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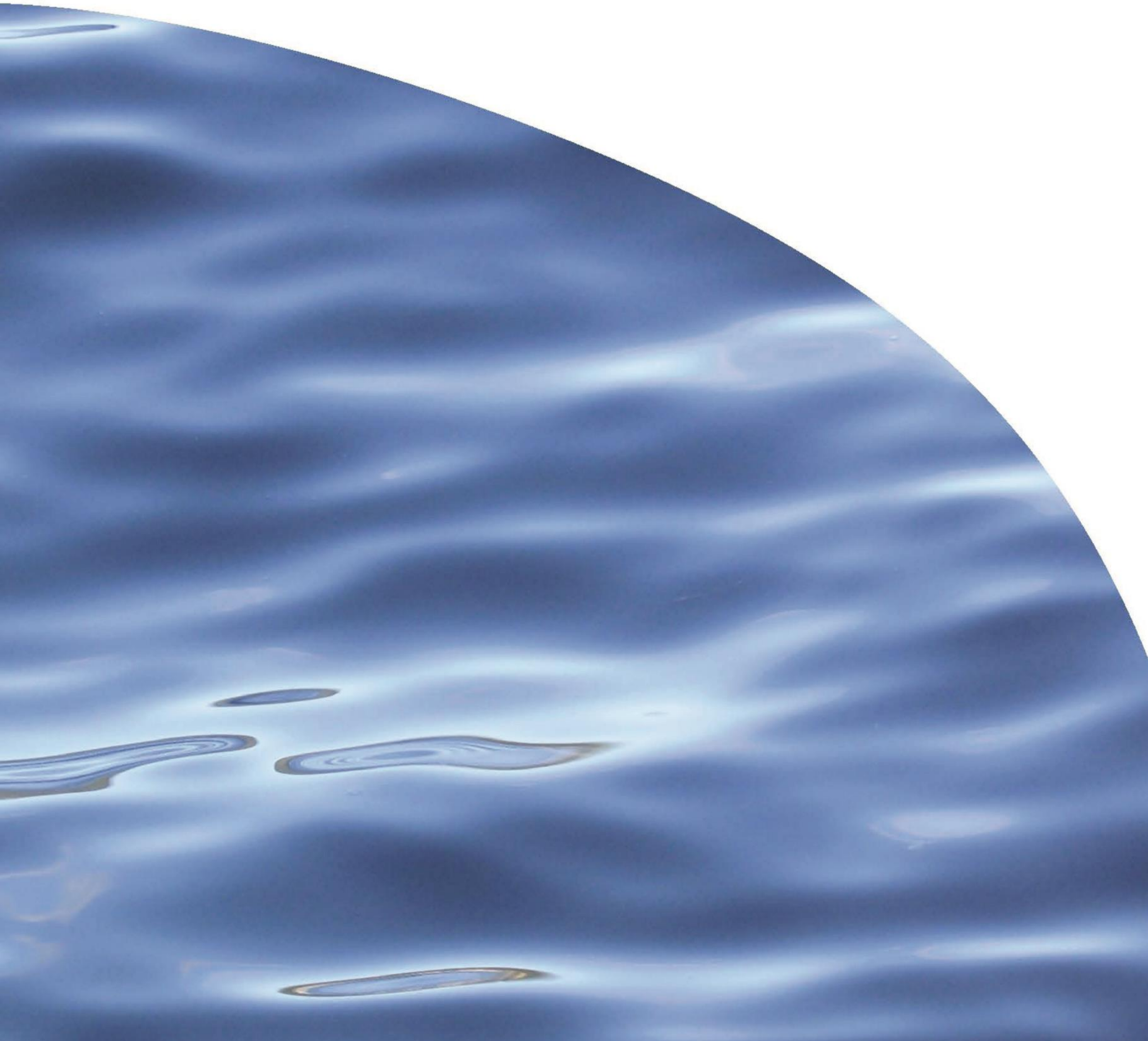
IMPACTS OF VEHICLE ACCESS AT DELAWARE (WAKAPUAKA) INLET



IMPACTS OF VEHICLE ACCESS AT DELAWARE (WAKAPUAKA) INLET

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EXECUTIVE SUMMARY

In 1999 the opening of Maori Pa Road extended public vehicle access to the eastern side of Delaware Inlet (north of Nelson), which is the estuary of the Wakapuaka River. Since then an increasing number of vehicles have been using an informal boat launching site located on the south-eastern margin near the end of the public section of Maori Pa Road. Launching boats from this site involves vehicles driving across the tidal flats at low- and mid-tide levels. This has caused offence to the local hapū and Māori owners of the adjacent Wakapuaka 1B block. Nelson City Council commissioned Cawthron Institute to assess the ecological impact of vehicle traffic on the estuary and the nature and extent of boat usage, views of local residents and local hapū. The pros and cons of different options are then presented.

In 1998, the Māori Land Court recognised Te Huria Matenga Wakapuaka Trust as having freehold title to the Wakapuaka estuary in Delaware Bay. The Crown challenged the decision and in 2011 the Supreme Court subsequently dismissed the Trust's bid for freehold title. The debate contributed to the introduction of the Foreshore and Seabed Act in 2004, whereby the Crown vested ownership of the foreshore and seabed in the public domain.

Intertidal habitats associated with estuaries provide a link between terrestrial and marine environments. Delaware Inlet is recognised as being ecologically significant within the Nelson Biodiversity Strategy. It retains areas of intact vegetation sequences from coastal forest through to salt meadows, salt marsh and intertidal flats containing seagrass (rimurēhia, eelgrass) beds. The tidal flats contain invertebrate communities including shellfish beds. The inlet is also an important breeding, feeding and nursery area for a variety of fish and bird species and was listed as a site of national importance primarily as habitat for banded rail and banded dotterel. In a wider context, the productive habitats of Delaware Inlet contribute to the food web of Tasman Bay.

Physical disturbance of estuaries by vehicles can damage benthic habitats, including the plants and animals inhabiting them. In New Zealand, the area of seagrass beds has declined substantially for various reasons and damage caused by off-road vehicles can be a contributing factor in localised areas.

Assessment of ecological impacts

Cawthron assessed ecological impact of vehicle traffic on Delaware Inlet in two ways. First, we used aerial photography to assess changes in dominant habitat types relative to previous surveys and to identify any visible vehicle tracks. Second, using a fine-scale survey we looked for differences in sediment composition and benthic plants and animals (living both on and within the sediment) between areas with high and low vehicle usage.

Vehicle usage zones within the study area covered a relatively small amount (2%) of Delaware Inlet, yet accounted for around 16% of total seagrass beds within the estuary. Visible vehicle tracks showed direct physical damage to seagrass and other habitats in areas

subject to both higher and lower amounts of vehicle usage. Nearly complete loss of seagrass patches higher up the shore suggested a possible impact of vehicles, although this could not be confirmed due to differences in mapping methodologies from study to study and the possibility of changes due to natural fluctuation or other human stressors not related to vehicle impacts. Likewise, there was some evidence to suggest an historical (pre-1988) impact of vehicle usage on seagrass distribution, although the effects of this could not be separated from the influence of the type and distribution of sediments.

From the fine-scale survey, there were several apparent ecological impacts of higher vehicle usage in the midshore area, including sediment compaction, differences in infaunal community composition, lower infaunal abundance and reduced cockle numbers. The number of epifauna taxa was also lower within the higher vehicle usage zone in the low shore, although it was not possible to separate the effects of this from the influence of different sediment types.

In summary, there is good evidence of direct disturbance of seagrass from visible vehicle tracks and some evidence, albeit inconclusive, that vehicle traffic has caused a reduction in the extent of seagrass beds over time. Similarly, we consider that higher vehicle usage is likely causing some impacts in the midshore on sediment structure and the associated benthic animal community, including cockles.

Boat user counts and survey

We conducted site observations and a brief survey of boat users at Delaware Inlet and Cable Bay. Time lapse photography was used to count boat users at both sites.

Delaware Inlet was the more popular boat launching site, with an average of 68 boat launchings or retrievals per week, compared to 27 at Cable Bay. The highest weekly usage was 107 launchings or retrievals at Delaware Inlet during the week of 27 January 2017, with 49 at Cable Bay the same week. The highest vehicle count on a single day occurred on Saturday 25 February, with 33 vehicles at Delaware Inlet and 11 at Cable Bay. Numbers of vehicles dropped in early March.

Of the 62 people surveyed at Delaware Inlet, the most popular reasons for launching at that location were the proximity to good fishing grounds, safety, and qualities of the location such as quietness, wildness and beauty. Other reasons were the closeness to home, ease of access, suitability for small boats, suitability for children and families, fuel efficiency and no boat launching charge. Several respondents recounted incidents when they got into trouble while attempting to launch or retrieve boats at Cable Bay. Boats and vehicles needing to be towed at Cable Bay also create safety issues for others on the beach.

We asked 42 boat users about local ecology. Of these, 24% (n = 10) expressed some knowledge about the ecology of the estuary. Seven people said that they stayed on the main vehicle tracks on the estuary, avoided areas where seagrass is present, or only launched and retrieved their boats at high tide (to avoid driving over the estuary).

Views of local residents and iwi

Ten local residents were interviewed for their views on vehicle usage and boat launching at Delaware Inlet and Cable Bay. Many residents were attracted to the area for its natural beauty and recreational opportunities. Many of the interviewees (averaging 30 years residence) noted a substantial increase in vehicle numbers at Delaware Inlet since 1999 when Maori Pa Road became open to the public. Cable Bay had also increased in popularity in recent years. No residents were in favour of building a concrete ramp for boat launching at Cable Bay, citing factors that make this a challenging and sometimes dangerous place to launch a boat.

The majority of local residents interviewed supported the following: a marked route across the estuary to contain vehicles launching boats at low and mid-tides to a singular path, better signage with information and maps, and restrictions on boat size and a speed limit for motor boats. One couple opposed all vehicle and horse riding access at Delaware Inlet. Many residents mentioned the nuisance of ‘joyriders’ at Delaware Inlet who drive away from the main paths taken by vehicles launching boats, thereby extending areas of impact and sometimes getting their vehicles stuck. Harsher penalties were suggested by some local residents for those who deliberately deviate from a marked route, although others also noted the difficulty of enforcing regulations given the relative isolation of Delaware Inlet and Cable Bay.

A trustee of Ngāti Tama ki Te Waipounamu Trust and Te Huria Matenga Wakapuaka Trust was interviewed to gain the perspectives of the local hapū who are mana whenua of Wakapuaka. Unimpeded public access does not respect the concerns or mana of Ngāti Tama ki Te Waipounamu. Those concerns include the impacts of vehicles on the estuarine habitat and species, as well as increased access to other parts of Delaware Inlet, causing erosion of sand dunes on Delaware spit and disturbing wāhi tapu (sacred sites) such as urupa, where some interference with koiwi (bones) has occurred.

The Huria Matenga Trust remains opposed to all vehicle access on the tidal flats at Delaware. The Trust prefers that the recognised boat launching site at Cable Bay be improved. They consider that a marked route across the estuary for vehicles launching boats at Delaware Inlet would be ineffective at protecting the estuary. Instead, they suggested a single wooden ramp to protect the ecology of the estuary by ensuring that vehicles did not directly drive across and therefore impact the shellfish beds and eelgrass. Citing examples such as boat ramps at Kaiteriteri and Port Nelson, it was suggested that the cost of such a ramp could be met through user charges.

The table below summarises a preliminary assessment of options. A more complete assessment would require further consideration and consultation with affected parties.

Preliminary assessment of options for boat access at Delaware Inlet and Cable Bay:

Option	Pros	Cons
Status quo	Low financial cost (at least in short term).	Damage to estuary and associated cultural values continues. Rules in NCC coastal plan not being enforced.
No vehicle access to estuary at Delaware Inlet	No more damage to estuary (assuming rules can be enforced). Potential for seagrass rehabilitation.	Enforcement could be difficult and/or expensive. Safety issues for boat users. Renewed animosity between residents, iwi and boat users.
Marked route(s) at Delaware Inlet to limited number of launching points	Reduced damage to estuary. Potential for seagrass rehabilitation outside marked route(s).	Not all vehicles will stay on route. Some ongoing impacts to estuary. Some maintenance required of route markings.
Long wooden ramp at Delaware Inlet	Minimises on-going damage.	Cost. Structure would have visual effects, some shading effects and changes to currents. Possible damage to estuary during construction phase. On-going maintenance required.
Improve facilities at Delaware Inlet; booking system for parking	Improves experience for users.	Cost. Likely to lead to increased use and therefore more damage to estuary.
Improved signage about values of Delaware Inlet	Greater environmental awareness by boat users. With other measures, could help to reduce impact on estuary.	Unlikely to deter ‘joyriders’ and some boat users from inappropriate behaviour. Damage to estuary and associated values continues.
Restrictions on users of Delaware Inlet e.g. boat/trailer size limits; no jet skis	Reduced ecological and other impacts (depending on restrictions).	May be difficult to enforce.
Install concrete ramp and improve other facilities at Cable Bay	Safer and better experience for users. Some users diverted from Delaware Inlet so reduced impact to estuary.	Increased congestion at Cable Bay, conflict with beach users. Construction cost, with on-going maintenance. Cable Bay still not safe in some conditions.
Regular monitoring of Delaware Inlet	Provides basis for periodic review of approach.	Cost. May not provide definitive conclusions.

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1. INTRODUCTION

An increasing number of vehicles are using an informal boat launching site at Delaware Inlet that involves vehicles driving across exposed tidal flats (Figure 1). This has caused offence to the local hapū and Māori owners of the adjacent Wakapuaka 1B block who, among other things, are concerned about the damage caused by vehicles to the ecology of the estuary. The Nelson City Council (NCC) is reviewing its coastal plan and would like to include new provisions governing access to the estuary that address and, as far as feasible, reconcile the interests and concerns of local Māori, residents and boat users. The Council commissioned Cawthron Institute (Cawthron) to assess the nature and extent of boat usage, views of boat users, local residents and Māori, and the ecological impact of vehicle traffic on the estuary.

The report aims to:

- Assess the impact of vehicles on the ecology of the estuary, especially on seagrass and animals living in the sediments
- Gain an accurate account of vehicle numbers launching or retrieving boats at Delaware Inlet and Cable Bay
- Gather the perspectives of boat users at Delaware Inlet and Cable Bay
- Interview local residents and local hapū for their views on vehicle access at Delaware Inlet
- Provide a preliminary assessment of options for boat access at Delaware Inlet and Cable Bay.

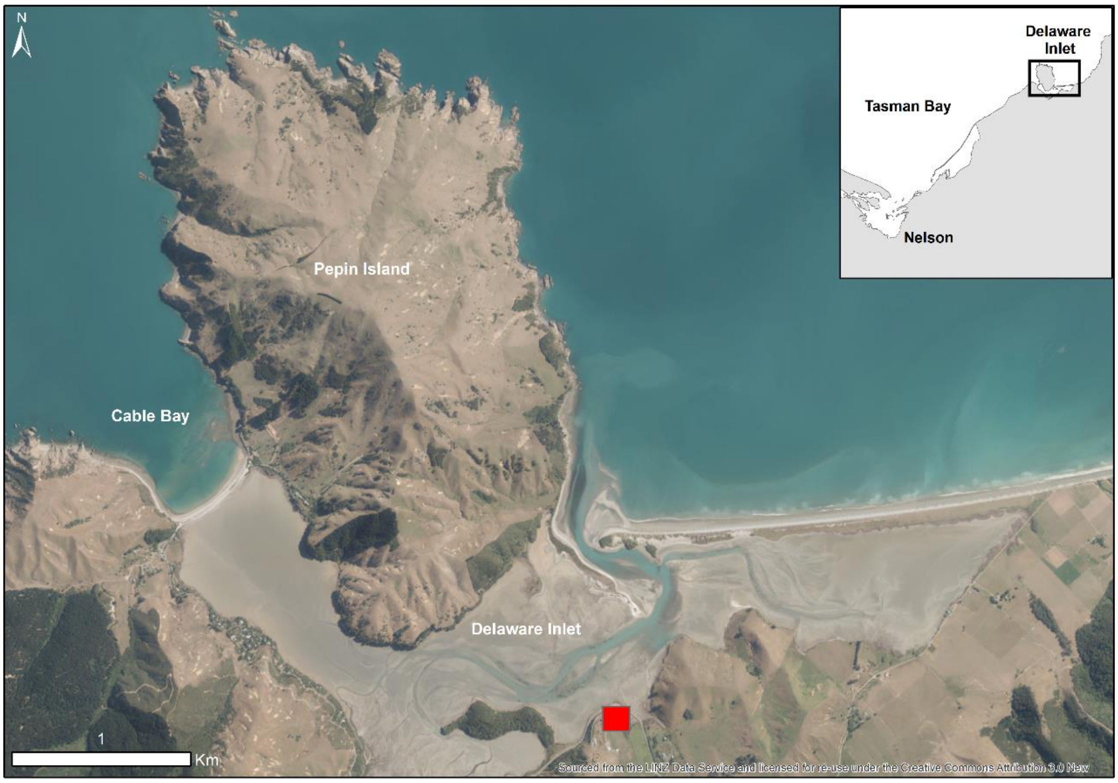

Figure 1. Delaware Inlet (pictured at low tide) and Cable Bay. Inset shows location relative to Nelson and Tasman Bay. The red area shows where vehicles can access the estuary.

1.1. Ecological significance of Delaware Inlet

Delaware Inlet is an estuary situated on the eastern side of Tasman Bay at the mouth of the Wakapuaka River and approximately 19 km northeast of the city of Nelson. It is separated from adjacent Cable Bay only by a narrow tombolo, which connects Pepin Island to the mainland. The inlet opens to Delaware Bay through a narrow channel and is classified as a permanently open tidal lagoon (Hume et al. 2016). It is approximately 353 hectares in size and mostly consists of estuarine tidal flats that are exposed at low tide (Figure 1).

Estuaries are dominated by intertidal habitats, which provide a link between terrestrial and marine environments. They perform important ecosystem functions, including primary and secondary production[1], nutrient retention/processing and sediment trapping. These roles contribute to the capacity of estuaries to function as a land/sea buffer that is critical to the sustainability of coastal ecosystems. Estuarine habitats are often of high ecological value and contain resources of significant cultural, recreational and commercial benefit.

[1] Primary productivity is the synthesis of new organic material from inorganic molecules e.g, photosynthesis. Secondary production is the generation of biomass of consumers, representing the quantity of new tissue created through the use of assimilated food.

Estuaries play an important role in the community for a diverse range of reasons. They are valued by Māori for the rich resources they provide in the form of timber for building materials, rongoa (medicine), harakeke (flax) for weaving, and many sources of kai (food).[2] Māori often established settlements near estuaries, and they were also a preferred site for European settlement—typically after clearing the 'swampy, forested, impenetrable edge of the land' (Park 1995, p. 236). Today estuaries are valued for various recreational opportunities and appreciated for their ecological values and the aesthetic enjoyment they bring to many.

Specifically, Delaware Inlet is ecologically important and recognised as being significant within the Nelson Biodiversity Strategy (Lawless & Holman 2006). It retains areas of intact vegetation sequences from coastal forest through to salt meadows, salt marsh and intertidal flats containing seagrass (rimurēhia, eelgrass) beds. The tidal flats contain invertebrate communities including shellfish beds (Gillespie et al. 2011b). Delaware Inlet is also an important breeding, feeding and nursery area for a variety of fish and bird species and is a site of national importance, primarily as habitat for banded rails (*Gallirallus philippensis assimilis*) and banded dotterels (*Charadrius bicinctus bicinctus*) (Davidson et al. 1994). Variable oystercatchers (*Haematopus unicolor*) have been reported breeding along its coastal margins (Boffa Miskell 2015).

In a wider context, the productive habitats of Delaware Inlet contribute to the food web of Tasman Bay by absorbing, processing and exporting terrestrial and marine nutrients (Gillespie 2008). The stretch of coastline potentially influenced by estuary outwelling is recognised to have special importance with regard to the Horoirangi Marine Reserve to the west and the Taiāpure Management Area and recreational fishing grounds in Delaware Bay.

