Sea Change – Tai Timu Tai Pari

Water Quality and Catchments
Synthesis of Initial Information and Issues



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Water Quality and Catchments; Synthesis of initial information and issues

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Summary

Over time many of the water purifying ecosystem services provided by forest cover, wetlands and mussel beds, have been lost or depleted. This along with increased loads of sediment and other contaminants, largely coming from the land, has resulted in reduction of water quality in many locations near the coast. River discharges extend the impact of contaminants further into the Gulf and can carry large amounts of sediment and nutrient. Coastal water quality is more impacted during and soon after heavy rain events which cause contaminant runoff from streams, rivers, stormwater and overflowing wastewater, to enter coastal water.

Sediment entering the marine environment from the land continues to be a concern. Accumulation rates have decreased from very high rates associated with former land development, but continue to be sufficiently rapid to have ecological and amenity impacts. Land developments have not stopped and these pose risks for further sediment impacts on the coast.

Microbial contamination of bathing water and shellfish can be an issue in some locations. Periods of high risk follow heavy rain where wastewater systems can overflow, or dirty runoff containing microbial contaminants washes from the land. It is expected that planed improvements to wastewater infrastructure, and better land management practises will help reduce these risks.

The population of boats in the Gulf will grow. Discharge of untreated sewage from boats is currently an issue and this problem will increase in urgency.

Heavy metal contaminants are an issue in the Auckland area. Zinc and copper from vehicles are of particular concern and likely to increase. A few locations have high levels of contaminant resulting from boat antifouling, historic activities or natural sources.

Sustained high amounts of nutrients from rivers entering the Firth of Thames are impacting on its water quality and could, in time, have negative consequences that will impact users. This is an issue requiring attention and could have wide reaching implications for the Firth and its catchment.

Continued urban growth, intensification of land use and marine activity, ongoing cumulative impacts and climate change all pose challenges to water quality that need to be addressed today to reduce their future impact.

1 Introduction

1.1 Roundtables and information needs

Sea Change – Tai Timu Tai Pari is a stakeholder led project to improve the health and productivity of the Hauraki Gulf. A Stakeholder Working Group (SWG) leads this process and is supported by statutory agencies. Roundtables (RTs) composed of stakeholders and focusing on specific topics (such as water quality and catchments) are a way for the SWG to break down the task of building understanding of the issues into smaller areas of enquiry. They allow the SWG members to be more effective as not every SWG member will need to be on every RT and they also provide a broader group outside the SWG to engage in the information gathering and problem solving stages. Adding more stakeholder representatives to the RTs allows the SWG to build deeper relationships and engagement with interest groups which themselves may not otherwise feel directly engaged in the process. This relationship is the platform for the collaborative plan building process, the creation of innovative solutions and the understanding and acceptance of proposed final plans.

The RTs will have at least three SWG members and will be supported by the officials who may assist in convening the meetings. The names of others who may be invited to join the RT will be signed off by the SWG before the RT proper starts its work. Two of the SWG members will be co-chairs of the RT.

1.2 Purpose and scope of this document

The SWG and the RTs need to be provided with technical and other information relevant to their work of developing a Hauraki Gulf marine spatial plan. The first part of this process for them is information gathering. The second is synthesis and issues, the third part is exploring solutions and the final part is developing the spatial plan.

This document summarises the technical information relevant for the information gathering phase and highlights some of the key issues that emerge from this material. This material is based on the technical information presented in the 'Hauraki Gulf Water Quality and Catchments – Collation of Information' document.

A brief review of the material was carried out by several technical experts who were asked

- For your area of expertise is this material up to date, or best currently available?
- Are there any key documents missing?
- Are the summary and conclusions in the synthesis document fair and balanced?
- Are there any comments you have that what will assist the stakeholders?

The reviewers comments were included wherever possible. However, editorial comments relating to the material copied directly from reports were not made.

2 Auckland Region

Summary

The main water quality issues Auckland faces are from fine sediment entering the marine environment and contaminants, such as heavy metals and organic pollutants from runoff and sewerage/stormwater overflows and discharges. Trends have shown little or no increase regarding nutrients and microbial contamination in the region – apart from a few well-known hotspots and after heavy rainfall events. As such, the main concerns are:

- High sediment accumulation rates and suspended sediment having a dramatic impact on the physical characteristics of estuaries and harbours, water clarity, coastal ecosystems and mangrove expansion.
- Heavy metal contamination, particularly of inner urban estuaries via discharges from the stormwater/wastewater network of metals such as copper, zinc and lead. This is mainly from industry, roofing, car brakes and antifouling from boats.
- Sewerage/stormwater overflows from overloaded and ageing networks, cross connections or high rainfall events. Raw sewage can introduce high levels of bacteria and viruses, leading to contamination of shellfish and unsafe bathing waters. On-site wastewater and boats are other sources of increasing concern.

2.1 Ecological health

2.1.1 Sedimentation rates

Sediment Accumulation Rates (SAR) have been drastically affected by human development. Prior to human settlement the SAR in Auckland's estuaries was less than 1mm per year. Large scale land clearance for pasture, roading and urban areas saw this rate increase by an order of magnitude. This caused rapid infilling of estuarine areas and a decrease in the water quality. Today estuary sedimentation rates are about 2 to 5 mm per year on the subtidal and intertidal flats and typically about 10 mm per year in tidal creeks near catchment outlets. Those areas most affected were small tidal creeks draining highly modified catchments. These creeks have seen an average of 20 mm of sediment per year over the last 50 years. This has resulted in many of these tidal areas becoming completely intertidal and exposed during low tides.

Sedimentation has not only occurred in tidal creeks but also in the main estuarine reaches of the harbour. This has created large intertidal deposits with many of these areas becoming a half a meter shallower due to accumulation over the last 50 years. This change in depth is significant as many of these areas were previously only 1 metre deep at high tide. While some estuaries have scope for further deposition to occur others such as the Wairoa in Clevedon are completely filled. This has resulted in land derived sediment being exported out of the estuary into the wider coastal environment.

