Distribution, disturbance and birds during a spring tide and neap tides October 2009 – March 2010 at Ruakaka Estuary

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INTRODUCTION

The Ruakaka wildlife refuge (Fig.1) is an area which contains unmodified habitat and completely modified areas. The refuge is the breeding area for waders including variable oystercatchers, New Zealand dotterels, and is the very high tide (spring tide) roost for most of Whangarei Harbour's bar-tailed godwit and lesser knot (Beauchamp & Parrish 2008).

The legislation covering wildlife refuge compliance relates to actions of disturbance. The actions that would be in violation of the law with regard to Wildlife Refuges are spelled out in section 14 (3) of the Wildlife Act 1953. They are in terms of this area any activity that caused wildlife to leave the refuge (temporarily or permanently). The issue is complicated by the multiple activities that may at times define where the birds are located and defining the exact cause of any movement.

It is sometimes difficult to ascertain if wildlife changes over time are due to changes in habitat, disturbance or other factors. Ruakaka has historically been recorded as being used by turnstones (*Aranaria interpres*) and the roost site has had far greater numbers of variable oystercatchers (Beauchamp & Parrish 2008). Work carried out by Kyle Wedge (2002) in Jul – Sep 2002 showed that most human disturbance events at Ruakaka did not result in wildlife deserting the refuge. However, this work did not cover the period of the summer and autumn peak and the period when Godwit and Knot use this site as a principal spring tide roost.

In the past most disturbance activity has been related to shore based activities and the occasional boat. However, in recent years more water craft and water-craft types have appeared in the area. Kite boarders began using the coastline 4 years ago and then started to use the estuary. Overseas data suggests that in some situations kite boarding could be one of those activities that may have greater impacts on bird disturbance than traditional activities. This has resulted in kite boarding being restricted within some overseas estuaries and near banks where substantial bird impacts are present. The Department of Conservation consulted with locals on the potential for kite boarding activity to contravene the provisions of the Wildlife Act. The kite boarders had developed a code of conduct and provided information on their areas of activity (Beauchamp 2009).

0n 14 February 2009 video footage taken at spring high tide showed considerable disturbance to the roosting bar-tailed godwit and lesser knot there by kite boarders within the wildlife reserve. In March 2009 an investigation of the tidal use of kite boarders in the estuary and an assessment of Palaearctic wader presence on the roost sites on the adjacent mudflats at spring high tides found a substantial potential overlap (Beauchamp 2009). This data led to discussion with the kite boarders and an agreement that there would be controlled access during spring high tides which were to be advertised by signs on the beaches, and on web sites. As part of that discussion it was agreed that the Department of Conservation would look at the total disturbance issues at the site during the periods that kite boarders would potentially use the site. This was to be carried out without reference to the wind energy conditions that the wind surfers would use the site as these conditions are not predictable in any year.

This study aimed to define:

- The various agents of disturbance at the site in and around diurnal spring tides
- The incidence of impact of those disturbances and the ways of mitigating all disturbance to breeding and roosting birds in the estuary
- The species that are most at risk from disturbance factors and their movement and location after disturbance
- The temporal presence and diurnal tide height that bar-tailed godwit and lesser knot are using Ruakaka Estuary
- The period of time that godwit and knot need to roost at this site so that this can be compared to the data in the March 2009 report
- The species that are being disturbed by the various causes within the main pubic holiday period
- The mechanisms of disturbance that are responsible for causing birds to leave the wildlife area prematurely

METHODS

Observations were made during high spring tide building periods and in mid January and mid February during neap tides. The periods were 18-22 October (28.5 hours); 4-6 (18.5 hours) & 18-20 December 2009 (10 hours); 1-6 (11 hours), 15-19 (12 hours), 30-31 January (6 hours); and 12-14 (12 hours), 27-28 February to 1 March 2010 (7 hours). The weather and tide states are given in Appendix 1.

Observations were made by Gerard Pilon using a 72 mm Leica telescope from one site on top of a 2.5 m dune during all dates except 1,2 3 and 6 January. During those dates Tony Beauchamp carried out the work

The site used for data collection was c 50 m east of the site used in March 2009 as this site was outside the bird-breeding exclusion fences. It was approximately 1.5 m above high tides on the top of a board area of foredune. All data was collected seated to reduce observer disturbance, and in silence.

The areas were split into 6 regions (Fig 1). These included the same 5 regions used in March 2009; the mouth or the estuary [SPIT], the northern beach [NORTH] and the camp ground [MOTOR], the southern walkway from the motor camp [SOUTH], and the island in the middle of the estuary [ISLAND]. In addition the area that was visible near where boats were launched at [BOAT] was counted and birds were noted when foraging in water [ESTUARY].

Every potential disturbance was recorded and the impact on the area of potential disturbance defined. Every hour a map of the location of all birds was compiled, and those estimated to be within 5 metres of the tide recorded. In addition, the spot location of people was also recorded. At the start and end of the period and each hour the weather conditions: cloud (categorical 8ths), temperature degrees, wind direction (compass), wind speed (recording devices) were noted (Appendix 1).

During the recording period all major bird movements and their known or potential cause was recorded. The time the middle island was submersed and re-exposed, and the exposure of the tidal flats was recorded. All people movements, except those that walked from the motor camp to the beach track and then along the beach track were recorded.

Site status during the study

The entrance to Ruakaka estuary is very unstable but there is generally an outer spit from the toe of the southern dunes that extends northwards and a channel that heads back to the dunes. During this period of data collection this channel was c. 120 m long. On the western side of the channel was an area of sand that was higher than the surround and formed an island during high tide. At low time this island was the tip of a sand bank that extended to the northern shoreline. At high tide the island was 0.1 (2.8 m HT) - 0.5 ha (2.6 m HT).

The climate conditions in October 2009 to February 2010 were dominated by El nino weather patterns which in Northland are westerlies with limited wind energies suitable for kite boarding. This was the exact opposite to the conditions in the summer of 2008-2009. However, the physical layout of the estuary had not changed to any obvious extent in the period between data collection in 10 -15 March 2009 (Beauchamp 2009).

