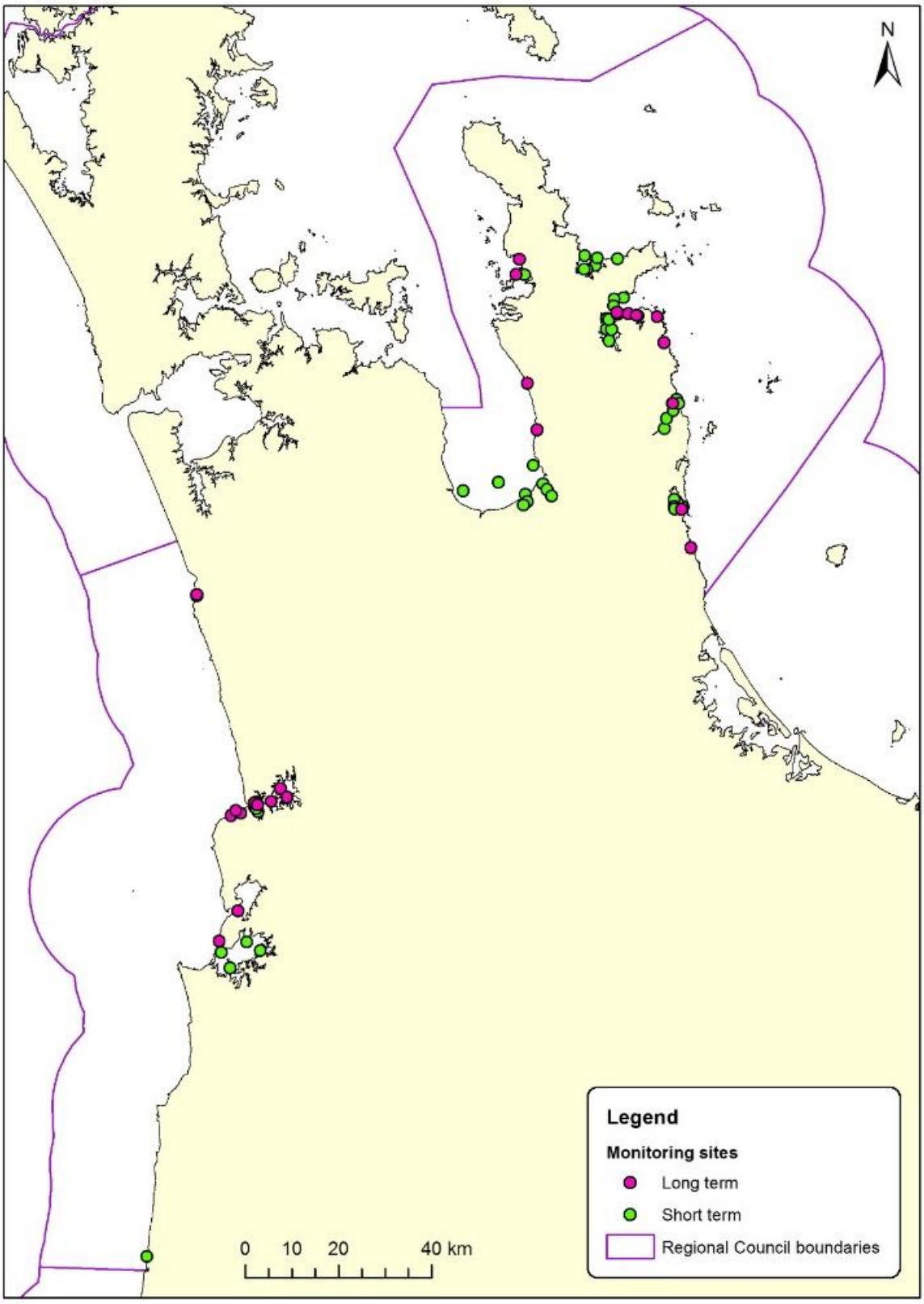

Figure 7: Location of coastal water quality monitoring sites in the Waikato Region for which recent (post-2000) data is available. Long term sites have been monitored for more than 10 years while short term sites have been monitored for less than 10 years. (Data from WRC).

