Vehicles on beaches in New Zealand: an annotated bibliography of research on physical and ecological impacts.

Introduction

The New Zealand Coastal Policy Statement 2010 (NZCPS) includes a policy (Policy 20) on vehicle access to the coast:

Policy 20 Vehicle access
(1) Control use of vehicles, apart from emergency vehicles, on beaches, foreshore, seabed and adjacent public land where:
(a) damage to dune or other geological systems and processes; or
(b) harm to ecological systems or to indigenous flora and fauna, for example marine mammal and bird habitats or breeding areas and shellfish beds; or
(c) danger to other beach users; or
(d) disturbance of the peaceful enjoyment of the beach environment; or
(e) damage to historic heritage; or
(f) damage to the habitats of fisheries resources of significance to customary, commercial or recreational users; or
(g) damage to sites of significance to tangata whenua;
might result.
(2) Identify the locations where vehicular access is required for boat launching, or as the only practicable means of access to private property or public facilities, or for the operation of existing commercial activities, and make appropriate provision for such access.
(3) Identify any areas where and times when recreational vehicular use on beaches, foreshore and seabed may be permitted, with or without restriction as to type of vehicle, without a likelihood of any of (1)(a) to (g) occurring.

Attempts by council and Department of Conservation (DOC) staff to apply Policy 20 are often met by requests for evidence to show that vehicles do cause damage to coastal systems in New Zealand. There are many international publications on the impact of vehicles on the physical and biological aspects of beaches and dunes, the purpose of this bibliography is to bring together documents on research carried out in New Zealand.

Stephenson (1999) undertook a review of vehicle impacts on the biota of sandy beaches and coastal dunes. He found very little work had been done in NZ. In a review of visitor impacts on marine reserves in New Zealand, McCrone (2001) referred to a couple of New Zealand articles Stephenson had missed, but also found a paucity of New Zealand work.

This bibliography is focused on impacts on the natural environment. It does not cover legal and planning documents.

This bibliography will not be complete. If you have any documents or research to contribute please contact me.

Presentation of documents

Documents are presented by category, and within each category by national and then regional, arranged north to south. Within each sub-category documents are arranged chronologically, as many build on what has been done before.

Reviews

Stephenson, G. 1999: Vehicle impacts on the biota of sandy beaches and coastal dunes: a review from a New Zealand perspective. *Science for Conservation 121*. Department of Conservation, Wellington. 48 pp.

https://ref.coastalrestorationtrust.org.nz/site/assets/files/5813/sfc121.pdf

This is the review that authors refer to most frequently in a New Zealand context. Stephenson relied almost exclusively on overseas work to draw his conclusions on future management of the coast with respect to vehicles. He identified the need to for future research into impact of vehicles on dunes and beaches to underpin decision-making processes.

McCrone, A. 2001. Visitor impacts on marine protected areas in New Zealand. *Science for Conservation 173.* Department of Conservation, Wellington. 68 pp.

https://dcon01mstr0c21wprod.azurewebsites.net/globalassets/documents/science-and-technical/sfc173.pdf

McCrone (1991) identified a couple of references that Stephenson missed in 1999. However, one of these (Harris) only contains a comment to the effect that 4WD vehicles and trial bikes had a major impact on foredune and stability and cover over the previous 10 years. I've included Harris (1988) should others seek it based on McCrone's review.

Taylor, G.F.; Marsden, I.D.; Hart, D. 2012a: Management of vehicle and horse users on sand beaches: implications for shellfish populations. *Estuarine Research Report 41*. School of Biological Sciences and Department of Geography, University of Canterbury, Christchurch. 48 pp.

https://ref.coastalrestorationtrust.org.nz/site/assets/files/7221/12642945_estuarine_research_report_41_review_of_sand_beach_management_for_shellfish.pdf

This report reviews management documents and peer reviewed literature to evaluate the level of protection intertidal shellfish are given from vehicle and horse users on sand beaches. It includes a good overview and listing of overseas literature. Although the focus was on peer-reviewed literature, the only New Zealand example used was from grey literature (Moller et al. 2009). The report also covered all biota, not just shellfish.

