Version of Record: https://www.sciencedirect.com/science/article/pii/S0308597X19303495
Manuscript_602488ab1f33c4946a49bb5888aff300

Title: Decision-making in a Mixed Commercial-Recreational Fishery for Atlantic Bluefin Tuna

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Acknowledgments

The authors are grateful to Brad McHale and Sarah McLaughlin of the NMFS HMS Management Division for their advice regarding survey development and their review of survey materials. We thank Kristy Wallmo and Clifford Hutt (NMFS) for their guidance regarding experimental design and modeling approaches. Rob Hicks (William & Mary), Ron Salz (NMFS), and Deborah Steinberg (VIMS) reviewed the manuscript and provided valuable input. The participation of 20 CHB permit holders at three focus groups was essential for gaining feedback on survey content, and we are appreciative of their efforts. We also thank *On The Water* magazine for assistance with survey outreach as well as QuanTech, Inc. for survey distribution and response collection. Lastly, we appreciate the thoughtful comments and constructive suggestions resulting from the anonymous review process. This article is contribution number XXXX from the Virginia Institute of Marine Science, William & Mary.

Funding

This work was supported by the NMFS Saltonstall-Kennedy Grant Program (15GAR020), a NMFS/Sea Grant Fellowship in Marine Resource Economics (NA15OAR4170179), and grants from the International Women's Fishing Association and the VIMS Foundation.

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Highlights

- Participants in the U.S. east coast bluefin tuna fishery can fish either commercially or recreationally on a trip-by-trip basis, but cannot harvest both recreationally and commercially on the same trip.
- This flexibility can complicate management efforts and increase uncertainty in harvest patterns as fishery and regulatory conditions change.
- A contingent sequential stated choice survey was used to examine fishermen decision-making regarding fish disposition over the course of a single trip.
- Model results indicated that recreationally-oriented anglers were likely to opportunistically harvest any fish that they caught, whereas commercially-oriented fishermen were more likely to only harvest fish exceeding the commercial minimum size limit, which is larger than the recreational minimum size limit.
- Simulations revealed wide ranges in the probability of harvesting a fish given changes in regulations, individual attributes, and aspects of the fishery, indicating that such factors can be drivers of considerable management uncertainty.

Abstract

While commercial and recreational fisheries are often considered to compete with one another, in the Atlantic bluefin tuna fishery along the U.S. east coast individual fishermen are permitted to fish either commercially or recreationally on a trip-by-trip basis. How these individuals choose to fish can impact the United States' compliance with domestic and international bluefin tuna management measures and the sustainability of the Atlantic bluefin tuna fishery. We applied a contingent sequential stated choice survey to bluefin tuna fishermen to identify key factors governing disposition decisions, evaluate the impact of inertia (habit formation), and forecast future harvest patterns. Those who primarily fished recreationally demonstrated more opportunistic harvest tendencies than their commercial counterparts, who were more stable in their preference to harvest fish for sale. Simulations based on model results indicated that fish disposition (harvest commercially, harvest recreationally, or release) varied widely based on regulatory, individual, and fishery characteristics. Such results can help managers to forecast harvest patterns and adopt regulatory tools to ensure that harvest remains within prescribed limits.

Keywords: Choice experiment; fisheries management; Atlantic bluefin tuna; random utility model; econometrics

1. Introduction

1.1 Mixed Commercial-Recreational Fisheries in the United States

In the United States, commercial and recreational fisheries are most often considered together in the context of competition for finite fishery resources. While National Standard 4 of the Magnuson-Stevens Fishery Conservation and Management Act calls for fair and equitable allocation of fishing privileges (C.F.R. §600.310; Plummer, Morrison, and Steiner 2012), Kearney (2002) posited that conflict between recreational and commercial fishery sectors is inevitable in developed nations. Indeed, controversies over allocation have repeatedly arisen for numerous species that are targeted by both groups, such as Pacific salmon (Berman, Haley, and Kim 1997), red drum (Thurman and Easley 1992; Schuhmann and Easley 2000), and Gulf of Mexico snappers and groupers (Gentner 2013; Agar and Carter 2014). Economic theory, typically drawing on the equimarginal principle, has been employed for decades to help inform the resolution of such allocation conflicts (e.g., Bishop and Samples 1980; Easley and Prochaska 1987; Easley 1992).

A tacit assumption of such analyses has been the distinct and mutually exclusive nature of commercial and recreational stakeholder groups (i.e., each fisherman belongs to one group or the other), but there are examples of U.S. fisheries in which individual fishermen partake in both the commercial and recreational sectors for a given species or species complex (referred to here as a mixed commercial-recreational fishery), complicating management efforts. In pelagic fisheries off Hawaii, for example, fishermen who possess a Commercial Marine License are able to fish both recreationally and commercially, and often do so on a trip-by-trip basis according to market and fishery conditions, thus blurring the distinction between the two sectors (Adams 1978; Pooley 1993; Miller 1996; McConnell and Haab 2001; Duffield et al. 2012). According to a survey of Hawaiian small-boat pelagic fishermen by Hospital, Bruce, and Pan (2011), over 30% of respondents who self-classified as "recreational" had sold fish in the previous year (often to cover trip costs), making it difficult to track and manage sector-specific harvest while also presenting an obstacle to potential future allocation of harvest between sectors.

The fishery for Atlantic bluefin tuna (*Thunnus thynnus*) along the U.S. east coast from Maine to North Carolina presents a particularly unique and challenging case of a mixed commercial-recreational fishery given the species' high profile and value, the complex domestic allocation structure, and the United States' accountability to the International Commission for the Conservation of Atlantic Tunas (ICCAT). The bluefin tuna quota allocated to the United States by ICCAT (1,059 mt for 2017 [ICCAT Rec. 16-08]) is domestically apportioned among fishery sectors according to the 2006 Consolidated Atlantic Highly Migratory Species (HMS; billfish, sharks, swordfish, and tunas) Fishery Management Plan (NMFS 2006) (Table 1).

[Insert Table 1 here]

The commercial and recreational fisheries for bluefin tuna are separated by the size classes targeted. Recreational anglers, who must possess an Angling category permit, cannot legally sell bluefin tuna and are restricted to the harvest of bluefin tuna measuring from 27 inches to less than 73 inches curved fork length (CFL), with the exception of one annual trophy fish of 73 inches CFL or greater per vessel per year (64 FR 29090, 5/28/1999). Commercial fishermen, meanwhile, whose permit requirements are based on gear type, are only allowed to harvest and sell fish measuring 73 inches CFL or greater (64 FR 29090, 5/28/1999). The 27 inch CFL recreational size limit reflects the historical minimum bluefin tuna size limit implemented by ICCAT in 1975 (ICCAT Rec. 74-01; the ICCAT minimum size was subsequently increased to 47 inches CFL in 1992 by ICCAT Rec. 92-04), while the 73 inch CFL commercial size limit reflects the presumed minimum size and age at maturity for the western stock of Atlantic bluefin tuna (Murray-Brown et al. 2007).

While available permit types generally correspond to the bluefin tuna fishery's allocation categories, a notable exception is the HMS Charter/Headboat (CHB) permit, which allows the permit holder to fish either under the Angling (recreational) or General (commercial handgear) category on a trip-by-trip basis (but not on the same trip), thereby contributing landings to both sub-quotas (64 FR 29090, 5/28/1999). This permit structure was developed to reflect the historical practice of charter boat operators in the fishery to fish commercially for bluefin tuna as a supplementary source of income when not operating as a charter vessel (60 FR 25665, 5/12/1995). In 2016, 263 CHB permit holders (approximately 11% of all CHB permit holders from Maine to North Carolina), sold at least one bluefin tuna under the General category (pers. comm., U. Forest-Bulley, NMFS, 2017). Because of the size class specifications for bluefin tuna regulations, the size of the first fish that a fisherman decides to harvest frequently dictates trip type. For example, because the minimum General category size limit is 73 inches CFL, 100% of trips on which the first fish retained measures less than 73 inches CFL are by definition recreational trips. Similarly, if a vessel retains a fish measuring 73 inches CFL or greater after the Angling trophy sub-quota is filled, or if that vessel has already retained its annual trophy for the year on a previous trip, that fish must be landed under the General category, constituting a commercial trip. As a result of these restrictions, in some circumstances a fisherman may release a bluefin tuna if harvesting that fish would result in an undesirable outcome (e.g., if retaining a fish for personal consumption would eliminate the possibility of landing a subsequent fish for commercial sale). While CHB permit holders are allowed to target other species on bluefin tuna trips, permit-holders must immediately return to port after harvesting the legal General category bluefin tuna trip limit (64 FR 29090, 5/28/1999).

The CHB permit was initially intended for for-hire captains, but anyone who possesses a valid Merchant Marine License or Uninspected Passenger Vessel License is allowed to obtain a CHB permit (64 FR 29090, 5/28/1999). As a result, if they possess the required license, vessel owners who do not carry paying charter clients on board when they target bluefin tuna are also allowed to obtain the CHB permit. For example, a recreational angler who primarily fishes without charter clients (i.e., for personal enjoyment) might obtain the CHB permit so that he or she could harvest a fish commercially if the opportunity were to arise. In addition, CHB permit-holders often have more liberal recreational harvest regulations compared to Angling category permit holders (i.e., higher bag limits in order to attract customers for charter captains) (FR 82 19615, 4/28/2017), further incentivizing harvest-oriented private recreational anglers to obtain the permit. Meanwhile, a CHB permit-holder who tends to fish commercially could harvest a fish measuring less than the commercial minimum size if, for example, he or she wanted to harvest a fish for personal consumption rather than for commercial sale. The extent to which permit holders utilize this flexibility, as opposed to fishing exclusively in either a commercial or recreational manner, is unknown.

