RESEARCH & DEVELOPMENT

Freight Planning Tool for Ferry Division

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Freight Planning Tool for the NCDOT Ferry Division

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16. Abstract

The NCDOT Ferry Division provides instrumental transportation needs to coastal communities in North Carolina. Transportation systems throughout the state must adapt to the changes in terms of meeting the needs for freight capacity, flexibility and expedient deliveries regardless of the location of the vendor. The Ferry Division desires to better understand the freight movement issues in order to accommodate coastal traffic flows and freight transportation. Currently, the Ferry Division transports a significant volume of freight along with a high volume of vehicle and walk-on commuters. For the NCDOT Ferry Service, the congruence of freight carriers and passengers is difficult given the needs specific of each. Although the overall freight transported by highway is typically reported and studied, freight carried by ferry vessel is a neglected topic. This research offers a perspective of a foundational view of freight transport on ferry vessels. A majority of the terminals are meeting the freight needs, but the results of the research suggest some additional data points to further analyze freight flows.

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EXECUTIVE SUMMARY

The NCDOT and the operations of the North Carolina Ferry Service (NCFS) provide seven service routes along the Carolina coast. These routes not only provide local commuters and North Carolina visitors with their public transportation needs, but also transport freight. Internal figures provided by NCDOT (NCDOT, 2018) indicates a reduction in ridership for Hatteras over the last 10 years. Basic services for riders may be affected as the needs for additional freight deliveries increase. Oversized vehicles and freight delivery trucks can potentially displace passengers. But when considering customer services for those requiring deliveries, ensuring that these deliveries can be made on-time and in a planned manner is also important since delays may also impact the delivery of those services. The results of this study will assist in the planning for long-term congruence of both passenger and freight needs and will assist with the larger multimodal planning with the inclusion of the NCFS and their current and future expansion needs.

For the NCDOT Ferry Service, the compatibility of freight carriers and passengers is difficult to reconcile, especially when considering larger freight carriers and rider displacement. Although the overall freight transported by highway is typically reported and studied, freight carried by ferry vessel is a neglected topic. This research offers a foundational view of freight traffic on ferry vessels. The results of the research suggest some additional data points to further analyze freight flows, which is discussed in detail as part of the Implementation Plan section of the report. Although there are suggested improvements, for the most part the results suggest that NCFS is meeting the primary needs of their commuters as well as their freight customers. There are opportunities discussed in the Recommendations section that suggests that NCDOT can utilize the new GIS maps and the new geodatabase for continued research regarding freight. Some of the implications stated in the report require additional years of data collection and analysis. The recommendations provide areas for consideration with regards to data collection.

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LIST OF ABBREVIATIONS

ACS	American Community Survey
AHP	Analytical Hierarchy Process
API	Asset Priority Index
BVP	Best Value Practice
CA	Condition Assessment
CI	Condition Index
DOT	Department of Transportation
FDOT	Florida Department of Transportation
FD	Ferry Division
FHWA	Federal Highway Administration
GIS	Geographic Information System
IDW	Inverse-Distance Weighted
NCDOT	North Carolina Department of Transportation
RP	Research Project
NCFS	North Carolina Ferry Service
SAP	Systems, Applications, and Products

1. INTRODUCTION AND RESEARCH OBJECTIVES

1.1 Introduction

NCDOT Ferry Division services provide both passenger transportation services as well as freight services to coastal communities in North Carolina. Transportation systems throughout the state must adapt to the changes in terms of capacity and flexibility and the ability to meet customer expectations of a quick delivery regardless of the location of the vendor. Oversized vehicles and freight delivery trucks displace riders (Figure 3). Likewise, when considering customer services for those requiring deliveries, ensuring that these deliveries can be made on-time and in a planned manner may also impact the perception of those services. Ferry vessels provide more than just an economic benefit in terms of passengers and freight; they also provide emergency services and assist with the evacuation (and freight deliveries) when necessary. An emergency route runs between Stumpy Point and Rodanthe when NC 12 is damaged (NCDOT, 2019).

The results of this research will assist in the planning for long-term congruence of both passenger and freight needs and will assist with the larger multimodal planning by the inclusion of the NCFS and their current and future expansion needs. As a foundational review of the available data, the research plan outlined the variables which may be used to analyze freight movement and the mechanisms to make sound decisions regarding scheduling for the NCFS based on the connections of waterway deliveries to each terminal location.

The primary objective of this research was to inform NCDOT about freight transport on ferry vessels and how freight impacts the NCFS. Additionally, the use of a GIS-based routing model highlights the effects of freight movement and traffic based on terminal locations. The analysis for estimating passenger displacement on the ferries utilized data from the historical ridership statistics and researcher site visits to the ferry terminals (NCDOT, 2018). The list provides all registered vendors with the Ferry Division. Throughout this report, the list of registered vendors that stated that they carry freight are referred to as freight vendors and was an integral part of the data analysis. The GIS-based analysis included the visualization of ferry terminals and routes with their tabular ridership statistics input into a geodatabase to show the display of vendors and their proximity to terminals, as well as a cluster analysis to show hot spot areas with freight activity, and its impact on congestion and ridership displacement. The final deliverable includes a product which the NCFS may utilize for decisions regarding scheduling freight deliveries for the 7 ferry routes along the North Carolina coastline as well as reported information to be used in a statewide plan.

1.2 Overview of NC Ferry System

The State of North Carolina's Department of Transportation is a performance-based organization which manages the state's infrastructure and its multiple networks for transportation and travel. NCDOT's (2017) annual performance report notes that North Carolina has the second-largest state-operated ferry system in the United States, and the second largest ferry system to Washington State, and therefore the largest ferry system on the eastern seaboard. The NCFS system is comprised of 20 ferries serving 7 routes and serves nearly 1.8 million passengers and 800,000 vehicles annually (NCDOT, 2019). The NCFS serves the needs of both freight and people, with operations supported by a full-service shipyard, dredge, crane barge, tugboats and other vessels (Table 1; Figure 1). These routes serve commuters to work and school, recreational travel and tourism, emergency services. Freight delivery occurs on all of the ferry routes, however this report will highlight the general extent of freight usage for each terminal. The 2012 (Atkins) Statewide Transportation Plan noted that "freight and logistics touch all key elements of the state's multifaceted economy including agriculture biomedical, tourism, education, military and

manufacturing" (p.21). The support of freight carriers can have an impact on the region's ability to assist in the economic growth of the region.

Table 1. Existing Ferry Routes of NCFS (NCDOT 2019)

Water Body	Terminal 1	Terminal 2	Distance (miles)	Sailing Time	One-Way Trips Per Day	
					Summer	Off-Peak
Pamlico Sound	Swan Quarter	Ocracoke South	30	2 hrs 40 min	8	6
Pamlico Sound	Cedar Island	Ocracoke South	26	2 hrs 15 min	10	6
Currituck Sound	Currituck	Knotts Island	5	40 min	10 (Year-round)	
Pamlico River	Bayview	Aurora	3.5	30 min	14	14
Cape Fear River	Southport	Fort Fisher	4	35 min	32*	28
Hatteras Inlet	Hatteras	Ocracoke North	4.5	60 min	72*	28*
Neuse River	Cherry Branch	Minnesott Beach	2	20 min	54 (Year-round)	

*This route has multiple on/off peak timeframes. Figures show the minimum and maximum number of routes within those timeframes. See the 2019 Ferry System Schedule for more information.

Atkins (2012) addressed the state ferry system in the NCDOT 2040 Plan regarding inventory and modal needs. They noted the considerable need to address infrastructure and added capacity for peak demand periods. The department estimated a $1.59 billion investment is needed for the ferry system by 2040. Three routes are classified as critical for connecting the mainland with communities onto Ocracoke island. Any new/replacement vessels are funded through the Strategic Transportation Investments (STI) process and expansion changes to terminals are also funded through STI or Capital funding. The existing mission for the past several years has included a plan to accommodate increases in ridership with new or replaced vessels and additionally with larger capacity terminals. Crainic et al. (2015) stated that due to vessel size, peak demand services occasionally cannot be satisfied due to limited deck space for passenger cars. Route planning and scheduling of freight flows may be a secondary means to increase passenger ridership (Crainic et al. 2015).

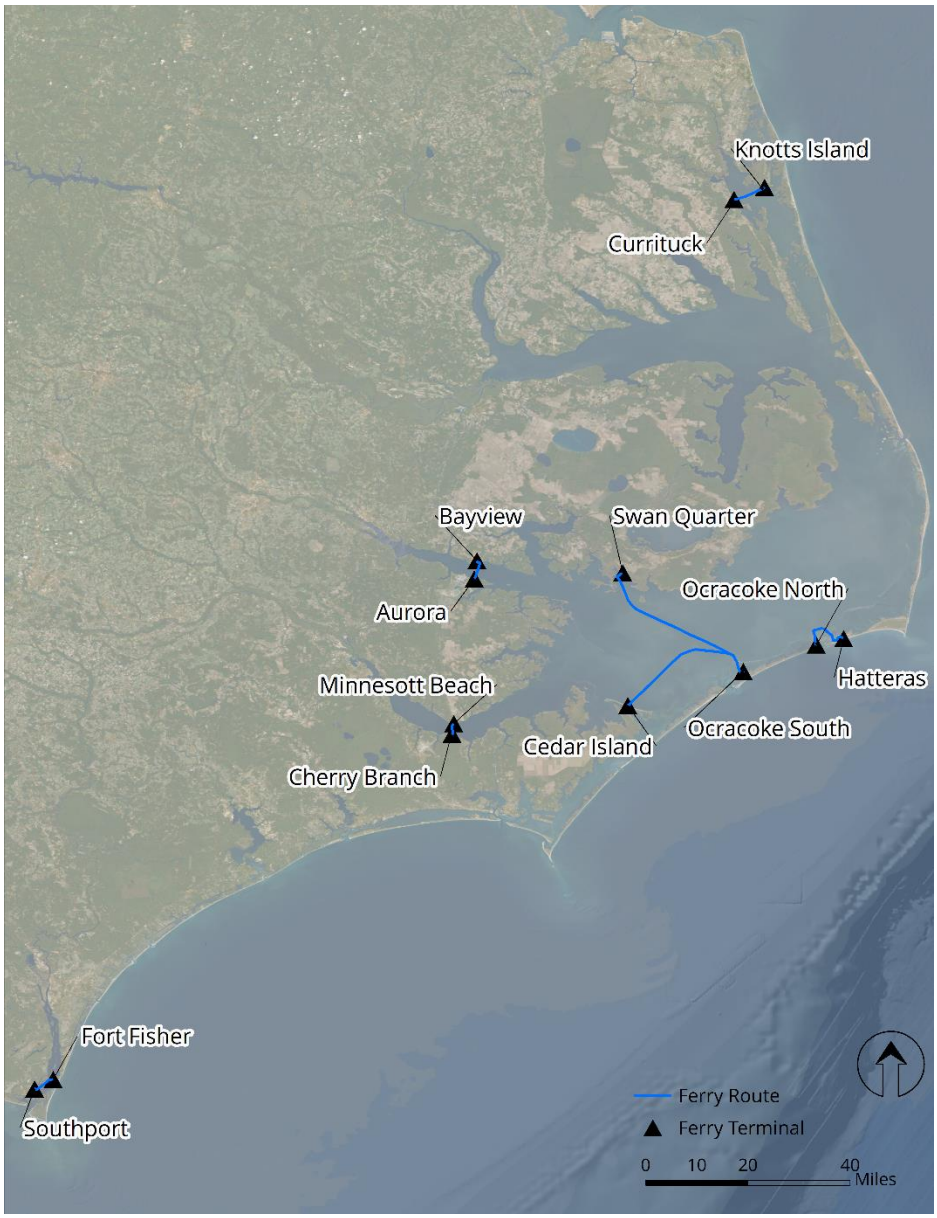

Figure 1. Ferry routes and terminals of the NCFS (Source: 2019 GIS map)

1.3 Ridership and Freight Challenges

Findley (2015) conducted a report at the Institute for Transportation Research and Education (ITRE), in partnership with Volkert and Atkins on the feasibility of the passenger ferry for Ocracoke and Hatteras. This study summarized the economic impact by highlighting expenditures per visitor but more importantly, the need for a predictable and consistent ferry service to maintain a stable economy. The importance of this information is also vital for freight services as well. The same study (Findley, 2015) also adds that since 2013, the Hatteras route is approximately 40 minutes longer due to shoaling and the impact has been dramatic. The number of daily crossings at that time decreased to 36 from 53. The impact reported the effect on ridership overall and did not delineate between passenger and freight.

Findley (2018) conducted a customer service survey for NCDOT for 2017-2018, which reported that the three areas needing the most attention over the next two years was a) frequency of ferry service on desired route b) reliability/timeliness of ferry service and c) availability of ferry schedule and information. Recent additions include the new Rodanthe vessel which was christened on June 28th and is now in operation with a 40-car capacity. Jed Dixon in an interview by Hampton, (2019) for the Virginia Pilot, stated that an 18-wheel tractor trailer carrying supplies to Ocracoke will be able to pull on and off more easily. The Rodanthe replaces the M/V Baum which had a 26-vehicle capacity. In 2020, the Ferry Division will be receiving two more ferry vessels which will accommodate 40 vehicles (the Avon and the Salvo) to replace older vessels (the Kinnakeet and the Chicamacomico, both with a 26-vehicle capacity).

1.4 Research Goals and Objectives

The NCDOT tracks information such as the number of vehicles as well as the number of passengers. This information is currently tracked as part of Coast Guard required documentation (Figure 2). The photo shows the documented 7:00 am departure with 23 vehicles and 30 people. This requirement to log vehicles and passengers however does not provide any of the details regarding the types of vehicles, and also does not track the delineation between truck vs car and/or freight vs general traffic.

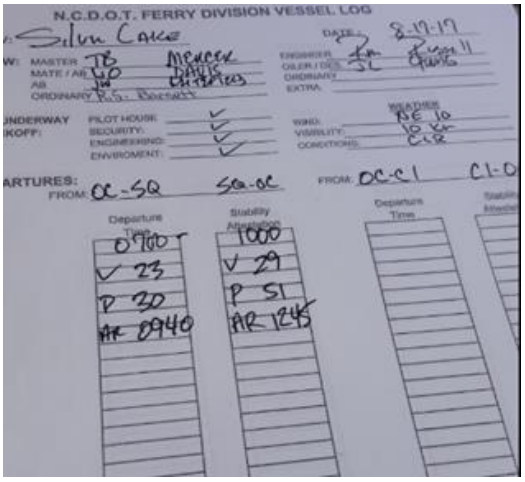

Figure 2. Example of Vessel Log for the Silver Lake Vessel

Information which would be of benefit in terms of freight planning would include the data pertaining to vendors, frequency of freight deliveries, and any anticipated increased future needs. Several of the freight types witnessed by researchers in July and August of 2017 included building supplies, trash services, produce, and fuel. Figure 3 shows an observed freight vehicle waiting at the Hatteras location for boarding. Documentation for freight carriers and frequencies of deliveries is needed to assist the NCDOT with the state level planning. Additionally, for the NCFS, planning will help reduce delays and ensure not only the satisfaction of the public ridership, but also may contribute to the increased efficiency (and thus customer perceptions) for freight services.

