

A W H I T E P A P E R
on Wave Ecology



TYBEE ISLAND

Wave Ecology & The Highway 80 Challenge

PREPARED FOR CHATHAM COUNTY & THE CITY OF TYBEE ISLAND

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An Introduction to Wave Ecology

Background

The Wave Ecology and Highway 80 Challenge Study was commissioned by Chatham County to assist the City of Tybee Island (and a committee of government and agency leaders) in defining localized solutions to issues surrounding the safety of citizens and visitors. Recognizing that often there is greater complexity to issues, and greater opportunity for solutions through a holistic study, the Chatham County Board of Commissioners adopted and appropriated funding in July of 2010.

What is Wave Ecology?

Urban ecosystems are not well understood, but they are absolutely critical to the health, economy, and quality of life of people who live in urban areas.

- Charlie Lord, Former Executive Director of Urban Ecology Institute

The concept of wave ecology is rooted in a subfield of environmental studies titled urban ecology. Urban ecology seeks to understand the natural systems of urban areas and the threats that face them. Knowing the relationships of the urban environment and the human impacts through pollution, over development, and other pressures assists community planners and policy makers in designing healthier, well managed communities. The same is true for understanding the health and safety of citizens within a community. These factors may relate to emergency management needs, as well as general day to day operations. Many coastal communities across the world contend with tourism waves that impact stress the capacity of a community. The fluctuation of variables or “waves” related to these population changes (peak tourism) and the natural climate (tidal changes, sea level rise) for Tybee Island led to the naming of this study “wave ecology.”

Within this study the human application of carrying capacity is utilized to gain a consistent and clear image of the City of Tybee Island, it’s citizen population, it’s natural resource limitations, and it’s existing infrastructure. By understanding where the environment, the economy and the community overlap, the health and sustainability for the island emerges.

The Integration of Visual Tools

This study integrated raw data analysis with visual, user-friendly geo-spacial and technological tools to reveal the waves impacting Tybee Island. Through the integration of Geographic Information Systems (GIS) technology and a variety of modeling software, multiple arrays of data are presented to bring clarity to the question of “How many people can Tybee Island safely accommodate?”



The History of Tybee Island

History on the Waves

To understand the current ecology for a community, it is important to visit the past. In this case, mobility guides the recent past of tourism and development on Tybee Island.



Steamboats, locomotives and automobiles all exist in the history of Tybee Island. In the 1840s, steamboats began offering day trips to Tybee Island from downtown Savannah. This development was halted by the Civil War until 1873 when a group of Savannah entrepreneurs formed the Tybee Improvement Company to develop a seaside resort. Multiple modes of transportation resulted to carry visitors from one location to another. These included a steamboat, a wooden tramway, and a mule and cart railway that traveled down what we know today as Butler Avenue. Within time, these modes gave way to the locomotive as the Island's chief transportation system. This train ride took only 45 minutes each way, diligently keeping time. During days of heavy riding, the train was pulled by two locomotives and as many as 12,000 passengers were taken to the beach.¹ In 1890, the Tybee rail-line became a unit of the Central of Georgia, linking the island to hundreds of towns and cities throughout Georgia and Alabama.²

¹ "Savannah Morning News" May 20, 1958

² Ciucevich, Robert. 2005. *Tybee Island: The Long Branch of the South*.

By the 1910s, Tybee Island had already begun to develop a small year-round population and supporting services blossomed. Two small grocers catered to citizen needs: Naylor's Store near Fort Screven and S.F. Smith's store near the resort area along what we know as Butler Avenue. Other community buildings, including City Hall, The Tybee Island School and St. Michael's Church were erected.³

The success of the community was unprecedented. During the 1910s, Tybee Island officials desired to continue this prosperity by linking the island to the emerging Dixie Highway. As early as 1915, the City of Tybee Island, the City of Savannah and Chatham County began discussing the construction of a roadway link. In 1923, construction was completed and the auto journey to Tybee Island began.⁴ Within time, Tybee Island joined many American municipalities in becoming auto-centric. The multi-modes of connectivity of the past, were replaced by the convenience and the infrastructure brought by the car.

³ Ibid.

⁴ Ibid.

2.0 Carrying Capacity

Background

Carrying capacity is often utilized by ecologists to examine the maximum population of species that can be sustained in their given environment. Traditionally, two patterns of carrying capacity emerge. One relates to a rapid population increase when food and habitat are abundant, and then slows down as regulatory factors such as low birth rate and reduced food availability become apparent. This is known as K-selection. The other, quite different pattern, known as the r-selection, relates to a population increasing so rapidly that it exhausts the resources on which it depends.⁵ While these patterns relate to species beyond humans, it remains important to consider the concept of the r-selection for Tybee Island. A carrying capacity that may service the population well in off-peak, non-tourist seasons, may be tremendously stressed when summer or festivals arrive.

Tourism provides opportunities for local and regional development, but as it increases it exerts pressures on environmental and cultural resources, altering the social and economic structures. Seasonal peaks only accentuate such problems. Many tourist destinations are now facing the same concerns as Tybee Island, with many solutions prioritized under costly infrastructure investments and less on growth management and a diversified tourist product.⁶

Understanding the human application for carrying capacity and the impact of tourism upon this capacity may assist Tybee Island in developing growth policies and partnering with the private sector to diversify their own tourist product.

The Human Application

The human application of carrying capacity began in the 1960s and gave rise to the equation $I = PAT$ illustrated below. This equation points out that the carrying capacity for humans is not only related to population size, but to many

levels of consumption, which are in turn impacted by the technologies and economies involved in the production of those consumer goods as outlined in Figure 1. Each variable within this equation has the opportunity to be impacted or reduced through a variety of regulatory and policy choices related to the current and future use of the Island.