In recent times the monitoring has shown sediment accumulation rates to have plateaued in some estuaries and continued to increase in all the others. One reason for the levelling out of SAR could be the estuaries have infilled as much as they are going to and are now exporting sediment into the wider coastal environment as with the Wairoa case. Of particular concern is the lack of evidence to show SAR is decreasing across the Auckland Region.

There is much debate around the leading sources of sediment. Horticultural land which is regularly cultivated and often exposed (fallow with no vegetation) can contribute large volumes of sediment especially during times of intense rainfall. Forestry is generally found on poorer quality land (often steep and less productive). Sedimentation rates are generally lower under forestry than grazing land, except immediately after harvesting when a large slug of sediment can be flushed downstream. The same occurs when land is developed into housing. Sediment rates from a construction site can be up to 1000 times greater than forestry and 10 to 100 times greater than pasture lands. However, these rates are temporary as once development is complete very little soil is exposed to runoff. Sedimentation from grazing lands vary tremendously due to stocking rates, slope angle, soil texture and climatic conditions.

Table 1; Land uses which contribute sediment to the Mahurangi harbour.

Land use	% of catchment	% contribution harbour sediments*	% contribution to deposited sediment on river delta**
Forest	8%	14%	50-54%
Pasture	70%	10-30%	15-55%
Native	20%	<10%	<30%

*The rest of the harbour sediments are made up of marine and estuarine sediments. ** Note that land-use percent of catchment figures change when considering just the Mahurangi river delta

2.1.2 Heavy Metal Contaminants

The close proximity of Auckland City to the marine receiving environment means that contamination from heavy metals is of concern. Copper (Cu), Lead (Pb) and Zinc (Zn) as well as arsenic (Ar), Polycyclic Aromatic Hydrocarbon (PAHs) and organchlorines are the main heavy metals reported on (other metals generally follow a similar trend to these metals). Older style zinc corrugated iron roofs and motor vehicles (copper brake pads and zinc in tyres) are the greatest sources of heavy metals in the urban environment. Large volumes of copper are also associated with antifoulants on the hulls of boats. The greatest concentration of metals is found in the muddiest parts of the estuaries in close proximity to the historically settled suburbs and industrial areas.

In the future levels of zinc are likely to drop significantly as old zinc coated corrugated iron roofing naturally deteriorates and is replaced by products with lower zinc-leaching rates such as pre-painted roofing material. The effects of population growth and increasing numbers of vehicles are minor compared to the drop expected to result from the phasing out of galvanised steel roofs.

The concentrations of lead levels have shown a wavering trend with levels potentially beginning to drop. The removal of lead from petrol halted its accumulation in coastal sediments and declining trends have been detected at a number of sites.

Copper levels are predicted to continue to increase due to increasing vehicle and boat numbers. There is potential for copper concentrations to decrease if copper is removed from brakepads. There is a wide selection of brakepads on the market and some pads contain significantly higher levels of copper than others. Legislation has been passed in a number of states in the US banning the use of copper and other heavy metals from brakepads. Similar legislation would have to be passed by central government with input by NZTA and the

Ministry of Transport for this to occur. Auckland council could undertake further research into the proportion of copper brakepads and increase the awareness of this problem.

