Surveys for the high priority COSEWIC-candidate *Ceropales bipunctata*

Ceropales bipunctata. Photographed 20 August 2015 at Cap Lumière

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Report to
New Brunswick Wildlife Trust Fund
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Introduction

Ceropales bipunctata, a species of spider wasp (Pompilidae) found in the eastern United States and southeastern Canada, is a high priority COSEWIC candidate. In southern Ontario this species was commonly collected in the past, with over 100 specimens from 15 different sites present in three major Ontario collections collected from the 1880s to the 1950s (Godsoe 2003). No specimens were taken in Ontario again between 1957 and the publication date of Godsoe's paper. Since 2003 it has been collected in Ontario at three locations (S. Paiero, University of Guelph Insect Collection, pers. comm.), however the overall trend of significant decline stills appears evident. A very similar pattern is evident amongst specimens collected United States, suggesting declines across the entire range (Godsoe, 2003). There are not enough records to know if there's been a similar decline in the Maritimes , though the available data suggests the species is limited to dune habitats here. The known historic records from the Maritimes are as follows: specimens from Shippagan and Tracadie (both collected in 1939, specimens at the Canadian National Collection [CNC] [Godsoe 2003]), and a Prince Edward Island specimen from Brackley Beach (collected in 1940, CNC [Godsoe 2003]). Contemporary records from prior to 2015 area as follows: photographic records from the Petit-Cap dune from 2012 and 2013 and the Maisonette dune from 2012 (all recent occurrences were documented by Stuart Tingley, see http://bugguide.net/node/view/119131).

Causes for the apparent decline of *C. bipunctata* are unclear. Like other members of the genus, *C. bipunctata* is a cleptoparasite of other spider wasps, meaning that instead of catching its own spider prey upon which to lay its eggs, it lays eggs on the spider prey that other spider wasps have captured (Townes 1957). It is possible that declines in the wasp that *C. bipunctata* parasitizes may be driving its decline (Godsoe 2003). This is difficult to test however, as it is not known which species *C. bipunctata* parasitizes.

The purpose of this project was to delineate the current distribution of *C. bipunctata* in New Brunswick, to document which species of spider wasp *C. bipunctata* parasitizes, and to better document little collected insect groups considered in the General Status program.

Methods

Surveys were conducted in dune and beach habitat on New Brunswick's Northumberland and Chaleur Bay coastline. Surveys were conducted in 2015 between 18 August and 3 September, which is within the period when *C. bipunctata* has been observed in the Maritimes and Ontario. Surveys consisted of one or two people walking survey sites on days of good weather (above 15°C, no precipitation between 0900 and 1800 ADT). Spider wasps were collected opportunistically, and efforts were made to collect a specimen of *C. bipuncata* at all sites where it was encountered. Notes were taken about *C. bipuncata* behaviour, and effort was made to capture any spider wasps and their spider prey that were observed being parasitized by *C.*

bipuncata. Spider wasps in general were collected opportunistically, as were a number of insect taxa that are of interest to the General Status program, namely scorpionflies (Mecoptera), robber flies (Asilidae), lacewings and their allies (Neuroptera), grasshoppers and crickets (Orthoptera), flower flies (Syrphidae), bee flies (Bombyliidae) and butterflies.

In total surveys were conducted at 33 sites (see Table 1 and Maps 1-34) and 19 person days were spent surveying (26 August is counted as a half day for both Sarah Robinson and John Klymko as poor weather meant surveys could only be conducted in the morning).

Results

Range extent and habitat preference

Ceropales bipunctata was found at 21 of the 33 sites surveyed (see Map 1). The species is now known from Youghall Beach in the northwest to Cape Tormentine in the southeast.

All sites where *C. bipunctata* was found are coastal sand dunes, and it appears this is the preferred habitat of the species in the region. Of the 12 sites where *C. bipunctata* was not found, seven are gravel bars and gravel beaches on Chaleur Bay. This habitat may not be suitable for *C. bipunctata*, or the hosts of *C. bipunctata*, and the species may be truly absent at these sites. *Anoplius cleora,* the host spider wasp of *C. bipunctata* as documented during these surveys (see discussion under *Hosts*) was not collected at any of these gravel beaches and bars.

Dunes where *C. bipunctata* was found range from very large and connected (e.g. the dunes in the Tracadie area offer over 50km of nearly contiguous habitat) to small and isolated (e.g. the dune at Bar-de-Cocagne is less than 500m long is more than 1.5km from the next nearest dune).

The documented host species *A. cleora* was also widespread in the dunes surveyed. It was collected at 19 of the 26 dune sites surveyed, including three of the five dune sites where *C. bipunctata* was not found.

Given that *Ceropales bipunctata* was found at 21 of the 26 dunes surveyed, that the documented host species appear to widespread, and that *C. bipuncata* was documented at very large and very small dunes, it is likely that *C. bipunctata* occurs in all or nearly all coastal sand dune habitat along New Brunswick's Northumberland coast.

Hosts wasps of Ceropales bipunctata *and their spider prey*

Three instances of *C. bipunctata* parastitizing another spider wasp were observed (one each at Cap Lumière, Petit-Chockpish, and Parlee Beach). In all three events a group of four to six *C. bipunctata* were seen swarming a spider wasp that was dragging a subdued spider (Figure 1). This was the only time that *C. bipunctata* were conspicuous, they were otherwise observed flying past (very often on the foredune along the edge of the beach vegetation) or found singly

Figure 1. Four *Ceropales bipunctata* (below white dots) swarming *Anoplius cleora* and its prey, *Arctosa littoralis* (below orange dot). Photographed 20 August 2015 at Cap Lumière.

Figure 2. *Ceropales bipunctata* ovipositing on an *Arctosa littoralis* that has been captured by *Anoplius cleora*. Photographed 20 August 2015 at Cap Lumière.

at flowers or perched on grass). Both sexes of *C. bipunctata* were present in at least one swarm - a male *C. bipunctata* specimen was collected from the Cap Lumière swarm. During the swarming event at Cap Lumière a female *C. bipunctata* landed on the spider as it was being dragged and oviposited (or at least attempted to, see Figure 2). At the Petit-Chockpish swarming event the host spider was observed pulling its spider prey into a previously dug burrow. A female *C. bipunctata* also entered the burrow, presumably to oviposit on the spider. During the swarming events at Cap Lumière and Parlee Beach the host spider wasp being parastized showed aggression toward *C. bipunctata*. Host wasps were observed temporarily leaving their spider prey and flying at *C. bipunctata*, presumably in an attempt to drive them away.

The host wasp was collected at Petit-Chockpish and Cap Lumière, in both cases it was *A. cleora.* As mentioned this species appears to be common in dune habitat in New Brunswick. It was taken at 19 of the 26 dune sites surveyed. This is the first time a host wasp has been documented for *C. bipunctata.* The spider prey was collected from all three swarms. In each case it was a mature female *Arctosa littoralis*. This is the first time the spider prey of *C. bipunctata* has been documented. *Anoplius cleora* and *Arctosa littoralis* are widespread in the Nearctic region. Both are sand associated species and their predator-prey relationship is well known (e.g. Kurczewski and Kiernan, 2015).

Discussion

The ease with which new locations for *C. bipunctata* came as a surprise. It would appear that in the short-term at least *C. bipunctata* is a relatively common but habitat restricted species in New Brunswick and its conservation status is relatively secure. The most obvious threat to the long-term persistence of the species in the Maritimes is the loss of coastal sand dune habitat to sea-level rise. It would be a worthwhile exercise to survey interior sites with sandy substrates such as freshwater beaches to determine if *C. bipunctata* and *Anoplius cleora* are found away from the coast in the province.

Given that *C. bipunctata* appears to be widespread and relatively secure on New Brunswick, it is likely that it will dropped from the COSEWIC candidate list, or at least downgraded from the high-priority list. Data from the survey will be shared with the COSEWIC arthropods specialist subcommittee, of which John Klymko is a member, so that it can be decided how best to proceed with the species. Having the species dropped from or downgraded on the candidate list is a significant contribution to COSEWIC. It will allow limited resources available for status assessments to be applied to species that are at a greater level of risk.

The cause of the apparent decline in Ontario (as presented in Godsoe 2003) is unclear. A potential cause of the decline proposed by Godsoe (2003) is a decline in the host species of *C. bipunctata*. Now that *A. cleora* is identified as a host, research can be done in southern Ontario

and other areas where there is evidence of a decline in *C. bipunctata* populations to see if there is evidence of a parallel decline in *A. cleora*.

This project establishes a baseline for the distribution and relative abundance of *C. bipunctata* in New Brunswick. If, in future, there appears to be a decline in population levels of the species in New Brunswick, which is entirely possible given that it has happened elsewhere in Canada, the methods used to survey the species, as documented in this report, can be repeated to produce a fairly accurate assessment of change in distribution and relative abundance.

Other taxa recorded

Spider wasps in general were collected opportunistically, as were a number of insect taxa that are of interest to the General Status program, namely scorpionflies (Mecoptera), robber flies (Asilidae), lacewings and their allies (Neuroptera), grasshoppers and crickets (Orthoptera), flower flies (Syrphidae), bee flies (Bombyliidae) and butterflies. Species recorded within these groups are presented in Table 2. Records of these taxa will be deposited in the AC CDC database where they will be available to the province and other interested parties. These records will be valuable for assigning and reviewing General Status Assessments going forward.

