Passenger-Only Ferry Service Between Vashon Island and Seattle, Washington

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On April 23, 1990, passenger-only ferryboat service was offered as an alternative to automobile ferry users commuting between the Seattle/Tacoma mainland and Vashon Island. The consequences of introducing this regularly scheduled passenger-only ferry service on Puget Sound are discussed. The results are being used by the Washington State Ferry System Planning Office to assist in decisions for expanding passenger ferry service in the future. Results of a survey of passenger-only and automobile ferry service riders were used to fit a logit model for predicting future mode shift. Since the survey data were attitudinal, the logit model was intended to identify the target populations most likely to shift mode from automobile ferry to passenger-only ferry service. The attributes of the ferry system that are most important in selecting between the two modes of transportation were investigated. The results indicate that providing passenger ferry service can cause a mode shift from drive-on automobile ferry passengers to walk-on passengers. For the passenger ferry service studied, 11.7 percent of the passenger ferry users were former single-occupant vehicle (SOV) drivers. Since the new passenger ferry carried 10.7 percent of the total afternoon ferry rides, this meant that a mode shift of nearly 2 percent of SOV drivers to walk-on passengers was realized after 1 year of passenger ferry service between Vashon Island and Seattle. The degree of mode shift depended on the ferry routes and location of the ferry terminals. Travel time was a significant factor in the choice between passenger ferry and automobile ferry service. The results indicated a significant number of new riders (25 percent). Some people moved to Vashon Island because passenger service was made available. It was concluded that the passenger ferry contributes to the regional goal of reducing reliance on the automobile.

The Pacific Northwest of the United States contains nearly every feasible transportation mode in existence. One type of transportation often associated with the Pacific Northwest is the ferry system. There are other ferry systems in the United States, but the Washington State Ferry (WSF) System is the largest in the Western Hemisphere and is crucial to the Puget Sound region. The WSF System carries more than 20 million passengers each year and approximately 9 million vehicles.

The WSF System operates as the Marine Division of the Washington State Department of Transportation (WSDOT). The ferry system, in an effort to contribute to the regional goal of reducing reliance on the single-occupant vehicle, recently began passenger-only ferry service and has plans to increase the use of these ferry vessels in the future. To maximize the effectiveness of using passenger-only ferry service, it was necessary to measure the impact of the newly established passenger-only ferry service. This paper documents that study.

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PROBLEM STATEMENT

Passenger-only ferryboat service was offered as an alternative to automobile ferry users commuting between Vashon Island and the Seattle-Tacoma mainland (see Figure 1) beginning April 23, 1990. There have been no previous studies of the behavior of ferry commuters when offered this alternative. The objective of this study was to determine the consequences of introducing regularly scheduled passenger-only ferry service on the Seattle-Vashon route on Puget Sound.

The WSF System planning office seeks to increase its knowledge base on passenger-only ferry service to enhance future policy decisions. It is likely that increased passenger-only ferry service on Puget Sound will be considered in the near future. By understanding the existing passenger-only service, it is hoped that some inferences can be drawn about future service on other routes and about policy decisions on fares, frequency of service, and effect on mode choice.

STATE OF THE ART

An exhaustive literature search was undertaken to identify the state of the art in passenger-only ferry service. Private consultants' reports for the WSF System were reviewed and ferry systems in New York and British Columbia were contacted. The search revealed a variety of information on the history of ferry service and vessel characteristics but very little on passenger-only ferry service and its effect on mode choice.

A few surveys were conducted for the WSF System before establishment of the first passenger-only ferry service. In February 1988 a one-page mail-back survey was sent to all Vashon/Maury Island households with a 25 percent response rate (*1*). The result indicated that the passenger-only ferry would have a usage of about 370 weekday round-trips with 15 to 36 percent of the vehicles being driven on the Vashon/Fauntleroy ferries removed by the passenger-only ferry service. Another survey conducted in January 1989 analyzed the trip characteristics of commuters traveling between Vashon Island, Southworth, and the Seattle-Tacoma mainland (*2*). Information on origins and destinations, departure times, travel patterns, attitudes, ferry information sources, and interest in passenger-only ferries was gathered. The interest in passenger-only ferry service was significant, with more than 40 percent of the respondents indicating that they would be very likely or somewhat likely

