Jointly Estimating Site-Choice and Trip Length for Non-Market Valuation

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Abstract

Traditional site-choice demand models ignore or oversimplify the trip length decision made by consumers, thus limiting the scope of analysis that can be done by the researcher. Researchers that consider site choice and trip length can calculate additional endpoints that can be used in dynamic simulations, providing more information to policymakers. We develop and estimate a joint site-choice, trip length, and on-site cost model that links site-choice and trip length decisions using a full-information maximum likelihood approach. We apply this model using data collected from non-resident anglers that participated in a recreational saltwater fishing trip in Alaska. Non-resident Alaskan anglers are individuals who live outside of Alaska, but who participate in a saltwater fishing trip in Alaska. These anglers typically visit Alaska very infrequently but spend multiple days participating in a saltwater fishing trip while visiting. Thus, fishing trip length is an important margin of choice. Our findings suggest that increasing the harvest rate may reduce fishing time and increase expected mortality at a slower rate than when on-site time is ignored. This result implies that researchers that ignore trip length may under- or overestimate the impact on expected recreational angler mortality.

Keywords: Non-market valuation; On-site time; Recreation demand; Full-information maximum likelihood; Alaskan fisheries; One-inflated zero-truncated negative binomial distribution

JEL Classifications: Q22, Q26, Q51, Q57

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1 INTRODUCTION

People routinely make decisions that have both space and time elements. For example, when an individual is planning a beach trip, she selects both the beach to visit and the amount of time to spend at the beach that maximizes expected utility (McConnell, 1992). Each site considered for a beach trip provides a set of amenities (presence of lifeguards, beach rentals, food availability, etc.) that can be expected to influence the location choice and the time spent enjoying various site-specific activities (Parsons, Massey, et al., 1999; Alegre & Pou, 2006; Lew & Larson, 2008; Martínez-Espiñeira & Amoako-Tuffour, 2008; Voltaire et al., 2017). Empirical work in recreation economics typically focuses on the spatial element of individual choice, typically modeling the decision of where to go as a choice between a set of discrete locations. Other types of individual economic activity involving space and time components include transportation and tourism (Alegre & Pou, 2006; Barros & Machado, 2010; Grigolon et al., 2014; Haghani & Sarvi, 2016; Sharma et al., 2019), hunting and fishing (Bell & Leeworthy, 1990; Berman & Kim, 1999; Herriges & Phaneuf, 2002; Hussain et al., 2016), rock-climbing (Shaw & Jakus, 1996; Scarpa & Thiene, 2005), and kayaking (Hynes et al., 2009). Relatively few empirical studies of spatial choice consider the temporal component of the same decision problem: how long to stay at the selected location (Shaw & Feather, 1999).[1]

Empirical models of spatial choice are standard tools used by economists to value natural resources and environmental amenities, which are often non-market goods.[2] A typical application using revealed preference (RP) data involves collecting information on the sites visited by individuals to estimate preferences for site attributes, for example, water quality at different lakes in a region. There are at least two categories of empirical results from this type of analysis that are of interest for both research and public policy. The usefulness of each type of result may be limited when the time component of spatial behavior is not

[1]Other models that link spatial and temporal components include the seasonal demand literature that jointly estimates site-choice and trip frequency (Creel & Loomis, 1992; Feather et al., 1995; Parsons & Kealy, 1995; Feather & Shaw, 1999; Hussain et al., 2016).

[2]Non-market environmental goods are goods that are not bought or sold in a explicit market but still have monetary value to consumers (e.g. clean air or water, etc.) The monetary value for non-market goods are not revealed through market prices so economist use non-market valuation methods to estimate the monetary costs and benefits from changes in environmental quality.

modeled empirically. The first category comprises estimates of well-known welfare measures, including willingness-to-pay for marginal changes in site attributes (e.g., local water quality at the beach) and average compensating variation for non-marginal changes in the same attributes (Freeman III et al., 2014). These estimates are nearly always denominated in per-choice occasion units. Unless the activity is one where site visits are naturally constrained to last roughly the same amount of time for all individuals, the analyst may need to make strong assumptions about the length of time per visit to assign welfare measures meaningful units of time. This limitation creates practical problems for applying welfare measures in environmental and resource policy analysis because other inputs to policy analysis–in particular costs increasing environmental quality–can be measured over intervals of time (e.g., a daily basis).

The second category of empirical results sought from models of spatial behavior related to natural resources and the environment are ecological endpoints of site visits (Boyd, 2007).[3] A major use of empirical models of location choice in fisheries economics, for example, is to predict shifts in the spatial distribution of harvest when a subarea is closed to fishing (Smith & Wilen, 2003). Lack of empirical information about time on-site often presents an even more severe problem for predicting ecological endpoints, since they may not be possible to construct reliably due to a fundamental apples-and-oranges problem: location visits are denominated in per-trip units, while auxiliary information about the impacts of location visits are frequently denominated in per-day or similar units. Absent an accompanying empirical model of time-on-site, strong assumptions may be needed to connect predicted spatial behavior to endpoints of interest, particularly when significant heterogeneity in time-on-site exists. Important secondary effects of site visits, such as local economic impact, are also challenging to derive from spatial models without linked information on time-on-site.

In this paper, we develop a model of individual site-choice and trip length. We estimate the model using data from a survey of non-resident anglers who participated in a recreational saltwater sport angling trip in Alaska (Lew et al., 2010; Lew & Larson, 2015). We use our model to estimate both the per-trip and daily welfare effects for changes in

[3]Ecological endpoints are explicit ecological attributes of environmental value, such as fecundity or recruitment (USEPA, 2015). Ecological endpoints are key outputs for related models in forestry (Hashida & Lewis, 2019), transportation (Horne et al., 2005), and agriculture (Lázár et al., 2015).

harvest policies, the value per Alaskan fishing trip, and the change in expected mortality associated with fishery management counterfactuals. Our model extends a handful of past studies in the non-market valuation literature that considers both site-choice and time spent on-site, either using a nested logit framework that includes a level of choice between a single- or multi-day trip (Lupi et al., 2001; Yeh et al., 2006) or a sequential approach where the time spent on site is predicted and substituted into a site-choice model (Berman & Kim, 1999). We improve on these papers by carefully linking the time spent on site and on-site costs in a jointly-estimated empirical framework. To the best of our knowledge, our analysis is the first to use a site-choice and time-on-site empirical model to predict expected harvest mortality caused by anglers. Fish mortality is a major ecological impact of recreational angling that is an increasing focus of fishery policy around the world (Arlinghaus et al., 2016; Punt et al., 2016). Fisheries policymakers are turning toward management strategy evaluations (MSE) to rank and compare harvest control rules based on the effectiveness of each outcome (Smith et al., 1999; Fulton et al., 2014; Punt et al., 2016). MSE is a simulation-based tool that uses social, physical, and life science data to replicate a biological system and estimate the trade-offs of different harvest control rules such as the impact to fish mortality. Existing MSEs still ignore the on-site impact from changes in fishery policy that limits their effectiveness (Massey et al., 2006; Lee et al., 2017).

Matching our prior expectations, model estimates imply that an increase in expected daily harvest rates will increase the trip length for most key Alaskan species. However, as the historical harvest rate for Pacific halibut (*Hippoglossus stenolepis*) increases, the estimated coefficients suggest that trip length may decrease. Anglers may substitute fishing time with other non-fishing activities while in Alaska once they reach a satiation point of Pacific halibut harvest. This implies that ignoring the on-site time component may bias oversimplified calculations of ecological endpoints and cause unintended policy consequences. Increases in the historical harvest rate will have a significant impact on trip length, but the direction and magnitude are unknown when on-site time is ignored. We use the fitted model to calculate the change in expected recreational harvest mortality from the implementation of a proposed change in the harvest rule for Pacific halibut in 2017. The proposed rule change would reduce the expected harvest rates for Pacific halibut by 10% in southcentral

Alaska and 15% in southeast Alaska. But these estimates ignore the on-site time decision. We find that the reduction in the historical harvest rate of Pacific halibut would cause expected recreational harvest mortality to decline by 8.8% in southcentral Alaska and 11.2% in southeast Alaska. This suggests ignoring the on-site time decision can significantly impact recreational harvest mortality predictions that can influence fishery managers' strategies in changing harvest rules.

In the next section, we discuss relevant literature pertaining to models that considered the site-choice and on-site time decisions, followed by our theoretical model of utility maximizing behavior subject to dual monetary and time constraints. In Sections 4 and 5, we provide a brief description of the recreational Alaskan fishery and describe the data used in the model. In Section 6, we describe the site-choice and trip-length specifications and how these models are linked. In Section 7 we present and discuss the results from the sequential and joint models. Using the estimated coefficients from the joint model, we estimate the welfare effect and change in trip length for a decrease in the historical harvest rate for Pacific halibut caused by a newly proposed harvest rule, discussed in Section 8. Within this section, we also present a simple illustration of a policy-relevant ecological endpoint that can be calculated using this framework. The final section discusses model limitations as well as the next steps for this research and additional directions to explore in the future.

2 RELEVANT LITERATURE

Researchers in the recreation demand literature have developed empirical models that consider the site-choice and trip length decisions for a given sample based on theoretical models of dual site-choice and on-site time (Smith et al., 1983; Bell & Leeworthy, 1990; McConnell, 1992; Berman & Kim, 1999; Lupi et al., 2001; Yeh et al., 2006). The nested logit model is more commonly used to model trip length and site choice decisions. A nested logit model may consist of many nests for each discrete trip length interval. But each nest must contain a few observations which may require a large sample size for studies with high variations in trip length (Cordeiro & McCullagh, 1991). The need for a large sample size commonly causes researchers to limit their analysis to single- and multi-day trips (Lupi et al., 2001; Yeh et al., 2006). Considering only single- and multi-day trips implicitly assumes all individuals in the multi-day trip nest participate in a trip of equal length and limits the analyses of trip length impacts from changes in site-specific attributes. We can specify our trip length model as a discrete or continuous model that allows the researcher to predict trip length with a smaller sample size compared to a nested logit model of equal trip length granularity.

We use the Berman and Kim (1999) structural framework as a basis for our joint model described further in Section 6. Berman and Kim (1999) discuss three methods (exogenous, reduced form, and structural) to account for on-site time when analyzing a site choice model based on the theoretical model developed by McConnell (1992). The structural model estimates on-site time as a function of the monetary trip expenditures, travel time, party size, other site-specific attributes and a constant using a censored normal regression model for on-site time predictions. On-site time predictions are used in a nested logit site-choice model that is a function of travel costs, travel time, on-site time differentiated by employment type, and site-specific attributes. This method estimates the on-site time model first, then uses the predicted on-site time values in the site-choice model. Our model improves upon the methods from Berman and Kim (1999) by considering on-site cost in the on-site time model based upon the work by Landry and McConnell (2007), considering the attribute-specific utility impact from increases to on-site time, and uses a full-information maximum likelihood (FIML) framework to simultaneously estimate all coefficients instead of using predicted values in multiple stages. Simultaneously estimating all coefficients using a FIML framework allows for correlated error terms between each model improving the efficiency of estimates (Enders & Bandalos, 2001).

Our linked site-choice and trip-length model is comparable to the methodology in the seasonal demand literature. The seasonal demand literature utilizes a joint model to estimate site-choice and trip frequency over a given season allowing for seasonal welfare estimates (Creel & Loomis, 1992; Yen & Adamowicz, 1994; Hausman et al., 1995; Parsons & Kealy, 1995; Feather & Shaw, 1999; Parsons, Jakus, et al., 1999; Parsons et al., 2009; Hussain et al., 2016). The seasonal demand literature commonly links the site-choice and trip frequency models via expected utility or the per-trip expected consumer surplus computed from the site-choice model coefficients (Yen & Adamowicz, 1994; Hausman et al., 1995; Parsons, Jakus, et al., 1999; Parsons et al., 2009; Hussain et al., 2016). Similarly, our model links site-choice and trip length using the expected trip length computed from the trip length model (McConnell, 1992; Berman & Kim, 1999). In the seasonal demand literature and our model, the link is based on the estimated coefficients from one of the sub-models allowing for correlation between the error terms in each sub-model.

3 THEORETICAL MODEL

In travel cost models, individuals are typically assumed to maximize their utility by choosing the number of trips to take subject to money and time constraints. Previous literature has extended this theoretical framework to allow for consideration of time spent on-site as a choice variable (Bockstael, Strand, et al., 1987; Bell & Leeworthy, 1990; McConnell, 1992; Larson, 1993; Berman & Kim, 1999). These models have many similarities between the inclusion of on-site time and in the implications for measuring recreation demand. Below, we present a theoretical model similar to those in the literature assuming individuals participate in a single trip that allow for site- and on-site time choices.

We assume that an individual's utility, $u(\mathbf{x}, \mathbf{t}, \mathbf{S}, z^M, z^T)$,), is a function of the number of trips taken to recreation sites (indexed from $j = 1, ..., J$) and represented by the vector $\mathbf{x}$, the total time spent on-site at each of the J sites, t_j, a (Q x J) matrix of Q quality characteristics of the J sites, S , a numeraire good that costs money but not time, z^M, and a numeraire good that costs time but not money, z^T. Individuals are assumed to maximize utility by choosing the number of trips and total time spent at each site subject to money and time budgets. The standard money and time budget constraints are:

$$M = \sum_{j=1}^{J} x_j \cdot p_j + p_z \cdot z^M \tag{1}$$

$$T^* = \sum_{j=1}^{J} x_j \cdot (\gamma_j + t_j) + \theta \cdot z^T \tag{2}$$

where M is income, p_j is the round-trip travel cost to site j, p_z is the cost of the numeraire good z^M and is assumed to equal 1, T^* is the total time available for leisure consumption, γ_j is the round-trip travel time to site j, and θ is the time spent consuming z^T and is assumed to equal 1. In many recreational demand studies, the total price of a trip is equal to the round-trip monetary travel cost. However, models that allow on-site time to be endogenous must also consider the on-site cost, which is the own-price of on-site time. Thus, we specify the total price of a trip as follows:

$$p_j = p_j^{tr} + p_j^{osc} \cdot t_j \tag{3}$$

where p_j^{tr} is the round-trip travel cost to reach the recreational site and p_j^{osc} is the daily on-site costs. The standard time budget assumes that time must be allocated to the consumption of goods, known as the commodity value of time, but the commodity value of time is not observable by the researcher (DeSerpa, 1971). Instead, the researcher should use the scarcity value of time measured as the monetary value of time and is commonly assumed to equal the marginal wage rate (Bockstael, Hanemann, et al., 1987; Larson, 1993). Using the scarcity value of time allows the time and budget constraints to be combined into a single constraint assuming that work does not yield utility or disutility and that the individual can freely choose their work hours (Becker, 1965; Larson, 1993). The available time for leisure, T^*, is exogenously determined from working hours h where the total amount of leisure time is equal to $T^* = T - h$ where T is the total time available. Using this property, we can re-write the wage earnings measured by angler i's wage rate w, shown below:

$$w \cdot h = w \cdot \left(T - \sum_j^J x_j \cdot (\gamma_j + t_j) - \theta \cdot z^T \right) \tag{4}$$

We can collapse the time and money budget constraints into a single constraint if an individual has a flexible work schedule by substituting the time constraint into the budget constraint (Becker, 1965; Bockstael, Strand, et al., 1987; McConnell, 1992). This results in the following single constraint:

$$y = \sum_j^J x_j \cdot \left(p_j^{tr} + \gamma_j \cdot w + p_j^{osc} \cdot t_j + w \cdot t_j \right) + z \cdot (p_z + w \cdot \theta) \tag{5}$$

where $y = M_0 + w \cdot T^*$ where M_0 is non-work income. The single budget constraint shows that non-work income plus the (monetary) opportunity cost of leisure time is equal to the sum of three things. The first is total round-trip travel cost which is equal to sum of the monetary cost of travel and the opportunity cost of travel time valued at the wage rate. The second is on-site costs. The total on-site cost is equal to the sum of total monetary on-site cost and the opportunity cost of on-site time, where the opportunity cost of on-site time is the trip length valued at the wage rate. The final term in the single budget constraint is the total cost for the numeraire goods where the opportunity cost of time in the time numeraire is valued at the wage rate. Using the single constraint, an individual's utility maximization problem is as follows:

$$\max_{x,t,z} \ u(\mathbf{x}, \mathbf{t}, \mathbf{S}, z^M, z^T) - \lambda \left(y - x_j \cdot \sum_j^J \left(p_j^{tr} + \gamma_j \cdot w + p_j^{osc} \cdot t_j + w \cdot t_j\right) - z \cdot (p_z + w \cdot \theta) \right) \quad (6)$$

The solution to this maximization problem for individuals with a flexible work schedule is $V_i(p_j^{tr} + p_j^{osc} \cdot t_j, t_j, s, z, q)$ known as the indirect utility function. Using the envelope theorem, we can show the Marshallian demand for number of trips and the on-site time for site j:

$$x(p_j^{tr}, p_j^{OSC}, p_z, s_j, y) = -\frac{\partial V / \partial p_j^{tr}}{\partial V / \partial y} \quad (7)$$

$$t(p_j^{tr}, p_j^{OSC}, p_z, s_j, y) = -\frac{\partial V / \partial p_j^{osc}}{\partial V / \partial p_j^{tr}} \quad (8)$$

Equation 7 is the common finding that theoretically supports the use of the multi-site travel cost model. It is also shown in equation 8 that on-site time is a function of not only on-site cost but round-trip travel cost too. Bell and Leeworthy (1990) develop a theoretical model for on-site time that complements the finding by McConnell (1992) using on-site cost and travel cost in their on-site time demand model. Although their model cannot be used for welfare estimates (McConnell, 1992), it can be used to estimate a multi-site travel cost model with exogenous on-site time.