Figure 1 Carrying Capacity



⁵ Coccossis, Harry and Alexandra Mexa. 2004. *The Challenge of Tourism Carrying Capacity Assessment*.

⁶ Ibid.

Understanding the Carrying Capacity for the City of Tybee Island

Carrying capacity is not a scientific concept or formula of obtaining a number, beyond which development should cease. The eventual limits must be considered as a guidance....Carrying capacity develops with time and the growth of tourism and can be affected by management techniques and controls.

-Alexis Saveriades, 2000, "Establishing the social tourism carrying capacity for the tourist resorts of the east coast of the Republic of Cyprus."

Within this study, carrying capacity will not reveal a definitive number. Instead this study should be regarded more as a management tool to assist in understanding the framework around Tybee Island as a community and the policy choices that may impact that framework. The $I=PAT$ formula illustrates the importance of many factors in the health of a community and reveals opportunities for policy and planning decisions that can increase the health, vibrancy and sustainability of Tybee Island.

The current national and global market structure has allowed for the development of many communities beyond a traditional mindset of carrying capacity. Within the boundaries of Tybee Island, we can see the immediate need for external import of a variety of goods and services to ensure the quality of life expected by many citizens. The following chapter delves into the many variables under the Population, Affluence, and Technology factors and will begin to highlight these areas, as well as open doorways for alternative thinking towards potential solutions.

Figure 2 Carrying Capacity & Tybee Island



3.0 The Factors

P - Factor (Population)

The population factor for tourist communities does not remain a constant variable. Long-term population projections in the comprehensive planning process may reveal the results of expected population growth to a region, but the rise and fall of population levels experienced by Tybee Island remains unique to tourist economies.

According to the 2000 Census, the City of Tybee Island had a resident population of 3,392. While this number represents the municipality, a portion of the island not included within the municipal boundary increased the population to 3,713. These numbers are important for policy makers and private industries when choosing how to smartly balance the footprint of the population on the ecosystem. However, as discussed above, a legacy of tourism alters these numbers dramatically.

According to numbers from the Tybee Island Tourism Council, tourist population numbers average an increase in of 10,000 persons during the months of June, July, and August. However, data revealed through traffic counts during this study showed large weekend populations occurring from April through August for the year 2010.

The peak of July 3rd brought 16,173 vehicles onto the Island according to traffic count data maintained by the City. Making assumptions from this data, beyond understanding the number of vehicles, would be erroneous. However, this study makes a simple hypothesis with this data to understand the population fluctuations for Tybee Island. Utilizing a very basic assumption of two persons per vehicle, one could hypothesize over 30,000 persons on the island. While the accuracy of this number is questionable, it offers a picture of the large flux (3,800 to 30,000) policy makers on Tybee Island must consider when choosing policies related to emergency management, general safety, and basic infrastructure needs such as water supply and treatment.

Certainly a more extensive study should be conducted if policy makers seek to understand this variable with large impacts on the island. Further data that could assist in gaining a clear picture of population include surveys of persons per vehicle coordinated with detailed hourly traffic counts during peak seasons that include directional flow both onto and off of the island, as well as assessing data from the hotel and motel industry

Figure 3 The Population Factor



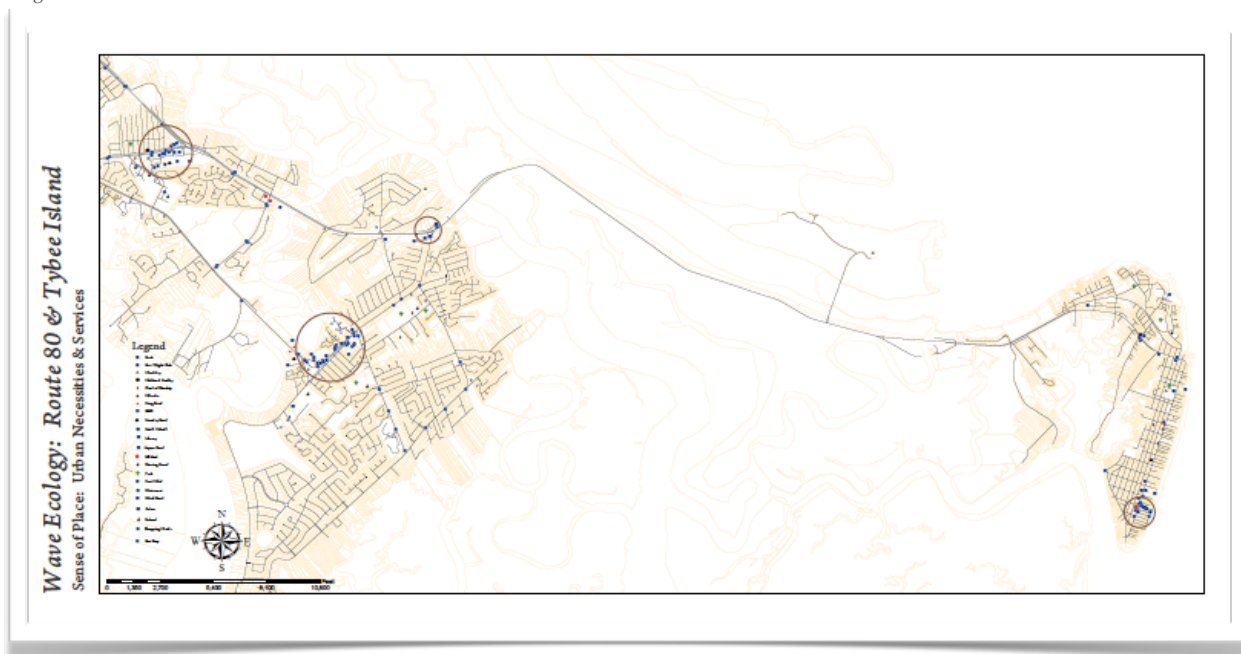
A - Factor (Affluence)

As defined by the I=PAT equation, the carrying capacity for people is not only related to population size, but must include the many levels of consumption for that community. This can include a variety of variables from economic spending power to the actual consumption trends of a population.