Note that identifications of the spider wasps must be confirmed by Matthias Buck. There is no doubt about the identification of the *C. bimaculata* and *A. cleora* specimens as these species are quite distinct, but many of the other identifications require expert review.

Many additional robber flies species were collected. These will be sent to Robert Cannings for identification.

Future plans

The results of these surveys will be published in a peer-reviewed journal in the coming months. This publication will discuss the conservation status of *C. bipunctata* in Canada, and document the novel life history observations (e.g. *C. bipunctata* behaviour, host wasp species, and spider prey species). The New Brunswick Wildlife Trust Fund will be acknowledged for funding the field surveys.

All specimens collected (381 in total) will be deposited at the New Brunswick Museum.

Acknowledgments

Eric Tremblay is thanked for arranging collecting permits for Kouchibouguac National Park of Canada. Stu Tingley is thanked for providing information about his the occurrence of *C. bipuncatata* in New Brunswick. Steven Paiero and Stephen Marshall are thanked for providing data on the recent *C. bipuncatata* records from Ontario. Matthias Buck is thanked for agreeing to verify the identifications of the spider wasp specimens collected during this project. Robert

Cannings is thanked for agreeing to verify the identifications of the robber fly specimens collected during this project

Works Cited

Godsoe, W. 2003. Evidence for the extirpation of *Ceropales bipunctata* Say (Hymenoptera: Pompilidae) in Ontario. Journal of the Entomological Society of Ontario. 134: 135-140.

Kurczewski, F.E. and D.H. Kiernan. 2015. Analysis of Spider Wasp Host Selection in the Eastern Great Lakes Region (Hymenoptera: Pompilidae). Northeastern Naturalist. 22(m11): 1-88.

Townes, H. 1957. Nearctic wasps of the subfamilies Pepsinae and Ceropalinae. Bulletin of the United States National Museum 209: 1-272.

Table 1. Details of *Ceropales bimaculata* surveys

Site Name	Habitat	Date (all 2015)	Observer(s)	Temp (°C)	% Cloud Cover	Start Time	End Time	Latitude	Longitude	Ceropales bimaculata Observed?
Bar-de-Cocagne	Coastal Sand Dune	24-Aug	JK&SLR	24	100	16:36	16:53	46.4172	-64.6200	Yes
Bayfield	Coastal Sand Dune	31-Aug	JK&SLR	20	0	11:21	12:13	46.1362	-63.8028	No
Beresford Beach	Gravel Beach	02-Sep	JK&SLR	25	20	14:30	15:16	47.7107	-65.6984	No
Bouctouche Dune	Coastal Sand Dune	24-Aug	JK&SLR	25	100	14:15	15:45	46.5264	-64.6836	Yes
Bourgeois	Coastal Sand Dune	28-Aug	JK&SLR	17	0	9:00	10:15	46.3067	-64.5240	Yes
Cap Bimet	Coastal Sand Dune	28-Aug	JK&SLR	25	0	12:46	13:12	46.2357	-64.4545	Yes
Cape Tormentine	Coastal Sand Dune	31-Aug	JK&SLR	20	0	10:10	11:00	46.1328	-63.7849	Yes
Cap-Lumiere	Coastal Sand Dune	20-Aug	JK	23	0	9:30	13:00	46.6772	-64.7143	Yes
Chiasson	Coastal Sand Dune	01-Sep	JK&SLR	18	0	15:53	16:28	47.7257	-64.6494	Yes
Daly Point	Gravel Beach	26-Aug	JK&SLR	23	90	13:00	13:16	47.6371	-65.6243	No
East Bathurst	Sand/Gravel Bar	26-Aug	JK&SLR	23	80	9:36	9:56	47.6179	-65.6395	No
Eel River Bar	Sand/Gravel Bar	02-Sep	JK&SLR	19	0	9:47	10:25	48.0299	-66.3703	No
Grants Beach	Coastal Sand Dune	31-Aug	JK&SLR	25	0	12:53	13:13	46.1779	-64.0483	Yes
	Coastal Sand Dune	19-Aug	JK	24	0	15:10	17:20			No
Green Point	Coastal Sand Dune	03-Sep	JK&SLR	20	0	9:34	10:37	47.6019	-64.8265	Yes
Hamilton Point	Sand/Gravel Bar	02-Sep	JK&SLR	20	-	10:50	11:24	47.9914	-66.2660	No
Hay Island Provincial Park	Coastal Sand Dune	19-Aug	JK	21	0	9:20	11:03	47.2285	-65.0747	Yes
Johnston Point	Coastal Sand Dune	31-Aug	JK&SLR	26	0	13:38	15:00	46.1738	-64.1020	Yes
L'Aboiteau	Coastal Sand Dune	31-Aug	JK&SLR	26	0	16:00	16:32	46.2306	-64.3056	Yes
Little Belledune Point	Gravel Beach	02-Sep	JK&SLR	25	0	12:20	12:59	47.9199	-65.8984	No
Miscou Centre	Coastal Sand Dune	01-Sep	JK&SLR	20	0	12:15	14:00	47.9568	-64.5657	No
Miscou Plains	Coastal Sand Dune	01-Sep	JK&SLR	20	10	10:05	11:40	47.9996	-64.5497	No
North Kouchibouguac Dune	Coastal Sand Dune	25-Aug	JK&SLR	22	90	11:27	13:32	46.8434	-64.9122	Yes

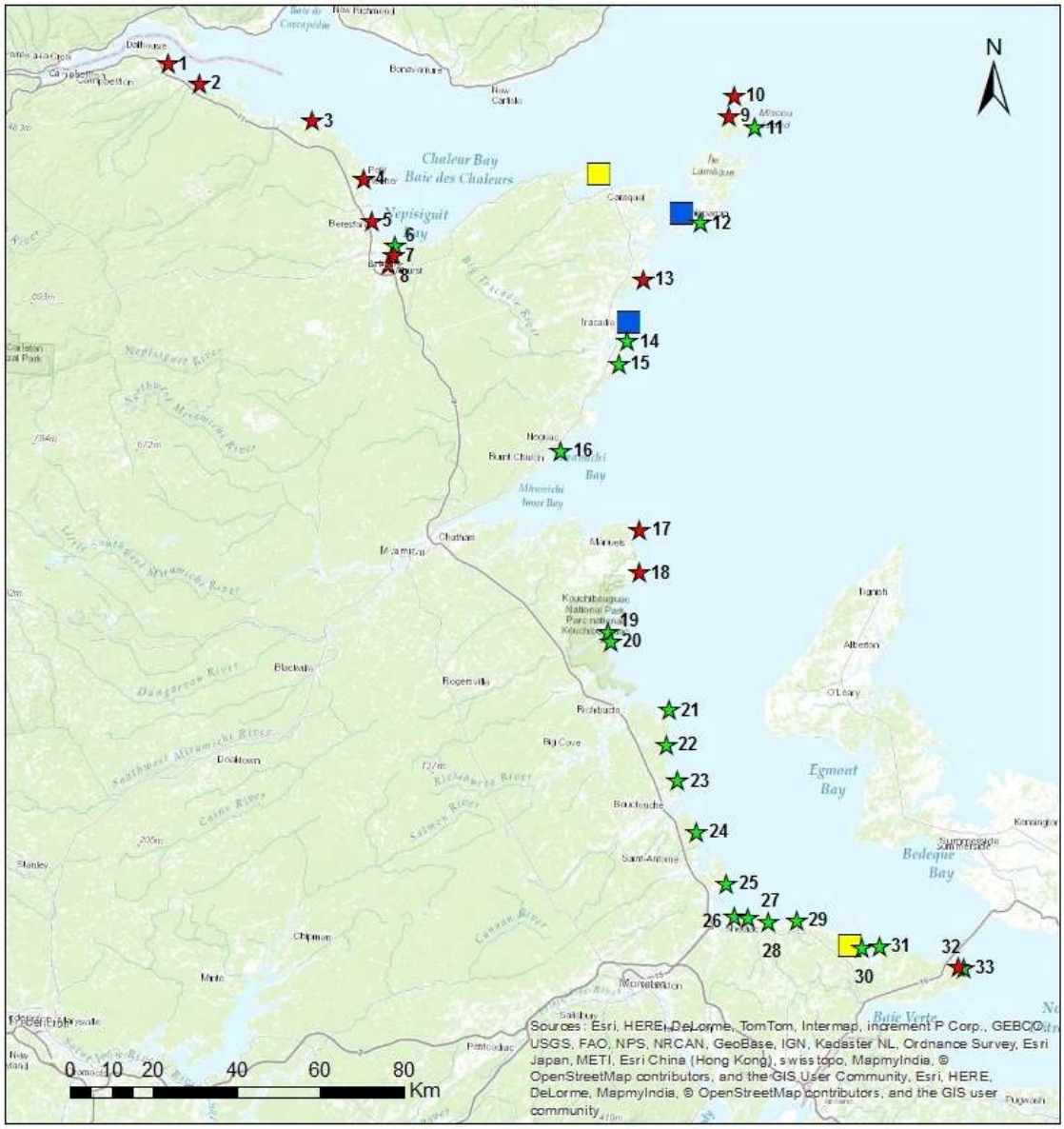
Site Name	Habitat	Date (all 2015)	Observer(s)	Temp (°C)	% Cloud Cover	Start Time	End Time	Latitude	Longitude	Ceropales bimaculata Observed?
Parlee Beach	Coastal Sand Dune	28-Aug	JK&SLR	22	0	11:08	12:10	46.2376	-64.4984	Yes
Petit-Chockpish	Coastal Sand Dune	20-Aug	JK	24	40	13:54	14:56	46.6026	-64.7224	Yes
Petit-Rocher Nord	Gravel Beach	02-Sep	JK&SLR	25	-	13:30	13:50	47.8010	-65.7270	No
Point Escuminac	Coastal Sand Dune	18-Aug	JK	26	0	15:40	17:20	47.0640	-64.8203	No
Pointe de Pruche	Coastal Sand Dune	18-Aug	JK	30	0	11:30	14:30	46.9717	-64.8178	No
Riviere-du-Portage	Coastal Sand Dune	19-Aug	JK	23	0	12:30	14:07	47.4198	-64.8990	Yes
Sainte-Henri-de-Barachois	Coastal Sand Dune	28-Aug	JK&SLR	25	0	13:33	14:20	46.2257	-64.3931	Yes
South Kouchibouguac Dune	Coastal Sand Dune	25-Aug	JK&SLR	27	0	15:00	17:30	46.8225	-64.9042	Yes
Val Comeau Provincial Park	Coastal Sand Dune	03-Sep	JK&SLR	20	0	11:20	11:53	47.4680	-64.8727	Yes
Wilson Point	Coastal Sand Dune	01-Sep	JK&SLR	18	50	14:20	15:00	47.9334	-64.4805	Yes
	Coastal Sand Dune	26-Aug	JK&SLR	23	90	10:45	11:43			Yes
Youghall Beach	Coastal Sand Dune	02-Sep	JK&SLR	25	80	15:41	17:00	47.6580	-65.6224	Yes