1.2. Brief history of Ngāti Tama at Delaware Bay

Ngāti Tama hapū are mana whenua of Wakapuaka (Delaware Bay), and are part of Ngāti Tama ki Te Waipounamu who whakapapa to northern tribes from the Taranaki region through the common ancestor, Tama Ariki, the tupuna who was a tohunga and navigator on the Tokomaru waka. Ngāti Tama descend from Paremata—the stepson and nephew of Te Pūoho ki te Rangi who, in 1828/29, led a taua of approximately fourteen waka into Wakapuaka (*Interview* 8 March 2017). Ngāti Tama gained land in Te Tau Ihu (the top of the South Island) as a result of conquest, maintained by settlement and through occupation and use of '…lands, forests, waterways, foreshores, sea and other resources' (Walters Williams & Co 2003, p.8).

[2] https://www.niwa.co.nz/education-and-training/schools/students/estuaries

Starting in the 1830s, European settlement and Crown interventions affected Ngāti Tama occupation and use of their lands. In their Treaty of Waitangi claim (Wai 723), Ngāti Tama outlined grievances resulting from Crown breaches of the Treaty of Waitangi 1840, including: surveys by the New Zealand Company in the late 1830s, the Wairau Incident in June 1843, the Spain Commission from 1844–1845, and surveys of Ngāti Tama boundaries in 1845 and 1847. These interventions resulted in land loss that had a detrimental impact on Ngāti Tama's economic and social stability:

> The Crown's failure to properly monitor the [New Zealand] Company's surveys of the boundary between the Company lands and Wakapuaka lands provoked the skirmishes which arose in 1845 and 1847, and the consequent losses of land suffered by Ngati Tama (Walters Williams & Co 2003, p.14).

In 1998, the Māori Land Court recognised Te Huria Matenga Wakapuaka Trust as having freehold title to the Wakapuaka estuary at Delaware Bay; however, '…the Registrar-General of Lands in 1999 refused to register the court's orders' (Ansley 2003). The Crown took the Māori Land Court decision to the Court of Appeal that overturned the ruling, and in 2011 the Supreme Court subsequently dismissed the Trust's bid to reverse that decision (NZPA 2011). The Trust's claim to title of the Delaware Inlet sparked national debate, which contributed to the introduction of the Foreshore and Seabed Act in 2004, whereby the Crown vested ownership of the foreshore and seabed to the public domain.

1.3. History of vehicle access to Delaware Bay

During our work for this report, we heard anecdotal accounts of boat users driving on the estuary to launch boats at Delaware Inlet since at least the 1970s. Prior to 1999, Maori Pa Road was private and vehicle access to Wakapuaka east of the Wakapuaka River was restricted by a locked gate. Fishers who wished to launch boats required approval from the local property owners (Nelson City Council 2004, p. 1).[3]

In 1997, a subdivision in the area was approved by NCC, and by July 1999 the bridge over the Wakapuaka River had been improved to Council requirements. Following that, Maori Pa Road was redesignated a public road; the private road continues just beyond where vehicles are currently gaining access onto the estuary.

[3] In the Court of Appeal case (2008) Judge Isaac summarised evidence provided by Jack Harvey (b.1928): "…iron gates were erected and kept locked 'even after the Matenga Estate sold the property. If you wanted to go fishing …you had to get permission from Mrs Martin (Huria Matenga [Trust]) … That was for fishing in the inlet and out in the Bay too … In my Dad's time, he and his brothers used to do a lot of fishing down there and they always went and got permission…'" The Trustee of Te Huria Matenga Whakapuaka Trust interviewed for this study confirmed: "There was only a handful of vehicles that utilised the estuary for the purpose of launching boats prior to the public road" (pers. comm. 10 May 2017).

The accessibility of Maori Pa Road to the public from 1999 enabled more recreational fishers to use the informal boat launching site. Boat users gain entry to the channel at low- and mid-tide by driving over the tidal flats at Delaware Inlet. Ecological damage to the estuary has long been a concern to local hapū, and Te Huria Matenga Wakapuaka Trust requested NCC take action to prevent further damage by vehicles.

In 1999, the Council installed a padlocked chain barrier (authorised vehicles could still gain access subject to approval by the Trust), and in 2001 this was replaced with a gate that was then padlocked in 2003. The gate was vandalised by unknown parties and subsequently removed by the Council. There is currently no physical restriction to vehicles driving onto the tidal flats at Delaware Inlet; this remains an unresolved and hence contentious issue.

According to chapter 13 of the Nelson Resource Management Plan, driving of vehicles on, and disturbance of the foreshore or seabed by vehicles, is permitted only in specific circumstances, e.g. the launching or retrieving of recreational or commercial vessels at launching ramps, which are mapped in the plan. The Cable Bay launching point is mapped in the plan, whereas the access point to Delaware Inlet at Māori Pa Road is not. In practice, councils exercise discretion regarding enforcement of conditions on permitted activity rules.

2. LITERATURE REVIEW OF VEHICLE IMPACTS ON ESTUARIES

Estuaries are subject to a range of anthropogenic stressors that can compromise their health (Ellis et al. 2015). Physical disturbance of intertidal areas caused by vehicle traffic can damage benthic habitats, including the plants and animals inhabiting them. While a comprehensive literature review was outside the scope of this study, we briefly summarise the literature regarding the effects of vehicles driving over tidal flats. Due to limited research on vehicle impacts within estuaries, the review was supplemented with information based on sandy beaches as well as similar human activities, e.g. human trampling, horse riding, boating activities and scientific experiments. Salt marsh habitats were not included in this review because there are no such habitats in the study area affected by vehicles.

2.1. Impacts on seagrass

Seagrasses are flowering marine plants that inhabit both intertidal and subtidal coastal zones. *Zostera muelleri* (eelgrass) is indigenous and the only species of seagrass present in New Zealand. Seagrass meadows are an important natural attribute of many New Zealand estuaries and have high ecological value (Matheson et al. 2009; van Houte-Howes et al. 2004). Although their photosynthetic contribution can be relatively modest by global standards (McRoy & McMillan 1977; Gillespie & MacKenzie 1981), they provide a stable physical habitat and a localised food source to support a diverse community of animals including a variety of fish species (e.g. snapper, garfish, trevally) (Matheson et al. 2009). Seagrass beds are important foraging areas for certain shorebirds (e.g. variable oystercatcher). They also help filter nutrients and trap sediments, thereby maintaining water quality (Turner & Schwarz 2006), and they release oxygen from their leaves and roots, which is beneficial for other biota and stimulates nutrient cycling (Matheson et al. 2009).

Seagrass meadows are disappearing at a rapid rate worldwide (McCloskey & Unsworth 2015). In New Zealand, seagrasses have also experienced serious decline (Matheson et al. 2009) and examples of relatively recent declines include losses of up to 90% of subtidal seagrass beds in Tauranga Harbour (Turner & Schwarz 2006) and 58% in intertidal seagrass beds in Nelson Haven (Gillespie et al. 2011a). New Zealand seagrasses face a variety of pressures and are particularly vulnerable to anthropogenic disturbance associated with catchment land use activities, e.g. sediment and nutrient runoff, and coastal development (Turner & Schwarz 2006). Physical disturbance, including damage from off-road vehicles, is an example of a threat that can damage seagrasses in localised areas (Turner & Schwarz 2006; McCrone 2001).

Overseas, physical disturbance of seagrass has led to fragmentation, a reduction in shoot density, canopy height and coverage, and potential permanent loss of habitat (e.g. McCloskey & Unsworth 2015). In New Zealand, a study in Otago Harbour found that off-road vehicles, as well as human trampling and horse riding, had caused physical disturbance to estuarine habitats. Four-wheeled motorbikes and horse riding dislodged seagrass rhizomes and roots leading to the formation of large bare patches, while heavy trampling resulted in the decline of above-ground biomass of seagrass and the beginning of trench formation (Miller 1998; McCrone 2001).

Within the Nelson/Marlborough region, vehicle traffic in the Ngakuta estuary and Delaware Inlet has resulted in visible track marks within seagrass meadows (Gillespie et al. 2011b, Gillespie et al. 2012b). Although localised, it was noted that damaged seagrass could take several seasons to regenerate, with any repeated disturbances potentially resulting in long-term damage or mortality. Experimental seagrass patch disturbance on intertidal reef platforms in Kaikoura resulted in increased erosion followed by decreased growth rates and, in many small patches, mortality (Ramage & Schiel 1999). Seagrass damage and decline overseas has in some instances been attributed to boating-specific activities such as moving propellers, dragging boat hulls across the ground and anchor damage (e.g. Bell et al. 2002; Martin et al. 2008; McCloskey & Unsworth 2015).

Physical disturbance can also indirectly cause harm to seagrass populations by making them more susceptible to diseases such as *Labyrinthula*, a wasting disease that has caused a decline in the health of seagrasses both overseas and in New Zealand (Turner & Schwarz 2006).

Efforts to facilitate the restoration of declining seagrass meadows at previously productive sites have generally met with limited success worldwide (Campbell 2002; Orth et al. 2006; van Katwijk et al. 2016). However, Matheson et al. (2017) reported survival and growth of transplanted *Zostera muelleri* and successful rehabilitation of declining seagrass meadows in Whangarei Harbour. Their work suggests the potential for restoring *Z. muelleri* meadows by transplanting from donor sites to sites formerly occupied. Re-instatement of suitable growing conditions at former sites was thought to be critical for transplantation success and donor sites recovered within nine months. These findings suggest that, in conjunction with proactive management of vehicle disturbance, there may be potential for promoting recovery of seagrass meadows that have been previously displaced.

2.2. Impacts on organisms inhabiting the sediments

Benthic invertebrate populations living in tidal flats, including those occupied by seagrass, can comprise a wide range of epifaunal[4] and infaunal[5] species. Changes in these communities can have negative consequences for the delivery of ecosystem services such as the provision of food for higher trophic levels. Benthic invertebrates are vulnerable to physical disturbance caused by vehicles. In Cape Cod (USA), tidal flat areas driven over by off-road vehicles were considered severely impacted, with effects including reduced survival of marine infauna such as worms, amphipods, clams and other molluscs (Leatherman & Godfrey 1979). This potentially limited the ability of shorebirds and fish to feed in these areas and decreased the amount of organic material supplied to the food web as detritus. Off-road vehicles also modified the environment by compacting the substrate to a pavement-like surface, interfering with normal exchange of seawater within the sediments and creating anaerobic conditions in the substrate. This prevented clams from extending their siphons to the surface to obtain food and water at high tide, which eventually results in death of filter-feeding organisms.

Besides modifying population dynamics and distributions of mudflat animals, compaction of the sediment can also alter the exchange of nutrients and oxygen between the sediment and the overlying water, and change the sediment accumulation rate (Contessa & Bird 2004; Rossi et al. 2007). Fifty passes by vehicles per day over 20 days on the Cape Cod tidal flats resulted in severe degradation, with recovery predicted to occur only after complete vehicle exclusion (Leatherman & Godfrey 1979).

Most research regarding vehicle impacts on intertidal benthic invertebrates has been conducted on exposed sandy beaches. An Australian study found that even low-level vehicle traffic could negatively impact the beach environment, with compaction, rutting and displacement of the sand matrix observed over a large area (Davies et al. 2016). This resulted in significant decreases in diversity and density of invertebrate species, and measurable shifts in community structure. Other overseas studies on sandy beaches have shown that vehicle impacts can cause mortality of surf clams, as well as sub-lethal effects such as impairment of burrowing performance and a reduction in body mass (e.g. Schlacher et al. 2008; Sheppard et al. 2009).

In New Zealand, vehicle damage was considered a cause of reduced adult toheroa (*Paphies ventricosa*) abundance along a considerable portion of the Oreti Beach in Southland (Moller et al. 2014). Around 4% of juvenile toheroa were found to be damaged (and presumed killed) each time they were driven over by a car or motorbike, and 2% killed per pass by utilities and four-wheel drive vehicles. Vehicle traffic also caused substantial mortality to toheroa on Ninety Mile Beach (Northland)

[4] Small invertebrates living on top of benthic (seafloor) habitats.
[5] Small invertebrates living within the sediment.

with mortalities (crushed shells) of up to 14% in small toheroa following heavy vehicle traffic associated with a recreational fishing contest (Hooker & Redfearn 1998; Morrison & Parkinson 2001).

Benthic invertebrates living within seagrass beds can also be affected by physical disturbance, either directly or indirectly as a response to damaged seagrass habitat. In overseas studies, it has been reported that intense human trampling in seagrass beds has reduced seagrass biomass as well as abundances of some invertebrate taxa (e.g. Eckrich & Holmquist 2000), and reduction in seagrass cover resulted in changing community composition and reduced species richness (McCloskey & Unsworth 2015).

2.3. Impacts on other animals

Vehicle impacts can extend to non-benthic animals, such as birds, although a review of this is not provided here. Impacts on birds can be direct, e.g. damage to nests and disruption of foraging, as well as indirect, e.g. reduction in a food source or quality of important habitats. In the Nelson region, vehicle traffic has been identified as having potentially adverse impacts on shorebirds (Schuckard & Melville 2013).

3. METHODS

3.1. Study area

The study area for the ecological assessment was located on the eastern side of Delaware Inlet and adjacent to a car pull-off area on Maori Pa Road from which vehicles drive onto the tidal flats (Figure 2). This area was chosen to encompass the intertidal habitat being driven over by vehicles, largely for the purpose of launching and retrieving boats. Immediate surrounding areas subject to low (or possibly no) vehicle usage were also included for the purpose of providing survey comparisons.

The boat users' survey and fixed camera-based vehicle count focused on the study area for Delaware Inlet as well as the northern end of the tombolo at Cable Bay, both marked in red in Figure 2. Local residents of Maori Pa Road and Cable Bay were included in the study interviews.

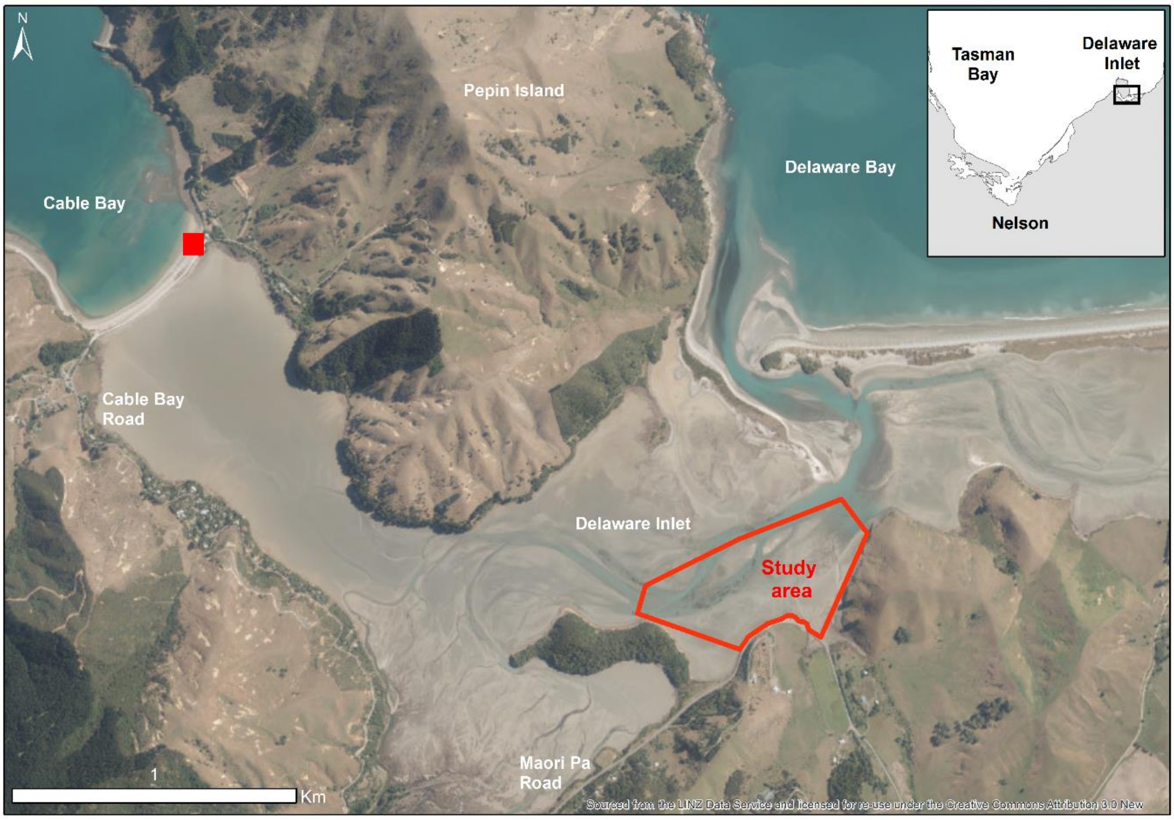

Figure 2. Delaware Inlet in relation to Tasman Bay, showing the ecological study area and Cable Bay boat launching location (marked with red square).

3.2. Habitat mapping

Field-verified habitat mapping of the intertidal environment was based on standardised methodologies outlined in the Estuarine Monitoring Protocol (EMP) (Robertson et al. 2002). These methods were modified slightly to provide more accurate measures (i.e. quantitative assessment of percentage cover categories) of vegetation to better suit the purposes of the current work.

3.2.1. Aerial photographs

High resolution aerial photographs of the study area in Delaware Inlet were collected from an altitude of 60 m by a Phantom 4 Pro drone at low tide on 28 January 2017. The photos were aligned to produce an orthophoto[6] that comprised 53659 x 46894 pixels with a pixel distance of 17 mm.

3.2.2. Ground-truthing and map digitisation

A field team of Cawthron scientists ground-truthed[7] the aerial orthophoto by identifying and delineating dominant habitats at low tide on 2 February 2017 (Figure 3). They recorded boundaries between areas of dominant substrata or biota using GPS tracking and sketched these directly onto a laminated orthophoto. They classified these areas by describing the dominant substrate types and the presence and density of vegetation. The classification system was based on an interpretation of the Atkinson (1985) system and the estuarine national classification system developed by Ward and Lambie (1999). Habitat types were coded according to EMP protocols and, where applicable, habitat names were aligned with previous mapping efforts that also followed EMP protocols within Delaware Inlet (e.g. Gillespie et al. 2011b). Substrate classification was based on surface layers only and did not consider underlying substrate (e.g. gravel fields covered by sand would be classed as sand). To reduce subjectivity, soft sediment substrates were categorised as either soft (grouping together 'soft' and 'very soft') or firm.

[6] An orthophoto is an aerial photograph geometrically corrected ('orthorectified') such that the scale is uniform i.e. the photo has the same lack of distortion as a map.

[7] Ground-truthing involves verifying features identified from an aerial photo (or potentially from a model) by physically inspecting a sample of these features on the ground and, where errors are found, correcting the identification.

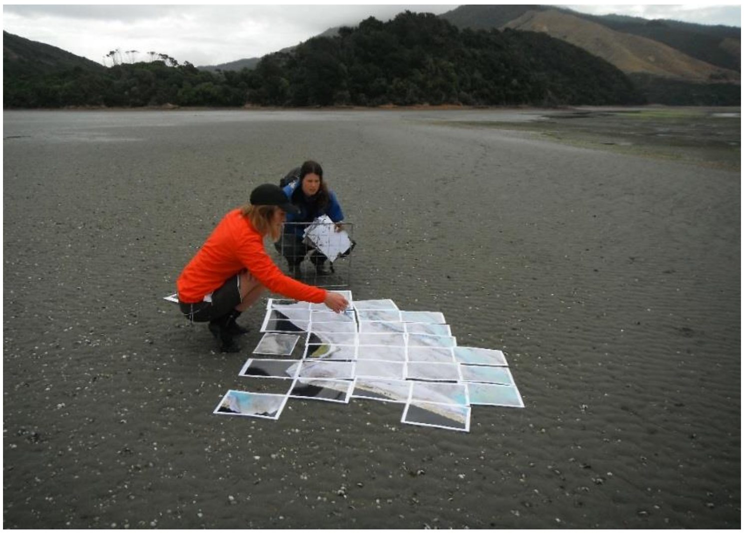

Figure 3. Cawthron scientists conducting ground-truthing for habitat mapping in the Delaware Inlet.

To standardise percentage cover estimates of vegetation, field team members took photoquadrats of seagrass and macroalgae randomly throughout the study area using a quadrat (of size 0.25 m^2) divided into 36 equally sized squares. They determined percentage cover by counting the number of gridline intersections (49 in total) that overlapped vegetation and converted the result to a percentage as in Robertson et al. (2002). The results were then classified into four categories of cover: < 20%, 20%–50%, 50%–90% and > 90%.