RESULTS

Data and data collection conditions

Appendix 1 gives the weather conditions during data collection.
The data is located in DOCDM-634771.

Six general areas and species distribution

The most used zones of each species of bird between October 2009 and February 2010 are given in Table 1.

Table 1 Detection zones for birds

Species	South spit	South margin	Motor camp	North margin	Island margin	Boat launch
Bar-tailed godwit	P		P	P	P	
Lesser Knot	P		P	P	P	
NZ pied oystercatcher					P	
Variable oystercatcher	P	P	P	P	P	P
NZ dotterel	P		P	P	P	
Banded dotterel			P		P	
Pied stilt		P	P	P	P	
Pied shag	P	P	P	P	P	
White-fronted tern	P	P	P	P	P	
Black-backed gull	P	P	P	P	P	P
Red-billed gull	P	P	P	P	P	P
Caspian tern	P	P	P	P	P	
Mallard duck		P	P	P	P	
Spur winged plover			P			P
Australasian gannet++						

++ used estuary waters to forage
P = present (the most used sectors are shaded)

Disturbance events

Observations showed that no part of the estuary is completely free of human disturbance even during high tide as swimmers and water movement of anthropogenic origin cause disturbance.

In October 2009 14 species including Northland residents; Australasian gannet (*Morus serrator*), pied shag (*Phalocrocorax varius*), variable oystercatcher (*Haematopus unicolor*), white-fronted terns (*Sterna striata*), spur-winged plover (*Vanellus miles*), New Zealand dotterel (*Charadrius obscurus*), pied-stilt (*Himantopus himantopus*), red-billed gull (*Larus novaehollandiae*), black-backed gull (*Larus dominicanus*), paradise shellduck (*Tadorna variegata*) and mallard/grey duck (*Anus* spp.); migrating New Zealand waders; New Zealand pied oystercatcher (*Haematopus ostralegus*),

banded dotterel (*Charadrius bicinctus*); and Palaearctic waders; the bar-tailed godwit (*Limosa lapponica*) and lesser knot (*Calidris canutus*). Other species were seen moving within and foraging in the area including the little black shag (*Phalacrocorax sulcirostris*) and New Zealand fairy tern (*Sterna nereis*).

In mid December 2009 paradise shellduck, banded dotterel and spur-winged plover were not present. In the period up to new year there were generally 11 species present, but from mid January to late February 5 species including Caspian terns, lesser knot, mallard/grey duck, New Zealand pied oystercatcher and pied stilt were absent.

The effort (observation hours) was not equal between periods. However, all of the species that were followed had a very high detection probability, if present, as they all occupied open habitats. Throughout the study all regions except the island remained substantially unchanged. The island was completely submersed for an hour during the highest tides (2.9 m).

During the data collection periods there were 833 potential disturbance events observed and 168 of these caused some form of disturbance. These comprised of 42 natural events (tide surges, wind gusts, bird aggression and other disturbance) and 126 anthropomorphic events (vehicles, people with dogs, laud noises, walkers/ runners, boats, kayaks, swimmers, surfers, kite boarders - Table 2).

Water contact vessels (boats, jetskis, kite boards and kayaks) were generally the only activities that impacted multiple regions. Boats, jetskis and kayaks could have potentially impacted all regions, while kite boarders generally only impact four regions; the northern shore, southern spit, island and part of the southern zone.

There were 46 kayak and paddled boat potential disturbance events of which 7 caused disturbance, 5 to godwit, 1 to mallard and 1 to variable oystercatchers. Two of these disturbances were caused by people exiting the craft onto land near birds. Only one disturbance caused godwits to change location.

There were 140 potential power boat launching or movement events 31 of which caused some disturbance. Most disturbances took place at the estuary entrance when boats were powering to leave or enter the estuary. There were 3 disturbances of variable oystercatchers at the launching site and 2 near the entrance. There were 19 disturbances of shags on the outer spit or north side. During the period when godwit roosting was occurring there were 33 boat movements of which 5 caused disturbance to godwit and knot, only one of which cause the birds to fly. Two of the disturbances occurred on the island from wash on the increasing tide.

There were 12 jetski movements, 3 of which caused disturbance once to shags and twice to godwits. The two disturbances of godwits caused the birds to fly to difference locations.

Swimmers had the potential to impact all regions but did not use the outer southern spit and the northern region. There was not indication that the presence of swimmers caused bird disturbance, however the area off the dune on the south side was a favourite swimming place and access to this along the water margin at high tide did cause some disturbance to variable oystercatchers in the fenced area. However, it is difficult to separate this from the actual disturbances caused by people just walking along the estuary margin.

Walkers were generally confined to the southern regions and the spit. The highest potential incidents were on the spit where there was the same level of potential disturbance, but due to the presence of nesting variable oystercatchers and New Zealand dotterel, and higher numbers of roosting birds there were higher levels of disturbance (Table 3). By contrast, there were only 22 walker potential disturbance events (0.5 %) in the northern region and only one caused disturbance. However, this one disturbance was of 2000 godwit and knot and was the result of a person wanting to dispose of scraps from a fish bin.

Dogs were seen 11 times in two regions, the southern spit (8) and the northern region (3). Eight of these dogs were within the wildlife reserve boundary and 4 of these times dogs were unrestrained and chased birds on the spit. Dogs were seen between 08:20 and 12:05 in the presence of people and when there was signage at the car parks and on the beach.