Figure 3. Freight vehicle waiting for departure at Hatteras

The primary objective of the research served to:

1) Assist NCDOT with intermodal budgeting and planning purposes with quantitative freight-flow analysis for:
    a. Analysis data for strategic planning:
        i. Freight traffic levels at each terminal
        ii. Loading restrictions, sizes, and capacities
    b. Future freight needs as designated by vendor and/or consignee
    c. Freight which can be planned (scheduled) vs. inconsistent freight timing
    d. Categorize the types of freight
    e. Timing (seasonal, morning, number of days a week)
2) The foundational analysis established a tool for understanding the freight transportation challenges.

2. LITERATURE REVIEW AND REVIEW RESULTS

2.1 General

The existing literature supporting waterway transportation and shipping is primarily concerned with large shipping vessels or cruise lines. However, within recent years, more reports (such as one by Tanko and Burke, (2017) were published. The reports discuss the economic benefits of ferry transportation, and also the marketing benefits for cities as a more popular transportation option. As the North Carolina coastal tourism industry grows, there may also be an increased need to ensure that freight does not affect passenger travel while also working to ensure that the economic benefits of vendors and expedited travel routes via ferry are also met.

2.2 State Freight Plan Comparisons

There are several states that transport freight through a ferry system. The Washington State Department of Transportation cites heavy usage of their ferry system in the transportation of freight and tracks the performance of the system by tons of freight moved (WSDOT, 2017) by ferry, barge and larger marine vessels. Although the study (NYMTC, 2007) is not current, the New York Metropolitan Transportation Council (NYMTC) completed a feasibility analysis freight services to Manhattan and delineated truck services by types of transport: truck barge, truck ferry, and conventional ferry. They explored the travel times, customer base and operational plans to

determine an optimum alternative. In Connecticut, the Fishers Island Ferry District operates a passenger and freight service (drop off option) between New London and Fishers Island (CTDOT, 2017). Similarly, the Fire Island Ferry service in NY (http://www.fireislandferries.com/freight-info/) operates a freight service whereby freight is dropped off and delivered to the island.

The Florida Department of Transportation (FDOT) adopted a multimodal policy initiative in 2003 to address the state's transportation resources and their service of interregional, interstate and international travel. A 2016 report on this initiative, the Strategic Intermodal System (SIS) policy plan, outlines how the flow of people and freight through the influence of policy implementation can impact interregional and intermodal connectivity and promote economic development (FDOT 2016). The report outlines the objectives of the SIS, one of which is to explore the underutilization of ferry services. Although FDOT's marine focus is on seaports, the connection of the FDOT planning to NCDOT is FDOT's GIS analysis of clusters of both economic activity, labor and the relation of the clusters near each other. This broad planning provides potential implications for assessing the locations of freight terminals near clusters of businesses and freight carriers, and passenger terminals near dense urban concentrations or tourism businesses (FDOT 2016). Similarly, the transportation departments of New Jersey, New York and Washington all operate ferry systems as a part of a multimodal transportation system that moves freight. The New York State Department of Transportation (2015) also notes various improvements to infrastructure and maintenance of ports as their maritime system is an integral part of their $7 billion multimodal freight transportation network.

While NCDOT may not currently be looking to increase the number of ferry terminals in their own transportation network, the use of GIS (following the principals using the locations and proximity to terminals (clustering), provides insight to future planning needs to accommodate freight flow.

Another option might be drawn from the service models for New York, New Jersey and Connecticut to increase infrastructure, and to mitigate land travel congestion by considering freight only service routes or other methods of assisting freight transport. Similar to previously mentioned studies such as the feasibility study by NYMTC, a feasibility study could determine the recommended options such as "drop off" service, trucks-on-board (roll on roll off), or consideration of a specific time for a freight only departure.

2.3 Using GIS to Help Determine Operational Needs

The literature search also included a review of GIS analysis methods. Geographic information systems (GIS) are a system of hardware, software and methodology to interact with spatial information. Murray (2010) notes GIS supports decision making through acquiring, managing (storing and accessing), manipulating (converting and interpolating), analyzing (querying) and displaying (geovisualization) spatial and aspatial data. With the development of geographic information systems (GIS) and accrual of spatial data, the integration of layers of information allows for manipulation in various applications. While a primary and well-known feature of GIS is the ability to visualize geographic data, its influence in other areas of analysis is continually developing through application in different fields (Murray 2010).

The results indicated that the studies were similar in GIS uses, but the approaches varied depending on the overall need of the study. The spatial location of registered and permitted freight vendors is considered when informing implications of routing to specific ferry terminals and scheduling of freight movement in response to ridership displacement. When considering the spatial location of these vendors, their likelihood of clustering, and their spatial dependency in regard to proximity to different ferry terminals, spatial autocorrelation methods like clustering

analysis can be employed to inform the routing and scheduling decisions. Murray (2010) argues that GIS is underestimated in substantive application or model building, typically used for visualization or displaying results due to a limited basic understanding of GIS.

Tanko and Burke (2017) discuss the emergence of ferries as an urban transportation (providing multiple modes of city transportation options) alternative in cities worldwide, by analyzing seven ferry systems around the world. By reviewing archival ferry materials and comparing system structures through GIS mapping and by visiting sites and interviewing key players involved in planning and operating each system, their study finds that these urban ferry systems have been implemented for commuting, increasing economic development, tourism and city branding.

Mangan et al. (2002) notes the neglect of ferries as a viable transportation choice in transportation literature, by reviewing the literature related to ferry and port choice. The study provided a qualitative and quantitative methodology for investigating transportation choices in Ireland and the United Kingdom. They note the importance of cost, speed, transit time reliability, characteristics of freight and service as variables in transportation choice. They conducted interviews with 24 key officials in the Irish freight market and shorter interviews with 245 freight truck drivers to assess the issues concerning operations and structure and analyzed survey data through input-oriented modeling techniques (including factor analysis). Lo et al. (2014) state the importance of incorporating the variation of transportation systems in routing analysis of a ferry service network. They formulated a stochastic program to save on costs and increase efficiency when compared to deterministic methods, as they address demand uncertainty and service reliability.

Tanko and Burke (2017) utilize GIS for comparatively mapping ferry systems around the world as a visualization tactic. GIS supports the visualization and analysis of data and spatial problems related to transportation, such as facility locating and routing (Fialkoff et al. 2017; Puenpatom and Jessup 2006). Puenpatom and Jessup (2006) note the use of GIS as an "ideal tool" for understanding the relationship between transportation infrastructure and businesses that rely on them (p. 3). While statewide transportation departments (including NCDOT) routinely gather traffic data on highway corridors, they may have limited information on the type of commodities moving through the road network on freight vehicles (Puenpatom and Jessup 2006). Fialkoff et al. (2017) call freight transportation systems critical infrastructure, discussing freight transportation routing by using a GIS routing analysis. Using GIS for transportation route choice analysis is shown to be useful and might be of interest to decision makers (Papinski and Scott, 2011; Badland et al., 2010; Donnelly, 1993; Fialkoff et al., 2017; Tanko and Burke, 2017; Fried et al., 2018). Route choice criteria can vary, such as minimizing distance or time, minimizing cost, fewest number of obstacles, restricting to a certain area or corridor, or avoiding congestion. Papinski and Scott (2011) conclude that shortest path does not represent observed routes in work commutes, giving suggestions to obtain detailed route choice data, to be used by this study. This data may influence planning parameters for decision makers regarding freight flows, the potential they have for traffic congestion, and the potential for planning freight deliveries and delivery times.

GIS variables and GPS routing inputs to GIS can be employed for route choice modeling (Papinski and Scott, 2011; Badland et al., 2010). GPS tracking facilitates route reconstruction for use in GIS applications, furthering understanding of route choice decisions while providing implications for route planning. Badland et al. (2010) contend GPS provides a more accurate approach for assessing urban commutes, while noting simulated GIS commute routes are comparable to actual commute routes in different travel modes. Puenpatom and Jessup (2006) geocode route data for evaluating freight transportation issues, relating to distribution of freight traffic (commodity, truck type, origin-destination category) on an infrastructure network that might

improve how transportation infrastructure is managed and optimized. Fried et al. (2018) also use a network analyst approach for understanding freight flows to optimize freight network planning. The GIS road network utilization by Puenpatom and Jessup (2006) and Fried et al. (2018), and the methods of GPS routing inputs for route choice modeling by Badland et al. (2010) are the most appropriate comparison to this research for estimating traffic density and analyzing freight flows from vendor location to ferry terminal.

These examples are exchangeable for this research by using buffer and cluster analysis to identify areas with a high density of freight vendors and their implications for route planning and terminal usage based on density. Currid and Stolarick (2010) add to a body of research that gauge the economic composition of a region, linking occupation and industry. They combine a traditional industry cluster analysis with occupational cluster analysis. While they only use these instances of analysis, combining these with methods of spatial autocorrelation and spatial data like business location can give implications for how geographic factors influence economic composition.

The existing literature outlines the similarities in the NCFS needs and the challenges it faces with freight flow and ridership displacement. The review covers the body of literature on ferry systems and freight transportation and the use of GIS as a tool for route analysis. The use of GIS can be useful to applications related to ferry terminal locations, freight flow and transportation planning. In summary, the spatial location of registered and permitted freight vendors is considered when informing implications of routing to specific ferry terminals and scheduling of freight movement in response to ridership displacement. When considering the spatial location of these vendors, their likelihood of clustering, and their spatial dependency in regard to proximity to different ferry terminals, spatial autocorrelation methods like clustering analysis is employed to inform the routing and scheduling decisions.

3. REPORT

3.1 Data Collection

The data utilized for the study includes data from the current ITRE Customer Survey (ITRE, 2019) as well as ridership data provided by the NCDOT. Multiple sources were utilized to collect the data, including:

- ITRE (2019) Customer Survey, using only the responses that indicated “delivery” for the purpose of their trip.
- Survey developed by the research team targeted to the current vendor list.
- Site visits to terminal locations which included witnessed freight and interviews with various employees at each terminal regarding what they typically witness in terms of freight travel.

Additionally, the data includes tabular data and GIS data as shapefiles. This data was used for both the GIS analysis and for future maintenance of data by linking them to locations. Multiple sources were also utilized to collect the data, including:

- Vendor priority pass data provided by the NCDOT, which included registered information about location, company name, and contact details. This data was then cleaned in Microsoft Excel where missing information was filled in where possible, including address correction, and phone number and email addition. This new data was collected from company websites and Facebook pages, company address book sites (like YellowPages ads), and Google location and contact information.

- Demographic information (population count and estimates from 2010 and 2017) came from the US Census Bureau and the American Community Survey (ACS), respectively. Data was collected from 2010 and 2017 to most closely match the data available from NCDOT regarding historical ridership and use of the ferry service (2010 and 2017 are the earliest and latest available datasets). Shapefiles containing boundary information at both US county and Census block group level also came from the US Census Bureau's mapping files data system, as TIGER/Line files.
- GIS shapefiles of a state road network and NCFS ferry routes and terminal locations were collected from NCDOT, via their ArcGIS online page (for the roads and ferry service routes using a state-maintained route layer) and geocoded from their ferry travel map webpage (for the terminal locations using addresses from an embedded Bing map).
- This data was added to a geodatabase created for the storage and maintenance of the data used in the analysis and was updated according to primary data collected by a web-based survey.

The primary source of data was collected through a web-based survey sent to the NCDOT Ferry Service priority pass vendors. The survey also allowed for supplementary input directly from the vendors. The questions were developed and then vetted through an input process with the NCDOT research team. The survey was released on April 25th, 2019 and was closed on July 15th, 2019. The survey link was provided along with the statement, "By being a registered permitted vendor, you have been selected to complete this survey**.** Completing the survey is estimated to take 5-7 minutes**.** By participating, your input will contribute to this research effort and ultimately assist to better serve you." The survey was sent to all of the vendors provided in the current vendor database as an email solicitation directly from NCDOT. *It is important to note that the respondents of the survey are those that own priority passes.* From the original list provided, there were 817 records, however many of those were duplicates. After cleaning the data, there were 318 unique records remaining. Within the 318, there remained a lot of duplicates for any vendor that listed two different contacts. There were 170 of those listed that provided PO Boxes, which was an issue for the GIS geocoding process. Additionally, there were issues with verification since approximately 25% of the respondents provided an email address. The final data clean removed duplicate names and focused on the remaining (211) vendors, which became the target list for survey responses. To provide an indication of the type of vendors using priority pass services, the researchers assigned each vendor a category. The categories and the count for each included:

- Hospitality (food, alcohol, and services for the hospitality industry) 45
- Services/Business (real estate, marine repair etc.) 81
- Retail 22
- Construction (to include any subcontracted type work within the construction industry) 57
- Freight (for general freight carriers such as Estes, and Farr trucking) 6

The survey yielded 84 vendor responses. To finalize data collection, phone calls were made to follow-up for partial responses and for several vendors that had not responded, but the researchers felt were a significant user of the ferry system for freight transport. However, of the 84 responses, 28 of them were not completed entirely but they did provide some of the basic required information. There were also 10 respondents that stated that they used a car/personal vehicle, which resulted in termination of the survey (but documents their response as a freight carrier by

vehicle). This left 46 responses. Of the 46, there were 8 respondents that only provided contact information and then did not complete any of the remaining questions. One vendor hires another company to carry freight and therefore this left 37 completed and valid responses remaining (18% response rate).

Site visits to the terminals were also conducted to increase the survey response rate. The team distributed flyers to the vendors as they arrived at the terminal(s). Several vendors were added to the survey as a result of the site visits that did not have a priority pass, and therefore were not included in the vendor list. Overall, the site visits highlighted the fact that the priority passes are only needed for the priority lanes at the Hatteras terminal. For remote terminals, there are no priority pass options and visits confirmed that there is not currently a significant demand. Appendix A provides a list of witnessed freight carriers. The terminals that do not utilize priority pass had fewer than 5 freight vehicles.

3.1 Analysis Methodology

The survey responses were collected in Qualtrics and analyzed directly within the survey tool. Survey results were also exported as tabular data to be used in both Microsoft Excel and within a SQL-based geodatabase created for the maintenance of GIS data pertaining to this analysis. The GIS analysis was conducted in Esri ArcGIS through various layers and tools used to manipulate the collected data. The specifics of the GIS analysis are explained in Section 3.5.

3.2 Survey Results - Vendor Survey

Customer comments from the ITRE Customer survey (2019) as well as for this research (freight vendor survey). The only data used from the ITRE (2019) survey results were the responses that indicated delivery/tanker/semi or trailer for the question concerning vehicle type which resulted in 22 responses. The ITRE data results were requested directly from ITRE and used to supplement this study and to potentially compare results. Their survey included responses ranging from November 2017 to July 2018. From the 20 responses (two did not respond to this question) regarding the number of trips "taken in the last month", the results indicated that on average 11 trips were taken with a range of 40 to 2. Since 40 appeared to be an outlier, the median number of trips taken in the last month was 5. Additionally, 20 of the respondents indicated that their work location is in North Carolina while only 1 stated South Carolina (and no state was reported for one of the responses). Lastly, 15 of the 22 stated that they utilize the service 10 or more months of the year. Although these figures do not report frequency or specific statistical results for deliveries, it provides some indication that there are no seasonal needs.