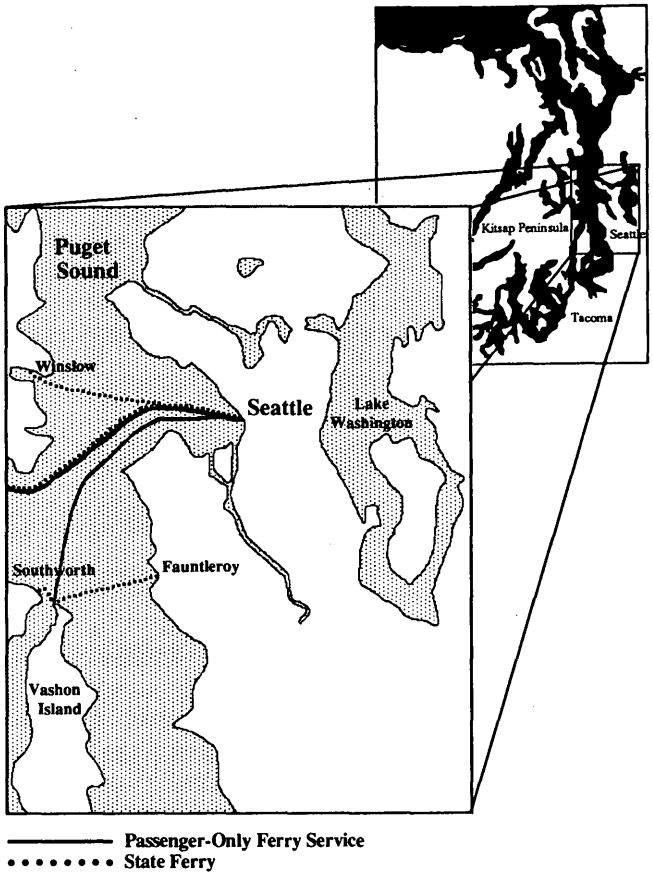

FIGURE 1 Vicinity map.

to use passenger-only service if the schedule met their personal needs.

Some pilot studies were also conducted before establishment of the passenger-only ferry system in the state of Washington. In August 1987 a study documenting the 1986 demonstration of passenger-only ferry service between Bremerton and Coleman dock in Seattle (*3*) indicated that the potential for converting noncommuters to passenger-only ferry service seemed much higher than that for converting commuters. Another passenger service test using a Boeing Jetfoil was documented in an internal report produced by WSDOT in December 1978 (*4*). The study concluded that there was a high degree of acceptance of high-speed passenger-only ferry service. However, the study also found that the test service was not successful in attracting a large number of cross-Sound commuters, particularly those who would have otherwise driven their vehicles. Although the report concluded that in the short term there were few routes that would make the service a viable option, a long-term commitment to promote passenger-only travel and reduce automobile usage had potential.

Two relatively recent studies of the Staten Island Ferry in New York hold promise for expanding passenger-only ferry service. The first, a case study of passenger-only ferry service between Staten Island and the Manhattan central business district (CBD) (*5*), evaluated high-speed passenger ferries operating at a cruising speed of 35 mph. The other modes available to these commuters involved commuting across one of two bridges or taking one of three automobile ferries. The report concluded that high-speed passenger-only ferry service holds great promise as a transportation alternative for this origin-destination pair. A second study by the same author (*6*) used a mail-back survey sent to more than 5,000 households in a selected area on Staten Island. The survey response produced approximately 1,000 observations for fitting a logit model. The model was developed to predict the mode split between ferry, express bus, and automobile. The results indicated that travel time is of extreme importance to persons using the ferry service. Other variables found to be significant for ferry riders were cost, access time to terminal, and comfort.

Although the transportation archives contain very few articles on this mode of transportation, interest in passenger-only ferry service seems to have increased in the last few years. As transportation agencies and policy makers review ways to maximize efficiency and reduce, or at least slow, the growth of automobile use, alternatives to the single-occupant vehicle are constantly being sought. The potential ridership for passenger-only ferry service will depend on the route selected and various factors influencing people's decisions to use this mode.

