FACTORS THAT IMPACT LIFE IN FRESHWATER STREAMS

Water clarity

Water clarity or turbidity is the cloudiness or haziness in a fluid caused by individual small particles (suspended solids).

An increase in turbidity results in a corresponding decrease in water clarity. High turbidity may be from an increase in phytoplankton (algae) or an increase in sediments. This may be in response to nutrient inputs and erosion due to land development, stormwater runoff from paved surfaces, wastewater/other discharges, or farming/forestry practices. Urbanisation, forestry, agriculture, industries that discharge into waterways, and mining are all likely to increase turbidity of nearby waterways, especially when these involve large quantities of stormwater and surface runoff.

Potential impacts of turbidity on water quality and mahinga kai

- Cloudy water that may be green or brown reduces the ability of fish to see prey and detect predators.
- Reduced light penetration - reduces or inhibits growth of aquatic plants and their ability to produce food and oxygen (DO) for species that depend on them.

Sediment

When soils erode, sediments are washed into waterways.

Sediment in a stream is natural, but if sediment levels get too high, it can disrupt ecosystems and kill mahinga kai. Excess sediments can cause damage by blocking light that allows algae (an important food source) to grow, harming fish gills, filling up important habitats, and stopping fish from seeing well enough to move around or feed.

Sediments are a natural part of a stream, lake, or river, and the type and amount found in streams are influenced by the geology of the surrounding area. Natural processes that add to sediments in waterways include instream scouring of the river bed and banks and erosion of sediments from the surrounding catchment from natural slips and any exposed soils. Sediments can enter streams from alongside a reach or from upstream via the myriad smaller interconnecting streams that form a river network within a catchment area.

While sediment movement is a natural part of a functioning freshwater ecosystem, human activities around a waterway (such as dam or road construction or land use change from native forest to pasture) can greatly increase the amount of sediment that enters the system. This can have considerable effects on water quality and the plants and animals that live there. The addition of sediment to rivers and streams above normal levels is a serious issue.

Sediments in waterways travel downstream in suspension when water velocity is high or turbulent. When there is a decrease in velocity, especially in pools and deep areas of a stream/river, sediments will eventually settle and can be seen as deposits of fine material or by the formation of sand bars on the river or stream bed.

Sediments in suspension can have a significant impact on the water quality of a waterway because sediments decrease water clarity, which reduces visibility. Water clarity is usually measured as turbidity. Turbid waters prevent the growth of aquatic plants and algae (because plants need light for photosynthesis) and decrease the ability of fish to find food or to detect predators and prey, thereby increasing stress. Sediments may smother stream invertebrates which are an important food source for fish.

Excessive sediment deposits on the river/stream bed can significantly alter and degrade habitat. Some animals are dependent on the rocky bottoms of streams, while others live in deep sandy pools or around woody debris. Sediments fill the spaces between stones that invertebrates live in, and in extreme cases can bury woody debris, stony substrates (gravels and cobbles), and root mats, and fill pools and channels. This reduces the amount of invertebrate habitat and cover and spawning grounds (a place to lay eggs) for fish. An increase in the amount of sediment deposited on the river/stream bed can also significantly change the flow and depth of rivers or streams over time and infill lakes and estuaries. Natural cleaning processes - where the water flows through the gravel bed of a stream and interacts with the microbes living on stone surfaces, removing nutrients and some pollutants - can also be short-circuited by excessive sediment deposits.

Potential impacts of sediment on water quality and mahinga kai

- Decreased water clarity - increased sediment loading into a stream will decrease water clarity and reduce visibility for fish seeking food and places to live.
- Damage to fish gills and filter feeding apparatus of invertebrates.
- Changes to the benthic (bottom) structure of the stream/river bed - coarse substrates such as gravels and boulders are replaced/smothered by sand and silt.
- Decreased numbers of invertebrate species from smothering of habitat - invertebrates are a food source to some mahinga kai (e.g., kōura and fish) and diverse invertebrate communities are also an indicator of healthy stream systems.
- Decreased algal food supply at base of food chain - sediments can scour algae from rocks, make algae unpalatable, or reduce light to levels where algae cannot grow, because plants need light to photosynthesise.
- Increased contaminants from surrounding land - sediments can transport attached pollutants such as nutrients, bacteria, and toxic chemicals from agriculture and horticulture into our streams.

Temperature changes

Temperature affects the number and type of animals and plants that live in a waterway.