In the empirical model, described further below, we jointly estimate equations 7 and 8. McConnell (1992) shows that if on-site time is endogenous and specified correctly, then the demand function can be used to calculate welfare measures that are consistent with utility theory. In the empirical multi-site travel cost model, we restrict the time horizon to a single choice occasion, $x_j = 1$, which implicitly assumes that site-choice is unaffected by the consumption decisions in other choice occasions (Phaneuf & Smith, 2005). Thus, the indirect utility function is conditional on the individual visiting site j. The on-site time decision is not similarly restricted as on-site time can vary within the time horizon of the choice occasion. The effect of on-site time on utility remains unknown because of the dual nature of on-site time on costs and utility (McConnell, 1992). Since the empirical model predicts on-site time for the trip demand model, the budget constraint remains linear and welfare calculations remain unchanged. The conditional indirect utility function derived from equation 6 and the demand for on-site time listed in equation 8 informs the empirical specification and link between the site-choice and on-site time models.

4 EMPIRICAL SETTING

Alaska is a major tourism destination for saltwater recreational anglers. In 2016, approximately 300,000 non-resident sportfishing licenses were sold with approximately two-thirds participating in a guided or charter trip (McDowell Group, 2018). The two most common species of fish targeted by recreational anglers are Pacific halibut and salmon (Romberg, 2017). Anglers travel from all over the world for the chance to catch and harvest Pacific halibut and salmon (Romberg et al., 2008). The long travel distance and opportunity to harvest prized species lead to many anglers spending multiple days fishing in Alaska (McDowell Group, 2017). The multiple fishing destinations plus the variation in trip lengths make this an ideal setting to empirically examine the joint site-choice and trip length model.

Pacific halibut along the west coast of the United States (U.S.) and Canada, known as "Convention" waters, are managed by the International Pacific Halibut Commission (IPHC). Convention waters are broken down into 10 IPHC management areas (Figure 1) that are used during stock assessments. The IPHC sets the annual total allowable catch (TAC) for each management area based on results from their annual stock assessment. The North Pacific Fishery Management Council (NPFMC) implemented a Catch Sharing Plan (CSP) in 2014 that describes the process to determine allocations of the TAC for each Alaskan

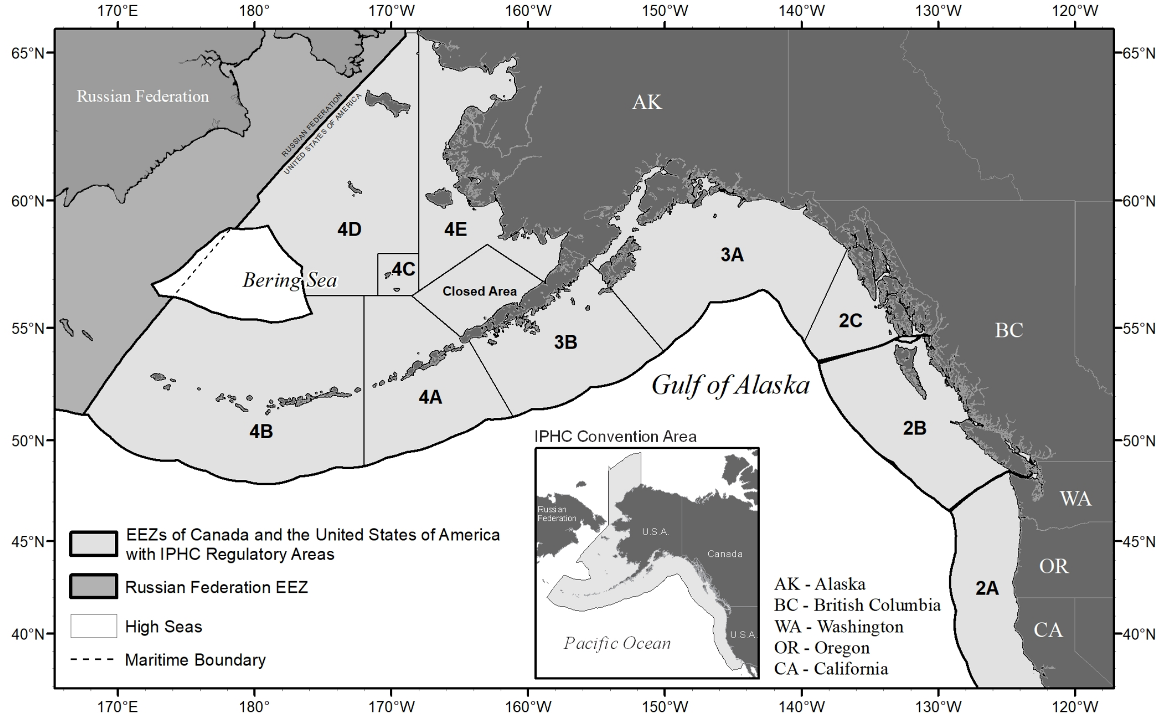


Figure 1: Map of the IPHC Areas along the west coast of the United States and Canada. This map shows the three major regulatory areas managed by the IPHC. Map taken from IPHC (IPHC, 2022)

management area between the commercial and recreational sectors (NPFMC, 2013). Areas 2C (southeast) and 3A (southcentral) record the highest harvest of Pacific halibut in Alaska (Romberg, 2017). The IPHC and NPFMC recognize the impact of recreational anglers on Pacific halibut stocks and began regulating recreational charter and non-charter harvest differently in Alaska since 2008. In 2008, charter and non-charter anglers had to follow different bag and size limits and charter anglers faced daily closures (NMFS, 2008). A reverse slot limit specifies the lower and upper length limit within which a fish must be discarded. In Area 2C in 2016, anglers were prohibited from harvesting a Pacific halibut if the length fell within the reverse slot limit (>43 inches and <80 inches). In Area 3A in 2016, anglers could harvest two fish where one fish could be any size and the second must be less than 28 inches in length (NMFS, 2016). Prior to the CSP, harvest regulations were less stringent. In 2011, the harvest regulation in Area 3A was two-fish of any size and in Area

2C was one fish with a maximum length of 37 inches (NMFS, 2011).

Silver salmon (*Oncorhynchus kisutch*) and king salmon (*Oncorhynchus tshawytscha*) are managed by the Alaska Board of Fisheries (BOF) and the Alaska Department of Fish & Game (ADF&G). The Alaska BOF establishes the harvest regulations for silver and king salmon and the ADF&G implements and enforces the BOF regulations. Although the IPHC and BOF areas do not overlap perfectly, Area 2C is similar to the southeast region and Area 3A, excluding Kodiak, is similar to the southcentral region. The bag limit for salmon harvested in saltwater differs among watersheds and the time of the year. Silver salmon typically has a greater bag limit than king salmon and a less restrictive slot limit. Additionally, non-residents must purchase a king salmon stamp each day that a fish is harvested, costing between $10 - $100 depending on the number of days spent fishing (Romberg, 2016).

5 DATA

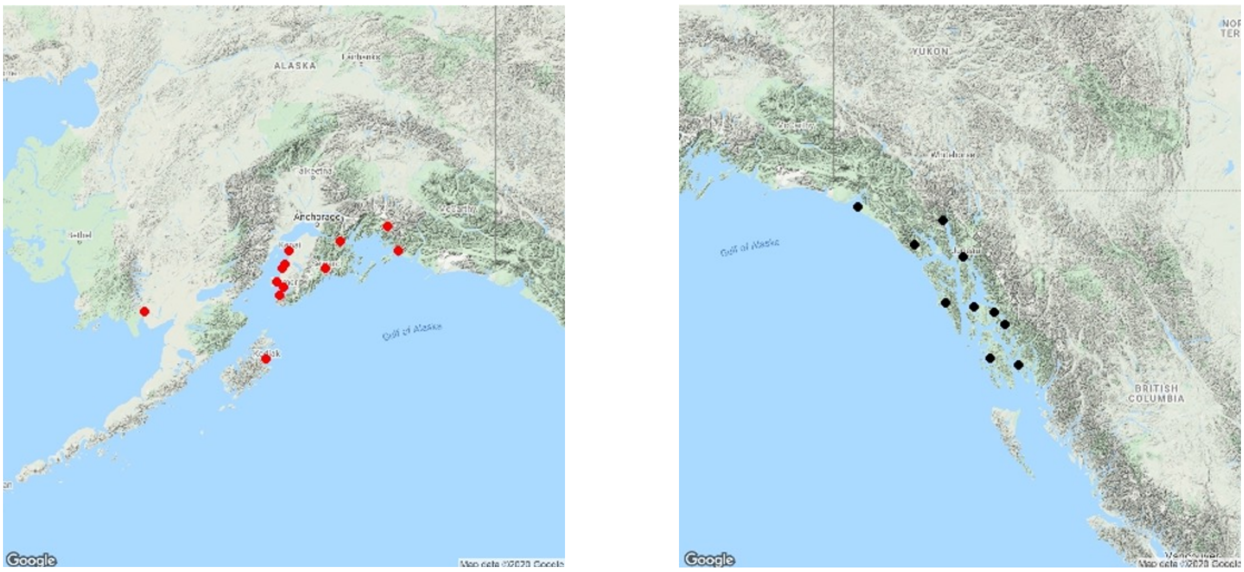
We analyze data collected in the 2017 Alaskan Saltwater Sport Fishing Surveys (Lew et al., 2010). In early 2017, a random sample of 2,200, non-residents who purchased a 2016 Alaska sport fishing license were sent the survey. Non-resident anglers are individuals that traveled from the contiguous U.S. and Hawaii to Alaska and participated in a saltwater fishing trip during their most recent Alaskan trip. Non-resident anglers are more likely than residents to participate in a single fishing trip to Alaska in a given year and participate in a multi-day fishing trip. Of those that received the survey, 463 respondents completed all the necessary questions for the site choice, trip length, and on-site cost model and visited a single site. Table 1 reports select demographics of survey respondents and those of the U.S. populations in 2017. Survey respondents are typically older, have a higher annual income, and have a higher likelihood of having a 4-year college degree than the U.S. population, and are more likely to be Caucasian and male.

Table 1: Comparison of demographic information between the 2017 survey samples and the 2017 U.S. Population

	2017 Non-Resident Survey	2017 U.S. Population
Gender – % Male	78.4%	49.2%
Age – Mean age in years	55.2	37.7
Ethnicity – % Sample Caucasian	94.0%	73.3%
Household Size – Mean # of people living in household	2.06	2.64
Education – % Sample with 4-year college degree or higher	60.0%	30.3%
Wage – Median hourly wage rate	\$30.00 \$39.99	NA
Income – Median household income	\$100,000 \$124,999	\$77,866

Note: Demographic information for the U.S. Population uses data from the 2017 American Community Survey (ACS) database (USCB, 2017). Wage and income ranges depict the ranges presented to respondents in the corresponding surveys.

The survey focused on fishing behavior in Alaska during the prior year (e.g. respondents in the 2017 survey were asked about trips in 2016). It included questions about an angler's most recent Alaskan saltwater sport fishing trip including the site visited, the length of the fishing trip, which species were targeted, the purpose of the trip, and other trip-related information. The survey asked about an angler's selection among 22 saltwater fishing sites in southeast Alaska (10 fishing sites) and southcentral Alaska (12 fishing sites). The Alaskan Saltwater Sport Fishing Surveys base the sites in each region on the management used by the ADF&G (Figure 2). The ADF&G regions differ slightly from the IPHC area definitions. Respondents provided information on which of the fishing site(s) they visited during their most recent trip to Alaska and the number of days spent fishing at each site. Approximately 82% of respondents that participated in a saltwater fishing trip visited a single site and approximately 54% participated in a fishing trip that lasted multiple days (Figure 3). To avoid the potential bias caused by multiple sites being visited on the same trip, we limit the analysis to anglers that visited a single site (Yeh et al., 2006). When anglers visit more than one site on the same trip, the underlying assumption of the travel cost model that trip cost proxies for the price of a given site breaks down (Parsons, 2003). By considering only trips to single sites, we eliminate the multi-destination bias and reduce the potential for multi-purpose bias.



(a) Southcentral Sites

(b) Southeast Sites

Figure 2: The two maps above show the central locations for each site listed in the choice set. These maps are produced using Google API (Google, 2020) and the ggmap package (Kahle & Wickham, 2013)

Approximately 50% of the single-site trips were taken to three sites: Homer (18.4%), Ketchikan (17.1%), and Seward (14.5%). We group all sites visited for each respondent into the 10 non-southeast Alaska sites and 10 southeast Alaska sites listed in Table A.2.1.[4] Respondents were asked to indicate the fishing mode (charter/guided fishing, private boat fishing, or shore fishing) used during their most recent Alaskan fishing trip. Approximately 71.5% of respondents participated in a guided or charter fishing trip with the remaining respondents indicating having fished by private boat or from shore. Private boat fishing

[4]Two sites in southeast Alaska (Kake and Wrangell) were not visited by any respondents in our sample and were excluded from the choice set.

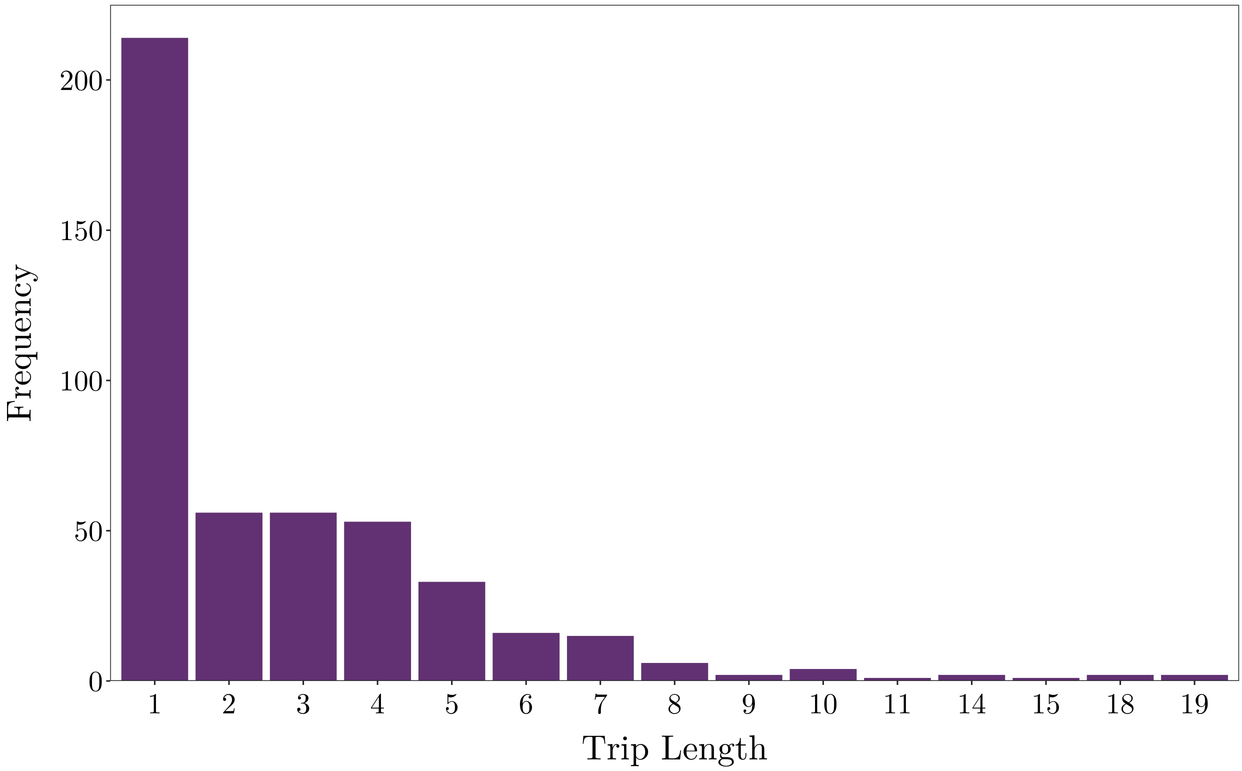


Figure 3: Frequency of reported fishing trip lengths from the 2017 survey. Approximately 46% of respondents participated in a single-day trip and 95% of all trips are 6 days or less.

generally refers to any unguided or non-charter fishing trip. Anglers that participate in a charter fishing trip may reserve the trip via a cruise ship excursion or part of a fishing lodge package. Fishing excursions via cruise ships typically last a single day because the cruise ship remains at a port for a limited period of time. Fishing lodges commonly offer multi-day fishing packages that allow anglers to target multiple species during their trip and are generally all-inclusive. Approximately 13.0% and 30.9% of anglers participate in a saltwater fishing trip via a cruise excursion and fishing lodge, respectively.

It is common for recreational anglers to participate in a fishing trip that targets one or many Alaskan species. Fishing trips that target a single or multiple species vary in charter fees, trip time to a fishing location, and other attributes. The survey asked respondents to indicate which species were targeted during their most recent Alaskan trip. The three species most commonly targeted in 2016 were Pacific halibut (76%), "other" fish (57%), and king salmon (40.8%). Many charter trips and fishing lodges offer specialized fishing trips targeting a single species or combination trips targeting a pair of species. Approximately 25.1% of respondents targeted a single species, 69% targeted multiple species, and 6% did not indicate targeting any species. The two pairs of species most often targeted during a fishing trip in 2016 are Pacific halibut and "other" fish (47.1%) and Pacific halibut and silver salmon (32.2%).