STUDY APPROACH

The primary objective of this research was to quantify the mode shift occurring after the passenger-only ferry service alternative was provided to commuters traveling between Vashon Island and the Seattle CBD. A secondary objective was development of a statistical model that predicts the likelihood of a person choosing passenger-only ferry service over the automobile ferry. The necessity of gathering information on commuters and the attributes of the ferry system that influence their decisions regarding mode choice led to the selection of a self-administered questionnaire for the data collection. The vicinity map in Figure 1 shows the routes under study.

The majority of the systemwide ferry service is provided by 22 automobile ferries ranging in vehicle capacity from 40 to 206 cars. The ferry system also operates three passenger-only ferryboats, two monohulls and one catamaran, each with a passenger capacity of 250. The catamaran is used when one of the monohull vessels is out of service due to routine maintenance or mechanical failure.

The automobile ferries that serve Vashon Island have broad, spacious, heated seating arrangements with large open windows and areas to walk outdoors on deck. The automobile ferries also have cafes on board and newspaper racks. The passenger ferries have two decks; one deck has four television sets, and there is also a small snack bar. The sailing and fare schedules in effect when this study was conducted are given in Tables 1 and 2.

SURVEY

The survey gathered results from one of three automobile ferryboats sailing between Fauntleroy and Vashon/Southworth. This boat accounted for three of nine weekday afternoon sailings. The survey also gathered results from all afternoon sailings of the passenger-only ferry from Seattle to Vashon Island for that day. The total observations of 711 riders were composed

TABLE 1 Sailing Schedule, Seattle/Vashon, Tuesday, May 14, 1991 (Approximate Crossing Time 25 min)—Passenger-Only Ferry

Leave Seattle	Leave Vashon
6:00 a.m.	5:30 a.m.
7:30	7:00
8:40	8:10
3:05 p.m.	9:25
4:35	3:45 p. m
5:50	5:15
7:00	6:20
8:00	7:35
11:30[A]	8:30
	12:00 Midnight[A]

BASIC FARE
$3.30 per passenger, round trip.
(10% discount with a commuter book)

[A] *Fridays only*

of 404 observations from the automobile ferry and 307 from the passenger-only ferry. The total number of afternoon automobile ferry users was 1,752, and the total number of afternoon passenger-only ferry users was 348, for a total of 2,100 afternoon ferry users on the date of the study. The automobile ferry users represent 83.4 percent and the passenger-only ferry users represent 16.6 percent of the total afternoon ferry users.

The timing of the project survey was designed to capture the afternoon commuter; the survey was conducted on Tuesday, May 14, 1991. As with many transportation studies, the best months for data collection are May and October. The typical days for data collection to capture commuter behavior are Tuesday, Wednesday, or Thursday. May 14th was selected because there was enough time between the study date and the Memorial Day holiday weekend to avoid any fringe effects from holiday traffic variations. The time for the survey was from 3:00 to 7:00 p.m. This included all westbound sailings on the passenger-only ferry. In addition, three westbound sailings of the automobile ferry *Klahowya* were surveyed. The exact sailings that composed the sample groups for this study are given in Table 3; the overall response rate was 79.5 percent.

The following seven modes on the automobile ferry were identified: walk-on, bicycle, motorcycle, single-occupant vehicle, shared ride, WSF-certified carpool, and bus. A specific category for handicapped passengers was not provided; if they used a wheelchair to board they were counted as a walk-on passenger for this survey. It may be useful in future studies of the passenger ferry to identify wheelchairs as a separate boarding mode. Persons living on the Kitsap Peninsula can take the passenger-only ferry to Seattle by riding the automobile ferry from Southworth to Vashon Island and transferring to the passenger-only ferry. Hence, the percentage of ferry users living in different areas had to be identified. Changing modes from the automobile ferry to the passenger-only ferry inherently involves a change in routes; hence, the distance of the final destination of each of the respondents to the ferry terminal was determined.

SURVEY RESULTS

More than 80 percent of the respondents who use the passenger-only ferry use it 4 or more days per week, indicating that it is a commuter service. Figure 2 shows the percentages of the former modes that provided the passengers on the passenger-only ferry. The observation total of 299 reflects the fact that 8 of the 307 passenger ferry observations did not respond to the question about former mode of boarding.

