Geography 309

Research Methods in Geography

Characteristics of Commercial Horse Trainers at Woodend Beach, Canterbury

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Executive Summary

Woodend Beach located in the Northern Pegasus Bay Area is a multi-use beach which can often lead to user conflict. It is a popular place for commercial horse training and other recreational activities to occur.

This research aimed to quantify the extent and characteristics of commercial horse training and the behaviour of the commercial horse trainers. Impacts to the physical environment were also of interest to the Waimakariri District Council. The findings from this research will be used for the User Agreement review.

Field studies using observational methodology were employed during primary data collection. A triangulated approach incorporated participant observation, time and motion camera footage, drone technology and physical measurement.

A four-week period saw 412 commercial horse trainers frequent the beach using motion sensor cameras. Compared to the eight observation days which saw 117. The commercial horse trainers spent an average 14 minutes 41 seconds, with a peak time between 7:00am and 7:59am. The commercial horse trainers were seen to prefer a pair formation. Drone footage captured the furthest extent of 3.84km and the most common extents between 2.7km and 2.9km. The average galloping speed found was 12.4m/s. Other users consisted with walkers, dogs, recreational horse riders and runners and joggers. The environmental impact from horse hoof imprints is dependent of the depth. Findings found that the speed and type of sand substrate influenced the depth. Shellfish were seen crushed in the hoof prints however it cannot be confirmed if they were dead or alive prior to being crushed

As the study was carried out in Winter/Spring months (August/September), these months may not consider for seasonal changes. Additionally, problems with the motion detection cameras that lead to omittance of some data in the photo analysis.

The terms of the user agreement have shown effective and should remain in place. Dogs that are not well trained, should be kept on a leash around commercial horse trainers to minimise the user conflicts and injuries. Riders are recommended to reduce their speed to minimise the impacts on Tuatua and risk of injuries to other users.
Further studies should be executed in spring and summer to account for seasonal fluctuations. Incorporating recreational riders, that are not restricted by area, could broaden the scope of characteristics and extent of the activity. Further interviews of beach users could give a clearer perspective about this activity.

1.0 Introduction

1.1 Background

The Waimakariri District Coastline is used for a variety of activities such as commercial horse training, recreational horse riding, jogging and a place for people to walk their dogs. As a result of Woodend Beach being a popular multi-use area, there is an increased risk of potential user conflict and damage to the coastal environment.

1.2 Northern Pegasus Bay Bylaw

The Northern Pegasus Bay Bylaw (NPBB) was brought into action in August 2016. The purpose is to ensure that both the environment and wildlife were not harmed, while still allowing everyone to enjoy the Waimakariri District beaches ("*Northern Pegasus Bay Bylaw Implementation Plan",* 2016).

The Waimakariri District Council (WDC) developed the Northern Pegasus Bay Implementation Plan to ensure that the NPBB was able to achieve its objectives. This consisted of a research and monitoring programme that was to be put in place. One component of this was on commercial horse training which is the focus of this report. The Bylaw is due to be reviewed in 2021, therefore, the findings in this report can be used to make recommendations during the review process.

The Implementation Plan outlines user agreements for commercial horse training. The Woodend Beach Commercial Horse Trainer's User Agreement addresses the key issues that were identified throughout the consultation process. As a part of this agreement it outlines that commercial horse training is restricted to 3.2km's either side of the Woodend Beach Access Trail. This allows them to train over a considerable distance while not disturbing the entire coastline. Within this restriction, commercial horse trainers are also not permitted to train above the high tide line due to impacts on erosion and bird nesting.

1.3 Research Aims

The WDC wanted to identify the extent and characteristics of commercial horse training, and where time permitted, note any impacts to the physical environment/beach interface. In turn, the following three research questions were produced:

1. What are the extent and characteristics of commercial horse-trainers on Woodend Beach?
2. How are the commercial horse trainers modifying their behaviour to ensure the protection of other users?
3. What are the environmental impacts from commercial horse trainers?

The research objective was specific to commercial horse training activity on the surrounding Woodend Beach environment and disregards recreational horse users.

1.4 Study Area

The area of study for this research is the coast managed by the WDC. Woodend Beach, located in the Northern Pegasus Bay (NPB) area is the coast where commercial horse training is permitted. The exact area along the coast is shown in Figure 1 below.

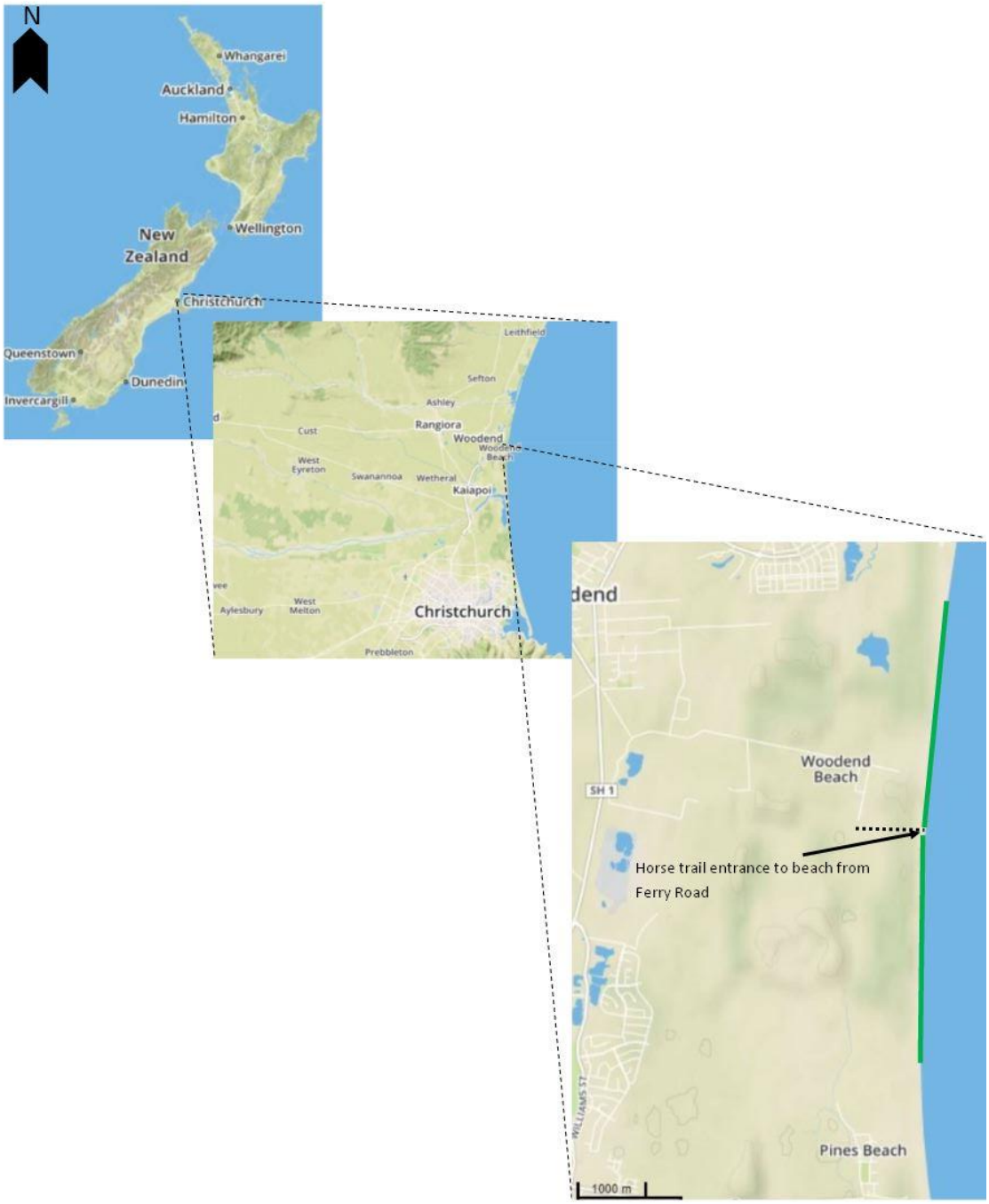

Figure 1. The study area used for this research was located along the Waimakariri District Coastline, Canterbury, South Island, New Zealand. The green line represents the 6.4km permitted extent (3.2km either side of Accessway) (Land Information New Zealand, 2015).