For the site-choice model, individual-level and site-specific travel cost and time information are required. In this study, travel costs and times are calculated for each respondent between each fishing site and where each individual is assumed to have begun their fishing trip, which we call the "home base." Two candidates for the home base are available in the data: an individual's residence (i.e., their home zip code) or where in Alaska they identified as their home base for their Alaska activities (asked in the survey). Which of these home base options to use is determined by responses to a question that identifies whether fishing was a primary purpose of the Alaska trip or not. The question asked respondents to categorize their trip into one of three types. The first indicates the trip was one where fishing was planned for most, or all, of the time spent in Alaska, which identifies a respondent whom we categorize as an "avid angler." The second type is a trip where saltwater fishing was planned, but other activities were also important. These individuals are termed "purposeful anglers." The final type of trip is one where there were no plans made prior to the trip to saltwater fish, but fishing was done opportunistically. These individuals are called "incidental anglers." Approximately 19.9% are incidental anglers, 47.6% are purposeful, 30.2% are avid, and 2.2% of anglers did not select a category. We assume that the home base for incidental, purposeful, and the anglers who did not select a category is the home base in Alaska that they identified in the survey. Avid anglers are assumed to start their fishing trip at their residence (outside Alaska), with the home-address zip-code being used. Additional information on travel cost calculations can be found in Appendix A.1.

We use site-specific historical harvest rates as a proxy for angler's expected harvest rate. Site-level estimates of annual catch, harvest, and trips collected by the ADF&G for the period 2011 to 2015 were used to construct the historical daily harvest rates used in the analysis (Romberg, 2017). These historical harvest rates consider harvest from guided and unguided trips where charter-specific harvest data was available.[5] We measure the historical harvest rates as the three-year average catch rate prior to the year they participated in a trip.[6] Table A.2.1 in Appendix A.2 reports the three-year average daily harvest rates for key Alaskan species by site used by respondents in 2016.

6 METHODS

This section introduces an econometric model of joint site choice and trip length. The trip length model estimates the probability that angler i's fishing trip will last l_i days based on the monetary travel cost to the site visited, daily on-site costs, historical harvest rates of Pacific halibut, king salmon, silvers salmon, and other fish, and site- and regional-specific fixed effects. On-site cost and trip length may be endogenous due to reverse causality and simultaneity. We account for this relationship by considering daily on-site cost as opposed to total on-site cost and substituting a daily on-site cost function into the trip length model (Landry & McConnell, 2007). The daily on-site cost model is a function of a constant, trip characteristics, angler-specific demographics, and regional- and site-specific fixed effects. The site-choice model is linked to the trip length model via the expected trip length. The site-choice model represents the conditional indirect utility of angler i choosing site j as a function of the full-trip costs, round-trip travel cost and on-site cost, the per-trip historical harvest rates of Pacific halibut, king salmon, silver salmon, and other fish, and site- and regional-specific fixed effects. Site-choice, trip length, and daily on-site cost sub-models are estimated by maximizing the joint log-likelihood using a full-information maximum likelihood approach.

6.1 Trip Length Model

Trip length is a strictly positive integer that measures the days spent fishing during an angler's most recent Alaskan trip. The trip frequency and trip length literature commonly

[5] Except for the following sites: Anchor Point, Clam Gulch, Ninilchik and Deep Creek, Kenai, and Seldovia. The ADF&G harvest rate data only differentiate by fishing mode for select Southcentral sites.

[6] E.g., historical daily harvest rates between 2013 and 2015 are used to compute historical harvest rates for 2017 survey respondents

adopt a count data model, frequently a Poisson (Creel & Loomis, 1992; Alegre et al., 2011; Pokki et al., 2018; Buason et al., 2021) or negative binomial model (Hussain et al., 2016; Boto-García et al., 2019) when this type of data is available. The Poisson distribution imposes a strong assumption that the mean and variance of the distribution are equal, known as equidispersion (Cameron & Trivedi, 2013). This assumption typically does not hold with trip length data because the mean is typically smaller than the variance. The negative binomial distribution is more flexible than the Poisson model because it considers an overdispersion parameter allowing the researcher to test for equidispersion (Cameron & Trivedi, 2013). An additional feature of the trip length data is that trip length is always greater than or equal to a single day. The zero-truncated negative binomial (ZTNB) distribution is a special case of the negative binomial model that tests for overdispersion while assuming no values can take a value of zero.

Within certain data sets, such as fishery bycatch and trip frequency, it may be common to see a large observation of zeros within the data (Minami et al., 2007; Kim et al., 2021). Researchers account for the high probability of zero observations using a zero-inflated negative binomial (ZINB) distribution where the probability of equaling zero is a function of select variables. We observe a similar characteristic in our trip length data, but instead of a large observation of zeros, approximately 46% of all trip lengths last a single-day. The zero-inflation property of the ZINB distribution can be adjusted to account for one-inflation or the additional probability that an angler will always participate in a single-day trip. For example, some anglers go on a fishing trip as part of a fishing excursion from a cruise ship. Despite changes in site-specific attributes, anglers fishing from a cruise ship are bound to a single-day trip because of the strict itinerary of cruise excursions. Since there is a high probability of an angler participating in a single-day trip in addition to the non-zero property, we assume that the trip length model follows a one-inflated zero-truncated negative binomial (OIZTNB) distribution. Additional details on the OIZTNB distribution can be found in Appendix A.3.1.

The OIZTNB distribution consists of two components. The first component is the probability angler i will participate in a single-day trip. The probability of participating in a single-day trip is a function of a binary logit model equal, known as the mixture function, and the probability of drawing a 1 from a ZTNB distribution. The mixture function depicts the probability angler i will participate in a single-day trip despite changes in site-specific attributes, shown below:

$$\omega = \frac{exp\left(\theta_0 + \theta_1 \cdot D_i^{Cruise} + \theta_2 \cdot D_i^{Lodge}\right)}{1 + exp\left(\theta_0 + \theta_1 \cdot D_i^{Cruise} + \theta_2 \cdot D_i^{Lodge}\right)} \tag{9}$$

where D_i^{Cruise} and D_i^{Lodge} are dummy variable equal to 1 if angler i participated in a fishing trip from a cruise ship and 0 otherwise or if angler i participated in a fishing trip from a fishing lodge and 0 otherwise. The second component is the probability angler i will participate in a trip lasting l_i days where $l_i > 1$ estimated as a zero-one-truncated negative binomial distribution. The mean of the negative binomial distribution, $\lambda_{i,j}$ is commonly estimated using an exponential function, shown below:

$$\begin{aligned}\lambda_{i,j} = \exp\Bigg(&\theta_1 \cdot \ln\left(OSC_{i,j}\right) + \theta_2 \cdot TC_{i,j}^{tr} + \theta_3 \cdot PH_j + \theta_4 \cdot KS_j + \theta_5 \cdot SS_j + \theta_6 \cdot OF_j + \\ &\theta_7 \cdot RSC_{SE} + \delta^{tl} \cdot SSC\Bigg)\end{aligned} \tag{10}$$

where OSC_i are the daily total on-site costs, $TC_{i,j}^{tr}$ is angler i's round-trip monetary cost to site j, PH_j, KS_j, SS_j, and OF_j are the daily historical harvest rates for Pacific halibut, king salmon, silver salmon, and other species at site j, and RSC and SSC are regional- and site-specific constants, respectively. The expected trip length for angler i visiting site j, $E\left[l_{i,j}\right]$, is equal to the expectation of the OIZTNB distribution, shown below:

$$E\left[l_{i,j}\right] = \omega_i + (1 - \omega_i) \cdot \lambda_i \cdot \left(1 - (1 + \alpha \cdot \lambda)^{-\alpha^{-1}}\right)^{-1} \tag{11}$$

Expected trip length is needed to link the trip length model with the site-choice model. But to estimate the total on-site fishing cost, we also need to estimate an exogenous daily on-site cost.

6.1.1 On-Site Cost Model

On-site costs may be endogenously determined with trip length. We would expect on-site cost to increase with trip length but trip length to decrease with rising on-site costs. Landry and McConnell (2007) introduce a daily on-site cost hedonic model and use the exogenous predictions in the trip length model to break this endogeneity. Our model estimates the daily monetary cost spent on fishing-related days and activities by an angler using observed on-site cost data. Total on-site fishing cost is the sum of lodging and food/restaurant costs during fishing days, charter and licensing fees, and other fishing-related costs such as ice and gear. The logged daily on-site cost model is shown below:

$$\ln(OSC_i) = \phi_0 + \phi_1 \cdot q_i + \phi_2 \cdot s_i + \phi_3 \cdot D_i^c + \phi_4 \cdot RSC_{SE} + \delta^{osc} \cdot SSC\epsilon_i^{os} \tag{12}$$

where q_i is a vector of angler-specific demographics, s_i is the number of anglers that were paid for in the on-site cost calculations, D_i^c is a dummy variable equal to 1 if angler i participated in a charter fishing trip, RSC_{SE} and SSC are regional- and site-specific constants, and ϵ_i^{os} is the stochastic disturbance term. We find that logging daily on-site costs provides a better statistical fit compared to the linear counterpart.

The trip length model is conditional on the realized standard deviation of the stochastic disturbance term from the on-site cost model. Instead of using the exogenous predictions from the daily on-site cost model, we substitute the daily on-site cost model from equation 12 into the daily on-site cost term in the trip length model shown in equation 10. This allows us to take advantage of the simultaneous decision of trip length and on-site cost and the stochastic error term in the on-site cost model. Substituting equation 12 into equation 10, the trip length model becomes:

$$\begin{aligned}\lambda_i = \exp\Big(&\theta_1 \cdot (\phi_0 + \phi_1 \cdot q_i + \phi_2 \cdot s_i + \phi_3 \cdot D_i^c + \phi_4 \cdot RSC_{SE} + \delta^{osc} \cdot SSC + \sigma_i^{os} \cdot \epsilon_i^{os}) + \\ &\theta_2 \cdot TC_{i,j}^{tr} + \theta_3 \cdot PH_j + \theta_4 \cdot KS_j + \theta_5 \cdot SS_j + \theta_6 \cdot OF_j + \theta_7 \cdot RSC + \delta^{tl} \cdot SSC\Big)\end{aligned} \tag{13}$$

where σ_i^{os} is distributed normally with a mean 0 and standard deviation 1.

By considering the stochastic disturbance term in equation 13, the trip length model is modeled using a random parameter one-inflated zero-truncated negative binomial (RPOIZTNB) distribution. The RPOIZTNB allows for preference heterogeneity by estimating the standard deviation associated with the given randomly-distributed coefficient (Hynes & Greene, 2016; Whitehead et al., 2018). In equation 13, we assume heterogeneous preferences for the logged daily on-site cost by considering the stochastic disturbance term. The probability for trip length, shown in equation A.3.1, must now be evaluated over the distribution of stochastic disturbance term. We use simulation methods to numerically solve for equation A.3.11 since this function does not have a closed-form solution. The simulated probability is based on the simulated mean of the negative binomial distribution using $5,000$ pseudo-random Halton draws taken from a normal distribution. The expected trip length and daily on-site cost are used when calculating the full-cost term that links the trip length model to the site-choice model.

6.2 Site-Choice Model

We use a site-choice model to quantify preferences among anglers in our sample for site-specific attributes. Our model builds on the conventional approach of formulating the angler's site choice as the solution to a random utility maximization (RUM) problem (Morey et al., 1993; Alvarez et al., 2014). The conditional indirect utility of angler i visiting site j is $U_{i,j} = V_{i,j} + \epsilon^{sc}_{i,j}$ where $V_{i,j}$ represents the deterministic portion of utility, as observed by the researcher, and $\epsilon_{i,j}$ represents the stochastic error, the component of utility known to the individual but not to the researcher. In the RUM model, angler i is assumed to choose the site that has the highest utility out of the J choices in the individual's choice set in a specific choice occasion. Thus, the probability angler i visits site j is $\text{Prob}[V_{i,j}+\epsilon^{sc}_{i,j} > V_{i,k}+\epsilon^{sc}_{i,k} \forall k \neq j]$. Here, we assume that the error follows a generalized extreme value (GEV) distribution, which results in the nested logit (NL) model. The nested logit model weakens the independence of irrelevant alternatives (IIA) property by placing site alternatives in relevant nests where the IIA property holds within the nest but not between other nests. Each nest contains a dissimilarity parameter, also called the inclusive value, that measures the correlation between alternatives within the same nest (Train, 2009). If the dissimilarity parameter is equal to 1, then the nested logit model collapses back into the conventional multinomial logit model. As long as the dissimilarity parameter is not equal to 1, then breaking the IIA property between alternatives is valid. But, for a nested logit model to be consistent with utility maximization theory, the dissimilarity parameter must be between 0 and 1 (Zachary, 1978).

We specify a two-level nested logit model where the angler decides on the fishing mode (charter v. non-charter) before site choice. Under this structure, the probability of angler i visiting site j is:

$$\pi_{i,j} = \pi_{i,j|m} \cdot \pi_{i,m} \tag{14}$$

where $\pi_{i,j|m}$ is the probability angler i visits site j conditional on fishing mode m and $\pi_{i,m}$ is the probability of angler i choosing fishing mode m. Additional details for the probability of angler i visiting site j conditional on fishing mode m and the probability of angler i choosing fishing mode m can be found in Appendix A.3.3.

The deterministic portion of utility, $V_{i,j}$ is shown below:

$$\begin{aligned} V_{i,j} = & - \exp(\gamma) \cdot Z_{i,j} + \delta \cdot RSC + \eta \cdot SSC + \\ & \beta_{1,1} \cdot (PH_j \cdot E[l_{i,j}] \cdot T_{PH,i}) + \beta_{1,2} \cdot (PH_j \cdot E[l_{i,j}] \cdot (1 - T_{PH,i})) + \\ & \beta_{2,1} \cdot (KS_j \cdot E[l_{i,j}] \cdot T_{KS,i}) + \beta_{2,2} \cdot (KS_j \cdot E[l_{i,j}] \cdot (1 - T_{KS,i})) + \\ & \beta_{3,1} \cdot (SS_j \cdot E[l_{i,j}] \cdot T_{SS,i}) + \beta_{3,2} \cdot (SS_j \cdot E[l_{i,j}] \cdot (1 - T_{SS,i})) + \\ & \beta_{4,1} \cdot (OF_j \cdot E[l_{i,j}] \cdot T_{OF,i}) + \beta_{4,2} \cdot (OF_j \cdot E[l_{i,j}] \cdot (1 - T_{OF,i})) \end{aligned} \tag{15}$$

where $Z_{i,j}$ are the full-cost for angler i visiting site j described further in equation 16, PH_j, KS_j, SS_j, OF_j are the daily historical harvest rates for Pacific halibut, king salmon, silver salmon, and other fish, $E[l_{i,j}]$ is the expected trip length (in days) angler i spends fishing at site j, $T_{k,i}$ is an indicator variable equal to 1 if angler i targeted species k, and RSC and SSC are regional- and site-specific constants. Multiplying the daily historical harvest rate by the expected trip length controls for higher expected harvest with longer expected trip lengths. We use a targeting indicator to control for differing preferences between anglers that planned a trip targeting specific species. Previous literature has considered targeting behavior to improve model fit and gain more information on different groups of anglers (Larson & Lew, 2013).

Following recommendations from Carson and Czajkowski (2019), we assume that the marginal utility of money, $\exp(\gamma)$, is strictly negative by specifying the cost term to be the negative exponential of the full-cost coefficient. The full-cost term is the sum of round-trip travel cost and on-site fishing cost. Round-trip travel cost is commonly calculated as the sum of round-trip monetary cost and the monetized cost of travel time (Haab et al., 2012; Alvarez et al., 2014; English et al., 2018). This travel cost calculation is due to the time and money-constrained consumer choice theory that states that an individual making a labor-leisure decision maximize their utility subject to a monetary and time budget constraint (Becker, 1965). Monetary travel cost is the amount of money spent during travel, while the opportunity cost of travel time is time spent in travel converted to a monetary value. The opportunity cost of travel time is the shadow value of travel time (SVTT) multiplied by the travel time to site j. It is common to assume that the SVTT is a proportion of an individual's exogenous income or wage rate (Cesario & Knetsch, 1970; Cesario, 1976). But the exact proportion is unknown forcing economists to make assumptions about the proportion when calculating travel costs. Researchers commonly assume that the proportion is between one-third and the whole wage rate (Cesario, 1976; McConnell & Strand, 1981; Train, 1998; Landry et al., 2012; English et al., 2018). The SVTT can also be jointly estimated with site-choice (Bockstael, Strand, et al., 1987; Feather & Shaw, 1999; Shaw & Feather, 1999; Lew & Larson, 2005, 2008, 2014). These latter studies find a better statistical fit for models that estimate a proportion of the wage rate to be used in the SVTT calculations rather than assume a constant proportion (Lew & Larson, 2005, 2008). It is likely that the employment status of angler's has an effect on the SVTT as employed angler's are trading a observed wage rate for travel where unemployed anglers are trading a shadow wage for travel. For this reason, we differentiate the SVTT based on employed, E and unemployed, U, anglers when calculating travel costs (Bockstael, Strand, et al., 1987).

The full-cost term also considers the monetary on-site fishing cost and the shadow value of on-site time. Monetary on-site costs are calculated as the product of the expected trip length and the exponential of the logged daily on-site cost estimated in equation 12. We assume that the shadow values of time are the same for travel and time spent on-site (Larson & Shaikh, 2001). Since travel time is measured in hours and expected trip length is measured in days, we multiply the expected trip length by 8 representing a full work day.

The full-cost calculation is shown below:

$$Z_{i,j} = 2 \cdot p_{i,j} + \eta \cdot m_{i,j} + (\kappa_E \cdot w_i \cdot D_E + \rho_U \cdot (1 - D_U)) \cdot (2 \cdot t_{i,j} + 8 \cdot E[l_{i,j}]) \tag{16}$$

where $p_{i,j}$ is the monetary travel cost of angler i visiting site j, $m_{i,j}$ is the total monetary on-site cost per fishing day calculated as $\exp(\ln(OSC_i)) \cdot E[l_{i,j}]$, $\kappa_E \cdot w_i \cdot D_E$ is the proportion of the wage rate used in the SVTT calculations for employed anglers where w_i is angler i's wage rate and D_E is a dummy variable equal to 1 for employed anglers and 0 for non-employed anglers, ρ_U is the monetary SVTT for unemployed anglers, $t_{i,j}$ is the travel time for angler i visiting site j, and $E[l_{i,j}]$ is the expected fishing trip length measured in days. Appendix A.3 contains the FIML function and additional information about log-likelihood functions for each sub-model.

