THE VIRGINIA STOCKED-TROUT PROGRAM: AN EVALUATION OF ANGLERS AND THEIR CATCH

By

Amanda A. Hyman

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Steve L. McMullin, Chair

Brian R. Murphy

Michael G. Sorice

Stephen J. Reeser

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Steve L. McMullin, Committee Chair

Abstract

Despite the long history of stocking trout and the popularity of stocked-trout fishing in Virginia, no study has investigated the use of the program nor attempted to describe anglers actively seeking stocked trout. Agencies have stocked trout in Virginia since the 1920s and today, Virginia Department of Game and Inland Fisheries (VDGIF) stocks the majority of the fish in the state, stocking over 1 million catchable-sized trout on over 180 waters. Given the expansive effort of VDGIF and the popularity of the program, VDGIF desired to understand how anglers utilize their program and who actively fishes for stocked trout. My objectives were 1) to assess catch, harvest, effort, and return-to-creel rates of stocked trout on various fishery and water body types, across seasons and number of days post-stocking in stocked waters in western Virginia, 2) to identify market segments of anglers seeking stocked trout based upon their demographic characteristics, motivations, and degree of specialization, 3) to compare satisfaction and management preferences of the market segments of anglers seeking stocked trout in Virginia and 4) to recommend stocking and management strategies that best meet the desires of stocked-trout anglers in Virginia and that produce managerially desired catch rates to the Virginia Department of Game and Inland Fisheries.

I conducted on-site surveys on 17 stocked-trout waters across Virginia. Most anglers reported high levels of satisfaction with their fishing experience that day and with the program in

the last 12 months. The majority of anglers caught something that day. Anglers had diverse fishing and management preferences.

Stocking density did not affect catch rate on lakes nor streams. Time following a stocking event did influence catch rate and effort; anglers caught fish the quickest on the day of stocking, but catch rate remained near 1 trout per angler-hr and did not significantly differ from the day after stocking to 30 days after stocking. Catch rate positively correlated with angler satisfaction, yet the majority of the anglers were highly satisfied, even if they did not catch any fish.

We identified four groups of anglers: casual anglers, consumptive-experienced anglers, avid anglers, and specialists. Social investment, experience, and fishery resource use varied among the four groups. The four groups also had differing motivations for fishing, fishing preferences, management preferences, and levels of satisfaction.

Multinomial logistic regressions showed that specialization, age, catch rate, importance an angler places on catching something, and waterbody type contributed to the best model for predicting angler satisfaction. Anglers on streams typically expressed greater satisfaction than anglers on lakes. Angler satisfaction negatively correlated with the importance an angler placed on catching something.

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Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Overview and Justification

Trout provide substantial recreational fishing opportunities in the United States. Nationwide in 2011, trout anglers accounted for 26% (7.2 million anglers) of all freshwater anglers, fishing nearly 76 million days (17% of all freshwater fishing days) for trout (U.S. Fish and Wildlife Service and U.S. Census Bureau 2011). Trout anglers spent $3.6 billion on fishing nationally in 2011, with an estimated overall economic impact of $8.6 billion and supporting over 60,000 jobs (U.S. Fish and Wildlife Service and U.S. Census Bureau 2011). This impact occurred despite a drastic decline in number of anglers over the last few decades, waning nearly 20% from 1996 to 2011 (U.S. Fish and Wildlife Service and U.S. Census Bureau 2011). As their numbers decrease, trout anglers are aging, with an increase of 55% in anglers over the age of 65 from 2006 to 2011. The declining and aging trends could have negative impacts on local economies dependent upon revenue from fishing.

Trout are economically important in Virginia. In 2011, trout anglers accounted for approximately 14% (1,116,000 days) of the total freshwater fishing effort in Virginia, spending more than $56 million in pursuit of trout (U.S. Fish and Wildlife Service and U.S. Census Bureau 2011). As of 2001, an estimated 80% of the trout angling effort in Virginia focuses on stocked-trout waters, which are primarily stocked by Virginia Department of Game and Inland Fisheries (VDGIF) (O'Neill 2001).

With such a strong reliance on stocked-trout waters in Virginia, VDGIF spends more than 30% of its total annual fisheries budget to operate and maintain trout hatcheries (FY 2010 budget, VDGIF 2013a). In 2013, sales of trout licenses and a portion of the sales of freshwater

fishing licenses provided all of the funding for the trout hatcheries in the state. This, however, may not be the case in the near future as trout license sales, not including Lifetime License sales, have declined approximately 45% from 2006 to 2013. This decline occurred at a substantially faster rate than the overall reduction of fishing licenses sold in the state (VDGIF 2013a, VDGIF unpublished data). Such a significant drop may reflect angler discontentment with the stocked-trout program, and thus satisfaction of anglers could determine the future of the program.

The agency has attempted to satisfy stocked-trout angler demands by increasing the number of trout stocked and diversifying opportunities to fish for stocked trout. Virginia Department of Game and Inland Fisheries currently stocks over 1.2 million catchable-sized trout (generally 8 to 11 inches in length) in 180 waters annually; the agency also stocks fingerlings (4 to 6 inches in length) in deep reservoirs, cold tailwaters, and spring-fed streams. Virginia Department of Game and Inland Fisheries offers an array of fishing experiences for anglers, stocking trout to "…establish sport fish in new, reclaimed, or renovated waters open to the public, supplement natural stocks…, introduce new species as predators and/or provide trophy fish, and to provide immediate fishing by introducing catchable size fish" (VDGIF 2013b). Opportunities to fish for stocked trout in Virginia currently include five different management strategies:

- Delayed harvest waters - designated stocked areas, where only catch-and-release fishing with artificial lures is allowed from October 1st to June 15th, but anglers may harvest fish for the remainder of the year;
- Put-and-take waters - the most abundant type of stocked water, where anglers may harvest up to six trout greater than seven inches long per day regardless of species and season;

- Fee areas – designated stocked put-and-take waters that cost $8 per day to fish and are stocked multiple times per week;
- Put-grow-take waters – typically cold-water systems where fingerlings are stocked;
- Urban fisheries – designated stocked sections of streams and lakes from November 1 to April 30 in or near urban areas, where the daily creel limit is four trout (VDGIF 2013b).

Put-and-take fisheries, the primary focus of this project, account for the majority of the stocked-trout waters managed by VDGIF. To increase the agency's efficacy and efficiency in stocking trout, VDGIF prioritizes its stocking of put-and-take waters based upon angling pressure, quality of trout habitat, stream size, public accessibility, and water quality. The agency classifies large, popular waters with the most suitable trout habitat and best water quality during the stocking season as Class A put-and-take waters. Class A waters receive eight stockings from October to the end of May. Class C streams, typically smaller waters, have the least amount of suitable trout habitat and often have low stream flows, while Class B waters fall somewhere between Class A and C waters. Class B waters receive five stockings per season and Class C waters receive three stockings per season (VDGIF 2013b).

Virginia Department of Game and Inland Fisheries stocks three different trout species at catchable size: Rainbow Trout *Oncorhynchus mykiss,* Brown Trout *Salmo trutta,* and Brook Trout *Salvelinus fontinalis*. On approved-stocking waters where native Brook Trout still reside, VDGIF generally attempts to stock only Brook Trout or triploid Rainbow Trout, which are sterile. The agency does not stocked Brown Trout within a Brook trout drainage, where they could establish a wild population (VDGIF 2015).

Virginia Department of Game and Inland Fisheries stocks a range of waters and species to accommodate their diverse constituents. Angler groups who fish for stocked trout often have

conflicting desires that make management difficult. O'Neill (2001) found two distinct segments of trout anglers in Virginia: just under 40% of the sampled trout anglers desired to catch large fish, while another 40% of the same sample wanted to catch fish to eat. Furthermore, trout anglers differ in terms of their level of specialization, varying in characteristics such as their fishery resource use, management preferences, experience, social and financial investment in the sport, and centrality of angling to their lifestyle. Trout anglers, including stocked-trout anglers, are diverse. Understanding the heterogeneity of the population and drivers of satisfaction will enable VDGIF to better meet anglers' preferences and desired outcomes, with the intention of improving the reported level of satisfaction with the program and, possibly, increasing the sales of licenses that fund it.

Many agencies use mail and on-site surveys to gather information about and opinions from their clientele. Much of VDGIF's previous information stems from mail surveys, which have targeted all licensed anglers and occasionally licensed-trout anglers specifically. Few surveys however, have targeted stocked-trout anglers. Using on-site, angler-creel surveys, I assessed a novel market for Virginia: anglers who actively fish stocked-trout waters.

This study will provide VDGIF valuable information regarding its active constituents by investigating stocked-trout anglers' motivations for fishing, levels of specialization, levels of satisfaction with the program, and management preferences. Moreover, it will provide VDGIF and other agencies managing stocked-trout programs with regulation and management options that best stimulate managerially desired catch rates.

Anglers' Levels of Specialization and Motivations

Anglers differ broadly in their level of specialization and their respective motivations for and attitudes toward trout fishing. Bryan (1977: pg 175) originally described recreational

specialization as "…a continuum of behavior from the general to the specialized," with regard to "…equipment, skills used, and preference for a specific recreational setting." Many projects have built upon the idea of specialization by further defining and refining specialization (in terms of observable traits) and ascertaining how anglers' behaviors, and preferences relate to specialization (Chipman and Helfrich 1988, Hahn 1991, Ditton et al. 1992, Scott and Shafer 2001).

