NJ-2018-002

Channel Usage Research and Analysis – Phase 3

FINAL REPORT

Submitted by

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In cooperation with

New Jersey
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16. Abstract

In 2014 Cambridge Systematics, Inc. and Greenman-Pedersen, Inc. (the "research team") undertook research on alternative methodologies to count and classify vessels on New Jersey's Marine Transportation System. During the late summer of 2017, the research team undertook a third phase of data collection with a goal of continuing to test field data collection methodologies under a wider range of field conditions and collect additional vessel data. Another objective of the third phase of research was to collect additional field data on state-maintained waterways.

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EXECUTIVE SUMMARY FOR PHASE 3 RESEARCH (AUGUST – SEPTEMBER 2017)

In 2014, Cambridge Systematics, Inc. and Greenman-Pedersen, Inc. (the "research team") undertook research on alternative methodologies to count and classify vessels on New Jersey's Marine Transportation System. During the summers of 2016 and 2017, the research team undertook second and third phases of data collection respectively with a goal of continuing to test field data collection methodologies under a wider range of field conditions and to collect additional vessel data. This report specifically addresses the data collection findings for the late August and early September 2017 boat counts.

The research approach consisted of the following steps:

- The research team collected data in the field at nine different locations along coastal Monmouth, Ocean, Atlantic, and Cape May Counties to gather additional channel and waterway usage volume data and to further test data collection methodologies and procedures; and

- The research team intended to investigate the impact of factors such as weekday vs. weekend and pre-Labor Day/post-Labor Day seasonal fluctuation on use of channels and waterways;

The field tests included manual observations taken from shore vantage points with and without binoculars (depending on waterway width).

Field data collection on shore vantage points was conducted from sunrise to sunset (6:30 AM to 7:30 PM) on the following five dates: Friday, August 25th, Saturday, August 26th, Friday, September 1st, Friday, September 8th, and Saturday, September 9th, 2017. The field data collection yielded the following results:

- **It was possible to conduct all counts via manual data collection from shore.** The locations chosen were field verified prior to the count as viable for data collection staff to sit either in their cars or outside with full view of the waterway of interest. The use of boats for observation was not needed. All but three locations, Gunners Ditch & ICW and Toms River, could be counted without the need for binoculars to see across the entire waterway. High power binoculars were used for the Toms River, and Gunners Ditch & ICW locations.

- **Manual counts from a shore vantage point appears to be the one of the most reliable and straightforward methodologies for conducting counts.** The research team did not encounter any situations at these locations where another methodology would be more reliable. If however, a waterway is identified for a count that does not have an adequate area for staff to be positioned on shore or is adjacent to only private inaccessible property, a boat may be needed to collect the data

- **More information is needed regarding variables that could affect counts of vessels by class.** Over two seasons, the research team encountered nearly uniform, ideal conditions for boating (sunny days with little to moderate wind), even though the field data collection days were chosen weeks in advance. These favorable conditions most likely skewed the count data to appear high on the range of waterway use for any given waterway. During this phase of counts, the counts were conducted at the end of the summer vacation season (Labor Day) and the weeks immediately after for comparison of peak and non-peak seasonal variations. Also, for the first time, counts were conducted on Fridays to compare the difference between weekday and weekend usage. Aside from weekend or weekday boating activity, weather is assumed to be among the variables most strongly correlated with daily vessel counts. However, the team does not have sufficient data to draw conclusions about how much each variable might affect use of the waterway.

BACKGROUND

The NJDOT Office of Maritime Resources (OMR) emergency response to Superstorm Sandy highlighted the importance of developing an asset management system to more efficiently manage New Jersey's Marine Transportation System. Storm response efforts included a preliminary economic value and vessel usage evaluation for most of the State's channels and waterways. Vessel usage was determined in part by compiling data on the availability of waterway services such as slips per marina per channel, residential docks per channel, boat ramps per channel, etc. However, usage is known to vary depending on numerous factors including but not limited to: weather, time of year, origin/destination, size and type of vessel, and availability of alternative routes. Actual vessel count data is required to validate the data that was collected and provide a more defensible assessment of actual channel and waterway usage.

For the purposes of this study, a channel is defined as an artificial watercourse with a definite bed and banks to confine and conduct flowing water. A channel is considered a type of waterway, although no actual artificial bodies of water were surveyed as part of this study, despite the two terms commonly being used interchangeably. It is anticipated that in later stages of the development of an asset management system on the part of NJDOT OMR, defined channels will be included as an important component.

OBJECTIVES

The primary objective of this research is to help NJDOT develop and implement a reliable, repeatable, and verifiable method or SOP (Standard Operating Procedure) to collect vessel count and classification information by time of day. The research involved field tests of several approaches that could be applicable to a broader statewide effort to collect vessel count information utilizing the selected method on approximately 214 state waterways and channels within the state's Marine Transportation System.

The study team was charged with collecting usage and classification data on a representative sample of the 214 state channels and waterways using a variety of

methodologies so that results can be compared, and guidance can be provided for future data collection efforts.

INTRODUCTION

In 2014, Cambridge Systematics, Inc. and Greenman-Pedersen, Inc. (the "research team") undertook research on alternative methodologies to count and classify vessels on New Jersey's Marine Transportation System. During the summers of 2016 and 2017 the research team undertook second and third phases of data collection respectively with a goal of continuing to test field data collection methodologies under a wider range of field conditions. This report summarizes the results of the third round of field tests and research on how NJDOT could set up an ongoing process for collecting and managing vessel count and classification data.

SUMMARY OF WORK PERFORMED

At the direction of NJDOT, the research team conducted field data collection efforts and researched factors that contribute to fluctuations in vessel count by classification. The following sections provide a detailed review of the activities and analyses performed throughout this effort.

FIELD DATA COLLECTION

Preparation for Data Collection Effort

- The project team met with the NJDOT Office of Maritime Resources to discuss the objectives for the 2017 counts and potential channels and waterways to conduct counts. The project team visited the proposed waterways to determine whether they could count vessels from the shoreline or if a rental boat would be required. The project team proposed a list of waterways to count from the shoreline. Note that based on the definition of channels used for this study, as an artificial body of water, no actual channels were selected for count.

- The research team and NJDOT Office of Maritime Resources coordinated with and notified local officials and police regarding the vessel counts. All were provided with an NJDOT project authorization letter as well as 24/7 contact information.

- The research team organized a training session for staff who would be conducting the field counts to familiarize staff with count equipment and procedures and to review vessel classification categories. The training session was intended to improve reliability of data collection and reduce discrepancies in vessel classification data, particularly given the subjective nature of the vessel classification scheme. Staff were trained to classify vessels using a standardized set of categories, and photos of examples of vessels in each category were provided to the counters as part of their field manuals.

Vessel classification counts were performed from land from sunrise to sunset (6:30 AM to 7:30 PM) on the following five dates: Friday, August 25th, Saturday, August 26th, Friday, September 1st, Friday, September 8th, and Saturday, September 9th, 2017.

- Characteristics of the count locations are summarized in Table 1.

Field Notes

There were no major issues encountered during any of the counts. The weather conditions on all count days were sunny and warm, with average temperatures of 80 degrees for August count days and 73 degrees for September count days.

Table 1 – Summary of Count Locations and Methodologies

Location	**Days and Hours Counted**	**Number and Position of Enumerators**
Double Creek Mainland, Barnegat Municipal Dock, Barnegat Township, Ocean County	6:30 AM to 7:30 PM: Friday, August 25th, Saturday, August 26th, 2017	Two (2) enumerators working in split shifts from 6:30 AM to 1:00 PM and 1:00 PM to 7:30 PM utilizing electronic count boards. The Gunners Ditch & ICW and the Toms River locations required the use of high power binoculars.
St. George's Thorofare, Brigantine Beach, Brigantine City, Atlantic County		
Oceanport Creek, Driveway Cul-de-sac, Oceanport Borough, Monmouth County		
Gunners Ditch & ICW, Traders Cove Marina Park, Brick Township, Ocean County		
Toms River, Bay Shore Drive, Toms River Township, Ocean County		
Manasquan River & Point Pleasant Canal, Riverfront Park, Point Pleasant Borough,	6:30 AM to 7:30 PM: Friday, September 1st, Friday, September 8th,	Two (2) enumerators working in split shifts from 6:30 AM to 1:00 PM and 1:00 PM to

Ocean County	Saturday, September 9th, 2017	7:30 PM utilizing electronic count boards. The Tuckerton location required the use of binoculars.
Tuckerton Creek Channel, South Green Street Park, Tuckerton Borough, Ocean County		
Long Reach Thorofare, Bay Park Marina, Avalon Borough, Cape May County		
Schellenger's Creek, Harborview Park, Cape May City, Cape May County		

Double Creek Mainland

The Double Creek Mainland is in Barnegat Township, Ocean County. The waterway runs parallel to the shoreline beginning at the Barnegat docks, traversing all the way to the East Bay Avenue Bridge.

Field staff conducted two counts from the Barnegat Municipal Dock/Pier utilizing an electronic count board. The first count was conducted north of the boat ramp and the second was conducted south of the boat ramp. This ensured that all vessels, including the ones being launched from the boat ramp, were included in the count. The staff counted all vessels utilizing an electronic count board from the two-story gazebo located near the water. Field notes were taken regarding a large pontoon boat carrying an excavator that did not fit into the predetermined categories.

St. George's Thorofare

St. George's Thorofare is in the City of Brigantine, Atlantic County. The waterway connects directly to Absecon Inlet across from Atlantic City. There is a designated safe harbor refuge in St. George's Thorofare Bay for vessels to anchor during storms, private docks and slips in the Bay. The Bay is also a popular destination for day boaters from around the region, including tourists who navigate personal watercraft rented in Atlantic City across Absecon Inlet to the Bay. Brigantine Beach, where the counts were conducted, is a popular recreation area where personal vehicles are allowed on the beach with proper permits from the town. A mix of fishers, sun bathers, and boat watchers tend to congregate on the beach.

Vessels using St. George's Thorofare were counted utilizing an electronic count board from Brigantine Beach at the mouth of the Thorofare. The count start time for Friday,

August 25th was 8:00 AM due to unforeseen issues for the data collector. Field notes were taken regarding large vessels anchored near the mouth of the waterway. These vessels did not impede traffic. Another photo was taken showing the mobile movie screen that was set up Friday night to show movies on the beach. An increase in vessels during this time was observed.

Oceanport Creek

The Oceanport Creek waterway is in Oceanport Borough, Monmouth County. The waterway runs north from the County Route 11, Oceanport Avenue Bridge to Seven Bridges Road Bridge then connects with Town Neck Creek, Blackberry Creek and Oceanport Creek Entry waterways.

Field staff conducted counts from a cul-de-sac at the end of Milton Avenue, on the south side of the bridge at Seven Bridges Road. The staff counted all vessels utilizing an electronic count board. The staff noted that the waterway was not very busy and due to the low clearance at the bridge although most vessels were small motor boats or personnel water craft.

Gunners Ditch

The Gunners Ditch and ICW waterways are in Brick Township, Ocean County. Gunner's Ditch and the parallel Intracoastal Waterway function as north-south connectors, with the Metedeconk River, Beaver Dam Creek, Bay Head Harbor, and the Manasquan River (via the Point Pleasant Canal) to the north and Barnegat Bay to the south.

Field staff conducted two counts, one for each of the waterways, from Traders Cove Marina, just south of Gunners Ditch. The staff counted all vessels utilizing an electronic count board from the benches located near the water using high power binoculars due to the sight distance from the marina. Field staff noted that the Gunners Ditch waterway appeared to get more use than the Intracoastal Waterway. In the 2014 counts, a local resident informed a member of the study team that most boaters avoid using the federal waterways due to regulations.

Toms River

The Toms River waterway runs east from the Mathis Plaza Park to the Intracoastal Waterway. It is a long waterway with many beaches, marinas, and yacht clubs.

Field staff conducted counts from the small parking lot along Bay Shore Drive that faced south utilizing an electronic count board. The last time this location was counted, multiple field staff members were used during a shortened count period from a 16-foot rented skiff which was anchored near the mouth of the waterway. Due to the logistical complexity of that count and safety concerns for field staff members, high powered binoculars were used to count this location from the parking lot enabling the staff to see across the waterway to the southern side. It was also noted that a sailboat school was

active in the mouth of the river throughout the mid-day hours. The sailboats were not counted unless they crossed the vessel count line. Most of the sailboats stayed west of the count line. The waterway did not have any wake restrictions, so boats were often traveling at a high rate of speed. There was also a marina on the south side of the waterway that had a lot of activity.

Manasquan River & Point Pleasant Canal

The Manasquan River & Point Pleasant Canal count location is in Point Pleasant Borough, Ocean County. The Manasquan waterway location is just south of Osborn Island and has a west-to-east orientation, while the Point Pleasant Canal is located between the Bay Head Harbor area and the Manasquan River.

Field staff conducted two counts from Riverfront Park. The first count was conducted between Osborn Island and the park's beach area for vessels heading east and west. The second count was conducted to the east of the beach area for vessels heading north and south out of the Point Pleasant Canal. The staff counted all vessels utilizing an electronic count board from the benches located near the water and from the beach area.

Tuckerton Creek Channel

The Tuckerton Creek Channel count location is in Tuckerton Borough, Ocean County. The waterway's mouth at the southern end is located at Tuckerton Cove and the northern extent terminates at the Tuckerton Seaport & Museum at Route 9. The waterway has numerous private residences with docks and slips as well as a few marinas.

Field staff conducted the count from South Green Street Park utilizing an electronic count board with high power binoculars from their vehicle or from the western gazebo facing the mouth of the waterway. The staff noted that the waterway was not very busy and that most vessels were small motor boats.

Long Reach Thorofare

The Long Reach Thorofare count location is in Avalon Borough, Cape May County. The waterway's southern extent starts at approximately 80th Street in Avalon and extends north to the Ingram Thorofare, southwest of County Route 601. Whale Harbor and Gravens Thorofare connect with Long Reach Thorofare near Pelican Drive. The waterway has numerous private residences with docks and slips as well as a marina.

Field staff conducted the count from Bay Park Marina. The staff counted all vessels utilizing an electronic count board from their vehicle or from chairs sitting near the edge of the waterway. The staff noted that a kayak training class was being held just south of the marina at the Avalon Kayak Park. The class members stayed in front of the park area and were not included in the count data as they did not cross the count location.

Schellenger's Creek

Schellenger's Creek waterway is in Cape May City, Cape May County. The waterway's mouth opens to the east at the Cape May Harbor and extends to the west under New Jersey Route 109 (Lafayette Street) towards Cape Island Creek. The waterway has numerous private residences with docks and slips as well as marinas and boat charter businesses. The Lobster House and Cold Spring Fish House eateries are located on the North side of the waterway. Larger clam and fishing vessels also dock on the north side of the waterway next to the restaurants.

Field staff conducted the count from Harborview Park. The staff counted all vessels utilizing an electronic count board from the gazebo located in the park overlooking the waterway or from chairs sitting near the edge of the waterway.

Summary of Data Collected

The following tables summarize the total daily vessel volume, peak boating hours and vessels by classification for each count location. The peak hour was determined by totaling both directions for each hour counted and identifying the highest volume.

Table 2 shows a general pattern of higher waterway usage on Saturday than the Friday that precedes it. At all locations that were observed on consecutive Fridays and Saturdays, the number of boats observed on Saturday was greater than those observed on the preceding Friday. Boats were not counted on Saturday, September 2nd, which was the weekend of Labor Day, but the number of boats counted the Friday of Labor Day weekend (9/1) greatly exceeded the number of boats counted the following Friday (9/8), which was a non-holiday weekend. Toms River had the highest count on Saturday, August 26 with 1,421 vessels followed by Gunner's Ditch which recorded 1,314 vessels also on Saturday, August 26.

Table 3 shows a general pattern of peak usage throughout the mid-afternoon hours, but this varies based on location. The most frequently observed peak usage was between the hours of 3:00 PM and 4:00 PM, however the range of peak usage times varied for locations. All locations had peak usage times during daylight hours after 12:00 PM except for the Manasquan River locations.

The Manasquan River locations of Manasquan River and Point Pleasant Canal had peak usage hours both between 10:00 AM and 12:00 PM and 6:00 PM and 7:00 PM on Friday, September 8; However, these locations saw very little waterway usage on that day (less than 100 boaters at each location all day) as compared to the previous Friday (greater than 300 boaters at each location).

The Schellenger's Creek location had later peak hours of 5:00 PM - 6:00 PM and 4:00 PM - 5:00 PM on the Friday counts of 9/1 and 9/8 respectively as compared to the peak hours observed on Saturday 9/9 (1:00 PM - 2:00 PM).

More data will be needed however to confirm both the Table 2 and Table 3 patterns and identify waterway usage trends.

Table 2 – Daily Total Volume Per Waterway

Waterway	8/25/2017	8/26/2017	9/1/2017	9/8/2017	9/9/2017
Gunner's Ditch					
Gunner's Ditch	720	1,314	-	-	-
ICW	217	275	-	-	-
Manasquan River					
Manasquan River	-	-	350	99	233
Canal	-	-	318	88	193
Double Creek Mainland					
North of launch	96	158	-	-	-
South of launch	87	167	-	-	-
St. George's Thorofare	158	207	-	-	-
Toms River	797	1,421	-	-	-
Tuckerton Creek	-	-	185	91	124
Ocean Port Creek	94	200	-	-	-
Long Reach	-	-	130	38	69
Schellenger's Creek	-	-	164	95	244

Table 3 – Daily Peak Hours and Volumes by Waterway by Date

Waterway	8/25/2017	8/26/2017	9/1/2017	9/8/2017	9/9/2017
Gunner's Ditch					
Gunner's Ditch	3:00 - 4:00 PM (79)	4:00 - 5:00 PM (169)	-	-	-
ICW	12:00 - 1:00 PM (24)	1:00 - 2:00 PM (50)	-	-	-
Manasquan River					
Manasquan River	-	-	3:00 - 4:00 PM (54)	11:00 AM - 12:00 PM & 6:00 - 7:00 PM (15)	3:00 - 4:00 PM (38)
Canal	-	-	3:00 - 4:00 PM (45)	10:00 - 11:00 AM & 6:00 - 7:00 PM (12)	1:00 - 2:00 PM (35)

Double Creek Mainland					
North of launch	1:00 - 2:00 PM (17)	3:00 - 4:00 PM (25)	-	-	-
South of launch	3:00 - 4:00 PM (18)	3:00 - 4:00 PM (35)	-	-	-
St. George's Thorofare	3:00 - 4:00 PM (22)	2:00 - 3:00 PM (43)	-	-	-
Toms River	4:00 - 5:00 PM (94)	2:00 - 3:00 PM (237)	-	-	-
Tuckerton Creek	-	-	1:00 - 2:00 PM (28)	1:00 - 2:00 PM (15)	1:00 - 2:00 PM (22)
Ocean Port Creek	3:00 - 4:00 PM (15)	4:00 - 5:00 PM (29)	-	-	-
Long Reach	-	-	4:00 - 5:00 PM (32)	12:00 - 1:00 PM (13)	12:00 - 1:00 PM (15)
Schellenger's Creek	-	-	5:00 - 6:00 PM (24)	4:00 - 5:00 PM (17)	1:00 - 2:00 PM (43)

The classification summary of the data indicates that the small motor boats make up the largest class of vessels for each waterway. The second largest class of vessels varied by location between medium motor boats, motorized, and non-motorized personal watercraft. The number of small sailboats counted was inflated from a sailing school that sailed through the count location several times throughout the day, with Toms River recording a particularly high number of small sailboats.

Table 4 to follow shows each count location and the total volume of vessels per class taken from the classified manual count.

Table 4 – Total Volume of Vessels Classified by Waterway

Waterway	Small Motor boat	Medium Motor boat	Large Motor boat	Small Sailboat	Medium Sailboat	Large Sailboat	Personal Water Craft Non-Motorized	Personal Water Craft Motorized
Gunner's Ditch - Gunner's Ditch	1,663	178	3	16	6	0	15	153
Gunner's Ditch - ICW	399	65	3	12	9	0	0	4
Double Creek Mainland – North of launch	185	3	0	33	15	0	12	6
Double Creek Mainland – South of launch	171	3	0	28	14	0	24	14

St. George's Thorofare	205	17	4	1	4	0	37	97
Toms River	1,230	340	5	334	126	0	17	166
Oceanport Creek	227	2	0	0	0	0	26	39
Manasquan River - Manasquan River	502	102	11	3	2	0	39	23
Manasquan River - Canal	504	90	3	1	1	0	0	0
Tuckerton Creek Channel	351	12	0	3	7	0	0	27
Long Reach Thorofare	148	2	0	6	0	0	57	24
Schellenger's Creek	313	62	28	5	5	1	62	27

VARIABLES THAT AFFECT VESSEL COUNTS

Table 5 below shows the variables that should be collected initially as part of a waterway count program. These variables may impact vessel counts by classification. Some variables may affect propensity to use a sailboat, as opposed to a powerboat differently, and some may affect recreational, as opposed to commercial boating differently. Some of the influences listed for these variables may be based on conjectures or assumptions and should not be taken as fact. However, because these influences are assumed to have an impact on vessel volumes, the associated variables should still be considered when establishing a data collection plan for vessel counts.

The statistical significance and thresholds for each of these variables will need to be determined in the future when more data are available to run a regression. Some variables could be dropped if they are found to be unrelated to vessel counts by classification.

Table 5 – Variables that May Influence Vessel Counts by Classification

Variable	Description	Influences
Day of the week	Indicate Monday-Sunday	• Saturdays and Sundays have highest traffic
Month	Indicate month	• Month of August is assumed to be peak of vacation season, particularly for vacation homeowners. • Weekdays in August may have higher traffic than weekends in other months. • Some school years in New Jersey, Pennsylvania, New York, and other states may begin in the last two weeks

Variable	Description	Influences
		of August, so this may impact the peak season • Water temperatures are generally assumed to be warmest in August
Holiday	Indicate any of the following: • Memorial Day weekend (Saturday, Sunday or Monday) • Labor Day weekend (Saturday, Sunday, or Monday) • 4th of July (one day) • Weekdays in the week of 4th of July • Weekends before or after 4th of July (Saturday or Sunday) • Weekdays in the weeks after Labor Day or Memorial Day • Weekends after Labor Day or Memorial Day (Saturday or Sunday)	• Higher volumes may be observed on holiday weekends, on average • Week of 4th of July (two weekends plus week in which July 4 falls) is assumed to be a peak vacation week • Higher than average weekday volumes may be observed on weekdays following Memorial Day Monday and Labor Day Monday
Weather Forecast	• Chance of precipitation after sunrise • Temperature forecast	• Forecasts of precipitation, particularly late in the day, can discourage people from boating. Commercial vessels may not be affected. • Temperature forecasts above and below certain thresholds may impact use of powerboats more than sailboats.
Actual weather conditions	• Precipitation • Small craft advisory issued • Peak wind velocity • Air temperature • Water temperature	• Precipitation or high winds can discourage people from boating. • Sailboats may be used less on days with very little wind. • Low temperatures may impact use of power boats more than sailboats

Variable	Description	Influences
High and Low Tides	• Time of high tide • Time of low tide	• Certain waterways might be more attractive to powerboats or commercial fishing close to high tide and may be unnavigable or less safe at low tide • Large boats may require a depth only achieved at high tide to pass through some waterways
Length of day	• Hours of daylight	• Earlier in the season, people may stay out longer on their boats to take advantage of daylight hours, or they may be more willing to take the boat out later in the day, resulting in more traffic.

Additional factors (not explored in this study) that may affect the counts in certain vessel classifications include:

a) Waterway depth;

b) Waterway width;

c) Presence of vertical clearance constraints and obstructions, including movable and fixed bridges;

d) Times at which draw bridges are raised; and

e) Proximity to watercraft access points.

