Seascape corridors : modeling routes to connect communities across the Caribbean Sea

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Routes Between Neighboring Islands

Connecting Partners in the Long Island Lithic Exchange Network

This chapter encompasses the first case study, which deals with Archaic Age communities in the northern Lesser Antilles. Sites were selected based on their connection with materials known to be exchanged widely in the region, primarily Long Island flint (Davis 2000; Hofman *et al.* 2014; Keegan and Hofman 2017; Knippenberg 2007; Knippenberg and Zijlstra 2008; van Gijn 1993; Verpoorte 1993). These sites all date between 2000 BC and AD 100 (Hofman *et al.* 2007; Keegan and Hofman 2017). Least-cost pathways from a set list of Leeward Islands sites occupied in the Archaic Age were constructed and evaluated. Emphasis will be placed on the interconnection between the Leeward Islands as evidenced by lithic exchange visible in shared lithic material within site assemblages.

Archaic Age occupation of the northern Lesser Antilles, referring here to the group of islands from Anguilla to Antigua (see Figure 28), coincided with the accumulation of knowledge regarding sea conditions and currents (*sensu* Lewis 1994; Tingley 2016) and the probable existence of an inter-island wayfinding mental map (*sensu* Crouch 2008; McNiven 2008; Terrell and Welsch 1998). Routes were modelled on the assumption that this accumulated knowledge supported canoers moving between several sites. The underpinning of these routes was the maintained knowledge of seafaring patterns in the region, described earlier in this work (see Chapter 2). Knowledge of canoe travel corridors between these islands may have influenced social networks and types of interaction in later periods.

Choosing sites that were used across the Archaic Age allows for the discussion of a broader range of sites and a larger network, rather than looking only at sites that were continuously used. The routes between these sites can be hypothesized to reflect those that may have existed in the minds of seafarers during this period and in this region. These routes imply the extension of wayfinding traditions, or the communication of known sea routes between community members. Measuring the hypothetical cost of travel between these places and evaluating the cost of visiting some sites on the way to others can help to judge the feasibility of connections between sites and the layout of mobility networks in the Lesser Antilles. The isochrone

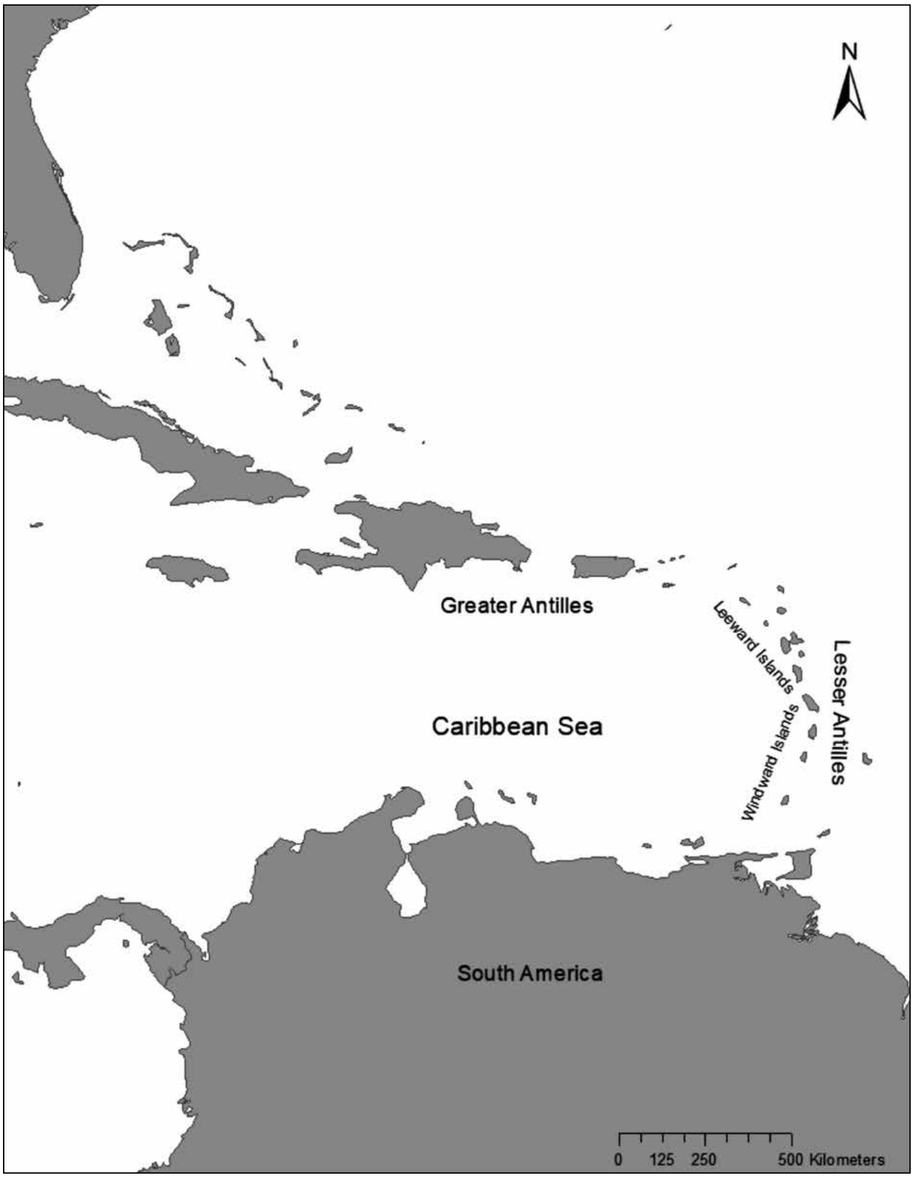


Figure 28: Map of the broader Insular Caribbean region.

model assumes a standard of seafaring existed that supported back and forth travel between the same groups of sites, facilitating the spread of island-associated peoples, materials, and ideas.

Much of the evidence for early connections between sites comes from lithic materials, particularly flint objects. The presence of flint at all the sites used for this case study suggests that there was a cultural tie between this material and Archaic Age Amerindians of the region (Hofman *et al.* 2014; Knippenberg 2007). The spread of Long Island flint is a fitting base for modeling least-cost isochrone pathways to analyse inter-island interconnection.

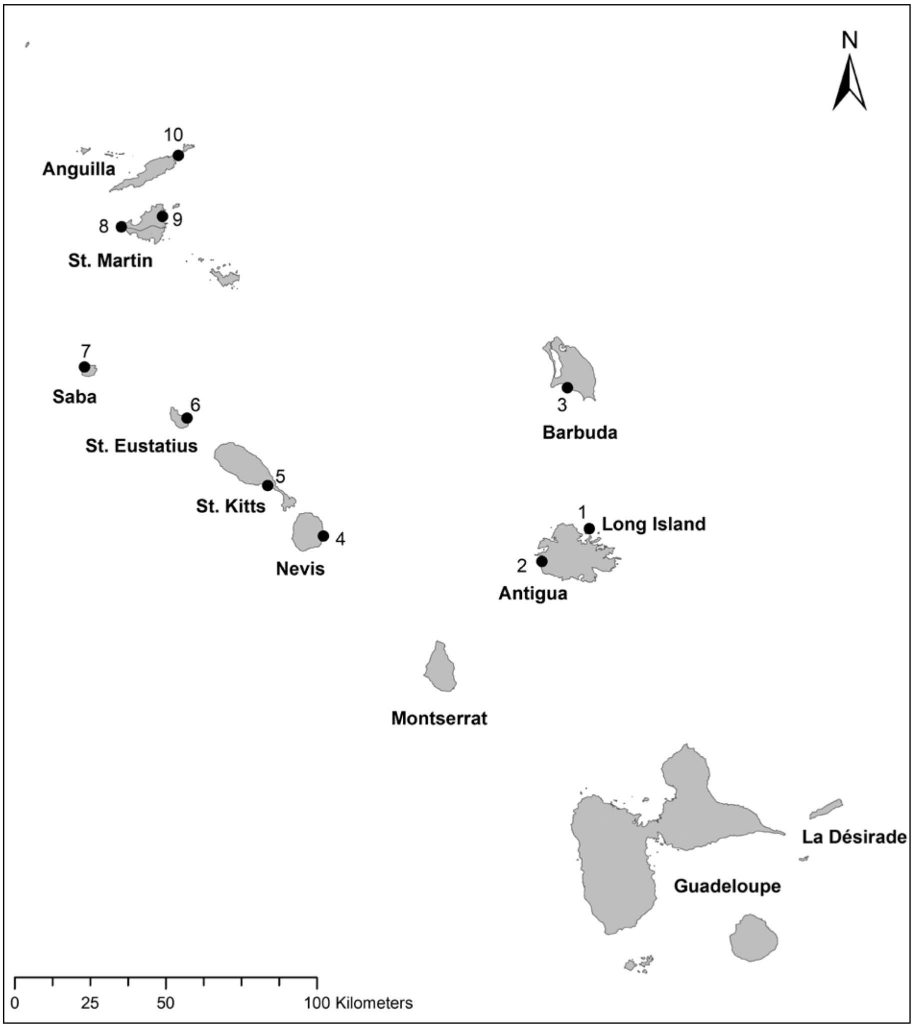


Figure 29: Map of the case study area (Leeward Islands) with the islands labeled. Sites numbered (from southeast to northwest), 1: Flinty Bay on Long Island, 2: Jolly Beach on Antigua, 3: River Site on Barbuda, 4: Hitchman's Shell Heap on Nevis, 5: Sugar Factory Pier on St. Kitts, 6: Corre Corre Bay on St. Eustatius, 7: Plum Piece on Saba, 8: Baie Orientale on St. Martin, 9: Norman Estate on St. Martin, and 10: White Head's Bluff on Anguilla.

It is important to note how infrequently flint is naturally found in the Leeward Islands (van Gijn 1993). As there are already multiple explanations for the formation of the Lesser Antillean island arc within the archaeological literature (Davis 2000; Hofman and Hoogland 1999; Knippenberg 2007; Sealley 1992), the geological forces behind the creation of these flint sources will not be discussed here. There are no known flint sources on Martinique, Guadeloupe, Dominica, Barbuda, St. Martin, or Montserrat (Christman 1953; Knippenberg 1999, 2007; Pinchon 1952; van Gijn 1993; Watters 1980). Although small nodules can be found on St. Kitts and St. Eustatius, these nodules do not seem to have been widely used by Amerindian peoples (van Gijn 1993: 183).

As a result, Antigua and the adjacent Long Island are the prime examples of where flint sources can be found, collected, and used (Davis 2000; Knippenberg 2007).

As two of the few sources of raw flint, Antigua and Long Island became integral to the inter-island exchange network that formed around 2000 BC (Davis 2000; Hofman and Hoogland 2004; Hofman *et al.* 2014). The specific patterns of use of Long Island flint hint at it being a prized resource produced specifically for export (Davis 2000; Knippenberg 2001; van Gijn 1996). Examples of these lithic materials are compelling evidence for connections between communities on Long Island and neighboring islands (Davis 2000; Hofman and Hoogland 2003; Knippenberg 2007; van Gijn 1993). The presence of Long Island flint at various sites hints at groups having direct access to the flint resource, or obtaining it through down-the-line exchange where an object may be procured through a third party (Knippenberg 2007; van Gijn 1993).

As such, Long Island plays a vital role in this case study as a destination of canoe travel corridors (de Mille 2001; Hofman and Hoogland 2003; Knippenberg 2007). Flinty Bay on Long Island was possibly used as a production and export site for flint to all other islands in the case study. Evidenced by the worked flint remains, much of the processing work to pre-form the flint into blades was done before transport during the Archaic Age (Davis 2000; Knippenberg 2007). The desire of Amerindian knappers to pre-work nodules before transport could be due to the distance between the sites and the source of the flint (Bérard 2013; Hofman and Hoogland 2003; Knippenberg 1995). Crews likely also wanted to keep cargo weight at manageable levels, which could be achieved by working flint prior to transport (Bérard 2013; Hofman and Hoogland 2003; Knippenberg 1995). No consistent analytical archaeological method can be used to classify or tie any cultural sequence to the flakes and ground stones found within Archaic Age sites (Davis 2000; Knippenberg 2001, 2007). However, the regularity in the stages of production found at different sites, as well as the artifacts' common origin, link Long Island-sourced lithic assemblages. Even though flint has also been found in Puerto Rico (Hofman *et al.* 2014), direct connections between the Greater and the Lesser Antilles is not discussed in this chapter. Instead, this case study seeks to evaluate connections between islands in direct range of Long Island. These will be evaluated for possible ties to the micro-regional flint exchange of the northern Lesser Antilles.

5.1 Some Islands and Sites

A typological comparison of Archaic Age sites from around the northern Lesser Antilles demonstrated several similarities between site types, use, and assemblage (Davis 2000; de Mille 2001; Hofman and Hoogland 2003, 2006). To evaluate how the modeling of least-cost routes can determine seasonal variance in the possible canoeing networks of a small island cluster, I chose to focus solely on the northern Leeward Islands. Though not discussed in this chapter, parallels can be seen in sites reaching from the Virgin Islands, specifically Krum Bay on St. Thomas to Pointe de Pies on Guadeloupe (Hofman and Hoogland 2003; Lundberg 1989). It is possible that seasonal rhythm of mobility also influenced connections to Guadeloupe, as suggested by least-cost routes modeled for this work, as well as the Virgin Islands. In the future, additional routes to Archaic Age sites to the west and south of the northern Leeward Islands can be modeled to build on the evaluation of mobility networks in this period.

Site	Date	Sample Type	Reference
Flinty Bay	Pre-ceramic (no radiocarbon dates)		Davis 1974; Knippenberg and Zijlstra 2008; Nicholson 1976; Rouse 1999; van Gijn 1993; Verpoorte 1993
Jolly Beach	4225 to 4095 BP	Charcoal	Davis 1982, 2000; Hofman *et al.* 2007; Nodine 1990; Olsen 1976
Plum Piece	3825 to 3470 BP	Land Crab	Hofman and Hoogland 2003; Hofman *et al.* 2006
Norman Estate	4380 to 3960 BP	Shell	Hofman *et al.* 2007; Knippenberg 1999; Nokkert *et al.* 1995
Etang Rouge	4950 to 2750 BP (1495 to 1400 BP)	Shell	Bonnissent 2003; Hofman *et al.* 2006
Baie Orientale	2750 to 1850 BP	Shell	Haviser 1999; Knippenberg 1999, 2004
White Heads Bluff	3365 to 3255 BP	Shell	Crock *et al.* 1995; Hofman *et al.* 2007
Corre Corre Bay	2360 to 2158 BP	Shell	Keegan and Hofman 2017; Versteeg 2000; Versteeg *et al.* 1993
Sugar Factory Pier	4100 and 2175 BP	Shell	Armstrong 1978; Goodwin 1978; Keegan and Hofman 2017
River Site	3875 to 3515 BP	Shell	Hofman *et al.* 2007; Watters *et al.* 1992

Table 2: Table showing date ranges for sites used as nodes in this case study.

Archaeological remains of resources found at these sites indicate a reliance on seasonal activities. These seasonal resources can include marine substance or land-based foodstuffs and materials (Hofman and Hoogland 2003; Keegan and Hofman 2017). The Archaic Age peoples from the northern Lesser Antillean region are assumed to have been non-sedentary foragers (Hofman *et al.* 2006; Keegan 1994; Keegan and Hofman 2017). Sites on these islands likely functioned as a part of a larger seasonal network of complementary settlements or camps (Hofman *et al.* 2006, 2014; Knippenberg 2007). Seasonal rhythms that may have enabled Amerindian peoples to visit multiple islands and establish temporary camps to make use of materials were dictated by both weather patterns and the availability of specific resources (Hofman *et al.* 2006). As indicated by their focus on marine substance and placement near the coast, Archaic Age sites in the Lesser Antilles served seasonal functions.

The sites discussed below span almost the entirety of the Archaic Age period. The following list of islands and sites will be considered in this work, though some as a by-product of route trajectory and not as origin and termination points. Flinty Bay on Long Island, Jolly Beach on Antigua, Plum Piece on Saba, Norman Estate on St. Martin, and Whitehead's Bluff on Anguilla date between 3200 to 2000 BC (Haviser 1991; Hofman *et al.* 2007; Hofman and Hoogland 1999, 2006; Knippenberg 1999, 2001, 2004, 2007; Ramos 2011; see Table 2). Later sites, ranging from 2000 to 800 BC, such as Corre Corre Bay on St. Eustatius, Sugar Factory Pier on St. Kitts, and River Site on Barbuda, represent an influx of peoples into the region (de Jong 1947; Hofman *et al.* 2007, 2014; Versteeg *et al.* 1993; Walker 1980; Watters 1980; see Table 2). Examples such as Baie Orientale on St. Martin (800 BC – AD 100), meanwhile, show an increase in specialisation of tool workshops alongside a decrease in Archaic Age sites around the northern Lesser Antilles (Bonnissent 2008; Bonnissent *et al.* 2016; Haviser 1999; Knippenberg 1999, 2004). Sites like Trants on Montserrat also appear, marking the introduction of Early Ceramic Age communities in the region (Hofman *et al.* 2014; Watters 1980).

These sites may not have all been in use at the same time. Still, it is possible that a mental map (*sensu* Agouridis 1997; Ingold 2009; Lewis 1994; Tilley 1994), which allowed canoers to move between sites seasonally, helped them to return to islands decade after decade. Routes with similar trajectories formed canoe corridors of movement and allow for research to analyze the consistency of connections between islands in the Lesser Antilles Sites from these islands will be briefly discussed to highlight the commonality between the sites and islands used for this case study. A comparison of the sites will demonstrate how modeling routes between Archaic Age sites in the northern Lesser Antilles is beneficial to the study of the mobility of peoples, materials, and ideas.

5.1.1 Antigua and Long Island

Contact with the island of Antigua was likely driven by the regional need for flint. Flint nodules protrude from the limestone in the northeastern areas of the island, which is similar to the environment enjoyed by the Long Island flint sourcing sites like Flinty Bay (Davis 2000: 93). These islands possess the only known places within the Lesser Antillean arc where during the islands' formation "old sea-bottoms" rose to the surface providing access to this quantity of workable flint (van Gijn 1993: 186). Most of Antigua's sites are centered along the northeastern coast (Davis 2000; Knippenberg 1995, 2006; Stokes 1991) and would have had relatively easy access to Long Island. The northeastern coast of Antigua provides a clearer geographic and visual link and a sense of proximity control over the smaller island (Davis 2000). These visual ties could have driven connection between communities on Long Island and Antigua. It may also have encouraged people from Antigua to interact with canoers they could see landing on Long Island for flint.

Communities from many of the surrounding islands were probably in direct contact with Antigua and Long Island, suggesting that these islands would have a high number of sites. Archaic Age sites on Antigua are typically comprised of shell middens (Rouse 1992; van Gijn 1993). These sites and shell middens are consistently placed in areas where the offshore water is shallow as it transitions into the sea (Davis 1982). This placement would have made it easier to moor canoes safely. The position of sites near the coast likely resulted from the preference of Antiguan Archaic Age peoples for water access for transportation purposes (Davis 2000). The placement of nodes for this case study can be linked to this preference for sea access.

Long Island itself was heavily used as a primary source for flint. Long Island's archaeological flint deposits are so dense that determining where a cultural scatter begins and ends can be difficult (van Gijn 1993: 188). To further obscure the image, agriculture and land use disturbance likely altered the position of flint nodules since the historic period (Knippenberg 2001). The abundant presence of flint on Long Island in some ways negates the disruption of the surface finds by modern peoples. At the site of Flinty Bay, for example, Davis (2000:13) found thousands of examples of worked flint. These pieces were crafted from nodules that eroded from limestone outcroppings near the water (Davis 2000). The number of worked pieces combined with the abundant availability of the raw product indicates that the activity at Flinty Bay centered on the "collection and primary production" of flint (van Gijn 1993: 193). Additional emphasis was put on turning out high quality cores from the collected nodules. The presence of primary and secondary blades and the near absence of any retouched tools or blade cores in Long Island assemblages suggests that blade cores were "pre-worked" on the island before export (Knippenberg 1999, 2001: 91).

Another example of an Archaic Age flint-focused site is Jolly Beach on the western coast of Antigua. Davis (2000: 26) found that more than 99% of the assemblage at this site was made up of flaked stone, most of which was flint. The resulting flakes and tools are like those found within sites on Long Island and suggest that these two areas shared the same toolkit (Davis 2000: 45). Van Gijn (1993: 194) argues that sites like this on Antigua likely served as the dwelling places for those who sourced and processed flint on Long Island.