Because the CHB permit holder group has no bluefin tuna quota allocation of its own, it directly competes with recreational anglers in possession of an Angling category permit and with commercial fishermen in possession of a General category permit. From 2002 to 2017, CHB permit holders annually harvested approximately 24-43% of the annual Angling category sub-quota and 19-46% of the annual General category sub-quota (pers. comm., NMFS Fisheries Statistics Division, 2017; pers. comm., K. Goldsmith, NMFS, 2017; pers. comm., D. Stephan, NMFS, 2019) (Figure 1). The CHB permit category thus represents a significant "swing" group whose behavior can substantially impact the volume and size distribution of U.S. bluefin tuna landings. For example, if numerous CHB permit holders elect to fish commercially (i.e., under the General category) for a given year, the risk of overharvesting the General category sub-quota—and the U.S. bluefin tuna quota as a whole—increases.

[Insert Figure 1 here]

During 2016 and 2017, General category landings exceeded the adjusted sub-quota by 73.8 mt and 6.3 mt, respectively (NMFS 2019; 81 FR 76874, 11/4/2016), although in neither year was the overall adjusted U.S. Atlantic bluefin tuna quota exceeded due to underharvest by other domestic fishery sectors.[1] The 73.8 mt overage in 2016 coincided with the second-highest CHB percent contribution to General category landings since 2002, at 43.3%. Since 2018, CHB permit holders have been required to acquire a free

[1] The annual U.S. bluefin tuna was adjusted upward from the baseline quota for both 2016 and 2017 due to underharvest of the quota for 2015 and 2016, respectively. Sector-specific sub-quotas were also adjusted due to the overall quota adjustment as well as inter-sector sub-quota transfers.

commercial sale endorsement in order to sell bluefin tuna under the General category (82 FR 57543, 12/6/2017); however, because the endorsement can be added to an existing permit at any time during the fishing season (pers. comm., D. Stephan, NMFS, 2019), it is not an appropriate tool for forecasting harvest capacity. Moreover, per international agreement, no more than 10% of the United States' annual quota (balanced over a two-year period) can consist of juvenile bluefin tuna measuring between 27 and 47 inches CFL (ICCAT Rec. 14-05); if a large proportion of CHB permit holders fish recreationally (including with charter clients) and harvest under the Angling category, that threshold could be exceeded. The flexibility afforded to CHB permit holders thus injects greater implementation uncertainty into management actions. Understanding how fishery conditions such as regulations and expected fish size might affect CHB permit holders' decisions to fish commercially or recreationally for bluefin tuna—and thus their harvest decisions—is critical for improving the ability of managers to predict permit holders' relative contributions to the Angling and General category sub-quotas, and by extension, to the U.S. bluefin tuna quota as a whole.

In this study, we applied a unique choice modeling approach that asked respondents to make choices prior to knowing fishing trip outcomes, and examined decision-making as conditions evolved over the course of a single trip. We explored factors determining targeting and trip type decisions in the mixed commercial-recreational fishery for Atlantic bluefin tuna, while also investigating the potential impacts of inertia (impact of previous decision-making on current decision-making) and uncertainty (e.g., future fish size) on such decisions. In particular, we examined the degree to which fishermen are opportunistic—that is, harvesting whatever bluefin tuna are available to them regardless of size or disposition options—versus having strongly defined preferences for harvesting under the General or Angling category (i.e., high inertia). Lastly, we sought to identify potential preference heterogeneity among bluefin tuna fishermen that could explain and predict harvest patterns in this highly valued fishery.

2. Methods

2.1 The Contingent Sequential Stated Choice Survey

We conducted an online stated choice survey of CHB permit holders from Maine to North Carolina that asked respondents to choose their most preferred options for simulated bluefin tuna fishing trip scenarios. Stated choice random utility models have often been used to identify preferences and values in numerous non-market and environmental settings, including recreational fisheries (e.g., Hanley, Wright, and Adamowicz 1998; Aas, Haider, and Hunt 2000; Wallmo and Edwards 2008). These models often utilize data collected through surveys that employ discrete choice experiments (DCEs), in which respondents are presented with several multi-attribute alternatives—for example, fishing trips with varying levels of catch, harvest limits, and cost—and are asked to select their most preferred alternative (e.g., Oh et al. 2005; Carter and Liese 2012).

While such stated choice models can provide critical welfare estimates and valuable insight into the tradeoffs that individuals make among attributes, one shortcoming of the static DCE approach is the ex-post nature of the choice scenarios: the respondent is able to choose between hypothetical fishing trips while already knowing the outcome of each trip. The trip, in other words, is considered a static good consisting of a bundle of attributes and attribute levels already known to the decision maker. Actual fishing decisions, however, take place in the context of uncertainty with regard to the outcome (i.e., fishing success) associated with a particular decision, and individual fishermen must evaluate the risks associated with each choice (Gates 1984; Holland 2008).

To capture evolving conditions over the course of a single bluefin tuna fishing trip, we extended the conventional static stated choice approach to develop what we call a contingent sequential stated choice (CSSC) survey, in which respondents were asked to make up to three decisions for each trip (Figure 2): 1) whether or not to take paying charter clients bluefin tuna fishing (or not go bluefin tuna fishing at all); 2) how to dispose of a first fish caught (retain under Angling, retain under General, or release); and 3) how to dispose of a second fish caught (retain under Angling, retain under General, or release).

[Insert Figure 2 here]

By specifying the trip as a bluefin tuna trip, respondents would not expect to have the opportunity to target, catch, or retain other species. Respondents did not know how many bluefin tuna they would catch (if any) over the course of a trip scenario. Given the size-differentiated nature of the commercial and recreational Atlantic bluefin tuna fisheries and the prohibition on retaining fish for both commercial and recreational purposes on the same trip, in many cases deciding to keep the first fish would bind the respondent to either a commercial or recreational trip and thereby restrict disposition options for subsequent fish (Figure 3). For instance, if a respondent kept a bluefin tuna measuring less than 73 inches CFL under the Angling category, a subsequent fish measuring 73 inches CFL or greater could not be retained under the General category, and could only either be released or retained under the Angling category as the vessel's annual trophy (if regulations permitted). Releasing the first fish, meanwhile, would enable maximum flexibility regarding disposition options for subsequent fish, but also meant that the respondent risked never encountering another fish on the trip, thus having no opportunity to harvest either commercially or recreationally. Permit holders were thus compelled to make decisions while in a position of uncertainty regarding future catch (both size and quantity), providing insight into how uncertainty may affect preferences and decision-making.

[Insert Figure 3 here]

2.2 Experimental Design

Attributes and attribute levels for the trip scenarios were developed in conjunction with CHB permit holders through three focus groups, and through meetings with NMFS HMS Management Division staff (Table 2). These attributes and their levels, which were subsequently combined into choice scenarios, reflected those factors believed to affect permit holders' decisions to fish for bluefin tuna in a given manner. They were representative of realistic fishery conditions and thus presented survey respondents with plausible circumstances under which decision-making would take place. For the first choice of whether to go bluefin tuna fishing with or without clients (or to go bluefin tuna fishing at all), five attributes, each with two to four levels, were included: Angling daily bag limits for the school (27 - < 47 inches CFL) and large school/small medium (47 - < 73 inches CFL) size classes; Angling annual (trophy) bag limit for the large medium/giant (73+ inches CFL) size classes; the General daily bag limit for the large medium/giant size classes; and the anticipated size range of fish to be encountered (assuming that fish were available in the area). The three anticipated size ranges represented trips during which a fish caught was likely to be below the General category size limit (45 to 75 inches CFL), a fish caught was likely to be above the General category size limit (75 to 100 inches CFL), and a fish caught had a reasonable chance of being either above or below the General category size limit (60 to 85 inches CFL). These size ranges were chosen to provide insight into the level of opportunism or inertia among respondents—for example, if a commercially oriented permit-holder decided to release a sub-73 inch CFL bluefin tuna even if most fish were expected to be 45 to 75 inches CFL, such a behavior would indicate strong inertia, or preference for attempting to harvest a fish for commercial sale.

[Insert Table 2 here]

For the second choice of how to dispose of the first fish caught, a sixth attribute, the size of the first fish, was added to the choice set, and impacted which disposition options were available. For the final choice of how to dispose of the second fish caught, the size of the second fish was added as a seventh attribute, with bag limit levels potentially adjusted depending on the respondent's previous choice of whether and how to harvest the first fish.[2]

Because presenting a full factorial experimental design that included all combinations of all attribute levels was not practical (3,456 simulated trips), macros in SAS software (SAS 9.3, SAS Institute, Inc., Cary, NC USA) developed by Kuhfeld (2010) were used to create a fractional factorial design capable of efficiently estimating parameters (Louviere, Hensher, and Swait 2000). A key objective of the study was to examine decision-making and tradeoffs with regard to harvest under the Angling or General category; therefore, the survey was designed so that respondents would frequently have to choose the disposition category for a given fish—in other words, scenarios in which a fish could be harvested under

[2]While bag limits were potentially adjusted across decisions within a single trip, they were not adjusted across trips within a survey, as the two trips were considered independent. For example, if a respondent chose to retain their annual trophy bluefin tuna measuring 73 inches CFL or greater on the first trip, such a decision did not necessarily mean that the trophy category would be closed on the second trip.

either category. Frequently, deciding to harvest a fish under one category or the other would restrict disposition options for subsequent fish, necessitating a tradeoff between the current decision and future opportunities. Restrictions were built into the construction of the trip scenarios so that actual fish size always fell within the range of anticipated fish size, and also that the aggregate Angling bag limit for fish measuring less than 73 inches CFL never exceeded three fish, as had typically been the case during the several years prior to survey development. In addition, scenarios in which a fish would have to be released without any prior decision-making on the part of the respondent (e.g., a 45 inch CFL fish when the school-size bag limit is 0) were not included. A total of 20 alternatives, each representing a single simulated trip scenario (i.e., up to three choices), was generated and blocked into 10 blocks of two trips each. Respondents were thus never required to make more than six choices over the two trip scenarios, similar to the number used in other stated choice surveys, in order to reduce the risk of respondent fatigue (Bennett and Adamowicz 2001; Hicks 2002; Oh et al. 2005; Carter and Liese 2012).