It is interesting to note that 25 percent of the passenger-only ferry riders are new to the system. This may be explained by the fact that there is a certain turnover on Vashon Island,

TABLE 2 Sailing Schedule, Seattle/Vashon, Tuesday, May 14, 1991 (Approximate Crossing Time 15 min)—Automobile Ferry

Leave Seattle		Leave Vashon	
5:30 a.m.	4:35 p.m.	5:05 a.m.	1:50 p.m.
6:20	4:55	5:30	2:10
6:55	5:30	6:00	2:45
7:55	5:45	6:25[T]	3:35
8:55	6:10	6:50	4:30
10:25	6:35	7:00	5:00
11:15	6:55	7:20	5:20
11:50	7:25	7:55	6:10
12:45 p.m.	7:50	8:15	6:30
1:15	8:15	8:30	7:05
2:20	9:20	9:30	7:50
2:35	10:15	10:00	8:35[J]
3:15	11:20	10:45	9:45
4:05	12:30 a.m.	11:25	10:35[J]
	1:50	12:20 p.m.	11:40[J]
		12:50	1:20

BASIC FARE
$2.15 per passenger, round trip.
$7.50 Auto and driver, round trip.
(10% discount with a commuter book)

[J] *Via Southworth, crossing time 35 minutes.*
[T] *Loads foot passengers and carpools/vanpools only*

TABLE 3 Sailings Sampled for Project Survey, Tuesday, May 14, 1991

PASSENGER-ONLY FERRY

Passenger-Only Ferry Sailing Times	Total Passengers on Sailing	Total Number of Observations
3:05 p.m.	60	49
4:35 p.m.	150	124
5:50 p.m.	112	108
7:00 p.m.	26	26
TOTAL	348	307

AUTO FERRY

Auto Ferry Sailing Times	Total Passengers on Sailing	Total Number of Observations
4:05 p.m.	182	124
4:55 p.m.	199	146
6:10 p.m.	190	134
TOTAL	571	404

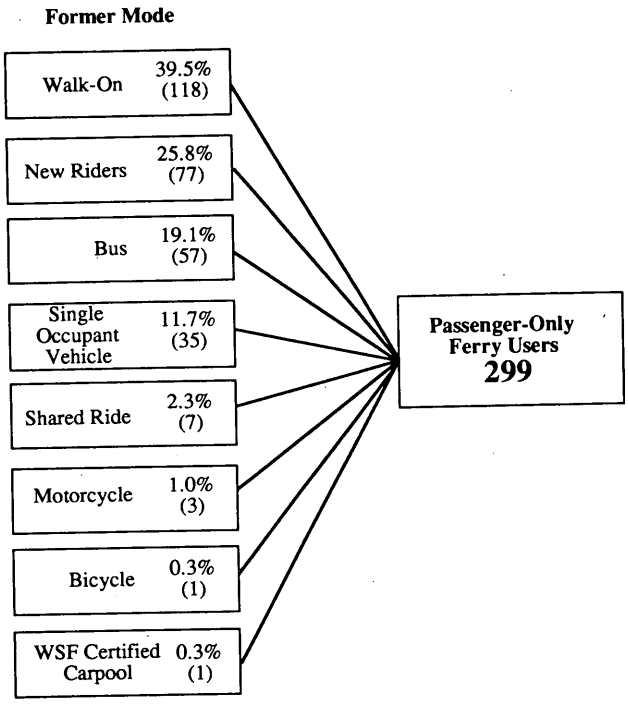

FIGURE 2 Former boarding modes of passenger-only ferry users.

that is, a constant migration of residents moving onto and off the island. In addition, there has been steady growth in the region, and some persons moved to Vashon Island because passenger-only ferryboat service was made available, as indiccated by their written comments. On the passenger-only ferry, 11.7 percent of the passengers were former single-occupant vehicle riders on the automobile ferry, which represents about 2 percent of the total passenger traffic between Seattle and Vashon/Southworth. Figure 3 shows where passenger-only ferry riders live.