2.0 Review of Existing Research

Initial research objectives were established following a review of previous literature in related fields - policy and agreements, observational methods, shellfish biota, impacts of horses on beaches.

Gareth Taylor produced a thesis titled 'Management of Sand Beaches and Protection of Shellfish Resources' (2013). This report was a guiding piece of initial research for this project providing the structural framework for further observational study of commercial horse training in the NPB area.

2.1 Policy and Agreements

The Commercial Horse Trainers Agreement (CHTA) (2016) was negotiated as a provision for horse trainer conduct whilst occupying a public use beach. The NPBB provides overarching context regarding management and beach protection strategies. This legislation communicates clear expectations regarding safe and responsible beach use for the horse trainers and is supplemented by the Implementation Plan.

2.2 Observational Based Methodologies

Yoder and Symons (2010) discuss the difficulties encountered during behavioural observation. Commonly, high quality observational research is attributed to intricate and detailed note taking which supplements analysis at a later stage (Clifford, Cope, Gillespie, & French, 2016).

Observational studies require positioning oneself without a preemptive bias for research authenticity. Gremillion (2013) suggests integrated cultural knowledge and participant observation when looking to identify gaps between ideology and practice. The concept of Community Based Monitoring (CBM) is a natural progression from Gremillion's earlier recommendation. Despite its merits, problems associated with CBM include inexperience, accuracy and community bias (Johnson et al., 2015).

2.3 Shellfish Biology

The National Institute of Water and Atmospheric Research [NIWA] discuss Tuatua burrowing behaviour within the sediment and the nature of their location, typically 10 metres from the sands surface with respect to the low tide (NIWA, 2008). Tuatua are recognised as an important food source for local iwi. (Fisheries New Zealand, 2008). Storm erosion, high temperatures, low available oxygen, toxic algal blooms and freshwater input are identified as leading causes of mortality among surf clams (Fisheries New Zealand, 2008).

Marsden's (2000) research offered insight into Tuatua behaviours and established that mature Tuatua were restricted to low tides following storm events due to size. Additionally, field studies suggest that per 5m of shoreline (between NPB and Taylors Mistake) the average number of Tuatua was between 0.1 and 62 (Marsden, 2000).

2.4 Impact of Horses on Beaches

An Australian study (Smyth, 2016) examined the effects of horse traffic on coastal dune systems, revealing extensive erosion and disturbance to bird communities. Taylor, Marsden and Hart (2012) outlined permit systems and seasonal access as key management practices. Successful mitigation controls regarding horse activity are dependent on extensive knowledge of impacts and ecosystem knowledge (Newsome, Smith & Moore, 2011).

The environmental impacts of commercial horse training on Tuatua has been established previously. However, a research gap exists in the form of the extent, characteristics and behaviour of commercial horse trainers exists. This observational study therefore sets out to establish parameters for these variables and accumulate data for the WDC's monitoring programme.

3.0 Methodology

3.1 Data Collection Process

3.1.1 Direct Observation

This study consisted of observational study methods, complemented with physical measurements. Primary data was obtained through observational site visits between the hours of 6am-1pm Monday – Saturday. Location, weather, tide, number of horses on the beach, formation, distance travelled, depth of hoof imprints and other users were the data characteristics captured and recorded using an Observation Chart (Appendix D). Eight site visits were conducted over the course of the project.

3.1.2 Motion Sensor Cameras and Photo Analysis

Two motion sensor cameras were set up on the Woodend Beach Accessway to capture commercial horse trainer's entry and exit times to the beach. These ran simultaneously on a continual basis. Figures 2a and 2b show camera placement along the access trail.

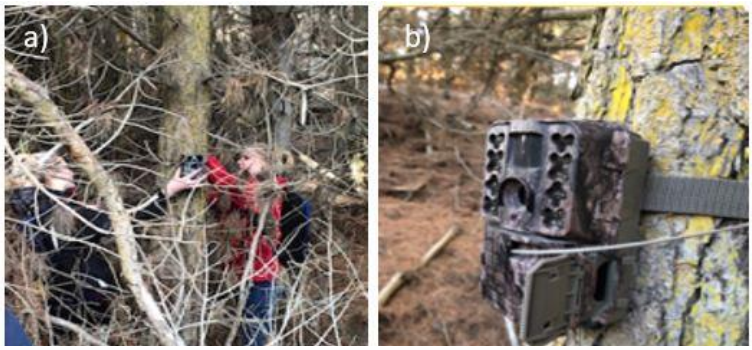

Figure 2a. Installing motion sensor cameras along the access trail. August 1, 2019. Figure 2b. Motion sensor camera. August 1, 2019.

3.1.3 Drone Footage

Drone footage was obtained to determine the average speed and distance covered by commercial horse trainers during daily training sessions. Figure 3 shows data captured for analysis. Drone footage was forwarded to the WDC for consultation and planning purposes.

Figure 3. Drone footage capturing a horse, indicated by the red circle. August 29, 2019.

3.1.4 Physical Measurement (Horse Hoof Imprints)

Physical measurements of the hoof imprints were taken in centimetres (cm) during each site visit for comparison. Measurements were taken from wet and dry sand profiles with comparison to gait. Figure 4 depicts a measurement of a horse hoof imprint. Figure 5 provides overview of the occurrences of hoof prints on a beach stretch.

Figure 4. Measurement of hoof imprint (at the toe of the hoof) along Woodend Beach. August 1, 2019.

Figure 5. Woodend Beach South facing along training run. August 1, 2019.

4.0 Results

4.1 Count of Commercial Horses

The two motion sensor cameras were running for four weeks (16th August – 12th September). Photo analysis of these cameras showed that 412 commercial horse training trips were captured on Woodend Beach (see Appendix B). The total amount of horses observed over eight days of observations was 117 (see Appendix D). It is important to note that the 117 horses observed are included in the overall total from the photo analysis.

The photo analysis had a maximum total of 43, on the 31st August (see Appendix B). The maximum count of horses observed over one day was 26 on 10th September (see Appendix D). On the last day (12th September) the cameras were taken down at 7:50am, therefore did not capture a full day of data. Both the observations and photo analysis found that on some occasions the minimum count of 0. These dates can be seen in Figure 7 and Appendices B and D.

4.2 Extent of Time Commercial Horse Trainers Spent on the Beach During Study

4.2.1 Total Time Commercial Horse Trainers Spent on the Beach

Figure 6 showed that the median time spent on the beach was 16 minutes with a mean time of 14 minutes 41 seconds. The upper outlier was 37 minutes and the lower outliers as 3 and 1 minutes.