These peoples from Antigua worked the flint before taking it off Long Island. Often peoples preferred to take perfect lithic cores from Long Island sites (Knippenberg 2001). This made the flint 'lighter' for travel to nearby habitation areas where the flint cores could be worked further (Knippenberg 2007; van Gijn 1993). Minimizing weight was essential for efficient long-distance transport of flint between Archaic Age settlements (Knippenberg 2001). The need to transport people and subsistence items alongside flint could have further compounded this concern. However, not all nodules were fully processed by the Amerindian knappers before leaving the island. Evidence for flint knapping has been found on other islands in the northern Lesser Antilles (Hofman *et al.* 2006; Knippenberg 2007). It could be that pre-worked blades provided necessary ballast for the canoe. This would have made it easier to keep the canoe level in the water and prevent the boats from capsizing during the transportation of flint (Bérard 2013).

5.1.2 Anguilla

Whitehead's Bluff on Anguilla dates to around the same period as the sites of Jolly Beach on Antigua, although it has a slightly later date (around 1000 BC) (Crock *et al.* 1995; Keegan and Hofman 2017; Knippenberg 1999). Like the other sites, Whitehead's Bluff shows a marine orientation and examples of Long Island flint that arrived on the island pre-worked, as is the case with other sites dating to this period (Crock *et al.* 1995; Hofman and Hoogland 2003).

The examples of flint found at Whitehead's Bluff differ from Jolly Beach as "only one blade and some cores with traces of blade production were found" amidst a significant number of flakes and flake cores (Crock *et al.* 1995; Knippenberg 1999: 43). This is due to the distance between the two islands, or the distance between the assemblage and the source. The exotic nature of this material could account for the thorough use of these flakes (Crock *et al.* 1995; Knippenberg 1999). Amerindian peoples had to make more frugal and full use of the limited resource once it reached Anguilla (Hofman and Hoogland 2003; Knippenberg 1995). This effort to make optimal use of Long Island flint is also seen in the treatment of blades imported to the other sites in the area, for example Norman Estate (Knippenberg 2007). The commonality in blade transport, manufacture, and use highlights the shared practices involved in the export and import of Long Island flint.

Much like other settlements in the region, Whitehead's Bluff was probably a seasonal encampment (Crock and Petersen 1999; Hofman and Hoogland 2003). The site's location and comparatively small size suggest its placement was centered on access to marine resources (Hofman and Hoogland 2006: 148). It is also possible that this site was used as a connection point between movement to and from St. Martin. Testing the location of hypothetical least-cost paths may show how movement through Anguilla was connected to other sites.

5.1.3 St. Martin

Flint types found on St. Martin are both Long Island flint specimens and a second likely non-local flint (Knippenberg 1999). Secondary working is infrequently observed on flint pieces found at Archaic Age sites (Knippenberg 1999: 44). However, some flint pieces in assemblages show signs of re-chipping and shaping, representing both an increase in the initial effort in constructing the tool and in its durability (Knippenberg 2007). This re-working of flint pieces is consistent with how Long Island blades were prepared for transport. The further reduction done on-site could confirm the transportation of partially processed lithic tools from Long Island (Knippenberg 2007). As mentioned earlier, this points to these materials being part of the ballast for canoe voyages heading north or west.

The sites of Etang Rouge, Norman Estate, Pont de Sandy Ground, Baie Nettle, Trou David, Lot 73, Salines d'Orient, Belle Créole, Pointe du Bluff, Baie Longue 2, Hope Hill, and Baie Orientale on St. Martin are contemporary with Jolly Beach (Bonnissent 2013a, 2013b; Bonnissent *et al.* 2016: Figure 3; Davis 1982; Keegan and Hofman 2017). I have chosen to focus on Etang Rouge and Norman Estate to limit the tested connections to St. Martin, as settlements on this island's coastline were often clustered on the northwest or east side of the island and their assemblages establish ties between St. Martin and Long Island. Movement between these two areas and other islands within this case study can suggest routes headed from and to nodes placed at on either side of the island. Although it is not the earliest example of Archaic Age occupation, Norman Estate, where flint was also further worked (Bonnissent 2011; Knippenberg 1999: 38-40), was one of the first sites dating to this period discovered on the island (Hofman and Hoogland 1999; Keegan and Hofman 2017). Etang Rouge is one of the earliest sites known in St. Martin (Bonnissent 2008). It was occupied from 3000 to 800 BC (Bonnissent 2003, 2013; Keegan and Hofman 2017). Like the nearby site of Plum Piece on Saba, the assemblages contain an abundance of non-local flint types. The absence of unworked nodules at Etang Rouge is consistent with flint remains from Saba (Bonnissent 2013).

5.1.4 Saba

The site of Plum Piece on Saba also contains pieces of Long Island flint, most of which were "un-retouched whole flakes" (Hofman and Hoogland 2003: 18). However, blade production at Plum Piece may have been limited (Hofman and Hoogland 2003). This ties into the hypothesis that partially pre-formed blades were exported from sites like Flinty Bay to those like Jolly Beach before being distributed throughout the region. The inhabitants of Plum Piece either procured the material and transported it to Saba or were the recipients of these modified pieces. The absence of nodules at this site suggests they were received from other places within the network as well (Hofman and Hoogland 2003). This indicates that like Flinty Bay and Jolly Beach, Plum Piece was a node within the larger lithic exchange network (Hofman and Hoogland 2003; Knippenberg 2007). The amount of imported and worked Long Island flint present at the site is a strong argument for its inclusion within the Archaic Age lithic network.

The archaeological assemblage of Plum Piece also provides information on community life besides the movement of flint. Seasonal divisions of life at Plum Piece can help to explain the purpose of the site located away from Long Island but still under its influence. The collection of specific types of marine and terrestrial resources provides one argument for seasonal habitation of these islands (Hofman and Hoogland 2003). The seasonal diet for Amerindians at Plum Piece consisted partially of conch, including *Lobatus gigas* or queen conch. People likely extracted and processed the meat from these mollusks on the beach, perhaps near canoe landing sites (Hofman and Hoogland 2003). The site's focus on crab and bird populations also suggests a seasonal component to the occupation of the island. The most common type of bird remains found at Plum Piece are classified as Audubon's Shearwater (*Puffinus lherminieri iherminierii*) (Hofman and Hoogland 2003). These birds commonly roost on the island between February and July (Hofman and Hoogland 2003: 17; Hofman *et al.* 2006).

The Audubon's Shearwater's roosting period could indicate which months to closely study when comparing seasonal routes to and from Saba. Routes that followed the flight paths of birds could indicate that people were interested in subsistence collection. Routes that also pass by other islands indicate routes where people may have wanted to connect with seasonal resources or peoples on neighboring islands. A comparison of different travel routes and rhythms in February to July and other parts of the year can indicate what routes were used for convenience, for external social reasons, or for the collection of subsistence resources.

Audubon's Shearwater could also have been used as a part of navigation practices or a mental map. Audubon's Shearwater fish by diving from the air towards their prey (Nellis 2001). Amerindian seafarers could have followed the flight and fishing patterns of these birds out to sea to seek out fish (*e.g.*, Lewis 1994). Evaluating whether canoe routes pass near or over areas with higher densities of fish schools could indicate a connection between gathering marine resources and travel. This includes routes through areas like the Saba Bank, which may have been a resource collection area connected to the site of Plum Piece (Hofman and Hoogland 2003). However, this technique may have been minimally used with other species due to some birds' preference for night fishing (Nellis 2001).

The stratigraphy of the site with seasonal materials accumulated during different stages of deposition within larger refuse middens and caches of conch adzes suggests that Plum Piece may have been used, abandoned, and reoccupied several times during the its lifespan (Hofman and Hoogland 2006: 154). This continual occupation and abandonment of a site indicates that peoples inhabiting it knew both the site's location and enough navigation to maneuver to it multiple times. These seasonal occupations show that Archaic Age Amerindian peoples were competent canoers with transferable knowledge of seafaring practices and technology. Amerindian canoers might also have had a shared mental map with the locations of sites like Plum Piece on Saba and Flinty Bay on Long Island (*sensu* Agouridis 1997; Crouch 2008; Lewis 1994; McNiven 2008; Terrell and Welsch 1998), which would have allowed these seafarers to travel between sites on different islands during the optimal season.

Plum Piece may have served more than one role within the Archaic Age Amerindian canoeing community due to its position inland. It is located high in the hills on Saba (Hofman and Hoogland 2003). Amerindians who camped there had access to wood that could be used to build vessels and likely used this seasonal campsite as a base for canoe construction (Hofman and Hoogland 2003). Further research is needed to evaluate if the February to July seasonal period coincides with the time of year when trees were cut down and made into canoes.

5.1.5 St. Eustatius

The site of Corre Corre Bay on St. Eustatius ascribes to the pattern of other Archaic Age sites in the region. Hofman and Hoogland (2006) determined that Corre Corre Bay on St. Eustatius was contemporaneous with other Archaic Age sites in the region due to the similarity of the assemblage. Radiocarbon dates for Corre Corre Bay indicate it was in use around 900 BC (see also Versteeg *et al.* 1993). The location of the site suggests it is a good candidate for comparisons with other northern Lesser Antillean Archaic Age sites. Corre Corre Bay is positioned on the southeastern coastal area of the island (Haviser 1985). It is more difficult for canoers to land near the site, as it is located on the part of the island that receives heavy winds and waves. However, it is positioned to take advantage of canoe travel corridors. This offers an opportunity to relate site position to the routes between two other islands, tying site placement to inter-island travel.

There was a prevalence of marine remains in the site's assemblage. Much of the marine focus of this site was on conch and *Cittarium pica* (West Indian top-shell) (Morsink *et al.* 2013). The presence of these marine materials suggests Amerindian peoples on St. Eustatius were more interested in coastal resources. This focus was possibly tied to the method of accessing sites in Corre Corre Bay, where canoes moved into the bay on calmer days for short-term visits (Morsink *et al.* 2013).

Long Island flint was also found in the area around Corre Corre Bay (Haviser 1985). These flint objects may have been used to cut mollusks from their shells, linking the lithic presence to the marine focus of the site (Morsink *et al.* 2013). The presence of flint demonstrates the connection between St. Eustatius and the inter-regional network of exchange tying the islands of the northern Lesser Antilles together.

5.1.6 St. Kitts

Two Archaic Age shell middens make up the site of Sugar Factory Pier on the island of St. Kitts (Armstrong 1979; Goodwin 1978) and indicate that the site was used between 2100 and 200 BC (Goodwin 1978). The long-term use of both middens supports the existence of a strong link within a community shared, or individually referenced, mental map used by Amerindian navigators, a map that could lead them to return to 'known' areas over long time spans (*sensu* Schlanger 1992; Terrell and Welsch 1998; Terrell *et al.* 1997; Tilley 1994). Both middens are predominantly comprised of marine shells. However, the shells were mostly the remains of clams instead of conch that is found at most other sites dating to the Archaic Age (Goodwin 1978). Though this site may have looked more towards coastal resources, as no pelagic fish bones were found in either deposit, the site's marine focus is still consistent with the other sites used for this case study (Goodwin 1978; Versteeg *et al.* 1993).

There is no strong evidence of a lithic tradition visible at Sugar Factory Pier (Goodwin 1978). The presence of one large chert blade found in the older midden is the best support for including this site in a broader inter-island network, especially as there are no chert outcrops on the island (Goodwin 1978: 7). The chert's presence indicates importation from another island (Walker 1980), perhaps as a part of the chain of seasonal movement that connected Antigua to Saba. Though there is not enough evidence at the site to determine if Sugar Factory Pier was a seasonal encampment or whether it was only used for a short period, it is worthwhile to include its presence within the model to evaluate its potential as a stopover point on routes between other islands. The placement of Sugar Factory Pier should be checked against routes to and from other islands to confirm its possible inclusion in a navigator's wayfinding map.

5.1.7 Nevis

The assemblage at Hitchman's Shell Heap on Nevis has a marine focus, with coastal scatters consisting of fish bones and mollusk shell remains, including conch (Wilson 1991). Fish bones found at the site came from reef fish, such as grouper and parrotfish, and pelagic fish, such as barracuda. As is the case with other Amerindian Archaic Age sites in the region, the presence of deep-sea fish links this site with canoe use. Like the diets of communities inhabiting Plum Piece on Saba, land crabs were also part of the subsistence pattern of Amerindians living at Hitchman's Shell Heap (Versteeg *et al.* 1993; Wilson 1991). Lithic tools were recovered from the site (Wilson 1991), indicating people at Hitchman's Shell Heap also engaged in the movement or exchange of stone tools. These factors indicate that the site of Hitchman's Shell Heap merits inclusion in this case study.

5.1.8 Barbuda

Barbuda's River Site is located on the south coast of the island. It faces both Antigua and Long Island, both of which are located roughly 60 km south across the channel. River Site lies adjacent to the coast and follows the marine influence present at other Archaic Age sites in the region (Nicholson 1994; Watters *et al.* 1992). The site is also physically close to other Archaic Age sites on the island, most of which are near the large shell midden called the Strombus Line (Rousseau *et al.* 2017). This geographic placement mirrors that of the other sites mentioned above in its location near the coast and its potential for connections to canoe travel corridors or its possible position in communal or individual mental wayfinding maps.

Like Plum Piece (Hofman and Hoogland 2003), remains of shell tools made from *Lobatus gigas* were found within the River Site (Watters *et al.* 1992). Piles of *Strombus gigas* were recovered near the site along the coast (Watters *et al.* 1992). Like the site of Corre Corre Bay, evidence of *Cittarium pica* was also found within the site. Two shell celts, or Archaic Age tools, from the site were dated to between 1700 and 1875 BC (Watters *et al.* 1992). Unlike earlier assumptions that the River Site was merely a mollusk collection point for Ceramic Age communities (Watters 1980), this suggests that the site falls within the Archaic Age (Watters *et al.* 1992). The lack of ceramic material at the site also indicates the site belongs to the Archaic Age. This allows it to be used as an origin and termination point for routes modelled here.

5.1.9 Montserrat

There is one proposed Archaic Age site on the island of Montserrat. Lithic materials at the Upper Blake site are consistent with those found at other sites discussed in this case study (Cherry *et al.* 2012). Though no dates have been returned for this site, archaeologists were able to place the characteristics of the lithic materials to ca. 4000 and 2500 BP (Cherry *et al.* 2012). The site on Upper Blake is located away from the coast at an altitude of about 1000 feet (Cherry *et al.* 2012). This makes Upper Blake's placement similar to that of Plum Piece on Saba, which is at an altitude of about 1300 feet (Hofman and Hoogland 2003).

Though not an Archaic Age site, it is important to briefly mention Trants, as many pathways modeled for this work pass by the island. Trants sprung up in the transition between the Archaic Age and the Ceramic Age (Cherry *et al.* 2012; Hofman *et al.* 2014). It served as a production site for microlapidary objects (Crock and Bartone 1998; Watters 1997). Amerindians from Antigua and Montserrat may have maintained either direct or indirect relationships into this period, as indicated by the Antiguan-sourced carnelian artifacts found within Trants assemblages (Hofman *et al.* 2007; Murphy *et al.* 2000). The strong bonds between this island and others from this region suggest that there may be more to explore in terms of mobility and exchange in the southwest portion of the case study region (Slayton *et al.* 2014). Though not included as an origin point, the relation of these sites to the pathways modelled between nodes used for this work could indicate a connection between route and site placement.

5.2 Modeling Interpretations

The sites discussed above were used as origin points for least-cost pathway modeling. Tying origin points to sites with Long Island flint linked the computer-modeled routes to reality. Islands will be evaluated both on an individual and interconnected basis. The specific nodes will be connected and the direction of travel discussed.

The potential length of voyages in the northern Lesser Antilles can be compared against those hypothesized for early colonization paths across the Caribbean Sea, for example those proposed by Callaghan (2001), Altes (2012), or Rouse (1992). The layout of the Lesser Antilles meant canoers did not have to travel as far as those colonization routes and offered shorter trips depending on the season. In comparison to colonization routes that could last over five days (Callaghan 2001), maximum travel times in the northern Lesser Antilles of one and a half days seems like an easily feasible goal. As these communities were making trips between neighboring islands regularly, canoers would be aware of the risks and rewards of longer journeys. These shorter routes relate to the canoers' possible preference for optimal pathways, if indeed crews followed similar travel corridors. These pathways might represent possible recurring avenues of movement learned over several trips, like remembering how certain currents affected moving through an area. Canoers or navigators remembering currents or travel corridors is consistent with Ingold's (2011) suppositions about the development of mental maps based on both on an individual's past trips.

The availability of resources is another way to gauge the optimal season for departure. An example of how the change in seasonal resources might affect the launch times of canoes is the access to flocks of birds. As mentioned above, birds can serve as food directly, or as an indicator for the location of fish schools (Lewis 1994). Birds, like humans, have preferred daily rhythms and season-specific activities (Cowx 2008). The presence or absence of birds perhaps motivated canoers to head out during different seasons (Lewis 1994). For example, the presence of the Audubon's shearwater on Saba during the February to July season possibly influenced the travel of canoers (Hofman and Hoogland 2003). Different optimal departure times exist for optimal routes from Saba to Long Island in this period. Further evaluation of currents coinciding with migration patterns of several bird species out to sea over the Saba Bank or the west coast of Saba is necessary to confirm this hypothesis.

5.2.1 Route Costs

Testing the possibilities of movement between islands relies on an understanding of how difficult it would have been to connect with communities on neighboring islands. For this study, the difficulty of canoeing between sites is measured through the time it takes to complete a journey from origin point to termination point. To determine these costs, I use two methods. First, I determine how the underlying current might affect movement through the region. Second, I use the isochrone route tool (see Chapter 4), which models an optimal canoe route by calculating which direction of travel results in the lowest time cost over several time fronts. Comparing the cost to Amerindian seafarers of different routes can also hint at what routes returned by the model were more likely used. Together these runs help to evaluate of current strength and route cost can suggest seasonal canoeing periods.

5.2.1.1 Currents and Seasonality

Route modeling done for this work is meant to reflect real currents and hypothetical routes used by Amerindian navigators, possibly relating to the existence of a communal mental map. During the prospective phase of this study it became apparent that checking for differences in the current shifts prior to modeling was appropriate when discussing seasonality. Data on modern currents can point to seasonal trends that must be taken into account when modeling the isochrone routes. Evaluating current data before modeling allows for the months associated with sailing seasons to be given more attention. To look for these canoeing seasons I evaluated information on current prior to its inclusion in the model. Two methods were used to evaluate the difference in current force over the year. One focused on analyzing the currents themselves. The second compared the results of a single 'test route' over several months to check for seasonal fluctuations in time cost.

Three points were sampled for evaluation using the current tool (see Chapter 4). The northernmost point was placed near St. Martin and the southernmost point below Antigua (see Figures 30, 32, and 34). I selected areas in or near island channels and near areas of route-heavy activity. Channels typically have currents with higher associated forces moving through them, because in areas of sea with few islands there is nothing to slow currents down and cause drag (Bowditch 2002). I placed two points in an island channel to evaluate how routes might overcome areas of higher current intensity. I also wanted to check one area of higher concentration of travel. The space in the middle of the northern Lesser Antillean island cluster, as represented by the chosen Point 1, likely had many canoes passing through it annually. All points are located between several islands of comparative assemblages and sizable occupation during the Archaic Age.

Point 1 (17.30, -62.38) corresponds to a location in the middle portion of the northern Antillean island cluster (see Figure 30). Current at this point pushed to the northwest. The force direction shifted during the fall months, or September to October towards the northeast when calculating the average over 30 days. When calculating the average over 15 days, currents shifted towards the northeast from the latter part of September to the beginning of October (see Figure 31). There is also a period between September and May where the current pushes out to the southwest. However, these aberrations were short, and likely would not have prevented canoers from connecting with other islands during most of the year (see Figure 31).

Figure 30: Point 1 sampled by the current tool.