They found that: *Internationally, policies controlling vehicle and horse users utilise five common options: complete bans, seasonal closures, permits, area-based and zone-based designation. These management options usually focus on erosion prevention and ensuring*

safety of users with little consideration of ecological impacts. When ecology is considered, this concentrates on protecting the more visible species (e.g. nesting birds) rather than infaunal biota. Shellfish were not directly mentioned in any management policies that control vehicle and horse users.

They concluded that, in order to successfully protect intertidal species such as tuatua, scientific information which identifies and describes the distribution, vulnerable life-stages and the relationship between beach traffic and shellfish vulnerability is needed.

The report used Pegasus Bay as a case study of how the management of vehicles relates to shellfish management.

This report contains valuable references to international literature, and does well to relate current management to environmental impacts.

Department of Conservation. 2018. NZCPS 2010 guidance note. Policy 20: Vehicle access. Department of Conservation, Wellington.

https://www.doc.govt.nz/globalassets/documents/conservation/marine-and-coastal/coastal-management/guidance/policy-20.pdf

This guidance note explains the rationale behind the policy, includes links to case law and policy, as well as a few links to documents assessed in this annotated bibliography.

Shellfish

National

Heasman K, Keeley N, Sinner J. 2012. Factors affecting populations of Toheroa (*Paphies ventricosa*): a literature review. Manaaki Taha Moana Research Report No. 10. Cawthron Report No. 1997. 29 p. Plus appendices.

https://www.mtm.ac.nz/wp-content/uploads/2017/03/report-10.pdf

This report recognises vehicle damage as a potential cause of decline in toheroa populations. It draws on international literature and some of the work in Northland.

Williams, J.R.; Sim-Smith, C. & Paterson, C. 2013. Review of factors affecting the abundance of toheroa (*Paphies ventricosa*). *New Zealand Aquatic Environment and Biodiversity Report* No. 114. Ministry of Primary Industries.

https://ref.coastalrestorationtrust.org.nz/documents/review-of-factors-affecting-the-abundance-of-toheroa-paphies-ventricosa/

This report introduces the section on vehicle impacts (pg 12) by referring to international literature that shows vehicle beach traffic has adverse effects on beach flora and fauna. It then discusses the NZ situation with reference to toheroa specifically. It summarises the limited quantitative data that are only available for Ninety Mile Beach, Muriwai Beach and Oreti Beach.

There's a section on documented vehicle activity on toheroa beaches (pg 19; Table 5; Figure 9). Not all of these references refer to impacts, so they won't necessarily be included in this bibliography.

Their conclusion was: The literature review provided strong evidence that toheroa are vulnerable to the effects of vehicles traversing the beach. However, there are few data available on the number of vehicles driving on toheroa beaches at present to be able to compare to historical values. Furthermore the areas that vehicles use when traversing the beach are also not regularly monitored. Vehicle users may not be aware of the potential impacts of driving vehicles on beaches where toheroa are present (Reynolds 2009). A programme that aims to educate beach users about the possible effects could be used in tandem with zoning to reduce impacts and increase awareness.

This report includes as an appendix a report by Smith (2009 (but 2013 on actual report)) on factors affecting the abundance of toheroa on Northland beaches, based on key informant interviews. Deleterious effects of vehicles was a common issue. Respondents also raised the issue of vehicles accessing beaches through dunes, and their impact on vegetation, particularly pingao.

I see this as one of the main reports to consult for anybody wishing to address the impact of vehicles on beaches.

Ross, P.M.; Beentjes, M.P.; Cope, J.; de Lange, W.P.; McFadgen, B.G.; Redfearn, P.; Searle, B.; Skerrett, M.; Smith, H.; Smith, S.; Te Tuhi, J.; Tamihana, J. & Williams, J.R. 2018. The biology, ecology and history of toheroa (*Paphies ventricosa*): a review of scientific, local and customary knowledge. *New Zealand Journal of Marine and Freshwater Research* 52: 196-231.

https://www.tandfonline.com/doi/full/10.1080/00288330.2017.1383279?scroll=top&needAccess=true (full access – the initial link failed while working on this report, so may require a google scholar search)

Like many reports this paper highlights the international situation then provides a summary of the New Zealand situation based on similar reports to Williams et al. (2013). Williams et al. (2013) contains more detail on the impacts of vehicles on toheroa than this review.