Table 2 - Bird species disturbed by natural and anthropomorphic disturbance events

Species	Natural				Anthropomorphic							
	birds	waves	wind	tide	boat	kayak	kite boarder	vehicle	surfer	swimmers	walkers	dog
Pied shags	4			1	21		1	1			5	1
Bar tailed godwit & lesser knot	24	1	1	13	8	4		1	2	2	12	
NZ dotterel	1										4	
Variable oystercatchers	10			2	6	1	1	1		3	52	3
Black-backed gull	1				1		1				5	1
Red-billed gull	1			1	1						5	
White-fronted tern			2	1							3	
Mallard						1						

NOTE this table assigns multiple species disturbance events to each of the species concerned

Table 3 - Impact of walkers on bird disturbance by region

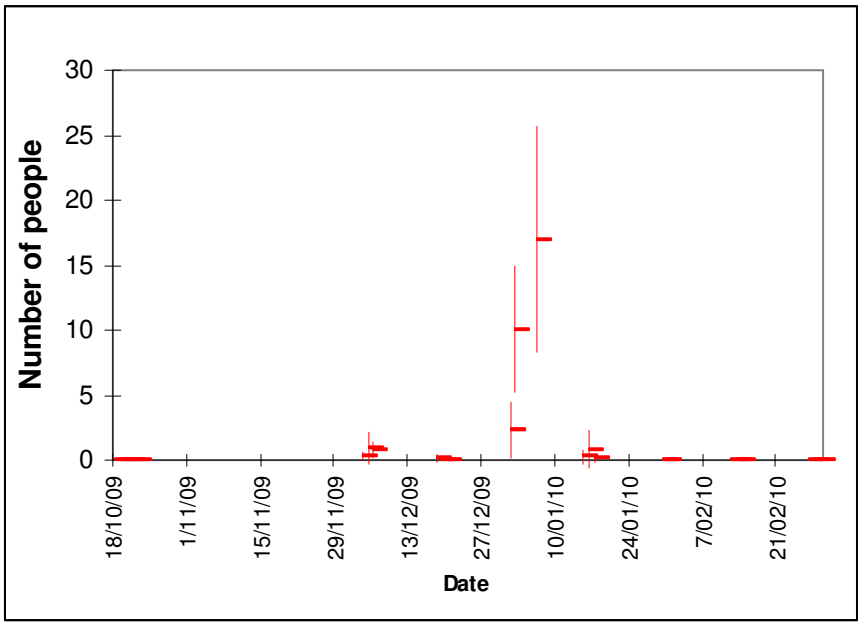
Region	Likely disturbance events	Actual disturbance events	Impact h^{-1}
Boat ramp	7	0	0.00
Motor camp	108	16	0.15
South margin	123	23	0.22
Southern spit	129	38	0.36
Island	4	1	0.01
Northern	22	1	0.01

Table 4 – Potential and actual anthropomorphic disturbance rates (events per hour)

Period	swimmers		vehicles		walkers		surfer	
	potential	actual	potential	actual	potential	actual	potential	actual
18/10/2009	0.1	0.0	0.2	0.0	1.4	0.2	0.0	0.0
4/12/2009	0.2	0.0	0.3	0.1	2.4	0.2	0.0	0.0
18/12/2009	0.4	0.0	0.5	0.0	4.8	0.6	0.0	0.0
1/01/2010	1.4	0.1	0.1	0.1	6.5	2.4	0.0	0.0
15/01/2010	1.3	0.1	0.1	0.0	7.9	1.6	0.2	0.0
30/01/2010	1.0	0.0	0.0	0.0	6.7	0.8	0.3	0.3
12/02/2010	0.9	0.1	0.4	0.0	5.0	0.8	0.0	0.0
27/02/2010	0.0	0.0	0.1	0.0	1.1	0.0	0.0	0.0

Period	boat		dog		kayak		Kite boarder	
	potential	actual	potential	actual	potential	actual	potential	actual
18/10/2009	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0
4/12/2009	0.8	0.3	0.1	0.0	0.2	0.1	0.0	0.0
18/12/2009	1.3	0.6	0.2	0.1	1.1	0.0	0.0	0.0
1/01/2010	5.4	0.5	0.1	0.0	1.5	0.1	0.0	0.0
15/01/2010	1.5	0.1	0.1	0.0	0.8	0.2	0.0	0.0
30/01/2010	0.7	0.0	0.3	0.0	0.3	0.2	0.0	0.0
12/02/2010	0.8	0.3	0.4	0.2	0.3	0.0	0.0	0.0
27/02/2010	0.4	0.1	0.0	0.0	0.3	0.1	0.4	0.3

Figure 2 – Mean number of people (±SD) counted during each day during hour intervals during the survey in Ruakaka Estuary



NOTE: Not included are those in vehicles or boats

Disturbance rates and bird distribution

The number of people in the area was not constant between each data collection period (Fig 2) and the number of hours in each period was also not constant. When these events were converted to disturbances per hour the highest actual disturbance incidences were found to be boats, walkers, surfers and kite boarders (Table 4).

The relative rates are more difficult to compare because the actual potential for each disturbance event is difficult to quantify. A disturbance event may for instance result in there being no birds left in a region to be disturbed. The total potential anthropomorphic disturbance event rate was 7.6 disturbances per hour or which we recorded an actual rate of 1.4 disturbances per hour (Table 4). As the number of disturbances accumulated during summer the birds became more confined to the areas of fencing in the southern and motor camp zones and the island, outer southern spit and northern region (Figures 3-5). These were the areas of least disturbance by walkers who were the biggest disturbance factor (Table 4).

The island opposite the southern bathing areas was only disturbed twice by people swimming and landing on it, three times by boat produced wash and twice by kayakers getting too close. The island had three pairs of nesting variable oystercatchers and flocks of other species throughout the observation periods.

Overall disturbance and presence in the Wildlife Refuge

The current wildlife refuge boundary excluded the northern region and the northern half of the spit. The data collection location could not be positioned to accurately define fine movements inside and outside the gazetted zone so only gross movements are reported here.

There were 54 events that caused birds to move between regions, 27 being caused by natural event (tide (n = 9), waves (n = 1), wind (n = 3) and bird aggression (n = 14)) and 27 by anthropomorphic factors (boats (n = 14), dogs (n = 2), kayak (n = 1), swimmers (n = 1), vehicles (n = 1), walkers (n = 7)). Most movements were between the island the southern spit, and leaving the estuary (Table 5).