Table 2. Species within target groups recorded (spider wasps (Pompilidae), scorpionflies (Mecoptera), robber flies (Asilidae), lacewings and their allies (Neuroptera), grasshoppers and crickets (Orthoptera), flower flies (Syrphidae), bee flies (Bombyliidae) and butterflies (Hesperiidae, Pieridae, Lycaenidae, Nymphalidae). SRank definitions available at http://accdc.com/en/rank-definitions.html.

Order	Family	Scientific Name	Common Name	SRank	Comment
Diptera	Asilidae	*Stichopogon trifasciatus*	A robber fly	-	
Diptera	Bombyliidae	*Exoprosopa fascipennis*	A bee fly	SU	
Diptera	Bombyliidae	*Villa spp.*		-	At least two species in the genus *Villa* were collected. Species in this group are poorly defined and most specimens can not be identified.
Diptera	Syrphidae	*Eristalis arbustorum*	A flower fly	SNA	Exotic

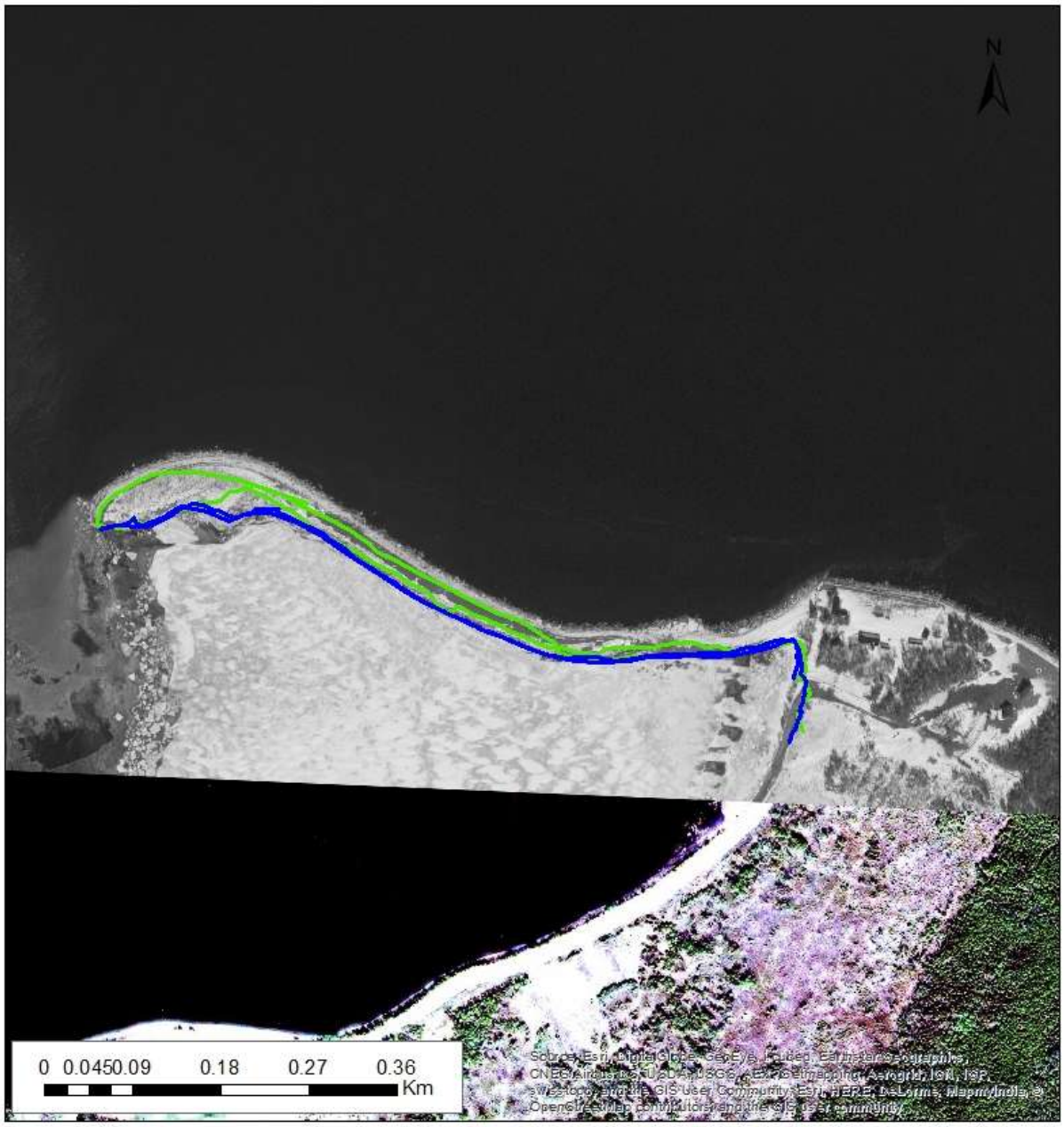
Order	Family	Scientific Name	Common Name	SRank	Comment
Diptera	Syrphidae	*Eristalis tenax*	A flower fly	SNA	Exotic
Diptera	Syrphidae	*Eupeodes lapponicus*	A flower fly	SU	
Diptera	Syrphidae	*Platycheirus rosarum*	A flower fly	S4S5	
Diptera	Syrphidae	*Polydontomyia curvipes*	A flower fly	SU	
Diptera	Syrphidae	*Sericomyia chrysotoxoides*	A flower fly	S5	
Diptera	Syrphidae	*Syritta pipiens*	A flower fly	SNA	Exotic
Diptera	Syrphidae	*Syrphus ribesii*	A flower fly	S5	
Diptera	Syrphidae	*Syrphus torvus*	A flower fly	S4S5	
Diptera	Syrphidae	*Toxomerus marginatus*	A flower fly	S5	
Hymenoptera	Pompilidae	*Ammosphex luctuosus*	A spider wasp	-	
Hymenoptera	Pompilidae	*Anoplius apiculatus*	A spider wasp	-	
Hymenoptera	Pompilidae	*Anoplius cf. brevihirta*	A spider wasp	-	
Hymenoptera	Pompilidae	*Anoplius cleora*	A spider wasp	-	
Hymenoptera	Pompilidae	*Anoplius nigerrimus*	A spider wasp	-	
Hymenoptera	Pompilidae	*Anoplius semirufus*	A spider wasp	-	
Hymenoptera	Pompilidae	*Anoplius tenebrosus*	A spider wasp	-	
Hymenoptera	Pompilidae	*Ceropales bipunctata*	A spider wasp	-	
Hymenoptera	Pompilidae	*Ceropales maculata*	A spider wasp	-	
Hymenoptera	Pompilidae	*Episyron quinquenotatus*	A spider wasp	-	
Hymenoptera	Pompilidae	*Evagetes hyacinthinus*	A spider wasp	-	
Hymenoptera	Pompilidae	*Evagetes ingenuus*	A spider wasp	-	
Hymenoptera	Pompilidae	*Evagetes parvus*	A spider wasp	-	
Lepidoptera	Hesperiidae	*Hesperia comma*	Common Branded Skipper	S5	
Lepidoptera	Lycaenidae	*Lycaena hyllus*	Bronze Copper	S3	Found in salt marsh at Bourgeois. Species has been recorded at this location previously.
Lepidoptera	Lycaenidae	*Lycaena phlaeas*	American Copper	S5	