IDENTIFYING TRENDS AND GRAPHS FROM ALL COUNTS (2013-2017)

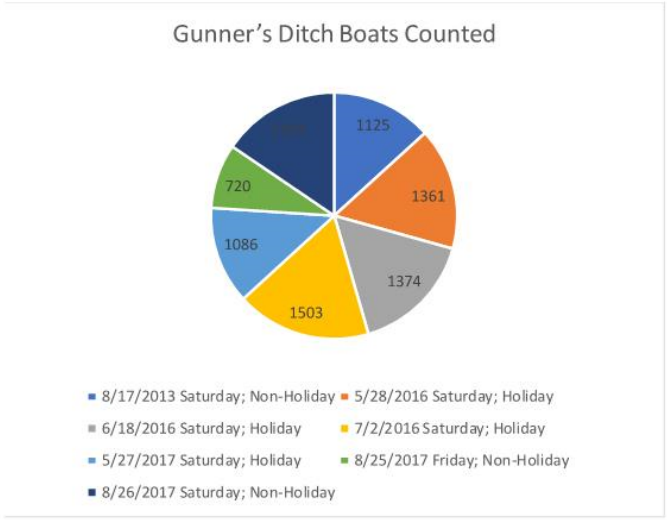
The following section combines the data collected from Phase three of the Channel Usage Research and Analysis with data from previous phases to highlight trends at each count location as well as any overall trends. It is noteworthy that not all the count dates have the exact same count times. Counts on the day of 8/17/2013 were conducted from 6:00 AM to 8:00 PM. Phase two counts with the dates of 5/28/2016, 6/18/2016, 7/2/2016, and 5/27/2017 were conducted from 6:00 AM to 8:00 PM with the exception of the count at the Toms River Location on 6/18/2016 which was conducted from 7:30 AM to 6:45 PM. Phase three counts on the dates of 8/25/2017, 8/26/2017, 9/1/2017, 9/8/2017, and 9/9/2017 were conducted from 6:30 AM to 7:30 PM.

Individual Count Location Trends and Graphs

The data for each count location is summarized with a temporal distribution for each count day, a summary of vessel classification for each count day, as well as a

comparison of the total number of vessels per count day. A map of each location is also included to illustrate the waterway width and characteristics. Following the maps and graphs is a summary of the data observed at that count location. What is observed at each count location should be considered when shaping the overall data collection plan so that the micro-level trends identified at each location can be tested across all locations and with data from multiple years.

Gunner's Ditch



Approximate Channel Width: 456 ft
Total Number of Count Days: 7
Average Number of Boats Counted per Day: 1212
Population of Surrounding Municipality: 75,368

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 1. Gunner's Ditch location and count summary

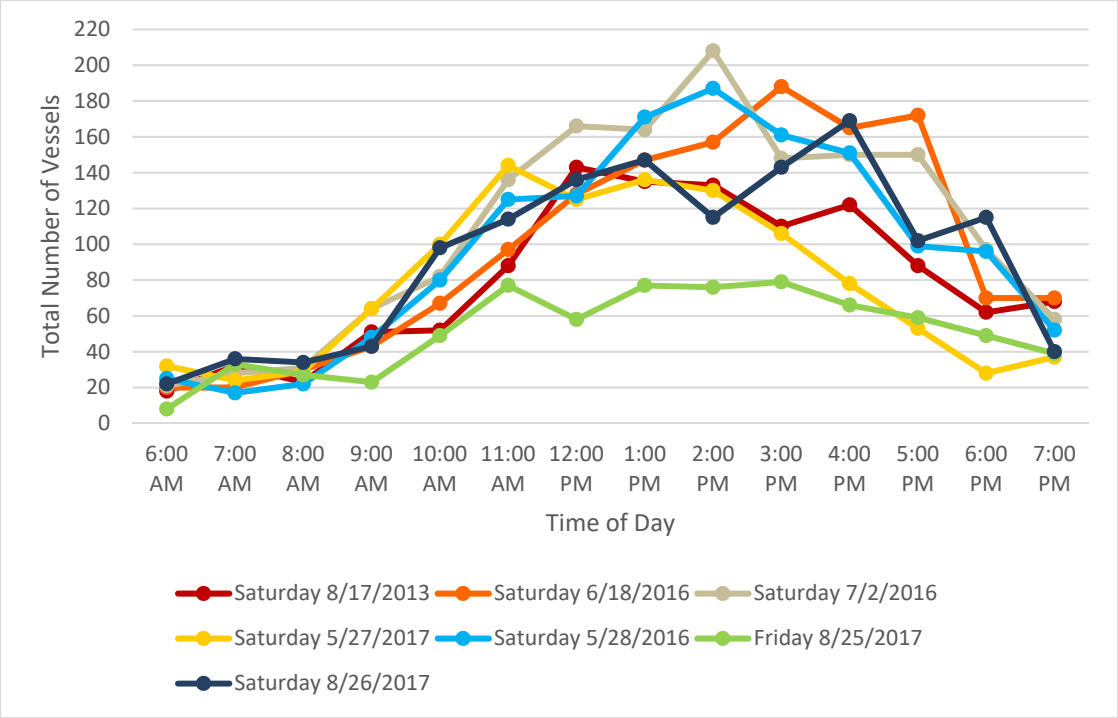


Figure 2. Gunner's Ditch daily peak hours and volumes

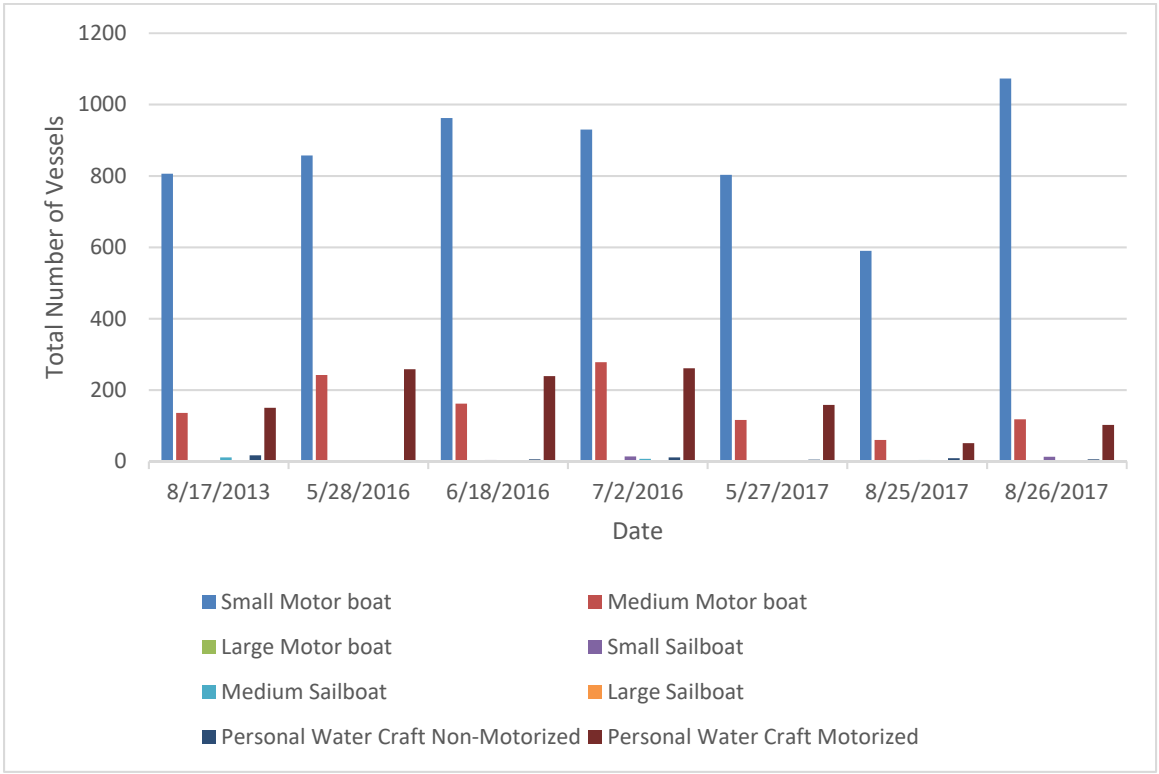


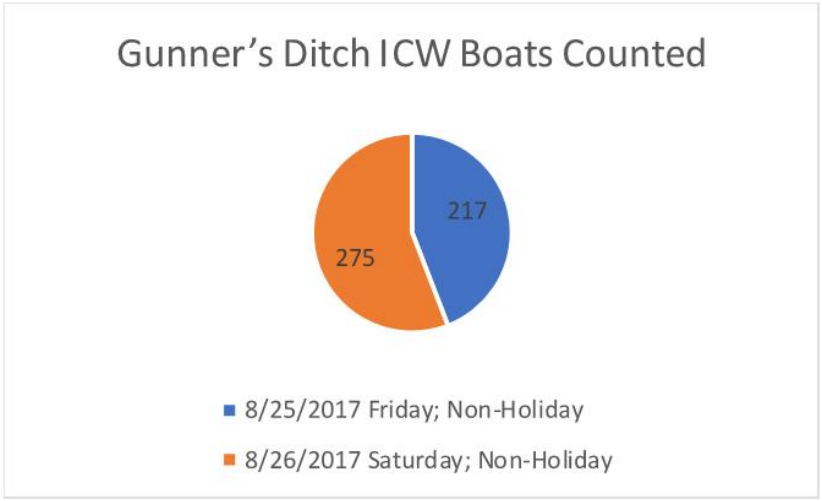
Figure 3. Gunner's Ditch vessel classification

Peak hours for Gunner's Ditch occurred between 11:00 AM and 4:00 PM for the count days. Holiday Weekends (5/27/2017, 7/2/2016, and 5/28/2016) averaged a peak hour of 1:00 PM, while non-holiday weekends averaged a peak hour of 2:30 PM. These peak hours are an accurate representation of the peak hours observed across most count locations. When moving forward with an overall data collection program, count times could be adjusted to reflect these peak hours.

The Saturday before the 4th of July holiday (7/2/2016), had the highest total number of vessels, but there is not a strong relationship between other holidays and the total number of vessels classified at this location. More data collection would be necessary to determine if the 4th of July could be used to capture maximum vessel volumes as a part of the overall data collection plan.

For all counts at Gunner's Ditch, small motor boats were overwhelmingly the largest class, followed by motorized personal watercraft on four of seven counts, and medium motor boats on the remaining three. Personal Watercraft accounted for 15 percent of the total volume, of consisting primarily of motorized (over 95 percent of personal craft), as opposed to non-motorized watercraft.

Gunner's Ditch ICW



Approximate Channel Width: 741 ft
Total Number of Count Days: 2
Average Number of Boats Counted per Day: 246
Population of Surrounding Municipality: 75,368

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 4. Intercoastal Waterway at Gunner's Ditch location and count summary

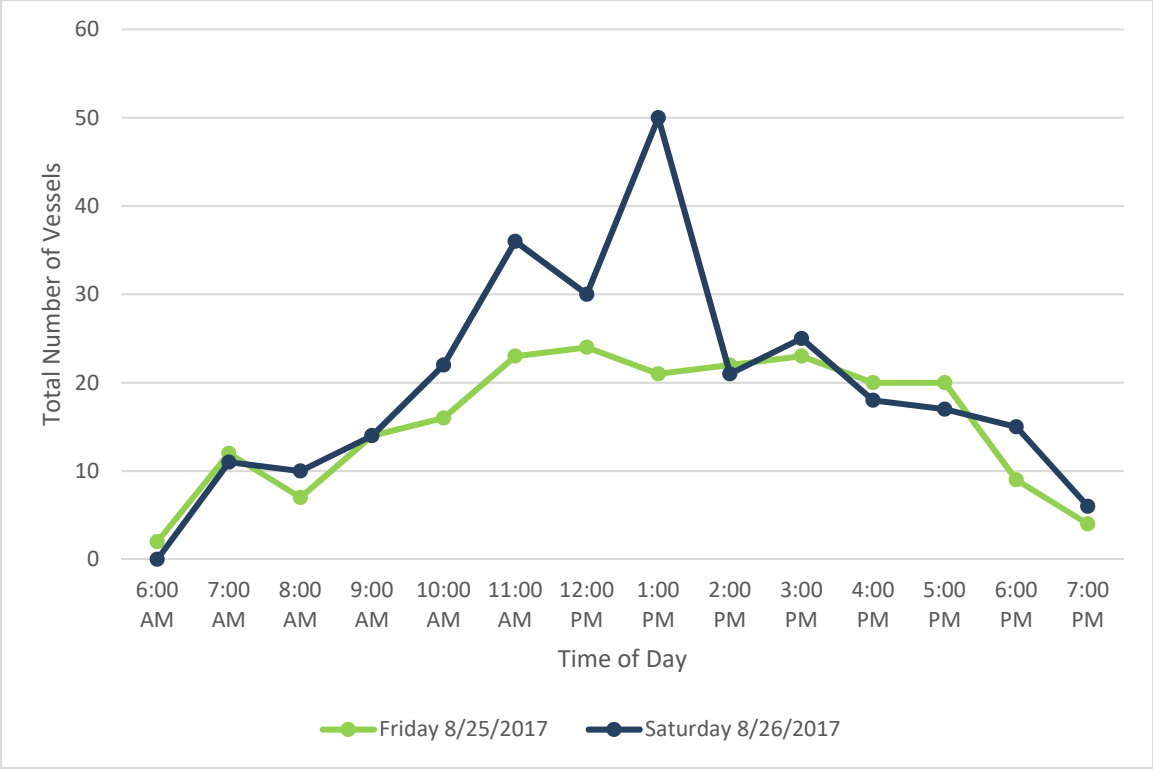


Figure 5. Intercoastal Waterway at Gunner's Ditch daily peak hours and volumes

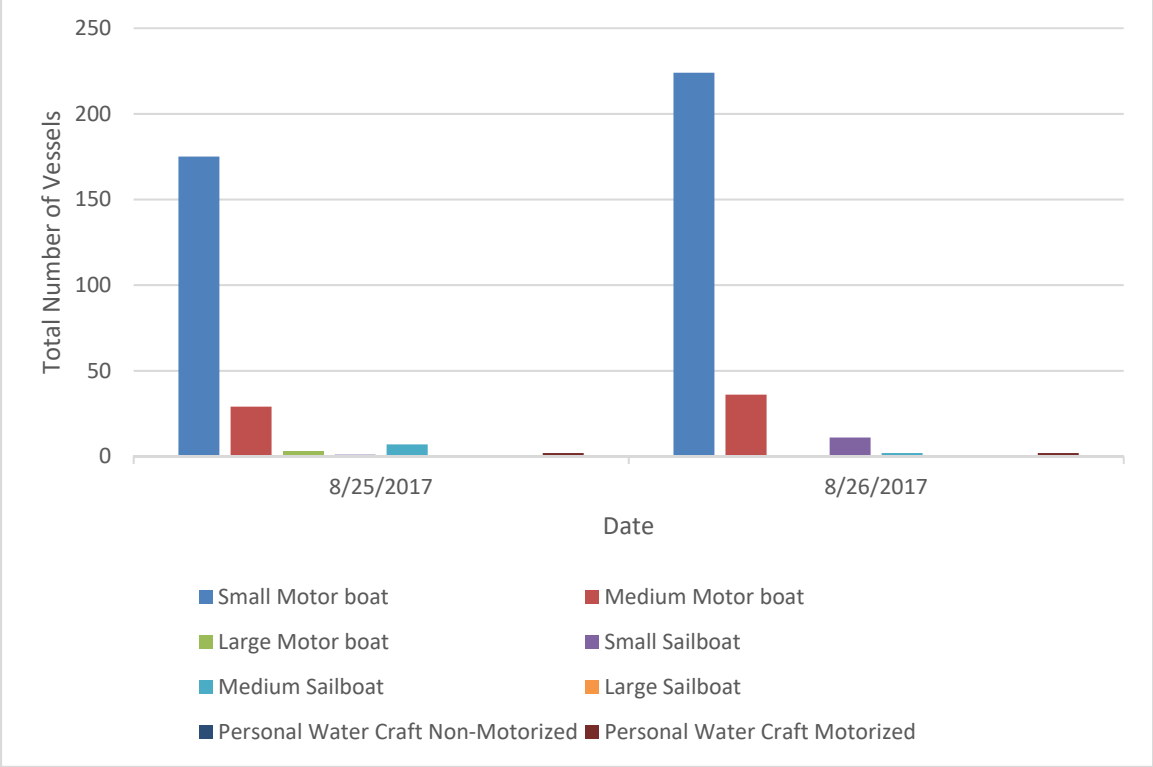


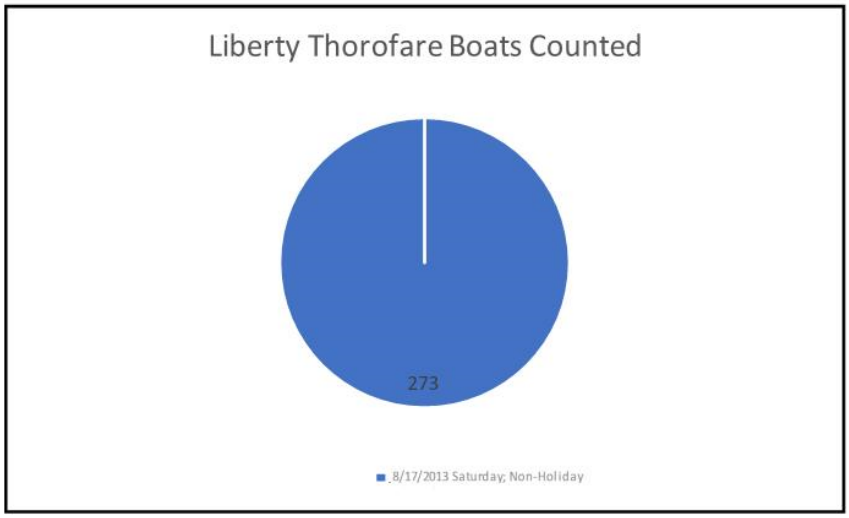
Figure 6. Intercoastal Waterway at Gunner's Ditch vessel classification

The Intracoastal Waterway (ICW) to the east of Gunner's Ditch experiences significantly less traffic then Gunner's Ditch itself. Peak hours for traveling the ICW occurred between 12:00 PM and 1:00 PM with weekend volume being much higher than weekday volume. As previously stated, this may be attributed to the federal status of the waterway, and a perception of cumbersome regulations when compared to state-designated waterways.

More count locations would need to be setup in the future to determine if these vessels were traveling a longer distance through the ICW, or operating locally and using the waterway for convenience. The current data collection methodology made no consideration as to whether a waterway was a part of the ICW or not, but this could be considered in the overall data collection plan.

Small motor boats comprised the majority of traffic with medium motor boats accounting for the second largest group. The reduced traffic at the ICW section of Gunner's ditch was reflected in the very small proportion of personal watercraft. Such craft only accounted for less than 1 percent of total vessel volume, comprised entirely of motorized craft. Gunner's Ditch ICW was one of only five count locations where personal watercraft comprised less than 10 percent of overall total vessel volume.

Liberty Thorofare



Approximate Channel Width: 635 ft
Total Number of Count Days: 1
Average Number of Boats Counted per Day: 273
Population of Surrounding Municipality: 1,170

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 7. Liberty Thorofare location and count summary

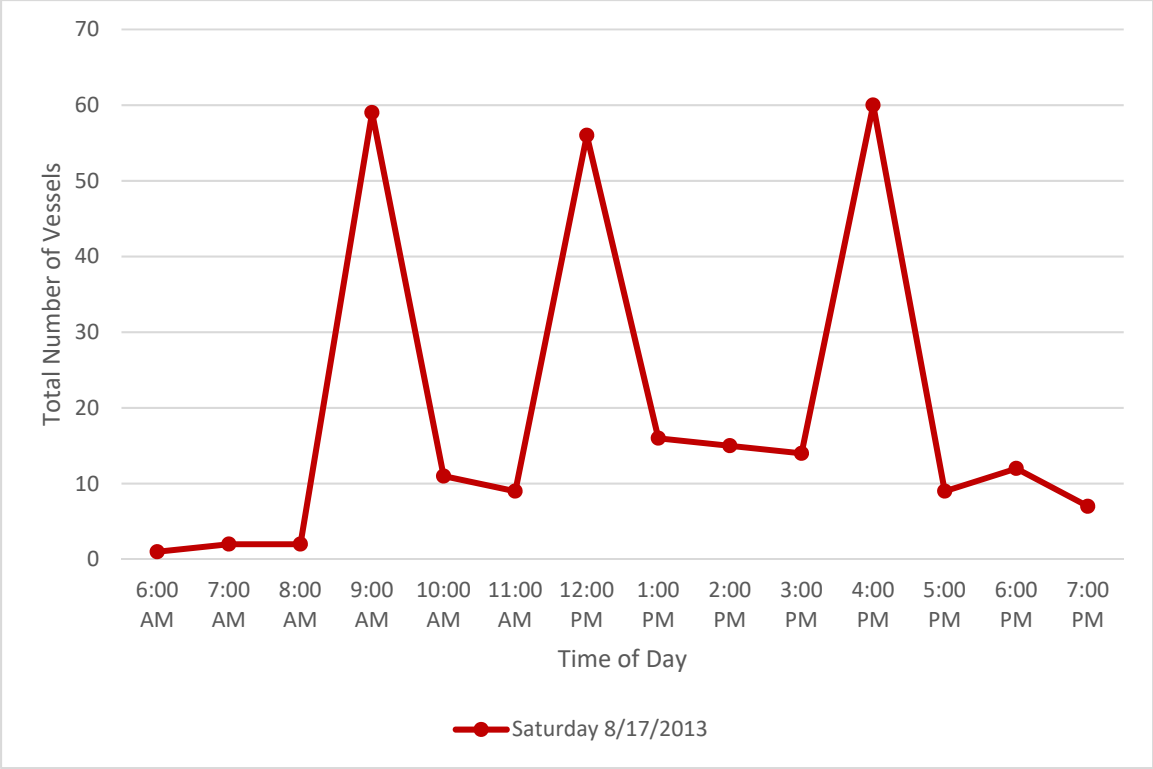


Figure 8. Liberty Thorofare daily peak hours and volumes

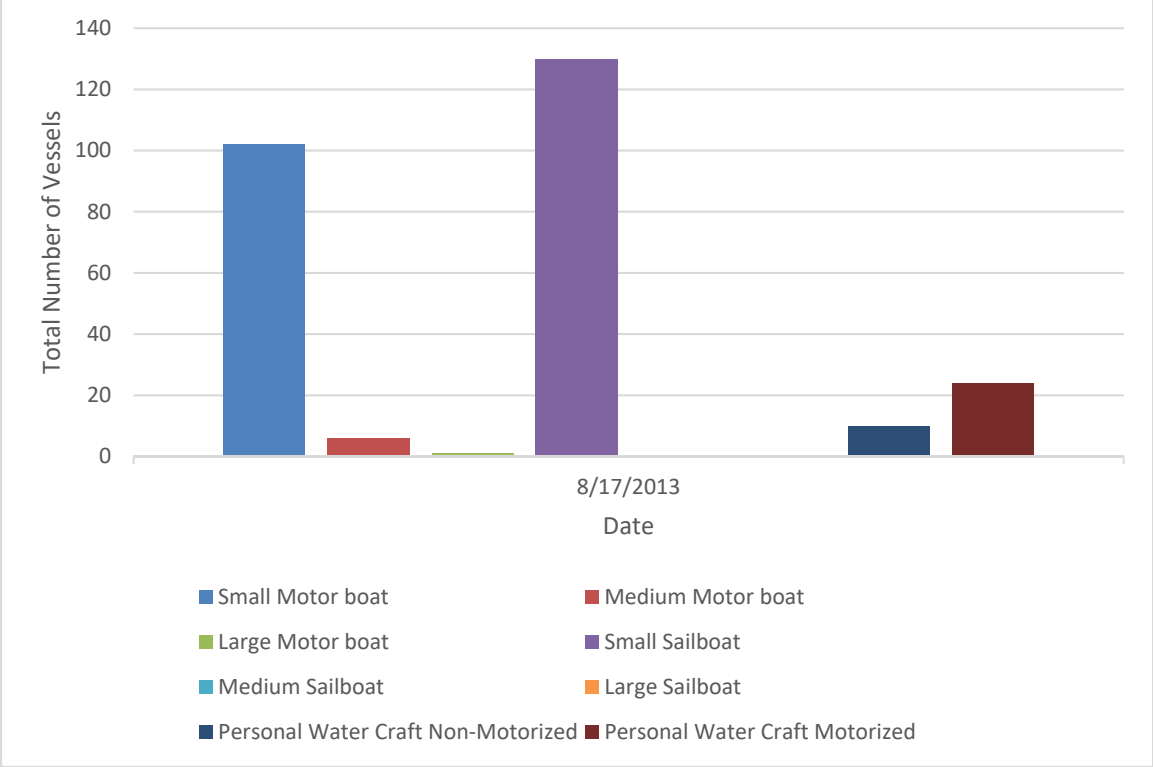
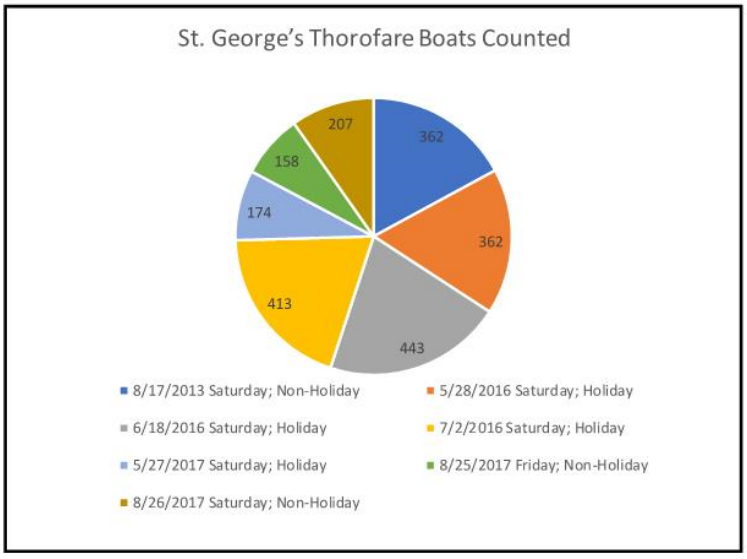


Figure 9. Liberty Thorofare vessel classification

The large spikes in volume at 9:00 AM, 12:00 PM, and 4:00 PM at Liberty Thorofare were due to large numbers of small sailboats counted within the same hour. This observation comes from the 15-minute interval data (not included in this summary report). This indicates small sailboats operate together at this count location, however more count dates would be necessary to identify if this is a regular occurrence or irregularity. If this was a regularly occurring trend, it may be due to the presence of a sailing school or boating event and due to the large impact on waterway volume should be considered for the data collection plan.