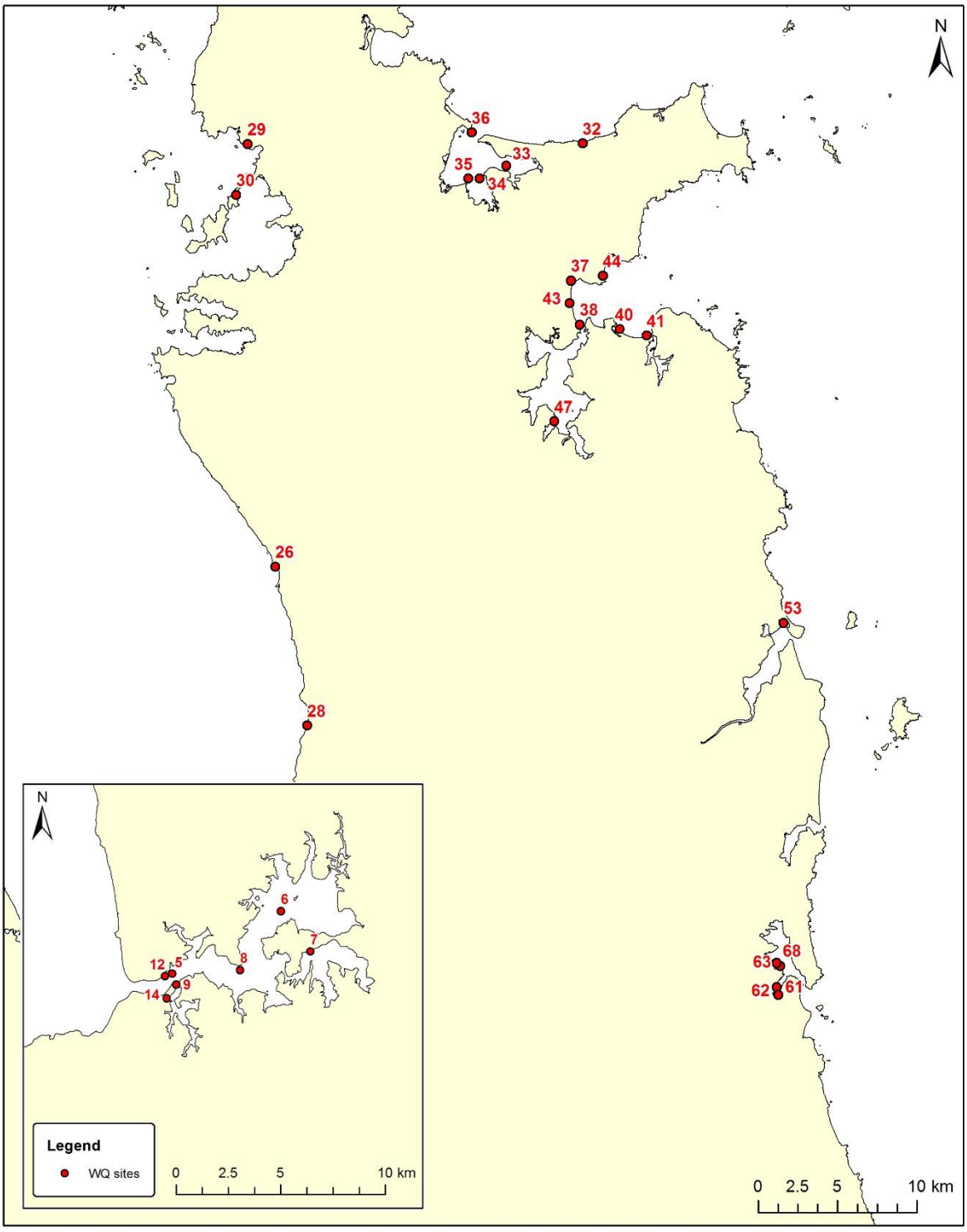

Figure 8: Coastal water quality monitoring sites in the Waikato Region that have exceeded 280 Enterococci/100 mL on at least one occasion. Inset map shows Raglan Harbour. Sites have been number from 1–68 for ease of reference in this report and correspond to the geographic co-ordinates provided in Table 5 (monitoring data from WRC).

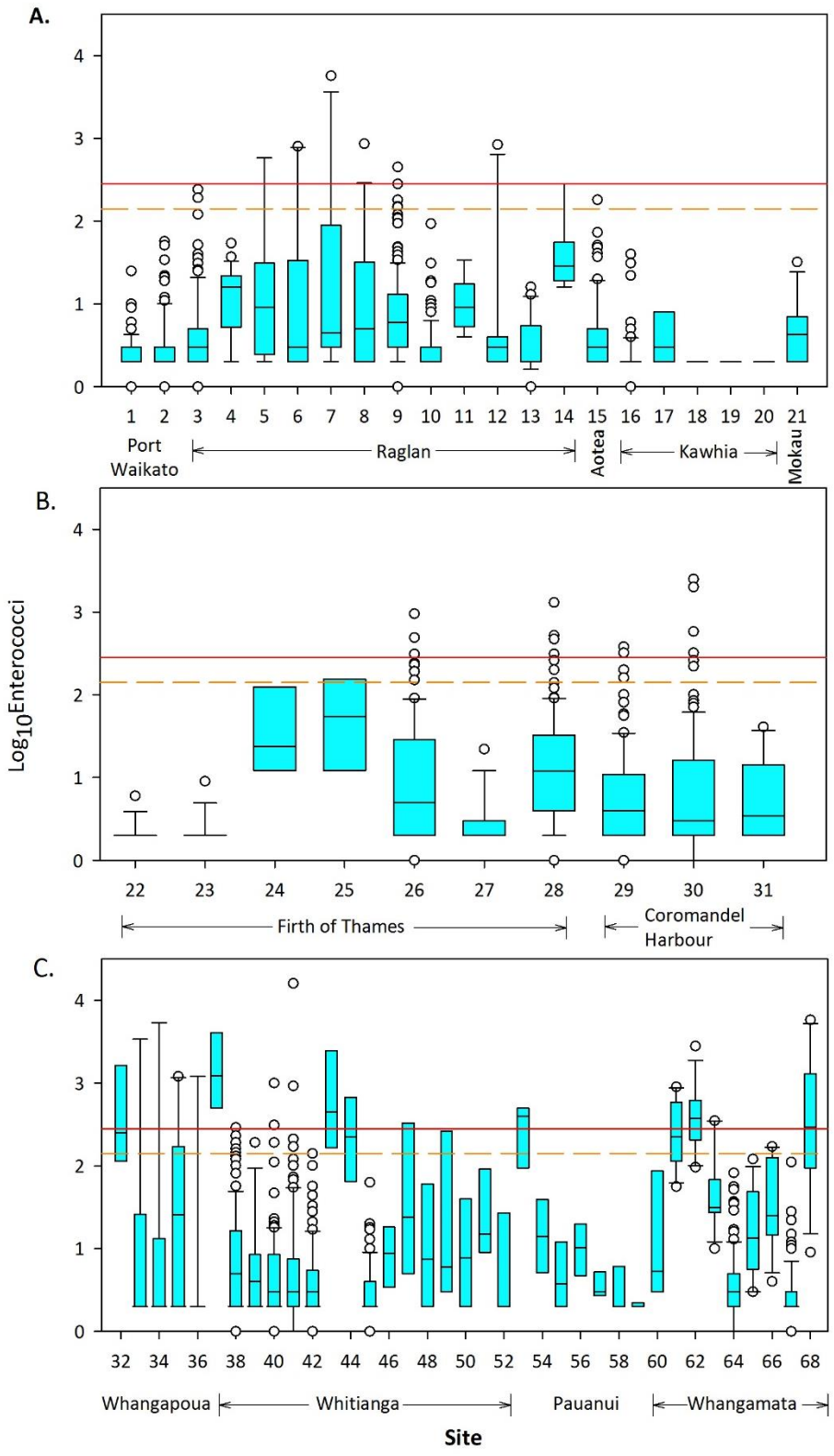

Figure 9: Box and whiskers plots for log_{10}Enterococci concentrations at monitoring sites in the Waikato Region. A) western zone sites, B) west coast of the Coromandel Peninsula sites, C) east coast of the Coromandel Peninsula sites. The amber line shows the MfE amber trigger value (equivalent to 140 Enterococci/100 mL), and the red line shows the unsafe limit for marine recreation (equivalent to 280 Enterococci/100 mL). Locations of sites are given in Figure 8. Note that the number of samples and monitoring period differs for each site (Data provided by WRC).

6.1 Raglan Harbour

The majority of exceedances in Enterococci concentrations in Raglan Harbour (Figure 12A) appear to be the result of land run-off. Enterococci exceedances (above 280 Enterococci/100 mL) at sites 6, 7, 8 and 12 in June 2014 coincided with a period of very heavy rainfall (Figure 10). Sites 5 and 14 in the harbour appear to have a large, point source of faecal contamination somewhere upstream of the monitoring locations. Examination of Enterococci concentrations over a nine hour period at these two sites showed that there was a large spike in concentration that coincided with low tide (Figure 11). Low Enterococci concentrations in the hour before and after the exceedance suggest that the contaminants originate for a concentrated, localised source.