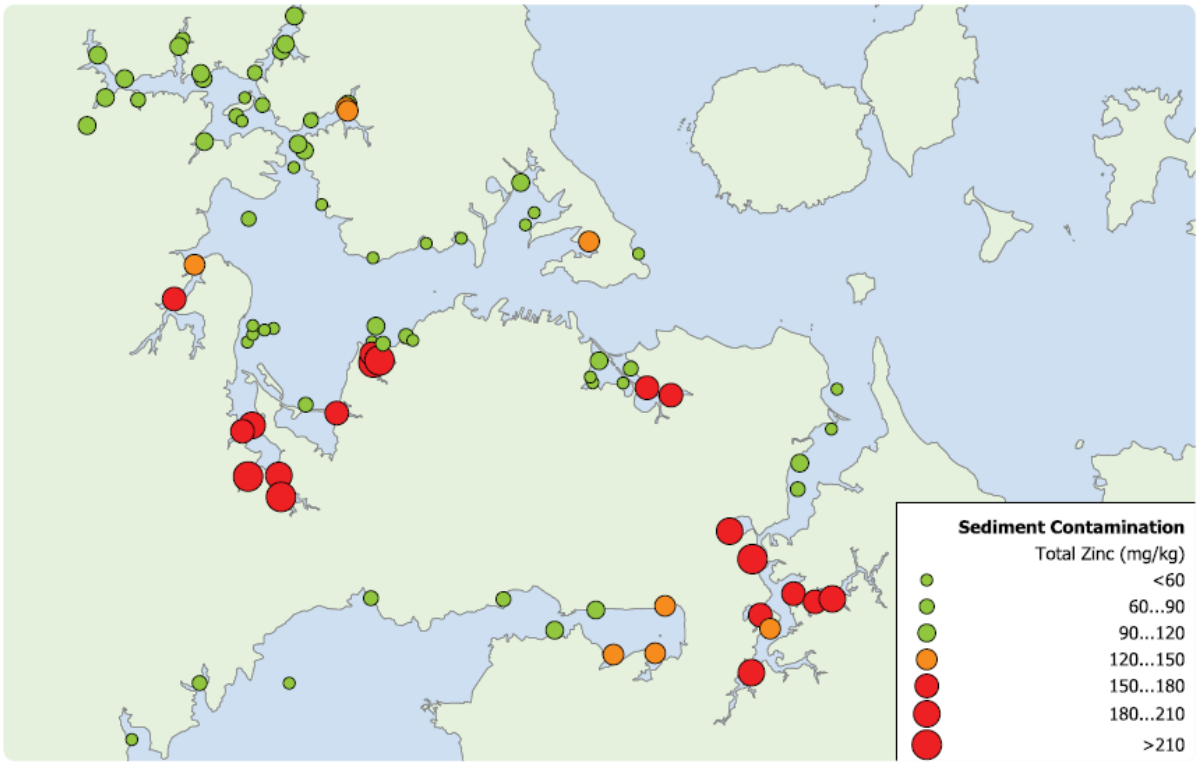

Figure 1; Zinc concentrations in the Auckland area

Monitoring of copper concentrations in eight Auckland marinas revealed extremely high levels of copper, five of which exceeded ANZECC (2000) water quality guidelines for aquatic protection. The major sources of copper are from antifouling paints used on hulls of boats and stormwater inputs from the surrounding hardstand areas. Westpark and Milford were the worst examples with dissolved copper recordings of 2.8 and 5.4 and total copper levels of 20 µg/L and 9.5 µg/L respectively. Bayswater had the lowest recorded values possible due to the open floating walls as opposed to the others which are enclosed by rock walls. It is highly likely that such high levels of copper would be having a significant negative effect on sensitive marine organisms living in these marinas.

Copper resulting from increased boating activities may offset any reduction in copper levels following any removal of copper from car brakepads unless it, too, is reduced.

2.2 Human Use

2.2.1 Bathing

Overall, the water quality at Auckland's bathing beaches is very good and meets New Zealand health guidelines the majority of the time. However, certain events such as overflows from the wastewater network and pollutant discharges from the stormwater system can periodically have adverse effects on water quality (i.e. not suitable for swimming).

Auckland's Safeswim monitoring programme regularly collects water samples from 54 beaches and bays that link to the Hauraki Gulf and tests these samples for Enterococci

bacteria to identify any potential public health risks. This program is only conducted during summer, therefore the true level of contamination could be underestimated outside of this season.

Monitoring data dates back to 2000 and the results show that over time there has been an improvement in bathing water quality at the majority of the beaches[1]. This can be attributed to an increased and improved reticulated wastewater network, such as the new Kawakawa Bay treatment plant and the recent 2010 upgrade of the Rosedale Treatment Plant. However, there are some sites that now have permanent warnings due to ongoing water quality issues (Cox's Bay, Meola Reef, Wairau Outlet, Little Oneroa Lagoon).

Research shows there to be problematic areas closer to the city that produce high concentrations of bacteria during rainfall. The source of this contamination is predominantly from engineered overflows from the wastewater network, which delivers large volumes of untreated wastewater to marine environments. Furthermore, accidental and illegal waste water cross connections to the stormwater network pose a greater threat to public health, as these connections discharge very high bacteria levels in the absence of rainfall.

2.2.2 Shellfish Gathering

The suitability and quality of coastal marine waters for recreational activities are of increasing importance, primarily for reasons of human health and public safety, but also for the continued health of the marine environment. Unfortunately, there are periods when wastewater, stormwater and microbiological contaminants enter coastal marine waters, which may lead to bans on shellfish gathering. Consuming shellfish gathered from urban parts of Auckland is generally regarded as unsafe because of the health risks associated with microbiological contamination.

Microbiological contaminants, which may cause illness in humans, enter the marine environment through stormwater runoff and wastewater (sewage) overflows. These overflows occur when pipes become blocked, equipment fails, and when heavy rainfall overloads the wastewater pipeline network. Stormwater discharges can also contain microbiological contaminants as pathogens from human and animal faecal material enter the drainage system through overland runoff, infiltration from sewers, and illegal wastewater connections to the stormwater network.

2.2.3 Aquaculture

There is not a large extent of Aquaculture in the Auckland part of Hauraki Gulf. Oyster farms can be found in Waiheke, Clevedon and Mahurangi, while mussel farms can be found around the west side of Great Barrier, Waiheke Island and off Matingarahi.

Oyster farms require contaminant free water and employ rigorous, weekly water testing in order to make sure the shellfish are fit for human consumption. Naturally occurring oyster spat is harvested from the Hauraki Gulf and then grown on wire racks in the intertidal zone. Oysters are filter feeders and therefore can be prone to a build-up of heavy metals in their tissues.

[1] http://www.aucklandcouncil.govt.nz/EN/environmentwaste/researchmonitoring/beach_water_quality_safeswim/Pages/historical_monitoring.aspx

Cadmium has been report as a potentially big issue for oyster growers as some countries have restrictions on the metal concentrations in oyster meat. For example Australia has a maximum limit of 2.0 mg/kg of cadmium for molluscs and 0.2 mg/kg in fish. The maximum concentration measured in Mahurangi Oysters was 0.54 mg/kg with a mean of 0.36 mg/kg (Butler and Timperley 1996). The largest source of cadmium is from phosphorus fertiliser and is transported into the marine receiving environment coupled with sediment. Nationally, there is a Cadmium Working Group assigned the task of coming up with a tiered fertiliser management system with trigger values to help limit the build-up of cadmium in production land.

Green Lipped Mussels (*Perna canaliculus*) were once a significant fishery in the Hauraki Gulf. Extensive, naturally occurring mussel beds once dominated the sea floor in the Firth of Thames and through Tamaki Straight (see below map). These naturally occurring mussel beds filtered the entire water volume of the Hauraki Gulf every day. Dredging these mussel beds in the 1950's destroyed these reef systems and they have failed to recover (Paul, 2012). The demand for mussels was met through some good old fashioned kiwi ingenuity which pioneered the growing of mussels on ropes and buoys. A restoration project (Revive Our Gulf) has a vision to restore these mussel beds to their former glory. Initial trials show live mussels placed on the seafloor are doing well and have formed mattered beds. The next stage of the restoration is to secure funding in order to expand the restoration efforts.