UNC Charlotte conducted a vendor survey and the results are summarized in this section. Each question is reported with a response rate since some of the questions were not answered (not set as a mandatory question). In some cases, responses were nearly complete but there were missing answers for several skipped questions. This research proposes a combination of analysis methods which focused on a strategic level assessment with regards to the parameters which impact North Carolina freight planning, as well as planning at the NCFS level. This portion of the analysis was conducted to provide an indication of the specific challenges of freight movement via the ferry service. Additionally, the analysis provides guidance for recommendations regarding optimum freight flow and scheduling.

The survey responses for each question are summarized and if appropriate/needed, also includes the number of respondents (n=#of respondents). In some cases, the number indicated for those questions allowing multiple responses will exceed the N=37 total responses. The demographics for the responses provided (n=30) indicate that 24 respondents are from North Carolina, 4 were from Virginia and 1 from Florida and 1 from Pennsylvania. The remaining

respondents did not provide this demographic (replied "anonymous"). Half of the NC respondents indicated that their primary business location is in Manteo, Kitty Hawk and Buxton. Freight deliveries are primarily by companies that operate intrastate (60%) as shown in Figure 4.

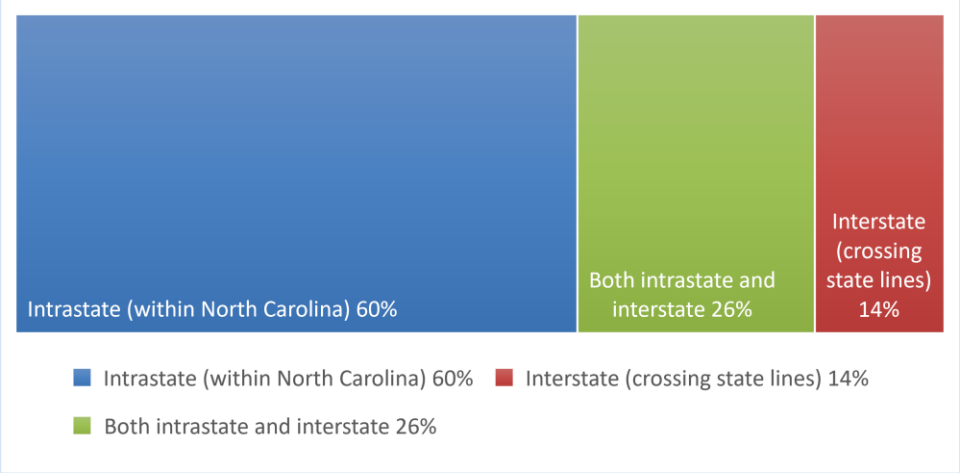

Figure 4. Intra/Inter Focus

A question regarding truck fleet sizes was added to assist with an understanding of the operations of each vendor. The results indicated that 80% of the respondents stated that they operate their own truck/fleet, 3% uses hired trucking to move their freight, and 16% uses a combination of both. To assist with data regarding potential displacement of general ridership, the survey inquired about vehicle sizes on average for the company fleet. Keith Stegall (2019) provided the categories below that are used internally by the Ferry Division and provided online for customer information regarding commuter passes.

- Vehicle and/or Combination Less Than 20 Feet (Single)
- Vehicle and/or Combination 20 to 40 Feet (Double)
- Vehicle and/or Combination 40 to 55 Feet - *Above 65' requires a permit (Triple)

**Single, Double and Triple are terms utilized by the Ferry Division for the vehicle size categories and does not represent axle or Federal Highway trucking industry terms.*

The survey was designed to further delineate vehicle sizes and resulted in 7 size categories as shown in Figure 5. The results indicate that a majority of the freight carriers have vehicles that are less than 25 feet in length and if including the two smallest categories, over half (55%) are utilized truck sizes that are 30 feet and smaller. However, as noted in Figure 2, counts are maintained by the crew for each passage. The data provided by NCDOT for October of 2017 reports sizes based on the internal Ferry Division Categories. The reported results from the 2017 NCDOT provided data indicates that 82% of the vehicles were "singles" and 16% are Doubles, and the remaining 2% were Triples. The reporting offers two different categories and the largest difference between the current vendor survey and the NCDOT reporting is the 40'+ category where the 2017 data shows the Triples account for 2% while the vendor survey shows that category as reporting 19%. Currently, NCDOT tracks the sizes for Hatteras specifically and then a combination of all sound routes. Further investigation of what data collection metrics should be used to provide value for freight research should be considered. (Also, see the Implementation section for recommendations.)

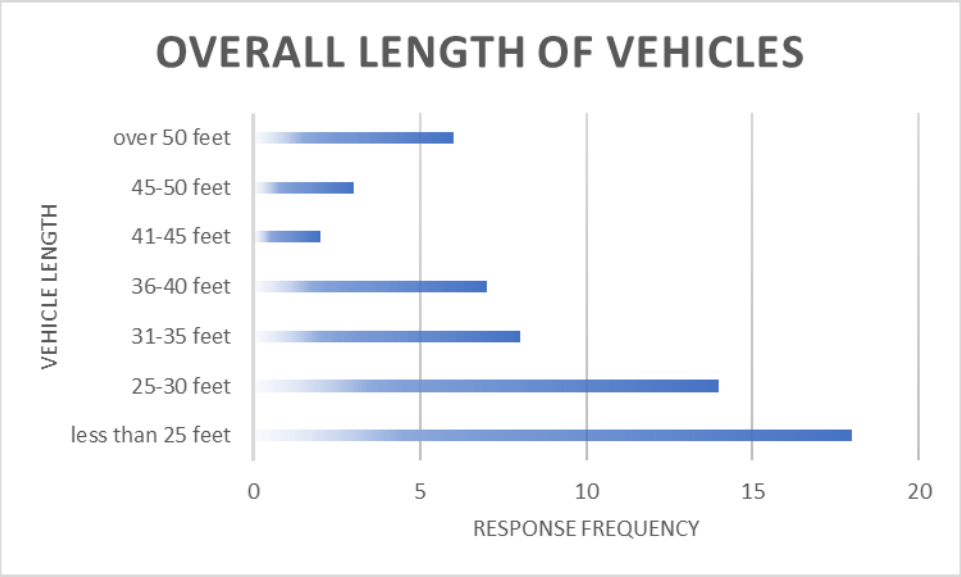

Figure 5. Overall Length of Vehicles.

The responses obtained regarding the type of vehicle (n=54) indicates that a majority of the vehicles are general delivery trucks (37%) while 19% were personal vehicles, and 24% indicated "other" for specific vehicle types (including lo-boy, chipper truck, dump truck and large pickup trucks). Figure 6 showcases that approximately 26% of the responses indicated that they have more than 10 vehicles in their company fleet but that the largest percentage has just 1 vehicle.

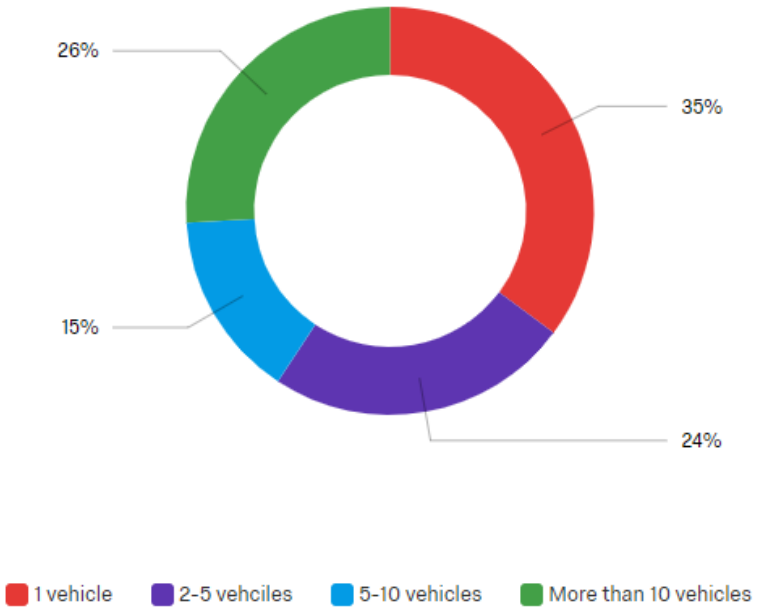

Figure 6. Fleet Size

The freight survey included a question regarding wait times (n=40). The question asked the respondent to rate their opinion on wait time from a scale of 1-7, where 1 is "minimal wait time" and 7 is "extensive wait time". When combining the responses for "minimal wait time" (a 1, 2 or 3) 80% of the users indicated this range for wait times. To quantify the wait time, the respondents were also asked, "Approximately how long does it take you to board the ferry from the time you arrive at the dock?" The (n=42) responses were provided and 3 respondents stated that they wait less than 15 minutes. Next, 31 respondents stated that they wait 15-30 minutes, 8 indicated 30 min to an hour and no respondents stated that they wait over an hour. Additionally, 77% of (n=40) stated that they only "sometimes" miss a ferry sailing and 20% stated that they never miss a sailing.

An additional inquiry concerned the type freight being carried using the ferry service. As shown in Figure 7, the most frequent categories include construction, food / beverage supplies (primarily for the hospitality industry), and other retail goods category (a combined category for items that did not easily fit into a specific industry segment).

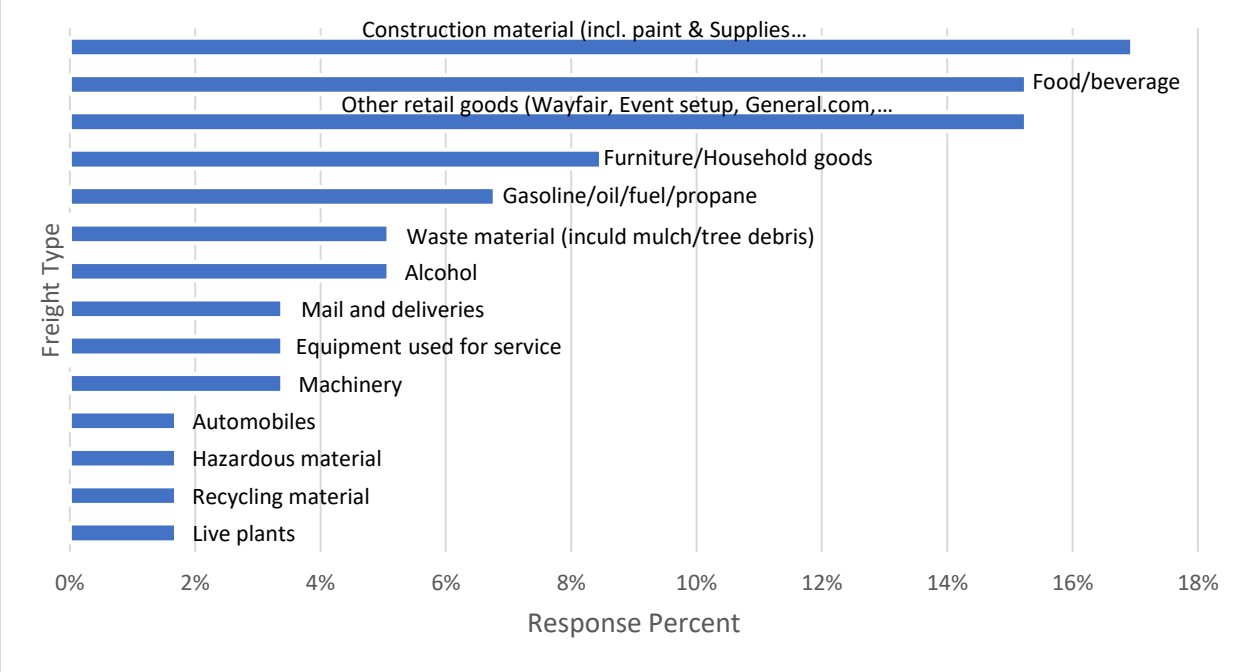

Figure 7. Freight Types

The Hatteras Island to Ocracoke Island (North Terminal aka Southdock) ferry route is the most frequently utilized by the freight-carrying vendors. A question asked which routes were used by the vendor to provide a ranking. The responses (n=44) show that Hatteras to Ocracoke North ranked the highest, with 80% of the respondents indicating that they used it the most. The only other routes that indicated usage were both at a 5% response rate for Swan Quarter to Ocracoke South and Cedar Island to Ocracoke South. Those that ranked the highest with a response of "not used" included:

Bayview to Aurora (95%)
Cherry Branch to Minnesott Beach (95%)
Southport to Fort Fisher (91%)
Currituck to Knotts Island (86%)

Freight carriers with a priority pass may use the lines labeled PRIORITY for both sides of the Hatteras Inlet. It is important to note that the respondents of the survey are those that own priority passes. Additionally, there are also vendors that utilize the ferry service but have never requested a priority pass as evident during the site visits. There were 11 additional vendors without priority passes were recorded. Therefore, a small number (11) of the freight carriers in the population of users were identified through the site visits and interviews and additionally, three of the 11 new recorded vendors also completed the survey.
Site visits were conducted on:

May 29, 2019, Hatteras
May 30, 2019, Swan Quarter
June 19, 2019, Southport
June 19, 2019, Cherry Branch
June 20, 2019, Cedar Island
June 20, 2019, Ocracoke

The site visits also provided a good indication of the freight usage for those terminals that do not utilize the priority lane option. On the day of each of the visits, there were no freight vehicles noted for Southport or Fort Fisher, and the ticket booth attendant stated that there is typically a freight truck per day on average at that location. Cherry Branch on the other hand stated that the deliveries are generally related to the Minnesott Beach businesses such as furniture deliveries, log trucks, lumber, and sod from the two sod farms (Neuse and Pamilico Sod). However, these are businesses that do not request a priority pass and therefore are not listed in the vendor database.

The survey also asked, "How many trips (#) aboard a ferry do you estimate your company/organization's transporter takes per week (where a round trip is 2 trips)?" The responses (n=43) indicated that generally 1-5 trips are taken (Figure 8). The site visit responses also revealed that food service industry vendors deliver once per week to the Ocracoke Island for restaurant provisions such as seafood, beer/wine, and hospitality supplies.

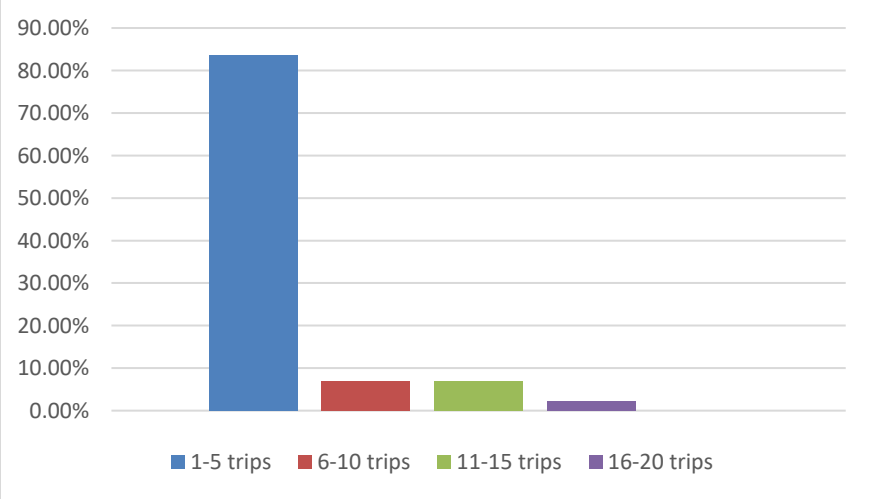

Figure 8. Number of Trips

To fully explore the freight needs, the research also inquired about seasonal freight. For most of the respondents (n=61), freight is consistent across seasons (see Figure 9).