In addition to the trip scenarios, surveys included a series of questions that asked permit holders about their bluefin tuna fishing behavior and experience, attitudes concerning the management of the fishery, top three target species, and demographic characteristics. Responses to these questions were used to explore drivers of heterogeneity in trip decision-making as well as to examine consistency between stated use of the CHB permit and trip scenario choices, similar to convergent validity (Freeman 2003). Prior to survey delivery, focus groups were held with CHB permit holders in Hyannis, MA, Toms River, NJ, and Nags Head, NC, in which attendees beta tested the online survey to ensure comprehension and compatibility with a variety of mobile devices (e.g., laptops, smartphones, and tablets). The survey was approved by William and Mary's Protection of Human Subjects Committee (Protocol # PHSC-2015-11-19-10758-amscheld).

2.3 Survey Delivery

Survey distribution and collection were conducted by the survey research firm Quantech, Inc. (Rockville, MD USA) from April-August 2016. Names and contact information for all CHB permit holders as of December 31, 2015 (n = 2410) with a listed primary port from Maine to North Carolina

(Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, and North Carolina) were obtained from the HMS Management Division and shared with Quantech. For each state, permit holders were randomly assigned to one of the 10 survey blocks while maintaining an equal number of each survey version in each state to the extent possible.

Given the complex nature of the survey, with attribute levels and available alternatives able to vary over choices within a trip scenario, a web survey was used. To contact CHB permit holders and invite them to participate, a mixed-mode approach modified from Dillman, Smyth, and Christian (2009) was employed consisting of up to five contacts over five weeks: an initial email invitation with a unique survey link (for the 86% of permit holders with a valid email address); a reminder email invitation; a mail invitation with a survey link and unique access code; a postcard reminder; and a final reminder email. To increase response rates, several measures were taken in accordance with recommendations from focus group attendees and previous published studies. Correspondence materials explicitly mentioned that the study was being led by the Virginia Institute of Marine Science (VIMS), as focus group attendees suggested that aligning the study with an academic organization (rather than a government agency) would increase responses. Because low-odds, high-reward lotteries have been shown to be the most-cost effective way to increase response rates (Gajic, Cameron, and Hurley 2012), permit holders were entered into a random drawing to win one of two $500 cash prizes upon completing the survey. In addition, permit holders were informed that following the study's conclusion, respondents would receive a summary of survey findings.

2.4 Choice Modeling

While respondents were asked to make up to three decisions for each trip scenario, only responses to the latter two decisions—the dispositions of the first and second fish caught—were modeled, given the interest in understanding and predicting harvest decisions rather than the decision of whether to go bluefin tuna fishing at all. Responses to the first question of whether or not to take paying clients on a given bluefin tuna trip were used as a means to contextualize subsequent choices, as the presence of clients on board might impact permit holder behavior (e.g., a permit holder may be more compelled to retain a fish under the Angling category for clients). However, given the presumed diversity of CHB permit holders (some of whom may never take paying clients), imposing whether or not clients were on board as an initial attribute was not considered a reasonable approach, as it would not necessarily provide an appropriate or reasonable context for subsequent bluefin tuna harvesting decisions (Swait et al. 2002).

To model CSSC responses, a random utility theoretic approach was used, which assumes that an individual will select the alternative (harvest under the General category, harvest under the Angling category, or release) that maximizes his or her underlying utility function. The estimation of preferences through such an approach allowed for the prediction of bluefin tuna harvest behavior across a broad range fishery conditions, including those not explicitly incorporated as scenarios developed for the CSSC survey. For individual *n*, the overall utility *U* of alternative (harvest disposition) *i* can be decomposed into an observable component V_{ni} and a random error component ε_i not captured by the model; alternative *i* will be selected if its associated utility is greater than that for all other available alternatives *j*. In this study, for a given choice scenario the number of available disposition alternatives varied from one (i.e., the fish had to be released) to three according to the size of the fish, the Angling and General category bag limits, and any constraints placed on available alternatives by previous choices on that trip.[3] The observable component of utility V_{ni} can be written as βx_{ni}, where x_{ni} is a vector of the attributes in alternative *i*, and β is a vector of associated utility parameters (Train 2009). If each unobserved component of utility ε_i is assumed to follow an independent and identical extreme value type I distribution, the probability of individual *n* choosing alternative *i* can be expressed by the conditional logit (CL):

$$P_{ni} = e^{\beta'} \quad / \textstyle\sum_j e^{\beta'} \quad {}_j \tag{1}$$

An extension of the conditional logit, the random parameters logit (RPL), allows each random parameter β associated with each factor in *x* to vary across each respondent *n* according to a specified mixing distribution (Train 2009):

[3] Choice scenarios in which the only possible alternative was to release the fish (i.e., there was no choice, which would only occur as a consequence of previous decisions) were not included in the model.

$$P_{ni} = \int \left(e^{\beta'} \quad / \sum_j e^{\beta'} \quad {}^{j} \right) f(\beta) d\beta \tag{2}$$

This general form, which allows for unrestricted substitution patterns across alternatives, random taste variation across respondents, and correlation in errors across decisions, has been used in numerous stated choice studies of fishermen (e.g., Carter and Liese 2012; Lew and Larson 2012). For this study, in which bluefin tuna fishermen were suspected to utilize the CHB permit in different ways, the RPL was considered a potentially critical tool for quantifying the degree of heterogeneity among respondents, which could be used for forecasting future behavior.

To account for the panel nature of the data—each respondent was able to make up to four decisions (over two trips) regarding the disposition of bluefin tuna—the log-likelihood function included the product of individual mixed logit probabilities across *t* choice occasions:

$$ln\, L = \sum_{n=1}^{N} ln \left\{ \prod_{t=1}^{T} \int (e^{\beta'} \quad {}^{t} / \sum_j e^{\beta'} \quad {}^{jt}) f(\beta) d\beta \right] \Big\}. \tag{3}$$

While the model described in Equation 3 accounts for correlation in unobserved factors across the multiple fish disposition decisions that an individual makes through the course of the survey by allowing for heterogeneous individual preferences, it does not distinguish between decisions within a given simulated trip and decisions that occur on separate trips. In order to allow for correlation in unobserved factors at the trip level (i.e., the multiple decisions on a single trip), the random parameters in the model, which were associated with trip-specific attributes and assigned normal distributions, were permitted to be correlated with one another (Hensher and Greene 2003; Hess and Train 2017). In order to do so, we specified the individual-specific random coefficients $\beta'_n \sim N(b,\Omega)$, with b representing the mean across individuals and Ω representing the covariance matrix where off-diagonal elements are allowed to be non-zero. The vector of random coefficients can then be written as $\beta'_n = b_n + L\mu_n$, in which L denotes a lower triangular Choleski factor of Ω and μ represents a vector of independent standard normal deviates (Revelt and Train 1998; Train 1998; Carter and Liese 2012).

In addition to including trip-specific attributes as factors in the model, alternative- and individual-specific dummy variables, identified through conversations with fishermen and managers, were also included to examine hypotheses believed to be relevant to managing this mixed commercial-recreational fishery (Table 3). To investigate whether the effect of fish size varied depending on the disposition options available, two fish size variables were included in the model, allowing differentiation of behavioral responses for fish less than and greater than 73 inches CFL (the commercial minimum size) as fish size changed. This variable enabled us to examine, for example, if a respondent was less likely to harvest a sub-73 inch CFL fish if that fish was larger (i.e., closer to 73 inches CFL), as the availability of such a fish could signal the availability of commercial-sized bluefin tuna in the area. Of particular interest was evaluating the level of opportunism among respondents—for example, if the first fish caught was harvested regardless of size, even if doing so bound the respondent to an Angling or General category trip. Conversely, the effect of inertia (i.e., habit formation) was investigated through the addition of dummy variables describing decision-making on previous choice occasions (Adamowicz 1994; Morikawa 1994). Inertia was investigated on two levels. First, for both scenarios, respondents' stated primary trip type orientation for bluefin tuna (Angling or General)—which can be considered a revealed preference in this context because it indicates past behavior—was included as a factor in deciding whether to harvest a fish under the Angling or General category. Second, for the second trip scenario, the first trip type was included as a factor. Together, these variables examined the level of consistency in trip type selection regardless of trip-level attributes.

[Insert Table 3 here]

Model fit for the standard CL, the RPL without correlated random parameters, and the RPL with correlated random parameters was assessed using Akaike's Information Criterion (AIC; Akaike 1973) and the Bayesian Information Criterion (BIC; Schwarz 1978). The RPLs with and without correlated random parameters were further compared using three tests: the Wald test; the Lagrange multiplier test (a.k.a. score test); and the likelihood ratio test. All model estimation was performed using the "mlogit" package (Croissant 2013) in the statistical programming software R (R Core Team 2016).

To estimate the marginal effects of trip- and individual-specific variables on the probability of disposing of a fish in a given manner, the bootstrapping method of Krinsky and Robb (1986) was used, based on 10,000 random draws from a multivariate normal distribution with a mean set at parameter means (b_n for the RPLs) and a covariance matrix corresponding to the model's variance-covariance matrix. Marginal effects—the effect of a single unit change in a continuous variable (e.g., fish size, bag limits), or the discrete change of a dummy variable from 0 to 1 (e.g., for individual-specific variables)—were then calculated by estimating the difference in disposition probability associated with a marginal change in the variable of interest while holding other variable levels constant at mean values.

