

Estuarine Research Report 41

*Management of vehicle and horse
users on sand beaches: Implications for
shellfish populations*

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Executive Summary

A review of management documents and peer reviewed literature was undertaken to evaluate the level of protection intertidal shellfish are given from vehicle and horse users on sand beaches. Database searches were conducted to find policies that related to vehicle and/or horse management on sand beaches. Using findings from peer reviewed literature, policies were assessed for how shellfish populations could be impacted. For example, policies that concentrate vehicle traffic into specific areas which contain shellfish were considered to have negative impacts because literature has shown heavy traffic has detrimental effects.

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.

Shellfish in New Zealand are protected similarly to the rest of the world, and no policies designed to directly benefit these types of animals. Vehicle and horse users on sand beaches are controlled with bylaws; the creation and implementation of which depends on each local authority. Management of these users therefore does not occur uniformly over New Zealand regions. Where bylaws are in place, these generally confine vehicle and horse users to the intertidal zone; areas that shellfish, such as tuatua (*Paphies donacina*) and toheroa (*P. ventricosa*), are abundant. Seasonal beach restrictions are also generally rare, with the amount or type of traffic used on the beach unregulated.

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.

1 Introduction

Management of sand beaches in regard to human activities does not usually have a high level of consideration for ecology. If ecology is considered, only easily visible species are protected, and infaunal intertidal biota is ignored. Often this results coastal assemblages being altered from their natural state. Designation of the intertidal zone for recreational activities such as vehicle driving and horse riding is a good example of how this could occur. Bird nests are protected, but the effects that this may have on intertidal biota is not considered. If this lack of consideration continues the effects are likely to be felt by future generations.

The overall aim of this review is identify key drivers and the management methods which may affect intertidal shellfish. This chapter discusses why ecological considerations are important (Section 3), reviews the current management that exists for vehicle and horse users internationally (Section 4 and 5), and in New Zealand (Section 7). It then examines how intertidal shellfish may be affected by these methods (Section 6). The successfulness of New Zealand's management system is evaluated in relation to shellfish (Section 8) and Pegasus Bay is a case study with implications discussed(Section 9).

2 Sand beach management practices impacts on ecology

Sand beach management focuses on a range of areas including physical or geomorphic hazard reduction and recreational safety; however, issues of ecological protection are largely overlooked. Much attention is paid towards physical hazard management and this prioritisation can have a range of adverse impacts when ecological implications are not considered. For example, seawalls and breakwaters are necessary tools used to facilitate the global shipping trade but they have altered the ecosystem in which they are built. Although the reduction of physical or geomorphic hazards is often necessary for significant human populations to inhabit and use the coastal zone, it is important that management practitioners understand the impacts of the methods they choose to employ. Methods need to be sensitive to the ecosystem; otherwise, species assemblages may become permanently altered (Connell, 2001).

A hazard cannot be easily defined; its definition depends on how humans are using environmental resources (Burton, Kates & White, 1978). Therefore, a hazard depends on the interaction between humans and the environment (Figure 1) Management involves indentifying and mitigating these hazards.

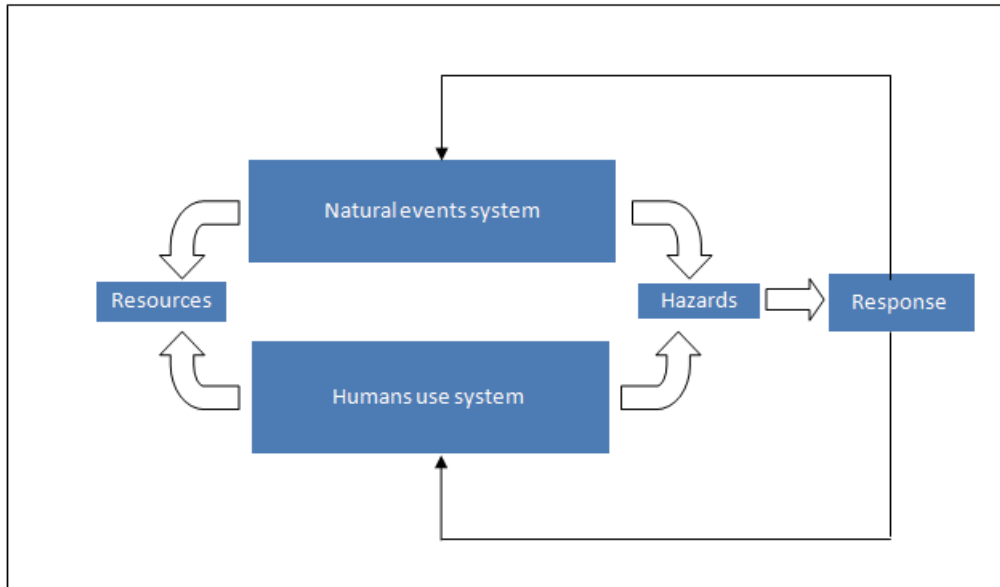


Figure 1- Flow diagram of the interaction between nature and humans that create resources and hazards which initiate response from management authorities (Adapted from Burton, Kates & White, 1978).

Methods used in hazard management can have detrimental effects on ecosystems by smothering infaunal species, changing and disturbing substrate (Thrush *et al.*, 2004; Bulleri, 2005). For example, beach nourishment involves depositing sand on the shoreline which smothers the species directly below it. Hazard management allows human populations to build structures immediately on the coast, and is particularly evident with residential and commercial buildings which seek to maximise scenic potential. For example, the 'Q1', the world's tallest residential tower, is built within 100m of the beach at Surfers Paradise, Australia. These commercial investments drive many coastal economies by bringing in tourists and high income residents, so it is important to develop sufficient strategies to protect the coast and such development from negative impacts. Emphasis is most often placed upon hazard management to protect human developments, and ecological protection is considered as an afterthought. Komar (1997) has identified four options available when a coast begins receding:

- 1) No action – the coast is allowed to encroach into development.
- 2) Retreat and relocation – the human population and sometimes buildings are moved away from the coast.

- 3) Beach nourishment – considered the ‘soft’ engineering option and involves depositing sand on the beach and allowing wave action to build the beach
- 4) Stabilization – a ‘hard’ engineering solution: solid structures are made that aim to take or dissipate wave energy and reduce erosion.

‘No action’ or ‘retreat and relocate’ responses to coastal erosion could be considered to be the best responses where ecosystems are concerned. This is because it allows for the ecosystem to be left in as natural a state as possible continuing to adapt to natural disturbances.

Beach nourishment is another option considered to be successful in preventing coastal erosion in certain situations (Komar, 1997) and is deemed to be an aesthetically and ecologically favoured option over ‘hard’ solutions. Such methods include using similar sediment to the natural shore, and dumping small amounts over time rather than one large amount, or placing material on the backshore (Spreybroeck *et al.*, 2006). However, literature shows that large deposits of sediment can have negative effects on intertidal ecosystems through smothering (Thrush *et al.*, 2004). The quantity of the deposit also influences the rate of recovery (Zajac and Whitlach, 2003). Beaches that contain shellfish populations are more likely to experience adverse effects from this sediment deposition. In addition to infaunal biota, predators such as birds are affected by nourishment methods. A study found that beach use by shore birds was reduced by 70-90% on nourished beaches as a result of the reduction of prey species and habitat area (Peterson *et al.*, 2006). Although this study found that the time taken to recover may be as little as one season, this is still an unnecessary pressure. In New Zealand beach nourishment occurs but is not a highly popular option due steep initial and ongoing maintenance costs. There are examples where nourishment has been used to create recreational beaches as has been done with Oriental Bay in Wellington. One of New Zealand’s main ‘soft’ engineering methods of coastal protection is dune enhancement, primarily using planting programmes that trap sediment landward of the Mean High Water Spring (MHWS) line. This method attempts to mimic natural processes to create dunes; however, it can take a long time to build a dune that will provide sufficient protection from the coast and when introduced plant species are used, can displace indigenous ecosystems and lead to dramatically different types of dune systems.

‘Hard’ solutions to coastal erosion are another popular option due to the perceived permanence and reliability of such structures, although these perceptions are more a function

of a domination type attitude to nature than a physical reality. The two main types of 'hard' defences are shore-parallel seawalls and revetments, and shore-normal groynes and breakwaters (Komar, 1997). These structures can have a range of adverse effects on coastal ecosystems. Seawalls are the most common method employed and are designed to take the full force of coastal waves. Groynes and breakwaters are used to create buffer zones by trapping sediment and dissipating coastal forces (Komar, 1997). Each of these methods of defence has its own implications associated with the nature of the structure.

Breakwaters are situated in the subtidal zone and can alter species assemblages by increasing the heterogeneity of the environment through the addition of a new substrate. A breakwater designed to incorporate long-shore processes can be more beneficial than other hard solutions because sand builds up over time. This allows shellfish to maintain a stable population adapting to slow changes over time. Invasive species could spread more rapidly with the help of these structures. Increases in habitat heterogeneity created by breakwaters allows new organisms to enter an area that otherwise would not (Bulleri, 2005). Invasive species are known to use artificial structures, such as breakwaters as vectors for transport (Floerl *et al.*, 2009) and breakwater used in harbours facilitate invasive species dispersal via ship ballast discharges and other fouling organisms on the hull. Species assemblages may be altered and community success reduced. Breakwaters and groynes also have indirect effects on shellfish by facilitating other species. For example, artificial structures attract fish, increasing the presence of predator species (Clynick, 2008). Wave climates are also reduced, creating less turbidity and better vision for fish predators making the protruding siphons of shellfish in the sand more visible.

