Glosten

SKAGIT COUNTY
Serving With Pride
WASHINGTON

GUEMES ISLAND FERRY REPLACEMENT

VESSEL CAPACITY STUDY

PREPARED FOR

SKAGIT COUNTY PUBLIC WORKS
MOUNT VERNON, WASHINGTON

20 OCTOBER 2017
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Revision History

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References

1. Guemes Island Ferry annual ridership records, Skagit County, 1980-2000.
2. Guemes Island Ferry detailed ridership records, Skagit County, 2001-2017.
3. Guemes Island Ferry ticket sales records, Skagit County, 1996-2017.
4. Guemes Island Ferry revenue records, Skagit County, 1992-2017.
5. *Guemes Island Ferry Capital Facilities Plan*, Skagit County, 2007.
6. *Skagit County Transportation Systems Plan*, Skagit County, 2003.
7. Record of Construction Year of Dwelling Units on Guemes Island, Skagit County, 2017.
8. 46 CFR, *Shipping*, 2017.
9. *124-Foot Ferry for Skagit County: Vents, Sounding Tubes, and Deck Drainage System Arrangement*, Nickum and Spaulding Associates, Drawing No. 77083-11-1, Rev. –, 4 November 1977.
10. Guemes Island Ferry Committee (letter to R. Rowe of Skagit County Public Works), "Re: 'Capacity' of the Guemes Ferry System," 29 April 2014.
11. *Washington State Department of Transportation – Ferries Division – Final Long-range Plan*, Washington State Department of Transportation, 30 June 2009.
12. Decennial, Intercensal, and Postcensal Population Records for Skagit County, Washington State Office of Financial Management, 1960-2017.
13. Consumer Price Index – All Urban Consumers (Seattle), United States Bureau of Labor Statistics, Series No. CUURA423SA0, 1914-2017.
14. Guemes Island Ferry schedules and fares, Skagit County, 1977-2017.
15. Guemes Island Subarea Plan, Skagit County, 2010.
16. Google Earth Pro [software], Google, Version 7.3.0.3832, 18 August 2017.
17. *Property Search*, Skagit County Assessor, https://www.skagitcounty.net/Search/Property/, September 2017.
18. *Skagit County Growth Projections*, Berk Consulting, February 2016.
19. *Skagit Alternative Futures Population Projections (2010-2060)*, Skagit County, April 2009.
20. Zhao, Y. [Washington State Office of Financial Management], "2012 Growth Management Act Provisional Population Projections for County Review," 23 April 2012.
21. *M/V* Guemes *Replacement Plan*, Elliott Bay Design Group, Rev. B, 22 November 2013.

Executive Summary

The purpose of this report is to analyze past Guemes Island Ferry ridership, to estimate future Guemes Island Ferry ridership, and to calculate the capacity of a new Guemes Island Ferry intended to be in service from 2020 to 2060.

Skagit County provided annual ridership records from 1980 through 2000 and detailed ridership records from January 2001 through July 2017. Glosten analyzed the full record set in order to produce graphs and commentary on annual ridership, passenger-vehicle ratios, and the prevalence of trucks and trailers. Some key conclusions are:

- Passenger ridership (including passengers in vehicles) increased 101% from 1980 to its peak in 2007, and 85% from 1980 to 2016.
- Vehicle ridership increased 158% from 1980 to its peak in 2002, and 125% from 1980 to 2016.
- Truck and trailer ridership increased from 2% of the total vehicle count in 1980 to 6% of the total vehicle count in 2016.

Glosten analyzed the detailed ridership records in order to define a full vehicle load, to determine the probability distributions of passenger and vehicle load size, and to calculate a provisional standard for level of service. Some key conclusions are:

- Approximately 0.005% of all ferry trips are likely to contain a full load of passengers (including drivers and passengers in vehicles), which Glosten defines as 100 passengers based on the vessel's certificate of inspection.
- Approximately 1% of all ferry trips are likely to contain a full load of walk-on passengers, which Glosten defines as 36 or more walk-on passengers based on an analysis of available passenger space.
- Approximately 22% of all ferry trips are likely to contain a full load of vehicles, which Glosten defines as 19 or more vehicles based on an analysis of double runs before lunch, which are most likely full when they occur.

Based on these passenger and vehicle utilization rates, Glosten concluded that the Guemes Island Ferry's capacity and size are dominated by vehicle demand.

Glosten developed a ridership forecasting model that accounts for local population, fares, and parking at the terminals. Increasing population increases ridership, whereas increasing fares reduces ridership, and increasing parking reduces vehicle ridership. Glosten found that these three factors have statistically significant impacts on ridership. Glosten found no substantial correlation between ridership and the housing market, unemployment, ferry schedule, and weather. The ridership forecasting model had a correlation coefficient of 0.95 with the passenger dataset and 0.92 with the vehicle dataset, indicating a fairly close fit.

Glosten modeled two operational scenarios in its ridership forecast:

- A lower-ridership scenario with higher fares and an increase in the number of free parking spaces to discourage ridership growth (especially vehicle ridership growth).
- A higher-ridership scenario with average fares and no change in the number of free parking spaces to have minimal impact on ridership growth.

Glosten's ridership forecast used low, medium, and high population projections that were prepared for Skagit County's Department of Planning and Development Services. The most likely outcome is the medium population projection; it was applied to both operational scenarios. In order to bracket the most likely range of outcomes, the low population projection was applied to the lower-ridership scenario, and the high population projection was applied to the higher-ridership scenario.

The range of Glosten's ridership forecasts are shown in Figure 1 and Figure 2 for the years 2020 to 2060. These forecasts represent average lines about which annual ridership is predicted to oscillate, and they assume that demand is independent of vessel size. A 40-year forecasting period was chosen to match a common economic life of a steel ferry in the Pacific Northwest. Skagit County has chosen to pursue the medium-low outcome for ferry planning purposes, which yields the following ridership targets:

- Annual passenger ridership is forecasted to be approximately 346,000 in 2060, an increase of 77% over 2016 levels.
- Annual vehicle ridership is forecasted to be approximately 170,000 in 2060, an increase of 74% over 2016 levels.

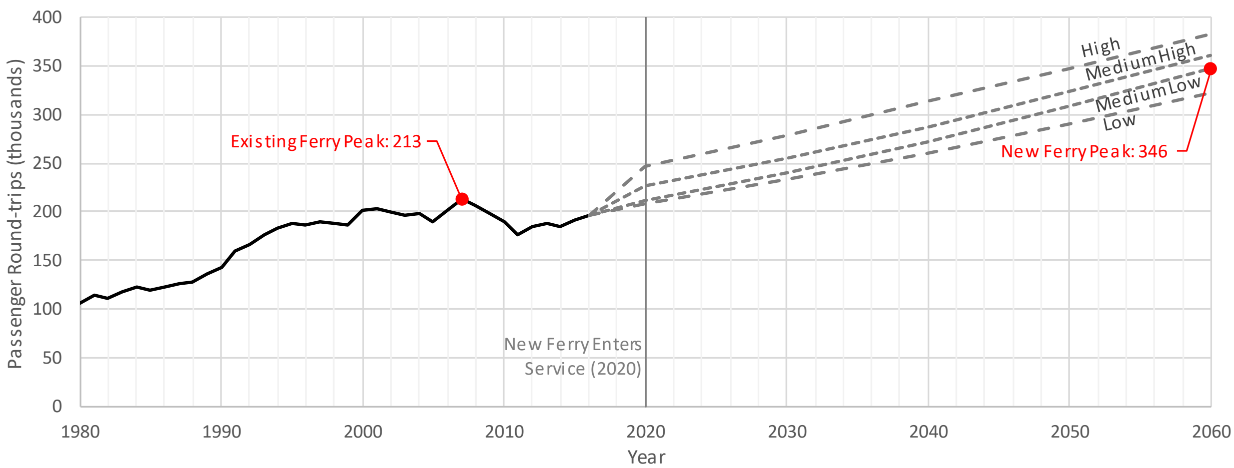

Figure 1 Passenger ridership history and forecast with four growth trends (medium-low chosen)

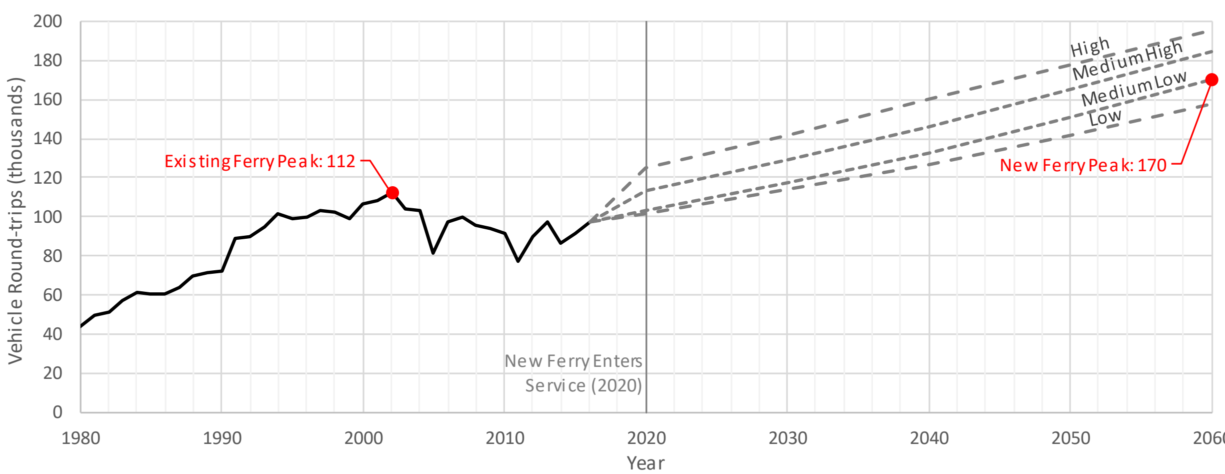

Figure 2 Vehicle ridership history and forecast with four growth trends (medium-low chosen)

Glosten based its vessel sizing methodology on the following premises:

- The understanding that the existing vessel has provided an acceptable level of service throughout its life.
- The understanding that a single replacement vessel would be operated on the same peak schedule of two round-trips per hour.
- The assumption that cyclical annual demand patterns would remain unchanged.

Glosten scaled the capacity of the new vessel from the capacity of the existing vessel by the ratio of forecasted ridership in 2060 to the existing vessel's ridership in its busiest year. The resulting vessel capacities are presented Figure 3 and Figure 4, along with the capacities of the existing and previous ferries (*Guemes* and *Almar* respectively) for reference. A horizontal line in Figure 3 labeled "Subchapter T Limit" indicates a regulatory capacity limit of 150 passengers. Exceeding this limit to avoid inconveniencing 0.1% of riders in the year 2060 is economically impractical; therefore, a point is shown identifying the new ferry's capacity to be 150 passengers. A capacity of 32 vehicles corresponds with Skagit County's medium-low forecast target; it is also identified by a point. Glosten is in the process of calculating the maximum number of vehicles that could be carried while maintaining a schedule of two round-trips per hour; it appears likely to be approximately 33 vehicles. There is little to gain by exceeding the medium-low vehicle capacity forecast. Therefore, the new ferry will have a capacity of 32 vehicles.