http://reviveourgulf.org.nz/resources/Paul-(2012)-FoT-Mussels-AEBR-94.pdf

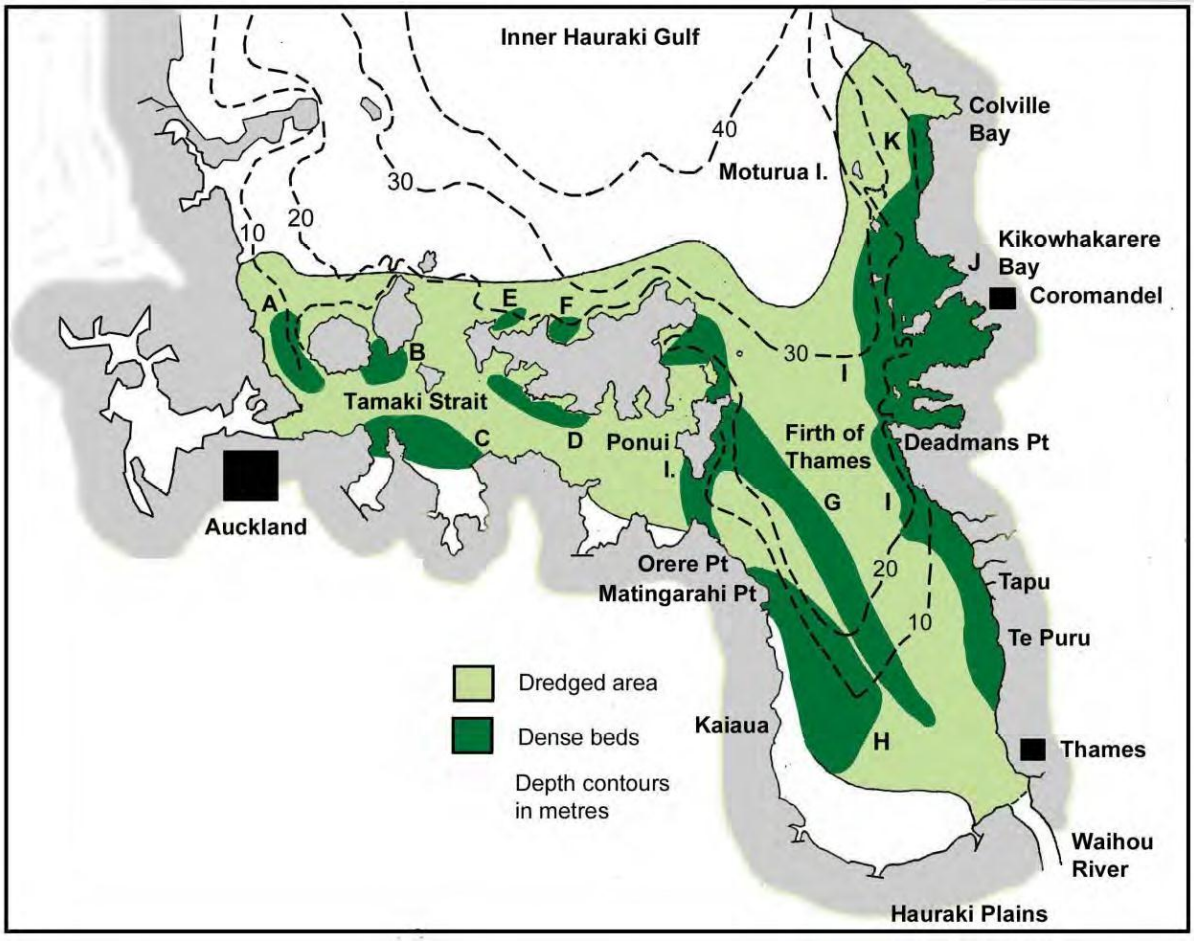

Figure 2; Map of the inner Hauraki Gulf and the Firth of Thames, showing the area worked by the green-lipped mussel dredge fishery and the position of the main mussel beds. Redrawn from Reid (1969), with depth contours added.

2.2.4 Wastewater Discharges and Overflows

Wastewater flows into the Hauraki Gulf from point sources (wastewater treatment plants, stormwater network, boats) or non-point sources (on-site wastewater systems, overland run-off). There are 9 wastewater treatment plants that discharge (directly or indirectly) to the Hauraki Gulf, with the Rosedale plant which serves approximately 220,000 people being the largest[2].

Beachlands, Rosedale and Army Bay treatment plants have all undergone recent upgrades and treat wastewater to a high standard. Matakana, Waiwera and Waiheke plants are at capacity and no new connections can be made to these networks. Rather than the treatment plants discharge points themselves, the main issue arises from heavy rain events, which affect the whole network and lead to uncontrolled overflows from manholes an pump stations[3].

Wet and dry weather overflows discharge untreated wastewater into the Waitemata Harbour at more than 200 points. The proposed central interceptor scheme seeks to address this issue (construction scheduled to start in 2017), reducing the average wastewater overflow volume by 80%[4]. This will have a significant impact on improving water quality and reduce the high bacteria counts that plague areas like Meola Reef, Cox's Bay and Point Chevalier.

Another source of discharges causing localised pollution to coastal water is the thousands of on-site wastewater treatment and disposal systems along the eastern seaboard of the Auckland Region. On-site systems tend to fail due to lack of maintenance, poor system design or installation and cumulative impacts from an increase in the number of houses being built. Waiheke Island is home to over 8000 residents[5] and does have a few problematic areas such as Little Oneroa and Oneroa Bay. However the rest of the east coast that is not reticulated is under less density pressure and therefore has little effect on water quality.

The final route that wastewater enters the Hauraki Gulf is from boat/yacht/ship discharges. The number of vessels in Auckland is estimated to increase from 132,000 in 2011 to 222,000 by 2031[6] posing a significant risk to the use and enjoyment of Auckland's coastal and marine environments. The main issue with untreated discharges from vessels is the adverse effect on amenity for recreational users. The impact tends to be localised and relatively temporary, as sewage breaks down and disperses rapidly. However low tidal, sheltered bays are often shared between recreational vessels and the general public (such as Oneroa Bay, Waiheke) and have less capacity to disperse sewage. Here, the presence of sewage in coastal waters severely impacts recreational activities.