The loss of suitable habitat is a greater problem that exists from accelerated sea level rise induced by climate change. In New Zealand, seawalls are used to protect coastal infrastructure and as sea levels rise, these hardened backshores prevent intertidal and saltmarsh ecosystems from retreating via the process of succession. This has been termed 'Coastal Squeeze', when sea level rise causes horizontal shrinkage and loss of habitat and coastal retreat and erosion are stopped by hard defence structures. A good example of this occurring is a boulder wall constructed at Scarborough Beach, Canterbury. Although this wall protects the Sumner community, there is no beachface landward of the Mean High Water Spring (MHWS) because the wall is now positioned on the foreshore. This results in some species not being able to exist here due to a lack of sand beach habitat area.

Future hazard management practices require both subaerial and intertidal/submarine ecological impacts to be considered. Failure to do so may result in direct impacts on populations from smothering in 'soft solutions' or replacement of habitat in 'hard' solutions. The facilitation of predators and invasive species can also have adverse effects on the shellfish population.

2.1 Why sand beach management should consider intertidal shellfish

Sand beach management must not only consider visible species, such as birds, but also infaunal biota because all components of an ecosystem are necessary for functioning. Bivalves are a major infaunal component of sand beach ecosystems and exert control of ecosystem function and structure (Vaughn and Hakenkamp, 2001). Intertidal biota such as tuatua (*Paphies donacina*) carry out a range of ecosystem services and failure to recognise their importance can have flow-on effects for a coastal ecosystem. Such services include facilitation of other species, filter feeding and as a food source. Facilitation is a key attribute of bivalves in an ecosystem. Bivalves burrow into the sediment of sand beaches (Hull *et al.*, 1998) and facilitate microbial activity by increasing the oxygen levels of the sediment with bioturbation (Vaughn and Hakenkamp, 2001). Filter feeding recycles nutrients into the ecosystem by increasing nitrogen in the water column (Pfister, 2007). Bivalves occupy a low trophic level in the ecosystem, providing food for fish, crustaceans, and birds (Knox, 2001). Due to their importance in sand beach ecosystems bivalve changes have both bottom-up and top-down trophic effects when abundances are altered. A loss of a single species of bivalve can trigger trophic cascades which can have large impacts on ecosystem functioning. If bivalve abundance reduces then it would be expected that its predators of a higher in trophic status will also be reduced due to lack of food (Bhattacharya and Sarkar, 2003). Species that were previously facilitated by bivalves, such as polychaete worms, would be expected to be less abundant. The value of bivalves to humans is underappreciated; if their filtering of the water is disrupted this could result in more turbid water, which can be less appealing for human beach users (Vaughn and Hakenkamp, 2001). This aspect can further influence tourism and coastal economies that are driven by beach goers.

Management of shellfish is largely focused on two aspects; contamination and sustainable fisheries. However, while emphasis is placed on maintaining a healthy adult population of shellfish, no consideration is given to the juvenile stages (World Health Organization, 2010). Many species of bivalves are restricted the subtidal zones of beaches, but some species utilise

the intertidal zone at certain stages of their life cycle, usually at juvenile stages. Tuatua (*P. donacina*) are one example of these in New Zealand. Other species include *Donax deltoides* in Australia (Schlacher and Thompson, 2007), and *Donax variabilis* in North America (Ellers, 1995). Protection at juvenile stages is as important as protecting adults because they are buried shallower and have a weaker shell providing protection. Management practices need to consider juvenile intertidal shellfish because failure to do so would adversely affect the population if recruitment is reduced.

3 Vehicle and horse use and the effects on biota

Recreational use of sand beaches often entails the use of vehicles and horses on the intertidal zone, the same areas where juvenile shellfish are known to be present. Amenity users and tourists use vehicles to access fishing spots or hard-to-reach areas. Horses are used by tourists and locals who enjoy riding in the coastal environment and may live in close proximity to the beach for this reason. Commercial trainers also use beaches to train gallop and harness racers. A majority of vehicle and horse traffic occurs within the intertidal zone where the sand is more compact, making driving and horse riding easier. Management strategies that control vehicles and horses often focus on safety of other users and protection of shore bird species, such as the fairy tern (*Sterna nereis davisae*) (Department of Conservation, 2011). As shore birds nest above the high tide line, this results in vehicles and horses being allowed only in the intertidal zone. In Australia, tourist vehicles can reach traffic volumes of up to 500 vehicles per day and can affect up to 65% of species present on sand beaches (Schlacher and Thompson, 2007).

Vehicle users effects on shellfish populations had previously been underestimated (Wolcott and Wolcott, 1984); recent literature has quantified these relationships (Schlacher, Richardson, and McLean, 2008; Schlacher, Thompson, and Walker, 2008). Despite research on the distribution of bivalve species in the intertidal zone, shellfish are largely overlooked in management policies (Table 1). This could be due to perceptions of the shell providing sufficient protection to the individual from disturbance (Wolcott and Wolcott, 1984).

Table 1: Table showing the focus of international literature sourced that examines the effects of recreational activities in coastal environments

		No. of papers	Crustaceans	Bird	Plant	Shellfish	Other
Mortalities	Vehicle	11	2	4	5	2	2
	Horse	0	0	0	0	0	0
	Both	0	0	0	0	0	0
	Other	2	0	1	1	0	0
Sub-lethal	Vehicle	12	8	0	3	3	3
	Horse	0	0	0	0	0	0
	Both	0	0	0	0	0	0
	Other	3	0	0	1	0	1

Vehicles affect intertidal infaunal organisms, with higher traffic causing increased mortality (Marsden and Taylor, 2010; Moller *et al.*, 2009; Schlacher *et al.*, 2008a; Schlacher, Thompson and Price, 2007; Foster-Smith *et al.*, 2007; Schlacher, Richardson, and McLean, 2008). There are sub-lethal effects on organisms such as changes in behaviour (Schlacher and Lucrezi, 2010) and the morphology of individuals (Lucrezi and Schlacher, 2010). Little is known of the effects of horse traffic in the intertidal zone. Previous studies in terrestrial environments have shown that trampling by horses has had significant effects on diversity and biomass of vegetation (Torn *et al.*, 2009; Whinam and Chilcott, 1999; Whinam and Comfort, 1996). Quantifying the effects of vehicle and horse users on shellfish is vital if management is to cater to the needs of intertidal biota.

4 Vehicle management issues and practices

Vehicle management on sand beaches is focused on three main issues; safety of beach users, erosion, and wildlife conservation, and employs a variety of options including permits, area and zone based designation, seasonal closures and complete bans. In most cases these methods are not used with the intent to benefit shellfish. A study by Priskin (2003) found that tourists perceive vehicle driving on sandy beaches as harmful for multiple reasons, but not due to crushing of biota in the intertidal zone. A lack of knowledge of biota on sand beaches is likely that this reason was not mentioned. Often perceptions of sand beaches are that of a

‘dead’ zone with very few living organisms. This may also be the view of management practitioners because in many places around the world vehicles are allowed on beaches with very little or no control.

4.1 Vehicle management for safety

The safety of both vehicle and other types of beach users is a key concern in sand beach management. In New Zealand bylaws are put in place to control vehicle users on beaches, but every country has their own legislative systems for controlling activities. The two main options used worldwide to ensure safety include permit systems and the designation of areas. Designating areas for certain activities allows a specific use to occur without compromising safety of other users. Area-based designation is good for addressing safety because some activities are not compatible in the presence of others, especially if they require similar environmental characteristics (Phillips and House, 2009). For example, the use of vehicles and horse riding requires low profile beaches with compact sand, so both activities usually occur in the intertidal zone. Safety can be compromised when both users are present so other methods of management may be needed to address this. Permit systems are another method that can be used to address safety of user groups. This allows management authorities to control traffic volumes on the beach and gives them the opportunity to inform users of the risks before they use the beach.

4.2 Vehicle management for erosion prevention

Erosion is a key concern with vehicle use on sand beaches and, if such effects are unmanaged, this could significantly impact on coastal settlements. This is because some coastal settlements may rely on sand dunes for protection. Previous studies on dune ecosystems have successfully evaluated the use of vehicles in dunes to be hugely detrimental. Vehicles reduce vegetation (Anders and Leatherman, 1987; Brodhead and Godfrey, 1977), result in high mortalities of dune biota (Luckenbuch and Bury, 1983), decrease species richness (Hosier and Eaton, 1980), and accelerate shoreline erosion through vegetation damage and removal (Thompson and Schlacher, 2008). Importantly, if above ground vegetation is reduced then the sand trapping capacity of the dune system is decreased. Erosion effects occur indirectly from reduced dune vegetation not holding sediment together, rather than vehicles displacing sediment. Most countries recognise the effects of vehicles on dune vegetation so management policies aim to keep vehicles away from areas that are susceptible to erosion. Most policies devised permit traffic on the rest of the beach which

contains other vulnerable biota. This can be seen in the Waimakariri and Hurunui Northern Pegasus Bay Bylaw, 2010 which has pushed vehicles below the high tide line.

4.3 Vehicle management for ecological protection

Ecological protection is also an issue that should be considered when controlling any activity that takes place on a beach (and any other natural resource). The two main methods commonly applied for reducing wildlife loss from vehicle use on beaches are seasonally closing the beaches or designating areas of the coastal zone: that is, only allowing vehicles below the high tide line. If vehicle use is considered to be too detrimental, a complete ban may be enforced. South Africa has opted for this complete ban but still allows the deputy-director general to grant exceptions (South Africa: Full 4x4 regulations, 2004). The main benefit of keeping vehicles away from wildlife is that floral and faunal habitation of beaches can occur without disturbance from human activities. This allows for assemblages to remain in a natural state.