The field team conducted ground-truthing for the majority of the study site (red area in Figure 2), but restricted this to habitats exposed by the low tide on the boat launching (south-eastern) side of the main channel. A Cawthron scientist used GIS software (ArcMap 10.4) to digitise habitat features with reference to the ground-truthing exercise explained above.

Vehicle usage

Where possible, vehicle tracks noted in the orthophoto were verified by the field team during ground-truthing. The longevity of visible vehicle tracks within the study area was unknown and likely dependent on substrate type and the amount of interstitial water present. Therefore, in order to determine the boundaries of zones subject to differing amounts of vehicle usage, the abundance of vehicle tracks, a photographic time series from a fixed camera, and field observations of boats being launched were all used in our calculations. We digitised the vehicle tracks and created polygons to represent five vehicle usage zones, for use in planning the positioning of fine-scale survey sites (Figure 4). Vehicle usage intensity zones (considered for the intertidal region only) were categorised using an inverse scale, with Zone 1 having the highest vehicle usage and Zone 5 the lowest (Figure 4). The zones represent usage intensity at the time of the 2017 survey (6 January to 9 March); it is possible that usage intensity was distributed differently in previous years.

3.2.3. Comparisons of key habitats

We made comparisons of the area cover of key habitats within the vehicle usage zones between regions subject to differing vehicle usage intensities during the current study, as well as against historical habitat maps by Franko (1988) and Gillespie et al. (2011b). The lack of pre-vehicle usage baseline data, or a suitable control area within the current study, generally limited the interpretation of vehicle impacts in this report to the effects of higher versus lower vehicle usage rather than a comparison with no vehicle usage at all.

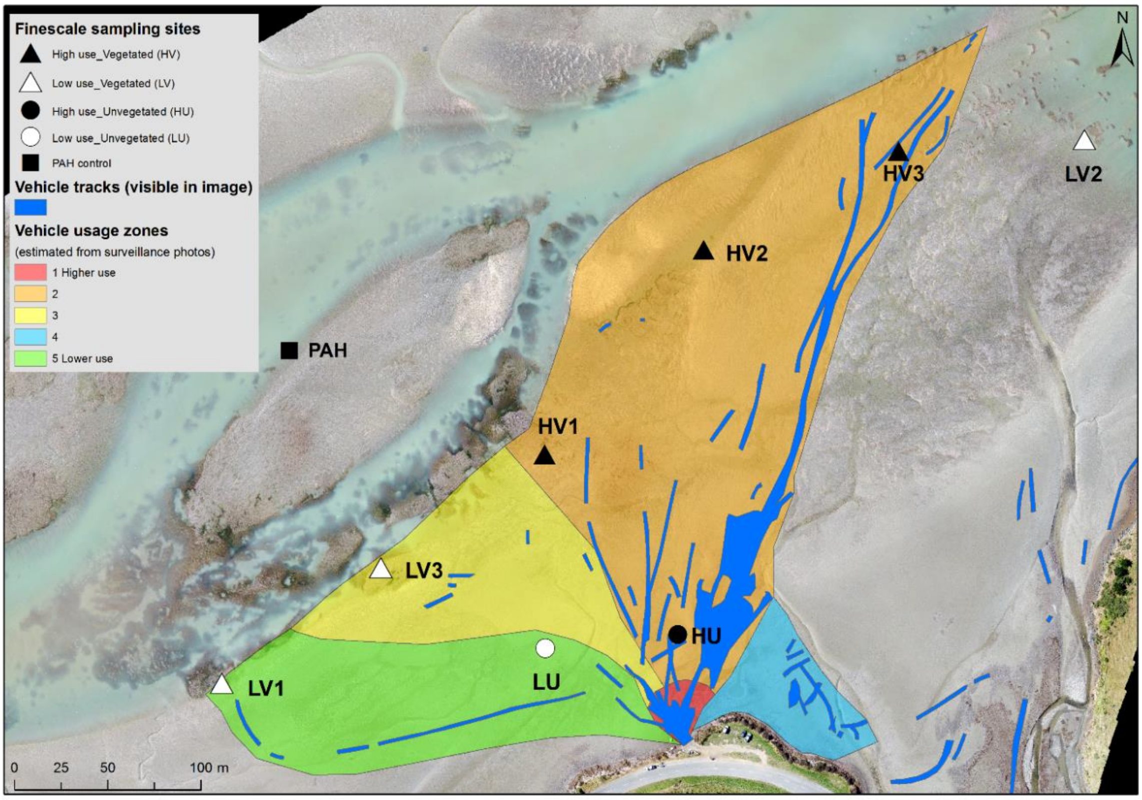

Figure 4. Map of the study area in Delaware Inlet showing the position of the eight main fine-scale sites, as well as the polycyclic aromatic hydrocarbon (PAH) control site, and vehicle usage zones. Visible vehicle tracks are also displayed.

3.3. Fine-scale survey

The field team conducted a fine-scale ecological survey at low tide on 15 March 2017, and sampled eight main sites overall (Figure 4). They positioned six sites in vegetation (seagrass beds) within the low shore (Table 1). Three of these sites were in the high vehicle usage zone positioned at or nearby visible vehicle tracks (see sites labelled HV), and three in the low vehicle usage zone (see sites labelled LV). They positioned the other two sites on unvegetated substrate within the midshore, with one subject to high and the other to low vehicle usage (sites labelled HU and LU respectively). Note that, for the purposes of the fine-scale survey, we simplified vehicle usage into two zones overall: high (Zones 1 and 2), and low (Zones 3–5 plus the one site located outside the zones).

Table 1. Description of the fine-scale survey design in regards to the locations of the eight main study sites.

Usage	**Vegetated (V) (low shore)**	**Unvegetated (U) (midshore)**
High vehicle usage (H) (located in Zones 1 and 2)	3 sites (n = 3 for each site) (HV)	1 site (n = 3) (HU)
Low vehicle usage (L) (located in Zones 3 and 5, as well as outside the vehicle usage zones)	3 sites (n = 3 for each site) (LV)	1 site (n = 3) (LU)

Infauna (including cockles), epibiota[8] and sediment samples were collected and/or surveyed within a 2 metre radius from the centre of the main fine-scale sites. One sediment core profile was also collected at each site.

3.3.1. Sediment

Core profiles

At each site, we collected one sediment core in a random location using a 62 mm diameter Perspex tube pushed to a depth of at least 150 mm into the substrate. We described sediment colour, stratification and texture profiles and paid particular attention to any black (anoxic) regions. Where anoxic regions occurred, we recorded the average depth of the lighter-coloured surface layer as the depth of the apparent redox discontinuity layer (RDL)—defined as the transitional zone between aerobic (oxygenated) sediments and anaerobic (deoxygenated) sediments. Any noticeable sulphide odours were also noted as further indication of anoxic conditions.

Grain size and polycyclic aromatic hydrocarbons (PAH)[9]

At each site, we scraped three sediment samples for grain size analysis from the top 20 mm of sediment and mixed them together to form one composite sample. We also

[8] Plants and animals living on top of benthic habitats.

[9] PAHs are a group of complex hydrocarbons that are common constituents of fuels and lubricating oils but most typically arise from the incomplete combustion of organic materials.

collected sediment samples for PAH analysis from all sites within the high vehicle usage zone and mixed these into one composite sample. Another sample was also collected at a control site outside the vehicle usage zones (site PAH in Figure 4). All sediment samples were chilled prior to analysis by Hill Laboratories (see Appendix 1 for analysis methods).

3.3.2. Epibiota and infauna

At each site, we identified and recorded all visible epifauna within three 0.06 m^2 quadrats (0.25 x 0.25 m). We also estimated the percentage cover of macroalgae and seagrass within each quadrat using the method described in Section 3.2.2. The percentage of seagrass with darkened (as opposed to green) leaves was estimated by eye in each quadrat and categorised as either uncommon, common or abundant.

At each site, we collected three infauna samples by inserting a 130 mm diameter core to a depth of 100 mm into the sediment. Core contents were gently washed through a 0.5 mm mesh sieve and the residual preserved with 95% ethanol (plus 5% glyoxal) in seawater. Cawthron taxonomists later stained infauna with rose-bengal solution before identifying and counting them. In addition, they sieved cockles (tuangi, *Austrovenus stutchburyi*) in each core through 10 mm and 15 mm sieves and recorded the numbers for the three resulting size categories (< 10 mm, 10–15 mm, > 15 mm).

We evaluated infauna and epifauna data according to the number of taxa and the number of individuals (abundance). Differences in benthic animal (epifauna and infauna) communities between replicate samples from sites within the low shore, and between replicate samples from sites within the midshore, were visualised using non-metric multidimensional scaling (nMDS; Clarke & Warwick 1994) based on Bray Curtis similarities (Bray & Curtis 1957). This method places sites in a two-, three- or multi-dimensional space according to their similarities and differences. If a two-dimensional (2-D) representation explains a sufficient proportion of the sample differences observed, these can be assessed spatially on a 2-D plot, where the distance between sample points corresponds to the degree of difference observed between benthic communities. A stress statistic provides a measure of how well the plot represents the differences between all of the individual samples. We applied a square-root transformation to the data during this process to reduce the influence of the most dominant species (Clarke & Warwick 1994). For infauna communities, the major taxa contributing to the similarities and differences were identified using the similarity percentages routine (SIMPER) based on Bray-Curtis similarity and 70% contribution cut-off (Clarke & Warwick 1994). We conducted all multivariate analyses using the software package PRIMER v.7 (Clarke & Gorley 2006).

Cockles

At each of the two midshore sites (HU and LU), the field team collected all cockles within three 0.25 m^2 quadrats to a depth of approximately 6 cm using a rake and small trowel. They sieved the cockles through two mesh sizes (10 mm and 15 mm) and recorded the numbers for each of the three resulting size classes (< 10 mm, 10-15 mm and > 15 mm). Infauna cores from each of the eight sites (see Section 4.3.1) also provided cockle abundance information, although the core size was likely too small to provide reliable data regarding the abundances of larger-sized cockles.

Statistical analyses

We compared average values for epibiota, infauna and cockle data between the high and low vehicle usage zones at both vegetated (low shore) and unvegetated (midshore) tidal heights. Note that a difference was considered unlikely if there was an overlap between average values ± 2 x standard error (SE) (Altman & Bland 2005).

3.4. Boat users' survey

Cawthron employed a graduate student from the University of Canterbury from 9 January until 3 March 2017 on a Cawthron summer scholarship. The student observed boat users and their use of vehicles to launch or retrieve boats at Delaware Inlet and Cable Bay (Figure 5). Over a period of five weeks, the student was present in the field for 13 days at either or both locations to observe characteristics of vehicle use and, where possible, to conduct a short survey with those boat users.[10]

Figure 5. Cawthron scholarship student stationed on site to observe boat users at Delaware Inlet.

[10] The student was in the field on the following days: 11, 13, 14, 17, 20, 21, 24, 28, 29 and 30 January, and 5 February. She was also in the field two days earlier in January, but no boat users were available to be surveyed.

An observation chart (Appendix 2) was developed to record attributes of each boat user, including the type of boat (e.g. motorised launch or kayak), number of occupants, length of boat, horsepower of the boat, and size class of the vehicle (e.g. 2WD, 4WD or van). We also recorded locational information, such as the date and time, tidal information taken from the Land Information New Zealand (LINZ) website (rounded to the nearest five minute interval), weather conditions and wind speed (e.g. calm, light, moderate or strong).[11]

In addition to the observation chart, the student approached boat users with an invitation to take part in a short boat user survey in the form of a qualitative questionnaire (Appendix 3). The questionnaire sought to gather further information on user demographic, type of use, behaviour and attitudes with respect to the estuary. The questionnaire was voluntary and took between 1-5 minutes. Most boat users happily accepted the invitation.

The boat user survey was originally planned for four intervals of five consecutive days, but after the student spent two days in the field with no survey results the field days were decided on a day-by-day basis. Factors affecting that decision were weather forecast, incoming/outgoing tides, wind speed and swell. Websites (including metservice.com, swellmap.co.nz and marineweather.co.nz) were consulted in order to ascertain sea conditions that would be favourable for boat users at either Delaware Inlet or Cable Bay on any given day.

The busiest periods for launching and retrieving boats were later in the week and during weekends, early in the morning (around 0600 h), and two hours either side of high tide. It was evident that Delaware Inlet was more popular for launching and retrieving boats than Cable Bay which was quieter, especially during weekdays. As a result, the student adjusted her days in the field to spend the majority of survey days at Delaware Inlet, on weekdays and weekends between the hours of 6 am and 12 noon, and on statutory holidays (which included Nelson Anniversary and Waitangi Day). The student continued to check at Cable Bay and to interview boat users she encountered. If there was a boat trailer there, she left a note informing the boat user of the study and providing contact details should they wish to participate.

3.5. Photographic capture

In order to obtain an accurate record of vehicle usage, cameras were mounted overlooking the boat launching sites at Cable Bay and Delaware Inlet. Both cameras were located on private property with permission of landowners.

[11] Note that the tides in Delaware Inlet are delayed by about one hour from those predicted for Nelson due to flow restriction at the narrow tidal entrance. We accounted for this adjustment in our records.

The cameras recorded a continuous series of images, at five minute intervals, for nine weeks from Friday 6 January until Thursday 9 March 2017. No individual vehicle or boat registration details were identifiable from the photographic images recorded.

Images were downloaded every two weeks and boat user numbers were recorded at both sites. In addition, the student plotted the launching and retrieval locations on an image taken from the fixed camera. By cross-checking the time with tide information, we were able to identify which locations were popular at high, mid and low tides. This information was used in the ecological habitat mapping work to identify zones subject to different intensities of vehicle usage within the Delaware Inlet study area.

3.6. Interviews with local residents

Nelson City Council notified a number of local residents who live along Maori Pa Road and Cable Bay Road of this study by letter in December 2016. Cawthron researchers contacted these residents in January 2017, inviting them to be interviewed as part of the study. A Social Research Ethics Application was completed to ensure appropriate interview protocol and conduct. Each interviewee was given an Information Sheet and a Consent Form. Written consent was obtained from each interviewee before proceeding with the interview and audio recording. A Cawthron social scientist attended the first three interviews along with the student, and thereafter the student completed the remaining five interviews alone. A total of eight interviews involving ten participants were completed between 31 January and 15 February 2017.[12] Interviews took place at the resident's home with each lasting no more than an hour.

The interviews established the residents' history in the area; explored the issues concerning protection of the estuary and environs (values, changes observed, feelings, and their personal recreational use); and enquired about ways of finding a solution acceptable to local iwi, local residents and recreational boat users (Appendix 4).

3.7. Interview with Trustee of Ngāti Tama ki Te Waipounamu Trust and Te Huria Matenga Wakapuaka Trust

A Cawthron social scientist interviewed a Trustee of Ngāti Tama ki Te Waipounamu Trust and Chair (also a trustee) of Te Huria Matenga Wakapuaka Trust at the Cawthron Institute on 8 March 2017. The interview took one hour and followed a similar social research ethics protocol to that outlined above (for interviews with local residents), obtaining the interviewee's oral permission before recording the interview. The interview was subsequently transcribed, checked by the interviewer, and then

[12] Three interviews with four residents took place on 31 January 2017; other interviews were conducted on 5, 7 and 9 February, and two more interviews (with three residents) were completed on 15 February 2017.

sent to the interviewee for verification and/or amendment on 31 March 2017. See Appendix 5 for the interview questions.

4. RESULTS AND DISCUSSION

4.1. Habitat mapping results

Unvegetated habitats within the study area were covered largely by firm shell/sand and gravel field (Figure 6). The area covered by all vehicle zones was 6.6 ha out of a total of 353 ha comprising Delaware Inlet. Zones 1 and 2 covered 3.9 ha and all other zones combined covered 2.7 ha. Visible vehicle tracks imprinted into the substrate covered approximately 58% of Zone 1, 11% of Zone 2, and 1.5–8.8% for all other zones (Figure 4, Figure 7).

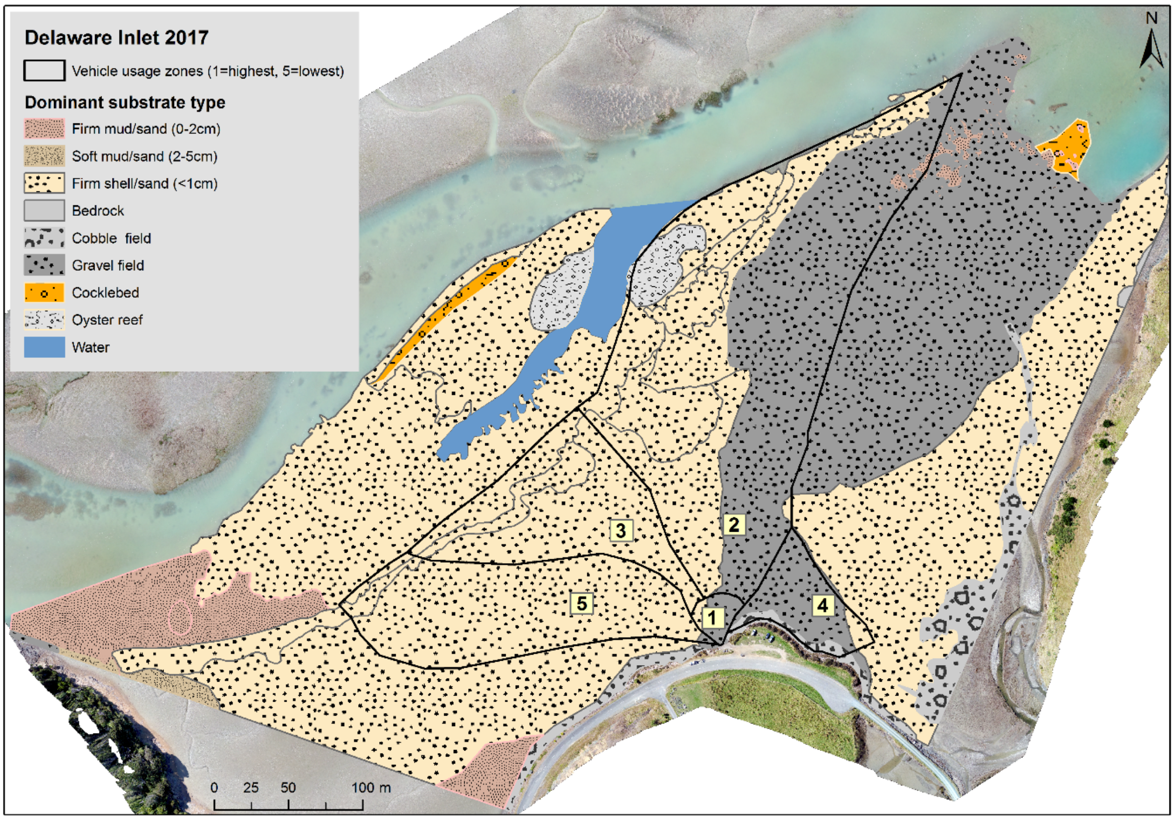

Figure 6. Unvegetated substrate, showing only dominant categories, within the Delaware Inlet study area in 2017. Boundaries for vehicle usage zones (1–5) are also shown and numbered.