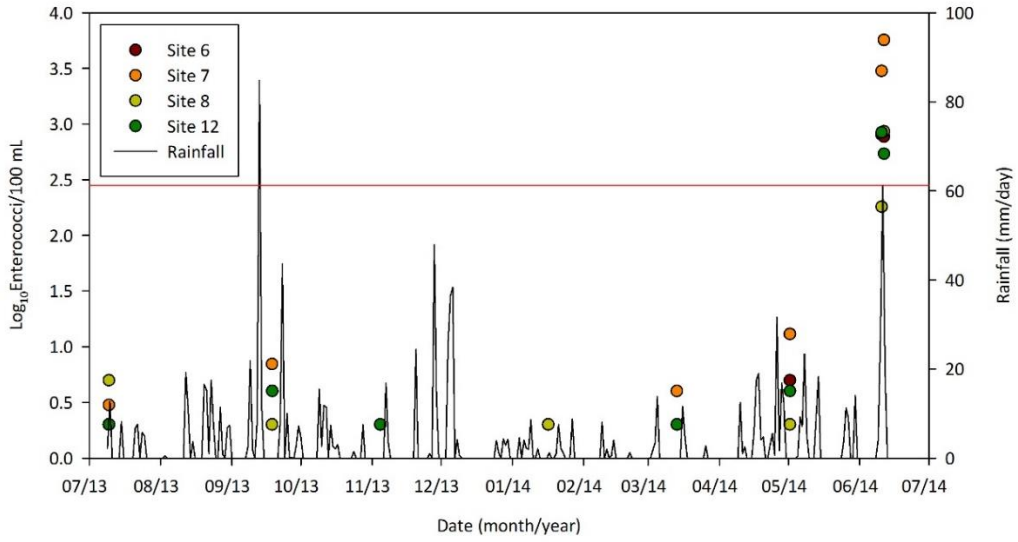

Figure 10: Relationship between Log_{10}Enterococci concentrations and daily rainfall at four sites within Raglan Harbour. The red line shows the unsafe limit for marine recreation (equivalent to 280 Enterococci/100 mL). (Enterococci data from WRC; rainfall data from NIWA (2015)).

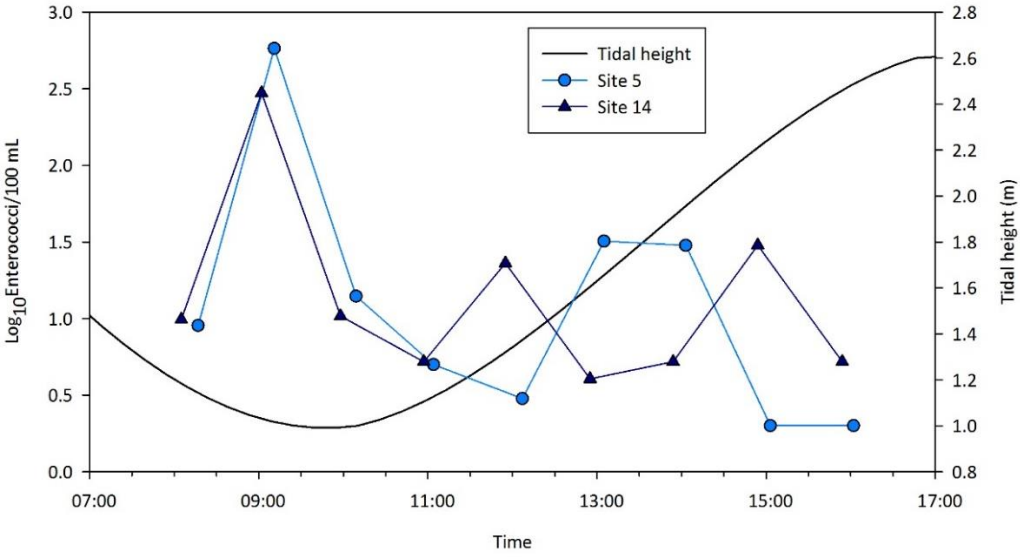

Figure 11: Relationship between Log_{10}Enterococci concentrations and tidal height at two sites within Raglan Harbour over a nine hour period. (Enterococci data from WRC; Tidal data from LINZ).

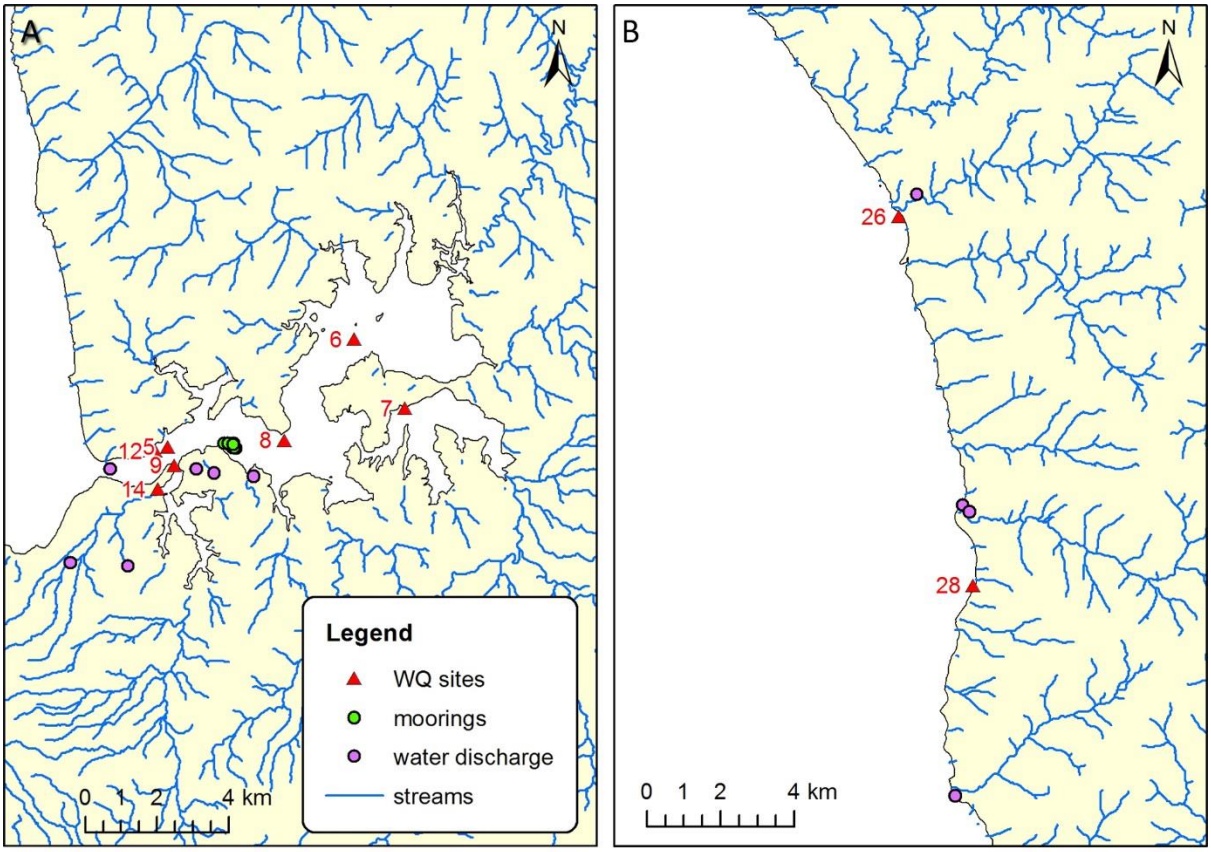

Figure 12: Location of water quality monitoring sites that exceeded the red alert level, consented water discharge sites, consented moorings and surrounding streams in A) Raglan Harbour and B) inner Firth of Thames (water quality, mooring and discharge data provided by WRC; stream data from LINZ). Geographic co-ordinates for site numbers are provided in Table 5.