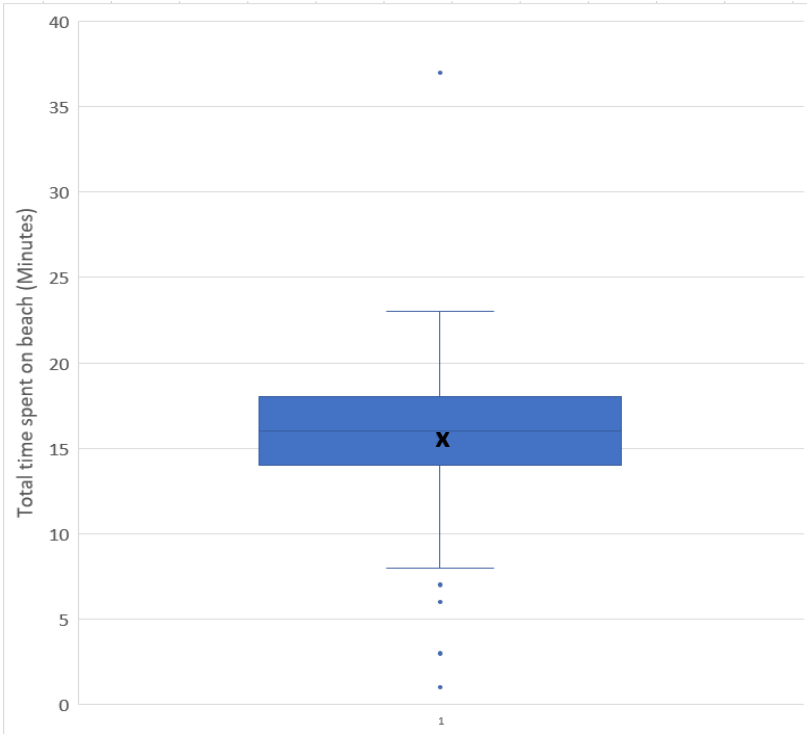

Figure 6: This box plot represents the total time commercial horse trainers spent on the beach using the photo analysis. This specifies the mean, minimum, maximum values and lower and upper quartiles. Additionally, this plot displays the outliers of time spent on the beach.

Figure 7 represents the average time commercial horse trainers spent on Woodend Beach. Sunday consistently had commercial horse trainers train. The maximum average time (20 minutes 33 seconds) commercial horses spent on the beach was on Thursday (22 August). The minimum average time disregarding Sunday was Friday 23rd and Wednesday 28th was 0.

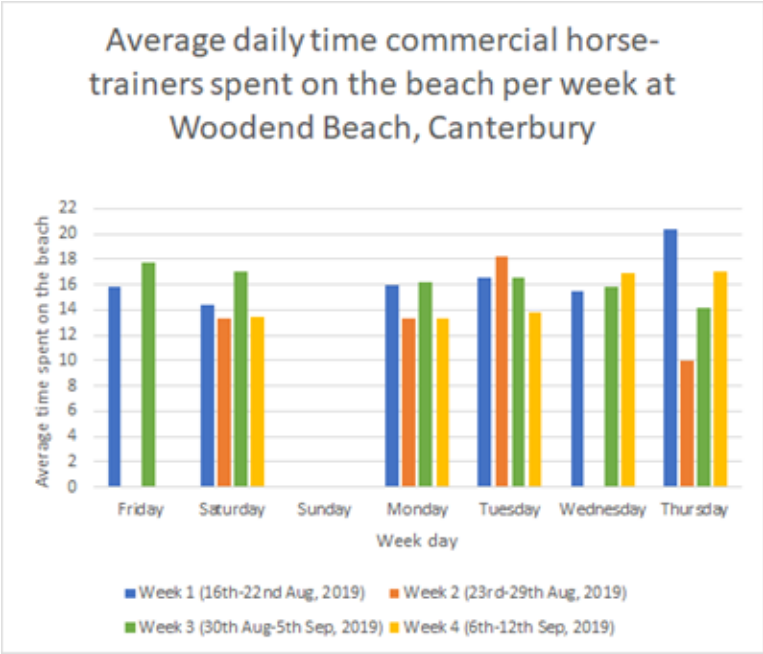

Figure 7: A four-week period displaying the average time of each day that commercial horse trainers spend on the Woodend Beach.

4.2.2 Peak Time for Commercial Horse Training

Figure 8 indicates the peak time that commercial horse trainers frequented the beach, being between 7:00-7:59am. 18 additional horses were accounted for leaving the beach, however, the research was not able to quantify these as they were not captured entering. An accurate estimation can be made for some of these horses, as average time spent and exiting time can be correlated to one time period. However, as there are horses that could be in one of two periods (see Appendix B) the decision was made to omit all with no entering time.

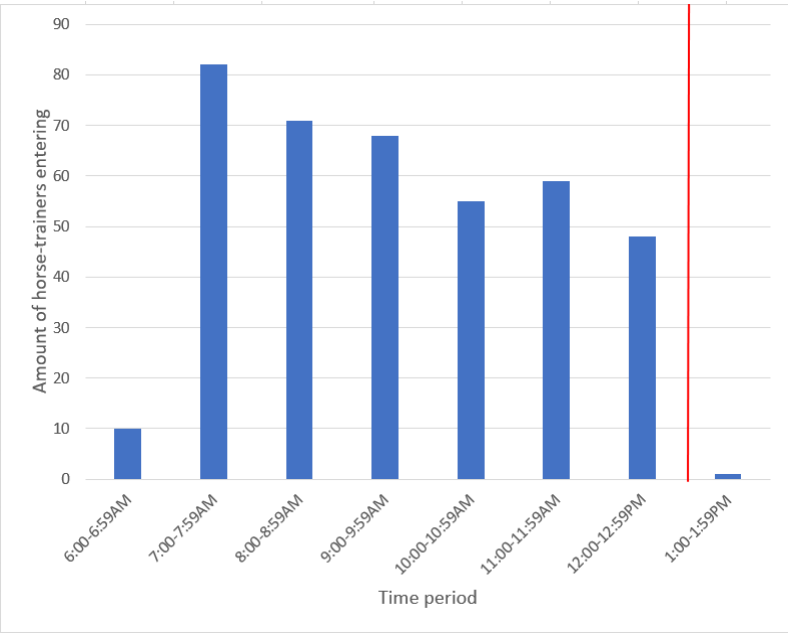

Figure 8: The peak time period used by the commercial horse trainers on Woodend Beach, Christchurch.

4.3 Characteristics

4.3.1 Formation Frequency

Figure 9 represents the formation observed when travelling at the fastest gait on the return whilst emulating race conditions. While observing the horses, it was noted that the largest grouping of horses was 10. The most frequent formation was observed to be a pair with a frequency of 32.