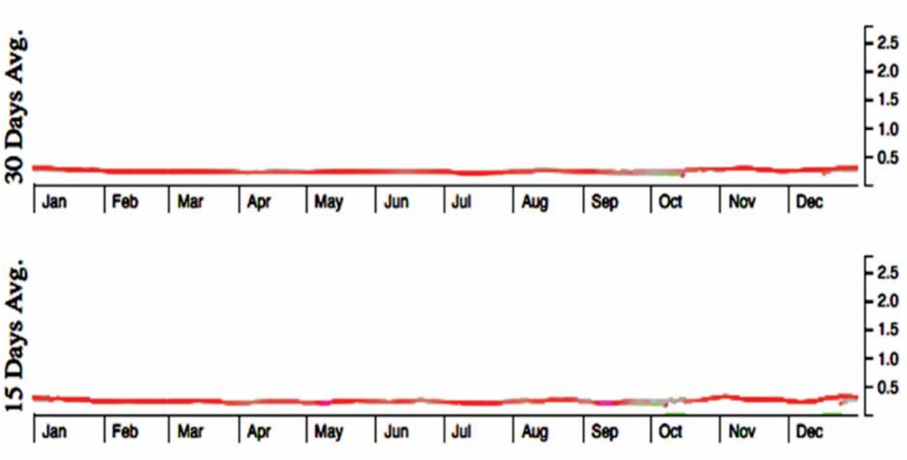


Figure 31: 15- and 30-day averages for current strength and direction between 2010 and 2016 for Point 1. The color wheel below indicates the standard direction, north, in grey. Deviations from this are depicted by the color tied to the direction on the wheel.

Seasonal interpretations may be limited when looking at the force behind the currents at Point 1. Though the direction is important, the overall force may be so similar throughout the year that these values do not reflect an overarching seasonal narrative that can be applied to voyaging. This is reflected in the averaged data graphs where current force remains within the band of 0 to 0.5 knots (see Figure 31).

Point 2 (16.7, -61.61) samples an area south of Antigua, north of Guadeloupe, and east of Montserrat (see Figure 32). This area was chosen because in early runs of the model some routes that should have gone directly north instead came south towards this area. The resulting current data for this point is more erratic than Point 1, probably because of its position in the center of an unprotected channel. There was a wider spread of force bearings in July and September 2013 to 2016 (see Figure 33).

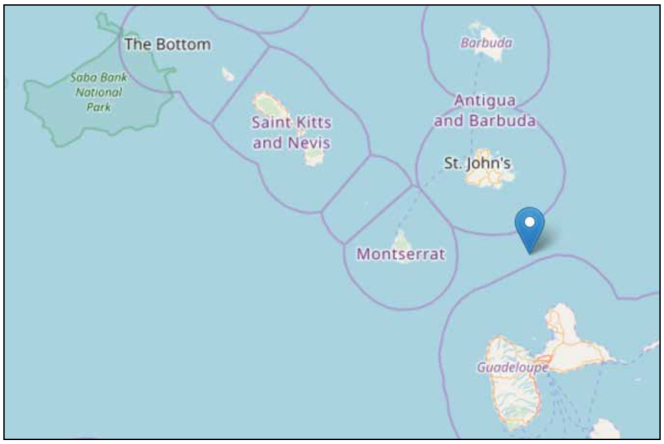


Figure 32: Point 2 sampled by the current tool.

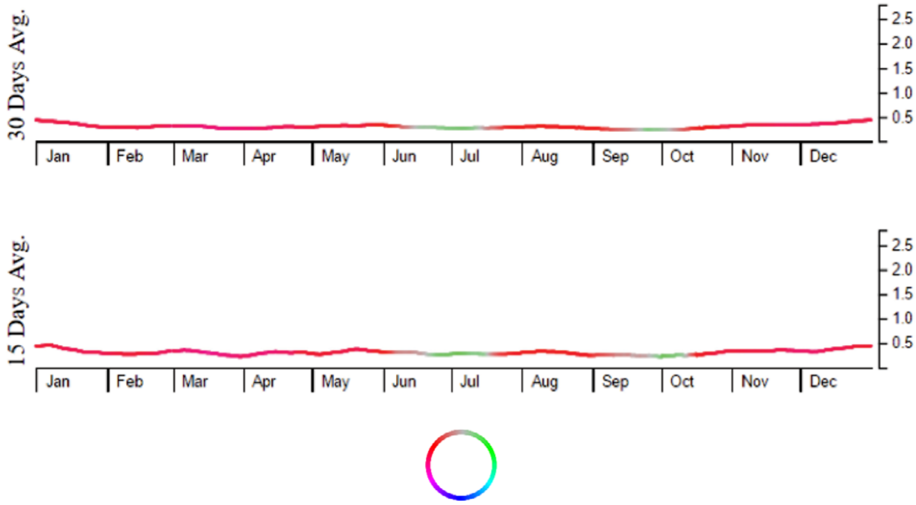


Figure 33: 15- and 30-day averages for current strength and direction between 2010 and 2016 for Point 2. The color wheel below the map indicates the standard direction, north, in grey. Deviations from this are depicted by the color tied to the direction on the wheel.

Together with the data from Point 1, this could indicate that September was a particularly difficult month for travel.

Point 3 (17.83, -63.16) lies at the northern end of the case study region. Located between St. Martin and Saba, I chose to place a point here to assess current movement through an additional channel in this region (see Figure 34). Data returned for Point 3 has a higher discrepancy in current averages between years than is apparent in the values returned for the other two points. The bands representing the current averages in Figure 35 show current force was more variable at this location. These bands also indicate that force values for Point 3 had a slightly higher average than currents at other points, especially in December (see Figure 35). However, these values are still low enough that any influence of seasonal values was limited.

Figure 34: Point 3 sampled by the current tool.

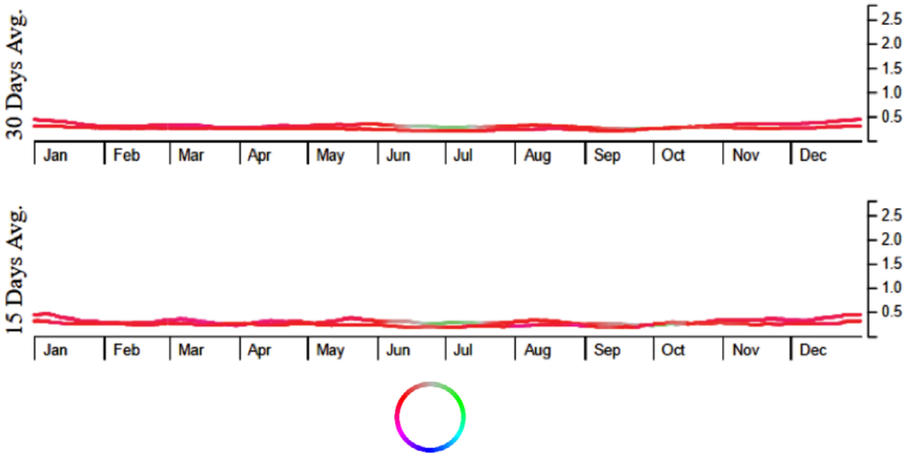


Figure 35: 15- and 30-day averages for current strength and direction between 2010 and 2016 for Point 3. The color wheel below the map indicates the standard direction, north, in grey. Deviations from this are depicted by the color tied to the direction on the wheel.

Direction values for travel periods at Point 3 also differ from the previous examples. June and July are the best months to travel to the northeast from this point. This suggests that people wanting to canoe southeast from this area should leave earlier in the year than those living further south. When one looks at the year's data without averaging, it appears that September was also a good period to travel east. The results from the tool suggest that when arriving at Point 3 it is best to find land quickly or the current may take the crew further out to sea.

The window of opportunity when the currents are moving east is small, in some cases only a month (see Figures 31 and 33). However, it would have allowed any real-world canoers that followed travel corridors close to these route trajectories to travel in different directions. The shift in current force from the northwest to the northeast during June and July could have allowed people to carry out voyages that were inadvisable at other times of year. Changes in current heading had larger implications for

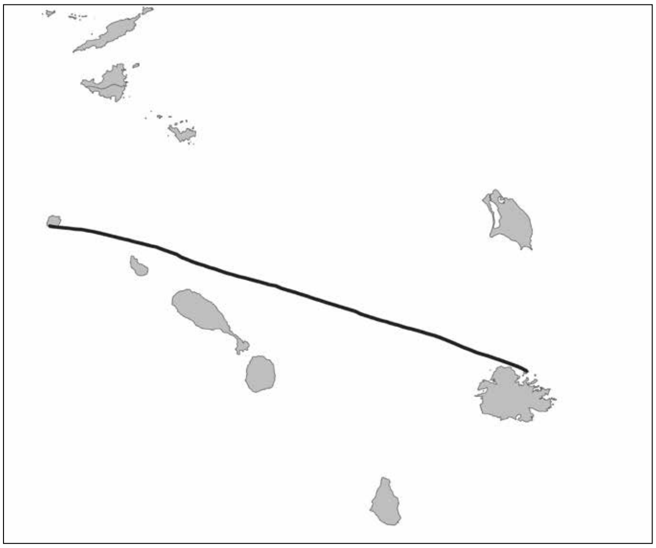


Figure 36: Pathway of the route (indicated in black) evaluating the current's effect on route placement using the least-cost isochrone tool developed for this model.

the direction of least-cost travel, or more specifically whether crews that might have followed along these travel corridors went directly to an island or undertook return voyages. These shifting canoeing periods called for seasonal visiting. For example, seafarers might have left from Saba in June to take advantage of the current pushing east. They could then return in August when the currents once again moved towards the west (see Figure 33). Staggering the direction of travel through the year to fit seasonal parameters may have pushed these communities to travel east in September and return in November (see Figure 31).

I wanted to ensure that the underlying current was reflected in the results of the model. If modeled routes closely related to the averages expressed by the current tool it could mean that years evaluated using the tool can stand in for longer periods of time and that the model reflects real world conditions. The route connecting Long Island to Saba was chosen to check against the results of the current tool to propose base seasonal values for this region (see Figure 36). I ran the isochrone tool for the route from the years 2010 to 2015 with runs beginning every three hours.

The time cost results from this group of runs showed no broad variance in the returned values for several runs of this pathway. The differences in the time costs amounted to an average of zero to five hours. These returns suggest that most trips were within the realm of human capability and of a similar difficulty level. No season stood out as the clear choice for canoe trips. This is reflected in the tables below, all of which demonstrate the resulting route costs return values within the same period.

A series of boxplots was generated to further evaluate how these routes varied over several years. All boxplots represent one month and the time costs of routes from each day within that period (see Appendix B). When looking at the boxplot graphs in sequence it is easy to see slight trends of current flowing between months within a year, though this is likely due to the range in time values observed throughout each day. When regarding the test route using the isochrone tool, there is no disruption in the current flow between modeled periods. This is consistent with the assumption that the model reflects real world values.

In the January boxplot, route time costs more closely correspond to one another than in graphs from other months (see Appendix B). Route time costs from February and March also keep to a time band of between 25 and 30 hours (see Appendix B). Returns for April have a similar spread but keep to between 25 and 33 hours (see Appendix B). As route time costs remain more consistent these months are more reliable for further analysis. Voyaging may also have been safer for crews in these months. Canoers that may have followed pathways similar to the ones suggested here and set off in these periods would have had a more reliable sense of the voyage's expected length. Conversely, time costs returned for August, September, and October were less consistent (see Appendix B). These months were less likely to be used for travel.

These boxplots demonstrate that many of the routes returned for the test run finished within five hours of one another across all seasons. As a result, no month is observably optimal for canoeing based on the similarity of time cost returns. It may be that longer routes were avoided by the Amerindian navigators. The difference of five hours does suggest that these journeys would have been less attractive to crews. Five hours is close to the time cost necessary to travel across an island channel. For example, it takes roughly six and one-half hours to canoe between Martinique and St Lucia (Bérard personal communication 2014).

Extreme differences in time costs were returned in some cases and routes that exceed a month's average time cost were not considered truly optimal possible routes and have been excluded from analysis of route costs. For example, there was an extreme return of over 36 hours for one route's time cost in July. This is over 10 hours longer than the mean time cost for the month before (see Appendix B). This route also exceeds the daily allotment of canoeing by an individual crewmember, in accordance with Callaghan's theory of route shifts lasting eight hours (Callaghan 2001). This canoe pathway likely coincided with an extreme weather event and can be seen as an outlier in the data and thus excluded from consideration. As mentioned previously (see Chapter 4), the isochrone tool cannot account for extreme weather events and instead returns an optimal route for whatever current data is inputted into it.

Testing the possibilities of movement through the northern Lesser Antilles with this trial run defined the appropriate factors to include for evaluation of canoe pathway route costs. Looking towards the seasonal fluctuation apparent in other routes may point to canoeing trends or optimal seafaring seasons. However, the currents are relatively stable. This is demonstrated both by the returns of the current tool and the test route run between Long Island and Saba. In the next section, I will explore if pathways modeled between other sites display similar seasonal averages, or lack thereof, for route costs.

5.2.1.2 Route time costs

One advantage to approaching connections in the Archaic Age northern Lesser Antilles with route modeling is the sheer number of canoe pathways returned. However, this can also lead to an overabundance of results. The large number of results makes it difficult to properly analyze the connections shown by these routes. As the model samples the sea current data set every three hours, there are eight cost values returned for every day of the month for each route. This number is then multiplied by every year where routes could be run. As there is also no one month that contains all the positive (or shortest) or all the negative (or longest) routes I have selected several times of year for targeted analysis.

5.2.1.3 Seasonal Averages

The best origin point to start analysis of seasonal periods is Long Island's Flinty Bay. As Long Island flint is the binder used to connect all the nodes within this study, it seems appropriate that it should be a part of a seasonal approach. However, as Long Island's Flinty Bay lies close to Antigua, some of the analysis provided here will deal with both.

Movement from Flinty Bay to other sites has a lower general associated cost than canoe routes from the site of Jolly Beach on the west coast of Antigua. Time costs in June and August are still within a three-hour margin of each other and these months represent an optimal canoeing period. Comparatively, the highest minimum value for a least-cost route comes in at 10 hours for a pathway in December. When travelling from Flinty Bay to Jolly Beach it is better to travel in January and April where the average time costs are between four and one-half and six hours. However, most routes have a cost of between four and one-half and nine hours. These low costs demonstrate the distance between Jolly Beach and Flinty Bay may have been relatively easy for those crews that moved along the same corridors as the routes model here. The ease of movement between these two sites supports that archaeological evidence that this link was a cornerstone of the flint exchange (see Davis 2000).

After modeling movement between Long Island and Antigua, which were geographically the closest of all case study nodes, I computed connections towards other sites. Each route corridor has a different average time cost associated with it, though these route times do not diverge widely from one another. For example, the mean time costs returned are very like one another when looking at movement from Long Island to Saba in January and July (see Tables 3 and 4). This is true both between months and for different departure times evaluated in the same month. The average standard deviation for routes moving between Long Island and Saba is 4.34 in January and 5.3 in July, which is higher than the standard deviation for routes connecting Saba to Long Island (see Tables 3 and 4; Appendix B) The difference in standard deviation could also indicate that movement in January was more predictable than movement in July. Navigators likely preferred predictable travel and may have preferred traveling during the winter month.

	Min.	Median	Max.	Mean	standard	missingAbs	missingPerc
0:00	25.4	27.96	39.11	29.46	3.838289	7	22.58065
3:00	26.02	27.59	50.88	31.42	7.515236	5	16.12903
6:00	25.08	27.42	40.54	28.23	3.74079	8	25.80645
9:00	25.51	27.72	44.03	29.72	5.088017	7	22.58065
12:00	25.45	27.54	44.69	29.91	5.451259	8	25.80645
15:00	25.52	28.07	51.71	31.16	6.322937	6	19.35484
18:00	25.39	27.47	40.05	28.16	3.013735	8	25.80645
21:00	25.22	27.57	43.42	29.21	4.869163	8	25.80645

Table 3: Long Island to Saba least-cost route values for January. Columns from left to right: Minimum Time Cost, Median Time Cost, Maximum Time Cost, Mean Time Cost, Standard Deviation, Number of Missing Routes (or routes that did not complete), Percentage of Missing Routes (or routes that did not complete). Time value is represented in hours. Rows represent time of day the canoe launched.

	Min.	Median	Max.	Mean	standard	missingAbs	missingPerc
0:00	24.87	27.39	43.36	30.32	5.923895	12	38.70968
3:00	24.78	27.31	52.12	30.56	6.79233	7	22.58065
6:00	24.52	28.52	50.01	31.77	6.248519	6	19.35484
9:00	25.43	27.44	39.37	29.31	4.60132	8	25.80645
12:00	24.02	26.98	43.24	29.63	5.926337	13	41.93548
15:00	25.6	27.37	38.38	29.03	4.428893	12	38.70968
18:00	24.77	27.21	49.91	31.38	7.833633	9	29.03226
21:00	24.73	27.08	46.53	29.72	5.87873	5	16.12903

Table 4: Long Island to Saba least-cost route values for July. Columns from left to right: Minimum Time Cost, Median Time Cost, Maximum Time Cost, Mean Time Cost, Standard Deviation, Number of Missing Routes (or routes that did not complete), Percentage of Missing Routes (or routes that did not complete). Time value is represented in hours. Rows represent time of day the canoe launched.

	Min.	Median	Max.	Mean	standard	missingAbs	missingPerc
0:00	34.03	38.33	43.38	38.42	1.75881	2	3.225806
3:00	34.68	38.05	42.11	38.08	1.89476	4	6.451613
6:00	34.5	37.94	41.85	37.7	1.831388	1	1.612903
9:00	34.7	38.08	41.45	38.2	1.827556	3	4.83871
12:00	34.76	38.91	42.08	38.78	1.727511	2	3.225806
15:00	33.39	39.23	48.39	38.94	2.177015	2	3.225806
18:00	32.51	38.75	42.01	38.4	1.930089	3	4.83871
21:00	33.49	38.29	43.13	38.42	1.724355	2	3.225806

Table 5: Saba to Long Island least-cost route values for January. Columns from left to right: Minimum Time Cost, Median Time Cost, Maximum Time Cost, Mean Time Cost, Standard Deviation, Number of Missing Routes (or routes that did not complete), Percentage of Missing Routes (or routes that did not complete). Time value is represented in hours. Rows represent time of day the canoe launched.

	Min.	Median	Max.	Mean	standard	missingAbs	missingPerc
0:00	34.72	38.36	41.51	38.26	1.40164	1	1.612903
3:00	35.08	38.1	41.69	38.08	1.65805	1	1.612903
6:00	34.36	37.43	41.37	37.67	1.791822	1	1.612903
9:00	34.32	37.88	40.62	37.62	1.526579	3	4.83871
12:00	34.18	37.26	39.82	37.43	1.203651	4	6.451613
15:00	34.11	37.01	42.4	37.18	1.564748	5	8.064516
18:00	33.78	37.66	42.15	37.32	2.134544	33.78	54.48387
21:00	34.08	38.7	44.53	38.02	2.145172	1	1.612903

Table 6: Saba to Long Island least-cost route values for July. Columns from left to right: Minimum Time Cost, Median Time Cost, Maximum Time Cost, Mean Time Cost, Standard Deviation, Number of Missing Routes (or routes that did not complete), Percentage of Missing Routes (or routes that did not complete). Time value is represented in hours. Rows represent time of day the canoe launched.

In comparison, standard deviation values for movement from Plum Piece to Flinty Bay reflect the lower variation in time costs. The standard deviation for this route averages to between one and two when compared against all months (see Tables 5 and 6; Appendix B). This indicates that movement from Plum Piece to Flinty Bay was more reliable than traveling in the opposite direction. With a smaller and more stable range of time costs any real-world canoers that followed routes similar to the ones generated would have had a better idea of what supplies might be necessary for the standard time of the voyage.

Comparing the time costs of these routes between Long Island and Saba suggest that movement from the east was easier. As demonstrated by tests run with the current tool, these eastward routes fit with the strong current moving east to west in this region (see Figures 31, 33, and 35). It takes on average 29.5 hours to canoe from Long Island to Saba in January (see Appendix B). In contrast, it takes an average of 38 hours to make the reciprocal crossing. Similarly, the annual cost for moving between Jolly Beach and Saba in January is around 37 hours with a reciprocal cost of 26.5 hours (see Appendix B). Movement from Jolly Beach in July runs towards the limits established for this case study. Canoers may have chosen to stop after 50 hours to comply with the human physical cap equivalent to the channel crossing of the Anegada Passage. These time costs suggest that voyagers would have preferred heading west so that the current from the east could push them forward. Use of this technique resulted in shorter route times.

A difference of around 10 hours has implications for how much planning is needed for a voyage (Bérard personal communication 2014; Billard *et al.* 2009). Crews would have to adapt their plans based on the amount of food supplies needed, the number of paddlers supplying propulsion, and, depending on what time the canoe left harbor, if the journey would end at night or during the day. These considerations may have led navigators to favor stopping at in-between islands when traveling east to west. When evaluating movement from Saba to Long Island, canoers could have followed along the coast of St. Kitts to take advantage of stopovers to rest. Movement between Long Island and Antigua as well as Long Island and Saba set the trend for movement east and west in the northern Lesser Antilles.