6.2 Inner Firth of Thames

Faecal contamination at the Te Mata site in the Firth of Thames (site 26) was likely to originate from land run-off, potentially due to defective septic tank systems. The site is located at the mouth of the river and stormwater from the Te Mata settlement discharges upstream of the site (Figure 12B). Exceedances often followed very heavy rainfall events (>40 mm/day), but high Enterococci concentrations also occurred during dry periods (Figure 13).

The cause of elevated faecal contaminant concentrations at Thornton Bay in the Firth of Thames (site 28, Figure 12B) is uncertain. There had been no rain in the week prior to all four exceedances and two of the exceedances were recorded within the three days following a holiday weekend. Boat sewage discharges are a potential cause, but aerial surveys suggest that numbers of recreational boats using the area tend to be quite low. The exposed nature of the site also means that boats are less likely to overnight in the bay. Septic tank seepage may be a more likely explanation.

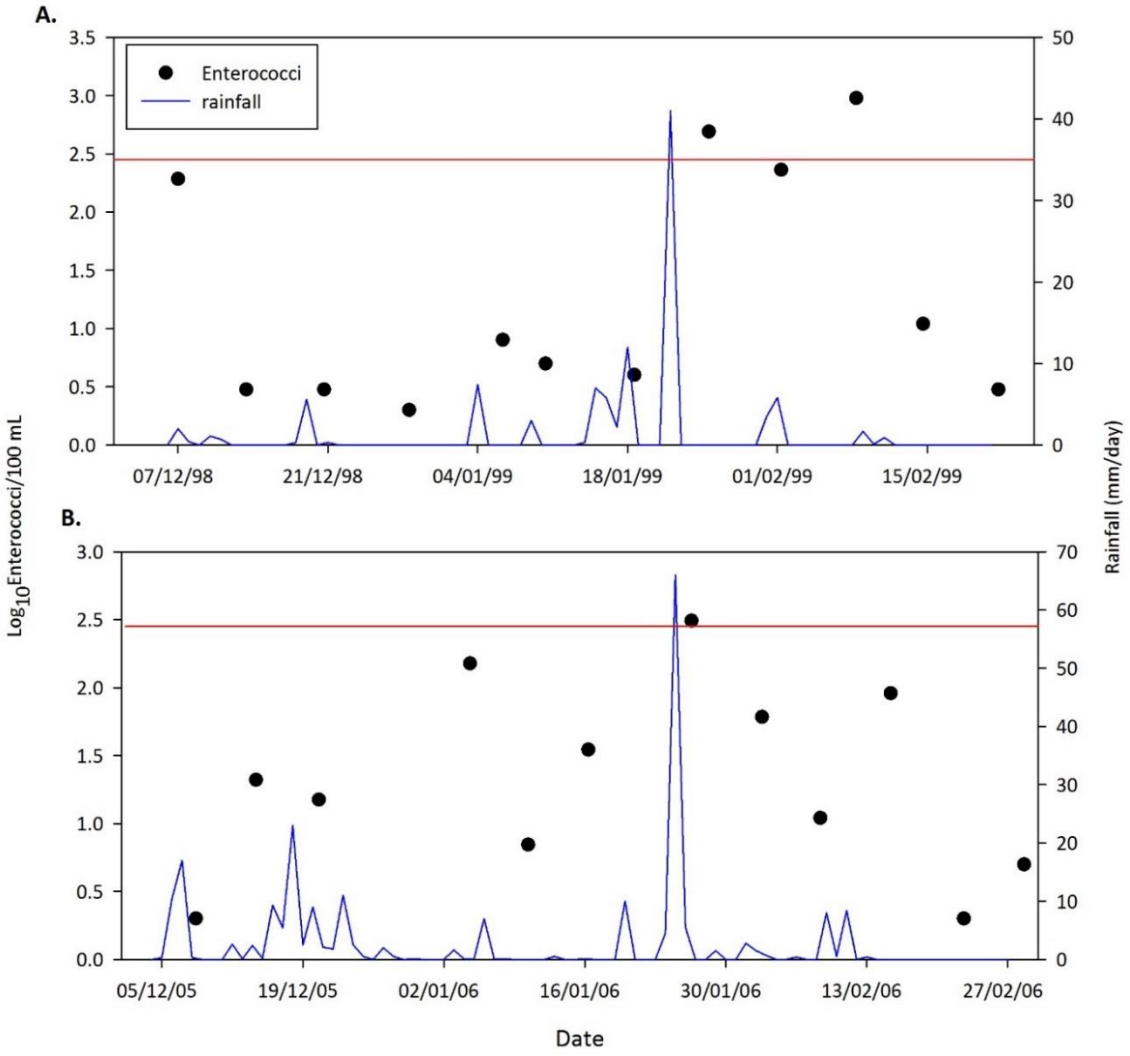

Figure 13: Relationship between Log_{10}Enterococci concentrations and daily rainfall at Te Mata during the summers of A) 1998–1999 and, B) 2005–2006. The red line shows the unsafe limit for marine recreation (equivalent to 280 Enterococci/100 mL). (Enterococci data from WRC; rainfall data from NIWA (2015)).

6.3 Coromandel Harbour

High enterococci concentrations in Wyuna Bay, Coromandel Harbour (site 30), are possibly due to boat sewage. There had been no rain in the three days prior to the exceedances, and two of the four exceedances occurred within the three days following a holiday weekend. Furthermore, the embayment has a number of popular anchorages and there are over 50 consented moorings in Wyuna and McGregor Bays (Figure 14A). However, treated wastewater from a sewage treatment plant and fish processing wastewater are both discharged into the wider embayment and these discharges may also be potential sources of Enterococci (Figure 14A).

Similarly, faecal contamination in the Oamaru Bay (site 29) is possibly due to boat sewage because it is a popular anchorage and there are 16 consented moorings in the bay. However, contamination could also be caused by land run-off because moderate rainfall occurred the day prior to both exceedances, and a relatively large river discharges into the neighbouring bay (Figure 14A).