Figure 3 Passenger capacity history and forecast with four growth trends (limited by Subchapter T)

Figure 4 Vehicle capacity history and forecast with four growth trends (medium-low chosen)

These vessel size forecasts indicate that the next vessel replacement effort in the middle of the 21st century could be more challenging, as a larger vessel may have difficulty maintaining two round-trips per hour without a two-lane loading system. Rider demand may require the vessel to carry more than 150 passengers, thereby changing the regulatory regime and adding considerable cost. A two-vessel system could be an alternative solution to both of these problems, but it has its own disadvantages. These issues may merit consideration in future long-range planning exercises.

There is no "perfect" capacity for the new Guemes Island Ferry. Historical ridership records indicate that there is almost certainly ongoing elasticity in rider demand. Given incentives and alternatives, riders have found a way to share *Guemes* harmoniously with more than twice the number of people who used it in its first year of service. The ridership and capacity forecasts in this report reflect Skagit County's and Glosten's best attempt to make a scientific and sensible decision regarding vessel size. The Guemes Island Ferry's success in the next 43 years depends largely on the way that riders decide to use it.

Section 1 Ridership History

1.1 Ridership Records

Skagit County provided annualized passenger and vehicle counts from 1980 through 2000 (Reference 1) and detailed per-trip passenger and vehicle counts from January 2001 through July 2017 (Reference 2). Minor errors were found in the detailed records, including:

- Missing data.
- Reversed or overwritten passenger and vehicle records.
- Mistyped passenger and vehicle counts.
- Long-term imbalances in counts of inbound and outbound passengers and vehicles.

These errors were determined to affect the annual totals by no more than approximately one percent, which is acceptable. Glosten applied sampling filters to improve data quality for the detailed analyses presented in Sections 1.5 and 1.6.

Skagit County also provided records of ticket sales from January 1996 to July 2017 (Reference 3) and revenue from January 1992 to July 2017 (Reference 4). These records yielded some useful information regarding trucks and trailers, but the existence of multiple-trip passes with varying discounts and redemption rates confounds most attempts to extract accurate ridership statistics from sales and revenue data.

1.2 Annual Ridership

Annual round-trip rider counts for passengers and vehicles are shown as solid lines in Figure 5 and Figure 6 respectively. These figures are annotated with supplemental information:

- Ridership forecasts made in the 1991 and 2007 Guemes Island Ferry Capital Facilities Plans (GIFCFPs; both forecasts are found within Reference 5) and the 2003 Skagit County Transportation Systems Plan (SCTSP; Reference 6).
- Recent years with extended service outages (2005, 2011, and 2014).
- Recent years with impactful operational changes—namely the start of fare increases in 2004 and the completion of parking expansion at both terminals in 2006. The weekday schedule was also extended in 2006.
- The first year (2012) after a recent three-year period (2009 through 2011) during which the annual average unemployment rate in the Anacortes – Mount Vernon area was greater than 10%.

Annual passenger ridership increased at a fairly steady rate between 1980 and 2007, reaching a peak of 213,000 round-trips per year (an increase of 101%). Since that time it has remained roughly constant at approximately 191,000 round-trips per year. Annual vehicle ridership increased at a fairly steady rate between 1980 and 2002, reaching a peak of 112,000 round-trips per year (an increase of 158%). Since that time it has remained roughly constant at approximately 93,000 round-trips per year. Hypotheses for these trends will be presented in Section 2.

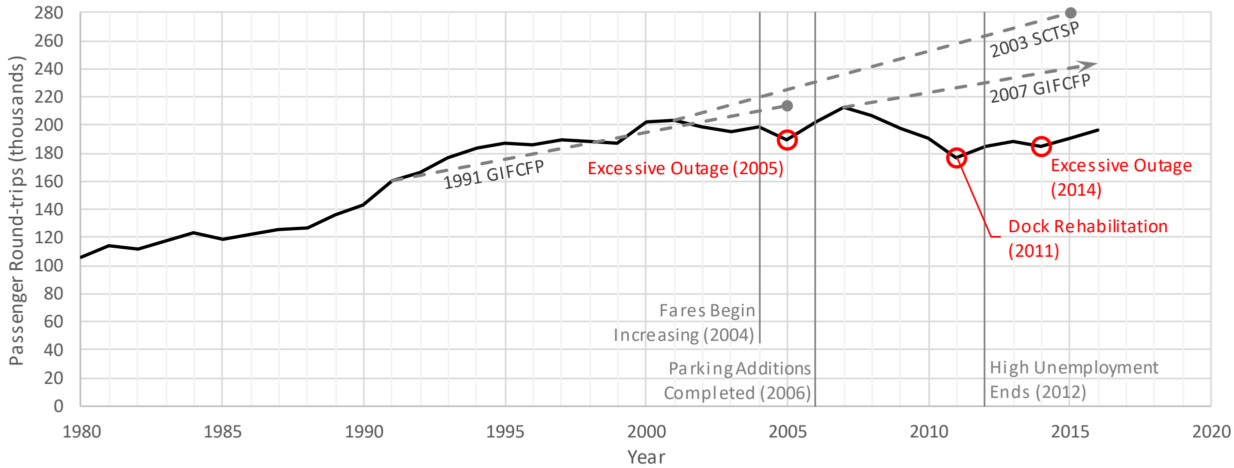

Figure 5 Annual ridership, passengers (including drivers and passengers in vehicles)

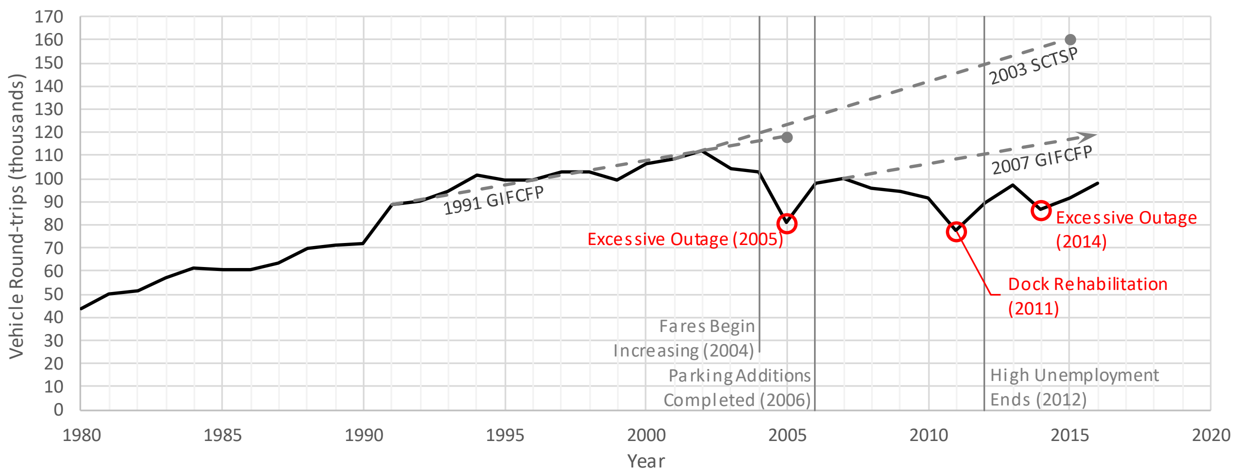

Figure 6 Annual ridership, vehicles

1.3 Demand Composition

Glosten examined Skagit County's ridership records in order to understand the characteristics of different groups of riders and how their demand for the ferry might have changed over time.

1.3.1 Passengers and Vehicles

Figure 7 shows the annual ratios of total passengers (including drivers and passengers in vehicles) to vehicles. The ratio dropped from its historic high of 2.4 when *Guemes* entered service in 1980 (replacing a ferry with a much smaller vehicle capacity) to a persistent low of 1.9 throughout the 1990s. The passenger-vehicle ratio increased again in the mid-2000s, and it seems to have leveled off at approximately 2.1.

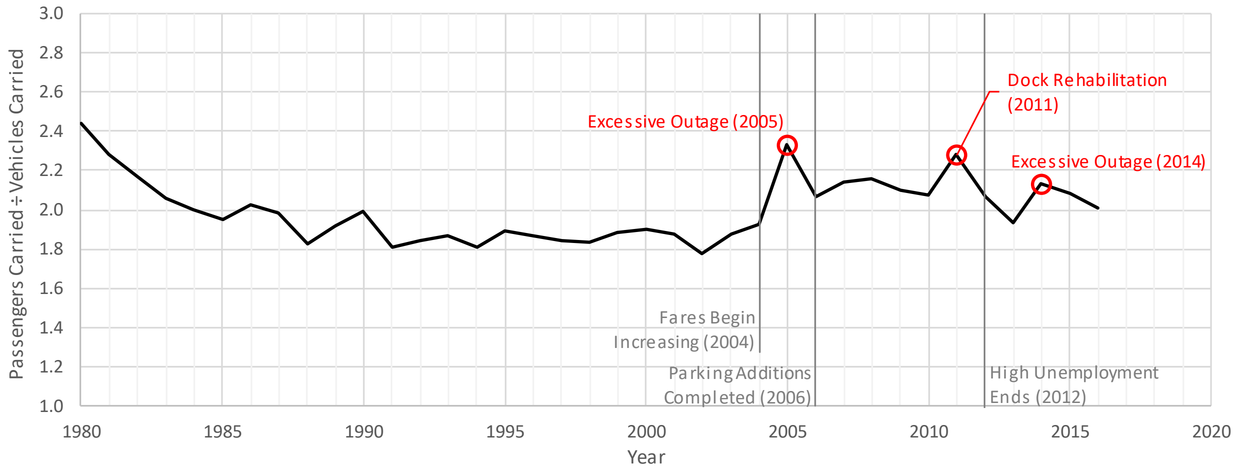

Figure 7 Ratio of passengers carried (including drivers and passengers in vehicles) to vehicles carried

1.3.2 Trucks and Trailers

Trucks and trailers presently serve a wide range of industries on Guemes Island, including road maintenance, well and septic services, utility services, fuels, domestic and commercial supplies, agriculture, logging, construction, and recreation. Glosten examined total ticket sales of all trucks and trailers in order to understand the component of ferry demand driven by large vehicles. Figure 8 shows the fraction of trucks and trailers relative to total vehicles carried. This fraction has grown from two percent in 1980 to six percent in 2016. Because trucks and trailers are usually at least 50% longer than the average vehicle, the fraction of space that they consume on the ferry is at least 50% greater than their fraction of total vehicles carried. Presently the average truck/trailer is over 32 feet long, and trucks/trailers consume approximately 10% of vehicle space on the ferry.