North to south movement also remains largely consistent. There is some variation in route time costs depending on whether least-cost routes ran slightly to the west or east of the origin point before heading south or north to the termination point. For example, routes from Long Island typically arced to the west before heading north into Barbuda's western coast (see Appendix B). Routes charting the reciprocal voyage often arced to the east before connecting with Long Island (see Appendix B). Pathways originating from River Site on Barbuda towards all other end points seem to be consistent in terms of time cost over all months (see Appendix B). The shortest routes heading to Flinty Bay averaged six to 11 hours no matter the time of day or year (see Appendix B). Reciprocated journeys from Long Island average between seven and one-half to eight hours (see Tables 5 and 6; see Appendix B). This slight change in route time cost could be connected to the arc of the pathway heading with the current when routes moved north and against the current when moving south.

This can be compared to travelling from Long Island to the furthest point from it, White Head's Bluff on Anguilla. October is the fastest month for travel with a range of cost times for routes of 22 to 50 hours and an average voyage of 30 hours (see Appendix B). These time costs are different from those produced for the other months.

For example, January routes range from 29 hours to 50 hours (see Appendix B). Despite the average journey times for these months being similar, the standard deviation of route variance also fluctuates between a 4.5 standard deviation in January and a 5.5 standard deviation in July. The lower standard deviation in January suggests that any actual canoers that may have followed similar routes in winter months were more likely to know the time cost associated with travel than in summer months. This could indicate that the summer season, or the period from April to July, was not the best for voyaging north due to uncertain route times.

However, there are some cases of 'optimal' routes with time costs up to 45 hours, for example, routes travelling across the Anegada Passage, and some routes heading from Long Island to Saba (Table 3 and 4; see Appendix B). These costlier routes between Long Island and Saba likely corresponded to voyages with loops (see Chapter 4). Their time costs can be discounted as they do not hold to the spirit of least-cost pathway analysis and it is possible that canoes with strong navigators may have been able to avoid becoming stuck in these loops by making a choice to head in a non-optimal direction at a key point within the journey. Routes that had a true higher cost were typically associated with movement from Barbuda to Saba (see Appendix B). This is consistent with these islands occupying the furthest east and west points within the case study.

5.2.1.4 Direct and Suggested 'Indirect' Travel

Many of the times returned for the direct movement between two sites, such as Saba and Antigua, indirectly support the theory of connections between multiple islands. These routes together represent a total time cost of over 50 hours. This is a greater time cost than what may have been acceptable to Amerindian seafarers. If a crew chose a bad time to leave, one leg of the voyage from Saba to Antigua could be 52 hours (see Appendix B). Even though routes between Saba and Long Island take on average 38 hours, the time cost still pushes the limits of what humans would find comfortable (see Appendix B). Previous water modelers (Altes 2012; Callaghan 2001) and exertional projects (Bérard *et al.* 2011, 2016; Bottome personal communication 2017) have suggested trips of this duration were possible. However, actual canoers likely did not prefer routes similar to these least-cost pathways. Stopover points probably played a role in alleviating the crew's physical and mental stress.

Time costs overall remain relatively consistent. The evenness of the time cost returns indicates that there may not be a clear-cut canoeing season in this portion of the Caribbean based on route cost alone. I will now turn towards a discussion of route placement to determine if canoeing seasons existed. Unlike time costs, route layouts show the physical relationship between canoe pathways and the broader world. These routes should be able to add to our understanding of the 'when' of seafaring during the Archaic Age.

5.2.2 Route Trajectories

The time cost and trajectory of routes are linked. Route trajectory is determined by the underlying costs to movement. Because the returned time costs for the optimal routes produced by the isochrone tool are similar, the route trajectories returned by the model indicate possible connections contained in a mental navigation map. As a result, these modeled routes possibly suggest that past real-world canoers may have had the opportunity to prioritize social and economic factors when choosing to paddle between islands. To explore the hypothetical connections open to Lesser Antillean canoers, I have chosen to evaluate route trajectory through the seasonal breakdown used to study Caribbean seafaring routes in the past (Callaghan 2001; Hofman *et al.* forthcoming; Slayton 2013). These seasons were chosen for their even spread across the year and their relationship to modern sailing seasons (Callaghan 2001). Routes were evaluated for January, April, July, and October.

As I began to evaluate the routes discussed in the last section, it became clear that determining how close a route passing by an island had to come to the coastline to have stopover potential was important. Torres and Rodríguez Ramos (2008) determined that landing would be a certainty at five km from the coastline. This distance covers many examples returned by the model, in particular those routes that make physical contact with coastlines. Torres and Rodríguez Ramos (2008) also suggest that once an island is in sight landing on its coastline could be a foregone conclusion. Based on the understanding that canoe navigators would have had the wayfinding knowledge necessary to connect with the coast, I assume that crews moving within five km from the coastline would have been able to make landfall. This ties with the existence of mental maps, which rely on visual cues to build navigation markers.

Connections between visual perception and mobility through a space has been discussed by Gibson (1979). He states that "all optical flow vanishes at the horizon and at the two centers that specify going toward and coming from" (Gibson 1979: 174), which has interesting implications for sea travel. When traveling on a surface that vanishes directly into the relatively flat plan of the sea's surface, it is possible that the elements protruding in the line of sight along the lane of travel going towards and coming from a point would appear prominently. These prominent points that occur near travel corridors would have made convenient route markers for generations of travelers. For example, Frake (1985) discusses the continual use of navigation markers as a base for generations of medieval seafarers being able to find their way, connecting visual cues to longstanding seafaring routes. Just as the position of coastlines off travel corridors in Europe might have acted as visual markers, so too would Caribbean islands for Amerindian canoers.

The routes generated here can be related not only to the origin and termination points of pathways but to the sites they pass by as well. Even if routes move directly towards the destination point along the shortest path, how routes are laid out and the existence of possible stopover areas can suggest either alternative direct or indirect connections. This is demonstrated through the relationship of the Sugar Factory Pier site on St. Kitts to canoe routes running to and from Saba. Finding possible evidence of connections between sites on neighboring islands in the Lesser Antilles can identify who may have been in contact even if the connection is only minimally evidenced by archaeological remains.

The opportunity to evaluate how route layout may have influenced the structure of mobility and exchange networks is one advantage of sea-based least-cost pathway modeling. This section will also evaluate some choice routes that went 'off course.' Some of these off-course routes passed by other islands or ran far into the sea away from the destination point, leading to a phenomenon I am calling 'indirect routes.'

Indirect routes are interesting for this work as they can indicate the location of possible stopover points. Many of the exaggerated route times coincide with indirect routes. This analysis can indicate the location of navigation corridors used in this period and into the Ceramic Age. Connecting known sites with modeled least-cost canoe pathways highlights the possible relationship between seascapes, navigation along known corridors of movement, and Amerindian canoe crews.

5.2.2.1 Island Layout

To understand how pathways were laid out between islands it is necessary to discuss the geographic placement of the islands within the northern Lesser Antilles, which are shaped almost in a cluster or ring (see Figure 29). Though pathways would often run through the center of the island cluster, many steer closer to neighboring islands that come between the origin and termination points.

In some cases, pathways between two islands come in proximity to or contact with a third island in the cluster. Canoers who passed by in-between islands may have been able to connect with those islands physically due to the high levels of visibility from canoes to the islands. Many islands are inter-visible or become visible from the center of a channel. Canoeing between these islands' visual spheres would have made paddling from island to island intuitive or linked to a community navigation mental map. The visual link between islands in the region would have allowed for a strong backdrop for wayfinding points. Though some canoe crews may have chosen to not follow along the least-cost corridors modeled in this work, subject to a voyage's time cost, the visual links between islands would have been accessible in all seasons.

There was probably a seasonal component to when people canoed between two islands, here referred to as islands 'A' and 'B'. Canoers may have waited for optimal currents to help push them towards their intended destination. This can be seen in voyages where one route passes by a third island when moving between points 'A' and 'B' (*e.g.*, routes Flinty Bay to Jolly Beach reaching St. Kitts; see Appendix B). It is possible that people canoeing along these routes were more focused on stopping at this in-between island. These islands and sites represent stopgaps for those routes veering off course. Montserrat, for example, is visited several times by routes heading towards sites on the northern islands of Saba, St. Kitts, St. Martin, and Barbuda from Flinty Bay and Jolly Beach. Even when routes were ultimately headed towards the north, the currents sometimes took them south first. Montserrat provides a convenient, or life-saving, stopping point for those voyages that were pushed off course by strong currents. The patterns observed in pathways going to one island and stopping or connecting with a site on another hint that accidental voyages resulted in new sites. These sites were possibly incorporated into the yearly mobility cycle and eventually the Amerindian shared navigation map of the northern Lesser Antilles.

The route trajectories mentioned below relate to the time costs discussed in the previous section. As with the multitude of time cost results, due to the sheer number of routes evaluated only a few images will be put in text (see Appendix B). These maps exemplify the key aspects of normal and atypical routes through the northern Lesser Antilles.

5.2.2.2 Failed Routes and Navigation Challenges

Certain routes can be discarded in the pursuit of uncovering optimal canoe pathways due to their atypical placement. For example, some routes from Flinty Bay to Plum Piece looped around the island of Antigua to achieve the 'least-cost' route. Because the majority of these looped routes show that pathways departing from Flinty Bay were more likely to have moved directly away from land or run slightly west along the coast before heading out to sea, these pathways can be rejected (see Figure 37; Appendix B). This 'logical' trend is reflected in most routes from Flinty Bay to Jolly Beach over all seasons. I had to consider how these looping pathways affected what

Figure 37: An example of a route with loop. The route is from Long Island to Saba, launched at 3am on the 1st of October 2013, Route: 0-2_2013-10-24T09.

least-cost routes crews might have chosen to follow, if they followed any, if the currents along a pathway forced them away from their goal. There must have been some instances when canoers were caught unaware, especially if they were unfamiliar with the environment or misread the signs of the currents. These cases cannot be measured by least-cost pathway routes. A canoe crew's reaction to these unusual circumstances falls outside the current research.

Some routes between Flinty Bay and Jolly Beach can be discounted as they show the island being circled more than once before landfall is made (*e.g.*, route 0-2_2013-10-24T09). This is an indication of canoers that may have traveled along similar trajectories were unable to make landfall at a certain point due to strong currents. Plausibly there would have been a better way to deal with this issue. For example, crews could have chosen to either wait for a better time to launch or they could have canoed along the coastline until they could make landfall.

There are a few examples of routes that likely were not used either because they push too far off the typical path between origin and termination points or because they contain loops that add unnecessary time to the route cost. The trajectories in route 0-2_2013-09-24T21 and route 0-2_2013-10-19T15 run so far into the Caribbean Sea that actual Amerindian canoers who wanted to travel along similar corridors would have tried to circumvent these currents at all costs, even by staying at home if necessary. However, in terms of the successful implementation of the isochrone tool to the analysis, the model deals well with projecting routes for when currents surprised canoers. That these routes were still able to complete shows that possibilities of voyages to overcome obstacles at sea.

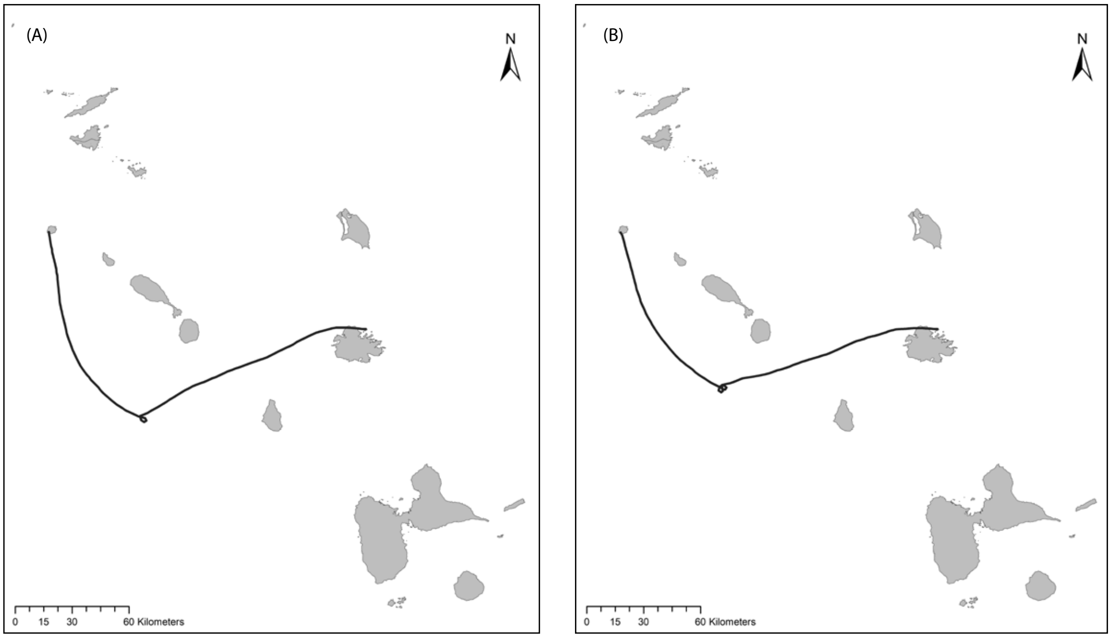


Figure 38: Examples of routes running past islands into the Caribbean Sea. (A): The route is from Long Island to Saba, launched at 9pm on the 24th of September 2013, Route 0-2_2013-09-24T21, and (B): The route is from Long Island to Saba, launched at 3pm on the 19th of October 2013, Route 0-2_2013-10-19T15.

Loops that occur in routes add unnecessary time and danger to any voyage. They show the inability of a crew to move directly towards their goal. Despite the inclusion of an anti-loop calculation in the underpinnings of the model (see Chapter 4), loops still appear in some routes (*e.g.*, route 0-3_2013-11-17T15, route 0-2_2013-05-28T9). As both the layouts and the time costs are inaccurate, these routes can also be discounted. Other routes, like route 1-0_2013-0121T18, show movement that laps back onto itself so often it would be problematic to consider it a representation of a route which would be chosen and navigated by humans. Pathways that double back onto themselves are illogical for two reasons: first, there may not have been a reason to turn back. As each modeled route constantly looks for the optimal route, it is unable to discern where actual canoers may have waited for better currents or pushed forward to reap long term benefits; second, because there is a cost associated with continually turning to face the brunt of the current. This can be compared to instances when the model could not generate a route, signifying

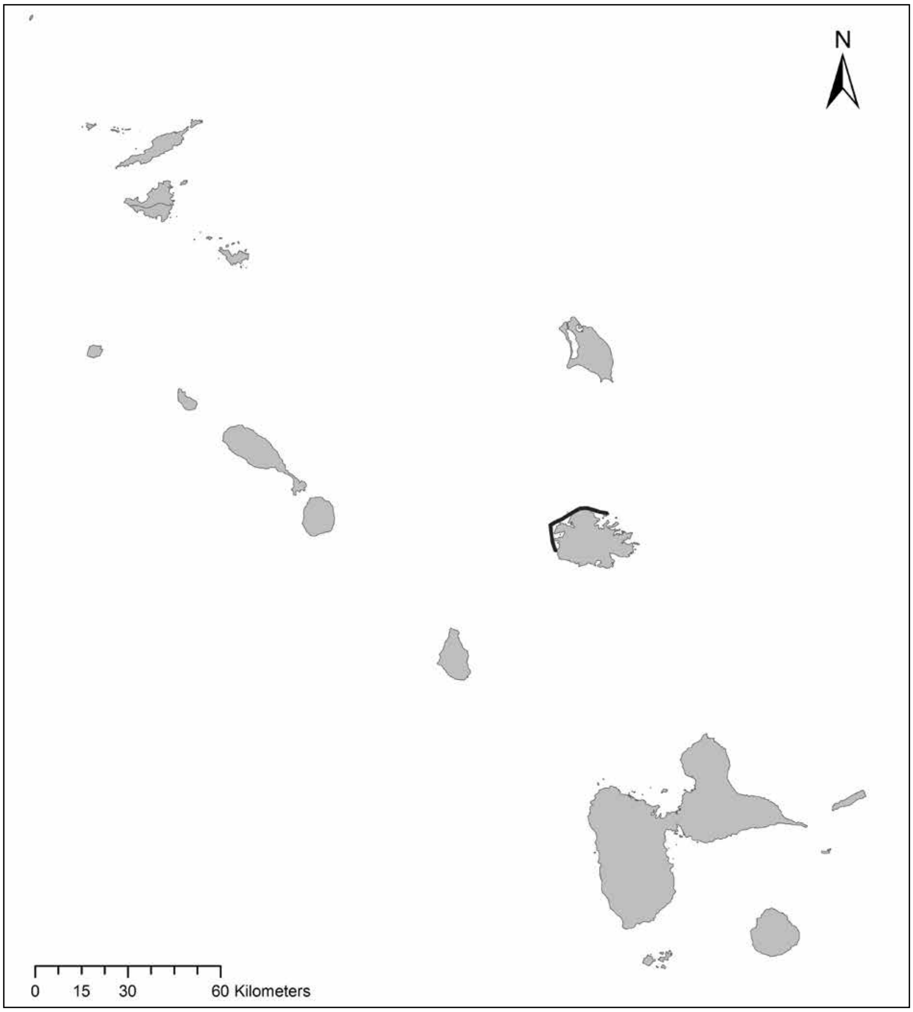


Figure 39: Example of typical route from Flinty Bay, Long Island to Jolly Beach, Antigua. The route launched was launched at 3 am on the 30th of March 2011, Route: 0-1_2011-03-30T03.

the current was too powerful to be overcome and successful voyaging was impossible. Assuming that most of these canoers were expert or at least adequate navigators, it stands to reason that steps were taken to prevent this outcome.

5.2.2.3 Flinty Bay and Jolly Beach

The first pathway layout I will examine is the reciprocal route between Flinty Bay and Jolly Beach (see Figure 39). As discussed in the archaeological background above, Flinty Bay served as a major source of flint for the Archaic Age communities in the northern Lesser Antilles. Jolly Beach and Flinty Bay were connected through exchange or direct contact evidenced by the lithic materials sourced from the smaller island (Davis 2000; Knippenberg 2007). These flint nodules were refined at Jolly Beach, possibly before export to other islands (van Gijn 1993). The close working relationship between these two

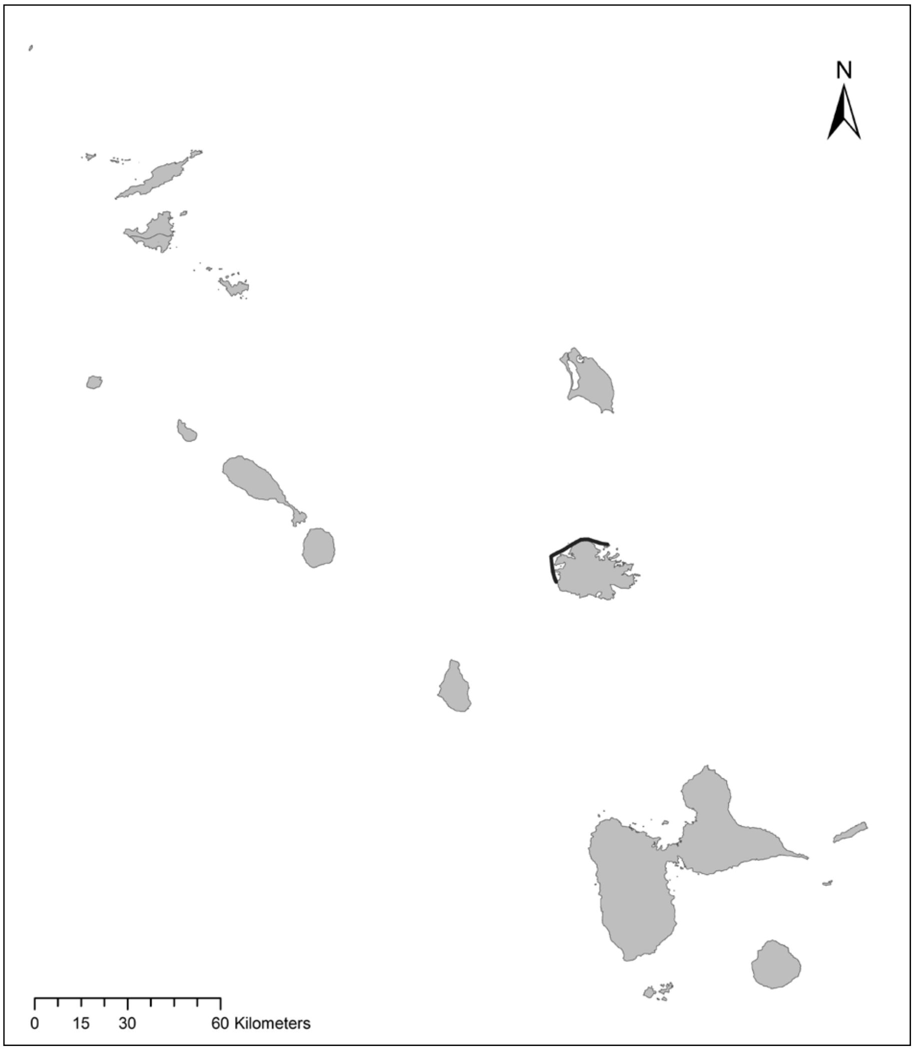


Figure 39: Example of typical route from Flinty Bay, Long Island to Jolly Beach, Antigua. The route launched was launched at 3 am on the 30th of March 2011, Route: 0-1_2011-03-30T03.

sites is mirrored in their assemblages, particularly in the transportation and modification of flint nodules. It is clear that Amerindian peoples traveled between these two sites.