7 RESULTS

This section discusses the estimated coefficients for the trip length and site-choice models, discussed in Section 6, when estimated sequentially and simultaneously. The sequential method is similar to the methodology presented in Berman and Kim (1999). In the sequential framework, we first estimate the trip length model (equation 13) to get exogenous predicted trip lengths (equation 11) that are substituted into the site-choice model (equation 15). This approach does not assume correlation between the error terms of the sub-models. The simultaneous model considers all decisions jointly allowing for correlation between the error terms estimated in a full-information maximum likelihood framework. The estimated coefficients for the trip length and site-choice models have similar signs and magnitudes across the sequential and simultaneous estimation approaches. The primary difference comes in the statistical significance of select coefficients in the trip length model, explained further below. For full model results, including regional- and site-specific constants and the estimated coefficients for the on-site cost model, see Table A.6.3 in Appendix A.6.

7.1 Trip Length Model Results

Results for the trip length model can be found in Table 2 and the full results with the on-site cost coefficients and regional- and site-specific constants can be found in Table A.6.3. The trip length model has two components. The first component is the mixture parameter that describes the likelihood of participating in a single-day trip despite changes in site-specific attributes and is estimated as a binary logit model. We find that the decision to participate in a fishing trip via a cruise excursion has a significant influence on the probability of a single-day trip. The results suggest that an angler participating in a fishing trip from a cruise excursion has a 91.5% probability of participating in a single-day trip.[7] The lodge dummy variable is not statistically significant in the simultaneous framework. The positive sign suggests that anglers participating in a fishing trip via a fishing lodge are less likely to participate in a single-day trip than anglers that participated in a fishing trip without staying in a fishing lodge. The second component of the trip length model estimates the number of days an individual may spend fishing. We find that monetary travel costs and select historical harvest rates have a significant impact on trip length. Also, we find that the overdispersion parameter is significantly different from 0 suggesting overdispersion is present in the data and the use of a Poisson distribution would be limiting.

We find that travel cost has a positive and significant correlation with the number of days spent fishing at a given site. This result is consistent with findings in the transportation literature that suggests more expensive travel costs lead to longer trip lengths (Alegre & Pou, 2006). The daily on-site cost has a significant negative correlation with trip length when estimated sequentially suggesting that increases in the daily on-site cost may reduce trip length. However, when estimated simultaneously, we find that daily on-site cost is positive but statistically insignificant. This is due to the dual nature of daily on-site costs. On-site costs enter the jointly estimated model in the trip length sub-model and the site-choice sub-model. As on-site cost increases, the fishing trip length remains unaffected but, as we will see below, reduces the probability of site j being chosen. Fishing in Alaska is not a frequent trip for many non-resident saltwater anglers. It is likely that anglers consider the full cost of

[7]In the sequential approach, an angler participating in a fishing trip via a cruise excursion has a 93.8% probability of participating in a single-day trip and 1.0% probability if fishing from a fishing lodge

Table 2: Selected fishing trip-length coefficients for the trip length sub-model when following a OIZTNB distribution

	Sequential	Simultaneous
Mixture Function:		
Constant	-0.523***	-0.286*
	(0.166)	(0.149)
Cruise Dummy	3.247***	2.658***
	(0.627)	(0.608)
Lodge Dummy	-4.032**	-6.072
	(1.969)	(9.662)
Trip Duration Model:		
Logged Monetary Travel Cost	0.109***	0.110***
	(0.024)	(0.028)
Logged Daily On-Site Cost	-0.189***	0.042
	(0.053)	(0.054)
Pacific Halibut - Targeted	-0.503	-0.955***
	(0.388)	(0.354)
Pacific Halibut - Not Targeted	-0.136	-0.894**
	(0.429)	(0.394)
King Salmon - Targeted	11.086*	3.245
	(6.617)	(7.296)
King Salmon - Not Targeted	12.336*	4.053
	(6.574)	(7.271)
Silver Salmon - Targeted	3.929**	1.553
	(1.730)	(1.680)
Silver Salmon - Not Targeted	3.873**	1.505
	(1.740)	(1.677)
Other Fish - Targeted	1.295	0.958
	(0.794)	(0.632)
Other Fish - Not Targeted	1.298	0.945
	(0.797)	(0.629)
Overdispersion	0.079**	0.199***
Parameter (α)	(0.031)	(0.057)
N	463	463

Note: Full results, including goodness-of-fit measures, can be found in Table A.4.1.

a trip before deciding to participate more than a small marginal change in the daily on-site costs.

We also find that the daily historical harvest rates for key Alaskan species impacted the trip length for anglers in 2016. Angler preferences for the historical harvest rates for all species except Pacific halibut are positive suggesting an increase in the historical harvest rate will increase trip length. Since the bag limit for Pacific halibut is a single fish in Area 2C and two fish in Area 3A, increasing harvest rates will lead to the bag limit being reached more quickly. It is possible that the negative coefficient for Pacific halibut may reflect that once an angler reaches their expected harvest rate of Pacific halibut, they would substitute their time spent fishing with a non-fishing activity. Utility parameters for all other key species have the same sign in the sequential and joint models but are only statistically significant in the sequential model. Similar to the daily on-site cost coefficient, the historical harvest rate enters the trip length and site-choice sub-models in the joint framework. The trip length model in the sequential framework ignores the spatial decision by anglers, while the simultaneous model jointly considers both the spatial and temporal angler decisions. The trip-length and site-choice models are linked through the expected trip length, shown in equation 11.[8]

7.2 Site-Choice Model Results

The site-choice model is estimated as a two-stage nested logit model where the first decision is mode choice (charter vs. non-charter) followed by site choice. The inclusive value for the first level of the nested logit model, mode choice, is not significantly different from 1 suggesting that the IIA property is overly restrictive. The full-cost coefficient is negative and significant matching a priori expectations. This suggests that an angler is less likely to visit a site as it becomes more expensive relative to all other sites in the choice set. The full-cost calculation considers the monetary value of travel and on-site cost and the opportunity cost of time for employed and unemployed anglers. It is common to assume that the shadow value of travel time (SVTT) is equal to a proportion of the wage rate where the proportion is assumed to be between 0.25 and 1 (Cesario & Knetsch, 1970; Cesario, 1976). The results suggest that the proportion of the wage rate used in SVTT calculations is near 0.50 for employed anglers. We estimate the average implicit SVTT in dollar units

[8]For additional discussion on the expected trip length, see Appendix A.7.

Table 3: Select coefficients for the site-choice sub-model estimated as a two-level nested logit model

	Sequential	Simultaneous
Travel Cost (γ)	-5.572***	-5.473***
	(0.083)	(0.113)
κ_E	0.591***	0.527***
	(0.106)	(0.130)
ρ_U	28.084***	28.722***
	(5.347)	(6.776)
Total On-Site Cost (η)	-0.046***	-0.107***
	(0.010)	(0.036)
Pacific Halibut - Targeted	0.165	0.286
	(0.133)	(0.215)
Pacific Halibut - Non-Targeted	-0.727***	-0.942**
	(0.234)	(0.402)
King Salmon - Targeted	-0.871	1.351
	(0.669)	(1.595)
King Salmon - Not Targeted	-2.427***	-1.324
	(0.694)	(1.136)
Silver Salmon - Targeted	0.789***	1.066***
	(0.123)	(0.220)
Silver Salmon - Not Targeted	0.343**	0.518**
	(0.151)	(0.211)
Other Fish - Targeted	0.649***	0.901***
	(0.220)	(0.301)
Other Fish - Not Targeted	0.164	0.242
	(0.305)	(0.280)
$IV_{Charter}$	0.894***	0.923***
	(0.051)	(0.077)
N	463	463

Note: Other Fish includes the historical harvest rates for rockfish, lingcod, "other" salmon, and "other" species. Full table results can be found in Table A.4.1.

for unemployed anglers since they do not have an observable wage rate. The results imply that the SVTT for unemployed anglers is approximately $28. The additional component of the full cost calculation is the monetary value of on-site cost. We find that the monetary on-site cost coefficient is negative and significant suggesting that the cross-price parameter between monetary on-site cost and monetary travel cost is the opposite. This suggests that monetary travel cost may be substituted for monetary on-site cost. In other words, anglers may choose a site that is relatively cheaper to visit and substitute the remaining travel cost with increased on-site costs.

Site choice is also a function of the three-year average daily historical harvest rates of Pacific halibut, king salmon, silver salmon, and "other" fish which consists of lingcod, rockfish, "other" salmon, and "other" species differentiated by respondents targeting behavior. The daily historical harvest rates are interacted with the expected trip length to allow for higher expected harvest from longer fishing trips. The sign and significance for all species, excluding anglers targeting king salmon, are similar between the sequential and joint framework. Angler preferences for the historical harvest rates of all targeted species are positive in the joint model implying increases in the historical harvest rate or trip length yield increases to utility. Although preferences for king salmon are negative when targeted in the sequential framework, the coefficient is not statistically different from zero. Angler preferences for non-targeted species are negative or insignificant excluding silver salmon. Since anglers commonly participate in fishing trips targeting specific species, harvesting a non-targeted species may be viewed by some as bycatch causing disutility.

8 SCENARIO ANALYSIS

We use the estimated coefficients to calculate daily welfare estimates and the impact on recreational harvest mortality from changes in the historical harvest rate of Pacific halibut due to a proposed shift in management strategies. In 2017, ADF&G proposed adjusting the Catch Sharing Plan using the Blue Line Fishery Constant Exploitation Yield to reduce the Pacific halibut mortality from charter boats (Meyer & Powers, 2016). The adjustment was known as the Blue Line Management Plan (BLMP). The outcome of the BLMP was a reduction in expected harvest rates of Pacific halibut by 15% in southeast Alaska and 10% in southcentral Alaska for charter anglers. However, the analysis did not account for changes in trip length as a result of reductions in the historical harvest rate. We estimate the welfare impact (Table 8.1) and change in expected harvest mortality within our sample (Figure 4) from this proposed plan. Since we do not have mode-specific harvest rates for all sites, we assume a 15% and 10% reduction in the historical harvest rate for all anglers. We present the median welfare effect and 90% confidence intervals for the statewide impact of the BLMP, region-specific changes, and changes in expected trip length using the Krinsky-Robb simulation approach (Krinsky & Robb, 1986). The welfare results are calculated using 5,000 draws over the standard deviation of each estimated sub-model coefficients.

8.1 Welfare Analysis

The compensating variation (CV) for changes in site-specific attributes, excluding travel cost, and site closures can be calculated from RUM models (McFadden et al., 1973). The additional trip length decision in our joint model does not change per-trip welfare calculations for the site-choice model. But we do have to consider how changes in site-specific attributes impact trip length since the site-choice model is linked via the expected trip length. Therefore, a change in the historical harvest rate will cause an increase in utility from more harvest but disutility from an increase in on-site cost from a longer fishing trip. The sign of the CV estimate largely depends on the relationship between these two opposing effects. The CV calculation for a nested logit model is shown below:

$$CV_i = \frac{\log\left(\sum_j^J \exp\left(V_{i,j}^1/\lambda_c\right)^{\lambda_c}\right) - \log\left(\sum_j^J \exp\left(V_{i,j}^0/\lambda_c\right)^{\lambda_c}\right)}{\exp\left(\gamma\right)} \tag{17}$$

where $\exp(\gamma)$ is the travel cost coefficient, the superscript 0 and 1 indicates calculations using the observed site-specific attributes and hypothetical site-specific attributes, respectively, and λ_c represents the dissimilarity coefficient for the charter nest relative to the non-charter nest. The expected trip length for OIZTNB distribution is shown in equation 11. Since the trip length model considers the stochastic error component from the on-site cost model, we must simulate the expected trip length, as we did during the estimation of the trip length model, to account for potential heterogeneity among anglers. The simulated expected trip length is shown below:

$$\hat{E}\left(L = l_i | L > 0\right) = \frac{1}{R}\sum_{r=1}^{R} \omega_i + (1+\omega_i)\cdot\lambda_i^r \cdot \left(1 - (1+\alpha\cdot\lambda_i^r)^{\alpha^{-1}}\right)^{-1} \tag{18}$$

where $r = [1, ..., R]$ for R Halton draws from a standard normal distribution. The table below presents the welfare effect (equation 17) and the change in expected trip length (equation 18) from the reduction in harvest of Pacific halibut suggested by the Blue Line Management Strategy Plan. We also analyze the regional impact by reducing harvest in a specific region while assuming no change in the opposite region.

Table 4: Welfare impact from the Blue Line Management Plan when fully implemented and when implemented in only one region

	Change in Daily Welfare		**Change in Trip Length**	
	Targeted	Not-Targeted	Targeted	Not-Targeted
BLMP	-\$13.65 (-\$23.76, -\$3.75)	\$8.11 (-\$5.03, \$22.36)	0.091 (0.031, 0.176)	0.095 (0.031, 0.176)
Area 2C	-\$4.65 (-\$9.12, -\$0.80)	\$7.97 (-\$0.50, \$17.46)	0.054 (0.017, 0.100)	0.053 (0.017, 0.099)
Area 3A	-\$7.74 (-\$13.26, -\$1.84)	\$1.06 (-\$3.96, \$5.08)	0.051 (0.017, 0.100)	0.051 (0.017, 0.099)

Note: Numbers in the parentheses represent the 90% confidence interval using 5,000 Krinsky-Robb simulations; Area 2C and Area 3A rows do not have to add up to the Blue Line Management Strategy row as each regional change assumes zero change to the opposite region being simulated.

A reduction in the historical harvest rate for Pacific halibut by 15% in Area 2C and 10% in Area 3A results in a decrease in angler welfare when targeted. The reduction in historical harvest rates partially causes a reduction in total welfare. But, as we see from column 4, the expected trip length increases as anglers prefer to fish longer with declining historical harvest rates. The decrease in angler welfare is primarily derived from the increase in on-site cost associated with a longer fishing trip in addition to the decrease in utility from lower historical harvest rates. Anglers not targeting Pacific halibut gain welfare from reductions in the historical harvest rate despite longer fishing trips. This suggests that the positive utility from lower harvest outweighs the disutility from higher on-site costs. We also find spatial differences in the CV for regional changes in the historical harvest rate. We find a greater welfare impact for a decrease in the historical harvest rate of Pacific halibut in Area 3A compared to Area 2C when targeted. Area 3A generally has higher historical harvest rates of Pacific halibut than 2C leading to a larger decrease in magnitude from the BLMP. But anglers not targeting Pacific halibut may substitute to sites within Area 2C due to the lower historical harvest rate and the larger percentage reduction in harvest causing a larger positive impact to welfare than Area 3C.

We can also calculate the value per trip using traditional welfare measures. The value per trip is calculated by artificially closing all sites in the choice set. In other words, the new indirect utility is equal to zero. The per-trip value calculation is shown below:

$$\hat{CV_i} = \frac{log\left(\sum_j^J exp\left(V_{i,j}^0/\lambda_c\right)^{\lambda_c}\right) + 0.5572}{exp(\gamma)} \tag{19}$$

where 0.5572 is Euler's constant. The median value per-trip in 2016 is \$971.40 (\$593.59, \$1,370.39) with 90% confidence intervals in parentheses.

8.2 Change in Expected Recreational Mortality

Considering trip length allows the researcher to estimate additional endpoints other than the traditional welfare calculations described above. We use the site choice and trip length parameters to calculate the percentage change in the expected recreational mortality within our sample from the reduction of historical harvest rates associated with the BLMP. To calculate the change in expected mortality, we first need to know how harvest may change based on changes in the historical harvest rate. We use a simulation approach to calculate the harvest before and after the implementation of the BLMP. The simulation uses random draws from the on-site cost and site-choice probability functions. Using the random draw of site- and angler-specific on-site cost, we calculate the expected trip length before and after changes in the historical harvest rate. The angler- and site-specific expected trip length is substituted into the site-choice model to parameterize the site-choice probability function. Based on these probability functions, we randomly draw and store the site angler i visited and the expected trip length for each draw. We repeat this procedure 5,000 times. We calculate the expected mortality within our sample for each draw by multiplying the site-specific historical harvest rate by the expected trip length, shown below:

$$E[Mortality_{i,j}] = E[Harvest_j] \cdot E[l_{i,j}] \tag{20}$$

We sum the expected harvest mortality across anglers for each draw. The percentage change in mortality is calculated as the difference in expected mortality before and after the implementation of the BLMP for each draw. Figure 4 presents the median percentage change in expected recreational harvest mortality. If trip length has no impact on the expected recreational harvest mortality, we should find similar percentage changes as those presented in the BLMP. The bar graph below compares the simulated expected harvest compared to the suggested change in expected harvest rates. The first column illustrates the statewide impact. The BLMP does not discuss the statewide impact of the management strategy so there is no comparison value. The last two columns compare the change in the expected recreational harvest in each management area to that suggested by the BLMS.