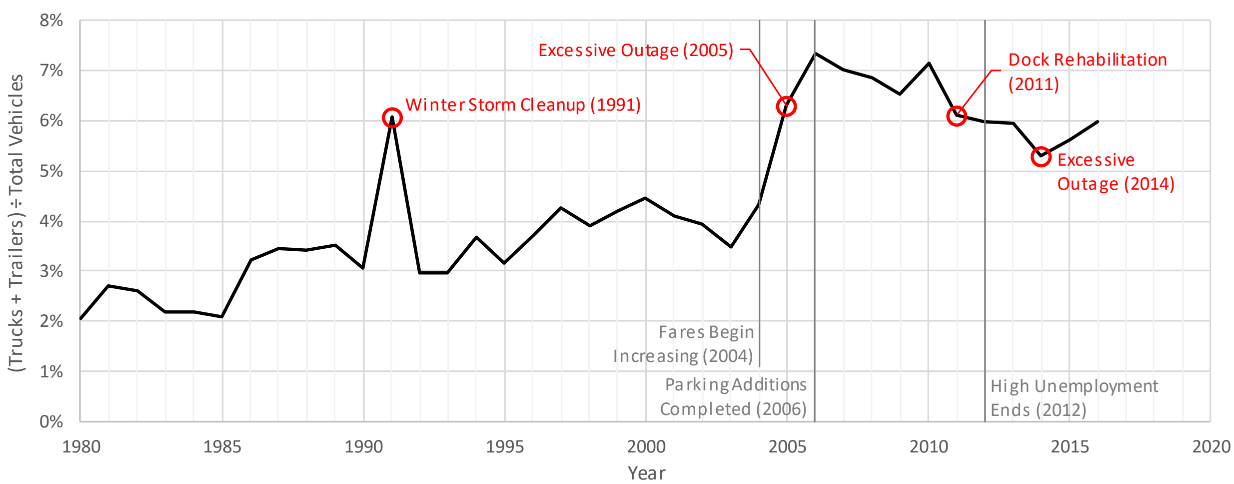

Figure 8 Trucks and trailers as a fraction of total vehicles carried

1.4 Monthly Variation

Figure 9 and Figure 10 show the minimum, average, and maximum monthly variation in passenger and vehicle ridership as a fraction of the annual total for the years 2001 through 2016, excluding 2005 and 2011 to reduce the impact of major outages. Passenger ridership is a better indicator of underlying demand, because passenger service is maintained even when the primary vessel or docks are out of service. The months of May through September are busier than average; approximately half of the year's ridership occurs during these five months. While the ratio of maximum ridership to average ridership is fairly consistent, minimum vehicle ridership fluctuates considerably because it is most affected by outages in several different years.

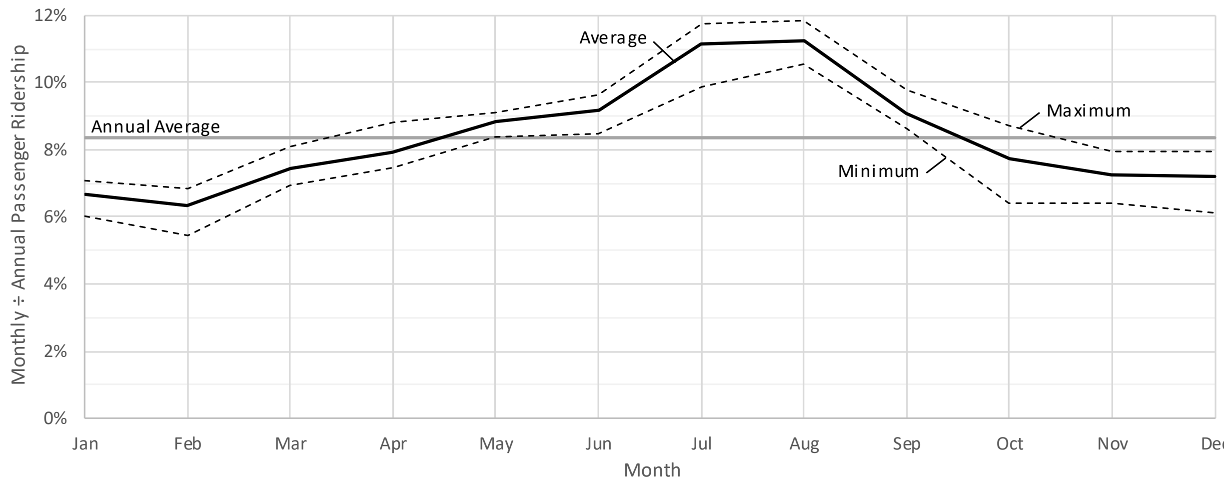

Figure 9 Monthly ridership variation, passengers

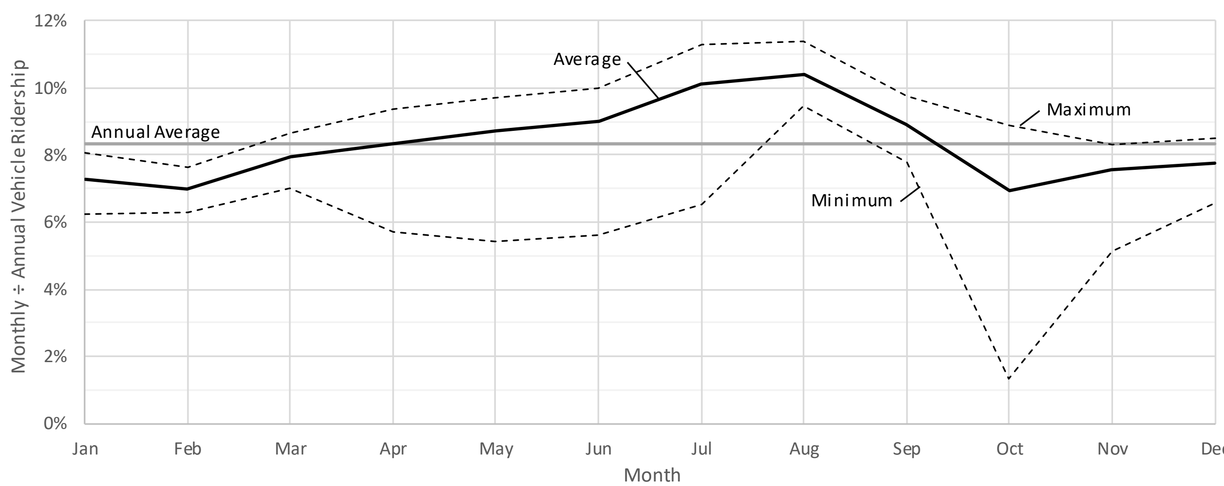

Figure 10 Monthly ridership variation, vehicles

1.5 Load Characteristics

Glosten used the detailed ridership dataset (January 2001 through July 2017) to examine the characteristics of ferry loads.

1.5.1 Definition of Capacity

Glosten defines the vessel's capacity in two ways:

1. The *nominal capacity* is the maximum number of passengers or vehicles that the vessel could carry, either for regulatory reasons (e.g. the number passengers permitted by the certificate of inspection) or practical reasons (e.g. the amount of space available to park average-size cars). Nominal capacity is used as the basis for determining the new ferry's capacity.

2. The *threshold capacity* is the number of passengers or vehicles at which point the vessel usually has no room for additional riders. The threshold capacity is less than the nominal capacity because of the variation in space that passengers and vehicles consume. A threshold vehicle capacity is used in Section 1.6 of this report to estimate the prevalence of full loads because ridership records do not indicate whether the ferry departed full.

1.5.1.1 Total Passengers

The vessel's nominal passenger capacity (including drivers and passengers in vehicles) is limited to 100 by the vessel's certificate of inspection.

1.5.1.2 Walk-on Passengers

Glosten calculated that the existing vessel's designated passenger spaces have a nominal walk-on capacity of 36 passengers based on the following assumptions:

- Passengers sitting on benches in the cabin each occupy two linear feet (the Coast Guard specifies a minimum of 1.5 linear feet per 46 CFR § 115.113 (Reference 8), but Glosten believes that two linear feet is more realistic).
- Passengers standing in the vestibule of the cabin (when it is not occupied by a wheelchair) each occupy five square feet (the Coast Guard specifies a minimum of 10 square feet per 46 CFR § 115.113, but based on observations of passenger behavior, Glosten believes that five square feet is more realistic for this small vestibule).
- Passengers standing on the exterior passenger deck (often with bicycles, strollers, wheelbarrows, coolers, or other personal effects) each occupy 10 square feet per 46 CFR § 115.113.

1.5.1.3 Vehicles

When vehicles are left behind on the last scheduled run before lunch or the last scheduled run of the day, the ferry makes an additional unscheduled run to accommodate the vehicles left behind. The presence of a lunch double (i.e. a run prior to 1:00 pm that follows a run at 11:00 am or 11:15 am, depending on the year) indicates that the last scheduled run before lunch was almost certainly full in at least one direction. Glosten isolated the full runs before lunch doubles because they were numerous and easy to identify.

Figure 11 shows the probability density and the cumulative probability of vehicle load sizes on the full runs before lunch doubles (3,147 samples). From this figure, Glosten drew the following conclusions:

- The existing vessel's nominal vehicle capacity is the most probable full load: 21 vehicles.
- The existing vessel's threshold vehicle capacity is the load size that includes roughly 80% of the full runs before lunch doubles: 19 vehicles. An original Nickum and Spaulding drawing of the existing Guemes Island Ferry (Reference 9) also shows 19 vehicles on deck. Threshold full loads are shown as darker bars in Figure 11. Using this threshold capacity to detect full runs will inevitably exclude some full runs and include some runs that are not full, but the long-term count is likely to be approximately correct.