Testing movement along this route will show how currents influenced pathways with the shortest Euclidean distance connection in this case study. A few months will be selected to stand for broader annual trends, as the evaluation of route time cost showed there was limited variation through the year. Some months had routes with more consistent layouts than others did. For example, the travel corridor between Flinty Bay and Jolly Beach is more stable in January than in April. Canoe movement in these months can be compared against variations throughout the year. These variations can mark those months that have semi-stable indirect routes that pass by a third site when moving between Flinty Bay and Jolly Beach.

How does this movement past other islands compare with typical corridors between Long Island and Antigua? Routes between Flinty Bay and Jolly Beach in March show little deviation from the typical least-cost pathway along the north coast of Antigua (see Figure 39; Appendix B). Over 92 percent of routes stay above the island of Antigua and close to its coastline in 2011 and 2013 (see Appendix B). In March 2011 only two routes come close to meeting another island pathway. For example, route 0-1_2011-03-06T21 heads west of Antigua to make contact with St. Kitts (see Figures 40 A and B). This trend continues in 2012, with 88 percent of routes staying above the island. In 2013 only a few routes veer away from Antigua when making a run between Long Island and Jolly Beach. Two routes pass by the north coast of Montserrat (*e.g.*, route 0-1_2013-3_09T12). More routes pass by St. Kitts (*e.g.*, route 0-1_2013-03-14T00, route 0-1_2013-18T3). Though possessing indirect routes, March represents one of the most stable periods for canoe travel and links St. Kitts to for reciprocated movement from Jolly Beach to Flinty Bay.

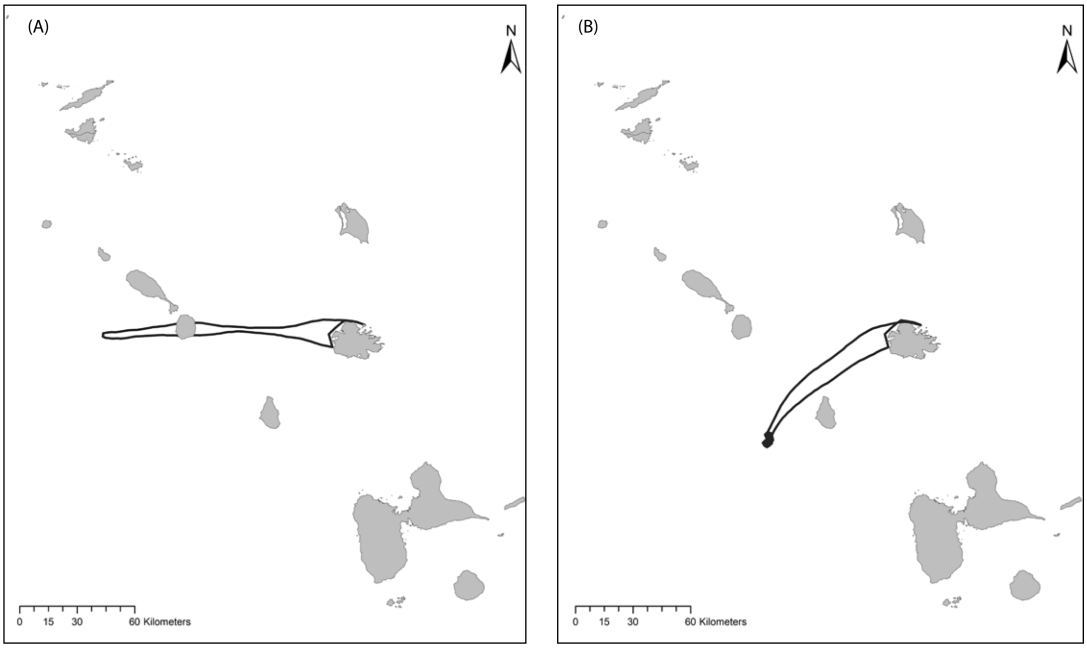


Figure 40: Routes from Flinty Bay, Long Island to Jolly Beach, Antigua that make contact with both St. Kitts and Montserrat. (A): The route launched was launched at 12pm on the 6th of March 2011, Route: 0-1_2011-03-06T21, and (B): The route launched was launched at 12pm on the 9th of March 2013, Route: 0-1_2013-3_09T12.

Many routes from Flinty Bay to Jolly Beach run into the center of the island cluster and parallel to St. Kitts (see Appendix B). Depending on the proximity of the route to the island, sightlines towards St. Kitts may have aided passing canoers. Views of the island would have given these voyagers a feeling of relative safety. There are some modeled pathways that pass very close to the island. Many simulated canoe paths even passed within five km of the coastline (see Figure 40; Appendix B). Applying the theory from Torres and Rodriguez Ramos (2008), if crews did undertake the least-cost routes modeled here they would have been able to make landfall. Amerindian seafarers on this route possessed waypoints for navigation and paddlers may have known there was a nearby island where they could rest.

Other indirect routes in March indicate movement from Long Island towards Jolly Beach could have travelled south away from Antigua. Canoe pathways that pushed south of Long Island and Antigua sometimes ran parallel to the east coast of Guadeloupe. Other exceptions to direct routes returned by the model follow the second example of an indirect route from March 2011. The route 01_2011-03_20T12 heads south of Long Island and almost connects with the island La Désirade off the east coast of Guadeloupe (see Figure 41 A). There is also route 01_2012-03-13T12 that runs first by Pointe de la Grande Vigie at the northern end of Guadeloupe before heading east to Montserrat and then north to Jolly Beach (see Figure 41 B). This is one of the only routes in the study that reaches Guadeloupe and Montserrat on the same journey. Four other routes connect with Guadeloupe around Moule (route 0-1_2013-3-14T18), Le Désirade (route 0-1_2013-3-21T21, 0-1_2013-3-23T9), and the island

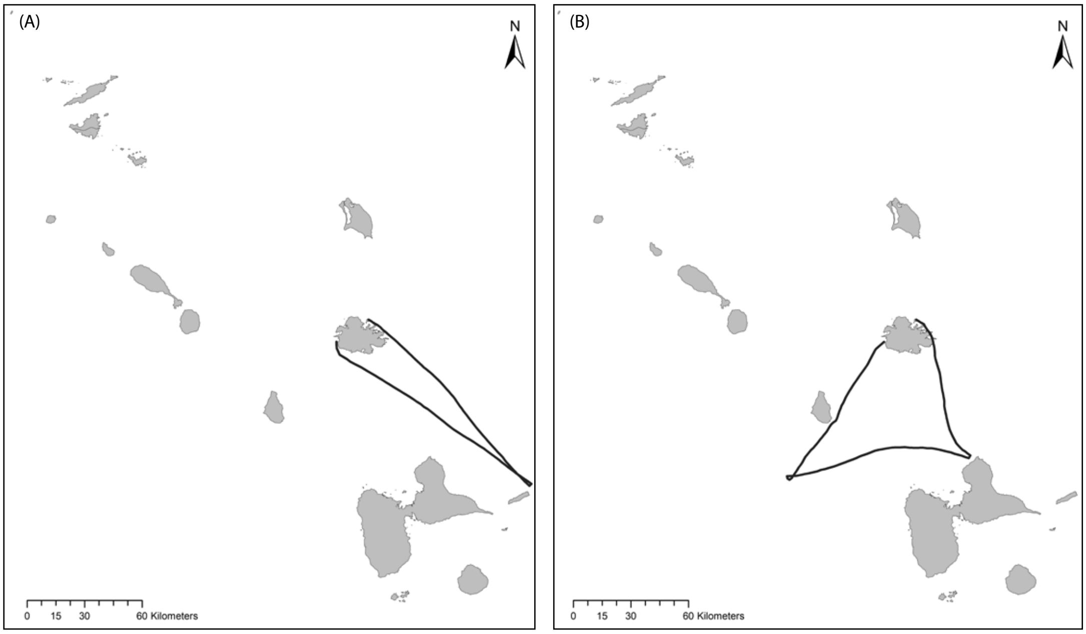


Figure 41: Routes from Flinty Bay, Long Island to Jolly Beach, Antigua that move towards La Désirade or Guadeloupe and Montserrat. (A): The route launched was launched at 3pm on the 31st of March 2011, Route: 0-1_2011-03_20T12, and (B): The route launched was launched at 12pm on the 13th of March 2012, Route: 01_2012-03-13T12.

of Fajou (route 0-1_2013-3-16T0). Possible real-world canoe crews following the same trajectory as these least-cost routes, *i.e.* those that were pushed this far south, may have decided to stop along the coast of Guadeloupe or La Désirade. This travel processes may link to the materials found on the Island of La Désirade that tie more closely to the northern Lesser Antilles than materials on Guadeloupe.

In keeping with trends observed in March, routes typically follow the coast of Antigua conforming to the logical least-cost pathway in May. Indirect routes in May sometimes go down towards Guadeloupe (*e.g.*, route 0-1_2011-05-12T15, route 0-1_2013_05_08T15, route 0-1_2013-05-14T9, and route 0-1_2013_05-21T18), Montserrat (*e.g.*, route 0-1_2011-05-17T06), and St. Kitts (*e.g.*, route 0-1_2011-05-14_00, route 0-1_2013-05-09T6). Canoe routes that veer off course in May are like those observed in April (see Appendix B). With more routes heading widely off course than in 2011 and 2012 combined, pathways from May 2013 are particularly indirect. Unlike in other months, pathways do not extend towards Barbuda. This could indicate that connections between Flinty Bay and Barbuda were less common during this time of year. This may have influenced annual trends of interaction between peoples to the south and west of Long Island and those to the north.

Differentiation between spring and winter travel can also extend to route differenced in autumn. Like in winter and spring, many autumn routes also pass by in-between islands. Extreme indirect routes in September include pathways passing by or running into St. Kitts (*e.g.*, route 0-1_2011-9-7T12, route 0-1_2011-9-18T18, route 0-1_2011-9-25T6, 27T3, route 0-1_2012-9-15T12, and route 0-1_2012-9-28T3). The latter two of these routes (*e.g.*, route 0-1_2012-9-15T12 and route 0-1_2012-9-28T3) also pass closer to Montserrat. Other routes connect with (*e.g.*, route 0-1_2011-9-20T21) or circle (*e.g.*, route 0-1_2012-9-16T09) the island. Most September deviations in routes occur to the south, pushing towards Guadeloupe. Three notable cases are route 0-1_2011-9-16T18 and route 0-1_2012-09-29T03, which meet the northern coast of La Désirade, and route 0-1_2011-9-08T21, which moves towards Anse à La Gourde on the northeast coast of Grande Terre, Guadeloupe (see Figures 43 A, B, and C). Again, these routes could indicate seasonal push for Amerindian canoers to travel towards certain islands, where they might engage in exchange or resource collection.

Compared to other months, the most unique aspect of the September routes is the frequency of movement north to Barbuda when traveling from Flinty Bay towards Jolly Beach. Route 0-1_2011-9-26-T21 comes close to connecting with the western extreme of the island, consistent with the placement of Barbuda's River Site (see Figure 43). This route, and a few others noted in September, push north towards St. Martin (*e.g.*, route 0-1_2012-9-23T00). Pathways heading in this direction fit the trend of movement further north that occur when moving from Flinty Bay to other sites in the autumn season. This may suggest that communities on Barbuda were more engaged with the wider exchange network in Autumn, perhaps curtailing the availability of certain resources.

In October, routes also tend to stay closer to Antigua. It appears that after March, October is the month with the least number of 'off-course' voyages. However, there are still the occasional routes that meet St. Kitts (*e.g.*, route 0-1_2012-10_06T21, route 0-1_2013-10T15, and route 0-1_2013-10-01T18).

The modeled runs show routes infrequently pushing towards, or connecting with, La Désirade (*e.g.*, route 01_2012-10_31T15 and route 0-1_2013-10-11T00). Modeling in the month of October was hindered by the inability of currents from 2011 to be included in the model due to their absence from NOAA files. As a result, these assumptions of October's seasonal makeup may need further support from future modeling efforts.

November has similar route trajectories to October. The similarities in route layout between the two months indicate that they may have formed a 'sailing season'.

Figure 42: Routes from Long Island to Antigua that make physical contact (or come close) with the coast of La Désirade. (A): The route launched was launched at 6pm on the 16th of September 2011, Route: 0-1_2011-09-16T18, (B): The route launched was launched at 3am of the 29th of September, 2012, Route: 0-1_2012-09-29T03, and (C): The route launched was launched at 9pm on the 8th of September, 2011, Route: 0-1_2011-09-08T21.

November also has some routes that head towards Guadeloupe and La Désirade (*e.g.*, route 0-1_2011-11-6T21, route 0-1_2011-11-11T9, route 0-1_2012-11-10T9, route 0-1_2012-11-11T21, route 0-1_2012-11-13T3, route 0-1_2012-11-21T00, and route 0-1_2013-11-20T18). The November routes that head southeast of Antigua predominantly occur in 2011. Conversely, November 2013 has more routes that run north before reconnecting with Antigua (*e.g.*, route 0-1_2013-11-18T03). These routes include more pathways that run into the east-central coast of St. Kitts (*e.g.*, route 0-1_2013-11-26T21). Routes running to the east suggest a level of non-conformity to the broader cycle during 2013. Conforming to this sailing season, travel from Long Island this far east occurs less frequently than in other months.

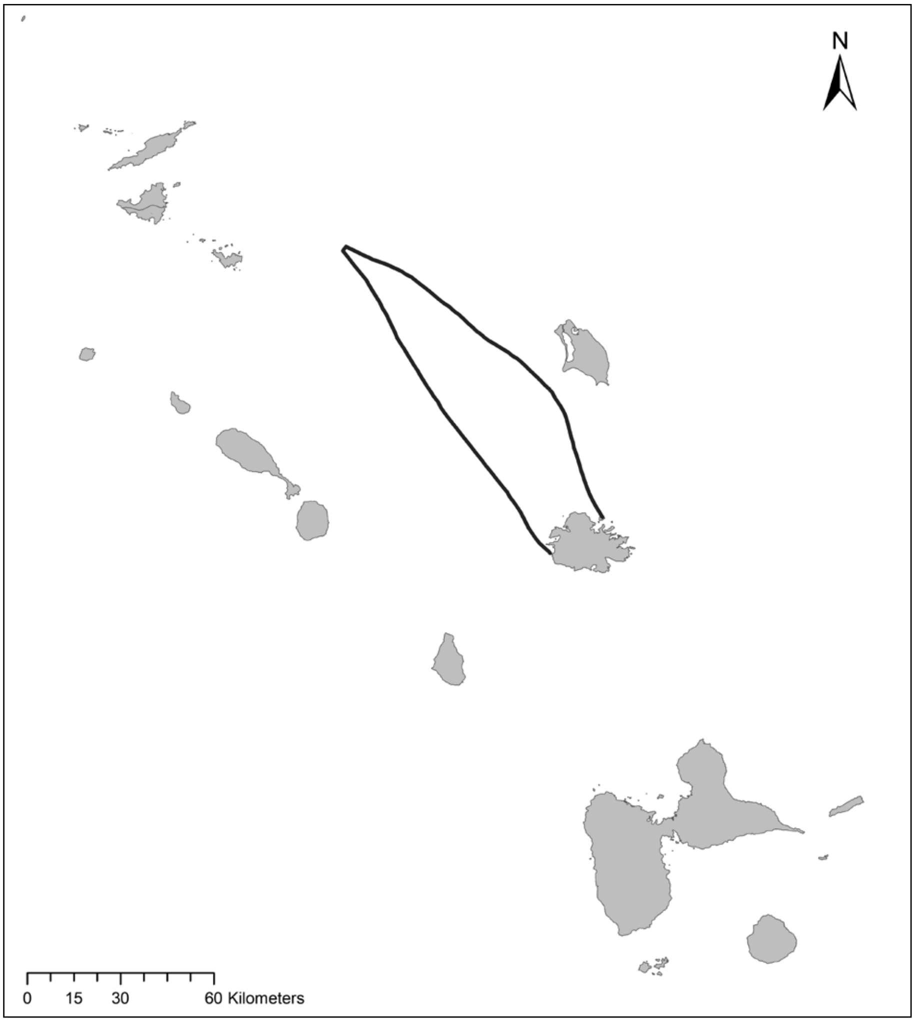


Figure 43: Route from Long Island to Antigua that runs past Barbuda. The route launched was launched at 9pm on the 26th of September 2011, Route 0-1_2011-09-26-T21.

5.2.2.4 Jolly Beach to Flinty Bay

The typical least-cost corridor that connects Jolly Beach and Flinty Bay is almost a mirror image of those modeled for travel from Flinty Bay to Jolly Beach. Most direct least-cost routes between these sites accrue a similar time cost over all seasons. Pathways modeled for this section represent hypothetical reciprocal routes to those from Flinty Bay to Jolly Beach and the seasonal similarities between time costs and route placement continue to indicate that real-world canoers traveling similar sea corridors may not have been obliged to travel in specific months. These routes further suggest that seasonality was not a major factor when undertaking direct routes between these sites.

These direct routes between Long Island and Antigua also suggest that there was a level of familiarity when traveling along the coastline in both directions. Coastal areas of Antigua have corresponding Archaic Age sites that could have acted as breaks between Flinty Bay and Jolly Beach (Davis 2000). These sites also confirm the consistency of this route-corridor.

Routes running the reciprocated corridor from Jolly Beach to Flinty Bay also encountered extreme currents that would lead them into indirect routes. Routes headed east on these routes often traveled north to meet Barbuda (*e.g.*, route 1-0_2013-04-13T21; see Figures 44 A and B). In some cases, routes from Antigua even looped up over the northern island before returning south to Long Island (*e.g.*, route 1-0_2013-04-21T00; Figure 44 B). Unlike for voyages that originated in Flinty Bay, least-cost routes run in this direction were more likely to head past the east coast of Barbuda. Archaic Age sites have yet to be found around the points of pathway contact with this section of Barbuda's coast. To confirm if these routes resulted in any stopover points, more research into the placement of Archaic Age sites along the east coast of Barbuda is

Figure 44: Routes from Antigua to Long Island that move by Barbuda. (A): The route launched was launched at 9pm on the 13th of April 2013, Route: 1-0_2013-04-13T21, and (B): The route launched was launched at 12am on the 21st of April 2013, Route: 1-0_2013-04-21T00.

necessary to match the work that has been done on the west coast near the River Site and the Strombus Line (Rousseau *et al.* 2017; Watters *et al.* 1992).

Canoes could also be pushed further east when leaving Jolly Beach. Canoes that ran towards St. Kitts when traveling between Jolly Beach and Flinty Bay move one of two ways. Routes either went to the south of the island, where they may also pass close to Montserrat, or up the eastern coast (see Appendix B). Routes typically approached the island from the southeast, which fits with the direction of travel out of Antigua. Some pathways start with the canoe moving more to the north and then turning left into the eastern coast of St. Kitts (see Appendix B). This corresponds to the northwestern push of the current common throughout the year (see Figure 35). The points of contact between routes running away from Antigua and the coastline of St. Kitts can stand as approximations for stopover points over the entire year. Many of these routes touch either the center or southern extremity of the island. The sections of coastline these indirect routes pass would be areas to further survey for archaeological materials or sites.

Modeled routes were sometimes pushed towards Monserrat in April (*e.g.*, route 1-0_2013-04-25T15). As was the case with trips that run north towards Barbuda, these Monserrat routes loop around the island before heading north back towards Antigua. Pathways like these were probably not used by Amerindian canoers. Routes leaving Jolly Beach would need to head west before heading east to make this connection possible. I find it hard to believe that this additional effort, reflected in the time cost for this route (see Appendix B), would have been worth the expense if the only goal of the crew was to reach Flinty Bay. Pathways that reach Monserrat in January are less likely to connect with the south side the island. Instead, they connect with the northeastern coast (*e.g.*, route 1-0_2013-01-13T6). This could indicate that Archaic Age communities had seasonal encampments in this area during the winter season.