Because a key objective of this study was to forecast how harvest patterns might change as a function of both fishery conditions (fish size, bag limits) and the characteristics of participating fishermen (e.g., primary trip type orientation, geographic location), varying levels of the factors included in the model derived from survey responses were combined to generate four diverse yet realistic mock decision scenarios that could be experienced by fishery participants. The scenarios, based on the researchers' knowledge of plausible combinations of attributes and on input from focus group participants and managers, were used to illustrate how the results of the model could predict permit holder behavior for different fishery conditions and fishermen characteristics. The four example mock scenarios developed included fishery conditions within the range of those included in the CSSC survey, but were not necessarily reflective of the exact scenarios that a respondent might have encountered in the survey. For each of these mock scenarios, the same 10,000-row Krinsky-Robb matrix used to estimate marginal probabilities was used to generate a distribution of harvest probabilities under either the Angling or General category, providing insight into both the anticipated behavior of permit holders and potential variability in responses.

3. Results

3.1 Response Rates and Respondent Characteristics

Out of 2,394 eligible respondents, 788 permit holders completed the survey, for an effective response rate of 32.9%. The proportion of respondents by state was similar to the proportion of permit holders by state, suggesting that responses were generally not biased based on geographic location, although Fisher exact tests revealed that Rhode Island permit holders were significantly over-represented and that North Carolina permit holders were significantly under-represented ($p < 0.01$) (Table 4).

[Insert Table 4 here]

Responses to general questions regarding demographics, bluefin tuna fishing behavior, and use of the CHB permit revealed striking heterogeneity (Table A.1). Despite the permit's being originally intended for for-hire captains, of those who answered that they had targeted bluefin tuna in the past five years, only slightly more than half (56%) indicated that they had captained a charter trip targeting bluefin tuna during that time. Questions regarding primary target species also revealed heterogeneity by region (Table A.2). While "tuna" (all species) were the most commonly selected target species/species group across all three regions, New England (Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut) and New York/New Jersey respondents listed inshore or demersal species such as striped bass and summer flounder as primary target species more frequently than did Mid-Atlantic (Delaware, Maryland, Virginia, and North Carolina) respondents. A greater percentage of those in the Mid-Atlantic, meanwhile, listed other pelagic species such as dolphinfish and sharks among their top targets. The most common primary bluefin tuna trip type indicated by respondents was private recreational (39.9% of respondents), followed by charter recreational (33%), private commercial (23.7%), and charter commercial (charters on which the intent is to catch and sell a large medium or giant-size bluefin tuna; 3.4%), meaning that over 70% of respondents primarily fished recreationally (as expected) and over 60% of respondents primarily fished for bluefin tuna without paying clients on board.

Responses also suggested significant heterogeneity in permit use by geographic region. New England permit holders were far more likely to target and sell commercial-sized bluefin tuna, while New York/New Jersey-based permit holders largely targeted school-size bluefin tuna recreationally. In addition, a greater proportion of New York/New Jersey permit holders supported the idea of a separate sub-quota for the CHB category—perhaps a result of the fact that they tend to directly compete with the

Angling category for landings of juvenile bluefin tuna, as opposed to fishing under both the Angling and General categories.

Of the 577 respondents who elected to go bluefin tuna fishing for both scenarios (i.e., did not select the "Do not go bluefin tuna fishing" option for either scenario), 14% chose to harvest fish under the Angling category for both trips, 23% chose to harvest fish under the General category for both trips, 29% chose to harvest fish under the General category on one trip and under the Angling category on the other trip, and 34% chose to release all bluefin tuna on at least one trip. Stated primary trip types generally aligned with the types of trips selected in choice scenarios, suggesting convergence between stated behavior and choices in hypothetical scenarios (Table 5).

[Insert Table 5 here]

Of respondents who indicated that they had taken paying clients on a bluefin tuna charter in the previous five years and completed at least one scenario trip (n = 358), 69.8% chose to take clients on at least one scenario trip, compared to 32.2% of respondents who had not taken clients in the previous five years (n = 289) (Fisher exact test: $p < 0.001$). In addition, 82.3% of respondents who had ever sold a bluefin tuna and who completed at least one scenario trip (n = 247) chose to harvest a fish under the General category on at least one trip, compared to 43% of respondents who had never sold a bluefin tuna (n = 398) (Fisher exact test: $p < 0.001$).

3.2 Model Specification

The RPL model, both with and without correlated random parameters, provided a significantly better fit to the data than did the CL according to both information criteria (Table 6). Including correlation among random parameters provided a better fit than not including correlation according to AIC but not BIC, likely because BIC imposes a larger penalty for additional parameters than does AIC. Similarly, both the likelihood ratio test (p = 3.9e-06) and score test (p = 4.12e-07) rejected the null hypothesis that the random parameters were uncorrelated, but the Wald test did not (p = 0.12). We elected to use the model with correlated random parameters for our analyses given that it had support from two of the three hypothesis tests, in addition to the fact that correlation among random parameters was intuitive and allowed us to account for intra-trip correlation in unobserved factors.

[Insert Table 6 here]

Parameter estimates for the RPL with correlated random parameters are provided in Table 7. The model provided strong evidence for heterogeneity in preferences among CHB permit holders. With the exception of the FishSize_Under73 and FishSize_Over73 variables, both the parameter mean and standard deviation estimates for all random coefficients were significant. The random parameter estimates for FirstFish and AntSize_Small_Ang indicated that while some permit holders appeared to be opportunistic, harvesting whatever bluefin tuna they were able to, others demonstrated clear preferences for harvesting under the General or Angling category. The mean value for FirstFish was positive and significant, indicating that, on average, a fish was more likely be harvested if it was the first fish of the trip, regardless of what category such harvest would fall under. The parameter estimate was far and away the largest of any variable, meaning that FirstFish was on average the most deterministic factor. For 11% of respondents, however, the FirstFish coefficient was less than 0, meaning that a fish's being the first of a trip was actually a negative inducement to harvest. Similarly, while the mean coefficient for AntSize_Sm_Ang was positive and significant, the coefficient was estimated to be negative for 35% of respondents, who were less likely to harvest a fish under the Angling category when the anticipated fish size was less than 75 inches CFL. For both bag limit variables, parameter estimates were positive, suggesting that an increase in a category's bag limit increased the probability of harvesting under that category. However, large and significant standard deviations for each variable indicated that the parameter estimates for the General and Angling category bag limits were less than 0 for 27% and 31% of the respondent population, respectively. In other words, for some individuals, the probability of harvesting under a given category decreased when the bag limit for that category increased. Mean values for both FishSize variables were not significantly different from 0, meaning that as the size of a fish in a given size category (above or below 73 inches) increased, it was no more or less likely to be harvested.

There was thus no evidence for changes in marginal utility of harvest among respondents as fish size changed in each of the two size categories.

[Insert Table 7 here]

Several random parameters were significantly correlated with one another. The positive correlation between the bag limit variables indicated that those who responded positively to an increase in the bag limit for one category (i.e., became more likely to harvest under that category) tended to also respond positively to an increase in the bag limit for the other category. The negative correlation between the FirstFish and FishSize parameters suggested that individuals more likely to harvest a fish if it was the first of the trip—that is, the opportunists—were less responsive to increases in fish size regardless of whether the fish was greater or less than 73 inches CFL. The negative correlation between the General bag limit and FishSize parameters, meanwhile, indicated that individuals whose probability of harvesting under the General category increased with an increasing bag limit also tended to be less affected by fish size increases. The negative correlation between the Angling bag limit and the FishSize_Over 73 parameter indicated that respondents who were more likely to harvest a fish under the Angling category as the bag limit increased were less impacted by increases in fish size for bluefin tuna over 73 inches CFL.

Non-random factors included in the model suggested strong inertia effects among some respondents—in particular, those who tended to harvest under the General category—as well as geographic heterogeneity in harvest tendencies. Respondents who indicated that their primary trip type was commercial (either private or charter) and who had previously sold a bluefin tuna were significantly more likely to harvest a fish under the General category. In addition, if the harvest of a fish bound a respondent to an Angling trip (e.g., if the fish was less than 73 inches CFL), those who were primarily General category fishermen were significantly less likely to harvest, demonstrating a marked preference for commercial harvest. Similarly, respondents who indicated that they primarily fished recreationally were more likely to harvest under the Angling category. The type of trip chosen for the first trip scenario, however, was not a significant predictor of the type of trip chosen for the second trip scenario for either category. Geographic heterogeneity was demonstrated by the positive and significant dummy variables associated with the release alternative for the New England and Mid-Atlantic regions, indicating that respondents from New England and the Mid-Atlantic were significantly more likely to release bluefin tuna than those from New York/New Jersey. Thus, by extension, fishermen from the New York/New Jersey region were significantly more likely to harvest a fish, regardless of available disposition options.

3.3 Marginal Effects and Mock Scenarios

The marginal probabilities of harvest associated with the factors included in the model are shown in Table 8. FirstFish had the highest marginal probability of all factors; if the fish was the first of the trip, the probability of its being harvested under the Angling or General category increased by 32% and 44%, respectively. Having clients on board, anticipating catching bluefin tuna ranging from 45-75 inches CFL, and being from New York or New Jersey increased the probability of harvesting a fish under the Angling category by 15%, 11%, and 9%, respectively. For harvesting under the General category, having previously sold a bluefin tuna (28%) and being a primarily General category bluefin tuna fisherman (28%) had the largest marginal effects other than FirstFish.

[Insert Table 8 here]

Mock scenario results (Figure 4) indicated that harvest patterns for bluefin tuna of a given size could vary dramatically based on both fishery conditions and the individual characteristics of the permit holder. The mean probability of a New York/New Jersey permit holder's harvesting a 60 inch fish under the Angling category with clients on board and a liberal Angling bag limit (four fish) (Scenario A) was 0.97; for the same fish caught by a New England permit holder without clients on board, a strict Angling bag limit (one fish), and no expectations regarding fish size (Scenario B), meanwhile, the mean probability of harvest was 0.10. For an 80 inch fish caught by a New England permit holder who primarily fished under the General category and had previously sold a bluefin tuna, when the General bag limit was high (four fish) and the Angling trophy category was closed (Scenario C), the mean probability of harvest under the General category was 0.9998. Meanwhile, for a fish of the same size caught by a Mid-Atlantic permit-holder who primarily fished under the Angling category and had never sold a bluefin tuna, when the General bag limit was strict (one fish) and the trophy category was closed (Scenario D), the mean probability of harvest under the General category was 0.67. While harvest probabilities for the 10,000 draws were tightly clustered for Scenarios A and C, they were spread broadly in Scenarios B (ranging from 0.012 to 0.47) and D (ranging from 0.23 to 0.95).