5 Horse management issues and practices

In many countries, including New Zealand, South Africa, and Australia, sand beaches are popular areas for horse riding by tourists and amenity users, but management is less common to that of vehicles. Where management does occur, similar methods are used. As such, management of horse use on beaches focuses on safety for other users and erosion. If ecological considerations are made, these typically disregard intertidal biota. For example, many coastal plans push traffic into the intertidal zone to protect other species above the high tide line. A significant problem is that many countries and relevant authorities have no management in relation to horses; these tend to be poorer countries such as Mozambique. A lack of management means that horses can be ridden at any speed, time, or location on the beach, which can result in widespread environmental damage as well as affect safety of other users. Literature suggests that horses are likely to cause similar damage to dunes and nesting birds as vehicles (Luckenbach and Bury, 1983). Whether the damage would be similar for shellfish is unknown and one of the aims of the present study is to determine this.

5.1 Horse management for safety:

Safety of other users is a key concern in controlling horse riders. Permit systems are a reliable system for this and are used to control and monitor horse users. Permit systems can be informative to managers by providing knowledge as to the amount of users in a given day as

well as to make users aware of regulations. This system is widely for many beaches in the United States of America (USA) and is being developed for use in Sefton, UK (Fylde Borough Council, 2011). The permit system for Island Beach, USA, allows horse use of the beach to occur between 1st October and the 30th April (New Jersey Department of Environmental Protection, 2011). This is presumably when there are less people on the beach, making it the safest time for horse riding to take place. A permit system is also used for Crane Beach, USA, to prevent large amounts of horse users by only allowing 50 horses per day. This is mostly done for safety of other users rather than ecological protection.

5.2 Horse management for erosion prevention

Horses have similar effects on dune systems as vehicles so the impacts on erosion are likely to be similar. The effects include vegetation reduction, altered community composition (Törn *et al.*, 2009) and accelerated erosion due to the churning of tracks (Whinam and Comfort, 1996). For this reason, the horse management strategies are similar to that for vehicles with horses not being allowed on sand dunes and in other erosion prone areas.

5.3 Horse management for ecological protection

Ecological protection is important in sand beach management but deciding which species to protect over others is a contentious issue. Past decisions have resulted in more visible species being protected over others. This prioritisation can be detrimental to ecosystems by altering natural abundances of certain species. In New Zealand, horse use is generally controlled by bylaws which are instituted by the territorial authority responsible for each beach. Unlike vehicles, horses tend to be allowed almost everywhere on some beaches and may be allowed to be ridden above the high tide line (Tauranga City Council, 2007). It is more beneficial for shellfish if horses are above the high tide line because aquatic fauna do not inhabit the dry beach face (Davenport & Macalister, 1996). Avoidance of nesting birds above the high tide line at times of the year may encourage horse users to concentrate lower down the beach face. Horse users can be difficult to control in large expanses of coast and additional incentives may be needed to assist in preventing environmental degradation. Awards, such as the Green Business Award given to Tassariki Ranch, Australia, in 2007 and 2008 (Tassriki Ranch, 2011), can help to get companies to behave in a more environmental friendly manner. This company arranged horse treks during low tide so that riding was done on the intertidal zone; this was in order to protect the nesting bird populations.

In the USA, nesting species such as hooded plovers and loggerhead turtles utilize the dry beach face and are protected by management policies that only permit horses on the intertidal zone (Cape Hatteras National Seashore Off-Road Vehicle Negotiated Rulemaking and Management Plan/EIS, 2010). Horse users restricted to the intertidal zone could be causing detrimental effects to the intertidal ecosystem. Nesting birds also have influenced the management of beaches in some areas of the USA by dictating which seasons a beach can be ridden on. For example, at Crane Beach, Massachusetts, horses are only allowed on the beach by permit from the 1st October to the 31st of March and have to be ridden below the high tide line (Ipswich Council, 2011). Seasonally closing the beach to protect nesting species is very beneficial as it prevents destruction of nests during these times of vulnerability. These methods can achieve effective protection of native shorebirds, but protection of prey species, such as shellfish, crustaceans, and polychaetes, which inhabit the intertidal zone should also be considered and incorporated in these plans to give beneficial outcomes for the ecosystem as a whole.

6 How shellfish are affected by horse management

Management of the effects of vehicles and horses on sand beaches is often done using similar options due to the perceived similarity of the two activities. There are five main options that are used to control horse and vehicle movements which have the potential to impact shellfish populations. These methods are issuing permits, designating areas for use, designation of specific zones of the beach face, seasonal closures, or complete banning of the activity (Table 2). To successfully manage shellfish populations it is necessary to understand the benefits and disadvantages of choosing a particular system. The following sections examine the effects of each type of management technique and how these could be applied to shellfish.

Management of vehicle and horse users on sand beaches

Table 2: A summary of management papers found that control vehicle and horse use on beaches with number of documents listed. The overall effects of management of shellfish is rated as beneficial (+), neutral (0) and disadvantageous (-).

Activity Controlled	Method of Control		Areas benefited			Areas disadvantaged			Managements effect on Shellfish (+/-)
			Dunes	Beach face	Intertidal zone	Dunes	Beach face	Intertidal zone	
Vehicle	Permit	1							+
	Seasonal Closure								
	Area closure	3	3	3	3	3	3	3	+
	Designation of zones	1			1			1	+
	Banning	1	1	1	1				+
Horse	Permit	1							+
	Seasonal Closure	1	1	1	1				+
	Area closure								
	Designation of zones	1	1	1				1	-
	Banning								
Both	Permit	1							+
	Seasonal Closure	2	2	2	2				+
	Area closure	3	3	3	3	3	3	3	0
	Designation of zones	3	3	3				3	-
	Banning								

6.1 Permits

Permit systems for vehicle and horse users is a method for monitoring and informing users for a particular area of coast. This can be used to ensure safety of other users and the environment. By issuing permits for a particular day, the management authority can obtain data on the number of vehicle and horse users on the beach for a given day. Seasonal trends can be identified using the data. Permit systems are most widely used in the United States of America to control vehicle and horse users, and vary between management authorities in the way they are run and may only be focused on single user groups. At Cannon Beach, Oregon, the application for a permit must be for a specific reason such as retrieval of gear or to access hard-to-reach areas. This requirement is beneficial to shellfish beds because it would limit the amount of beach traffic by excluding 'joy riders' from accessing the beach. Permit systems also allow authorities to ensure vehicles are not modified in a way that shellfish will be detrimentally affected. For example, vehicles fitted with off-road tyres dig deeper in the sediment and may cause more damage. In Donegal County, Ireland, horse users require permits to use the beach during June, July and August between 11am and 7pm. These times are when beaches are busiest, so management of horse use is necessary to ensure safety of other users. The use of a permit system allows the authority to inform users of possible outcomes of their behaviour and how impacts can be mitigated. A permit system is beneficial for shellfish because it limits traffic and prevents unwanted behaviour, but it is necessary to use other methods of control to ensure environmental protection.

6.2 Seasonal or temporary closures

Seasonal closures are used to ensure safety of other users or to protect wildlife at vulnerable lifestages. A seasonal closure is when a particular activity is not allowed on the beach during certain months of the year. For example, when safety is the main issue, beaches are closed from vehicle and horse use during warmer months when more bathers are present. Seasonal closures for wildlife conservation largely focus on nesting species and do not include intertidal biota. In Cape Hatteras, U.S.A., vehicles are managed by a permit system which restricts use during certain months which are at times of birds and turtles nesting (Cape Hatteras National Seashore Off-Road Vehicle Negotiated Rulemaking and Management Plan/EIS, 2010). Protecting a species during this vulnerable lifestage removes artificial selection pressure (e.g. vehicle driving and horse riding). A study on birds found that up to 81% of nests were run over by vehicles during the incumbent period (Buick and Paton, 1988). Removing artificial selection pressure (i.e. vehicle crushing) allows the offspring to

experience natural selection pressures. In addition to crushing, vehicle tracks can increase the effect of other selection pressures. For example, tyre tracks increase the time Loggerhead turtle (*Caretta caretta caretta*) hatchlings take to reach the sea, increasing the predation risk from birds (Hosier *et al.*, 1981).

Seasonal closures tend to focus on species that are visible such as birds and turtles, and species hidden from human eyes are ignored. Incorporating these latter species into sand beach management policies would require significant new efforts to supply scientific information. Bivalves are one of these species because when they inhabit the intertidal zone they are small (<30mm) and buried shallowly in the sediment. Information is also needed about when recruitment is taking place. Marsden (2002) suggests that recruitment of bivalves occurs during the warmer months, but often the difficulty in obtaining this can further stymie and delay efforts to understand their population and protect it. Using seasonal closures to protect shellfish during vulnerable life stages would be beneficial to the population because it would give them a chance to recruit without vehicle and horse traffic crushing individuals.