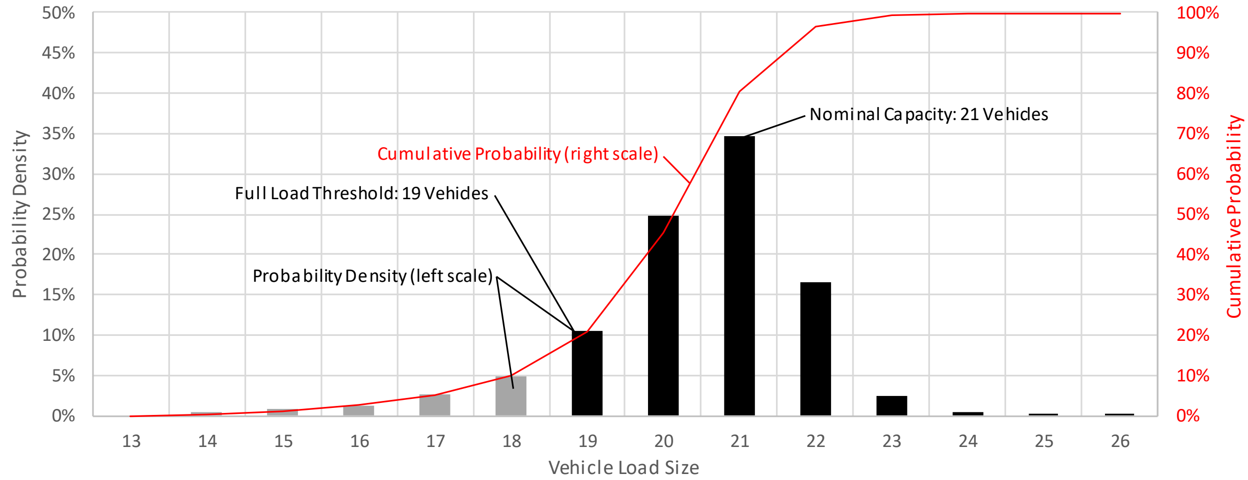

Figure 11 Load size probability distribution for full vehicle runs before lunch doubles

1.5.2 Probability of Load Size

Glosten calculated the probability of passenger and vehicle load sizes using the detailed ridership records, which cover a period of fairly stable annual ridership (January 2001 through July 2017).

1.5.2.1 Total Passengers

Figure 12 shows the probability density and cumulative probability of total passenger load sizes in the detailed ridership dataset. Load sizes from zero to 30 passengers are roughly equally probable. Loads of more than 50 passengers are somewhat rare (3.2%), and only about 13 crossings per year (0.08%) have more than 90 passengers aboard.

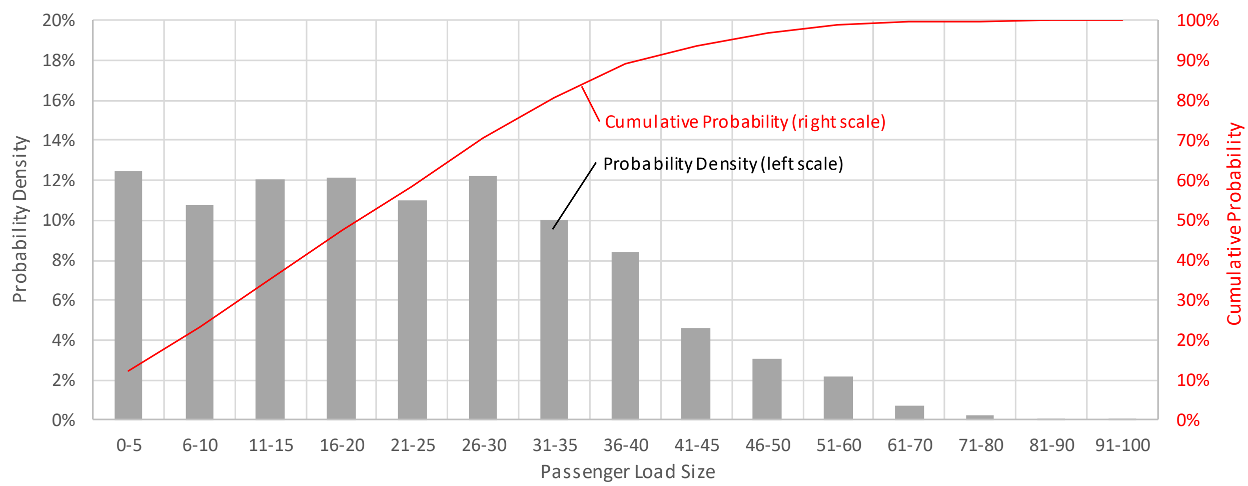

Figure 12 Load size probability distribution for total passengers

1.5.2.2 Walk-on Passengers

County records do not separate walk-on passengers from passengers who rode aboard in vehicles. Glosten created a synthetic record of walk-on passengers from the detailed dataset by subtracting the number of passengers estimated to have ridden aboard in vehicles on each crossing. To create this record of walk-on passengers, Glosten started with the total passenger count for each crossing and subtracted 1.7 passengers for every vehicle aboard the vessel on that crossing. This ratio of 1.7 passengers per vehicle is based on Glosten's observations of two afternoons of ferry service during the 2017 Labor Day weekend, which may not represent the most common usage patterns.

Figure 13 shows the probability density and cumulative probability of estimated walk-on passenger load sizes in the detailed ridership dataset. The most probable walk-on load is a nearly empty load. Only about 1.2% of walk-on loads (210 crossings per year) reach or exceed the vessel's nominal capacity of 36 walk-ons (represented by darker bars that are too small to be seen).

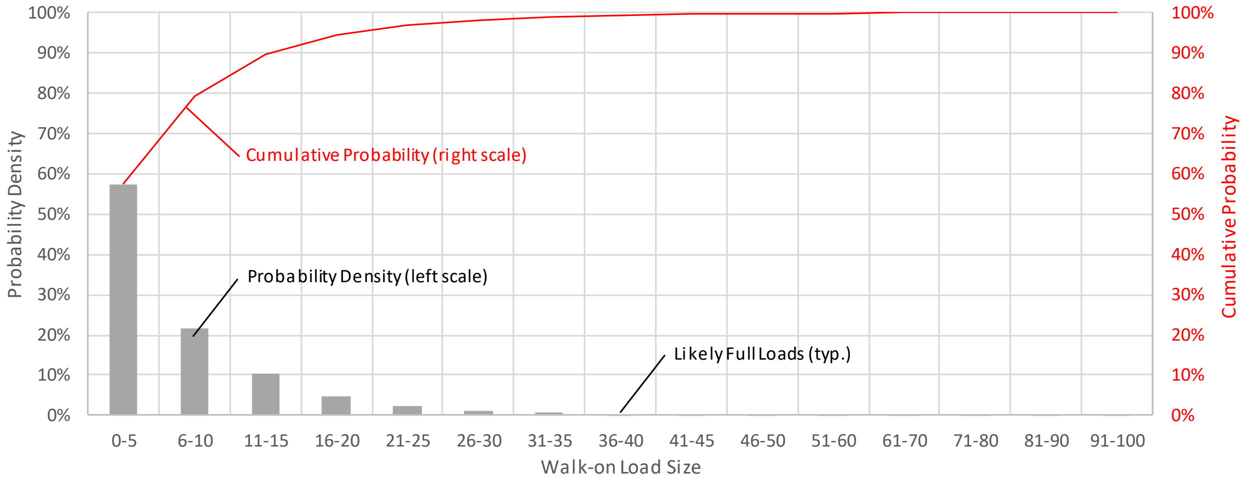

Figure 13 Load size probability distribution for walk-on passengers

1.5.2.3 Vehicles

Figure 14 shows the probability density and cumulative probability of vehicle load sizes in the detailed ridership dataset. The most probable load size is the nominal full capacity of 21 vehicles, and the least probable load is an empty load (zero vehicles). Applying the threshold capacity of 19 vehicles to define a full load (shown as darker bars), it is likely that approximately 22% of vehicle loads (3,700 crossings per year) are full. For loads that are not full or empty, any other load size is roughly equally probable.

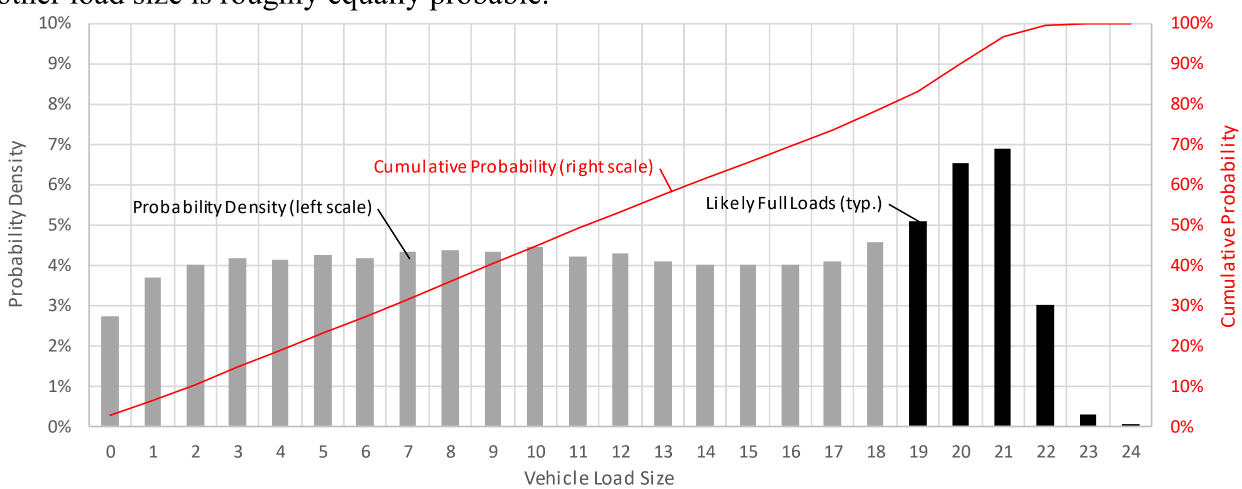

Figure 14 Load size probability distribution for vehicles

1.6 Level of Service for Vehicles

In 2009, Washington State Ferries (WSF) proposed an improved method of measuring the level of service (LoS) that it offers its riders. In this new method, WSF measures the "percent of total sailings filled to capacity in May, August, and January" (Reference 11). Figure 15 shows the new WSF LoS measurement method applied to Skagit County's detailed vehicle ridership record (January 2001 through July 2017) using the threshold vehicle capacity (19 vehicles) to define a full sailing (or crossing). The frequency of full crossings generally decreased from 2001 to 2011 or 2012, and it has been increasing since that time. Following changes to fares and parking, the prevalence of full crossings dropped by a proportionally greater amount in the January sampling period, which is probably most indicative of the behavior of full-time residents. Demand elasticity will be discussed in Section 2.