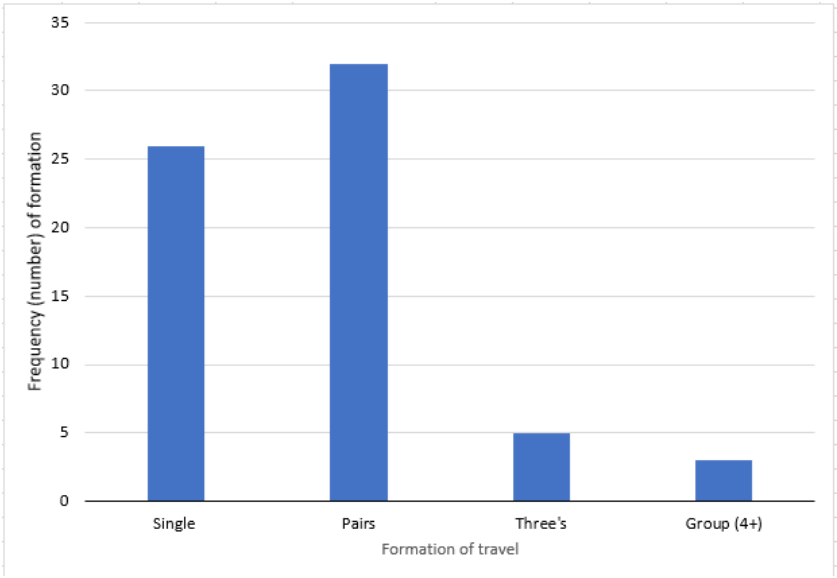

Figure 9: Various formations used by commercial horse-trainers on Woodend Beach, Christchurch

4.3.2 Extent of Beach Used

The extent of the beach used by the commercial horse trainers is confined by Bylaw (2016). Figure 10 shows the furthest extent of 3.84km captured by the drone. This measurement exceeds the average speed measurement as horses travel a further 500m north of the accessway on the return. The extent reached south by this horse trainer was seen to be at the boundary of the permitted zone (Figure 10 and 11).

The most frequent extent was between 2.7-2.93km (Figure 10). This data was correlated with estimated visual observations. All measurements of extent were made from drone footage capturing horse trainers travelling south from the Woodend Accessway. Comparing Figure 10 and 11, the most frequent extent is within the permitted area.

One observation had horse trainers travelling north instead of south. It is unknown how far north the horse trainers travelled, as this direction of extent was not captured or observed. It was assumed that they travel approximately the same distance north as they do south due to travelling approximately 500m south of the Accessway.

The width of the beach used by commercial horse trainers was measured to be between 15-30 metres depending on the tide. This measurement does not take into consideration the beach used when the horse trainers enter the water before leaving. There is no rule or agreement specifying that horses are not permitted to enter the water, thus complying with the User Agreement.

Figure 10: The extent of Northern Pegasus Bay used for commercial horse training, Christchurch

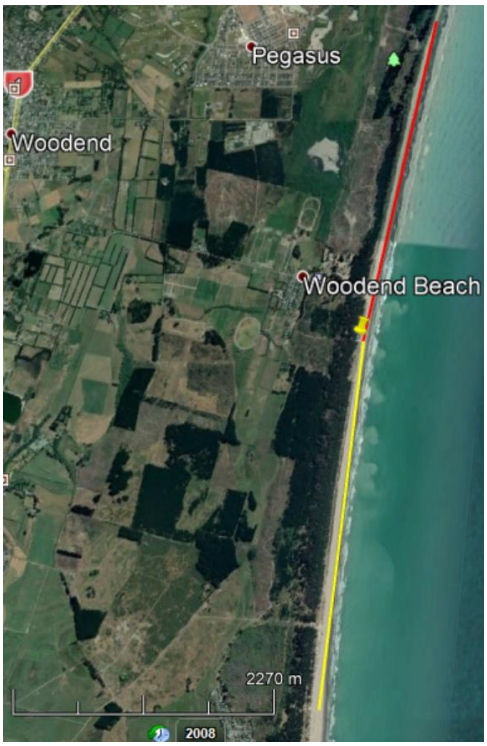

Figure 11: The designated area 3.2km north (red line) and 3.2km south (yellow line) that horse trainers are permitted to go, NPB, Christchurch

4.3.3 Speed

The average speed taken from all drone footage videos was calculated at 12.4m/s (44.6km/h). For horses to run the full extent from 3700m (measured from drone

observations) south to the Woodend Accessway north took 309 seconds, at an average speed of 11.9m/s (43.1km/h), see Appendix A for all measurements.

4.4 Other Users

Whilst observing commercial horse trainers, other users on Woodend Beach were noted during the eight days of site visits. Also noted was how they interacted with the commercial horse trainers and how the trainers modified their behaviour to reduce user conflicts. Walkers, dogs, runners/joggers and recreational horse riders recreate on Woodend beach, shown in Table 1. The most frequent other users were walkers, with a total of 27. Joggers/runners were less frequent, with the same two people identified on different occasions.

Additional behaviours noted of others using the beach would be that people would leash their dogs if a commercial horse trainer was in proximity. This behaviour suggests that other users of the beach are aware of the commercial horse trainers during this time. Commercial horse trainers would take a wider berth around another user. There were no issues of user conflict between other users and commercial horse trainers.

Table 1: Type and number of other users observed on the beach over the eight-day site visit observation.

Other Users	**Total**
Walkers	27
Dogs	14
Jogger/Runner	5
Recreational Horse Riders	7

4.5 Environmental Impacts

4.4.1 Hoof Depths, Gaits and Sand Types

Hoof imprint depths increased with speed, for example, the average hoof depths for galloping was 2.54cm, trot 2.43cm and walk 1.81cm, seen in Figure 12. Sand substrates noted a variance in hoof imprint depths. Hoof imprints for walking gait deepened considerably as sand substrate became softer and drier, from an average 1.81cm in hard sand to an average 5.73cm in soft-dry sand using a walking gait (Figure 12).

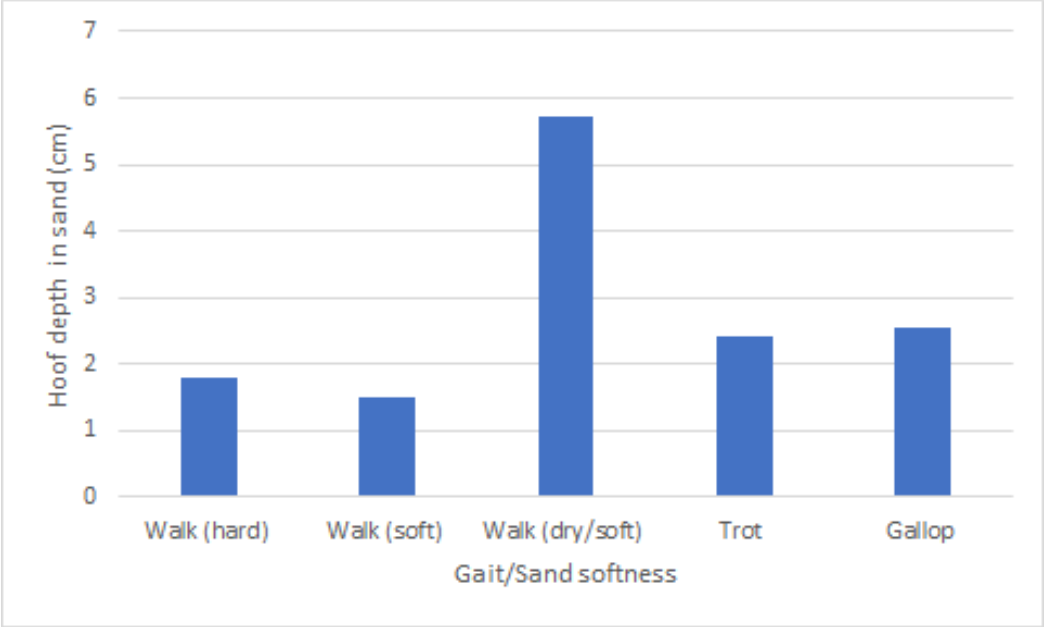

Figure 12: The average horse hoof depths for different sand softness and gaits (walk, trot and gallop).