We find that the change in the expected recreational harvest mortality within our sample is less, in absolute value, than the change in the expected recreational harvest mortality stated in the BLMP (Meyer & Powers, 2016). In Area 2C, the BLMP suggests a reduction in harvest by 15%. However, when considering trip length, we find that expected harvest mortality is reduced by approximately 11.2% due to longer trips by anglers. Anglers looking to fill their bag limit participate in longer fishing trips as historical harvest declines causing more fish to be harvested than may have been anticipated by management. Similarly, the BLMP suggests a reduction in expected harvest mortality by 10% in Area 3A but our model suggests a reduction of approximately 5.5%. The BLMP does not explicitly state the statewide impact on expected harvest mortality. Using our model, we find a statewide reduction in the expected recreational harvest mortality of approximately 8.7%. Ignoring trip length causes an overestimation in the reduction of the expected recreational harvest of Pacific halibut due to the negative correlation between harvest rates and trip length. We find a significant difference between the BLMP and our joint model that considers trip length

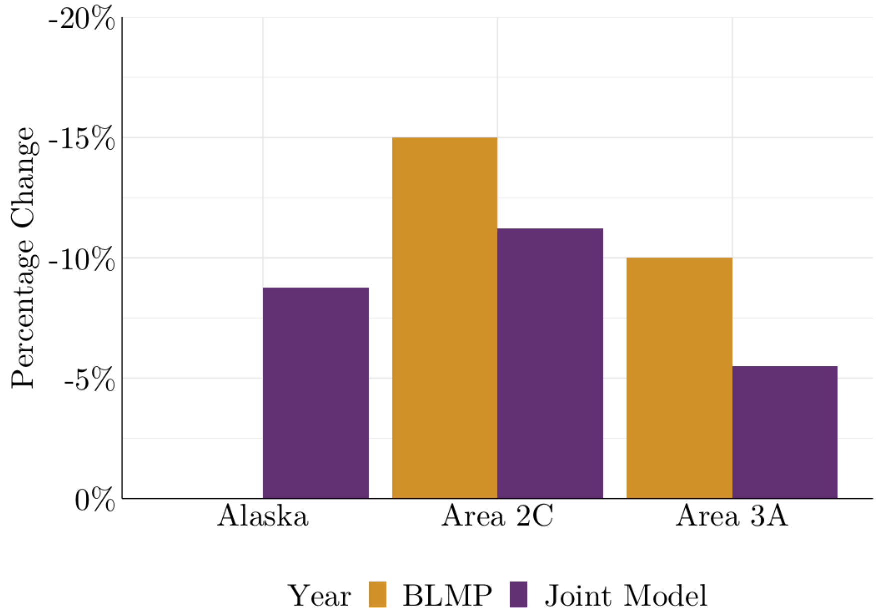


Figure 4: The figure above compares the simulated percentage change in the recreational harvest mortality within sample to the proposed change in the BLMP. The first column estimates the predicted statewide change from the BLMP but there is no comparison bar as the report did not list an estimated statewide impact. As we can see, the regional reductions in recreational mortality are lower, in absolute value, when considering trip length.

suggesting that the trip length decision is impactful in the sustainable management of Pacific halibut.

9 CONCLUSION

We develop a linked site-choice, trip length, and daily on-site cost model. This model framework can be applied to various recreational activities where the researcher is interested in the impact a policy change may have on site choice and trip length components. If a researcher is only interested in per-trip welfare effects, then linking site-choice and trip length is not necessary and one can simply estimate a site-choice model (McConnell, 1992). But researchers interested in the on-site time impact, daily welfare effects, or the change in ecological endpoints should consider the on-site time and site-choice decisions. Incorporating the site-choice and on-site time components can increase the realism and applicability of MSE models in policy decision-making.

We apply the linked model to a survey of recreational non-resident anglers that participated in an Alaskan saltwater angling trip in 2016. In the trip length model, we find that the historical harvest rates for most key Alaskan species are positively correlated with trip length when targeted by anglers, matching previous expectations. However, increasing the Pacific halibut harvest rule may shorten trip length as the expected harvest rate is reached more quickly causing a reduction in fishing trip length. We estimate how a change in the management strategy for Pacific halibut will impact the expected non-resident recreational mortality. We find that a reduction in the historical harvest rate reduces expected harvest mortality at a slower rate than expected due to longer trip lengths. Additionally, spatial changes in the historical harvest rate do not cause uniform spatial changes in the expected harvest mortality as anglers may substitute between sites with different harvest restrictions. We made some simplifying assumptions about the biology of the Pacific halibut stock and angler selectivity from a reduction in the historical harvest rate. Future work will relax these assumptions by introducing additional biological data and models to simulate a recreational bioeconomic model. The simple calculation is meant to illustrate how researchers could utilize changes in trip length to calculate additional endpoints.

This model framework does contain areas that can be addressed in future research. The first is related to the specification of the full-cost term. We assume that the marginal utility of money is the same between total travel and on-site costs, allowing for a simplified welfare calculation. The marginal utility of money may be separated into the marginal utility of money for travel and the marginal utility of money for on-site time. But separating these terms brings additional complications into the welfare calculation that have to be addressed. Similarly, we currently assume that the shadow value of time is the same between travel and on-site time but past research suggests that the shadow value of travel time may differ among leisure activities (DeSerpa, 1971; Palmquist et al., 2010). Future work will attempt to disentangle the marginal value of money and the shadow value of time between travel and on-site time improving the realism of the model.

The second area for future research is improving trip length predictions. Predicted trip length is the link between the trip length and site-choice model. Having accurate predictions is crucial for the applicability of this model. We currently use a OIZTNB distribution that weighs predicted trip lengths by the probability of an angler being bound to a single-day trip. But the predicted values in our empirical model tend to over-predict single-day trips and under-predict trips longer than 5 days. Future work will explore other trip length specifications of the trip length model, such as a hurdle or latent class model, to provide better predictions and potentially the non-participation decision.

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A APPENDIX

A.1 TRIP COST CALCULATIONS

We calculate the travel cost from each respondent's home-base to each fishing site in their choice set. Detailed driving, airfare, and ferry trip costs and travel time data were collected by the Pacific States Marine Fisheries Commission (PSMFC). Commercial airfare and air-time data were collected from the U.S. Department of Transportation's' (USDOT) Bureau of Transportation Statistics for 2016 (USDOT 2017). These data include the average one-way fare and flight time between all airports in 2016. Non-commercial (seaplane) airfare and flight time was calculated using the average fare and flight time between locations based on estimates from Alaska Seaplanes (Alaska Seaplanes 2020). All driving cost to the airport, marine port, and fishing location are computed using the 2016 AAA average cost-per-mile of $0.56, respectively. The AAA average cost-per-mile considers average annual fuel expenditures for a medium-sized sedan with depreciation that travels an average of 15,000 miles per year. This does not include other vehicle costs such as insurance, maintenance, or registration. Maritime costs and times were calculated using the average 2016 one-way ferry fare between ports from the Alaskan Maritime Highway System. We assume that non-resident's with a home base outside of Alaska choose the trip with the lowest total travel cost and non-resident's with a home base within Alaska choose the trip with lowest travel time. Since the primary purpose of the fishing trip for anglers with a home base within Alaska was not fishing, they most likely had additional Alaskan activities planned where total trip time had a higher constraint.

A.1.1 Airfare

The initial cost for each respondent is the driving cost from the respondent's home-base to the nearest airport. All driving costs in the model are calculated by multiplying the total distance (in miles) by the 2016 AAA average cost-per-mile of $0.56. Non-residents whose home-base is in Alaska can travel to Juneau, AK or Anchorage, AK from their nearest airport then to the fishing location nearest each fishing site. Juneau and Anchorage are the two largest airports in Alaska and act as a hub for all other Alaskan regional airports. In other words, from Juneau or Anchorage, all other airports can be reached but our data does not allow for direct travel between regional Alaskan airports. The airfare is the average ticket price between each location during 2016 based on data from the U.S. Department of Transportation's (USDOT) Bureau of Transportation Statistics (USDOT 2017). Respondent's drive the remaining distance from the fishing sites nearest airport to the actual fishing site. If maritime travel is required then we use the driving cost from the airport to the nearest ferry location and the average ferry cost to the port nearest the fishing site plus the driving cost from the ferry port to the fishing site.

Calculating air-travel for non-residents whose home-base is outside of the Alaska involves additional steps. As with the Alaskan non-residents beginning inside Alaska, the initial driving cost from the address to the nearest airport is calculated for each respondent. However, non-residents beginning outside of Alaska must travel to one of four major airports that made trips to Alaska in 2016, Chicago, Honolulu, Portland, or Seattle, before flying to Alaska. Then, from each of these airports, the respondent can fly to Juneau, Anchorage, or, directly to the fishing site if a direct flight is available. Once the respondent arrives at the nearest airport to each fishing site, the driving cost or ferry cost is calculated from the airport to the fishing site, mirroring the final step for the Alaskan non-residents. We also allow respondents to travel to Juneau or Anchorage from Chicago, Honolulu, Portland, or Seattle before travelling to the fishing site. The flowchart below illustrates all possible air-travel combinations to reach the same fishing site. This results in 12 possible airfare combinations for each non-resident. Airfare and driving costs are summed together for each possible combination.

A.1.2 Driving

Non-residents whose home-base is within Alaska have the option of driving directly from their home-base to each fishing site in their choice set. If a road is available, then the road distance is used to calculate total driving costs using the AAA average cost-per-mile. But, if no road distance is available, then the straight-line distance is used to calculate the driving costs. This is typically the minimum cost option of travel for non-respondents beginning within Alaska. Non-Alaskan residents whose home-base begins outside of Alaska do not have the option of driving directly from their address to a fishing site.

A.1.3 Travel by Ferry

Non-residents beginning within Alaska have the option of taking a ferry to each fishing site in Southeast or Southcentral Alaska. Similar to calculating total airfare, we calculate the driving cost from the resident's home-base to the nearest ferry port. Once at the ferry port nearest the home base, the average cost between each fishing port is the assumed costs of maritime travel to each fishing site if a route is available. From the port nearest the fishing site, we calculate the driving cost from the ferry port to each fishing site. The ferry method with the minimum total time is the assumed maritime route taken that is compared with all other travel methods above. Most respondents whose home base began within Alaska choose to drive directly to the Alaskan site or take ferry.

A.1.4 Travel Time

We compute the travel time for each step of the trip based on the travel method with the minimum cost for each site. Driving times from the respondents are recorded using Google Maps and CDX ZipStream (CDXZipStream 2017). Flight times are provided by the USDOT Bureau of Transportation Statistics (USDOT 2017). Flight time is the in-air flight time between destinations. Ferry time is the time from departing the port to arriving at the destination port. If commercial airfare is used within the travel route, then an additional 2-hours is added in accordance with the Transportation Security Administration (TSA) recommendations for security, boarding, and other potential delays (TSA 2020). Similarly, if a ferry or seaplane is used within the travel route, then an additional hour is added in accordance with travel recommendations (Alaska Seaplanes 2021; AMHS 2021).

A.2 HISTORICAL HARVEST RATES

The table below lists the three-year average daily harvest rates for Pacific halibut, king salmon, silver salmon, and “other” fish.

Table A.2.1: Average 3-year expected harvest rates for each site and species

	Pacific Halibut	King Salmon	Silver Salmon	“Other” Fish
Southeast Alaska				
Glacier Bay (Gustavus)	1.058	0.253	0.570	1.532
Haines (and Skagway)	0.200	0.140	0.045	0.480
Juneau	0.512	0.192	0.483	1.160
Ketchikan	0.250	0.365	0.675	1.084
Petersburg	1.249	0.114	0.297	0.695
Prince of Wales (Klawock)	0.602	0.450	1.384	1.681
Sitka	0.507	0.859	0.983	2.205
Yakutat	0.836	0.140	1.151	1.371
Southcentral Alaska				
Alaska Peninsula (Bristol Bay)	0.587	0.067	0.315	3.091
Anchor Point	1.578	0.067	0.048	0.388
Anchor Point	2.703	0.083	0.129	0.448
Clam Gulch	1.578	0.067	0.048	0.388
Clam Gulch	2.703	0.083	0.129	0.448
Cordova	0.517	0.081	0.536	1.123
Homer	1.118	0.144	0.070	0.800
Homer	2.610	0.109	0.154	0.828
Kenai	1.578	0.067	0.048	0.388
Kenai	2.703	0.083	0.129	0.448
Kodiak	0.868	0.246	0.385	2.299
Ninilchik (and Deep Creek)	1.578	0.067	0.048	0.388
Ninilchik (and Deep Creek)	2.703	0.083	0.129	0.448
Seldovia	1.364	0.137	0.090	0.823
Seldovia	2.610	0.109	0.154	0.828
Seward	0.818	0.052	1.031	1.497
Valdez	0.379	0.016	0.896	0.700
Whittier	0.380	0.027	0.274	0.943

Note: Italicized sites represent historical harvest rates for charter-specific trips and the corresponding non-italicized sites represent historical harvest rates for non-charter-specific trips

A.3 JOINT LOG-LIKELIHOOD FOR THE SITE CHOICE, TRIP LENGTH, AND ON-SITE COST MODELS

A.3.1 Detailed Probability Density Function for OIZTNB Distribution

The probability density function for the one-inflated zero-truncated negative binomial (OIZTNB) distribution has two components. The first is the probability an angler will participate in only a single-day trip and the second is the probability an angler will participate in a trip of length l if they participate in a multi-day trip. The probability function for a OIZTNB distribution is shown below:

$$\pi_{i,j}^{l}\left(l_i\right) = \begin{cases} \omega_i + \left(1-\omega_i\right)\cdot p_+\left(1,\alpha\right) & l_{i,j}=1 \\ \\ \left(1-\omega_i\right)\cdot p_{++}\left(l_{i,j},\alpha\right) & l_{i,j}>1 \end{cases} \tag{A.3.1}$$

where ω_i is the mixture parameter, $p_+\left(1,\alpha\right)$ is the probability of observing a one for the ZTNB distribution, $p_{++}\left(l_i,\alpha\right)$ is a zero-one-truncated distribution, and α is the overdispersion parameter. The mixture parameter is estimated as a binary logit model, shown below, that is a function of a constant, a cruise dummy variable, and a lodge dummy variable. The cruise dummy variable is equal to 1 if angler i participated in a fishing trip via a cruise excursion. The lodge dummy is equal to 1 if angler i participated in a fishing trip from a fishing lodge. If $\omega_i = 0$, then the probability function in equation A.3.1 collapses to a zero-truncated negative binomial distribution (Godwin, 2017).

$$\omega = \frac{exp\left(\theta_0 + \theta_1\cdot D_i^{Cruise} + \theta_2\cdot D_i^{Lodge}\right)}{1+exp\left(\theta_0 + \theta_1\cdot D_i^{Cruise} + \theta_2\cdot D_i^{Lodge}\right)} \tag{A.3.2}$$

where D_i^{Cruise} and D_i^{Lodge} are dummy variable equal to 1 if angler i participated in a fishing trip from a cruise ship and 0 otherwise or if angler i participated in a fishing trip from a fishing lodge and 0 otherwise. To calculate the log-likelihood function for the trip length model, we use the following relationship for the gamma function as shown in Cameron and Trivedi (2013) When determining the probability of a single day trip we add the logit model that determines the likelihood that an individual will participate in only a single-day trip and the probability that the zero-truncated negative binomial distribution is equal to 1 if they participate in a non-single day trip. The probability of 1 for a zero-truncated negative binoimal distribution is:

$$p_{+}\left(1,\alpha\right)=\alpha^{-1}\cdot\left(\frac{\alpha^{-1}}{\alpha^{-1}+\lambda}\right)^{\alpha^{-1}}\cdot\frac{\lambda}{\alpha^{-1}+\lambda}\cdot\frac{1}{1-\left(1+\alpha\cdot\lambda\right)^{\alpha^{-1}}} \tag{A.3.3}$$

The second step is estimating the probability an angler will particiapte in a trip of length l if they do participate in a multi-day trip. In other words, the probability they will participate in a trip greater than or equal to 2 days. For this, we need to know the probability of a zero-one-truncated negative binomial distribution. The probability function of a zero-one-truncated negative binomial distribution is:

$$\begin{aligned} p_{++}\left(l_i,\alpha\right)=&\frac{\Gamma\left(l+\alpha^{-1}\right)}{\Gamma\left(l+1\right)\Gamma\left(\alpha^{-1}\right)}\cdot\left(\frac{\alpha^{-1}}{\alpha^{-1}+\lambda}\right)^{\alpha^{-1}}\cdot\left(\frac{\lambda}{\alpha^{-1}+\lambda}\right)^{l}\cdot\\ &\left[1-\left(1+\alpha\cdot\lambda\right)^{-\alpha^{-1}}-\alpha^{-1}\cdot\left(1+\alpha\cdot\lambda\right)^{\alpha^{-1}}\cdot\frac{\lambda}{\left(\alpha^{-1}+\lambda\right)}\right]^{-1} \end{aligned} \tag{A.3.4}$$

We calculate the log-likelihood for the OIZTNB distribution using the following approximation (Cameron & Trivedi, 2013):

$$\ln\left(\frac{\Gamma\left(l_i+\alpha^{-1}\right)}{\Gamma\left(\alpha^{-1}\right)}\right)=\sum_{c=0}^{l_i-1}ln(c+\alpha^{-1}) \tag{A.3.5}$$

where c are discrete integers. Substituting this relationship into equation A.3.8 yields the following log-likelihood function for a single-day trip:

$$\ln\left(\pi_i^{TL}(l_i=1)\right)=\ln\left(\omega+(1-\omega)\cdot\alpha\cdot\left(1+\alpha\cdot\lambda\right)^{\alpha^{-1}}\cdot\frac{\lambda}{\left(1-\left(1+\alpha\cdot\lambda\right)^{-\alpha^{-1}}\right)}\right) \tag{A.3.6}$$

and for a multi-day trip:

$$\ln\left(\pi_i^{TL}(l_i > 1)\right) = \ln(1-\omega) + \sum_{c=0}^{l_i-1} \ln\left(c - \alpha^{-1}\right) - \ln(l_i!) - \left(l_i + \alpha^{-1}\right)\ln(1+\alpha\cdot\lambda) + l_i \ln(\alpha) + \\ l_i \ln(\lambda) - \ln\left(1 - (1+\alpha\cdot\lambda)^{\alpha^{-1}} - \alpha\cdot(1+\alpha\cdot\lambda)^{-\alpha^{-1}} \cdot \left(\frac{\lambda}{\alpha^{-1}+\lambda}\right)\right) \tag{A.3.7}$$