Services and Commodities

While many of the daily human needs for citizens may be met on Tybee Island, they all rely on one modality source external to the municipal boundaries of the City. Services such as food, fuel, medical personnel and consumption commodities do exist within the City's boundaries, but in order to have a daily presence they must travel the Highway 80 corridor. While less of a concern for inland municipalities with multiple connection points to neighboring services, this unique situation presents concerns on the sustainability of Tybee Island. The map in Figure 4 illustrates the fragile nature of the current quality of life citizens and tourists depend on via the Highway 80 corridor.

Figure 4 Services: The Affluence Factor



Business as Usual: The Economic Picture

Variables related to the affluence of a society travel beyond the locations of stores and commodities. They must include income levels, employment opportunities, and a clear understanding of which economic sectors drive the affluence of the community. As a resort destination, Tybee Island has three NAICS code sectors employing over 20 people. These include the retail trade sector (59 employees), real estate/rental sector (23 employees) and the accommodation and food service sector (322 employees). While linked to the tourism market, these economic engines also rely on a specific tourist product and goods imported via the Highway 80 corridor. Further assessments on the ratio of annual residents employed in these sectors will reveal greater detail on the economic picture.

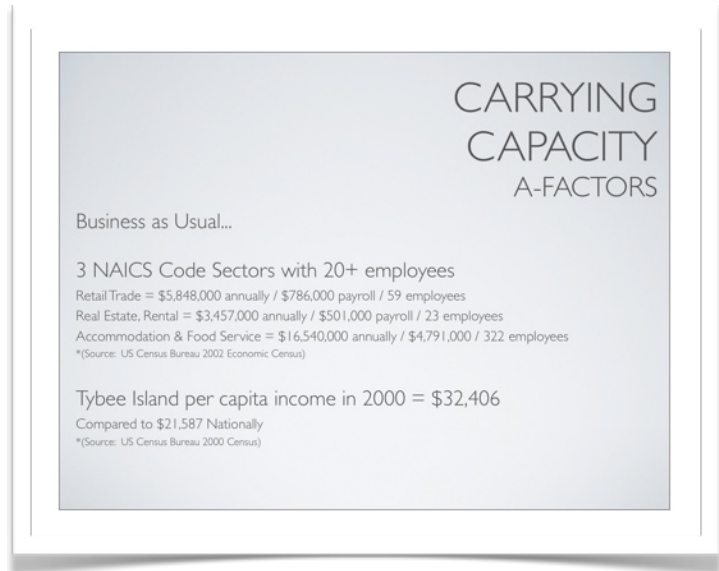
The Power of Per Capita

The per capita income for annual residents on Tybee Island (\$32,406) lies above the national average (\$21,587) and nearly double the City of Savannah average (\$16,921).⁷ Purchasing power cannot be concluded based simply on the per capita income for a region, yet it remains important to note this affluence factor. Based on this same Census data,

⁷1999 dollars - not adjusted for inflation. 2000 U.S. Census Bureau Fact Finder www.factfinder.census.gov

the median for monthly mortgage payments for owner-occupied housing on Tybee Island was \$1,261. When viewing this data as a percentage of total household income the two largest percentages are opposing. Mortgage payments for 36.6% of citizens is less than 15% of their total household income, while mortgage payments for 20.3% of citizens is 35% or more of their income. This data may indicate a variety of factors related to real estate values and suggests potential economic home-ownership retention issues for the over 20% of citizens paying 35% or more of their monthly income on a mortgage. Upon release of the 2010 Census data a more updated picture may be revealed, offering greater insight into changes related to the housing market downturn that occurred between 2008-2010.

Figure 5 Business: The Affluence Factors



The influx of a tourist population, and the clear indicators of tourism as the main economic engine for Tybee Island reveal that affluence factors may fluctuate in the same manner as population variables since the affluence of a society is directly linked to the population demographics of that society.

T - Factor (Technology)

As noted earlier, applying carrying capacity to many American communities may almost be deemed pointless. In many ways municipalities are structured in a global society far beyond the capacity of one community. For Tybee Island this is certainly true. The infrastructure (technology factor) of energy sourcing, medical services, solid waste disposal, economic engines, emergency response, and consumer goods for the expected quality-of-life are all currently being imported. While this community pattern occurs in many areas, there is one stark difference. Many points of connectivity exist within the roadway, train, shipping, and airline infrastructure of most areas. The City of Tybee Island must rely upon two bridges and one six-mile roadway for connectivity.

Taking a closer look at what infrastructure is available to the community, and what infrastructure has future development potential, may assist in understanding this question of carrying capacity.

Water & Sewerage

One of the most fundamental infrastructure factors for a community is the development of their water supply and treatment. Tybee Island, like most of the coastal South Carolina, Georgia, and Florida region relies on groundwater from the Upper Floridan aquifer system.