[2] *Watercare*, www.watercare.co.nz
[3] Watercare Services Ltd Asset Management Plan 2011
[4] The Central Interceptor factsheet, Watercare, December 2013
[5] http://www.stuff.co.nz/travel/destinations/nz/9399522/Paradise-Island-on-Aucklands-doorstep 2013
[6] Auckland Recreational Boating Study (2012) Beca Infrastructure Ltd

3 Waikato Region

Summary

For water quality the main issues are coming from the land, particularly during storm events when rivers and streams deliver sediment and microbial contaminants to the marine area. The trends for nutrient in rivers are slowly increasing over time for nitrogen and decreasing for phosphorus. There have been improvements in point discharges such as sewage treatment from settlements. Some of these improvements have had a significant impact on decreasing the amount of phosphorus entering the rivers.

Overall, sediment, microbes and nutrients still need addressing, particularly that from farmed and plantation forest areas. Currently boating is having a small impact on water quality but over time this will increase, as will further impacts from intensification of farming and potentially from finfish farming.

The main areas of concern are;.

- The high incidence of unsatisfactory levels of microbes in harbour and estuary water making it potentially unsafe to gather shellfish. The main causes are runoff from the land, septic tanks and potentially effluent from boats
- Negative ecological impact of the high incidence of unsatisfactory levels of nitrate and total phosphorus in harbours and estuaries. Mainly from agricultural runoff.
- Cumulative impacts of sediment in harbours and estuaries causing decreases in species number, diversity and resilience, and accelerating infilling and mangrove growth. Sediment is also associated with carrying microbial and agricultural contaminants to the marine area. Main sediment sources are from hillside and stream bank erosion.
- The periodic low oxygen levels in the bottom waters of the Firth of Thames, along with increasing pH may be an indication that the cumulative impacts of nutrients from rivers are beginning to have a serious effect. This could negatively affect uses of the firth such as aquaculture, fisheries and amenity. The main source of nutrients is from the land.

Locations needing special attention

- Firth of Thames
- Aquaculture farms
- Firth of Thames Ramsar site
- Hahei marine reserve
- Shellfish gathering locations

Future pressures

- Increased nutrient from intensification and expansion of farming and finfish aquaculture
- Increased sediment from storms associated with climate change
- Increase in degraded locations as cumulative impacts become apparent
- Increased sewage and antifouling contaminants from boats
- Increased sediment infilling from new subdivisions, earthworks, causeways and land reclamation

3.1 Ecological health

3.1.1 Water quality

Water in the estuaries monitored was generally well oxygenated. pH was within the limits of both the WRC standards/guidelines and the ANZECC guidelines on most occasions. Concentrations of ammonia were within acceptable levels at all sites. However, levels of the nutrient indicators, nitrate and total phosphorus, were classified as 'unsatisfactory' in many estuaries[7]. Nitrate is unsatisfactory in Whangamata, Whitianga and Whangapoua harbours, and both phosphorus and nitrate in the Firth of Thames. The other estuaries have yet to be measured.

Table 2: Water quality for ecological health. Percentage of samples collected in each category.

	Ecological health		
	Excellent	Satisfactory	Unsatisfactory
Whangapoua Harbour	59%	30%	12%
Whitianga Harbour	39%	51%	10%
Whangamata Harbour	54%	36%	10%
Firth of Thames	51%	22%	27%

http://www.waikatoregion.govt.nz/Environment/Natural-resources/coast/How-healthy-are-our-estuaries/Estuarine-water-quality-monitoring-map/

WRC's water quality standards for ecological health are based on the *Australian and New Zealand guidelines for fresh and marine water quality* (Australian and New Zealand Environment and Conservation Council (ANZECC) 2000; commonly referred to as the ANZECC guidelines). Seven parameters are used for assessment these are.; dissolved oxygen, pH, turbidity, total ammonia, nitrate, total phosphorus and chlorophyll a.

Table 3: Water quality nutrient levels. Percent samples in the unsatisfactory category.

	% unsatisfactory samples	
	Nitrate	Phosphorus
Firth of Thames	36%	93%
Whangamata Harbour	25%	17%
Whangapoua Harbour	38%	17%
Whitianga Harbour	50%	4%

http://www.waikatoregion.govt.nz/Environment/Natural-resources/coast/How-healthy-are-our-estuaries/Estuarine-water-quality-monitoring-map/

In February 2012 and January 2014 hundreds of bird deaths from botulism outbreaks occurred in the vicinity of the Piako river mouth. The water quality of this river is very poor. In summer these conditions are of the type conducive to botulism outbreaks. No studies have been done confirming this link, but it is a likely source.
http://www.stuff.co.nz/waikato-times/news/6479697/Bird-sanctuary-at-risk-from-disease-outbreak
http://www.youtube.com/watch?v=SKF9e455TxQ

[7] Nitrate and Total Phosphorus (TP) were categorised as 'unsatisfactory' for large percentages of samples in all estuaries. Levels of these variables were 'unsatisfactory' for as many as 91% of samples (TP in the Firth of Thames) in some estuaries.

3.1.2 Contaminants

A study in the inner Firth of Thames found that sediments are enriched in mercury, lead, cadmium, copper, zinc and arsenic. Arsenic and mercury were found to be present in the upper firth at concentrations oscillating around the Australian and New Zealand Environmental Conservation Council (ANZECC) low interim guideline values, indicating a level of risk to aquatic organisms from these metals.