The log-likelihood for the trip length model is simply the sum of these two function multiplied by indicator variables signaling if angler i participated in a single-day or multi-day trip, shown below.

$$SLL_1 = \sum_i^I d_i^{Multi} \cdot \ln\left(\pi_i^{TL}(l_i > 1)\right) + d_i^{Single} \cdot \ln\left(\pi_i^{TL}(l_i = 1)\right) \tag{A.3.8}$$

A.3.2 Probability Function for Daily On-Site Cost Model

The daily on-site cost model is estimated using a Gaussian distribution. We find a better statistical fit when daily on-site cost is logged. By logging daily on-site cost, we are changing the stochastic disturbance term from a Gaussian distribution to a log-normal distribution. The PDF for the log-normal distribution is:

$$\pi_i^{osc}(\ln(OSC_{ij})|\theta) = \prod_{i=1}^{I} \frac{1}{\sqrt{2\pi\sigma_{os}^2}} \cdot \exp\left(-\frac{\ln(OSC_i) - \theta_0 - \theta_1 \cdot q_i - \theta_2 \cdot s_i - \theta_3 \cdot D_i^c)^2}{2\sigma_{os}^2}\right) \tag{A.3.9}$$

where σ_{os} is the standard deviation of the log-normal distribution. Using the PDF in equation A.3.9, we can write the log-likelihood function as:

$$LL_2(\theta,\sigma) = -\frac{I}{2}\ln(2\pi) - \frac{I}{2}\ln(\sigma_{os}^2) - \frac{1}{2\sigma_{os}^2}\sum_{i=1}^{I}(\ln(OSC_i) - \theta_0 - \theta_1 \cdot q_i - \theta_2 \cdot s_i - \theta_3 \cdot D_i^c)^2 \tag{A.3.10}$$

where I is the total number of respondents. In equation 13, we assume heterogeneous preferences for the logged daily on-site cost by considering the stochastic disturbance term. The probability for trip length shown in equation A.3.1 must now be evaluated over the distribution of stochastic disturbance term, shown below:

$$\pi_i^l(l_{i,j}) = \int_0^1 \omega_i + (1-\omega_i)\cdot p_+(1,\alpha)\, f(\sigma_{os})\cdot d\sigma_{os} \int_1^{\text{inf}} (1-\omega_i)\cdot p_{++}(l_i,\alpha)\, f(\sigma_{os})\cdot d\sigma_{os} \tag{A.3.11}$$

We use simulation methods to numerically solve for equation A.3.11 since this function does not have a closed form solution. The simulated probability is based on the simulated mean of the negative binomial distribution, shown below:

$$\pi_i^l\left(l_{i,j}\right) = \frac{1}{R}\sum_{r=1}^{R}\frac{\Gamma\left(l+\alpha^{-1}\right)}{\Gamma\left(l+1\right)\left(\alpha^{-1}\right)}\cdot\left(\frac{\alpha^{-1}}{\alpha^{-1}+\lambda_i^r}\right)^{\alpha^{-1}}\cdot\left(\frac{\lambda_i^r}{\alpha^{-1}+\lambda_i^r}\right)^{l}\cdot\left(1-\left(1+\alpha\cdot\lambda_i^r\right)^{-\alpha^{-1}}\right)^{-1} \tag{A.3.12}$$

where $r = [1, \cdots, R]$ is the number of pseudo-random Halton draws taken from a normal distribution. The expected trip length and daily on-site cost are used when calculating the full-cost term that links the trip length model to the site choice model.

A.3.3 Probability Function for Nested Logit Model

We assume a two-level nesting structure where angler i can choose between charter or non-charter modes of fishing before choosing the site. There are 21 sites within the charter nest and 20 within the non-charter nest as Kake was only visited by charter anglers. The probability function for angler i choosing site j can be found in equation 14. The first term in equation 14 is the probability of choosing site j conditional on fishing mode m, shown below:

$$\pi_{i,j|m} = \frac{\exp\left(V_{i,j}/\lambda_m\right)}{\sum_{j=1}^{J}\exp\left(V_{i,j}/\lambda_m\right)} \tag{A.3.13}$$

where λ_m is the dissimilarity coefficient of all charter sites. We constrain the dissimilarity coefficient to be between 0 and 1 to remain consistent with utility theory by setting λ_m equal to:

$$\lambda_m = \frac{\exp\left(\lambda_m\right)}{1+\exp\left(\lambda_m\right)} \tag{A.3.14}$$

We cannot estimate a dissimilarity coefficient for each nest. So we constrain the dissimilarity coefficient for non-charter sites equal to 1 and estimate the dissimilarity coefficient related to the charter sites. The second term in equation 14 is the probability of choosing fishing mode m shown below:

$$\pi_{i,m} = \frac{\exp\left(\lambda_m IV_{i,m}\right)}{\sum_{m=1}^{2}\exp\left(\lambda_m IV_{i,m}\right)} \tag{A.3.15}$$

where $IV_{i,m}$ is the inclusive value, also known as the log-sum, calculated as:

$$IV_{i,m} = \ln \sum_{j \in B_m}^{J} \exp\left(V_{i,j}/\lambda_m\right) \tag{A.3.16}$$

The probability of choosing fishing mode m is a function of only the inclusive value as most demographics are used in the on-site cost model.

The log-likelihood function for the site choice model is:

$$LL_3 = \sum_{i=1}^{I} \sum_{j=1}^{J} d_{i,j} ln(\pi_{i,j}) \tag{A.3.17}$$

where $d_{i,j} = 1$ if angler i visited site j and 0 otherwise. The joint site-choice, trip length, and on-site cost model are estimated using a full-information maximum likelihood (FIML) function. The joint log-likelihood function is the sum of the log-likelihood functions for the on-site cost model and the site-choice model and the simulated log-likelihood for the trip length model, shown below:

$$LL = SLL_1 + LL_2 + LL_3 \tag{A.3.18}$$

where SLL_1 is the simulated log-likelihood function for the trip length model, LL_2 is the log-likelihood function for the on-site cost model, and LL_3 is the log-likelihood function for the site choice model. We use the bbmle package in RStudio to maximize the joint site-choice, trip length, and on-site cost log-likelihood function listed in Equation A.3.18 (Bolker & Bolker, 2017).

A.4 FULL MODEL RESULTS WHEN SITE-CHOICE AND TRIP-LENGTH ARE SEQUENTIALLY AND SIMULTANEOUSLY ESTIMATED

Below are the estimated coefficients for fully sequential, partially sequential, and simultaneously estimated models. The fully sequential model estimates daily on-site costs first, then uses the exogenous angler- and site-specific daily on-site cost predictions in the trip length model. The partially sequential model estimates daily on-site costs and trip length simultaneously. The fully sequential and partially sequential models use the exogenous angler- and site-specific trip length predictions in the site-choice model. These models have identical specifications as described in Section 6. Select coefficients for the partially sequential and simultaneous models are presented in the paper above.

We find similar signs and levels of significance for each coefficient in the site-choice model. The proportion of the wage rate used in SVTT calculations for employed anglers is approximately 0.55 and the SVTT for unemployed anglers is approximately \$27. We find that preferences for targeted species are positive for all species except king salmon in the sequential models. Preferences for species not targeted are negative and statistically significant for all species but king salmon in the simultaneous model. The additional difference between the three site-choice models is the dissimilarity coefficient. The dissimilarity coefficient, denoting correlation among charter sites, is between 0 and 1 for all models but the fully sequential model. Since the dissimilarity coefficient is greater than 1, it no longer conforms with RUM theory.

We find differences in sign and level of significance for select coefficients in the trip length model. In the mixture function, or the probability of participating in a single-day trip despite changes in site attributes, the sign and significance for the constant and cruise dummy are similar among all models. However, the lodge dummy coefficient is only significant in the sequential models but remains negative. Similarly, the daily on-site cost coefficient is negative and significant in the sequential models but is positive and insignificant in the simultaneous model. Discussed further above, this suggests that considering the full cost of a trip may be more important than the daily on-site cost as anglers balance travel and on-site costs. The signs for the historical harvest rate for each species is the same across all models. But the significance and magnitude often change. In the sequential models, Pacific halibut is negative and insignificant but in the simultaneous model, Pacific halibut becomes significant. Similarly, king salmon and silver salmon are positive and significant in the sequential model but become insignificant in the simultaneous model.

Finally, the signs and significance levels for the coefficients in the daily on-site cost models are very similar. We would expect this as the daily on-site cost model is a simple linear regression model. The primary difference comes in select site-specific constants. When we look at the goodness-of-fit parameters, we find the simultaneous model provides a better fit than considering each model separately.

Table A.4.1: Estimated site-choice coefficients for a jointly estimated site-choice and trip length model

	Full Sequential	Partially Sequential	Simultaneous
Site Choice Model:			
Travel Cost (γ)	-5.427***	-5.572***	-5.473***
	(0.094)	(0.083)	(0.113)
κ_E	0.564***	0.591***	0.527***
	(0.102)	(0.106)	(0.130)
ρ_U	26.600***	28.084***	28.722***
	(5.143)	(5.347)	(6.776)
Total On-Site Cost (η)	-0.042***	-0.046***	-0.107***
	(0.010)	(0.010)	(0.036)
Pacific Halibut - Targeted	0.188	0.165	0.286
	(0.150)	(0.133)	(0.215)
Pacific Halibut - Non-Targeted	-0.835***	-0.727***	-0.942**
	(0.268)	(0.234)	(0.402)
King Salmon - Targeted	-0.957	-0.871	1.351
	(0.761)	(0.669)	(1.595)
King Salmon - Not Targeted	-2.715***	-2.427***	-1.324
	(0.791)	(0.694)	(1.136)
Silver Salmon - Targeted	0.904***	0.789***	1.066***
	(0.142)	(0.123)	(0.220)

Continued below

Table A.4.1: (continued from previous page)

	Sequential	Sequential	Simultaneous
Silver Salmon - Not Targeted	0.405**	0.343**	0.518**
	(0.172)	(0.151)	(0.211)
Other Fish - Targeted	0.731***	0.649***	0.901***
	(0.251)	(0.220)	(0.301)
Other Fish - Not Targeted	0.221	0.164	0.242
	(0.344)	(0.305)	(0.280)
Southeast Constant	2.136***	1.903***	2.503***
	(0.592)	(0.527)	(0.695)
$\eta_{GlacierBay}$	-0.720	-0.591	-1.521*
	(0.712)	(0.626)	(0.786)
η_{Homer}	3.504***	3.080***	3.251***
	(0.244)	(0.208)	(0.299)
η_{Juneau}	0.422	0.408	-0.465
	(0.568)	(0.501)	(0.657)
$\eta_{Ketchikan}$	0.668	0.601	-0.446
	(0.572)	(0.501)	(0.670)
η_{Kodiak}	2.505***	2.218***	1.598**
	(0.504)	(0.446)	(0.626)
$\eta_{Petersburg}$	0.726	0.648	-0.349
	(0.626)	(0.548)	(0.769)
η_{PoW}	0.275	0.310	-1.779*
	(0.678)	(0.598)	(0.920)
η_{Seward}	1.958***	1.741***	1.566***
	(0.250)	(0.231)	(0.342)
η_{Sitka}	0.406	0.404	-2.038*
	(0.733)	(0.644)	(1.163)
$IV_{Charter}$	1.152***	0.894***	0.923***
	(0.056)	(0.051)	(0.077)
Probability of Single-Day Trip:			
Constant	-0.522***	-0.523***	-0.286*
	(0.166)	(0.166)	(0.149)
Cruise Dummy	3.247***	3.247***	2.658***
	(0.627)	(0.627)	(0.608)
Lodge Dummy	-4.032**	-4.032**	-6.072
	(1.967)	(1.969)	(9.662)

Continued below

Table A.4.1: (continued from previous page)

	Sequential	Sequential	Simultaneous
Trip Duration Model:			
Logged Monetary Travel Cost	0.109***	0.109***	0.110***
	(0.024)	(0.024)	(0.028)
Logged Daily On-Site Cost	-0.182***	-0.189***	0.042
	(0.053)	(0.053)	(0.054)
Pacific Halibut - Targeted	-0.525	-0.503	-0.955***
	(0.387)	(0.388)	(0.354)
Pacific Halibut - Not Targeted	-0.158	-0.136	-0.894**
	(0.428)	(0.429)	(0.394)
King Salmon - Targeted	11.281*	11.086*	3.245
	(6.634)	(6.617)	(7.296)
King Salmon - Not Targeted	12.539*	12.336*	4.053
	(6.590)	(6.574)	(7.271)
Silver Salmon - Targeted	3.918**	3.929**	1.553
	(1.737)	(1.730)	(1.680)
Silver Salmon - Not Targeted	3.865**	3.873**	1.505
	(1.747)	(1.740)	(1.677)
Other Fish - Targeted	1.265	1.295	0.958
	(0.798)	(0.794)	(0.632)
Other Fish - Not Targeted	1.273	1.298	0.945
	(0.801)	(0.797)	(0.629)
Southeast Constant	1.411***	1.437***	1.002***
	(0.511)	(0.517)	(0.324)
$\eta_{AnchorPoint}$	0.313	0.330	0.320
	(0.484)	(0.490)	(0.498)
$\eta_{GlacierBay}$	-3.399***	-3.405***	-2.135***
	(0.689)	(0.693)	(0.534)
η_{Homer}	-0.475	-0.458	-0.168
	(0.413)	(0.416)	(0.417)
η_{Juneau}	-2.202***	-2.204***	-1.322***
	(0.611)	(0.616)	(0.426)
$\eta_{Ketchikan}$	-4.082***	-4.077***	-2.313***
	(0.756)	(0.759)	(0.592)
η_{Kodiak}	-2.979***	-2.953***	-1.909*
	(1.060)	(1.060)	(1.082)

Continued below

Table A.4.1: (continued from previous page)

	Sequential	Sequential	Simultaneous
$\eta_{DeepCreek}$	0.409	0.431	0.314
	(0.547)	(0.553)	(0.493)
$\eta_{PrinceofWales}$	-6.650***	-6.651***	-3.201***
	(1.317)	(1.318)	(1.116)
$\eta_{Petersburg}$	-0.875	-0.869	-0.631
	(0.557)	(0.563)	(0.398)
η_{Seward}	-3.929***	-3.927***	-2.090*
	(1.239)	(1.235)	(1.217)
η_{Sitka}	-8.954***	-8.914***	-4.459**
	(2.002)	(1.998)	(2.118)
η_{Valdez}	-0.653	-0.639	-0.527
	(1.150)	(1.146)	(1.108)
$\eta_{Whittier}$	-0.241	-0.231	-0.691*
	(0.441)	(0.446)	(0.386)
$\eta_{Yakutat}$	-4.471***	-4.487***	-2.153**
	(1.224)	(1.225)	(1.051)
Overdispersion Parameter	0.081***	0.079**	0.199***
	(0.031)	(0.031)	(0.057)
Daily On-Site Cost Model:			
Charter Dummy	1.499***	1.536***	1.459***
	(0.113)	(0.110)	(0.111)
Party Size	0.310***	0.293***	0.266***
	(0.058)	(0.057)	(0.051)
Party Size^2	-0.023***	-0.023***	-0.020***
	(0.005)	(0.004)	(0.004)
Male	0.060	0.052	0.030
	(0.126)	(0.124)	(0.112)
Graduate Dummy	0.466***	0.542***	0.422***
	(0.165)	(0.162)	(0.156)
Undergraduate Dummy	0.656***	0.724***	0.534***
	(0.154)	(0.150)	(0.147)
Household Size	0.088**	0.079**	0.072**
	(0.036)	(0.035)	(0.030)
Logged-Age	0.964***	0.943***	1.026***
	(0.080)	(0.079)	(0.071)

Continued below

Table A.4.1: (continued from previous page)

	Sequential	Sequential	Simultaneous
Southeast Constant	3.487***	3.535***	-0.144
	(0.255)	(0.256)	(0.579)
$\eta_{AnchorPoint}$	1.388***	1.462***	0.760**
	(0.440)	(0.440)	(0.330)
$\eta_{GlacierBay}$	-3.569***	-3.564***	0.003
	(0.297)	(0.297)	(0.683)
η_{Haines}	-3.310***	-3.285***	0.100
	(0.396)	(0.396)	(0.696)
η_{Homer}	0.488*	0.536*	0.469*
	(0.293)	(0.293)	(0.266)
η_{Juneau}	-3.715***	-3.701***	-0.238
	(0.188)	(0.188)	(0.636)
$\eta_{Ketchikan}$	-3.366***	-3.362***	0.226
	(0.139)	(0.140)	(0.635)
η_{Kodiak}	0.620*	0.664*	0.656**
	(0.352)	(0.353)	(0.300)
$\eta_{DeepCreek}$	1.111***	1.149***	1.220***
	(0.431)	(0.431)	(0.337)
$\eta_{Petersburg}$	-3.115***	-3.704***	0.559
	(0.258)	(0.201)	(0.646)
$\eta_{PrinceofWales}$	-3.703***	-3.104***	-0.081
	(0.201)	(0.258)	(0.654)
η_{Seward}	0.369	0.422	0.537**
	(0.300)	(0.301)	(0.270)
η_{Sitka}	-3.500***	-3.502***	0.259
	(0.158)	(0.158)	(0.643)
η_{Valdez}	0.876**	0.957**	0.277
	(0.432)	(0.433)	(0.343)
$\eta_{Whittier}$	0.530	0.587	0.332
	(0.426)	(0.426)	(0.343)
$\eta_{Yakutat}$	-3.203***	-3.211***	0.420
	(0.309)	(0.309)	(0.522)
Standard Deviation (s)	1.052***	1.053***	1.065***
	(0.035)	(0.035)	(0.036)

Continued below

Table A.4.1: (continued from previous page)

	Sequential	Sequential	Simultaneous
N	463	463	463
LL - On-Site Cost Model	-680.389		
LL - Trip Length Model	-661.490	-1,341.556	
LL - Site Choice Model	-1,119.298	-1,122.074	
LL - Total	**-2,491.177**	**-2,463.63**	**-2,440.75**
AIC - On-Site Cost Model	1,410.779		
AIC - Trip Length Model	1,380.979	2,791.113	
AIC - Site Choice Model	2,284.596	2,290.147	
AIC - Total	**5,076.354**	**5,081.260**	**5,035.492**
BIC - On-Site Cost Model	1,514.222		
BIC - Trip Length Model	1,500.973	3,014.550	
BIC - Site Choice Model	2,379.764	2,385.315	
BIC - Total	**5,394.959**	**5,539.865**	**5,354.097**

Note: Other Fish includes the historical harvest rates for rockfish, lingcod, "other" salmon, and "other" species.