Prior to the population growth and industrial development of the 20th century, the aquifer systems of Georgia, including the Upper Floridan aquifer, were fed by recharge areas from an east-southeast direction, extending in a broad arc from Valdosta to Waynesboro. This groundwater system eventually discharged offshore. After World War II well systems were implemented to pump this pristine water supply for development needs. By the 1970s urban centers around Hilton Head Island, Savannah, Brunswick, Jesup, Riceboro, St. Marys, and Jacksonville were pumping

at large rates that formed cones of depression in the potentiometric surface. As a result, the water flow direction changed, bringing oceanic/salt water into the aquifer system.⁸

This concern over water supply and the intrusion of saltwater into the Upper Floridan aquifer led to the development and adoption of the Georgia Water & Wastewater Plan for Managing Salt Water Intrusion in 2006. Within this plan the City of Tybee Island (Chatham County) is located in a *Sub-Region 1 Red Zone*, which adopted a no net increase goal for extraction from the Upper Floridan aquifer.

Tybee Island's water withdrawal permit currently allots for an average yearly limit of 0.960 MGD and an average monthly limit of 1.6 MGD. According to EPA estimations, this services an average of 10,000 persons.⁹ While not a direct concern when considering the residential population, the introduction of a tourist population stresses this permit limit.

Housing

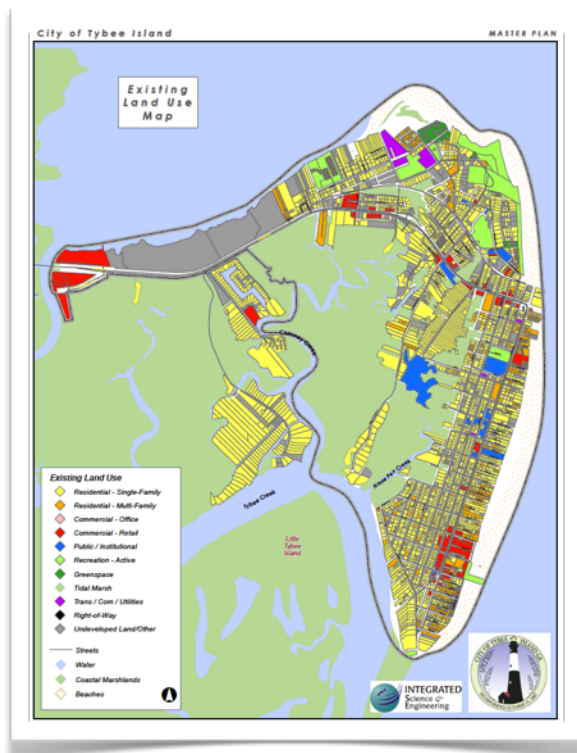
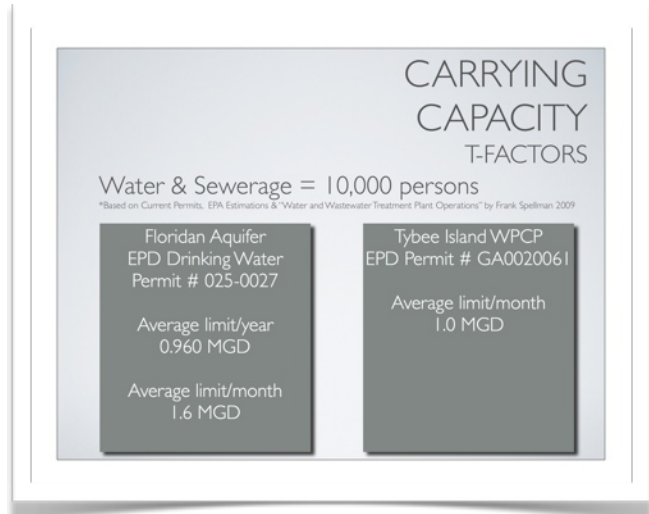


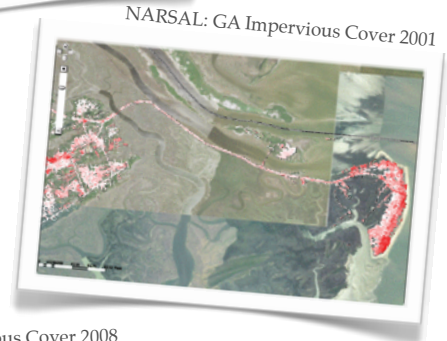
Figure 6.0 Water: The Technology Factor



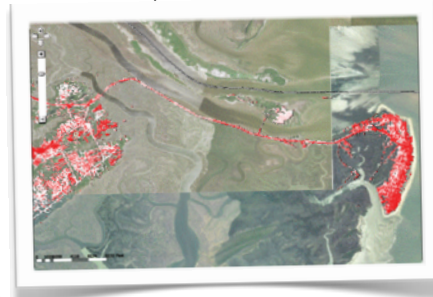
NARSAL: GA Impervious Cover 1991



NARSAL: GA Impervious Cover 2001



NARSAL: GA Impervious Cover 2008



⁸ 2006. Georgia Water & Wastewater Plan for Managing Salt Water Intrusion.

⁹ Frank Spellman. 2009. "Water and Wastewater Treatment Plant Operations."

According to the 2008 Tybee Island Comprehensive Plan, the City of Tybee Island has closely reached it's build-out potential.¹⁰ While density changes from single-family residential to multi-family can increase the population size and opportunity for carrying capacity related to housing, the availability of undeveloped land is limited, as noted in the 2008 Existing Land Use Map from the Tybee Island Master Plan and the sequenced NARSAL spatial data. The dark red indicates areas 95-100 percent impervious at the time of analysis.¹¹

There are 2,859 housing units on Tybee Island.¹² Only 41.75 percent of these units are owner occupied, with 40.35 percent of the units vacant or utilized as short-term rentals. Thus, the large economic engine of tourism emerges once again. Figure 7 notes the housing units available on the island with relation to the number of households based upon the Census tracts.