This trend could demonstrate the engagement of Monserrat in the broader network of lithic exchange and mobility around the northern Lesser Antilles. The transitional Archaic Age to Early Ceramic Age site of Trants on Monserrat also lies along these looped routes, suggesting it connected with peoples canoeing through this travel corridor. Although pathways occasionally pass on the south side of the Antigua (*e.g.*, route 1-0_2013-01-17T18), they never head south towards Guadeloupe. The movement of crews along these modeled least coast routes, if they were actually followed by canoers, around Antigua and Monserrat indicates that the emphasis of movement passed these islands perhaps connected with Long Island. These connections may have been direct or indirect, dependent of the engagement of peoples from Monserrat with the other islands in the northern Lesser Antilles. This possibility can be further tested in future by modeling least-cost routes from Monserrat outwards and comparing the results against archaeology from that island.

As the most routes heading out from Jolly Beach traveled north east, voyages very rarely go towards St. Kitts (*e.g.*, route 1-0_2013-04-27T3). In some cases, routes first connect with Montserrat before heading north to St. Kitts (*e.g.*, route 1-0-2011-07-12T15). Pathways running in this direction do not pass by the western side of the island near the site of Sugar Factory Pier. Routes meet the southeastern coast of St. Kitts before heading west again. The route leaving Jolly Beach at 3 pm on July 12, 2011 runs into Monserrat and St. Kitts before heading north to run parallel to Barbuda (see Figure 45). This route demonstrates the possible interconnectivity between communities on these islands. That the route connects with all four islands in the same period suggests that a navigator's mental map would have to include all islands to make full use of the connecting sea (*sensu* Terrell and Welsch 1998; Tilley 1994). The steps to this route show that sometimes thinking about a short direct route may have entailed planning a long circuitous multi-site voyage.

Long Island's position within the northern Lesser Antillean arc may have supported its role as a connection point for Amerindian peoples throughout the region. Many routes from this site are indirect routes. These routes show a trend for least-cost pathways to group into corridors, offering some consistency to movement in this direction. In reality, canoers paddling towards Long Island possibly knew they might also be catching up with their neighbors on the return journey due to the current pushing their vessel towards another island. The inhabitants of Jolly Beach may

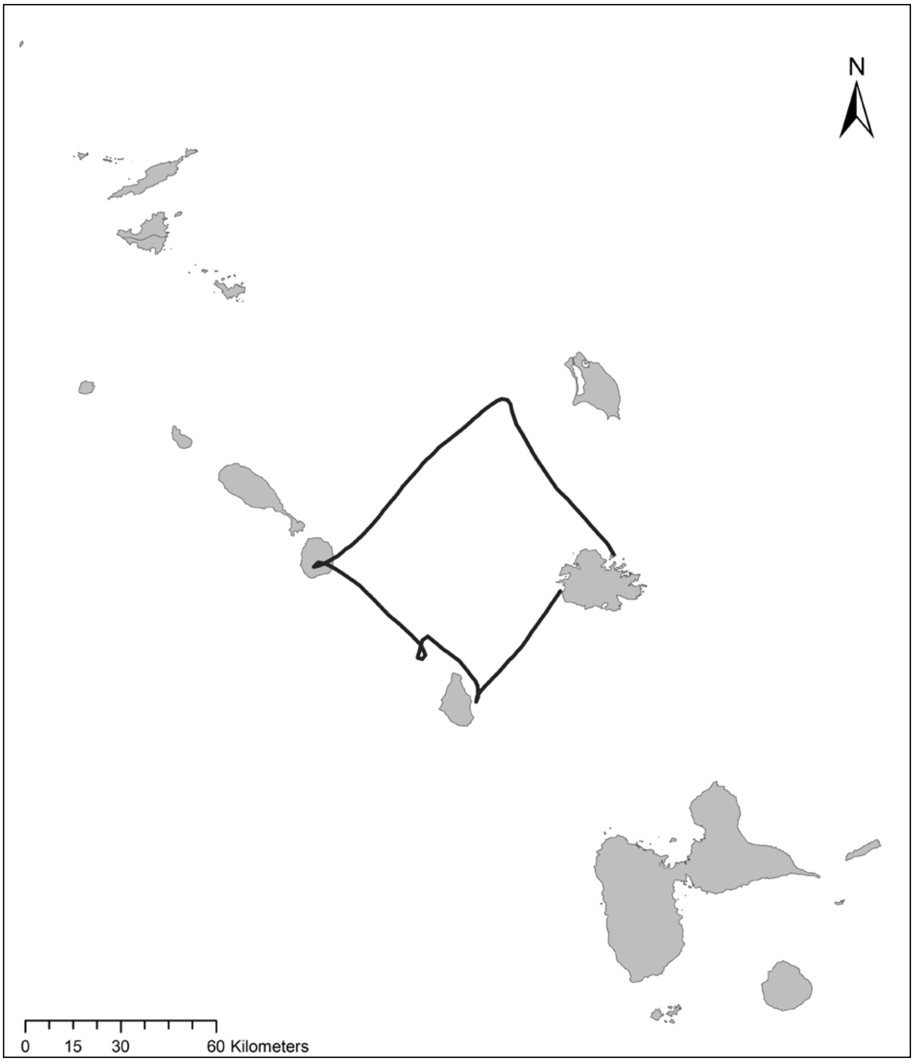


Figure 45: Route showing movement passed Montserrat, the site of Hitchman's Shell Heap on Nevis, and Barbuda. The route launched was launched at 3pm on the 12th of July 2011, Route: 1-0_2011-07-12T15.

have been less interconnected to the northwest islands in the region. Instead, communities at this site may have played a key role in connecting peoples on Monserrat to the lithic exchange network.

5.2.2.5 Long Island and Saba

To fully place Long Island within the broader inter-island network that connected Archaic Age communities in the Lesser Antilles, it is vital to model routes from Flinty Bay to other sites. Plum Piece on Saba and the nearby site of Fort Bay were identified early in this study as key nodes within the patchwork of interconnected sites. While these sites were not fully contemporaneous, dates from Plum Piece and Fort Bay do overlap at some points (Hofman and Hoogland 2016; Hofman *et al.* 2003). As Fort Bay postdates Plum Piece (Hofman and Hoogland 2016), it is possible that communities inhabiting the later site knew of the landing places near the former. The inclusion of Fort Bay allowed a wider array of comparable routes. Any effect of the distance between Plum Piece and Fort Bay is minimized by the fact that it would be very easy to canoe between these two points. As a result, physical, and possible mental, connections between these sites and the routes to both sites from Long Island will be reviewed here. When looking at the reciprocal component of this route, only pathways from Plum Piece will be evaluated. This tactic fits within the concept that routes leave one harbor but approach destinations from several avenues. During all seasons routes from Flinty Bay to Plum Piece generally go through the center of the northern Antillean island cluster. Pathways passing through the center of the cluster coincide with the persistent push of the current directly across the expanse between Long Island and Saba. These

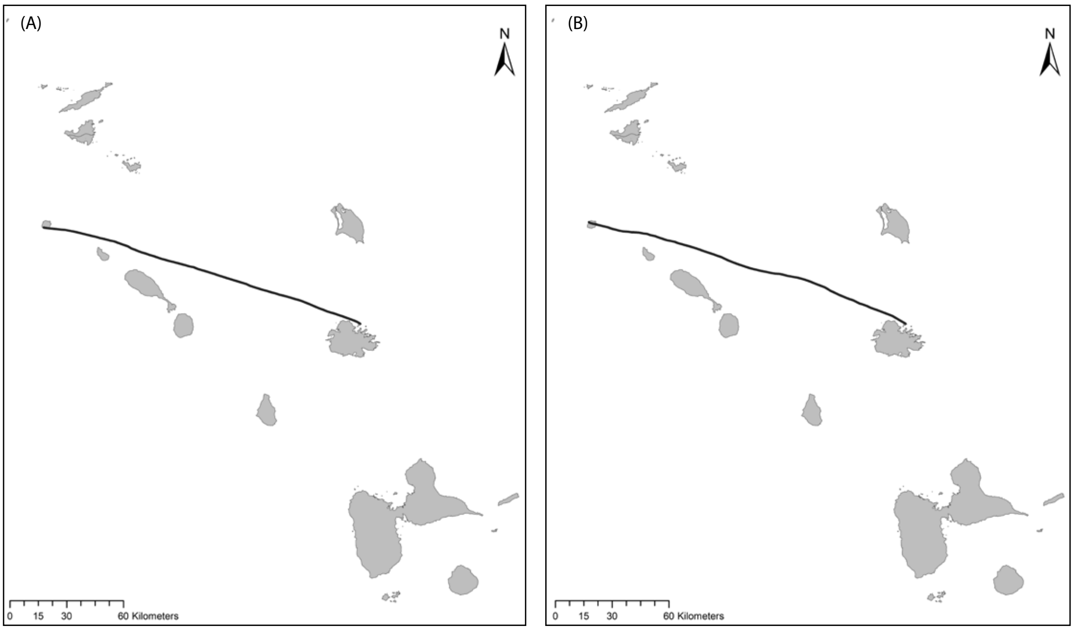


Figure 46: Routes showing direct routes from Long Island to Saba, (A): The route launched was launched at 9am on the 15th of February 2012, Route: 0-2_2012-02-15T09 and, (B): The route launched was launched at 6pm on the 8th of March 2013, Route: 0-2_2013-03-08T18.

routes form a corridor of movement between the two islands (*e.g.*, Bell and Lock 2000; Surface-Evans 2012). The best examples of following the expected straight-across corridor are seen in December, January, and February (*e.g.*, route 0-2_2012-02-15T09, route 0-2_2013-03-08T18; see Figures 46 A and B).

Any divergence from this corridor highlights the basis for connections between Flinty Bay and other sites. It can point to stopover islands or sites engaged with indirect or stopover exchange along this route. The number of indirect routes likely results from the presence of the strong current observed in the analysis of movement to and from Saba. Saba is both the most western point physically from Long Island and the point requiring the most in-between stops. Movement from Long Island to sites on the western end of the island cluster, like Plum Piece, leads to more indirect routes. It may be that Saba connects other sites to Long Island because travel to Plum Piece required the most stopovers.

In most months, these indirect corridors frequently push to the limits of the channel and come into contact with St. Kitts (see Appendix B). Some routes from Flinty Bay run along the north coast of St. Kitts before running into the Saba Bank on their way to Saba (*e.g.*, route 0-2_2012-01-09T6, route 0-2_2011-3_23T15, route 0-2_2012-5-7T3, route 0-2_2012-05-21T9, route 0-2_2012-08-11T03, and route 0-2_2012-11-21T21_00). Fishing in the Saba Bank was likely associated with travel between St. Kitts and Saba.

St. Kitts is also connected directly to the routes from Saba to Long Island and Long Island to Saba. While the eastern side of St. Kitts is often passed via indirect routes to and from Saba, as is the case with many runs from Flinty Bay to Jolly Beach, many pathways would head up the western coast of St. Kitts passing along the northern coast

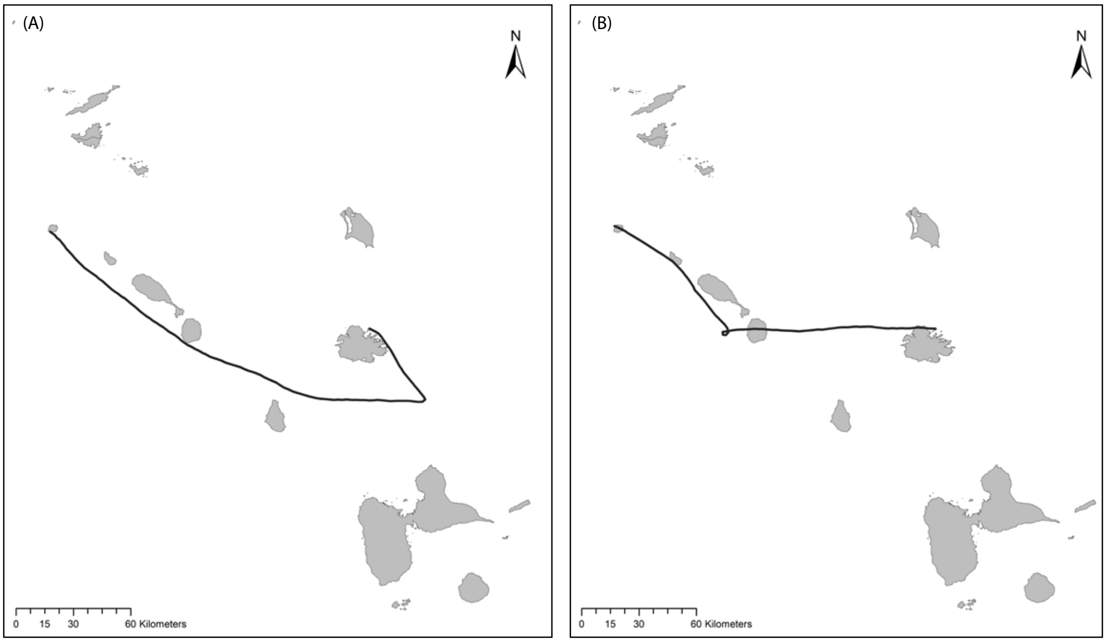


Figure 47: Canoe routes from Long Island to Saba that pass by the site Sugar Factory Pier on St. Kitts. (A): The route launched was launched at 6am on the 27th of May 2012, Route: 0-2_2012-05-27T06, and (B): The route launched was launched at 6am on the 5th of September 2013, Route: 0-3_2013-09-5T03.

of Nevis. Moving along the western edge of St. Kitts also ensures that routes went past the site of Sugar Factory Pier. These routes thereby establish that the site of Sugar Factory Pier on the west coast of St. Kitts is connected into a broader exchange network (*e.g.*, route 0-2_2012-05-27T06, and route 0-3_2013-09-05T03; see Figures 47 A and B). Routes from Long Island to Saba had a higher probability of passing by the west side of St. Kitts and Nevis in December (*e.g.*, route 0-2_2013-12-02T15). Most December routes that run through this layout occur in 2013. The modeled routes from December also showed a tendency for canoe routes to cross by the north coast of Nevis and the west coast of St. Kitts (*e.g.*, route 0-2_2013-03T18).

However, there are indirect routes that run towards the extent of the central space between the islands in the winter season that are not observed in other months. This includes movement around the north coast of Anguilla past the site of White Heads Bluff (*e.g.*, route 0-2_2012-12-05T6, route 0-2-2012-12-05T18, and route 0-2_2012-12-29T21). Canoe pathways rarely pass by this site in other seasons. In fact, it occurs in less than 20 routes modeled for the entire case study. Routes in December also pass by the underside of Anguilla and the north and east coast of St. Martin (*e.g.*, route 0-2_2012-12-19T0). Other pathways demonstrate the canoe routes' connection with the south side of St. Martin, most notably near Baie Orientale (*e.g.*, route 0-2_2013-12-17T03).

When modeled canoe routes head towards Saba from Long Island they sometimes pass the western side of Nevis (*e.g.*, route 0-2_2012-05-27T3, route 0-2_2012-12-04T3). However, Hitchman's Shell Heap, located on the eastern side of Nevis, is currently the only site on the island that dates to the Archaic Age (Wilson *et al.* 1991). The fact that many sites elsewhere in the region lie off constructed canoe routes indicates there may have been Archaic Age sites or rest areas on both sides of the island. Real-world canoers who may have been following similar routes moving past the island were under no obligation to stop, suggesting that stopover locations indicated by these possible routes are also hypothetical. More research should be done on Nevis to investigate if there is a site that corresponds to the layout of these routes. It is possible that there is a site on the island that has a comparable placement or that played a similar role to Sugar Factory Pier on St. Kitts as a possible connection point for the distribution of materials and rest area for canoe crews.

Least-cost route travel corridors that move further north into the middle of the northern Lesser Antillean island cluster often pass by the islands to the north when crossing from Long Island to Saba. In fact, all months have routes that move further north into the channel (see Appendix B). These routes sometimes headed by the eastern side of St. Eustatius when moving between Flinty Bay and Plum Piece (*e.g.*, route 0-2_2011-09-13T09, route 0-2_2013-10-18T6, route 02_2011-11-15T00, and route 0-2_2012-04-03T06). The western side of the island is also passed (*e.g.*, route 0-2_2012-9-4T12, route 0-2_2012-09-04T18, route 0-2_2013-10-16T12, and route 0-2_2011-05-01T0). Movement north towards St. Martin is most notable in April and August, and least in February (see Appendix B).

Canoe routes modeled in March, April, and May were more consistent. Many modeled pathways from Long Island head north of Saba before meeting Plum Piece (see Appendix B). Routes during this period sometimes connect with the eastern edge of St. Martin (*e.g.*, route 0-2_2011-05-11T18, route 0-2_2012-05-19T12, and route 0-2_2013-5-21T18) or with the island's southern coastline (*e.g.*, route

0-2_2012-04-18T21, route 0-2_2012-05-25T6, route 0-2_2013-5-27T15, and route 0-2_2013-5-30T15). In rare instances, these routes run along the entire north coast of the island (*e.g.*, route 0-2_2012-04-26_T3). Additional pathways merely move towards St. Martin (*e.g.*, route 0-2_2012-05-12T21, route 0-3_2012-05-12T21) or pass directly by its east coast (*e.g.*, route 0-2_2012-05-15T21, route 0-2_2013-05-14T9). On some occasions, the routes traveling between Long Island and Saba detoured past the coast opposite the site of White Head's Bluff on Anguilla (*e.g.*, route 0-2_2011-03-24T6, route 0-2_2011-03-24T18, route 0-2_2011-03-27T3, route 0-2_2012-04-27T3, route 0-2_2013-05-23T21, and route 0-2_2013-05-31T21). In very few cases, pathways run right by the site (*e.g.*, route 0-1_2012-04-22T9). As with St. Kitts, the removal of the island from the cost surface is not fully functional in these images, and these later routes may not be wholly accurate. Routes also connect with the island of La Désirade in a similar fashion to indirect routes from Flinty Bay to Jolly Beach (*e.g.*, route 0-1_2013-05-05T12).

Pathways heading north from Long Island had a greater chance of meeting with the coastlines of different islands than routes leaving Antigua, though which coastlines they encountered varied depending on the canoe season in which they were run. In September, October, and November optimal routes heading from Long Island to Saba tended to move north towards St. Martin (*e.g.*, route 0-2_2013-10-20T03, route 0-2_2011-11-23T00, and route 0-2_11-14T12). Three routes in November even meet the east coast of St. Martin near the site of Etang Rouge and Norman Estate (*e.g.*, route 0-3_2012-11-01T21, route 0-2_2013-11-9T21; route 0-2_2013-11-19T09; see Figures 48 A, B, and C). Other canoe routes during November head up to Baie Orientale before turning south towards Saba (*e.g.*, route 0-2_2013-11-19T9; see Figure 48 C). One pathway connects with the south end of Anguilla (*e.g.*, route 0-3_2012-11-01T21). Sometimes northerly run routes originating at Long Island pass close to Barbuda and pathways close to Barbuda typically fall near the River Site (*e.g.,* route 0-2_2012-08-23T0, route 0-2_2012-11-10-10T9, and route 0-2_2012-08-20T12).

Reminiscent of travel in the winter season, routes heading east from Saba to Long Island in March ran through the center of the northern Antillean island cluster (*e.g.*, route 0-3_2011-04-14T15). Routes rarely extended north of Barbuda's latitude, though some passed by the island of St. Eustatius where the current had them keeping a southeastern trajectory. A few pathways run along the south coast of the island (*e.g.*, route 0-2_2011-04-15T21). Other routes towards Saba also moved east, before traveling under Antigua, past Jolly Beach, before reaching their destination (*e.g.*, route 0-3_2013-10-01T09, route 0-2_2012-11-07T03).

Even when moving between Flinty Bay and other nodes, a preference for Saban connections is sometimes shown in a route's trajectory. When traveling to Nevis from Long Island in April several canoe routes overshoot their destination and bypass, or loop, around Saba (*e.g.*, route 0-9_2012-04-01T18, route 0-9_2012-04-03T21). Overlap with the Saba Bank is also observed in a few of these routes (*e.g.*, route 0-9_2012-04-05T12, route 0-9_2012-04-07T0). A crew's access to the fishing resources around the Saba Bank could have made pathways like these preferable. Routes that run through the Saba Bank mirror connections between Nevis and Saba that occur for routes heading from Flinty Bay to Plum Piece. The hypothetical pathways suggest a deeper connection between these three islands.