A.5 FULL MODEL RESULTS WHEN USING DIFFERENT HARVEST RATE CALCULATIONS

The results in the paper proxy site-specific expected harvest rates using a three-year average beginning with the previous year of participating in an Alaskan fishing trip. In the results below, we change that assumption by proxying for site-specific expected harvest rates using a one-year to the five-year average. The estimated coefficients for all non-harvest-related variables have similar signs, levels of significance, and magnitudes among all models. The signs and levels of significance for the harvest of key species are similar among all models except when only including a single year. We decided to not use a single year because of the possibility of an uncharacteristic year and trips are normally planned years in advance due to the high cost and the limited opportunity to participate in a trip. Similarly, in the trip length model, the signs for the harvest of all key species are the same. But when using a four-year average, the significance of many key species are high. Prior to final submission, we may use the four-year average as opposed to the three-year average due to the greater level of explanatory power.

Table A.5.2: Estimated coefficients for a simultaneously estimate trip length and site-choice model using varying years of harvest rate data as a proxy for expected harvest rates

	2015	2015 - 2014	2015 - 2013	2015 - 2012	2015 - 2011
Site Choice Model:					
Travel Cost (γ)	-5.429***	-5.432***	-5.473***	-5.441***	-5.472***
	(0.102)	(0.105)	(0.113)	(0.107)	(0.121)
κ_E	0.499***	0.476***	0.527***	0.487***	0.522***
	(0.115)	(0.113)	(0.130)	(0.112)	(0.129)
ρ_U	27.795***	25.805***	28.722***	26.463***	27.817***
	(6.163)	(5.927)	(6.776)	(5.959)	(6.605)
Total On-Site Cost (η)	-0.089***	-0.097***	-0.107***	-0.099***	-0.114***
	(0.026)	(0.031)	(0.036)	(0.033)	(0.042)
Pacific Halibut - Targeted	0.133	0.173	0.286	0.333	0.304
	(0.227)	(0.216)	(0.215)	(0.218)	(0.214)

Continued below

Table A.5.2: (continued from previous page)

	2015	2015 - 2014	2015 - 2013	2015 - 2012	2015 - 2011
Pacific Halibut - Non-Targeted	-1.145***	-1.142***	-0.942**	-0.872**	-0.791**
	(0.424)	(0.412)	(0.402)	(0.384)	(0.353)
King Salmon - Targeted	3.250**	1.394	1.351	1.109	0.074
	(1.289)	(1.320)	(1.595)	(1.591)	(1.600)
King Salmon - Not Targeted	-0.064	-0.988	-1.324	-1.661	-2.194*
	(0.869)	(0.923)	(1.136)	(1.154)	(1.130)
Silver Salmon - Targeted	0.989***	1.118***	1.066***	1.134***	1.015***
	(0.224)	(0.263)	(0.220)	(0.241)	(0.233)
Silver Salmon - Not Targeted	0.375*	0.489**	0.518**	0.579**	0.492**
	(0.201)	(0.246)	(0.211)	(0.233)	(0.229)
Other Fish - Targeted	0.956***	0.952***	0.901***	0.995***	0.960***
	(0.234)	(0.261)	(0.301)	(0.305)	(0.315)
Other Fish - Not Targeted	0.331	0.386	0.242	0.297	0.452
	(0.228)	(0.255)	(0.280)	(0.291)	(0.283)
Southeast Constant	2.522***	2.374***	2.503***	2.594***	2.678***
	(0.692)	(0.689)	(0.695)	(0.703)	(0.723)
$\eta_{GlacierBay}$	-1.730**	-1.417*	-1.521*	-1.499*	-1.857**
	(0.796)	(0.784)	(0.786)	(0.782)	(0.832)
η_{Homer}	3.272***	3.292***	3.251***	3.289***	3.248***
	(0.295)	(0.300)	(0.299)	(0.298)	(0.307)
η_{Juneau}	-0.394	-0.239	-0.465	-0.398	-0.355
	(0.642)	(0.637)	(0.657)	(0.647)	(0.655)
$\eta_{Ketchikan}$	-0.485	-0.454	-0.446	-0.625	-0.613
	(0.672)	(0.669)	(0.670)	(0.678)	(0.686)
η_{Kodiak}	1.211**	1.158**	1.598**	1.636***	1.704***
	(0.542)	(0.587)	(0.626)	(0.625)	(0.628)
$\eta_{Petersburg}$	-0.282	-0.088	-0.349	-0.471	-0.606
	(0.760)	(0.759)	(0.769)	(0.760)	(0.784)
η_{PoW}	-1.914**	-1.980**	-1.779*	-2.082**	-1.966**
	(0.898)	(0.918)	(0.920)	(0.919)	(0.949)
η_{Seward}	1.645***	1.453***	1.566***	1.533***	1.561***
	(0.335)	(0.370)	(0.342)	(0.344)	(0.346)
η_{Sitka}	-3.418***	-2.320**	-2.038*	-2.083*	-1.531
	(1.089)	(1.134)	(1.163)	(1.132)	(1.201)

Continued below

Table A.5.2: (continued from previous page)

	2015	2015 - 2014	2015 - 2013	2015 - 2012	2015 - 2011
$IV_{Charter}$	0.951***	0.939***	0.923***	0.929***	0.914***
	(0.071)	(0.075)	(0.077)	(0.075)	(0.083)
Probability of Single-Day Trip:					
Constant	-0.332**	-0.322**	-0.286*	-0.286*	-0.290*
	(0.148)	(0.148)	(0.149)	(0.147)	(0.152)
Cruise Dummy	2.725***	2.675***	2.658***	2.650***	2.649***
	(0.599)	(0.601)	(0.608)	(0.605)	(0.603)
Lodge Dummy	-5.578	-5.873	-6.072	-5.783	-6.748***
	(6.934)	(8.110)	(9.662)	(6.401)	(0.380)
Trip Duration Model:					
Logged Monetary Travel Cost	0.109***	0.113***	0.110***	0.111***	0.119***
	(0.026)	(0.025)	(0.028)	(0.026)	(0.028)
Logged Daily On-Site Cost	0.072*	0.049	0.042	0.046	0.009
	(0.039)	(0.048)	(0.054)	(0.051)	(0.070)
Pacific Halibut - Targeted	-1.181***	-1.095***	-0.955***	-0.932***	-0.793**
	(0.377)	(0.353)	(0.354)	(0.268)	(0.328)
Pacific Halibut - Not Targeted	-1.111***	-1.044***	-0.894**	-0.849***	-0.701*
	(0.420)	(0.401)	(0.394)	(0.309)	(0.369)
King Salmon - Targeted	2.104	2.898	3.245	3.875***	3.552
	(4.869)	(7.346)	(7.296)	(0.731)	(6.920)
King Salmon - Not Targeted	3.099	3.658	4.053	4.700***	4.292
	(4.812)	(7.312)	(7.271)	(0.684)	(6.924)
Silver Salmon - Targeted	1.606**	2.232	1.553	1.815	2.087
	(0.712)	(2.362)	(1.680)	(1.281)	(2.113)
Silver Salmon - Not Targeted	1.559**	2.217	1.505	1.770	2.008
	(0.711)	(2.355)	(1.677)	(1.278)	(2.109)
Other Fish - Targeted	0.638	0.792	0.958	0.851*	1.012
	(0.431)	(0.585)	(0.632)	(0.514)	(0.718)
Other Fish - Not Targeted	0.657	0.782	0.945	0.846*	0.995
	(0.429)	(0.587)	(0.629)	(0.507)	(0.705)
Southeast Constant	0.955***	0.984***	1.002***	0.989***	1.018**
	(0.293)	(0.319)	(0.324)	(0.303)	(0.399)
$\eta_{AnchorPoint}$	0.505	0.337	0.320	0.309	0.287
	(0.486)	(0.531)	(0.498)	(0.351)	(0.471)

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Table A.5.2: (continued from previous page)

	2015	2015 - 2014	2015 - 2013	2015 - 2012	2015 - 2011
$\eta_{GlacierBay}$	-1.732***	-2.034***	-2.135***	-2.006***	-2.374***
	(0.531)	(0.564)	(0.534)	(0.544)	(0.625)
η_{Homer}	-0.103	-0.165	-0.168	-0.166	-0.164
	(0.390)	(0.449)	(0.417)	(0.270)	(0.391)
η_{Juneau}	-1.093**	-1.268**	-1.322***	-1.239***	-1.289***
	(0.465)	(0.584)	(0.426)	(0.453)	(0.500)
$\eta_{Ketchikan}$	-1.951***	-2.475***	-2.313***	-2.455***	-2.715***
	(0.580)	(0.740)	(0.592)	(0.685)	(0.738)
η_{Kodiak}	-1.570**	-1.929**	-1.909*	-1.964***	-2.011*
	(0.681)	(0.943)	(1.082)	(0.398)	(1.057)
$\eta_{DeepCreek}$	0.234	0.272	0.314	0.314	0.384
	(0.500)	(0.496)	(0.493)	(0.479)	(0.487)
$\eta_{PrinceofWales}$	-2.728***	-3.737**	-3.201***	-3.405***	-3.831***
	(1.010)	(1.496)	(1.116)	(1.290)	(1.477)
$\eta_{Petersburg}$	-0.624*	-0.615	-0.631	-0.696*	-0.744
	(0.375)	(0.406)	(0.398)	(0.361)	(0.454)
η_{Seward}	-2.180***	-2.669	-2.090*	-2.165**	-2.428*
	(0.571)	(1.804)	(1.217)	(0.869)	(1.441)
η_{Sitka}	-3.884*	-4.685*	-4.459**	-4.680***	-4.878**
	(2.157)	(2.476)	(2.118)	(1.033)	(1.973)
η_{Valdez}	-0.799	-0.521	-0.527	-0.489	-0.769
	(0.500)	(1.107)	(1.108)	(0.639)	(1.267)
$\eta_{Whittier}$	-0.730**	-0.699*	-0.691*	-0.624*	-0.709*
	(0.354)	(0.418)	(0.386)	(0.368)	(0.386)
$\eta_{Yakutat}$	-1.860***	-2.473*	-2.153**	-2.264**	-2.536*
	(0.596)	(1.424)	(1.051)	(0.964)	(1.459)
Overdispersion Parameter	0.215***	0.194***	0.199***	0.192***	0.178***
	(0.058)	(0.055)	(0.057)	(0.055)	(0.053)
Charter Dummy	1.451***	1.454***	1.459***	1.460***	1.459***
	(0.111)	(0.111)	(0.111)	(0.111)	(0.111)
Party Size	0.260***	0.264***	0.266***	0.267***	0.265***
	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)
Party Size^2	-0.020***	-0.020***	-0.020***	-0.020***	-0.020***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)

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Table A.5.2: (continued from previous page)

	2015	2015 - 2014	2015 - 2013	2015 - 2012	2015 - 2011
Male	0.046	0.034	0.030	0.031	0.024
	(0.113)	(0.112)	(0.112)	(0.113)	(0.112)
Graduate Dummy	0.406***	0.416***	0.422***	0.421***	0.438***
	(0.155)	(0.155)	(0.156)	(0.156)	(0.157)
Undergraduate Dummy	0.521***	0.530***	0.534***	0.532***	0.540***
	(0.147)	(0.147)	(0.147)	(0.147)	(0.148)
Household Size	0.070**	0.071**	0.072**	0.072**	0.071**
	(0.031)	(0.030)	(0.030)	(0.030)	(0.030)
Logged-Age	1.013***	1.017***	1.026***	1.018***	1.020***
	(0.071)	(0.072)	(0.071)	(0.072)	(0.072)
Southeast Constant	-0.396	-0.198	-0.144	-0.092	-0.119
	(0.519)	(0.585)	(0.579)	(0.629)	(0.607)
$\eta_{AnchorPoint}$	0.813**	0.829**	0.760**	0.808**	0.780**
	(0.341)	(0.335)	(0.330)	(0.333)	(0.330)
$\eta_{GlacierBay}$	0.316	0.094	0.003	-0.015	-0.018
	(0.643)	(0.701)	(0.683)	(0.731)	(0.707)
η_{Haines}	0.460	0.185	0.100	0.089	0.083
	(0.664)	(0.715)	(0.696)	(0.742)	(0.723)
η_{Homer}	0.562**	0.522**	0.469*	0.495*	0.475*
	(0.263)	(0.265)	(0.266)	(0.266)	(0.270)
η_{Juneau}	0.121	-0.122	-0.238	-0.246	-0.239
	(0.598)	(0.660)	(0.636)	(0.687)	(0.662)
$\eta_{Ketchikan}$	0.567	0.328	0.226	0.207	0.219
	(0.590)	(0.657)	(0.635)	(0.686)	(0.664)
η_{Kodiak}	0.698**	0.672**	0.656**	0.694**	0.669**
	(0.300)	(0.301)	(0.300)	(0.301)	(0.303)
$\eta_{DeepCreek}$	1.438***	1.347***	1.220***	1.276***	1.226***
	(0.319)	(0.330)	(0.337)	(0.337)	(0.350)
$\eta_{Petersburg}$	0.919	0.691	0.559	0.532	0.514
	(0.613)	(0.672)	(0.646)	(0.694)	(0.672)
$\eta_{PrinceofWales}$	0.224	-0.009	-0.081	-0.122	-0.047
	(0.610)	(0.677)	(0.654)	(0.707)	(0.694)
η_{Seward}	0.607**	0.578**	0.537**	0.563**	0.570**
	(0.271)	(0.272)	(0.270)	(0.271)	(0.272)

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Table A.5.2: (continued from previous page)

	2015	2015 - 2014	2015 - 2013	2015 - 2012	2015 - 2011
η_{Sitka}	0.520	0.336	0.259	0.232	0.299
	(0.595)	(0.661)	(0.643)	(0.696)	(0.677)
η_{Valdez}	0.426	0.378	0.277	0.325	0.276
	(0.332)	(0.331)	(0.343)	(0.343)	(0.347)
$\eta_{Whittier}$	0.359	0.288	0.332	0.347	0.297
	(0.347)	(0.343)	(0.343)	(0.347)	(0.342)
$\eta_{Yakutat}$	0.737	0.515	0.420	0.398	0.418
	(0.470)	(0.548)	(0.522)	(0.584)	(0.554)
Standard Deviation (s)	1.064***	1.065***	1.065***	1.065***	1.067***
	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
N	463	463	463	463	463
Log-Likelihood	-2,440.44	-2,439.94	-2,440.75	-2,438.93	-2,440.26
AIC	5,034.882	5,033.882	5,035.492	5,031.864	5,034.527
BIC	5,353.487	5,352.487	5,354.097	5,350.469	5,353.132

Note: Other Fish includes the historical harvest rates for rockfish, lingcod, “other” salmon, and “other” species.

A.6 FULL MODEL RESULTS WHEN USING A ZERO TRUNCATE NEGATIVE BINOMIAL DISTRIBUTION

In the paper above, we assume that trip length follows a one-inflated zero-truncated negative binomial (OIZTNB) distribution. The one-inflation component allows us to address the large number of single-day trips observed in the data. But this is not a common distribution used in the economics literature. We estimate the same set of models as in Table A.4.1, but assume that trip length follows a zero-truncated negative binomial (ZTNB) distribution and place the cruise and lodge dummy variables into the mean function of the ZTNB distribution. We do find that when using the OIZTNB distribution, the log-likelihood value (-2,440.75) is significantly less, in absolute value, compared to the log-likelihood value when using the ZTNB distribution (-2,653.58). This suggests that the OIZTNB distribution provides a better statistical fit. Additionally, when predicting expected trip lengths compared to observed trip lengths, the OIZTNB distribution provides slightly better predictions than the ZTNB distribution.