4.5.2 Tuatua

Crushed Tuatua were observed within hoof imprints (Figure 13), however, it cannot be confirmed if they were alive before being crushed. Observations noted that there was an abundance of Tuatua within one-metre of the horse tracks (Figure 14), providing evidence of Tuatua existing within these tracks.

Figure 13: Crushed Tuatua at Woodend Beach. August 14, 2019

Figure 14: Tuatua seen in the field to be within 1-2m(s) within hoof imprints south of Woodend Beach Horse Access trail. August 14th, 2019

5.0 Discussion

5.1 Characteristics and Extent of Commercial Horses on Woodend Beach

The findings regarding the characteristics and extent of commercial horse training have not been researched previously. These findings provide a significant step towards further recommendations that should be considered during the NPBB review in 2021.

The count of horses found on the beach varied with the day of the week and the time of day. The total count observed by photo analysis and observations could potentially be influenced by the season. In turn, later sunrises in winter (June - August) can deter commercial horse trainers from using the beach as visibility is poor. Furthermore, the maximum and minimum count for horse trainers coincided with tidal changes and sunrise hours. Moreover, high tides limit the beach space for horse trainers and are at risk of breaching the User Agreement of staying below the high tide line. For example, the maximum count of horse trainers captured from the field observations (see Appendix D) coincided with a sunrise time of 6:42am ("*Christchurch, NZ - Sunrise*", 2019) and low tide at 7:25am (NIWA, 2019). Thus, these favourable conditions allowed for more horse trainers to use the beach as there was greater visibility and wider beach area to train.

The average time for horse trainers to spend on the beach was governed by the training routine and User Agreement criteria. This restricts trainers to start and finish training between 6am and 1pm. The most frequent time for training was between 7:00am and

7:59am. Horse trainers would not commence training in high tide or in poor weather conditions.

The formation patterns found during a training session were usually dependent on the number of trainers that arrived on the beach. Spence, Thurman, Maher, & Wilson (2012) supports training in this way as it enables horses to become accustomed to a racing environment. Larger groups were also found to cover a wider area of the beach than those who trained as a pair. However, the width of horse tracks did not extend to the high tide line.

The extent used by trainers suggests that trainers are aware of the conditions within the user agreement and have estimated this area well. Physical observations carried out at Kaiapoi Beach Accessway (4.19km south of the Woodend Beach Accessway (GoogleMaps, 2019) revealed no evidence of hoof prints and concluded that horses were training within the restricted training area. An additional observation for the direction in which horses trained was influenced by the wind direction. This claim was supported by Hernlund et al. (2014), which found that training horses into the wind desensitises them and ensures that the horse can perform well with distractions during a race.

The average speed identified was comparable with research from Witte, Hirst, & Wilson (2006) that measured the average galloping speeds of thoroughbreds to be within 9 - 17m/s. Taylor (2013) has stated that there is no speed limit for horses on the beach which could be a potential hazard to other users.

5.2 Interactions Between Commercial Trainers and the Public

The interaction between the general public and commercial horse trainers was mutually respective and no user conflicts were evident. The interaction between joggers/runners and commercial horse trainers were the most likely to show any significant user conflict, as the type of sand preferred for use for each user was similar. A wider berth was given to the public using this area.

The interaction between the horse trainers and walkers was not as common, as it was observed that most walk along the water line or above the high tide mark, near the dune system. This characteristic is suggested to ensure that both parties have considerable space to carry out their activities.

Dog walkers would leash their dogs when they came within proximity to the horses. It is suggested that these users were aware of the commercial horse trainers using the beach at this time. However, those who did not put their dogs on leads could control their dog or kept a considerable distance from the horses.

5.3 Environmental Impacts

Tuatua were found crushed within some hoof prints, as expected the cause of fatalities was due to frequent passes along the beach from commercial horse trainers. Live and deceased Tuatua were found within 1 - 2 m(s) of the hoof tracks. The cause for these fatalities is unknown. Some deceased Tuatua only had one shell or were open with an absence of flesh. It is suggested that seabirds drop live Tuatua from a height to open the shells and gain access to flesh adding to the mortality. Such behavioural characteristics were supported by Maron (1982), where adult Western Gulls in California were observed to perform this behaviour when feeding on clams. Other fatalities of crushed shells in proximity to horse tracks was potentially caused by other users.

The greatest density of hoof prints and widest tracks were found near the accessway. As expected, the wideness and density of horse hoof tracks caused disturbance to the sand surface. This observation was also supported by Taylor (2013), to be the cause of higher shellfish mortality. Horses led into the water after a training session, possibly caused impacts to the intertidal biota.

The hoof imprint depths found, confirmed that depth increased with softer and drier sand surfaces and with faster gaits. The impact depth is influenced by sand deformation and cohesion characteristics due to change in water content. Chateau et al, (2010) and Witte et al, (2006), found that the weight distributed over fewer limbs as gait increased, had a greater vertical force exerted on the sand surface, resulting in deeper hoof imprints. Furthermore, as hoof imprints deepen in drier sands, posing greater risk to Tuatua populations. Tuatua are known to be found buried between the immediate surface of the sand to being buried to depths of up to 10m (NIWA, 2008).

The size and weight of a horse can create discrepancies in the depth of the hoof print. A horse with shoes may penetrate deeper into the sand substrate at the toe of the hoof than unshod horses (Taylor, 2013).

The additional environmental impact noted during the study was of horse faeces on the foreshore, near the high tide line. Though, the source of these faeces was unknown (recreational or commercial). However, the location seemed to be in too close to the high tide line to be sourced from commercial horses as they are restricted from training in this area. Furthermore, horse faeces have an unpleasing appearance and odour and can leach excess nutrients (nitrates) into the environment.

5.4 Compliance with the Commercial Horse Trainers User Agreement

From the findings of the research, the extent that most commercial horse-trainers travel along the foreshore appears to comply with the regulations set out within the Commercial Horse Trainers User Agreement and the NPBB 2016. Whereby, this agreement states that horses are to train within 3.2km either side of the Woodend Beach Accessway.

5.5 Limitations

Despite these findings, there were some limitations within this research. Firstly, the research was carried out during the Winter/Spring months of August and September and may not consider seasonal fluctuations.

Difficulties with technology also posed problems. After the initial set up it was noted that one of the cameras was not recording. Thus, validating the entering and exiting times of horses was unable to be achieved for the first week of data collection.

Structured interviews could have proved useful to determine community viewpoints. Despite some good comments regarding the interaction with Woodend Beach residents and commercial horse trainers, it was deemed appropriate to disregard this as it could lead to potential bias in the research. A longer research period could have led to research into these interactions.

6.0 Conclusion

Following the literature review and research conducted at Woodend Beach, there is an apparent absence of information on the extent and characteristics of commercial horse trainers. Through observation, the extent and characteristic were found to comply with the User Agreement.

6.1 Recommendations

The suggested recommendation is to keep these restrictions in place and maintain the status quo. The User Agreement has been effective in ensuring that commercial horse trainers use the beach safely without compromising other users. It is recommended that dogs are kept on a leash, unless the dog is well trained around the commercial horses, to prevent potential conflict and risk of injury.