Contaminant loads are highly linked with sediment transport, as many contaminants adhere to fine sediments. Elevated concentrations of arsenic and copper are believed to be attributable to catchment geology rather than historic mining activities. Elevated levels of mercury in the upper firth are not well understood but may be related to drainage of wetlands in the Piako River catchment. Historically, mining activities are likely to have contributed additional zinc, cadmium and lead to the firth. Currently, agricultural activity is likely to be a significant ongoing source of zinc and cadmium. Zinc is associated with facial eczema remedies, and cadmium is an impurity in superphosphate fertiliser.

In terms of agricultural chemicals, DDT still exists at elevated levels in some pastures and sediments (33%-40% of Waikato farms). Other residual agricultural chemicals potentially of concern include Dieldrin (potentially present in 7000 unused sheep dip sites remaining in the region), Paraquat and Diquat which have long half-lives, but which are highly bound up in soils and sediments. Control of sediment run-off can limit contamination of water bodies. Recent sampling by Environment Waikato indicated that total DDT levels was approximately four times the ANZECC low level guideline in the Firth of Thames. Other contaminants from various point sources (for example, domestic and industrial) were below ANZECC low guidelines. The potential for problems related to these various contaminants is very low, though DDT levels are in the range where some adverse effects may occur. DDT usage has been banned since 1970, so dilution over time is likely.
http://www.waikatoregion.govt.nz/Services/Publications/Technical-Reports/Trace-Elements-in-Sediments-of-the-Lower-Eastern-Coast-of-the-Firth-of-Thames/

3.1.3 Sediment

http://www.waikatoregion.govt.nz/PageFiles/9922/tr0812.pdf

Introduction
Sedimentation in estuaries is a natural process that can be accelerated by changes in land use or land management within the catchment, or by development of structures within the estuary. Estuaries are under increasing pressure from coastal development or catchment activities such as farming, forestry, subdivision and vegetation clearance. Estuaries on the east coast of the Coromandel Peninsula are at high risk of infilling because of the erosive nature of their catchments (steep topography and frequent high intensity rainfall events) and the physical nature of the estuaries (sandbars or barriers narrow the harbour entrances). It is likely that shallow landslides are the biggest source of sediment to estuaries. These occur on all land use types and are caused by intense rainfall events. Landsliding most commonly occurs on slopes greater than 25°. On these slopes forest cover rather than pasture reduces this risk, and permanent forest reduces the risk further.

The effects of sedimentation on the biological communities

- High levels of suspended sediment within the water column increase the turbidity and decrease the light available to plants, such as seagrass and plankton. This can decrease the food available to benthic animals and clog their feeding structures.
- Deposition of sediments can smother seagrass beds, encourage mangrove growth and bury benthic animals.
- Contaminants attached to sediment affect benthic behaviour, reproduction, survivorship, and population and community structure.
- Changes in the plant and animal communities can reduce feeding ground and habitat for bird and fish species and can impact on kai moana species.
- Cumulative effects on plants and animals from low levels of sedimentation may be detrimental.
- Sedimentation is not the only pressure on coastal plant and animal communities, and the impacts of sedimentation should be considered in conjunction with other pressures.

With climate change projected to increase both the frequency and intensity of storms and rainfall events in some places, and with intensification of land use, the role of these stressors is likely to increase.

Sedimentation rates

Sediment cores from harbours and estuaries comparing pre and post-European sediment yields show increased sediment accumulation with the advent of European settlement. Extremely high rates occurred during the 1800's with forest clearing and this continued into the early 1900's. Rates are now reduced to about 2 to 9 mm of sediment accumulation per year, however, this is still about 20 to 80 times higher than pre-European rates.

These accelerated rates of sedimentation resulting from changes in land use are thought to have resulted in declines in species abundance and habitat degradation. There has also been a period of rapid mangrove expansion over the last 25 years or so in the majority of estuaries on the Coromandel Peninsula. Increased sedimentation raises the intertidal flat level, which allows mangroves to become established in areas that were once too frequently submerged by the tide.

3.2 Human use

3.2.1 Bathing and shellfish gathering

Fish stocks, aquaculture, amenity, infrastructure

Introduction

Recreational activities such as swimming, shellfish gathering, surfing and water-skiing can be unsafe when water quality is poor. Sometimes pathogens from human and animal faeces - contaminants like microscopic protozoans, bacteria and viruses - can get into waterways. These 'bad bugs' can cause illness when people are exposed to them.

The region's coastal waters generally receive less bacterial contaminants than inland waters. Also, on the coast any contaminants are often diluted quickly and dispersed by tidal flushing and waves. Because of this, the levels of contaminants in the region's coastal waters are often much lower than in rivers. But after heavy rain, contaminants from runoff are likely to be higher. Agricultural land is a significant source but forested areas with animals are also a source. Poorly functioning septic tanks can also overflow and cause localised pollution, affecting water quality and/or causing a public health nuisance. A large number of communities in the District are served by on-site systems. Communities where septic tanks

are suspected to be functioning inadequately include: Hikutaia, Matatoki, Puriri, Thornton Bay, Te Puru, Waiomu, Tapu, Te Mata, Manaia, Kikowhakarere Bay, Koputauaki Bay, Oamaru Bay, Little Bay, Whangapoua, Kuaotunu West, Opito, Hahei, Hot Water Beach and Opoutere. At most of these locations, on-site disposal from traditional septic tank systems is not suitable due to soil conditions, small lot sizes and/or old, outdated tanks, etc.
Wastewater discharges from boats also influence coastal water quality. Such discharges are likely to become more frequent as the District's population and visitor numbers increase. While Whitianga Marina and Pauanui Waterways contain wastewater pump-out facilities, anecdotal reports suggest that usage of these facilities within the TC District is very low, probably because off-shore discharge (permitted under the Resource Management (Marine Pollution Regulations 1998) is an easier option.