[Insert Figure 4 here]

4. Discussion

This study used a sequential stated choice approach to examine within-trip decision-making regarding fish disposition by participants in the mixed commercial-recreational bluefin tuna fishery. Results revealed substantial heterogeneity in how fishermen respond to uncertainty regarding catch outcomes for a given trip. Specifically, permit holders who were primarily commercially oriented appeared to exhibit stronger inertia and well-defined harvest preferences, and were willing to forgo the opportunity to retain a fish under the Angling category in order to have a later opportunity to retain a fish under the General category. Conversely, those who identified as recreationally oriented (~73% of all respondents) appeared more opportunistic and more inclined to harvest whatever fish were made available regardless of disposition option, rather than risk not catching (and retaining) any subsequent fish.

4.1 Inertia versus Opportunism

The finding that respondents who primarily fished in a commercial manner were less willing to harvest a fish recreationally than vice versa is not wholly surprising given the expectation of income generation (either to cover expenses or turn profit) among those who typically fish commercially—the harvest of an Angling category fish thus may be considered a loss. The interpretation that primarily commercial fishermen are less likely to harvest a fish for recreational purposes is consistent with Hospital, Bruce, and Pan's (2011) survey of Hawaii small-boat fishermen, which found that full-time commercial fishermen (> 50% of personal income derived from fishing) on average did not sell fish on only 4% of trips, while part-time commercial fishermen (< 50% of personal income derived from fishing but had sold fish in the previous 12 months) did not sell fish on 38% of trips.

However, for those who primarily fish recreationally, the experience of catching a fish for commercial sale—plus the money obtained from its sale—may make such an alternative appealing even as the prospect of obtaining a fish for personal consumption is foregone. Additionally, it should be noted that while fish harvested under the General category are typically sold, it is technically legal to harvest a fish under the General category and not sell it as long as either: 1) a federally permitted seafood dealer affixes a dealer tag to the fish and reports the landing to NMFS; or 2) the vessel operator contacts a NMFS enforcement agent, providing the necessary reporting information (pers. comm., S. McLaughlin, NMFS, 2017). This provision, included as a harvest option ("Retain under General category, but do not sell") in the CSSC scenarios where applicable, might further explain the additional tendency of primarily recreational permit holders to harvest under the General category, as doing so could provide a means for harvesting a fish measuring more than 73 inches CFL for personal consumption even when the Angling trophy category is closed.[4] An exception to the general pattern of increased opportunism among those who primarily fish recreationally may be for CHB permit holders who take paying clients, who are 15% more likely to harvest a fish under the Angling category; this more fixed preference for recreational harvest is in all likelihood due to the desire to meet the wishes of customers on board.

While inertia was detected between stated primary trip type and the trip type selected in each of the scenarios, the RPL model did not provide evidence of inter-trip inertia—that is, the harvest disposition chosen in the first trip scenario did not significantly impact the choice of harvest disposition on the second trip. In the CL model, which did not allow for individual preference heterogeneity or account for the multiple choice occasions that could be experienced by an individual, the choice of fish disposition on the first trip was shown to be a significant predictor of fish disposition on the second trip. This finding suggests that the preferences of respondents were consistent throughout the scenarios. Since the RPL model indicated that primary stated trip type significantly impacted harvest disposition under both the

[4] Respondents chose to harvest under the General category but not sell in about 17% of all instances in which harvesting under the General category was the selected alternative. Because no data are available regarding whether fish harvested under the General category are sold or not, it is unknown whether this frequency is representative of what occurs in the fishery.

Angling and General categories, inertia appeared to exist given that choice behavior in trip scenarios aligned with stated prior fishing behavior. The selected trip type in the first scenario, meanwhile, did not affect the selected trip type in the second scenario after accounting for preference heterogeneity. Long-term habit formation thus does appear to play an important role in predicting harvest behavior when outcomes are uncertain, at least for some respondents.

4.2 Counterintuitive Findings

A few parameter estimates from the model initially appear counterintuitive, but can be explained when considered in the context of the fishery and its participants. The finding that between a quarter and a third of respondents had negative coefficients associated with the bag limit variables could be due to the fact that for some fishermen, a high bag limit may suggest that management strategies are too lax for effectively conserving the bluefin tuna stock, leading them to voluntarily release fish that they would otherwise be allowed to keep. This behavior is more likely for recreational than commercial fishermen, but considering that nearly three quarters of respondents primarily fish for bluefin tuna recreationally, such a mindset could have contributed to model results. Such a conservation ethic among recreational anglers may also explain why some respondents had a negative coefficient associated with AntSize_Sm_Angling, which suggests that some anglers prefer to catch and release small bluefin tuna rather than harvest them. It is important to remember, however, that these negative values may also be an artifact of our choice of a normal distribution to describe the random parameters, and that the choice of another distribution (e.g., lognormal, triangular) could have led to a different finding.

4.3 Interpreting Correlated Random Parameters

Allowing random variables to be correlated provided further insight into the contrast between opportunists and high-inertia individuals in situations with uncertain outcomes. For example, the significant positive correlation between the General and Angling bag limit parameters makes sense in that more opportunistic permit holders are likely to respond positively to any increase in allowable harvest, whereas those with well-defined preferences (for Angling or General category harvest) will likely be inclined to continue harvesting in a given manner regardless of the bag limit levels for the two categories.

Given that the majority of respondents indicated that they were primarily recreational anglers, who were found to have higher opportunism than primarily commercial fishermen, the strong correlation identified in the model is not surprising.

Similarly, the negative correlations between the FishSize variables and the FirstFish and bag limits variables suggests that those who are more likely to harvest the first fish or are more likely to harvest under an increasing bag limit—that is, the opportunists—are less likely to be affected by fish size, regardless of whether the fish is greater than or less than 73 inches CFL. Those with more defined fish size preferences, however, may be more inclined to release the first fish caught in hopes of harvesting a fish of their preferred size later in the trip. While the lack of significance for the two FishSize variables was somewhat surprising, this may be due to heterogeneous preferences across the respondent population, which could be masked by the correlation of the FishSize variables with the FirstFish and bag limit variables. There are plausible explanations for why fishermen would prefer to harvest either larger or smaller fish above or below the 73 inch CFL breakpoint. For example, recreational anglers may desire the largest sub-73-inch CFL fish they can harvest to maximize yield, but could also prefer a smaller fish due to storage limitations or other logistical reasons. Similarly, a larger fish greater than 73 inches CFL could be worth more to a commercial fisherman, but smaller commercial-sized bluefin tuna could also be preferred because they tend to fetch a higher price per pound and because for the wholesalers who buy bluefin tuna from fishermen, smaller fish represent a less risky investment on the global market, which often involves the expensive shipment of bluefin tuna to Japan (C. Hutt, NMFS, 2017; Carroll et al. 2001).

4.4 Regional Effects

The region that appears to be most harvest-oriented—and whose harvest behavior thus may be most sensitive to fishery conditions—is the New York/New Jersey region, whose respondents were significantly more likely to harvest a fish than were respondents from the New England or Mid-Atlantic regions. One explanation for this opportunistic behavior may be that, among those who had targeted bluefin tuna in the past five years, New York/New Jersey permit holders took significantly fewer bluefin tuna trips in 2015 (3.9) compared to permit holders from New England (9.8) or the Mid-Atlantic (5.5) (Table A.1). Given the small number of trips, New York/New Jersey fishermen may be compelled to harvest whatever fish they are able to, while fishermen elsewhere may be less harvest-oriented due to having more chances to harvest on other trips.

It is important to consider, however, that New York/New Jersey permit holders indicated that they were significantly more likely to target school-size bluefin tuna and significantly less likely to target large medium or giant-size bluefin tuna compared to New England or Mid-Atlantic permit holders. From 2012-2016, estimated catch (harvest and release) of large medium and giant-size bluefin tuna in the New York/New Jersey region was quite small, ranging from 0-87 fish (with percent standard errors of 70-100%), or 0-4.2%, of total estimated U.S. catch for these size classes (pers. comm., NMFS, Fisheries Statistics Division, 2017). The ability of New York/New Jersey permit holders to retain large medium or giant-size bluefin tuna in the CSSC scenarios thus represents a potential issue with respect to content validity, in that the scenario specified may be unfamiliar to the respondent, meaning that they do not necessarily have well-defined preferences (Freeman 2003). This notion was reinforced during a Toms River, NJ, focus group discussion, in which attendees mentioned that they rarely encountered bluefin tuna measuring larger than 73 inches CFL. That being said, attendees also indicated that if such fish did become available, they would happily retain and sell them under the General category. While it is unclear how exactly permit holders in this region would react to an influx of larger bluefin tuna, stated preferences derived from the model suggest that, if regulations permitted, harvest of bluefin tuna under the General category could rise dramatically, complicating efforts to maintain General category harvest—and overall U.S. bluefin tuna harvest—within internationally specified limits. This challenge underscores the need to integrate biological information regarding fish size and spatial distribution with fishermen behavior and preferences, as suggested by Fulton et al. (2010) and Hunt, Sutton, and Arlinghaus (2013).