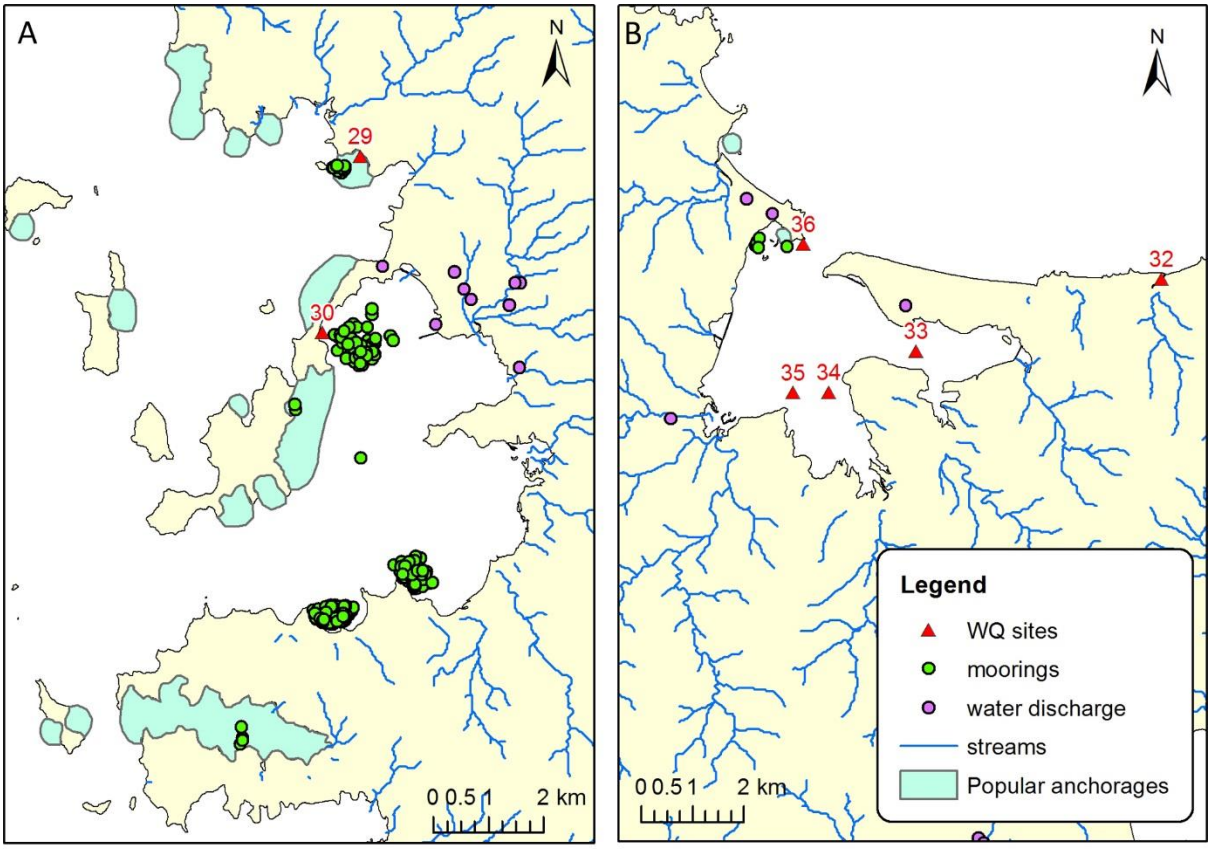

Figure 14: Location of water quality monitoring sites that exceeded the red alert level, consented water discharge sites, consented moorings, popular anchorages and surrounding streams in A) Coromandel Harbour and B) Whangapoua Harbour. (Mooring, discharge and water quality monitoring data provided by WRC; popular anchorages data provided by WRC, Auckland Council and DOC; stream data from LINZ).

6.4 Whangapoua Harbour

Two isolated incidences of faecal contamination at the four sites in Whangapoua Harbour were likely to have been the result of land run-off, with very heavy rainfall (>50 mm/day) occurring on the two exceedance days. The fifth site in Matarangi (site 32, Figure 14B) exceeded the red alert value 38% of the time. This site is located in a small, brackish stream that is surrounded by farms and urban development and is likely to be frequently contaminated by livestock or leaking septic tanks.

6.5 Whitianga Harbour

Exceedances at site 47 in Whitianga Harbour were not well correlated to rainfall (Figure 15). This site is located in the inner estuary and may be affected by livestock run-off from the surrounding farmland. A marina and over 100 consented moorings are present in Whitianga Harbour, and there is significant urban development around the harbour, which may also be sources of faecal contamination (Figure 16A). Three sites in the bays surrounding Whitianga Harbour (sites 37, 43 and 44) exceeded the red alert value 100%, 63% and 38% of the time, respectively. These sites are located in shallow, brackish streams that are surrounded by farms and urban development, and are likely to be contaminated by sewage from livestock or leaking septic tanks. The one exceedance at Buffalo Beach (site 38) is likely to be due to land run-off because it was preceded by heavy rainfall in the previous day. Four, relatively

rare exceedances at Cooks Beach (sites 40 and 41) were not associated with any rainfall, and three of the four exceedances occurred over the Christmas holiday period. Boat sewage is a possible cause of faecal contamination at these sites because Cooks Beach is a popular anchorage and there are over 30 consented moorings in the bay (Figure 16A). However, there is also substantial urban development in the area that may also be a source of faecal contamination.

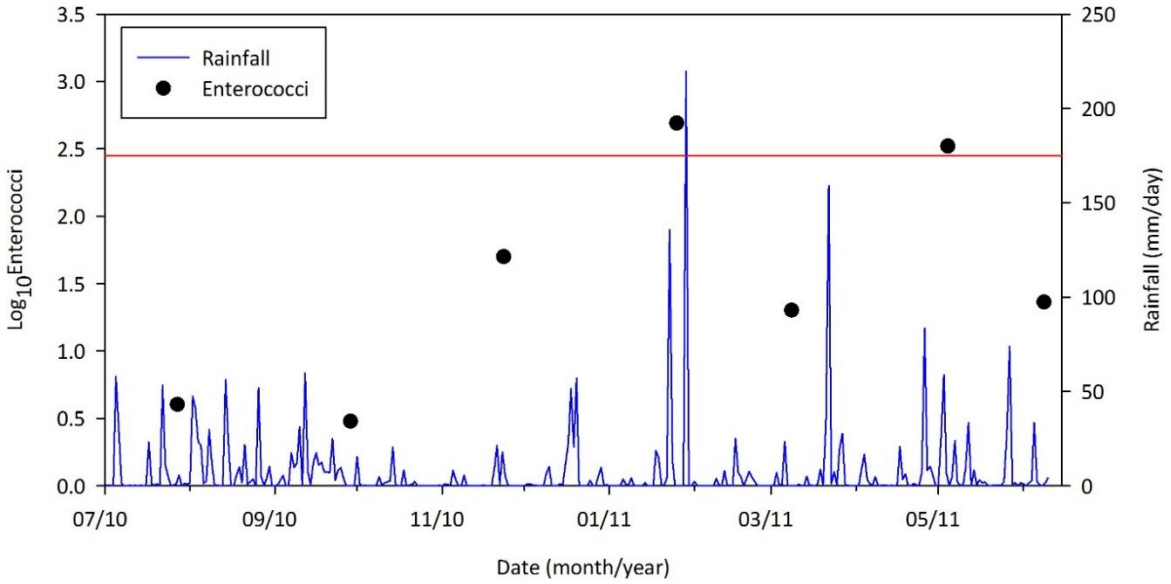

Figure 15: Relationship between Log_{10}Enterococci concentrations and daily rainfall at site 47 in Whitianga Harbour. The red line shows the unsafe limit for marine recreation (equivalent to 280 Enterococci/100 mL). (Enterococci data from WRC; rainfall data from NIWA (2015)).

6.6 Whangamata Harbour

The four sites in Whangamata Harbour (sites 61–63, 68) were only tested on four days during the summer of 2001, but they exceeded the red alert values on two to three of the days. Exceedances were poorly correlated to rainfall. The harbour channel is a popular anchorage and also contains a marina and over 100 consented moorings, consequently, boat sewage is a potential source of faecal contamination (Figure 16B). The harbour is also surrounded by significant urban development and farmland, which may also be sources of faecal contamination.