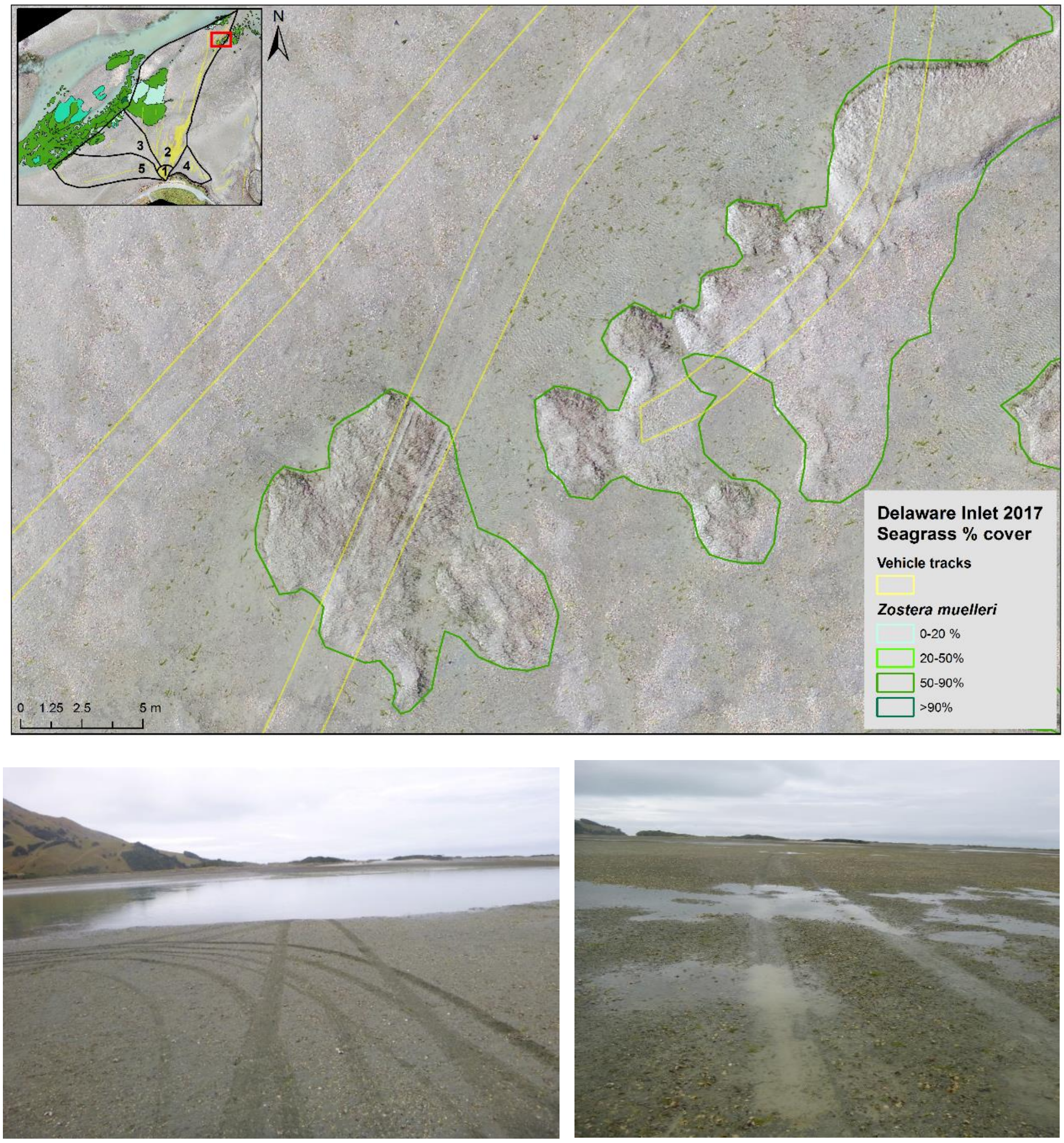

Figure 7. Vehicle tracks on benthic substrates in the vehicle usage zones in Delaware Inlet. Aerial image taken by drone with accompanying map (top), and photo taken by camera (bottom), during habitat mapping 2017.

4.1.1. Vegetation

Seagrass

In 2017, seagrass was present in all vehicle usage zones that extended down to the low shore, and covered 1.0 ha of the 6.6 ha total area of all zones (Figure 8, Figure 9). Vehicle tracks were visible in seagrass habitat (Figure 7). An area generally devoid of seagrass ran along the eastern side of Zone 2 and was subject to relatively high vehicle usage (Figure 8). This area coincided with a dominant surface substrate of gravel field (Figure 6), as well as being an area with a relatively high number of visible vehicle tracks (Figure 4). Comparisons of seagrass cover in the study area in 2017 (Figure 8) against historical maps from 1988 (Figure 10) and 2009 (Figure 11) indicated that seagrass beds have contracted and expanded over time, both within and beyond the area subject to vehicle traffic. In Zone 2, there was nearly complete loss of some seagrass patches higher up on the shore (approximately 0.14 ha in combined size in 2009); these were present historically (1988 and 2009) but barely observed in 2017.

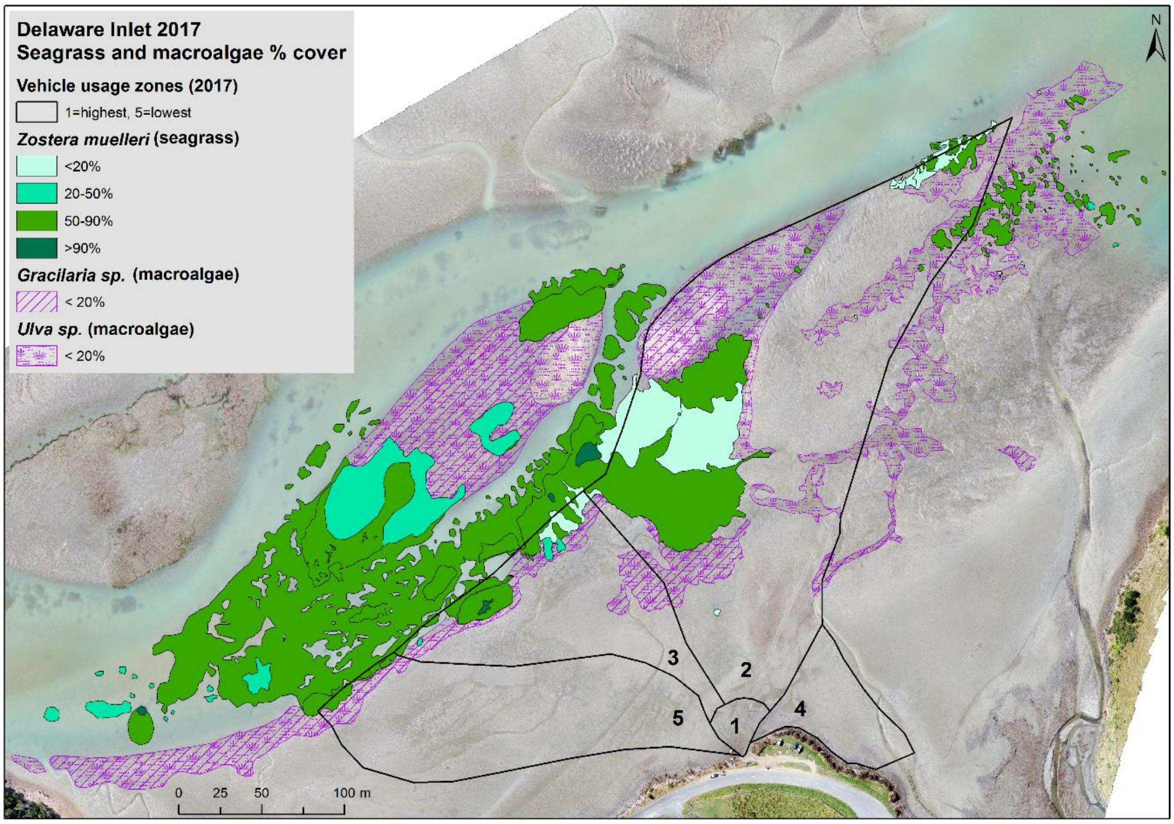

Figure 8. Percent cover of vegetation (seagrass beds and macroalgae) within the Delaware Inlet study area in 2017. Boundaries for vehicle usage zones (1–5) are also shown and numbered.

Figure 9. Seagrass beds within the Delaware Inlet study area, 2017.

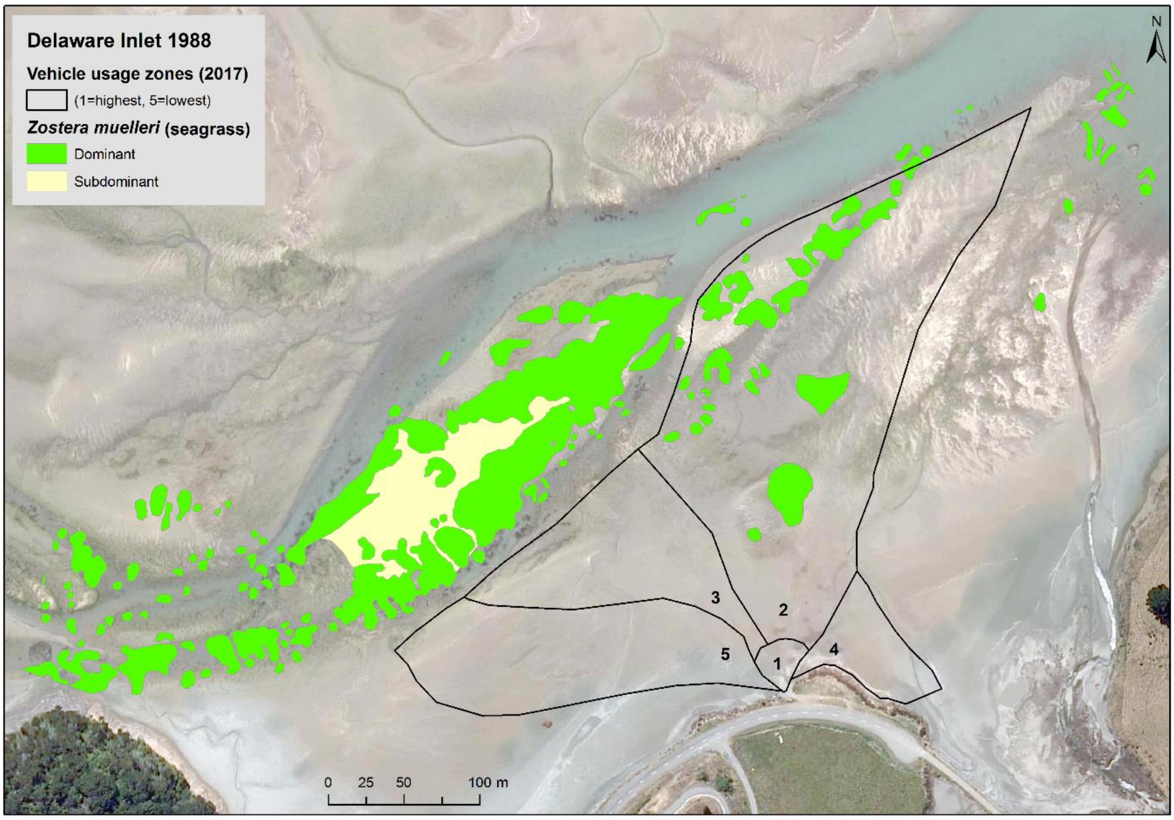

Figure 10. Location of seagrass beds in 1988 (Franko 1988) within the study area. Boundaries for vehicle usage zones (1–5) in 2017 are also shown and numbered.

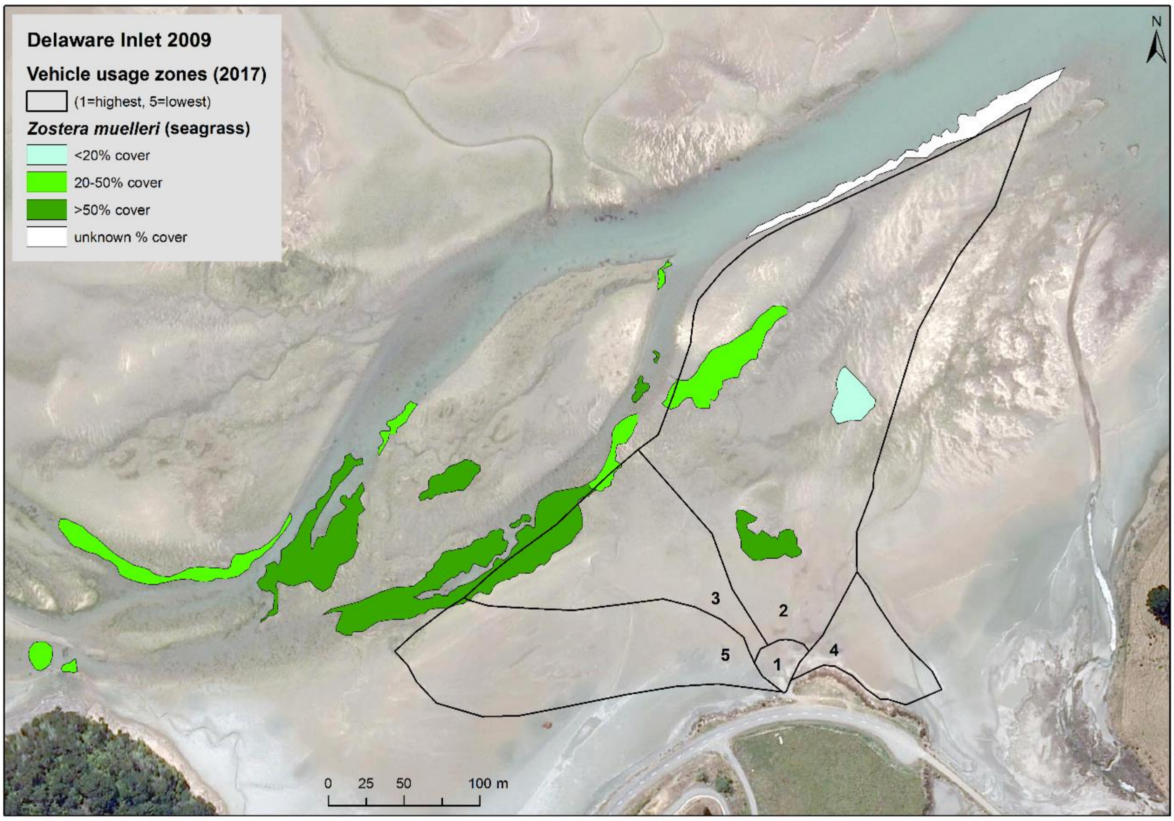

Figure 11. Location of seagrass beds in 2009 (Gillespie et al. 2011b) within the current study area. Boundaries for vehicle usage zones (1–5) in 2017 are also shown.

Macroalgae

Sea lettuce (*Ulva* sp.) and agar weed (*Gracilaria* sp.) were present at low levels (< 20% cover) throughout the study area (Figure 8). An area containing limited macroalgal cover (and also lacking seagrass) was located along the eastern side of Zone 2 (relatively high vehicle usage).

4.2. Changes to area of key habitats

4.2.1. Seagrass

Seagrass within the vehicle usage zones represented 16% of the total 6.3 ha of seagrass recorded in Delaware Inlet in 2009 (Gillespie et al. 2011b)[13], even though the vehicle usage zones represent only approximately 2% of the Inlet. The 2009 coverage of 6.3 ha was a reduction from 8.9 ha of seagrass estimated in 1988[14], although the 1988 estimate included some subtidal seagrass beds that may have

[13] These figures for seagrass coverage include areas where seagrass was subdominant vegetation as well as areas where it was dominant.
[14] Map created in 1988 based on photographs taken in 1983.

accounted for some of the temporal difference (Gillespie et al. 2011b). In addition, historical contraction and expansion of seagrass beds was apparent outside the vehicle usage areas. This may have been due to natural variation (e.g. Turner & Schwarz 2006), deterioration caused by non-vehicle related pressures (e.g. sedimentation) (Gillespie et al. 2011b), and/or differences in mapping methodologies.

In this study, we found visible vehicle tracks on benthic habitats (including seagrass) in all vehicle usage zones, as well as outside the zones in some areas, indicating direct physical damage caused by vehicles. Vehicle tracks were also observed in Delaware Inlet in seagrass beds by Gillespie et al. (2011b).

The eastern side of Zone 2 had a relatively high number of vehicle tracks and hence may be an area of possible impact on seagrass. In this zone, small seagrass patches higher up the shore were present in 1988 and 2009 but barely observed in 2017, an impact that may have been caused by vehicle usage. However, the possible impact of vehicle usage on seagrass in this area was confounded by the presence of gravel field substrate (and possibly other unmeasured environmental variables, such as elevation). Little is known about the sediment grain size preference of seagrass (*Z. muelleri*) in New Zealand. In Australia, *Zostera capricorni* has generally been found to grow better in coarse (i.e. sandier in comparison to fine) sediments, although coarse sediments are generally lower in nutrients and organic matter and, in some cases, increasing grain size was considered likely to be detrimental to the distribution and biomass of seagrasses (Turner & Schwarz 2006). In Europe, *Zostera* species can grow on gravel as well as mud (Greve & Binzer 2004).

There did not appear to be much (if any) seagrass growing on gravel field substrate outside of the vehicle usage zones in Delaware Inlet, suggesting that seagrass may be favouring other substrates. The prevalence of visible vehicle tracks indicates that gravel field was possibly targeted for driving over. However, the eastern side of Zone 2 also lacked seagrass in 1988 and 2009. Therefore, if vehicle damage was the cause, it would be historical (i.e. prior to 1988) and related to low vehical usage during that time.

Further results regarding seagrass cover are found in the results of the fine-scale survey (see Section 5.3.2).

4.2.2. Macroalgae

Due to the ephemeral nature of macroalgae, it was not considered appropriate to use changes in their distribution to assess vehicle impacts.

4.3. Fine-scale survey

4.3.1. Sediment results

Core profiles

There were no obvious differences in sediment core profiles between the high and low vehicle usage zones at the vegetated (low shore) sites. Cores were generally light brown/medium grey to a depth of 3–8 cm with darker sediment (sometimes becoming black with a slight hydrogen sulphide odour) below this depth (Figure 12). The unvegetated (midshore), sediment cores were light brown in the top 2–3 cm with light grey sediment (from cores taken in the low vehicle usage zone), and medium grey (high vehicle usage) below this depth, with no distinct hydrogen sulphide odour. At the high vehicle usage/unvegetated (midshore) site, sediment was highly compacted, preventing the collection of a core profile below 4 cm.

Figure 12. Photograph of a sediment core from one of the vegetated (low shore) sites.

Grain size and PAH

Sediments at all sites comprised largely sand (from 73–98%) (Table 2). Levels of mud and gravel/shell within sediments were generally low, although some variability existed with a relatively high amount of mud at site LV1, and relatively high amounts of gravel/shell at sites LV2 and LU. No PAHs were detected from sites within the high vehicle usage zone or the control site outside the vehicle usage zones.

Table 2. Sediment grain size composition at the vegetated low shore (V) and the unvegetated midshore (U) survey sites subject to low (L) and high (H) vehicle usage in Delaware Inlet.

Sediment (g/100g dry wt)	HV1	HV2	HV3	LV1	LV2	LV3	HU	LU
Gravel/shell (Fraction ≥ 2 mm)	1.7	0.6	0.2	0.5	17.9	0.05	9.2	19.5
Sand (Fraction < 2 mm, ≥ 63 µm)	93	97.8	94.6	84.2	77.4	96.1	84.3	73.4
Mud (Fraction < 63 µm)	5.3	1.7	5.2	15.3	4.7	3.8	6.5	7.2

4.3.2. Epibiota results

Epifauna

Overall, 18 epifauna taxa were recorded from the fine-scale survey with the small gastropod *Micrelenchus tenebrosus* (topshell) and cockle the most abundant (Appendix 6 and Figure 13). Average epifauna abundance was similar between sites within the vegetated (low shore) and between sites within the unvegetated (midshore) (Table 3). In the low shore sites, the number of taxa was slightly higher within the low, compared to the high, vehicle usage zone, with the opposite pattern occurring in the midshore, although very low numbers were present. Multivariate analysis (non-metric MDS) indicated considerable overlap (i.e. no obvious differences) in composition between epifauna communities from the low and high vehicle usage zones from both vegetated and unvegetated sites (Figure 14).


Figure 13. Examples of quadrats from vegetated and unvegetated sites within which epibiota were quantified.

Table 3. Average (± 1 SE) total number of taxa and total abundance for epifauna communities in the high vehicle usage (H) and low vehicle usage (L) zones at vegetated low shore (V) (shaded cells, n = 9) and unvegetated midshore (U) (unshaded cells, n = 3) site groupings in Delaware Inlet.