Bathing
Water quality for swimming in the Coromandel coastal waters was monitored from 1991 to 2008 and is usually at least satisfactory, often it is excellent. Occasionally, some beaches experience high bacteria levels. These are Cooks Beach West and Pepe Stream in Tairua harbour. Both are near streams that drain areas of septic tanks or farmland, respectively. Inner harbours are more likely to have unsatisfactory results where they are influenced by runoff from farmland, forested land with animal pests, and septic tanks.
Water quality in harbours and estuaries (or their mouth) during or soon after a storm is likely to be poor because of the high proportion of runoff in the water. Swimmers and surfers are particularly vulnerable if in the water at those times. Whangamata surf break is one example.

Shellfish gathering
Water quality results for shellfish-gathering has the largest proportion of 'unsatisfactory' classifications and is poor. This is because of high microbial contamination in the water and because most edible shellfish are filter feeders which concentrates these microbial organisms in the shellfish. While there are methodological shortcomings in the way in which shellfish-gathering water quality data have been derived, it is still valid to say that there are issues about water quality for shellfish gathering.

Table 4: Percentage of samples meeting our guidelines for excellent, satisfactory, or unsatisfactory coastal water quality for shellfish gathering.

	Shellfish gathering		
	Excellent	Satisfactory	Unsatisfactory
Firth of Thames	33%	50%	17%
Whangamata Harbour	13%	50%	38%
Whangapoua Harbour	13%	25%	63%
Whitianga Harbour	0%	42%	58%

Shellfish-gathering water quality guidelines are derived from the *Microbiological water quality guidelines for marine and freshwater recreational areas* (Ministry for the Environment and Ministry of Health 2003).
http://www.waikatoregion.govt.nz/Environment/Natural-resources/coast/How-healthy-are-our-estuaries/Estuarine-water-quality-monitoring-map/

3.2.2 Aquaculture and fisheries

Shellfish aquaculture is concerned about water containing faecal microbes. These can be from the land or from boats. Heavy rain can delay harvesting because of concern over run-off from livestock farms in the region can affecting the quality of the sea water. Testing is undertaken by the Coromandel Marine Farmers Association to ensure that the water quality

is of sufficient standard before harvesting can be carried out. Intertidal oyster farms are particularly vulnerable to impacts from the land.

Research commissioned by MFish has demonstrated strong links between the effects of land-based activities and impacts on fisheries resources. These effects are primarily the result of elevated sediment and nutrient levels which can result in changes to the productivity of the marine environment by, for example, the loss of sea grass and sediment intolerant organisms such as horse mussels which provide important habitats for juvenile fish. The intensive agricultural production of the Waikato region means the region's coastal marine area, rivers and streams are at potential threat from these effects. Accordingly, managing land-based activities to avoid, remedy or mitigate effects on the marine environment and fisheries resources is important.

3.3 Special places

3.3.1 Firth of Thames

Introduction

The Firth of Thames hosts aquaculture, commercial and recreational fishing, migratory birds and the southern part is an internationally significant Ramsar site of ecological importance. Monitoring of changes in the Firth is limited but initial observations indicate emerging issues resulting from sediment accumulation from present and historic inputs, nutrient enrichment causing a change to a largely decomposing biological cycle and decreased water pH, which in time could negatively impact on the healthy functioning of the Firth and affect its ecology, fishing and aquaculture.

Nutrients

It is suggested that nutrients and sediment from land development has resulted in strong effects on the Firth of Thames ecosystem. Present day water quality in the Firth is significantly enriched, and it is likely that its productivity is substantially higher now than before the arrival of humans. The system is now largely based on decomposition (net-heterotrophic), consuming substantial organic matter and at times oxygen, and producing lower water pH, inorganic nutrients and dissolved inorganic carbon (DIC)[8].

On average, river supply of nitrogen (N) to the Firth is greater than the supply from the ocean across the boundary between the Firth and the Hauraki Gulf. During periods when ocean downwelling is dominant, rivers contribute about 70% of the total dissolved inorganic N (DIN) load, and when upwelling is active, 50% of the load arises from rivers, the rest coming from the ocean.

[8] DairyNZ and WRC are jointly funding NIWA to undertake a wide ranging review of the state of knowledge of ecosystem health in the Firth of Thames. This includes an assessment of the observed and modelled data held by NIWA, to accurately represent the spatial and seasonal effects on water quality attributed to changes in each of five indicators:

- Sediment loading (in-column and at the mud-water interface);
- Nutrient loading and bioavailability
- Algal composition and biomass
- Dissolved oxygen
- pH

For each of the above, NIWA will assess the data and research conducted in the Firth of Thames, in order to:

- Address the impacts on water quality associated with that indicator;
- Describe the processes governing that indicator and relate these to the Firth of Thames (i.e., effects of internal and external processes);
- Describe if the available evidence is representative of the wider environment (spatially and temporally);
- Detail any evidence for a concern arising from that indicator on 'ecosystem' or 'human' health (i.e., determination from trends whether or when a critical threshold will be passed);

Output will include a publicly-available report written for DairyNZ and WRC but for use by the Stakeholder Working Group. This is due for completion in January 2015.

The Waihou and Piako river mouth combined deliver 98% of the nitrogen and 96% of the phosphorus (P) discharges into the Firth. The total annual load of N and P discharged into the Firth from rivers is 3,360 and 270 tonnes respectively. This N is the equivalent amount needed to fertilise 336 100 ha dairy farms at the usual rate of 100kg of N per hectare. N is increasing annually by about 33 t/yr (1%) and P is decreasing. The greatest source of nutrient in the rivers is from agricultural land which contributed 70% of the nitrogen load and 46% of the phosphorus. Point sources contributed 8% of the nitrogen and 25% of the phosphorus. The Firth will respond to changes in catchment management that affect nutrient loadings.

Sediment

A risk analysis identified significant stressors and risks associated with accumulation of terrestrial sediment, particularly mud, in the southern Firth of Thames. Historically the southern shore area was dominated by sandy intertidal environments and beaches which have now been extensively displaced by muddy environments. The greatest risk posed is to the tidal flats of the Ramsar site with lesser, but relatively important risks for the water column, the sub-tidal seabed, and stilt ponds.

