Tracking dingoes on Fraser Island

Final Report

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Greg Baxter & Nicole Davies

School of Geography, Planning & Environmental Management

The University of Queensland

This report is stage 2 of the Dingo Population Study under the Fraser Island Dingo Management Strategy (2006)

1.0 Introduction

Wild dingoes (*Canis lupus dingo*) are an important part of the faunal community of Fraser Island (*Ngari* in the Butchula Aboriginal language). They represent one of the important natural values for which the island was inscribed on the register of World Heritage sites in 1992. However, the management of dingoes has been problematic. They have interacted with humans on the island in unacceptable ways, with regular attacks and even a death of a child from a dingo attack being known. Under these circumstances there is an imperative to manage the dingo/human interaction in a different way. One of the most basic pieces of ecological knowledge necessary to manage wild animals is an understanding of their population dynamics and behaviour. To enhance this understanding in 2009 the Queensland Government commissioned a study to determine the efficacy of using mark-recapture methodology to estimate dingo abundance on Fraser Island and also sought advice on how best to quantify the movements and home ranges of the dingo population. Advice was provided by QPWS in partnership with dingo experts from Biosecurity Queensland, The University of Queensland and Griffith University. Peer review of the plan was provided by a number of dingo and wildlife experts including Dr Lee Allen of Biosecurity Queensland, Dr Greg Baxter and Dr Luke Leung from the University of Queensland and Associate Professor Darryl Jones and Rob Appleby from Griffith University.

It was determined that given the limited human resources available, the time frame when results were required, and the difficulty in accessing most of the island, the best option was to fit up to 20 dingoes with global positioning system (GPS) collars which fix locations accurately and remotely. The collars included a release mechanism which was pre-set to release on the required date, and most data was retrieved without the need to recapture the dingoes. Those collars were also fitted with VHF transmitters to assist monitoring and retrieval of the collars.

The University of Queensland was engaged under contract to analyse and report on this data. This is the final report of the findings of this study. It summarises all the data that was downloaded by satellite to 23rd March 2012 and all the extra data to the end of September 2012 that was retrieved from the collars as they were recovered after dropping off dingoes.

2.0 Methods

Sampling Strategy

In 1998 a well-known dingo expert, Dr Laurie Corbett, estimated Fraser Island dingo numbers to be between 100 and 200 individuals (Fraser Island Dingo Management Strategy. Those animals live in a range of habitats which vary in attributes such as vegetation and topography, proximity to the beach or human settlement and infrastructure, whether they lived on the east or west coast, or whether the dingoes were predominantly beach or inland dwellers. In order to obtain a representative sample the island was divided into 10 zones. The intent was to collar up to 20 dingoes on the island; 2 dingoes in each zone and if possible one adult and one sub-adult and one male and one female.

Animal Capture

The author of this report played no role in the capture, handling, or collaring of any dingoes. Those functions were performed by QPWS staff and a specialist dingo/wild dog trapping contractor. Trapping was done using soft-catch leg hold traps which grasp the animal’s leg. All animal trapping and handling was carried out under animal ethics approvals issued to QPWS.

Dingo capture and collaring began in May 2011 and was completed by July 2011, by which time 18 individual dingoes had been captured and collared. As well as the GPS/VHF radio collars the dingoes were fitted with uniquely coloured ear tags to facilitate individual identification when any animal was sighted. All animals were also fitted with a subcutaneous passive micro-chip transponder that allowed for individual identification at any future capture occasion even if the ear tags had not remained in place.

At the time of capture the dingoes had a detailed health assessment including recording weight, had their sex determined and their age estimated by experienced QPWS officers.

Radio Tracking Equipment

The radio collars were pre-set to record an animal position every two hours, depending on environmental conditions and availability of satellites. The weight of the collars was kept as low as possible and with a positional fix every two hours the batteries would last approximately eight months. To reduce stress to the animals the collars were also fitted with a pre-set automatic release mechanism which reduced the necessity to recapture animals to remove the collars. The total weight of the collars, including battery and automatic release mechanism, was approximately 500g, which is slightly more than 3% of the weight of a 15 kg dingo (Figure 1).

Figure 1. Example of the GPS collars fitted to dingoes. These units contained a GPS tracker, satellite transmitter, VHF transmitter, automatic drop-off mechanism and battery.

Best practice wildlife research is that no attachment of any kind to a wild animal should exceed 5% of an animal's body weight. However, when that attachment is a collar, rather than a harness, the convention is that it should not exceed 3.5% of the body weight (Kenward 2001). These collars were easily accommodated by the dingoes (Figure 2).

Figure 2. One of the GPS collars being carried by an adult male dingo. Transmitters were deliberately coloured to be inconspicuous on the dingo.

Due to the time frame of the collaring project, around half the collars were programmed to release on 31 January and the remainder on 31 March 2012. The collars communicated automatically with Global Positioning System satellites operated by Argos Ltd. Locations were downloaded by QPWS staff and provided to the author for analysis.

Home range statistical analysis

GPS coordinates were projected into UTM meters and these data were used to calculate the home range sizes in ArcMap (ArcGIS 10, ESRI, Australia) using the telemetry extension package ABODE (Laver 2005a). Each position was mapped in ArcMap 10, which provided a visual indication of the home ranges. Home range sizes were calculated from the 95% fixed kernel (FK) distributions. Smoothing parameters were calculated using the Least-Squares Cross-Validation (LSCV) method (Seaman & Powell 1996). The fixed kernel can emphasize the areas of greatest use while not being highly sensitive to outliers (Pope et al. 2004). Unfortunately, there is no perfect home range estimator. Previous studies have recommended the kernel density estimator as a reliable home-range estimator (Powell 2000; Seaman *et al.* 1999; Seaman and Powell 1996 ; Silverman 1986; Worton 1995). For the fixed kernel estimate, the two statistical methods that are commonly used for automatically choosing a smoothing parameter are the LSCV and the reference smoothing (href) methods. The href method is known to preform poorly and oversmooth the data (Gitzen and Millspaugh 2003; Seaman *et al.* 1999), whereas the LSCV offers lower bias and higher flexibility in handling complex location patterns (Powell 2000; Seaman *et al.* 1999; Seaman and Powell 1996 ; Swihart and Slade 1997; Worton 1995). Therefore, the use of fixed kernels with LSCV is recommended as the technique for choosing the smoothing parameter (Kie *et al.* 1996; Seaman *et al.* 1999; Seaman and Powell 1996). However, depending on the magnitude of discretization, LSCV may underestimate the smoothing parameter causing this method to fail and resulting in discontinuous home ranges (Kernohan *et al.* 2001; Laver 2005b; Seaman and Powell 1996 ; Silverman 1986). Hemson *et al* (2005) also found that intensive use of core areas and site fidelity by animals caused LSCV to fail. An indication that discretization may be affecting data analysis is the depiction of contours around single points or small clusters (Laver 2005b), however, as can be seen for the maps of this study this has not occurred. ABODE also has an option to correct for discretization problems while estimating the smoothing factor using LSCV. To ensure that discretization was not affecting the results, this correction option was tested for a number of the animals to see if this changed the results – it did not, suggesting that discretization was not causing any problems in the data analysis using the LSCV method. Furthermore, previous research on wild dogs in south-eastern mainland Australia have calculated 95% fixed kernel using the LSCV and unit variance standardization methodology (Claridge *et al.* 2009). Fixed kernel methods using the LSCV method for calculating the smoothing parameter has also been used to calculate home ranges for a number of other *Canis* species, including wolves (Kusak *et al.* 2005; Oakleaf *et al.* 2003) and coyotes (Schrecengost *et al.* 2009). Minimum convex polygons (95% MCP) were also calculated using OzTrack (OzTrack, Australia) to allow comparisons among other dingo home range studies (Harris et al. 1990). Home ranges were also calculated for Mating (March-May), Pupping and Whelping (June-August), Dependent Young (September-November), and Non-breeding (December-February) seasons. To ensure that the sampling duration covered the full range of each dingo, home range asymptotes were estimated, using ABODE (Harris et al. 1990). Only home ranges that reached an asymptote were included in analyses. Some home ranges that were calculated included areas of ocean that could not possibly be a part of the home range, therefore, it was necessary to trim these areas out of the home ranges. Using a shapefile of Fraser Island, home range polygons were clipped to the Fraser Island shapefile using the clip analysis feature in ArcMap.

The distance between each consecutive location was measured using Geospatial Modeling Environment (Beyer 2009). Diurnal (March-August: 6am-5pm; September-February: 5am-6pm) and nocturnal (March-August: 5pm-6am; September-February: 6pm-5am) distances were then estimated for each animal. The proportion of each vegetation class within FK home ranges were also estimated for each animal using regional ecosystem maps of Fraser Island.

In all analyses that follow the data was tested for normality using the Shapiro-Wilk normality test. If they failed that test data were log transformed and those data tested if they were acceptable. If data could not be successfully transformed a non-parametric Mann-Whitney test was run.

Home Range Size

Home ranges can be calculated in a number of ways and the estimate of the size of the home range will vary depending on the method used to calculate it. The simplest method is an estimate based on a minimum convex polygon (MCP) which is a polygon drawn around all the points defining the location of the animal (for example see White and Garrot 1990). This estimate will include places where the animal has never been located and gives no indication of the relative use of different parts of the home range. Another method is to calculate a fixed kernel estimate (FK) which takes into account the frequency with which the animal uses different parts of its home range. In the home range sizes which appear below both types of estimates are recorded. The MCP was the first estimator developed and it is still widely used, though not rated to perform well against other estimators (Kernohan, et al 2001). The FK estimator is rated as being of much greater utility because it is free of assumptions about the distribution of the data, and simulation studies have shown that it is superior to other methods at estimating home range size (Kernohan et al 2001).

An animal’s home range was first defined in 1943 as “that area traversed by the individual in its normal activities of food gathering, mating and caring for young” (Burt 1943, p. 351). This definition has a number of deficiencies such as what is meant by ‘normal’ and there is no specification of the temporal component of range occupation. These deficiencies have been discussed widely (e.g. Kernohan, et al 2001; White and Garrot 1990), but no authors have successfully suggested a better, and universally acceptable, definition.

In practice the biggest problem is the high probability that over time animals will move away from the places they visit during their ‘normal’ daily activities. They will do this because they may need to do things like detect or chase a potential rival or escape a predator. If that happens the home range size estimated by any method will be inflated. Hence the standard practice, no matter what the estimator, is to discount the fewest locations which together add 5% to the total size of the home range. Thus a 95% convex polygon or 95% fixed kernel estimate are routinely employed and those are the estimates that are given in this report.

For each animal there is an estimate of the total home range size and one for the mating season (March to May), Pupping and Whelping season (June to August), the season when there are dependent young (September to November) and the non-breeding season (December to February).

Association of home ranges with vegetation type

Different vegetation types on Fraser Island are influenced by factors such as position on the dune, elevation, access to soil nutrients and distance from the ocean. Hence it may be that different vegetation types offer different quality of home ranges. For this analysis, the vegetation of Fraser Island was categorised into Regional Ecosystem type from GIS data supplied by QPWS. The proportions of 95% FK home ranges within each vegetation type were calculated. Then the proportion of the whole island occupied by each vegetation type was calculated. The similarity of the use of the vegetation type compared to the availability (measured by proportional area) of the different vegetation types was compared using a Bray-Curtis measure (Bray and Curtis 1957). This measure is usually used to compare the similarity of species composition in different plant communities. Here, it has been used to compare the similarity of use of vegetation types on the island to their availability where it weights common species more highly than rare ones, so that rare species will contribute relatively little to the coefficient (Krebs 1999). This analysis was undertaken after inspecting the maps of dingo movements during this study. Those indicated that, while some animals stayed within a relatively well-defined home range, others moved over most of the island. Given that the study area is an island, and that animals demonstrated an ability to move over almost its entire area the whole island was considered potentially available to each dingo and the calculations were based on the vegetation of the whole island. It is possible to draw buffers of differing sizes around points and calculate the vegetation types available within those buffers, but the size of the buffer dramatically affects the result and given the above observations it was considered that such an approach would be arbitrary and not justifiable. Only data which reached an asymptote was included in these analyses.

3.0 Results

Data Quantity and Quality

To September 2012 data had been obtained from 18 dingoes (Tables 1 & 2), the goal of studying 20 animals not being feasible given the logistical constraints. Most locations were obtained with fixes from between 4 and 10 satellites, but some locations were fixed with up to 15 satellites. The greater the number of satellites the more accurate the location will be. Due to any short-term effects from capturing animals and fitting the collars the positions taken from the first 24 hours after collaring were deleted from the analyses which follow. From current understanding of the ecology of Fraser Island dingoes, the following months were assigned to different stages of their breeding cycle; mating – March to May, pupping & whelping – June to August, dependent young – September to November, non-breeding – December to February.

Table 1. Characteristics of, and data received from, collared dingoes.

Animal ID	Estimated (or known) Year of Birth	Gender	Total Position Fixes Used in Analyses	Timing in Dingo Reproductive Cycle When Locations Received			
				Mating	Pupping & Whelping	Dependent Young	Non-breeding
76861	2008	♀	141		141		
76987	(2010)	♂	3120	387	679	1016	1038
77153	2006	♀	854	114	565	175	
77165	(2010)	♂	914	103	635	176	
77168	2010	♂	3218	113	1110	1115	880
77193	(2007)	♂	972	118	854		
78030	2007	♂	1413		766	647	
78031	(2010)	♀	3190	115	1073	1029	973
78032	2009	♀	3074	244	970	1127	733
78187	(2007)	♀	183	119	64		
78203	2009	♀	2803	218	984	1028	573
78213	2009	♀	2858	146	1112	976	624
78215	(2006)	♀	2712		948	1032	732
78256	2009	♂	2847	236	640	939	1032
78259	2006	♀	811		291	520	
78421	(2005)	♂	1762	190	295	666	611
78422	(2009)	♂	1497	83	476	529	409
78423	2008	♀	696	35	110	298	253

Table 2. Social characteristics of collared dingoes. A = adult, S = Subadult, M = Male, F = Female. * These observations were supplied by QPWS Rangers on Fraser Island, based on observing the animals in the field.

Animal ID	Age	Age/Sex Class	Observed Social Status*
76861	3	A/F	Breeding in a pack
76987	1	S/M	Not Part of a pack during this study
77153	5	A/F	Breeding in a pack
77165	1	S/M	Not Part of a pack during this study
77168	1	S/M	Not Part of a pack during this study
77193	4	A/M	Part of a pack
78030	4	A/M	Not Part of a pack during this study
78031	1	S/F	Part of a pack
78032	2	S/F	Breeding in a pack
78187	4	A/F	Part of a pack
78203	2	S/F	Unknown
78213	2	S/F	Part of a pack
78215	5	A/F	Breeding in a pack
78256	2	S/M	Probably part of a pack
78259	5	A/F	Possibly part of a pack
78421	6	A/M	Breeding in a pack
78422	2	S/M	Not Part of a pack during this study
78423	3	A/F	Possibly part of a pack

The value of any study depends on the quality of the data obtained. If the data are too few or inaccurate the conclusions which can be drawn from analysis are limited. In this study the data which have been produced appear to be excellent because of their volume, duration over which they were collected, and the small number of inconsistent locations that had to be discarded (Table 2). When the amount of data that is used to calculate home range size is small it is considered unreliable because when more data are added, the home range size will increase. For that reason all home range sizes were plotted against the number of data points available to estimate that home range size. Estimates are regarded as reliable if they reach an asymptote and do not continue to rise as the number of data points increases. In this study the home range size for only four animals failed to reach an asymptote for total home range size, though when the data was broken down into seasons of the year, more failed to reach an asymptote (Table 3).

Table 3. Quality of data received. In the “Points Deleted” column, ‘time’ means the points were deleted because they were recorded either before the collars were deployed or within a few minutes of a programmed fix, and ‘location’ means the points were deleted because they were in a location that the animal could not have occupied, mostly the ocean.

Animal ID	Asymptote Reached					Points Deleted
	Total	Mating	Pupping & Whelp	Dependent Young	Non-breeding	
76861	Yes	No Data	Yes	No Data	No Data	21 time
76987	Yes	Yes	Yes	Yes	No	331 location & time
77153	Yes	Yes	Yes	Yes	No Data	116location, & time
77165	Yes	Yes	Yes	No	No Data	32 location, & time
77168	Yes	No	No	Yes	Yes	289 location & time
77193	No	No	No	No Data	No Data	126 location & time
78030	Yes	No Data	Yes	Yes	No Data	164 location & time
78031	Yes	No	Yes	Yes	Yes	365 location & time

Animal ID	Asymptote Reached					Points Deleted
	Total	Mating	Pupping & Whelp	Dependent Young	Non-breeding	
78032	Yes	Yes	Yes	No	Yes	366 location & time
78187	Yes	Yes	Yes	No Data	No Data	142 location & time
78203	Yes	Yes	Yes	Yes	Yes	295 location & time
78213	Yes	No	Yes	Yes	Yes	353 location & time
78215	No	No Data	Yes	No	Yes	299 time & location
78256	Yes	Yes	Yes	Yes	Yes	15 location & time
78259	Yes	No Data	Yes	Yes	No Data	104 location & time
78421	No	Yes	Yes	Yes	Yes	234 location & time
78422	Yes	No	No	Yes	Yes	15 location & time
78423	No	Yes	Yes	Yes	Yes	1 time

There was a good spread in age of study dingoes. At the time they were tracked 11 were aged 3 years or younger and 7 were aged 4 to 7 years. The data demonstrate a good split between male (10) and female (8) dingoes, with a large number of positions for most animals and these were spread over the full range of the dingo breeding cycle (Table 1). This suggests that the results reported below are meaningful and representative of the greater Fraser Island dingo population.

Home Range Size

Home ranges calculated for Fraser Island Dingoes are shown in Table 4.

Table 4. Home range estimates (ha.). Figures in **bold** indicate an estimate where the data did not reach an asymptote, therefore these may be an under-estimate of home range size.

Dingo	**Period**	**95% FK (ha)**	**95% MCP (ha)**	**Number of Points**
76861	Total	742.98	2259.23	191
	Pupping & Whelping (Jun-Aug)	313.97	2218.93	183
	Dependent Young (Sept-Nov)	534.74	5.85	8
76987	Total	25956.42	60717.07	3120
	Mating (Mar-May)	10148.73	20602.13	387
	Pupping & Whelping (Jun-Aug)	24567.43	31880.1	679
	Dependent Young (Sept-Nov)	17351.17	49847.54	1016
	Non-breeding (Dec-Feb)	**15671.75**	26406.81	1038
77153	Total	3947.21	7186.43	854
	Mating (Mar-May)	4341.97	5125.62	114
	Pupping & Whelping (Jun-Aug)	4096.58	7194.3	565
	Dependent Young (Sept-Nov)	2845.38	3940.81	175
77165	Total	4704.44	10422.08	914
	Mating (Mar-May)	7797.23	5948.8	103
	Pupping & Whelping (Jun-Aug)	2973.24	7123.93	635
	Dependent Young (Sept-Nov)	**4093.82**	7174.58	176

Dingo	**Period**	**95% FK (ha)**	**95% MCP (ha)**	**Number of Points**
77168	Total	57459.25	106719.2	3218
	Mating (Mar-May)	**2801.05**	3199.65	113
	Pupping & Whelping (Jun-Aug)	**59078.94**	106531.8	1110
	Dependent Young (Sept-Nov)	26959.81	29949.87	1115
	Non-breeding (Dec-Feb)	5560.84	5600.06	880
77193	Total	23105.04	42545.03	972
	Mating (Mar-May)	**12515.64**	3219.6	118
	Pupping & Whelping (Jun-Aug)	**23818.3**	42505.52	854
78030	Total	**5455.3**	7149.89	1418
	Pupping & Whelping (Jun-Aug)	5110.92	6941.42	766
	Dependent Young (Sept-Nov)	5200.7	6408.11	652
78031	Total	2877.54	10222.82	3190
	Mating (Mar-May)	**6939.52**	5959.24	115
	Pupping & Whelping (Jun-Aug)	1343.34	2639.59	1073
	Dependent Young (Sept-Nov)	2342.11	4267.25	1029
	Non-breeding (Dec-Feb)	2886.77	5981.35	973
78032	Total	8984.65	17584.44	3074
	Mating (Mar-May)	9663.72	9668.7	244
	Pupping & Whelping (Jun-Aug)	4765.6	8613.41	970
	Dependent Young (Sept-Nov)	**6319.1**	14083.37	1127
	Non-breeding (Dec-Feb)	8155.88	14481.12	733
78187	Total	546.87	611.85	1343
	Mating (Mar-May)	7952.88	6939.56	119
	Pupping & Whelping (Jun-Aug)	14.04	23.16	1154
	Dependent Young (Sept-Nov)	0.049	0.08	70
78203	Total	4973.54	7820.52	2803
	Mating (Mar-May)	3047.91	3588.59	218
	Pupping & Whelping (Jun-Aug)	2111.29	2581.25	984

Dingo	**Period**	**95% FK (ha)**	**95% MCP (ha)**	**Number of Points**
	Dependent Young (Sept-Nov)	3272.04	4713.01	1028
	Non-breeding (Dec-Feb)	3087.91	3442.51	573
78213	Total	1549.35	2545.37	2858
	Mating (Mar-May)	**1289.04**	1517.81	146
	Pupping & Whelping (Jun-Aug)	1164.17	1811.01	1112
	Dependent Young (Sept-Nov)	1710.87	1896.95	976
	Non-breeding (Dec-Feb)	1587.66	1913.91	624
78215	Total	**2161.69**	5177.17	2712
	Pupping & Whelping (Jun-Aug)	1318.88	3006.01	948
	Dependent Young (Sept-Nov)	**1099.29**	2653	1032
	Non-breeding (Dec-Feb)	2899.01	4241.56	732
78256	Total	11602.03	12754.99	2908
	Mating (Mar-May)	5791.49	9477.95	297
	Pupping & Whelping (Jun-Aug)	6900.13	7917.19	640
	Dependent Young (Sept-Nov)	10616.39	12034.63	939
	Non-breeding (Dec-Feb)	11436.81	12764.29	1032
78259	Total	5972.28	6335.98	811
	Pupping & Whelping (Jun-Aug)	5039.33	4749.1	291
	Dependent Young (Sept-Nov)	5998.29	6077.48	520
78421	Total	12266.49	20653.99	1762
	Mating (Mar-May)	14612.55	14943.28	190
	Pupping & Whelping (Jun-Aug)	4029.66	6547.86	295
	Dependent Young (Sept-Nov)	8081.7	14258.3	666
	Non-breeding (Dec-Feb)	14372.57	20811.31	611
78422	Total	15160.73	24527.32	1497
	Mating (Mar-May)	**1146.06**	2247.08	83
	Pupping & Whelping (Jun-Aug)	**11904.42**	19826	476
	Dependent Young (Sept-Nov)	17917.93	30877.75	529

Dingo	**Period**	**95% FK (ha)**	**95% MCP (ha)**	**Number of Points**
	Non-breeding (Dec-Feb)	4535.97	5753.52	409
78423	Total	**9883.28**	9594.39	696
	Mating (Mar-May)	4995.56	6075.87	35
	Pupping & Whelping (Jun-Aug)	3565.75	5573.77	110
	Dependent Young (Sept-Nov)	8202.52	8197.51	298
	Non-breeding (Dec-Feb)	9782.42	9291.81	253

Gender Analysis

Considering all the males together and comparing them to all the females together, the total 95% FK and MCP for males was significantly larger than females (FK (Fig. 3): t = 3.395, df = 13,P = 0.0048; MCP: t = 2.667, df = 16, P = 0.0169). While the 95% FK and MCP home ranges for males and females were not significantly different during the mating season (FK: t = 1.657, df = 7, P = 0.1415; Mann-Whitney test: P = 0.1905; MCP: t = 1.058, df = 12, P = 0.3109).