Unlike at Gunner's Ditch, small sailboats comprised the majority of vessels counted on the single day (130), although small motor boats also comprised a sizable amount (102). Personal watercraft accounted for about 12 percent of the total volume at Liberty Thorofare, of which about 75 percent of craft was motorized.

St. George's Thorofare



Approximate Channel Width: 130 ft
Total Number of Count Days: 7
Average Number of Boats Counted per Day: 303
Population of Surrounding Municipality: 49,008

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 10. St. George's Thorofare location and count summary

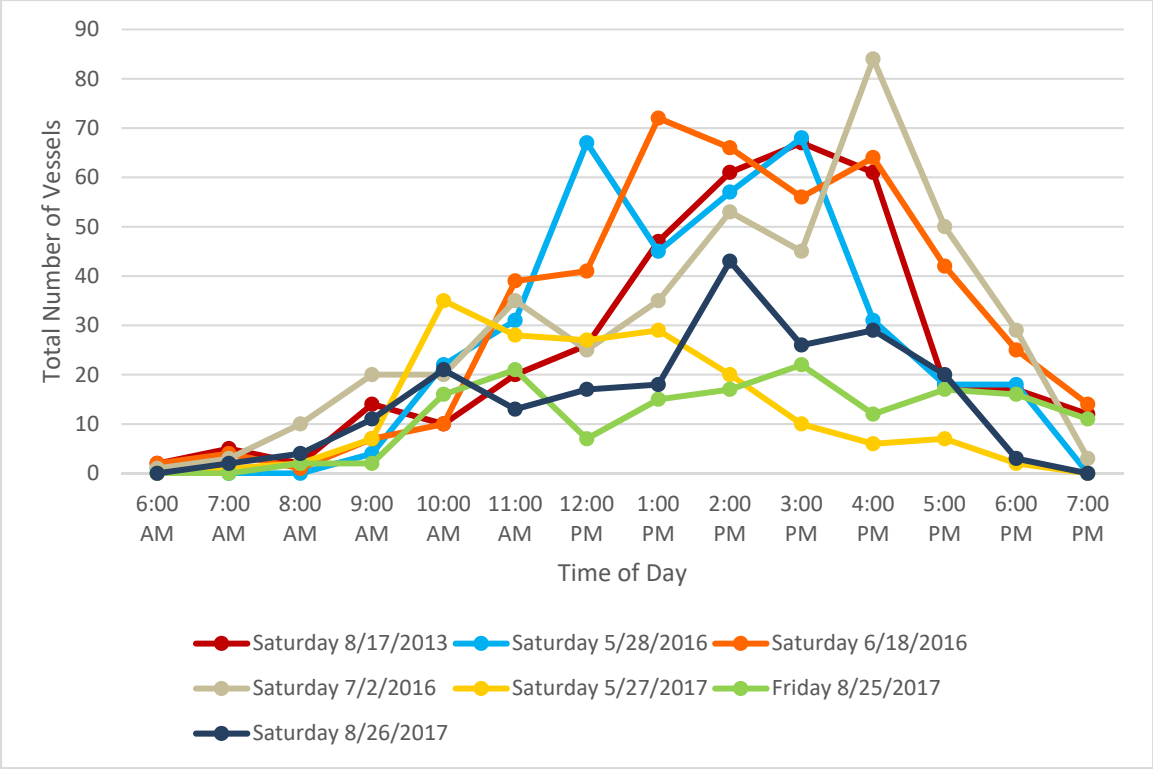


Figure 11. St. George's Thorofare daily peak hours and volumes

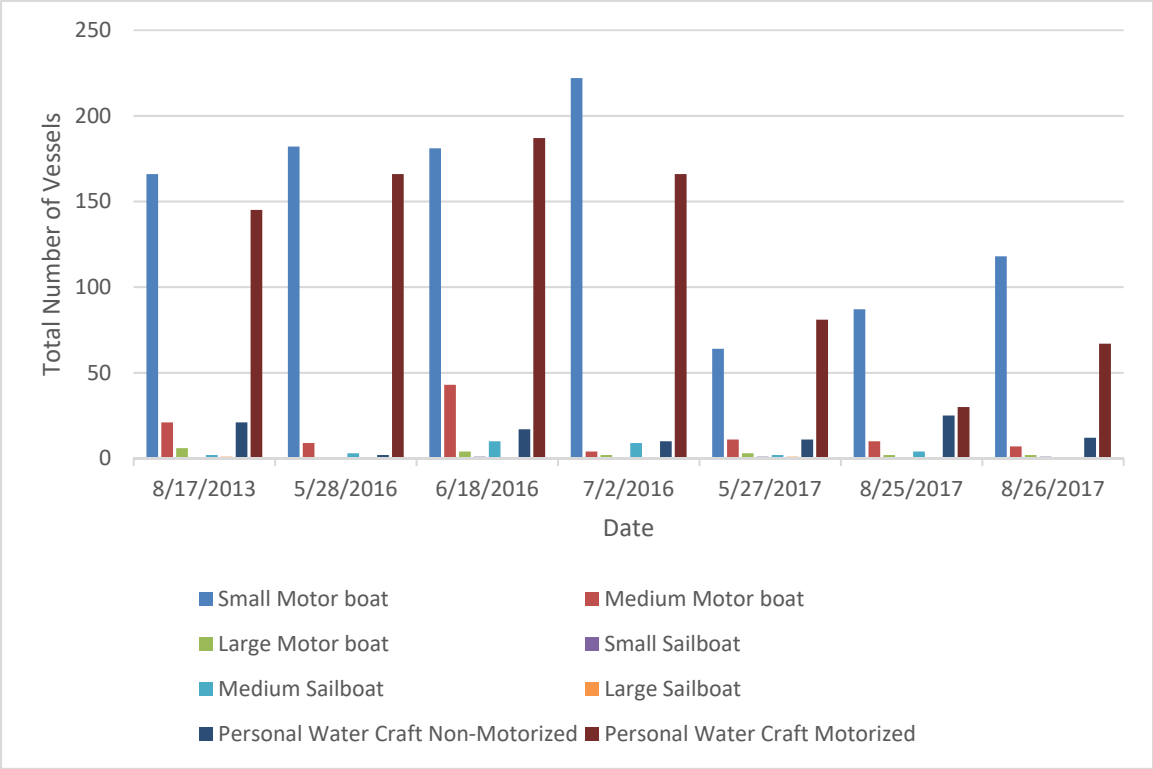


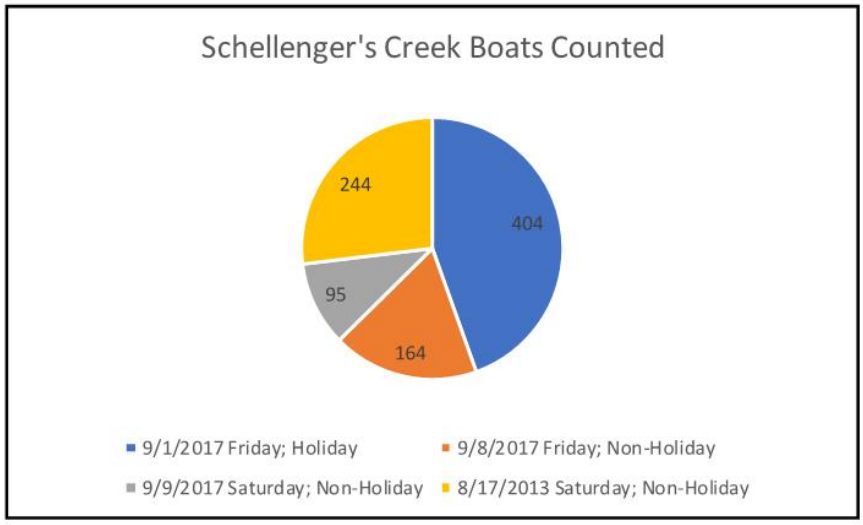
Figure 12. St. George's Thorofare vessel classification

St. George's Thorofare had peak hours between 10:00 AM and 4:00 PM for all count days, with an average peak hour of 2:00 PM. Peak hours do not appear to be closely related to holidays or weekends. On two of the seven count days, personal water craft volume exceeded small motor boat traffic, especially during the peak hours of traffic.

Personal watercraft accounted for 44 percent of the total volume at St. George's Thorofare, the highest recorded count percentage of any of the count locations. Of these craft, over 90 percent were motorized. The high proportion of personal watercraft is likely attributed to the small size of St. George's Thorofare, especially in comparison to other the waterways surveyed. Personal watercraft (the majority of which being motorized) are more likely to operate within a small area and may be counted several times as they travel back and forth, as opposed to other craft such as motor boats which are designed to travel a further distance and therefore would likely only be counted once when leaving and once again when returning.

The current count methodology considers a vessel counted each time it crosses the line indicated on the map. As such, since personal watercraft likely cross this line more frequently, given the lack of external propellers, considerations for such trends should be reflected in the data collection plan. These considerations would take into account the waterway width, and any other qualitative or quantitative characteristics that would tend to generate more personal watercraft traffic.

Schellenger's Creek



Approximate Channel Width: 291 ft
Total Number of Count Days: 4
Average Number of Boats Counted per Day: 227
Population of Surrounding Municipality: 26,473

Figure 13. Schellenger's Creek location and count summary

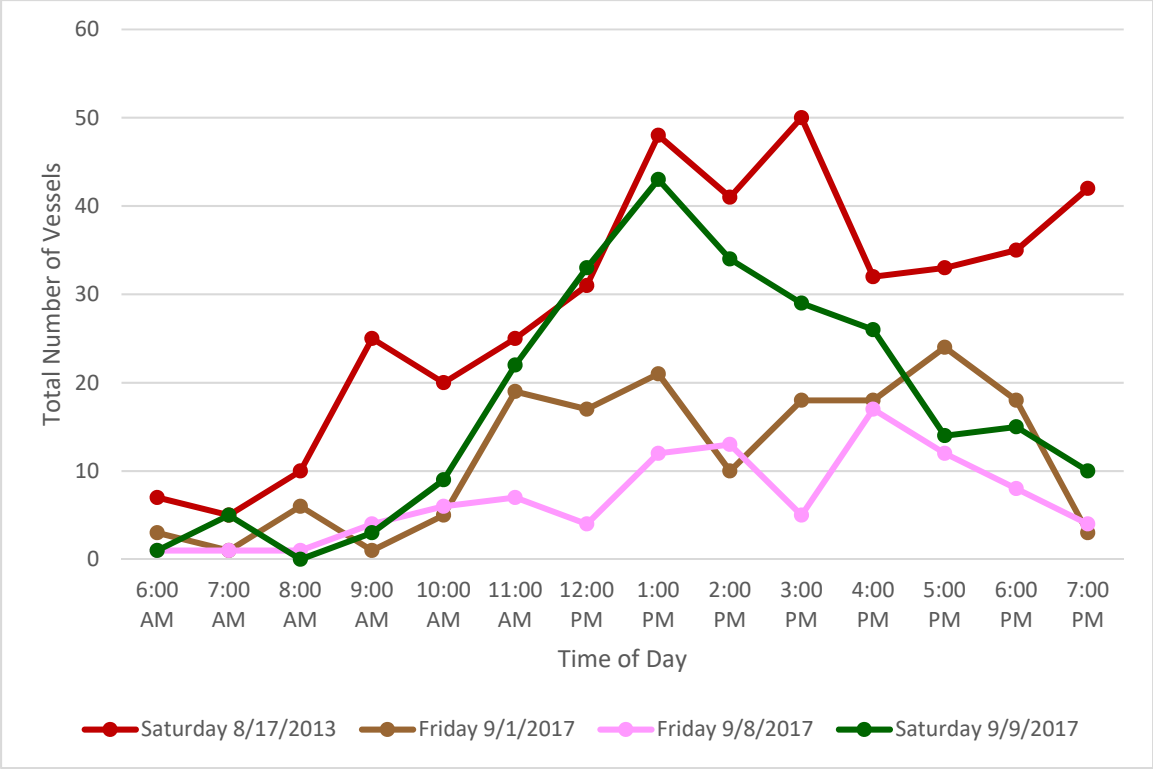


Figure 14. Schellenger's Creek daily peak hour and volumes

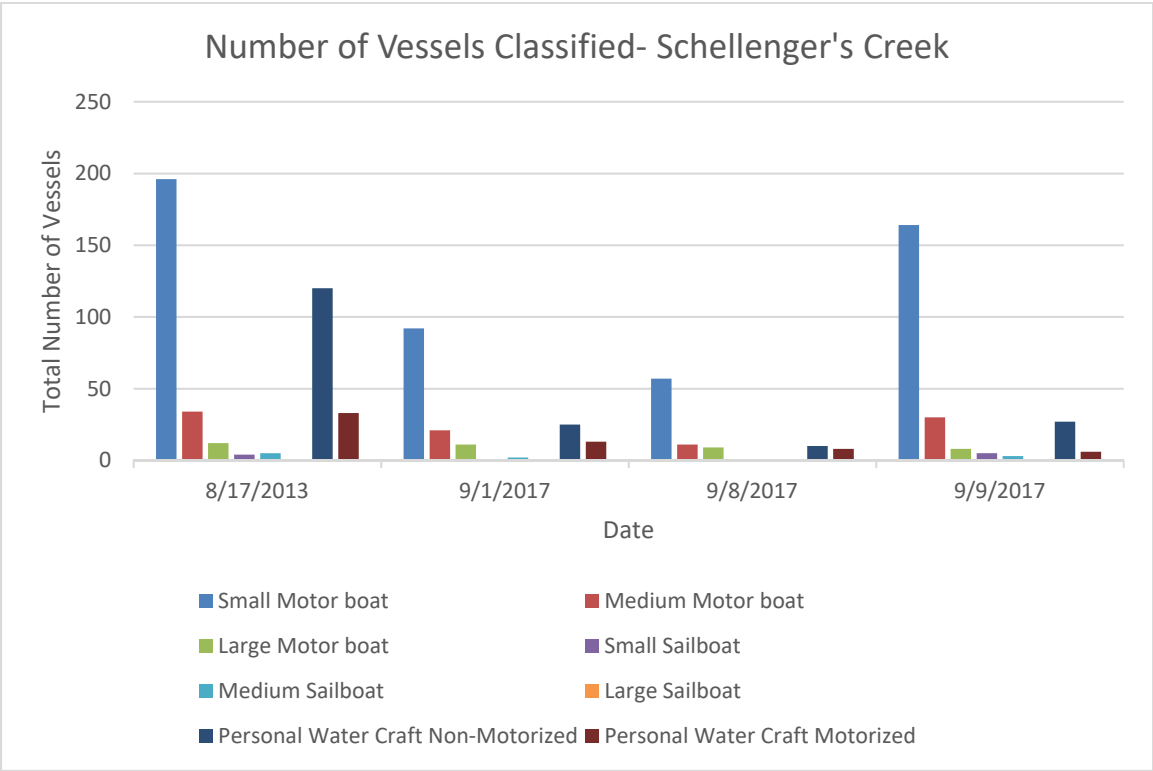


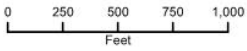
Figure 15. Schellenger's Creek vessel classification

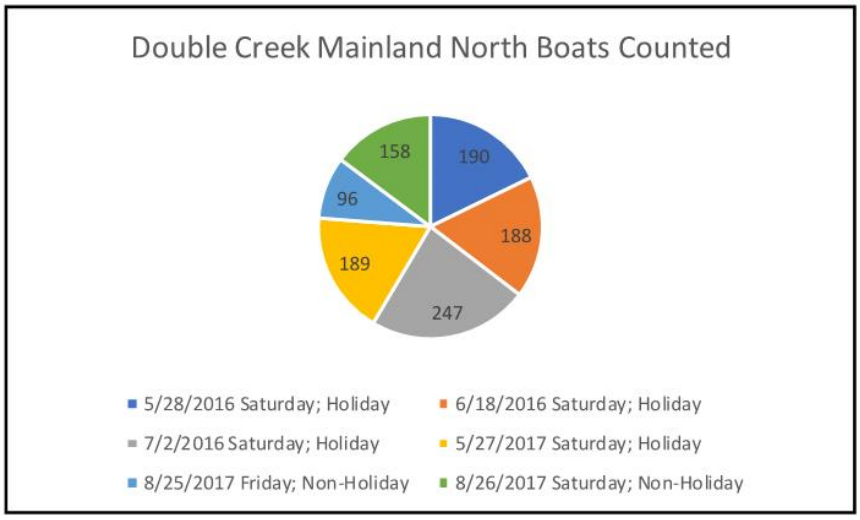
Schellenger's Creek is notable for being the count location with the greatest amount of waterway usage by large motor boats. This is due to the large commercial vessels that dock on the north side of the waterway. Large motor boats were still a small percentage of the total number of vessels, with small motor boats making up the largest percentage. Non-motorized personal water craft were the second largest class at this location and medium motor boats were the third largest class.

For Saturday counts, peak hours occurred between 1:00 PM and 3:00 PM and for Friday counts, peak hours occurred between 4:00 PM and 5:00 PM. This is likely because much of the boat traffic in this area comes from local residents who may have work or other obligations on weekday afternoons that they do not have on weekend afternoons. As expected the weekday volumes were lower than the weekend volumes. These trends are predictable given that this waterway is connected to several other waterways with residential slips and docks. This is an indication that the types of waterways that feed into a waterway should also be considered when establishing an overall data collection plan.

Of the total traffic, personal watercraft accounted for about 27 percent of the total volume at Schellenger's Creek. Unlike the previous locations however, the majority of this volume (75 percent) was non-motorized craft. It should be noted additionally that Schellenger's Creek was one of only four count locations that had a higher percentage of non-motorized personal watercraft than motorized personal watercraft.

Double Creek Mainland North





Approximate Channel Width: 225 ft
Total Number of Count Days: 6
Average Number of Boats Counted per Day: 178
Population of Surrounding Municipality: 20,936

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 16. Double Creek Mainland North location and count summary

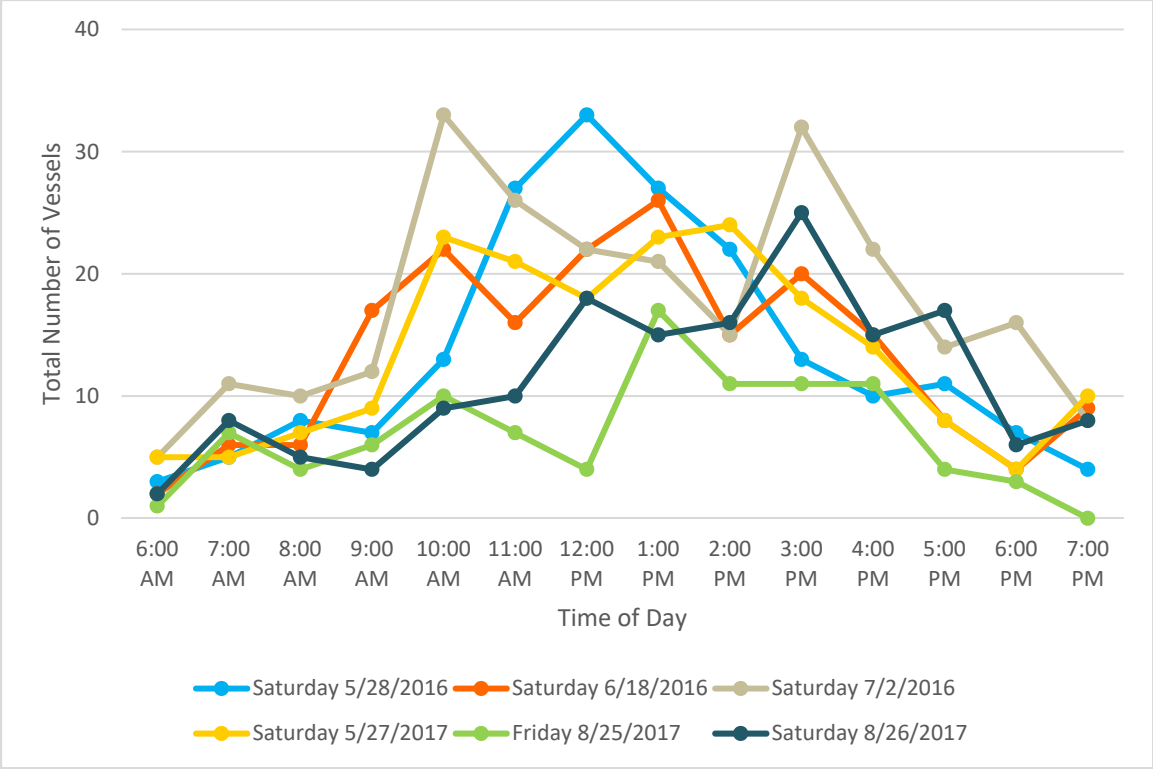


Figure 17. Double Creek Mainland North daily peak hours and volumes

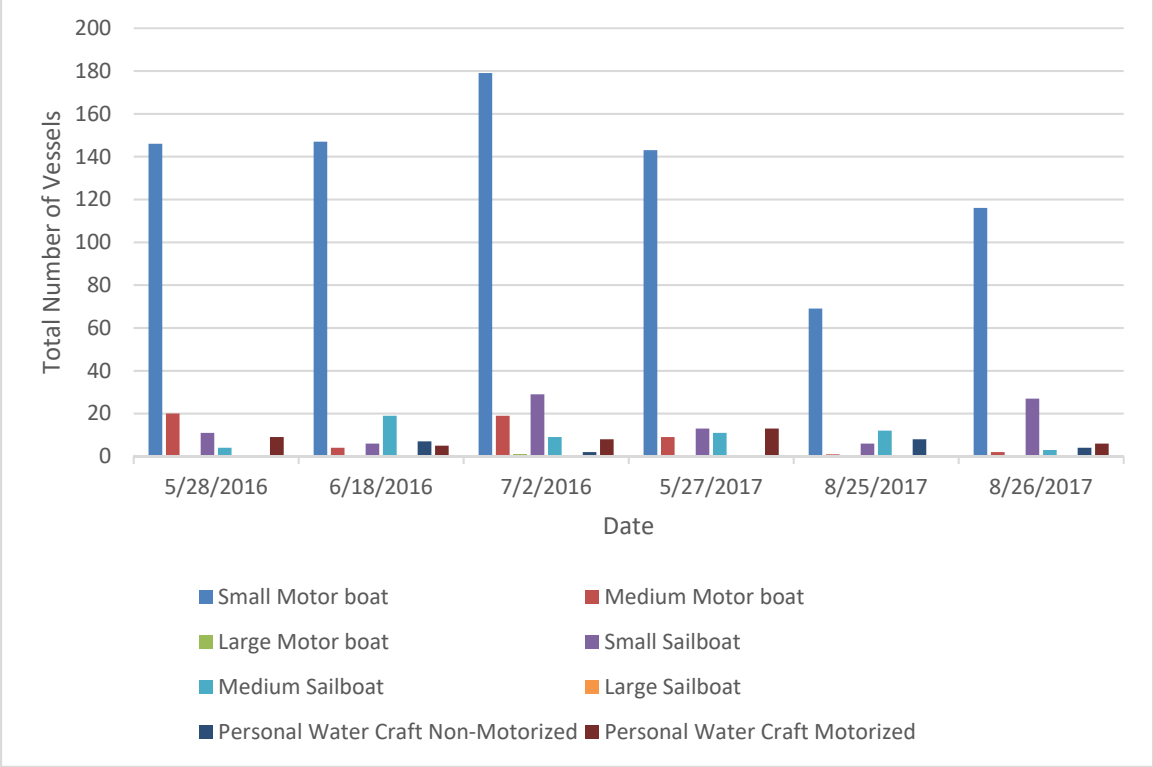
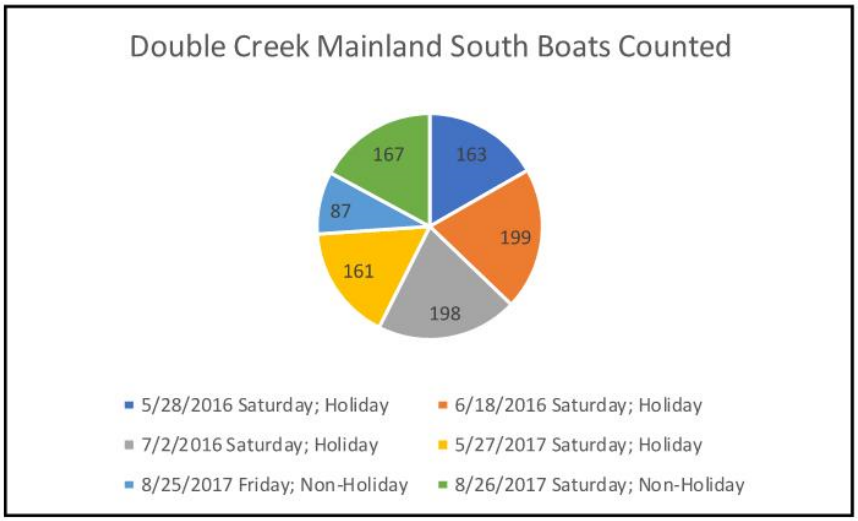