Order	Family	Scientific Name	Common Name	SRank	Comment
Lepidoptera	Nymphalidae	*Cercyonis pegala*	Common Wood Nymph	S5	
Lepidoptera	Nymphalidae	*Phyciodes cocyta*	Northern Crescent	S5	
Lepidoptera	Papilionidae	*Papilio polyxenes*	Black Swallowtail	S4	
Lepidoptera	Pieridae	*Colias eurytheme*	Orange Sulphur	S4B,S4M	
Lepidoptera	Pieridae	*Colias philodice*	Clouded Sulphur	S5	
Lepidoptera	Pieridae	*Pieris rapae*	Cabbage White	SNA	Exotic
Orthoptera	Acrididae	*Camnula pellucida*	Clear-winged Grasshopper	S4	
Orthoptera	Acrididae	*Dissosteira carolina*	Carolina locust	S5	
Orthoptera	Acrididae	*Melanoplus femurrubrum*	Red-legged Grasshopper	S5	
Orthoptera	Acrididae	*Melanoplus sanguinipes*	Migratory Grasshopper	S5	
Orthoptera	Acrididae	*Melanoplus stonei*	Stone's Grasshopper	SU	Found at the Miscou Plains. Potentially the second ever record for New Brunswick. A western distjunct associated with dune habitat in the east that has been recorded at Kouchibouguac NP and on PEI.
Orthoptera	Gryllidae	*Gryllus pennsylvanicus*	Fall Field Cricket	S5	
Orthoptera	Tettigoniidae	*Conocephalus fasciatus*	Slender Meadow Katydid	S5	

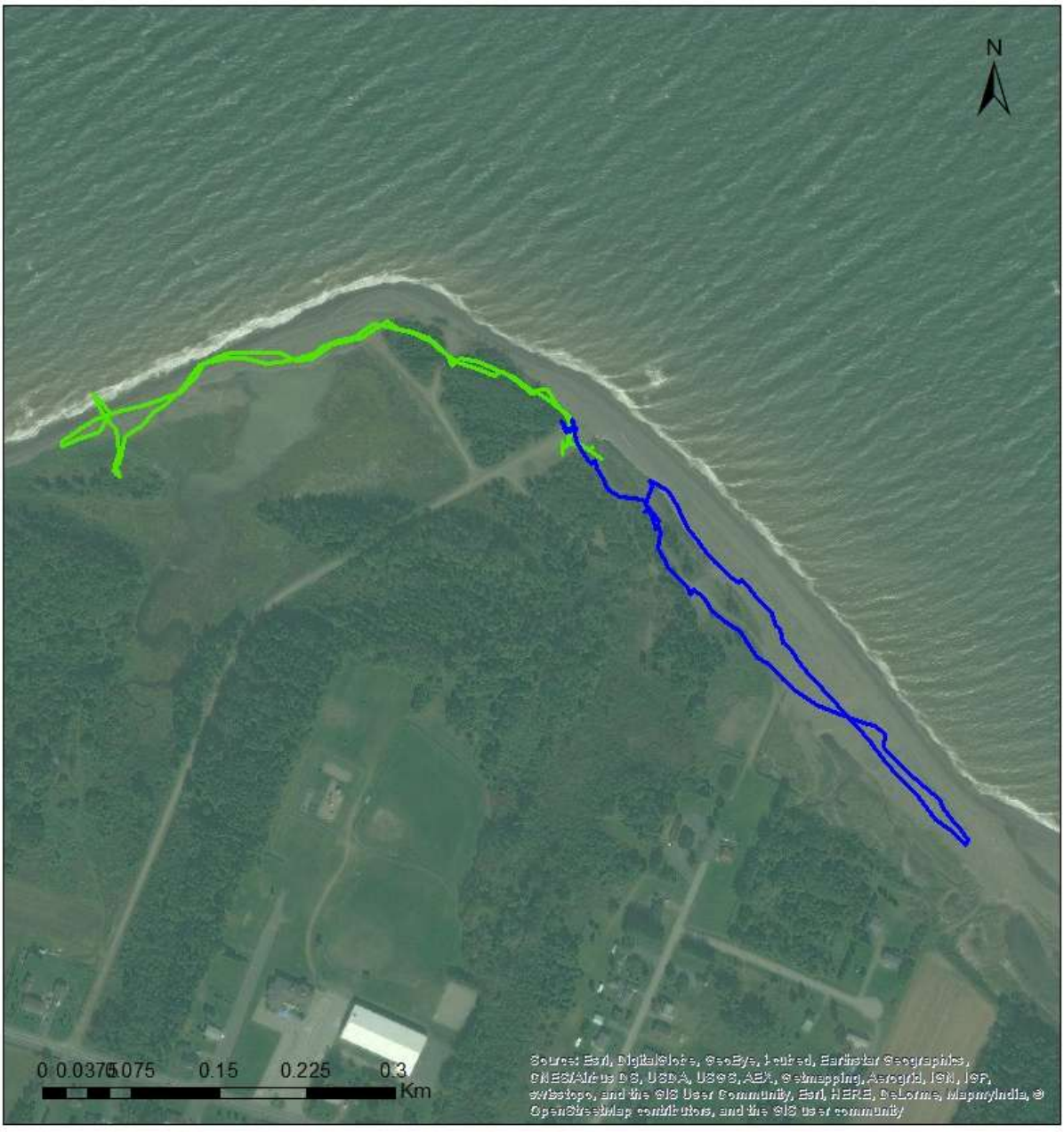


Map 1. 2015 survey sites and sites where Ceropales bimaculata was previously known. Stars represent 2015 survey sites: *1. Eel River Bar, 2. Hamilton Point, 3. Little Belledune Point, 4. Petit-Rocher Nord, 5. Beresford Beach, 6. Youghall Beach, 7. Daly Point, 8. East Bathurst, 9. Miscou Centre, 10. Miscou Plains, 11. Wilson Point, 12. Chiasson, 13. Green Point, 14. Val Comeau Provincial Park, 15. Riviere-du-Portage, 16. Hay Island Provincial Park, 17. Point Escuminac, 18. Pointe de Pruche, 19. North Kouchibouguac Dune, 20. South Kouchibouguac Dune, 21. Cap-Lumiere, 22. Petit-Chockpish, 23. Bouctouche Dune, 24. Bourgeois, 25. Bar-de-Cocagne, 26. Parlee Beach, 27. Cap Bimet, 28. Sainte-Henri-de-Barachois, 29. L'Aboiteau, 30. Johnston Point, 31. Grants Beach, 32. Bayfield, 33. Cape Tormentine.* Green and red stars indicate where Ceropales bipunctata was and was not found, respectively. Blue squares are sites of historical records, yellow squares are sites of recent records from before 2015.

Map 2. Survey tracks at Eel River Bar. Blue line is track of Sarah Robinson, green line is track of John Klymko. Survey conducted 2 September, 2015.



Map 3. Survey tracks at Hamilton Point. Blue line is track of Sarah Robinson, green line is track of John Klymko. Survey conducted 2 September, 2015.



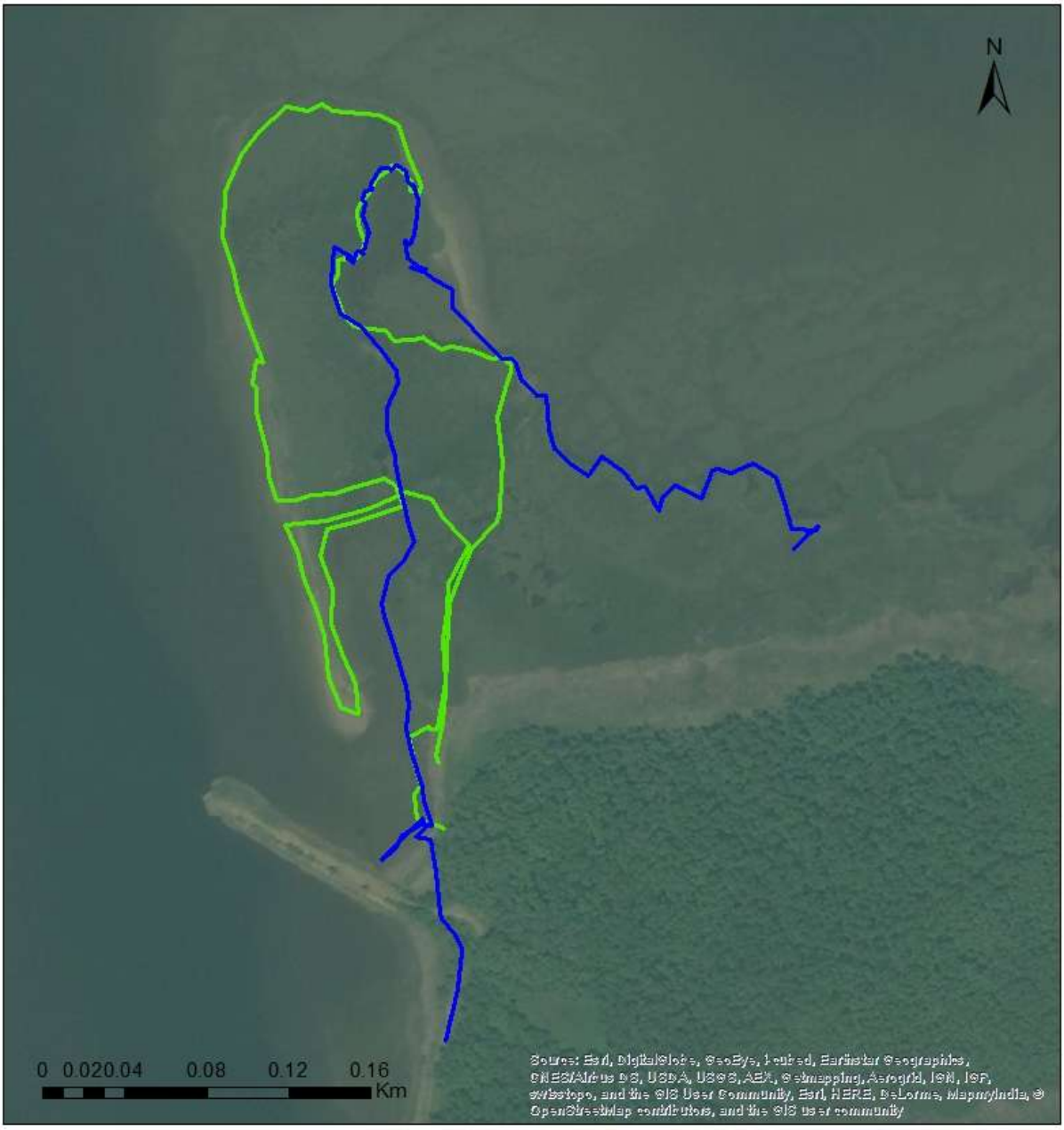
Map 4. Survey tracks at Little Belledune Point. Blue line is track of Sarah Robinson, green line is track of John Klymko. Survey conducted 2 September, 2015.