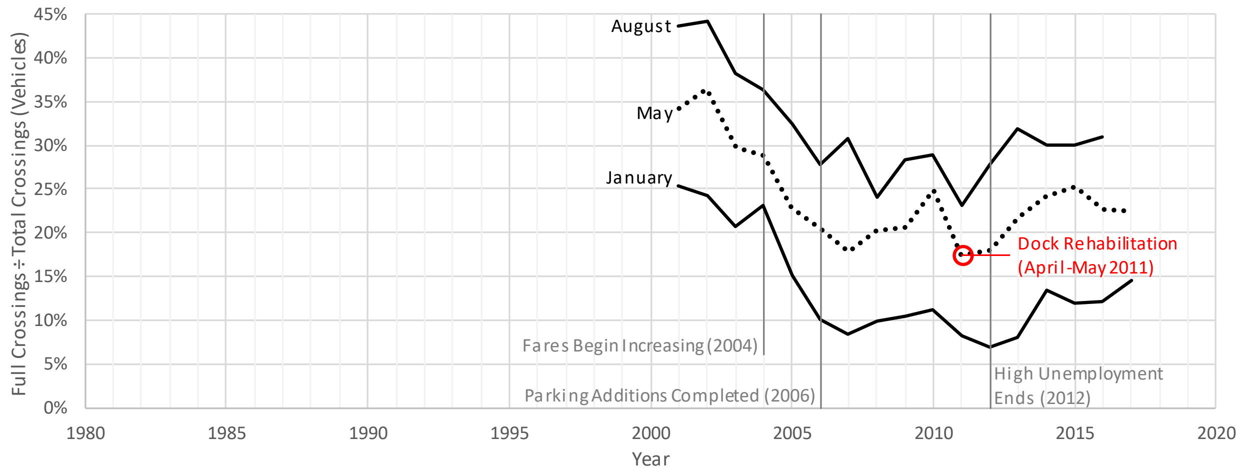

Figure 15 Observed level of service for vehicles

WSF proposes two tiers of standards for its new LoS measurement method. The first tier is a percentage of full crossings above which WSF would implement demand management strategies (e.g. peak pricing or reservations) to reduce congestion. The second tier is a higher percentage of full crossings above which WSF would deploy additional capacity (e.g. a larger vessel). Unlike WSF, Skagit County has no additional capacity on standby, and to date it has not intentionally applied demand management strategies as aggressively as WSF has. Rather than applying WSF's LoS standards, Glosten used Skagit County's observed LoS to develop a provisional standard for the Guemes Island Ferry.

There is evidence that the Guemes Island Ferry has consistently provided a LoS that riders perceive to be adequate. Skagit County is not aware of any widespread complaints regarding vessel capacity. The Guemes Island Ferry Committee, which represents the interests of ferry riders, stated in 2014 that "the physical vehicle capacity of the *Guemes* has not been reached," and that summer congestion remains tolerable (Reference 10). Based on this information, Glosten has compiled the highest percentages of observed full crossings in Table 1 for use as provisional LoS standards. These provisional standards apply to a single vessel running on the existing schedule. These standards are provisional because riders might accept higher percentages of full crossings if they were exposed to them. To some degree, the percentage of full crossings may be self-limiting, as would-be drivers may forgo driving at the busiest times.

Table 1 Provisional level-of-service standards for the Guemes Island Ferry

Month	Acceptable Full Crossings
January	25%
May	36%
August	44%

Glosten did not calculate a provisional LoS for total passengers or walk-on passengers because full loads are rare. When walk-on loads exceed the vessel's nominal capacity, there is almost always passenger overflow space on the vehicle deck.

Available evidence suggests that the existing Guemes Island Ferry has provided a satisfactory LoS throughout its life. This observation carries into the sizing of the replacement vessel in Section 4.

Section 2 Forecasting Methodology

Glosten developed a multivariable forecasting model for annual passenger and vehicle ridership based on factors that drive demand, such as population, fares, and free parking. The three recent years of excessive outages (2005, 2011, and 2014) were discarded from the sample data used to build the model, which reduces the effect of recent events on the model's coefficients.

2.1 Ridership Pool

Ridership has roughly doubled since 1980. In its simplest terms, this increase in ridership must be caused either by the same number of people riding the ferry more frequently, or by many more people riding the ferry. It is logical to conclude that many more people now ride the ferry. The term *ridership pool* refers to this growing group of people who would like to ride the Guemes Island Ferry.

Glosten's ridership forecast model is an econometric model. It tests the theory that people in the ridership pool respond to changes in fares and service, even though the ferry is the only practical means of crossing Guemes Channel. In order to test this theory, Glosten needed a way to measure the strength of demand expressed by the ridership pool, regardless of the ridership pool's size. Removing the data's dependence on pool size allows one year's ridership demand to be compared directly with another year's ridership demand.

The size of the ridership pool changes over time, and it cannot be determined directly. Therefore, it must be estimated indirectly by a proxy population that is an unknown but fairly stable multiple (or fraction) of the ridership pool size. The ideal proxy population must have an accurate historical record in order to build a good model, and it must also have reliable forecasts available in order to be a meaningful predictor.

Glosten considered the following datasets as proxies for the ridership pool, assuming that they would account for the most active riders:

- **Dwelling units on Guemes Island:** This record was thought to indicate the number of destinations on Guemes Island, thereby linking it closely with the size of the ridership pool. A multivariable model including the number of dwelling units on Guemes Island matched the historical ridership data very well. Unfortunately, this record could not be used as a predictive tool because existing forecasts vary considerably as a result of uncertainties in planning policies and sensitivity to landowners' decisions.
- **Population of Guemes Island:** This record is represented by Skagit County census tract 9501, block group one. It was ruled out because it may exclude many part-time residents, because data do not exist between 1971 and 1999, and because no forecasts have been made for this small group.
- **Population of Anacortes and 98221 zip code:** These records were ruled out because rigorous forecasts have not been made.
- **Population of unincorporated Skagit County:** This record was ruled out because rigorous forecasts have not been made.
- **Population of Skagit County:** This record is represented by Reference 12. It offered a rich historical dataset and the most rigorous forecast treatments and planning policies, so Glosten chose it as the proxy for the ridership pool.

Figure 16 shows a time history of Skagit County population on the left and the relationship between Skagit County population and ridership on the right. Ridership is strongly positively correlated with Skagit County total population (a correlation coefficient of 0.85 for passengers and 0.67 for vehicles), indicating that this population may be a reasonable proxy for the ridership pool.

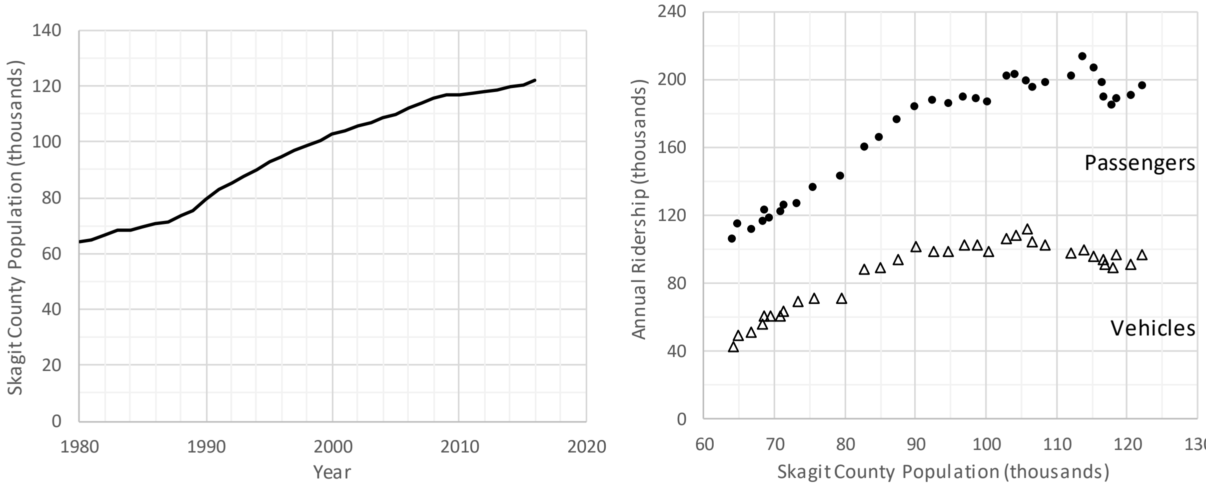

Figure 16 Population as a function of time (left) and ridership versus population (right)

Glosten calculated *ridership per capita* by dividing the annual Guemes Island Ferry ridership by the population of Skagit County in that year. Based on the assumption that Skagit County population is a stable multiple of the ridership pool size, ridership per capita indicates the variation in rider demand from year to year. Figure 17 shows the historical record of passenger and vehicle ridership per capita over time. Demand appears to have increased from 1980 to 1990; it was fairly steady from 1991 to 2002; it dropped from 2003 to 2012; and it has been steady since then. Glosten's econometric model seeks to explain these variations in demand in order to improve the accuracy of the ridership forecast.

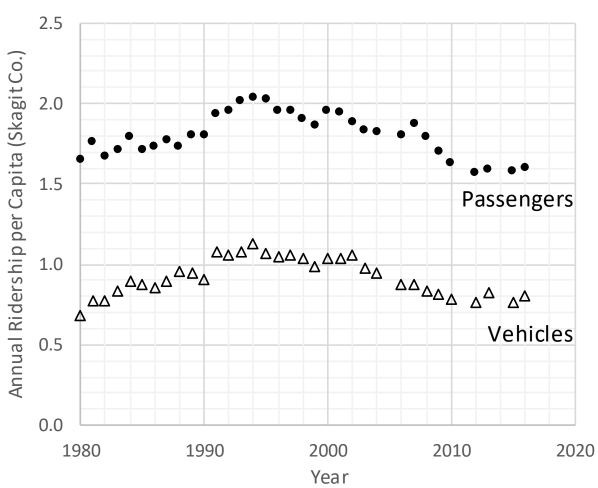

Figure 17 Ridership per capita versus time

2.2 Input Variables

Glosten considered a range of publicly available data that could potentially affect rider demand. The budget and scope of this analysis limited the number of input variables that could be considered, so Glosten focused on identifying variables whose values could be predicted, thereby making them useable in the forecast. The result of Glosten's variable search is summarized below. All monetary values were adjusted for inflation to summer 2017 by means of the Consumer Price Index–Urban (CPI–U) for Northwest Washington (Reference 13).

- **Fares:** Summer and winter fares for passengers and cars (with drivers). Increased fares reduce passenger and vehicle ridership. This relationship is discussed in Sections 2.2.1.1 and 2.2.1.2.
- **Housing market:** Case-Shiller Index (national); Housing Market Index (national, starting in 1985). No justifiable correlations were found.
- **Macroeconomics:** Unemployment rate (Washington State annual; Anacortes & Mount Vernon area starting in 1990). Increased unemployment slightly reduces ridership, but unemployment cannot be predicted. Glosten concluded that economic cycles affect ridership mildly in ways that cannot be predicted or planned.
- **Parking:** Number of parking spaces at the Anacortes and Guemes terminals. Increased parking reduces vehicle ridership. This relationship is discussed in Section 2.2.2.
- **Schedule:** Number of scheduled round-trips per week (summer and winter); number of hours of service per week (summer and winter). A brief increase in ridership coincided with the 1992 schedule extension, but the major schedule extension in 2006 appears to have had no effect on ridership. The overall relationship was statistically insignificant; schedule was not used in the model.
- **Weather:** Average summer air temperature in the Puget Sound region. No justifiable correlation was found.