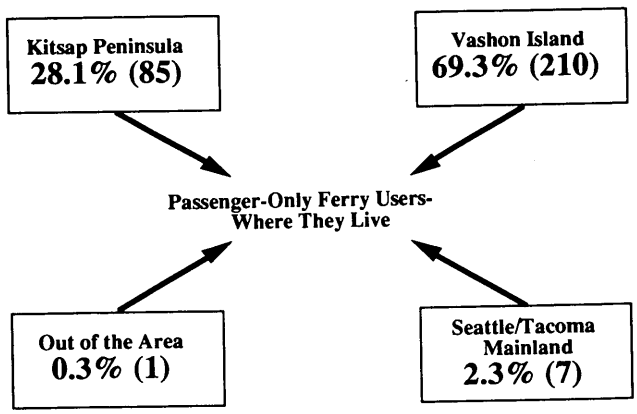

FIGURE 3 Passenger-only ferry users—where they live. Of 307 observations, 303 responses were provided.

MODE CHOICE MODEL

To understand what influences a commuter to choose the automobile ferry or passenger-only ferry, a number of attitudinal and demographics questions were asked. The information provided from the responses to these questions facilitated the development of a logit model. This model predicts the likelihood of a person with a given set of attributes choosing to ride the automobile ferry or the passenger-only ferry. Using logit regression techniques, a binary choice model was developed to model the behavior of the ferry commuters traveling between the Seattle-Tacoma mainland and Vashon/Southworth. The selected model is presented in Table 4; Table 5 describes each of the variables in the model.

The independent variables included in the final model demonstrate the significant factors ferry commuters take into consideration when choosing between the automobile and passenger-only ferries. The model, with these independent variables, is an attitudinal model rather than a model based on physical characteristics of the alternative transportation modes or demographics of the population. Several goodness-of-fit measures were used with other criteria to select the best model. For each of the estimated coefficients, the *t*-statistics are presented in Table 6.

Along with the *t*-statistics in Table 6, several auxiliary statistics for the model are provided in Table 7. Using the likelihood ratio test, we can test the null hypothesis that all coefficients are zero, that is, $b_1 = b_2 = \ldots = b_k = 0$. Assuming a chi-square distribution, the critical value for χ^2 with eight degrees of freedom and $\alpha = .05$ is 21.95, and for our model $21.95 < 217.68$, so we are 99.5 percent confident that the null hypothesis, that all coefficients are zero, can be rejected. The ρ^2 statistic is analogous to R^2 used in regression, but the accepted values of ρ^2 are generally much lower than the values for R^2. Using the estimated coefficients, the following utility function results:

$$U = 1.398 - 0.537(\text{carper}) + 0.726(\text{ttvi}) - 0.948(\text{ttfvui}) - 1.038(\text{farevi}) + 0.635(\text{endvi}) - 0.736(\text{sov}) + 2.238(\text{bus}) + 0.753(\text{walk}) \quad (1)$$

Using the utility function in Equation 1, the probability of a decision maker selecting each of the modes can be predicted.

TABLE 4 Estimated Coefficients for Logit Model

Independent Variable	Estimated Coefficient	Standard Error	t-Statistic
constant	1.398	NA	NA
carper	-0.537	0.108	-4.966
ttvi	0.726	0.189	3.832
ttfvui	-0.948	0.571	-1.660
farevi	-1.038	0.188	-5.529
endvi	0.635	0.182	3.488
sov	-0.736	0.243	-3.023
bus	2.238	0.379	5.905
walk	0.753	0.207	3.635

Number of observations = 711
NA = Not Applicable

TABLE 5 Description of Variables

Independent Variable	Description of the Independent Variable
constant	constant term
carper	number of cars per workers who work outside the household
ttvi	total travel time 'important' (0=no,1=yes)
ttfvui	ferry travel time 'very unimportant' (0=no,1=yes)
farevi	the fare 'very important' (0=no,1=yes)
endvi	endpoint of the ferry trip 'very important' (0=no,1=yes)
sov	used as prior boarding mode (0=no,1=yes)
bus	used as prior boarding mode (0=no,1=yes)
walk	used as prior boarding mode (0=no,1=yes)