Map 5. Survey tracks at Petit-Rocher Nord. Green line is track of John Klymko and Sarah Robinson. Survey conducted 2 September, 2015.

Map 6. Survey tracks at Beresford Beach. Blue line is track of Sarah Robinson, green line is track of John Klymko. Survey conducted 2 September, 2015.

Map 7. Survey tracks at Youghall Beach. Blue line is track of Sarah Robinson, green line is track of John Klymko. Surveys conducted 26 August and 2 September, 2015.

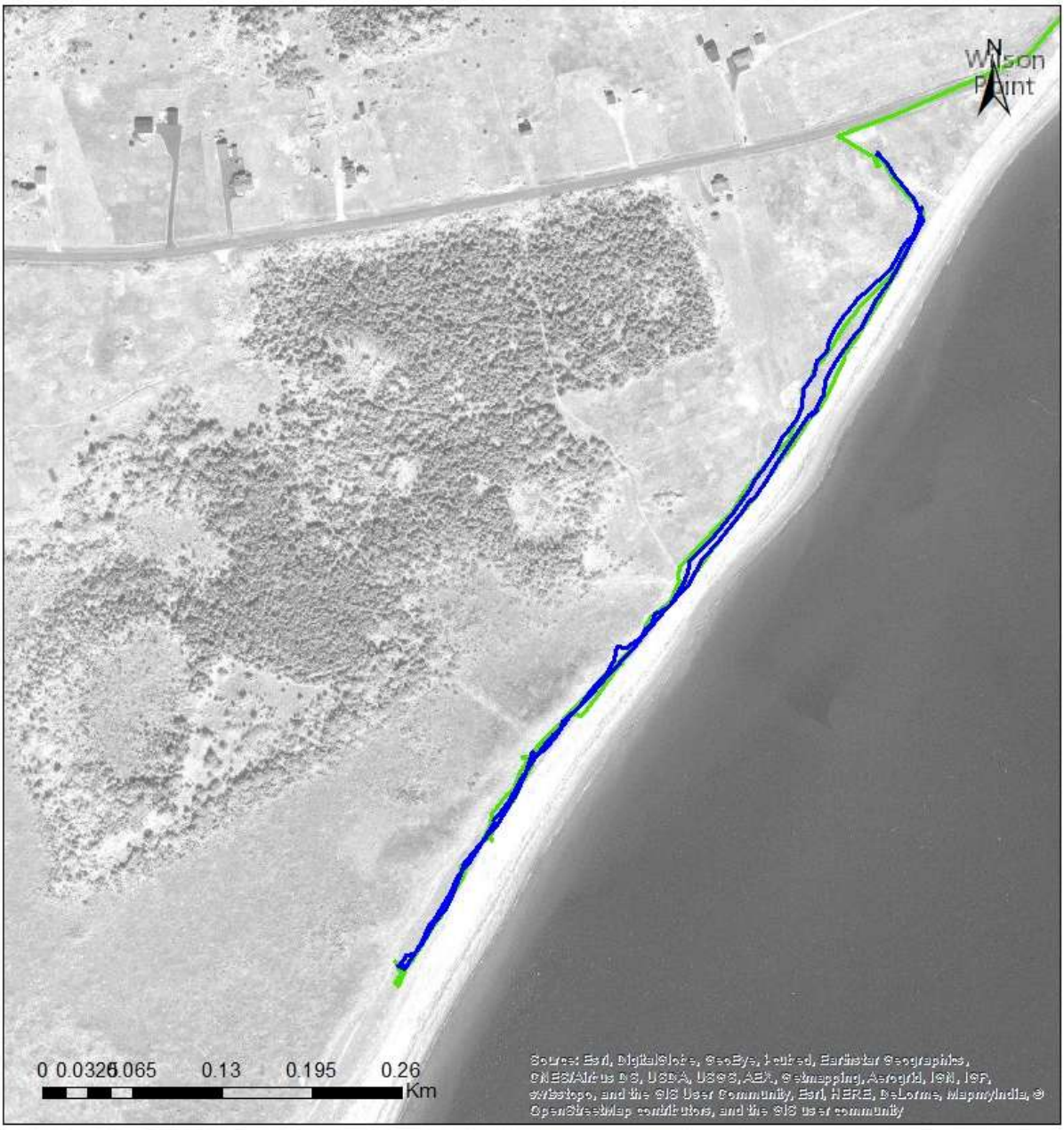
Map 8. Survey tracks at Daly Point. Blue line is track of Sarah Robinson, green line is track of John Klymko. Surveys conducted 26 August and 2 September, 2015.



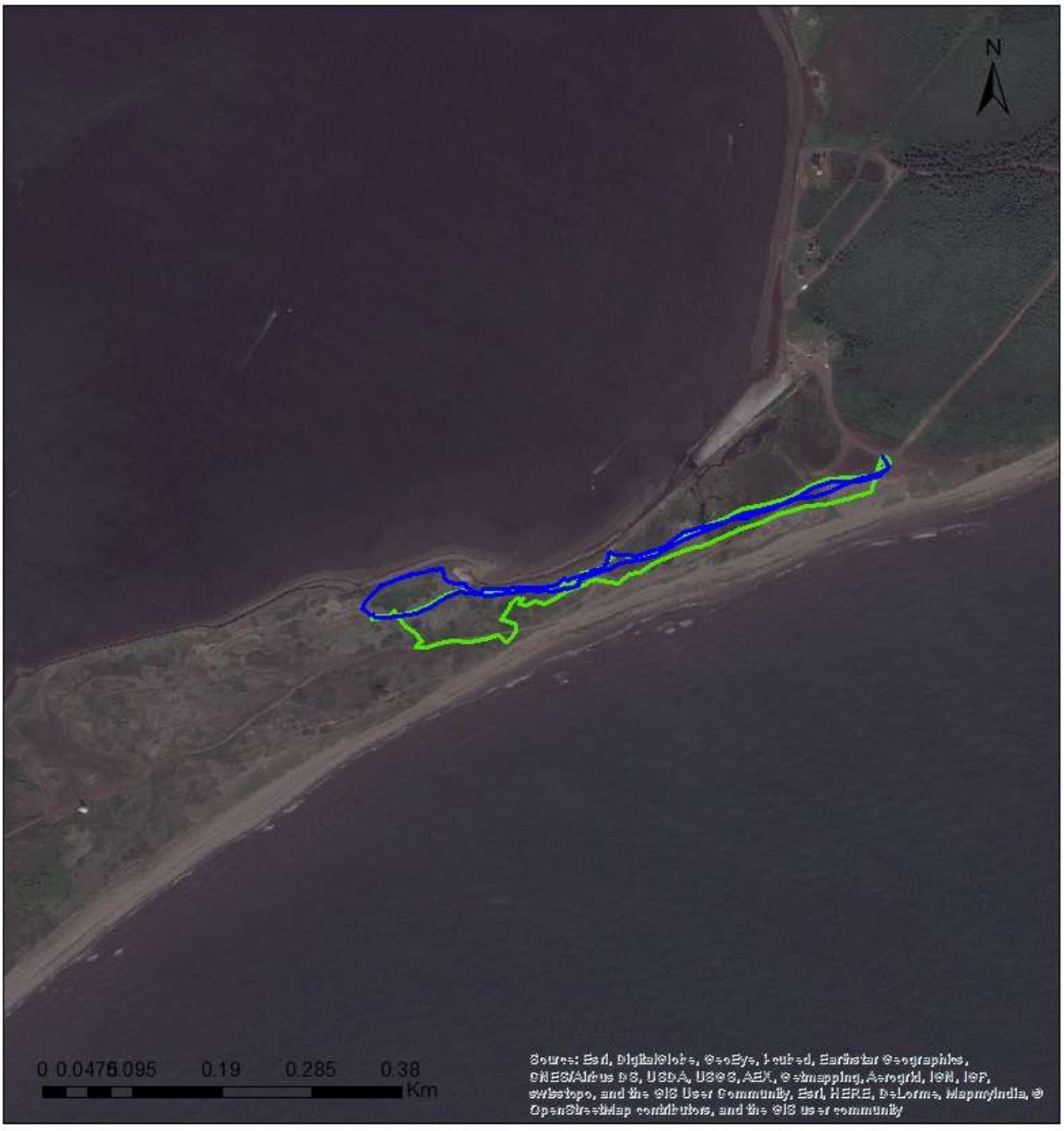
Map 9. Survey tracks at East Bathurst. Blue line is track of Sarah Robinson, green line is track of John Klymko. Survey conducted 26 August, 2015.