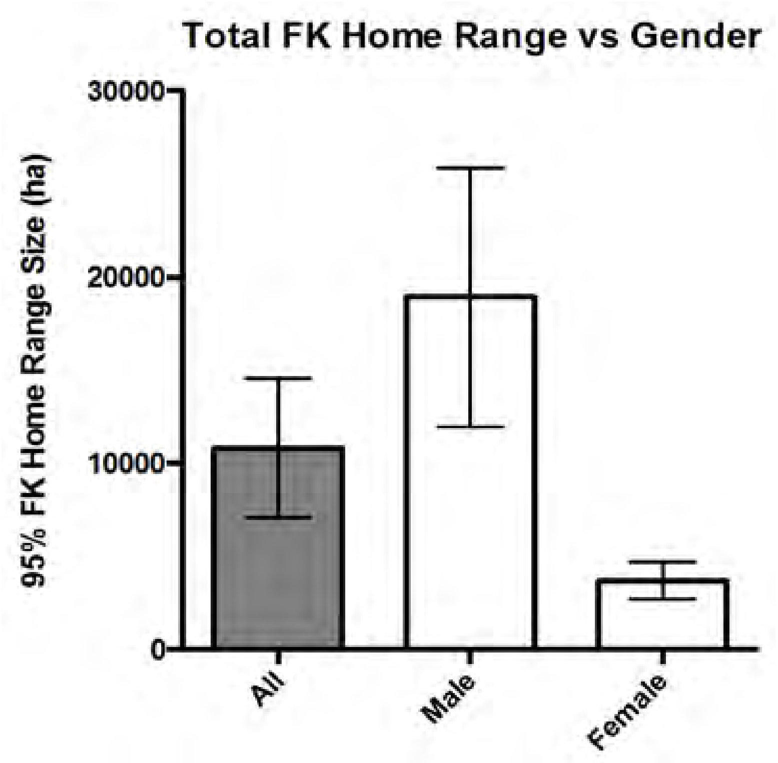

Figure 3. Mean total FK home range for males and females. Error bars are standard deviations.

The male and female 95% FK home ranges were not significantly different in size during non-breeding seasons (t = 1.401, df = 7, P = 0.2040; Mann-Whitney test: P = 0.1905), but they were significantly larger for males during the pupping and whelping season (t = 2.438, df = 12, P = 0.03; Man-Whitney test: P = 002), and the dependent young season (t = 3.744, df = 12, P = 0.0028; Mann-Whitney test: P = 0.0047).

When considering 95% MCP home ranges, males had a significantly larger home range than females during the pupping & whelping (t = 3.201, df = 16, P = 0.006), and dependent young seasons (t = 3.229, df = 15, P = 0.006).

Seasonal Analysis

There were no significant differences in 95% FK home range size for males and females combined between seasons of the year (Mating, Pupping & Whelping, Dependent Young, Non-Breeding; ANOVA: F (3,42) = 1.394, P = 0.2580:Kruskal-Wallis test: P = 0.174). For males there were no significant differences in 95% FK home range size between breeding seasons (Kruskal-Wallis: P = 0.496), nor for females between seasons (Kruskal-Wallis: P = 0.166).

Distances Travelled

Considering all travel, across all seasons combined, dingoes travelled significantly further during the night than the day (Fig. 4.; Mann Whitney test: P = <0.0001).

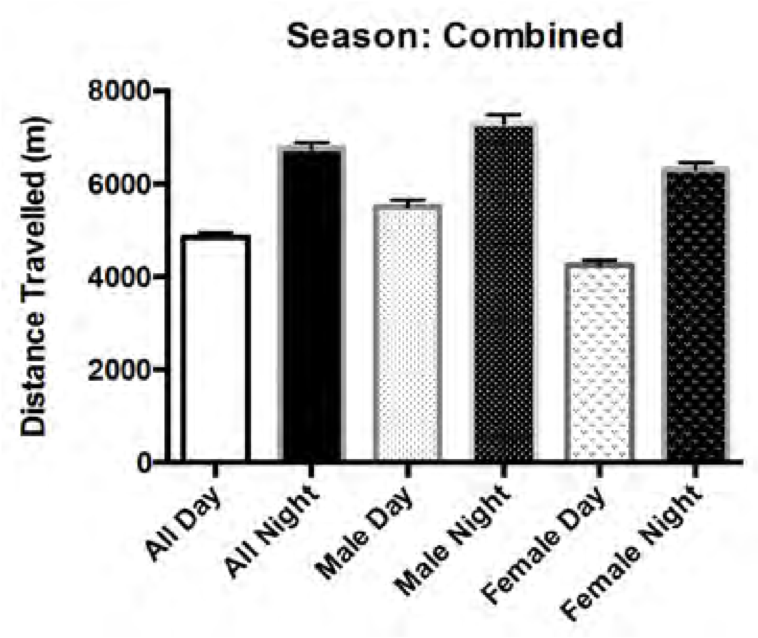

Figure 4. Mean distances travelled per 12 hour period over all seasons combined. Error bars are standard deviations.

Similarly, during the pupping & whelping season the distances travelled were significantly larger during the night than day (Fig. 5. Mann Whitney test: P = <0.0001).

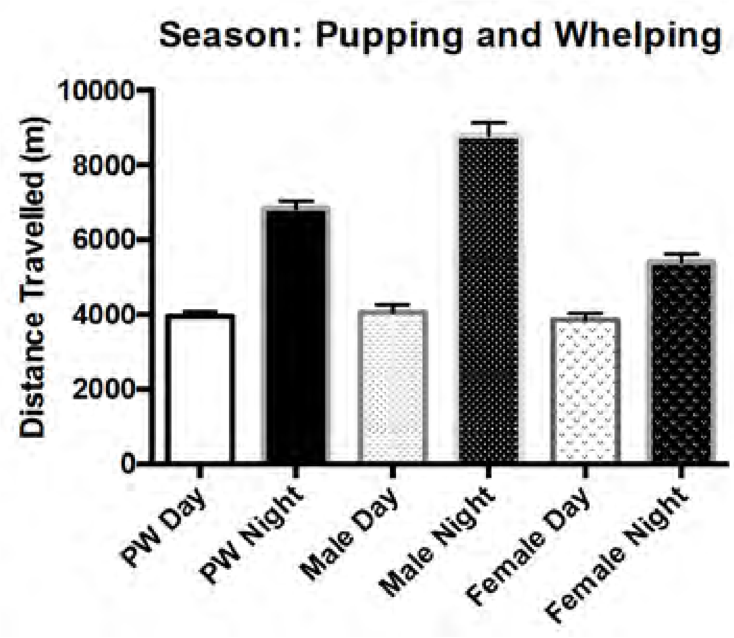

Figure 5. Mean movements per 12 hour period during the pupping & whelping season. Error bars are standard deviations.

For males and females combined there were no other significant differences in movements during the night or day in any other season.

When comparing the daily movement of males and females for all seasons combined the movement by both males and females was significantly larger at night than day (Kruskal-Wallis test: P = <0.0001). Males had significantly larger movements than females by both night and day (Kruskal-Wallis test: P = <0.0001).

Examining the seasonal movements of males and females separately showed that during the pupping & whelping season both males and females travelled significantly further at night than during the day (Kruskal-Wallis test: P = <0.0001). Males travelled significantly further during the night than females during that season, (Kruskal-Wallis test: P = <0.0001), though there was no significant difference in the distances travelled during the day between genders during that season (Fig. 5).

During the dependent young season there were no significant differences in the distance travelled by night or day for males, whereas females travelled significantly further during the night than they did during the day (Kruskal-Wallis test: P = 0.0126). During this season the distances travelled by females were at night were significantly larger than those travelled by males (Fig. 6.).

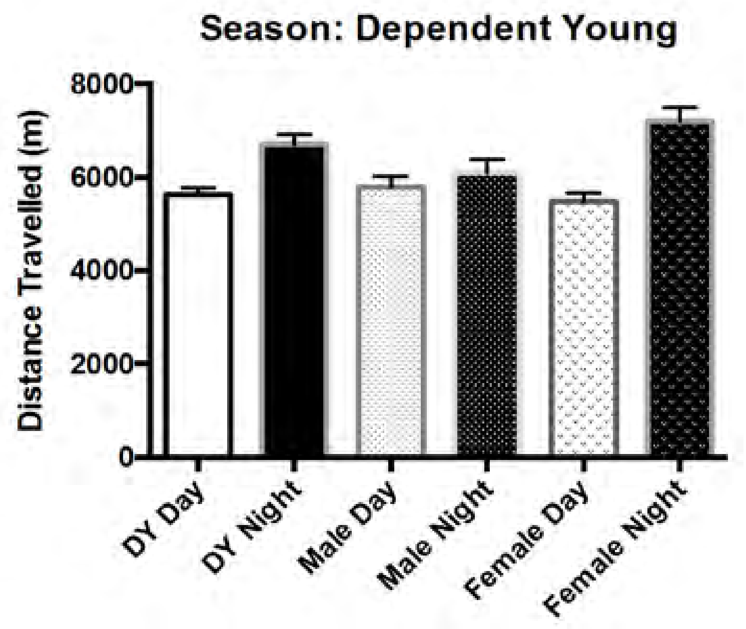

Figure 6. Mean distances travelled by males and females during the dependent young season. Error bars are standard deviations.

During the non-breeding season both males and females travelled significantly (Kruskal-Wallis test: P = <0.0001) further at night than during the day, and males travelled significantly further than females during the day, but not at night (Fig. 7).

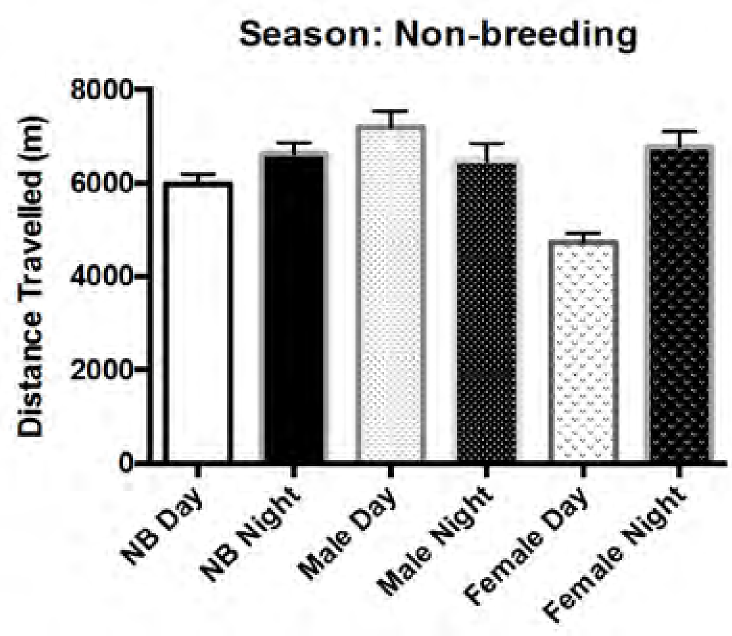

Figure 7. Mean distances travelled by males and females during the non-breeding season. Error bars are standard deviations.

Association of home ranges with vegetation type

There were changes in the selectivity of dingoes across breeding seasons, as measured by their use of vegetation type relative to its availability (Table 5).

Table 5: Bray-Curtis Similarity measure based on a comparison of the proportion (%) of animal fixes in each vegetation type in FK home ranges for each animal during each period, relative to the availability of that vegetation across the island. This measure is 1-Bray-curtis Dissimilarity Index, so a figure close to 0 indicates the number of position fixes for that dingo was totally dissimilar to the relative proportions of vegetation types, while a value of 1 indicates that the number of fixes was completely similar to the relative proportions of vegetation types. To aid interpretation the relative use (% observed occupancy - % measured availability) of the three most commonly used vegetation types is included. A negative value there indicates that the animal was observed in that vegetation type less than the proportion of its availability, and a positive value indicates the animal was observed in that vegetation type more often than the proportion of its availability.

Individual	Season	Bray-Curtis Similarity	Difference in % Observed use and % Availability		
			Riparian Foredune Beach Ridge	Shrubby Open Forest to Woodland	Dry Coastal Heath
76861	Total	0.71	15.8	-9.5	-3.1
	Pupping & Whelping	0.73	15.8	-6.5	-2.1
	Dependent Young	0.52	5.8	-20.5	40.9
76987	Total	0.67	2.8	24.5	-25.1
	Mating	0.63	2.8	28.5	-25.1
	Pupping & Whelping	0.68	-1.1	16.5	-25.1
	Dependent Young	0.69	1.8	22.5	-23.1
77153	Total	0.27	35.8	-19.5	5.2

	Mating	0.36	26.8	-13.5	-27.1
	Pupping & Whelping	0.29	35.8	-19.5	-0.8
	Dependent Young	0.18	37.8	-28.5	-29.1
77165	Total	0.68	7.8	-15.5	8.9
	Mating	0.72	0.8	-9.5	18.9
	Pupping & Whelping	0.68	5.8	-15.5	1.8
77168	Total	0.83	10.8	-6.5	-0.1
	Dependent Young	0.67	9.8	-16.5	11.9
	Non-Breeding	0.51	27.8	-15.5	-16.1
78030	Total	0.55	-9.2	28.5	-23.1
	Pupping & Whelping	0.56	-9.2	27.5	-22.1
	Dependent Young	0.53	-9.2	29.5	-0.8
78031	Total	0.44	38.8	-0.5	-29.1
	Pupping & Whelping	0.29	60.8	-14.5	-29.1
	Dependent Young	0.55	38.8	-5.5	-28.1
	Non-Breeding	0.48	33.8	1.5	-28.1
78032	Total	0.53	-7.2	-16.5	44.9
	Pupping & Whelping	0.46	-6.2	-22.5	53.9
	Mating	0.62	-7.2	-8.5	33.9
	Non-Breeding	0.57	-7.2	-13.5	38.9
78187	Total	0.54	32.8	4.5	-27.1
	Pupping & Whelping	0.13	86.8	-31.5	-29.1
	Dependent Young	0.09	90.8	-31.5	-29.1
	Mating	0.54	23.8	10.5	-27.1
78203	Total	0.65	0.8	-9.5	34.9

	Pupping & Whelping	0.53	-2.2	-14.5	46.9
	Dependent Young	0.46	3.8	-18.5	40.9
	Mating	0.61	-9.2	8.5	30.9
	Non-Breeding	0.58	4.8	-14.5	33.9
78213	Total	0.39	37.8	-28.5	-5.1
	Pupping & Whelping	0.34	-40.8	-29.5	-9.1
	Dependent Young	0.40	37.8	-28.5	-3.1
	Non-Breeding	0.38	38.8	-28.5	-5.1
78215	Pupping & Whelping	0.36	62.8	-30.5	-6.1
	Mating	0.51	42.8	-16.5	-5.1
78256	Total	0.65	-8.2	20.5	-20.1
	Pupping & Whelping	0.63	-9.2	8.5	-23.1
	Dependent Young	0.35	-8.1	21.5	-18.1
	Mating	0.63	-8.1	16.5	-21.1
	Non-Breeding	0.63	-8.2	21.5	-20.1
78259	Total	0.56	-9.2	34.5	-23.1
	Pupping & Whelping	0.54	-9.2	32.5	-23.1
	Dependent Young	0.56	-9.2	35.5	-23.1
78421	Pupping & Whelping	0.50	-5.2	-21.5	48.9
	Dependent Young	0.60	-7.2	-9.5	36.9
	Mating	0.62	-8.2	-11.5	34.9
	Non-Breeding	0.68	-7.2	-5.5	29.9
78422	Total	0.81	5.8	-1.5	9.9
	Dependent Young	0.76	8.8	-5.5	13.9
	Non-Breeding	0.67	-6.2	11.5	21.9

78423	Pupping & Whelping	0.60	-9.2	16.5	-21.1
	Dependent Young	0.61	-8.2	18.5	-20.1
	Mating	0.61	-82.0	26.5	-24.2
	Non-Breeding	0.66	-8.2	18.5	-17.1

There was no significant difference in male 95% FK home range size based on the dominant vegetation class ("Shrubby open forest to woodland", "Dry coastal heath") within each home range (Mann-Whitney test: P = 0.7429; Fig. 8).

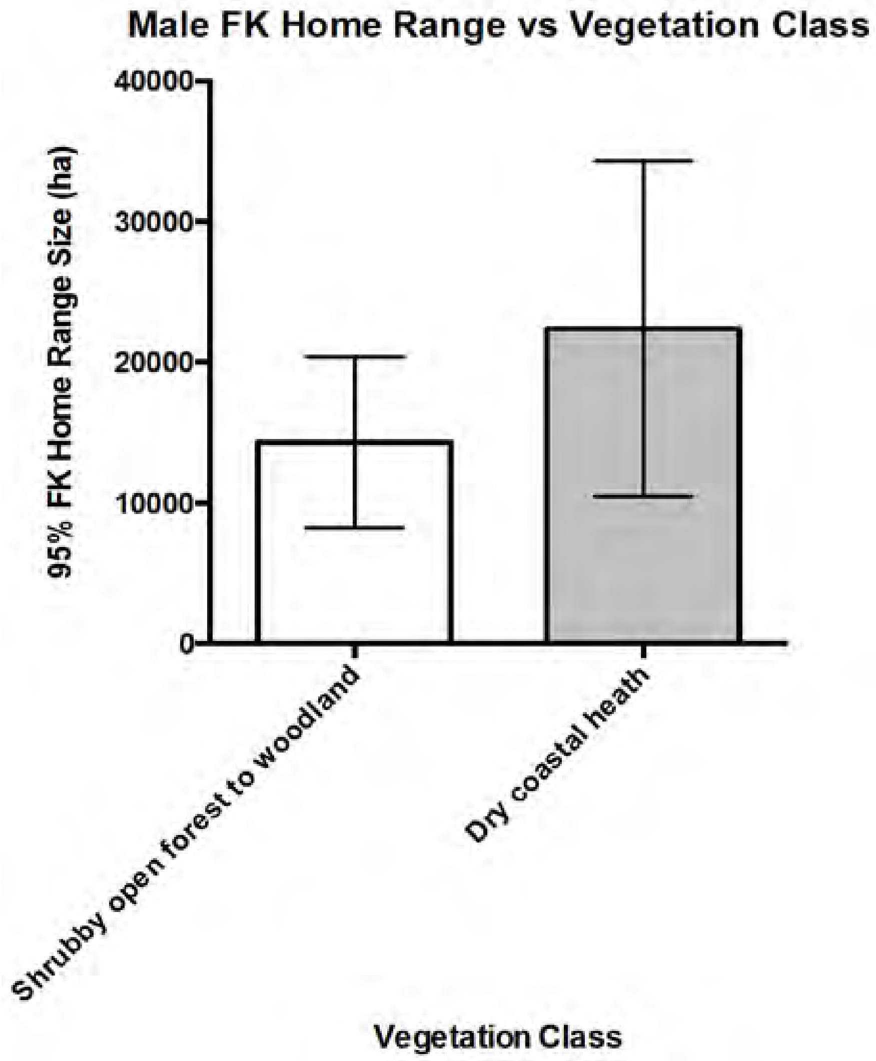

Figure 8. Mean male FK home range size categorised by the amount of open forest and woodland, or coastal heath in the home range.

Females in general had more riparian foredune or beach ridge habitat in their home range, but there was no significant difference in female 95% FK home range size based on the dominant vegetation class ("Riparian foredune/ beach ridge", "Dry coastal heath") within each home range (Mann-Whitney test: P = 0.4000; Fig. 9).