5. Conclusion

By considering prevailing fishery conditions (i.e., fish size and geographic distribution), the regulatory setting, and the individual characteristics of respondents, we were able to investigate harvesting behavior across the range of the mixed commercial-recreational bluefin tuna fishery on the U.S. east coast in order to improve the ability of managers to forecast harvest patterns in this unique fishery. The application of a CSSC survey approach to CHB permit holders was an effective means for characterizing the decision-making of fishermen when trip outcomes are uncertain. The incorporation of inertia variables and correlated random parameters allowed us to test for responsiveness of decision-making to fishery conditions and to account for correlation in unobservable factors across multiple fish disposition choices over the course of a single trip. The sensitivity of harvest patterns to the factors identified in the model is demonstrated by the wide range in harvest probabilities indicated by the mock scenarios, underscoring the challenge that managers face. Future work should consider additional variables that might impact the decision to fish in a given manner, including bluefin tuna ex-vessel prices and weather conditions. Due to the regional heterogeneity in primary target species and the fact that this study only modeled decision-making within a "bluefin tuna trip," the availability of and regulations for other species were not included as factors driving the initial decision of whether or not to target bluefin tuna. However, further region-specific work examining the impact of potential species substitution could provide key insights into the intensity of bluefin tuna fishing effort (commercial or recreational) and thus harvest. Lastly, we recommend that factors driving the dichotomy in opportunistic bluefin tuna harvesting behavior between commercially and recreationally oriented permit holders be further explored.

Acknowledgments

The authors are grateful to Brad McHale and Sarah McLaughlin of the NMFS HMS Management Division for their advice regarding survey development and their review of survey materials. We thank Kristy Wallmo and Clifford Hutt (NMFS) for their guidance regarding experimental design and modeling approaches. Rob Hicks (William & Mary), Ron Salz (NMFS), and Deborah Steinberg (VIMS) reviewed the manuscript and provided valuable input. The participation of 20 CHB permit holders at three focus groups was essential for gaining feedback on survey content, and we are appreciative of their efforts. We also thank *On The Water* magazine for assistance with survey outreach as well as QuanTech, Inc. for survey distribution and response collection. Lastly, we appreciate the thoughtful comments and constructive suggestions resulting from the anonymous review process. This article is contribution number XXXX from the Virginia Institute of Marine Science, William & Mary.

Funding

This work was supported by the NMFS Saltonstall-Kennedy Grant Program (15GAR020), a NMFS/Sea Grant Fellowship in Marine Resource Economics (NA15OAR4170179), and grants from the International Women's Fishing Association and the VIMS Foundation.

References

Aas, O., Haider, W., and L. Hunt. 2000. Angler Responses to Potential Harvest Regulations in a Norwegian Sport Fishery: A Conjoint-based Choice Modeling Approach. *North American Journal of Fisheries Management* 20:940-50.

Adams, M. F. 1978. Alternative Estimates of Net Economic Benefits for Billfish-Tuna Recreational-Commercial Fishermen in Kailua-Kona, Hawaii. Southwest Fisheries Center Administrative Report 18H. Southwest Fisheries Center, NMFS, NOAA, Honolulu, HI.

Adamowicz, W. L. 1994. Habit Formation and Variety Seeking in a Discrete Choice Model of Recreation Demand. *Journal of Agricultural and Resource Economics* 19(1):19-31.

Agar, J. J., and D. W. Carter. 2014. Is the 2012 Allocation of Red Snapper in the Gulf of Mexico Economically Efficient? Technical Memorandum NMFS-SEFSC-659. Southeast Fisheries Science Center, NMFS, NOAA, Miami, FL.

Akaike, H. 1973. Information Theory as an Extension of the Maximum Likelihood Principle. In *Second International Symposium on Information Theory*, ed. B.N. Petrov and F. Csaki, 267-281. Budapest: Akadémiai Kiadó.

Bennett, J., and V. Adamowicz. 2001. Some Fundamentals of Environmental Choice Modeling. In *The Choice Modeling Approach to Environmental Valuation*, ed. J. Bennett and R. Blamey, 37-69. Massachusetts: Edward Elgar Publishing Limited.

Berman, M., Haley, S., and H. Kim. 1997. Estimating Net Benefits of Reallocation: Discrete Choice Models of Sport and Commercial Fishing. *Marine Resource Economics* 12:307-27.

Bishop, R. C., and K. C. Samples. 1980. Sport and Commercial Fishing Conflicts: A Theoretical Analysis. *Journal of Environmental Economics and Management* 7:220-33.

Carroll, M. T., Anderson, J. L., and J. Martínez-Garmendia. 2001. Pricing U.S. North Atlantic Bluefin Tuna and Implications for Management. *Agribusiness* 17(2):243-254.

Carter, D. W. and C. Liese. 2012. The Economics Value of Catching and Keeping or Releasing Saltwater Sport Fish in the Southeast USA. *North American Journal of Fisheries Management* 32:613-25.

Croissant, Y. 2013. Mlogit: Multonomial Logit Model. R package version 0.2-4. https://CRAN.R-project.org/package=mlogit.

Dillman, D. A., Smyth, J. D., and L. M. Christian. 2009. *Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method*. New York, New York: Wiley.

Duffield, J., Neher, C., Allen, S., Patterson, D., and B. Gentner. 2012. Modeling the Behavior of Marlin Anglers in the Western Pacific. *Marine Resource Economics* 27(4):343-57.

Easley, J. E. Jr. 1992. Selected Issues in Modeling Allocation of Fishery Harvests. *Marine Resource Economics* 7:41-56.

Easley, J. E. Jr., and F. J. Prochaska. 1987. Allocating Harvest between Competing Users in Fishery Management Decisions: Appropriate Economic Measures for Valuation. *Marine Fisheries Review* 49(3):29-33.

Freeman, A. M., III. 2003. *The Measurement of Environmental and Resource Values: Theory and Methods*. Washington, D.C.: Resources for the Future.

Fulton, E. A., Smith, A. D. M., Smith, D. C., and I. E. van Putten. 2011. Human Behaviour: The Key Source of Uncertainty in Fisheries Management. *Fish and Fisheries* 12(1):2-17.

Gajic, A., Cameron, D., and J. Hurley. 2012. The Cost-effectiveness of Cash Versus Lottery Incentives for a Web-based, Stated-preference Community Survey. *European Journal of Health Economics* 13(6):789-99.

Gates, J. M. 1984. Principal Types of Uncertainty in Fishing Operations. *Marine Resource Economics* 1(1):31-49.

Gentner, B. 2013. Allocation Analysis of the Gulf of Mexico Gag and Red Grouper Fisheries. Prepared for the Coastal Conservation Association. Gentner Consulting Group.

Hanley, N., Wright, R. E., and V. Adamowicz. 1998. Using Choice Experiments to Value the Environment. *Environmental and Resource Economics* 11(3-4):413-28.

Heinisch, G., Rosenfeld, H., Knapp, J. M., Gordin, H., and M. E. Lutcavage. 2014. Sexual maturity in western Atlantic bluefin tuna. *Scientific Reports* 4:7205.

Hensher, D. A., and W. H. Greene. 2003. The Mixed Logit Model: The State of Practice. *Transportation* 30:133-76.

Hess, S., and K. Train. 2017. Correlation and Scale in Mixed Logit Models. *Journal of Choice Modeling* 23:1-8.

Hicks, R. L. 2002. Stated Preference Methods for Environmental Management: Recreational Summer Flounder Angling in the Northeastern United States. Requisition Request # NFFKS=18. Final Report prepared for the National Marine Fisheries Service, Office of Science and Technology, Fisheries Statistics and Economics Division.

Holland, D. S. 2008. Are Fishermen Rational? A Fishing Expedition. *Marine Resource Economics* 23:325-44.

Hospital, J., Bruce, S. S., and M. Pan. 2011. Economic and Social Characteristics of the Hawaii Small Boat Pelagic Fishery. Administrative Report H-11-01. Pacific Islands Fisheries Science Center, NMFS, NOAA, Honolulu, HI.

Hunt, L. M., Sutton, S. G., and R. Arlinghaus. 2013. Illustrating the Critical Role of Human Dimensions Research for Understanding and Managing Recreational Fisheries within a Social-ecological System Framework. *Fisheries Management and Ecology* 20(2-3):111-24.

Kearney, R. E. 2002. Co-management: The Resolution of Conflict between Commercial and Recreational Fishers in Victoria, Australia. *Ocean & Coastal Management* 45:201-14.

Krinsky, I., and A. L. Robb. 1986. On Approximating the Statistical Properties of Elasticities. *The Review of Economics and Statistics* 68(4):715-19.

Kuhfeld, W. F. 2010. *Marketing Research Methods in SAS: Experimental Design, Choice, Conjoint, and Graphical Techniques*. SAS Institute, Inc., Cary, NC.

Lew, D. K, and D. M. Larson. 2012. Economic Values for Saltwater Sport Fishing in Alaska: A Stated Preference Analysis. *North American Journal of Fisheries Management* 32(4):745-59.

Louviere, J. J., Hensher, D. A., and J. D. Swait. 2000. *Stated choice Methods: Analysis and Application*. Cambridge: Cambridge University Press.

McConnell, K. E., and T. C. Haab. 2001. Small Boat Fishing in Hawaii: Choice and Economic Values. SOEST 01-01, JIMAR Contribution 01-336. Pelagic Fisheries Research Program, Joint Institute of Marine and Atmospheric Research, University of Hawaii.

Miller, M. L. 1996. Social Aspects of Pacific Pelagic Fisheries—Phase I: The Hawai'i Troll and Handline Fishery. SOEST 96-04, JIMAR Contribution 96-302. Pelagic Fisheries Research Program, Joint Institute of Marine and Atmospheric Research, University of Hawaii.

Morikawa, T. 1994. Correcting State Dependence and Serial Correlation in the RP/SP Combined Estimation Method. *Transportation* 21:153-65.

Murray-Brown, M., McLaughlin, S., and C. Lopez. 2007. History of United States Atlantic bluefin tuna size classification and changes. National Oceanographic and Atmospheric Administration (NOAA), NOAA Fisheries Atlantic Highly Migratory Species Management Division, Gloucester, MA.