	Number of Taxa (Taxa per core)	Abundance (individuals per core)
LV	6.1 ± 0.6	48.9 ± 7.0
HV	3.8 ± 0.5	36.4 ± 13.6
LU	2.3 ± 0.3	5.3 ± 1.5
HU	4.0 ± 0	6.0 ± 0.6

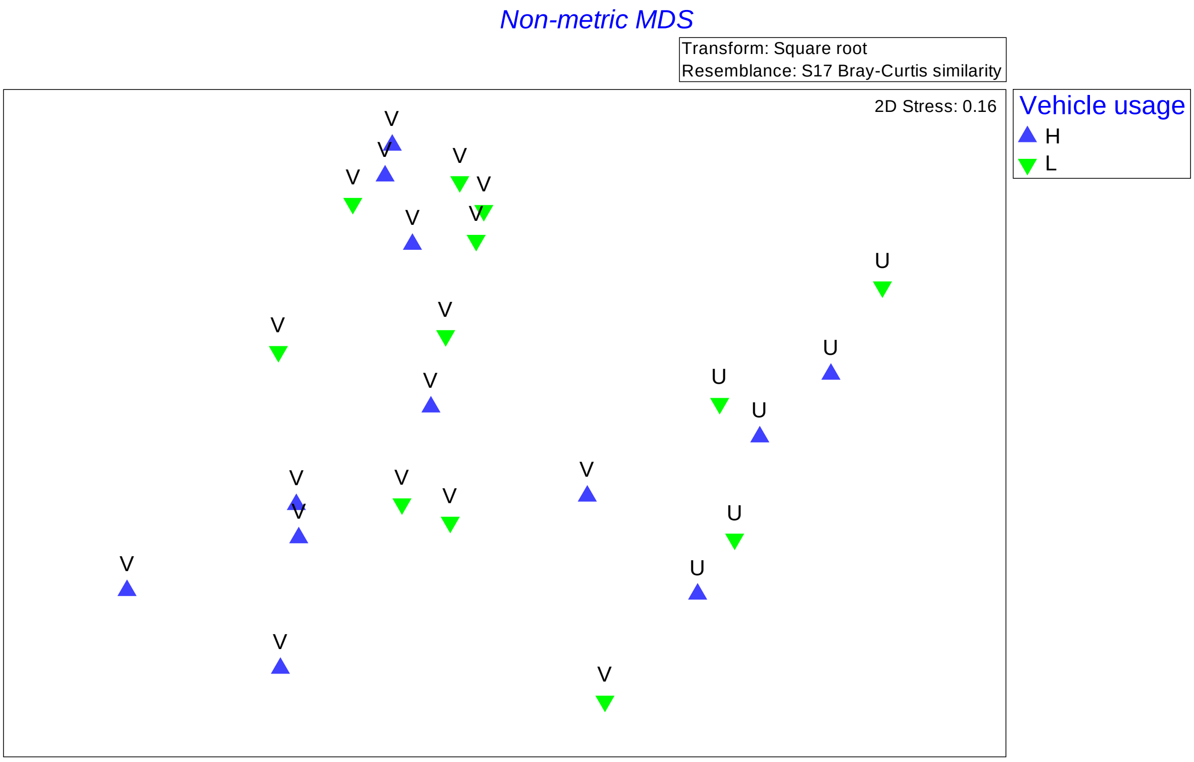

Figure 14. Non-metric MDS showing epifauna communities from vegetated low shore (V), and unvegetated midshore (U) sites subject to high (H – blue triangle) and low (L – green triangle) vehicle usage in Delaware Inlet.

Seagrass

The average percentage cover of seagrass (low shore), at 81% (± 2.4 SE), was consistently high and much less variable within the low vehicle usage zone, in comparison to the high vehicle usage zone (58% ± 10.0 SE) (Appendix 6). However, this difference falls short of the statistical test for significance, so we are not able to conclude that there is a statistically significant difference in the cover of seagrass between these two zones. Seagrass with darkened leaves (Figure 15), indicative of partial decay likely due to *Labyrinthula* (wasting disease) infection, was common at all vegetated (low shore) sites, with no obvious differences observed between sites at the high and low vehicle usage zones.

Figure 15. Seagrass from Delaware Inlet showing patches of darkened leaves likely caused by *Labyrinthula* infection.

Macroalgae

Sea lettuce, the most commonly occurring macroalga recorded during the fine-scale survey, was observed only within the high vehicle usage zone, although in very low abundance (< 1% cover in any one quadrat) (Appendix 6). Two other macroalgal taxa (agar weed and an unidentified red alga) were also present although extremely low in abundance.

4.3.3. Infauna results

Overall, 67 infauna taxa were recorded from the fine-scale survey, with polychaetes (e.g. capitellids and *Prionospio aucklandica*) and bivalves (e.g. *Arthritica bifurca* and cockle) the most abundant (Appendix 7). At the vegetated (low shore) sites, the average number of taxa and total abundance were similar between the high and low vehicle usage zones with relatively high variation in total abundance (Table 4). At the unvegetated (midshore) sites, the average number of taxa was similar although total abundance was somewhat higher within the low vehicle usage zone.

At the vegetated (low shore) sites, multivariate analyses (MDS and SIMPER) indicated relatively high variability in community structure within the high and low vehicle usage zones but there was evidence for some slight compositional differences between the zones. As shown by the spatial separation in Figure 16, at the unvegetated (midshore) sites, community differences were apparent. The SIMPER analysis revealed that *Prionospio* sp. (a polychaete) contributed proportionally more to the infauna community in the high vehicle usage zone whereas *Arthritica bifurca* (a bivalve) contributed proportionately more in the low vehicle usage zone (further details in Appendix 8).

Table 4. Average (± 1 SE) number of taxa and total abundance for infauna communities in the high vehicle usage (H) and low vehicle usage (L) zones at unvegetated midshore (U, n = 3, unshaded cells) and vegetated low shore (V, n = 9, shaded cells) site groupings in Delaware Inlet.

	Number of Taxa (Taxa per core)	**Abundance (individuals per core)**
LV	20.6 ± 1.9	170.0 ± 29.2
HV	18.8 ± 1.4	135.1 ± 33.6
LU	10.0 ± 1.5	77.0 ± 10.0
HU	6.0 ± 1.0	31.3 ± 5.7

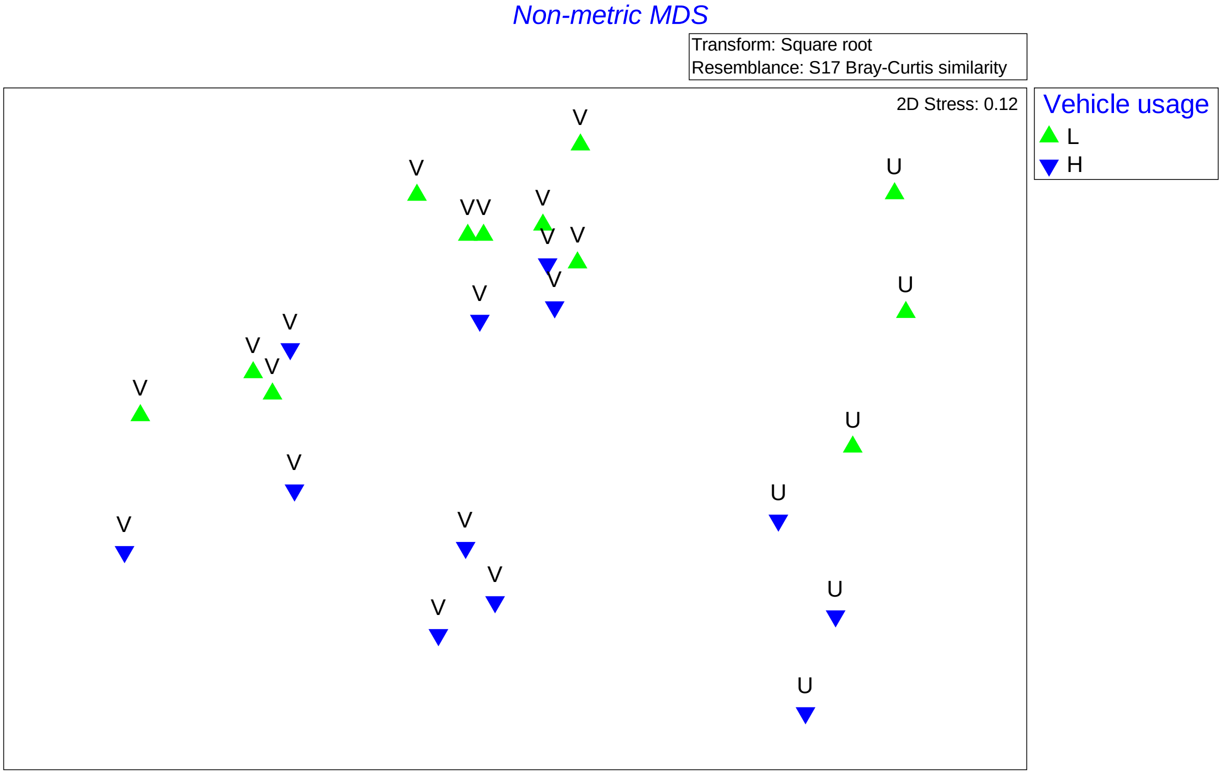

Figure 16. Non-metric MDS showing infauna communities from vegetated low shore (V), and unvegetated midshore (U) sites subject to high (H – blue triangle) and low (L – green triangle) vehicle usage in Delaware Inlet.

Cockles

At the two unvegetated (midshore) sites, the average abundance of cockles (Figure 17) from the quadrats was higher in all three size classes within the low, compared to the high, vehicle usage zone (Table 5). Cockle numbers in cores from the two unvegetated sites were similar within the < 10 mm and 10–15 mm size classes, and slightly higher within the size > 15 mm size class, at the low versus high vehicle usage zones. At the vegetated sites (cores only), average abundance cockle in all size classes was comparable between the high and low vehicle usage zones.

Figure 17. Image of a cockle (tuangi, *Austrovenus stutchburyi*).

Table 5. Average abundance (± 1 SE) of cockles in three size classes collected from 0.25 m^2 quadrats (shaded cells, n = 3) and from (130 mm diameter and 10 mm deep) cores (unshaded cells, n = 3 for U and n = 9 for V) in the high vehicle usage (H) and low vehicle usage (L) unvegetated midshore (U) and vegetated low shore (V) sites in Delaware Inlet.

Cockle size classes	< 10 mm	10-15 mm	>15 mm
HU Quadrat	18.0 ± 6.1	24.3 ± 10.7	2.7 ± 1.2
LU Quadrat	95.7 ± 28.8	333.7 ± 32.0	108.0 ± 13.6
HU Core	16.0 ± 3.5	4.0 ± 2.1	2.0 ± 1.5
LU Core	31.7 ± 16.3	17.7 ± 4.8	10.0 ± 4.4
HV Core	10.7 ± 3.4	6.1 ± 1.6	0.4 ± 0.2
LV Core	11.2 ± 3.5	3.1 ± 0.9	0.6 ± 0.8

4.4. Fine-scale survey discussion

In New Zealand estuaries, the taxonomic composition of sediment-dwelling invertebrate communities is well known to be strongly influenced by sediment grain size, although most studies look specifically at the amount of mud present (e.g. Hewitt et al. 2005; Ellis et al. 2015; Robertson et al. 2015). In this study, the possible impacts of higher vehicle usage were at least partially confounded by varying sediment grain size composition (as well as possibly other unmeasured variables unrelated to vehicle usage). This was particularly so at the unvegetated (midshore) sites, where the proportion of sand was approximately 10% higher (and consequently gravel/shell 10% lower) at the high versus low vehicle usage site.

That said, differences in sediment composition and structure may also be related to vehicle traffic. For example, sediment compaction within the unvegetated (midshore) high vehicle usage site was likely to have been caused by higher vehicle usage, as visible vehicle tracks were present at this site and it was positioned relatively close to Zone 1, the highest usage zone, where nearly all vehicles entered the estuary.

The vegetated (low shore) sites within the low vehicle usage zone also exhibited variation in sediment composition. At the vegetated (low shore) sites within the high vehicle usage zone, grain size was relatively uniform, although the surface substrate[15] indicated by habitat mapping, i.e. the gravel field at site HV3, may be influencing epibiota.

Lack of statistical significance of results may have also partially been due to the relatively small number of replicates in the current survey.

4.4.1. Biotic communities

For epifauna, the overall evidence does not support a conclusion of an impact of higher vehicle usage on average abundance or number of taxa. At the vegetated (low shore) sites, the number of epifauna taxa was slightly lower at sites subject to higher vehicle usage, but this was confounded by varying sediment grain size. In the midshore sites, there were slightly higher numbers of epifauna taxa and abundance at the high vehicle usage site, but only a relatively small number of taxa were recorded overall.

For infauna, abundance was somewhat lower at the unvegetated (midshore) site subject to higher vehicle usage, and community differences between the low and high vehicle usage sites were apparent. It is possible that this was caused by differing sediment grain size composition, although sediment compaction, and other vehicle impacts such as mortality through direct crushing, at the midshore high vehicle usage site were considered likely to be having a detrimental effect on the composition of infauna communities.

There was little statistical evidence of an impact of higher vehicle usage on the total number of infauna taxa at any of the sites, or on infauna abundance at the vegetated (low shore) sites. At these sites, there was evidence of only slight community

[15] Note that the surface substrate recorded during habitat mapping does not necessarily reflect the grain size of the underlying sediment measured from sediment samples collected during the fine-scale survey.

differences between high and low vehicle usage zones, insufficient to attribute to possible vehicle impacts.

4.4.2. Cockles

In New Zealand, cockles are present within soft mud to fine sand although they tend to be more abundant in sediments with larger grain size (Michael 2008). Bivalve shellfish can also be affected by sediment compaction, which can prevent them from extending their siphons to the surface to obtain food (Leatherman & Godfrey 1979). Vehicles also can cause direct mortality through crushing and sub-lethal effects.

In our study, at the two unvegetated (midshore) sites subject to higher vehicle usage, cockle abundance from the quadrats was lower than at the sites with lower vehicle usage. This could be explained by the preference of cockles for coarser grain size, although the presence of sediment compaction at the site suggests that vehicle traffic is likely to be contributing to reduced cockle numbers at this site.

Unlike the results from the quadrats, average cockle numbers measured from the smaller cores were not consistently higher at the lower vehicle usage sites. However, it is possible that the cores were not large enough in size to accurately reflect cockle abundances, particularly for larger sized cockles.

4.4.3. Seagrass

There was inconclusive evidence of an impact of higher vehicle usage on the percentage cover of seagrass. The higher usage zone had greater variation in seagrass cover and lower average cover (although the difference in average cover was not statistically significant). It is possible that surface substrate type was the cause of the greater variation (see Section 5.2) although there was no evidence for this in the site-level data. With regard to the disease detected in the Delaware Inlet seagrass, *Labyrinthula*-infected seagrass beds have also been detected in other estuaries within the Nelson region (e.g. Gillespie et al. 2012a, 2012b).

Due to the ephemeral nature and low abundance of sea lettuce (a macroalga), it was not considered appropriate to use it as an indicator of possible impacts of higher vehicle usage.

The lack of detection of any PAHs within the sediment suggested that vehicles were not causing this type of contamination within the study sites.

4.5. Field observations of boat usage

The Cawthron summer scholarship student was stationed in the field at Delaware Inlet and Cable Bay boat launching locations for a total of 13 days over a five week period in January and February 2017. She kept a logbook for noting factors that influenced vehicle use at both locations. Noteworthy observations included the following:

- There appeared to be a large number of natural factors [i.e. weather, tide, swell] that determined the volume of use. For example, over the Nelson Anniversary and Waitangi Day holiday weekends, besides the fact that they were public holidays, the weather was good and there was little wind or swell. With high tide around midday, people could launch in the morning and come back around lunch time before the afternoon sea breeze picked up. In contrast, ordinary weekends were a lot quieter when the weather was bad, or if there was a moderate amount of wind (this would usually mean it was even windier out in the bay).
- The majority of boat users launched early in the morning between 5:00 am and 7:00 am, regardless of the tide. However, families and more casual users who were more concerned with safety and convenience would launch at mid tide and return on high tide.
- Very few boat users were encountered on weekdays between Monday and Thursday, or on bad weather days.
- A couple of times people were observed launching in a second location, roughly 100 metres east of the main launching point, where a stream emerges into the estuary (Zone 4). When queried, they explained that they didn't want to wait for other boat users trying to launch or load at the main launch location. However, this was a rare occurrence.
- Apart from the abovementioned, everyone we observed used similar routes. Although tracks were visible in other parts of the estuary, these were not necessarily from vehicles launching a boat and no one was observed launching in unusual locations or driving to random places in the estuary.
- A couple of people were observed gathering cockles, etc. They did not drive out onto the estuary; however, in the photographs several vehicles can be seen parked on the estuary without boats. It is unclear what activities they were engaged in: gathering food, walking or something else.
- One man drove down to the estuary especially to speak to our student, as he had heard from others that we were interviewing and wanted to have his say. He wanted the estuary to remain open to boat users. Three people also telephoned the student in response to the notice she left on their windscreen at Cable Bay.
- One man sailed his small sailboat in the estuary almost every day. He had a hand trolley that he used to launch his boat without driving on the estuary.

- Cable Bay attracted very few boat users on weekdays. However, on weekends when the weather was good, the beach was very crowded and the car park very full, mostly with swimmers and other beach users.
- At Cable Bay, one boat user was observed getting into trouble while attempting to load his boat. The waves crashed over into the boat and nearly submerged it. He needed help from several other adults to get his boat on the trailer. When interviewed afterwards, he said he would never launch or load at Cable Bay again.
- At Cable Bay, another boat user was observed getting his vehicle stuck in the sand while trying to pull his boat back up the beach. Another boat user towed him to stable ground.

4.6. Boat users' survey

The Cawthron student spoke to 77 boat users out of a total of 115 observed sightings of users while on site at Delaware Inlet (n = 69) and Cable Bay (n = 8). Some users were encountered more than once. Most boat users were frequent users of the area; in fact, only seven at Delaware Inlet were launching boats for the first time at that location. Similarly, only two at Cable Bay were new to that boat launching site. At Delaware Inlet, several of the first-time users expressed uncertainty about where and how to launch their boats safely.

Asked how many times they had used the site over the past month, the average response at Delaware Inlet was 2.4 times (with a maximum of 16 times, by a resident of Cable Bay), whereas at Cable Bay (from a much smaller sample) only one user surveyed had used the site more than once in the past month.

Of the 77 users surveyed, 17 were from the local area (Cable Bay, Delaware Bay or Hira), 49 came from Nelson or Richmond, 10 from elsewhere in Tasman District and one from Havelock.

The majority of users launched small motorised boats (typically for the purpose of recreational fishing) at either Delaware Inlet or Cable Bay, thereby driving over the estuary or beach (respectively) to launch and retrieve their boat. However, not all users used vehicles to launch their crafts: kayakers and paddle boarders typically walked their vessels across the estuary.

Boat users were asked about the following (see Appendix 3 for the actual questions):

- reasons for use
- preference for Delaware Inlet or Cable Bay
- boat users' knowledge of the ecology, history and cultural heritage of the area
- suggestions for improving boat access in the area.

4.6.1. Reasons for using Delaware Inlet and Cable Bay

The student asked respondents: "Why do you use this particular location?" Of the 62 people interviewed at Delaware Inlet (excluding first-time users who did not offer responses as they considered they didn't have enough prior knowledge of the area), the most popular reasons for launching at that location were the proximity to good fishing grounds, safety, proximity to home, and qualities of the location such as quietness, wildness and beauty. Other reasons were the ease of access, suitability for small boats, suitability for children and families, fuel efficiency and no boat launching charge. Of the six people interviewed at Cable Bay (excluding the two first-time users), the most popular reason for launching boats at that location was proximity to good fishing grounds (or in one case, diving). The other reasons mentioned were safety, closeness to home, suitability for children and families, and the beautiful location.

Note that numbers in Table 6 indicate the number of times that reasons were mentioned by boat users (not the number of users per se).

Table 6. Count of boat users' reasons for launching at Delaware Inlet and Cable Bay.

Reasons for use	Delaware Inlet	Cable Bay
Proximity to good fishing grounds	30	5
Safety	20	1
Quiet, wild and beautiful location	16	1
Close to home, accessible	16	1
Ease of access	12	0
Suitable for small boats	11	0
Suitable for children and families	3	1
Fuel efficient	3	0
Free (no boat launching charge)	2	0

4.6.2. Preference for Delaware Inlet or Cable Bay

The student asked boat users whether they used other boat launching locations in the area and to assess what made those boat launching locations better or worse. Specifically, she asked why they chose to launch at Delaware Inlet over Cable Bay, or vice versa.

Of the 62 people interviewed at Delaware Inlet (excluding first time users for the same reason explained above), 25 (37%) claimed that Cable Bay was "too dangerous" or that Delaware Inlet was "safer". Several respondents recounted incidents when they had been "caught out" or got into trouble while attempting to launch or retrieve boats at Cable Bay. Likewise, 13 respondents (19%) said that Cable Bay is “too difficult” to launch/retrieve boats or that Delaware is “much easier”.