TABLE 6 Discussion of Coefficients

Ind.Var.	Est. Coeff.	Discussion of Variable and Estimated Coefficient
carper	-0.537 (t=-4.97)	As the number of cars available to the worker increases, the less likely the person will be to use the passenger-only ferry. This seems intuitively correct.
ttvi	0.726 (t=3.83)	If total travel time is very important, the decision maker may be more likely to choose the passenger-only ferry. Especially if the ferry component is the major component of the trip, as with most passenger-only ferry commuters.
ttfvui	-0.948 (t=-1.66)	If the travel time on the ferry is very unimportant, the rider is less likely to take the passenger-only ferry. If the ferry component of the trip is small, relative to the total trip, the leg of the trip on water is less significant. This reflects that many persons using the auto ferry retain the use of their personal transportation, and the shorter crossing time of the auto ferry.
farevi	-1.038 (t=-5.53)	If fares are very important to the user, the likelihood of using the passenger-only ferry is reduced. Currently, fares on the passenger-only ferry are higher than the fare for a walk-on passenger on the auto ferry.
endvi	0.635 (t=-3.49)	If the endpoint is very important to the user, it is more likely the passenger-only ferry will be used. Over 80% of persons using the passenger-only ferry had their destination within five miles of the passenger-only ferry terminal.
sov	-0.736 (t=-3.02)	A person who used a single occupant vehicle on the auto ferry is less likely to use the passenger-only ferry. This may reflect a commitment to personal transportation.
bus	2.238 (t=5.90)	A bus rider is more likely to use the passenger-only ferry. The size of this coefficient suggests a strong correlation between bus riders and passenger-only ferry use.
walk	0.753 (t=3.63)	As with the bus the sign is positive, but the size of the coefficient is smaller. This may reflect the fact that some persons who walked on the auto ferry did so because the auto ferry terminal is convenient to their final destination.

The equation for predicting the probability of selecting the passenger-only ferry is provided in Equation 2:

$$P(m_1|U) = \left[\frac{1}{1 + e^{(-U)}}\right] \quad (2)$$

where m_1 = Mode 1 = passenger-only ferry.

This model was developed directly from the responses given by ferry users. Specific questions about weather were not asked, but questions about the importance of ferry terminals being located conveniently to the origin and destination were asked. It may be inferred that responses to questions on the location of ferry terminals reflect some consideration given to weather.

The use of this model can be illustrated by examining a hypothetical decision maker (dm) with the following attri-

TABLE 7 Auxiliary Statistics

Number of Observations	711	
Likelihood Ratio (χ^2)	217.68	
ρ^2	.221	
corrected ρ^2	.213	
Log Likelihood	at convergence	initial
	-383.99394	-492.82765

butes: the dm's household has 1.5 cars per worker working outside the household, the total travel time is very important to the dm, the ferry travel time is very unimportant, the fares are very important, the endpoint of the ferry trip is very important, and the former boarding mode on the automobile ferry was walking. Using this description of the decision maker gives the following:

$$U = 1.398 - 0.537(1.5) + 0.726(1) - 0.948(1) - 1.038(1) + 0.635(1) - 0.736(1) + 2.238(0) + 0.753(0)$$

$$P(m_1|-0.769) = \left[\frac{1}{1 + e^{(0.769)}}\right] = .317$$

For this hypothetical decision maker, the probability of choosing the passenger-only ferry is 0.317, and, hence, the probability of this person choosing the automobile ferry is 0.683. The choice model has one continuous independent variable, carper, the number of licensed, working automobiles per worker working outside the home. The elasticity of this variable was computed as -0.51. This indicates that a 1 percent decrease in the number of automobiles per worker results in only a 0.51 percent increase in the probability of the decision maker choosing the passenger-only ferry; hence this variable is inelastic.

Subsequent to the analysis of the data and completion of the model, the authors examined the influence of frequency of service on the behavior of ferry commuters. The frequency of service variable was tested during the development of the logit model and found to have low *t*-statistics (less than 1). The ferry system has experienced increased ridership on automobile ferries in the past by increasing the frequency of service. Our study indicated that frequency of service is nearly equal in importance to passenger-only and automobile ferry riders. Thus, although it is an important variable in attracting ferry ridership, its importance to one mode or the other was not unique. This fact accounts for the low *t*-statistics of the frequency of service variable in the logit model. Hence this variable was excluded from the final model. Whereas this finding may be counterintuitive when considering weather conditions (frequency is expected to be a greater factor for the passenger ferry than for the automobile ferry), several factors may influence its lack of significance in the study. One is the fact that the study was conducted on a beautiful spring day with warm sunny weather. Hence the weather may have been taken for granted by the respondents. Another factor is that most people living in the Pacific Northwest accept the fact that rain is a part of life in this region and are less sensitive to rainy weather than those in other regions of the United States.