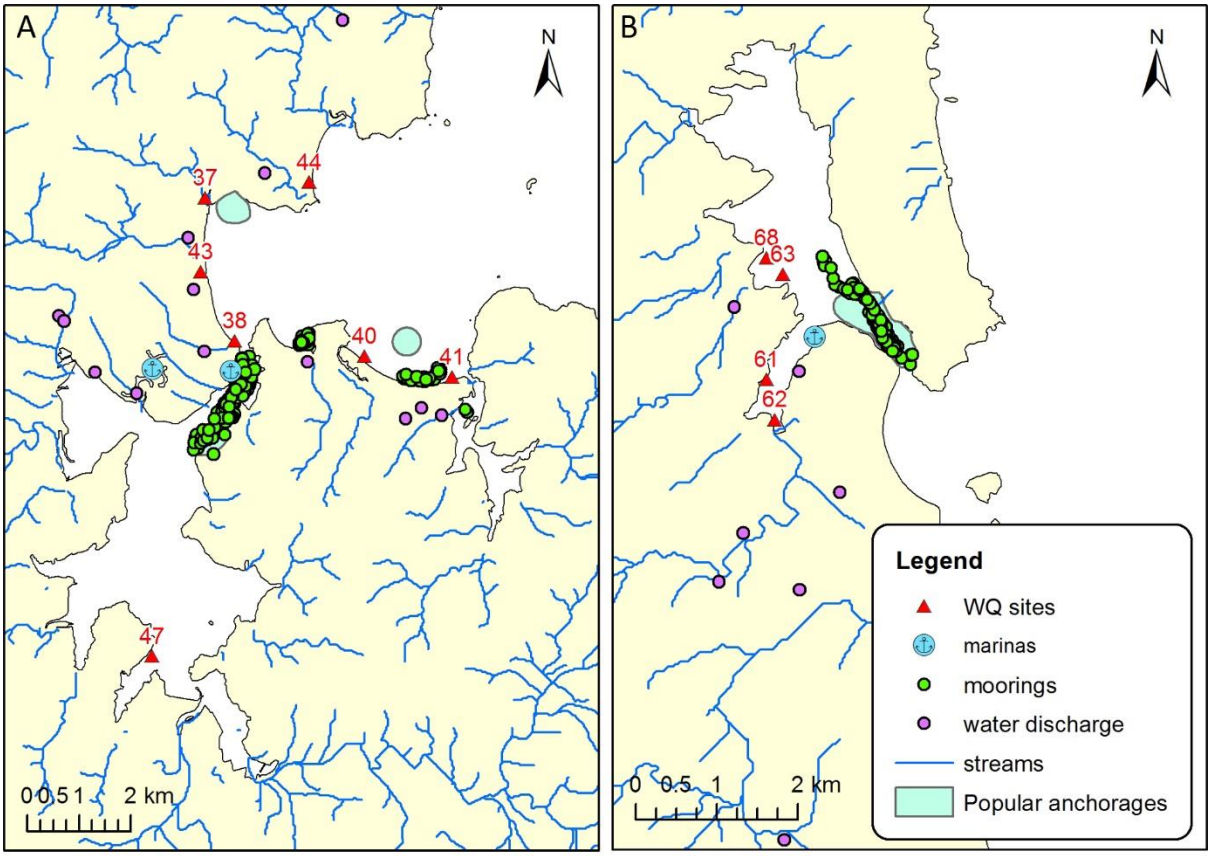

Figure 16: Location of water quality monitoring sites that exceeded the red alert level, consented water discharge sites, consented moorings, popular anchorages, marinas and surrounding streams in A) Whitianga Harbour and B) Whangamata Harbour. (Mooring, discharge and water quality monitoring data provided by WRC; popular anchorages data provided by WRC, Auckland Council and DOC; stream data from LINZ).

In summary, coastal water quality at monitored sites in the Waikato Region is generally good to excellent. The majority of exceedances in Enterococci concentrations occurred in estuaries or near freshwater discharges, and are most likely to be affected by contaminated land run-off. This is supported by the fact that many exceedances coincided with periods of heavy rainfall. Exceedances at some popular boating locations in Coromandel Harbour, Whitianga and Whangamata were not correlated to rainfall, and boat sewage may be a potential source of faecal contamination at these sites. However, all of these sites had multiple potential sources of faecal contamination (e.g., livestock, septic tanks, boats, freshwater discharges), and consequently, it cannot be ascertained from the existing monitoring data whether boat sewage is a source of faecal contamination. Specific experiments that aim to test for boat sewage are required to provide more conclusive evidence for boat sewage contamination (see Section 7 for more details).

Table 5: Monitored sites that exceeded the red alert trigger value at least once, and possible sources of faecal contamination.

Site #	Location	Site co-ordinates		Monitoring period		No. of exceed-ances	Possible faecal source	Explanation
		Easting	Northing	Start	End			
5	Raglan Harbour	1764061	5815231	2015	2015	1/9	Land	Hourly sampling over 9 hrs, exceedance coincided with low tide (Figure 11). No rainfall.
14	Raglan Harbour	1763796	5814062	2015	2015	1/9	Land	
6	Raglan Harbour	1769258	5818229	2013	2014	2/16	Run-off	
7	Raglan Harbour	1770669	5816305	2013	2014	3/16	Run-off	Two monthly sampling, exceedance coincided with very heavy rainfall (Figure 10).
8	Raglan Harbour	1767304	5815415	2013	2014	1/16	Run-off	
12	Raglan Harbour	1763713	5815119	2013	2014	2/15	Run-off	
9	Raglan Harbour	1764251	5814716	1994	2009	2/146	?	Exceedances not well correlated to rainfall.
26	Te Mata Bay, Firth of Thames	1822301	5905233	1991	2008	3/95	Run-off and river discharge	Heavy rainfall (>40 mm/day) occurred 1–3 days prior to 2/3 exceedances. Site is situated at the mouth of Te Mata River and there is a stormwater discharge point into the river from the Te Mata subdivision.
28	Thornton Bay, Firth Of Thames	1824322	5895234	1991	2008	4/102	Septic tanks?	No rain occurred in the week prior to the exceedances. Two exceedances were after holiday weekends.
29	Oamaru Bay	1820545	5931835	1991	2008	2/94	Boats? Run-off and river discharge	Moderate rainfall the day prior to both exceedances. A river discharges into the neighbouring bay. A popular anchorage and numerous moorings present.