Figure 18. Double Creek Mainland North vessel classification

Double Creek Mainland South



Approximate Channel Width: 175 ft
Total Number of Count Days: 6
Average Number of Boats Counted per Day: 163
Population of Surrounding Municipality: 20,936

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 19. Double Creek Mainland South location and count summary

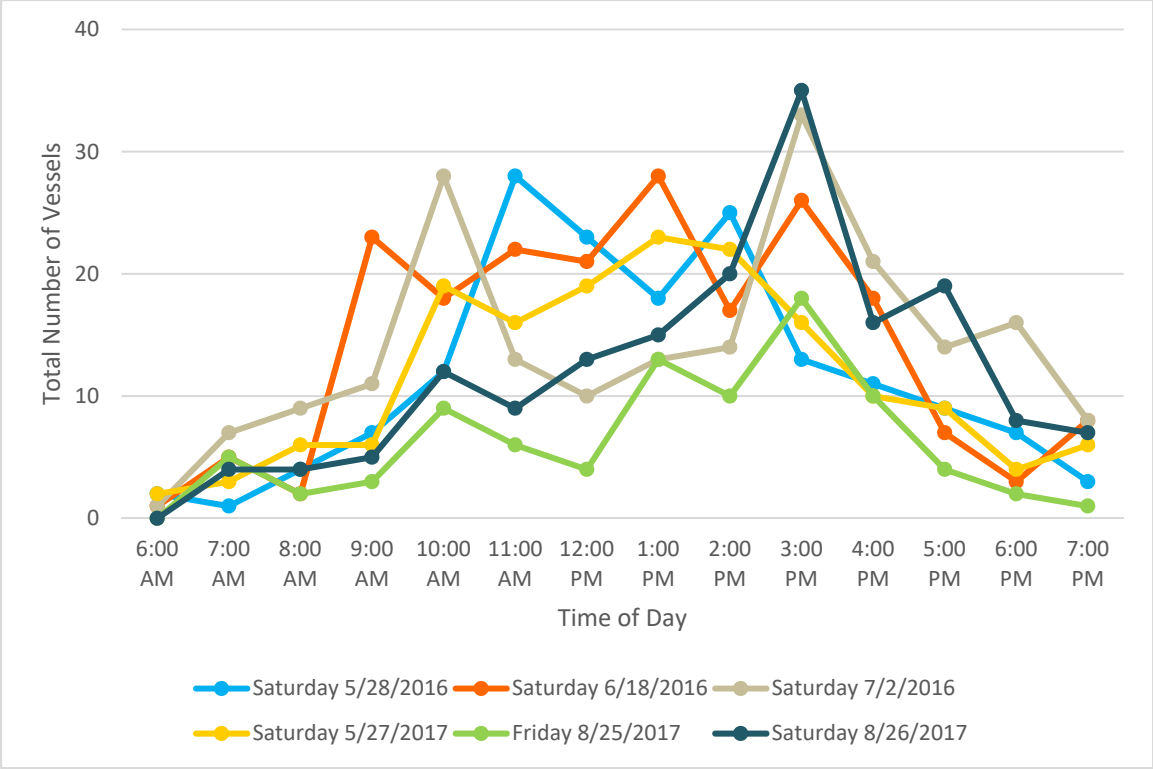


Figure 20. Double Creek Mainland South daily peak hours and volumes

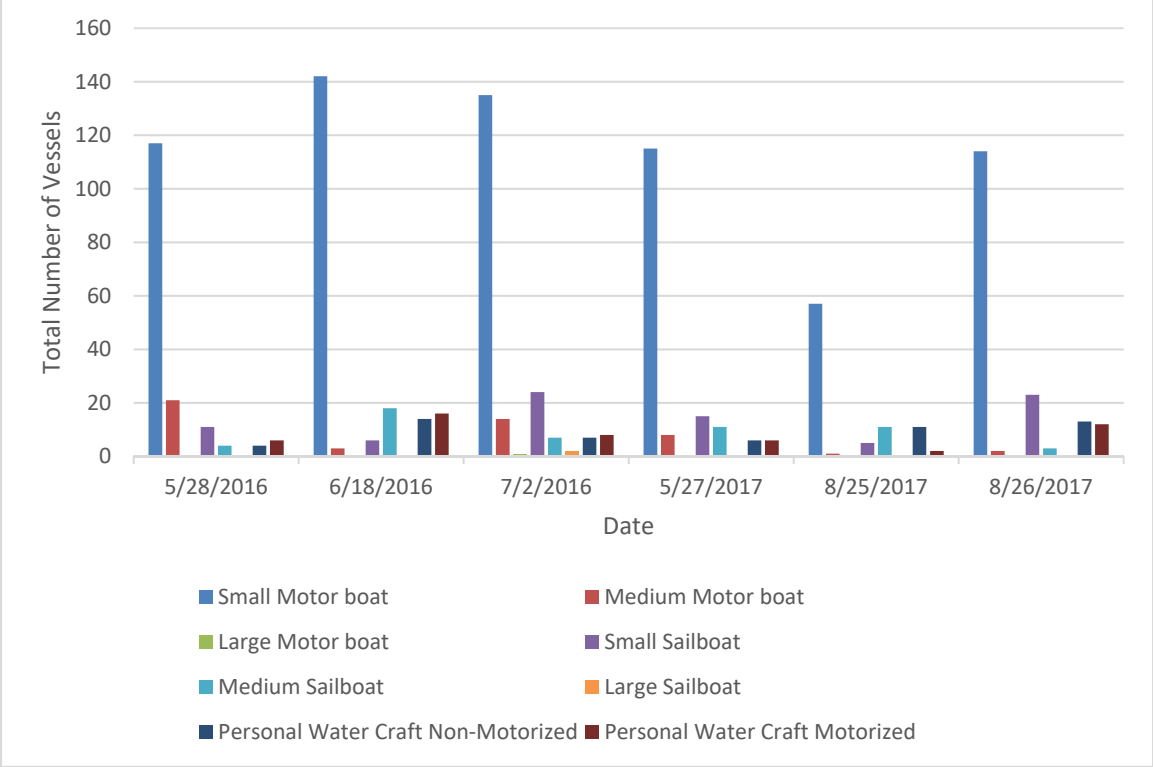


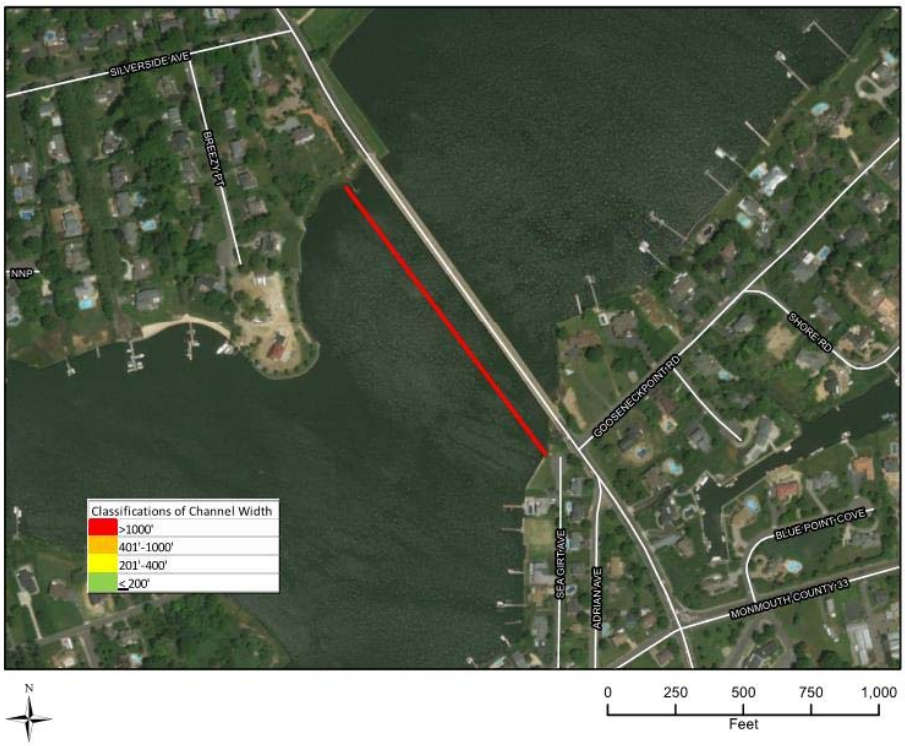
Figure 21. Double Creek Mainland South vessel classification

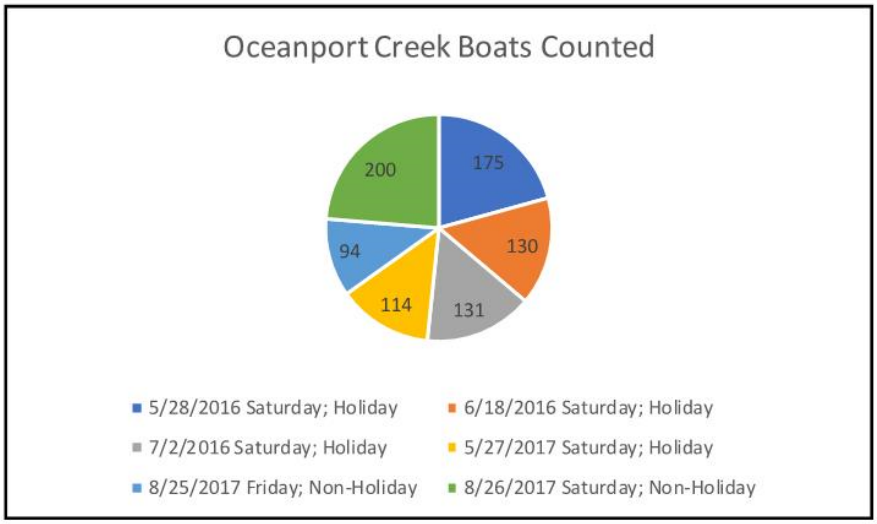
The Municipal Dock at Double Creek Mainland, Barnegat Township receives similar amounts of vessels traveling north and south. For both directions, small motor boats made up the largest class of vessels with small sail boats making up the second largest class. On 75 percent of count days, peak hours fell between 1:00 PM and 3:00 PM. Holiday weekends averaged peak hours between 12:00 PM and 1:00 PM, while non-holiday weekends averaged peak hours at 2:00 PM.

Similar to the Gunner's Ditch location, Double Creek Mainland had its highest volume on the 4th of July weekend, but the two Memorial Day weekend counts had volumes similar to that of a non-holiday Saturday. There likely is not a trend for all holiday weekends to have higher volumes of boat, but of the four locations counted on 7/2/2016, two locations had their highest volumes of any count day, so there may be a trend towards the 4th of July being an exception. Additional counts would be necessary to determine if this trend is applicable to a data collection plan that aimed to capture maximum volumes of vessels.

Personal water craft accounted for 6 percent of the total vessel volume at the Double Creek Mainland North location, and 11 percent at the Double Creek Mainland South location. Broken out between motorized and non-motorized craft, motorized craft constituted 66 percent and 45 percent of respective volume, collected across 6 days. The larger proportion of non-motorized watercraft at the southern portion of the waterway may be attributed to the presence of small residential waterways south of the on-site boat launch ramp. It should be noted that Double Creek Mainland North was one of five locations at which personal watercraft made up less than 10 percent of the overall total vessel volume. Additionally, Double Creek Mainland South was one of four locations that had a higher proportion of non-motorized than motorized personal watercraft.

Oceanport Creek





Approximate Channel Width: 1175 ft
Total Number of Count Days: 6
Average Number of Boats Counted per Day: 141
Population of Surrounding Municipality: 11,782

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 22. Oceanport Creek location and count summary

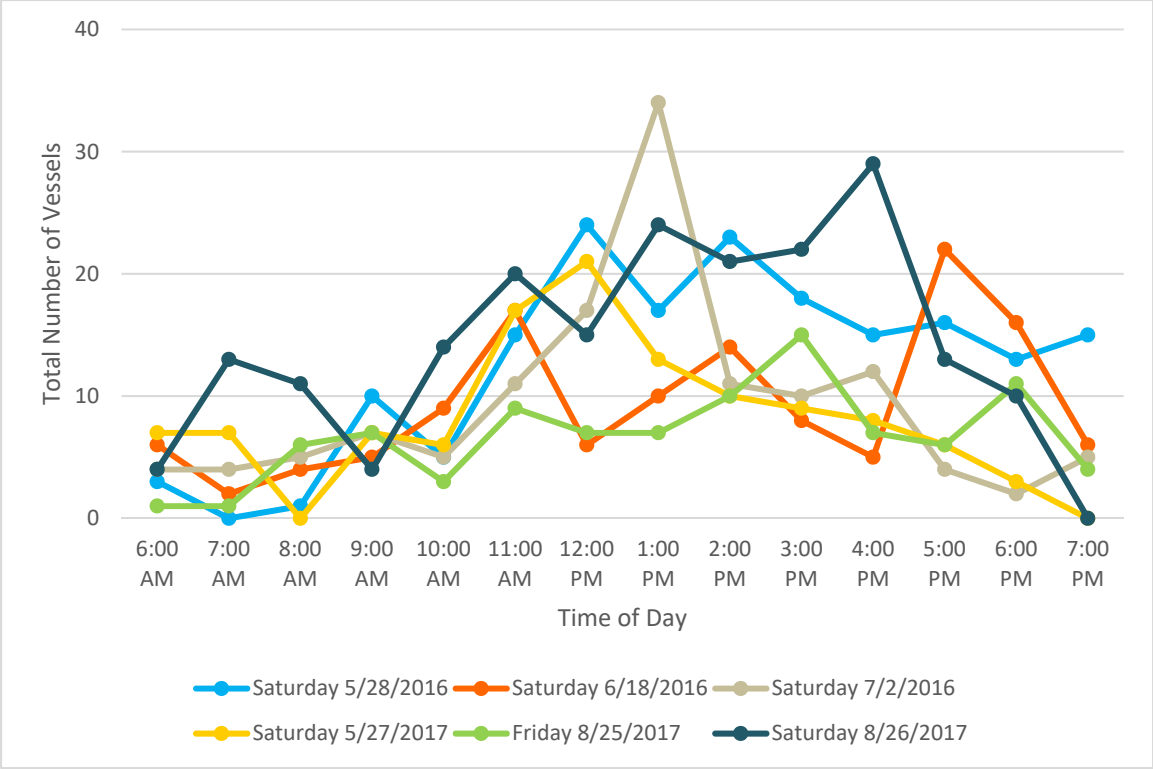


Figure 23. Oceanport Creek daily peak hours and volumes

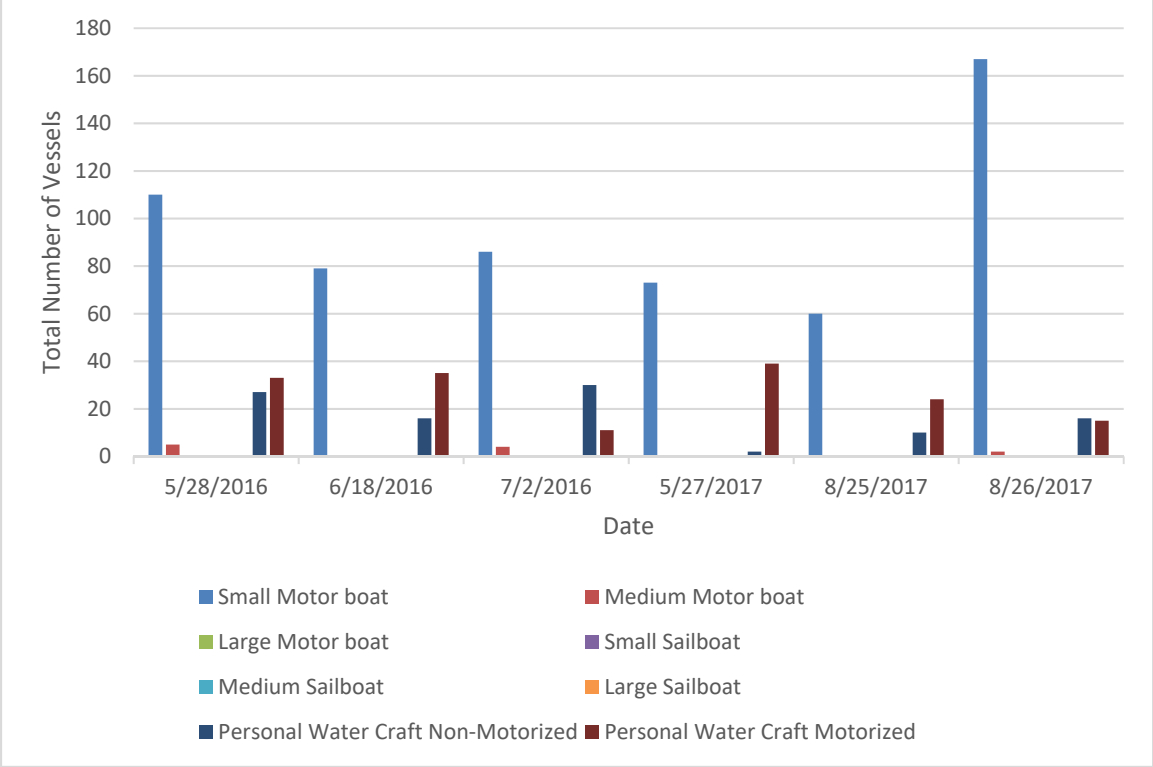
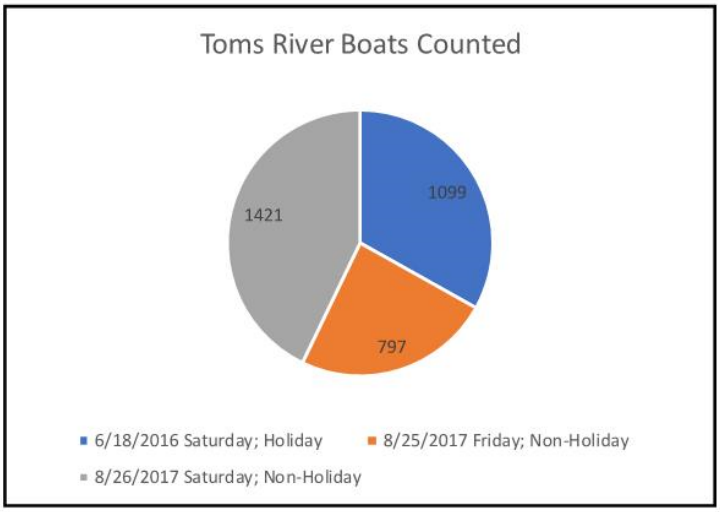


Figure 24. Oceanport Creek vessel classification

Peak hours were on average 12:00 PM for holiday weekends and 4:00 PM for non-holiday weekends for Oceanport Creek. As expected, weekday volumes were less then weekend volumes. The highest volume for a single day occurred on a non-holiday (8/26/2017), but the highest volume for a single hour occurred on the 4th of July weekend (7/2/2016) from 1:00 PM to 2:00 PM. This may be more evidence that on average, the 4th of July weekend contains volumes higher than most other days. If capturing maximum volume was the focus of the data collection plan, this weekend may be the best weekend for data collection, but this would need to be confirmed with more counts both on this weekend and on other weekends for comparison.

The largest class of recorded vessels at Oceanport Creek was small motor boats. This is likely attributed to the low height clearance of the Seven Bridges Road bridge over Oceanport Creek. In terms of the breakdown of motorized and non-motorized personal watercraft, motorized craft accounted for about 60 percent of the volume.