NMFS (National Marine Fisheries Service). 2006. Final Consolidated Atlantic Highly Migratory Species Fishery Management Plan. NMFS, NOAA, Silver Spring, Maryland.

NMFS (National Marine Fisheries Service). 2019. 2017 Commercial Atlantic Bluefin Tuna Landings Updates. https://www.fisheries.noaa.gov/atlantic-highly-migratory-species/2017-commercial-atlantic-bluefin-tuna-landings-updates (last visited 10/29/2019)

Oh, C., Ditton, R. B., Gentner, B., and R. Riechers. 2005. A Stated Preference Choice Approach to Understanding Angler Preferences for Management Options. *Human Dimensions of Wildlife* 10:173-86.

Pooley, S. G. 1993. Economics and Hawaii's Marine Fisheries. *Marine Fisheries Review* 55(2):93-101.

Plummer, M. L., Morrison, W., and E. Steiner. 2012. Allocation of Fishery Harvests under the Magnuson-Stevens Fishery Conservation and Management Act: Principles and Practice. NOAA Technical Memorandum NMFS-NWFSC-115. Northwest Fisheries Science Center, NMFS, NOAA, Seattle, Washington.

R Core Team. 2016. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Revelt, D., and K. Train. 1998. Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level. *The Review of Economics and Statistics* 80(4):647-57.

Schuhmann, P. W., and J. E. Easley, Jr. 2000. Modeling Recreational Catch and Dynamic Stock Adjustments: An Application to Commercial-Recreational Allocation. *Land Economics* 76(3):430-47.

Schwarz, G. E. 1978. Estimating the Dimension of a Model. *Annals of Statistics* 6(2):461-4.

Swait, J., Adamowicz, W., Hanemann, M., Diedrich, A., Krosnick, J., Layton, D., Provencher, W., Schkade, D., and R. Tourangeau. 2002. Context Dependence and Aggregation in Disaggregate Choice Analysis. *Marketing Letters* 13(3):195-205.

Thurman, W. N., and J. E. Easley, Jr. 1992. Valuing Changes in Commercial Fishery Harvests: A General Equilibrium Derived Demand Analysis. *Journal of Environmental Economics and Management* 22:226-40.

Train, K. E. 1998. Recreation Demand Models with Taste Differences Over People. *Land Economics* 74(2):230-9.

Train, K. E. 2009. *Discrete Choice Methods with Simulation*. 2nd edition. Cambridge: Cambridge University Press.

Wallmo, K., and S. Edwards. 2008. Estimating Non-market Values of Marine Protected Areas: A Latent Class Modeling Approach. *Marine Resource Economics* 23(3):301-323.

[Insert Table A.1 here]

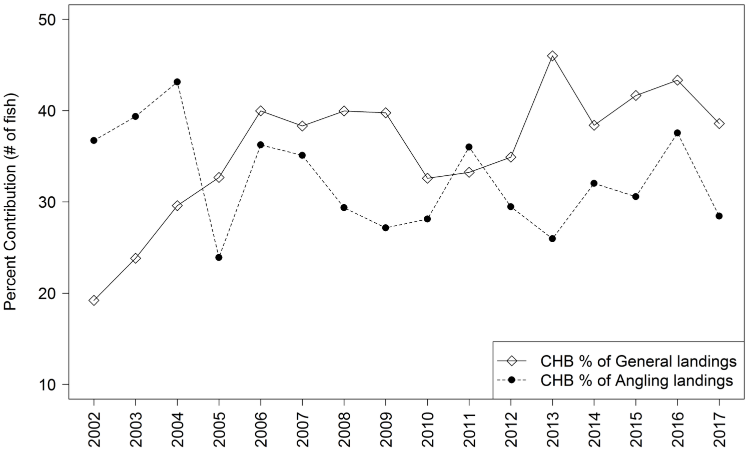
[Insert Table A.2 here]

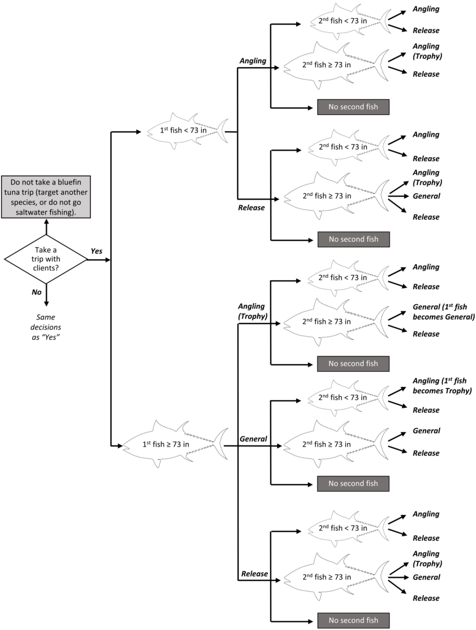
Figure 1. Bluefin tuna landings estimates (numbers of fish) by the Charter/Headboat (CHB) permit holder group as a percentage of the General and Angling category sub-quotas from 2002-2017. Numbers of fish are used as a proxy for weight because landings percentages in weight were only available for the General category (not shown here), but did not differ from landings percentages by number by more than 5% for a given year. Angling category landings do not include fish harvested as annual trophies (≥ 73 inches CFL), which are generally less than 30 fish per year and would not meaningfully change percent contributions. A negative correlation between CHB permit holder percent contributions to the two groups ($R^2 = 0.19$; $p = 0.095$) suggests potential shifts in effort between the two categories. A steady increase in contribution percentages for both categories from 2002-2004 likely reflects increased acquisition of CHB permits following the establishment of the permit in its current form in 2002 (67 FR 77434, 12/18/2002).

Figure 2. Decision tree for contingent sequential stated choice survey. Respondents were not aware of how many fish they would catch on a given trip scenario. Note: Available disposition options above assume that Angling and General category bag limits permit harvest, which may or may not be the case in individual choice sequences.

Figure 3. Example of a fish disposition choice task during a simulated fishing trip scenario. In this instance, the respondent selected to retain their first fish under the Angling category. As a result, when a fish measuring more than 73 inches CFL is caught, as above, the option to harvest the fish under the General category is unavailable; the respondent can only either retain it as the annual Angling trophy or release it.

Figure 4. Disposition probabilities for four bluefin tuna fishing scenarios based on 10,000 random draws (in all scenarios, the fish is the first fish of the trip). **A**: NY/NJ permit holder; clients are on board; Angling category bag limit is 4; anticipated size is 45-75 inches CFL; fish size is 60 inches CFL; mean P(Angling) = 0.97. **B**: New England permit holder; no clients are on board; Angling category bag limit is 1; anticipated size is 45-75 inches CFL; fish size is 60 inches CFL; mean P(Angling) = 0.10. **C**: New England permit holder; primarily a General category fisherman; has previously sold a bluefin tuna; Angling trophy category is closed; General category bag limit is 4, fish size is 80 inches CFL; mean P(General) = 0.9998. **D**: Mid-Atlantic permit holder; primarily an Angling category fisherman; has never sold a bluefin tuna; Angling trophy category is closed; General category bag limit is 1, fish size is 80 inches CFL; mean P(General) = 0.67.


Percent Contribution (# of fish)
50
40
30
20
10
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
CHB % of General landings
CHB % of Angling landings



Do not take a bluefin tuna trip (target another species, or do not go saltwater fishing).
Take a trip with clients?
Yes
No
Same decisions as "Yes"
1st fish < 73 in
1st fish ≥ 73 in
Angling
Release
Angling (Trophy)
General
2nd fish < 73 in
2nd fish ≥ 73 in
No second fish
Angling
Release
Angling (Trophy)
General
General (1st fish becomes General)
Angling (1st fish becomes Trophy)

Reminder of trip characteristics:

Recreational Regulations	2 fish 27"-<47" CFL daily 1 fish 47"-<73" CFL daily 1 annual trophy (73"+ CFL)
Commercial Regulations	4 fish over 73" CFL daily
Size range of bluefin tuna that you expect to encounter	45" - 75" CFL

Annual trophy already retained?	No
Clients on board?	No
Catch Disposition	
1st bluefin tuna	Length: 70" CFL You chose to: Retain under Angling category
2nd bluefin tuna	Current question, see below

Disposition options

NOTE: Not all of these options will be available for each fish caught; options for disposition depend on regulations, the size of the fish, and the size of any fish previously harvested on the trip

Retain under Angling category: Harvest a sub-73" fish for recreational (non-sale) use by yourself or by your clients; report catch under Angling category.

Retain under Angling category as annual trophy: Harvest a 73"+ fish for recreational (non-sale) use by yourself or by your clients; report catch under Angling category.

Retain under General category for commercial sale: Harvest a 73"+ fish for commercial sale; report catch under General category.

Retain under General category, but do not sell: Harvest a 73"+ fish for some purpose other than commercial sale (e.g., personal or client consumption); report catch under General category.

Release: Do not harvest the fish.

*

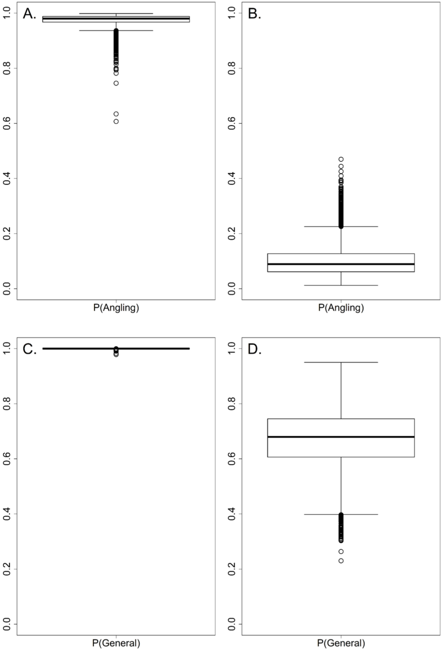
You hook another bluefin tuna, which measures 75" CFL.