Site #	Location	Site co-ordinates		Monitoring period		No. of exceed-ances	Possible faecal source	Explanation
		Easting	Northing	Start	End			
30	Wyuna Bay	1819851	5928633	1991	2008	4/102	Boats? wastewater discharge?	No rain occurred in the 3 days prior to the exceedances. A popular anchorage and numerous moorings present. Treated wastewater and fish processing water is discharged into the wider embayment.
32	Pitoone Stream, Whangapoua	1841650	5931882	2015	2015	3/8	Livestock or septic tanks	Site is situated in a small stream that is unsuitable for boats. Stream is surround by farms and urban development.
33	Whangapoua Harbour	1836852	5930471	2006	2007	1/9	Land	Heavy rainfall (>70 mm/day) occurred on the day of the exceedance.
34	Whangapoua Harbour	1835153	5929667	2006	2007	1/9	Land	
35	Whangapoua Harbour	1834453	5929665	2006	2007	2/10	Land	Heavy rainfall (>50 mm/day) occurred on the day of both exceedances.
36	Whangapoua Harbour	1834646	5932566	2006	2007	1/9	Land	Heavy rainfall (>70 mm/day) occurred on the day of the exceedance.
37	Taraporiki Stream	1840898	5923247	2015	2015	8/8	Livestock or septic tanks	Site is situated in a small stream that is unsuitable for boats. Stream is surrounded by farmland and urban development.
38	Buffalo Beach	1841475	5920478	1991	2016	1/113	Land	Heavy rainfall (94 mm/day) occurred on the day before the exceedance.
40	Cooks Bay	1843976	5920183	1991	2008	2/101	Boats or septic tanks?	

Site #	Location	Site co-ordinates		Monitoring period		No. of exceed-ances	Possible faecal source	Explanation
		Easting	Northing	Start	End			
41	Cooks Bay	1845678	5919786	1991	2008	2/101	Boats or septic tanks?	No rain. A popular anchorage and numerous moorings present in the bay. Substantial urban development present.
43	Taputapuatea Stream	1840817	5921814	2015	2015	5/8	Livestock or septic tanks	Site is situated in a small stream that is unsuitable for boats.
44	Tohetea Stream	1842916	5923550	2015	2015	3/8	Livestock or septic tanks	Site is situated in a small stream that is unsuitable for boats.
47	Whitianga Harbour	1839875	5914389	2010	2011	2/7	?	Exceedances not well correlated to rainfall. A marina and numerous mooring present in the harbour. Substantial urban development present.
53	Grahams Stream	1854321	5901707	2015	2015	5/8	Livestock or septic tanks	Site is situated in a small stream that is unsuitable for boats.
61	Moanaanuanu Estuary	1853865	5878786	2001	2001	2/4	?	The majority of exceedances were not associated with rainfall. A marina and moorings are present in the harbour. Substantial urban development is also present around the estuary.
62	Moanaanuanu Estuary	1853966	5878286	2001	2001	3/4	?	
63	Waikiekie Estuary	1854063	5880087	2001	2001	2/4	?	
68	Waikiekie Estuary	1853862	5880287	2001	2001	3/4	Livestock or septic tanks?	Site is situated at the mouth of a small stream that is surrounded by farmland and urban development.

7 Knowledge gaps & recommendations

Available information indicates that Coastal Plan provisions on sewage no-discharge zones have either defaulted to the MPR provisions, or larger buffers have been established to address perceived risks to cultural, health and/or amenity values. The perceptions of submitters opposing the extension of the default no-discharge zones have also been influential. Factual data is lacking in several key areas, which are discussed below. A proposed approach for filling these gaps in a structured manner is also provided.

7.1 Perceptions, practices and preferences of the boating sector

The acceptability and efficacy of sewage discharge regulations cannot be determined because data is lacking on community knowledge about the regulations, preferences of the community, and actual discharge practices. For instance, representative bodies and a small number of individuals submitted on the discharge provisions of the Auckland Unitary Plan, but the information they provided tended to be anecdotal and may not reflect the true values and practices of the majority of the boating sector.

Actual data is lacking on fundamental matters such as:

- perceptions about whether sewage discharge from boats is currently a problem and the reasons for those concerns (e.g. health concerns, cultural concerns and/or impacts on their enjoyment of the coast);
- the proportion of boats that stay at sea overnight (particularly around Coromandel Peninsula) (e.g. where, when, how often, average stay length);
- the proportion of boats with holding tanks;
- sewage pump-out/disposal practices for boats with and without holding tanks (e.g. how, where and when do they discharge);
- impediments to the use of marina pump out facilities;
- familiarity with the discharge regulations;
- whether discharges should be prohibited in specific areas where shellfish such as scallops are gathered and/or from high-use recreation areas[10];
- whether there are additional areas where the discharge of sewage should be prohibited;
- preferences on the size of no-discharge zones.

Robust data on these matters would provide a more factually-based foundation for considering the acceptability, uptake, efficacy of regulatory options for the boating public. We therefore recommend that an engagement plan is developed that would identify a range of data collection methods, which could include face-to-face interviews, boat ramp surveys, and a regional on-line survey, to capture the views of the wider boating community that may be under-represented on this topic.

[10] Note that Māori consider the discharge of sewage into food gathering areas highly offensive. Other members of the public may hold similar views, even if health guidelines are not exceeded.

7.2 Efficacy of current regulations

The MRP provisions (and associated Plan provisions) have been in place since 2000, yet compliance rates and the environmental outcomes have not been determined. It is therefore recommended that data on these matters is obtained before, or in parallel to, the consideration of alternatives to the default provisions. The information would be used to evaluate whether the current regulatory framework is actually effective at protecting water quality within the existing no-discharge zone. If not, alternative or additional approaches to setting no-discharge zones may be warranted.

The proposed engagement plan and data collection methods recommended in Section 7.1 will provide valuable information on the sewage discharge practices of the boating sector. That information could then be compared with the regulations to provide an estimate of compliance rates and identify the most vulnerable areas. Note however, that there is likely to be some bias if self-reporting data is used.

It is recommended that quantitative data are also obtained on anchorage usage and water quality to validate self-reported data. Good data is already available for the daytime distribution of fishing boats, but the majority of these boats are trailer boats that are likely to be only used for day excursions. There is little quantitative information available on the usage of anchorages in the region, particularly during peak boating periods. Aerial surveys should therefore be conducted in the late evening or early morning during holiday periods to: a) estimate peak boat densities (anchored) per bay; b) determine the most popular anchorages; and, c) identify the types/sizes of boats present.

Targeted water quality testing should be carried out in association with the aerial surveys to confirm whether boat sewage is causing faecal contamination in nearshore regions. Water quality testing should be conducted before, during and after peak boating periods and during fine weather. Testing locations should include popular anchorages (< 500 m from MHWS) that are least likely to be contaminated by other sources (i.e., freshwater discharges, livestock, urban run-off). Ideally, a number of sites should be tested with samples collected at increasing distances away from the anchorages to determine the scale and magnitude of effect. Testing of popular fishing spots within 500 m of marine farms, and sewage disposal areas that were commonly identified by the boating sector (see Section 7.1) should also be considered.

7.3 Justifying an extension to the existing no-discharge zones

An expansion of the existing no-discharge zones may not be warranted unless evidence indicates an adverse impact of discharges:

- beyond no-discharge zones; or,
- within no-discharge zones despite high compliance with the default regulations.