The layouts of these least-cost routes indicate that crews looking to engage in lithic exchange with Long Island could have structured their journey to benefit from seasonal advantages or the direction of current flow. Connections between canoe routes and the islands of Nevis and St. Kitts strongly suggest that these northeastern sections of coastline may have been utilized as stopover points by crews that could have followed routes similar to the least-cost pathways modeled towards Saba. In fact, though not viewed as a major player in the regional exchange of Long Island flint, the tendency of these routes to run past St. Kitts and Nevis suggests these islands should be further explored.

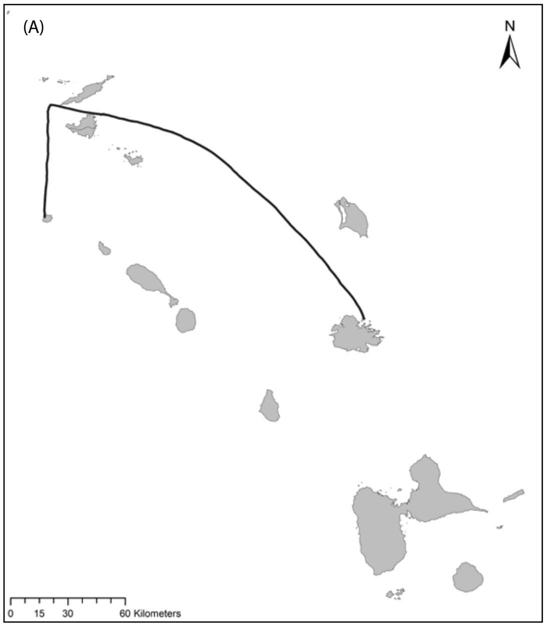
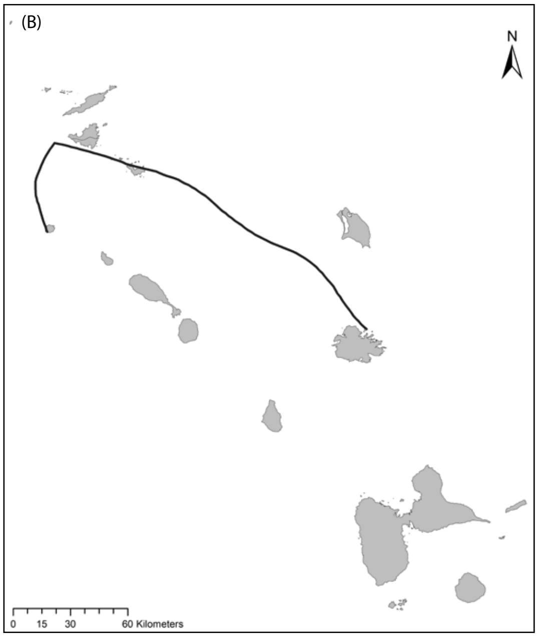
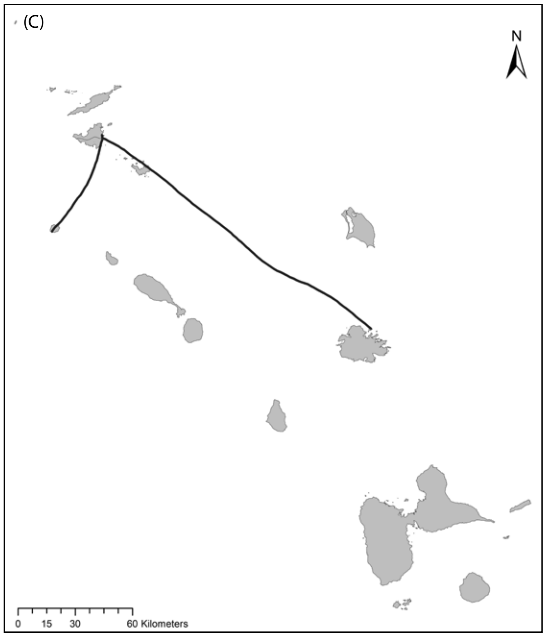


Figure 48: Movement from Long Island to Saba that passes by the St. Martin sites of Etang Rouge, Norman Estate, and Baie Orientale. (A): The route launched was launched at 9pm on the 1st of November 2012, Route: 0-3_2012-11-01T21, (B): The route launched was launched at 9pm on the 9th of November 2013, Route: 0-2_2013-11-09T21, and (C): The route launched was launched at 9am on the 19th of November 2013, Route: 0-2_2013-11-19T09.





This is also the case for St. Eustatius. In fact, many of the routes that pass by this island on their way to Plum Piece go directly past the site of Corre Corre Bay. The location of Corre Corre Bay could have been selected to take advantage of the Long Island to Saba route, either in terms of access or visual and physical relationships. Visual connections from and to passing canoes may have connected peoples living at this settlement to the broader rhythms of exchange or seasonal mobility that moved through the region. It is also possible that these visual connections translated into a form of influence over these travel corridors. If these modeled pathways were in use, canoers passing between Saba and Long Island may have been tied more closely to peoples living on St. Eustatius with whom they were in direct visual contact. This is juxtaposed to relationships with other island communities, like on Anguilla and Barbuda, with which there was no direct visual contact.

Similarly, routes traveling on this path would not have had to deviate much to reach the island, unlike routes from St. Martin or Anguilla. The cost of moving past this island is not widely different from passing further north in the channel. Further evaluation of the materials found in the assemblages at Corre Corre Bay and Plum Piece could tell us whether these islands are more closely linked than others in the region. More research into potential sites on the southern coast of St. Eustatius should be carried out to determine if there are any Archaic Age sites that could connect both with movement from Plum Piece and Long Island. An analysis of the assemblages of these south coast sites could also be compared with those from Corre Corre Bay to further connect this site with regional exchange.

The sheer number of indirect routes that run past Anguilla and St. Martin demonstrates that the sites of White Head's Bluff, Baie Oriental, and Norman Estate could be tied to communities on Saba. Future research along the edges of coastline passed by routes modeled here may determine if there are any Archaic Age sites that have as yet not been uncovered. Furthermore, comparisons of assemblages from these sites could enable us to see if there are any materials that indicate a strong outward connection with island communities to the west.

Seasonality is visible in route layouts between Long Island and Plum Piece. The best time for traveling directly, with the least indirect routes, is in winter between December and February. The best time to take advantage of indirect routes is between April and July. The dichotomy between January and April suggests that comparing these periods can be used to assess the possibility of traditional views of sailing months. In keeping with themes established in earlier research (Callaghan 1999; Hofman *et al.* forthcoming; Slayton 2013), the remaining routes analyzed for this study will be run in January, April, July, and October.

5.2.2.6 Flinty Bay and Other Sites

This is not to say that Plum Piece is the only site on the edge of the northern Lesser Antillean cluster that encourages stopover points or indirect and stopover connections. As mentioned above, the distances between Long Island and Saba to the east are matched by travel from Long Island to islands in the north. Crews navigating these optimal routes, or pathways with similar trajectories, traveling north may also have prioritized pathways with stopover potential. Routes between Long Island and the site of Baie

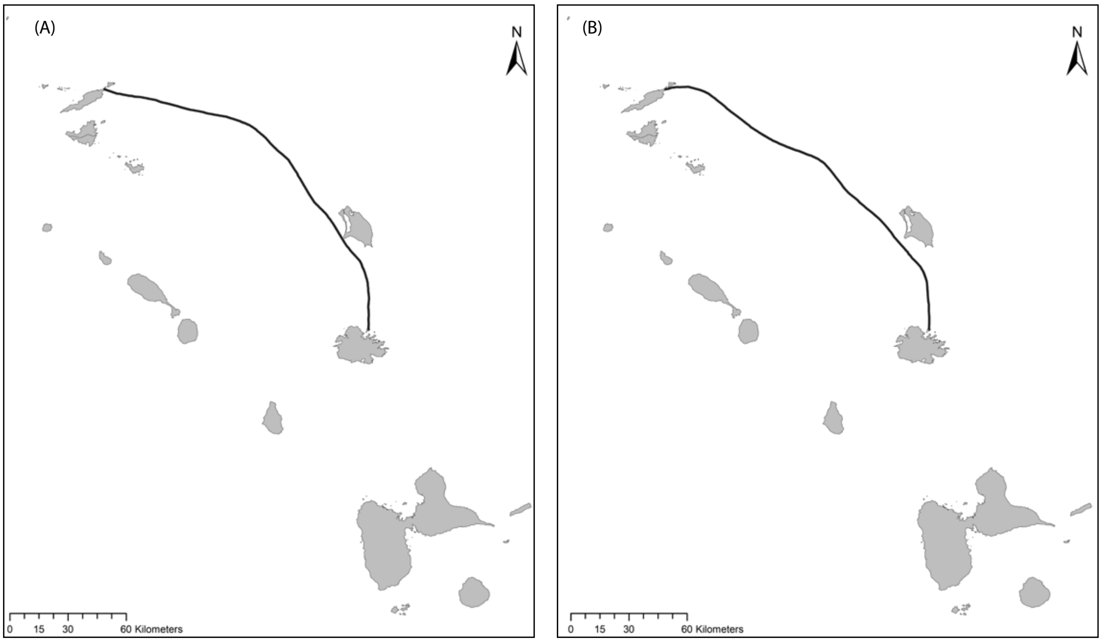


Figure 49: Routes from Long Island to Anguilla that pass by Barbuda and the River Site. (A): The route launched was launched at 12am on the 3rd of April 2013, Route: 0-4_2013-04-03T00 and (B): The route launched was launched at 3pm on the 27th of April 2013, Route: 0-4_2013-04-27T15.

Orientale on St. Martin often went past Barbuda (*e.g.*, route 0-8_2013-04-11T18). Barbuda's River Site may have provided a convenient stopping place.

Barbuda could also act as a stopover on least-cost routes between Flinty Bay and White Head's Bluff. Pathways running from Long Island to Anguilla sometimes went by Barbuda's River Site as well (*e.g.*, route 0-4_2013-04-3T0, route 0-4_2013-04-27T15; see Figures 49 A and B). Voyages from White Head's Bluff to Jolly Beach on Antigua arc sharply just below the site (*e.g.*, route 1-0_2012-01-01T15). Barbuda is passed more often when Flinty Bay is the start point. This is congruent with Long Island's position almost directly south of the River Site.

Many of these routes' arcs comply with the common-sense curved or 'banana' technique used by experimental canoers (Bérard personal communication 2014). Currents running through this area may have influenced the modeled routes' outcome and may reflect the canoer's 'choice' to pivot in this location. The change in the arc or pivot-position to above or below Barbuda shows the seasonal influence on moving from Anguilla to Long Island and vice versa. Pivots above the island occur in October and below in January. Curving east away from St. Martin, the route only turns west when parallel with the island. Thus, if actual canoers were following similar routes, the current may have done most of the work for the crews at the end of this voyage (*e.g.*, route 0-8_2013-04-11T18). Other routes to Baie Orientale are pushed further to the west before redirecting towards the site, which would have made connecting with St. Martin more difficult.

Some modeled routes suggest that site location was tied to Amerindian sea travel corridors. For example, routes moving from Flinty Bay on Long Island to Sugar Factory Pier on St. Kitts sometimes traveled past Barbuda (*e.g.*, route 0-10_2013-04-11T03, route 0-10-2013-04-11T9). These pathways either directly connect with the island or sweep past its southern coast. Though they make landfall near Coco Point on Barbuda, the routes turn back towards St. Kitts once they pass near the River Site. Canoers may have stopped here if they needed a rest or more supplies. The River Site is well placed to take advantage of these routes alongside the pathways from Flinty Bay to Plum Piece mentioned above.

Routes from Flinty Bay to Sugar Factory Pier link Long Island and Barbuda in ways that pathways to Plum Piece do not and highlight the possibility of a connection between Barbuda and St. Kitts. More research into the archaeological material collected at sites from both islands is necessary for this theory to be confirmed. Several least-cost pathways towards St. Kitts went past Montserrat (*e.g.*, route 0-10_2013-04-22T0; see Appendix B). These routes passing in-between islands indicate that movement away from Long Island fostered indirect or stopover exchange between several sites in the archipelago. Connections with these islands also hint at the importance of stopover points along routes.

Though a logical aspect of canoe voyaging, the stopover phenomenon played a larger role than expected within the analysis of these modeled routes. These in-between, indirect, or stopover connections could have extended to routes to and from Antigua's west coast. As mentioned above, when moving towards Jolly Beach from Long Island there is a higher chance of moving towards St. Kitts in January (*e.g.*, route 1-0_2012-12-27T09). Movement from the north of the northern Lesser Antilles island cluster, particularly Anguilla, in July and October shows a higher chance of passing by the east side of St. Kitts and Nevis and making contact with the coastline near the site of Hitchman's Shell Heap on Nevis (*e.g.*, route 1-2_2012-10-12T9). Movement from Long Island in these autumn months is more direct, with few arcing routes. As such, where and when the voyage terminates can influence what islands a canoe crew passes on the way to their final destination. Likely these factors had implications for the structure of Amerindian navigation maps.

5.2.2.7 Saba and Anguilla

It is possible that crews traveled between islands without moving to or connecting with Long Island. Canoers could have been looking to exchange flint as a part of the short-hop process, or seeking out seasonal resources available by taking advantage of travel corridors passing by the coastlines of other islands. Amerindian navigators would have been versed in how to move between these islands as well, if only to recalibrate direction after resting at a stopover point. Routes leaving from and arriving at Saba can provide examples of connections between islands in the northern Lesser Antilles that did not run through Long Island.

Least-cost routes from Plum Piece to White Heads Bluff typically sweep along the coastline of St. Martin. Pathways making the reciprocated journey follow the same trend. This is in keeping with the common-sense sailing technique of prioritizing movement along an island's coastline. These routes reflect that real-world canoers traveling from Saba to Anguilla may have had the opportunity to choose to move to the right or left side of St. Martin when making this trip (see Appendix B). Some of the pathways run next to Etang Rouge, close to Norman Estate, or pass by the site of

Baie Orientale (see Appendix B), linking the routes to known Archaic Age sites. (see Appendix B). Modeled canoe routes running past these sites suggest that these areas had stopover potential. It is also possible that these sites were founded in these locations to take advantage of existing routes between Saba and Anguilla.

As reciprocal connections from Whitehead's Bluff to Plum Piece always include St. Martin, it is possible that the island acted as a broker for interaction between communities on Anguilla and Saba. The placement of Norman Estate and Baie Orientale further indicate the sites could have exerted influence over canoers following similar routes passed St. Martin to those least-cost pathways seen here. How this possible influence manifested itself is unclear. Genesis of these communities could have centered on wanting to be a part of the network or to influence use of these pathways.

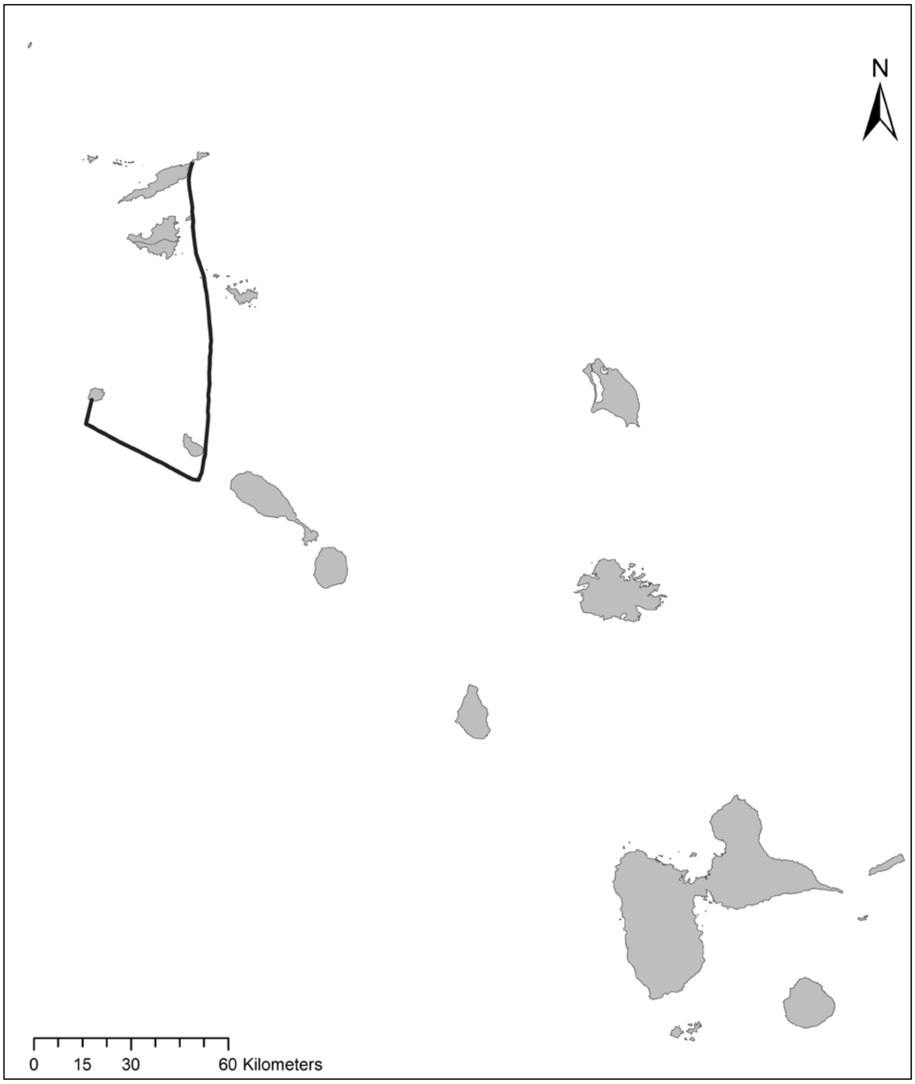


Figure 50: Routes from Anguilla to Saba that pass by the island of St. Eustatius. (A): The route launched was launched at 9am on the 14th of October 2012, Route: 1-3_2012-10-14T09.

When moving from Anguilla to Saba, routes sometimes loop past Corre Corre Bay on the far side of St. Eustatius (*e.g.*, route 1-3_2012-10-14T9, route 1-3_2012-10-16T3; see Figures 50 A and B). Similar routes from White Head's Bluff on Anguilla pivot north of Corre Corre Bay before heading west to Saba (*e.g.*, route 1-3_2013-07_15T6). This tendency shows another reciprocal connection between Anguilla, St. Eustatius, and Saba. It is possible that movement to and from Anguilla also marked it as a connection point for communities traveling around the northern Lesser Antilles. More work should be done to examine archaeological and modeled route connections between Anguilla, St. Eustatius, St. Martin, and Saba to determine if the specifics of these island links can be uncovered.

5.2.2.8 Visiting Saba through Other Islands

Plum Piece on Saba has been proposed as a major player in the lithic exchange network of the northern Lesser Antilles (Hofman *et al.* 2006, forthcoming). Its placement close to the Saba Bank and its role as a possible canoe producer make it a key figure for analysis in the current research. Its distance from the pivotal site of Flinty Bay makes Plum Piece a contender for supporting additional or indirect links to other islands, as discussed above.

It has been suggested that canoers leaving Long Island may have headed for Anguilla or St. Martin before turning to visit Saba (Hofman *et al.* forthcoming). These possible side connections are supported by the modeled routes discussed in the previous two sections. Routes that optimize multiple connections include pathways generated for several seasons (in March routes, *e.g.*, route 0-2_2011-03-19T21, route 0-2_2011-03-21T12, route 0-2_2011-03-23T03; in May route 0-2_2012-05-02T14, and route 0-2_2012-05-19T12; in September routes, *e.g.*, route 0-2_2011-09-8T21_00, route 0-2_2011-09-09T12, route 0-2_2011-09-20T15, and route 0-3_2011-09-09T12; in November routes, *e.g.*, route 0-2_2011-11-01T03; see Figures 51 A, B, C, and D). These pathways head north before arcing alongside the north coast of St. Martin, past the sites of Norman Estate and Baie Orientale, before heading south to Saba. Routes from Long Island to Saba that pass through the islands in the north of the cluster suggest that under the right current conditions Anguilla would also have been an important locus in an extended circular multi-seasonal route. The November pathways (*e.g.*, route 0-2_2011-11-26T12, route 0-3_2011-11_01T3, and route 0-2_2012-11-01T21) demonstrate this, as the routes run into the south side of the island.