2.2.1 Fares

In the discussion of fares that follows, fares are shown in 2017 dollars. Figure 18 shows passenger fares (left) and car & driver fares (right) in nominal dollars and in 2017 dollars to provide additional context regarding the effect of inflation. Figure 18 indicates that passenger fares and car & driver fares have generally stagnated or increased together. This correlation makes it difficult to separate the effects of passenger and vehicle fare increases.

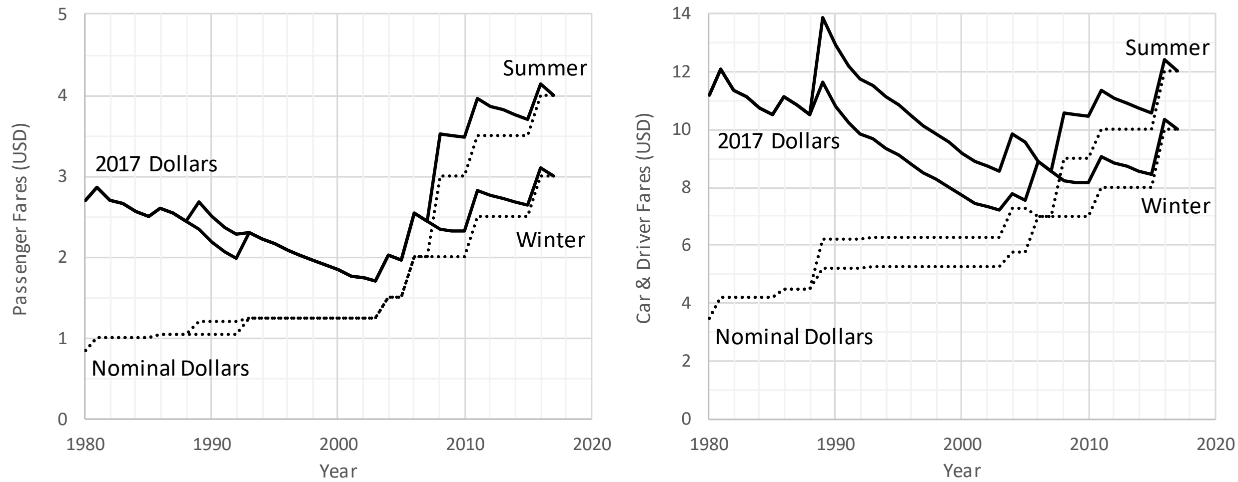

Figure 18 Passenger fares (left) and car & driver fares (right) in nominal dollars and in 2017 dollars

Another factor that clouds the effects of fare increases is the relative cost of driving on versus walking on. As the left plot in Figure 19 shows, the marginal cost of driving on was decreasing or steady between 1989 and 2015. As the right plot in Figure 19 shows, car fare is now only three times the cost of a passenger ticket, whereas it used to be four to five times the cost of a passenger ticket.

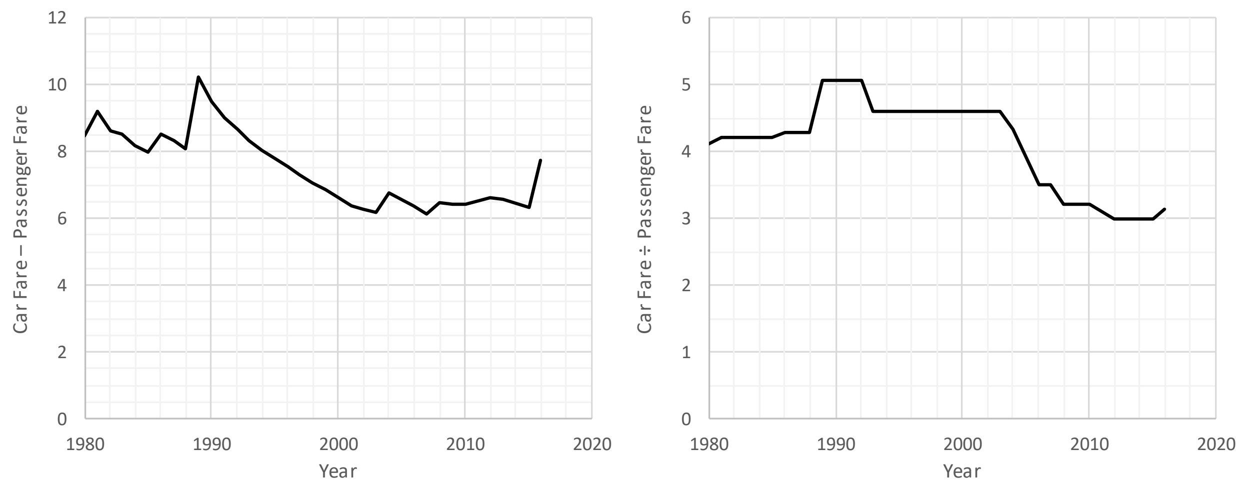

Figure 19 Difference (left) and quotient (right) of car fare and passenger fare as a function of time

2.2.1.1 Passenger Fare

Glosten selected the average of summer and winter passenger fares (Reference 14) in 2017 dollars as a simplified proxy for passenger fare. Figure 20 shows a time history of average passenger fare on the left and the relationship between passenger fare and ridership per capita on the right. After declining in real terms for at least 26 years, passenger fare began increasing again in 2003. The average passenger fare is now 27% higher than it was when the existing ferry entered service, and twice as high as it was in 2003. Ridership is negatively correlated with passenger fare, although the elasticity in demand appears to disappear below $2 and above $3. The drop in ridership per capita between $2 and $3 may indicate the fraction of trips that riders consider discretionary or nonessential in that price range.

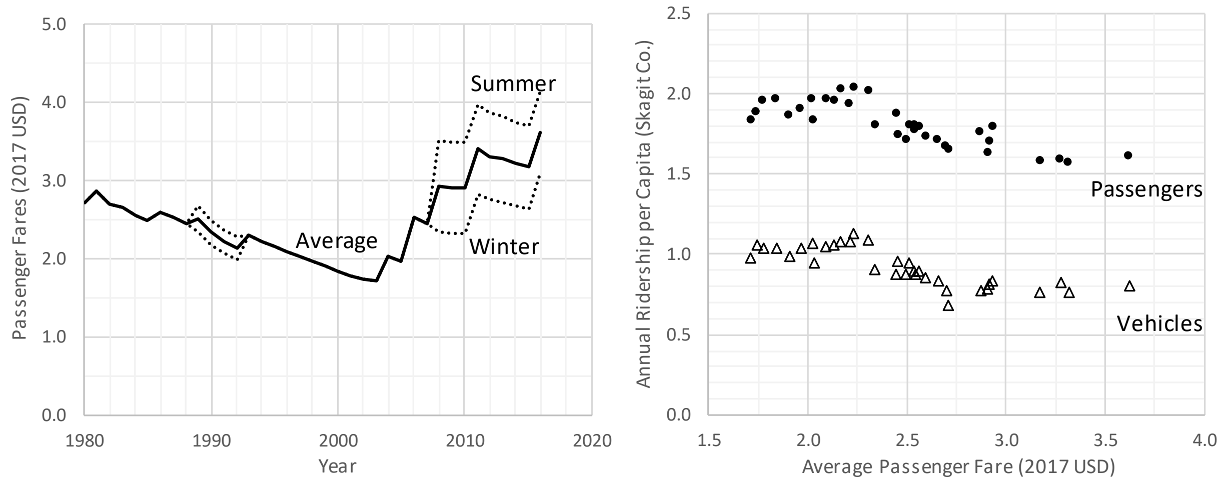

Figure 20 Passenger fare as a function of time (left) and ridership plotted against passenger fare (right)

2.2.1.2 Car & Driver Fare

Glosten selected the average of summer and winter car (and driver) fares (Reference 14) in 2017 dollars as a simplified proxy for vehicle fare. Figure 21 shows a time history of average car fare on the left and the relationship between car fare and ridership per capita on the right. Car fare mostly decreased in real terms in the two decades prior to 2003. It has increased 39% since 2003, although it has not yet reached its 1989 level. At first glance, ridership appears to be only slightly negatively correlated with car fare. Yet as the solid red points show, after a period of riders' indifference to car fares, demand became elastic after car fares bottomed out in 2003 and began rising. This elasticity was pronounced between \$8 and \$10; above \$10 there appears to be no further elasticity. Vehicle elasticity is probably limited by drivers who are less willing or able to accept walking on as a substitute, especially if there is limited parking near the terminals.

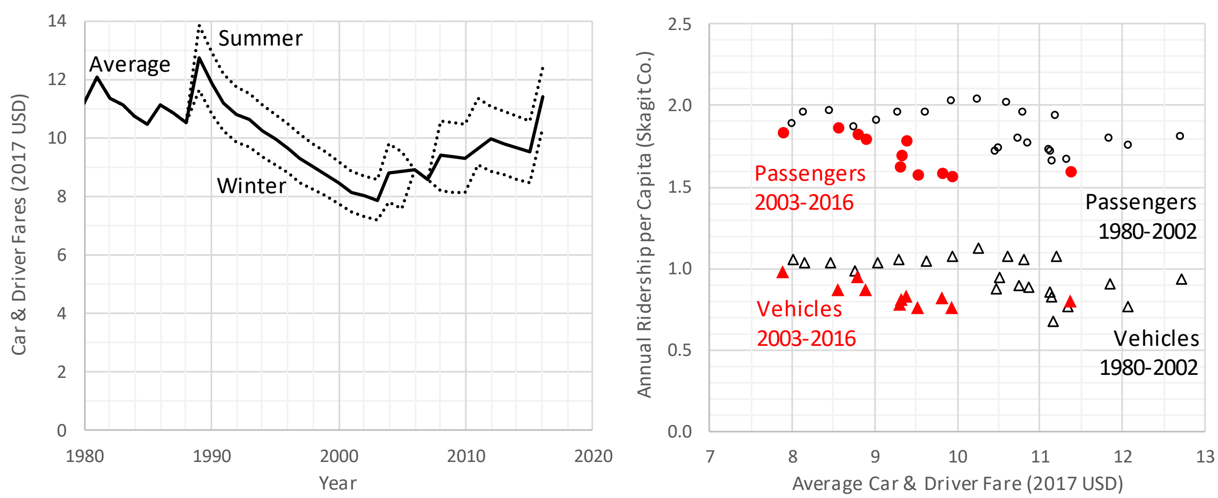

Figure 21 Car & driver fare as a function of time (left) and ridership plotted against car & driver fare (right)

2.2.2 Parking

Glosten calculated the average number of parking spaces between the Anacortes and Guemes terminals per 1,000 Skagit County residents as a proxy for the amount of parking available to the ridership pool. These calculations were based on the Guemes Island Subarea Plan (Reference

15), historical and current aerial photographs (Reference 16), and assessor records (Reference 17). Figure 22 shows a time history of parking on the left and the relationship between parking and vehicle ridership on the right. Vehicle ridership is negatively correlated with parking. Looking back to Figure 7, the passenger-vehicle ratio rose when parking facilities expanded at both terminals in 2005-2006, and it has remained elevated since that time, indicating that would-be drivers may be taking advantage of convenient parking and walking on instead. To date, parking has been free. The impact of parking would change if Skagit County began charging for it.