Map 10. Survey tracks at Miscou Centre. Blue line is track of Sarah Robinson, green line is track of John Klymko. Survey conducted 1 September, 2015.

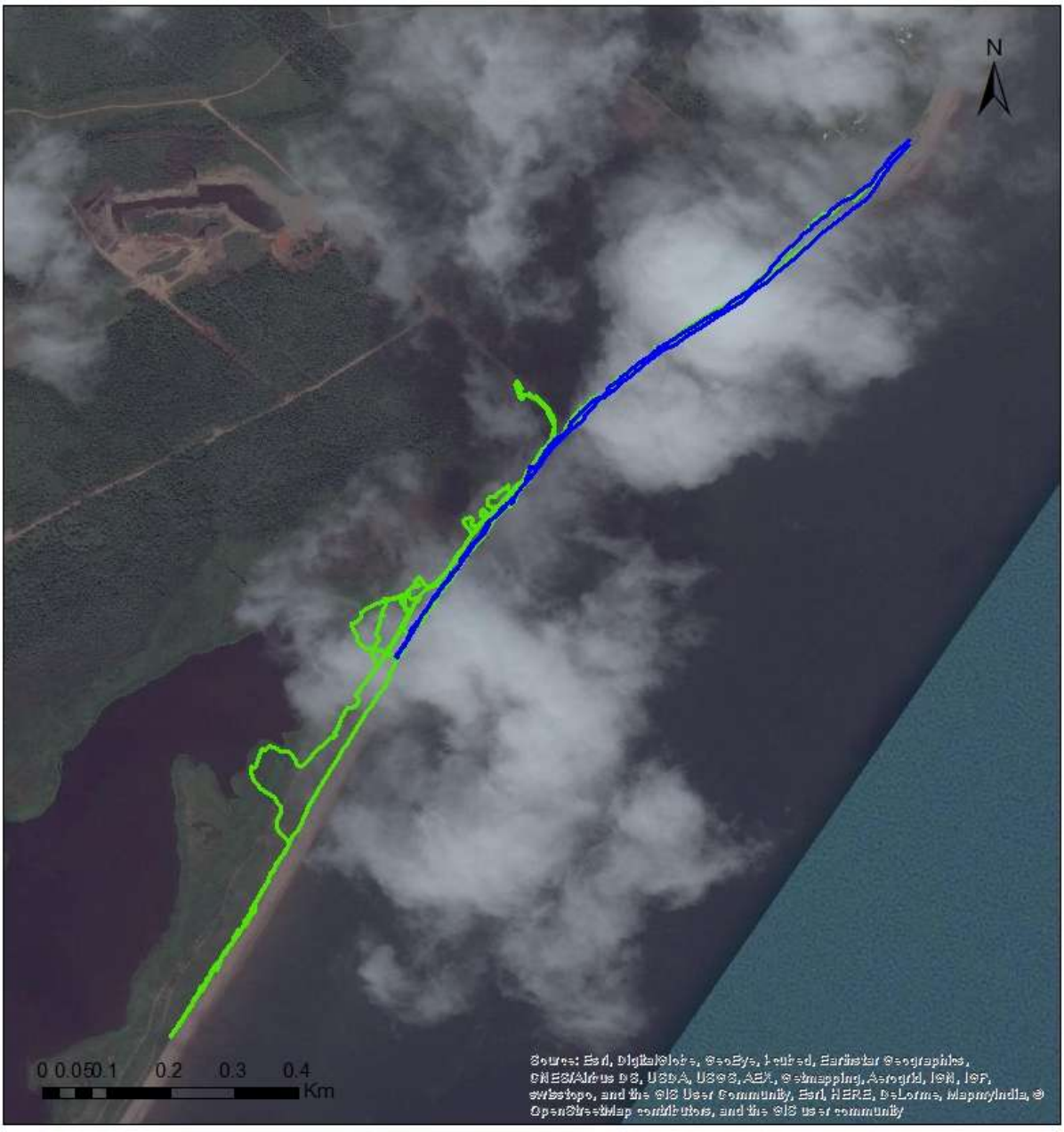
Map 11. Survey tracks at Miscou Plains. Blue line is track of Sarah Robinson, green line is track of John Klymko. Survey conducted 1 September, 2015.



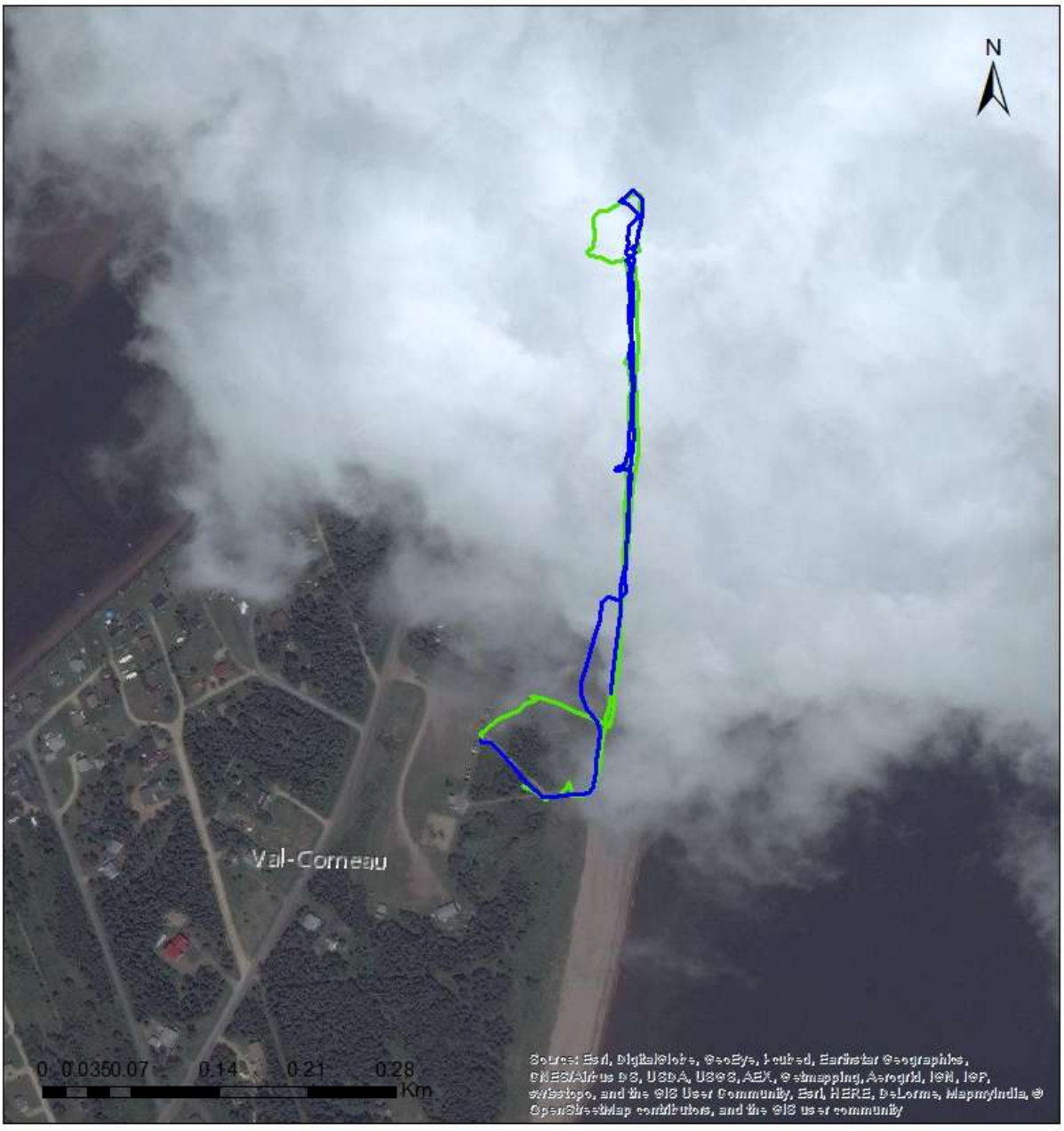
Map 12. Survey tracks at Wilson Point. Blue line is track of Sarah Robinson, green line is track of John Klymko. Survey conducted 1 September, 2015.



Map 13. Survey tracks at Chiasson. Blue line is track of Sarah Robinson, green line is track of John Klymko. Survey conducted 1 September, 2015.