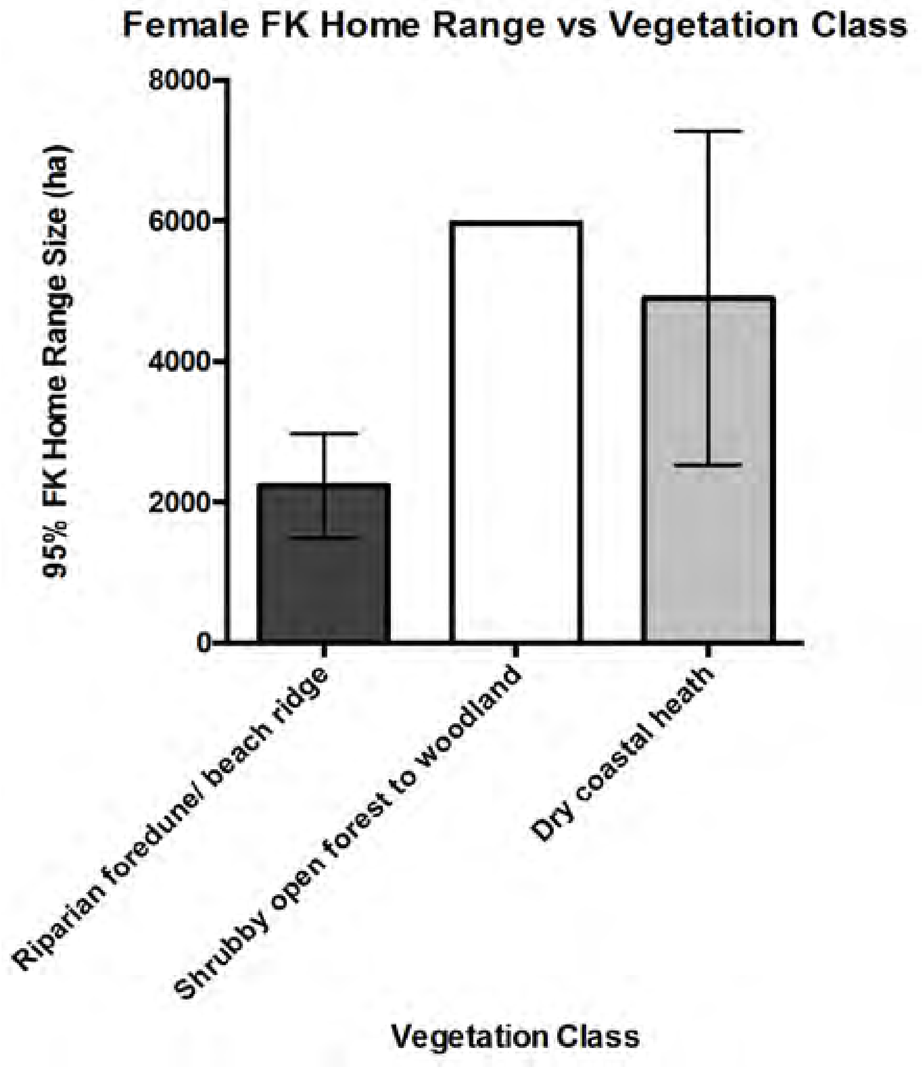

Figure 9. Mean female FK home range size categorised by the amount of riparian foredune or beach ridge woodland, open forest and woodland, or coastal heath in the home range.

For both male and female dingoes there was no significant difference between day or night distances travelled based on dominant vegetation classes within home ranges (Kruskal-Wallis test: Males P = 0.1470, Females P = 0.4201).

Preference or Avoidance of Vegetation Type

Overall, there was a trend for younger, non-pack animals to be less selective of habitat (as defined by vegetation type) than pack animals (Table 6). Although older animals were more likely to be a pack member than younger ones, there was no strong trend in habitat selectivity with age (Table 7).

Table 6. Ascending Indices of Similarity.

Animal ID	Age	Age/Sex Class	Social Status	Bray Curtiss Similarity (Total)
77153	5	A/F	Pack	0.27
78213	2	S/F	Pack	0.39
78031	1	S/F	Pack	0.44
78215	5	A/F	Pack	0.44
78032	2	S/F	Pack	0.53
78187	4	A/F	Pack	0.54
78030	4	A/M	Non-pack	0.55
78259	5	A/F	Pack(?)	0.56
78421	6	A/M	Pack	0.61
78256	2	S/M	Pack(?)	0.65
78423	3	A/F	Pack(?)	0.65
78203	2	S/F	Unknown	0.65
77193	4	A/M	Pack	0.66
76987	1	S/M	Non-pack	0.67

Animal ID	Age	Age/Sex Class	Social Status	Bray Curtiss Similarity (Total)
77165	1	S/M	Non-pack	0.68
76861	3	A/F	Pack	0.71
78422	2	S/M	Non-pack	0.81
77168	1	S/M	Non-pack	0.83

Although older animals were more likely to be a pack member than younger ones, there was no strong trend in habitat selectivity with age (Table 7).

Table 7. Bray-Curtis Similarity Indices Sorted by Ascending Age.

Animal ID	Age	Age/Sex Class	Social Status	Bray Curtiss Similarity (Total)
78031	1	S/F	Pack	0.44
76987	1	S/M	Non-pack	0.67
77165	1	S/M	Non-pack	0.68
77168	1	S/M	Non-pack	0.83
78213	2	S/F	Pack	0.39
78032	2	S/F	Pack	0.53
78256	2	S/M	Pack(?)	0.65
78203	2	S/F	Unknown	0.65
78422	2	S/M	Non-pack	0.81
78423	3	A/F	Pack(?)	0.65
76861	3	A/F	Pack	0.71
78187	4	A/F	Pack	0.54
78030	4	A/M	Non-pack	0.55
77193	4	A/M	Pack	0.66
77153	5	A/F	Pack	0.27
78215	5	A/F	Pack	0.44

Animal ID	Age	Age/Sex Class	Social Status	Bray Curtiss Similarity (Total)
78259	5	A/F	Pack(?)	0.56
78421	6	A/M	Pack	0.61

Females tended to be more selective of vegetation type than males (Table 8), and there was no strong trend in selectivity with age. However, older males were less selective than younger males (Table 8).

Table 8. Bray-Curtis Similarity Indices Sorted by Sex.

Animal ID	Age	Sex	Social Status	Bray Curtiss Similarity (Total)
77153	5	F	Pack	0.27
78213	2	F	Pack	0.39
78031	1	F	Pack	0.44
78215	5	F	Pack	0.44
78032	2	F	Pack	0.53
78187	4	F	Pack	0.54
78259	5	F	Pack(?)	0.56
78423	3	F	Pack(?)	0.65
78203	2	F	Unknown	0.65
76861	3	F	Pack	0.71
78030	4	M	Non-pack	0.55
78421	6	M	Pack	0.61
78256	2	M	Pack(?)	0.65
77193	4	M	Pack	0.66
76987	1	M	Non-pack	0.67
77165	1	M	Non-pack	0.68

Animal ID	Age	Sex	Social Status	Bray Curtiss Similarity (Total)
78422	2	M	Non-pack	0.81
77168	1	M	Non-pack	0.83

In the mating season there were 9 animal with sufficient data to reach asymptote during home range calculations. Of those the adult females were the most selective of vegetation type and the sub-adult males were the least selective (Table 9).

Table 9. Ascending Bray-Curtis Similarity Indices During the Mating Season.

Animal ID	Age	Age/Sex Class	Observed Social Status	Bray-Curtis (Mating)
77153	5	A/F	Pack	0.36
78215	5	A/F	Pack	0.51
78187	4	A/F	Pack	0.54
78203	2	S/F	Unknown	0.61
78423	3	A/F	Pack(?)	0.61
78032	2	S/F	Pack	0.62
78421	6	A/M	Pack	0.62
76987	1	S/M	Non-Pack	0.63
78256	2	S/M	Pack(?)	0.63
77165	1	S/M	Non-Pack	0.72

During the pupping & whelping season there was clear evidence that pack animals of both sexes, and irrespective of age, tended to be more selective in their use of different vegetation types than non-pack animals (Table 10). During this season some pack animals were relatively unselective in their use of vegetation type, but they were all male (Table 10).

Table 10. Ascending Bray-Curtis Similarity Indices During the Pupping & Whelping Season. No Bray-Curtis value provided where the home range data did not reach asymptote.

Animal ID	Age	Age/Sex Class	Observed Social Status	Bray-Curtis P&W
78187	4	A/F	Pack	0.13
77153	5	A/F	Pack	0.29
78031	1	S/F	Pack	0.29
78213	2	S/F	Pack	0.34
78215	5	A/F	Pack	0.36
78032	2	S/F	Pack	0.46
78203	2	S/F	Unknown	0.53
78259	5	A/F	Pack(?)	0.54
78030	4	A/M	Non-Pack	0.56
78423	3	A/F	Pack(?)	0.60
78256	2	S/M	Pack(?)	0.63
76987	1	S/M	Non-Pack	0.68
77165	1	S/M	Non-Pack	0.68
76861	3	A/F	Pack	0.73
77168	1	S/M	Non-Pack	
77193	4	A/M	Pack	
78421	6	A/M	Pack	
78422	2	S/M	Non-Pack	

From September to November, when dependent young are present on the Island, the adult females known to be part of a pack were much more selective of the available vegetation types than at any other time of the year. Other classes of animals were much less selective (Table 11).

Table 11. Ascending Bray-Curtis Similarity Indices During the Dependent Young Season. No Bray-Curtis value provided where the home range data did not reach asymptote.

Animal ID	Age	Age/Sex Class	Observed Social Status	Bray-Curtis DY
78187	4	A/F	Pack	0.09
77153	5	A/F	Pack	0.18
78256	2	S/M	Pack(?)	0.35
78213	2	S/F	Pack	0.4
78203	2	S/F	Unknown	0.46
76861	3	A/F	Pack	0.52
78030	4	A/M	Non-Pack	0.53
78031	1	S/F	Pack	0.55
78259	5	A/F	Pack(?)	0.56
78421	6	A/M	Pack	0.6
78423	3	A/F	Pack(?)	0.61
77168	1	S/M	Non-Pack	0.67
76987	1	S/M	Non-Pack	0.69
78422	2	S/M	Non-Pack	0.76
77165	1	S/M	Non-Pack	
77193	4	A/M	Pack	
78032	2	S/F	Pack	
78215	5	A/F	Pack	

During the non-breeding season (December to February) there is more limited data than at other times of the year. But the data does show that the pattern of habitat use in this season flipped to mirror the pattern during breeding times. The young animals of both sexes were much more selective in their habitat use than the adults (Table 12).

Table 12. Ascending Bray-Curtis Similarity Indices During the Dependent Young Season. No Bray-Curtis value provided where the home range data did not reach asymptote.

Animal ID	Age	Age/Sex Class	Observed Social Status	Bray-Curtis NB
78213	2	S/F	Pack	0.38
78031	1	S/F	Pack	0.48
77168	1	S/M	Non-Pack	0.51
78032	2	S/F	Pack	0.57
78203	2	S/F	Unknown	0.58
78256	2	S/M	Pack(?)	0.63
78423	3	A/F	Pack(?)	0.66
78422	2	S/M	Non-Pack	0.67
78421	6	A/M	Pack	0.68
76861	3	A/F	Pack	
76987	1	S/M	Non-Pack	
77153	5	A/F	Pack	
77165	1	S/M	Non-Pack	
77193	4	A/M	Pack	
78030	4	A/M	Non-	

Animal ID	Age	Age/Sex Class	Observed Social Status	Bray-Curtis NB
			Pack	
78187	4	A/F	Pack	
78215	5	A/F	Pack	
78259	5	A/F	Pack(?)	

There was no significant difference in home range size between pack and no pack animals –between male and female combined (Mann-Whitney test P = 0.0539) or males (Mann-Whitney P = 0.571) pack/no-pack animals (Figure 10). No test could be performed for females because there were no females not in a pack with a home range that reached an asymptote.

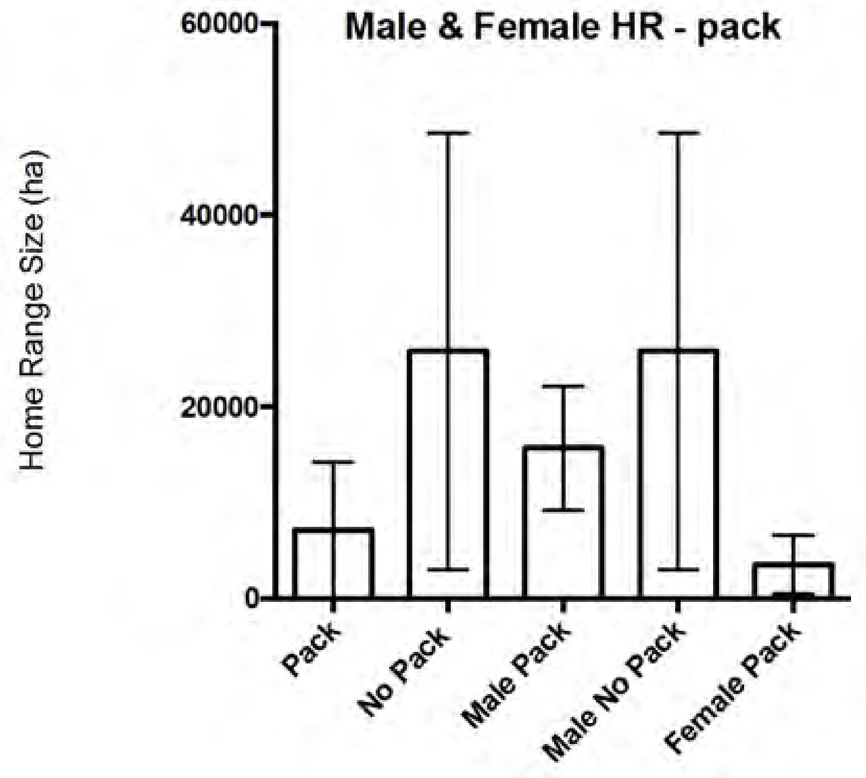

Figure10. Home Range Size of Pack and Non-Pack Animals.

Interaction Between Distance Travelled and Vegetation Class

For male dingoes there was no significant difference between day or night distances travelled based on dominant vegetation classes within home ranges (Kruskal-Wallis test: P = 0.1470, Figure 11).

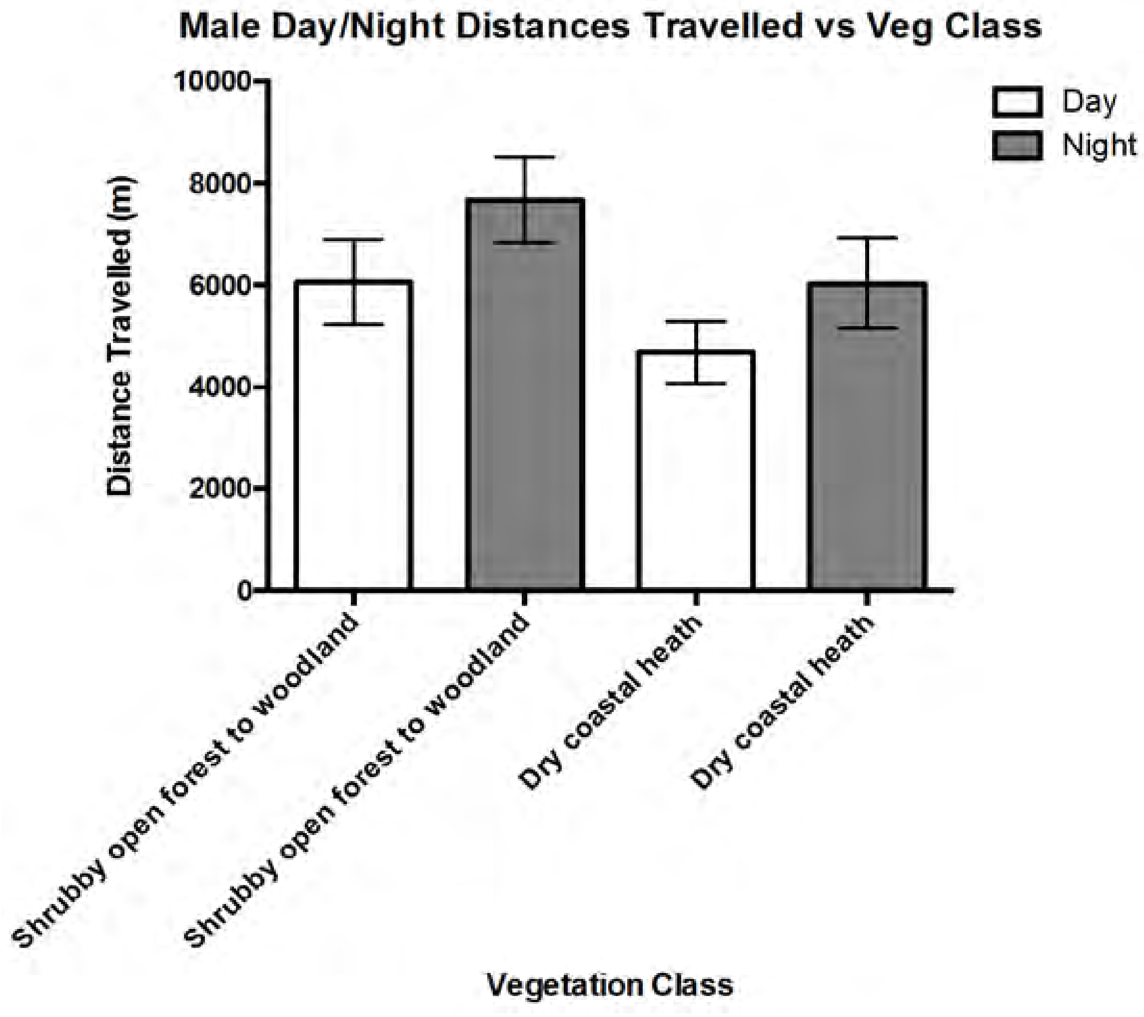

Figure 11. Male Day and Night Distances Travelled in the Major Vegetation Types Within Home Ranges.

Similarly for females there was no significant difference between day or night distances travelled based on dominant vegetation classes within home ranges (Kruskal-Wallis test: P = 0.4201, Figure 12).

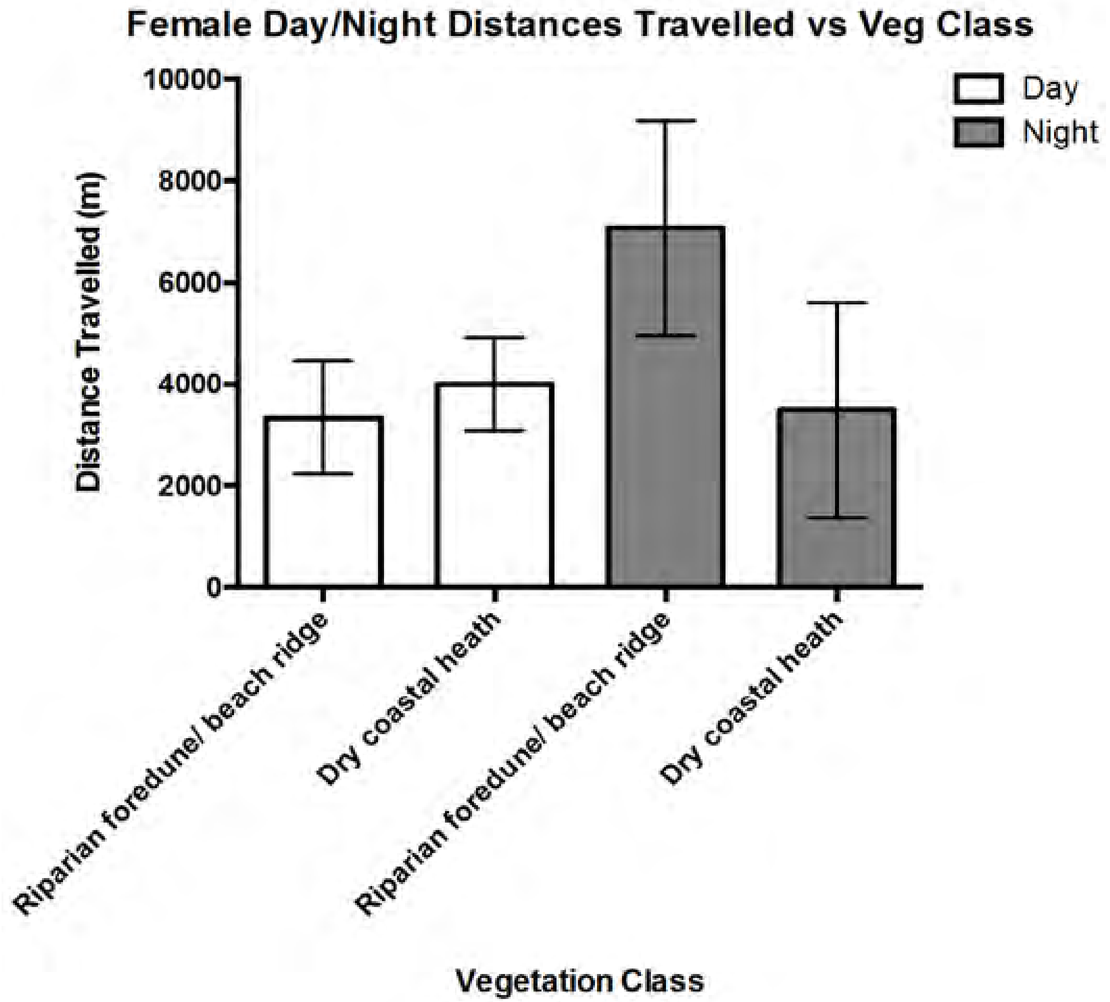

Figure 12. Female Day and Night Distances Travelled in the Major Vegetation Types Within Home Ranges.

Home Range Maps

In this section plots of the 95% MCP and 95% FK home range estimates are presented for each dingo. There are plots of total home range and, if there was sufficient data, a plot for each seasonal home range. On each map there are consecutively numbered location points which reflect the order in which the locations were fixed. Most of the consecutive locations will have been obtained 2 hours apart, but some will be separated by more than 2 hours because in some cases a location could not be fixed by the satellites every two hours for every dingo, due to a lack of satellites or dense vegetation obscuring the transmission. Please note that all the data received have been plotted in the following maps whether the home range estimator reached asymptote or not. Hence some of the home ranges plotted below do not appear in the above analyses.