Figure 18. Soft sand at the Cable Bay boat launching area.

One user explained that he had been using Delaware Inlet for 20 years, but prior to that he had used Cable Bay and had “got stuck” three times. A local resident confirmed that boat users at Cable Bay frequently get their vehicles stuck in the soft sand (Figure 18) when trying to tow their boat back up the beach. This was also observed during fieldwork for this study (see Section 4.8.4). Towing boats and/or vehicles with high tension ropes creates safety issues for boat users, swimmers and other beach users—who include families with small children. Another boat user recounted an experience at Cable Bay wherein his friend was attempting to load his boat onto the trailer, but the incoming swell was too strong and his boat smashed through the car’s back window.

One boat user at Cable Bay explained that he never launches his boat at Delaware Inlet, but instead always brings a tow rope to Cable Bay in case he or others encounter difficulties. Another boat user, after getting his vehicle stuck in the sand, stated that he will never launch there again because it was too difficult to retrieve the boat and load it onto the trailer due to waves and the sandy slope. He intended to use Delaware Inlet next time he wished to launch in the vicinity.

4.6.3. Knowledge of local ecology, history and cultural heritage

Questions in the qualitative questionnaire were reviewed and then updated from 28 January 2017 to include the following: "How much do you know about the area's history and cultural heritage?" and "How much do you know about the estuary's ecology?" In both cases, a further question was then asked: "Has this knowledge affected the way you use the estuary? Why/why not?"

Of the 42 boat users who were asked this question (post-28 January), 64% (n = 27) claimed to know something about the history and cultural heritage of the area. When asked whether this knowledge affected the way they used the estuary in any way, 67% (n = 28) were mindful of their use, whether that be through respecting culturally sensitive areas, being conscious of noise, looking after nature or sticking to the main vehicle routes, with 30% (n = 13) specifically mentioning the latter. Of those who claimed to know something about the history and cultural heritage of the area, 27% (n = 11) said that knowledge didn't affect the way they used the estuary in any way.

Of the 42 people interviewed at both locations, only 24% (n = 10) expressed some knowledge about the ecology of the estuary. This was despite there being a recently erected information board at Delaware that explains the ecological importance of the Delaware Bay ecosystem (Figure 19). When asked whether that knowledge affected the way they used the estuary, seven people explained that as a result they stuck to the main vehicle tracks on the estuary, avoided areas where seagrass is present, or only launched and retrieved their boats at high tide (to avoid driving over the estuary).

Figure 19. Cawthron summer scholarship student beside Nelson City Council signage at the Delaware Inlet, informing visitors of the importance of estuaries in terms of ecological, recreational and heritage values.

4.6.4. Suggestions for improving boat access in the area

Out of the total of 77 boat users who responded to the questionnaire at both locations, 42% (n = 32) asserted that they wanted boat access in the area to “remain the same” (Table 7). Many of those respondents expressed their attraction to the area as a wild, relatively untouched and isolated recreational location.

Other popular suggestions were to mark a vehicle route (or routes) across the estuary to guide vehicles (17%, n = 13) and to build a ramp at Cable Bay (16%, n = 12). Less frequently mentioned was a suggestion to provide more signage and information at the boat launching sites (6%, n = 5) and to provide more parking space (5%, n = 4). Other suggested alterations to the Delaware Inlet were to widen and smooth out access points onto the estuary, to build a concrete slip, and to provide facilities (such as a toilet).

Others were adamantly opposed to any suggestions for improving boat users’ access at Delaware Inlet, claiming that such improvements would likely attract more people to the area and thereby detrimentally impact the natural character of the area.

Table 7. Summary of boat users’ suggestions for improving boat access in the area.

Suggestions	Frequency suggested
Keep as is	32
Marked route/s in estuary	13
Ramp at Cable Bay	12
More signage and information	5
More parking space	4
Widen and smooth out access point to Delaware Inlet	3
More facilities at Delaware Inlet	3
Breakwater at Cable Bay	2
Concrete slip at Delaware Inlet	1
Get rid of Cable Bay as a launching location	1
Restrict access	1
Hard fill the shoreline around Delaware Inlet	1
Address boat traffic at Port Nelson	1
Build a boat ramp at the Glen (Glenduan)	1

4.7. Vehicle and boat counts

Fixed cameras were set up at locations overlooking boat launching sites at Delaware Inlet and Cable Bay. Photographic images collected over a period of nine weeks were downloaded and then analysed to tally up the total number of vehicles driving on the beach at each location over a continuous 24-hour, nine week period (Table 8). Note that boat user numbers included kayakers only if a vehicle was used to launch them.

In all but one week (20–26 January 2017), Delaware Inlet was a more popular boat launching site than Cable Bay—averaging more than twice the volume of traffic. Counts were especially high when long holiday weekends coincided with good weather and fishing conditions (Nelson Anniversary on Monday, 30 January and Waitangi Day on Monday, 6 February). The highest count on a single day occurred on Saturday, 25 February, with 33 vehicles at Delaware Inlet and 11 at Cable Bay. A drop-off in vehicle numbers was noted going into March.

Table 8. Number of boat launchings and retrievals at Delaware Inlet and Cable Bay as recorded from time-lapse photography. See paragraph below regarding possible double-counting.

Week	Dates (Friday 12am to Thursday 11.59pm)	Delaware	Cable Bay
1	Friday 6 – Thursday 12 January 2017	61	13
2	13 – 19 January	41	*
3	20 – 26 January	28	38
4	27 January – 2 February	107	49
5	3 – 9 February	82	35
6	10 – 16 February	83	26**
7	17 – 23 February	72	24**
8	24 February – 2 March	99	12
9	3 – 9 March	40	18
Average occurrences per week		**68**	**27**

* No photos were obtained from Cable Bay during this period.

** The fixed camera at Cable Bay was interfered with on 14 February and later corrected on 21 February. During this period the altered field of view may have caused some vehicles to be missed.

The following caveat should be taken into account when considering the data in Table 8. If both launching *and* retrieval of a boat occurred at low or mid tides, then double-counting is likely. Given that individual vehicle data (e.g. registration plates) were not identified from the photographs, it was impossible to determine and hence eliminate instances of double-counting. At high tide at Delaware Inlet, a boat can be either launched or retrieved in only a few minutes from Maori Pa Road and the camera is less likely to have recorded the event (depending on the time-lapse sequencing). Such a boat was likely to be counted only once.

4.8. Interviews with local residents

Eight interviews were conducted with ten residents of Maori Pa Road and Cable Bay to gather their views on boat launching activities at Delaware Inlet and Cable Bay. The interviews established the residents' history in the area; explored the issues concerning protection of the estuary and environs (values, changes observed, feelings, and their personal recreational use); and enquired about ways of finding a solution acceptable to local iwi, local residents and recreational boat users (Appendix 4). The overall results are summarised in Table 9.

Table 9. Summary of interviews with local residents of Maori Pa Road and Cable Bay.

Resident Number	Location	Boat user	What they value about the estuary	Changes in the estuary or people's use	Concerns for estuary	Driving over the estuary	Has rescued stuck vehicles	Build a ramp at Cable Bay?	Open/ close vehicle access
1 & 2	Maori Pa Road	No	Uniqueness, feeling of remoteness	Number of people has increased, more trespassers	Damage to DOC reserve, fires, litter, people not respecting private land	Strongly disagree	No	No answer	Close
3	Maori Pa Road	Yes	Beauty, history, wildlife, recreation	Number of people has increased, end of beach is eroding	Not enough signage, not enough parking at Delaware	Agree	Yes	Disagree	Leave open
4	Cable Bay	No	Beauty, changing views	Number of people has increased, silt and debris from 2012 flood	Not enough parking at Cable Bay, safety of beach users	Agree	Yes, lots at Cable Bay	Strongly disagree	Leave open
5	Maori Pa Road	Yes	Tranquillity, views, access to fishing	None	Maintaining access to Delaware Inlet	Strongly agree	No, but has told them off	Strongly disagree	Leave open
6	Maori Pa Road	Yes	Changing views, recreation	None	Ill-informed people driving over estuary	Agree, but with restricted access	Yes	Strongly disagree	Leave open
7	Cable Bay	No	Naturalness, history	Number of people has increased, spit on Delaware Bay is eroding	Quality of Cable Bay road, noise pollution	Agree, but need to find a compromise	Yes	Disagree	Leave open
8	Maori Pa Road	No	Recreation	Number of people has increased, silt from floods	None	Agree	Yes, one instance where she was asked for help and refused	Disagree, but thinks it would divert people from the estuary	Leave open
9 & 10	Cable Bay	Yes	Access, nature	Increase in sediment from logging in the valley, increase in number of people	None	Strongly agree	Yes	Disagree	Leave open

4.8.1. What local residents value most about Delaware Inlet

The interviews with local residents characterised the community as non-transient, with interviewees residing in the area for an average of 30 years (ranging from 10 to 55 years' residence). When asked "What do you value most about Delaware estuary and why?" most interviewees expressed appreciation for the outstanding natural character of Delaware Inlet: "I value the nature of it, the wildlife, the history, and the opportunity to recreate…" (*Interview* 31 January 2017). Others also appreciated aesthetic and amenity values, commenting on "the pristine, the quietness", the "tranquil" and "ever-changing views", the "beauty", and its ecological uniqueness: "Its naturalness. There's very little human impact on the estuary at this point compared to other estuaries in the area. It's quite unique" (*Interview* 9 February 2017).

Recreational activities were also mentioned by local residents who valued opportunities for multiple recreational uses including swimming, surfing, wind surfing, kayaking, paddle boarding, boating, fishing, horse riding, beach walking and collecting shellfish. Safety for boat launching and fishing with children and families was noted by one interviewee. For another resident, fishing was paramount: "That's the sole reason why we live here; because we love our fishing and we've got access" (*Interview* 5 February 2017). He explained that his boat was custom-built 30 years ago for the sole purpose of launching at Delaware Bay.

Value for the natural history of the Delaware Inlet was mentioned by one resident: "There's a mix of archaeology, so you've got the history. You've got the birds that breed out there, there's fish stock. Occasionally there's surf, which I love to do [surfing] out here. It's just a really beautiful, peaceful place. There's good wildlife" (*Interview* 31 January 2017). A resident of Cable Bay explained: "Because we've been here so long, we also value the history" (*Interview* 9 February 2017).

4.8.2. Residents' observations of changes to Delaware Inlet and Cable Bay

Regarding changes to the estuary at Delaware and to the way that people are using it, a number of interviewees commented on the increased number of people launching boats at Delaware Inlet and the related increase in traffic. That observation included kayakers as well as those using power boats. The increase was explained as a consequence of opening Maori Pa Road to the public in 1999 following approval by Nelson City Council for a subdivision development.

One Cable Bay resident of 42 years commented that the population had doubled in her time of residence, and that the increasing number of people using the area to access the coast was putting pressure on the area. Another long-time resident of Cable Bay confirmed that the number of visitors to Cable Bay had increased rapidly. He explained that parking during peak seasons had become an issue, sometimes requiring the towing of vehicles that blocked facilities on privately owned land. Parking at Delaware Inlet was also mentioned: “Down the track, there will be issues with where they park; there’s only so many vehicles that can fit” (*Interview* 31 January 2017).

Vehicles used to launch boats and ‘hoons’ getting stuck on the mudflats were specifically mentioned by a number of interviewees with regard to impacts on the estuary. However, disrespectful behaviour also extended to other recreationists and tourists who might assume unrestricted access and thereby trespass on the private road (despite signage) and cross private land without seeking prior permission. As one interviewee summed up: “People think they can come and go out here as they like” (*Interview* 31 January 2017). Concern about the spit (which is partly privately owned) at Delaware Bay included trespassing on private land, people setting fires and littering, and damage to the Department of Conservation reserve. One long-term resident had even been threatened and physically attacked by a trespasser who he had approached to evict from his land.

Some interviewees pointed out concern for erosion at the end of the beach and on the spit at Delaware Bay, but acknowledged that natural processes play a part in that. Other interviewees commented on the impact of floods on the estuary ecosystem, with increased amounts of siltation and debris at times discolouring the estuary.

4.8.3. Residents’ views about people driving over the estuary

As summarised in Table 9, most residents (with the exception of two residents interviewed together) agreed that driving over the estuary at Delaware Inlet should be allowed and that access onto the estuary for boat launching should be open to the public. One local resident reported that: “At the moment I have no problem with the usage and, in fact, I really enjoy seeing everyone enjoying it [while] out with their family and friends having a good time” (*Interview* 31 January 2017). The same resident expressed concern about people who “don’t know where to go” to launch their boats at Delaware Inlet and consequently end up: “…driving over the eelgrass beds. I don’t think that’s good. But that’s only because of their ignorance; they don’t know” (*Interview* 31 January 2017).

It was noted by one resident that those who drive over muddy areas leave behind vehicle tracks for a long time. Another interviewee said that due to the “hard substrate” he considered there to be minimal impact to the estuary by vehicles and that the tide washed away any tyre marks. The same interviewee argued that only a small fraction of the estuary is used and that: “There’s not the slightest bit of damage out there at all; that’s complete and utter rubbish” (*Interview* 5 February 2017).

The two residents who “strongly disagreed” to vehicular access on the estuary would also like to see a ban applied to horses. All local residents who were interviewed had witnessed vehicles stuck at Delaware Inlet, and nearly all interviewees had at some stage helped vehicle owners who got into trouble. One local resident recounted an incident where she and her husband refused to use their tractor to help tow a vehicle stuck in mud in the estuary and the vehicle was then submerged at high tide: “Our tractor is worth way more than their car!” (*Interview* 7 February 2017).

Several interviewees characterised the ‘offenders’ as: “…bloody idiots who have gone for a joy ride or something across somewhere they shouldn’t have gone…” (*Interview* 15 February 2017). A similar sentiment reveals local residents’ frustration: “You get the odd idiot that goes out there and does donuts and things and drives in silly places, and you think ‘well, they get what they get’ [i.e. stuck]” (*Interview* 15 February 2017) (Figure 20). However, not all of these people are young or ‘hoons’; some are four-wheel drivers and “just people that are ill-informed” (*Interview* 7 February 2017).

In contrast, vehicles driven onto the estuary for the purpose of launching or retrieving boats at Delaware Inlet were considered far less likely to get stuck, as one interviewee explained:

> People with boats are normally pretty responsible, 99 percent of the time. They don’t want to lose their boat. They are experienced boaties; they can tow a boat for a start. They wouldn’t go out there unless they asked where to go or they probably watched somebody (*Interview* 15 February 2017).

This observation was confirmed by another resident:

> I work here, I look out every day and every night. I see everything that goes on down there [at Delaware Inlet] and I would say it’s very rare that you would get someone being a total idiot and driving all over the place. And if they do, they get told off. There’s always a local that will yell out at them and give them their opinion (*Interview* 31 January 2017).

One of the local residents who has seen three or four people “going for a hoon” around the estuary described his interaction with the young drivers:

> I’ve given them a few rark-ups and they’ve been so apologetic that they’ve almost been in tears by the time I’m finished with them… They never come back. They say they’re sorry, that they didn’t realise and it’s only because there’s no signs (*Interview* 5 February 2017).

Figure 20. A ‘joyrider’ at Delaware Inlet captured on the fixed camera at mid-afternoon on Thursday 23 February 2017.

4.8.4. Residents’ views about building a concrete ramp at Cable Bay

Vehicles getting stuck in the soft sand at Cable Bay when launching or retrieving boats was a far more frequent occurrence according to one interviewee, a long-term resident of the Cable Bay area. He has been involved in many rescues of boats at sea as well as called on to assist boat users’ vehicles that get stuck in the sand, which he explained is sometimes due to them using heavy four-wheel drive vehicles to tow large boats. Other times, vehicles get stuck due to the naturally variable condition of the beach where, on a hot summer day, the sand “puffs up” with the heat and is loosened:

> One week they’ll pull their boat out okay and the next week they won’t… The beach changes so much here; it’s hard to know whether you can launch or not on any given day. People will say ‘I’ve done it two or three times, but I got stuck today. Can you pull me out?’ (*Interview* 31 January 2017).

Delaware Inlet is recognised by local residents as being safer for launching small boats than Cable Bay. One resident said he had seen three or four boats tip over and someone break their leg. He explained: “It’s highly dangerous around there, and not only [because] you have all those people swimming and all those boats getting close. It’s just ludicrous!” (*Interview* 5 February 2017).

Local residents were unanimous in their stance that a concrete ramp should not be built at Cable Bay to assist boat users' with launching or retrieving their vessels (with the exception of a resident who offered no opinion). One resident summarised the potential backlash from residents in these terms: "You would open a can of worms in Cable Bay if you talk about building a boat ramp down there. All the Cable Bay people that use the beach, they don't want a concrete ramp and thirty cars and trailers parked down there" (*Interview* 31 January 2017). Another resident asserted: "Putting a ramp in here would be counterproductive to the people that use it. You're doing it for ten fishermen versus one hundred beach users. It's not a place to have a boat ramp" (*Interview* 31 January 2017).

One interviewee considered Cable Bay as too unsafe, regardless of suggested improvements: "Even with a ramp, when you get those big surges you know it's not safe… because of the waves. There's been a few boats driven through the back window of vehicles…" (*Interview* 15 February 2017). Another resident pointed out that the changing geomorphology of Cable Bay means that the boulders are constantly in motion and would quickly destroy a concrete ramp.

Two residents of Cable Bay raised concern about the winding, narrow road to Cable Bay and highlighted potential safety hazards with increased traffic (especially larger vehicles towing boats). Others noted that there is already insufficient parking without the added pressure of more boat trailers. The cost of improving infrastructure along the route would need to be factored in. Another resident of Cable Bay asserted that it was already a congested launching site. This was also noted by another resident: "Ten boats waiting to put their boats back on the trailer, on the boat ramp, with the sea picking up would be really full on; it would be really tense and quite easy to sink a boat" (*Interview* 31 January 2017).

Another Cable Bay resident reported that there is already conflict between boat users, swimmers and families on the beach (all congregated at the far end of the beach), and that this would likely escalate with any improvement to the boat launching area: "You're either going to have a concrete ramp or swimmers: you can't have both… Kids running around and people backing boats—it's a recipe for disaster. It's going to end badly one day soon" (*Interview* 31 January 2017). This scenario is illustrated in Figure 21 below.

Figure 21. An example of a 4WD vehicle towing another 4WD vehicle with boat trailer that got stuck in the soft sand at Cable Bay. The proximity to swimmers and young families on the beach highlights a safety concern. Photo taken on Saturday 4 February 2017.

4.8.5. Summary of local residents' suggestions regarding vehicle access on Delaware Inlet

In the final line of questions put to local residents, interviewees were invited to offer suggestions for improving where and how boat users' launch and retrieve their boats in the area. Interviewees were also asked to state whether they think Delaware Inlet should be closed to vehicles on the estuary and, if so, what the consequences would be for them and for others. They were also invited to offer thoughts on how they might envisage a compromise between local iwi, local residents and recreational boat users. Suggestions are summarised in Table 10.

Table 10. Summary of suggestions made by local residents regarding the future of vehicle access on Delaware Inlet.

Resident Number	Suggestion
1 & 2	A single marked route as a last chance scenario; if someone strays from that route, then close access completely.
3	Two low concrete or stone markers to mark areas where people can launch, speed limit and boat size restrictions, more informative and detailed signage.
4	Put guidelines in place, grade out parking area.
5	A sign with a map showing three main areas that you can launch, indicated by a series of concrete disks; consequences for those caught outside areas.
6	A sign with a map clearly defining three main launching areas where it is safe to launch and where the damage is going to be minimised; restricted access to vehicles launching and retrieving boats.
7	Designate areas where you can drive and mark with stakes in the ground, access restricted to vehicles launching and retrieving boats, booking at peak holiday periods.
8	A sign with a diagram showing an area that you can launch in, buoys or something to indicate this.
9 & 10	Low fibreglass poles to indicate areas where people can launch, a simple sign telling people to take care and why.

Some interviewees asked that iwi be consulted and one local resident said that: "…there's grievance there and we need to respect that's where they're coming from" (*Interview* 31 January 2017). The same resident suggested that iwi be invited to identify on map signage any areas they don't want people to go or to "have it worded with a little marker" (*Interview* 31 January 2017). Another resident expressed their desire for the community to come together on this issue, and not be divided by it. The resident suggested that a facilitated meeting would require those attending to consider the following: "Being sensitive to each other's needs and recognising that all of the users care about the environment. It's about respecting it and the space, and creating safe usage for the environment and for the people" (*Interview* 7 February 2017).