6.3 Area-based designation

Area-based designation is a common option used by many management authorities worldwide, including in New Zealand. The areas closed to vehicle and horse traffic tend to coincide with popular swimming areas. If areas closed for safety reasons contain shellfish populations, they are likely to benefit from this option. Area-based control can result in traffic being condensed into smaller areas, which can bring with it additional safety issues and ecological damage for those areas. The main ecological benefit of this method is that there would be an area with no human activities, allowing the ecosystem to function naturally. Studies have shown that beaches that are open to vehicle traffic have altered and less-diverse assemblages than closed beaches (Schlacher *et al.*, 2008). Ghost crabs (*Ocypode* spp.) change behaviour, compress home ranges, and even stop reproduction in areas with vehicle traffic (Lucrezi and Schlacher, 2010; Schlacher and Lucrezi, 2010; Steiner and Leatherman, 1981). A closed area would be likely to benefit all species that are protected from these users. However, if traffic is to continue at the same frequency but be condensed, ecological damage could be increased to a level that species abundance is reduced.

If this method was adapted to protect shellfish, there are a range of factors that need to be considered. It is difficult to designate specific areas for the protection of shellfish and many other intertidal biota because reproduction patterns can vary and are not easily detectable.

The population is also hard to detect, with sampling techniques being labour intensive. When the population's distribution is found, knowing what size area to close can be very contentious. Which species management is trying to protect and the individuals' mobility and dispersal range are two key factors in deciding this (Halpern and Warner, 2003). The dispersal range of shellfish is very hard to determine because they have a planktonic life stage (Marsden, 2002) and dispersal patterns can depend on longshore processes like current speed and direction, factors which can vary day-to-day and year-to-year. If long shore processes result in juveniles being taken into neighbouring zones where high beach traffic exists, crushing may occur during this crucial time of recruitment. Designating a zone of the beach for users away from where species are vulnerable is another option to combat this issue.

6.4 Zone-based designation

Designating particular zones of the beach is another way to control activities and prevent erosion and ecological damage. Under current management practices this method has the most potential to be detrimental to intertidal biota because most strategies in New Zealand and worldwide designate the intertidal zone for horse and vehicle use, usually to protect bird life (e.g. Waimakariri Northern Pegasus Bay Bylaw, 2010). Furthermore, this zone is likely to be picked because beach zones can be unclearly defined due to the dynamic nature of the coastal environment. The most recognisable part of beach zones is the high tide line, which can be easily identified where dry sand becomes wet sand (Figure 2).



Figure 2: Photo showing the last high tide line, where the dry (light) sand meets the wet (dark) sand.

The visibility of this line may be the reason it is used in many strategies that designate zones for activities. For example, on beaches that protect nesting birds, all vehicles and horses must be used below the high tide line. Designating traffic below the high tide line is very common and is done on most beaches with vehicle management in place (Table 2). One exception to this is in Cape Cod, USA, where no vehicles are permitted below the high tide line. This is because set vehicle tracks are in place above the high tide line. Restricting traffic to below the last high tide line has the most potential to be harmful to intertidal biota including shellfish. This is because traffic effects get condensed so there is a higher frequency of disturbance to biota. In order to protect intertidal biota, traffic would have to be restricted to zones above the high tide line where nesting birds are present. This creates a conflict between which wildlife species are protected: a diverse intertidal population that is a food source for many species versus a single bird species. If shellfish and birds are to be protected from vehicle and horse use, a dynamic plan catering for all would need to be created. In areas where environmental

protection was to become a higher priority, consideration of banning detrimental activities such as vehicle and horse use on sand beaches should be considered.

6.5 Complete banning of horses and vehicles

A complete ban of activities that can have a detrimental effect on sand beach ecosystems is by far the most favourable conservation outcome especially if an area has high conservation values. This is because vehicles and horses which may have been acting as a selection pressure will be removed (Schlacher *et al.*, 2008a). A complete ban of vehicles means that any organism living on a sand beach can inhabit an area and be protected from human disturbances at any life stage. For shellfish, recruitment into the intertidal zone can take place without the risk of being crushed. If a ban was enforced on an area that previously was affected by horse and vehicle users outcomes expected would be increases in species diversity and abundance, and the size of individuals. The rate of recovery could be rapid because clean sand communities, like those found in sand beaches, are found to have fast recovery times (Dernie *et al.*, 2003). The benefit of increasing diversity is that communities can be more resilient to other environmental changes allowing faster recovery in the future (Loreau *et al.*, 2001). By banning vehicles and horses, conservation goals can be easily achieved but this can create uproar from such stakeholders that use coastal resources. It is necessary for scientific information to be present that shows the effects these users are having on the environment in order for ecological stakeholders to have a larger voice and to convince vehicle and horse users of the benefits of removing their activity from the beach.

7 Management of Sand Beaches in New Zealand: recreational use vs. shellfish

Management of recreational activities on New Zealand's sand beaches, such as vehicle and horse use, is highly important in order to protect the unique ecosystems that the coastline facilitates. This coastline is arguably made up of a network of every type of beach system that exists (Hesp *et al.*, 1999). Sand beaches are widely distributed along the coastline and, using Short's (1999) international classification scheme, can be classified into three different types: dissipative, intermediate and reflective. Dissipative beaches are low flat beaches and wave energy is dissipated across the surf zone, whereas reflective beaches are steep with breakers that surge up the beach and reflect energy back out to sea. Such characteristics can make certain beaches more desirable to user groups than others. For example, surfers prefer beaches with high profile waves in the surf zone, whereas families prefer more dissipative features (Phillips & House, 2009). These types of preference can be used to classify beaches according to their recreational purpose. In New Zealand there is limited conflict between users, due to the 11,000 km of coastline (Woodroffe, 2002), which provides sufficient space for all activities without encroaching on each other. In New Zealand 96.6% of the population is within 50km and 64.6% are within 5km of the coastline (Statistics New Zealand, 2011). This can create conflict between beach users in centralised locations. For example, during the summer months Taylors Mistake Beach, Canterbury, is a popular swimming and bathing location for people from Christchurch, but surfers also use this beach in high numbers. Safety issues can occur if swimmers are in the surf zone; therefore, some form of management control is required. In this case, surfers are not allowed inside the flags that swimmers are required to swim between.

New Zealand coastal systems contain unique biota that is endemic due to the country's isolation: the dispersal ranges of the species are not far enough to reach other land masses allowing speciation to occur (Shluter, 2001). Consequently, many species have adapted independently to inhabit New Zealand's beaches. For example, on wave exposed sand beaches, tuatua species (*P. donacina* and *P. subtriangulata*) bury into the sediment to avoid wave forces, and they filter water in order to feed (Cranfield *et al.*, 2002). New Zealand's unique ecology also influences the way in which some beaches are used. For example, whitebaiting is a common seasonal activity. Whitebait (*Galaxiidae* spp.) is caught using large nets and gear that are taken to the water's edge by vehicles. High abundance of whitebait in certain rivers attracts higher numbers of people and vehicles. In Canterbury, the Waimakariri

River is heavily populated during this time, on average 50 vehicles are daily parked at the river's mouth (personal observations). River mouths are important nesting areas for endangered seabirds such as the Fairy Tern (*Sterna nereis davisae*), who nest on the ground camouflaged amongst shells (Department of Conservation, 2011). Protecting and preserving such species in their surrounding ecosystems makes coastal management important to ensure environmental damage does not occur from activities in the coastal zone.

7.1 New Zealand's coastal management system

New Zealand uses a system of coastal management that is characterised by top-down control in an integrated framework guided by the Resource Management Act (RMA) 1991. The purpose of the RMA 1991 is 'to promote the sustainable management of natural and physical resources' with particular reference to the land, water and air. There are several levels of management policy for the coastal zone that aim to achieve the goals of the RMA 1991. These policies focus on particular areas of the coast and are prepared and administered by the relevant local and central government authorities (Figure 3).

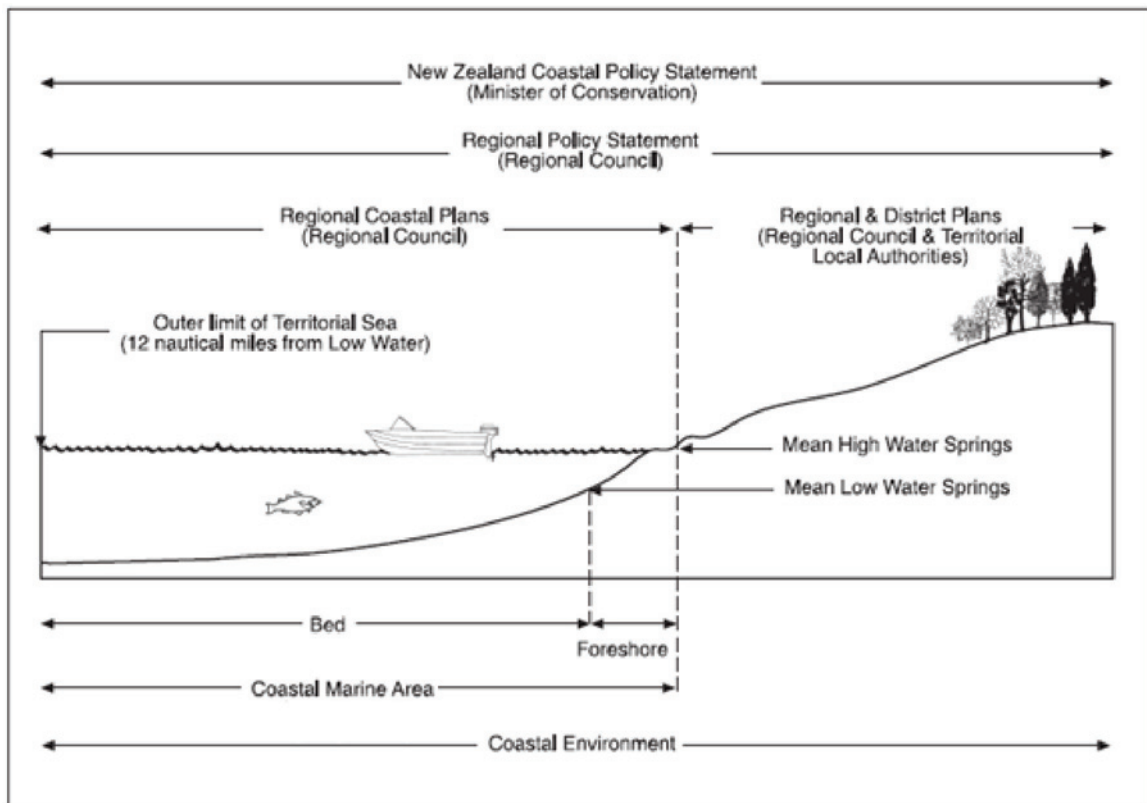


Figure 3: Management policies that control areas of the beach face and the relevant government agency responsible for their creation (in brackets). (Adapted from the Regional Coastal Environment Plan for Canterbury Region 2005)