Chipman and Helfrich (1988) developed four overarching dimensions of angler behavior to define angler specialization: fishery resource use, experience, investment, and centrality of angling to lifestyle. They defined fishery resource-use preferences as those related to equipment and bait use, species and site preference, and harvest habits. Recent studies have begun to parse out varying types of anglers based on catch-related attributes: size preference for fish (e.g., trophy anglers), frequency of harvest, and desires to catch many fish (Hutt et al. 2013, Schroeder and Fulton 2013, Ward et al. 2013b). The experience dimension, which Salz and Loomis (2005) described as cognitive development, encompasses fishing frequency and years of experience. The investment dimension included equipment ownership and overall investment in angling. In addition, recent researchers have used a combination of distance traveled to fish and number of fishing trips taken as an indicator of investment (Oh et al. 2005, Ward et al. 2013b). Membership in a fishing organization, subscription to a fishing magazine, social setting, and role of fishing in anglers' lives defined the centrality to lifestyle dimension, which Kim et al. (1997) later defined as psychological commitment. More recent studies have also incorporated use of fishing related (digital) media into the centrality-of-angling-to-lifestyle dimension, which has increased and enabled the spread of knowledge and communication amongst anglers (Beardmore et al. 2013). Scott and Shafer (2001) also pointed out that the centrality dimension should include not only

decisions made in light of an angler's interest in the activity, but also the rejection of other leisure activities.

With the use of these four specialization dimensions and other related work, human-dimension scientists have segmented angler populations into relatively homogeneous groups (Bryan 1977, Chipman and Helfrich 1988, Hutt and Bettoli 2007). Although studies of freshwater anglers differ slightly, the majority of the groupings in the studies parallel the classification scheme described by Bryan (1977), ranging from the "occasional angler" to the "generalist" and the "advanced" or "technique-setting specialist." The occasional angler fishes infrequently and has limited fishing skills or interest in fishing, while a generalist fishes regularly and uses a variety of techniques. The two more-advanced types of anglers, the technique specialist and the technique-setting specialist, focus much of their leisure time and fiscal means on fishing, immersing themselves into an angling social world with strong preferences for one method of fishing. Technique-setting specialists also have a strong preference for the type of water to practice the activity (Bryan 1977, Chipman and Helfrich 1988, Ditton et al. 1992, Beardmore et al. 2013).

Many of these representative preferences and behaviors differ due to an individual angler's motivations for fishing, frequently described as his/her desired outcomes of a fishing experience (Holland and Ditton 1992, Fedler and Ditton 1994, Arlinghaus 2006). An angler's reasons for fishing can vary with both activity-specific motivations (e.g., desires to catch a trophy fish, a fish to eat, or to catch the bag limit) and non-activity specific motivations (e.g., desires to be with family and friends, to get away from a regular routine, or to enjoy the outdoors) (Fedler and Ditton 1994, O'Neill 2001, Anderson et al. 2007, Beardmore et al. 2011).

Fishery managers can more effectively develop fishing programs and services by better understanding the array of anglers' motivations (Fedler and Ditton 1994).

Many studies throughout the last several decades attempted to group anglers in terms of both their level of specialization and motivations for fishing (Chipman and Helfrich 1988, Ditton et al. 1992, Fisher 1997, Connelly et al. 2001, Hutt and Bettoli 2007, Beardmore et al. 2013, Kim and Oh 2013). These studies typically identified one or two highly specialized groups of anglers that place more emphasis on activity-specific motivations, yet had less interest in harvesting fish, and had a greater willingness to pay than groups of less-specialized anglers. These studies also generally identified groups of less-specialized anglers, who tended to consider non-activity-specific motives (such as relaxation and spending time with family) as more important than activity-specific motives, and yet commonly harvested the fish they caught. While specialization and motivation correlate across many studies, the papers point out one caveat: although generalizations can be made from previous studies, they may not properly inform specific management practices since motivations tend to be situation-specific (Holland and Ditton 1992, Ditton 2004).

Angler Satisfaction and Success

Although studies consistently link angler specialization and motivation, the relationship between specialization and angler satisfaction with the success of stocked-trout programs remains undetermined. Anglers' motivations and levels of specialization have complex connections to angler satisfaction. Arlinghaus (2006) defined angler satisfaction as "…the difference between the outcomes an angler desires…and the perceived fulfillment of the desired outcomes." Arlinghaus's (2006) argument parallels the description of the multiple-satisfactions of hunters in Hendee (1974), which focused on the idea that participants seek a variety of

outcomes. Arlinghaus (2006) found that across levels of catch-oriented anglers, activity-specific, typically catch-related, motivations drove seasonal angler satisfaction. This result implies that despite the high importance of non-activity-specific motivations for fishing, angler satisfaction still can depend primarily upon catch-related motives. Ditton (2004) likewise, cautioned against misinterpreting low levels of importance placed on motivations for catching and keeping fish. Improving management relies heavily on comprehending the relative importance of desired outcomes to anglers across the target population throughout the angling season and the ease with which anglers can achieve their desired outcomes (Hendee 1974, Ditton 2004, Arlinghaus 2006).

Linking angler success and angler satisfaction

Although anglers' satisfaction can vary for many reasons, ranging from the weather that day to the anglers' companions to the number or size of fish they catch, managers of stocked-trout fisheries tend to focus their efforts on evaluating measurements of catch-related satisfaction. McCormick and Porter (2014) reported higher levels of satisfaction with increased mean length of catch, but those values shifted with the age of the anglers. As McCormick and Porter (2014) showed, levels of satisfaction relating to catch are multi-dimensional and challenging to parse apart. Due to the ambiguous nature of satisfaction measurements, managers attempt to measure satisfaction in terms of angler success (i.e., catch per unit effort), and stocking success in terms of return-to-creel rates (the ratio of the number of stocked trout caught to the total number of trout stocked) (Borawa et al. 1993, Walters et al. 1997, Bettoli 1999, Wiley 2006, Patterson and Sullivan 2013). Recent studies have found a positive correlation between angler satisfaction and catch rate, which Pollock et al. (1994) described as "…the number or weight of a particular species of fish caught per trip, per angler-hour, or per some other unit of fishing effort."

Effects of catchability and trout survival on angler success

Throughout the past few decades, a plethora of studies have explored how species of trout influence angler success. These studies have not focused on anglers seeking stocked trout, but primarily investigated the actual trout stocked and management practices that affect catchability of stocked trout, retention, and survival (Cresswell 1981, Fay and Pardue 1986, Borawa et al. 1993, Wiley et al. 1993, Bettoli and Bohm 1997, Walters et al. 1997, Bettoli et al. 1999, Bettinger and Bettoli 2002, Baer et al. 2007, Baer and Brinker 2008, Patterson 2011, Askey et al. 2013). Catchability may vary with domestication of strain and species stocked (Fay and Pardue 1986, Pawson 1991, Bettoli and Bohm 1997). Virginia-freshwater anglers catch domesticated strains of Rainbow Trout (i.e., strains that had a greater number of generations in the hatchery since the collection of wild eggs) more rapidly and more frequently than less-domesticated strains (Fay and Pardue 1986). Species of trout stocked also appears to affect catch rates; anglers consistently catch Rainbow Trout more readily than Brown Trout (Pawson 1991, Bettoli and Bohm 1997, Bettoli et al. 1999) and one study (Baird et al. 2006) found anglers caught a larger portion of Brook Trout that were stocked than Rainbow Trout and Brown Trout that were stocked. Species also affects the typical direction of dispersal following stockings: stocked Brook Trout and Rainbow Trout tend to disperse downstream of stocking site, while Brown Trout typically move upstream of the stocking site. Although directions differed in the studies, total dispersion distances did not vary consistently among species (Cresswell 1981, Helfrich and Kendall 1982).

Regardless of trout species, several stocking practices affect the survival of stocked trout and their catch rates. Stocking large, legally catchable-sized trout, increases trout survival, catch rates, and return-to-creel rates in both streams and lakes (Cresswell 1981, Wiley et al. 1993,

Walters et al. 1997, Askey et al. 2013). Increasing stocking density may slow growth rates and decrease survival, due to increased competition for resources (Bentz Jr et al. 1991, Baer and Brinker 2008, Patterson 2011). Stocking large trout and stocking at a lower density may increase trout survival and growth rates, while creating delayed-harvest sections of streams can enhance the efficiency and efficacy of a stocked-trout program. Anglers caught fish multiple times in delayed-harvest sections of North Carolina streams, at rates ranging from three to six trout per hour, compared to slower catch rates (approximately two trout per hour) in other hatchery-supported waters (Borawa et al. 1993). Unlike delayed-harvest sections, anglers can harvest fish immediately following stocking on put-and-take designated fisheries. On put-and-take waters, time after a stocking event plays a major role in angling pressure and total catch. The days immediately following stocking typically see greatest fishing pressure and total catch of fish (Sztramko 1991, Greene et al. 2006, Baer et al. 2007). With high post-stocking natural and angling mortality rates, few trout remained in stocked waters beyond two to four months in previously studied systems (Wiley et al. 1993, Baer et al. 2007).

Irrespective of stocking management and practices, fish survival ultimately hinges on the quality of stocked water relative to that of the hatchery waters. Stream discharge has mixed effects on catch rates (Bettoli 1989, Luisi and Bettoli 2001), while increased stream temperature negatively affects trout health. Luisi and Bettoli (2001) noted that Rainbow Trout acclimated to 10˚C, a temperature approximately 5˚C below typical hatchery waters, began to experience partial to total equilibrium loss within 8 minutes after experiencing temperatures at 24˚C and above, temperatures that Virginia freshwater systems often reach during summer months.