Disturbance	New bird location				
	Motor camp	Island	Southern spit	Northern Zone	left Estuary
Estuary waters			5		3
Boat Ramp		2			1
Motor camp		4			
Island	1		9	1	5
South margin		2			
Southern spit	1	8		3	3
North margin		3	2		1

Table 5 Movement of birds between all regions and all natural and anthropomorphic disturbance factors

The vast majority of disturbance did not cause birds to move outside of the wildlife reserve boundaries (n = 23) and most other movements were between the wildlife refuge and the areas the estuary (n = 18). However, there were 5 anthropomorphic events that caused birds to leave the wildlife refuge and the estuary. These were caused by boats (n = 3), a fisherman (n = 1) and a walkers (n = 1). Two of the boat disturbances were of shags that were fishing in the estuary. In addition, mass movements to outside the estuary were cause by tide surges (n = 1), wind gusts (n = 2) and bird aggression disturbance (n = 5).

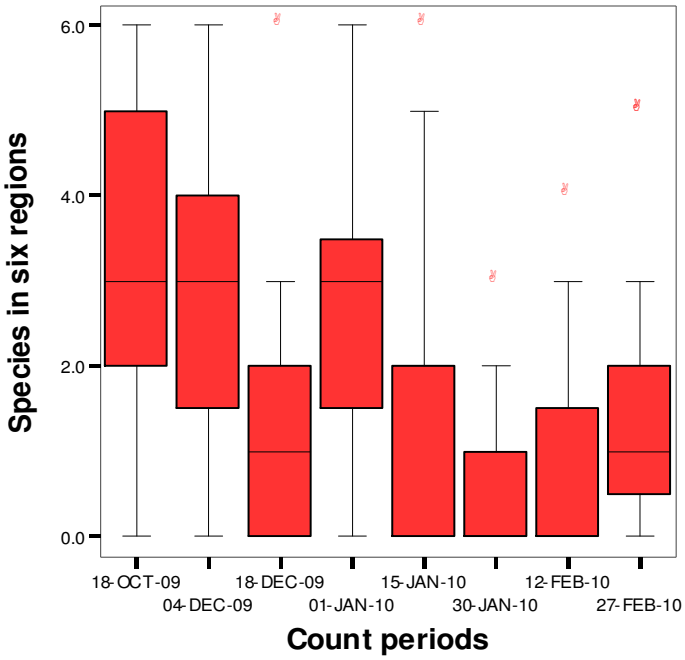


Figure 3 – Species spread (number of regions occupied) in the six regions over time (box plots are median, quartiles and outliers)

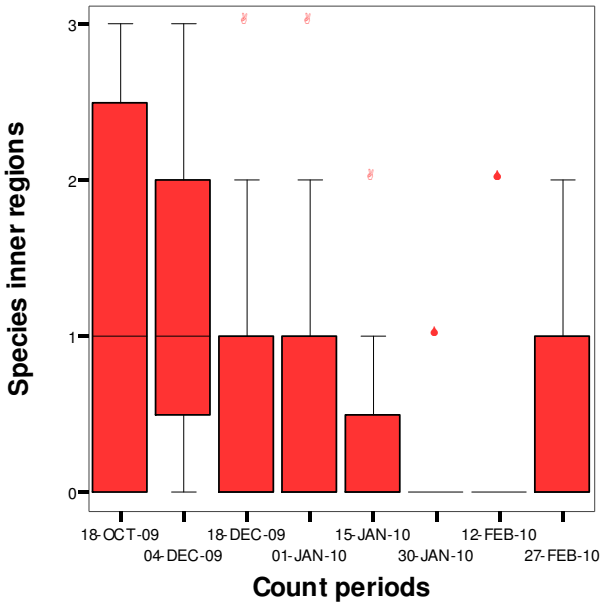


Figure 4 - Species spread (number of regions occupied) in the inner three regions (boat ramp, motor camp and southern margin).

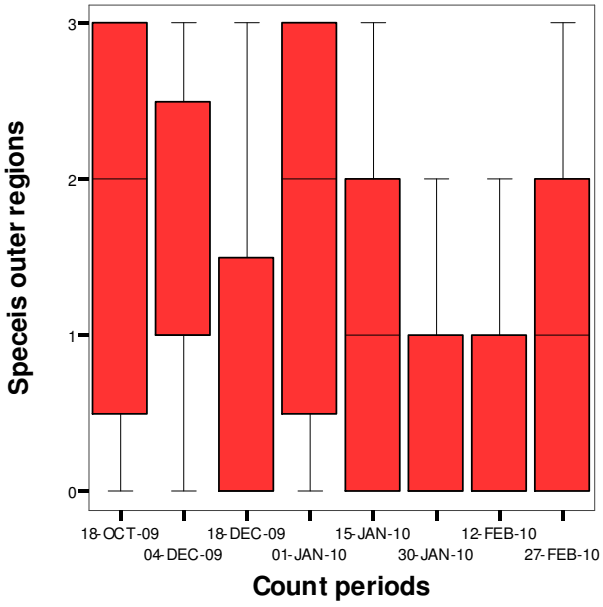


Figure 5 - Species spread (number of regions occupied) in the outer three regions (southern spit, northern margin and Island).

Key species and disturbance

Bar tailed godwit

Presence zones and general activity

Bar tailed godwit were resident in the area and were present during all high tides. Outside of the spring tide periods (<2.7 m high) the average number of godwits counted was 49.7 (SE = 12.5, n = 12). In the spring tide period when substantial numbers of godwit and knot were expected and when kite boarding was controlled by access rules the average number was 1253 (SE = 340, n = 17).

Godwit and knot arrived at the site from the harbour on mass during high tides above 2.7 m (LINZ tables Marsden Point) in the 50 minutes before high tide (Table 6). The only earlier time, on 1 March 2010, was on the day of the Tsunami and the time that they left was not recorded. This data overlapped that collected in March 2009 (Table 6). Godwits and knots were present in greatest numbers during increasing tide heights (Appendix 2) and over subsequent days of king tides they distributed themselves more widely but to sights that were not determined. This pattern was present in the absence of disturbance at Ruakaka Estuary. However, the resident bar-tailed godwit remained in the area to roost there throughout the period.