Toms River



Approximate Channel Width: 4975 ft
Total Number of Count Days: 3
Average Number of Boats Counted per Day: 1106
Population of Surrounding Municipality: 132,494

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

6/18/2016 counted from boat
8/25/2017 and 8/26/2017 counted from shore with binoculars

Figure 25. Toms River location and count summary

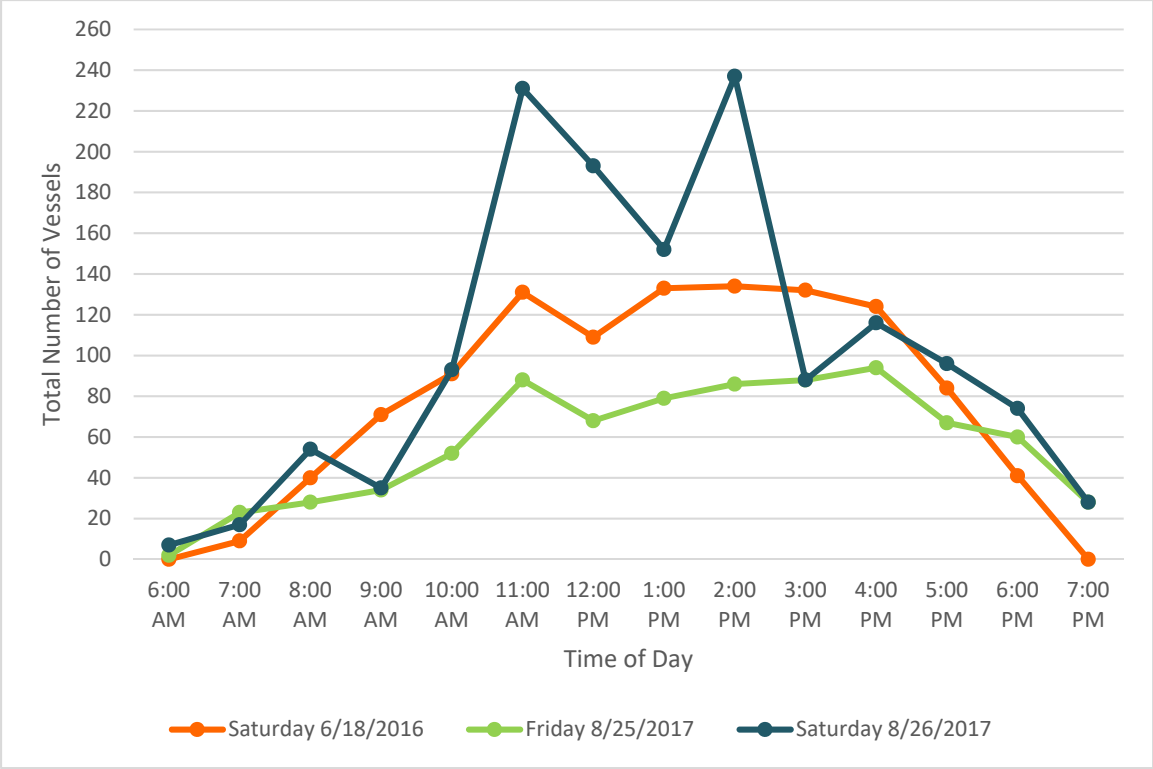


Figure 26. Toms River daily peak hour and volumes

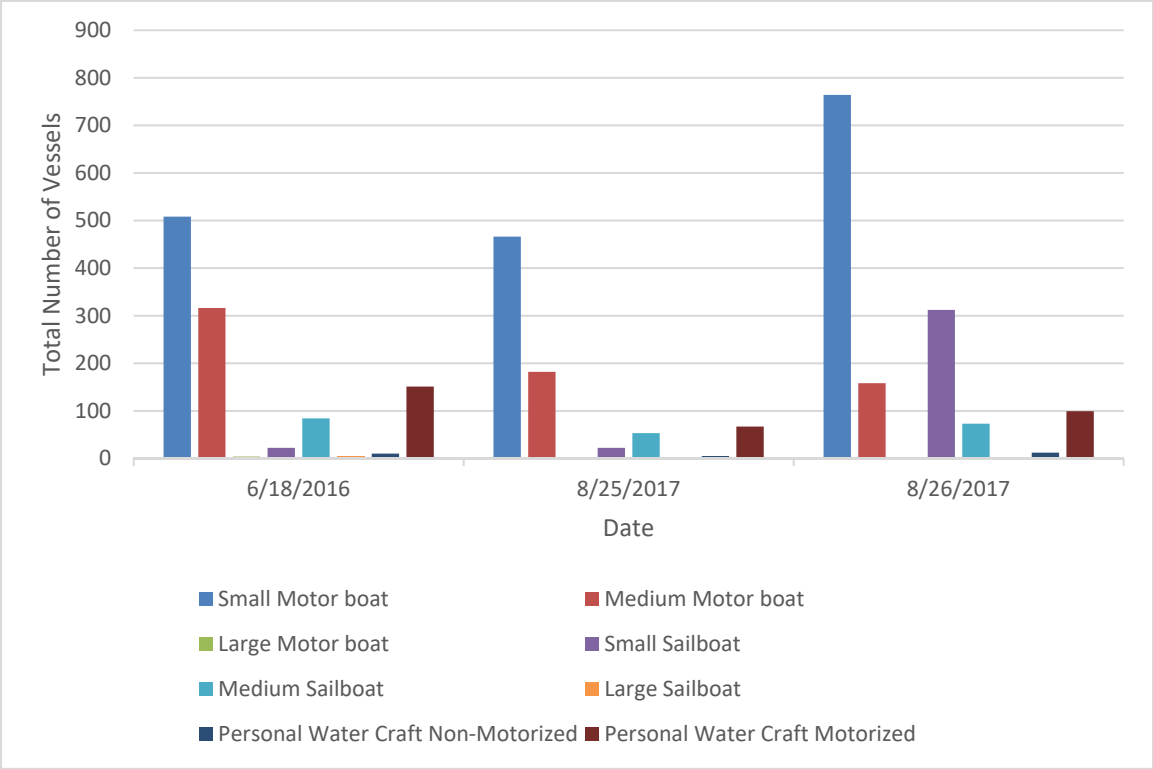
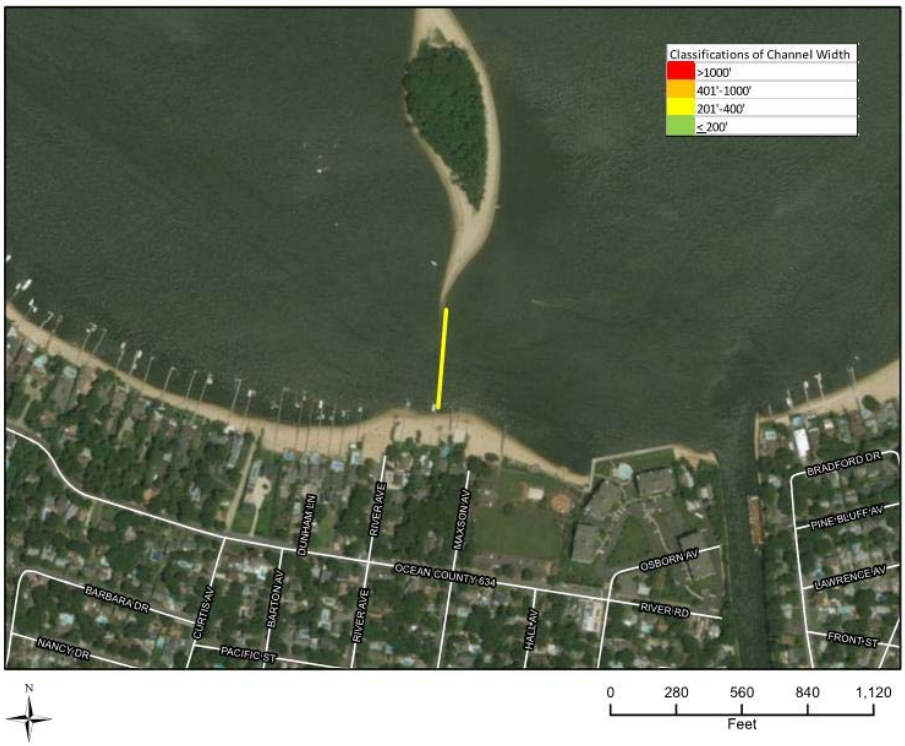


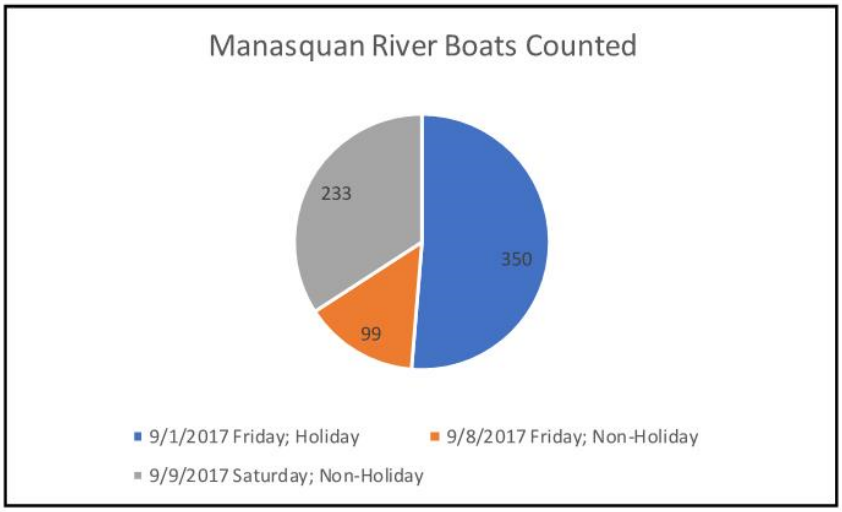
Figure 27. Toms River vessel classification

At Toms River, the two large spikes in hourly data on 8/26/2017 at 11:00 AM and 2:00 PM correspond to periods of the count with above average numbers of small sailboats. This observation comes from the 15-minute interval data (not included in this summary report). It is possible that data on this day was inflated by the large number of small sailboats because a similar spike did not occur on the other Saturday count. This may indicate that in an overall data collection plan it may be useful to count each waterway more than three times, and also consider weekday as opposed to weekend and holiday as opposed to non-holiday when selecting count dates. If this were done it would be easier to try and determine the reasons for irregular occurrences like the one seen here.

Overall, Toms River reflected a greater variety of vessel classification compared to the other count locations. Small motor boats were the largest class, followed by medium motor boats, small sailboats, motorized personal watercraft, and then medium sailboats. Personal watercraft accounted for about 10 percent of the total volume, of which about 90 percent was motorized. In the case of Toms River, the large proportion of motorized personal watercraft as opposed to non-motorized, is likely attributed by the very high amount of boat traffic in the river, set in a wide body of water. In this scenario, non-motorized personal watercraft operators may find those conditions less desirable compared to some of the smaller, calmer, and less-trafficked locations.

Manasquan River





Approximate Channel Width: 325 ft
Total Number of Count Days: 3
Average Number of Boats Counted per Day: 227
Population of Surrounding Municipality: 23,116

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 28. Manasquan River location and count summary

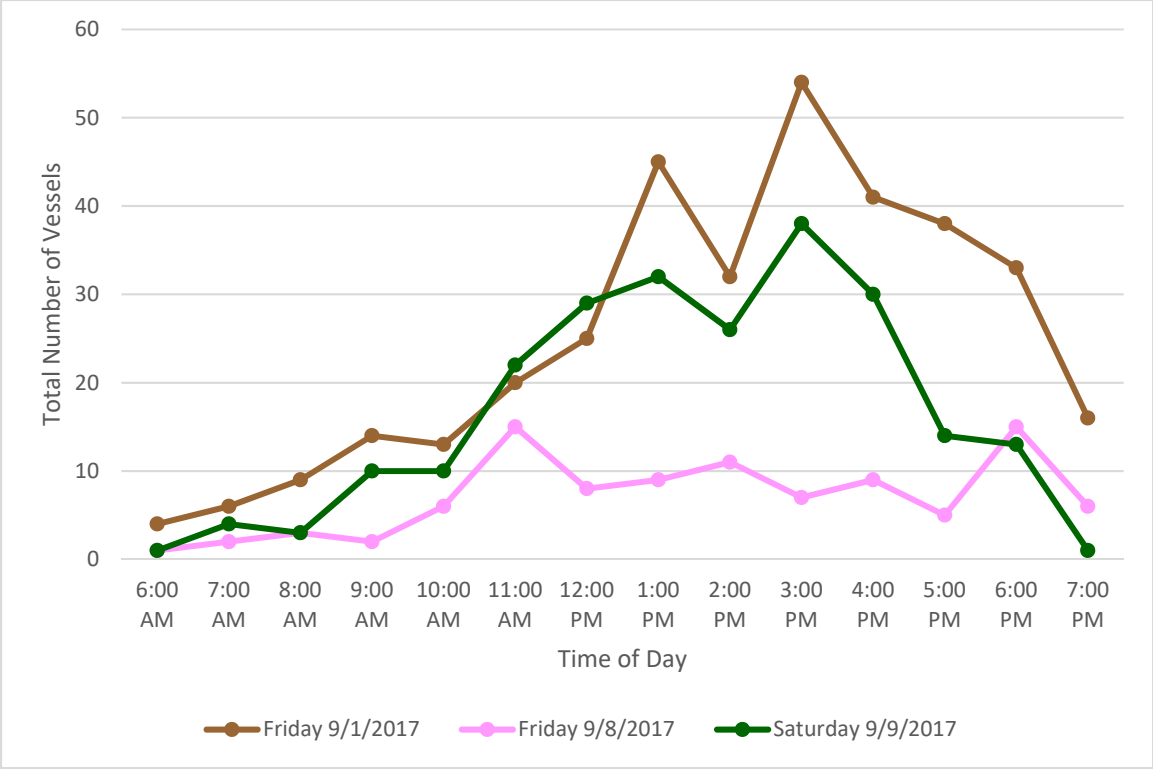


Figure 29. Manasquan River daily peak hours and volumes

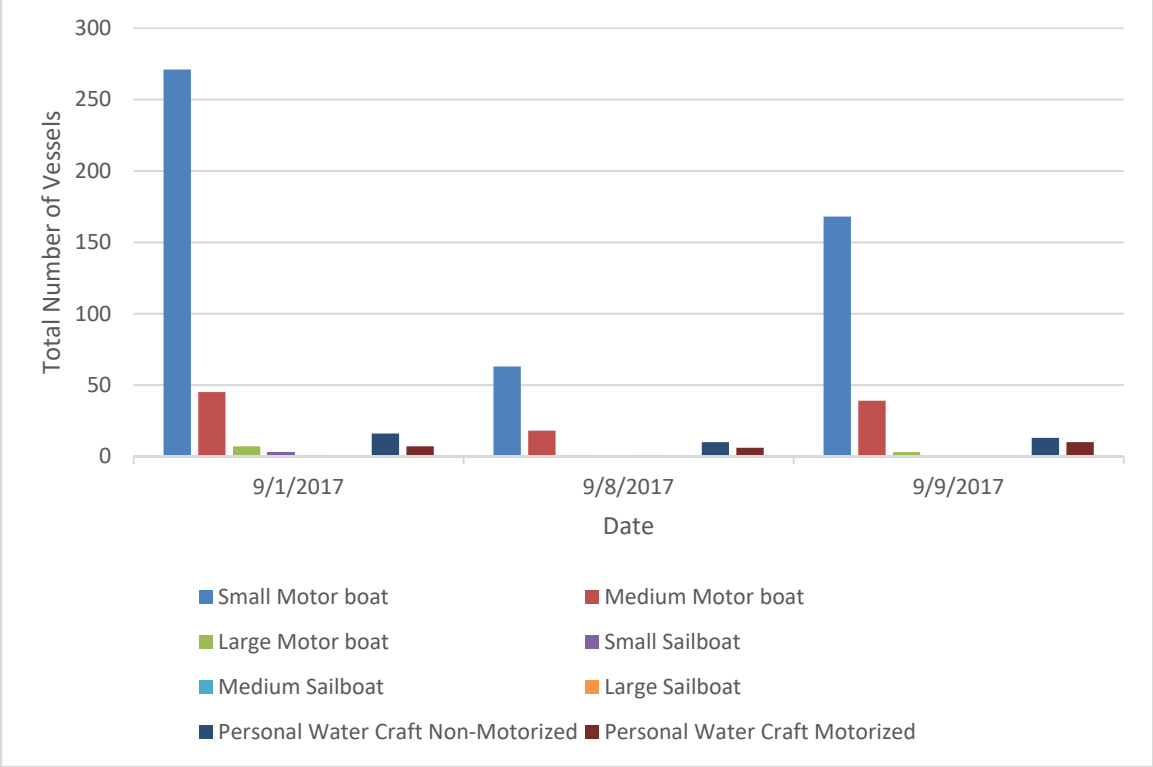
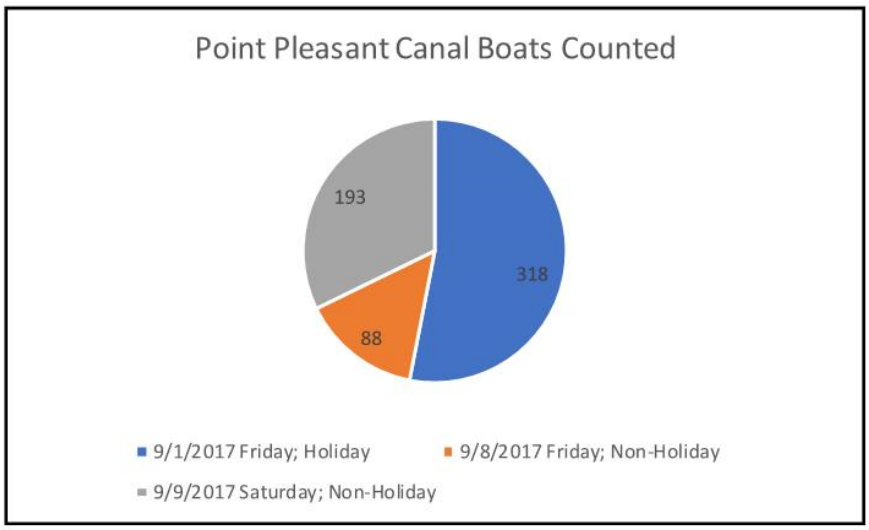


Figure 30. Manasquan River vessel classification

Point Pleasant Canal



Approximate Channel Width: 175 ft
Total Number of Count Days: 3
Average Number of Boats Counted per Day: 200
Population of Surrounding Municipality: 23,116

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 31. Point Pleasant Canal location and count summary

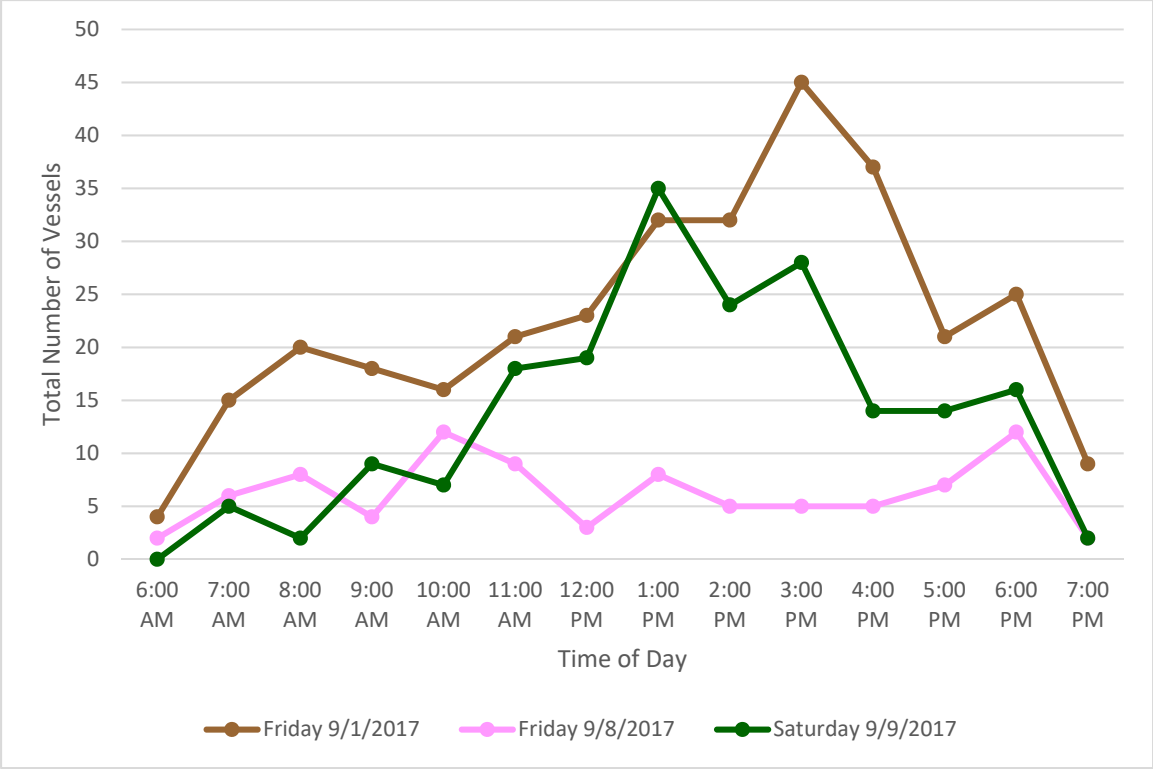


Figure 32. Point Pleasant Canal daily peak hours and volumes

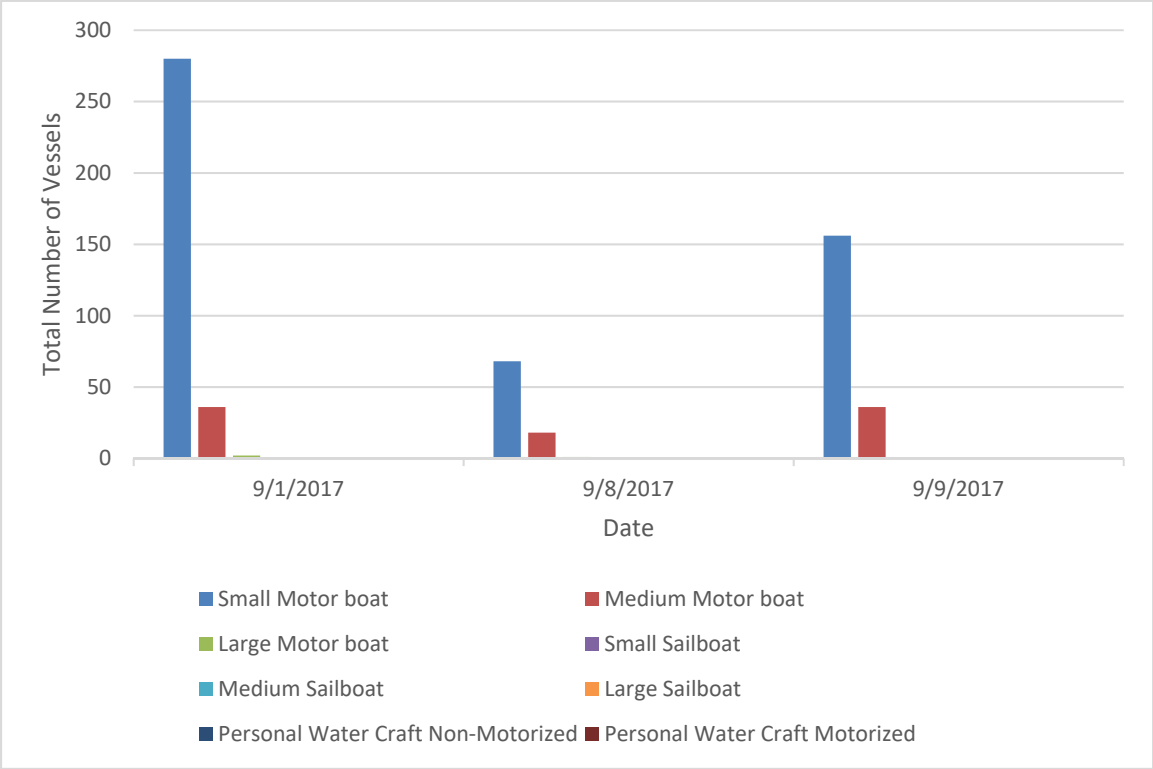
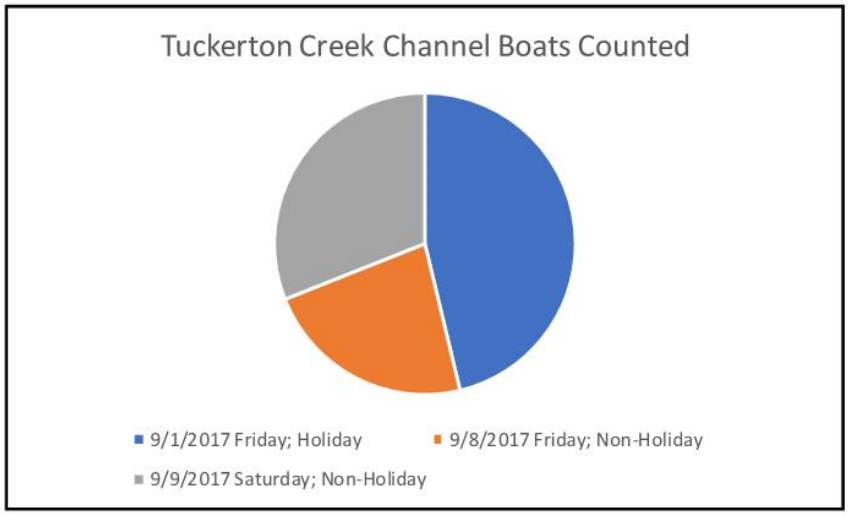


Figure 33. Point Pleasant Canal vessel classification

The Manasquan River and the Point Pleasant Canal, counted from the same location at Riverfront Park, share the same characteristics regarding daily volumes. The highest total volume of the three count days occurred on 9/1/2017, the Friday of Labor Day weekend. As expected, the least busy day fell on 9/8/2017 which was a weekday after the end of peak summer season. The trends for Friday as opposed to Saturday and peak season as opposed to post season appear to be the most consistent trends of any identified and should be major factors in the data collection plan. These variables can be used to shape the data collection plan depending on the goal of the data collection.

Personal Watercraft accounted for 9 percent of the total vessel volume at Manasquan River location. Of these craft, approximately 37 percent were motorized, making the Manasquan River one of four count locations that had a higher percentage of non-motorized personal watercraft, and one of five locations with a personal watercraft recorded volume of less than 10 percent. Interestingly enough, no personal watercraft were recorded at Point Pleasant Canal.