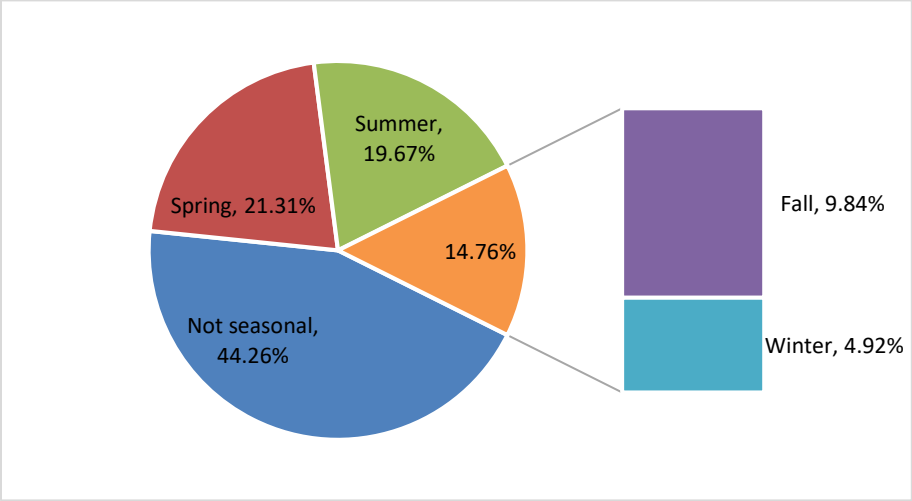

Figure 9. Seasonality

In the discussions with delivery drivers regarding seasonal deliveries, several indicated that there is a slight increase during the summer months but overall, they did not feel that there was a significant change in the number of deliveries that they made in a particular season. The question asked that respondents "select all that apply" and the responses for the spring and summer showed that approximately 20% for each, indicated a seasonal increase for their deliveries. Most likely, the increased times provided by NCFS during the summer months assists to offset the seasonal differences for freight. The increase noted during the winter months (for the small 14.76% noted in Figure 9) is also offset by the winter season ridership decrease.

The literature provided two options for accommodating freight (CTDOT, 2015; Fire Island, 2019). The first option is to provide a storage area where freight providers (as a paid service) can leave freight items to be loaded, instead of the freight vehicle making the trip. This requires a freight storage area and also requires additional implications regarding operations that would need to be considered. The second option was a freight customer only service trip that would be outside of peak commute times. As a result of these suggestions within the literature, a question was added that survey that inquired whether a "freight only" service trip would be of interest to the company. The responses (n=22) were split with 51.2% stated yes and 48.8% responding no. For those that responded yes, almost half of those stated that an early (before 8:00 am) time would be preferred and 36% percent responded with an 8:00 am to 11:00 am timeframe would be second. The number of responses to this question (n=22) as well as the lack of a significant number stating "yes" is indication that the NCFS is currently meeting the needs for freight service providers.

3.3 Terminal Data Collection (Witnessed Data)

The witnessed data was observed at all locations except for Currituck and Aurora routes. The information provided in Appendix A shows observations for one or one-half day observations at each terminal as well as interviews with ticket booth agents if applicable. Note that if there were no freight vehicles during the observations, the appropriate vessels for that location were not included in Appendix A (there were only 4 ferry vessels documented for that reason). It is

important to note that this discussion is based on a single day of observations at each terminal (multiple days of observation). Repeated observations may produce different results. The primary observation was that most of the traffic at Hatteras at 5:00 am for the first departure time is freight. Figure 10 shows a 5:00 am truck waiting for departure at the Hatteras terminal. This particular vehicle is classified by the Ferry Division as Vehicle length longer than 65 feet and thus requires a permit.

There was no displacement of ridership before 9:00 am but departures after 8:00 a.m. at Hatteras typically had displaced riders; however, their wait was generally minimal since this terminal runs multiple vessels. As the day progressed, mid-day appeared to be the timeframe where the terminal became extremely busy and wait times were longer.

Figure 10. Freight at 5:00 a.m.

There was no apparent displacement at any other terminals visited. There were no witnessed 40'+ freight vehicles at the terminals the days of observation so most of the freight at terminals other than Hatteras had no issues getting on the next available departure and there was no displacement of commuters or visitors.

3.4 GIS – Map Analysis

A SQL-based geodatabase was created in an ArcGIS environment to store and manipulate the data used in the analysis. The analysis includes a block group, defined by Esri as the smallest unit for which the U.S. Census Bureau reports a full range of demographic statistics. There are about 700 residents per block group. A block group is a subdivision of a census tract. All shapefile layers collected from the various sources mentioned in Section 3.1, including the county and block group boundaries, the state road network, and the NCFS ferry service routes and terminals were imported into the geodatabase. Population counts and estimates as tabular data were then spatially joined to the county and block group shapefiles for mapping. Vendor information was also added to the geodatabase as tabular data, and certain vendors were geocoded for further analysis and mapping.

Maps were used as visual representation of ferry service historical ridership and change, vendor location, population change in geographies which have a vendor, and select information from the web-based survey responses.

3.4.1 Schedule Optimization

The researchers utilized GIS to assist with information pertaining to freight flows for optimization. Further explanation of the use of GIS as a schedule optimization tool is provided in Section 4. However, further exploration is needed to determine additional data that may aid in the use of GIS as a tool to be used by the NCFS. Since the Hatteras terminal was the only terminal with documented wait times for vendors, and since those wait times were minimal, schedule optimization is not an issue. However, to determine schedule optimization as it pertains to freight usage, more documentation is needed to determine specific freight times. Also, see section 3.2 where it was also noted that vendors do not currently see a need to add a freight only departure time.

3.4.2 Determining Permitted Vendor Locations

The GIS application was used to explore the vendor locations for those vendors which had an address reported to NCDOT by their permit application (or was acquired in cleaning the NCDOT data discussed in Section 3.1), or who completed the survey. In cleaning the original tabular dataset from NCDOT which contained 323 records, duplicate records were removed to yield 211 unique records. These records were then parsed to find if their addresses were accurate as some were missing data (i.e. no zip code, no street address, etc.) as explained in Section 3.1. Of these parsed 211 records, records with post office boxes were removed as they would not accurately portray vendor locations, yielding only 193 records with an accurate address used as a proxy for vendor location. These 193 records were geocoded with a batch geocoder, which would only take accurate addresses.

The vendors are shown with the 2017 American Community Survey (ACS) total population data by county and block group which contain at least one vendor (Figure 11; Figure 12). The purpose of this information was to explore the density of the vendor locations to understand where businesses who are registered to utilize the ferry service were located as compared to population. Most of the vendors/businesses are based along the Outer Banks and not necessarily located in areas of large populations as some vendors are in some of the lowest population areas by both county and block group (Figure 11; Figure 12). Higher populated counties and block groups are located further from the coast with fewer vendors (Figure 11; Figure 12).

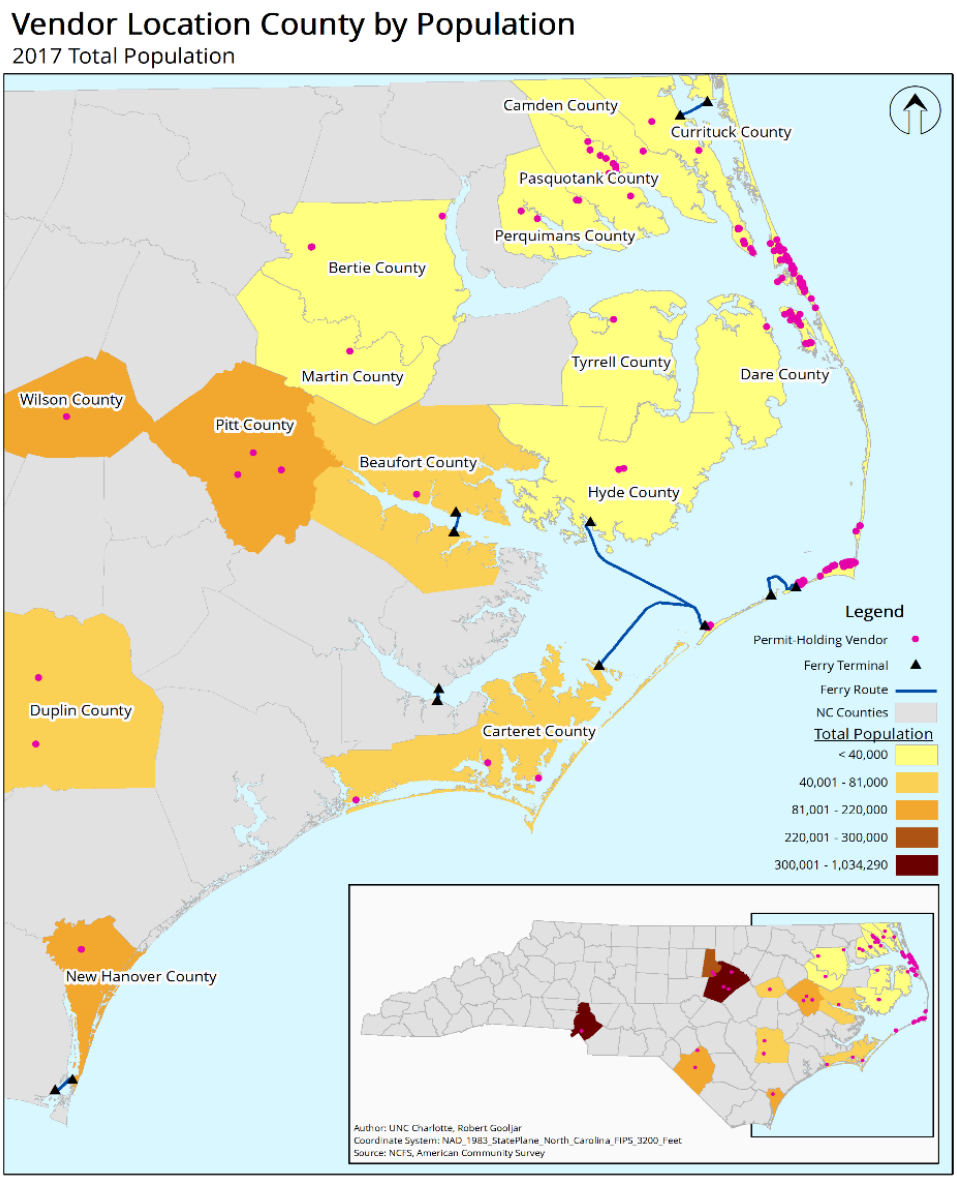

Figure 11. Vendor location and Population by County

It is again, important to note that the researchers documented that vendors using the Cherry Branch terminal (for example) are not documented in the recorded list of vendors since they do not utilize the priority pass. This map reflects those vendors that were either documented during site visits or are a part of the original vendor list. It is recommended that this map be updated to reflect all vendors with new operational procedures to collect this data.

The benefit of comparing location by county population is to create a foundation for potential correlations if NCDOT continues to collect vendor location data. There are potential implications for increased populations with regards to required deliveries to serve the increased populations.

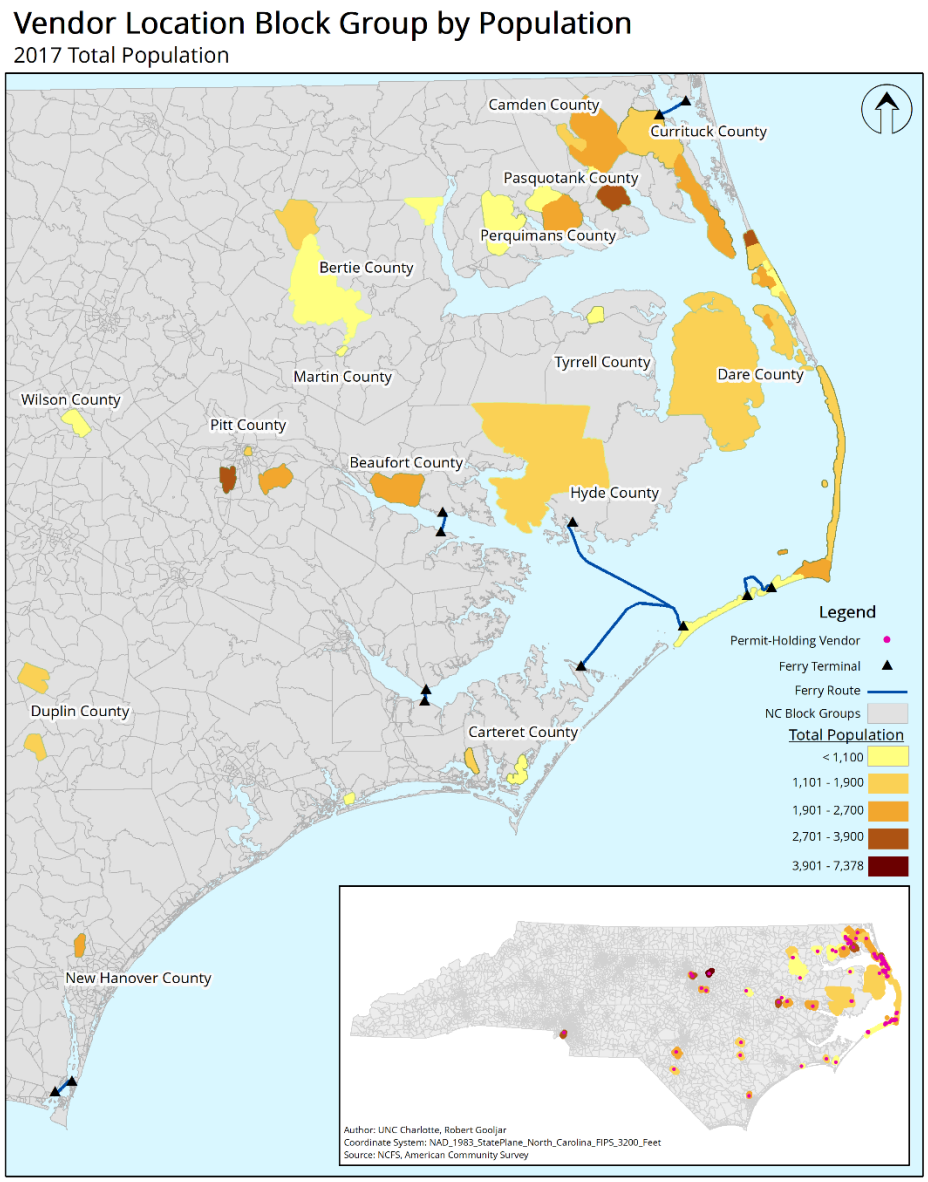

Figure 12. Vendor location and Population by Block Group

3.4.3 Determining Vendor Travel Routes

The survey data asked respondents to note what major roadways were primarily taken in their routes from their origin location to the ferry terminals. This question was asked to provide not only an overview for NCDOT of specific freight-related routes, but to also showcase the connections of highway routes and volume as it pertains to each terminal location. Figure 13 shows the routes mentioned by survey respondents. Only 39 respondents provided route information. The routes are displayed where line thickness increases with frequency of mention by the respondents. For example, the most used (most mentioned) route is NC-12 with a frequency of 23 mentions. The most used routes by respondents seem to be NC-12, US-64, and US-158 (with frequencies over 15) and NC-168 (with a frequency of 11). Only some of these routes coincide with ferry terminal location, specifically around the Ocracoke and

Hatteras terminals (Figure 13). This information could be useful in understanding trans modal freight flows.