Regarding residents' views on whether Delaware Inlet should be closed to vehicles, two residents stated that they wished to see Delaware Inlet permanently closed to all vehicles and horses. When questioned further, they were willing to seek a compromise and suggested a single marked route on the estuary with the proviso that if vehicles deviate from that route, then the estuary be permanently closed to all vehicles.

Other local residents expressed unease about potential backlash if the Delaware Inlet was closed to vehicles, as one resident explained: "I think that there would be a tremendous amount of resentment between locals and it would cause a lot of tension if it was closed off completely. It has the potential to get very political—people will not rest" (*Interview* 9 February 2017). Another resident affirmed that opinion: "It's never going to happen. If they [Nelson City Council] ever think they are going to shut it, they're in for a way bigger fight than they realise. And I tell you what—it'll get nasty" (*Interview* 5 February 2017). The same resident threatened personal action: "As long as I've got a machine, there's no way you'll ever put a gate up there. It'll get ripped out!" (*Interview* 5 February 2017).

Other local residents interviewed offered a range of potential solutions which they considered to be fair to everyone. Many suggested better signage with information about the history, wildlife and cultural heritage of the estuary; notification for keeping dogs under control; and a map indicating three areas to launch boats from.[16] Limiting this information to one sign was considered appropriate in order to prevent visual pollution: "We want to see the beauty of the place, not damn signs" (*Interview* 5 February 2017). Others agreed that an information sign should contain content such as: "…respect the estuary, don't drive around here" (*Interview* 31 January 2017).

Most interviewees suggested a marked route across the estuary to minimise damage and limit vehicle impact to a small section of the estuary. It was suggested that such a route could take the form of: "At low tide all you would need is two concrete or stone markers, or even one. Just have a little thing on the map saying this is where you launch at low tide" (*Interview* 31 January 2017). Another resident detailed that the markers could be a series of concrete disks with a white dot; easy to see when you're driving but not visible from far away. It was pointed out that is was unnecessary to have markers at high tide (as boats can be launched directly from the road), and so markers that are low and submersible were regarded as most appropriate: "It doesn't have to be a great big pole sticking up!" (*Interview* 31 January 2017). In contrast, someone else suggested the use of "a couple of white fibreglass poles" (*Interview* 15 February 2017). Suggestions for specific places where marker routes could be placed were outlined by some residents, and it was recommended that frequent boat users should also be consulted for their existing knowledge of the channel and best launching spots at different tides.

In addition to a marked route, some local residents expressed interest in implementing other restrictions such as a speed limit for motor boats and a size limit for boats (i.e. under six metres in length). It was suggested that larger boats can launch from Nelson port, whereas smaller boats are better suited for Delaware Inlet which is safer given that it's sheltered from the sea. Another resident suggested restricting vehicles only to those who are launching or retrieving "marine craft" (including kayaks, paddleboards). Others wished to discourage jet skis—both at Delaware Inlet and Cable Bay, largely

[16] Note that there is already an information sign at Delaware informal boat launching site that outlines the ecological value of the estuary (Figure 19).

as a result of the noise they generate. Another resident suggested that at peak holiday times, people may need to book to reserve a parking space as this is already an issue at Cable Bay.

One resident was particularly interested in the ecological results of this study, and reasoned that if vehicles were proven to cause a lot of damage to the shellfish beds, then restrictions should apply. That could include tidal restrictions, limiting launching or retrieving boat to low or high tides (thereby excluding mid-tide launching sites). The natural changeability of the estuary and shifting areas of soft and hard sand would require that any designated launching sites be re-evaluated on a frequent basis. This might also influence where different-sized boats could be launched from. Another resident was convinced that vehicles do not cause any damage to the estuary, and claimed that sediment transported by rivers into the estuary is more harmful. He voiced concern that that the ecological results from this study will reflect badly on boat users.

Many residents conceded that it would be difficult to enforce any restrictions that the Nelson City Council might apply. One resident reflected: “You can’t force people to stick within a boundary, but you can only request that they do and put something up that gives them a guideline” (*Interview* 15 February 2017). The two residents who are opposed to vehicle use on the estuary were not convinced that boat users would comply: “…the arrogant ones will never change, whatever restrictions you put in place” *(Interview* 31 January 2017). One local resident suggested that the Council could fine (up to $500) those who deviated from an agreed marked route. It is noted that currently local residents, by default, monitor and ‘enforce’ vehicles stuck at Delaware Inlet and Cable Bay, and those who trespass onto private land. In at least one incident reported to Cawthron researchers, a resident has been involved in a physical altercation with a trespasser (which was reported to police).

4.9. Interview with Trustee of Ngāti Tama ki Te Waipounamu Trust and Te Huria Matenga Wakapuaka Trust

A Cawthron social scientist interviewed a Trustee of Ngāti Tama ki Te Waipounamu Trust and Trustee Chair of Te Huria Matenga Wakapuaka Trust at the Cawthron Institute on 8 March 2017. The Ngāti Tama ki Te Waipounamu Trust[17] represents “Ngāti Tama people within the rohe of Wakapuaka down to the West Coast” (*Interview* 8 March 2017). The interviewee is also a Trustee of Te Huria Matenga Wakapuaka Trust set up in 1986 by Judge Isaac under Te Ture Whenua Māori Act 1993. The Wakapuaka 1B Trust, the farm adjacent to the Delaware Inlet, was formerly under the Huria Matenga title.

[17] This is the post-Treaty settlement name of what was formerly the Ngāti Tama ki Te Tau Ihu Trust.

4.9.1. Mana whenua of Wakapuaka rohe

The Ngāti Tama trustee stated that, as mana whenua, the ability to express rangatiratanga with respect to the moana, whenua and awa (sea, lands and rivers) within the rohe of the Delaware Inlet is as important as the ability to exercise kaitiakitanga in protecting those natural resources.[18] The introduction of the Foreshore and Seabed Act 2004 detrimentally affected the ability of Ngāti Tama to exercise their full rights and responsibilities as mana whenua of the Delaware Inlet. As the interviewee explained: “They set the boundaries which you could partake actively in marine areas. It gives no recognition to our ‘supermarket’ that’s there, our ‘motorway’ that’s there” (*Interview* 8 March 2017).

According to the interviewee, following the Supreme Court decision, there are three options Ngāti Tama could pursue with regard to their rights and interests in the Delaware Inlet. They could apply to amend the certificate of title, they could claim customary protective rights, or they could claim customary marine title. Regarding the first option, the interviewee doubted it would be successful, “given the way that records have been held”. The second option, customary protective title, allows continuation of customary activities and would give Ngāti Tama a governance role with the Department of Conservation and Ministry for Primary Industries. However, protective title provides no ability to undertake commercial activities, whereas this would be possible under the third option, customary marine title. The interviewee commented:

> Just having a look at it, personally I think customary marine title may be the more beneficial to us looking at future aspirations if we so chose to do a commercial activity within that area. Protected customary right doesn’t give us that ability, so personally I’d like to go down customary marine title which allows for commercial activities or research. I see it as prime area for research involving both the taiāpure and the marine reserve. But then to do research you need to have capital behind you, so you need to be looking at them both working together in some areas (*Interview* 8 March 2017).

The Treaty of Waitangi settlement Wai 785 (Te Tau Ihu o Te Waka a Maui, Northern South Island Claims) provided iwi in the Top of the South with clearer status in forming direct relationships with Government and government departments. The Ngāti Tama interviewee reported that relationships with operational and managerial staff in Nelson City Council and the Department of Conservation, as well as consultants employed by both, were generally positive: staff are “extremely helpful” and

[18] *Rangatiratanga*: chieftainship, right to exercise authority, chiefly autonomy, chiefly authority, ownership, leadership of a social group, domain of the *rangatira*, noble birth, attributes of a chief. *Kaitiakitanga*: guardianship, stewardship, trusteeship, trustee. Sourced from: http://maoridictionary.co.nz/

understand “the ramifications from [the] Treaty settlement and what [the] obligations are for Nelson City Council” (*Interview* 8 March 2017). As the interviewee explained:

> The fisheries settlement … started the ball rolling for iwi to have some sort of autonomy out there in the community…, but the Treaty of Waitangi [settlement] actually gave us a bit of teeth to be working with councils and [other organisations based on our] statutory declarations from Government and obligations of councils and government departments (*Interview* 8 March 2017).

4.9.2. Aspirations for kaitiakitanga and rangatiratanga with respect to Wakapuaka

In 2002 Ngāti Tama applied for, and were granted, a taiāpure-local fishery under section 181(9)(b) of the Fisheries Act 1996. The taiāpure is for a small special purpose area and covers over 15 km of coastline extending up to 4 km offshore from Cable Bay to Whangamoa Head in northern Tasman Bay. The resultant ‘Whakapuaka Taiāpure’ forms part of Ngāti Tama’s aspirations for rangatiratanga, as summarised in the *New Zealand Gazette*:

> The application by Ngāti Tama seeks by means of a taiāpure to administer and control their fisheries and is a major element of rangatiratanga. The fact that Ngāti Tama seek to exercise that management and control by virtue of a consultative process with all interested parties, does not detract from their rangatiratanga but enhances it (Hodgson 2001, p.2320).

The negotiations between the Taiāpure Management Committee and the commercial fishing sector resulted in a ‘gentleman’s handshake’ that the commercial sector would not fish within the taiāpure area (*Interview* 8 March 2017). According to the interviewee, this voluntary agreement has generally been respected by commercial fishers, although some transgression across the taiāpure boundary at night has been noted by locals. The pressure of increased numbers of recreational fishers, with unimpeded access via the Delaware Inlet boat launching site, has again raised concern for mana whenua about the ecological fragility of the estuary and the sustainability of surrounding coastal and marine environments.

The Taiāpure Management Committee and the Department of Conservation contracted NIWA to map the rocky reefs and other seafloor features using a submersible to take photographs of the substrate on the bottom (Grange 2005). The Taiāpure Committee wanted a detailed picture of the location of different habitat types and resources (e.g. reefs are habitats for kina and crayfish) to assist with management decisions. The interviewee, currently Chair of the Taiāpure Committee, expressed interest in supporting further scientific research on the local ecology (particularly on the kina barrens) within the boundaries of the taiāpure. However, lack of financial resources is limiting further research. The potential benefit of comparative research across different management regimes within the region was highlighted in the following passage:

> To be able to do viable research in the future with comparisons of that area [the Wakapuaka taiāpure], the outside area where commercial activity goes on (bottom trawling, scallops and trawling) and the marine reserve—so, you've got an area of 'no take', an area of recreational take and commercial, [and an area of just] recreation—there could be value in having those areas for the sake of research (*Interview* 8 March 2017).

Research on the ecology of the Delaware Inlet is seen as vital to Ngāti Tama's ability to exercise their ancestral duty as kaitiaki with respect to their taonga. Similarly, a duty to provide for present and future generations' needs through the creation of socioeconomic opportunities (e.g. jobs and education) is seen as critical to the future of a people who wish to continue to reside within their rohe (tribal territories). The interviewee alluded to this in the following:

> Why should one have to move from an area of association instead of being able to… [live and work here]? Okay, we might not have jobs and that here, but you could create jobs. Aquaculture—there's opportunities there. It's [the Foreshore and Seabed Act 2004] just taking away an ability for whanau/hapū to be able to develop (*Interview* 8 March 2017).

Under the operative Nelson Resource Management Plan, aquaculture structures are currently prohibited in estuaries, including Delaware Inlet. The interviewee expressed frustration at the differential treatment of aquaculture and driving on the estuary, both in terms of consent status and enforcement:

> I went to Nelson City Council to have a look about doing a commercial activity on the estuary in aquaculture. I got told it wasn't a permitted activity. Then I read through their [regional coastal] plan and I see that launching and retrieving vessels on the estuary is not a permitted activity. So, it makes me wonder why a small group of the community with short association to the area are allowed to do this when we've had continuous association with the area and we can't move forward (*Interview* 8 March 2017).

4.9.3. Concerns about impacts on Delaware Inlet

The Ngāti Tama interviewee noted that there is a lot more activity on the estuary now: "In the last 12 months I think there's been three vehicles that have been stuck there; two have been totally submerged. You've got vehicles, people just driving all over the place on it" (*Interview* 8 March 2017). The interviewee noted that most boat users who drive over the estuary to launch or retrieve boats do not get their vehicles stuck: "…it's only the joyriders that are getting stuck, going into stupid areas" (*Interview* 8 March 2017) (Figure 20, Section 5.8.3).

The interviewee was concerned about the impact of vehicles on the cockle habitats: "As they're driving over them now, they're compacting the dirt and lessening the biomass within that area. Even though it's not great or the sizes aren't great, [in] the end, that's an animal that's been in that area longer than we've been in Aotearoa" (*Interview* 8 March 2017). Although not specifically mentioned by the interviewee, the destruction of cockle habitats would negatively impact the ability of Ngāti Tama to collect shellfish and exercise mahinga kai (traditional food gathering), which is part of an iwi/hapū's ability to express their mana as tangata whenua when hosting manuhiri (visitors).

Siltation in the estuary was also highlighted as a concern, resulting from human habitation, farmland, forestry, deforestation and "farmland slippages" (erosion on hillsides exacerbated by high rainfall events). Other impacts incur offshore: "I've even heard [name omitted] picked up about three 20 litre used oil containers off the front out here [end of the spit]. [They] came off a ship or someone… going out and dropped it off" (*Interview* 8 March 2017).

On Delaware spit, increased dog activity from recreationists exercising their pets was noted by the interviewee as a threat to nesting birds. Sand dune instability was also raised as an impact due to people making pathways through the sand dunes and the southerly or offshore wind further opening up those pathways, thereby increasing dune erosion and habitat loss for nesting birds.

Other recreational activities have had a direct cultural impact on Ngāti Tama, including the following episode:

> This here [pointing on the map] used to be an area… well it is still, an urupa [burial ground] in there. It used to be an island when I was a kid; now it's eroded away and it's just a build-up of shell midden. We had people coming over here, driving to there and digging up the shell… They were digging up the shell to put on their driveway to have a nice driveway. It was in fact an old urupa and I had this chappie bring up someone's skull and saying 'my boy found this'! So I then turned it back over to the urupa over here [another location] (*Interview* 8 March 2017).

4.9.4. Ngāti Tama interviewee's preferences regarding vehicle access on Delaware Inlet

When asked "what does Ngāti Tama and the Trust feel about people driving over the estuary?" the interviewee responded: "Well, Huria Matenga Trust are very much against it" (*Interview* 8 March 2017). The interviewee affirmed that Ngāti Tama members do not use the Wakapuaka Inlet to launch boats. When asked what the consequences would be for Ngāti Tama if the Inlet was closed to vehicle access, the interviewee explained:

> One, [in] the kaitiaki sense we would be protecting that area… Other than that, I couldn't see anything in terms of consequences, other than stopping us from being able to go forward in doing aquaculture within there. Possibly, hikoi [journeys] with clear bottom barges as in tours over the estuary. Kayaking—that wouldn't be a problem… (*Interview* 8 March 2017).

Noting that Te Huria Matenga Trust are opposed outright to vehicles accessing and driving over the estuary—whether for the purposes of launching a boat or other recreational activities such as walking the dog or gathering cockles—a follow-up question was posed: "If vehicle usage were to continue to occur, what are your suggestions for improving how or where they [vehicle users] launch in this area?" The Ngāti Tama interviewee responded as follows:

> A wooden ramp down to the low tide of a channel and reverse all the way down there. Otherwise you're still going to have people going off [to the sides of a single track]. You might put markers out, [but] if someone sees 'oh, it'll be better I don't have to go as far if I can go down here, I'll take off onto another area.' But if there's only access onto that ramp, and that was it… It's the only way to really control that area or to control the activity of driving down there, so it's specifically for launching and retrieving (*Interview* 8 March 2017).

Regarding the cost of constructing a wooden ramp, the interviewee suggested:

> Huge cost, I know. 'No cost' would be to stop [access] altogether… we could easily have 'user pays' [to pay for the ramp]. For using the boat ramp down on the [Port Nelson] wharf, they pay. You go to Kaiteriteri, you pay for the boat ramp there. [If] people want to use it, it's user pays—they pay (*Interview* 8 March 2017).

The interviewee was in favour of improving the concrete ramp for launching boats at Cable Bay and upgrading it to a "proper concrete pad much like [at] Kaiteriteri" (*Interview* 8 March 2017), although also cognisant of the local conditions when the afternoon sea breeze picks up and issues such as limited parking space at Cable Bay. The interviewee asserted: "I fully support improving that area because it's a recognised area [for launching boats]" (*Interview* 8 March 2017).

When asked about the option of having a marked route onto the estuary, as some local residents and boat users suggested, the Ngāti Tama interviewee considered that option unlikely to deter those who are causing problems. Signage to dissuade vehicle access was similarly considered an inadequate measure: "If there's access onto the estuary, you're always going to have those small minority that are going to see how far they can go" (*Interview* 8 March 2017).

The Ngāti Tama interviewee reiterated an aspiration to developing aquaculture in the local area:

> If [Nelson City] Council was to allow for [aquaculture as] a permitted activity, then I would expect them to allow our hapū to look at aquaculture within the estuary as well as research. We were looking to do research on geoducks [large clams] in the estuary, but because it's not a permitted activity we couldn't do something as simple as that (*Interview* 8 March 2017).

4.10. Assessment of options

Table 11 provides a preliminary assessment of options that have been identified in the course of this study. Some options could be implemented in conjunction with others. Regular scientific monitoring of the ecological effects of any vehicle usage at Delaware Inlet has been included at the suggestion of Nelson City Council staff. A more complete assessment would require further consideration and consultation with affected parties.

Table 11. Preliminary assessment of options for boat access at Delaware Inlet and Cable Bay.

Option	Pros	Cons
Status quo	Low financial cost (at least in short term).	Damage to estuary and associated cultural values continues. Rules in NCC coastal plan not being enforced.
No vehicle access to estuary at Delaware Inlet	No more damage to estuary (assuming rules can be enforced). Potential for seagrass rehabilitation.	Enforcement could be difficult and/or expensive. Safety issues for boat users. Renewed animosity between residents, iwi and boat users.
Marked route(s) at Delaware Inlet to limited number of launching points	Reduced damage to estuary. Potential for seagrass rehabilitation outside marked route(s).	Not all vehicles will stay on route. Some ongoing impacts to estuary. Some maintenance required of route markings.
Long wooden ramp at Delaware Inlet	Minimises on-going damage.	Cost. Structure would have visual effects, some shading effects and changes to currents. Possible damage to estuary during construction phase. On-going maintenance required.
Improve facilities at Delaware Inlet; booking system for parking	Improves experience for users.	Cost. Likely to lead to increased use and therefore more damage to estuary.
Improved signage about values of Delaware Inlet	Greater environmental awareness by boat users. With other measures, could help to reduce impact on estuary.	Unlikely to deter 'joyriders' and some boat users from inappropriate behaviour. Damage to estuary and associated values continues.
Restrictions on users of Delaware Inlet e.g. boat/trailer size limits; no jet skis	Reduced ecological and other impacts (depending on restrictions).	May be difficult to enforce.
Install concrete ramp and improve other facilities at Cable Bay	Safer and better experience for users. Some users diverted from Delaware Inlet so reduced impact to estuary.	Increased congestion at Cable Bay, conflict with beach users. Construction cost, with on-going maintenance. Cable Bay still not safe in some conditions.
Regular monitoring of Delaware Inlet	Provides basis for periodic review of approach.	Cost. May not provide definitive conclusions.

5. SUMMARY OF KEY FINDINGS

5.1. Summary of ecological assessment

Vehicle usage zones covered a relatively small amount (2%) of Delaware Inlet but represented 16% of seagrass beds within the estuary. Visible vehicle tracks showed direct physical disturbance to seagrass and other benthic habitats in areas subject to both higher and lower amounts of vehicle usage. It is likely that other vehicle-related ecological impacts are also occurring in midshore zones, including sediment compaction, differences in infaunal community composition and lower infauna abundance, including reduced cockle numbers.