Northland

Greenway, J.P.C. 1969. Population surveys of toheroa (Mollusca: Eulamellffiranchiata) on Northland Beaches, 1962–67. *New Zealand Journal of Marine and Freshwater Research*, 3:2, 318-338. https://www.tandfonline.com/doi/pdf/10.1080/00288330.1969.9515300

This paper includes an early observation on the possible impact of vehicles on toheroa on pg 337, including the potential for impacts on surface-dwelling juveniles that had not at that stage been observed: "*Though more widespread use of cars has increased the amount of traffic on the beaches, there is no evidence to support the widely-held belief that traffic shatters living toheroas beneath the surface; certainly larger sized animals are unharmed. Surface-dwelling juveniles might be affected, but this has not been observed*."

Redfearn, P. 1974. Biology and distribution of the toheroa, *Paphies (Mesodesma) ventricosa* (Gray). Fisheries Research Bulletin No. 11. Fisheries Research Division, New Zealand Ministry of Agriculture and Fisheries, Wellington. 52 pp.

https://docs.niwa.co.nz/library/public/FRB11.pdf

In this report Redfearn postulates that heavy vehicular traffic semi-liquefies the sand, and the toheroa are floated up towards the surface, where a small hummock is pushed up. photographs of this are included. He suggests that this may cause the toheroa to be leached out of the sand in the next high tide.

Brunton, P.M. 1978. Toheroa predation by black-backed gulls on Dargaville beach, North Auckland, New Zealand. *Notornis* 25: 128-140

https://ref.coastalrestorationtrust.org.nz/site/assets/files/7002/notornis_25_2.pdf

Brunton suggested a mechanism to explain Redfearn's observations. His main points were:

- Toheroa disturbed by the passage of a vehicle actively moved upwards.
- Some reached the surface quickly, other took several minutes.
- One pass was sufficient to cause a very notable response.
- The elevation response occurred mainly during the warmer months.
- Possibly pressure provides a cue which elicits the elevation response in toheroa prior to migration up the beach.
- Toheroa which have raised themselves in response to the stimulus probably can't rebury unless there's a certain minimum amount of water in the sand, and so are highly vulnerable to predation.

Redfearn, P. (1997). Statement of evidence by Peter Redfearn concerning toheroa. *Document D8 in the Muriwhenua Land Report (Wai 45) Record of Inquiry*.

Reports by NIWA staff often refer to this evidence. Evidence often synthesises a situation very succinctly. However, I have not been able to trace the document, so cannot comment on it's value to council officers. It is unlikely to contain new research.

Hooker, S. & Redfearn, P. 1998. Preliminary survey of toheroa (*Paphies ventricosa*) populations on Ninety Mile Beach and possible impacts of vehicle traffic. *NIWA Client Report AK98042 for Northland Regional Council.* 33pp.

https://ref.coastalrestorationtrust.org.nz/site/assets/files/9883/hooker_and_refearn_1998_niwa_client_report_ak98042_toheroa.pdf

This is the first report I'm aware of that quantifies vehicle usage at a beach and relates that to environmental impacts, in this instance shellfish at Ninety Mile Beach during a fishing competition. It also postulates further on the reaction of shellfish to the passage of vehicles.

Their conclusions include:

- *The fishing contest creates unique traffic conditions on the beach. Extremely high traffic volumes were recorded during the fishing contest of which most of the vehicles were four wheel drives. The distribution of the traffic was modified by the state of the tide, which often resulted in the vehicles driving over the main part of the toheroa beds.*
- *The high volume of traffic during the fishing contest produced reasonably high levels of immediate mortality of juvenile toheroa from one site due to the repeated impact of high volumes of vehicles. There was little immediate mortality observed of adult toheroa observed during this study.*
- *This preliminary study was confined to the immediate impacts of vehicle traffic on the beach and it is not known what longer term impacts vehicles may have on toheroa. Toheroa may have been stressed by the vehicle passage and died sometime later. The study was also confined to a high traffic volume fishing contest and it is not known what happens outside the fishing contest when traffic volumes on the beach are lower.*

Morrison, M.; Parkinson, D. 2001. Distribution and abundance of toheroa (*Paphies ventricosa*) on Ninety Mile Beach, March 2000. New Zealand Fisheries Assessment Report 2001/20. 27 pp.

https://docs.niwa.co.nz/library/public/FAR2001-20.pdf

This report includes heavy vehicle traffic as a possible reason for the decline in toheroa population declines. It refers to data from Hooker and Redfearn (1998), but doesn't contain any new quantitative material.