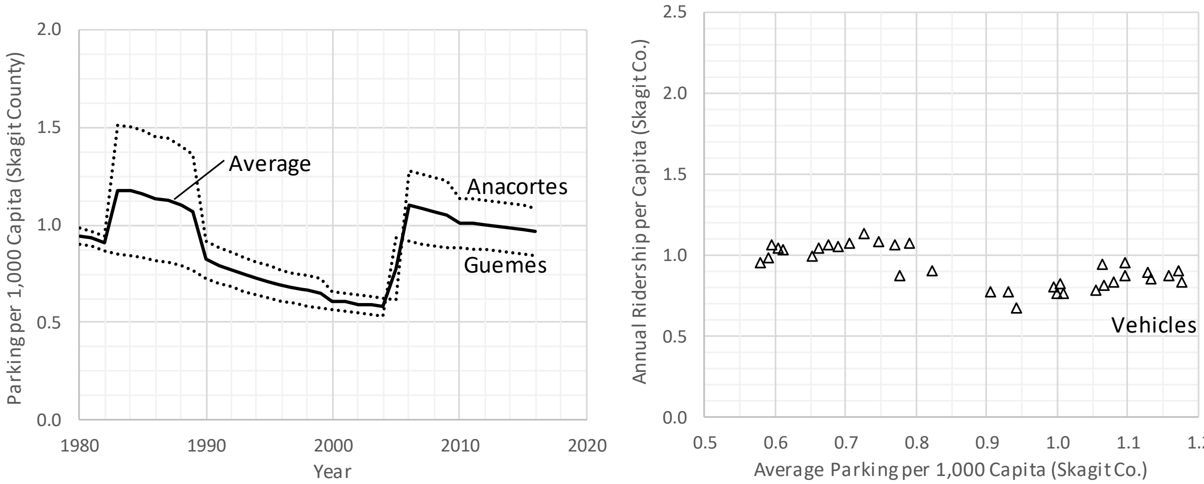

Figure 22 Parking spaces as a function of time (left) and vehicle ridership plotted against parking (right)

2.3 Forecast Model Validation

Figure 23 shows the fit of Glosten's forecast model to the underlying data. The correlation coefficient is 0.95 for passengers and 0.92 for vehicles, indicating a fairly close fit. The model is a function of Skagit County total population, average fares, and average number of parking spaces (for vehicles only). Glosten chose these variables because they exhibit the strongest influence on past ridership, and because it is possible to estimate or to manage their levels in future decades.

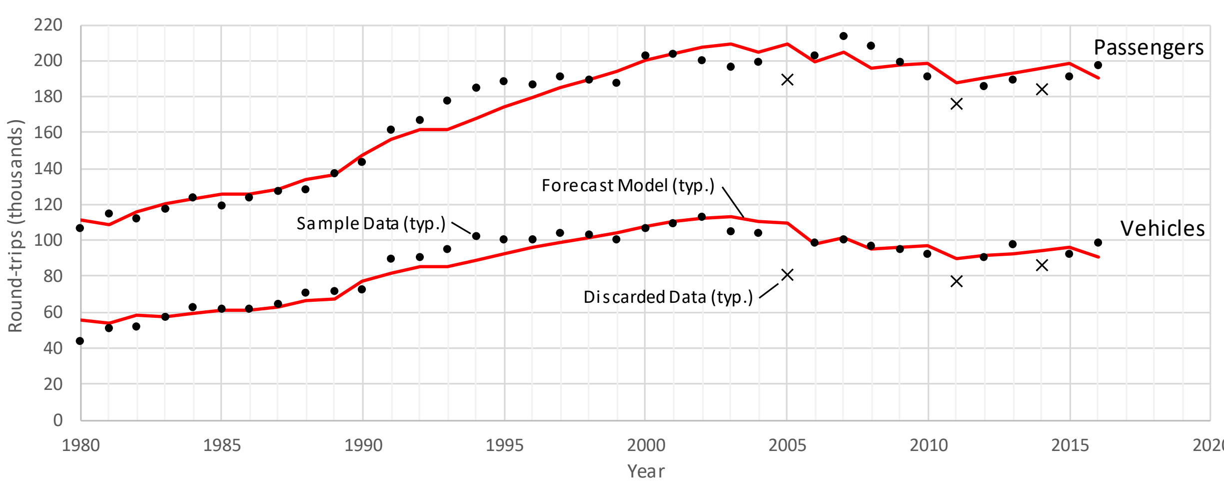

Figure 23 Forecast model of passenger and vehicle ridership with underlying data

2.4 Forecast Model Assumptions

Glosten's forecast model was used to estimate ridership, and ultimately vessel capacity, for the years 2020 through 2060. A starting year of 2020 was selected because it coincides with Skagit County's target date for the new vessel to enter service. An ending year of 2060 was selected because it represents a 40-year service life, which is toward the high end of a typical ship's economic life, and because many ferries in the Pacific Northwest have been in service for 40 or more years. Given that the existing Guemes Island Ferry will be 41 years old in the target replacement year, it seems reasonable to assume that the new ferry would need to serve the route for approximately 40 years thereafter.

Table 2 shows the two operational practices considered in the forecast model. The data show that fare elasticity exists but is inconsistent: riders seem to react differently to changes in fares depending on the context of the changes. Sensibilities may change over time as well. In order to account for the ongoing impact of fare elasticity on ridership, Glosten chose a fare that resulted in lower than average ridership per capita, and a fare that resulted in average ridership per capita. In order to evaluate the impact of parking on ridership, Glosten evaluated a scenario where the present level of parking per capita is maintained by incrementally adding parking, and a scenario where no further parking is added and parking per capita gradually declines as population increases.

Table 2 Ridership forecast operational practices

Description	Lower Ridership	Higher Ridership
Fares	Maintain a fare structure that discourages ridership.	Maintain a fare structure that neither encourages nor discourages ridership.
Parking	Add spaces to keep parking per capita constant from 2017 to 2060.	No additions; parking per capita declines from 2017 to 2060.

Glosten considered three different population growth projections:

- **Low population growth:** This scenario uses the "modified OFM low" population projection released by Berk Consulting in 2016 (Reference 18), extrapolated beyond its endpoint in 2036 using the growth rate of the "OFM 2000-2030 low-series linear trend" in the Skagit Alternative Futures Population Projections (Reference 19), which extend to 2060.
- **Average population growth:** This scenario uses the 2012 medium population projection released by the Washington State Office of Financial Management (OFM; Reference 20), extrapolated beyond its endpoint in 2040 using the growth rate of the "OFM 2000-2030 medium-series linear trend" in the Skagit Alternative Futures Population Projections. Skagit County planning officials believe that it is the most probable population trend (Reference 18).
- **High population growth:** This scenario uses the "hypothetical SCOG target" population projection released in the Skagit Alternative Futures Population Projections. This population projection was envisioned as a middle path when it was released in 2009, but it now appears unlikely to be exceeded in 2060 without aggressive growth.

Table 3 presents the four ridership forecast scenarios that Glosten considered. The medium-low and medium-high scenarios bracket the most likely outcome, and the low and high scenarios bracket the range of probable outcomes.

Table 3 Ridership forecast scenarios

Scenario	Operational Practice	Population Growth
Low	Lower Ridership	Low Growth
Medium-low	Lower Ridership	Medium Growth
Medium-high	Higher Ridership	Medium Growth
High	Higher Ridership	High Growth

2.5 Model Limitations

The coefficients of the forecast model are based on rider behaviors that have been observed over the past 37 years. The inputs of the forecast model are based on planning predictions and past ferry operations. If the ridership pool's behavior appears to change, or if the forecast scenarios appear to be invalid, then the forecast should be updated. Some additional factors that affect ridership but are not accounted for in the forecast are as follows:

- **Demographic changes:** The demand pool could expand, shrink, or shift in a way that is no longer represented by Skagit County total population. Riders' requirements and attitudes could change over time, affecting their responses to operational practices. Seasonal demand patterns could change over time.
- **Economic cycles:** Economic cycles affect ridership mildly, but they cannot be predicted.
- **Induced demand:** When the new ferry enters service, there may be a surge in vehicle ridership to absorb the extra vehicle capacity, because driving on is more convenient than parking and walking on.
- **Natural events:** Adverse weather generates spikes in truck traffic. Major natural disasters could reduce population, housing, and demand.
- **Policy changes:** Changes in land-use, planning, and development policies could change the population on and around Guemes Island and the ways in which the land on Guemes Island is used, ultimately changing the size and characteristics of the demand pool.
- **Technological changes:** Advances in technology and automation may change the quantity and pattern of passenger and vehicle demand. These advances may also affect operations in ways that cannot be foreseen today.

Section 3 Annual Ridership Forecast

Figure 24 and Figure 25 show the range of ridership forecasts for passengers and vehicles to the year 2060. These forecasts represent average lines about which annual ridership is predicted to oscillate, and they assume that demand is independent of vessel size. The past ridership record is shown for reference. The prediction from the 2007 Guemes Island Ferry Capital Facilities Plan (GIFCFP; Reference 5) is shown for reference. The peak ridership year of the existing ferry and the forecasted peak ridership year of the replacement ferry are identified as points. Skagit County has chosen to pursue the medium-low outcome for ferry planning purposes. Annual passenger ridership is forecasted to increase to approximately 346,000, which is 77% above 2016 levels. Annual vehicle ridership is forecasted to increase to approximately 170,000, which is 74% above 2016 levels. By comparison, passenger ridership increased 85% from 1980 to 2016, and vehicle ridership increased 125% from 1980 to 2016.