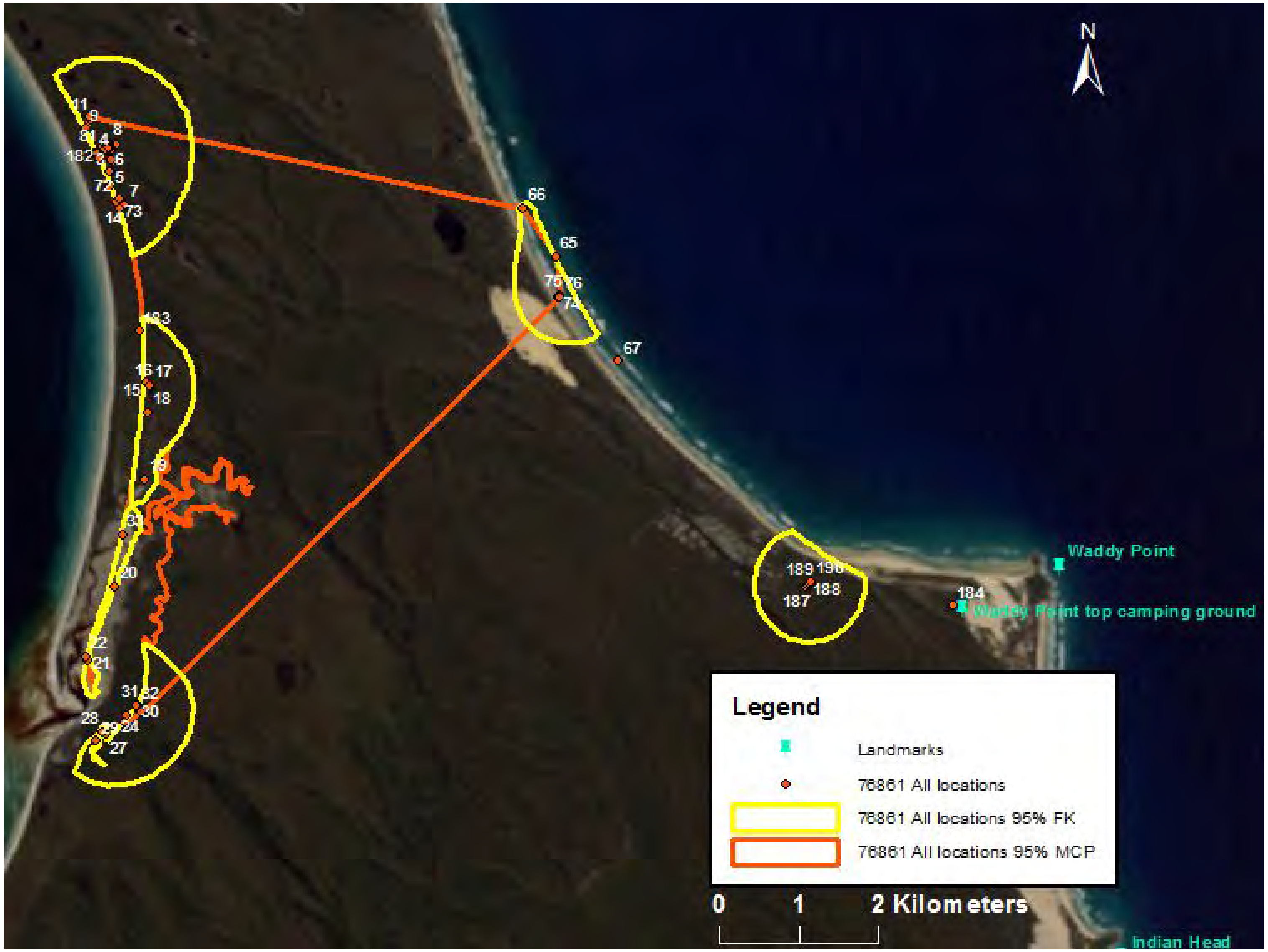

Figure 12A. Total home range 76861

Figure 12B. Pupping & Whelping home range 76861

Figure 12C. Dependent young home range 76861

Figure 13A. Total home range 76987

Figure 13B. Mating home range 76987

Figure 13C. Pupping & whelping home range 76987

Figure 13D. Dependent young home range 76987

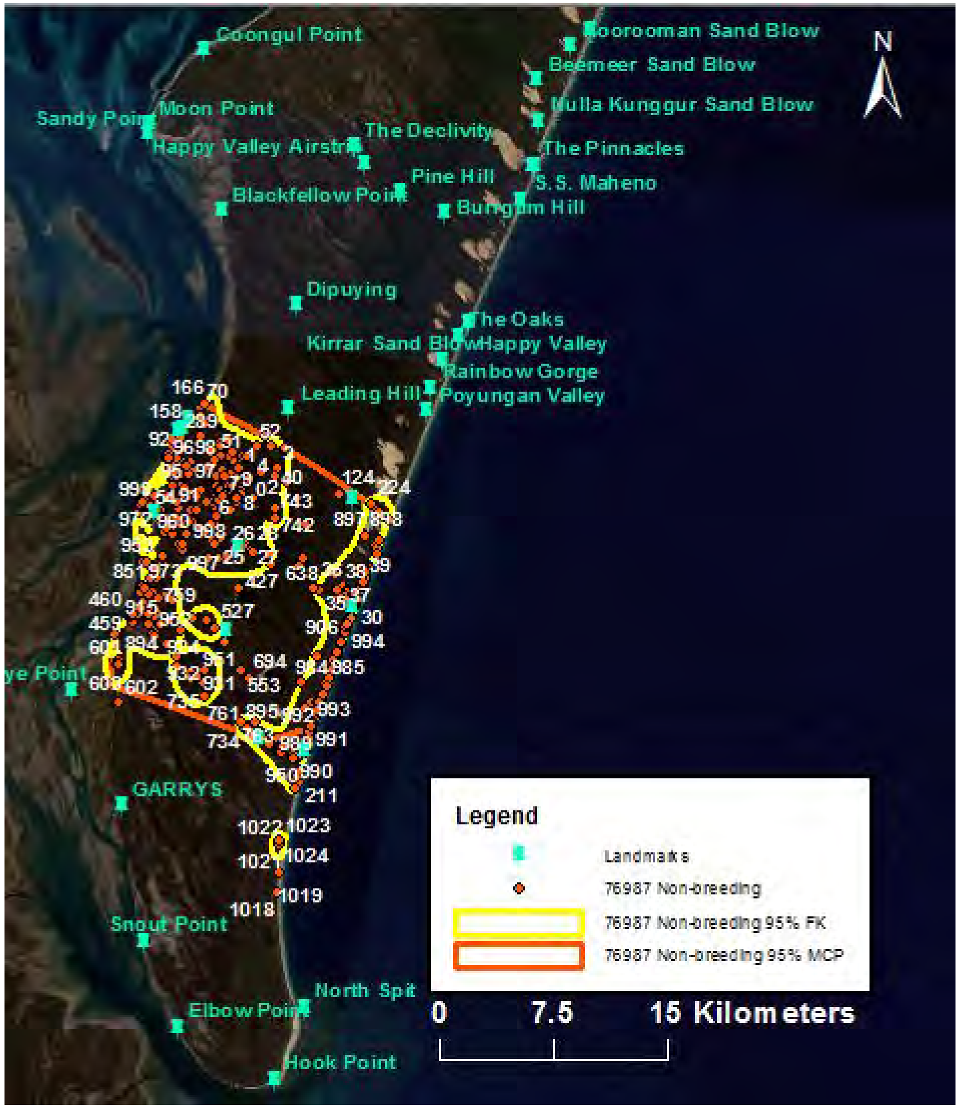

Figure 13E. Non-breeding season home range 76987

Figure 14A. Total home range 77153

Figure 14B. Mating home range 77153

Figure 14C. Pupping & whelping home range 77153

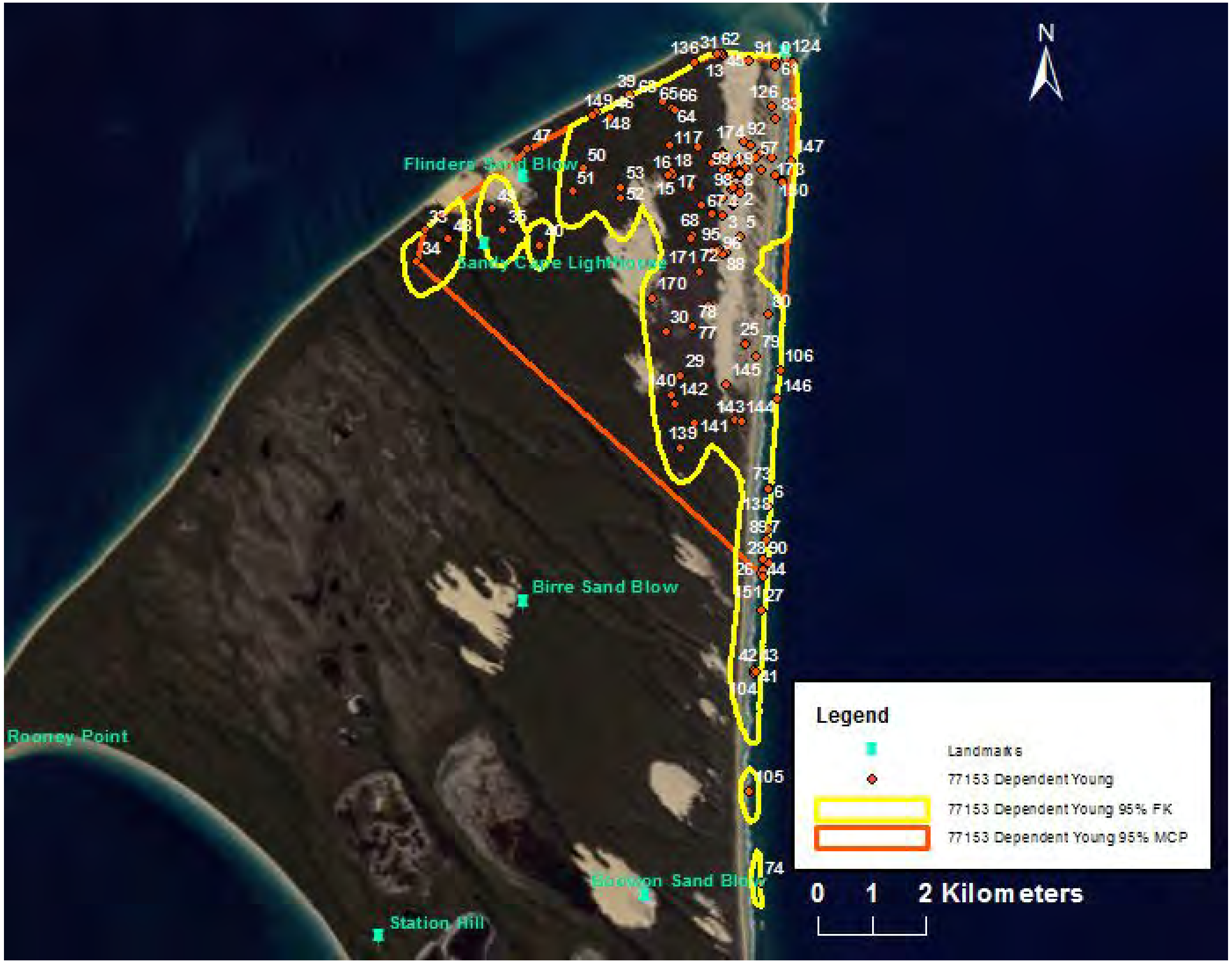

Figure 14D. Dependent young home range 77153

Figure 15A. Total home range 77165

Figure 15B. Mating home range 77165

Figure 15C. Pupping & whelping home range 77165

Figure 15D. Dependent young home range 77165

Figure 16A. Total home range 77168

Figure 16B. Mating home range 77168

Figure 16C. Pupping & whelping home range 77168

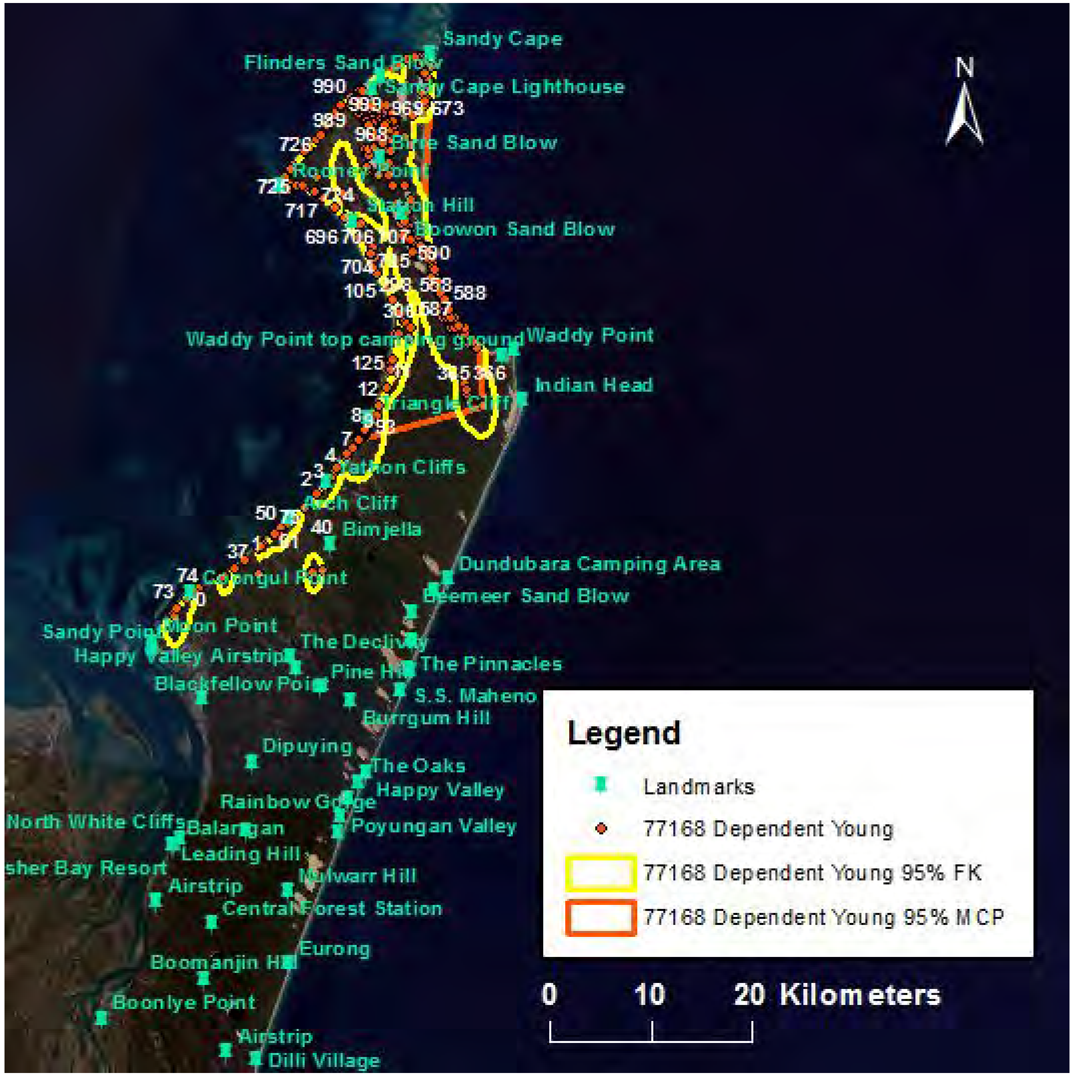

Figure 16D. Dependent young home range 77168

Figure 16E. Non-breeding season home range 77168

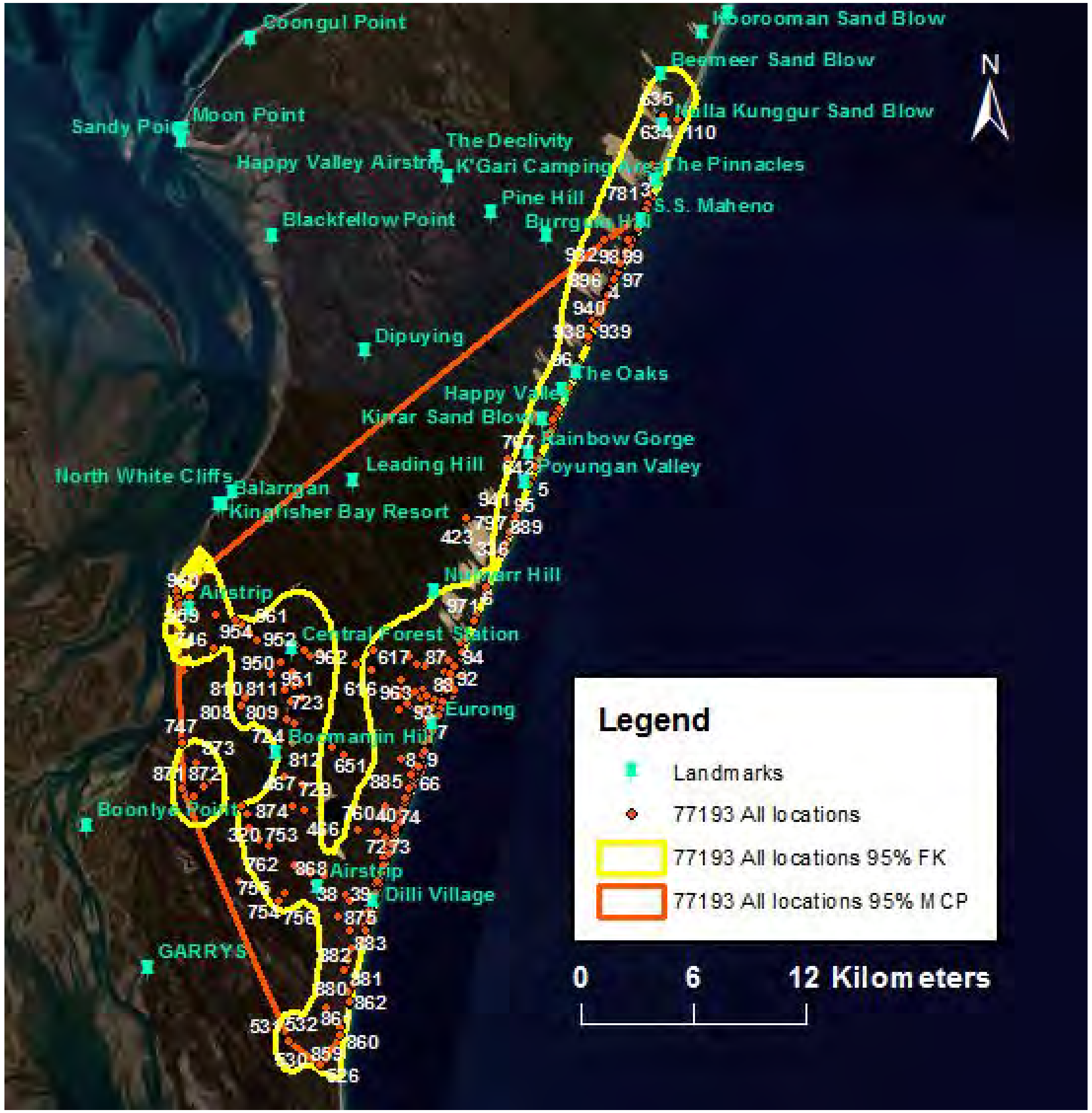

Figure 17A. Total home range 77193

Figure 17B. Mating home range 77193

Figure 17C. Pupping & whelping home range 77193
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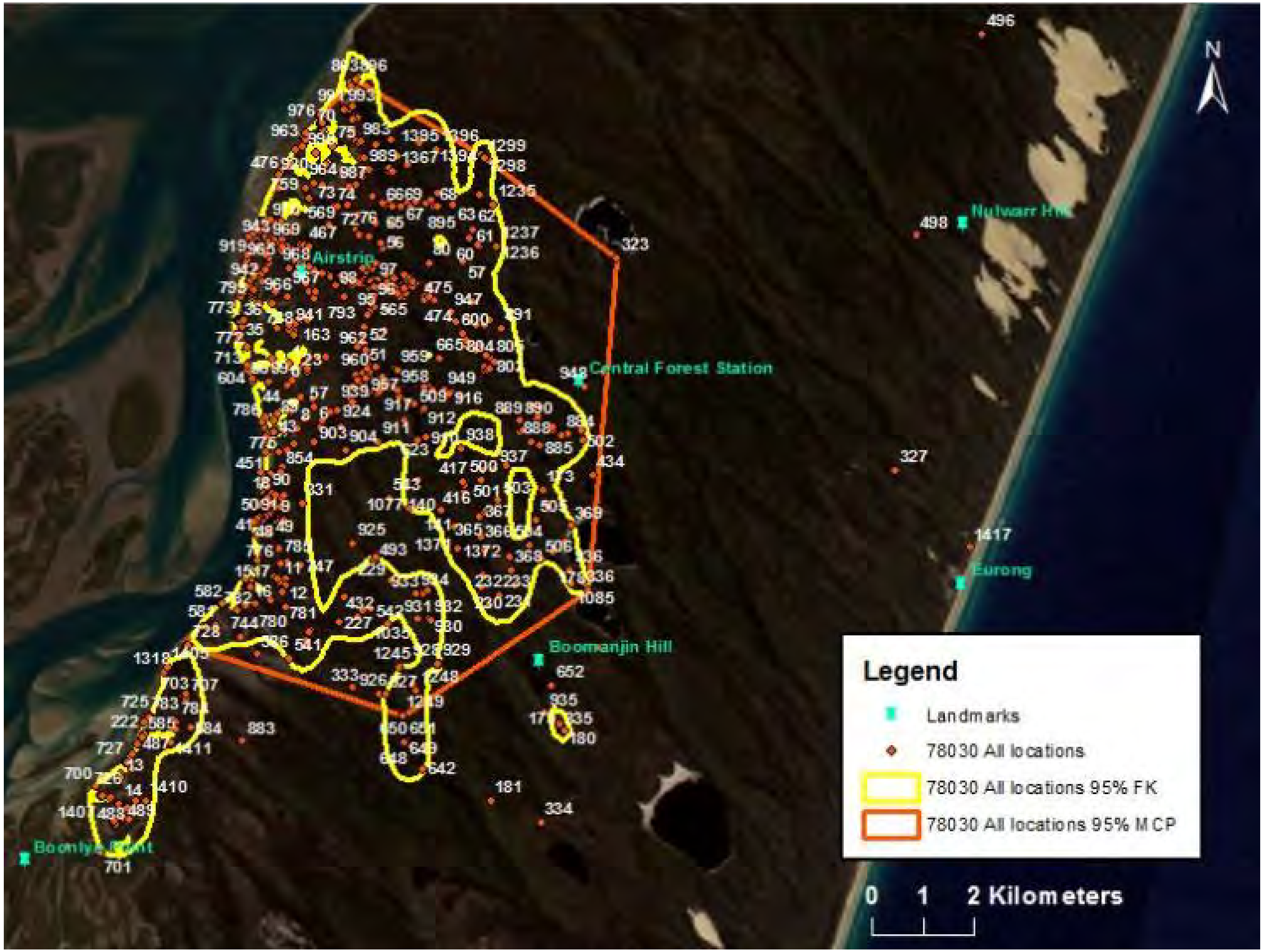