On-site Creel Surveys

On-site creel surveys enable mangers to estimate catch, harvest, and return-to-creel rates, while human dimension scientists often use self-administered surveys to assess opinions, anglers' demographics, motivations, levels of specialization, levels of satisfaction, and management preferences. Combining the two types of surveys may allow managers to verify that motivation, preference and satisfaction data gathered through self-administered surveys truly represent anglers actively using the resource (Pollock et al. 1994).

On-site creel surveys usually consist of roving creel surveys or access-point surveys. The two methods differ in terms of the type of access to the survey site and when angler interviews occur. When anglers access a site via many points, roving creel surveys often provide accurate and reliable creel data. When few (often only one) access points exist, access-point surveys may provide more-accurate and reliable data. For roving creel surveys, clerks travel along a prescribed route encompassing all possible angler locations. As clerks travel along the route, they interview anglers as they fish, generally resulting in incomplete trip interviews. Access-point surveys generally result in completed trip interviews at the time that anglers leave the fishing site (Hayne 1991, Robson 1991, Pollock et al. 1994).

As with any survey method, on-site surveys have strengths and weaknesses. On-site surveys provide site-specific angler information, which benefits managers seeking information about users of a particular body of water. On-site surveys minimize memory recall issues regarding catch and levels of angler satisfaction, since trained clerks can directly measure and count fish and interview anglers during or shortly after their angling experience (Pollock et al. 1994). If the interview occurs while the angler fishes, however, length-of-stay bias can occur, as anglers who fish longer are more likely to be contacted. Estimating catch rate from incomplete

trip data also assumes constant catch rates and that clerks have accounted for all anglers during the sampling period. However, interviewing all anglers at high-use sites and during times of high angling pressure may be impossible for an individual clerk. Additionally, on-site surveys typically cost more per respondent than self-administered surveys (Hayne 1991, Robson 1991, Pollock et al. 1994, Zweifel and Stanovick 2003).

Virginia's Use of Creel Surveys

A few studies have provided information on anglers' specialization, motivations, and drivers of satisfaction and, in some instances, classified the heterogeneous population of freshwater anglers in Virginia (Chipman and Helfrich 1988, O'Neill 2001, Bugas 2005, Bugas 2007, U.S. Department of the Interior 2011, Duda 2012). These studies suggest that trout anglers differ significantly from other subpopulations of species-specific anglers and even within the population in terms of their fishing preferences and motivations, which parallels findings in other regions (Bryan 1977, Hummel and Foster 1986, Chipman and Helfrich 1988, O'Neill 2001). O'Neill (2001) found that roughly 40% of trout anglers in Virginia desired to catch a large fish while another 40% wanted to eat the fish they caught, which challenges managers to satiate multiple (and often times conflicting) preferred outcomes for fishing experiences. O'Neill (2001) and a subsequent VDGIF survey in 2008 reported that 22-23% of trout anglers were dissatisfied with freshwater fishing in Virginia, approximately 50% more than the general angler population (Victor DiCenzo, VDGIF, personal communication and unpublished data). Despite their continued dissatisfaction with fishing, less than 50% of anglers properly identified VDGIF as the agency enforcing regulations, and even fewer anglers (less than 21%) knew what the acronym VDGIF stands for (Duda 2012).

Study Objectives

Due to the challenge of satisfying a diverse demographic, the lack of knowledge anglers have regarding VDGIF, and reported low levels of satisfaction with trout fishing, VDGIF has begun to use surveys to gauge anglers' knowledge regarding fishing regulations, their preferred management practices, and their preferred method of communication from the agency (Bugas, 2005, Victor DiCenzo, VDGIF unpublished data). These studies, however, concentrated on all freshwater anglers, not stocked-trout anglers specifically. Given that approximately 80% of trout fishing in Virginia focuses on stocked-trout waters, and that more than 20% of trout anglers remain dissatisfied with freshwater fishing in Virginia, the agency had an obvious need to understand stocked-trout anglers better and the management strategies that impact the anglers' experiences (O'Neill 2001, Duda 2012).

This research focuses on assessing catch and harvest rates, who the anglers are, and angler satisfaction in relation to various management strategies and concerns; in particular, this project evaluates the effects of time after stocking events. The results of this study complement a statewide-mail survey of stocked-trout anglers and inform the development of a management plan for Virginia's stocked-trout program by incorporating desires of anglers in the process of using the resource. Specifically, the project attempted to address the following objectives:

1. To assess catch, harvest, effort, and return-to-creel rates of stocked trout on various fishery and water body types, across seasons and number of days post-stocking in stocked waters in western Virginia.
2. To characterize anglers seeking stocked trout based upon their demographic characteristics, motivations, and degree of specialization.

3. To compare satisfaction and management preferences of the anglers seeking stocked trout in Virginia.
4. To recommend stocking and management strategies that best meet the desires of stocked-trout anglers in Virginia and that produce managerially desired catch rates to the Virginia Department of Game and Inland Fisheries.

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Chapter 2: Interactions of Stocking Density, Time, Catch Rates, and Angler Satisfaction in a Stocked-Trout Fishery

Abstract

To enable Virginia Department of Game and Inland Fisheries to understand better how anglers utilize their current catchable-stocked-trout program, we interviewed 5,689 stocked-trout anglers on 14 put-and-take waters during their fishing trips from October 2013 – May 2014 and October 2014 – May 2015. We asked anglers about their effort fishing for stocked trout, catch, and level of satisfaction with their fishing experience that day. Stocking density did not affect catch rate on streams or lakes, but site, number of days after stocking, and month affected both angler effort and catch rate. Piecewise regression analysis showed that increasing catch rates below a threshold (0.46 trout/angler-hr on lakes and 1.21 trout/angler-hr on streams) greatly increased angler satisfaction; above those rates however, increasing catch rate had diminishing returns on angler satisfaction on both lakes and streams. Our results suggest that Virginia Department of Game and Inland Fisheries could reduce their stocking rates without fear of losing anglers. To establish better quantitative management objectives, agencies can use these results to more effectively manage their fisheries.

Introduction

Government agencies have stocked trout in the state since the 1920s and, today, Virginia Department of Game and Inland Fisheries (VDGIF) stocks the majority of the trout in the state. The agency stocks three species of catchable-sized trout (≥ 7 inches): Brook Trout *Salvelinus fontinalis*, Rainbow Trout *Oncorhynchus mykiss*, and Brown Trout *Salmo trutta*. The agency stocks over one million catchable-sized trout in over 180 waters from October through May each year (VDGIF 2015).

Virginia Department of Game and Inland Fisheries stocks trout for a variety of reasons: to establish a sport fishery in new or reclaimed waters that are seasonably suitable, to provide trophy fish, and to supplement natural stocks. For the catchable-stocked-trout program, VDGIF specifically seeks to provide immediate, typically short-term (i.e., usually one season), trout fishing by introducing catchable-sized fish in waters open to the public. Without stocked trout, trout fishing would be limited to a small portion (9%) of the intact subwatersheds of native Brook Trout in Virginia due to overfishing and degradation of suitable year-round habitat (Trout Unlimited 2006). Because of these declines in native stocks, poor year-round habitat, and a well-established history of stocking trout, over 80% of Virginia's trout angling effort focuses on stocked-trout waters (O'Neill 2001).

In Virginia, trout are the second most popular sport fish, accounting for approximately 14% (1,116,000 days) of the total freshwater fishing effort. In 2011, anglers spent over $56 million in their pursuit of trout in Virginia. Although still substantial, trout fishing has drastically declined across the nation, waning nearly 20% from 1996 to 2011. To add to the concern, trout anglers are aging. From 2006 to 2011, the percentage of trout anglers over the age of 65 increased 55% (U.S. Fish and Wildlife Service and U.S. Census Bureau 2011).

Currently, Virginia's stocked-trout program is financially self-sustaining, as trout license sales and a portion of the freshwater fishing license sales provide all of the funding for the trout hatcheries in the state. This, however, may not be the case in the future. Excluding lifetime license sales, trout license sales have declined approximately 45% from 2006 to 2013, a much faster rate than the national average (U.S. Fish and Wildlife Service and U.S. Census Bureau 2011) and faster than the overall reduction of other fishing licenses sold in the state (unpublished VDGIF data).

Virginia stocked-trout anglers are not only numerous, but vocal. Virginia anglers have expressed concerns about the program, primarily revolving around the quantity of fish stocked and perceived inequities in opportunities to catch stocked trout (S. Reeser, VDGIF, personal communication). Virginia stocked-trout anglers' beliefs align with a conceptual model regarding catchable-stocked-trout programs tested on lakes and reservoirs in Alberta, Canada (Patterson and Sullivan 2013): stocking more fish increases catch rates, which satisfies anglers and attracts additional anglers. A very few studies (Patterson and Sullivan 2013, Hunt et al. 2014) found that fish abundance and stocking rates positively correlated with angler catch rates on lakes. These findings make sense assuming a closed system, i.e., no immigration or emigration from other water bodies, and that anglers will catch most of the stocked fish. Only one study (O'Bara and Eggleton 1995) has looked at this relationship on lotic systems, where trout can disperse several kilometers from their stocking location (Cresswell 1981, Helfrich and Kendall 1982). O'Bara and Eggleton (1995) found no correlation between stocking density and catch rate on three put-and-take streams in Tennessee.