Making a simple population extraction based upon the current household size and existing housing units (includes owner occupied and second/rental homes), a housing capacity of 5,918 persons emerges.¹³

Mobility

The history of mobility onto Tybee Island reveals many modes and methods that frequently overlap to meet the service needs of citizens and visitors. The current mobility infrastructures for the Island are discussed below. Note that all infrastructure for mobility onto the island currently requires private ownership of an automobile or boat. No public transportation is utilized on existing infrastructure.

Island Access

Roadway: Determining the roadway capacity requires a number of variables related to the

Figure 7 Housing: A Technology Factor

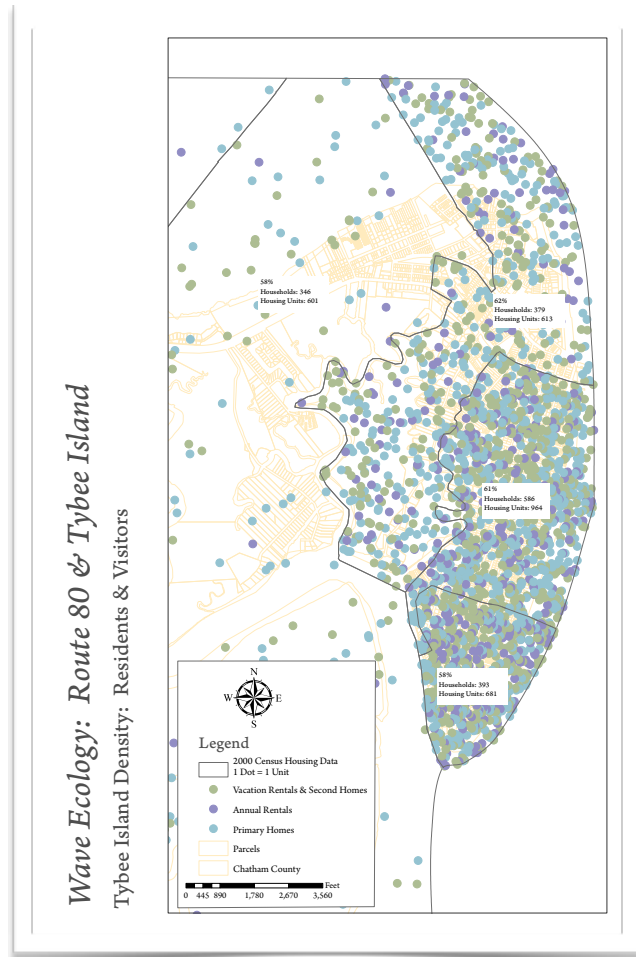


Figure 8.0 Highway 80: A Technology Factor



¹⁰ City of Tybee Island. 2008. Master Plan.

¹¹ UGA Natural Resources Spatial Analysis Lab (NARSAL) <http://narsal.uga.edu/glut/state.html>

¹² 2000 U.S. Census

¹³ Based upon 2000 U.S.Census data (2.07 Avg. Household Size x 2,859 Existing Housing Units = 5,918 persons)

specific corridor under examination. Issues such as travel speed, ingress and egress points onto the roadway, as well as lane shifts and turns are all calculated to provide a vehicle capacity number. Conducting such a study for the Highway 80 corridor is not a direct scope for this report. However, defining a relatively accurate variable is critical in gaining clarity on the carrying capacity for Highway 80. After consultation with traffic engineers, the Highway Capacity Manual v2000 and several studies on similar roadways, a capacity level of 12,000 vehicles per day per direction was chosen.

According to traffic count data maintained by the City of Tybee Island, approximately 11 percent of the time (23 days) between January and July 2010 the highway exceeded its capacity. Friday, Saturday, and Sunday comprise the majority of these days, as depicted in Figure 8.

However, it remains important to note that roadway capacity on a daily basis, may result in a much different performance when assessed at an hourly rate. For example, traffic counts over the Labor Day Weekend (September 3rd-6th) revealed that the highway capacity was exceeded, based on the assumption of 12,000 vehicles per day.¹⁴ Detailed data on the traffic counts assessed traffic flow on fifteen minute intervals. Analyzing these intervals on the hourly Volume/Capacity Ratio (v/c) revealed that while the daily capacity was breeched, at no one set time did the v/c ratio reveal maximum capacity. This result indicates that while a daily examination of the corridor exposes a stressed roadway during times of peak tourism, the actual flow capacity for Tybee Island may not be breeched. Utilizing detailed traffic counts that assess time intervals over an extended period of months may help bring clarity to understanding the annual capacity.

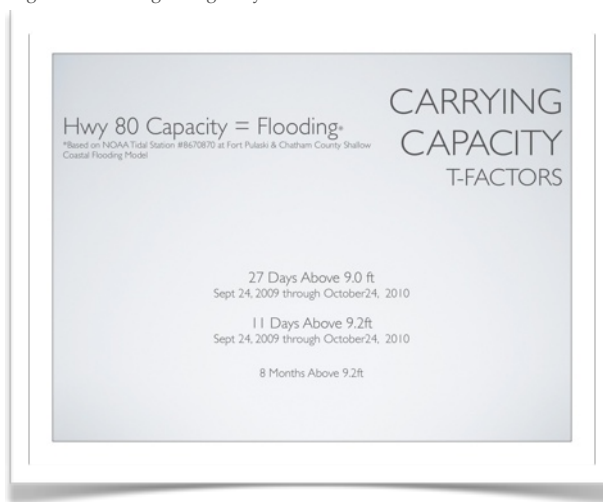
Bicycle access was noted as an important mobility option in the 2008 Tybee Island Master Plan. Existing infrastructure on the McQueen's Island Bike Trail offers the opportunities for recreational, as well as commute cycling uses. However, two disconnect points exist within this infrastructure at the Lazaretto Creek Bridge and the Bull River Bridge, where cyclists must share travel lanes with automotive traffic.