Amerindian navigators almost certainly knew of these routes and could have used them as links between Long Island and Saba. These extended multi-island routes probably affected the distribution of materials found between Long Island, St. Martin, and Saba (Knippenberg 2007). The presence of worked cores that reached Saba may have passed through other islands first, expanding the area in which flint that reached Plum Piece may have been knapped (Hofman 2003). The routes that run north from Flinty Bay also hint at Barbuda's River Site as a stopover point in these multi-stop multi-seasonal routes.

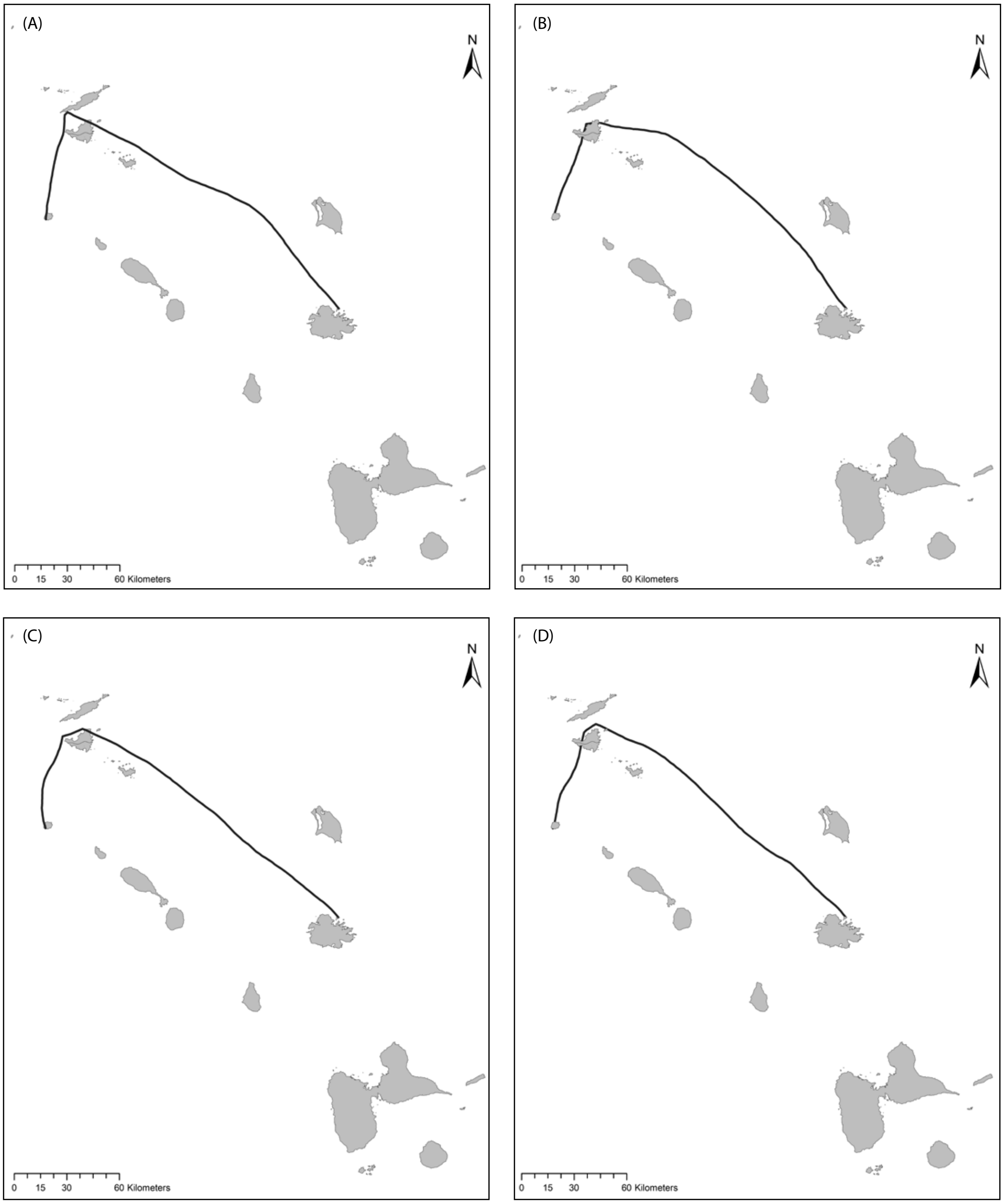


Figure 51: Routes from Long Island to Saba that pass by Anguilla and St. Martin. (A): The route launched was launched at 12pm on the 21st of March 2011, Route: 0-2_2011-03-21T12, (B): The route launched was launched at 12pm on the 19th of May 2012, Route: 0-2_2012-05-19T12, (C): The route launched was launched at 12pm on the 9th of September 2011, Route: 0-2_2011-09-09T12, and (D): The route launched was launched at 3am on the 1st of November 2011, Route: 0-2_2011-11-01T03.

5.2.2.9 Guadeloupe

Although not initially included in this case study, the generated models show that the islands of Guadeloupe and La Désirade seem to be heavily connected to communities traveling to and from Flinty Bay. Known Archaic Age sites on and around Guadeloupe are clustered towards the bottom half of the big island and the small islands that lie directly south (Beets *et al.* 2006; Hofman *et al.* 2014; Keegan and Hofman 2017), including the sites of Pointe des Pies and Anse à La Gourde as well as the island of La Désirade (see Figures 42 A, B, and C; Appendix B). Later sites like Anse à La Gourde on the tip of Pointe des Chateaux and those found on La Désirade dating to the Ceramic Age suggest that connections between Antigua and Guadeloupe began in earlier periods (Beets *et al.* 2006; de Waal 2006, 2014; Hofman *et al.* 2007; Hofman and Hoogland 2011; Knippenberg 2007).

Flint from Long Island and greenstone from St Martin crossed these waters to Guadeloupe, supporting the existence of earlier connections (Bonnissent 2013; de Waal 2006; Hofman and Hoogland 2011; Knippenberg 2007). The routes mentioned above suggest that the coastlines around Guadeloupe and La Désirade could hold more evidence of Archaic Age settlements, information which is valuable to archaeologists seeking to explore this region. Pathways between Archaic Age sites that pass these islands suggest the placement of the later sites. Amerindian seafarers moving to and from Flinty Bay on Long Island could have learned of these convenient stopping points through canoeing misadventures and thereby included them in a navigational mental map. The occupation of these sites following the Archaic Age could be signs of their inclusion in the mental wayfinding map of northern Lesser Antillean canoers.

5.2.2.10 Realistic Navigation

Many of the routes produced by the model display elements of real-world sailing techniques fitting with practices used by small vessels in the northern Lesser Antilles, confirming the validity of using this least-cost approach. For example, modelled routes seem to favor passing island coastlines when possible. Movement along the western coast of islands in the northern Lesser Antilles fits with sailing techniques that dictate taking shelter behind an island when possible.

Some crews may have chosen to use passing island coastlines to their advantage. Modeled journeys from the St Kitts' site of Sugar Factory Pier began by hugging the coast going north. These routes remain protected against the currents and winds passing through the channel. Tactics like this are in line with modern seafaring techniques (Bérard personal communication 2014; Billard *et al.* 2009). However, in some cases (St. Kitts route 1-2-2011-01-05T14_24), modeled routes from St. Kitts suggest that canoes would have moved west in the Caribbean Sea before turning around and heading north over the island to reach Long Island, which may have affected the level of protection offered by the coastline of St. Kitts.

As mentioned above, it is important to highlight the curved route, or banana effect, when discussing common-sense sailing techniques (Bérard personal communication 2014). Curves or arcs appear in many of the modeled pathways. Canoeing into the current at the beginning of a trip pushes the vessel towards the coastline of the destination island. This would allow canoe crews to avoid having to fight against the current when the paddlers would have been most tired. It is a common technique applied in experimental voyages (Bérard personal communication 2014). Movement in this fashion allows the current to push the seafarer into the site at the end of a run, saving the crew's energy for the channel crossing. Curved routes also make voyages safer. They ensure the vessel is being pushed in the direction of land. The presence of arcs within canoe pathways legitimizes the validity of these routes. One conflicting example of this phenomenon within the model is in reciprocal travel from Long Island to Barbuda. As observed in route LI 0-12-2011-01-04T19-12, route LI 1-2-2011-10-06T19_12, and route LI 1-2-2011-01-06T09_36, the movement towards Barbuda shows a curve into the current. However, the majority of pathways to Long Island show a curve with the current. The safer option for any actual crews attempting similar voyages would be from travel Long Island to Barbuda as movement with the current taxes canoers' strength less.

Pathways towards and away from Barbuda provide an exception to this rule, as they seem to follow a straighter, more Euclidean, route through the center of the channel. This is because the model aligns with the current moving west past the northern Lesser Antilles (see Figure 31). When moving into the current, or towards Barbuda, the route bows south. When moving with the current, or away from Barbuda, the routes tend to arc in the north. Like arcs that connect Barbuda to Long island, the shape largely depends on whether the terminal point is found to the north or south. This pattern of the apex of the route arc being on the west side when travelling south and to the east when travelling north is also apparent when looking at canoe pathways to and from Long Island's Flinty Bay and White Head's Bluff on Anguilla. The trend also emerges in pathways from Long Island to St Martin. These routes are bowed with the arc to the right towards Barbuda (Antigua route 0-6-2011-28T14_24). Routes closest to Barbuda when moving from Long Island to Anguilla (Antigua route 0-4-2011-01-06T09_36).

When observing the path's curve towards Barbuda in the spring season, the pathway typically goes to the right or left of a straight line between the start and end points. Broad-scale bowed routes can be seen in route 0-2_2011-9-8T21 and route 0-2_2012-9-02T03 that connect Flinty Bay, Long Island to Plum Piece, Saba. These routes parallel Barbuda before heading west and pushing into Saba's eastern coast (see Figure 49; Appendix B). The position of the outermost point of the curve varies; if these right or left arcs occurred sporadically for any real-world voyages there was a greater risk to canoers. Amerindians paddling these canoes could not rely on the consistency of the current's flow. This reduced consistency would have lowered the ability of the crew to carry out a successful voyage.

The placement of arcs along these routes in the models represents a real-time reaction to the current. However, crews that wanted to cross the distance from Saba to Long Island also had to plan whether they would arc to the north or the south ahead of time. The model's approach to analyzing multiple routes across the same surface and selecting the least-cost route could represent canoers knowledge of where it was beneficial to push against the current and where it was better to let the current push the boat. More research needs to be done in comparing these bowed routes to real-world navigation strategies.

As I evaluated route trajectories it became clear that current force can push in the same direction for short periods. Here, though the pathways arcs may not terminate at the same location, the current force direction can be consistently seen. Thus, when looking at routes that make landfall or arc in the same general area, times can be viewed as a micro-seasonal sailing period. Similar trajectories of extreme routes between Flinty Bay and Jolly Beach were noted for several micro-seasonal periods. Lasting anywhere from six hours to two days, these periods reflect what are likely to be prolonged weather events. Micro-seasonal periods also suggest that opportunities would be present for long-distance travel between two islands at various points during the year. I assume that the navigational prowess and knowledge of Amerindian canoers would have allowed crews to take advantage of these opportunities, which can be observed in some of the least-cost routes modeled for this case study (*e.g.*, route 0-1_2013-10-01T15 to route 0-1_2013-10-01T21).

Micro-seasonal periods could facilitate voyages, as they may have enabled crews to read periods of wave movement and more accurately follow a wayfinding map. These periods in part result from consistency in indirect routes. One example of this type of stabilized route trajectory and seasonal push is seen when moving from Flinty Bay to Plum Piece. Here, routes between these islands pass along the western side of St. Kitts leaving between 3 am and 6 am on the May 27, 2012. Another instance of this indirect-route stabilization comes from routes modeled on May 2 leaving between 6 am to 3 pm. These routes from Long Island to Saba pass by St. Martin. This represents nine hours of consistent movement north away from the target towards other sites in the case study. However, routes modeled over this micro-season do not connect with St. Martin in the same way. The pathways hit the southeastern coast (*e.g.*, route 0-3_2012-05-02T09), the southwestern coast (*e.g.*, route 0-3_2012-05-02T12), and travel over the northern side of the island past the sites of Norman Estate and Baie Orientale (*e.g.*, route 0-3_2012-05-02T6, route 0-3_2012-05-02T15). These links could have been noticed by past canoers and used by navigators to determine what currents should be followed to reach what islands.

Micro-seasonal consistency can also be seen in an example of movement linking Long Island and St. Kitts from April 10 at 9 pm to 12 pm on April 11 (*e.g.*, route 0-10_2013-04-10T21 to route 0-10-2013-04-11T12). Between these times all routes are pushed north towards the coastline of Barbuda. Only two runs from this stretch come close to Barbuda. This again suggests that Amerindian canoers could have relied on these persistent currents to reach Barbuda during this period. Navigators with prior knowledge could use these micro-seasons to plan connections between sites. It could also be that canoers were able to read the current well enough to recognize when these short windows of opportunity arose.

The progression of current strength is seen in the comparison of a string of routes. For example, the arc of routes from Flinty Bay to Jolly Beach from March 26 at 3 pm to 9 pm moves further away from Antigua at every time step (*e.g.*, route 01_2013-3-26T15 to route 0-1_2013-26T21). As the strength of the current increases and routes are pushed farther out to sea, adept crews following similar routes would have been able to read the signs and choose to wait until they could pass the island. It is assumed that knowledgeable navigators would be able to avoid being swept out to sea. In choosing and analyzing least-cost routes these aberrant pathways can be ignored.

5.3 Conclusion

Both in the Caribbean and on other global waterscapes, there is a lot left to consider as to the 'when', 'how', and 'where' of connections between island seafaring communities. Instead, I focused on initial exploration, such as whether the regularity of canoe routes could have influenced social connection between islands of the northern Lesser Antilles. When Archaic Age communities had access to certain resources, or resources became available, seasonality could also have influenced what routes canoers took in addition to when and where they chose to travel. If each site is treated as if its inhabitants were part of separate groups, the issue of movement and connection between these sites is complicated.

Judging the consistency of travel over the same month during different years proved more challenging than initially expected. When I began this research, I worked from the assumption that the seasons would line up easily into best and worst travel periods. This has not been the case. In fact, there are parallels between seasonal periods. The consistency in these values is enough to suggest a loosely-linked sailing season, but the results are not conclusive. This can also be said for the variance between launching at different times of year. There is only a slight relationship between launch times, route cost, and route placement.

The largely seasonal nature of site use in this region and time suggests groups made use of the sites mentioned above at different times of year. That movement to and from Long Island was easier from different sites at various times of year could indicate that a system was in place for communities from each site to collect flint seasonally. It is also possible that Amerindian communities were maintained by an extended seasonal circle of movement around the northern Lesser Antilles. To my knowledge there has been no substantial work to organize the seasonal movement of Archaic Age peoples between various islands in such a way as proposed here. Once a larger number of zooarchaeological and archaeobotanical seasonal studies have been executed in the region, it would be useful to return to this analysis and compare results.

Many sites appear prominent within the inter-island network of Long Island lithic exchange. These sites include Flinty Bay, where the resource was collected, and Plum Piece, which has been theorized as a connection point by other researchers (Hofman and Hoogland 2003). Evaluation of route layout between several sites in the region indicates that St. Kitts could also have played a large role in Archaic Age lithic mobility and exchange networks in the northern Lesser Antilles. As of this moment, I am unaware of archaeological evidence or analysis that suggests this island's linchpin status. While routes may not directly influence the placement and connection of sites, the number of indirect routes that pass by known sites leads me to believe that pathway location can link to site location. The placement of modeled routes suggests that pathways were a part of social considerations in the Archaic Age, including site settlement and community interaction.

The routes calculated in this chapter demonstrate places where pathways may suggest stopover connections. If canoers were following similar routes to these least-cost travel corridors, they may have 'broken -up' their voyages instead of only following direct connections between sites. The extent to which these islands engaged with these practices is not known. It is difficult to gauge the number of materials, like Long Island flint, within an assemblage that were traded directly versus indirect trade that may have taken advantage of stopover options to visit other sites. In the past few years, researchers have been considering the issues of lithic sourcing and exchange in the Lesser

Antilles using network models (*e.g.,* Amati *et al.* 2014; Hofman *et al.* 2014, forthcoming; Knippenberg 2007). These models are, as yet, not fine-grained enough to make a clear statement about when seafarers were stopping at several locations and when they were not. As such, sea-based least-cost route modeling is currently one of the only ways to track how and where this movement could have occurred. Hypothetical pathways can at least indicate possible options for stopover connections in various seasons. The indirect routes discussed above are good starting points to evaluate the process of moving materials in the Archaic Age Caribbean.

Stopover points proved to be a fundamental aspect of route layouts. Several sites evaluated as potential links within the northern Lesser Antilles lithic exchange are positioned along routes headed elsewhere. The occurrence of these sites along the modeled least-cost pathways suggests that the location of stopovers and sites involved in the exchange of Long Island flint were connected. These data show that what had been thought of in the past as island-to-island relationships in some cases needs to be re-evaluated as potential island-through-island relationships. Routes between two sites often link three islands allowing for Amerindian peoples to expand their social networks without accruing additional time cost. Amerindian communities may also have sought to take ownership over these routes, allowing for Amerindians living at these sites to exert more influence over these social networks.

Investigations and discussions about potential stopovers points should include seasonality. This region does not display large variations in returned route costs, as reflected in the points evaluated or runs made using either the current tool and the route tool. However, the layouts of the pathways associated with these time costs show that season does influence route trajectory. Throughout the year these northern Lesser Antillean stopover points have a continually shifting status from connected to unconnected, which can be linked to seasonal variations. Canoers could have opted to travel at a specific time of year to take advantage of social or economic opportunities.

When looking at the direct movement between the second and third legs of certain voyages, routes often follow a similar trajectory to those observed in indirect routes. This confirms the prominent influence of current direction on these modeled canoe pathways. Current's effect likely shaped which legs of long distance voyage were undertaken in which seasons. For example, route 1-0-2011-07-12T15 that travels between Jolly Beach, Monserrat, St. Kitts, and by Barbuda may represent only the first two legs in a three- or four-leg voyage. If there were crews that followed the same trajectories as the least-cost routes modeled here it could be after stopping at St. Kitts they would have chosen to head back towards Jolly Beach when currents were more favorable. Perhaps the hypothetical canoers had to wait to head to Barbuda until there was a seasonal current that pushed them closer to the island.

The separate legs of a prolonged multi-island voyage can be checked against seasonally-available resources, such the Audubon's Shearwater that roost on Saba from February to July (Hofman and Hoogland 2003). As discussed above, Audubon's Shearwater and other birds represented food and a way to navigate towards islands and fishing grounds. The routes traveling towards Saba in this season have relatively similar returns to other routes. However, there is a slight ease in movement between Anguilla and Saba in the same period as when birds would be available. Other resources, like the Saba Bank, would have been easy to reach from the site of Plum Piece. Positioned behind the west coast of Saba, the Saba Bank is passed by some routes in this case study. That there may have been canoers traveling through this area is a sign that the Saba Bank was connected to Amerindian seafarers making rounds in the northern Lesser Antilles. Routes also move through the Anguilla Bank in some cases, indicating that this area was also a part of a broader inter-island exchange network. Connections between Saba and Anguilla made by Amerindian seafarers may have incorporated these areas as part of their seasonal movement. Further analysis of species collected from these environments and materials from other islands can shed light on whether routes to Saba and Anguilla were also centered on making use of these resources.

Route trajectories could have also impacted connections between islands in later periods. Archaic Age routes sometimes moved past areas possessing sites from later periods, as evidenced by the connections between Long Island and Guadeloupe. Identifying routes that transcend the Archaic Age can be difficult. In part, this is because several of the sites used during this time continue to function as either lithic source or seasonal encampments in later periods (Hofman *et al.* 2007; Knippenberg 2007). However, the fact that these connections can be seen in modeled routes indicates that the sharing and passing down of wayfinding maps often led to the construction of sites.

From the myriad of possible routes modelled, it is clear that no least-cost route should be taken as the 'one true' path. Instead, canoe routes modeled for this work can be overlaid and compared to suggest a corridor through which canoers likely paddled in the Archaic Age, thus placing weight on the human element. The general layout of these pathways hints at the constancy of these corridors through different periods. This fact likely enhanced the confidence in and accuracy of navigation patterns used by Amerindians. It enabled these seafarers to maintain the connections used as the template for this case study. What is important about this case study to the broader conversation of seafaring in the Caribbean is the focus on route cost between islands. These generated isochrone travel costs can be used to discuss repeated social interaction between peoples and materials from different islands.