Tuckerton Creek Channel



Approximate Channel Width: 335 ft
Total Number of Count Days: 3
Average Number of Boats Counted per Day: 133
Population of Surrounding Municipality: 23,412

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 34. Tuckerton Creek Channel location and count summary

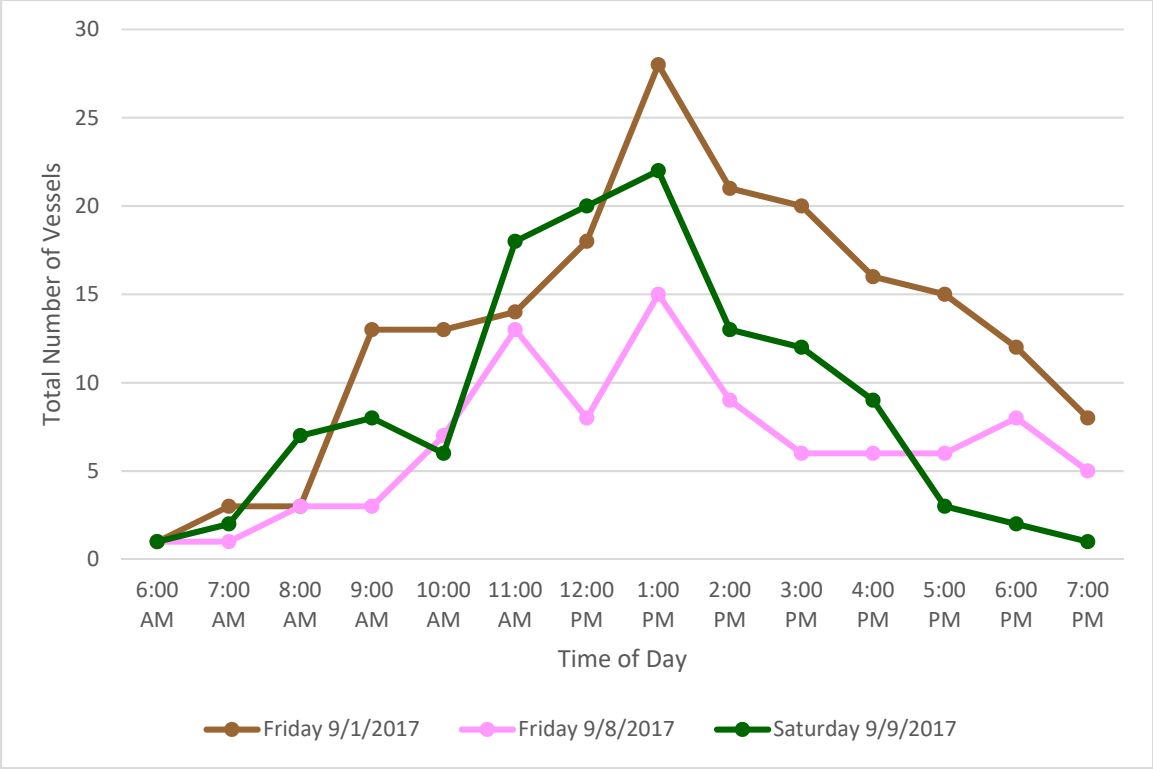


Figure 35. Tuckerton Creek Channel daily peak hour and volumes

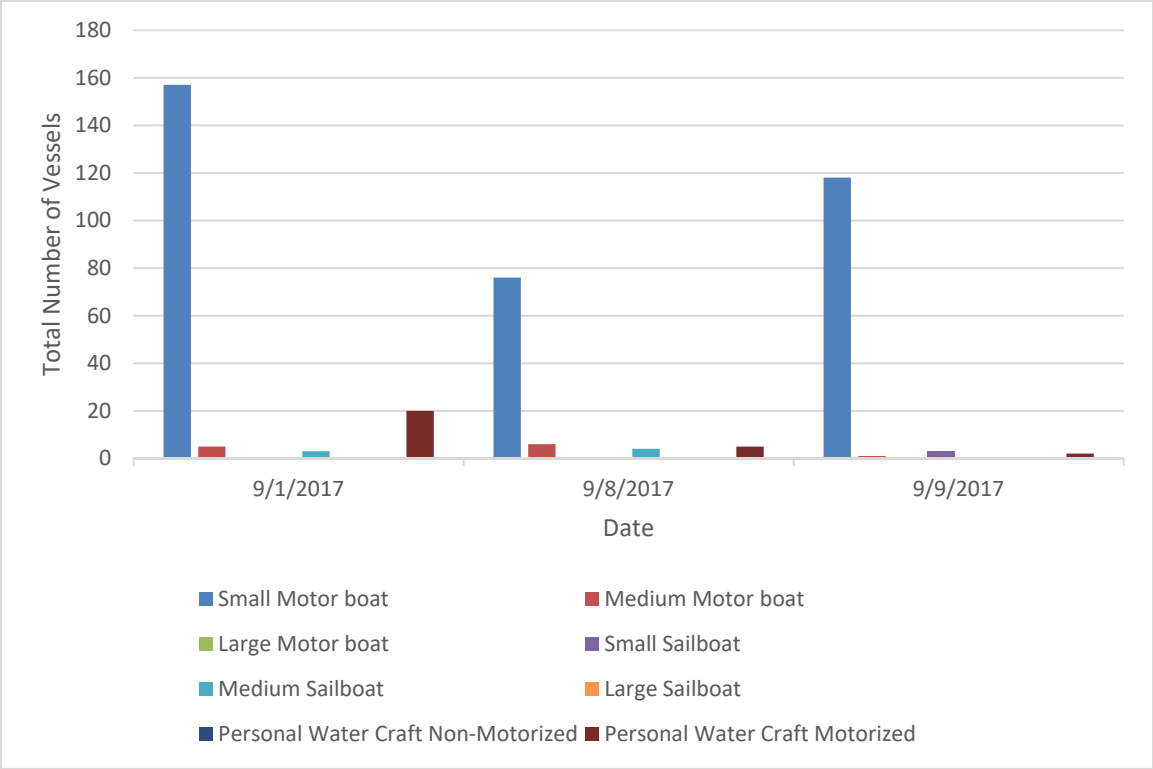
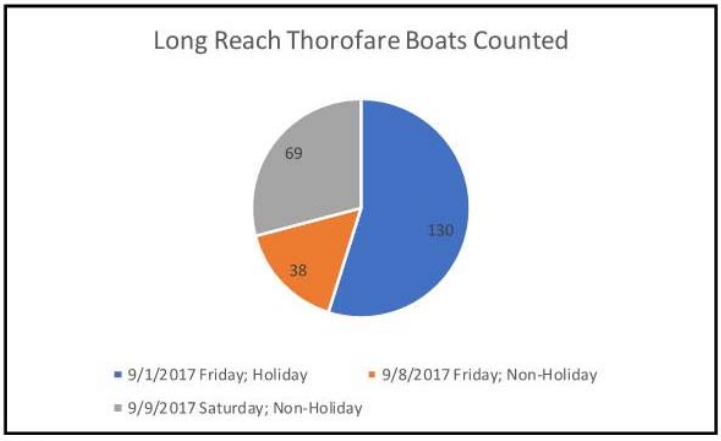


Figure 36. Tuckerton Creek Channel vessel classification

On all three count days, peak hours for Tuckerton Creek Channel occurred at 1:00 PM. The values for the total daily volumes were predictable given the count days – highest on the Friday of Labor Day weekend, and lowest on Friday 9/8/2017 which is after the peak summer season. More counts should be conducted at this location because these three counts occurred at the end of or after the peak season. The data would be more useful if it could be compared to early and mid-season data to make observations over the course of a full season. This confirms the need for a data collection plan to cover all the variables to be as thorough as possible.

Personal watercraft accounted for just under 7 percent of the total vessel volume at Tuckerton Creek Channel, all of which in the form of motorized craft. As such, the Tuckerton Creek was one of five count locations where personal watercraft made up less than 10 percent of the overall total vessel volume.

Long Reach Thorofare



Approximate Channel Width: 410 ft
Total Number of Count Days: 3
Average Number of Boats Counted per Day: 79
Population of Surrounding Municipality: 1,334

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 37. Long Reach Thorofare location and count summary

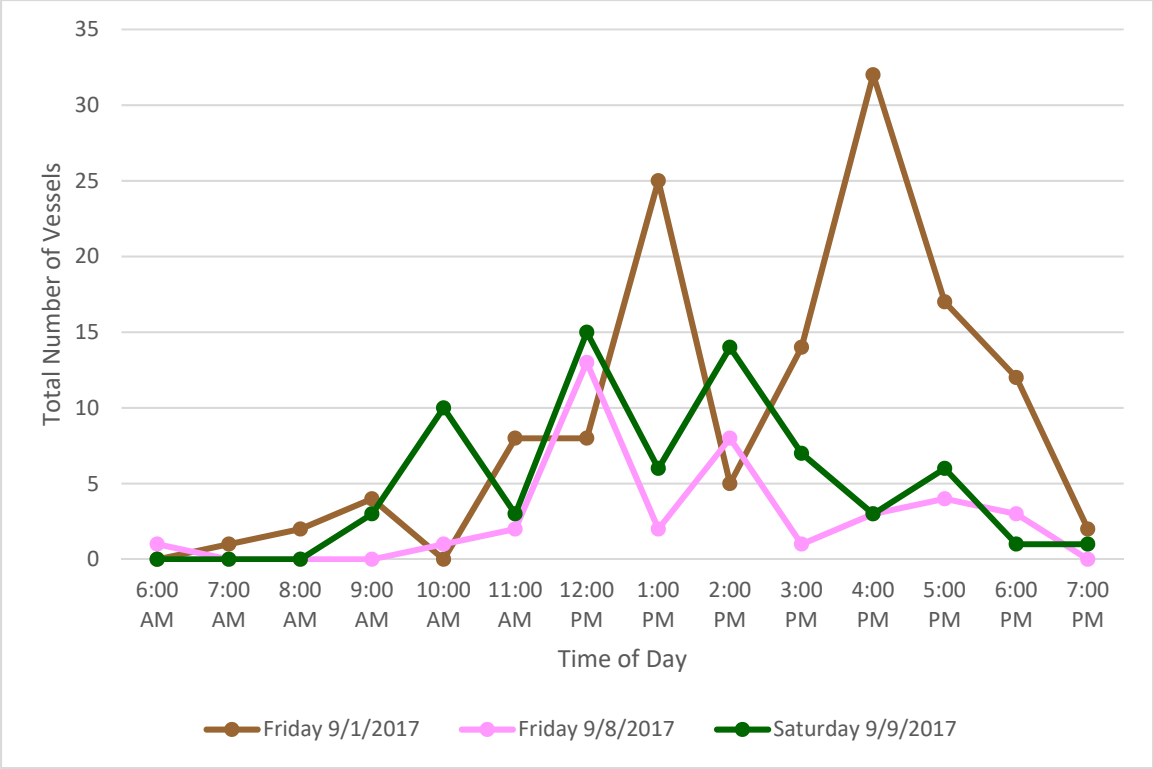


Figure 38. Long Reach Thorofare daily peak hours and volumes

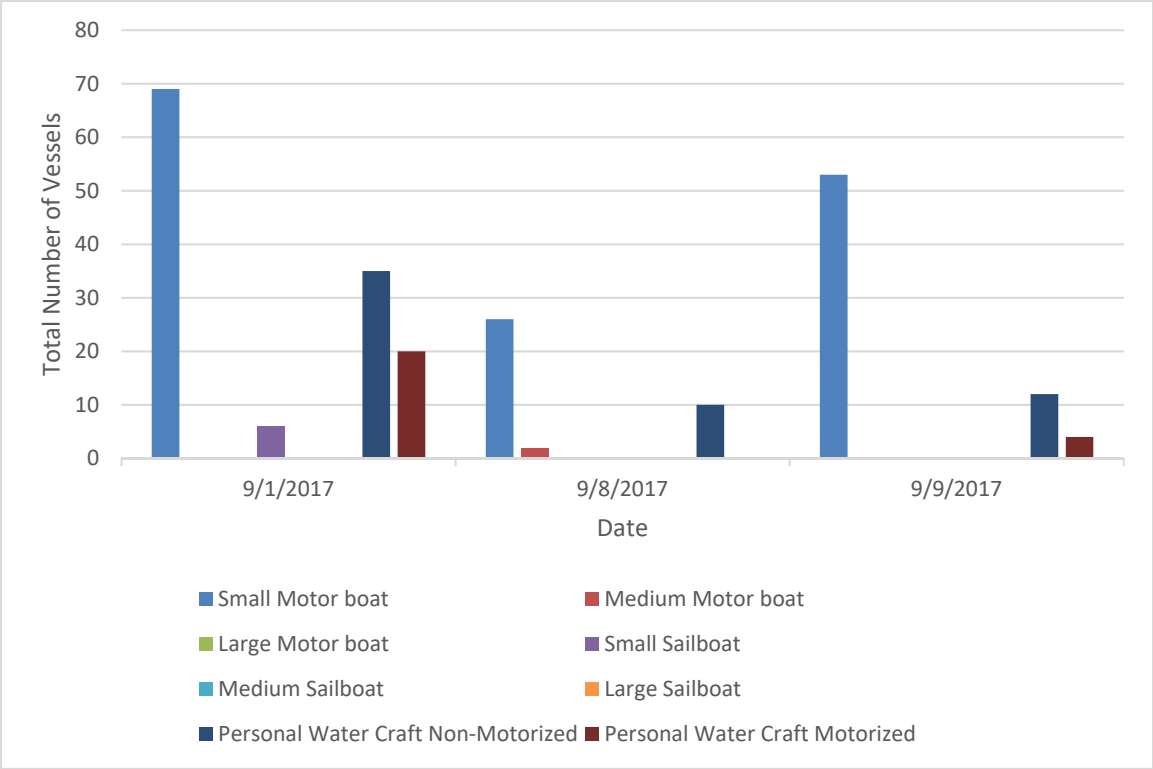
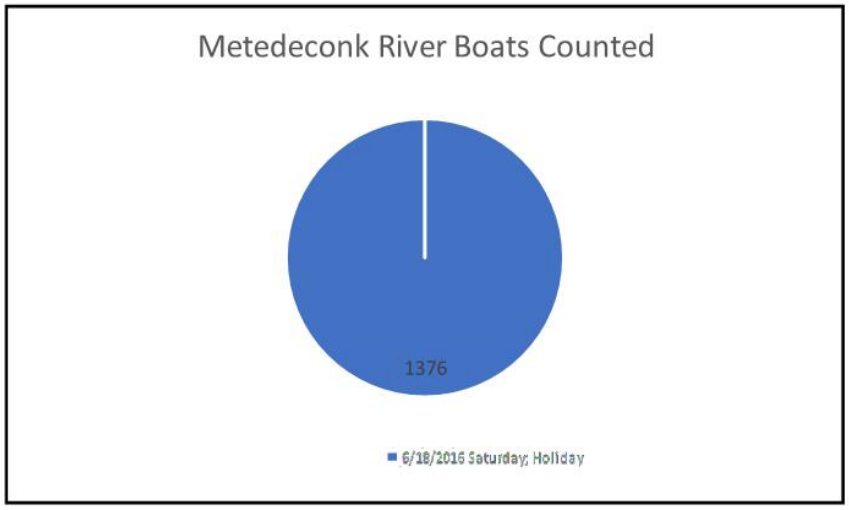


Figure 39. Long Reach Thorofare vessel classification

Data for Long Reach Thorofare was predictable for the fact that the busiest of the three count days was on Labor Day Weekend (9/1/2017), and the other two count days were following Labor Day. The two large spikes in volume that occurred at 1:00 PM and 4:00 PM on 9/1/2017 correspond to above average numbers of both motorized and non-motorized personal water craft. This observation comes from the 15-minute interval data (not included in this summary report). This is an indication that at this count location, users of personal watercraft may be traveling in groups because they are being counted within the same 15-minute interval.

Personal Watercraft accounted for 34 percent of the total vessel volume at the Long Reach Thorofare count location. Of this volume, about 30 percent was motorized, and 70 percent was non-motorized. This makes Long Reach Thorofare one of four count locations that had a higher percentage of non-motorized personal watercraft than motorized.

Metedeconk River



Approximate Channel Width: 2175 ft
Total Number of Count Days: 1
Average Number of Boats Counted per Day: 1376
Population of Surrounding Municipality: 93,464

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 40. Metedeconk River location and count summary

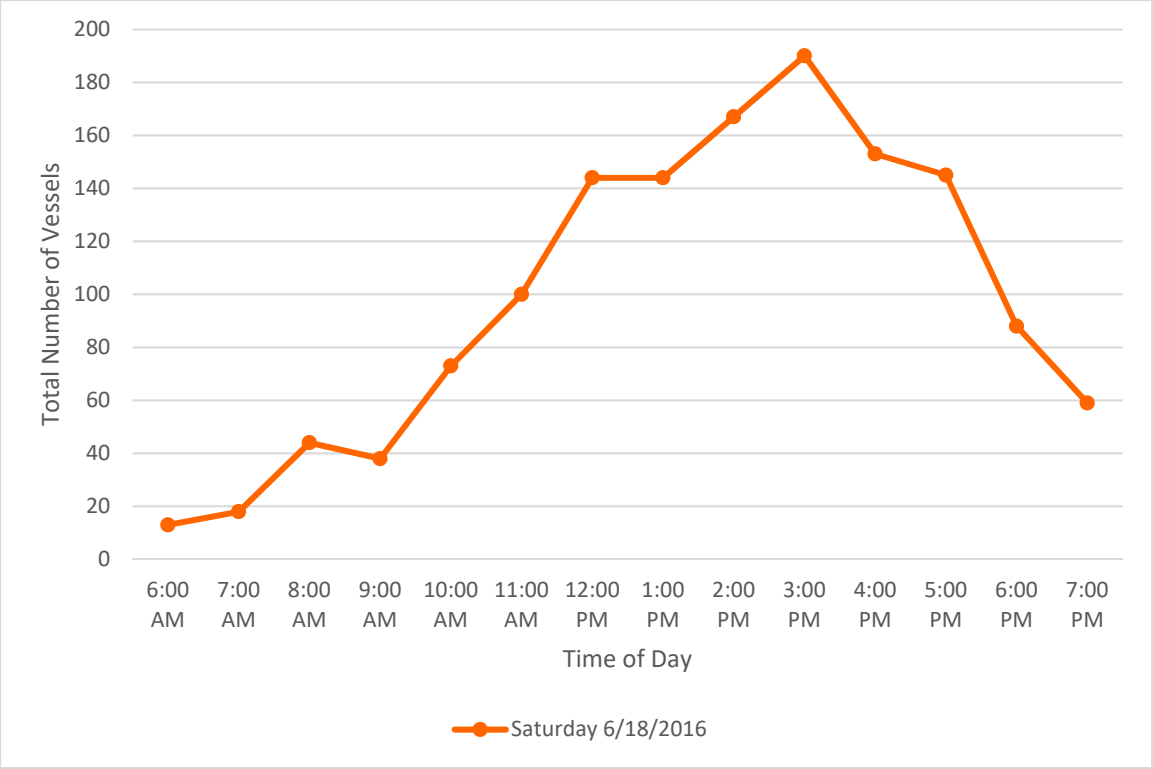


Figure 41. Metedeconk River daily peak hours and volumes

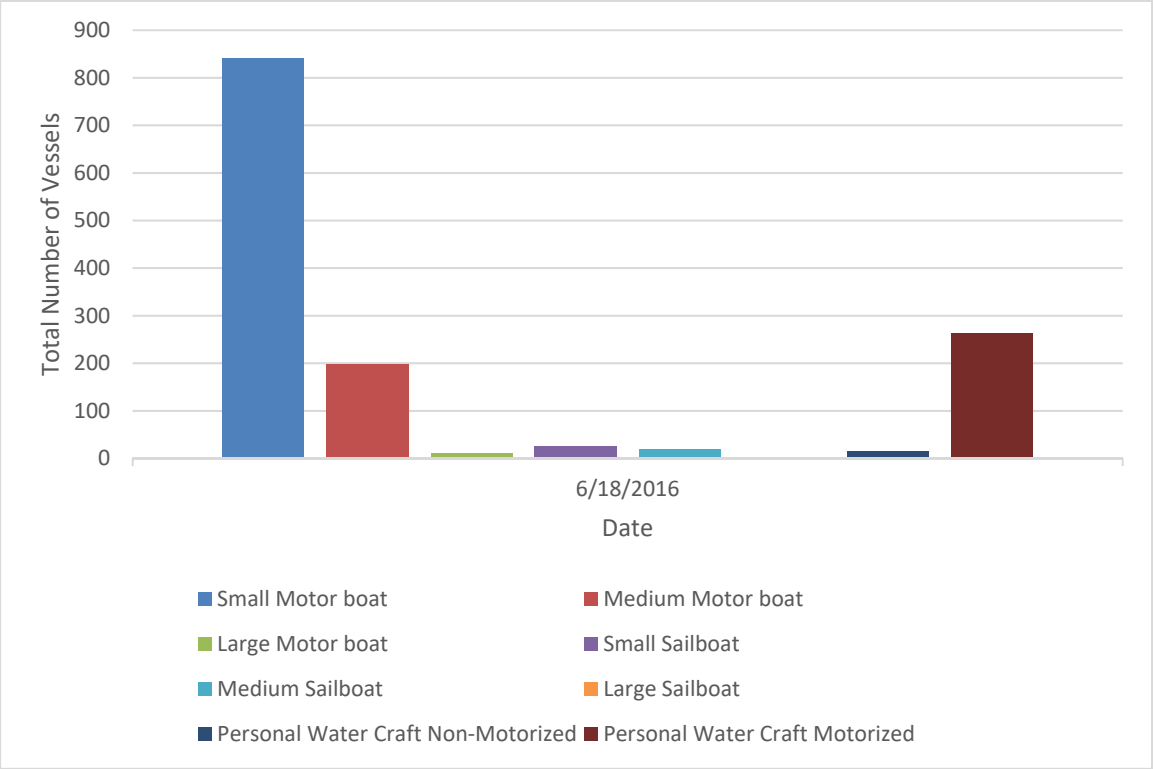
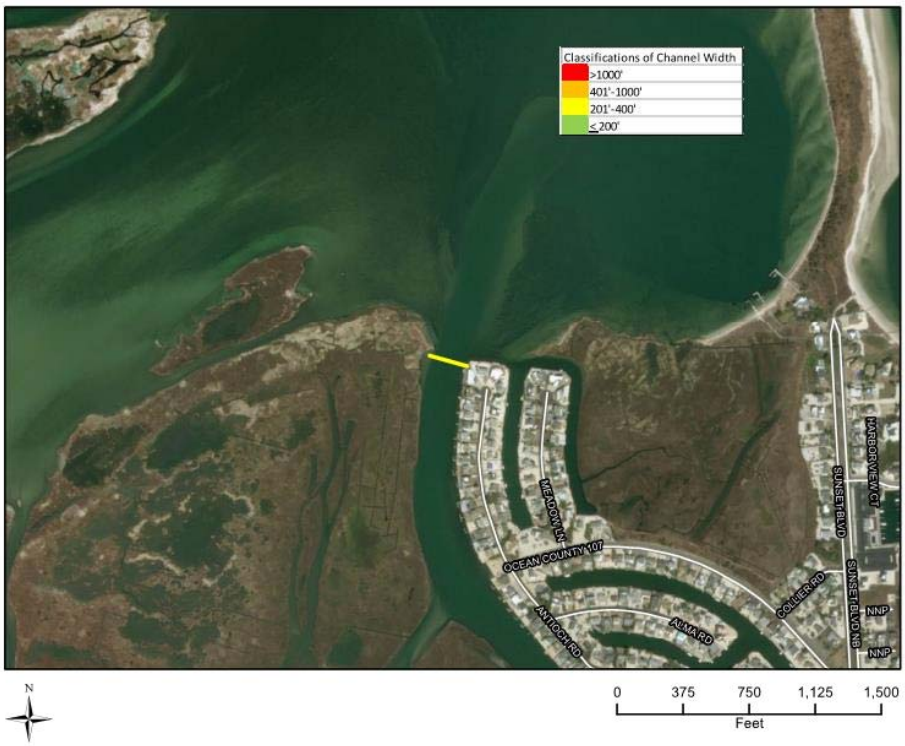


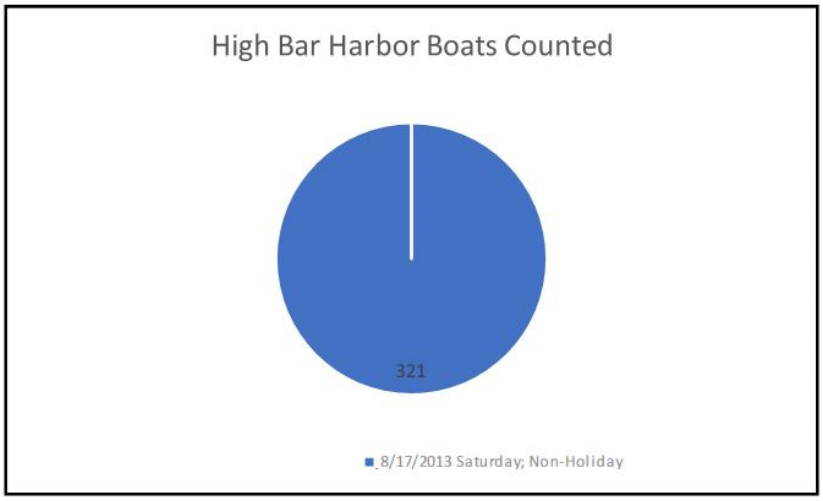
Figure 42. Metedeconk River vessel classifcation

The Metedeconk River location was geographically very close to the Gunner's Ditch location. When looking at the two locations on a map, one would assume that if both locations were counted on the same day many vessels would pass through and be counted at both locations. Both locations have similar volume data, which would seem to confirm this assumption.