Sim-Smith, C.; Jeffs, A.G.; Cole, R. 2007. Assessment of the impact of mechanical harvesting of mussel spat on the infauna of Ninety Mile Beach. *Unpublished NIWA Client report AKL2007-21*. 17pp.

This report was done for a private company, Kaitaia Spat. The original report has not been sighted, however, its findings and ongoing iwi concerns are reported in:

Fisheries New Zealand. 2019. Green-lipped mussel. In: Review of sustainability measures for 2018/19. Ministry of Primary Industries, New Zealand.

https://www.mpi.govt.nz/dmsdocument/29702/direct

pt 549 on pg 112:

Members of the Te Hiku o Te Ika Fisheries Forum have raised concern about expansion of the fishery. In particular, the increasing use of mechanical harvesters (modified tractors) which have been adopted by fishers to increase efficiency in gathering the combined seaweed and spat material. In 2007 research was undertaken on this topic by NIWA for a key quota holder (Kaitaia Spat). This report concluded that there was little difference in the impact between the mechanical harvesting method and hand-gathering methods. However concerns remained about the harvesting methods and in a management plan developed by iwi, fishing and marine farming representatives in 2010 it was agreed that industry would consider the appropriateness of current and further means to avoid adverse effects from vehicles and or harvesting practices on Te Oneroa a Tohe/ Ninety Mile Beach. Members of the Te Hiku o te Ika Fisheries Forum have reported continued concerns about ongoing and increased use of mechanical harvesting methods and have reported that tractors are being used in a way which is aggressive to the beach environment.

Results are also reported in Sim-Smith (2009), where data are included.

Morrison, M. & Parkinson, D. 2008. Distribution and abundance of toheroa (*Paphies ventricosa*) on Ninety Mile Beach, 2006. New Zealand Fisheries Assessment Report 2008/26. 27 pp.

Abundance of blue cod off Banks Peninsula in 2005 (niwa.co.nz) (badly titled link – the link is correct for the reference)

This report is very similar to their 2001 report. It includes heavy vehicle traffic as a possible reason for the decline in toheroa population declines. It refers to data from Hooker and Redfearn (1998), but doesn't contain any new quantitative material.

Sim-Smith, C. 2009. A literature review on the ecological health of Ninety Mile Beach, Northland. NIWA Client Report AKL2009-11 prepared for Office of Treaty Settlements, Ministry of Justice
https://ref.coastalrestorationtrust.org.nz/site/assets/files/6270/akl2009-11_literature_review_of_90_mile_beach_final_draft.pdf

This review draws on earlier research and proposed mechanisms in which toheroa are impacted. Sim-Smith pulls these ideas together very well and adds to them. A very good overview of the situation and how it may play out.

Canterbury

Cranfield, H.; Michael, K; Dunn, A. 2002. The distribution, abundance and size of tuatua (*Paphies tuatua*) on New Brighton Beach, Christchurch, in 2001. National Institute of Water & Atmospheric Research Ltd. New Zealand Fisheries Assessment Report 2002/5.

https://fs.fish.govt.nz/Doc/17433/2002%20FARs/02_05_FAR.pdf.ashx

In the discussion (pg 22) the authors speculate about spat in the high intertidal being particularly vulnerable, possibly contributing to the variability in recruitment. They comment on the area around the high tide mark being favoured by vehicles, providing details on how vehicles alter the physical packing of sand. Tuatua spat are unable to burrow in the physically altered sand, desiccate and die. No data are provided. Like many authors they call for further study on different levels of compaction.