Table 6 - Periods of mass bar-tailed godwit and lesser knot presence at Ruakaka Estuary in relation to high tide time

Date	Tide maximum	Principal Palaearctic arrival time (hours:minutes)	Principal Palaearctic departure time (hours:minutes)
10/3/2009	2.7	-0:14	+4:14
11/3/2009	2.8	-0:18	+1:24
12/3/2009	2.8	-0:26	+2:59
13/3/2009	2.8	-0:12	+2:32
14/3/2009	2.7	-0:36	+3:44
4/12/2009	2.7	-0:43	>+4.15
5/12/2009	2.8	-0:28	+2:13
6/12/2009	2.8	-0:27	+2:58
2/1/2010	2.8	-0:05	+1:39
3/1/2010	2.9	-0:51	+1:34
31/1/2010	2.9	-0:35	+1:20
28/2/2010	2.8	-0:39	
1/3/2010	2.9	-1.16	>+1:00*
		Kite boarder arrival time	**Kite boarder leave time**
15/3/2009	2.6	-0:29	+ 3:26

* Tsunami warning and beach deserted at 10:45
Shaded areas are March 2009 records (Beauchamp 2009)

Godwit and knot were very touchy when they arrived at the site and after disturbances and took up to 30 minutes to settle down. They tended to land beside the water and then move inland to non-tide exposed sites to roost. However, any disturbance during the roost time led the godwit to seek the tidal margin again. Subsequent disturbance caused them to rise and circuit until they settled again or left the area.

Consequently, godwit and knot were most likely to be displaced by waves from boat movement when they first arrived. However, 98 of the 139 boat movements took place before the godwit and knot arrived on the incoming tide or after they had left. Three of these movements displaced godwit from the island before the main body of birds arrived during the increasing tide. Only 5 of 41 boat movements caused disturbance of godwits when high numbers were present and in all cases the birds moved or circuited and landed again. Only twice did kayaks cause godwit to move and this was due to them getting too close.

The mean disturbance rate per hour of godwits and knot observed throughout the period of mass godwit and knot presence was 1.05 disturbances h (21 anthropomorphic disturbances in 19.9 h).

The summer was not one that had substantial easterly winds and the impact on kite boarders would have been limited. On 5 January 2010 the wind was in the south east and the kite boarders phoned the Department and indicated that it was now two hours after high and no godwits were present. Two staff members were passing the site and called in to look at it. They did not see the 30 bar-tailed godwits located at the end of the spit and informed me that there were none, and therefore that kite boarding could commence. The kite boarders entered the area and left it after seeing that godwits were present. The next day 36 godwit were present on the island.

Variable oystercatcher *Haematopus unicolor*

Variable oystercatchers appeared to be tolerant of walkers and the pairs that were in public areas (Table 3) were very vocal to any intruder. Nesting took place on the island, and in fenced areas on the southern side, southern spit and northern region. The fate of the nests was not known but some were lost in the high tides on 3 January on the island. One nest was laid just in from of the observation position around 1 January 2010 and was lost between 3 and 6 January 2010.

At low disturbance sites during high tide, variable oystercatchers were generally not feeding, and were away from the tide margin. Consequently displacement by walkers and other disturbance factors was not substantial. As the tide lowered they started to feed and it is more likely that disturbance events would be picked up at low tide.

Pied Shag *Phalocrocorax varius*

Pied shag roosted on the margins of the estuary and also used the estuary for foraging. Pied shags were disturbed by boats when roosting (n = 8) and foraging (n = 13) and they generally relocated within the region of the northern margin, southern spit or the island. Only twice did the shags disperse after disturbance from the estuary.

DISCUSSION

Impacts of overall disturbance on the estuarine bird community in the absence of kite boarding

Likely compounded impacts of these activities and kite boarders during spring high tides on the bird population and other users

The mean non-kite boarder anthropomorphic disturbance rate was 1.4 per hour and was only slightly greater than the 0.5-0.7 disturbance rate found during March 2009. Both rates were far lower than kite boarding disturbance rates which were 2.5 per hour on Sunday 15 March 2009 and 12 per hour on 14 February 2009 (Beauchamp 2009).

The number of people present at Ruakaka was however far higher than during March 2009. The lower than expected disturbance rates in this study primarily reflected cumulative disturbance, which left some areas devoid of birds (Appendix 3). Cumulative disturbance was most evident from early January and if fencing in the motor camp region, southern coast and spit were was not in place then it is very likely these areas would also have lack birds altogether.

The result of all this human activity was the retreat of birds to the island, northern end of the southern sand spit and the northern shoreline. The current activities that impact on these remaining roost regions are boats, kayaks, surfers, fishermen and walker (with and without dogs). Their combined disturbances are currently insufficient to prevent roost use. However, kite boarding would add substantially to the disturbance of the remaining sites. Kite boarding in March 2009 displaced all lesser knot, variable oystercatchers and pied shags from the entrance margins. All the species that left were as a direct result of kite boarders entering the estuary or as a result of their displacing birds to other areas from the safer island roost site. In the higher tides the island is small or on the biggest tide inundated. This means that addition, of kite boarding to all other disturbance factors would result in almost all the waders exiting Ruakaka outer estuary.

Kite boarding would also be in conflict with a number of other uses in the estuary at this time. Swimmers used the areas at the base of the spit and opposite the southern sand dunes. There were also substantial boat and kayak movements in the estuary. Power craft generally observed a five knot speed in the upper estuary but kite boarding was generally at faster speeds.

In addition, power craft entering or exiting the estuary may have difficulty manoeuvring in the presence of kite boarders.

Mitigation of impacts within the wildlife refuge

Importance of fencing off the spit during spring tides

The fenced off areas are important in allowing undisturbed roosting and potential breeding sites for variable oystercatchers and New Zealand dotterels. Nests of both species were present on the spit and northern side during the data collection period. Unfortunately walker disturbance on the northern side allowed a black-backed gull to raid a nest there and the tide destroyed nests at other locations.

Human impacts are so high, and godwit and knot are so disturbance averse, that to retain the Ruakaka roost site will require human intervention. The Ruakaka shorebird group must be commended for fencing off,and talking to the public on 2 January 2010, as that saved the substantial numbers of waders from being disturbed. However, this degree of effort will need to be ongoing to ensure the site remains a godwit and knot spring tide roost site.