Temperature determines the number and type of animals and plants that live in a waterway. Temperatures vary naturally with the seasons, while water is also usually colder at the bottom (due to groundwater input) and warmer on the surface (due to higher air temperature) of a stream, river, or lake.

Many activities have the ability to change water temperatures, including the discharge of warmer cooling water from thermal power stations, the release of water from dams, the removal of riparian planting that shades and maintains temperatures in waterways, a reduction or increase in water levels due to abstraction or diversion of water used for irrigation, and the addition of warmer geothermal water.

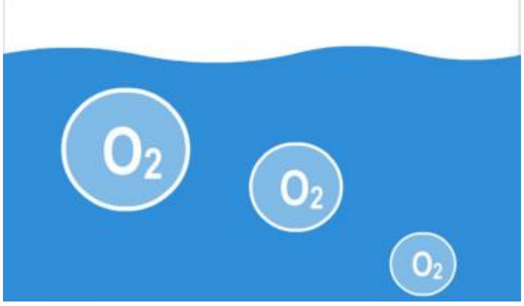
Most animals and plants that live in our waterways prefer a certain temperature range for optimum growth and reproduction and when temperatures change outside a preferred range they can be significantly impacted.

Potential impacts of changing temperatures on water quality and mahinga kai

- Decreases in available oxygen (DO) with increasing temperatures - reduces oxygen available for mahinga kai.
- Increases in fish metabolic rates - sudden changes, like those found at a discharge points, are more likely to cause stress and possibly death.
- Increases in algal abundance and changes in the dominant species present - as the water gets warmer algal growth increases, often resulting in algae blooms.
- Changes in the amount and type of animals present - some animals cannot tolerate extreme changes in temperature and will avoid these areas (habitats) of a waterway if unfavourable.
- Changes in migration patterns - water temperature triggers the time of migration for breeding as mahinga kai travel to and from the sea.
- Changes in water temperature and flow throughout streams or rivers or at localised points can have significant impacts on movement of fish through the water column (deep and shallow).

Dissolved oxygen

Dissolved oxygen (DO) is a relative measure of the amount of oxygen (O_2) dissolved in water.



Oxygen gets into the water by diffusion from the atmosphere, aeration of the water as it tumbles over rocks and waterfalls, and as a product of photosynthesis. The oxygen content of water will decrease when there is an increase in nutrients and organic materials from industrial wastewater, sewage discharges, and runoff from the land. (Intensive land uses such as farming produce more nutrients in runoff than native forest.) Excessive plant and algae growth and decay in response to increasing nutrients in waterways can significantly affect the amount of dissolved oxygen available.

A wastewater indicator such as biochemical oxygen demand (BOD) is a laboratory test that measures the relative oxygen-depletion effect of a waste contaminant when the contaminant reacts (through biochemical reactions) with nutrients and bacteria. The negative effect wastewater has on mahinga kai and aquatic plant life, by reducing the amount of available oxygen, is indicated by an elevated BOD reading.

Potential impacts of low dissolved oxygen (DO) on water quality and mahinga kai

- Increased stress on aquatic life - mahinga kai and invertebrates require adequate oxygen levels, an essential for all aquatic life. Fish 'breathe' oxygen through their gills, and are able to absorb oxygen directly from the water into their bloodstream. A concentration of 5 mg/L DO is recommended for optimum fish health. Sensitivity to low levels of dissolved oxygen is species specific; however, most species of fish are distressed when DO falls between 2 and 4 mg/L. Death usually occurs at concentrations less than 2 mg/L. Larger fish are affected by low DO before smaller fish are. The number of fish that die during an oxygen depletion event is determined by how low the DO gets and how long it stays down.
- Reduced available habitat limiting where species can live and grow, i.e., fish avoid areas with low oxygen.

Instream barriers and altered water flow

Instream barriers and diversions alter the natural flow of rivers, streams, and lakes.

Instream barriers may include culverts, fords, dams, weirs, and pipes that are used in infrastructure such as bridges and road building, town water supply, and for stormwater discharge into waterways. These alter the natural flow of rivers, by taking, diverting, or damming water, which in turn alters the habitat that species rely on to live, migrate, and breed. Altered water flow can also lead to erosion of river banks and disruption of river bed habitats.