There is currently no speed limit along the beach, one recommendation would be for commercial horse trainers to reduce speed to a fast trot than a gallop. This speed reduction could potentially reduce the hoof depth as well as the risk of damaging or killing Tuatua immediately beneath the sand surface. However, an appropriate numerical speed for this fast trotting gait is unknown.

6.2 Future Research

Further studies should be conducted during the spring and summer seasons which could potentially find that more horses use the beach for training over this period. Incorporating recreational horse riders could give a better understanding of the scope of characteristics and extent of the activity. Recreational riders are not restricted to use a designated area of the beach and have been identified by Taylor (2013) to cause impacts to the ecosystem.

Although the WDC have conducted an intercept survey of beach users' perspectives, further studies could interview beach users while horse trainers are using the beach. This could enable beach users to give a clearer perspective of this activity. It is acknowledged that collecting this information from interviews could be difficult, as only a small amount of beach users are on the beach at any one time or may reject an interview. Therefore, the sample size of beach users could potentially be too low to have statistical significance

Local indigenous knowledge of traditional kai moana staples, abundance in the area and decline over time in conjunction would have provided an additional perspective to our primary data findings. Connecting with tangata whenua and Iwi on such matters provides scope for an integrated Maori world view, and a collaborative approach.

Acknowledgements

We would like to give thanks to Daniel Cox and Mike Kwant from the Waimakariri Council as our community partners. Further acknowledgements to Sebastian Pitman for guidance as our tutor. A thank you to Justin Harrison and Paul Bealing for their technical support. Finally, thanks to Simon Kingham and Gillian Frater as the GEOG309 course coordinators.

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8.0 Appendix

8.1 Appendix A- Speed

Measurements for average speed across the foreshore of Woodend Beach.

Video name	**Time 1 (s)**	**Time 2 (s)**	**Time 3 (s)**	**Average time (s)**	**Direction of horse**	Distance (m)	Speed (m/s)	Average speed (m/s)	Speed (km/h)	Average speed (km/h)
DJI_0039.MP4	31	31	30	30.67	North	370	12.07		43.43	
DJI_0040.MP4	29	29	29	29.00	North	370	12.76		45.93	
DJI_0042.MP4	32	31	32	31.67	North	370	11.68		42.06	
DJI_0046.MP4	133	132	133	132.67	North	2300	17.34		62.41	
DJI_0048.MP4	308	311	308	309.00	North	3700	11.97		43.11	
DJI_0050.MP4	355	359	358	357.33	North	3081	8.62		31.04	
								12.41		44.66

8.2 Appendix B- Photo Analysis

Date	Horse	Time entered	Time Left	Time Spent
16/08	1	10:25	10:40	15
	2	10:25	10:40	15
	3	10:44	11:06	16
	4	10:44	11:06	16
	5	11:04	11:21	17
	6	11:04	11:21	17
	7	11:09	11:25	16
	8	11:09	11:25	16
	9	11:52	12:08	16
	10	11:52	12:08	16
	11	11:53	12:08	15
	12	11:53	12:08	15
17/08	13	8:41	8:55	14
	14	8:41	8:55	14
	15	8:42	8:55	13
	16	8:42	8:55	13
	17	9:16	9:26	10
	18	9:16	9:26	10
	19	9:32	9:46	14
	20	9:32	9:46	14
	21	9:45	9:52	7
	22	9:45	9:52	7
	23	9:52	10:03	11
	24	9:52	10:07	15
	25	10:04	10:26	22
	26	10:04	10:26	22
	27	10:10	10:28	18
	28	10:10	10:28	18
	29	10:31	10:45	14
	30	10:31	10:45	14
	31	10:44	11:00	16
	32	10:44	11:00	16
	33	11:57	12:13	16
	34	11:57	12:13	16
	35	12:06	12:21	15
	36	12:06	12:21	15
	37	12:47	1:02	15
	38	12:47	1:02	15
19/08	39	9:51	10:06	15
	40	9:51	10:06	15
	41	10:29	10:43	14
	42	10:29	10:43	14
	43	10:55	11:14	19
	44	10:55	11:14	19
	45	10:58	11:14	16
	46	10:58	11:14	16
	47	11:00	11:14	14
	48	11:00	11:14	14

	49	11:23	11:39	16
	50	11:23	11:39	16
	51	11:33	11:47	14
	52	11:33	11:47	14
	53	11:41	11:59	18
	54	11:41	11:59	18
	55	12:15	12:31	16
	56	12:15	12:31	16
	57	12:49	1:07	18
	58	12:49	1:07	18
20/08	59	11:10	11:30	20
	60	11:10	11:30	20
	61	11:34	11:53	19
	62	11:34	11:53	19
	63	11:42	11:56	14
	64	11:42	11:56	14
	65	12:16	12:34	18
	66	12:16	12:34	18
	67	12:27	12:39	12
	68	12:27	12:39	12
21/08	69	12:05	12:20	15
	70	12:05	12:20	15
	71	12:49	1:05	16
	72	12:49	1:05	16
22/08	73	12:10	12:31	21
	74	12:10	12:31	21
	75	12:28	12:49	21
	76	12:28	12:49	21
	77	12:31	12:50	19
	78	12:31	12:50	19
24/08	79	6:45	7:01	16
	80	6:45	7:01	16
	81	6:54	7:02	8
	82	6:54	7:02	8
	83	6:58	7:07	9
	84	6:58	7:14	16
	85	7:09	7:19	10
	86	7:09	7:24	15
	87	7:19	7:37	18
	88	7:19	7:37	18
	89	7:21	7:37	16
	90	7:21	7:37	16
26/08	91	7:00	7:09	9
	92	7:00	7:09	9
	93	7:11	7:18	7
	94	7:11	7:18	7
	95	7:13	7:19	6
	96	7:13	7:19	6
	97	7:15	7:28	13
	98	7:15	7:28	13
	99	7:27	7:44	17

100	7:27	7:44	17
101	7:27	7:44	17
102	7:48	8:05	17
103	7:48	8:05	17
104	7:53	8:06	13
105	7:53	8:06	13
106	7:56	8:10	14
107	7:56	8:10	14
108	8:22	8:38	16
109	8:27	8:39	12
110	8:27	8:39	12
111	8:31	8:50	19
112	8:31	8:50	19
113	8:33	8:49	16
114	8:33	8:49	16
115	8:54	9:06	12
116	8:54	9:06	12

	117	8:59	9:14	15
	118	8:59	9:15	16
	119	9:08		
	120		9:14	
	121	9:21	9:32	11
27/08	122	7:21	7:40	19
	123	7:12	7:40	19
	124	7:12	7:40	19
	125	7:24	7:41	17
	126	7:24	7:41	17
	127	8:06	-	-
	128	8:06	-	-
29/08	129	10:49	11:06	17
	130	10:49	11:06	17
	131	12:49	12:51	3
	132	12:49	12:51	3
30/08	133	7:24	7:41	17

134	7:24	7:41	17
135	7:25	7:43	18
136	7:25	7:43	18
137	8:00	8:18	18
138	8:00	8:18	18
139	8:45	9:05	20
140	8:45	9:03	18
141	8:45	9:03	18
142	9:02	9:22	20
143	9:02	9:22	20
144	9:07	9:26	19
145	9:07	9:26	19
146	9:44	10:02	18
147	9:44	10:02	18
148	9:51	10:09	18
149	9:51	10:07	16
150	9:51	10:07	16