Another reason why frequency of service may not be a strong attribute in the model has to do with how people perceive frequency or service as opposed to how people perceive travel time. If commuters depart at a regular time each day, the provision of additional trips may not be as readily perceived by the commuter as a reduction in travel time. This reasoning, along with the observation stated earlier regarding frequency of service being nearly equal in importance to automobile ferry and passenger-only ferry users, may explain the lack of its significance in this model. This should not be interpreted to mean that the frequency of service is inconsequential to passenger-only ridership.

CONCLUSIONS

Statistical analysis of the survey results contributes to the data base of knowledge regarding waterborne transportation. As the country grows in population, there will be an increasing demand for land and space. Land and space near the water will be especially desirable. It is unlikely that the passenger-only ferry will replace the automobile ferry. Increased automobile ferry service may be inevitable. However, if the ferry system is to truly serve as an extension of the Washington State highways, it must have the means to carry out that role. The passenger-only ferry service can be an integral part of the ferry system network. The passenger-only ferry service can potentially slow the growth of automobile use on the ferries, an environmentally sound goal.

This study indicates that providing passenger-only ferry service can result in a mode shift from drive-on ferry passengers to walk-on passengers. Former single-occupant vehicle users composed 11.7 percent of the persons responding to this passenger-only ferry survey question. Extrapolated to the entire passenger-only commuter population, this represents approximately 40 persons who shifted from single-occupant vehicles on the automobile ferry to walk-on passengers on the passenger-only ferry. This results in a mode shift of 1.94 percent out of the total afternoon ferry commuter population of 2,100 after approximately 1 year of passenger-only ferry service between Seattle and Vashon Island.

The degree of mode shift depends on the ferry routes and the location of ferry terminals. Whether the amount of mode shift measured in this study will prove economically viable remains to be determined. The study revealed that passengers believe that travel time on the passenger-only ferry is important and will influence their decisions regarding mode choice. In addition, the door-to-door travel time is a significant factor when people choose between passenger-only ferry service and automobile ferry service. The study also indicated a significant number of new riders (25 percent). This is primarily a result of land use turnover and growth in the region. Some people actually moved to Vashon Island specifically because the service was made available. A consistent advertising program regarding the availability of alternative modes of transportation could have a significant impact on this market. Such a program should be considered to maximize use of the passenger ferry.

Should another transportation alternative, such as a cross-Sound bridge, be chosen at some time in the future, it will only replace a small portion of the ferry system's network.

The value of the passenger-only ferry to the transportation system of the Pacific Northwest and its contribution to the overall ferry system is clear. WSDOT's plan for future accommodation of efficient and environmentally desirable modes of transportation must consider increasing the number of passenger-only ferries serving Puget Sound ferry commuters. The passenger-only ferry contributes to the regional goal of reducing reliance on the automobile.

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REFERENCES

1. *Passenger-Only Ferry Survey of Vashon/Maury Island Residents.* METRO Transit, Seattle, Wash., 1988.
2. *Survey of Riders on the Fauntleroy-Vashon/Southworth Runs.* Carolyn Brown Consultants, Seattle, Wash., 1989.
3. *Passenger-Only Ferry M.V. Express, Report on Demonstration Project.* TAMS Consultants, 1987.
4. *Test Service on Puget Sound—Summer 1978. Report on Jetfoil.* Washington State Department of Transportation, Olympia, Dec. 1978.
5. C. Berkowitz. High-Speed Passenger Ferry Service: A Case Study. In *Transportation Research Record 1263,* TRB, National Research Council, Washington, D.C., 1990.
6. C. Berkowitz. Modelling Waterborne Transportation User Characteristics. In *Transportation Research Record 1263,* TRB, National Research Council, Washington, D.C., 1990.

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