A high proportion of New Zealand's indigenous fish fauna are diadromous (18 species of the total 35 indigenous freshwater fish migrate as a part of their natural life cycle) requiring connection between high quality adult habitat and marine or lake environments. Incorrectly installed or maintained instream structures can prevent or restrict upstream and downstream migration of fish as well as modify the natural hydrology of a waterway.

Some species, such as tuna, are able to use the wetted margins of waterfalls, rapids, and spillways to bypass obstacles. Other species rely on short burst of swimming to get past high velocity areas. However, many species are unable to negotiate instream barriers that are not designed for fish passage, e.g., culverts that are perched, undercut, have sustained high velocity water flow, or lack wetted margins.

Potential impacts of instream barriers on water quality and mahinga kai

- Altered fish migration - barriers may prevent native fish that move from sea to freshwater as part of their life cycle (such as īnanga - part of the whitebait catch), from moving upstream and downstream and accessing otherwise suitable habitat.
- Increased velocity - sustained high water velocity prevents some fish access to upstream habitats.
- Modified channel form - erosion from vegetation removal along banks and changes to stream flow after construction of a road crossing or similar barrier can lead to scouring and breakdown of stream and river banks, impacting on mahinga kai habitat.
- Modified flow - flow changes as stream banks are modified and realigned, which can lead to changes in the benthic (bottom) structure of the stream/river bed when coarse substrates such as gravels and boulders are replaced and covered by sand and silt.
- Loss of species habitat - many mahinga kai species need the protection and habitat provided at upstream sites inland from the sea. Barriers that make upstream habitat inaccessible to species that prefer higher elevation can result in loss of breeding and feeding sites.
- Damage to banks and floodplains - varying flows and flash floods threaten the stability of a river bank, increasing its vulnerability at times of flooding and damaging breeding and feeding habitat for mahinga kai.
- Increased water temperature - flow affects temperature. Loss of flow means waterways can fluctuate in temperature and, if unshaded, water can reach high temperatures unsuitable for mahinga kai. Fish generally cannot tolerate temperatures over 25ºC.
- Decreased water clarity - erosion and increased sediment loading into a river due to changes in flow will decrease water clarity and reduce visibility and the ability of fish to find food.
- Increased nutrients - a decrease in flow may increase the concentration of nutrients within a river.

Modified habitat

A habitat is an environment or place where animals normally live.

Mahinga kai are found in streams, lakes, rivers, estuaries and the sea at different stages of their life cycle. Mahinga kai require habitat to live, and their requirements vary depending on the type and life stage of species. Rocky boulders, sand banks, and vegetated margins are all parts of a stream that is important mahinga kai habitat. A waterway with a diverse range of habitats is likely to have a greater number of mahinga kai species present in a range of age groups (i.e., both juveniles and adults).

When we alter the habitat available in a waterway, we can significantly impact the species that live there. The way we use the land around a waterway, or when we discharge wastewater into a waterway - can potentially modify important mahinga kai habitats. Examples of these modifications include altering stream characteristics such as the bottom substrate, the water margins, stream bank, surrounding riparian vegetation, water flow, or by increasing the amount of nutrients and sediments going into a waterway, through inappropriate land use practices.

How mahinga kai respond to these changes depends on the species and how their particular habitat, behaviour (competition and predation), and food supply change. However, simplification of habitat usually results in a decrease in the number of mahinga kai present. One of the most important features we can maintain to ensure mahinga kai habitat is protected and enhanced is the riparian vegetation around the water margins.

Potential impacts of modified habitat on water quality and mahinga kai

- Loss of breeding and feeding habitat.
- Increases in erosion and sedimentation (sands and silts) or excessive scouring, which reduces water quality and visibility.
- Increases in nutrients and contaminants.
- Loss of riparian vegetation for shade and water temperature control, and reduced inputs of wood and leaf litter, which provide cover and food.
- Changes in water flow, currents, and velocity.

Loss of riparian vegetation

Plants and trees along the water margins and banks are called riparian vegetation.

A riparian buffer zone is a vegetated strip of land along the margins of a waterway. Riparian vegetation provides a barrier (buffer) between the water (river, streams, and estuaries) and the land. When surface water (runoff) from the surrounding catchment runs through the riparian zone, contaminants (sediments, nutrients) contained in the runoff are trapped in the roots of any riparian vegetation, allowing the silty or contaminated water to infiltrate the soils.