Map 14. Survey tracks at Green Point. Blue line is track of Sarah Robinson, green line is track of John Klymko. Surveys conducted 19 August and 3 September, 2015.



Map 15. Survey tracks at Val Comeau Provincial Park Point. Blue line is track of Sarah Robinson, green line is track of John Klymko. Surveys conducted 3 September, 2015.

Map 16. Survey tracks at Riviere-du-Portage. Green line is track of John Klymko. Survey conducted 19 August, 2015.

Map 17. Survey tracks at Hay Island Provincial Park. Green line is track of John Klymko. Survey conducted 19 August, 2015.

Map 18. Survey tracks at Point Escuminac. Green line is track of John Klymko. Survey conducted 18 August, 2015.

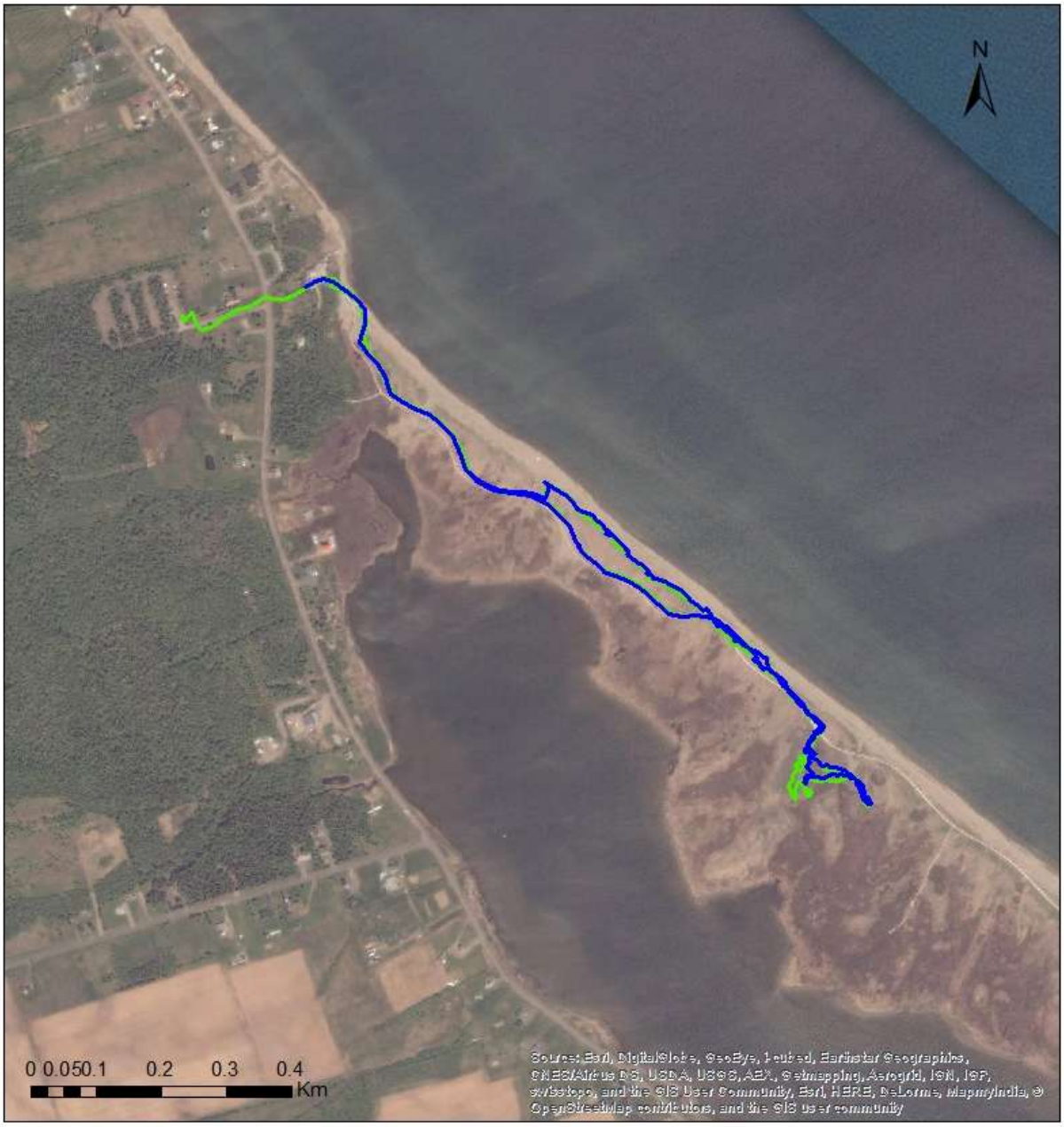
Map 19. Survey tracks at Pointe de Pruche. Green line is track of John Klymko. Survey conducted 18 August, 2015.

Map 20. Survey tracks North Kouchibouguac Dune. Green line is that of John Klymko. Sarah Robinson track not shown. Survey conducted 25 August, 2015.

Map 21. Survey tracks North Kouchibouguac Dune. Green line is that of John Klymko. Sarah Robinson track not shown. Survey conducted 25 August, 2015.

Map 22. Survey tracks at Cap-Lumière. Green line is track of John Klymko. Surveys conducted 20 August 2015.

Map 23. Survey tracks at Petit-Chockpish. Green line is track of John Klymko. Surveys conducted 20 August 2015.



Map 24. Survey tracks at Bouctouche Dune. Blue line is track of Sarah Robinson, green line is track of John Klymko. Surveys conducted 24 August, 2015.

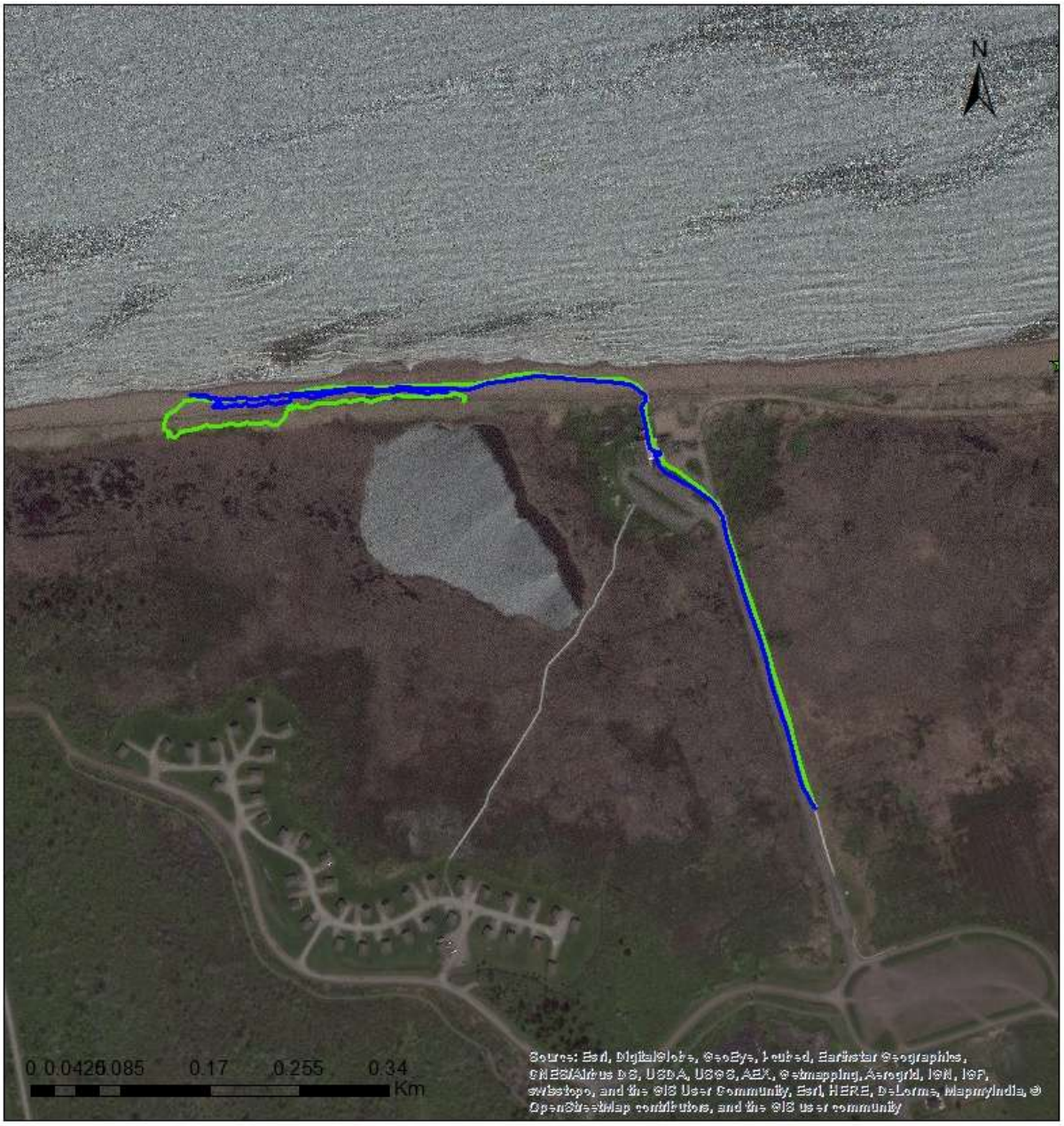
Map 25. Survey tracks at Bourgeois. Blue line is track of Sarah Robinson, green line is track of John Klymko. Surveys conducted 28 August, 2015.