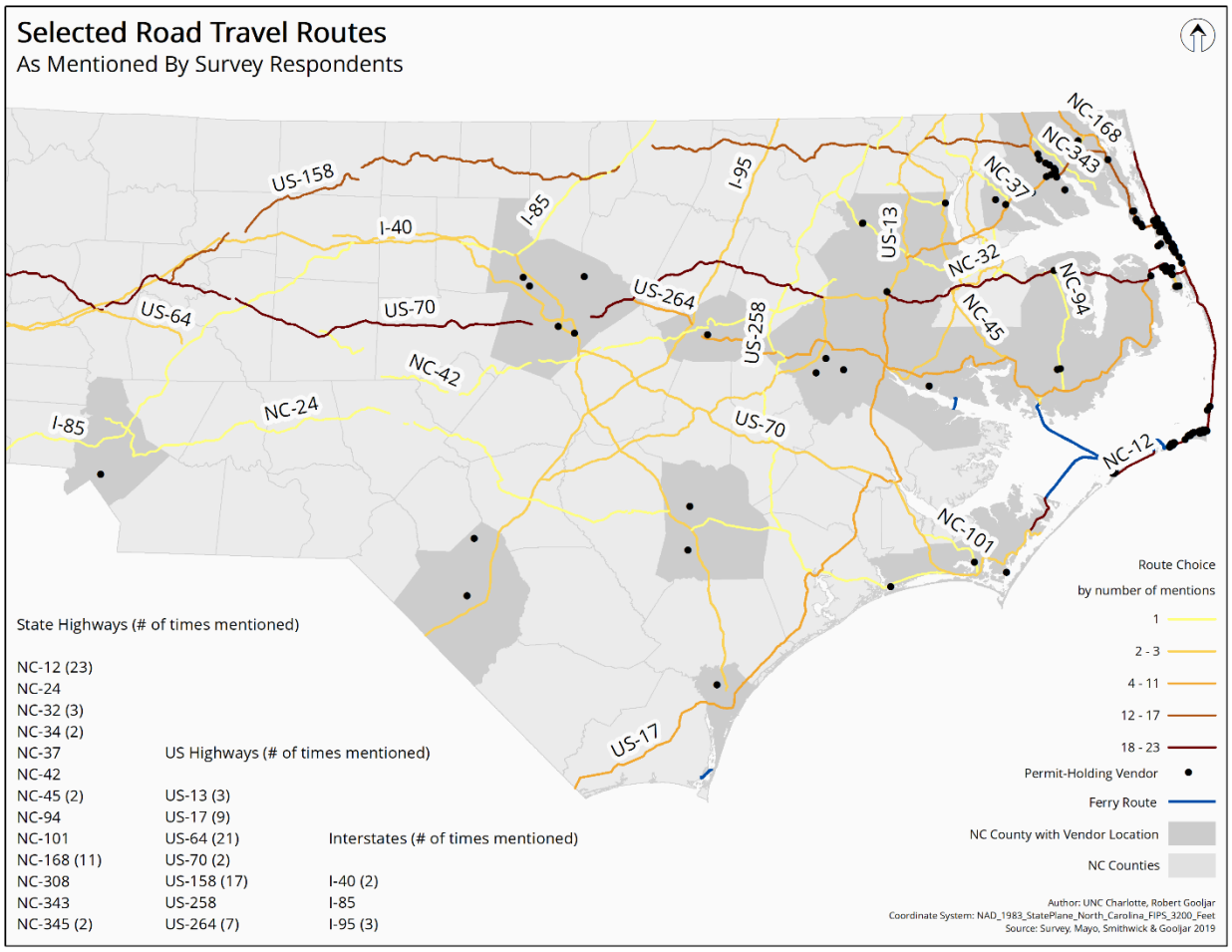

Figure 13. Survey Respondent Vendor Routes

3.4.4 Determining Vendor Freight Classifications

The survey data asked respondents to choose categories to classify their freight they transport via the ferry system. This question was asked per previous literature noting the importance of freight classification in understanding freight movement (Puenpatom and Jessup 2006). Only 34 respondents provided information related to freight classification. Figure 14 displays these respondents by categorical freight types. The most common classifications were “Other” with a frequency of 12, “Construction material” with a frequency of 9, and “Food/beverage” with a frequency of 7. Six respondents selected more than one category.

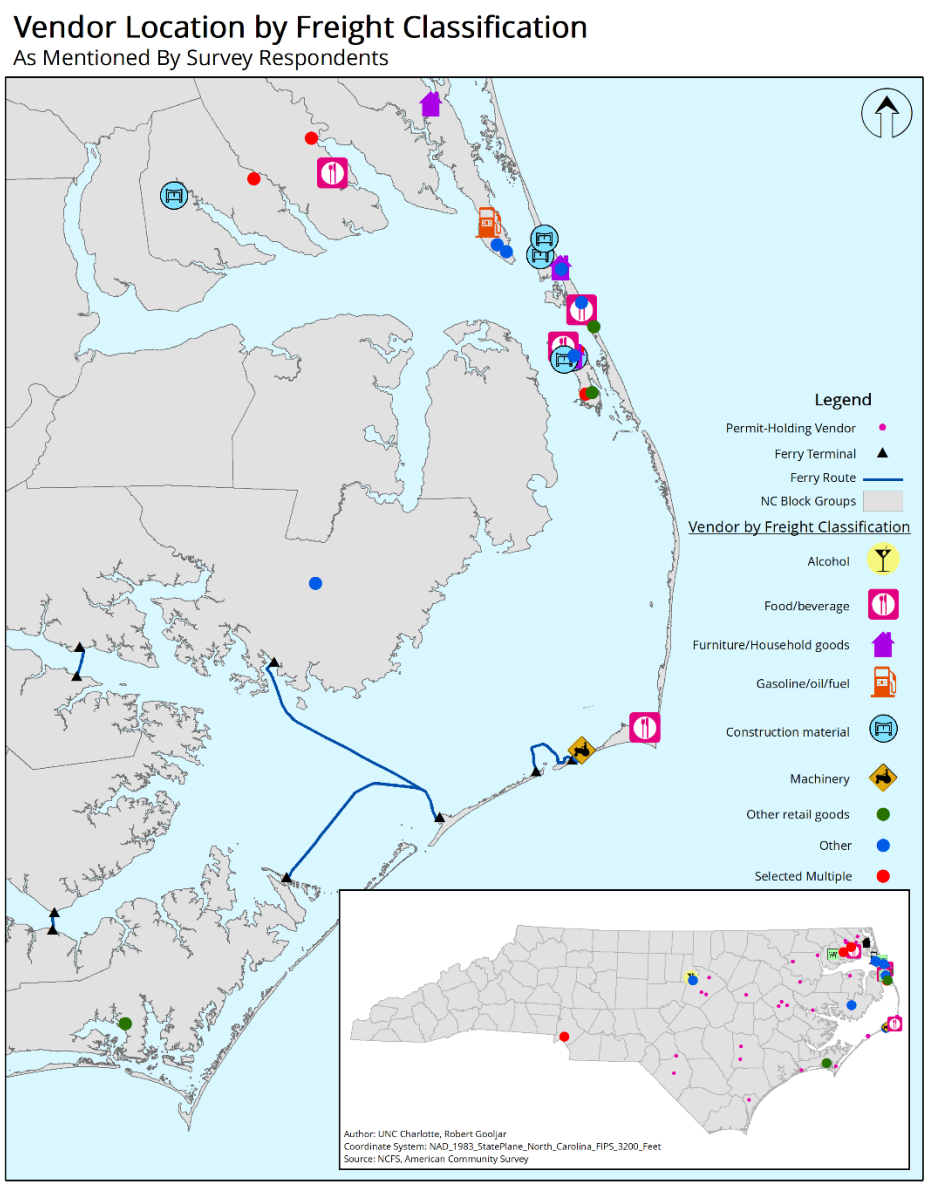

Figure 14. Vendor location by Freight Classification

3.4.5 Ferry Vessel Route (Change in Ridership by Total Passengers and by Total Vehicles)

The NCDOT data also supplied the potential to review ferry routes and the 10-year change in ridership. Although this research purpose was to review the freight usage, it is important to also include ridership changes for potential impact. Ferry usage for freight travel may be impacted by numerous variables which were not a part of this analysis, however the researchers have included these summaries for future tracking for potential correlations. For each of the terminals/routes shown in Figure 14 and Figure 15, the number of passengers and the number of vehicles for 2018 is provided as well as the 10-year change. The inset maps of Figure 15 and 16 are displayed in decreasing order and labeled accordingly from 1 to 7. The ridership implications as noted in the study can also provide insight as to potential limitations for vendors as well. The study notes that during the noted time frame, the duration of the ferry ride between Hatteras Island and Ocracoke Island has increased by 50 percent, reducing the total number of trips that can be made each day from 53 to just 36. Additionally, if visitors to the island are down, then so is the need for hospitality and food product deliveries. The study recommended the fast ferry to help increase passengers to Ocracoke; however, this solution does not provide resolution for businesses who still need the additional trip options.

According to the historical ridership data provided by NCDOT, there has been a decrease in ridership by total passengers over the ten-year period from 2008-2018 for every route except for Fort Fisher to Southport and Ocracoke to Swan Quarter (Figure 15). This is similar to ridership based on vehicle count over the same ten-year period, where all routes have seen a decrease in vehicle counts except for Fort Fisher to Southport and Ocracoke to Swan Quarter (Figure 16). The Currituck to Knotts Island route has seen the largest decrease by passenger (over 44%), while Cedar Island to Ocracoke has seen the largest decrease by vehicle count (over 29%). While Fort Fisher to Southport is currently the 3rd busiest route by vehicle count, it is also currently the busiest by total passengers. Ocracoke to Hatteras is currently the busiest route by vehicle count (and 2nd busiest by passenger count). Currituck to Knotts Island is currently the least busy route, both by passenger total and vehicle count.