Both Highway 80 and the McQueen's Island Bike Trail remain threatened by high tides and sea level rise. According to the Chatham County Shallow Coastal Flooding Model roadway capacity is impacted at 9.2 feet MSLW and completely impassible by automobile at 10 feet MSLW. A brief movie of the model depicting these impacts of tidal rise on the roadway can be accessed by [clicking here](#).

Figure 9 outlines the frequency at which the Highway 80 corridor was impacted due to tidal levels over the past year. Repeat flooding on a roadway often reduces the lifespan of the infrastructure.

Marinas: Communities, such as Tybee Island, have the potential for multiple modes of transport beyond land.

Figure 9 Flooding & Highway 80



¹⁴ Numbers given for estimation purposes. Exact highway capacity would need further calculation and traffic count data collected from two lane portion of the roadway. Traffic count data presented represents the four lane capacity area where two lane capacity of the Lazaretto Creek bridge turns into four lane. Since few ingress and egress points are located between the two lane to four lane conversion the data may still be utilized for estimation purposes.

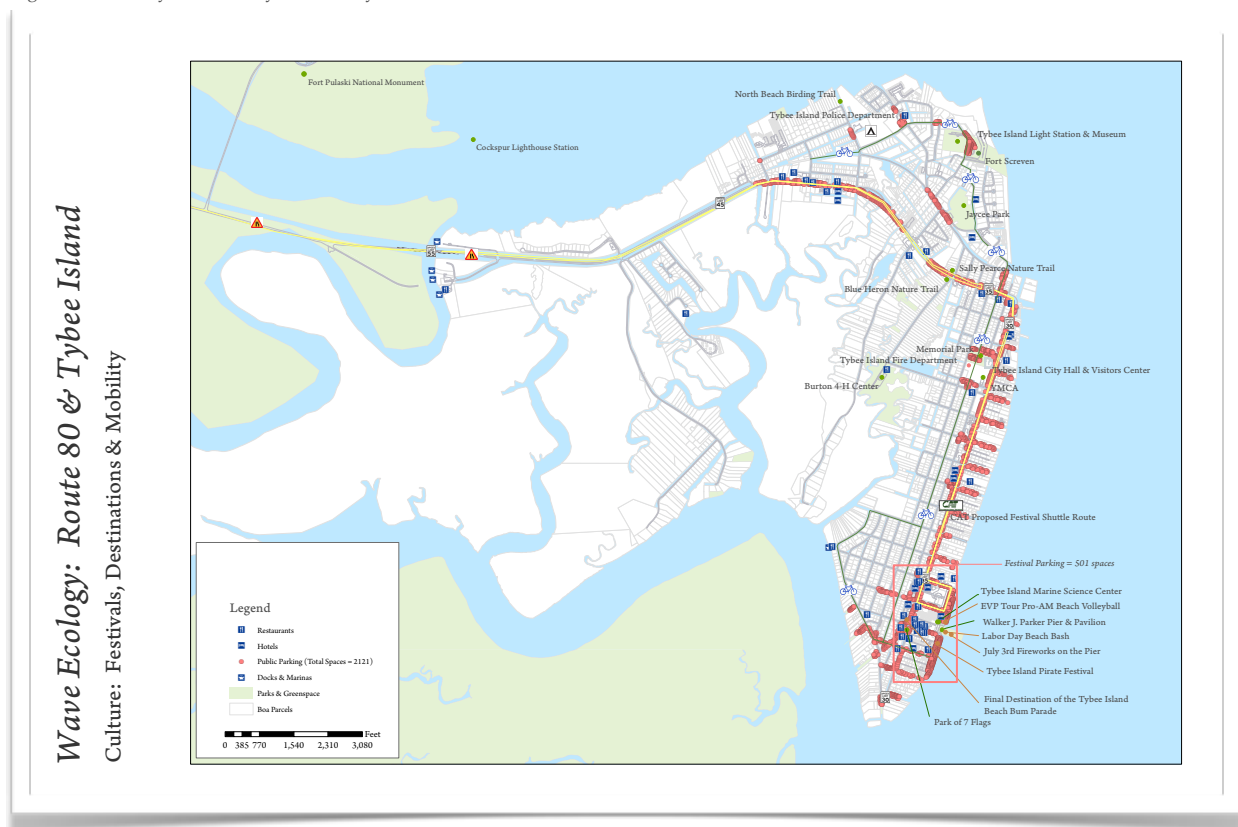
Fostering this mode of transport from a recreational base to commuter base requires an evaluation of the infrastructure in existence, as well as an evaluation of the larger connectivity points to bus or shuttle routes. A detailed study for the coastal Georgia/South Carolina region was conducted with results compiled into an interactive Google map with public access. This map may be found by [clicking here](#).

Currently two marinas offering dock space are located on Tybee Island near the Lazaretto Creek Bridge.¹⁵ When assessing waterways for mobility rather than simply recreation, fuel sourcing, repair services, and connectivity to alternative transport (bus, van shuttle, pedestrian, bike, etc.) must be considered. Looking closely at the existing infrastructure offers many potential public /private partnerships to enhance this form of mobility for Tybee Island.

Activity Hubs

Land use patterns for the City of Tybee Island expose areas with concentrated activity resulting from the tourism industry. The current tourist products for Tybee Island link to historical areas, such as the Tybee Island Lighthouse, the oceanfront, and the Strand Downtown Historic Business District. Festivals and activities are typically located in these areas, with the majority of events being held in the Strand Downtown Historic Business District, as depicted in Figure 10.