Marsden, I.D. & Taylor, G.F. 2010. Impacts of vehicles on juvenile tuatua, *Paphies donacina* on Pegasus Bay surf beaches. Estuarine Research Report 38. School of Biological Sciences and Department of Geography, University of Canterbury, Christchurch.

https://ref.coastalrestorationtrust.org.nz/documents/impacts-of-vehicles-on-juvenile-tuatua-pahies-donacina-on-pegasus-bay-surf-beaches/

This detailed field experiment done for Environment Canterbury investigated the effects of driving an off road vehicle on intertidal tuatua on an exposed surf beach adjacent to Bottle Lake Forest Park. They conducted experiments over several days and trialled different numbers of vehicle passes.

Their conclusions were: *…that the main factors affecting the susceptibility of juvenile tuatua to*
vehicle passes were body size, the frequency of passes and the sand conditions. Other features likely to be important include the ground pressure exerted by the vehicle and also the level within the intertidal zone where the vehicle is driven. Further research is needed to understand whether the findings reported here apply to other areas and at different times of the year.

They also recorded different impacts on different days, highlighting the importance of having a decent study design.

This report contains a wealth of information, and I would recommend it as a source to anyone concerned about vehicle impacts on shellfish.

Taylor, G.F., Marsden, I.D. & Hart, D.E. 2012b. Seasonal effects of vehicles on juvenile tuatua (*Paphies donacina*) on an intertidal surf beach in Canterbury, New Zealand. Estuarine Research Report 42. School of Biological Sciences and Department of Geography, University of Canterbury, Christchurch.

https://ref.coastalrestorationtrust.org.nz/documents/seasonal-effects-of-vehicles-on-juvenile-tuatua-paphies-donacina-on-an-intertidal-surf-beach-in-canterbury-new-zealand/

This field experiment was similar to Marsden & Taylor (2010), but it compared impacts in summer and winter. The percent mortality increased with increased vehicle passes for both seasons, and the mortality rate was the same.

This is another useful report using *in situ* populations of shellfish. It complements Marsden & Taylor (2010) very well.

Taylor, G.F. 2013. Management of sand beaches for the protection of shellfish resources. Unpublished PhD thesis, University of Canterbury, Christchurch.

https://ref.coastalrestorationtrust.org.nz/site/assets/files/8071/management_of_sand_beaches_taylor_phd_uoc_2013.pdf

This PhD is the research that the Marsden et al. (2012a, b) reports are based on. It also refers to this work being an extension of Marsden & Taylor (2010). It's the only PhD I've come across that addresses the impact of vehicles on biota in New Zealand.

Southland

Gray, M.C. 2004. Toheroa on Oreti Beach: Management to minimize threats of local extinction. submitted in partial fulfilment of the degree of Bachelor of Applied Science- Environmental Management, University of Otago, Dunedin, New Zealand.
https://ourarchive.otago.ac.nz/bitstream/handle/10523/4221/GrayMatthewC2004BAppSc.pdf?sequence=2&isAllowed=y

This was a university project. Gray monitored vehicle traffic at different times of year, and assessed sediment size at various sites on the beach.

He concluded: *Surveys on Oreti Beach demonstrated a predominance of vehicular traffic within two kilometres of, and concentrated 100 metres around, the public access point. Most of those vehicles were between the spring and high tide marks. Comparisons with the findings of a previous survey on Oreti Beach revealed an abundance of juveniles in this area, with only small numbers of adults. This indicates that vehicle traffic could influence the species' population dynamics through enhanced mortality of juveniles.*

Moller, J.S.; Moller S.I.; Futter, J.M.; Moller, J.A.; Harvey, J.P., White, H.A., Stirling, F.F. & Moller, H. 2009. Potential impacts of vehicle traffic on recruitment of Toheroa (*Paphies ventricosa*) on Oreti Beach, Southland, New Zealand. *He Kōhinga Rangahau* No. 5. 61 pp. University of Otago, Dunedin.

https://ref.coastalrestorationtrust.org.nz/documents/potential-impacts-of-vehicle-traffic-on-recruitment-of-toheroa-paphies-ventricosa-on-on-oreti-beach-southland-new-zealand/

This report provides an estimate of the number of juvenile toheroa deaths associated with Burt Munro motorcycle races on Oreti Beach. It only assessed the racetrack, not the spectator vehicles, so they recognise it'll be an underestimate of the impact of the event. They also conducted experiments with different types of vehicle driven over experimentally placed toheroa. This is the first experiment in NZ comparing the impacts of different vehicle types.