Healthy native forest riparian vegetation usually consists of a canopy of large trees accompanied by a thick undergrowth of shrubs and grasses. The thick undergrowth acts as a filter for surface runoff, while canopy trees above a stream can intercept airborne material, such as pesticide or fertiliser sprays, and provide shade that maintains stream water temperatures. Large canopy trees also have extensive root structures that stabilise stream banks and intercept nutrients in water flowing underground towards the stream.

Potential impacts of reducing or removing riparian vegetation on water quality and mahinga kai

- Increased bank erosion - the loss of roots decreases the stability of the bank, increasing its vulnerability at times of flooding.
- Increased water temperature - loss of shading from trees or overhanging streamside vegetation means waterways become more exposed and are more liable to fluctuate in temperature. (New Zealand native fish generally cannot tolerate temperatures over 25ºC and trout need temperatures to be less than 19ºC for growth.)
- Decreased dissolved oxygen through increased aquatic plant growth - plants and weeds growing within the waterway are more likely to thrive in unshaded waterways, potentially clogging and stemming flow, which can decrease oxygen levels.
- Modified channel form - erosion through loss of vegetation can lead to scouring and breakdown of stream and river banks, eventually changing the form of the channel.
- Loss of species habitat - many mahinga kai species need the protection and habitat provided by riparian vegetation growing around streams and rivers. (Trees provide wood and roots to the stream that are habitat for fish and kōura, and loss of cover can result in loss of breeding and feeding habitat.)

- Decreased water clarity - erosion and increased sediment from bank erosion may contribute to decreased water clarity and reduced visibility for fish to find food.
  Increased nutrients in streams - riparian vegetation filters contaminants and sediment from the land. (Loss of riparian vegetation may also be associated with changes in land use (e.g., farming, forestry) that increase the amount of contaminants that are present in surface water runoff.)

Chemical contamination

Chemical contaminants are chemicals toxic to plants and animals in waterways.

The phrase 'chemical contamination' is used to indicate situations where chemicals are either present where they shouldn't be, or are at higher concentrations than they would naturally have occurred. Chemical contaminants can be found as organic and inorganic molecules in mass produced products used day to day by almost everybody. These include plastics, resins, pharmaceuticals, disinfectants, deodorants, detergents, petroleum products, road runoff, pesticides and biocides, along with the results of land fill and incineration.

For many of these substances accumulation into aquatic environments can cause environmental problems, although some chemical contaminants do not damage the environment, and for many chemical contaminants the consequences are currently unknown. Chemical contaminants are often transported by water as it flows across the land, roads, and other impermeable surfaces. With little prior treatment, many of these contaminants may eventually discharge into waterways.

Some contaminants can increase bacteria growth and oxygen consumption within a waterway. In extreme cases, such as a large spill of sewage or milk, low oxygen conditions may kill mahinga kai species. Lower levels of nutrient contamination in waterways can result in eutrophication. Most eutrophication is due to the inorganic nutrients nitrate and phosphate that induce the growth of algae. The algae subsequently die, resulting in more organic matter and low oxygen conditions.

There are two types of chemical contaminants:

(1) Organic contaminants

These include oil and petrol spills from roads and concreted areas, hormones, pesticides, herbicides, and fungicides originating from agricultural and horticultural industries that are situated close to waterways. Organic contaminants are not only present as single molecules dissolved in water but can also be found as suspended solids.

(2) Inorganic contaminants

Inorganic contaminants include nitrogen (N), phosphorus (P) and potassium (K). Increases in these simple chemicals in waterways are nearly always as a result of land use activities like fertiliser runoff or direct discharges from industry. Both the concentration of these chemicals and the means by which they enter a waterway vary greatly. The impacts of these simple chemicals are discussed in the nutrients pages. Inorganic contaminants also include metals and metal particles. These can be found in stormwater runoff from urban development and will accumulate in drainage systems or low lying areas of land. Many of these contaminant sources eventually discharge into waterways with little prior treatment to remove chemicals.

Alternatively, industries like forest processing, meat and dairy processing, mining, energy, and wastewater treatment may discharge wastewater that can potentially contain inorganic chemical contaminants (e.g., bleach and curing agents, and certain metals like mercury, copper, chrome, zinc, iron, arsenic, and lead). Prior treatment of these discharges is now strictly regulated and controlled via the resource consenting process, and will vary depending on the type and quantity of material discharged.