Figure 18A. Total home range 78030

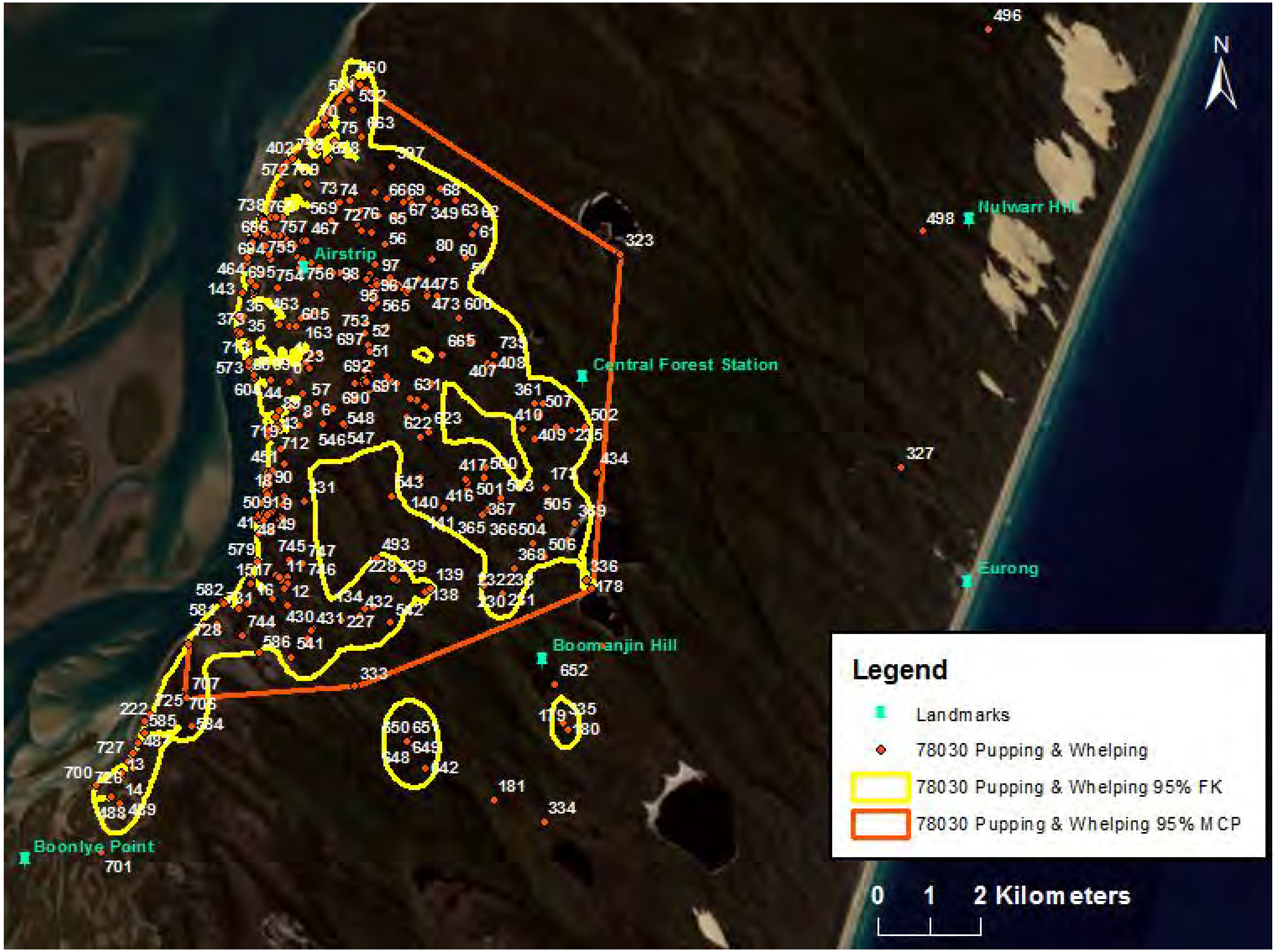

Figure 18B. Pupping & whelping home range 78030

Figure 18C. Dependent Young home range 78030

Figure 19A. Total home range 78031

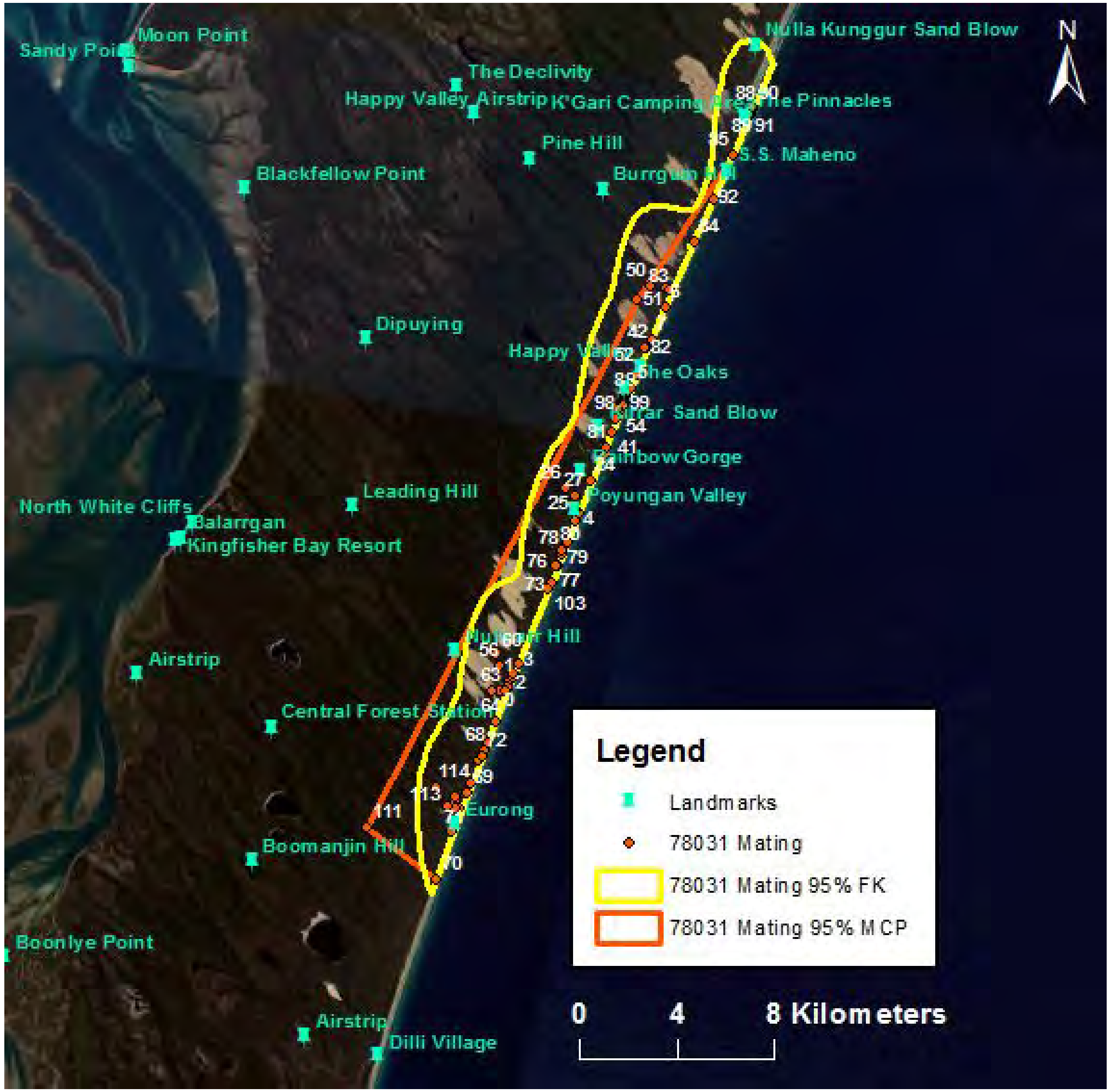

Figure 19B. Mating home range 78031

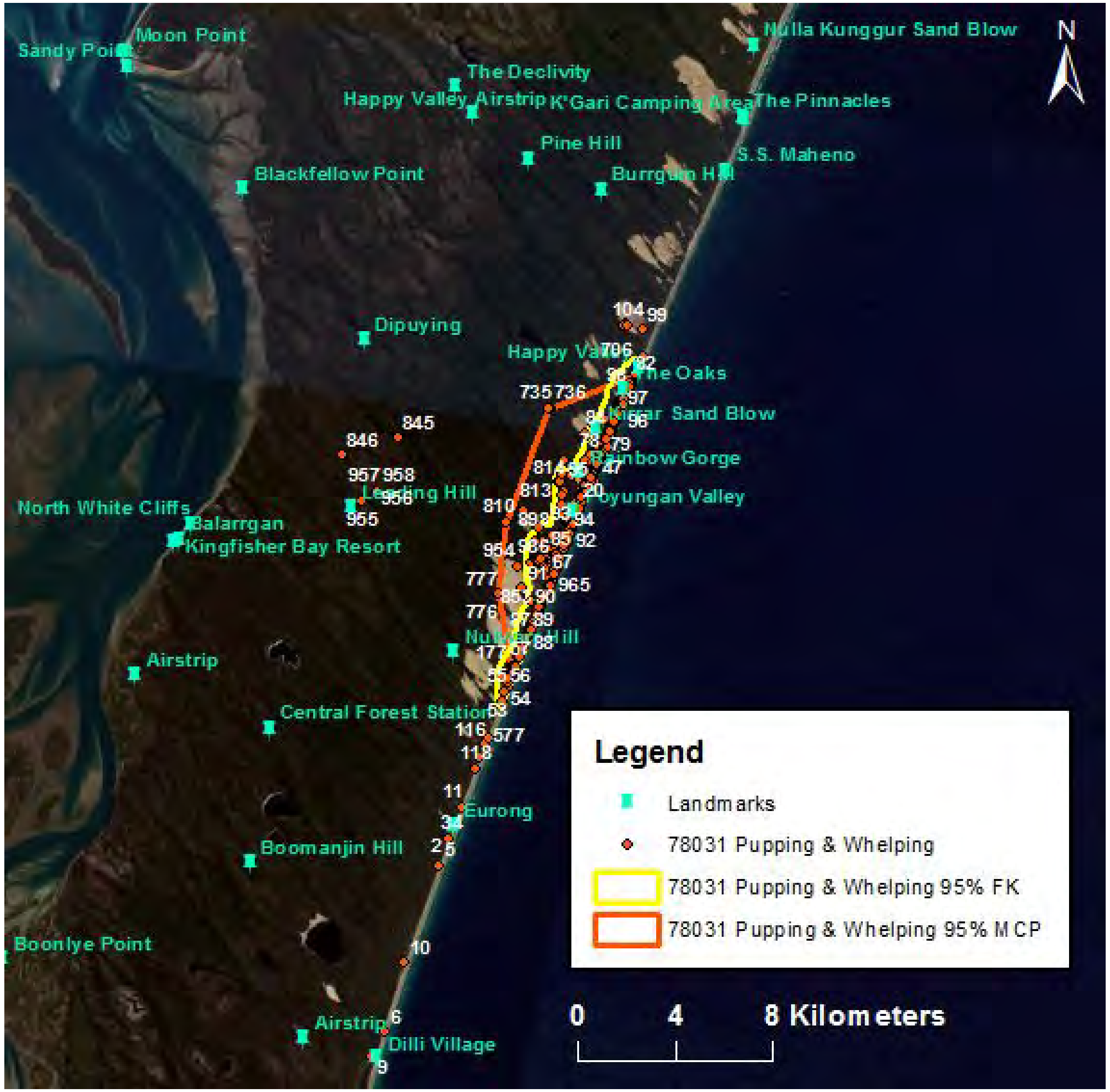

Figure 19C. Pupping & whelping home range 78031

Figure 19D. Dependent young home range 78031

Figure 19E. Non-breeding season home range 78031

Figure 20A. Total home range 78032

Figure 20B. Mating home range 78032

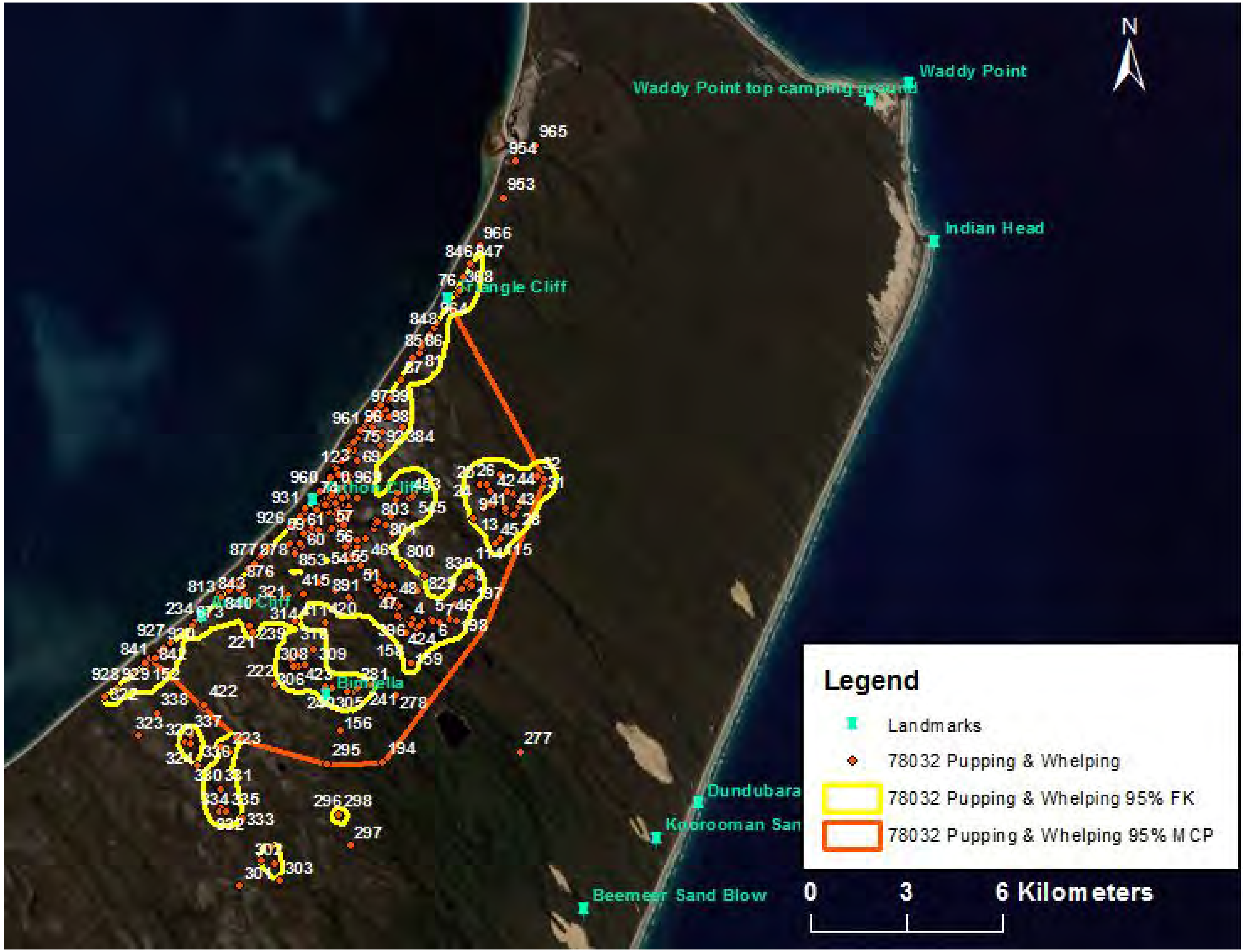

Figure 20C. Pupping & whelping home range 78032

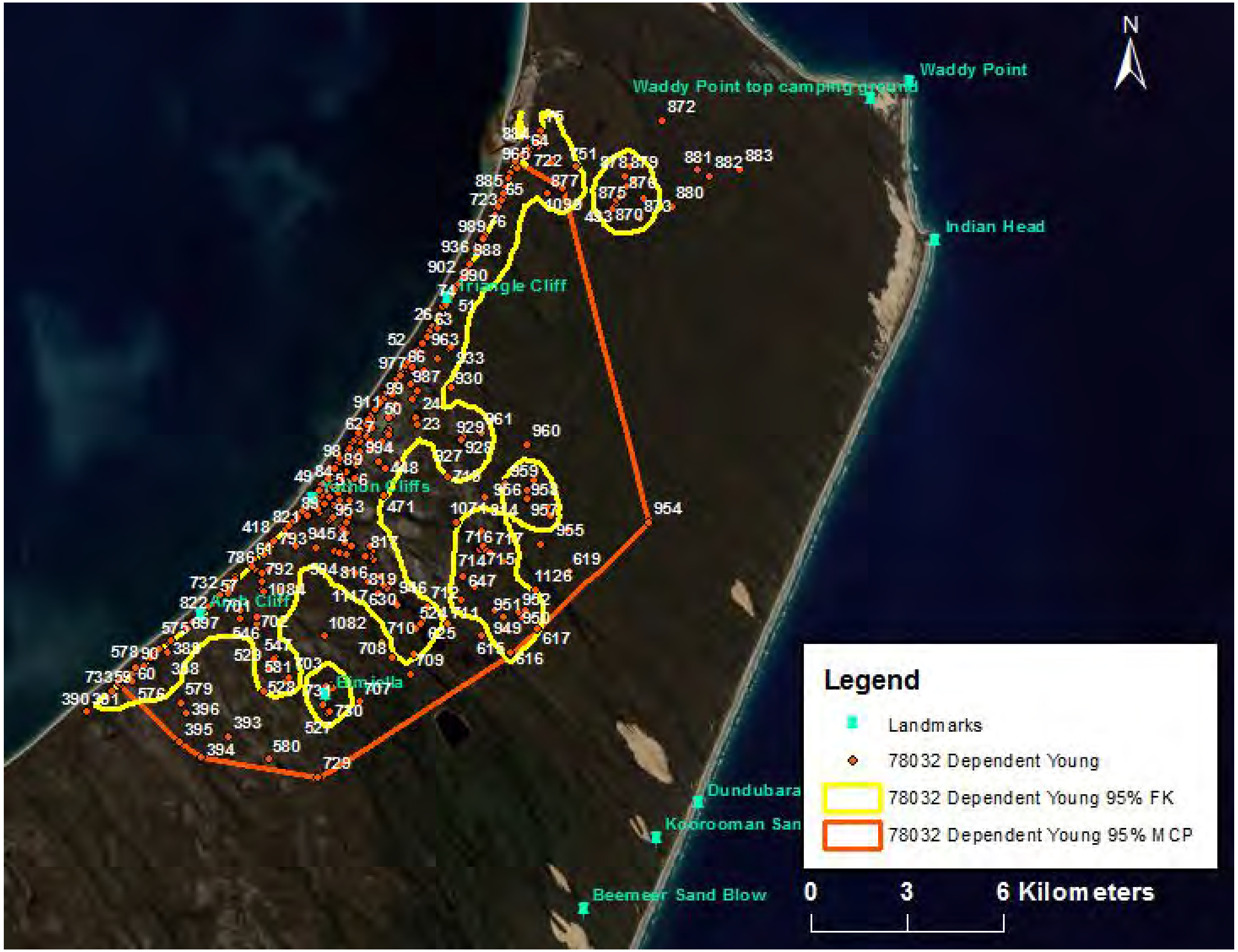

Figure 20D. Dependent young home range 78032

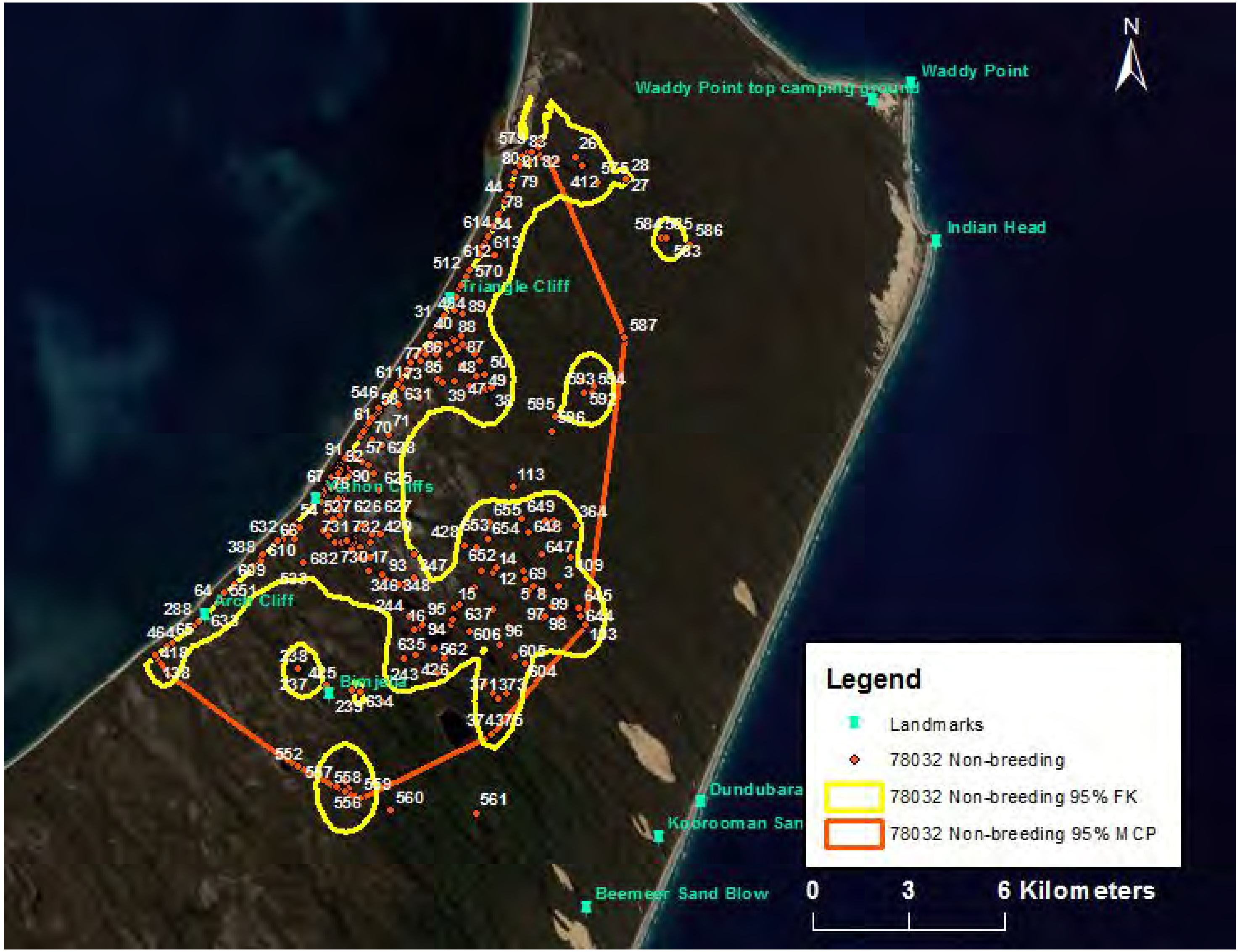

Figure 20E. Non-breeding season home range 78032

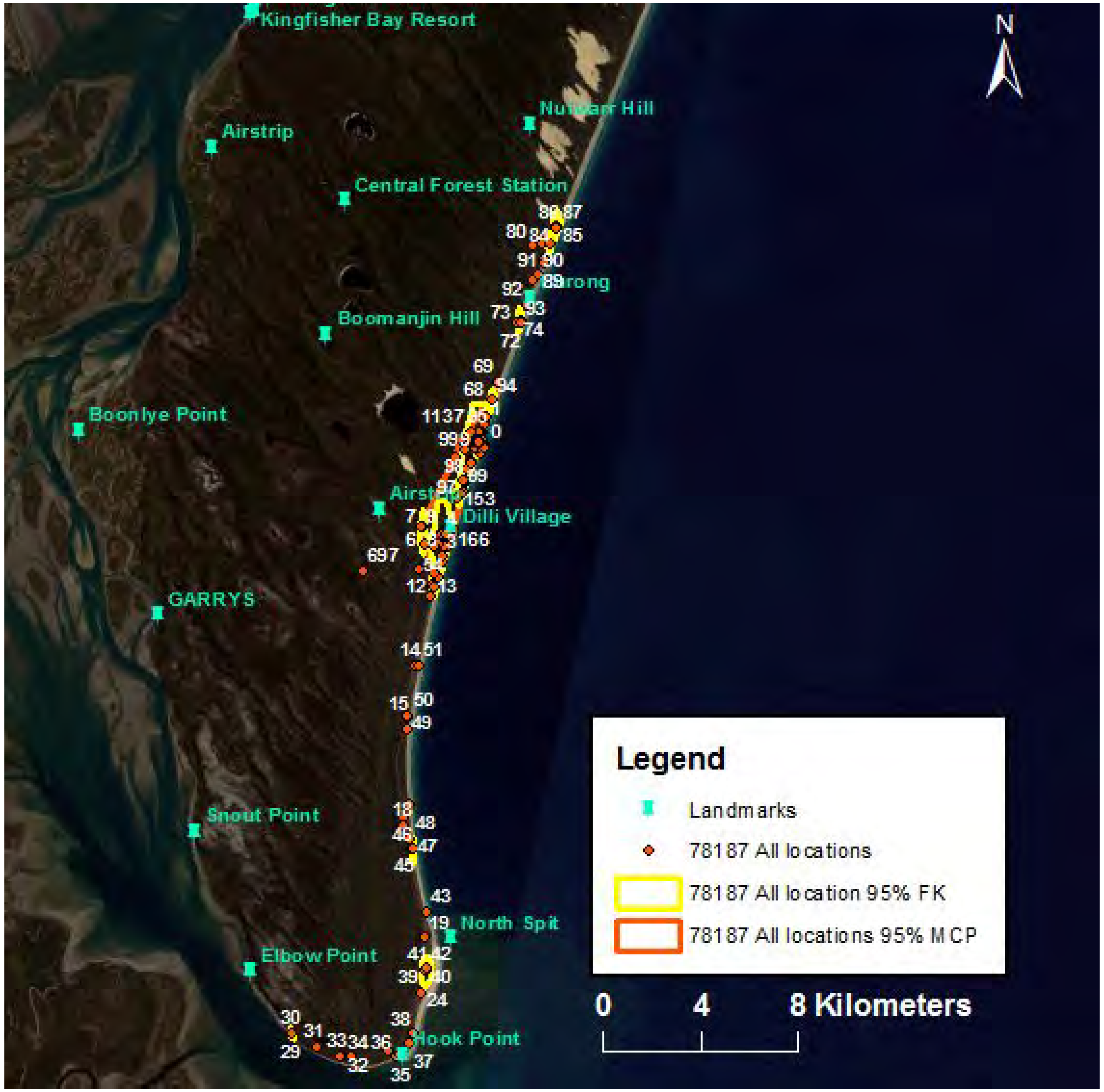

Figure 21A. Total home range 78187

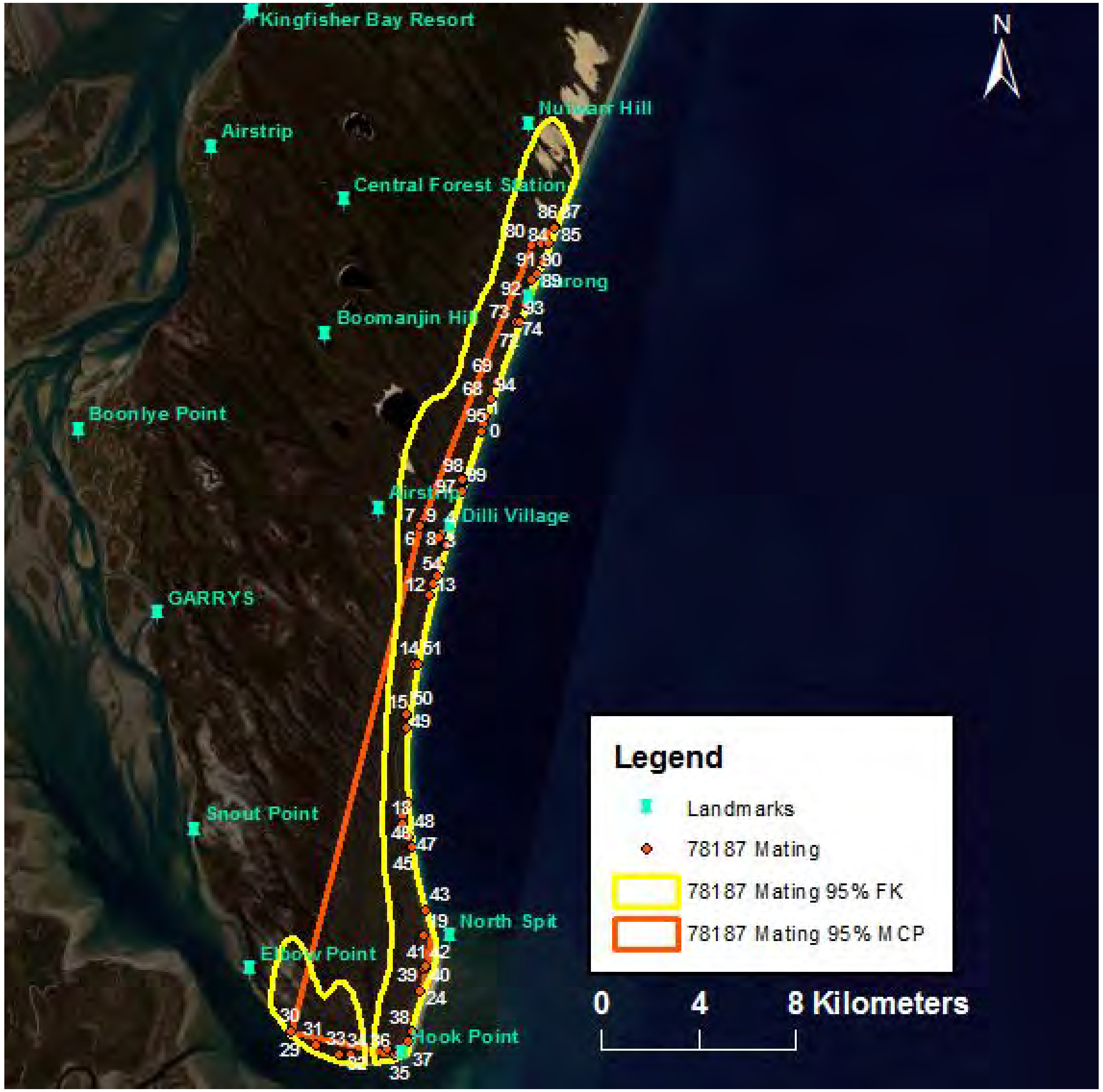

Figure 21B. Mating home range 78187

Figure 21C. Pupping & whelping home range 78187

Figure 21D. Dependent young home range 78187

Figure 22A. Total home range 78203

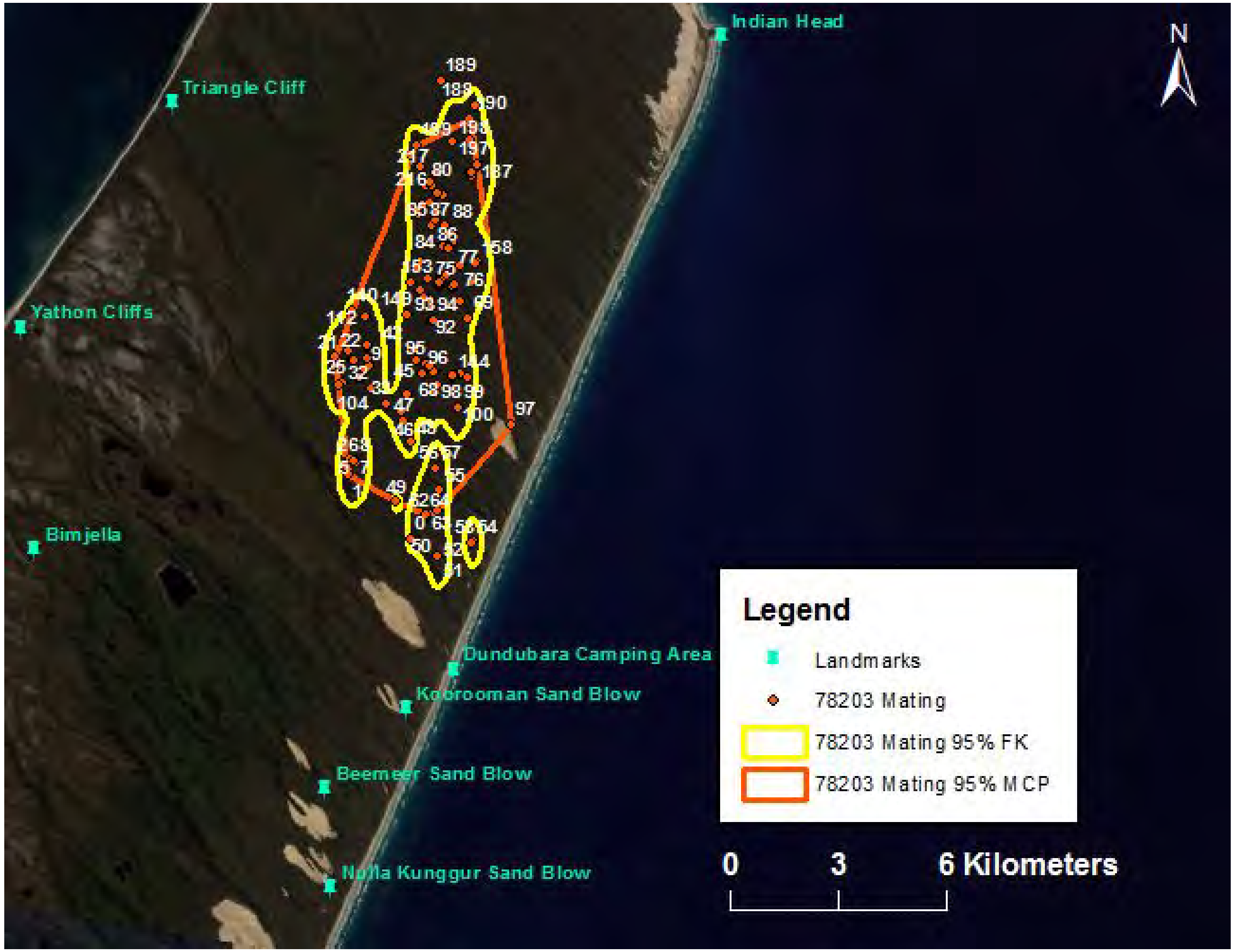

Figure 22B. Mating home range 78203

Figure 22C. Pupping & whelping home range 78203

Figure 22D. Dependent young home range 78203

Figure 22E. Non-breeding season home range 78203

Figure 23A. Total home range 78213

Figure 23B. Mating home range 78213

Figure 23C. Pupping & whelping home range 78213

Figure 23D. Dependent young home range 78213

Figure 23E. Non-breeding season home range 78213

Figure 24A. Total home range 78215

Figure 24B. Pupping & Whelping home range 78215

Figure 24C. Dependent young home range 78215

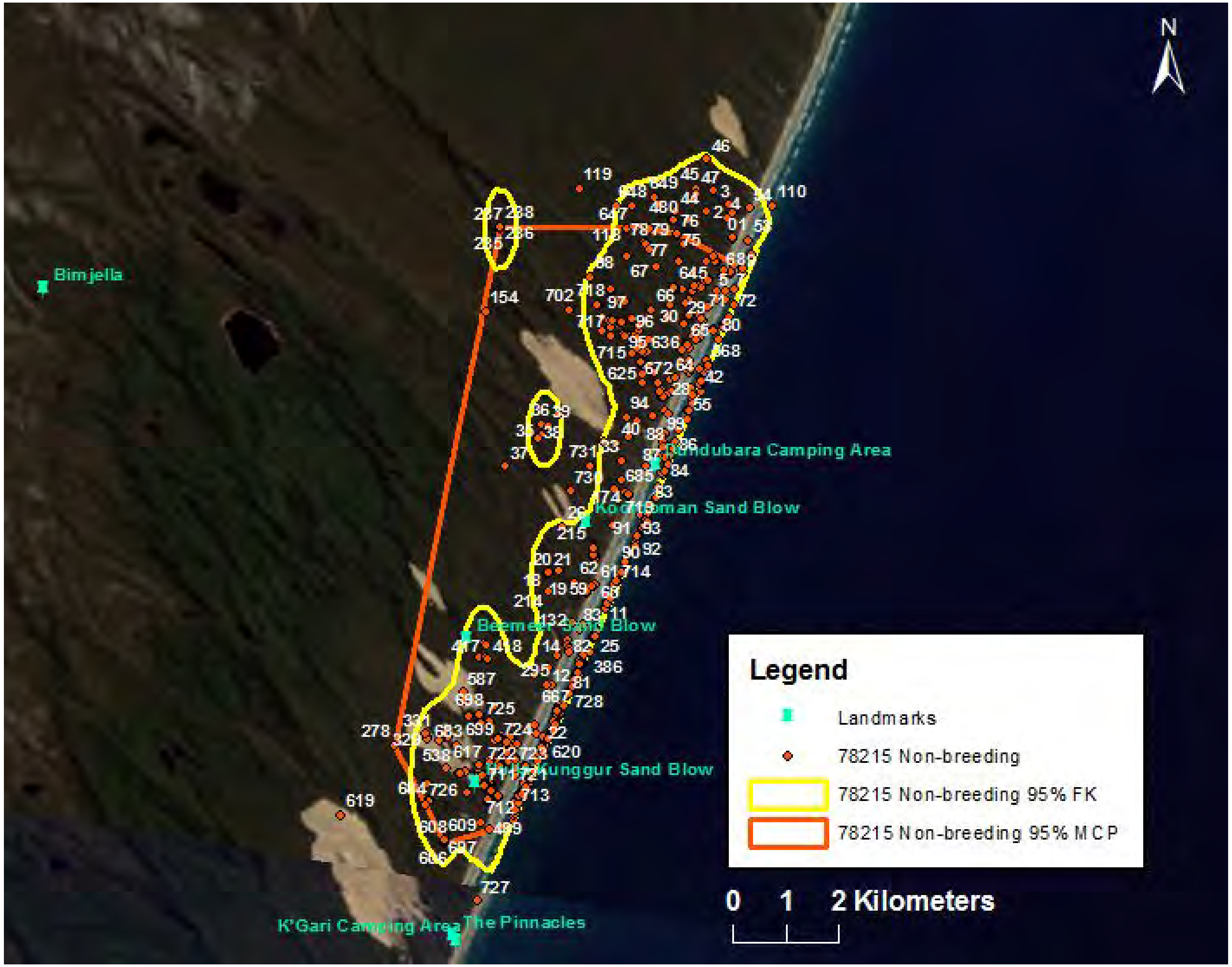

Figure 24D. Non-breeding season home range 78215

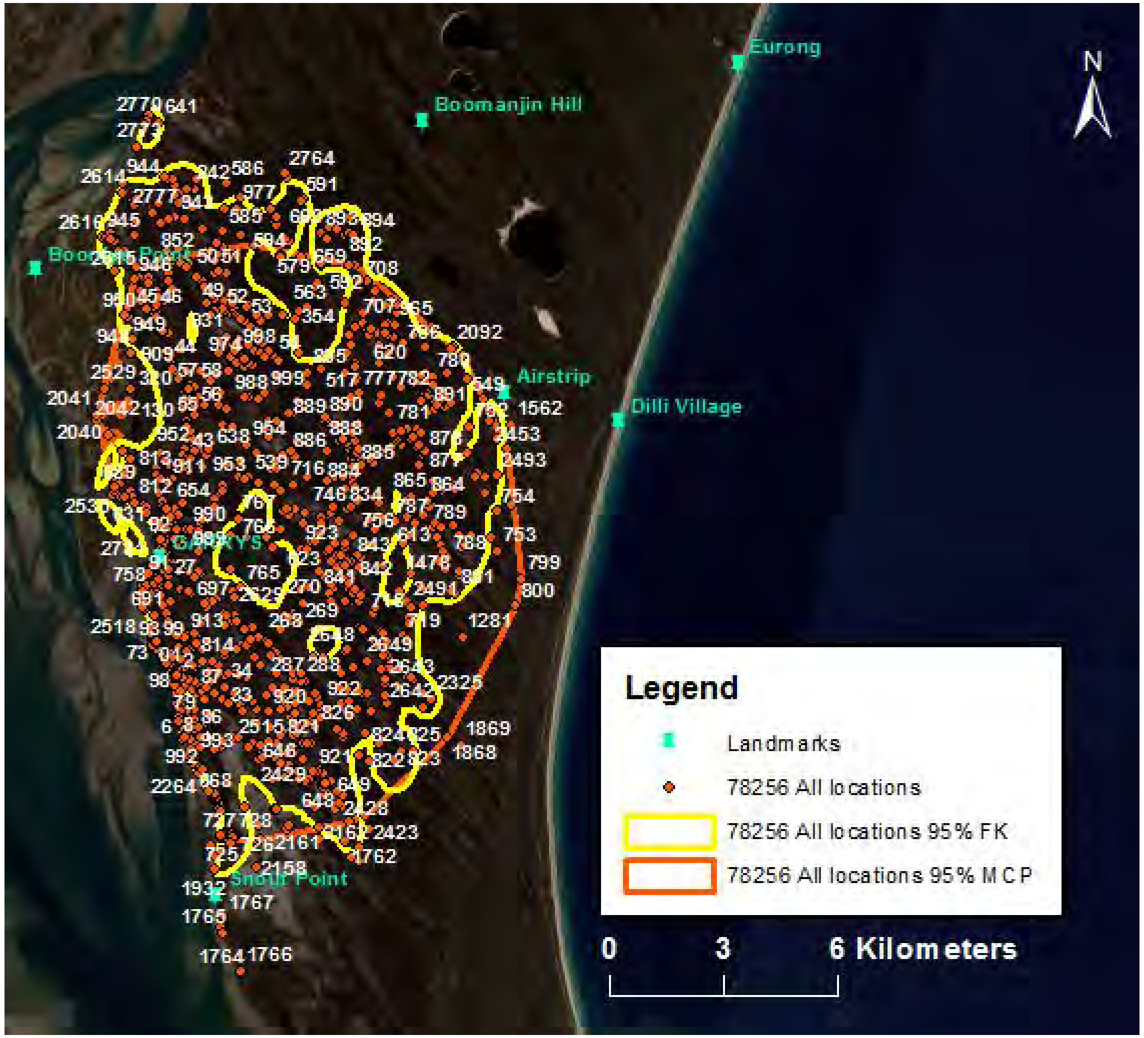

Figure 25A. Total home range 78256

Figure 25B. Mating home range 78256

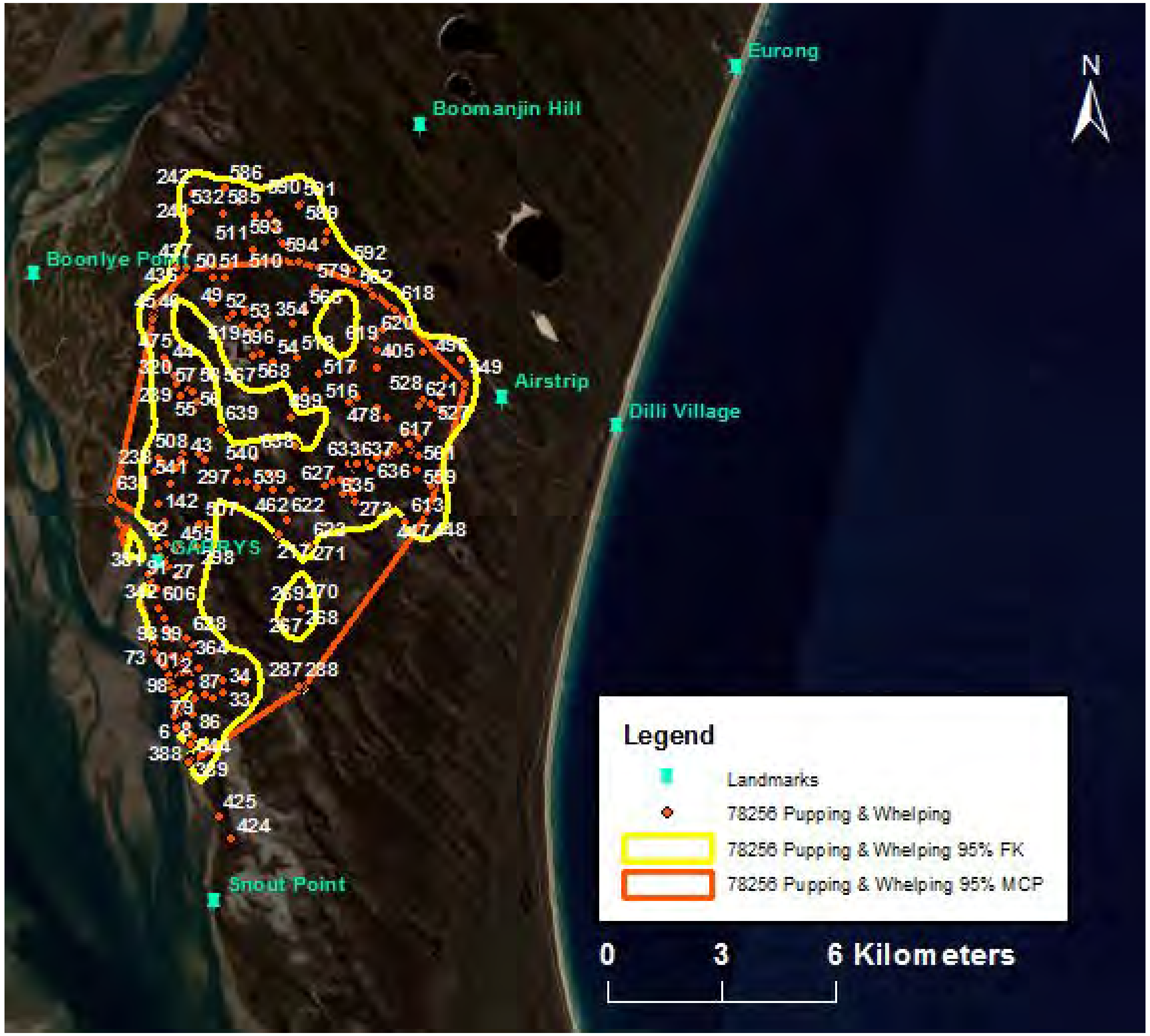

Figure 25C. Pupping & whelping home range 78256

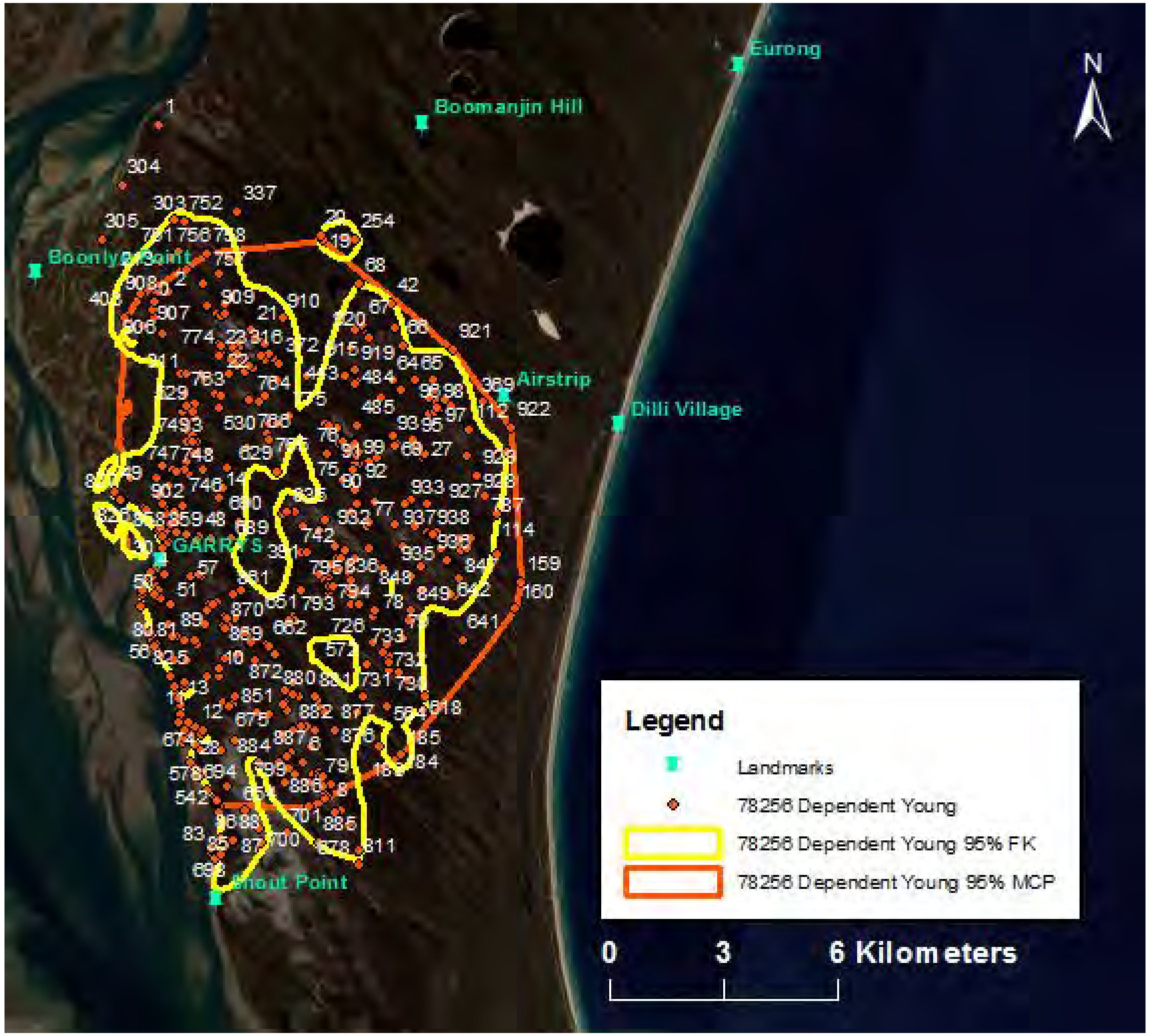

Figure 25D. Dependent young home range 78256

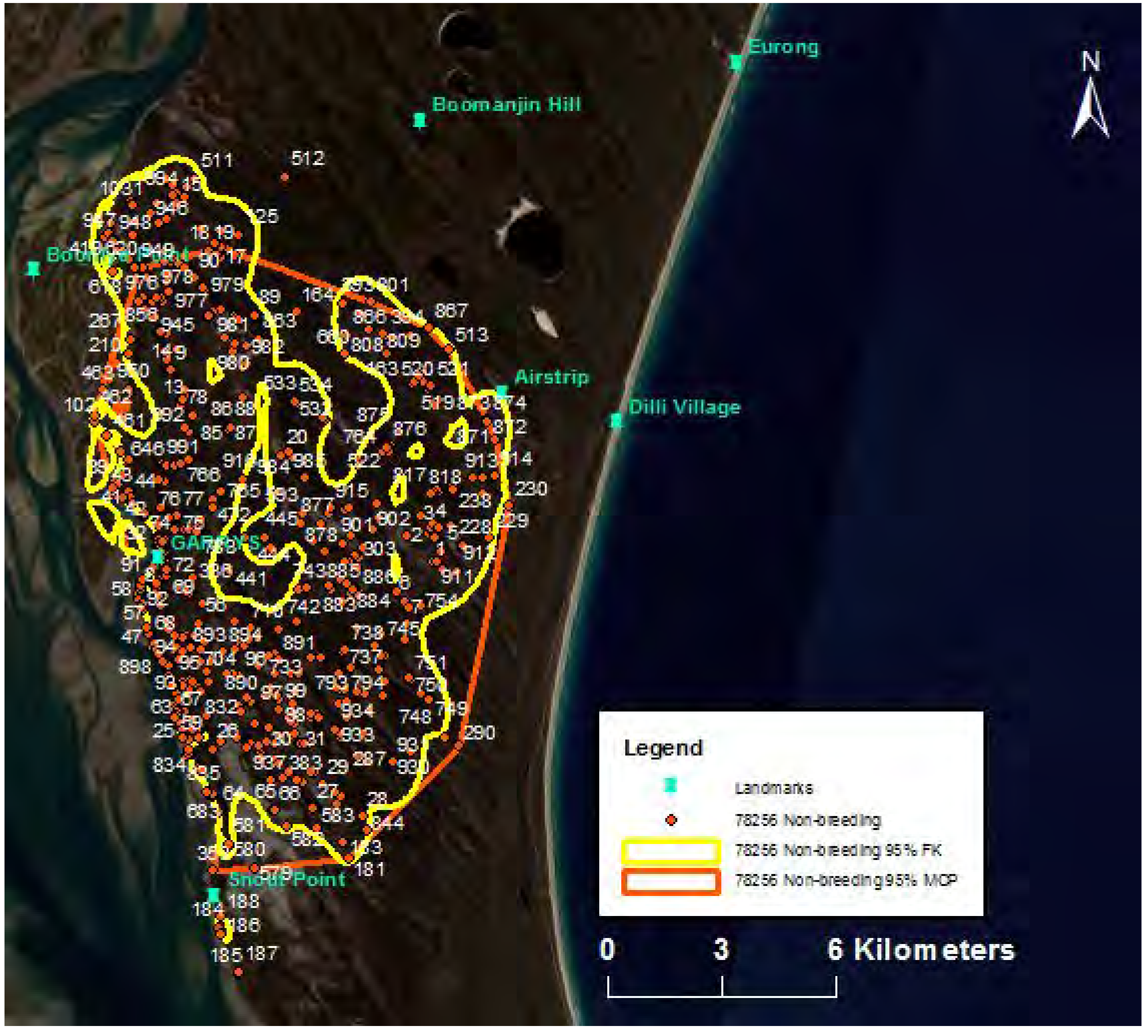

Figure 25E. Non-breeding season home range 78256

Figure 26A. Total home range 78259

Figure 26B. Pupping & whelping home range 78259

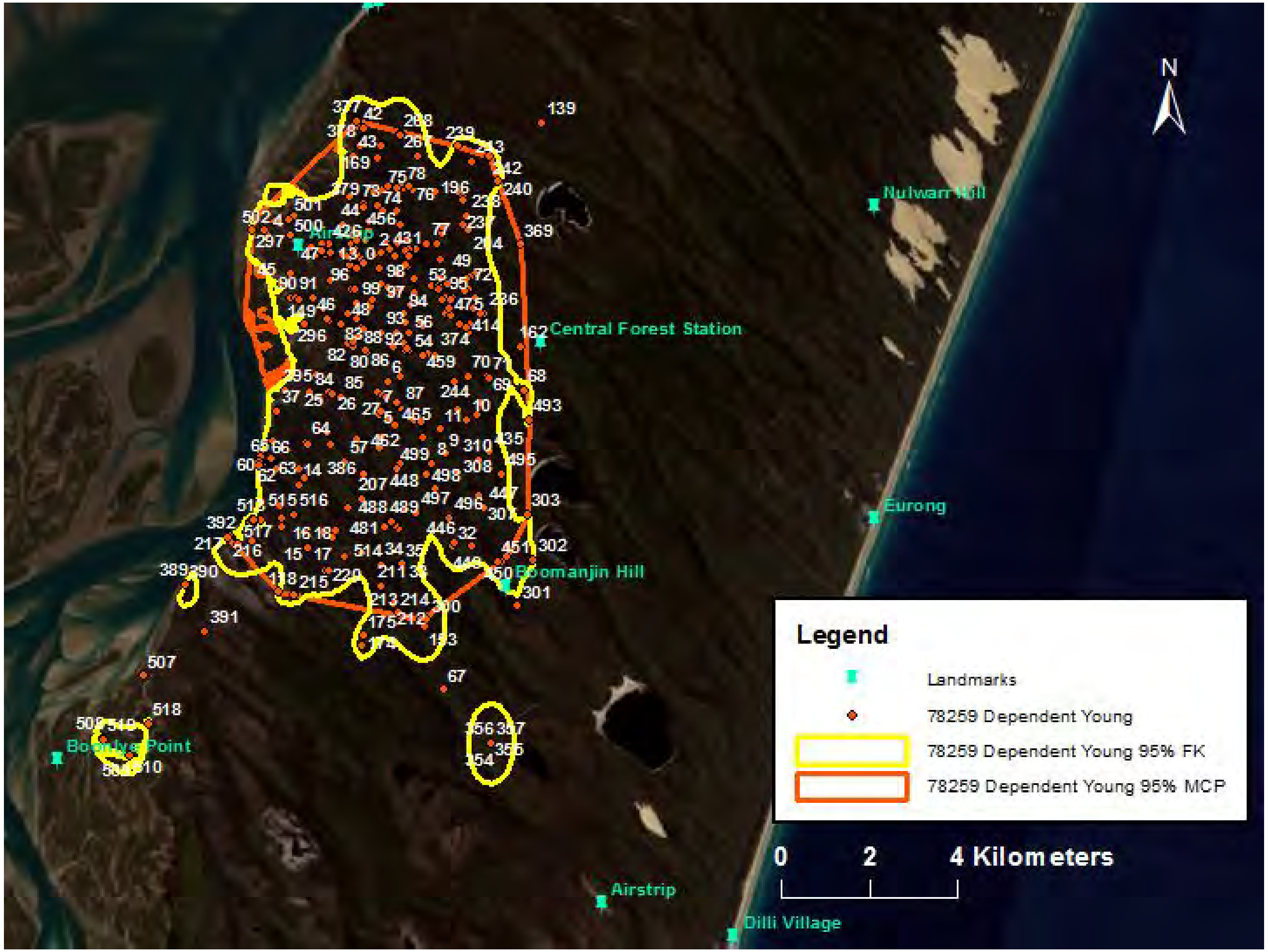

Figure 26C. Dependent young home range 78259

Figure 27A. Total home range 78421

Figure 27B. Mating home range 78421

Figure 27C. Pupping & whelping home range 78421

Figure 27D. Dependent young home range 78421

Figure 27E. Non-breeding season home range 78421

Figure 28A. Total home range 78422

Figure 28B. Mating home range 78422

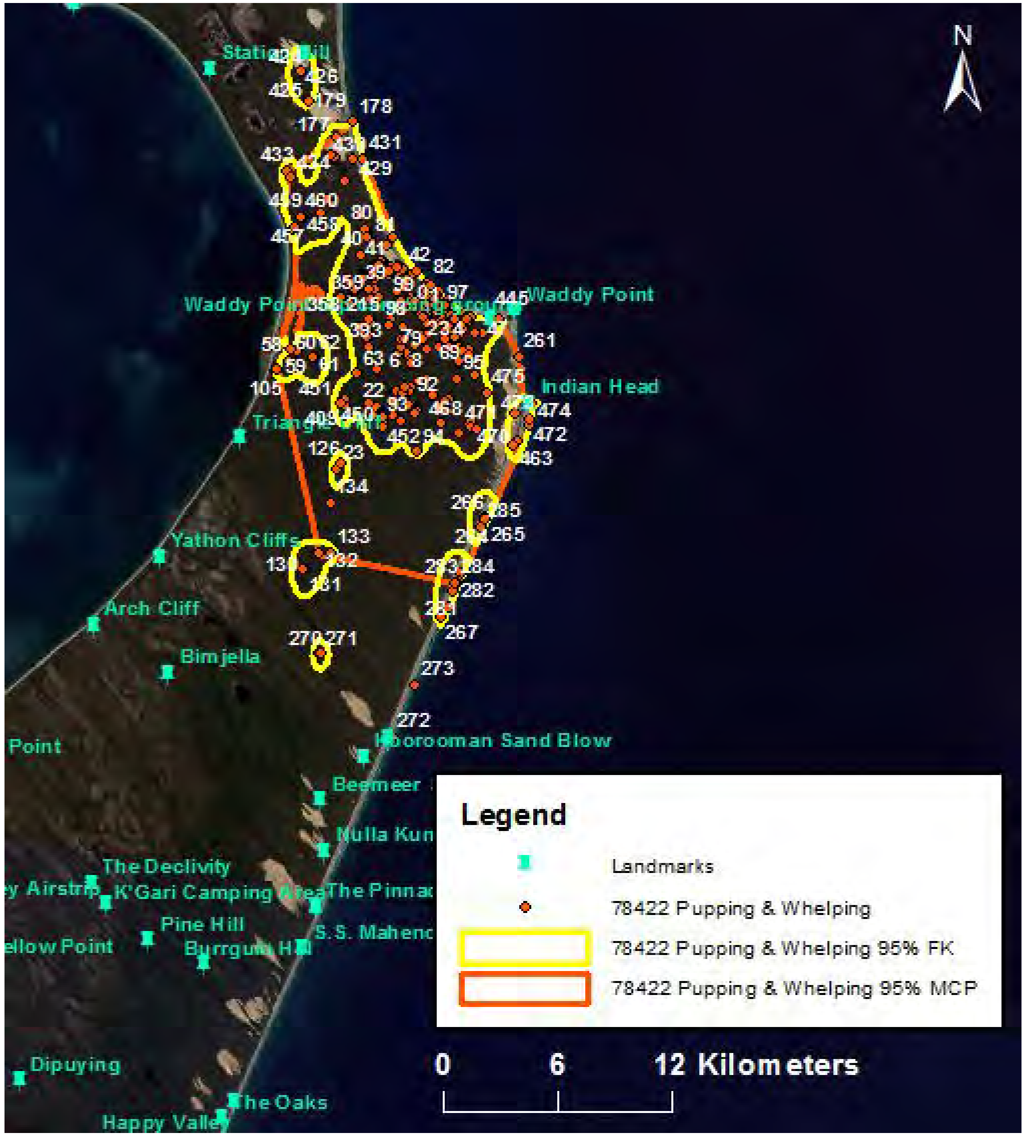

Figure 28C. Pupping & whelping home range 78422

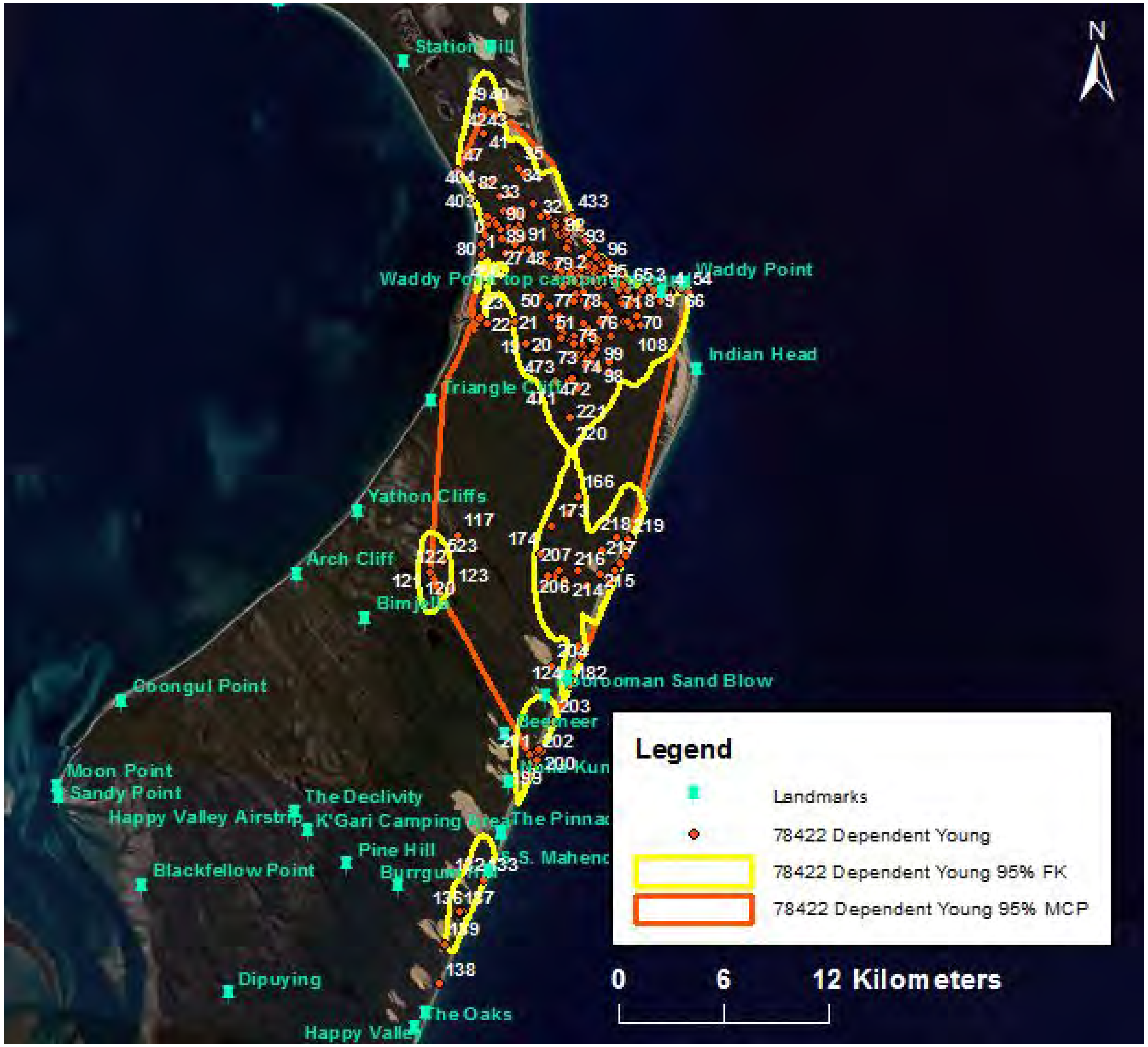

Figure 28D. Dependent young home range 78422

Figure 28E. Non-breeding season home range 78422

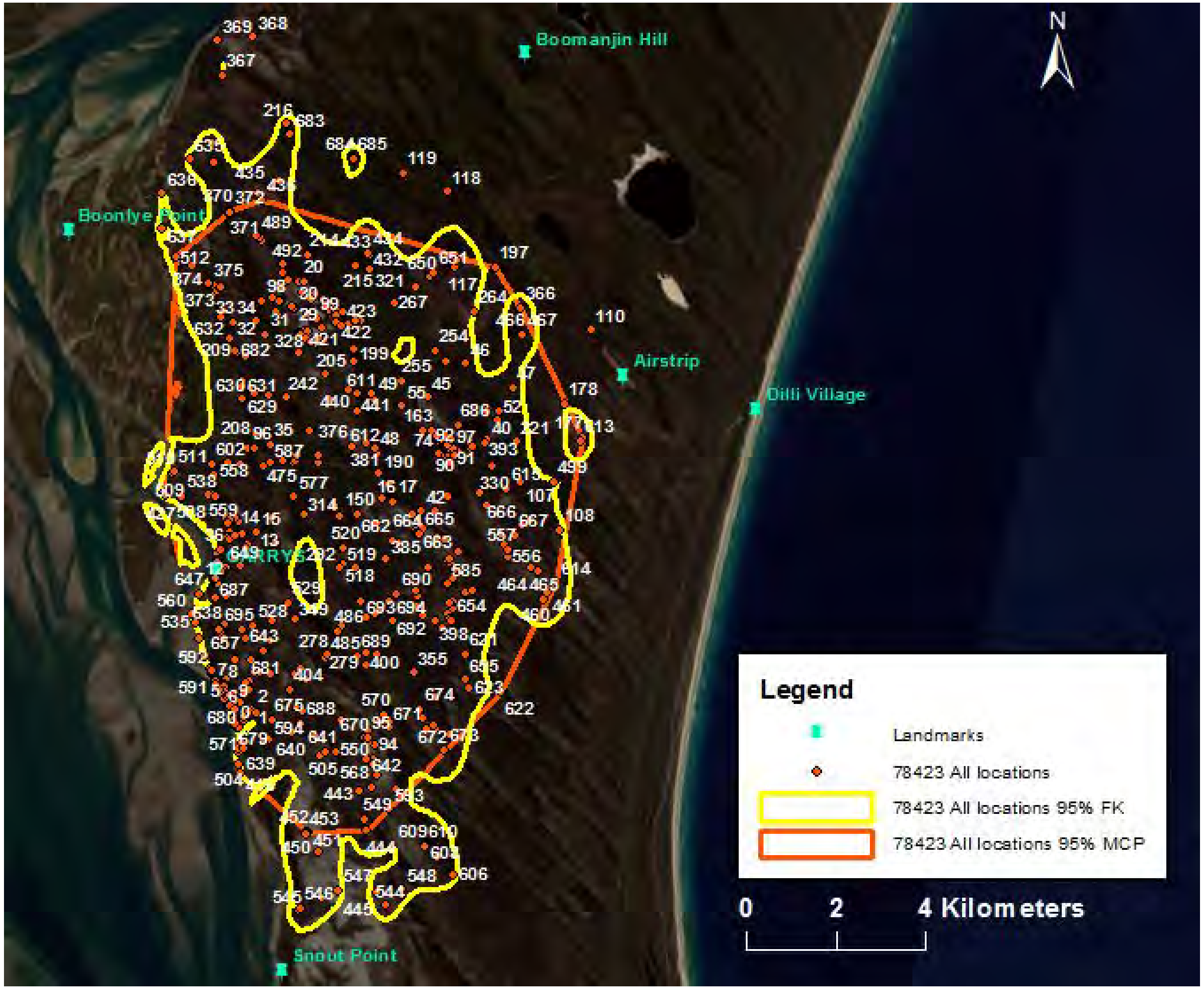

Figure 29A. Total home range 78423

Figure 29B. Mating home range 78423

Figure 29C. Pupping & whelping home range 78423

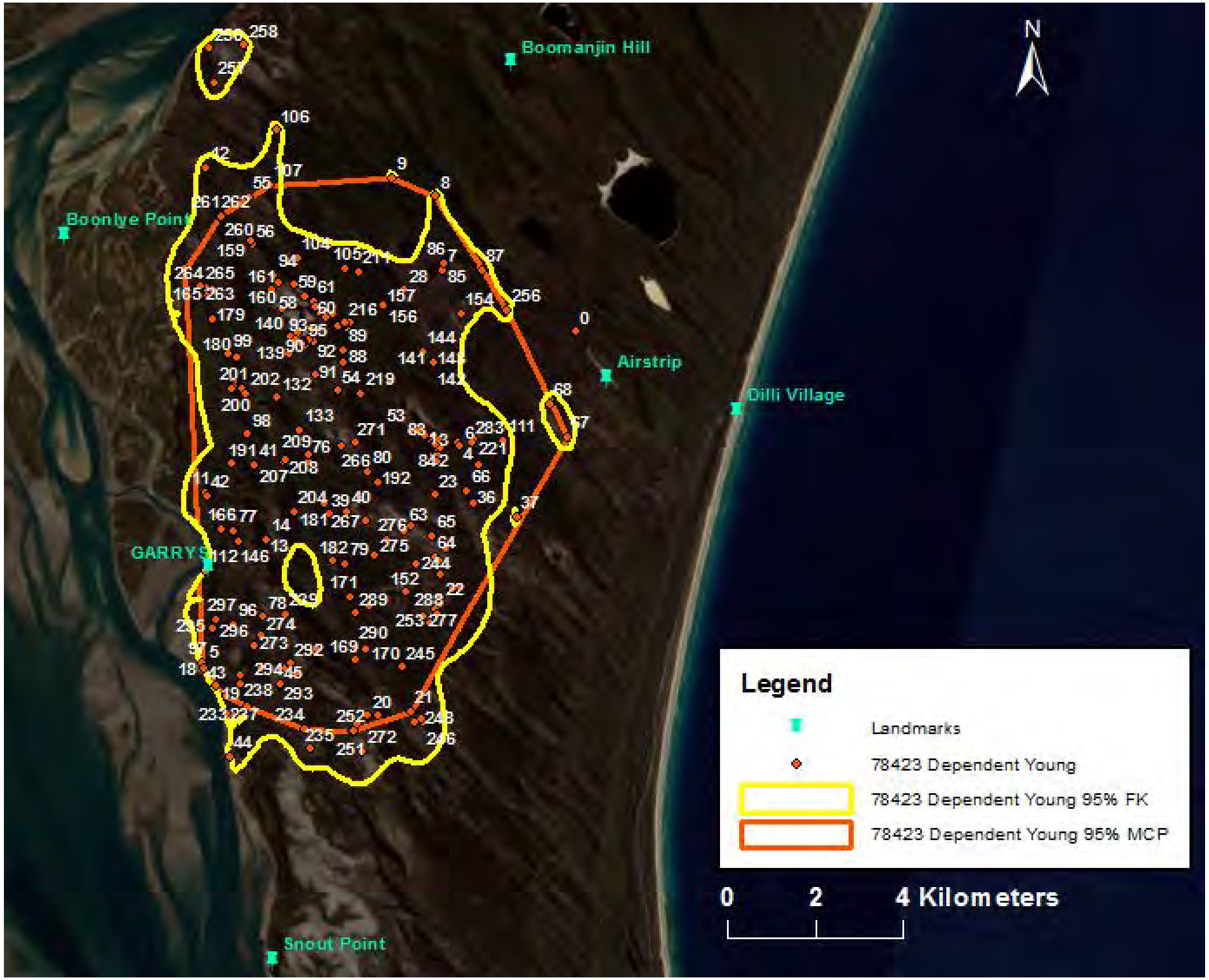

Figure 29D. Dependent young home range 78423

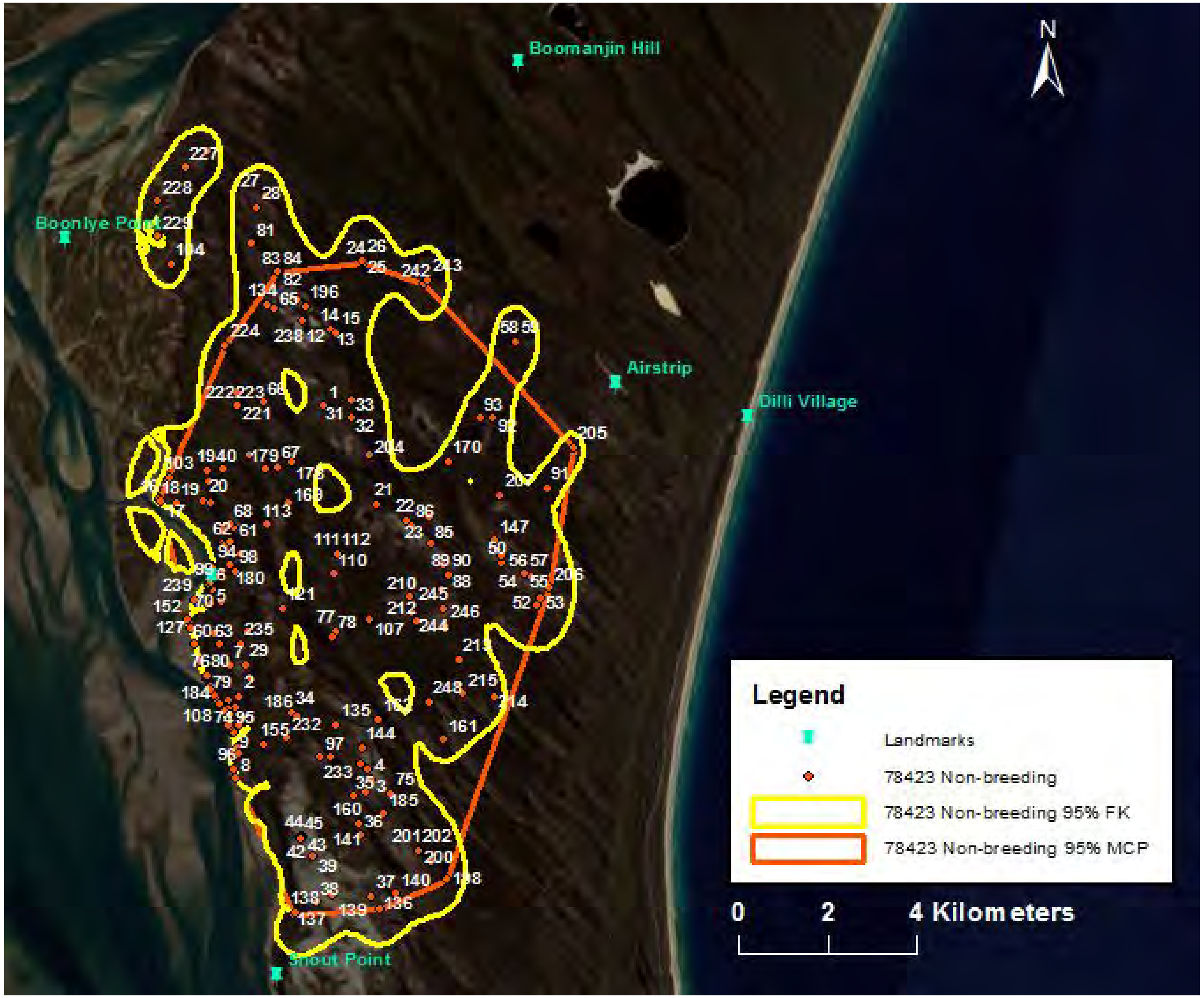

Figure 29E. Non-breeding season home range 78423

It appears from the above that there are four general types of dingo movement patterns on Fraser Island Most of the collared dingoes (13/18) had home ranges that included a substantial portion of their locations being in both forest and beach habitat. Only 5 of the collared dingos used beach and coastal habitat much more heavily than forest habitat.

1. Beach Dwellers. These are dingoes which roam freely along the beaches with few movements deep into the island's interior (Figure 10A, p. 36 & 19A, p.73). Only two dingoes showed this type of movement and both were females (numbers 76861 & 78187). These were approximately 5 years old and 6 years old respectively. Rangers have observed these dingoes in previous years to both be breeders who belonged to packs.