Under the same assumption that more fish means higher catch rates, anglers fret about the declining catch rates following a stocking event. They fear that the majority of the fish stocked are caught or leave the system (via migration, dispersal, or mortality) within the first few days of stocking. For catchable-stocked-trout waters, VDGIF does not announce a stocking event until 1600 hours on the day of stocking. Under the current announcement system, many anglers believe that "truck followers," a known class of anglers who wait for a hatchery truck to leave a given hatchery and follow it to a stocked-trout water, have an unfair advantage to catch stocked trout compared to anglers who must wait until succeeding days to fish (S. Reeser, VDGIF, personal communication). Paralleling many anglers' qualms, several studies (Sztramko 1991,

Greene et al. 2006, Baer and Brinker 2008) have reported higher angling effort and greater total catch on stocking day and the days immediately after a stocking event compared to longer time periods after stocking. These studies, however, do not report effort or catch-related metrics over a fine temporal scale after stocking events. As recent studies (Patterson and Sullivan 2013, McCormick and Porter 2014) confirm the positive correlation between catch rate and satisfaction, understanding such metrics over a temporal scale could help managers refine their programs and announcement systems for their anglers.

This study sought to fill information gaps by exploring how stocking rates and time affect catch rates following a stocking, and how changing catch rates contribute to angler satisfaction. Specifically, our objectives were 1) to explore the effects of stocking rates of catchable-sized fish on angler catch rates on both lakes and streams, 2) to investigate how catch rates and angler effort change over time following a stocking event, and 3) to analyze the effect of anglers' catch rates on their reported levels of daily satisfaction.

Methods

Study Sites and Data Collection

We examined angler populations on 14 put-and-take waters within all four management regions in Virginia, U.S.A (Table 1 and Figure 1). We chose waters that represent the range of waterbody types (i.e., lakes and stream reaches), and the range of physical characteristics (e.g., water quality, angler access) that exist within the program. Many of these waters support both fishes of special concern (e.g., Candy Darter *Etheostoma osburni*) and popular sport fishes (e.g., Largemouth Bass *Micropterus salmoides*). Virginia Department of Game and Inland Fisheries stocks each water 3 – 8 times, depending upon available habitat, water quality, and angler access,

from October through the end of May with various combinations of Rainbow Trout, Brown Trout, and Brook Trout.

We designed the creel survey to assess changes in catch, effort, and angler satisfaction in relation to time elapsed since stocking occurred. We conducted angler creel surveys on at least five days per stocking event during October 2013 – May 2014 and October 2014 – May 2015 using roving creel survey methods (Malvestuto et al. 1978). We used a two-stage random stratified design, where days were the primary sampling unit. We interviewed anglers between sunrise and sunset for each day that stocking occurred as well as the day after stocking. We randomly chose the other survey days within set timeframes following each stocking: one day of the first weekend, 7-10 days, 11-15 days, and when possible 16-30 days. Each of these shifts was assigned randomly with equal probability as an AM (sunrise to midday) or PM (midday to sunset) shift. During each shift, creel clerks traveled along a prescribed path (e.g., upstream to downstream) and interviewed anglers they encountered. Using a systematic random sampling design to estimate effort, creel clerks would pause from interviewing anglers to travel the entire route at three predetermined times to conducted instantaneous counts of active anglers (Pollock et al. 1994).

We clipped unique fins (e.g., adipose fin clip for an October cohort and a left pelvic fin clip for a November cohort) for 3 – 8 cohorts on 12 of the waters. We clipped all of the trout stocked in these cohorts so we could identify each harvested fish's cohort and observe how long each cohort remained in the stocked waterbody.

We interviewed anglers 18 years and older during their fishing trip. We asked anglers questions regarding how long they fished for that day and how many trout they caught and harvested within that timeframe. We inspected their creels for number and species of trout. In

addition to traditional catch and effort questions, we inquired about the anglers' levels of satisfaction with their fishing experience that day, motivations for fishing, fishing and management preferences, and general demographics (Appendix A). We used a single measure of satisfaction on a 7-point Likert scale from very dissatisfied (1) to very satisfied (7) to gauge anglers' levels of satisfaction with their fishing experience that day. In parties of multiple anglers, we interviewed each willing angler separately. If we interviewed an angler on a previous day, then we only ask him/her questions relating to their effort, catch, harvest, and levels of satisfaction with that day's fishing experience.

Data Analysis

To calculate daily catch and harvest rates, we used the mean of ratio (MOR) estimator because we obtained incomplete trip information (Pollock et al. 1994):

$$\hat{R} = \frac{\sum_{i=1}^{n} c_i/L_i}{n}$$

where $\hat{R}$ represents the mean of each angler's catch to trip length ratio, c_i is the catch (or harvest) for the *i*th survey day, n is the number of anglers surveyed that day, and L_i is the length of the fishing trip (Pollock et al. 1994). We then calculated angler effort, $\hat{E}$ for each survey day:

$$\hat{E} = \frac{I_i \; x \; T}{\pi_i}$$

where I_i is the average of the instantaneous counts on the *i*th day, T is the total length of the fishing day (hr), and π_i is the total probability that the *i*th fishing period is included in the sample. For half-day AM and PM shifts, we assumed equal probability (i.e., $\pi_i = 0.5$ for both AM and PM shifts). We then expanded effort to account for the total number of days in the

sample timeframe. We then calculated total catch, C, and total harvest for each day (Pollock et al. 1994):

$$C = \hat{E}\ x\ \hat{R}$$

where all variables are previously defined. We then expanded each daily total catch and harvest to account for the total number of days in the sampling timeframe.

Pollock et al. (1997) suggested using only survey data collected from anglers fishing for more than 0.5 hours. We tested this recommendation by first calculating MOR using all catch and harvest data and then calculating MOR using a truncated data set of only anglers fishing for 0.5 hours or longer. To determine which estimate more accurately described our sample, we resampled our data set using bootstrapping with replacement and determined the variance of each estimation (R version 3.0.3). We then used the estimate with less variance for all further calculations.

Many anglers believe that anglers fishing on or immediately after the day of stocking catch most of the trout stocked and, therefore, have an unfair advantage over anglers who are unable to follow trucks from the hatchery to the site of stocking (S. Reeser, VDGIF, personal communication). To address these concerns, we ran a generalized linear model (GLM) in JMP Pro 11 to explore the impact of month, site, and number of days after stocking on average daily catch rates (MOR) and angler effort. We then ran a simple linear model (lm in R version 3.0.3) to investigate the effect of stocking density (fish per kilometer or fish per hectare) on daily catch rates. On stocking day, we assumed all trout were equally catchable and density was simply the number of fish stocked divided by the size of the lake or length of the stream reach stocked by VDGIF. On days following, we accounted for angling mortality by removing an estimate of total

harvest for all previous days we did and did not creel and divided the cumulative remainder, assuming a closed system (i.e., uncaught fish from previous stocking were still present) by the size of the waterbody. As we had no reason to believe natural mortality would differ across sites, we did not adjust estimates for natural mortality.

Fishery managers frequently associate angler satisfaction with angler success (i.e., catch rates). We ran a piecewise regression to assess the effect of individual anglers' catch rates (trout/angler-hr) on their reported daily level of satisfaction because we believed at a certain threshold catch rate would minimally affect angler satisfaction and did not want to use a transformation that would negate catch rates of zero (e.g., natural log in Patterson and Sullivan 2013). We ran separate piecewise regressions for anglers on lakes and streams (SiZer package in R version 3.0.3).

Results

The MOR estimate using the truncated data set using only data from anglers that fished for more than 0.5 hours had less variance than the MOR estimate using all of the data; thus, we used a truncated data set to estimate catch, harvest, and effort rates. Of the 5,689 surveys conducted, 145 anglers declined and 384 were not complete and/or the angler did not fish at least 0.5 hours; hence, we used the remaining 5,239 surveys of stocked-trout anglers on the 14 put-and-take waters for this analysis. Males comprised 93% of the interviewed anglers. Respondents ranged in age from 18 to 91, with an average age of 48. The majority of the interviewees were either employed (55%) or retired (27%); the remainder of the anglers were students (6%), unemployed (4%), disabled (3%), or homemakers (1%). Anglers fished for stocked trout in Virginia an average of 25 days per year, traveling 24 miles one-way, on average, to fish that day. Over half of the anglers (57%) caught at least one fish and of those who caught something, 67%

harvested at least one fish. Approximately 34% of anglers sampled preferred advanced announcements, 31% preferred the current announcement system, 15% preferred stockings to be unannounced, and 20% had no preference on the timing of announcements. Nearly 76% of our sample wanted VDGIF to keep the daily bag limit the same, while over 15% wanted the daily bag limit to increase and the remainder wanted a smaller bag limit.

Objective 1: To explore the effects of stocking rates of catchable-sized fish on angler catch rates.

Virginia Department of Game and Inland Fisheries stocked 28,824 trout in the six lakes and 53,355 trout in the eight streams throughout our respective eight-month survey periods (Table 2-1). During this study (2013-2015), VDGIF annually stocked, on average, 1,802 trout/ha on the six lakes and 1,142 trout/km on the eight streams (Table 2-1). Anglers caught an estimated 52,245 (64%) stocked trout, releasing 17,620 (34%) of them and harvesting 34,625 (66%) of them. Anglers caught trout at the rate of 1.03 ± 1.09 fish/angler-hr (mean ± SD). We found no significant relationship between stocking density and daily catch rate on either streams or lakes (Figure 2-2).