The number of epifauna taxa was lower at the higher vehicle usage zones in the low shore, although the effects of this could not be separated from the influence of grain size composition. Likewise there was some evidence to suggest an historic impact of vehicle usage on seagrass distribution although the effects of this could not be separated from the influence of gravel field substrate. Nearly complete loss of seagrass patches higher up the shore also suggested impacts of vehicle usage, although this could not be confirmed due to differing mapping methodologies, naturally occurring contraction of seagrass beds, and consequences of potential habitat deterioration not related to vehicle impacts.

The 2017 survey results provide a point-in-time benchmark that could be used to track any future changes in the integrity of seabed habitats with regard to effects of higher vehicle usage.

5.2. Summary of social and cultural impacts

Over thirteen non-consecutive days in January and February 2017, 115 boat users were observed accessing Delaware Inlet and Cable Bay. In all but one week in January, Delaware Inlet was twice as popular for boat launching than Cable Bay—averaging 68 occurrences per week as opposed to 27 on average at Cable Bay. Numbers were particularly high when long holiday weekends coincided with good weather and fishing conditions.

Of the 77 boat users surveyed at Delaware, the majority wanted boat access in the area to “remain the same”, meaning continuing the full unimpeded access of vehicles across the tidal flats at Delaware Inlet. Other popular suggestions were to mark a vehicle route (or routes) across the estuary to guide vehicles, and to build a ramp at Cable Bay. Less frequently mentioned were suggestions to provide more signage and information at the boat launching sites, create more parking space, improve access points onto the estuary, build a concrete slip at Delaware Inlet, and provide facilities (such as a toilet). A small number were adamantly opposed to any improvement for boat users' access at Delaware Inlet, claiming that such improvements would likely attract more people to the area and thereby detrimentally impact the natural character of the area.

Local residents noted a substantial increase in vehicle numbers at Delaware Inlet since 1999 when Maori Pa Road became open to the public. The majority of local residents interviewed supported the following: marked route(s) across the estuary to contain vehicles launching boats at low- and mid-tides to a defined path(s), better signage with information and maps, and restrictions on boat size and a speed limit for motor boats. No residents were in favour of building a concrete ramp for boat launching at Cable Bay, citing factors that make this a challenging and sometimes dangerous place to launch at the best of times.

Many residents mentioned the nuisance of 'joyriders' at Delaware Inlet who drive away from the main routes taken by vehicles launching boats, thereby extending the area of impact and sometimes getting their vehicle stuck. Some local residents suggested harsher penalties for those who deliberately deviate from a marked route, although others noted the difficulty in enforcing regulations given the relative isolation of Delaware and Cable bays.

Unimpeded public access does not respect the concerns or mana of Ngāti Tama ki Te Waipounamu. Te Huria Matenga Trust remains opposed to all vehicle access to the tidal flats at Delaware Inlet. They would prefer that the recognised boat launching site at Cable Bay be improved. They consider that a marked route across the estuary at Delaware Inlet would be ineffective; rather, containing boat users to a single wooden ramp was offered as a measure to protect the ecology of the estuary by ensuring that vehicles did not directly drive across and therefore impact the shellfish beds and eelgrass. It was suggested that the cost of such a ramp could be met through user charges.

A taiāpure was established in Delaware Bay in 2002 and Ngāti Tama are looking at options for further research as well as opportunities to provide socioeconomic benefits for their people, potentially including aquaculture. To support this, the Trust has recently applied for a customary marine title to the Wakapuaka estuary, which may enable Ngāti Tama to better express kaitiakitanga and rangatiratanga in their rohe.

We have provided an initial assessment of options that have been identified in the course of this study (see Table 11). A more complete assessment would require further consideration and consultation with affected parties.

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8. APPENDICES

Appendix 1. Hill Laboratory results for grain size and PAH.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Individual Tests			
Dry Matter	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-8
3 Grain Sizes Profile*		0.1 g/100g dry wt	1-8
3 Grain Sizes Profile			
Fraction < 2 mm, >/= 63 µm*	Wet sieving using dispersant, 2.00 mm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-8
Fraction < 63 µm*	Wet sieving with dispersant, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-8

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Polycyclic Aromatic Hydrocarbons Trace in Soil	Sonication extraction, SPE cleanup, GC-MS SIM analysis US EPA 8270C. Tested on as received sample [KBIs:5784,4273,2695]	0.002 - 0.010 mg/kg dry wt	1-2
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	1-2

Appendix 2. Boat User Survey–Observation Chart.

Boat User Survey – Observation Chart

Record number	Location C/D	Date	Time	High Tide*	Weather Conditions	Wind speed**	Type of boat i.e. motorised launch, kayak	Number of occupants	Length of boat	Horsepower of boat	Size of vehicle ***	Vehicle track recorded Y/N

Key:
Location C=Cable Bay, D=Delaware Estuary.
*Tide information taken from Land Information New Zealand (LINZ) website and rounded to the nearest 5 minute interval.
**Wind speed categorised as either calm, light, moderate or strong.
***Size of vehicle will be categorised by 2WD, 4WD or van.
Vehicle track recorded Y=Yes, N=No.

Appendix 3. Boat User Survey–Qualitative Questionnaire.

Boat User Survey – Qualitative Questionnaire

*Adapt questions according to the timing of the interview, the tide and any previous observations

Record number:

1. Where have you come from today? i.e. Stoke, Richmond, Nelson

2. What is your main activity for today?

3. How long do you plan on being out for? Or when did you depart?

4. What length is your boat in metres or in feet?

   - *How much horsepower is it?*

5. What is the make and model of your car? Is it 4WD?

6. How often do you use this boat ramp? How many times have you used it in the past month?

7. Why do you use this particular location to launch?

8. What other boat ramps in the area (if any) do you use?

   - *What makes those boat ramps better/worse?*

   - *Do you ever use Cable Bay? Why Cable Bay over Delaware estuary? Why Delaware estuary over Cable Bay?*

9. How much do you know about the area's history and cultural heritage?

   - *Has this knowledge affected the way you use the estuary in any way? Why/why not?*

10. How much do you know about the estuary's ecology?

    - *Has this knowledge affected the way you use the estuary in any way? Why/why not?*

11. What suggestions do you have for improving boat access in the area? Cable Bay included.

12. What would you like Delaware estuary to look like in the future?

Additional comments

Appendix 4. Interview Questions–Local Residents.

Name: ________________________
Date: ________________________

About the resident

How long have you lived at this residence (or in the area)?

Exploring the issues *(What are we protecting?)*

What do you value most about Delaware estuary? Why?

Throughout the time you have lived here, have you noticed any changes in the estuary or in the way people are using it?

- If so, do these changes concern you? Why/why not?

How do you feel about people driving over the estuary?

Do you have a boat?

- If so, how often do you use Delaware estuary for boating purposes?
- Where do you tend to launch and load? (Show on map)
- How often do you use Delaware estuary for other purposes? Give examples.

Have you witnessed any boat users getting stuck coming back in or going out?

- How often do you hear about this happening?
- Where does this commonly occur? (Show on map)
- Have you had to assist in anyway? And if so, does this bother you?

Exploring solutions (*What is fair to everyone? What is the wise way?)*

What are your suggestions for improving where and how boat users launch boats in this area?

What is your opinion on building a concrete ramp at Cable Bay?

- Do you think this would redirect boat users from Delaware to Cable Bay? Why/why not?

Do you think Delaware estuary should be closed to vehicle access or vehicle access should continue?

- If it were closed, what would the consequences be for you and for others?

Finding a solution *(What needs to happen? Who can help? How can we all work together?)*

Can you envisage a compromise between local iwi, local residents and recreational boat users? What would it look like?

How can everyone work together to make that happen?

Any further comments? Thank you very much.

Appendix 5. Interview Questions – Ngāti Tama ki Te Waipounamu Trust.

Ngāti Tama ki Te Waipounamu Trust / Te Huria Matenga Wakapuaka Trust
Names: ________________________
Date: ________________________

About Ngāti Tama

For practical purposes, are you able to speak for both Ngāti Tama ki Te Waipounamu Trust and Te Huria Matenga Wakapuaka Trust? Are their opinions the same?

Could you please share with us some of the early history of the area, particularly from the 1820s onwards when Ngāti Tama came here from Taranaki?

We understand that the Māori Land Court confirmed Ngāti Tama's title to the estuary in 1988 and 1998, but that this was appealed to the High Court and then the Court of Appeal:

- What is the current land title status regarding the Wakapuaka (Delaware) estuary?
- How has your ability to exercise your title been affected by the Foreshore and Seabed Act 2004?

Has the Treaty of Waitangi Settlement (Te Tau Ihu o te Waka a Maui, Wai 785) changed things, i.e. enabled Ngāti Tama to express te tino rangatiranga or fulfill kaitiaki responsibilities over the Wakapuaka and adjacent whenua and moana? How? Why/why not?

Exploring the issues *(What are we protecting?)*

Has the Wakapuaka Taiāpure (est. 2002) been effective in enhancing the ecological and cultural relationships that Ngāti Tama sought to protect?

Who owns the land on which the urupa is located? *[NB: The block containing the cemetery with Huria Matenga's grave was sold in the 1930s.]*
- Is current protection of the urupa sufficient? If not, how might that be improved?

Over time, have you noticed any changes in the estuary or in the way people are using it?
- If so, do these changes concern you? Why/why not?
- What do you think is being damaged or threatened by this activity?

How does Ngāti Tama and the Trust feel about people driving over the estuary?

Do Ngāti Tama members use Wakapuaka/Delaware estuary for boating purposes?
- Where do they tend to launch and load? (Show on map)
- How often do you/others use Wakapuaka/Delaware estuary for other purposes? Give examples.

Have you witnessed any boat users getting stuck coming back in or going out?
- How often do you hear about this happening?
- Where does this commonly occur? (Show on map)
- Have you had to assist in anyway? And if so, does this bother you?

Exploring solutions

What are your suggestions for improving where and how boat users launch boats in this area?

What is your opinion on building a concrete ramp at Cable Bay?

- Do you think this would redirect boat users from Wakapuaka/Delaware to Cable Bay? Why/why not?

Do you think Wakapuaka/Delaware Estuary should be closed to vehicle access or vehicle access should continue?

- If it were closed, what would the consequences be for Ngāti Tama and for others?

Finding a solution *(What needs to happen? Who can help? How can we all work together?)*

Can you envisage a solution that would be acceptable to all parties – Ngāti Tama, local residents and recreational boat users? What would it look like?

The widespread consultative process that Ngāti Tama undertook in preparation for the Wakapuaka Taiāpure was praised by the Tribunal. What lessons could you offer from that experience in terms of how all parties might come together to reach agreement/resolution with respect to the Wakapuaka estuary?

Any further comments? Kia ora and thank you very much.

Appendix 6. Average abundance of epifauna taxa, and % cover of vegetation, at the vegetated low shore (V) and unvegetated midshore (U) survey sites subject to low (L) and high (H) vehicle usage in Delaware Inlet. Each site has three replicates (n = 3).

Taxa name	**Common name**	**HV1**	**HV2**	**HV3**	**LV1**	**LV2**	**LV3**	**HU**	**LU**
Cominella glandiformis	Mudflat whelk		0.3		0.7	1.0	0.3	0.7	
Cominella maculosa	Spotted whelk					0.3			
Diloma surostrata	Mudflat topshell	0.3		2.7	2.0	8.7	1.0	1.3	1.0
Micrelenchus tenebrosus	Topshell	60.3	5.0	6.3	21.3	5.7	33.7		
Zeacumantus subcarinata	Small spire shell							0.3	
Zeacumantus lutulentus	Spire shell				0.7			1.0	
Notoacmea helmsi	Estuarine limpet	4.3		1.7	6.7	0.3	0.3	1.0	1.7
Lunella smaragdus	Cats eye		0.3	2.0		4.0	0.3		
Austrovenus stutchburyi	Cockle	12.3	2.0	0.3	17.3	4.3	7.0	1.7	2.7
Perna canaliculus	Green mussel						0.3		
Chiton glaucus	Chiton					0.7			
Patiriella regularis	Starfish					0.3			
Halicarcinus sp.	Pilbox crab					0.3			
Hemiplax hirtipes	Stalk eyed mud crab	0.7							
Sphaeromatidae	Isopod				0.3				
Austrominius modestus	Estuarine barnacle	0.3			0.3				
Tubeworm						5.3			
Anthopleura aureoradiata	Mudflat anemone	10.3			18.7		4.7		
	Total average epifauna abundance per core (± 1 SE)	88.7± 10.9	7.7± 2.4	13.0 ± 5.6	68.0 ± 5.0	31.0 ± 6.1	47.7 ± 13.7	6.0± 0.6	5.3 ± 1.5
	Total average no. epifauna taxa per core (± 1 SE)	5.0± 0.6	2.7± 0.3	3.7± 0.9	7.0± 0.6	6.7± 0.9	4.7± 1.5	4.0± 0.0	2.3± 0.3
Ulva (%cover)	Sea lettuce	0.3	0.7						
Gracilaria (%cover)	Agar weed							<0.7	
Zostera muelleri (%cover)	Seagrass	89.3	28.7	54.7	78.7	76.7	88.0		
Unidentified red algae (%cover)									< 0.3

Appendix 7. Abundance of infauna taxa at the vegetated low shore (V) and unvegetated midshore (U) survey sites subject to low (L) and high (H) vehicle usage in Delaware Inlet. Each site has three replicates (n=3).

Taxa name	**Common Name**	**HV1**	**HV2**	**HV3**	**LV1**	**LV2**	**LV3**	**HU**	**LU**
Anthopleura aureoradiata	Mud flat anemone	9.7			1.3		2.3		0.3
Edwardsia sp.	Burrowing anemone					0.3			
Nemertea	Proboscis worms	1.3		1.0		1.7	0.3	1.0	0.3
Nematoda	Roundworm			1.0	0.3	0.7	1.7		
Chiton glaucus	Green chiton		0.3	0.3					
Lunella smaragdus	Cats eye			1.0		1.3	0.3		
Cominella glandiformis	Mud flat whelk	1.3	0.3	1.3	1.0	0.7	2.0	0.7	0.7
Diloma subrostrata			0.3	1.0	0.7	2.0	0.3		1.0
Micrelenchus huttoni	Small top shell	4.7	0.7	0.7	8.0	0.7	11.3		
Notoacmea sp.	Limpet	1.3	4.7	1.7	1.3	1.7	1.0		0.7
Zeacumantus lutulentus	Spireshell								0.7
Haminoea zelandiae	Bubble shell	0.3							
Bivalvia			0.3	0.7					
Nuculidae				0.3					
Arthritica bifurca	Small bivalve	21.3			15.7	0.3	35.3	0.3	6.0
Austrovenus stutchburyi	Cockle	23.0	15.3	13.3	7.3	14.0	23.3	22.0	59.3
Lasaea parengaensis									0.3
Linucula hartvigiana	Nut shell	1.0	0.3	3.7	1.3	1.3	1.7		0.3
Macomona liliana	Wedge shell/ Hanikura	3.3	1.3	4.0	3.7	0.7	9.0		0.7
Musculus impactus				0.3					
Paphies australis	Pipi		1.0						
Soletellina sp.	Golden sunset shell	1.3	1.3				0.3		0.3
Oligochaeta	Oligochaete worms			1.0		4.7	0.7		
Polydorid		0.3		2.0		12.7			
Lagis australis			0.3						
Orbinia papillosa							0.3		
Scoloplos sp.				0.3					
Paraonidae		1.0		5.3	2.3	4.3	1.3		
Aonides sp.		0.3		0.3		8.3			
Prionospio aucklandica		32.3	7.7	64.7	28.7	69.3	22.7	2.7	1.0
Prionospio sp.		0.3	1.3	5.3	2.3	5.7	0.3	3.3	
Capitellidae		7.3	1.3	37.7	4.0	24.3	16.0	0.3	0.3
Barantolla lepte			3.3	7.0		25.7			
Capitella capitata		1.0	5.0	13.0	0.7	4.7	1.3		0.3

Taxa name	Common Name	HV1	HV2	HV3	LV1	LV2	LV3	HU	LU
Heteromastus filiformis			0.3	10.3		1.7			
Maldanidae	Bamboo worm							0.3	
Armandia maculata						2.0			
Scalibregmatidae	Polychaete worm	11.7		0.3	2.3		12.0		
Polynoidae	Scale worms			0.3					
Exogoninae					14.3	0.3	6.0		0.3
Para-syllid			1.3						
Nereididae				0.3		0.3	0.7		
Perinereis sp.		0.3				0.3			
Glyceridae		1.7	2.0	1.3	1.3	7.7	0.7		
Dorvilleidae						1.0			
Owenia petersenae	Polychaete worm	0.7	4.3	16.3	0.3	38.3	0.3		
Acrocirridae				0.3		0.3	0.3		
Spirobranchus cariniferus	Fan worm			0.3					
Cirolanidae		0.3							
Isocladus sp.	Isopod						0.3		
Corophiidae	Amphipod (family)				0.3				
Lysianassidae	Amphipods					0.7			
Phoxocephalidae	Amphipod (family)	0.7	13.3	6.3		7.0	1.7	0.3	
Amphipoda	Amphipods					1.3			0.3
Austrohelice crassa	Tunnelling mud crab	0.3	0.3	0.3		1.0			
Halicarcinus sp.	Pill-box crab					0.7			0.3
Halicarcinus whitei	Pill-box crab	3.0		0.7	1.0		1.7	0.3	1.0
Hemigrapsus crenulatus	Hairy-handed crab; mud crab	0.3				0.3	0.3		
Hemiplax hirtipes	Stalk-eyed mud crab				0.3				0.3
Brachyura				0.3			0.7		0.7
Ostracoda	Ostracod	0.7	0.3	1.7	0.3	3.3	1.0		
Copepoda	Copepods						0.3		
Elminius modestus	Estuarine barnacle		0.7						1.3
Diptera									0.3
Phoronida	Horseshoe worm			0.3					
Asteroidea	Sea stars			0.3		0.3			
Patiriella regularis	Cushion star					1.7			
	Total average infauna abundance per core (± 1 SE)	131.0 ± 9.8	67.7 ± 6.3	206.7 ± 92.9	99.0 ± 32.0	253.3 ± 50.0	157.7 ± 25.6	31.3 ± 5.7	77.0 ± 10.0
	Total average no. infauna taxa per core (± 1 SE)	18.0 ± 0.6	15.3 ± 1.9	23.0 ± 2.1	15.7 ± 0.9	24.0 ± 4.5	22.0 ± 1.5	6.0 ± 1.0	10.0 ± 1.5

Appendix 8. One-way SIMPER analysis of infauna communities at the vegetated low shore (V) and unvegetated midshore (U) survey sites subject to low (L) and high (H) vehicle usage in Delaware Inlet.

Vegetated (low shore) sites

Low vehicle usage

Average similarity: 49.24

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Prionospio aucklandica	5.88	9.26	2.52	18.80	18.80
Austrovenus stutchburyi	3.68	6.50	4.36	13.19	32.00
Capitellidae (other)	3.27	4.43	1.36	9.01	41.01
Arthritica bifurca	3.29	4.03	0.82	8.18	49.19
Micrelenchus huttoni	2.17	3.06	0.96	6.22	55.41
Macomona liliana	1.73	2.27	0.87	4.61	60.02
Paraonidae	1.47	2.20	1.55	4.47	64.49
Exogoninae	1.92	2.08	1.02	4.23	68.72
Linucula hartvigiana	1.03	1.46	1.07	2.97	71.69

High vehicle usage

Average similarity: 45.20

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Prionospio aucklandica	5.20	8.72	2.46	19.30	19.30
Austrovenus stutchburyi	3.76	7.04	1.45	15.58	34.88
Capitella capitata	2.15	3.45	1.26	7.63	42.51
Glyceridae	1.27	2.89	4.04	6.40	48.92
Owenia petersenae	2.10	2.82	1.08	6.23	55.15
Phoxocephalidae	2.02	2.58	0.72	5.71	60.85
Macomona liliana	1.45	2.38	1.12	5.28	66.13
Notoacmea sp.	1.32	1.99	1.11	4.39	70.52

Unvegetated (midshore) sites

Low vehicle usage

Average similarity: 51.33

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Austrovenus stutchburyi	7.64	35.43	10.99	69.02	69.02
Arthritica bifurca	2.41	10.73	9.50	20.91	89.93

High vehicle usage

Average similarity: 68.97

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Austrovenus stutchburyi	4.64	36.89	8.63	53.48	53.48
Prionospio sp.	1.75	11.89	2.66	17.24	70.72