2. Predominantly coast and beach dwellers, but these dingoes do enter and spend considerable periods of time inland (Figure 13A, p. 48, 14A, p. 52, 17A, p. 63). One of the dingoes that showed this pattern was a 3 year old female. All the others were males, aged 3 years.
3. Coast to coast, these dingoes predominantly remained in the island's interior but they did move to either the west or east coast and spent a significant portion of their time there. Four females (4-7 years old; Figures 12A, p. 44, 18A, p. 68, 21A, p.82, 22A, p. 87,) and two males aged 3 and 8 years (Figures 11A, p. 39, 25A, p. 99) showed this pattern.
4. Mostly inland dingoes. These moved widely in the island's interior and rarely, if ever, moved onto the beach. Three males (two aged 4 years; Figures 23A, p. 91 & 26A, p.104, and one aged 6 years Figure 16A, p.60) and two females aged 5 and 7 years respectively (Figures 27A, p. 109 & 24A, p. 96) showed this pattern. These dingoes demonstrated a marked change in movements during their breeding cycle and it is possible to pinpoint areas of activity which may be den sites.

Discussion

Some of the home ranges reported here (e.g. animal 77168) are large. In the analyses presented here care has been taken to excise areas where the animal cannot have been found. Hence the movements observed for this animal are consistent with wide-ranging movement of a sub-adult animal that is looking for a location to establish a permanent home range.

There is a region of the central west of the island where there is less data than the north and south of the island. This part of the island is remote and has few tracks. Whilst an effort was made to trap dingoes across the entire island, by chance the animals that were captured on the west of the island happened to have moved north (76861 Platypus Bay - Moved north, collar deployed 22 July 11 found deceased 23 August 11 & 78030 Ungowa Creek – Remained in southern area, collar deployed 28 June 2011 and subsequently escaped collar in November. 78259 Wanggoolba and Ungowa Road junction – remained in southern section of quadrant 6 in well-defined home range. 76987 also used southern section of quadrant 6 but did foray to east coast also and much time around central station) and south this leaving parts of the island with no GPS tracked dingoes. However, there is no indication that any different results may have been obtained if animals had been collared in that gap zone because we have good results for animals on the east and west of the island in both the north and south and there seem to be patterns general to both groups.

In this study males had larger home ranges than females. This is consistent with behaviour where males move further in search of mates and in efforts to exclude other males from their range. Further, males had larger home ranges in the pupping & whelping seasons and in the season when there would likely be dependent young, but not during the mating and non-breeding seasons. This indicates that during times when the females are whelping or have dependent young they are not able to move as far as males which are not so directly committed to breeding activities.

The home ranges reported here did not differ between males or between females over the seasons, probably demonstrating that it is resource availability that determines home range size and not age or social status of the animal.

Combined (male and female combined) nightly (dusk-dawn) distances travelled were significantly larger than daily (dawn-dusk) distances. This may be an attempt by dingoes to minimise the costs of travel during the hottest part of the day, or it may be a reflection of the predominantly nocturnal activity of their prey, such as rats and bandicoots. However, when combined distances travelled were split into seasons only PW nightly distances were significantly larger than day.