Future population pressures

The current safe roost sites are for the most parts the areas where the public have the least access or the furthest to walk. Use of the northern shoreline by anthropomorphic factors is very likely to increase with two major housing subdivisions. The retention of roost sites and breeding sites there will be dependent on controlling walker disturbance.

There is unlikely to be any reduced used of the southern estuary which is for the most part generated by the use of the motor camp. A re-routing of the track to the coastline may assist with reducing some movement of people along the estuary margin, however it is obvious that at high tide the patrons of the motor camp see the southern beach as a safe place for sunbathing and for children to swim. They also tend to see the access to the beach along the estuary margin as a good circular walking route. This route may be more difficult to get along at high tide but it is still accessed because it is a good place to swim from during the incoming tide. The placement of the fence along this coastline must take account of the safety of the people as it has little or no benefit to the birds. Other fencing must be large enough to allow limited disturbance. However such disturbance cannot be guaranteed while there is a substantial flouting of the no dog rule.

Current and likely future bird presence at Ruakaka

The current level of disturbance at high tide is substantial and observations undertaken at low tide on 3 January 2010 suggest that the level of disturbance observed remains throughout the day, and is more widely dispersed at low tide. Despite this disturbance both godwit and knot are

present in the estuary at low tide and the other species found there remain. Increased anthropomorphic disturbance is likely to reduce the numbers and species present there during the most intense use period and ultimately more development without considerable public buy in will potentially reduce wader biodiversity there.

Conclusions

The Ruakaka Estuary wildlife refuge has unique values that are not replicated at Whangarei, Waipu and Mangawhai. These are the mass foraging by gannets on fish entering and moving up the estuary, and the presence during increasing high spring tides of Whangarei harbour's bar-tailed godwit and lesser knot population. At other times on peek spring tides the godwit and knot are at sites that we are currently unaware of. A high level of commitment will be needed to fence these roost sites at key times.

The compounded disturbance in the busiest periods resulted in waders only remaining in the fenced areas and the least disturbed sites on the island and the outer spit and estuary entrance. Kite boarding in March 2009 displaced all birds from the entrance and the outer spit areas and if allowed during the peak summer period would lead to most birds not having access to roost sites there.

In future, the potential for disturbance will be higher. A reconfiguration of the track system may assist with reducing some impacts but it is unlikely they will be sufficient to reduce disturbance alone. Substantial advocacy and community buy-in are required to ensure that the number and diversity of birds remain at the estuary.

Recommendations

1. **The wildlife reserve should be extended to cover the northern extent to at least 100 m north of the current foredunes.**

This area should then encompass the full extent of the entrance of the estuary. If this is not done then the ability to control the impacts of activities is totally dependent on good will and the configuration of the entrance of the estuary.

2. **Kite boarding should continue to be banned when tides equal or exceed 2.7 m or above between September and April**.

This should not be linked to godwit presence as the impacts of kite boarding during this time would be more extensive. The timing of kite boarding activity and its level of impact is in direct conflict with the presence of Palaearctic waders and the presence of most of the roosting birds around the entrance spit and northern shoreline. Kite boarding has the potential to displace birds from the estuary roost areas during important periods of the bird's lifecycle.

3. **Fencing need to be used to maintain the presence of the godwit and knot spring tide flock site and to protect areas for other species.**

The level of anthropomorphic disturbance in the absence of kite boarding is sufficient to displace birds from all areas, especially if housing development and access increase on the northern shoreline.

4. **That the routes that are provided for the public (especially those from the camp ground to the beach), be redirected behind the dune area to deter unnecessary use of the estuary margin**.

5. **Advocacy and education programmes should be directed at motor camp users, and the public at the car parks, and be backed up by compliance at the estuary especially over the time that mass godwit and knot roost in the area.**

This should be used as a vehicle for informing people of the importance of the area and their impacts. Data from this study could be used.

6. A user attitude and knowledge study should be carried out on the beach or in association with the motor camp.

A study should be carried out to assess the attitudes and behaviours of residents and visitors to this area. Such studies have been used in the past to find ways of changing behaviour based on prevailing attitudes.

Acknowledgements

I especially thank Gerard Pilon collected the data and loaded the database. I would like to thank the members of the Ruakaka Protection Society and the kite boarders for allowing the data collection to be undertaken unhindered.

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Appendix 1 Weather data during data collection

Date	Time	Tide maximum height	Wind	Wind Direction	Cloud cover	temp	Wet / Dry
18/10/2009	7:00:00		0- 10		50%	15	Dry
18/10/2009	8:00:00		10-15	NW	30%	15	Dry
18/10/2009	9:00:00		15-20	ne	50%	20	Dry /Rain in Hills
18/10/2009	10:00:00		15-20	NE	50%		Dry
18/10/2009	11:00:00		15-20	NE	70%	16	Dry
18/10/2009	12:00:00		10-20	NE	70%	20	Dry
18/10/2009	9:28:00						Showers
18/10/2009	9:38:00						Showers Stopped
19/10/2009	7:00:00		0		10%	14	Dry
19/10/2009	8:00:00		0-10	SW	10%	14	Dry
19/10/2009	9:07:00		5-15	SW	20%	18	Dry
19/10/2009	10:15:00		0-15	SW	20%	20	Dry
19/10/2009	11:00:00		15-20	sw	70%	20	Showers
19/10/2009	12:00:00		0-15	SW	90%	19	Showers
19/10/2009	13:00:00		0-15	sw	100%	18	Showers
20/10/2009	8:00:00		10-15	W	40%	14	Dry
20/10/2009	9:00:00		15-20	SW	20%	17	Dry
20/10/2009	10:00:00		10-15	SW	70%	18	Dry
20/10/2009	11:00:00		10-20	SW	70%	18	Dry
20/10/2009	12:00:00		10-20	SW	70%	20	Dry
20/10/2009	13:00:00		15-25	ssw	100%	18	Showers
21/10/2009	9:00:00		10	SW	10%	15	Dry
21/10/2009	10:00:00		<10	SW	10%	18	Dry
21/10/2009	11:00:00		<5	SE	10%	21	Dry
21/10/2009	12:00:00		0-10	SE	10%	20	Dry
21/10/2009	13:00:00		10-15	SE	20%	22	Dry
21/10/2009	14:00:00		0-15	SE -E	30%	20	Dry
21/10/2009	14:55:00		10-15	S - SW	40%	19	Dry
22/10/2009	9:10:00		0-15	SW	50%	16	Dry
22/10/2009	10:00:00		0-15	SW	70%	18	Dry
22/10/2009	11:00:00		10-20	SW	50%	18	Dry
22/10/2009	12:00:00		10-15	SW	50%	18	Dry
22/10/2009	13:00:00		10-25	SW	60%	18	Dry
22/10/2009	14:00:00		10-20	SW	50%	18	Dry
22/10/2009	15:00:00		10-15	SW	40%	18	Dry
4/12/2009	8:30:00		0<10	E	50%	19	Dry
13/02/2010	10:15:00		5-15	w	30%	21	Dry
13/02/2010	11:15:00		5-15	sw	50%	21	Dry
14/02/2010	10:45:00		5-15		90%	23	Dry
15/01/2010	7:15:00		0<5	se	100%	20	Dry