Overall this is a useful study. They do well to place their results in the context of the wider beach.

Futter, J.M. & Moller, H. 2009. Sustaining toheroa (*Paphies ventricosa*) in Murihiku: mātauranga Maori, monitoring and management. *He Kōhinga Rangahau* No. 7. 90 pp. University of Otago, Dunedin.

https://ref.coastalrestorationtrust.org.nz/documents/sustaining-toheroa-paphies-ventricosa-in-murihiku-m-tauranga-m-ori-monitoring-and-management/

The authors conducted interviews with 25 kaitiaki, managers, scientists and knowledgeable locals. An aspect raised by many was the belief that vehicle traffic on Oreti Beach threatened recruitment of young toheroa and that the threat was increasing. The report highlights the need to address the impact of vehicles on the population of toheroa on the beach, rather than the impact of a racing event on a small part of the beach. Moller et al. (2009) showed that damage to juvenile toheroa does occur from vehicle traffic. There was a desire to consider different management practices rather than stop the event completely.

Futter, J.M. 2011. An investigation into the Murihiku toheroa (*Paphies ventricosa*): mātauranga, monitoring and management. Unpublished MSc, University of Otago, Dunedin.

https://ourarchive.otago.ac.nz/bitstream/handle/10523/6550/FutterJulieM2011MSc.pdf?sequence=2&isAllowed=y

The two reports above are based on the research in this MSc.

Moller, J.A.; Garden, C.; Moller, S.I.; Beentjes, M.; Skerrett, M.; Scott, D.; Stirling, F.F.; Moller, J.S.; Moller, H. 2014: Impact of vehicles on recruitment of toheroa on Oreti Beach, Southland, New Zealand. Ecosystems Consultants Report 2014/2. 79 pp.
https://ref.coastalrestorationtrust.org.nz/site/assets/files/8069/ecosystems-consultants-report-2014-02.pdf

This report takes the earlier reports, including Gray (2004) one step further, and addresses the impact of vehicles on the entire population of juvenile toheroa at Oreti Beach, not just impact of the race. The authors highlight the need to improve our understanding of the recruitment process in toheroa at Oreti, and speculate on future management of vehicles.

This is the only report that attempts to quantify and model the impacts of vehicles on the entire shellfish population at a beach in NZ. It's a critical contribution to our literature on the impacts of vehicles on beaches.

Estuaries/lagoons

Šunde, C.; Berthelsen, A.; Sinner, J.; Gillespie, P.; Stringer, L.; Floerl, L. 2017: Impacts of vehicle access at Delaware (Wakapuaka) Inlet. Report no. 3015, Cawthron Institute, Nelson. 75 p.

http://www.nelson.govt.nz/assets/Environment/Downloads/Nelson-Plan/Nelson-Plan-Coastal-Final-CawRpt-3015-Impacts-of-vehicle-traffic-Delaware-Inlet-Cawthron-Institute-June2017.pdf

This detailed study assessed impacts of vehicles accessing a boat launching site. It provides some coverage of the international impact of vehicles on seagrass beds. They utilised drone imagery as well as intensive sampling at a fine scale. Their findings were: *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.

Social aspects of this report are also worthwhile, so all round it's a well-balanced report based on quantitative and qualitative methods.

Blakely, J.E. 2020. Access and impact: the spatial effects of off-road vehicles on a saltmarsh wetland in Canterbury, New Zealand. Unpublished Master of Landscape Architecture thesis, Lincoln University, Lincoln.

https://researcharchive.lincoln.ac.nz/handle/10182/13174

This Masters thesis is useful on many fronts. It provides a good overview of the impacts of ORVs on a range of habitats, not just the coast. The focus of the study is on saltmarsh vegetation at Greenpark Sands Conservation Area on the shores of Te Waihora/Lale Ellesmere. Internationally there seems to be a gap in this knowledge. This study used GIS spatial analysis to measure the areal extent and intensity of off-road vehicle damage. The entire width of the reserve had vehicle impacts.

This is a useful study for showing impacts on saltmarsh vegetation.