There were also differences in the male and female day/night distances travelled for the pupping & whelping and non-breeding seasons but not the mating season. This probably reflects a desire of the males to associate with females during the mating season, and then being free to move further away from females in other seasons. For managers this might mean that capture of males may be easier in the breeding season than at other seasons, if the whereabouts of females can be obtained.

There was no significant difference in male or female home range size based on the dominant vegetation class found within each home range. Nor was there a significant difference in male or female day/night distances travelled based on the dominant vegetation class within home ranges. This is probably a result of the poor nutrient status of the island. While some vegetation has access to more nutrients than others, depending on which dune system it grows on, there are not the large differences between quality of habitat that exist on the mainland and there is no evidence here that some habitats are of higher quality than others, basing an assessment of habitat quality on vegetation type. However, there was evidence that dingoes became more selective in their habitat use during the times when pups were being born and while those pups would still have been dependent on their mother. This selectivity applied to both adult and sub-adult dingoes and probably reflects a change in the behaviour of the entire pack while very young pups are present. It is likely that the use of camera traps would be most effective during this time of the year.

Animal Welfare

During this study 4 of the 18 animals died and one was humanely destroyed (77165) due to aggressive behaviour towards people. One animal was a witnessed car strike incident (77193), a second displayed injuries consistent with a vehicle strike (78187). The cause of death for the other three animals (78256, 76861 & 78256) is unknown. Initially this death rate may seem high, however, if the maximum number of animals on the island is about 200 as the Griffith University study suggested, and breeding dingoes can produce up to 10 pups per year, it may be that the death rate recorded here accurately reflects the current dynamics of dingoes in the Fraser Island population.

The large distances travelled by dingoes in this study, the large home ranges and the fact that at least one collared dingo (78032) was seen to birth and raise pups gives no indication that the monitoring techniques employed during this study had adverse effects on the subject animals.

Implications of this study for deriving an island-wide population estimate

The information from this research combined with other studies can deliver a more accurate estimate of population numbers, movement and ecological cycles of the dingo on Fraser Island.

Some collared dingoes (e.g. 77168, 78030, 78032, 78203, 78213, and 78259), were rarely if ever seen by rangers. If an estimate of dingo numbers was arrived at by sightings alone it would almost certainly be an underestimate because of the behaviour of cryptic animals like these.

Some dingoes travel large distances around the island and there are some that do not base themselves in a single region. This information supports ranger observations from the trap and tag program running since 2002 on Fraser Island. This suggests that any population estimate should be based on mark-recapture methodology which will account for such movements and reduce the risk of missing animals entirely or double counting.