The New Zealand Coastal Policy Statement (NZCPS) is the main environmental policy that guides local authorities during development of coastal plans. The NZCPS is a unique policy statement because it is the only one that is directly required under the RMA 1991. The plans and policies created under this document must not be inconsistent with the NZCPS and more significantly, the purpose of the RMA, 1991 (Figure 4).

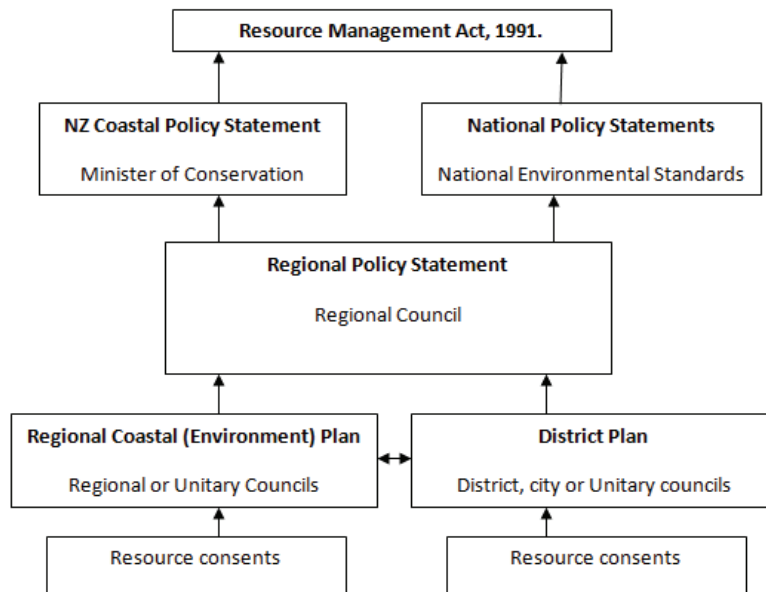


Figure 4: The implementation of management plans in New Zealand under the framework of the Resource Management Act, 1991. Arrows indicate to which policy another must be aligned. (Adapted from MFE, 2012)

In New Zealand, the responsibility for addressing regional coastal issues falls to local authorities. Each territorial authority has a set area over which they govern, the extent of these boundaries often aligning with geographical features. For example the Christchurch City Council's northern boundary is set as the southern edge of the Waimakariri River. Although different management techniques exist for managing coastal issues, many authorities enact bylaws for particular areas of beaches. Bylaws are perhaps the most commonly used tool to limit vehicle and horse use on beaches.

7.2 Vehicle and horse use on New Zealand's Beaches

Low sloping sand beaches are used by vehicles and horses, and have the potential to create environmental damage in the unique environments in which they take place unless controlled. Low sloping sand beaches are required by these users which could create conflicts if management does not control these users. Safety and environmental damage are two very

important issues when this occurs. Environmental damage encompasses issues such as erosion and ecological disturbances. Vehicles are driven to access fishing spots, joy ride and to access events. Horses are ridden on sand beaches for general recreation by amenity users as well as by professional trainers. Studies indicate that horse training on sand is beneficial for horse strength and rehabilitation (Crevier-Denoix *et al.*, 2010). Horse racing is a large industry in New Zealand and generates a similar amount of revenue to the wine and seafood industry. Racing earns \$1,635 million annually and has 52,732 people who are employed or participate in the industry. Most training occurs in Waikato (4,400 Thoroughbred & 364 Harness horses) but Canterbury has the highest number of trainers of harness racers (2,229) and is second in thoroughbred training (1,025) (New Zealand Racing Board, 2010). The intertidal zone of the beaches is most commonly utilised by these trainers due to the compact nature of the sand.

Traffic on the intertidal zone can disturb the many species that inhabit this zone, including the native toheroa (*Paphies ventricosa*), which has suffered a significant decline in numbers over recent decades causing the fishery to be closed (Ministry of Fisheries, 2011). Events such as the 'Burt Munro Challenge' (a motorcycle race) have caused detrimental effects on Toheroa, destroying juvenile populations, and are still permitted (Moller *et al.*, 2009). Other events, such as the '90 Mile Beach run' which is a marathon event and the 'Snapper Classic', a surfcasting fishing tournament can be detrimental to beach fauna due to their associated logistics. Vehicles are driven on the beaches to access areas and carry equipment. If these activities are not controlled this has the potential for major environmental damage. Surf lifesaving national competitions also bring additional traffic to the beaches. In 2011, the Nationals were held in Mount Maunganui, Bay of Plenty. The Tauranga City Council Beaches Bylaw 2007 has a specific clause allowing vehicles to be used for such events.



Figure 5: Pictures of various events throughout New Zealand. Clockwise from top left; 90 Mile beach run, Karekare Beach horse races, racers in the Burt Monro Challenge and competitors of the Surf Lifesaving Nationals, 2011.

(<http://www.90milebeachrun.com/procedures.cfm>, www.karekare.co.nz,
<http://www.surflifesaving.org.nz/Article.aspx?ID=12675#galleries>,
<http://www.burtmunrochallenge.com/>).

The Karekare Race Day, an annual horse racing event, could have adverse impacts on the ecosystem because it is concentrated in the intertidal zone where shellfish and polychaetes are abundant. Events like this are able to take place in Pegasus Bay, Canterbury because there is an exemption in the bylaws that allow for events to take place. The horse associated traffic is perceived to be likely to cause major disturbance to these populations and could have long-term effects.

8 Management of vehicle and horse users on New Zealand beaches

The issues relating to vehicle and horse use on sand beaches have not been addressed by all local authorities, but there are several organisations that have implemented control methods. These methods include banning vehicles on certain beaches (Tauranga City Council, 2007) or in certain areas (Whangerei District Council, 2008; Kapiti Coast District Council, 2009), two of the most common policies used. Other authorities have designated certain parts of the beach face for vehicle use (Northern Pegasus Bay Bylaw, 2010). In these situations, horse users are usually confined to the intertidal zone.

Management strategies employed to control vehicles and horses differ between regions and each has its pros and cons. Utilization of information from a range of sources is a key strength of New Zealand's management system, but other aspects may be ignored resulting in environmental damage.

8.1 Adopting the precautionary principle

Integrated management can be successful in achieving sustainable outcomes by using information from a wide range of sources. If this is done correctly an outcome will be achieved that compromises between stakeholders and achieves the purpose of the RMA, 1991. Policy 3 of the New Zealand Coastal Policy Statement (NZCPS), clause 1 advocates that managers "adopt a precautionary approach towards proposed activities whose effects on the coastal environment are uncertain, unknown, or little understood, but potentially significantly adverse". When such management policies are ignored the outcome can fail to achieve its goals. In front of the limited but clear research that has shown adverse effects of these users on coastal ecosystems. The precautionary principle has been ignored on all of New Zealand's beaches that permit heavy traffic (e.g. vehicles and horses). As mentioned in section 2.2, there are a wide range of known effects from vehicles on flora and fauna of sand beaches. Horses are expected to have similar effects yet have very little or no control placed on them in New Zealand. If the precautionary approach was used it would be expected that vehicles, horses and other such traffic would not be permitted on New Zealand's sand beaches.

8.2 The effects of defined management boundaries on ecological protection

In the coastal zone, many ecological community processes can take place over large spatial scales and will nearly always overlap management boundaries. As such, the populations within those boundaries may be subject to differing effects from recreation. An ecoregion is the term given to boundaries that a species can inhabit. Ecoregions are often defined by geographic boundaries, not boundaries defined by people (Bailey, 2005). Long-shore processes are a key factor in determining these for the coastal environment. Ecoregions overlapping management boundaries increases the importance of integration between neighbouring authorities. A lack of integration will mean that biological communities will receive protection in one part of its ecoregion and population dynamics would be altered. Policy 4 of the NZCPS 2010 aims to achieve consistency within regions by encouraging integration between management authorities. This co-management is particularly effective

when authorities each have the capacity to fulfil its responsibilities (Lyver, 2005). When a neighbouring authority cannot facilitate this certain areas of a coastal region will be protected by those that can.

Utilization of co-management aims to ensure biological communities receive equal amounts of protection throughout New Zealand. Management effort can focus on the same goals with ecological protection and resource use being balanced. Management needs to remain relative to the region; the idea that one-size-fits-all is not always applicable. For example, absence of sand beaches in a particular management authority's boundary would see no need for them to be involved in development of policies of this type. Promoting integration between management authorities needs to continue for effective policy development and implementation. More importantly, these organisations, unlimited by geological boundaries, can achieve protection of ecoregions as a whole.