Objective 2: To investigate how catch rates and effort change over time following a stocking event.

The model suggests that site, number of days after stocking, and month significantly affect daily catch rate and angler effort (Table 2-2). Daily catch rate was significantly higher on stocking day than any other day following stocking, but remained fairly consistent between 0.8 to 1.0 fish/hr throughout the remainder of the survey period. Daily catch rates on streams were significantly higher than on lakes and anglers had highest daily catch rates in December (Table

2-3). As observed in anglers' harvest, anglers caught trout up to seven months after they were stocked. Angler effort peaked on the day after stocking and dropped off dramatically following the first weekend after stocking (Figure 2-3). Anglers fished more on lakes than on streams (Table 2-3) and more in October and March through May than during the winter months (Figure 2-4).

Objective 3: To analyze the effect of anglers' catch rates on their reported levels of satisfaction.

Anglers' satisfaction with their fishing experiences on the days they fished averaged 5.5 ± 1.8 (mean ± SD), where 7 represents very satisfied. Seventy-seven percent of anglers reported being satisfied (≥ 5), with 47% choosing the highest level of satisfaction with their fishing experience that day. Only 13% expressed dissatisfaction (≤ 3) with their fishing experience that day (Table 2-4).

Anglers' level of satisfaction with their fishing experience that day correlated with catch rates above and below an optimal value for streams and lakes (Figure 2-7). The optimal value is a threshold where increases in satisfaction with catch rate begin to asymptote (Patterson and Sullivan 2013). The correlation of anglers' daily satisfaction to anglers' catch rates differed on streams and lakes. At catch rates below 0.46 trout/angler-hr on lakes, an increase of 1 trout/angler-hr produced, on average, an increase in satisfaction of 2.8 on a 7-point scale (Figure 2-3A, $X < 0.46$, $R^2 = 0.0236$, P-value <0.0001 , $Y = 2.78*X + 4.72$, $X \geq 0.46$, $R^2 = 0.0285$, P-value <0.0001, $Y = 0.14*X + 5.94$). On streams, an increase in catch rate of 1 trout/angler-hr up to the threshold of 1.21 trout/angler-hr produced, on average, an increase in satisfaction of 0.84 on a 7-point scale. Above that threshold of 1.21 trout/angler-hr on streams, an increase in 1 trout/angler-hr correlates with an increase in angler satisfaction of 0.08 on a 7-point scale (Figure

2-3B, $X < 1.21$, $R^2 = 0.0362$, P-value <0.0001, $Y = 0.84*X + 5.14$, $X \geq 1.21$, $R^2 = 0.0250$, P-value <0.0001, $Y = 0.08*X + 6.06$).

Discussion

We found no significant relationship between stocking rates and anglers' catch rates on neither lakes nor streams. Our results differed from those of Patterson and Sullivan (2013) who found that increased abundance of stocked trout correlated with higher catch rates on lakes and Hunt et al. (2014) who found that stocking more yearling salmon correlated with higher catch rates in lakes. Patterson and Sullivan (2013) stocked 120 to 1,457 trout/ha, averaging 551 trout/ha with an average size of 7.7 in in lakes similar in size to lakes in this study, compared to stocking rates of 704 to 3,232 trout/ha with a minimum size of 7 in and goal size of 10 in in Virginia lakes. At these rates, VDGIF is stocking well above other studied systems and may be saturating the lakes with high stocking densities (Wiley 2006, Patterson and Sullivan 2013). We also found no significant relationship between stocking rates and anglers' catch rates on streams, similar to previous research (O'Bara and Eggleton 1995). We propose three mechanisms that explain the lack of relationship between stocking densities and catch rates on stocked-trout waters: 1) the systems could be at saturation, i.e., even the lowest stocking densities in Virginia waters exceed levels that would affect catch rate, 2) fish could disperse beyond legal fishing areas, as several studies (Cresswell 1981, Helfrich and Kendall 1982) found trout to disperse several kilometers from stocking locations, and 3) more experienced and proficient anglers fish when and where fish densities have declined (Ward et al. 2013a). Virginia Department of Game and Inland Fisheries could most easily influence and test the first mechanism: overstocking. If VDGIF is stocking at or beyond saturation, the agency may be able to achieve management objectives by stocking fewer fish and still satisfy and retain anglers. With the decline of license

sales across the nation and the state (U.S. Fish and Wildlife Service and U.S. Census Bureau 2011, unpublished VDGIF data), reducing costs may become a serious concern for management agencies. For VDGIF, reducing the number of trout stocked could help reduce overall program expenses, given the high cost of raising a catchable-sized trout (in Virginia, estimated at $2.00 per trout, VDGIF 2015). The idea of stocking fewer fish without negatively affecting catch rates is counter-intuitive and may not be well received by anglers, but stocking fewer fish in current waters would allow VDGIF to either grow fewer but larger fish and/or expand the program by stocking the excess of trout on other suitable waters. If VDGIF pursues this strategy of decreasing stocking rates, it should do so on a limited basis at first and monitor the results to document effects.

Despite the high angler effort and catch rate on the day of stocking and the days immediately following stocking events, average catch rates subsequently remained at or near 1 trout/angler-hr, a typical managerial goal for trout fisheries (New Jersey Division of Fish and Wildlife 2005, Tennessee Wildlife Resource Agency 2006), for up to a month after stocking events. The high effort and catch on stocking day and days immediately following parallels that of other fisheries (Sztramko 1991, Greene et al. 2006, Baer et al. 2007). Many studies (Sztramko 1991, Greene et al. 2006, Baer and Brinker 2008) have looked at effort and catch on the day of stocking or opening day and the days following, but none have followed individual cohorts as comprehensively as we did. Our results show that catch rates remain consistent for up to a month after any given stocking event.

Fishery managers generally view put-and-take trout fisheries primarily as harvest-oriented programs and consequently tend to focus on maintaining high catch rates following stocking events. In contrast to the prevalence of catch-and-release fishing in wild trout fisheries,

managers of catchable-stocked-trout fisheries expect anglers to keep nearly all of the fish they catch. Our results suggest that Virginia stocked-trout anglers harvest fewer fish than previously thought (S. Reeser, VDGIF, personal communication), releasing 33% of their catch. For a stocked-trout fishery, this is a relatively unexpected release rate may contribute to the longevity of each cohort of stocked trout. If VDGIF effectively communicated information about persistence of cohorts of stocked trout, and resulting stability of catch rates up to 30 days post-stocking, it may alleviate some of Virginia's stocked-trout anglers' fears about declining catch rates days and weeks after stocking.

The longevity of catch rates following stocking events could be a result of saturating the system with frequent, high-density stockings. During spring, VDGIF frequently stocks more than once a month on any given water. Our results suggest that VDGIF could experiment with decreasing not only its rate of stocking, but also its frequency of stocking. Reducing both the rate and frequency would lower rearing costs by reducing the total fish produced and stocked. Decreasing the frequency of stockings could help alleviate associated costs (e.g., fuel and maintenance for hatchery trucks, personnel costs associated with delivering fish).

Anglers fishing on lakes expended significantly more effort on a daily basis, but caught fish at a slower rate than anglers fishing on streams. The higher effort on the lakes may be due to easier angler access and close proximity to city centers. The lower catch rate on lakes however, could be due to many factors. Surface temperatures in many of the lakes in our study reached temperatures above the preferred range of trout (10˚C - 24˚C, Gall and Crandell 1992), primarily from late spring to early fall. Warmer water negatively affects catch rates (McMichael and Kaya 1991), and post-stocking mortality rates increase with temperature in such systems (Luisi and Bettoli 2001). During the winter months, many stocked lakes completely or partially freeze over.

Although trout can survive in such systems given adequate oxygen levels, the ice hinders anglers' ability to catch fish efficiently. On many of the stocked lakes in Virginia, anglers fish from the shore or short piers. Trout stocked in lakes could simply reside in areas unreachable to shore-bound anglers. For more discussion on angler type and preferences, please see Chapter 3.

Anglers in this fishery had contrasting preferences regarding announcements of stocking events. Despite the delayed announcement, effort was still high on stocking day, as some anglers follow the hatchery trucks and disseminate this information to their friends and families before official announcements occur. To dilute effort and possibly increase residence time of the stocked trout, VDGIF could further delay their announcement, or leave the stocking events completely unannounced, which 15% of our sample preferred. Many of the interviewed anglers, however, preferred advanced announcements similar to Texas and Pennsylvania stocked-trout programs (Pennsylvania Fish and Boat Commission 2015, Texas Parks and Wildlife 2015). Many anglers desire advanced announcements for more equitable knowledge about stocking events and access to the trout. Advanced announcements would enable anglers (and their families) to plan vacations specifically for stocked-trout fishing, but advanced announcements could also cause crowding on waters. With such a divide amongst the anglers, VDGIF should attempt to vary the timing of their announcements of stocking events. Experimenting with a diverse announcement schedule could allow for anglers who desire to plan a fishing trip the capability of doing so with advanced announcements, while simultaneously providing an opportunity for anglers who wish to avoid large crowds with unannounced events.