	151	10:18	10:32	14
	152	10:18	10:35	17
	153	11:46	12:02	16
31/08	154	7:35	7:53	18
	155	7:35	7:53	18
	156	7:41	7:59	18
	157	8:21	8:39	18
	158	8:21	8:39	18
	159	8:24	8:39	15
	160	8:26	8:42	16
	161	8:26	8:42	16
	162	8:28	8:42	14
	163	8:28	8:42	14
	164	8:32	8:51	19
	165	8:33	8:46	13
	166	8:33	8:46	13
	167	9:00	9:18	18
	168	9:00	9:18	18
	169	9:00	9:18	18
	170	9:02	9:18	16
	171	9:02	9:18	16
	172	9:04	9:21	17
	173	9:04	9:21	17
	174	9:05	9:20	15
	175	9:05	9:33	15
	176	9:16	9:33	17
	177	9:16	9:33	17
	178	9:19	9:35	16
	179	9:19	9:35	16
	180	9:49	10:08	19
	181	9:49	10:08	19
	182	10:07	10:26	19
	183	10:20	10:42	22
	184	10:20	10:42	22
	185	10:35	10:54	19
	186	10:57	11:18	21
	187	10:57	11:18	21
	188	11:31	11:49	18
	189	11:31	11:50	19
	190	11:40	11:57	17
	191	11:40	11:57	17
	192	11:42	11:57	15
	193	11:42	11:57	15
	194	11:42	11:57	15
	195	12:25	12:40	15
	196	12:25	12:40	15
02/09	197	9:20	9:33	13
	198	9:20	9:33	13
	199	9:31	9:48	17
	200	9:31	9:48	17
	201	9:31	9:50	19

202	9:47	10:00	13
203	9:47	10:00	13
204	9:47	10:00	13
205	9:58	10:06	18
206	9:58	10:06	18
207	10:14	10:31	17
208	10:14	10:31	17
209	10:30	10:48	18
210	10:31	10:49	18
211	10:42	10:52	10
212	10:42	10:52	10
213	10:46	11:00	14
214	10:46	11:00	14
215	10:59	11:15	16
216	10:59	11:15	16
217	11:15	11:33	18
218	11:15	11:33	18

	219	11:15	11:33	18
	220	11:21	11:38	17
	221	11:21	11:38	17
	222	11:22	11:41	19
	223	11:22	11:41	19
	224	11:27	11:44	17
	225	11:27	11:44	17
	226	11:27	11:42	15
	227	11:27	11:42	15
	228	11:27	11:42	15
	229	12:01	12:17	16
	230	12:01	12:17	16
	231	12:11	12:31	20
	232	12:11	12:31	20
03/09	233	10:13	10:31	18
	234	10:13	10:31	18
	235	10:14	10:31	17

236	10:49	11:02	13
237	10:52	11:09	17
238	10:52	11:09	17
239	10:52	11:09	17
240	10:54	11:14	15
241	11:19	11:33	14
242	11:21	11:35	14
243	11:23	11:37	14
244	11:32	11:43	11
245	11:32	11:48	16
246	-	11:54	-
247	11:58	12:15	17
248	11:58	12:16	18
249	11:58	12:16	18
250	12:09	12:25	16
251	12:09	12:25	16
252	12:39	12:57	18

	253	12:40	1:02	22
	254	12:40	1:02	22
04/09	255	10:23	10:39	16
	256	10:24	10:39	16
	257	10:55	11:10	15
	258	10:56	11:10	14
	259	11:29	11:42	13
	260	11:29	11:48	19
	261	11:29	11:48	19
	262	11:30	11:48	18
	263	11:34	11:48	14
	264	11:55	12:11	16
	265	11:55	12:12	17
	266	12:06	12:22	16
	267	12:08	12:22	14
	268	12:09	12:24	15
	269	-	12:26	-

	270	12:42	12:58	16
	271	12:44	1:00	16
	272	12:44	1:00	16
05/09	273	-	11:00	-
	274	-	11:00	-
	275	-	11:00	-
	276	12:03	12:21	18
	277	-	12:21	-
	278	12:23	12:24	1
	279	12:23	12:24	1
	280	12:46	1:05	19
	281	12:46	1:06	20
	282	12:49	1:06	17
	283	12:49	1:07	18
	284	-	1:07	-
	285	1:26	1:45	19
07/09	286	6:38	6:51	13

	287	-	6:56	-
	288	6:54	7:11	17
	289	6:54	7:11	17
	290	6:54	-	-
	291	7:09	7:21	12
	292	7:09	7:24	15
	293	7:09	7:25	16
	294	7:18	7:25	7
	295	7:18	-	-
	296	7:30	7:42	12
	297	7:30	7:42	12
09/09	298	7:06	7:22	16
	299	7:07	7:24	17
	300	7:07	7:24	17
	301	7:11	7:24	13
	302	7:11	7:24	13
	303	7:13	7:26	15

304	7:20	7:30	10
305	7:20	7:30	10
306	7:22	7:31	9
307	-	7:40	-
308	-	7:40	-
309	7:49	8:01	12
310	7:50	8:01	11
311	7:50	8:07	17
312	8:00	8:07	7
313	8:00	8:07	7
314	-	8:08	-
315	8:11	8:28	17
316	8:11	8:27	16
317	8:14	8:32	18
318	-	8:15	-
319	8:21	8:33	12
320	8:21	8:33	12

	321	8:29	8:46	17
	322	8:31	8:46	15
	323	8:35	8:46	11
	324	8:50	9:04	14
	325	8:50	9:05	15
	326	8:50	9:05	15
	327	-	8:51	-
	328	9:18	9:33	15
	329	9:20	9:32	12
	330	9:21	9:33	12
	331	10:00	10:13	13
	332	10:00	10:13	13
10/09	333	7:08	7:28	20
	334	7:23	7:39	16
	335	7:23	7:39	16
	336	7:24	7:40	16
	337	7:25	7:40	15

338	7:34	7:40	6
339	7:48	8:06	18
340	7:48	8:06	18
341	-	7:53	-
342	-	7:53	-
343	8:05	8:22	17
344	8:09	8:22	13
345	8:10	8:23	13
346	8:10	8:27	17
347	8:11	-	-
348	8:11	-	-
349	8:15	8:36	21
350	8:26	8:41	15
351	8:28	8:45	17
352	8:29	8:45	16
353	8:29	8:45	16
354	8:43	8:57	14

	355	8:43	8:57	14
	356	8:45	8:57	12
	357	8:48	9:01	13
	358	8:55	9:01	6
	359	8:55	9:02	7
	360	9:10	9:22	12
	361	9:12	9:23	11
	362	-	9:23	-
	363	9:24	9:39	15
	364	9:26	9:39	13
	365	9:31	9:39	8
	366	9:38	9:45	7
	367	9:38	9:51	13
	368	-	9:52	-
11/09	369	7:12	7:28	16
	370	7:12	7:30	18
	371	7:21	7:40	19
	372	7:22	7:40	18
	373	7:22	7:40	18
	374	7:22	7:45	23
	375	7:23	Changing camera	-
	376	7:33	Changing camera	-
	377	7:33	Changing camera	-
	378	7:58	8:15	17
	379	7:58	8:16	18
	380	7:58	8:19	21
	381	7:58	8:14	16
	382	8:05	8:19	14
	383	8:05	8:19	14
	384	8:06	-	-
	385	8:14	8:31	17
	386	8:14	8:33	19
	387	8:17	8:33	16
	388	8:17	8:34	17
	389	8:35	8:55	20
	390	8:55	9:14	19
	391	9:03	9:14	11
	392	9:03	9:15	12
	393	9:04	9:15	11
	394	9:11	9:27	16
	395	9:11	9:27	16
	396	9:11	9:27	16
	397	9:30	9:40	10
	398	9:30	10:07	37
	399	9:34	9:50	16
	400	9:34	9:50	16
	401	9:53	10:08	15
	402	9:54	10:08	14
	403	10:27	10:43	16
	404	10:28	-	-
	405	10:29	-	-