15/01/2010	8:15:00					20	
15/01/2010	10:00:00					20	Damp
15/01/2010	11:00:00		5-10	E	100%		Dry
16/01/2010	8:00:00		0-5	NW	40%	24	Dry
16/01/2010	9:00:00		0<5	SE	40%	25	Dry
16/01/2010	10:00:00		5-10	SE	20%	20	Dry
16/01/2010	11:00:00		5-10	se		28	Dry
16/01/2010	11:40:00		0-10	SE	30%	28	Dry
17/01/2010	8:15:00		0-10	SW	100%	20	Dry
17/01/2010	9:15:00						
17/01/2010	10:15:00		0-10	SW	100%	22	Dry
17/01/2010	11:15:00		0-10		100%	25	Dry
17/01/2010	12:15:00		0-5		100%	24	Dry
30/01/2010	7:15:00		5-10	S	100%	20	Dry
30/01/2010	8:15:00						
30/01/2010	9:15:00						
30/01/2010	10:15:00		5<10	S	100%	23	Dry
31/01/2010			10-15	S	80%	20	Dry
4/12/2009	9:00:00		0-10		80%	19	Dry
4/12/2009	10:00:00		0-10		60%	20	Dry
4/12/2009	10:50:00						
4/12/2009	12:00:00		10-20		80%	21	Dry
4/12/2009	13:00:00		10-15	E	70%	18	
4/12/2009	14:00:00		10-15	E	100%	18	
5/12/2009	8:30:00		0-10	SW	100%	20	
5/12/2009	9:00:00		0-10	SW	100%	20	
5/12/2009	10:00:00		<10	SW	50%	24	
5/12/2009	11:35:00			SW	50%	21	
5/12/2009	12:00:00		<10	SW	50%	21	
5/12/2009	14:00:00		10-15	SW	80%	20	
6/12/2009	9:30:00		0<10	E	5%	20	
6/12/2009	10:00:00		0-10	N	5%		
6/12/2009	11:00:00			NW			
6/12/2009	12:00:00		0<10	NW	10%	20	
6/12/2009	13:00:00		<10	sw	50%	20	
6/12/2009	14:00:00		<15	sw	50%	20	
6/12/2009	15:00:00					21	
18/12/2009	8:15:00		0		10%	20	Dry
18/12/2009	9:00:00		0<15	sw	20%	21	Dry
18/12/2009	10:00:00						
18/12/2009	11:00:00						
19/12/2009	12:00:00		0<10		10%	21	
19/12/2009	13:00:00						
19/12/2009	14:00:00						

20/12/2009	9:00:00		5-15	SW	80%	19	
20/12/2009	9:50:00		10-20	sw	100%		
1/01/2010	8:00:00			sw	0%	19.3	Dry
1/01/2010	9:00:00			sw		22.3	Dry
1/01/2010	10:00:00			sw		26	Dry
1/01/2010	11:00:00			sw		26	Dry
2/01/2010	8:00:00			sw	0%	19.4	Dry
2/01/2010	9:00:00			sw	0%	23.6	Dry
2/01/2010	10:00:00			sw	50%	22.4	Dry
2/01/2010	11:00:00			sw	10%	24.8	Dry
3/01/2010	9:00:00			sw	10%	25.2	Dry
3/01/2010	10:00:00			sw	10%	30.6	Dry
3/01/2010	11:00:00			sw	10%	30.2	Dry
3/01/2010	12:00:00			sw	10%	30.2	Dry
6/01/2010	12:30:00			se	0%	24	Dry
6/01/2010	13:30:00			se	0%	23	Dry
6/01/2010	14:30:00			se	0%	22	Dry
27/02/2010	7:00:00						
27/02/2010	7:45:00						
27/02/2010	8:30:00						
27/02/2010	9:30:00						
27/02/2010	10:30:00						
28/02/2010	7:00:00						
28/02/2010	8:00:00						
1/03/2010	8:45:00						
1/03/2010	9:45:00						
1/03/2010	10:45:00						

Appendix 2 Maximum numbers of bar-tailed godwits and lesser knots counted at Ruakaka Estuary during each count period