Sediments smother the intertidal flats that wading birds are foraging on, and are a key driver of the recent expansion of mangroves, which reduces feeding and roosting habitat for many birds. Subtidal flats are also affected. Sedimentation can cause increased turbidity and reduction of light which in turn affects growth rates of phytoplankton and seabed algal communities. Deposition of mud may have short and long-term impacts by changing the structure of seabed communities (for example, from communities dominated by bivalve molluscs to communities dominated by polychaete worms). Increased concentrations of suspended sediments also influence nutrient and oxygen availability, and thereby negatively impact on filter-feeding bivalves such as horse mussels, pipi, scallops and cockles. Many nutrients and contaminants are also thought to be delivered and retained through attachment to sediments.

There is little information on measured sediment coming down the rivers. Modelled results predict 150,000 tonnes per year for the Waihou and 35,000 for the Piako. The foreshore of the southern Firth is on average extending seaward at an average rate of 20 m per year.
150,000 t/year is equivalent to spreading mud 1 meter deep and over the 21 km shoreline from Miranda to the Waihou river mouth

Unpublished estimates based on aerial photographs of shoreline increase, and carbon dating of inland shell ridges have been used to estimate rates of shoreline increase over time. From 1963 to 2007 the rate of shoreline advancement was about 19 metres per year (m/yr)r, in the 5 years from 2002-2007 the rate was about 8 m/yr. From 587 years ago to about the 1960's it was an average of about 2.6 m/yr, starting 1134 years ago gives an rate of 4.8 m/yr, and starting from 6418yrs ago gives an average rate of 1.95 m/yr.

The Waihou and Piako rivers together contribute about 78% of the sediment that runs off the land into the Firth of Thames. Modelling estimates about 150,000 tonnes per year from the Waihou and 35,000 from the Piako. If this sediment were one meter thick over the 21 km from Miranda to the Waihou river mouth it would produce a new shore line about 9 metres wide every year. This is about half what is occurring and the additional material is likely coming from pool of sediment stored in the Firth. These are very approximate figures and more work is required to verify the results.

The sedimentation changes are thought to be associated with changes in the sediment budget of the southern Firth arising from the following.

- Enhanced sediment input from terrestrial environments, particularly associated with historic land clearance activities. Current sediment supply rates from land are thought to be relatively low. However because of the large catchment area the total sediment input is still high and there are concerns associated with intensification of land use.

- Loss of wetland and other environments that once acted as sinks for large sediment volumes. For instance the drainage and development of the Hauraki Plains, and the construction of stopbanks all along the coast from the Waihou River mouth to the Miranda Stream resulted in the loss of over 32,000 ha of flood plain.

- Trapping and retention of mud from the existing sediment reservoir in the southern Firth by mangrove expansion[9].

These large-scale effects and changes demonstrate the potential for terrestrial inputs to significantly alter the coastal environment. The role of the existing sediment reservoir indicates that even if sediment run-off from land is reduced, trends of increasing sedimentation could continue for a while. Land use is being intensified in the catchment of the Firth of Thames, including potential conversion of large areas of pine forests to pasture (mainly along the southern margins of the catchment). The potential impact on sediment run-off is not yet known.

The highest loads of sediments, contaminants and nutrients are often associated with seasonal or periodic flood events. The frequency of these flood events may increase with global climate change effects, increasing the risks.

3.3.2 Firth of Thames Ramsar site

The risk modelling predictions for the Ramsar site and its catchment found the greatest stressor on the biological requirement for the site to be from the land. Agricultural land use (dairy farming) contributed by far the largest risk to the site. Climate change, Firth of Thames sediments, point sources, fishing, urban and industrial land use, and mangrove expansion posed lesser but important risks. Sedimentation was found to be the biggest stressor, and the largest sources of sediments were agricultural land use and sediments already in the Firth of Thames.

3.3.3 Hahei marine reserve

The Department of Conservation identified sedimentation of fine-grained particles within the Te Whanganui-a-Hei (Hahei) Marine Reserve as an issue of concern. This reserve is influenced by estuaries and rivers flowing into Mercury Bay, to the west of the reserve. Since the reserve was gazetted in 1993, several biological monitoring programs have been undertaken within the area of which some provided evidence for increased deposition of fine-grained sediment.
http://aut.researchgateway.ac.nz/bitstream/handle/10292/1456/DOC20108.pdf?sequence=2

[9] Reviewers comment; Recent investigations by NIWA show that sediment accumulation rates are similar whether mangroves are present or not..

4 Potential future concerns

There are three aspects of environmental change that may pose issues for the future. The first is negative impacts of intensification of use; the second is the cumulative impact of ongoing slow decline, and the third is climate change.

4.1 Intensification of use

On the land

- increased nutrient, sediment and microbial contamination from intensification of farming such as conversion of forestry to farming, change to more intensive systems with greater stock densities.

- Increased sediment infilling from new subdivisions, earthworks, causeways and land reclamation

- Expected increases in population growth leads to increases in impervious surface due to infill housing and expanding urban areas. This will increase stormwater volumes and associated contaminants.

On the sea

- Intensification of boating resulting in iincreased sewage discharge and antifouling contaminants from boats

- Introduction of finfish aquaculture adding more nutrients

4.2 Cumulative impacts

Cumulative impacts either become slowly apparent over time or go unnoticed. One of the dangers of cumulative impacts is that they are gradual and intervention may not occur until the resource is in serious difficulty or even beyond repair. If slow change continues unnoticed for a long time then the degraded state can become accepted as normal and never addressed.

The challenge is to retain existing high water quality, safeguarding it from any continued cumulative negative change occurring today, rather than responding only when it is sufficiently degraded to warrant intervention.

4.3 Climate change

- Increased sediment and other contaminants from more frequent storms associated with climate change
- Increases in ocean pH and temperature associated with increased atmospheric carbon dioxide.