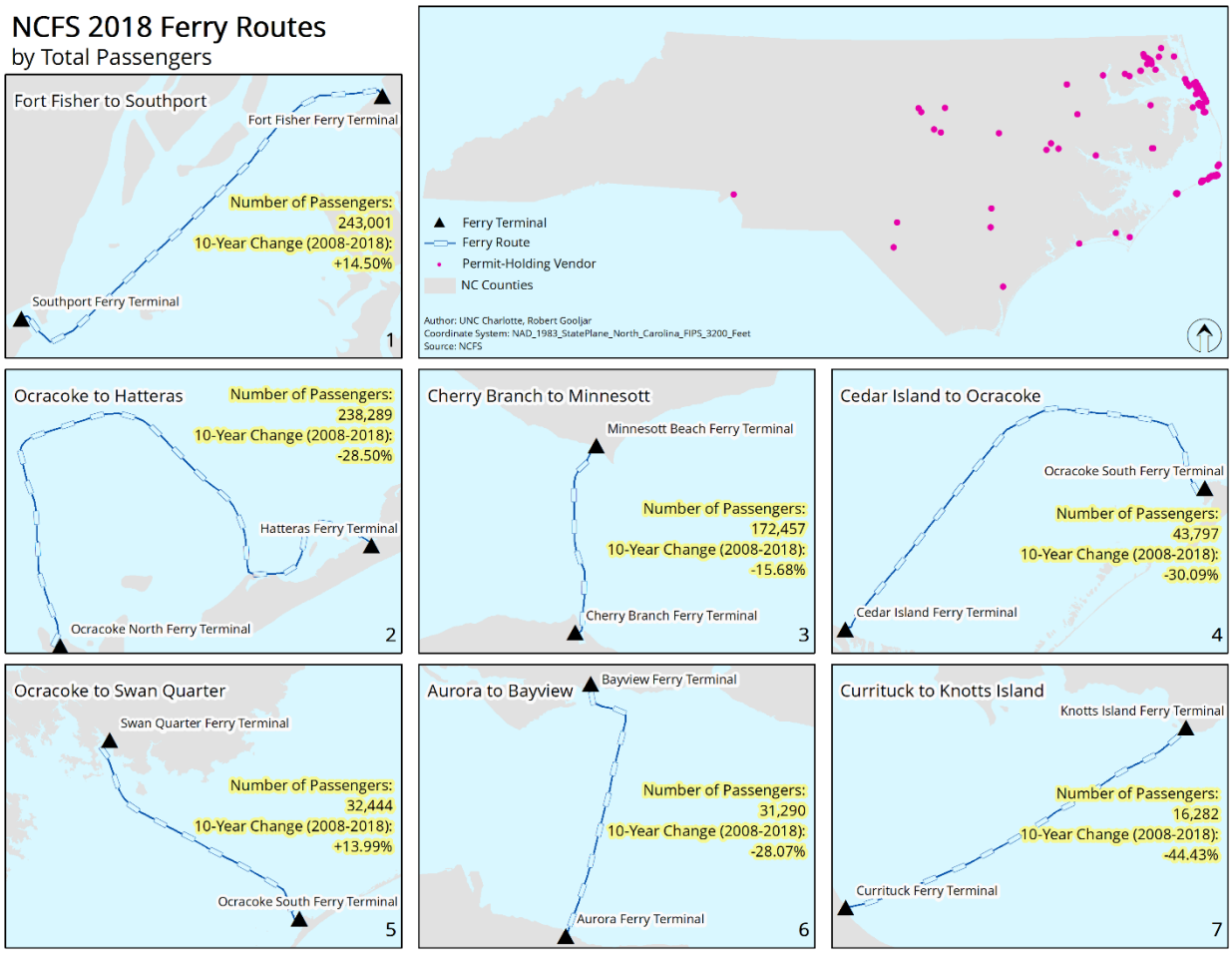

Figure 15. Ferry Route – Total Passengers

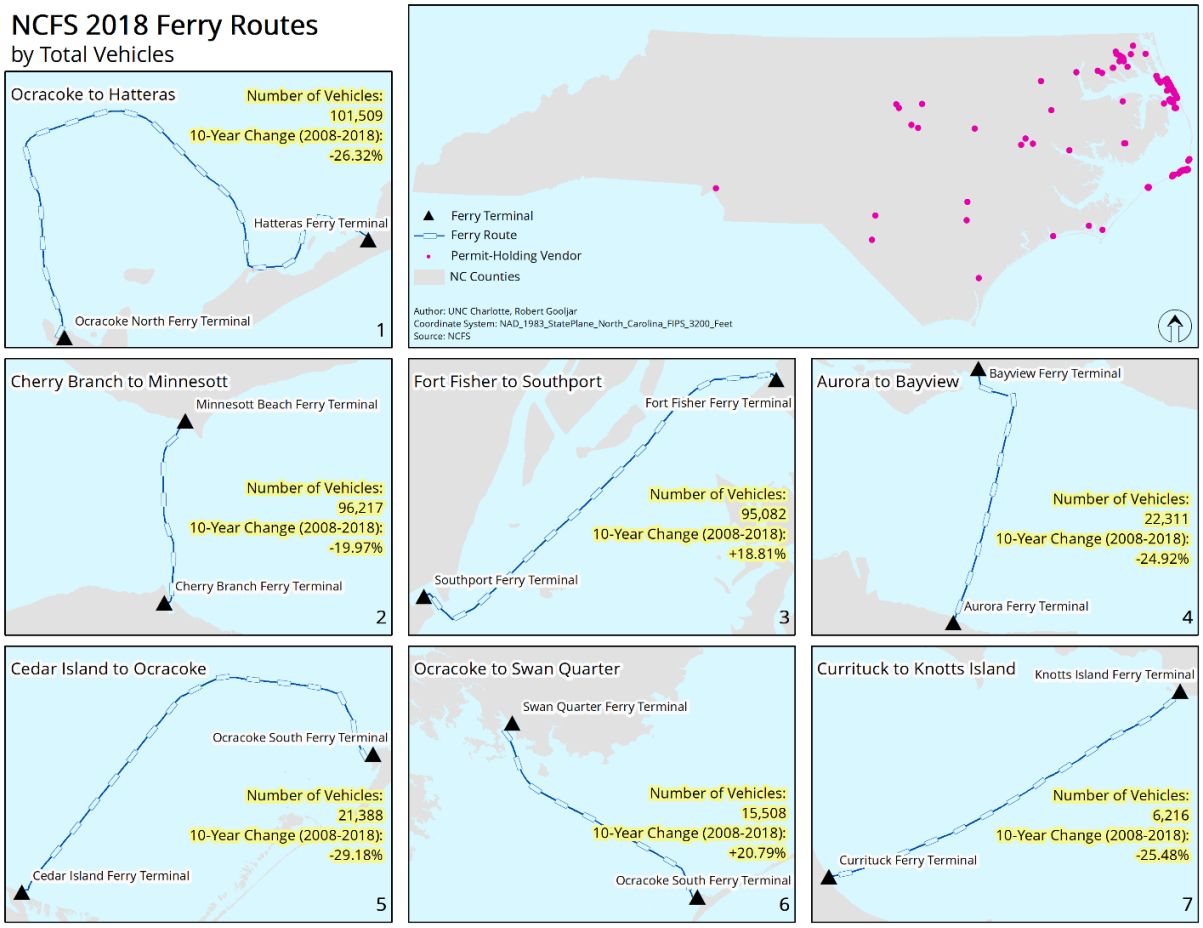

Figure 16. Ferry Routes – Vehicle Count

3.4.6 Population Change (County and Block Group by Vendor Location)

Population change metrics were calculated with percentage point change over the years 2010-2017 using data from the ACS and decennial census. These metrics were calculated and displayed at both the county and block group level which contain at least one vendor. County-level data was chosen to better recognize spatial heterogeneity across the state, while block group-level data was used to locate vendors within each county. Figure 17 shows the percentage point change in population at the county level. The highest change in population areas are in Mecklenburg and Wake counties, far from the coast. There is positive population change in counties along the coast, such as Carteret, Currituck, and Dare counties, and decreasing population inland, between Hyde and Martin counties. It is interesting to note that Currituck County saw the largest population increase along the coast but saw the most dramatic decreases in ferry ridership by both total passenger and vehicle. The pattern in block group is similar, with high increases in population toward the south of Currituck County and in Dare County along Hatteras and the Outer Banks (Figure 18).

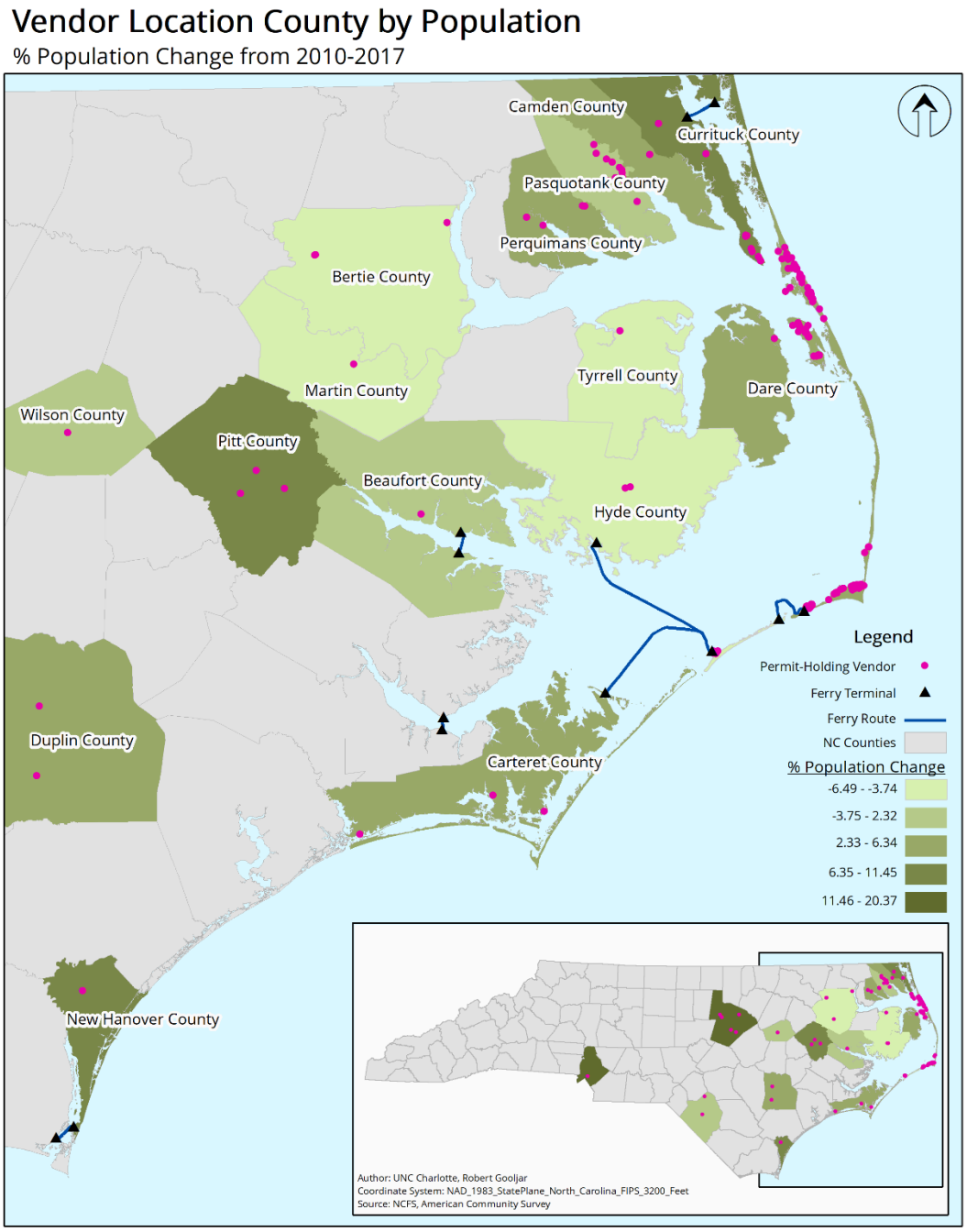

Figure 17. Vendor Location County by Population Change

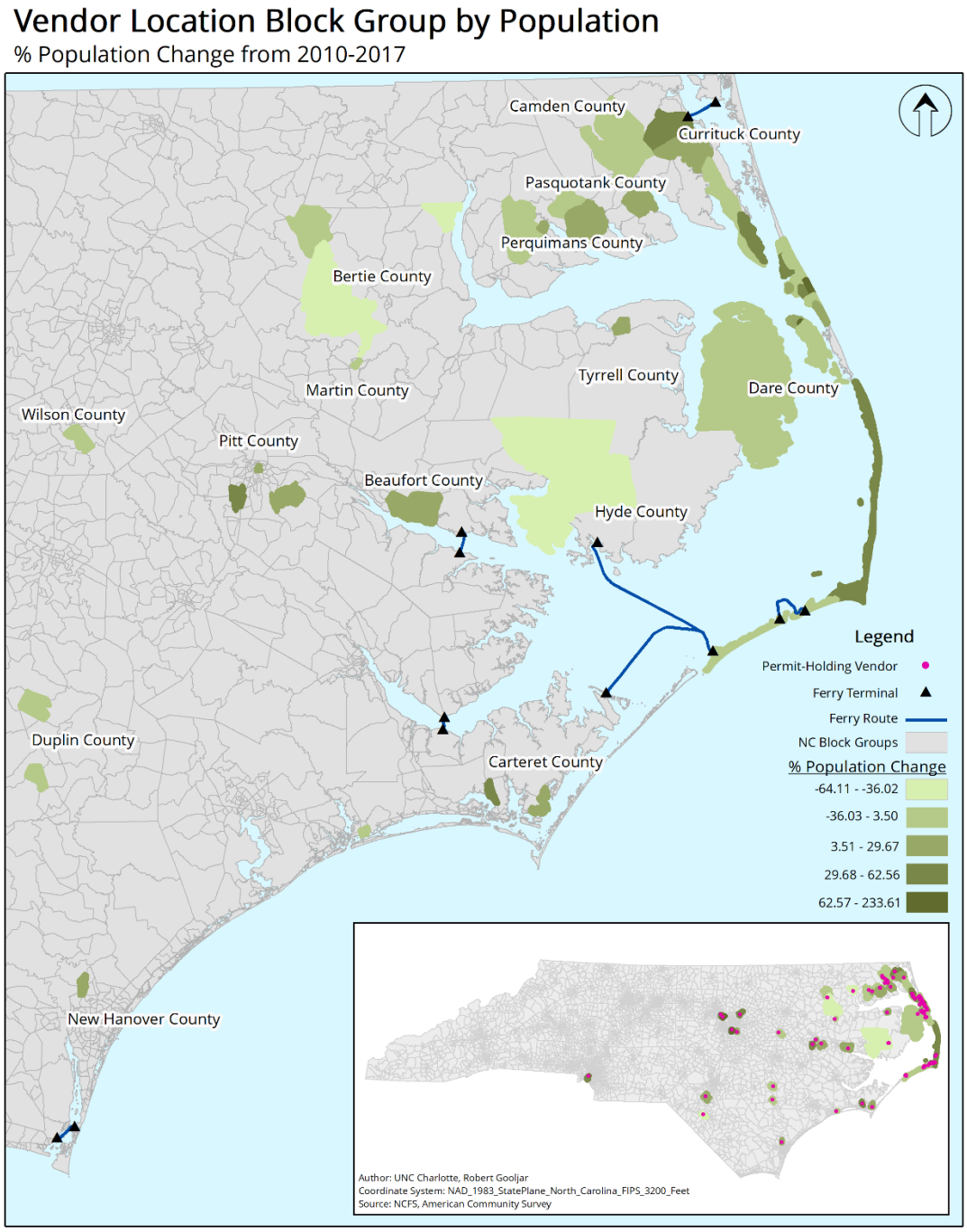

Figure 18. Vendor Location Block Group by Population Change

Figure 18 shows high increases in population toward the south of Currituck County and in Dare County along Hatteras which may imply higher needs for supplies and deliveries by freight carriers using the adjacent terminals. However, continued review (using the new geodatabase from this study) may assist to determine if there are correlations in population change and terminal use by freight carriers.

3.5 GIS – Hot Spot Analysis

The geocoded vendor locations were used in a Getis-Ord Gi* hot spot analysis to identify potential clustering and their implications related to routing, scheduling, and ridership. This analysis tool was utilized as it calculates a Gi* statistic for each feature in the dataset with z-scores and p-values noting where there may be high or low instances of clustering in the context of its neighboring features. Hot spots are noted by having features with high values surrounding other features with high values. They are calculated by comparing the local sum for a feature and its neighbors proportionally to the sum of all features (Figure 19). When the difference is large, it produces a statistically significant z-score which indicates clustering as opposed to proximal location related to random chance. While this indicates that vendors might be locating close to each other for a specific reason and not by random chance, the exact reason for clustering is not determined in this study.

The Getis-Ord local statistic is given as:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \bar{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \quad (1)$$

where x_j is the attribute value for feature j, $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of features and:

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \quad (2)$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - \left(\bar{X}\right)^2} \quad (3)$$

The G_i^* statistic is a z-score so no further calculations are required.

Figure 19. Calculating the Getis-Ord Gi* statistic (Esri 2019)

This analysis was conducted at the county and block group levels for the same reasons outlined in Section 3.5.6. Although there were 193 geocoded vendors from the original database, only certain vendors were chosen to be used in the hot spot analysis. Only vendors within the State of North Carolina were used in congruence of the North Carolina based data, leaving 177 vendors. From here, only vendor location points which scored over 80% (considerable geocoding metric accuracy) during the geocoding process were used for address accuracy, leaving a total of 164 vendor locations used in the hot spot analysis.

3.5.1 Vendor Hot Spot Analysis (County Level)

The 164 vendor locations chosen for use in the hot spot analysis were spatially joined to the counties they fall in. Only counties that contain at least one vendor were used in the hot spot analysis, yielding 19 counties used as input features. The analysis uses the inverse distance weighted (IDW) method, chosen as it measures the likelihood features might influence each

other based on spatial proximity, allowing each feature to be a neighbor of every other feature. Combined with a Euclidean distance measure and 0 distance threshold (used for IDW method), only Dare County is shown as a statistically significant hot spot at the 99% confidence interval. All other counties are shown as not significant. This indicates that there are high instances of clustering of vendors within Dare County, in congruence with the visible number of vendor locations on the Outer Banks and Hatteras (Figure 20).