Personal Watercraft accounted for 20 percent of the total vessel volume at the Metedeconk River location of which 95 percent was motorized, similar figures to Gunner's Ditch. As a result, a data collection plan might be able to assume that waterway volume could be partially predicted by the volumes of nearby waterways.

High Bar Harbor





Approximate Channel Width: 215 ft
Total Number of Count Days: 1
Average Number of Boats Counted per Day: 321
Population of Surrounding Municipality: 3,625

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 43. High Bar Harbor location and count summary

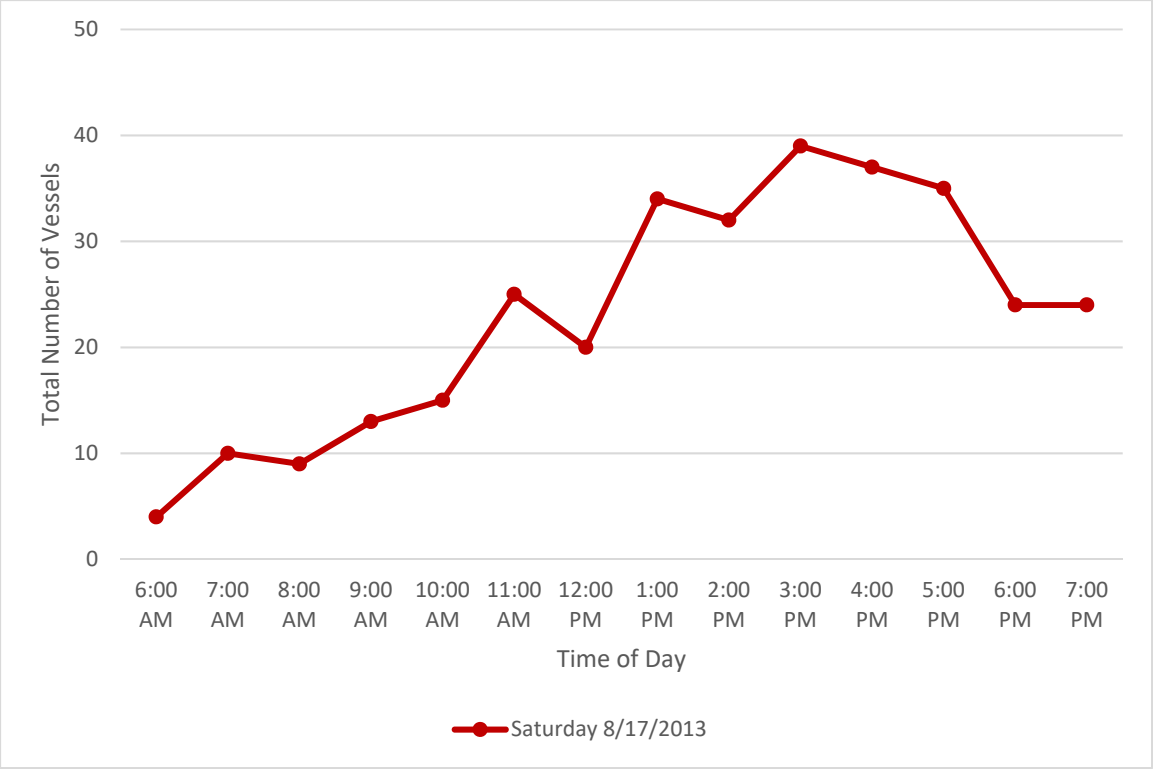


Figure 44. High Bar Harbor daily peak hours and volumes

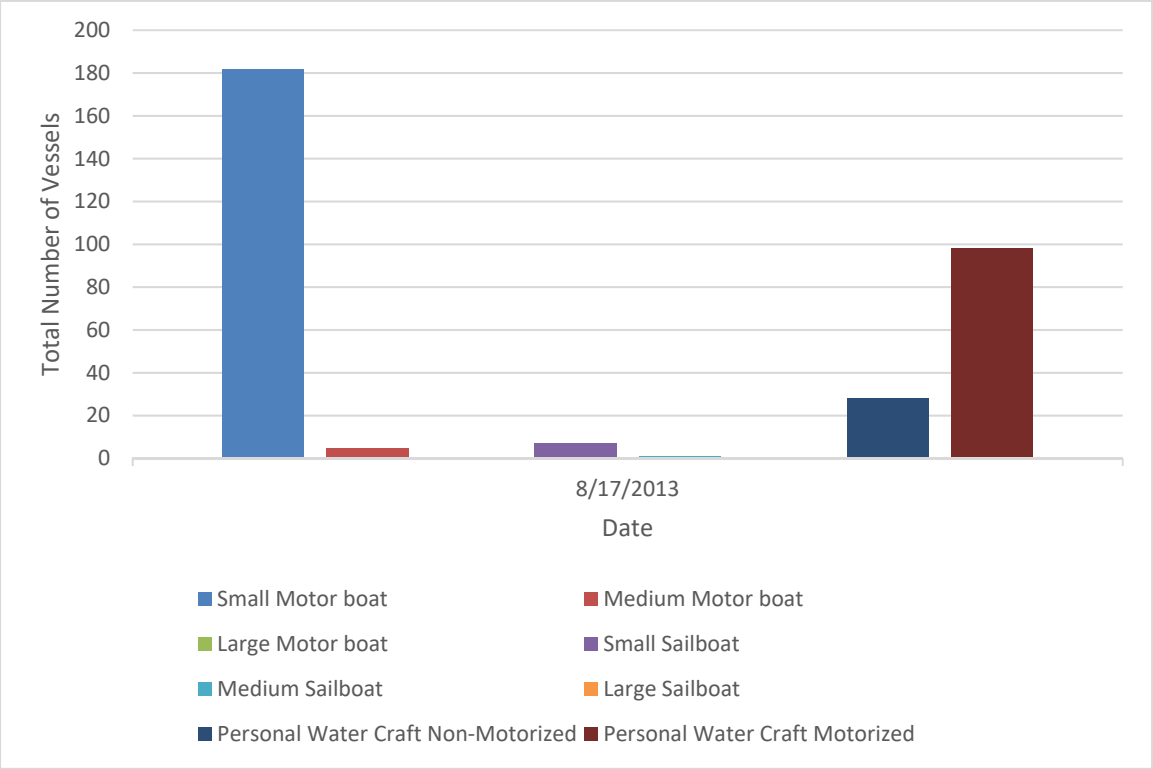


Figure 45. High Bar Harbor vessel classification

High Bar Harbor was counted only once on its own, so it is difficult to draw any conclusions. However, several of the needs listed above can be confirmed by this occurrence. One is the need for repeat data collection at a site so that observations and comparisons can be made. This is important to reconsider during the formation of a data collection plan. If data is to be compared between holidays and non-holidays, data collection would need to continue over the course of several more years. The hypothesis that the 4th of July is the weekend with the highest volumes is based on data collection that occurred in one year. Although this trend was not consistent over all count locations, more data collection should be repeated over several more years to test this hypothesis. The same should be done with the other trends regarding hourly volumes and other holidays.

That being said, personal watercraft accounted for 39 percent of the total vessel volume at the High Bar Harbor location. This was the second largest amount of all count locations. Of this figure, motorized craft comprised over 75 percent of the total volume.

Aggregate Trends

The aggregate trends explored in this section include comparing weekend data to weekday data, comparing holiday data to non-holiday data, and comparing average volumes per hour across for all count locations. The trends in the aggregate data will help shape the overall data collection plan by indicating the best times and conditions for conducting data collection. For instance, if the focus of the data collection plan was centered on collecting data around peak hours, this summary will be useful for identifying which days and at which times on those days peak hours generate the highest usage.

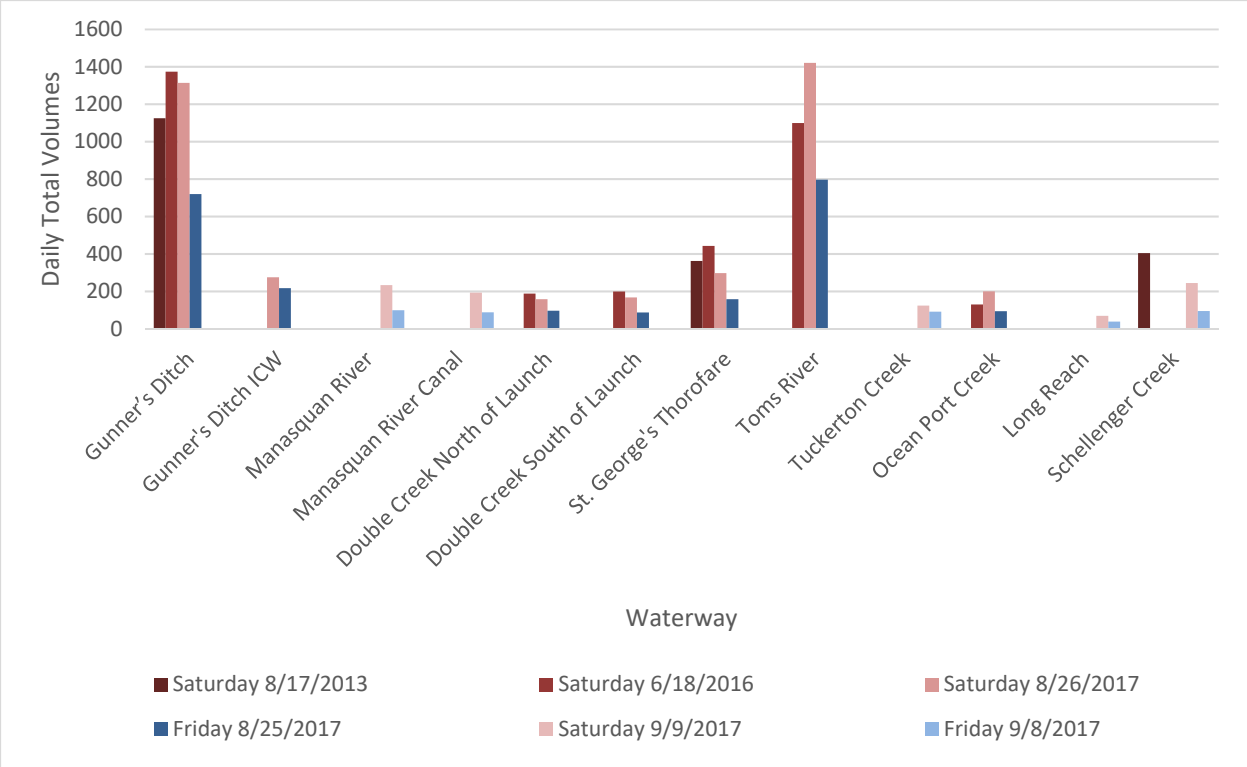


Figure 46. Non-holiday weekday and weekend usage

Figure 46 above indicates a trend that daily total volumes of waterway usage are greater on Saturdays than on Fridays, as is expected. This trend is present for the peak summer months, as well as after Labor Day. The data from Schellenger's Creek also indicates that daily total volumes decrease significantly after Labor Day, even when comparing a Saturday to another Saturday, which is also expected. The other locations counted after Labor Day were not counted on a non-holiday before Labor Day, but it's expected that this trend would be consistent throughout all locations given that Labor Day is the traditional end to the peak summer season.

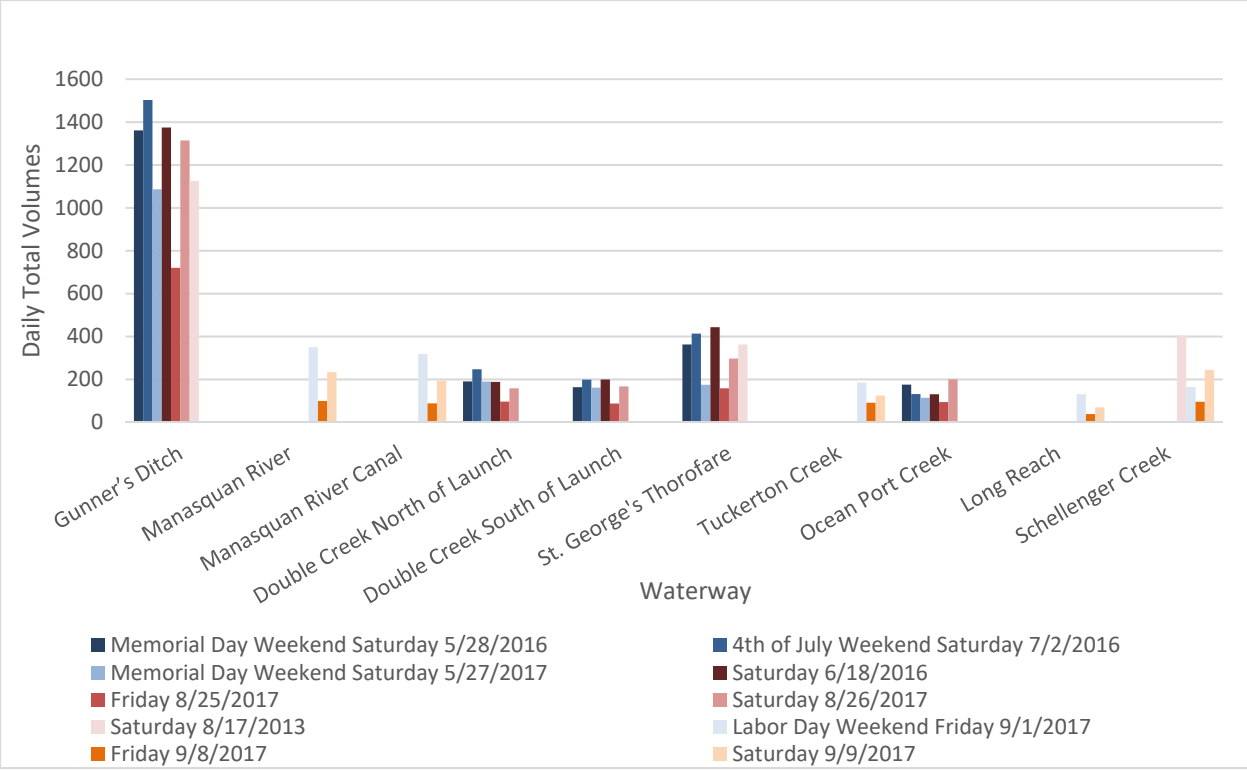


Figure 47. Holiday vs. Non-Holiday Waterway Usage

Based specifically off of the data collected, there isn't a consistent trend (Figure 47) that holidays have higher volumes than non-holidays or vice-versa. For the sites that were counted on the 4th of July weekend, the total volume on that date is the highest of all the holidays counts in many, but not all cases. However, there are also some non-holiday dates that came close to or exceeded the total volume from the 4th of July weekend, indicating that the mid-summer holiday weekend does not exclusively or necessarily generate the highest seasonal volume. Labor Day weekend, the unofficial end of the summer season, does have a higher volume than the following Saturdays which is not surprising given Labor Day ends the peak of the summer season. The only location that had data from Labor Day weekend and data from a Saturday within the peak season was Schellenger's Creek, and at this location Labor Day weekend actually had a much lower volume than a regular Saturday. More counts would be necessary to see if this trend is consistent at other count locations and what implications this may have on the data collection plan.

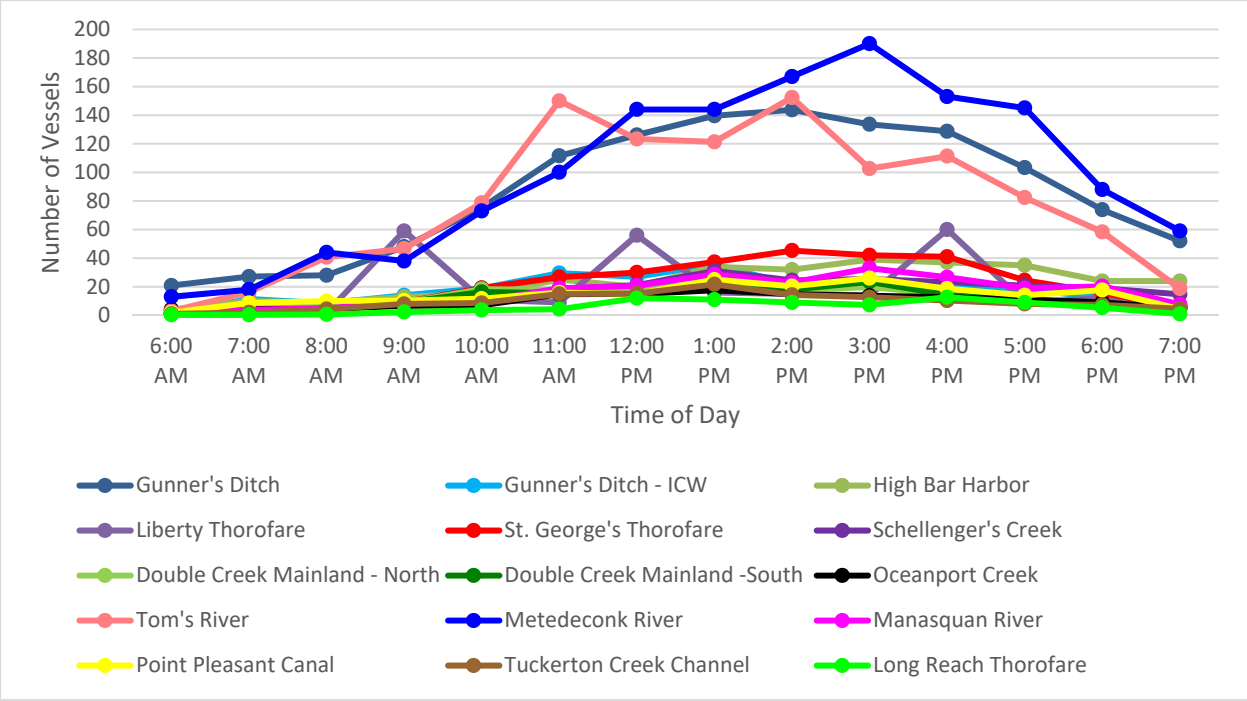


Figure 48. Average volume per hour at each count location

The above graph (Figure 48) shows the number of vessels per hour and peak hours at each count location. The data used for each location is an average of all counts conducted at that location. The overall trend is for the number of vessels tends to gradually increase throughout the morning, peak between 11:00 AM and 4:00 PM depending on the location, and rapidly decrease in the evening hours. If the focus of the data collection plan was to count at times of maximum volume, then it may not be necessary to conduct counts throughout the entire day, but rather focus on those day-time peak hours.

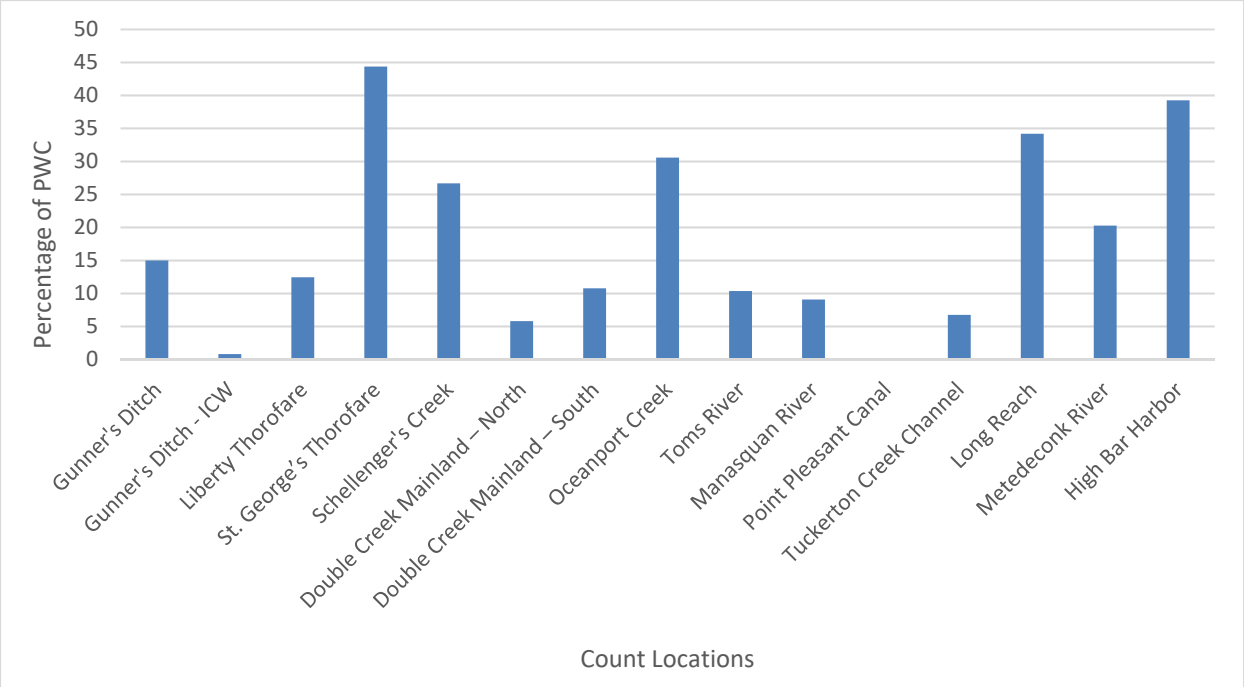


Figure 49. Personal watercraft at each count location

Figure 49 above breaks out the percentage of personal watercraft at all 15 surveyed locations. As Figure 49 shows, such proportions varied widely. The locations with the highest proportions included St. George's Thorofare at approximately 45 percent, followed by High Bar Harbor (approximately 40 percent), and Long Reach (approximately 35 percent). Unlike some of the more prominent waterways, these three were smaller in width and located in predominantly residential areas. As previously stated, there were five locations where personal watercraft accounted for less than 10 percent of total volume. These included Gunner's Ditch at ICW, Double Creek Mainland North, Toms River, Manasquan River, and the Point Pleasant Canal. In general, these waterways were located in or part of larger waterways, and especially in the case of Toms River, generated high traffic that would detract use of smaller personal watercraft given the presence of larger and faster vessels.

DRAFT WATERWAY CLASSIFICATION METHODOLOGY

Waterway Classification Scheme

The research team developed a 4-waterway classification scheme based on waterway width to group the 15 waterways that have been counted over all three phases of the project. Waterway widths were measured at the locations where counts were conducted. Measurements were taken from shoreline to opposing shoreline using aerial imagery wherever possible. The only location where this was not possible was Double Creek Mainland, north of the boat launch, because there is no opposing shoreline. For this location, best judgement was used to measure the width of the waterway that is navigable for boats. The classes break down as follows:

Class 1: Waterways with widths of 1,000 feet and greater
Class 2: Waterways with widths from 999 to 400 feet
Class 3: Waterways with widths from 399 to 200 feet
Class 4: Waterways with widths of 199 feet or less

Using this approach, waterways with similar width characteristics were classified together to identify trends and similarities with how these different size waterways are used. The value of this classification scheme is to be able to apply it to the overall data collection plan. Depending on the goals of the data collection plan, waterways of a certain class can be targeted for data collection. For example, if the waterways with the largest widths had the highest volumes, and the data collection plan was to focus on areas with the highest volumes, then it would be possible to pick those waterways based on the classification. The Table 6 below shows the classifications of the 15 waterways counted, along with their width.