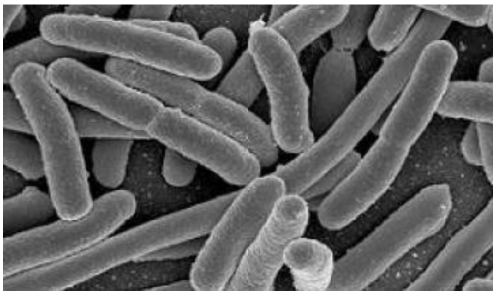
Potential impacts of chemical contaminants on water quality and mahinga kai

- Local loss of fish species - fish may be harmed by contaminated water. Discharges and runoff into rivers and streams can be lethal to aquatic life depending on the strength of the toxin and size of the waterway; contamination can cause fish kills.
- Local loss of invertebrate species - contaminants, such as synthetic pyrethroids (in sheep dip), can be particularly lethal to invertebrates, e.g., kōura. Invertebrates are also food for fish, and persistent discharges that kill invertebrates could cause fish to travel farther in search of food and expose them to greater risks and stress.
- Decreased dissolved oxygen (DO) levels - waste compounds released into waterways initiate biochemical reactions that use up oxygen as the stream bacteria break down the organic matter (Biogeochemical Oxygen Demand, BOD). Excess nutrients can also lead to algal blooms, and oxygen is used up when the algae die and decompose. Fish 'breathe' oxygen through their gills; a decrease in available oxygen (anoxia) in the water column threatens their ability to respire, which may lead to death. Fish that tolerate low levels of dissolved oxygen (such as the introduced fish gambusia) may replace native populations that are less tolerant.
- Increased turbidity and decreased water clarity - water may become cloudy or discolored with chemical contamination which reduces the ability of fish to see prey and detect predators.
- Damage to species - repeated exposure to sub-lethal doses of some contaminants can cause physiological and behavioural changes in fish that have long term effects on the population, such as reduced reproductive success, abandonment of nests and broods, a decreased immunity to disease, tumors and lesions, impairment of the central nervous system, and increased failure to avoid predators.
- Some contaminants, such as mercury, may bioaccumulate in animal tissues and be carried to human consumers of the fish.

Infectious substances

Waterways can easily become contaminated by pathogens when effluent is discharged nearby.

A pathogen or an infectious substance is a biological agent that causes disease or illness to its host. Pathogens are commonly found in farm animal waste and offal, discharges from factories and wastewater treatment systems, and leakages from septic tank systems.



Surface and groundwater can easily become contaminated by pathogens when effluent is discharged to a waterway or is discharged/deposited onto land near waterways. Although treatment of wastewater can take out many of the unwanted pathogens, the type of treatment used needs to be carefully considered. This will minimise any impact on a waterway. Adequate dilution rates should also be considered.

Contamination of freshwater may occur when the faeces of grazing animals are deposited near or in a waterway. This may happen when a cow crosses a stream or when cattle and sheep graze near unfenced waterways in pasture. Pathogens may also be washed into streams and rivers through surface runoff from the land, especially after periods of heavy rain.

A common pathogen found on the farm is the bacterium *Escherichia coli* or *E. coli*, which can be found in the lower intestine of warm-blooded animals. *E. coli* have the ability to survive outside the body of an animal for short periods of time and are therefore a good environmental indicator of faecal contamination in waterways. *E. coli* levels often exceed water quality guidelines in agricultural streams, especially when cows are crossing or entering the water or where there are discharges from meat and dairy processing plants. Maximum thresholds ensure point source discharges from wastewater treatment and oxidation ponds do not exceed these standards. Adequate mixing (dilution) of the discharge with water can reduce the effects. However, the amount that can be safely discharged depends on the size of the stream or river.
Pathogens that are potentially waterborne include zoonotic diseases (diseases that are transmitted between humans and animals and vice versa). These are of increasing concern because they make up more than three-quarters of the total notified illnesses. Of these, campylobacteriosis, salmonellosis, cryptosporidiosis, and giardiasis are of particular importance as they dominate the rates of reported diseases in Aotearoa. It is important to realise that zoonoses may be contracted from both ill and apparently healthy animals.

Potential impacts of infectious substances on water quality and mahinga kai

- Decreased water quality.
- Contaminated water and mahinga kai, especially shellfish, downstream of the discharge (source) that makes it unsuitable for harvesting (fishing or food gathering).
- Water becomes unsuitable for swimming or recreational use.
  Greater probability of disease-related impacts on fish populations.

https://www.niwa.co.nz/our-science/freshwater/tools/kaitiaki_tools/impacts