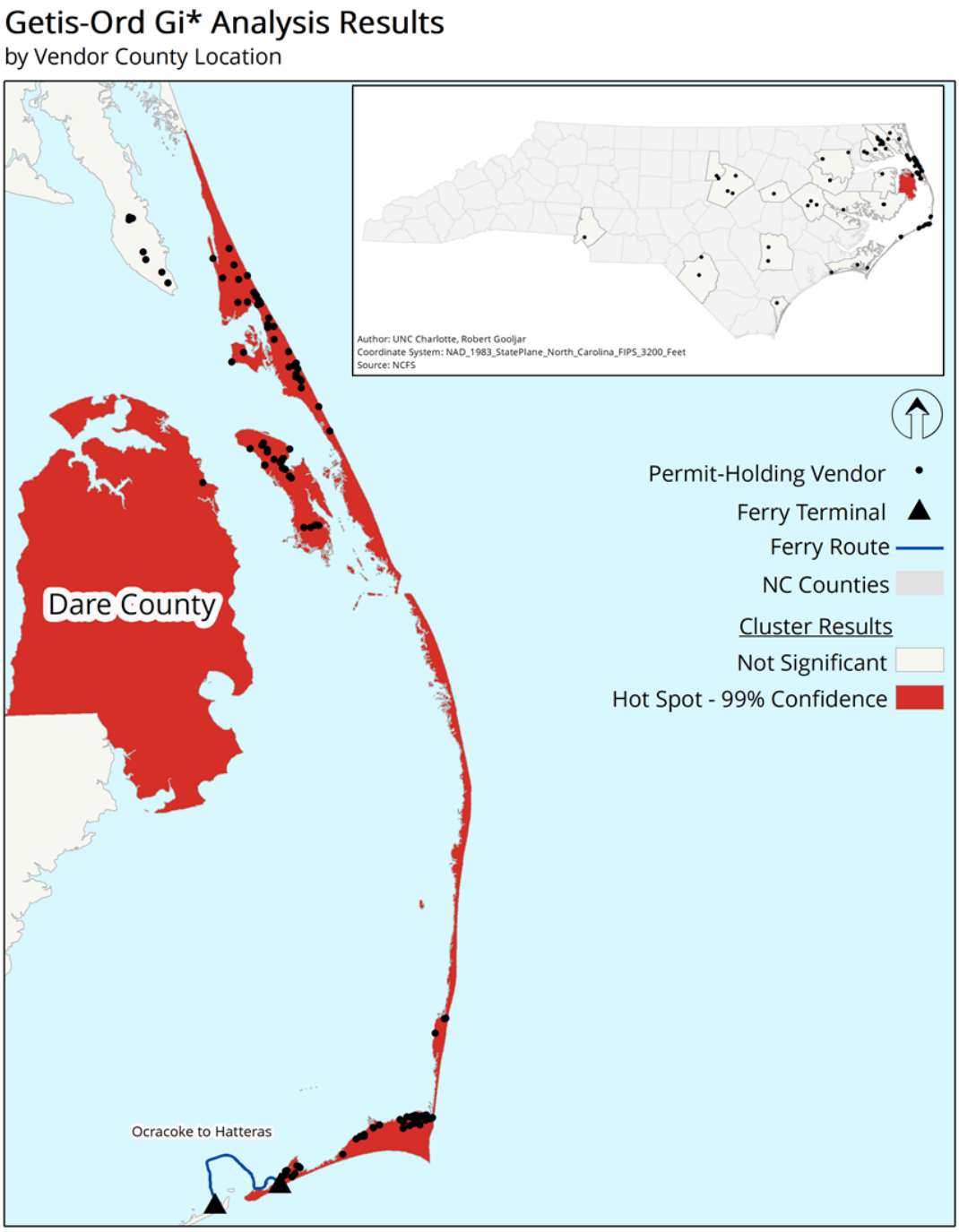

Figure 20. Vendor Cluster Analysis (County Level)

3.5.2 Vendor Hot Spot Analysis (Block Group Level)

The 164 vendor locations chosen for use in the hot spot analysis were then spatially joined to the block groups they fall in. Only block groups that contain at least one vendor were used in the hot spot analysis, yielding 63 block groups. The analysis again uses the inverse distance weighted (IDW) method, Euclidean distance measure and 0 distance threshold to show only two Dare County block groups as statistically significant hot spots at both the 95% and 99% confidence interval. All other block groups are shown as not significant. This indicates that there are high instances of clustering of vendors within the southern coastal portion of Dare County, in congruence with the high presence of vendor locations on Hatteras (Figure 21).

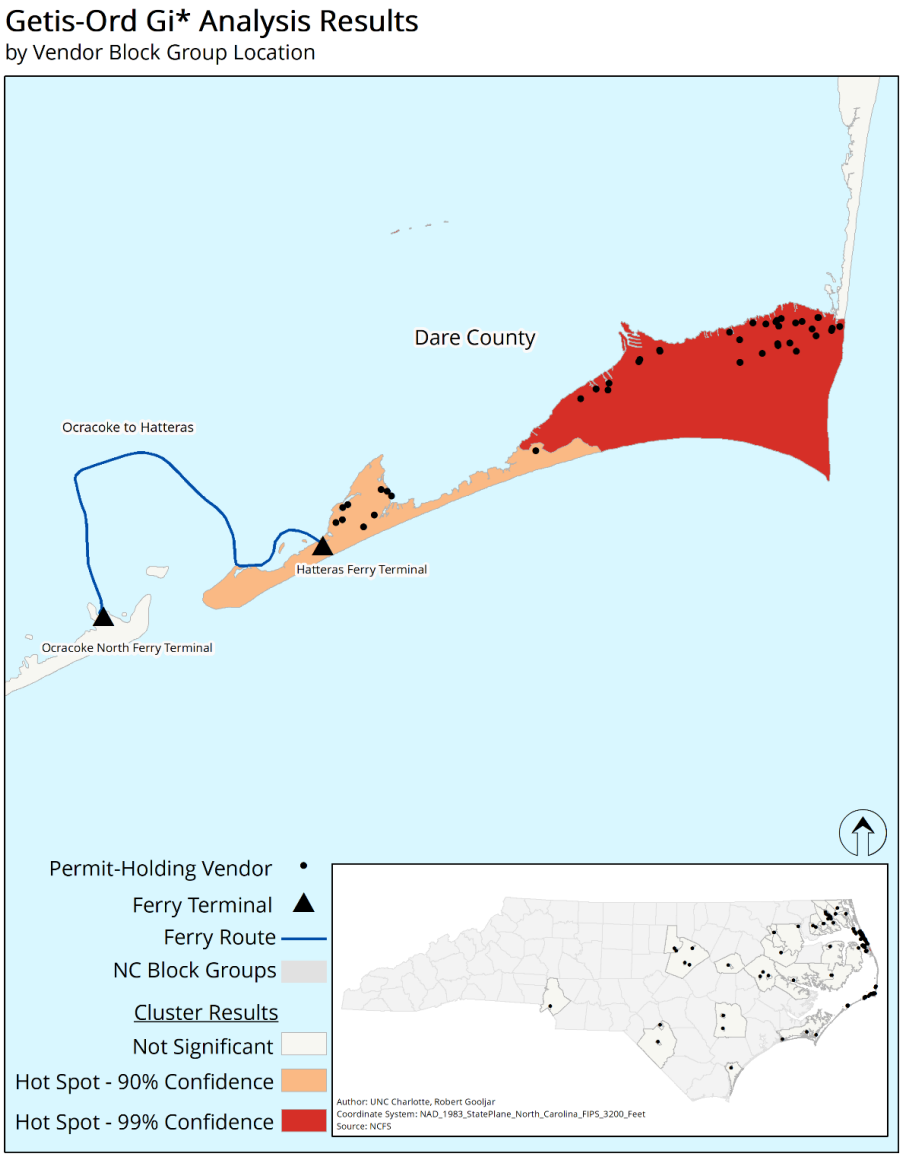

Figure 21. Vendor Cluster Analysis (Block Group Level)

3.6 Displacement

As stated in Section 3.3, there was no apparent displacement at any of the terminals visited with the exception of the Hatteras terminal. Table 2 shows the current capacity by vessel class for vehicles. With the new larger vessel purchases, the displacement potential decreases.

Table 2. Summary by Class for Vessel Capacity

Capacity Designation	River Class	Hatteras Class	Sound Class
Max Capacity vehicles	39	26	49
MaxDoubles	6	4	6
MaxSingles	38	26	42
MaxLargeVehicleSpace	((2 x Doubles) + (3 x Triples)) = 13	((2 x Doubles) + (2 x Triples)) = 10	((2 x Doubles) + (3 x Triples)) = 13
MaxCapacityHazmat	25 Passengers	25 Passengers	25 Passengers
MaxPassengers	300	149	300

*Double and Triples refer to the Ferry Division's internal categories.

4. FINDINGS AND CONCLUSIONS

4.1 Summation – Combining Multiple Data Sources

This study provides an overall view of the potential implications of several variables on freight travel using the ferry service. However, there were no significant connections of the existing data for passenger and vehicle statistics. For example, at terminals indicating an increase in ridership and vehicles, the data indicates low usage for freight vendors. Additionally, the census data related to growth indicates significant growth in the Currituck area but there are no freight needs for this terminal. Hatteras to Ocracoke is used the most for freight passage according to the surveyed vendors. The impact on this terminal based on the results of the cluster analysis shows that the NCFS serves a concentrated location of vendors in Dare County.

4.2 Freight Planning Tool

GIS is useful for spatial data analysis and for tying attributional information to spatial data.

5. RECOMMENDATIONS

The contribution of this study sets a foundation for the potential uses of specific data sets for freight analysis. Several recommendations are provided below – most of which include improvements for data collection and the potential for new research topics.

5.1 Data Collection, Use, and Future Updates by NCFS

It is suggested that the NCDOT and NCFS use the existing GIS maps to discern those that provide value to the organization and to modal planning. The database can be maintained and periodically supplied to the NCDOT GIS Department to update the maps. The benefit in this recommendation is that each department is implementing new products but based on the existing services that they already provide as part of their departmental duties. Additionally, the Planning and Development

Manager with the NCFS may also benefit with the updated statistics provided in an easy to disseminate format (maps).

5.1.2 Recommendation for Future Data Collection

As stated previously, the data obtained for this study was derived from multiple sources. To summarize the list of the items that may be added and for future reporting and map updates, Table 3 lists specific data points and their existing or potential sources. This provides a mechanism for planning for future updates.

Table 3. Data Needs and Sources

Datum	Use (User)	Source
Ridership Freight classification Type Freight Vendor Vendor origin points by vendor addresses, and vendor start points (within NC)	For cluster analysis, show locating terminals near clusters	Vendor Registration but with added questions to the form
Identification of ferry and vehicle length	Future Displacement Analysis	If needed, add vehicle lengths to registration form and begin tracking all freight, not just priority vendors
Historical ridership statistics	Input into geodatabase	NCDOT (2017) Data is currently tracked. Add size data.
Ferry route polylines	For geovisualization and easy updates	New information provided for NCDOT GIS
Street network polylines with road type	For routing analysis	New information provided for NCDOT GIS
Traffic volume with road type	For geovisualization to supplement terminal location data	New information provided for NCDOT GIS
Vendor terminal choices	For geovisualization	Not possible to map but included as part of original survey and updated by vendor pass information
2010 population count	for hot spot analysis implications	US Census Bureau
2017 population estimates	for hot spot analysis implications	American Community Survey

Currently, the form for priority vendors includes the data shown below. It was noted that during data entry that there is no current method of verifying email addresses and business locations. An online version of the form would assist in a consistent method for data entry by NCDOT employees or businesses. This provides another mechanism for businesses to request a priority pass in advance. An additional input feature for the form, to request the vehicle "type" as

a pull-down option that request data regarding the size of the vehicle will provide data needed to provide a future displacement model.

An additional observation is that the only freight information current collected pertains to the priority vendor requests. To track freight levels at the terminals, the NCDOT must implement either a "count" by the crew to add the types of vehicles in their Vessel Log reporting required by the U.S. Coast Guard (Figure 2), or establish a requirement for all vendors to complete a priority pass application even if it is not needed for a terminal location. The latter recommendation would require a change in operational procedures and mandate a check for the windshield stickers to ensure vendors are in compliance. The first recommendation will not provide a way to connect the vendors to the vehicle sizes but will improve the current recording mechanism to track overall freight usage for a specific terminal.

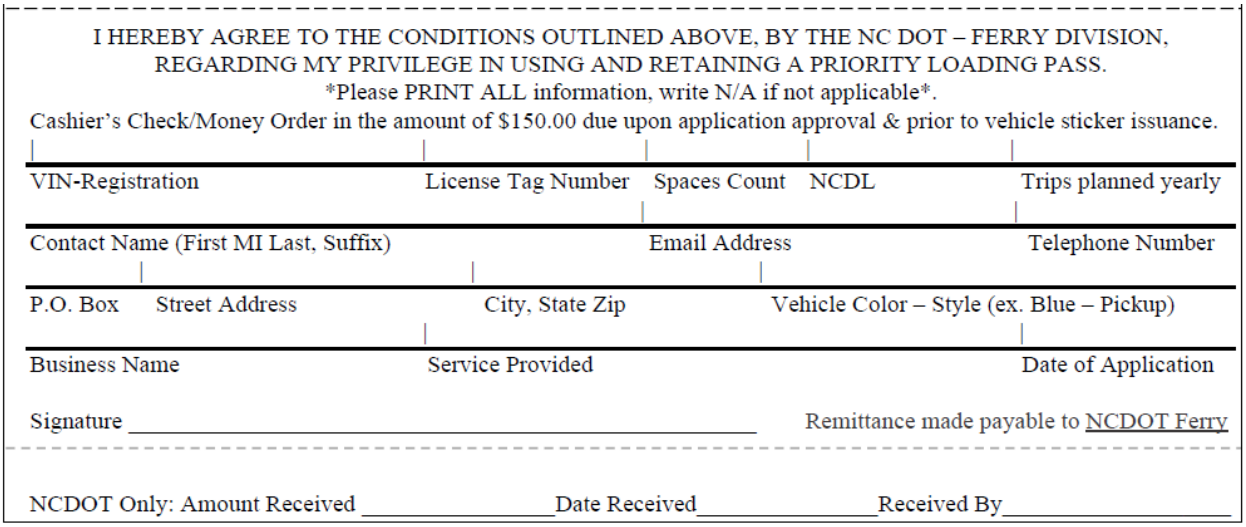
I HEREBY AGREE TO THE CONDITIONS OUTLINED ABOVE, BY THE NC DOT – FERRY DIVISION, REGARDING MY PRIVILEGE IN USING AND RETAINING A PRIORITY LOADING PASS.
Please PRINT ALL information, write N/A if not applicable.
Cashier's Check/Money Order in the amount of $150.00 due upon application approval & prior to vehicle sticker issuance.
VIN-Registration
License Tag Number
Spaces Count
NCDL
Trips planned yearly
Contact Name (First MI Last, Suffix)
Email Address
Telephone Number
P.O. Box
Street Address
City, State Zip
Vehicle Color – Style (ex. Blue – Pickup)
Business Name
Service Provided
Date of Application
Signature _____
Remittance made payable to NCDOT Ferry
NCDOT Only: Amount Received _____Date Received_____Received By_____

Figure 22. Application for Priority Loading Pass

5.1.3 Recommendation for Future Research Topics

A. An area to consider for future research is the potential to explore the combination of operational data and traffic volumes to further develop a complete computer simulation model for the ferry network and use the model to experiment with policies to show the impact on passenger and freight service.