Figure 10 Mobility and Activity Hubs on Tybee Island



Parking and inter-island mobility is as an issue for the City of Tybee Island. With a current public parking space limit of 2,121 and a vehicle count exceeding 12,000 daily during peak tourist times, the capacity for Tybee Island to maintain the level of tourism sought with current infrastructure is strained. Many communities faced with this issue

¹⁵ Data compiled from Dozier's Waterway Guide Atlantic ICW 2010.

are seeking to diversify their tourist product by integrating mobility both onto the island, as well as inter-island into their tourism economy. By linking with the private sector and integrating smart technologies, a carrying capacity that remains constricted due to vehicle use, is expanded with decreased solo-vehicle dependency.

Solid Waste

The City of Tybee Island relies on areas external to their boundaries for handling municipal waste. Both solid waste and recycling are all handled through a private contract with Waste Pro. These items are transferred via the Highway 80 corridor. As noted earlier, the sensitivity of the roadway to flooding may offer the opportunity to engage public policy and emergency management in a backup plan to assist in the management of waste in the instance that the connectivity is severed for a period of time.

Electricity Supply

When considering the carrying capacity for an area related to the current quality of life, electricity consumption becomes a key element. Currently, for both the municipal and community use, the vast majority of electricity is supplied external to the area. Georgia Power provides grid electricity to Tybee Island through the International Paper Savannah Mill. This plant receives coal supplied from Scott's Branch Mountain in Kentucky.

Currently municipal strategies are being enacted by the City of Tybee Island to promote localized, alternative energy sourcing through loan financing programs. These programs will assist in restructuring the energy supply.

Further Data

Further data not presented within this report is located at the study website:

<http://www.thempc.org/Transportation/WaveEcologyStudy.html>.

4.0 Conclusion: Opportunities Ahead

The Many Variables

As discussed throughout this report there are many variables linked to the carrying capacity for a community. The opportunity for increasing the carrying capacity for a Tybee Island, or for managing the current peak capacities of this tourist destination relies upon:

- Implementing new technologies
- Providing multiple modes of connectivity utilizing the resources within the area
- Diversifying the tourist product that Tybee Island provides
- Inter-governmental / Inter-agency coordination

Inter-governmental / Inter-agency Coordination

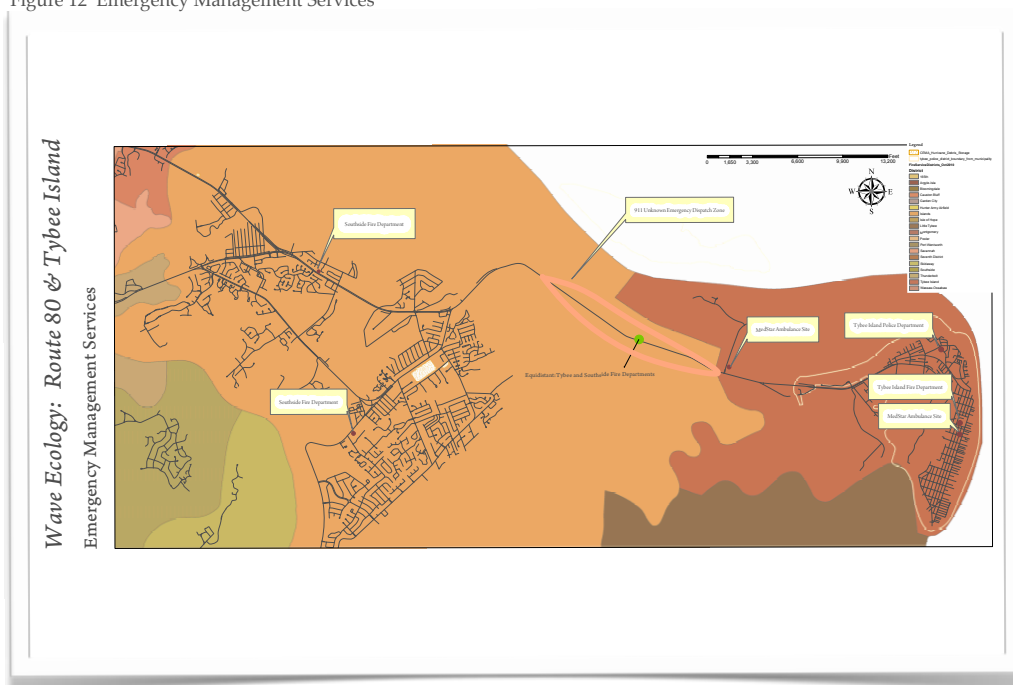
Just as the beauty and petals on this Dahlia in Figure 11 present symmetry and elegance, they also perform a function of species survival. Each petal and each line in this blossom has a role of inviting pollinator insects into the central core, the pistil, in order to stimulate the ovule and form new seeds. It is nature at it's finest. Reproduction. Sustained life.

In a community, the roles of various agencies and governments must be very similar and succinct in their purpose, coordinating well to ensure the sustained life of the community. This proves critical in a situation such as Tybee Island with one ingress and one egress point governed by multiple jurisdictions.

Figure 11 Dahlia & Community Services



Figure 12 Emergency Management Services



As highlighted by Figure 12, police and fire, emergency management, emergency dispatch and municipal boundaries all occur at differing points along the Highway 80 corridor. An assessment of the current emergency services provided and available to Tybee Island is listed in Figure 12 and 13. As depicted in Figure 14, traffic conflicts and needs for emergency management are largest beyond the City of Tybee Island municipal boundary and at the Highway 80, Johnny Mercer intersection.