Map 26. Survey tracks at Bar-de-Cocagne. Blue line is track of Sarah Robinson, green line is track of John Klymko. Surveys conducted 24 August, 2015.

Map 27. Survey tracks at Parlee Beach. Blue line is track of Sarah Robinson, green line is track of John Klymko. Surveys conducted 28 August, 2015.

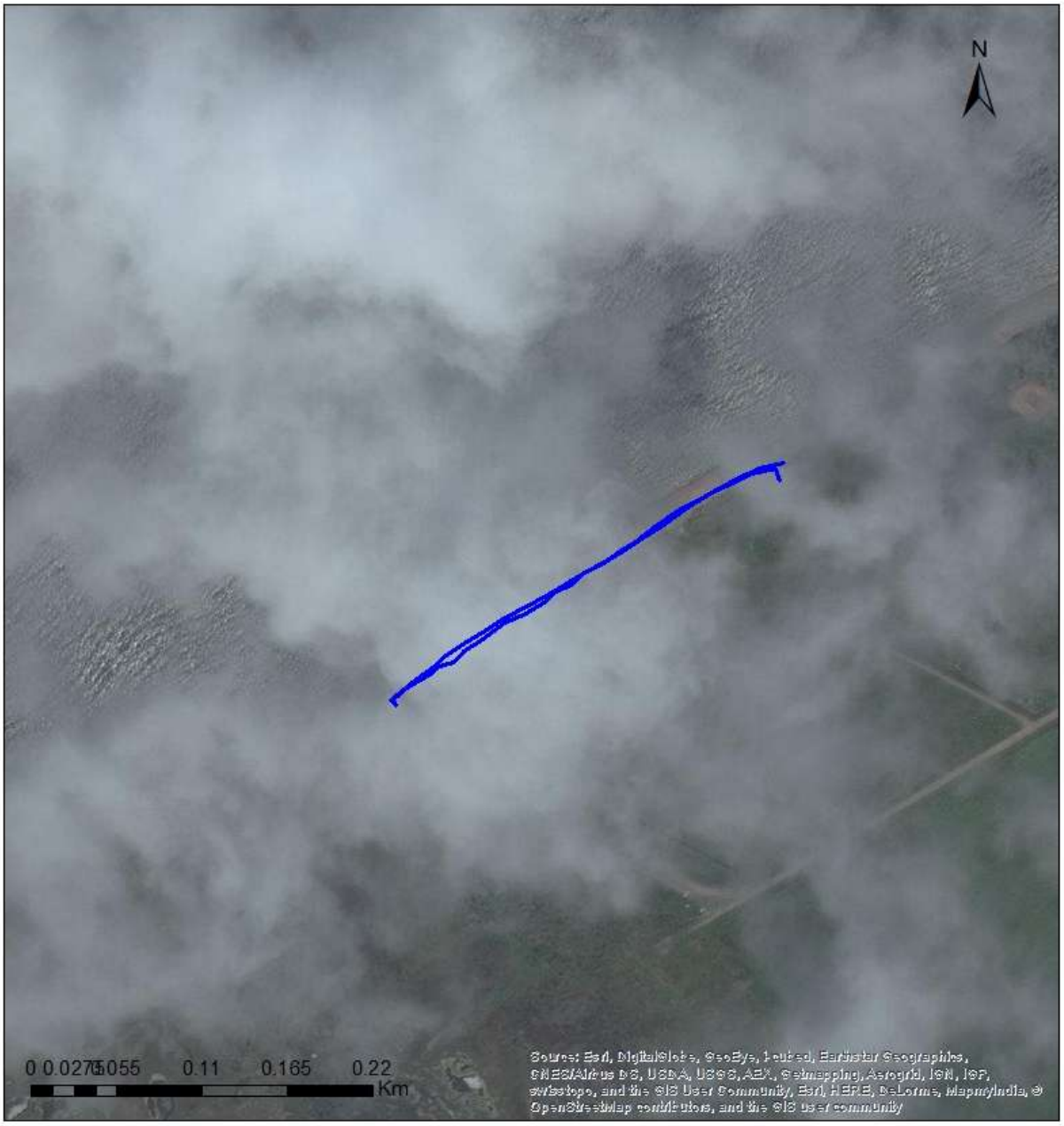
Map 28. Survey tracks at Cap Bimet. Blue line is track of Sarah Robinson, green line is track of John Klymko. Surveys conducted 28 August, 2015.

Map 29. Survey tracks at Sainte-Henri-de-Barachois. Green line is track of John Klymko. Track of Sarah Robinson not shown. Surveys conducted 28 August, 2015.



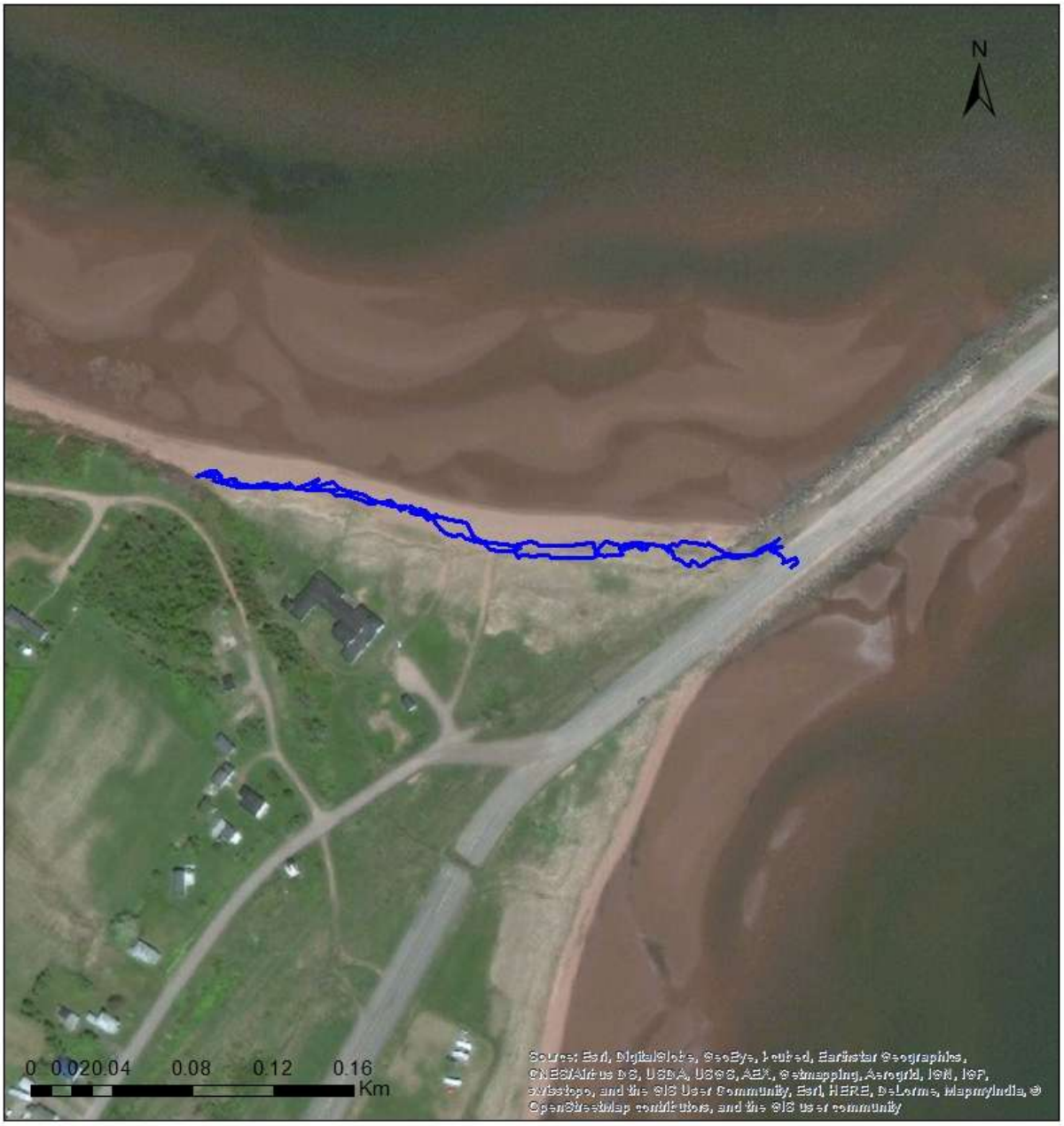
Map 30. Survey tracks at L'Aboiteau. Blue line is track of Sarah Robinson, green line is track of John Klymko. Surveys conducted 31 August, 2015.

Map 31. Survey tracks at Johnston Point. Blue line is track of Sarah Robinson, green line is track of John Klymko. Surveys conducted 31 August, 2015.



Map 32. Survey tracks at Grants Beach. Blue line is track of Sarah Robinson. Track of John Klymko not shown. Surveys conducted 31 August, 2015.

Map 33. Survey tracks at Bayfield. Green line is track of John Klymko. Track of Sarah Robinson not shown. Surveys conducted 31 August, 2015.



Map 34. Survey tracks at Cape Tormentine. Blue line is track of Sarah Robinson. Track of John Klymko not shown. Surveys conducted 31 August, 2015.