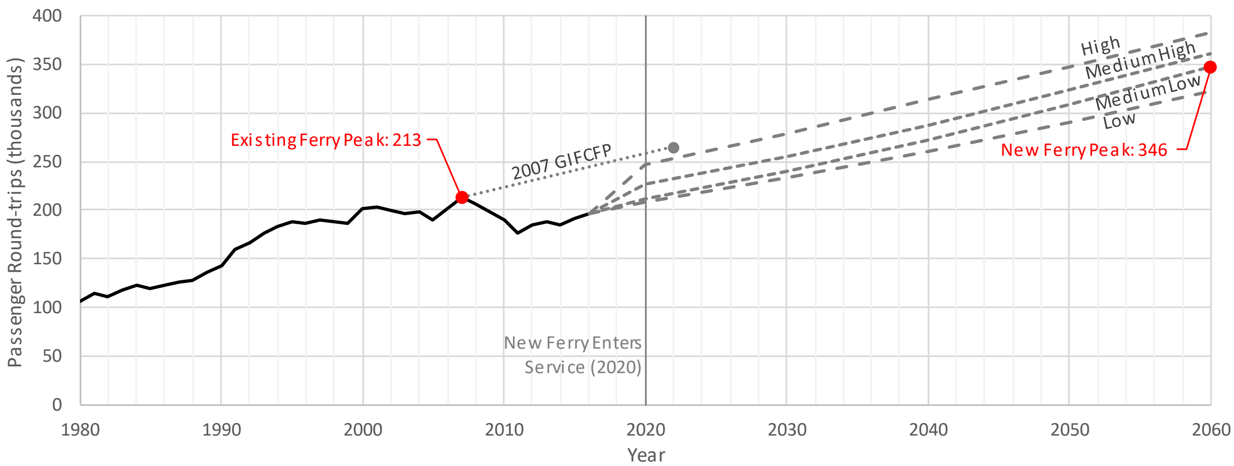

Figure 24 Passenger ridership history and forecast with four growth trends (medium-low chosen)

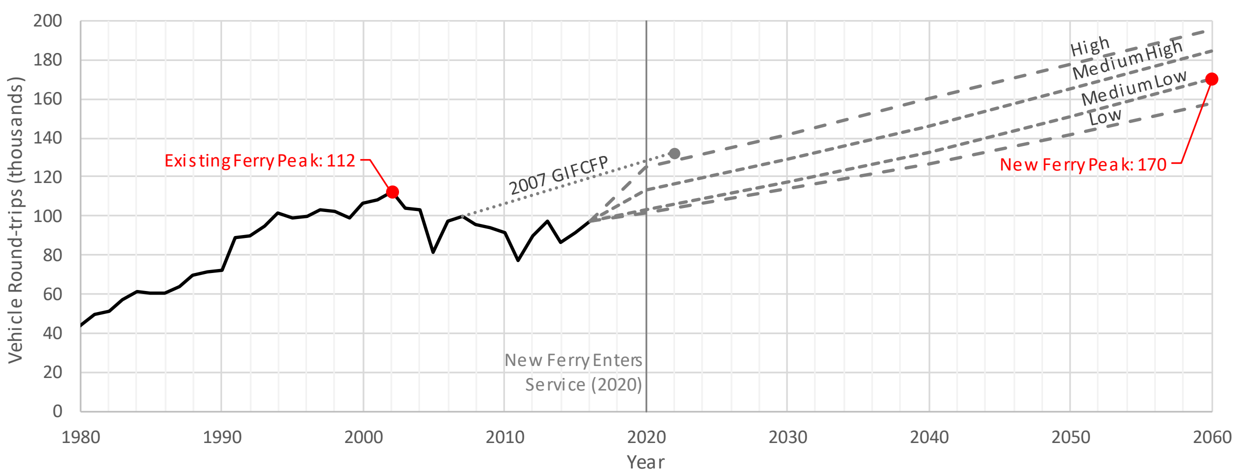

Figure 25 Vehicle ridership history and forecast with four growth trends (medium-low chosen)

The ratio of the replacement vessel's peak ridership to the existing vessel's peak ridership is used to scale the capacity of the replacement vessel. This method is described in Section 4.

Section 4 Vessel Capacity Forecast

Glosten's vessel capacity forecast is based on four key assumptions:

1. The same number of ferries will be serving the route.
2. The same schedule is maintained during peak demand times.
3. The cyclical distribution of demand does not change over the years (recall Sections 1.4 and 1.6).
4. Operations, terminals, and uplands do not impose lesser limitations on ferry capacity.

If these assumptions hold true, then the nominal capacity of the new ferry, C_n, is linearly scalable by the proportional increase in ridership:

$$C_n = C_e \frac{R_n}{R_e}$$

where:

C_e = nominal capacity of the existing ferry
R_n = annual ridership of the new ferry in its busiest year (assumed to be its final year of service)
R_e = annual ridership of the existing ferry in the busiest year that it provided an acceptable level of service

Values for R_e and R_n are identified in Figure 24 and Figure 25. Recall from Section 1.6 that the existing ferry appears to have met demand successfully in its busiest years of operation. Chosen values for C_e are as follows:

- 100 passengers per Section 1.5.1.1.
- 21 vehicles per Section 1.5.1.3.

Figure 26 and Figure 27 show the range of vessel capacity forecasts for passengers and vehicles, as well as the limitations to vessel capacity. The capacities of the existing and previous ferries (*Guemes* and *Almar* respectively) are shown for reference. Figure 27 also contains the recommendation made in the Guemes Island Ferry Replacement Plan (GIFRP; Reference 21) to add four vehicles to the existing vessel's capacity in order to gain an additional 15 years of service before retirement. The selected capacities of the new ferry are shown as points. These capacities were determined in the following ways:

- A capacity of 162 passengers corresponds with the medium-low ridership forecast. However, vessels subject to the US Coast Guard's Subchapter T regulations cannot carry more than 150 passengers per 46 CFR § 175.110 (Subchapter T limit; Reference 8). The next tier of regulatory requirements imposes significant additional capital and operational expenses. If current ridership patterns hold, then a capacity of 150 passengers would be sufficient for 99.9% of the new ferry's crossings in its busiest year. It would be impractical to exceed the Subchapter T limit in order to save a one-trip wait for a handful of riders in the final decade of the new ferry's life. Therefore, the new ferry will have a capacity of 150 passengers.
- A capacity of 32 vehicles corresponds with the medium-low ridership forecast. There is an upper limit to the number of vehicles that could be carried while maintaining a reliable schedule of two round-trips per hour. Glosten is in the process of calculating this limit; it appears likely to be approximately 33 vehicles, assuming that walk-ons and vehicles would be able to load (and to unload) simultaneously on the new vessel. Given these

limitations, there is probably little to gain by attempting to exceed the medium-low vehicle capacity forecast. Therefore, the new ferry will have a capacity of 32 vehicles.

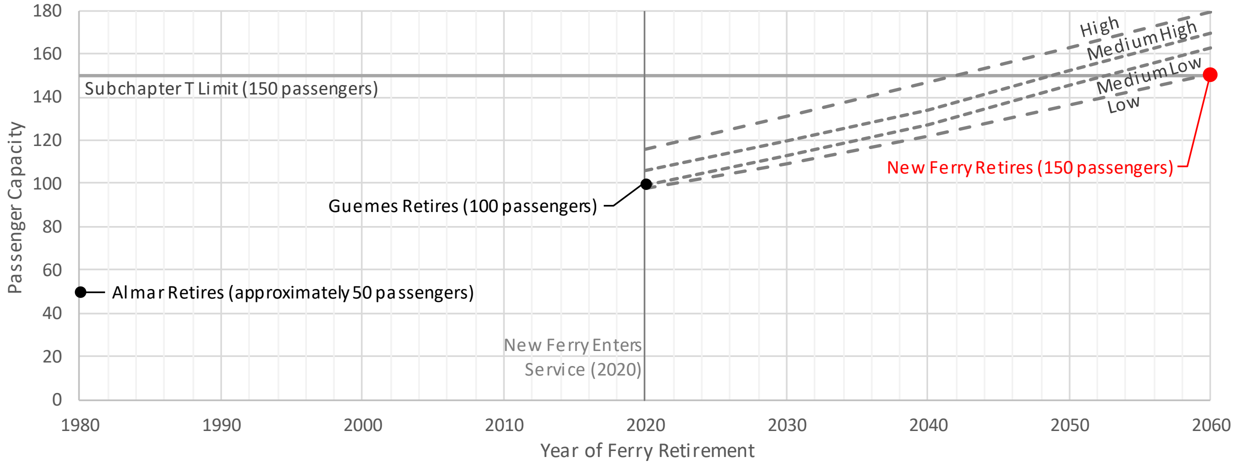

Figure 26 Passenger capacity history and forecast with four growth trends (limited by Subchapter T)

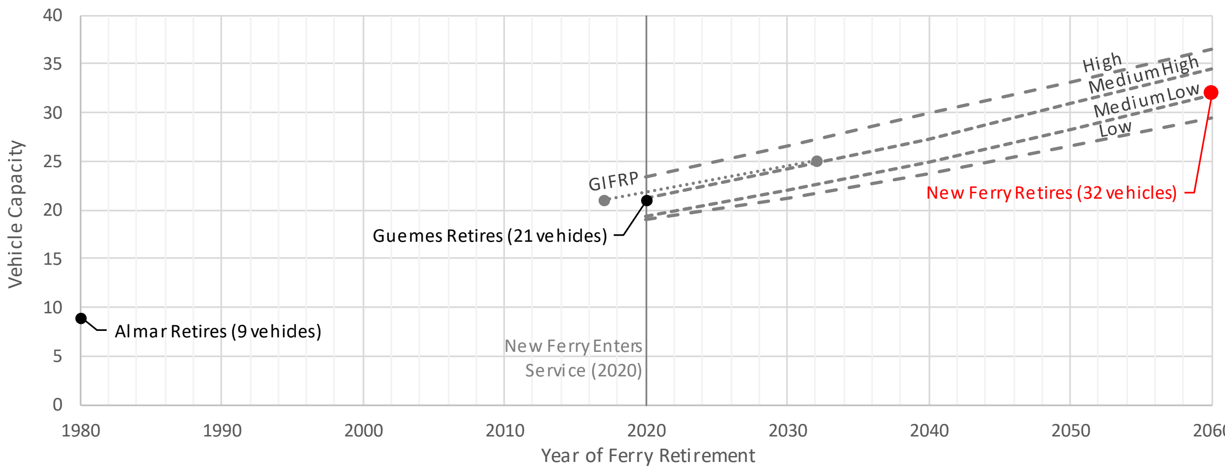

Figure 27 Vehicle capacity history and forecast with four growth trends (medium-low chosen)

These vessel size forecasts indicate that the next vessel replacement effort in the middle of the 21st century could be more challenging. The next replacement vessel may have difficulty maintaining two round-trips per hour without a two-lane loading system. Rider demand may require the vessel to carry more than 150 passengers, thereby changing the regulatory regime and adding considerable cost. A two-vessel system could be an alternative solution to both of these problems, but it has its own disadvantages. These issues may merit consideration in future long-range planning exercises.

There is no "perfect" capacity for the new Guemes Island Ferry. Historical ridership records indicate that there is almost certainly ongoing elasticity in rider demand. Given incentives and alternatives, riders have found a way to share *Guemes* harmoniously with more than twice the number of people who used it in its first year of service. The ridership and capacity forecasts in this report reflect Skagit County's and Glosten's best attempt to make a scientific and sensible decision regarding vessel size. The Guemes Island Ferry's success in the next 43 years depends largely on the way that riders decide to use it.