Angler effort peaked in March, April, and May, when the weather warmed and when anglers did not have to balance their outdoor recreation with fall hunting seasons. The increased spring effort parallels findings in Tennessee waters (Luisi and Bettoli 2001). If production at

VDGIF hatcheries was not able to meet overall demand for stocked trout, VDGIF could allocate more fish to spring stockings during times of high angler effort. Although effort peaks in the spring, effort in the fall and winter is worthy of attention as many anglers prefer to fish during the lesser-crowded seasons.

In Virginia, managers frequently hear complaints from unsatisfied stocked-trout anglers about low catch rates (S. Reeser, VDGIF, personal communication). We tested the assumption that catch rate influences anglers' reported level of daily satisfaction and found a positive correlation on both lakes and streams. These results parallel those in other studies (McMichael and Kaya 1991, Patterson and Sullivan 2013, McCormick and Porter 2014), which found positive correlations between angler catch rate and satisfaction. Other studies (Patterson and Sullivan 2013, McCormick and Porter 2014) found that as catch rate increases, its importance in determining angler satisfaction decreases, which is consistent with the lesser effect of catch rate on angler satisfaction on Virginia trout streams than on stocked-trout lakes. McCormick and Porter (2014) found that mean length of catch and age of the angler also contributed to variation in satisfaction. Only 13% of Virginia stocked-trout anglers reported being dissatisfied with their fishing experience that day. Studies should further explore why this group of anglers, as a whole, is highly satisfied (e.g., have dissatisfied anglers quit fishing for stocked trout?). Chapter 4 of this thesis explores what influences angler satisfaction on a daily and annual scale. Such studies could help enable VDGIF maintain such a quality program and possibly help improve their efficiency.

Despite frequent complaints about the program to VDGIF, active-stocked-trout anglers in Virginia are highly satisfied. Currently, VDGIF uses catch rate as a surrogate to angler satisfaction; VDGIF has a goal of providing anglers with a catch rate of one trout/angler-hr. Our

results suggest that although catch rate significantly influences angler satisfaction, perhaps anglers could be satisfied at lesser expense to VDGIF. Our results suggest they could significantly reduce stocking numbers without the fear of losing anglers due to low catch rates. If VDGIF wants to expand their program or satisfy even more anglers, they could experiment with altering the timing of their announcement of stocking events.

Table 2-1. Physical characteristics and stocking data for 14 stocked-trout waters in Virginia that were surveyed from October 2013 – May 2014 or October 2014 – May 2015.

Site	Type of Water	Size[a]	No. of Stockings	No. trout stocked[b]	Year Sampled
Big Stoney Creek	Stream	12.1	8	13,495	2013 – 2014
Dorey Park	Lake	2.0	5	3,485	2014 – 2015
Frying Pan Creek	Stream	8.0	3	4,095	2013 – 2014
Liberty Lake	Lake	0.7	8	2,359	2014 – 2015
Lincolnshire Lake	Lake	8.5	8	5,988	2013 – 2014
Locust Shade	Lake	3.2	5	7,424	2014 – 2015
Lake Thompson	Lake	4.0	8	5,028	2014 – 2015
Mill Creek	Stream	1.6	8	3,479	2014 – 2015
North Creek	Stream	4.0	5	4,352	2014 – 2015
Pandapas Pond	Lake	3.2	8	4,540	2013 – 2014
Rose River	Stream	4.7	8	6,585	2014 – 2015
Stock Creek	Stream	3.5	5	2,895	2014 – 2015
South Fork of Powell	Stream	3.8	8	6,257	2014 – 2015
Whitetop Laurel Creek	Stream	9.0	8	12,197	2013 – 2014

[a] kilometers reported for streams and hectares reported for lakes; [b] total for all stocked species: Brown Trout, Brook Trout, and Rainbow Trout

Table 2-2. Effects of site, strata (sampling interval following stocking events), and month on catch rate and angler effort as indicated by a GLM.

	df	X^2	P
Catch Rate			
Site	14	109.1	<0.0001
Strata	5	35.0	<0.0001
Month	7	14.9	0.0378
Effort			
Site	14	6.1	<0.0001
Strata	5	80.2	<0.0001
Month	7	5.9	<0.0001

Table 2-3. Average catch rate (fish/angler-hr) and average angler effort per waterbody type. Within a given row, means with the same lowercase letters are not significantly different at P-value < 0.05 as indicated by Tukey's test for multiple comparisons.

	Waterbody Type	
	Lake	Stream
Average Catch Rate (fish/angler-hr)	0.74 y	1.31 z
Standard Deviation of Catch Rate	0.78	1.26
Average Effort (angler-hrs per day)	87.0 z	55.7 y
Standard Deviation of Effort	95.9	76.0

Table 2-4. Percent of respondents that reported various levels of satisfaction with today's fishing, where 1 = very dissatisfied, 4 = neutral, and 7 = very satisfied.

	Level of Satisfaction						
Question	1	2	3	4	5	6	7
How satisfied are you with today's fishing experience?	5.4%	3.6%	4.5%	9.8%	14.9%	15.2%	46.7%

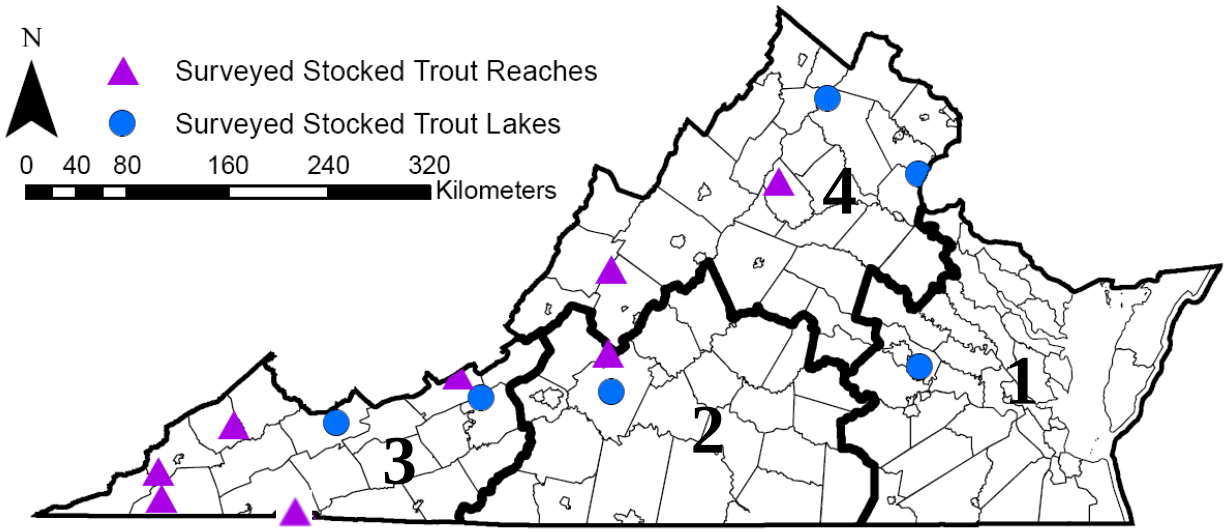

Figure 2-1. Locations of Virginia Department of Game and Inland Fisheries stocked waters that we studied from 2013 to 2015. The gray lines indicate county lines and the dark black lines denote management regions.