8.3 Consideration of intertidal biota for ecological protection

Coastal management in New Zealand has largely focused on safety, erosion and protecting bird nests so policies that control vehicle and horse users are usually confined these users to the intertidal zone. For example, the Kapiti Coast District Council Beach Bylaw 2009 permits traffic to be on the foreshore of beaches but not above the high tide mark. However, some management authorities do not designate beach zones for traffic to take place, so vehicle and horse use can occur in all areas of the beach face (e.g. Whangarei District Council Vehicles on beaches bylaw, 2008). Intertidal biota such as shellfish will benefit because traffic is spread over the whole beach reducing the probability of high levels of disturbance to individual shellfish. New Zealand's beaches contain a large amount of native fauna, the combination of which helps to create unique sets of ecosystem services. For example, tuatua are a large prey species that reduce water turbidity (Vaghn and Hakenkamp, 2001). With increased traffic in the intertidal area, functioning of these organisms would be reduced due to disturbance. Reduced ecosystem functioning will not only effect the biological community but also humans. For example, shellfish disturbed by vehicles may reduce the amount of filtration of water due to stress, which would result in more turbid water. This is not aesthetically appealing for humans, and could decrease phytoplankton production due to sunlight not penetrating as deep into the water column. Overall, less energy is then passed through trophic levels reducing productivity of the ecosystem.

It could be argued that the most ecologically beneficial outcome for intertidal biota would be achieved by banning vehicle and horse users. As many stakeholders are unlikely to meet this option with enthusiasm, local authorities, in permitting vehicle and horse use, must aim to reduce the frequency and impact of these disturbances. Reducing the spatial distribution and amounts of traffic on the foreshore of beaches would be two suitable methods to limit impacts. Currently, no management policies in New Zealand do this; a permit system would need to be implemented to achieve this.

8.4 The effects of frequent use of New Zealand's sand beaches on intertidal fauna

Vehicle and horse users can be found at beaches all year round subjecting fauna to daily disturbance. The intensity of this disturbance also varies temporally and is likely to be most damaging during sensitive life stages such as reproduction and recruitment. For example, activities such as whitebait and salmon fishing occur in the warmer months, at the same time when many beach species reproduce. The majority of management policies in New Zealand allow vehicle and horse users beach access all months of the year. Kapiti Coast District Council is the only known exception to this; they do not allow horses on beaches between 11am and 5pm from 1st December to the end of daylight savings (around April). Intertidal species could be protected during important life stages such as during reproduction if management policies considered this more often. Juvenile populations would be able to recruit without pressure from vehicles and horses. For this management option to work effectively, scientific information on the species life cycles is needed to identify appropriate timing of closures. The following section gives a brief summary of how management bylaws are used to control vehicle and horse users in Pegasus Bay, Canterbury. The environmental outcomes of these are discussed in relation to the impacts on shellfish populations.

9 Case study: Management of vehicle and horse users in Pegasus Bay, Canterbury.

Variation between regions of sand beach management makes it necessary to focus on one area of coast to evaluate the effects a particular strategy may have; Pegasus Bay, Canterbury. Pegasus Bay is eastern-facing bay which hosts a wide range of activities including vehicle driving and horse riding. Management that controls these activities aims to ensure safety of users and mitigate environmental damage. Beaches in Pegasus Bay are classified as wave

dominated long-shore bar trough beaches (Coastal explorer, 2011). Horse riding most commonly occurs on Ashworths, Woodend and Spencerpark Beaches on a daily basis. Vehicles are usually driven around the river mouths (Waimakariri and Ashley) during the whitebait and salmon seasons, but are present at lower numbers outside of these times.

9.1 Current management of users in Pegasus Bay

Vehicle and horse users are controlled through bylaws that are implemented by the Councils that manage the area. These bylaws are known as the Waimakariri District Council Northern Pegasus Bay Bylaw 2010 (Appendix 1) and the Hurunui District Council Northern Pegasus Bay Bylaw 2010. The Christchurch City Council does not have any bylaws directly relating to control of vehicles on its beaches; however, the Regional Coastal Environment Plan for the Canterbury Region 2005 (Policy 8.10) does cover this issue. Horse riding is permitted along most of the beach in these bylaws, however it is not allowed near the flags at surf lifesaving clubs dotted along the coastline. Vehicle use is not as widely permitted. This is allowed north of the Heyders Road gate to the Woodend Beach access way, and on Ashworths Beach. If drivers have a permit they may drive along an access way at Waikuku Beach. Permits can also be granted for access to other areas as needed. Vehicles have speed restrictions of 30 km/hour and which is reduced to 10 km/hour when within 50 m of people. Vehicles must also give way to other users, including horse riders. Another key requirement of this plan is that all vehicles and horses must go directly to the marked track or below the last high tide line. This is mostly to protect shore birds that seasonally nest above the high tide line. This use pattern is likely to have large effects on the intertidal biota as well as those in the tracks to the intertidal zone.

9.2 The expected effects of the current management strategy on shellfish

Like any management strategy, those for Pegasus Bay are likely to have a range of ecological effects on fauna. There are four main points of interest discussed for Pegasus Bay: the distribution of traffic on the beach face, free range of horses, high-use occurrence of traffic, and generally used definitions. The above management strategies have the potential to affect the success of shellfish populations on Pegasus Bay; the effects of these are examined below.

9.2.1 Distribution of traffic on the beach face

Shellfish, polychaetes and shorebirds inhabit and utilise the intertidal zone of these beaches. Frequent disturbances from vehicles and horses are perceived to have large effects on these populations but scientific research is needed to confirm this. A common species on these

beaches, the South Island Pied Oystercatcher (*Haematopus finschi*) forages on polychaetes and other species in the intertidal zone. Human disturbance has been found to reduce foraging potential of oystercatchers which could influence survival success (Stillman and Goss-Custard, 2002). Not only are visible species vulnerable, but also infaunal species such as juvenile Tuatua (*P. donacina*) which are found in high numbers in the intertidal zone. The current management policies have condensed vehicle and horse use to a small area which will further exacerbate the effects discussed in section 2. Traffic must enter and drive directly onto the intertidal zone; however, a path is not present which creates a fanning of vehicle tracks so that the effected of vehicles could spread (Figure 6).



Figure 6: Satellite image showing the fanning of vehicle tracks (yellow lines) from the vehicle entrance point (red dot) at the Waimakariri River mouth, Pegasus Bay, New Zealand. Scale 1cm=30m.

This will not only affect birds that this bylaw is aiming to protect, but will also results in high amounts of vehicle traffic in several areas of the beach. If a prescribed track was made this would be mitigated by reducing the spatial area of disturbance. Whilst the area that is selected for the track will likely suffer mortalities, the surrounding areas will benefit due to reduced disturbance. Mitigation of this would require for a set track to be established where low amounts of biota are present. The mobility of the river mouth would also need to be considered so the path's longevity would need to be considered in the design stages.

9.2.2 The free-range of horse users

Horses are currently used every day on the beaches of Pegasus Bay with no restrictions on the number of horses that can be brought onto the beach by an individual. For example, one person can run several horses on the beach multiple times with the potential to cause a large amount of damage to biota. It can be observed that many horse riders do not like to ride at speed over churned-up areas and will go higher or lower up the beach, depending on where existing tracks are situated, creating wider areas of disturbance (Figure 7)



Figure 7: Photo of Woodend Beach in Pegasus Bay, Canterbury, showing horse tracks distributed on the intertidal zone.

Higher numbers of individuals are being subject to disturbance than if the same tracks were to be used.

9.2.3 High-use timing of vehicles

Vehicles are used in higher frequencies between the months of August – April, during the whitebait and salmon seasons which coincides with many intertidal species' vulnerable life stages. This includes recruitment and reproduction in shellfish populations (Marsden, 2002). Shellfish at recruitment stages are smaller, with weaker shells, making them more vulnerable

to vehicle crushing. Recruitment takes place in the intertidal zone with individuals washing up and burying. A majority of the traffic is concentrated on the river mouths; however, the southern bank of the Waimakariri River mouth is 5km north of the entrance, so vehicles are driven on the beach to access this area. If vehicles were able to be kept away from the intertidal area during these times all populations that are breeding would benefit. By confining vehicles to the river mouths shellfish on beaches will be protected. This would still allow access for whitebaiters and salmon fishermen but would reduce disturbance to populations. A small proportion of individuals would be affected because river mouths have been shown to be areas where little recruitment takes place (Schoeman & Richardson, 2002). The ecosystem would likely benefit from this.