Habitat

Healy, T. 1978. Trail bike danger to sand dunes. *People and planning* (May); 2 (6): 16-17.

https://ref.coastalrestorationtrust.org.nz/documents/trail-bike-danger-to-sand-dunes/

This short article highlights the damage caused to dunes at Papamoa by trail bikes. Damage isn't quantified, however it includes matching photographs taken in 1973 and 1977 that clearly demonstrate the damage.

Kirk, B.; Snell, C.; Middleton, G.; Millet, M. & Wilson, S. 2020. The impact of vehicles on northern Pegasus Bay beaches. Unpublished GEOG309 project, University of Canterbury, Christchurch.

https://www.canterbury.ac.nz/media/documents/oexp-science/geography/community-engagement/geog-309/2020/GEOG309-20-The-Impact-of-Vehicles-on-Northern-Pegausu-Bay-beaches.pdf

This report used drone imagery to compare dunes at two sites with different management regimes (entry by permit only vs no permit needed). It used aerial photography from 2010, 2014 and 2020 to compare these same two sites through time, reflecting vehicle bylaws being implemented.

Marlborough District Council – response to altered coastline after Kaikoura earthquake

Marlborough District Council. 2019. Marlborough's East Coast – issues and options. Marlborough District Council, Blenheim. 48 pp.

https://ref.coastalrestorationtrust.org.nz/site/assets/files/9755/item_17_28_november_2019_marlboroughs_east_coast_issues_options.pdf

The Marlborough DC took a proactive approach to the changes in the coastline following the Kaikoura earthquake. Although this report doesn't contain any quantitative work, it does summarise the main access points to the coast and how they have changed. It includes many photographs and options for future management.

Orchard, S.; Falconer, T., Fischman, H., Schiel, D. R. 2020. Beach dynamics and recreational access changes on an earthquake-uplifted coast. Report to the Marlborough District Council, 42pp.

https://hdl.handle.net/10092/101043

This is a background report prepared as part of Marlborough District Council's response to a changed landscape and associated changes to vehicle access opportunities, following the Kaikoura earthquake.

The background section contains a very good succinct overview of the impact of vehicles on dunes and beaches. It's a well-constructed study that: *… provides findings that include mapping of indigenous dune system remnants, recruitment of the indigenous sand-binders spinifex (Spinifex sericeus) and pīngao (Ficinia spiralis) on uplifted beaches, distribution of red katipō (Latrodectus katipo) within earthquake-affected dune systems, distribution of banded dotterel / pohowera (Charadrius bicinctus bicinctus) nesting pairs to determine important areas, and spatial overlaps with vehicle tracking measurements along the coast.*

The vehicle track mapping introduced a new measure for New Zealand: *Vehicle tracking measurements were made at periodic intervals throughout the study area. At each monitoring point the cumulative width of visible vehicle tracks (as measured in the shore-perpendicular direction) was recorded to the nearest metre. This measure reflects the distance between the tyre tracks of individual vehicles, summed across the shore profile, or in the case of heavily tracked areas, the cumulative width of the beach that was tracked. To avoid biases introduced by the presence of recent tracks on the lower beach (below the position of high tide) which were only visible at some sites and dependent on the state of the tide, only tracking above the high tide line is reported here. Additional notes were taken on transition points between areas of noticeably different tracking patterns, for example, where tracks were seen to fan out or converge in response to barriers and topographic changes, and at the location of turnaround areas and access points.*

A simple measurement like this may be suitable for community groups that are interested in documenting vehicle activity. The report makes good use of photographs.

I highly recommend this report.

Marlborough District Council 2021. Proposed East Coast Beach Vehicle Bylaw: Technical report June 2021.

https://www.marlborough.govt.nz/repository/libraries/id:1w1mps0ir17q9sgxanf9/hierarchy/Documents/Your%20Council/Meetings/2021/Council%202021%20list/Cncl-240621-Item_6-Separate_Attachment_6.3_Technical_Report-Version_4-June_2021.pdf

This report brings together the views of experts and additional work identified by them. It contains a wealth of information on the values of the sites on the Marlborough East Coast, and identifies threats posed by vehicles.

These three documents are a very useful resource for anybody considering managing vehicles on their coast. They complement each other well.