12/09	406	7:05	7:23	18
	407	7:07	7:23	16
	408	7:31	7:48	17
	409	7:31	7:48	17
	410	7:38	Cameras taken down	-
	411	7:45	Cameras taken down	-
	412	7:45	Cameras taken down	-

8.3 Appendix C- Hoof Print Averages

14 August 2019						
No#\Gait		Walk (cm) (all on hard sand)	Trot (cm)	Canter (cm) *	Gallop (cm)	
1		2	2		4	
2		2	2.5		4	
3		1.5	3		4.5	
4		1.5	2.5		3	
5		2	1		3	
6		1.7	3.4		3	
7		1.5	2		3	
8		1.5	2.5		2.7	
9		1.5	2		2.5	
10		1.4	2		4	
Average:		**1.66**	**2.29**		**3.37**	* at this point we were still unsure about differentiating between canter and gallop
16 August 2019						
No#\Gait		Walk (cm) (all on hard sand)	Trot (cm)	Canter (cm) *	Gallop (cm)	
1		2.5	2.3		3	
2		2	2		1	
3		1.7	2		3.7	
4		1.5	1.7		3.5	

5		1.5	2.2		3.2	
6		1.5	3		2.8	
7		1.3	1.5		2.6	
8		1.5	2		4	
9		1.2	1.7		3.6	
10		1.7	2		3	
Average:		**1.64**	**2.04**		**3.04**	* at this point we were still unsure about differentiating between canter and gallop
19 August 2019						
No horses came to beach						
20 August 2019						
No horses came to beach						
27 August 2019						
No#\Gait	Walk (cm)	Walk @ entrance (dry, fluffy sand) (cm)	Trot (cm)	Canter (nth of entrance)	Canter (sth of entrance)	Gallop (cm)
1	wet sand 2	8	2.1	2.6	1.2	2.5
2	1.5	8.7	2.4	1.9	2	2.5
3	2	7.6	2.5	3	1.5	3.2
4	1.8	10	2	3	2.7	2.5

5	1.7	8	2	2.2	2	2.3
6	Dry sand 1.7		3	2.2	3	3.1
7	2		2.1	2.7	2.4	4
8	1.6		3	2.2	2.2	2.9
9	1.7		2.1	2.5	2.8	1.5
10	2.3		2.6	3	1.5	2.5
Average:	**1.83**	**8.46**	**2.38**	**2.53**	**2.13**	**2.77**

10 Sep 2019						
No#\Gait	Walk (1st 5 dry, 2nd 5 hard sand)	Trot	Canter/Gallop			
1	Dry sand 4	4	1.5			
2	5.5	3.2	2			
3	5	2.1	1			
4	5.5	1.8	1			
5	3.5	3.1	1.5			
6	Hard sand 2	2.5	2			
7	2.1	2.5	1			
8	2.4	1.5	1			
9	1.3	1.5	2			
10	1.7	2	1.5			
Average:	**3.3**	**2.42**	**1.45**			

11 Sep 2019						
could not measure hoof prints - no ruler						
12 Sep 2019						
No#\Gait	Walk (wet/soft)	Walk (wet/hard)	Walk (dry @ entrance)	Trot (wet/hard sand)	Gallop (wetish/hard sand)	
1	1	2	6.5	3	2.5	
2	2	2	5.5	3.5	3.5	
3	1	2	4	3.5	2	
4	1.5	2	6.5	3	1.5	
5	1.5	2	4	2.5	3.5	
6	1	2.5	4.5	3	2.8	
7	1.5	1.5	6.5	2.5	2.5	
8	1	2	5	3	3	
9	2	2	4.5	3	2	
10	1	2.5	4	3	2	
Average (cm):	**1.35**	**2.05**	**5.1**	**3**	**2.53**	

8.4 Appendix D- Observation Sheet Data

Date	Start time	End time	Location	Tide	Weather	Number of Horses	Formation	Gait	Extent of tracks	Average time spent (minutes)	Average depth (cm)	Other users	Micellanous
14/08	7:00 AM	9:00 AM	50m south of Wooded beach entrance	Low tide (9:30am, -0.58m)	Clear	19	Single going south, pairs or threes back north	Trot south, Gallop/Canter north, Walk back to entrance	South of entrance 2km, north of entrance 100-200m	14.57	2.44	3 people, 1 dog put on leash near entrance	All started south excpet one (only went 100m north; 11m width of beach used
16/08	7:30	9:17 AM	20-25m South of Wooded beach entrance	Low tide (10.44am, -0.79m)	Overcast, breezy	13	Single file, the rest pairs	Trot south, Gallop/Canter north, Walk back to entrance	South of entrance 2km, north of entrance 100m	13.25	2.24	3 people, 1 dog	-
19/08	7:00 AM	9:00 AM	50m south of Wooded beach entrance	High tide (6:53am, 0.63m)	Clear	0	-	-	-	-	-	-	-
20/08	9:30 AM	10:00 AM	50m south of Wooded beach entrance	high tide (7:39am, 0.61m)	Overcast	0	-	-	-	-	-	2 people with dog	lots of shellfish
27/08	7:15 AM	10:30 AM	50m south of Wooded beach entrance	Low tide (6:54am, -0.89m)	Clear, No wind	14	Single file, Pairs- raced back	Mostly trot south (few galloped), Gallop north, walk to entrance	South 2km, North 400-500m	14.36	2.27	few walkers	Shellfish alive within 1m of horse tracks,

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10/09	7:30 AM	9:31 AM	50m south of Wooded beach entrance	Low tide (7:26am, -0.81m)		26				14.16	Ref to Hoof Depths	few walkers, 2 recreational horses, 1 jogger on track	
11/9/2019 *	7:48 AM	9:34 AM	50m south of Wooded beach entrance	Low tide (8:10am, -0.72m)	Overcast, slight breeze(S.easterly [?]), Metservice: 4C	21	1st group of 4 travel side-by-side. Some pairs	Trot south, Gallop north.	Horse tracks extend north up to the entrance with surf life saving hut. Assumed tracks extend last entrance near kiapoi entrance.	15	-	1 person with 2 dog around lifesaving hut entrance. 1 peron with metal detector around the same place as first person.	Tracks start 18m below log on beach and are 28.8m wide. * man w/ 2 dogs approached us, said he's been here 40yrs, saw a change in shellfish, said dredging had affected shellfish, has seen juvenile shellfish taking the hit most, said hes put a submission into the

													'trust' (not sure what this is), and put complaint about Waikuku Beach.
12/09	8:00	9:45 AM	50m south of Wooden d beach entrance	Low tide (8:52am, -0.76m)	Sunny, light wind	24	In pairs mostly, sets of three occasionally, odd single horse	Mostly trot south (few galloped), Gallop north, walk to entrance		14.54	Ref to Hoof Depths	quite a few walkers (14) total of 6 dogs, 2ecreational horses	
					total count ->	117							