As the fish approaches the boat, which action would you most likely take?

- Retain under Angling category as annual trophy
- Release the bluefin tuna

Resume later

Previous Next



A.
B.
C.
D.
P(Angling)
P(Angling)
P(General)
P(General)
0.0
0.2
0.4
0.6
0.8
1.0

Table 1. Atlantic bluefin tuna permit structure and quotas.

	Angling	General	Harpoon	Purse Seine	Longline	Trap	Reserve	Charter/ Headboat
Percent of quota[a]	19.7%	47.1%	3.9%	18.6%	8%	0.1%	2.5%	--
2017 sub-quota (mt)[b]	195.2	466.7	38.6	184.3	148.3	1	24.8	--
Permits (Oct 2016)[c]	12,716	2,532	9	5	280	--	--	2,463

[a] The U.S. baseline Atlantic bluefin tuna quota for 2017 was 1,058.89 mt.

[b] The baseline tonnage allocated to each sector is not exactly the percentage of the overall U.S. baseline quota because 68 mt of the baseline quota are allocated to the Longline category quota, outside of the allocation framework, to account for bluefin tuna dead discards. (Source: 80 FR 52198, 8/28/2015)

[c] Permit holder numbers for the Angling, General, Harpoon, and Charter/Headboat categories only include permit holders located in states from Maine south to North Carolina, where the directed fishery for Atlantic bluefin tuna occurs. Permit holder numbers for the Purse Seine and Longline categories were not available by state and represent permit holders from all Atlantic and Gulf-of-Mexico states. (Source: NMFS 2017)

Table 2. Attribute levels for contingent sequential stated choice (CSSC) survey. Fish size attributes are in curved fork length.

Attribute	Number of levels (values)
Angling daily bag limit: school	3 (0, 1, 2)
Angling daily bag limit: large school/small medium	3 (0, 1, 2)
Angling annual bag limit: large medium/giant (trophy)	2 (0, 1)
General daily bag limit	4 (1, 2, 3, 4)
Anticipated fish size (inches)	3 (45-75, 60-85, 75-100)
First fish size (inches)	4 (45, 70, 75, 90)
Second fish size (inches)	4 (0 [no 2nd fish], 60, 75, 85)

Table 3. Factors included in the model.

Factor name	Description	Associated alternative	Distribution (if random)
BagLim_Gen	General bag limit	General	Normal
BagLim_Ang	Angling bag limit (all size classes combined)	Angling	Normal
AntSize_Sm_Ang	Anticipated size 45-75 inches	Angling	Normal
FirstFish	First fish of trip	Angling, General	Normal
FishSize_Under73	Fish length in inches if fish < 73 inches CFL (can only be harvested under Angling)	Angling	Normal
FishSize_Over73	Fish length in inches if fish > 73 inches CFL	Angling, General	Normal
Clients_Ang	Clients on board	Angling	--
FirstTripAng_Ang	First trip Angling	Angling	--
FirstTripGen_Gen	First trip General	General	--
NewEngland_Rel	Primary port in New England (Maine, New Hampshire, Massachusetts, Rhode Island, or Connecticut)	Release	--
MidAtl_Rel	Primary port in Mid-Atlantic (Delaware, Maryland, Virginia, or North Carolina)	Release	--
SellComm_Gen	Has previously sold a bluefin tuna	General	--
PrimaryAng_Ang	Primarily a recreational bluefin tuna fisherman	Angling	--
PrimaryGen_Gen	Primarily a commercial bluefin tuna fisherman	General	--
BindGen_PrimGen	Harvest binds to General trip, primarily commercial bluefin tuna fisherman	General	--
BindGen_PrimAng	Harvest binds to General trip, primarily recreational bluefin tuna fisherman	General	--
BindAng_PrimGen	Harvest binds to Angling trip, primarily commercial bluefin tuna fisherman	Angling	--
BindAng_PrimAng	Harvest binds to Angling trip, primarily recreational bluefin tuna fisherman	Angling	--

Table 4. Geographic distribution of survey respondents. Asterisks denote states whose proportion of respondents was significantly different from their proportion of the eligible sample frame according to Fisher exact tests ($p < 0.01$).

	Eligible sample frame		Responses (completed both scenarios)[b]	
State	No. of permit holders[a]	Percent of total sample	No. of permit holders	Percent of responses
Maine	112	4.7	36	4.6
New Hampshire	88	3.7	39	4.9
Massachusetts	683	28.5	243	30.1
Rhode Island	74	3.1	48	6.1*
Connecticut	125	5.2	33	4.2
New York	274	11.4	79	10.0
New Jersey	461	19.3	152	19.3
Delaware	66	2.8	22	2.8
Maryland	120	5.0	32	4.1
Virginia	97	4.1	37	4.7
North Carolina	294	12.3	67	8.5*
Total	2394	100	788	100

[a] As of December 31, 2015, when the sample frame was drawn.
[b] Includes individuals who selected "Do not take a bluefin tuna fishing trip (target another species, or do not go saltwater fishing)" for one or both trips.

Table 5. Percentage of respondents who completed at least one choice scenario of a given trip type (rows), by stated primary trip type (columns). Maximum values per column in bold. Sample sizes denote the number of respondents who completed at least one trip scenario.

	Stated Primary: Charter General (n = 21)	Stated Primary: Charter Angling (n = 212)	Stated Primary: Private General (n = 154)	Stated Primary: Private Angling (n = 260)
Charter General	**57.1%**	27.4%	26.6%	17.7%
Charter Angling	19.0%	**51.9%**	19.5%	21.1%
Private General	38.1%	17.9%	**68.2%**	37.7%
Private Angling	9.5%	7.1%	9.7%	**40.0%**
Release all	19.0%	17.9%	15.6%	38.5%

Table 6. Comparison of model fit. For the RPL models, the number of parameters refers to the number of non-random parameters in addition to hyperparameters characterizing random parameters.

Model	Number of parameters	Log likelihood	AIC	BIC
CL	20	-1329.9	2699.8	2793.5
RPL	26	-1233.8	2519.6	2641.4
RPL, correlated random parameters	41	-1207.3	2496.6	2688.8

Table 7. Model estimates for the conditional logit (CL) and for the random parameters logit (RPL) with correlated random parameters. Models included choice observations from a total of 801 respondents (788 who completed the survey plus 13 who only completed one trip scenario). A single asterisk denotes significance at p = 0.05; a double asterisk denotes significance at p = 0.01.

	CL	RPL with correlated random parameters	
	B	*B*	σ_β
Angling (intercept)	-2.354**	-4.991**	--
General (intercept)	-0.883	-2.938*	--
BagLim_Gen	0.301**	1.458**	2.416**
BagLim_Ang	0.177*	0.602**	1.192**
AntSize_Sm_Ang	0.760**	1.309**	3.316**
FirstFish	1.461**	4.000**	3.258**
FishSize_Under73	0.00395	0.000490	0.0634
FishSize_Over73	-0.00244	-0.0137	0.0305
Clients_Ang	0.966**	1.977**	--
FirstTripAng_Ang	1.030**	0.413	--
FirstTripGen_Gen	0.767**	-0.449	--
NewEngland_Rel	0.405**	1.131**	--
MidAtl_Rel	0.511**	0.956**	--
SellComm_Gen	1.296**	2.248**	--
PrimaryAng_Ang	0.356*	0.955*	--
PrimaryGen_Gen	1.116**	2.207**	--
BindGen_PrimGen	0.0205	0.0597	--
BindGen_PrimAng	-0.649**	-0.449	--
BindAng_PrimGen	-1.0573**	-2.666**	--
BindAng_PrimAng	0.0545	-0.385	--

Correlations (RPL)	BagLim_ Gen	BagLim_ Ang	AntSize_ Sm_Ang	FirstFish	FishSize_ Under73	FishSize_ Over73
BagLim_Gen	1	--	--	--	--	--
BagLim_Ang	0.719**	1	--	--	--	--
AntSize_Sm_Ang	0.103	-0.270	1	--	--	--
FirstFish	-0.0462	0.0616	0.137	1	--	--
FishSize_Under73	-0.836**	-0.780	-0.0459	-0.458**	1	--
FishSize_Over73	-0.688*	-0.845*	0.177	-0.538**	0.945	1

Table 8. Marginal probabilities. A single asterisk denotes a value that is significantly different from 0 at p = 0.05; a double asterisk denotes a value that is significantly different from 0 at p = 0.01.

Factor change[a]	Marg. prob, Angling	Marg. prob, General
One-fish increase, General bag limit	-0.0219**	0.105**
One-fish increase, Angling bag limit	0.0522**	-0.0199**
Anticipated size small (45-75 in)	0.107**	-0.0361**
First fish of the trip	0.319**	0.442**
One-inch increase in fish size (< 73 in)[a]	0.00111	--
One-inch increase in fish size (> 73 in)[b]	$4.106e^{-6}$	-0.00157
Clients on board	0.149**	-0.0553**
First trip Angling	0.0333	-0.0125
First trip General	0.0110	-0.0594
Binding to General, primarily General category fisherman	--	-0.0245
Binding to General, primarily Angling category fisherman	--	-0.0705
Binding to Angling, primarily General category fisherman	-0.216**	--
Binding to Angling, primarily Angling category fisherman	-0.0425	--
New England	-0.0460**	-0.0676**
Mid-Atlantic	-0.0258	-0.0403
New York/New Jersey	0.0850**	0.0878**
Has previously sold a bluefin tuna	-0.0585**	0.283**
Primarily Angling category fisherman	0.0708**	-0.0244**
Primarily General category fisherman	-0.0561**	0.276**

[a] The baseline fish size used to calculate marginal probabilities was 60 inches CFL.
[b] The baseline fish size used to calculate marginal probabilities was 90 inches CFL.