Muriwai

Auckland Council. 2021. Driving on Muriwai Beach: public engagement background information. 8 pp.

https://ehq-production-australia.s3.ap-southeast-2.amazonaws.com/2dee2c7b6c3675e9f38b3c914e2f7ab04ffedb63/original/1617664207/82a515cdf055c30e2ab866a9412e7376_Supporting_Document.pdf?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIBJCUKKD4ZO4WUUA%2F20210719%2Fap-southeast-2%2Fs3%2Faws4_request&X-Amz-Date=20210719T234626Z&X-Amz-Expires=300&X-Amz-SignedHeaders=host&X-Amz-Signature=2c1bbbc867cbb9a1f8ac47e4a24e02be2506591ad259e3557c505910851e5574

This consultation document includes a good time series of aerial photographs showing damage to the dune system. It includes a lot on the Muriwai gecko and loss of habitat to vehicles, but it's not quantified.

Vegetation

La Cock, G. 2008. In the matter of The Resource Management Act 1991 and in the matter of Hearings on submissions concerning the proposed Horizons Regional Council One Plan for the Manawatu-Wanganui Regional Council. Statement of Evidence of Graeme La Cock. (also see Supplementary statement of evidence in same link)

https://ref.coastalrestorationtrust.org.nz/site/assets/files/4357/skmbt_c28013031213150.pdf

Only report of quantified data on impacts of vehicles on vegetation. I introduced data from an intermediate science fair project by Andrew La Cock on the impact of a quad bike on spinifex *Spinifex sericeus* runners. He documented damage to runners based on nearest runner to random points along a transect in front of dunes at Castlecliff, Whanganui, and compared this to a nearby site that didn't have the vehicle tracks. At the quad bike site 59% of runners were snapped off, the other 41% had not been passed over by the vehicle. Every runner crossed by the vehicle track was snapped off. In the non-vehicle site 2% of runners were snapped off. I'd initially reported 69%, but there's a correction to 59% in the additional information.

Harris, M.J. 1988. Coastal erosion in Otago – the Ocean Grove Recreation Reserve sand dune stabilisation programme. *In: New Zealand Institute of Park and Recreation Administration Conference, Invercargill, 1987,* pg 117-135. New Zealand Institute of Park and Recreation.

https://ref.coastalrestorationtrust.org.nz/documents/coastal-erosion-in-otago-the-ocean-grove-recreation-reserve-sand-dune-stabilisation-programme/

Harris makes the following statement: "Four-wheeled drive vehicles, trail bikes and horses on the beach and the lower foredunes, have had a major impact on the stability and cover

over the past ten years. These uses have created a large number of tracks and denuded the vegetation cover on the tops and front of the foredunes."

He has not included data or photographs to justify his statement.

MacDonell, C.J. 2020. An eye on coastal change: Characterising spatio-temporal coastal sensitivity at high-resolution - Okia Reserve, Otago Peninsula, New Zealand. Unpublished MSc, University of Otago.

https://ourarchive.otago.ac.nz/handle/10523/9913

This is another example of the use of remote sensing techniques to identify potential issues, sites of heightened activity etc: *Advanced coastal monitoring techniques can detect and characterise modifications in the coastal environment in unprecedented spatial detail, across a relatively wide spatial area. Repeated use of high spatial resolution remote sensing technologies such as Remotely Piloted Aircraft Systems (RPAS) and Light Detection and Ranging (LiDAR) allowed a spatio-temporal signal of the evolution of both the vegetation and geomorphology at the 231 ha Okia Reserve (Otago Peninsula, Dunedin) to be measured across short (14 months) and long (12.5 years) temporal scales.*

Anthropogenic disturbance overall appeared to have a minimal, localised impact in the reserve attributed almost exclusively to vehicle and pedestrian access, and the apparent recovery growth of vegetation in most of these areas.

High-resolution quantification of anthropogenic interactions within the reserve accurately highlighted the magnitude and extent of localised changes to vegetation and topography as a result of some of these activities (e.g. vehicle access track maintenance and new tracks).

MacDonell's methods allowed him to identify track management activities, such as hardening the track substrate through wetlands, bypassing wet areas etc.