B. To fully explore the contributors for freight delivery predictors, more historical data pertaining to overall freight usage will permit the ability to analyze the correlation among pairs of variables and within and between sets of variables such as: (data exists for the first two but not for the third)

- Δ in ridership
- Δ in population
- Δ in vendor's use of ferry service for freight deliveries

6. IMPLEMENTATION AND TECHNOLOGY TRANSFER PLAN

Data for the Implementation and Technology Transfer Plan is provided in the format of a geodatabase. The database includes information that can be updated on a consistent basis and the NCDOT may request similar maps from the North Carolina GIS Department. The research team originally contacted Sarah Wray, the GIS Spatial Data Manager during the original request in

December of 2018. An additional resource to assist with implementation is the NCDOT GIS lead: Stacy Culpepper at wsculpepper@ncdot.gov.
The research products/deliverables include

- Survey Results
- GIS maps
  - Ferry Routes
  - Change in Population
  - Change in Ridership
  - Cluster Analysis for Vendor locations by County
  - Cluster Analysis for Vendor locations by Block

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Appendix A. Summary of visual data from Terminal Visits

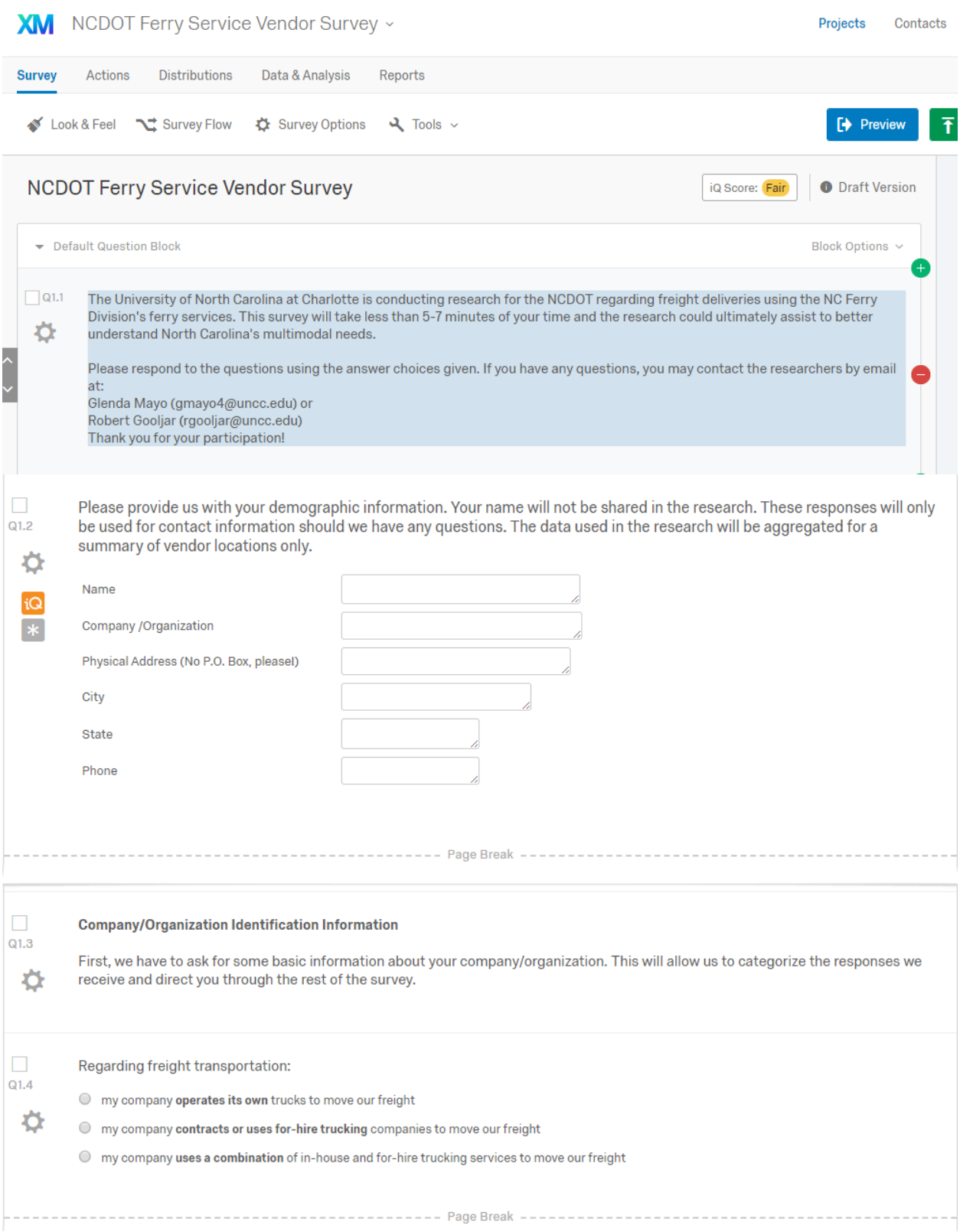
Vessel	Class	Length	Breadth	Veh.	Pass.
m/v CAPE POINT	**Hatteras**	**151' -9"**	**42'-0"**	**26**	**149**
Moneyworth Linen	8:30 AM	45'	Large Box truck - 1x/week		
UPS	11:30 AM	30'	Large Box truck - varies		
Atlantic Dominion	8:00 AM	35'	Va. Bch every other week		
Cape Dredging	8:30 AM	33'	Dump truck		
Estes Freight	8:30 AM	66'	Varies		

Vessel	Class	Length	Breadth	Veh.	Pass.
m/v KINNAKEET	**Hatteras**	**151'-9"**	**42'-0"**	**26**	**149**
Store Delivery	7:45 AM	14'	Small Box		
Land and Sea Distr	7:45 AM	20'	Sm Box - weekly		
Select Vending	12:30 PM	20'	Every Thursday		
Jernigan Oil & Prop.	12:45 PM	35'	All summer, every week		

Vessel	Class	Length	Breadth	Veh.	Pass.
m/v FLOYD J LUPTON	River	180'-0"	44'-0"	38	300
Kempsville Bldg Matls	7:00 AM	45'	Lumber Flatbed - various		
Atlantic Dominion Dist	7:00 AM	27'	Box 1x/week		
Manteo Furniture		45'	Box - varies		
UPS	11:30 AM	30'	Large Box truck - varies		
Island Hopper	11:30 AM	18'	Small Box truck - Daily		
Fed Ex	11:30 AM	15'	Van - Varies		
Onley Distr	4:45 AM	33'	Box 2x/week		
SYSCO	4:45 AM	48'	Large Box truck - 2x/week		
SYSCO	4:45 AM	48'	Large Box truck - 2x/week		
Spartan Nash	4:45 AM	72'	1x/week		

Vessel	Class	Length	Breadth	Veh.	Pass.
m/v STANFORD WHITE	**River**	**180'-0"**	**44'-0"**	**38**	**300**
City Bev. Co	5:15 AM	69'	1x/week		
Coastal Bev (Beer)	5:30 AM	57'	1x/week		
Tryon Distr (Wine)	5:45 AM	36'	Box 1x/week		
CB Chilly Ice Machines	6:00 AM	24'	Sm. Box - Daily		
Atlantic Sewage	6:00 AM	30'	Pump Truck - 2x/week		
City Bev. Co	8:00 AM	21'	Cargo Van - varies		
Atlantic Sewage	8:30 AM	30'	Varies		
Cape Dredging	8:30 AM	33'	Dump Truck - varies		
Empire Distributors	10:45 AM	27'	Box Van - 1x/week		
MS Foods	5:00 AM	50'	2x/week		
Performance Food	5:00 AM	50'	Penske truck		
Crossroads (Tank)	5:30 AM	40'	Tanker		
Redbox	6:00 AM	40'	Roll-off		

Appendix B. Survey



If transporting freight: Block Options

Q2.1

Vehicle Classification Information

Thank you for your responses so far! The following questions will allow us to classify the vehicles your company might use when transporting freight.

Q2.2

On a daily basis, **how many vehicles (#)** does your company/organization use for freight deliveries?

- 1 vehicle
- 2-5 vehciles
- 5-10 vehicles
- More than 10 vehicles

Q2.3

Which best describes the **type of vehicle** *primarily* used by your company when transporting freight?

- Rental truck
- Semi-/tanker truck
- Delivery truck
- Waste truck
- Van
- Car/Personal Vehicle
- Other:

Condition: **Car/Personal Vehicle Is Selected**. Skip To: **End of Survey**. Options

Q2.4

Great! There are just a couple more questions about your company's vehicles.

Q2.5

Please provide an estimate regarding the **overall length (in feet)** of your company/organization's *typical* freight vehicle(s). Please select all that apply.

- [ ] less than 25 feet
- [ ] 25-30 feet
- [ ] 31-35 feet
- [ ] 36-40 feet
- [ ] 41-45 feet
- [ ] 45-50 feet
- [ ] over 50 feet

Q2.6

Excellent work! Now we have a few questions about your delivery trips.

The following questions allow us to understand your company/organization's freight movement patterns.

Q2.7

Is your company/organization's vehicle:

- Intrastate (within North Carolina)
- Interstate (crossing state lines)
- Both intrastate and interstate

Q2.8

Where does your delivery trip begin? (City/Place)

Page Break

Q2.9

This next question is **crucial** to our analysis. Please answer as best as you can.

Which **main roads/highways/interstates** do you use when transporting freight? Please list as many route options as possible.

Q2.11

On a scale of 1-7, where "1" is "minimal and "7" is "extensive":
for most deliveries, would you consider the **wait time** to board the ferry:

	1	2	3	4	5	6	7	
Minimal wait time	○	○	○	○	○	○	○	Extensive wait time

Q2.12

Approximately how long does it take you to **board the ferry** from the time you arrive at the dock?

- less than 15 minutes
- 15 minutes to 30 minutes
- 30 minutes to an hour
- over an hour

Q2.13

How frequently does your truck(s) **miss a ferry sailing** and have to wait for another departure?

- Never
- Sometimes
- About half the time
- Most of the time
- Always

Q3.1

Freight and Delivery Information

The following questions allow us to understand your freight delivery needs.

Q3.2

How would you **classify your freight**? Please select all that apply. Use the "Other" option to clarify your answer or list a different classification.

- Furniture/Household goods
- Food/beverage
- Alcohol
- Livestock
- Live plants
- Grain
- Gasoline/oil/fuel
- Other
- Construction material
- Waste material
- Recycling material
- Hazardous material
- Machinery
- Automobiles
- Other retail goods

Q3.3

Excellent! Now just a couple questions about your ferry service utilization.

Q3.4

Regarding typical freight delivery times of your organization's transporter... (please select all that apply):

	Early Morning (before 8 AM)	Morning (8-11 AM)	Midday (11 AM-1 PM)	Early Afternoon (1-4 PM)	Late Afternoon (4-6 PM)
boards a ferry to deliver freight in the...					
ends all freight delivery for the day in the					

Page Break

Q3.5

Which **ferry service routes** are used by your company/organization's transporter? Please rank your answers from 1-7 where "1" is "least used" and "7" is "most used". Select "0" if not used at all.

	0 (Not Used)	1 (Least Used)	2	3	4	5	6	7 (Most Used)
Swan Quarter to Ocracoke South								
Cedar Island to Ocracoke South								
Currituck to Knotts Island								
Bayview to Aurora								
Southport to Fort Fisher								
Hatteras to Ocracoke North								
Cherry Branch to Minnesott Beach								

Page Break

Q3.6

Just a couple more questions regarding your deliveries.

Q3.7

How many trips (#) aboard a ferry do you estimate your company/organization's transporter takes per week (where a round trip is 2 trips)?

- 1-5 trips
- 6-10 trips
- 11-15 trips
- 16-20 trips
- 21 or more trips

Q3.8

If you consider your company/organization's freight deliveries to be seasonal, please select all seasons that apply for when your freight deliveries increase.

- Not seasonal
- Spring
- Summer
- Fall
- Winter

Page Break

Q3.9

Would a "freight only" ferry service trip be of interest to your company?

Yes, are interested in "freight only" ferry service

No, we are not interested

In Page Display Logic may behave unexpectedly with Validation Options

Display This Question:

If Would a "freight only" ferry service trip be of interest to your company? Yes, are interested in "freight only" ferry service Is Selected

Q3.10

Please select one time frame for a "freight only" ferry service trip.

- Early Morning (before 8 AM)
- Morning (8-11 AM)
- Midday (11 AM-1 PM)
- Early Afternoon (1-4 PM)
- Late Afternoon (4-6 PM)

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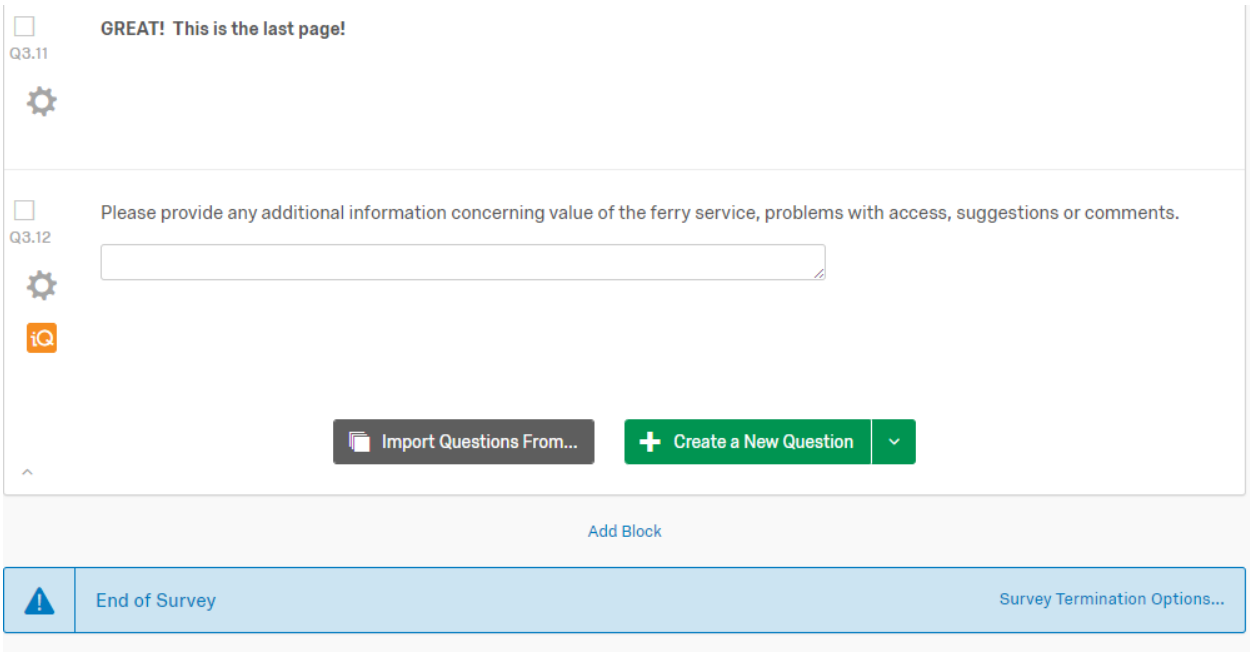

Appendix C. Qualitative Survey Responses

1. Since the ferry crossing from Hatteras to Ocracoke has increased due to shoaling we have cut back on deliveries to this area.
2. Route back from Ocracoke - issue with road where not more than 6 priority can get in the line.
3. Freight only if it does not take away from existing times. Would say that the service in place does an amazing job Hatteras/Ocracoke route.
4. Additional early morning runs would be best solution. Most delivery companies run on the same day - Mondays and Thursdays could use an added 6am run.
5. Priority pass has helped to speed up our ferry trips.