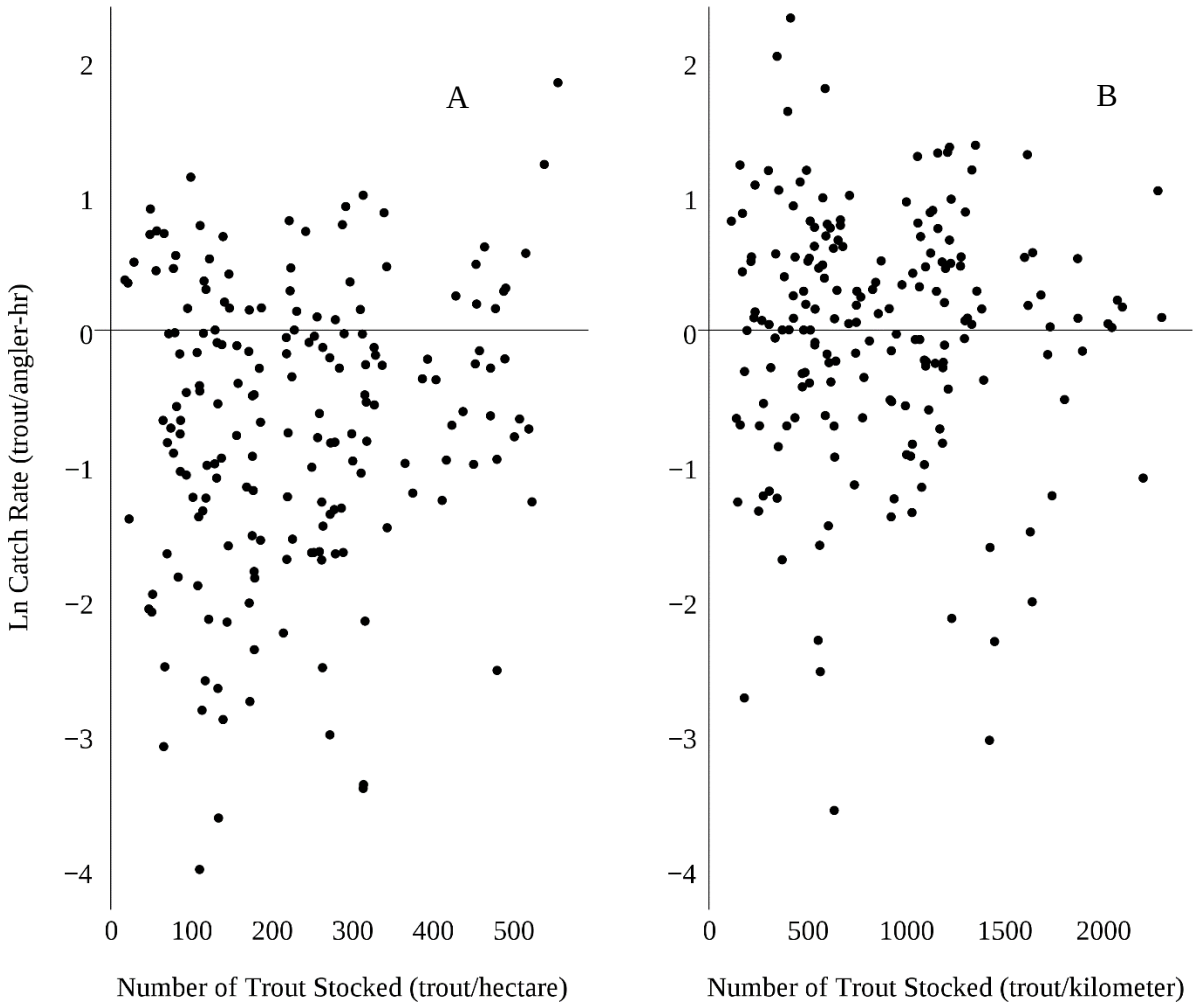

Figure 2-2. Relationships of number of trout stocked minus the previous catch and ln-transformed catch rate on lakes (A) and streams (B). The regression of trout stocked versus ln-catch rate was not significant for either waterbody type (A, $R^2 = 0.02$, P-value = 0.06, Y = 0.001*X – 0.96, B, $R^2 = 0.0004$, P-value = 0.77, Y = -0.00004* X + 0.01).

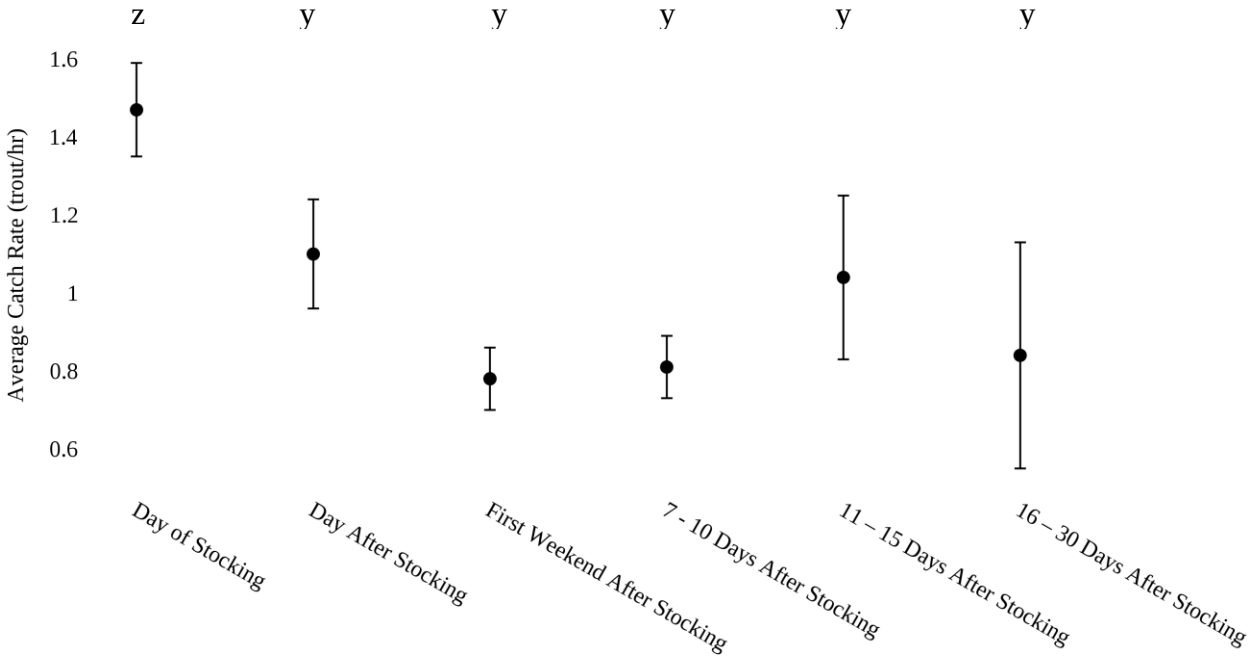

Figure 2-3. Average catch rate (trout/hr) with standard error bars per sampling time interval following a stocking. Averages with the same lowercase letters are not significantly different at P-value < 0.05 as indicated by Tukey's test for multiple comparisons.

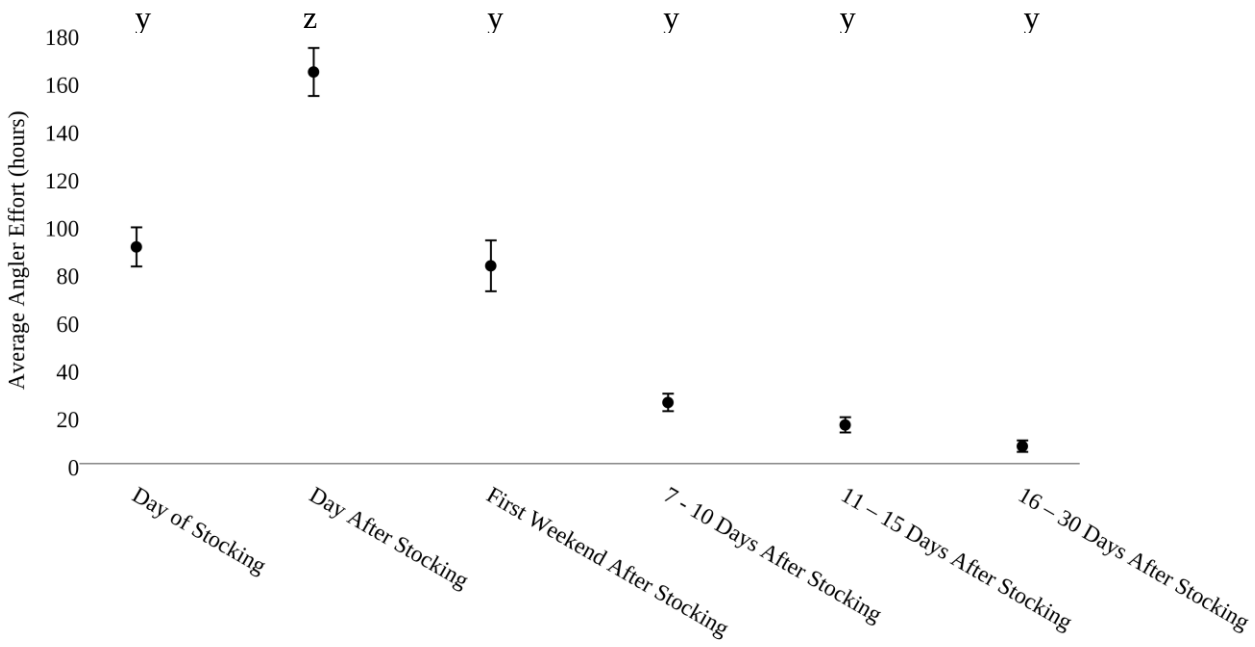

Figure 2-4. Average angler effort (hours) with standard error per sampling time interval following a stocking. Averages with the same lowercase letters are not significantly different at P-value < 0.05 as indicated by Tukey's test for multiple comparisons.

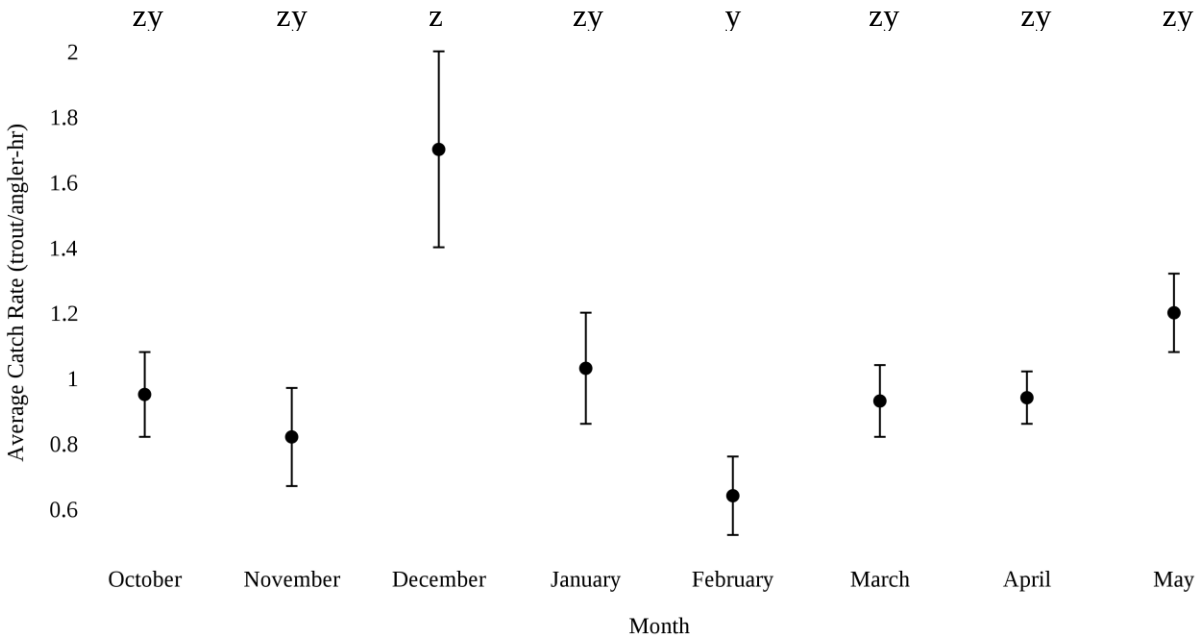

Figure 2-5. Average catch rate (trout/angler-hr) with standard error per month. Averages with the same lowercase letters are not significantly different at P-value < 0.05 as indicated by Tukey's test for multiple comparisons.