Adverse impacts may include impacts on the marine ecology, Māori cultural values, amenity values, and/or human health. Ecological effects are highly unlikely to be measurable given the probable scale and frequency of boat sewage discharge, and therefore, we believe that attempting to gather evidence of any ecological effects will most likely be unsuccessful. It is anticipated that Māori cultural values would be assessed through a cultural values assessment, and therefore, are not considered further in this report.

Areas with high amenity values are likely to be reflected in the distribution of fishing boats (Figure 2) and high recreation areas (Figure 4). This information, should be assessed in association with the

information gathered through a survey of the perceptions, practices and preferences of the boating sector. The key considerations are likely to be:

- whether discharges should be prohibited in specific areas where shellfish such as scallops are gathered;
- whether discharges should be prohibited in high use recreation areas; and,
- preferences on the size of no-discharge zones.

It is assumed that the discharge of sewage may affect the enjoyment of fishing and shellfish gathering by a proportion of the boating sector, even if health guidelines are not exceeded. The engagement plan could be designed to obtain quantitative feedback on these matters.

It is recommended that human health effects are assessed through targeted water quality testing and/or the development of a Quantitative Microbial Risk Assessment (QMRA). A QMRA is unlikely to be warranted unless water quality testing indicates that microbiological contaminant concentrations exceed guideline levels during peak boating periods. However, non-compliant disposal within the existing no-discharge zone could potentially confound test results. It is therefore proposed that initial tests are taken during peak periods, with samples collected from:

- the margins of the no-discharge zone during peak periods;
- areas outside the no-discharge zone that have high boat densities.

Low faecal bacteria concentrations in the water samples would indicate that there was little health risk under the default regulations, and that a QMRA or expansion of the no-discharge zone to protect the public from health risks is not warranted. Elevated bacteria concentrations should trigger further investigations into the source of contamination (inside or outside the no-discharge zone), and the scale and magnitude of health risks. The development of a QMRA could assist in this.

7.4 Determining appropriate sizes of no-discharge zones

No-discharge zone sizes required to minimise effects on cultural values should be identified through a cultural impact assessment, while the process for identifying buffers sizes to address amenity values are described in Section 7.3.

If it is ascertained that the majority of people are complying with current sewage discharge regulations, but faecal contamination from boat sewage is still a health risk, then an increase in the no-discharge zone is recommended to address this. Determining an appropriate size for the no-discharge zone to manage health risks is likely to require the development of a QMRA or another form of modelling. There are four steps to a QMRA:

1. hazard identification (describe the micro-organism, disease symptoms, severity);
2. determine dose-response (the relationship between dose and symptoms);
3. assess exposure pathways (describes the exposure pathway(s) and the size and duration of exposure by each pathway);
4. characterise risk (integrate steps 1–3 into a model to calculate the risk of infection, illness or death) (CAMRA 2016).

Note that a QMRA could estimate health risks for various no-discharge options. However, the identification of the acceptable level of risk would require input from the community.

8 Conclusion

In summary, very limited information is available on recreational boating and sewage discharge practices in the Waikato Region. The peak boating densities in popular anchorages and the degree of compliance with current sewage discharge regulations are unknown. Sewage pump-out facilities are almost never used, and the majority of public boat ramps do not have nearby shore-based toilet facilities, which suggests that the majority of people discharge their sewage at sea.

Currently, there is no conclusive evidence in existing water quality data that boat sewage is a source of faecal contamination to nearshore regions. High Enterococci concentrations at some popular boating locations in Coromandel Harbour, Whitianga and Whangamata were not correlated to rainfall, and boat sewage may be a potential source of contamination. However, all of these sites are potentially affected by multiple sources of faecal contamination (e.g., livestock, septic tanks, boats, freshwater discharges), and consequently, it cannot be ascertained from the existing water quality data whether boat sewage is the primary source.

Critical knowledge gaps in the assessment of the boat sewage discharge in the Waikato Region include:

1. Boat sewage discharge practices and preferences of the boating sector;
2. Live-aboard boat usage of the Waikato region (times, densities, areas);
3. Evidence for compliance with current regulations;
4. Evidence for adverse effects caused by current sewage discharge practices; and,
5. What size should no-discharge zones be to minimise adverse impacts on human health, cultural values and enjoyment of the coast, and effects on the environment?

Key lessons learnt from Auckland Council's recent discharge rule change include:

1. Engagement with a wider range of stakeholders, mana whenua and the general public would have provided valuable contextual information;
2. There is no reliable data on compliance with the current regulations;
3. Effective rule changes require support from the majority of stakeholders;
4. It is very difficult to monitor compliance or enforce boat sewage discharge rules; and,
5. There is a lack scientific evidence on any adverse environmental effects caused by current boat sewage discharge practices in New Zealand.

Outlined below is a recommended process to determine whether changes to the sewage discharge regulations in the Waikato Region are necessary. This work could be done in parts as time and resources allow.

1. Develop an engagement plan that identifies the best methods to gather information on boat sewage disposal perceptions, practices and preferences. The drafting of this plan should

include input from a representative group of boat owners to ensure that a high level of stakeholder support is achieved.

2. Gather information on the discharge perceptions, practices and preferences on the boating sector to ascertain:
    a. their perceptions about whether sewage discharge from boats is currently a problem and the reasons for those concerns (e.g. health concerns, cultural concerns and/or impacts on their enjoyment of the coast);
    b. the proportion of boats that stay at sea overnight (e.g. where, when, how often, average stay length);
    c. the proportion of boats with holding tanks;
    d. sewage pump-out/disposal practices for boats with and without holding tanks (e.g. how, where and when do they discharge);
    e. impediments to the use of marina pump-out facilities;
    f. familiarity with the discharge regulations;
    g. whether discharges should be prohibited in specific areas where shellfish such as scallops are gathered and/or from high-use recreation areas;
    h. whether there are additional areas where the discharge of sewage should be prohibited;
    i. preferences on the size of no-discharge zones.
3. Conduct aerial surveys to estimate live-aboard boat usage of the region (areas, boat densities, boat types, times).
4. Conduct water quality testing to assess the level of compliance with current regulations. Testing should be conducted:
    a. at popular anchorages before, during and after peak usage;
    b. at popular fishing spots that are within 500 m from marine farms before, during and after peak usage;
    c. during fine weather and in locations that are unlikely to be contaminated by other faecal sources;
    d. at increasing distances away from boats to assess the scale and magnitude of effects.
5. Conduct water quality testing to assess whether the current regulations are sufficient. Testing should be conducted in areas where sewage discharge is permitted including:
    d. just outside the 500 m boundary of popular anchorages during high use periods;
    e. in areas where sewage is frequently discharged (as identified by the boating sector);
    f. in areas where shellfish are harvested, particularly in areas where discharges are currently permitted (e.g., scallop beds and > 500 m from marine farms).
6. If it is ascertained in the steps above that the majority of people are complying with current sewage discharge regulations, but faecal contamination from boat sewage is still a health or environmental risk, then an increase in the no-discharge zone is recommended. The most robust method of determining the appropriate size of no-discharge zones is likely to involve a

Quantitative Microbial Risk Assessment, coupled with community consultation on acceptable levels of risk.

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