Table A.6.3: Estimated site-choice coefficients for a jointly estimated site-choice and trip length model when assuming a zero-truncated negative binomial distribution for trip length

	Full Sequential	Partially Sequential	Simultaneous
Site Choice Model:			
Travel Cost (γ)	-5.567***	-5.633***	-6.079***
	(0.109)	(0.098)	(0.194)
κ_E	0.583***	0.610***	0.982***
	(0.116)	(0.119)	(0.255)
ρ_U	28.809***	30.129***	46.823***
	(5.792)	(5.968)	(12.106)
Total On-Site Cost (η)	-0.056***	-0.060***	-0.102***
	(0.012)	(0.012)	(0.039)
Pacific Halibut - Targeted	0.049	0.041	0.415**
	(0.122)	(0.116)	(0.165)
Pacific Halibut - Non-Targeted	-0.973***	-0.923***	-0.529
	(0.237)	(0.223)	(0.322)

Continued below

Table A.6.3: (continued from previous page)

	Sequential	Sequential	Simultaneous
King Salmon - Targeted	-1.442**	-1.381**	-4.081***
	(0.630)	(0.597)	(1.042)
King Salmon - Not Targeted	-2.810***	-2.664***	-5.716***
	(0.680)	(0.645)	(1.344)
Silver Salmon - Targeted	0.776***	0.728***	0.682***
	(0.133)	(0.125)	(0.193)
Silver Salmon - Not Targeted	0.316**	0.287*	0.093
	(0.160)	(0.151)	(0.199)
Other Fish - Targeted	0.620***	0.593***	0.451**
	(0.202)	(0.193)	(0.218)
Other Fish - Not Targeted	-0.217	-0.251	0.090
	(0.296)	(0.286)	(0.219)
Southeast Constant	2.012***	1.923***	3.822***
	(0.582)	(0.561)	(0.935)
$\eta_{GlacierBay}$	-0.113	-0.045	-0.970
	(0.732)	(0.694)	(1.101)
η_{Homer}	3.434***	3.275***	3.268***
	(0.237)	(0.227)	(0.320)
η_{Juneau}	0.929	0.946*	2.179**
	(0.585)	(0.559)	(1.050)
$\eta_{Ketchikan}$	0.794	0.793	1.577
	(0.575)	(0.546)	(1.011)
η_{Kodiak}	2.528***	2.419***	3.413***
	(0.482)	(0.458)	(0.722)
$\eta_{Petersburg}$	1.060*	1.027*	0.280
	(0.617)	(0.584)	(1.047)
η_{PoW}	0.496	0.574	2.562**
	(0.741)	(0.705)	(1.248)
η_{Seward}	1.680***	1.638***	1.700***
	(0.245)	(0.247)	(0.346)
η_{Sitka}	1.192	1.188	5.657***
	(0.775)	(0.734)	(1.929)
$IV_{Charter}$	1.067***	0.974***	0.936***
	(0.056)	(0.058)	(0.080)

Continued below

Table A.6.3: (continued from previous page)

	Sequential	Sequential	Simultaneous
Trip Duration Model:			
Logged Monetary Travel Cost	0.119***	0.119***	0.172***
	(0.018)	(0.018)	(0.015)
Logged Daily On-Site Cost	-0.118***	-0.125***	-0.091***
	(0.036)	(0.037)	(0.025)
Cruise Dummy	-0.467***	-0.463***	-0.211**
	(0.112)	(0.112)	(0.104)
Lodge Dummy	-0.028	-0.023	-0.123***
	(0.073)	(0.073)	(0.047)
Pacific Halibut - Targeted	-0.543**	-0.526**	-0.205
	(0.239)	(0.241)	(0.235)
Pacific Halibut - Not Targeted	-0.450	-0.433	-0.151
	(0.280)	(0.281)	(0.269)
King Salmon - Targeted	11.960***	11.906***	1.555
	(4.512)	(4.492)	(2.411)
King Salmon - Not Targeted	12.998***	12.933***	1.428
	(4.480)	(4.460)	(2.445)
Silver Salmon - Targeted	1.984	1.983	1.518**
	(1.271)	(1.268)	(0.622)
Silver Salmon - Not Targeted	1.779	1.777	1.343**
	(1.274)	(1.271)	(0.624)
Other Fish - Targeted	1.192**	1.226**	0.695*
	(0.564)	(0.563)	(0.413)
Other Fish - Not Targeted	1.220**	1.251**	0.681*
	(0.566)	(0.565)	(0.411)
Southeast Constant	0.946***	0.980***	1.353***
	(0.316)	(0.323)	(0.192)
$\eta_{AnchorPoint}$	-0.005	0.011	0.029
	(0.326)	(0.331)	(0.268)
$\eta_{GlacierBay}$	-2.350***	-2.376***	-1.784***
	(0.497)	(0.498)	(0.379)
η_{Homer}	-0.509*	-0.496*	-0.254
	(0.281)	(0.283)	(0.222)
η_{Juneau}	-1.283***	-1.296***	-0.668**
	(0.421)	(0.424)	(0.306)

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Table A.6.3: (continued from previous page)

	Sequential	Sequential	Simultaneous
$\eta_{Ketchikan}$	-2.763***	-2.774***	-1.523***
	(0.543)	(0.544)	(0.380)
η_{Kodiak}	-2.833***	-2.829***	-0.888*
	(0.754)	(0.751)	(0.488)
$\eta_{DeepCreek}$	0.526	0.548	0.326
	(0.346)	(0.351)	(0.296)
$\eta_{PrinceofWales}$	-4.370***	-4.391***	-2.605***
	(0.996)	(0.995)	(0.653)
$\eta_{Petersburg}$	-0.373	-0.377	-0.552**
	(0.357)	(0.363)	(0.247)
η_{Seward}	-2.078**	-2.068**	-1.698***
	(0.900)	(0.899)	(0.511)
η_{Sitka}	-7.292***	-7.311***	-3.068***
	(1.427)	(1.416)	(1.190)
η_{Valdez}	-0.164	-0.136	-0.351
	(0.840)	(0.839)	(0.446)
$\eta_{Whittier}$	-0.252	-0.236	-0.330
	(0.296)	(0.301)	(0.255)
$\eta_{Yakutat}$	-2.484***	-2.509***	-1.634***
	(0.891)	(0.892)	(0.497)
Overdispersion Parameter	0.033**	0.032**	0.062***
	(0.016)	(0.015)	(0.019)
Daily On-Site Cost Model:			
Charter Dummy	1.499***	1.544***	1.481***
	(0.113)	(0.111)	(0.109)
Party Size	0.310***	0.298***	0.290***
	(0.058)	(0.057)	(0.053)
Party Size^2	-0.023***	-0.023***	-0.023***
	(0.005)	(0.004)	(0.004)
Male	0.060	0.067	0.084
	(0.126)	(0.123)	(0.118)
Graduate Dummy	0.466***	0.570***	0.507***
	(0.165)	(0.163)	(0.158)
Undergraduate Dummy	0.656***	0.746***	0.630***
	(0.154)	(0.151)	(0.150)

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Table A.6.3: (continued from previous page)

	Sequential	Sequential	Simultaneous
Household Size	0.088**	0.081**	0.063*
	(0.036)	(0.035)	(0.033)
Logged-Age	0.964***	0.924***	0.969***
	(0.080)	(0.079)	(0.077)
Southeast Constant	3.487***	3.557***	-0.843
	(0.255)	(0.256)	(0.562)
$\eta_{AnchorPoint}$	1.388***	1.493***	1.284***
	(0.440)	(0.441)	(0.351)
$\eta_{GlacierBay}$	-3.569***	-3.562***	0.709
	(0.297)	(0.297)	(0.679)
η_{Haines}	-3.310***	-3.278***	0.773
	(0.396)	(0.396)	(0.715)
η_{Homer}	0.488*	0.561*	0.575**
	(0.293)	(0.294)	(0.283)
η_{Juneau}	-3.715***	-3.697***	0.615
	(0.188)	(0.188)	(0.636)
$\eta_{Ketchikan}$	-3.366***	-3.362***	0.987
	(0.139)	(0.140)	(0.621)
η_{Kodiak}	0.620*	0.689*	0.679**
	(0.352)	(0.353)	(0.329)
$\eta_{DeepCreek}$	1.111***	1.168***	1.332***
	(0.431)	(0.432)	(0.341)
$\eta_{Petersburg}$	-3.115***	-3.701***	1.126*
	(0.258)	(0.201)	(0.660)
$\eta_{PrinceofWales}$	-3.703***	-3.101***	0.739
	(0.201)	(0.258)	(0.640)
η_{Seward}	0.369	0.442	0.600**
	(0.300)	(0.302)	(0.288)
η_{Sitka}	-3.500***	-3.498***	0.911
	(0.158)	(0.158)	(0.621)
η_{Valdez}	0.876**	0.991**	0.829**
	(0.432)	(0.434)	(0.369)
$\eta_{Whittier}$	0.530	0.618	0.392
	(0.426)	(0.427)	(0.384)

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Table A.6.3: (continued from previous page)

	Sequential	Sequential	Simultaneous
$\eta_{Yakutat}$	-3.203***	-3.213***	1.173**
	(0.309)	(0.309)	(0.505)
Standard Deviation (s)	1.052***	1.053***	1.057***
	(0.035)	(0.035)	(0.035)
N	463	463	463
LL - On-Site Cost Model	-680.39		
LL - Trip Length Model	-880.94	-1,560.90	
LL - Site Choice Model	-1,108.18	-1,109.74	
LL - Total	**-2,669.51**	**-2,670.63**	**-2,653.58**
AIC - On-Site Cost Model	1,410.779		
AIC - Trip Length Model	1,817.870	3,227.791	
AIC - Site Choice Model	2,262.368	2,265.472	
AIC - Total	**5,491.017**	**5,493.263**	**5,459.156**
BIC - On-Site Cost Model	1,514.222		
BIC - Trip Length Model	1,933.726	3,447.090	
BIC - Site Choice Model	2,357.536	2,360.640	
BIC - Total	**5,804.484**	**5,807.730**	**5,773.624**

Note: Other Fish includes the historical harvest rates for rockfish, lingcod, “other” salmon, and “other” species.

A.7 EXPECTED TRIP LENGTH COMPARED TO OBSERVED TRIP LENGTH

Figure A.7.1 compares the actual trip length to the expected trip length for sites visited when assuming that trip length is distributed as a one-inflated zero-truncated negative binomial (OIZTNB) distribution and a zero-truncated negative binomial (ZTNB) distribution. The x-axis represents the actual trip length angler i took to site j and the y-axis represents the expected trip length from the trip length model. The black line is a 45-degree line from the origin. If the model perfectly predicted the expected trip length, then all observations would fall on the black line. The whiskers of the box-plot represent the 5% and 95% quantiles. The trip length model over-predicts trip lengths for anglers that participated in a single-day trip despite when using the OIZTNB and ZTNB distribution. The mean difference in absolute value is smaller when using the ZTNB (0.65) compared to the OIZTNB (0.78). This is initially surprising considering the one-inflation component in the OIZTNB distribution. But the expected trip length for multi-day trips is better when using the OIZTNB distribution than the ZTNB distribution. The ZTNB distribution is overweighing single-day trips causing worse predictions of multi-day trips where the mixture parameter considers single-day trips while letting the negative binomial component consider multi-day trips. The mean absolute difference in trip length for multi-day trips when using the OIZTNB distribution is less than when using the ZTNB distribution. Additionally, the confidence interval is less when using the OIZTNB distribution suggesting better predictions at the tale of tails of each individual.

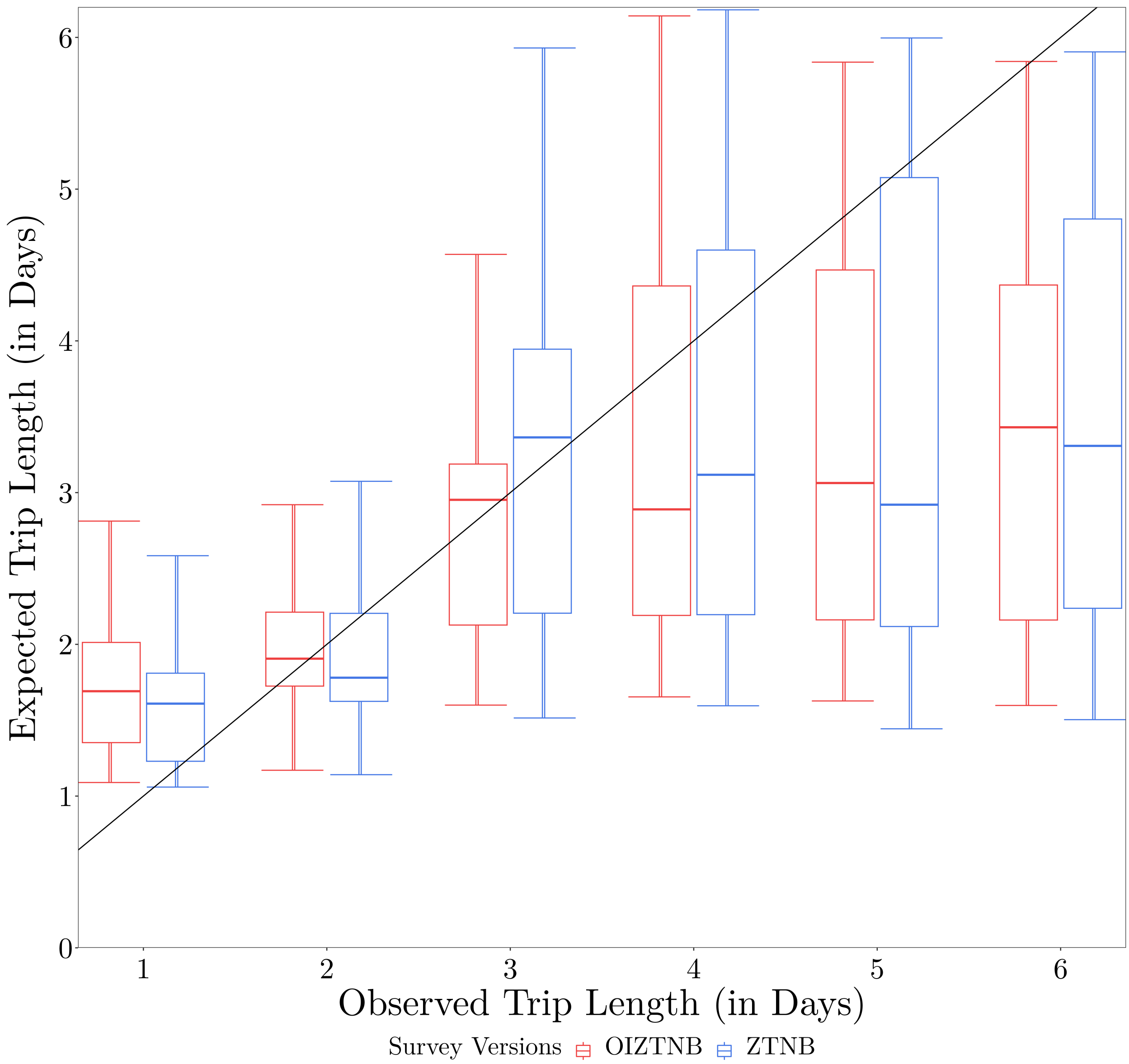

Figure A.7.1: Expected trip length compared to the length of the actual trip taken by the angler. This graph shows that the OIZTNB distribution slightly under-predicts single-day trips and under-predicts trips lasting longer than 5 days.

A.8 HISTOGRAM OF PER-TRIP VALUES

The figure below depicts Krinsky-Robb simulations of the value per trip anglers in 2016. The simulations suggest that anglers' median per-trip value was $971.40($593.59, $1,370.39).

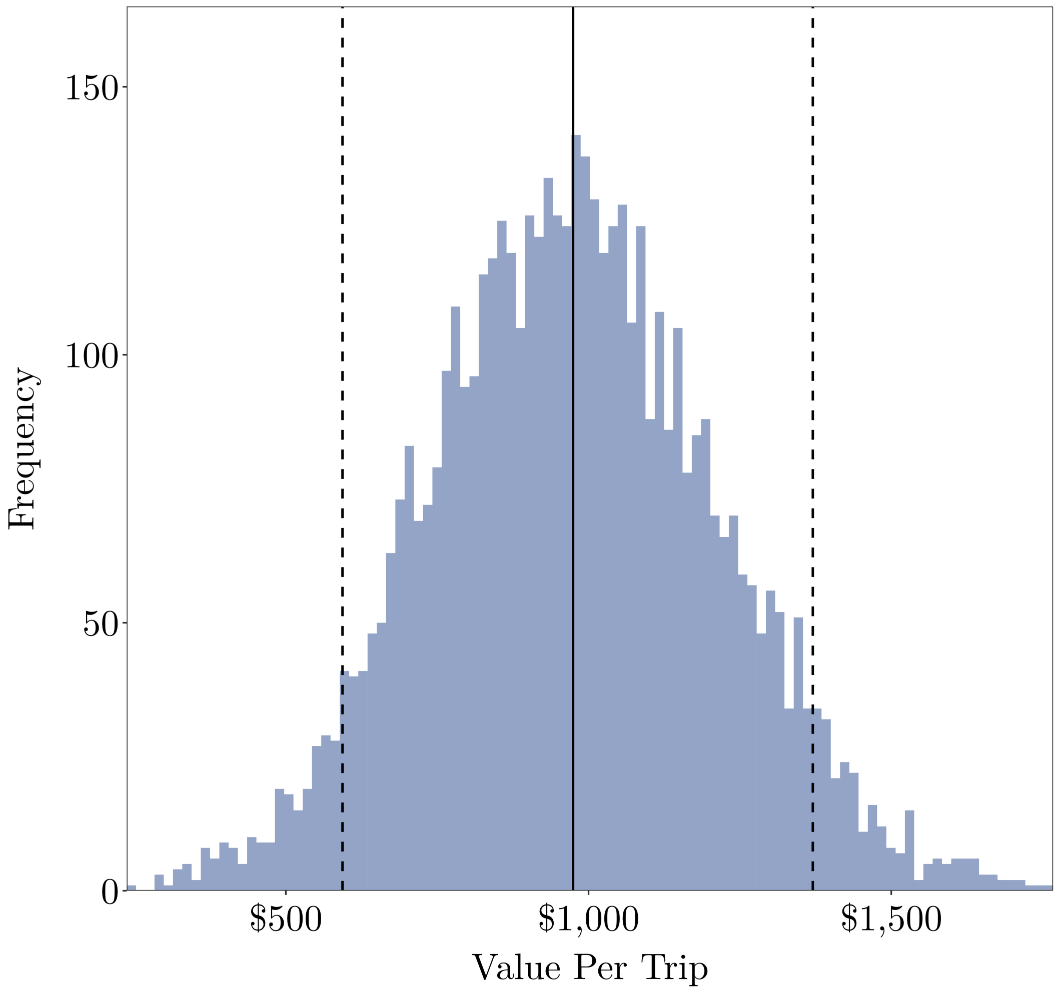

Figure A.8.2: Frequency of per-trip value estimates The solid black line represents the median value per trip and the dotted black lines represent the 90% confidence interval per trip.