Coordination for emergency and evacuation needs remain critical in gaining positive outcomes.

Figure 13 Emergency Services: The Technology Factor

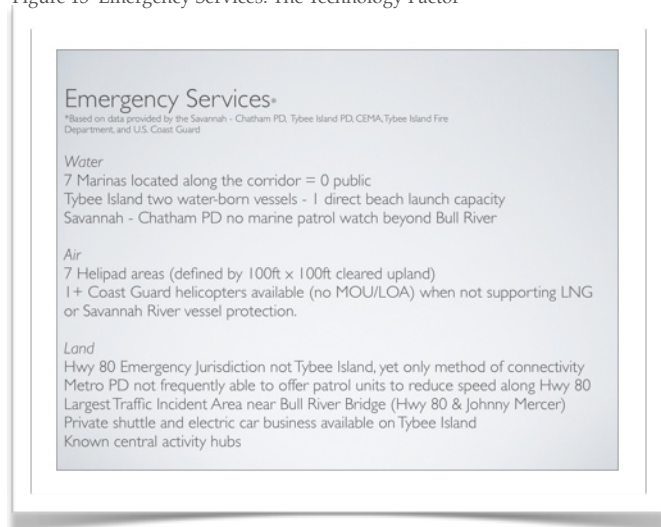
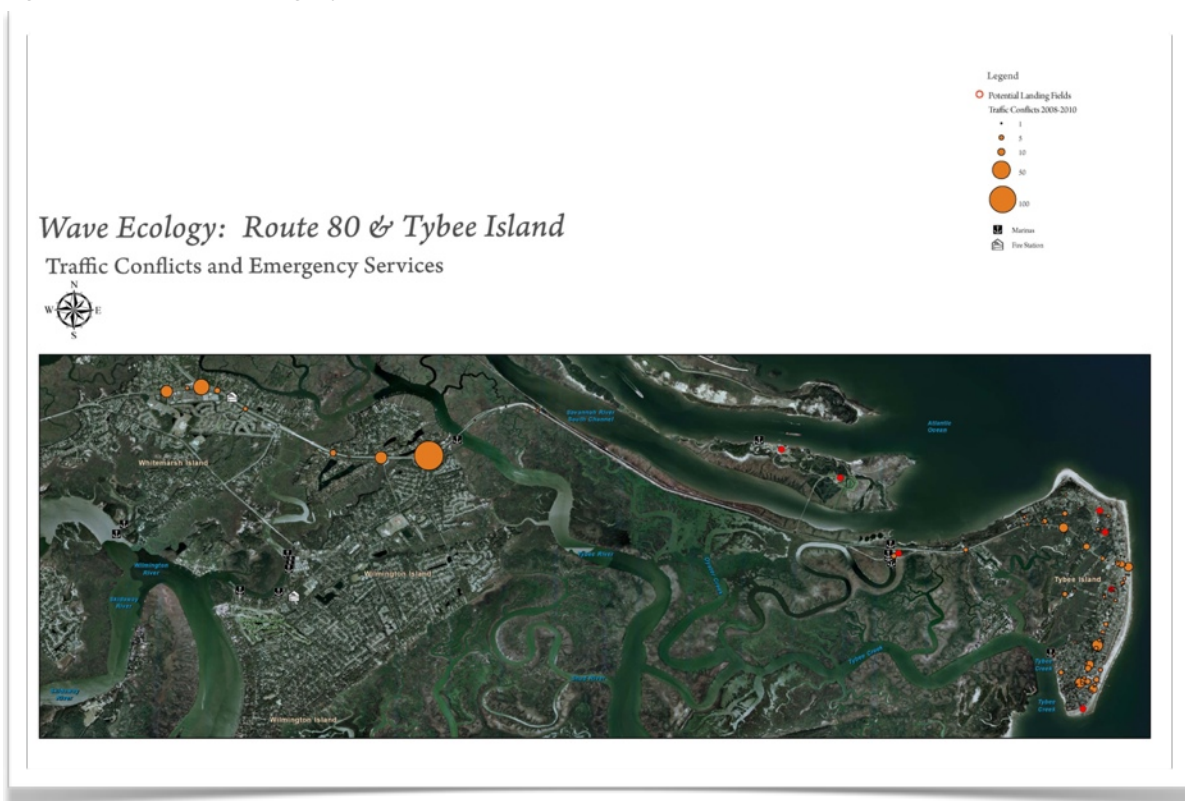


Figure 14 Traffic Conflicts & Emergency Services



Sustainable Tourism

Sustainable tourism involves social responsibility, a strong commitment to nature, and the integration of local people in any tourist operation or development. Sustainable tourism is defined by the World Tourism Organization, the Tourism Council, and the Earth Council as:

Sustainable Tourism Development meets the needs of present tourists, host regions while protecting and enhancing opportunity for the future. It is envisaged as leading to management of all resources in such a way that economic, social, and aesthetic needs can be fulfilled while maintaining cultural integrity, essential ecological processes, biological diversity and life support systems. Sustainable tourism products are products which are operated in harmony with the local environment, community and cultures so that these become the beneficiaries not the victims of tourism development.

The carrying capacity for tourism areas is a growing field of study. Ecological and social impacts from tourism has been noted for coastal communities throughout the world. The City of Tybee Island may strongly benefit from working collaboratively with the Tybee Island Tourism Council to integrate Sustainable Tourism Indicators into their planning process. For more information and resources on sustainable tourism [click here](#). Data gathered within this study may assist in answering certain capacity indicators, allowing Tybee Island to move towards alternative, progressive and viable opportunities to balance the desire for tourism, the carrying capacity of the environment, and the safety of citizens.