Table 6 – Waterway Width and Classification

Waterway	Classification	Waterway Width in feet
Toms River	1	4,975
Metedeconk River	1	2,175
Oceanport Creek	1	1,175
Gunner's Ditch ICW	2	741
Liberty Thorofare	2	635
Gunner's Ditch	2	456
Long Reach Thorofare	2	410
Tuckerton Creek Channel	3	335
Manasquan River	3	325
Schellenger's Creek	3	291
Double Creek Mainland North	3	225
High Bar Harbor	3	215
Point Pleasant Canal	4	175
Double Creek Mainland South	4	175
St. George's Thorofare	4	130

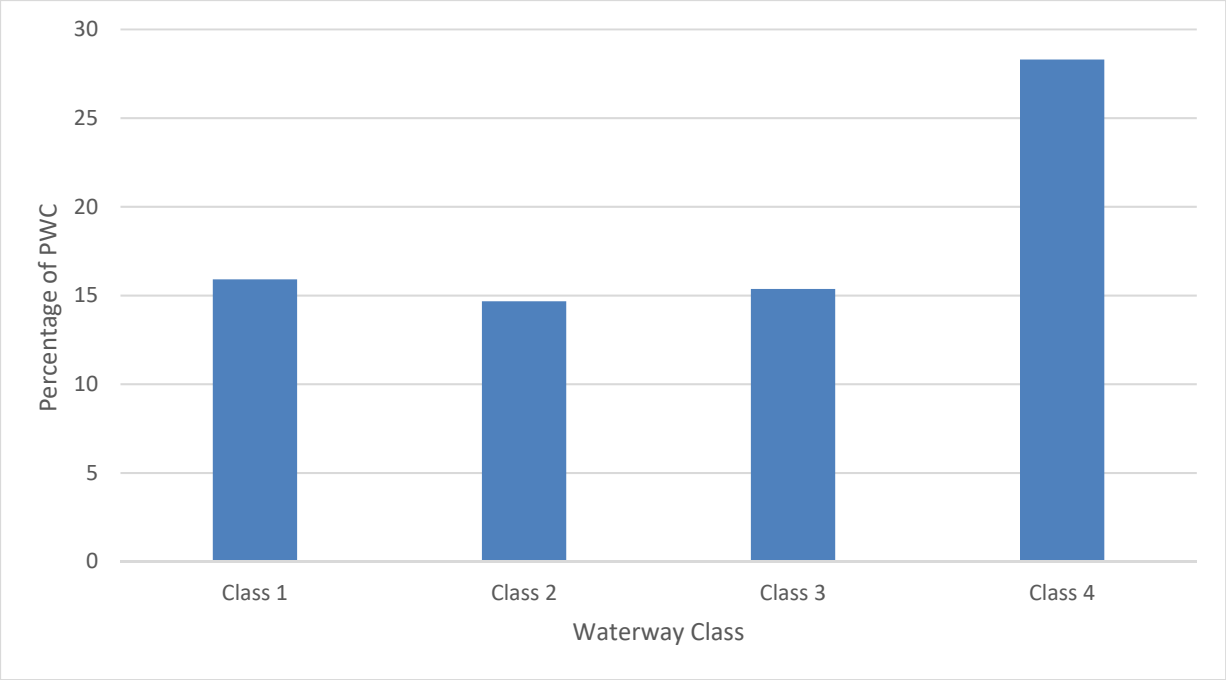


Figure 50. Personal watercraft by proposed waterway class

Waterway Classification and Volume

The volume used for this comparison is the average volume per count day. No special weight was given to holidays, day of the week, time of the season, or any other condition because not every location was counted on the same days. Weighing the average would mean treating each location in a different manner and skew the data differently in each case. The relationship between waterways width and volume is notable in Class 1 which contains the three largest waterways and two of the four highest averages of vessels per day. Class 1 has the highest average volume of vessels per day at 874. In the other three classes, waterway width is a weak indicator of volume. The average volume in Class 2 is 453 vessels per day, but if the outlying point of Gunner's Ditch is removed, the average volume of the remaining three waterways drops to 199. The average volume of vessels per day is 217 for class 3, and 222 for class 4. As shown in the table below there is no trend among classes 2, 3, and 4 and volume. This means that the largest waterways do on average have higher volumes, although Oceanport Creek is a large exception to this rule. Due to the low height of the bridge that spans Oceanport Creek at Seven Bridges Road vessels mainly utilize the center of the waterway where the bridge is tallest. This may explain why the volume at Oceanport Creek is more comparable to that of a waterway with a smaller width.

Table 7 – Waterway Class and Average Daily Volume

Waterway	Classification	Average Daily Volume
Metedeconk River	1	1,376
Gunner's Ditch	2	1,212
Toms River	1	1,106
High Bar Harbor	4	321
St. George's Thorofare	4	303
Liberty Thorofare	2	273
Gunner's Ditch ICW	2	246
Manasquan River	3	227
Schellenger's Creek	3	227
Point Pleasant Canal	4	200
Double Creek Mainland North	3	178
Double Creek Mainland South	4	163
Oceanport Creek	1	141
Tuckerton Creek Channel	3	133
Long Reach Thorofare	2	79

Table 8 – Average Class Volume

Classifications	Average Daily Volume
Classification 1	874
Classification 2	453
Classification 3	217
Classification 4	222

Waterway Classification and Other Factors

There are likely other factors with a stronger relationship to the volume of boats in a waterway than the waterway's width. Population was considered as one of these factors. It was assumed that an area with a higher population would have more boat slips and or launch ramps. This would likely lead to higher total volumes of boat traffic in these waterways. For waterways with locations that fall within one municipality, only the population from that municipality was used. If a waterway was located between two municipalities, the populations from both were combined to summarize the total number of people residing nearest to that waterway. This approach assumes that the people who live in the municipalities where waterway are located are the primary users of those waterways. However, this approach does not account for vacationers, people who travel to launch their boats, or boaters whose trips originated elsewhere. As shown in Table 9 below, population is a better indicator of volume then waterway width is. The three waterway locations with the highest populations coincide with the three highest average daily volumes of vessels. Of the next six highest populations, five have daily volumes above 200 vessels, and of the six lowest populations, four have daily volumes below 200 vessels. This information is valuable for creating a data collection plan because it could increase the accuracy of selecting which waterways to include for data collection. The volume analysis indicated that the largest waterway widths are correlated to the highest volumes. This analysis indicates higher volumes are also related to higher populations. In order to capture waterways with the highest volumes, it may be useful to collect data where waterway widths and volumes are largest.

Table 9 – Population and Average Daily Volume of Vessels

Waterway	Class	Municipality 1	Municipality 2	Total Population	Average Volume / Day
Toms River	1	Toms River Township	Berkeley Township	132,494	1106
Metedeconk River	1	Brick Township	Point Pleasant	93,464	1376
Gunner's Ditch	2	Brick Township	Mantoloking	75,368	1212
Gunner's Ditch ICW	2	Brick Township	Mantoloking	75,368	246
St. George's Thorofare	4	Brigantine	Atlantic City	49,008	303
Schellenger's Creek	3	Cape May	Lower Township	26,473	227
Tuckerton Creek Channel	3	Tuckerton	Little Egg Harbor Township	23,412	133
Manasquan River	3	Point Pleasant	Brielle	23,166	227
Point Pleasant Canal	4	Point Pleasant	Brielle	23,166	200
Double Creek Mainland North	3	Barnegat Township	-	20,936	178
Double Creek Mainland South	4	Barnegat Township	-	20,936	163
Oceanport Creek	1	Oceanport	Little Silver	11,782	141
High Bar Harbor	3	Barnegat Light	Long Beach Township	3,625	321
Long Reach Thorofare	2	Avalon	-	1,334	79
Liberty Thorofare	2	Beach Haven	-	1,170	273

Table 10 – Average Class Volume and Population

Classification	Average Total Population	Average Volume / Day
Class 1	79,247	874
Class 2	38,310	453
Class 3	19,522	217
Class 4	31,037	222

Income was also considered as a factor that affects the volume of boats on a waterway, given that higher income households and families could be more inclined to own boats for leisurely purposes. Interestingly enough, the data did not support this assumption. Instead it showed no correlation between income and waterway usage. The statistic used for this test was median household income broken down by municipality in the same fashion as population was in the example above. Figure 51 shows that

waterways with volumes between the 79 vessels per day and 321 vessels per day occur across the full range of incomes. While three of the high-volume waterways occur between incomes of $60,000 and $80,000, there are also lower volume waterways within this income range, so drawing any conclusions about volume based on income is unreasonable.

On the other hand, median household derived from the United States Census might not be the best indicator of wealth, especially in areas with a large number of second homes. For example, in Barnegat Light, a small borough at the northern end of Long Beach Island, median household income is about $76,000, which is only slightly higher than the state average, and less than half the amount of some of the more prominent wealthy suburbs scattered throughout the state. However, a quick scan of available real estate for sale shows multiple homes on the market for well over $1 million, including multi-million dollar waterfront homes which are likely marketed as second/vacation homes to the very wealthy. As a result, much of this 'wealth' wouldn't be reflected in median household alone. If income is considered a particularly important component of the proposed data collection plan, one potential methodology could be to combine both income and average housing value into one indicator, which would reflect the 'year-round' population as well as those with second homes used for leisurely purposes.

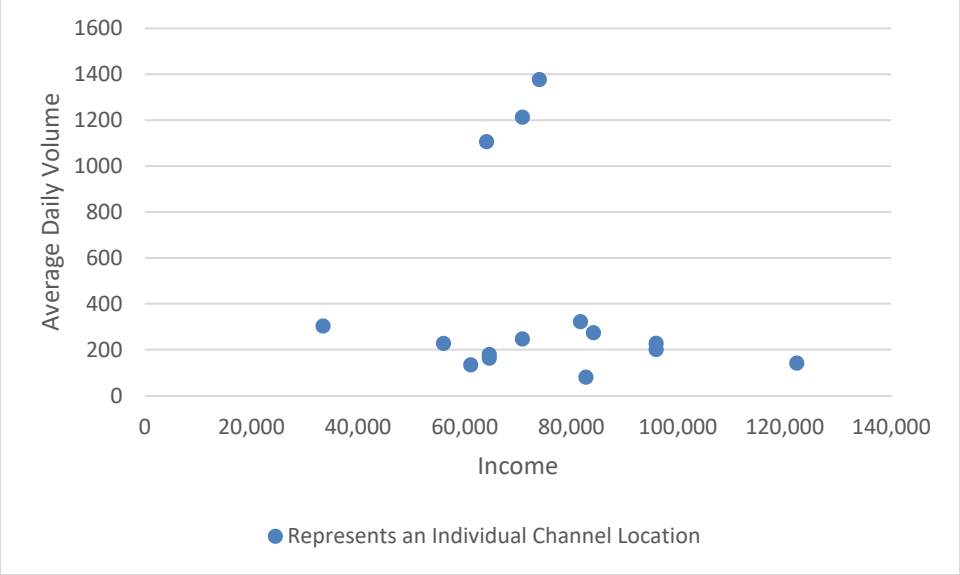


Figure 51. Waterway area median household income and average daily volume of vessels

Source for Income Data: United States Census Bureau

CONCLUSIONS

The data collection performed by the research team for the first three phases of vessel counts has led to lessons learned which are outlined ahead. The experience of collecting data in three different years has yielded a consistent and accurate process for conducting the vessel counts which could be implemented at a relatively low cost statewide. Count and classification data associated with channel and waterway use could be combined with other existing NJDOT data to help create an overall data collection plan to satisfy its asset management needs and priorities for the Marine Transportation System.

Research and field experience gained from the data collection effort also led to additional questions to consider for the creation of the data collection plan. One question would be the effectiveness of an alternate weather plan. The research team anticipated making weather-related decisions based on the forecast. Due to logistical needs however, any changes to the count dates would need to be made 24 to 48 hours prior to the count. A count initially scheduled for a Friday would be held on Thursday, and a count initially scheduled for Saturday would be held on Sunday. Throughout all 3 years of data collection, the research team experienced ideal weather conditions so an alternate weather plan was never tested. However, having a system in place for these conditions is necessary for successful data collection. Depending on the goals of the data collection, rescheduling Friday counts for Thursday and Saturday counts for Sunday may not be the most effective alternative plan. If maximum volumes are desired it would be more beneficial to reschedule for the following Saturday.

Geographically, all count locations were located at waterways along or closely linked to the eastern coast of New Jersey. No counts were conducted along the Delaware River side of the state. NJDOT may want to consider if waterways located along the Delaware River should be counted, because it is possible that these waterways are used differently than the waterways along the east coast, and the findings from the eastern waterways may not necessarily be applicable to Delaware River waterways.

Lastly, there are questions regarding trends already identified that should be researched further. Field data confirmed the hypothesis that Friday counts had lower vessel volumes than Saturday counts, but which weekday has the lowest volume? Which month has the lowest volumes? Can additional count data confirm the hypothesis that the 4th of July weekend has the highest volume of vessels? Previous data collection efforts focused on recreational boat traffic so no conclusions have been drawn about commercial boat traffic, including traffic generated by New Jersey's seafood industry. Depending on the goals of the data collection plan established by NJDOT, knowledge of commercial boat volumes may be important and further explored.

Posing additional questions is an important part of this research project to outline important areas for consideration that may affect the overall data collection plan. The following findings and conclusions are presented based on the lessons learned throughout the three years of data collection.

Data Collected on Different Days of the Week

The most consistent trend in the boat count data is that Friday has lower volumes of boats counted compared to Saturday. In order to extrapolate Friday data for comparison with Saturday data, it was determined a factor of 1.785 can be applied to data from a Friday count to estimate how much greater Saturday volume would have been. This factor was created by finding the average volume at each location for non-holiday Saturdays and non-holiday Fridays. The ratio between the Friday and Saturday volumes yields the 1.785 factor. Friday is the only weekday that had data collection conducted, so it is unknown whether this factor would apply to all weekdays or only Friday. Saturday was the only weekend day used for data collection, so a Sunday factor is also unknown. Because volume data was evenly distributed across the four classes of waterway width, the factor was based on and can be applied to all four classes. At this point it is not yet recommended that this factor be applied to any data because it is simply an estimate based upon this limited data set. More data collection is necessary to have a better-established relationship between Fridays and Saturdays, which would lead to a more accurate factor. However, the idea does hold potential that with the proper approach and data collection methods, a similar factor could be used to extrapolate on days that could not be counted.

Establishing Data Collection Procedures

Data collection may be done for varying reasons and those reasons may dictate the best time or scenario to collect data. The variables explored in this report are aimed at identifying what factors can best be used to set up the data collection plan. If finding the maximum volume is the goal, trends from the first portion of this report indicate the Saturday of 4th of July weekend would be the most optimal selection. Peak hours occurred most often between the hours of 3:00 PM and 4:00 PM, and for all locations except one occurred in the daylight hours after 12:00 PM. If part of the data collection plan was to capture the maximum volume it may only be necessary to count after 12:00 PM on the Saturday of 4th of July weekend. In addition to pinpointing waterways with the highest volumes, it would be most beneficial to collect data at waterways with the largest widths and highest populations.

If the data collection plan was aimed at capturing data that indicated the best time for dredging it would be necessary to conduct more counts outside of the peak season that runs from Memorial Day to Labor Day. The two count dates conducted after Labor Day show that volumes decrease after Labor Day, and that Fridays have less volume then Saturdays. Not enough counts were conducted to determine which month or day of the week has the lowest volume. This is assuming that dredging would be done when volume is the lowest.

It is important to identify these types of trends and relationships so that the data collection plan can be altered depending on needs. Some needs, such as determining areas to focus maintenance efforts, may require determining maximum volumes. Other needs such as the dredging example listed above, may require the need to identify the times of the year with the minimum volumes. The data collected so far has been used

to identify trends that should be incorporated into an overall data collection plan that can be used to satisfy many different needs.

Conclusions Regarding Waterway Classification

An accurate tool for making projections about waterway volume would be based on multiple variables, not all of which are included in this report. Additional research is necessary to determine which variables can be used for making volume projections. These variables may include waterway depth, number of boat slips near a waterway, the location of popular boating destinations, information on boaters most frequent points of origin, and numbers of vacationers as opposed to local residents using the waterway. The variables of waterway width, population, and income explored in the previous section are aimed at establishing relationships with waterway volume. There is a large value in being able to predict waterway volume based on these factors and potentially other factors because this allows the data collection plan to be altered based on needs. If there is a need to identify areas with high volumes, then knowing the relationship between volume and other variables lets those in charge of the data collection plan know where to focus their efforts.

More Data Collection is Needed

More data collection is needed to develop valid statistical models and regression equations that could help NJDOT determine which variables affect count and type of vessels in a waterway on a given day. Weather almost certainly impacts the number and type of vessels in each waterway on a given day, but the magnitudes of the impacts of weather conditions and correlations between weather and non-weather variables are unknown. Logistical needs dictate that vessel counts must be scheduled in advance, but ideal weather conditions cannot be guaranteed. Having a better understanding of the extent to which various weather variables impact vessel use could allow NJDOT to apply correction factors to future vessel counts conducted in less-than-ideal weather conditions. Unintentionally, all of the research team's counts were conducted in ideal weather conditions. Future counts will be needed to determine the impacts of clouds, rain, wind, temperature, or other weather variables on the number of vessels in the water on a given day.

Additional count data is also crucial for confirming some of the trends already identified. The hypothesis that the 4th of July weekend is the busiest weekend of the year is based on counting five locations on 7/2/2016. Additional 4th of July counts would confirm that this date is the best date for capturing maximum volumes. Additional count data is also necessary for dates after Labor Day to make hypothesis about when volumes are lowest, and the best time for dredging.

Data Collection Methodologies

Counts conducted during Phase one of this project, on 8/17/2013, used three data collection methodologies including classified manual collection using field staff, aerial imagery collection using Skycomp Inc., and video collection using Miovision's Scout

Video Collection Unit. It was determined that based on cost, the necessary sight distance for each approach, and accuracy of the data that classified manual counts were the best option. Manual counts were performed on a count board, such as a TDC Ultra count board by Jamar Technologies, Inc. This count board allowed field personnel to record the total number of vessels per 15-minute interval, vessel classification, and vessel direction. Although manual counts are reliant on the counter for proper vessel classification, this can be addressed with proper training (see Appendix A for the Greenman-Pedersen, Inc. Vessel Classification Manual). Using this data collection method also allows for a person to be onsite to communicate with local residents and address any issues that arise during the count. The other two data collection methods had some limitations that made them less ideal then using manual counts. Using Miovision's Scout Video Collection Unit depends on the camera being set up within 250 feet of the waterway, otherwise the camera's resolution is not good enough to accurately classify vessels. The camera's lens must also stay free of all obstructions. Video collection is also roughly double the cost of manual data collection. Using aerial imagery requires the plane to be able to fly at the appropriate altitude and with clear weather conditions so clouds, fog, and rain do not prohibit the capture of images. Due to the altitude of the photos taken, using the aerial imagery classification of vessels cannot be done accurately. Using Skycomp Inc. for the collection of aerial imagery is roughly five times the cost of performing a manual count.

A total of three different counts were conducted at the Toms River location using different methodologies. The count on Saturday 6/18/2016 was conducted from a boat in the middle of the waterway and the counts on Friday 8/25/2017 and Saturday 8/26/2017 were conducted from shore using high powered binoculars. The reason for these different methodologies is that due to the width of the waterway, it is not possible to accurately classify vessels on the opposite side of the waterway without using one of these two methods. When comparing the two Saturday counts, the count on 8/26/2017 which was conducted from the shore using high powered binoculars, had a total of 322 more vessels than the count conducted using a boat in the middle of the waterway. The person conducting the count from shore stated that high power binoculars were adequate for seeing across the entire waterway, so the difference in volume should not be due to methodologies. The difference could be partially due to count times. The count conducted from the boat was done from 7:30 AM to 6:30 PM and the counts conducted from shore were done from 6:30 AM to 7:30 PM. While it is possible that having a boat anchored in the middle of the waterway influenced the number of people willing to use the waterway, more counts would be necessary to determine if this variable caused the difference in volumes between the two counts. Other variables may have contributed to the difference in volumes, one of which may be that the two different methodologies were tested during different months.

There were several count locations that required the use of high powered binoculars due to longer sight distances either from one end of the waterway to the other, or from the waterway to where the field personnel could conduct the count from on land. Exact makes and models of binoculars varied between field personnel but in all cases, binoculars with 10x50 magnification were adequate for conducting the manual counts.

Understanding Waterway Networks

The Toms River count location was at the mouth of the river where it joins Barnegat Bay. The Metedeconk River location was also counted at its mouth. Applying some of the logic generally applied to roadway networks may clarify the volumes that occur at the mouths of rivers. At the mouth of a river, it is expected that the volume would come from the sum of the volumes of upstream waterways. Locations that have other waterways feeding into them will have greater volumes then the feeder waterways, and this should be factored when forecasting volumes for waterways that have not yet been counted.

Considerations for a Data Collection Plan

The data collection process can be approached in four separate phases: Waterway Analysis, Preparation, Field Collection, and Data Review.

The first phase of Waterways Analysis involves classifying all 214 channels and waterways into a classification scheme like the one from the previous section. A completed classification scheme should include additional factors likely found in NJDOT's existing database such as waterway depth and information about the number of boat slips and launch ramps located near the waterway. Next, the objectives of data collection must be established. Examples of such objectives would be counting the maximum or minimum volumes of vessels in a waterway. Maximum volumes would be used for identifying the busiest waterway if the desired approach was to focus resources on these busiest waterways. Identifying minimum volumes would indicate the times or areas of lowest use, and could be used for selecting when to do maintenance such as waterway dredging. Having all the waterways classified makes it possible to select which waterways to perform data collection on given many possible different objectives for data collection.

Phase two is preparation for the field collection of data, and is crucial for a successful data collection. This involves determining what waterways are being counted, and why they are being counted. If the objective is to capture maximum volumes of vessels the data collection approach could be to identify a subset of the 214 channels and waterways according to the waterway classification scheme and conduct counts from 6:00 AM to 8:00 PM to record volumes throughout the entire day. Alternatively, it may be more beneficial to count all waterways regardless of waterway size or classification on the busiest day of the year, between the peak hours of 10:00 AM and 4:00 PM, to record maximum volumes throughout the entire state. It would require a very large field staff to conduct counts in this manner. If the objective is to find the best time for waterways dredging the best approach may be to select a subset of the 214 channels and waterways that need dredging, and count those waterways on weekdays prior to Memorial Day and after Labor Day to identifying when waterway usage is the least. The next step in the preparation phase is to conduct a field visit to the waterway locations that were selected for data collection in step one. The purpose of this field visit is to ensure data collection can be conducted for that waterway. Things that may interfere with data collection include but are not limited to sight lines, accessibility for the

person conducting the manual count, and presence of private property. If the count needs to be conducted from private property, phase two is the appropriate time to try and get permission from the landowner. Once it is confirmed that there is a suitable location to conduct a manual count other considerations may be made, such as the use of restrooms for 6:00 AM to 8:00 PM full-day counts. If none are available it may be necessary to make arrangements for the counter to leave the count site. If one or more of the identified locations cannot be counted for any reason then it is necessary to go back and make changes to the field plan to include new locations where counts are possible.

The next step of Phase two is to finalize the logistical items necessary for performing the counts. This includes having an authorization letter stating the purpose of the count. It is also necessary to alert local and state authorities that a vessel count will be conducted prior to the count date. These two items ensure that if anyone has questions as to why the count is taking place, their questions can be answered professionally. Any equipment rentals, such as a boat rental for a larger waterway, should also be secured. Field sheets are also prepared for the counters that show where the count should be conducted from, where the waterway is located, and which direction is northbound, southbound, eastbound, and westbound.

Next, is the need to coordinate with and train the personnel performing the counts. Training should be conducted on the count equipment they will be using, procedures, and the vessel classification categories. A copy of the vessel classification protocol used by the research team is appended to this report (see Appendix A). It is also worthwhile to record a list of contact information and the vehicles used by the counters should any problems arise. Lastly, a schedule for which personnel are counting each location for each time and date needs to be established and all personnel performing counts should be given count boards and any additional equipment they may need such as high-powered binoculars.

Phase three is performing the Data Collection in the field. Because of the extensive preparation done in phase two all personnel should be trained and aware of their responsibilities at their respective count locations. This ensures phase three data collection is performed in a repeatable and accurate manner.

Lastly, Phase four includes all post processing steps after data collecting is performed. The first step of this phase is to coordinate with all counters to return their count boards to the person in charge of compiling and reporting the data. Data upload involves taking the information stored on the count board and transferring it to a format that can be analyzed using a software such as PETRAPro. The software used will likely vary depending on the type of count board used. Once data is uploaded data manipulation, or compilation of a summary report may or may not take place depending on the needs at that time.