9.2.4 Non-specific definitions: the potential for environmental damage

Definitions that are used in bylaws are important because if these are too general other unwanted users could have free access due to the loop hole created. This could occur in the Hurunui and Waimakariri District Councils Northern Pegasus Bay Bylaw, 2010, which uses the same definition given by the Land Transport Act 1988 for a motor vehicle. This is defined under section 2(1) of the Land Transport Act 1988 as:

Motor vehicle—

- *(a) means a vehicle drawn or propelled by mechanical power; and*
- *(b) includes a trailer; but*
- *(c) does not include—*
 - *(i) a vehicle running on rails; or*
 - *(ii) [Repealed]*
 - *(iii) a trailer (other than a trailer designed solely for the carriage of goods) that is designed and used exclusively as part of the armament of the New Zealand Defence Force; or*
 - *(iv) a trailer running on 1 wheel and designed exclusively as a speed measuring device or for testing the wear of vehicle tyres; or*
 - *(v) a vehicle designed for amusement purposes and used exclusively within a place of recreation, amusement, or entertainment to which the public does not have access with motor vehicles; or*
 - *(vi) a pedestrian-controlled machine; or*
 - *(vii) a vehicle that the Agency has declared under section 168A is not a motor vehicle; or*
 - *(viii) a mobility device*

This definition covers a wide range of vehicles including bulldozers and other heavy machinery, and if this heavy machinery was driven on the intertidal zone it could only take one pass to damage shellfish populations. While it is unlikely that this is common, I have observed that bulldozers and diggers have been driven on the beach to clear access roads and lift stranded boats onto trailers. A large amount of environmental damage could occur if this was to happen frequently. It is suggested here that the definition needs to be changed to only control vehicles, and heavy machinery being addressed separately.

10 Summary- International management

- Ecological protection is a small focus in most sand beach management policies and practices and is often superseded by physical and geomorphologic hazard management focusing on erosion protection and recreational safety.
- Where ecological protection does occur, policies are mostly focused on nesting shorebirds and turtles that are visible and no infaunal species are protected. This is despite bivalves making up a large biomass for sand beach ecosystems and facilitating other lower level species and being a food source (Knox, 2001).
- Horses are less controlled on sand beaches than vehicles, but both have been shown to cause a wide range of effects on sand beach biota. If management is present, focus is on user safety, preventing erosion, and protecting nesting wildlife.
- Vehicles and horses are managed using methods such as: permit systems, seasonal closures, designation of beach areas or zones, and complete bans. Each of these systems has benefits for shellfish; however, most benefits are indirectly achieved.
- For shellfish populations to be protected from the adverse effects of vehicles and horses on sand beaches a dynamic system using a combination of management methods should be employed.

11 Summary- Management in New Zealand

- New Zealand's coastline contains all types of beaches and unique biota is found throughout.
- Vehicles and horses are commonly used on sand beaches throughout New Zealand and the effects on intertidal biota are relatively unknown.

- New Zealand's management authorities are guided using an integrated framework set out by the Resource Management Act, 1991. As a result of this some policies may be ignored amongst the influx of information guiding management decisions.
- Some areas of New Zealand have developed policies that control vehicles and/or horses, but the method of control is not consistent throughout. Variations occur in how vehicles and horses are controlled but generally this is done by designating a zone of the beach for use; usually the intertidal zone.
- If vehicle and horse use is to continue on sand beaches more methods of control are needed to provide sufficient ecological protection. This may include permit systems to reduce traffic or seasonal closures at critical times of an organism's lifecycle.

12 Summary- Management in Pegasus Bay

- Pegasus Bay beaches are well managed when it comes to ensuring safety of users and erosion, but protection of intertidal biota is not addressed.
- Vehicles and horses are often used on a daily basis, and higher numbers of vehicles are used in the months between August and April. While most of this increased traffic is focused on the river mouths due to whitebait and salmon seasons, travel to and from these areas may be done over large stretches of beach which could be causing damage to shellfish populations.
- To mitigate the effects of users limiting the number of horses and/or vehicles on the beaches and closing beaches at times of the year may be necessary.
- Definitions for vehicles in these management plans are not specific to cars so heavy machinery such as bulldozers and diggers could be used on the beach. Definitions need to be made to be specific for the bylaw.

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Appendix 1- Waimakariri Northern Pegasus Bay Bylaw, 2010, Advert.

Better Beaches

The Waimakariri District Council Northern Pegasus Bay Bylaw 2010

This bylaw has been adopted by the Waimakariri District Council and comes into effect as from July 1st, 2010*

*Full details of the provisions of the Waimakariri District Council Northern Pegasus Bay Bylaw 2010 can be accessed from all Waimakariri District Council Service Centres (Porirua, Gopple and Okeano) and from www.waimakariri.govt.nz

Here's what it means to you:

- 1 Vehicle Access on the beach at the Ashley River mouth**

 - Vehicle use is prohibited on the beach between Woodend and Kaihaki.
 - There will only be seasonal vehicle access to the south side of the Ashley River mouth.
 - There will be a closed gate at the Ashley River Mouth during any period of storm and operators applying for motor vehicle access to the south of the Ashley River Mouth.
 - Permits and keys to the gate will be available from the Kaipara Senior Centre for bookings for swimming, windsurfing, fishing, boat launching, retrieval and disability access only from the 15th of August until the 30th of November each year. A suitable permit will be required. Out of season there will be no vehicle access permitted.
- 2 Vehicle Access on the beach at Kaihaki (across Environment Canterbury contracted land)**

 - The Council will require Environment Canterbury to erect a fence and vehicle barrier with open gate access at the Waimakariri Beach mouth across road of Kaihaki. This will channel vehicle access to the beach through a controlled point. signage will notify beach users of the new bylaw requirements.
 - The beach access will be reviewed within a two year period to assess its effectiveness in improved dune behaviour, protection, safety and ecological impact on the sand dunes and the beach between Woodend and Kaihaki.
 - It can be reviewed, this is not planned to be effective, further public consultation will take place on a permit and key system to provide vehicle access to the beach.
- 3 Vehicle Access North of the Ashley River mouth**

 - Vehicle use is permitted across the high tide line only on the area of the beach north of the Ashley River mouth for the northern boundary of the Waimakariri District Council.
- 4 The Ashley Estuary**

 - All vehicles are prohibited except for seasonal use of the inlet at low tide and other authorized uses.
- 5 Horses and Dogs**

 - All horse riding, including training, is permitted along the full stretch of the beach between the Waimakariri River Mouth and the Waimakariri District Council boundary including the area between Woodend and Kaihaki beaches.
 - The Council will investigate options for development of designated horse feed parking at Kaihaki and will consult the Waimakariri community and other interested groups on identified options.
 - All dogs must be kept on a leash in the prohibited areas around the Ashley/Kaihaki estuary shown on the map. Dog owners are allowed during the designated hunting season.
- 6 To Kohaka O Tuhaitara Trust Land (Coastal Forest)**

 - The bylaw prohibits motor vehicles and all other vehicles from entering the Kohaka O Tuhaitara Trust Land and sand dune areas along the beach.
- 7 Sand Dunes**

 - To maintain the environmental protection of coastal Waimakariri dunes, no vehicles are permitted on the sand dunes at any time.

MORE INFO

Visit the website for full information about the bylaw changes:
www.waimakariri.govt.nz/publications/bylaws/bylaws
or you can email: bestbeaches@waimakariri.govt.nz

Reynolds
240 MAIN STREET
PH: 03 371 1000

Kaipara
240 MAIN STREET
PH: 03 371 1000

Okeano
240 MAIN STREET
PH: 03 371 1000

WAIMAKARIRI DISTRICT COUNCIL

Website: www.waimakariri.govt.nz

WAIUKU BEACH ACCESSWAY

Permits required for motorised vehicles (see access)

WOODEND BEACH ACCESSWAY

Permitted horses and low speed vehicles only. No motorised vehicles.

KAIHAKI BEACH ACCESSWAY

Mid or low speed vehicle access permitted at designated gate.

Stay below last tide marking

Motorised vehicles and horses, where permitted, must remain below the last high tide mark.

*Visit www.waimakariri.govt.nz for more information

Appendix 2: Table of peer-reviewed literature

Location	Activity literature covers			Species focused on	Purpose	Findings	Author (s), year published.
	V	H	Other				
Fire Island, New York, USA.	X			Dune ecosystem	To evaluate effects of ORVs on dune systems	Vegetation severely reduced and erosion higher	Anders & Leatherman, 1987.
Algodunes Dunes, California, USA.	X			Dunes, Plants, mammals, birds	To evaluate effects of ORVs on dune ecosystems	Reduction in biota with low level passes. None in high use	Luckenbuch & Bury, 1983.
Queensland, Australia	X			All beach fauna	Quantify spatial and temporal trends in vehicle traffic	Up to 65% of species are exposed to vehicle traffic	Schlacher & Thompson, 2007.
Queensland, Australia	X			Intertidal Macrobenthos	Quantify ORV effects by comparing between beaches with different use	ORV beaches have reduced, less diverse populations and altered assemblages.	Schlacher, Richardson, & McLean, 2008.
Queensland, Australia	X			<i>Donax Deltoides</i> , Bivalve	Quantify the relationship between vehicle traffic and shellfish mortalities	Increase in mortalities at higher levels of passes	Schlacher, Thompson, & Walker, 2008.
Fraser Island, Australia	X			Dune, Fauna and Ghost Crab, <i>Ocypode</i> spp	Quantify ORV effects on dunes and link to biota	Accelerated erosion and shoreline retreat. No dune plants in tracks and reduced Ghost crab abundance	Thompson & Schalacher, 2008.
Queensland, Australia	X			<i>Donax Deltoides</i> , Bivalve	Evaluate the sub-lethal effects of ORVs	Increased passes impaired burrowing performance	Sheppard, Pitt, & Schlacher, 2009.