The radio tracking data clearly showed that some animals move large distance very quickly, often using tracks and beaches. This is supported by literature on predator movements (e.g. Allen and Engerman 1996, Engerman et al. 2000), but the data analyses to date shows that there are animals who do not use those routes (e.g. animal 78423).

This study has demonstrated that dingoes have different home range sizes and there is a seasonal change in home range size. It may be most prudent to conduct a population estimate in the breeding season when movements are the smallest and when it is possible to identify the location of dens. Laurie Corbett (Fraser Island Dingo Management Strategy) originally estimated that there might be 25-30 dingo packs on the island. When all the data are available it can be examined to test that assumption.

While this study was not designed to provide a population estimate, the preliminary findings suggest important implications for deriving such an estimate.

Firstly, the study clearly showed that there were some animals, predominantly female, but also some males (e.g. 77168, 78030, 78032, 78203, 78213, and 78259), that were captured and tracked but rarely if ever seen by rangers. If an estimate of dingo numbers was arrived at by sightings alone it would almost certainly be an underestimate because of the behaviour of animals like these.

Secondly, the study showed that animals travel large distances around the island and there are some animals that do not base themselves in a single region. That suggests that any population estimate should be based on mark-recapture methodology which will account for such movements and reduce the risk of missing animals entirely or double counting.

Thirdly, the GPS tracking study suggests the type of mark-recapture study which might be appropriate. One method would be collection of dingo scats and analysing the DNA in them to obtain individual identification. The radio tracking data clearly showed that some animals move large distance very quickly. Some of those animals use roads and the beaches and those places should be checked for scats. This is probably obvious and is supported by the literature on predator movements (e.g. Allen and Engerman 1996, Engerman et al. 2000), but the data analyses to date shows that there are animals who do not use those routes (e.g. animal 78423). Hence collecting scats only along roads and beaches would miss some animals entirely and result in an underestimate. Collecting scats in forest and heath away from roads would be extremely time consuming and haphazard, though the chance of success could be improved by the use of baits or chemical lures which attract dingoes.

Another method for a mark-recapture study would be to deploy remotely operated cameras and then individually identify animals from the photos. Again these would have to be deployed both along tracks and in continuous bushland away from tracks. The radio tracking study confirmed that dingoes move over all parts of the island and to be valid a camera trapping survey would have to be deployed widely over even remote parts of the island.

Fourthly, this study has demonstrated that animals have different home range sizes and locations. Some are very large and others are much smaller. There is also a seasonal change in home range size, particularly for males. It may be most prudent to conduct a population estimate in the breeding season when movements are the smallest. Also during the breeding season the locations obtained in this study suggest that the location of dens can be fixed. Cameras could then be deployed at the den sites and individuals identified. Animals which do not appear to frequent a den (e.g. animal 78421) would have to be accounted for in a different way, e.g. directly counting based on expert knowledge of its existence.

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