Date	Time	Tide height high tide	Godwit and Knot maximum
18/10/2009	8:08:00	2.6	93
19/10/2009	8:57:00	2.7	53
20/10/2009	9:43:00	2.7	35
21/10/2009	10:27:00	2.7	35
22/10/2009	11:10:00	2.6	37
4/12/2009	9:43:00	2.7	1000
5/12/2009	10:33:00	2.8	2300
6/12/2009	11:24:00	2.8	450
18/12/2009	9:43:00	2.5	77
19/12/2009	10:23:00	2.5	23
20/12/2009	11:01:00	2.5	20
1/01/2010	7:33:00	2.7	44
2/01/2010	8:25:00	2.8	3820
3/01/2010	9:17:00	2.9	3500
4/01/2010	10:07:00	2.9	300
5/01/2010	10:58:00	2.9	30 *
6/01/2010	11:48:00	2.8	36
15/01/2010	8:38:00	2.5	29
16/01/2010	9:20:00	2.5	26
17/01/2010	9:58:00	2.5	100
30/01/2010	8:12:00	2.7	3500
31/01/2010	9:05:00	2.9	2500
1/02/2010	9:56:00	2.9	500
12/02/2010	6:27:00	2.4	16
13/02/2010	8:12:00	2.4	13
14/02/2010	8:52:00	2.5	17
27/02/2010	6:52:00	2.6	146
28/02/2010	7:49:00	2.8	1000
1/03/2010	8:42:00	2.9	2200

* day that kite boarders entered estuary after being informed that no godwits were present

Appendix 3 Maximum numbers of waders at each site during each count period

Dates	Maximum Number	Boat	Island	Motor camp	North	South	Spit
18-Oct-09	Bar-tailed Godwit	14	58	21	9	28	66
19-Oct-09	Lesser Knot		5	4			4
20-Oct-09	Variable oystercatchers	24	39	5	18	12	16
21-Oct-09	NZ pied oystercatcher						
22-Oct-09	NZ Dotterel		4	1		2	10
	Pied Stilt						
	Pied Shag	5	18		22		17
	White-fronted tern			1			1
	Black-backed gull	3	4	1	29		33
	Caspian tern		2		1		2
	Red-billed gull	16	2	15		3	12
	Mallard duck	4	4	6		7	3
	Banded Dotterel						
	Spur Winged plover	2				2	
	Paradise Shellduck		4		2		
4-Dec-09	Bar-tailed Godwit	37	79	9			1000
5-Dec-09	Lesser Knot		170				
6-Dec-09	Variable oystercatchers	70	30	6	8	11	22
	NZ pied oystercatcher	12			3		
	NZ Dotterel		1	1	3	1	6
	Pied Stilt		2	5		2	
	Pied Shag				25	1	25
	White-fronted tern						
	Black-backed gull	2			2		15
	Caspian tern		1		2	1	4
	Red-billed gull	23					3
	Mallard duck	2	13	8	20	1	4
	Banded Dotterel			2			2
	Spur Winged plover		1				
	Paradise Shellduck						

Dates	Maximum Number	Boat	Island	Motor camp	North	South	Spit
18-Dec-09	Bar-tailed Godwit		70				20
19-Dec-09	Lesser Knot						
20-Dec-09	Variable oystercatchers	14	17	2	8	5	8
	NZ pied oystercatcher						
	NZ Dotterel			1		2	1
	Pied Stilt		2		2		
	Pied Shag		18			2	8
	White-fronted tern						
	Black-backed gull			20			
	Caspian tern		2				
	Red-billed gull	18					
	Mallard duck				25	3	
	Banded Dotterel						
	Spur Winged plover						
	Paradise Shellduck						
1-Jan-10	Bar-tailed Godwit		300	17	2500		2500
2-Jan-10	Lesser Knot		74		1000		1000
3-Jan-10	Variable oystercatchers	19	10	4	15	8	9
6-Jan-10	NZ pied oystercatcher		2				
	NZ Dotterel		2	3	3		2
	Pied Stilt		3	5			
	Pied Shag		13		22		32
	White-fronted tern		80		17		148
	Black-backed gull			19	30		5
	Caspian tern				2		2
	Red-billed gull	7	63	50	22		60
	Mallard duck			7	26		
	Banded Dotterel						
	Spur Winged plover						
	Paradise Shellduck						

Dates	Maximum Number	Boat	Island	Motor camp	North	South	Spit
15-Jan-10	Bar-tailed Godwit		7				12
16-Jan-10	Lesser Knot						
17-Jan-10	Variable oystercatchers	18	2		11	10	10
	NZ pied oystercatcher					3	
	NZ Dotterel		3		2		1
	Pied Stilt			2			
	Pied Shag				3		8
	White-fronted tern				3		5
	Black-backed gull		2		8		8
	Caspian tern						
	Red-billed gull		7	5			
	Mallard duck		10		29		
	Banded Dotterel						
	Spur Winged plover						
	Paradise Shellduck						
30-Jan-10	Bar-tailed Godwit		6				30
31-Jan-10	Lesser Knot						
	Variable oystercatchers		2		14	3	
	NZ pied oystercatcher						
	NZ Dotterel				2		
	Pied Stilt						
	Pied Shag				1		
	White-fronted tern						200
	Black-backed gull				11		
	Caspian tern						
	Red-billed gull					3	
	Mallard duck						
	Banded Dotterel						
	Spur Winged plover						
	Paradise Shellduck						

Dates	Maximum Number	Boat	Island	Motor camp	North	South	Spit
12-Feb-10	Bar-tailed Godwit		1	18		1	
13-Feb-10	Lesser Knot						
14-Feb-10	Variable oystercatchers			6	9	12	5
	NZ pied oystercatcher						
	NZ Dotterel			1		1	
	Pied Stilt						
	Pied Shag				11		
	White-fronted tern						
	Black-backed gull				5		1
	Caspian tern						
	Red-billed gull						1
	Mallard duck						
	Banded Dotterel						
	Spur Winged plover						
	Paradise Shellduck						
27-Feb-10	Bar-tailed Godwit			13			1500
28-Feb-10	Lesser Knot		40				700
1-Mar-10	Variable oystercatchers		12	4	4	10	8
	NZ pied oystercatcher						
	NZ Dotterel			4	4		4
	Pied Stilt			5			
	Pied Shag				10		
	White-fronted tern		50				70
	Black-backed gull				23		
	Caspian tern		1				
	Red-billed gull	20	5		10	5	10
	Mallard duck				31		
	Banded Dotterel						
	Spur Winged plover						
	Paradise Shellduck						

Figure 1. Ruakaka Estuary count and roost zones

▲ = data collection site March 2009,

■ = data collection site October 2009 to March 2010