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North Stradbroke Island, Australia	X			<i>Ocypode cordimanus</i> & <i>O. ceratophthalma</i> (Ghost Crabs)	Quantify magnitude and mechanism of ORVs on Ghost Crab populations	Crabs with deeper burrows have lower mortality. Lower densities in high traffic area. More mortalities at dusk.	Schlacher, Thompson, & Price, 2007.
North Stradbroke Island, Australia	X			Ghost crabs (<i>Ocypode spp.</i>)	Observe if movement patterns were affected by vehicle traffic	Traffic halved pop. densities and changed movement to be more erratic with compressed home ranges.	Schlacher & Lucrezi, 2010.
North Carolina, USA	X			Beach Macrofauna, including <i>Donax variabilis</i>	Evaluating the potential and actual impacts of ORVs	Most species predicted to be undamaged. Night driving would have largest effect on ghost crabs.	Wolcott & Wolcott, 1984.
Cape Cod, Massachusetts, USA	X			Dune vegetation	Evaluating impact of vehicles on dune grasses	All above ground is killed, but below ground biomass is enough to recover.	Brodhead, & Godfrey, 1977.
Coorong, South Australia, Australia	X			Hooded Plover, <i>Chardrius rubricollis</i>	Evaluate the vulnerability of bird nests	Over the incumbent period 81% of nests would be runover. Rate of 8% per day.	Buick, & Paton, 1988.
Cable Beach, Western Australia, Australia	X			Shore crabs, <i>Ocypode spp.</i> And sand bubbler, <i>Scopimera inflata</i>	Testing the link between human usage and shore crab abundance	Less dense crab populations in high vehicle use areas.	Foster-Smith <i>et al.</i> , 2007.
Algodunes, California, USA	X			Peirson's milk-vetch, <i>Astragalus magdalenae</i> var. <i>peirsonii</i>	Identify differences of abundance between high/low use areas to decide impact was significant	Reduced survival by 33%, but recovery did occur in closed off areas.	Groom <i>et al.</i> , 2007.

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Fort Fisher Beach, North Carolina, USA	X		Pedestrians	Loggerhead turtles, <i>Caretta caretta caretta</i>	Evaluate the effects of vehicles and pedestrians on behaviour and sea-approach	Tyre tracks caused increased transit time to reach the sea reducing survival chances.	Hosier <i>et al.</i> , 1981.
Cape Fear, North Carolina, USA	X			Dune and grassland vegetation	Determine the effects of vehicles on dune and grassland ecosystems	Vegetation cover and species richness decreased in vehicle area. Soil was more compacted in vehicle area.	Hosier & Eaton, 1980.
Sharon National Park, Israel			Pedestrian, Motorbike	Dune vegetation	Testing effects of passes and trampling on vegetation	Trampling had low effect on plants. Motorcycles had large immediate effects, highest in wheel tracks.	Kutiel <i>et al.</i> , 2000
Eastern Australia, Australia	X			Ghost crabs, <i>Ocypode</i> spp.	To test whether burrow architecture is affected by vehicle traffic	Vehicle beaches: Smaller crabs, deeper burrows, simplified shapes	Lucrezi & Schlacher, 2010.
Massachusetts, USA	X			Piping plover, <i>Charadrius melodus</i>	To document mortalities caused by vehicles on beaches	Piping plover were killed by vehicles and recommended closure of area at hatch date of nests.	Melvin <i>et al.</i> , 1994.
Alexandria Coastal Dunefield and University of Port Elizabeth, South Africa	X		Pedestrian	Dune vegetation	Investigate the effects of varying traffic intensities on vegetation height and cover for pioneer and climax dune	Vehicle: Curved path more destruction. Pioneer communities recover quickly. Impacts may not be realised for 3months.	Rickard <i>et al.</i> , 1994.
Assateague Island, Maryland-Virginia, USA	X		Pedestrian	Ghost crab, <i>Ocypode quadrata</i> Fab.	Determine if relative number of crabs was subject to recreational use	Vehicles likely to stop reproduction and crushing crabs. Pedestrians have no effect.	Steiner & Leatherman, 1981.

Management of vehicle and horse users on sand beaches

Alexandria Coastal Dunefield, South Africa	X		Fishermen	Dune breeding birds	Quantifying beach use through data and observations	50% of activity was in dune bird area. Potential for impact is high above the MHWS.	Watson <i>et al.</i> , 1996.
San Francisco Bay, USA	X			Vegetation and soil	Investigate the impacts of vehicles on vegetation and soil	Loss of vegetation cover promotes erosion. Erosion exceeds US standards.	Wilshire <i>et al.</i> , 1978.

Appendix 3: Table of reviewed management policies

Location	Reference	Activity management covers			Management control method	Positive outcomes for shellfish	Negative outcomes for shellfish
		V	H	Other			
East of south Island, New Zealand	Tuatua Quota for PDO3			Fisheries	Sets TACC for adult tuatua	Stops overfishing	Limits could be too high for certain areas. Dredging is an acceptable method of gathering.
Hurunui, New Zealand	Hurunui District Plan			All district issues	Puts policies in place to control activities	Aims to maintain natural values and prevent contamination of water.	No mention of shellfish in policies.
Hurunui, New Zealand	Hurunui Northern Pegasus Bay Bylaw 2010	X	X	Pedestrians	Defines where each activity can occur	Does not allow vehicles in all areas of the beach.	Horses are allowed everywhere. Vehicles and horses allowed in the intertidal zone= condensing of traffic
Waimakariri district, New Zealand	Waimakariri District Plan			All district issues	Uses policies to control activities	Prevents contamination. Aims to prevent loss of integrity	No focus on vehicles, want to improve access. Only mention of vehicles is in the dune area.
Waimakariri District, New Zealand	Waimakariri Northern Pegasus Bay Bylaw, 2010	X	X	Pedestrians	Defines where each activity can take place	Prevents vehicles from driving over all the beach	Horses are allowed everywhere. Vehicles and horses allowed in the intertidal zone= condensing of traffic.
Christchurch, New Zealand	Christchurch City Council City Plan	X		All city related issues	Policies	One aim is to increase public access so that vehicles are not needed	No other mention of activities despite the zoning being extended below the MHWS line
Canterbury, New Zealand	Regional Coastal Environment Plan	X		Other regional issues	Policies	Prohibits vehicles in certain areas. Give Pegasus Bay Beaches "Area of significant value" status.	Large focus on dunes. Still allows 4wd clubs to use areas in winter when authorised
Canterbury, New Zealand	Regional Environment Statement			Regional Issues	Policies	Focuses on protection of indigenous species, biodiversity and erosion.	No mention of shellfish protection, only mentioned in relation to mahinga kai

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New Zealand	New Zealand Coastal Policy Statement			All national priorities	Policies	Precautionary approach to be taken. Mentions protection at vulnerable life stages. States vehicles to be controlled where ecological harm may be caused	No mention of horses. Left up to regions to decide how to interpret this.
New Zealand	Resource Management Act, 1991			All national priorities	Policies that guide other documents	Mention of shellfish for water quality and gathering.	No specific mention of activities.
New Zealand	Fisheries Act, 1996			Fisheries	Policies	Stops overharvesting of shellfish for an area by setting a quota	Areas are often large which could result in some areas becoming depleted
Australia	Coastal Protection and Management Act 1995			National coastal issues	Give direction for management authorities to control activities	States that conservation should also be taken into account	States that public access must be considered.
Queensland, Australia	Queensland Coastal Plan, 2011	X	X	All state activities	Policies and principles	Vehicle use is unsupported and states that protection of foreshore species is important. Lists many beaches where it cannot occur due to erosion	Still states that vehicles are allowed if managed.
South-East Queensland, Australia	South-East Queensland Regional Coastal Management Plan, 2006	X		All regional activities	Policies	Vehicle use is same as for State coastal Plan	
New South Wales, Australia	Vehicle Access general Policy, 2010	X			Policies	Vehicle use is not to be expanded if a national park is gazetted. Not allowed if environmental damage will occur.	Is still allowed, no mention of where it is allowed.
South Africa	Full 4x4 Regulations 2004	X			Policies	Complete ban on vehicles for recreational use.	Exceptions are made, areas can be declared by the Deputy Director-General.
Whangarei, New Zealand	Vehicles on beaches bylaw, 2008	X			Bylaw	Vehicles not allowed in Safe zones (Near surf clubs). Also allowed anywhere on the beach face.	Allowed along most of the beach.
Kapiti Coast, New Zealand	Kapiti Coast District Council Beach Bylaw 2009	X	X	Other beach activities	Bylaw	Some areas are prohibited from use by vehicle and horses (at certain times of the year). Motor bikes are prohibited everywhere.	All traffic is on the foreshore. Horses are allowed everywhere apart from in the summer.
Tauranga, New Zealand	Tauranga City Council Beaches bylaw 2007	X	X	All other activities	Bylaw	No vehicles allowed, with few exceptions Activities allowed on whole beach face.	Horses are allowed almost everywhere.

Management of vehicle and horse users on sand beaches

Cape Cod, USA	No name (Web page)	X		Rules	No vehicles allowed on the foreshore.	Some allowed if track is cut off.
Cape Hatteras, USA	Cape Hatteras National Seashore Off-Road Vehicle Negotiated Rulemaking and Management Plan/EIS, 2010	X		Rules	Vehicles managed by permits and are not allowed during certain months around bird and turtle nests.	Horses are still allowed without permit.
Cannon Beach, Oregon, USA	Website	X		Rules	Vehicles only allowed with a permit for a specific reason.	Permits could vary.
Crane Beach, Massachusetts, USA	Website		X	Policies	Only allowed from Oct 1-Mar 31.	Have to stay in the intertidal zone. Up to 50per day.
Donegal County, Ireland	Donegal County Council (Regulation and Control of certain Beaches) Bye-Laws 2009	X		Policies	No vehicles allowed on most beaches. Horses not allowed in certain months without permit.	Horses are allowed.