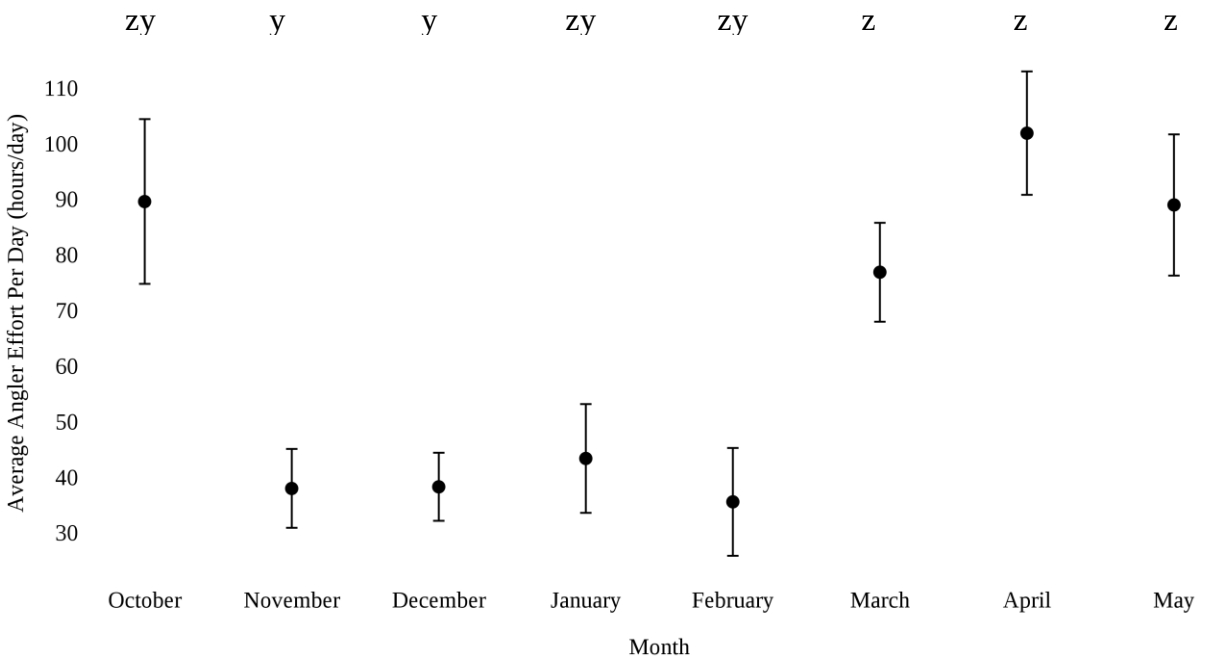

Figure 2-6. Average angler effort per day (hrs/day) with standard error per month. Averages with the same lowercase letters are not significantly different at P-value < 0.05 as indicated by Tukey's test for multiple comparisons.

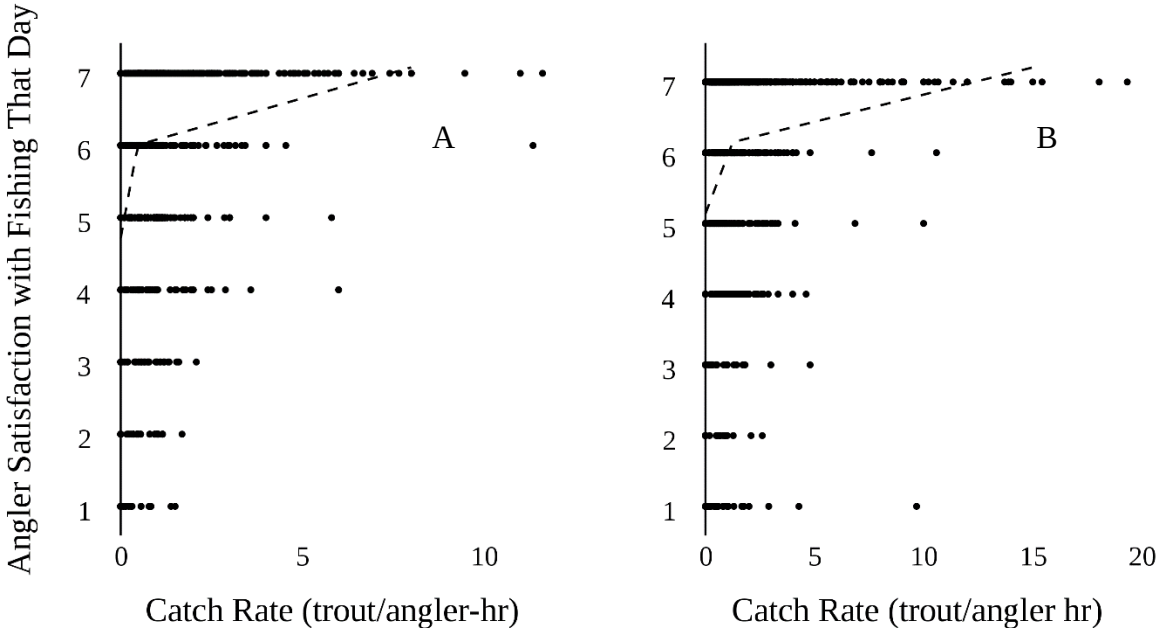

Figure 2-7. Relationship of catch rate (trout/angler-hr) and angler satisfaction with their fishing experience that day, where 1 = very dissatisfied, 4 = neutral, and 7 = very satisfied for lakes (A) and streams (B). The piecewise regression of catch rate versus angler satisfaction was significant for lakes ($X < 0.46$, $R^2 = 0.0236$, P-value <0.0001 , $Y = 2.78*X + 4.72$, $X \geq 0.46$, $R^2 = 0.0285$, P-value <0.0001, $Y = 0.14*X + 5.94$) and streams ($X < 1.21$, $R^2 = 0.0362$, P-value <0.0001 , $Y = 0.84*X + 5.14$, $X \geq 1.21$, $R^2 = 0.0250$, P-value <0.0001, $Y = 0.08*X + 6.06$).

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Chapter 3: Characterization and Management Preferences of Stocked-Trout Anglers

Abstract

Despite the popularity of stocked-trout fishing, few studies have attempted to describe stocked-trout anglers. To assist Virginia Department of Game and Inland Fisheries in understanding who actively fishes for stocked trout, we interviewed 3,367 anglers during their fishing trips on 17 stocked-trout waters across Virginia, U.S.A. We asked anglers questions relating to their demographics, motivations, fishing and management preferences, level of specialization, and level of satisfaction. Using a hierarchical clustering method with eight specialization questions, we identified four unique clusters of anglers: specialists, avid anglers, consumptive-experienced anglers, and casual anglers. The clusters differed in their motivations for fishing, fishing and management preferences, and level of satisfaction. Proportions of each cluster varied across fishery types and management regions. Results from this study depict how stocked-trout anglers differ from wild trout anglers. Results will help Virginia Department of Game and Inland Fisheries adjust management strategies for the various angler groups and regional preferences.

Introduction

Virginia has a long history of stocking trout. Various agencies have stocked trout in Virginia since the early 1920s. Today, Virginia Department of Game and Inland Fisheries (VDGIF) stocks the majority of the trout in the state, stocking over 1 million catchable-sized trout (≥7 inches) across 180 waters (VDGIF 2015). Approximately 80% of the trout angling effort in Virginia focuses on stocked-trout waters (O'Neill 2001).

Funding for the catchable-stocked-trout program derives from license sales. Anglers seeking stocked trout in Virginia must buy, in addition to a regular freshwater fishing license, a

special license for fishing on stocked-trout waters. Trout fishing and license sales however have declined nationally and in Virginia within the past two decades. On a national scale, trout fishing declined 20% from 1996 to 2011 (U.S. Fish and Wildlife Service and U.S. Census Bureau 2011). In Virginia, sales of annual trout licenses have decreased approximately 45% from 2006 to 2013, a much faster rate than the overall reduction of other fishing licenses sold in the state (unpublished VDGIF data). Fish and wildlife agencies throughout the United States recognize the need to recruit and retain anglers to offset the declining trend in participation. To do so in Virginia however, VDGIF first needs to understand who actively fishes for stocked trout, why they fish for stocked trout, and their management preferences.

The concept of recreational specialization provides a framework to understand heterogeneity in recreationists' behaviors. Bryan (1977) first described recreational specialization as "…a continuum of behavior from the general to the specialized," with regard to "…equipment, skills used, and preference for a specific recreational setting." Bryan (1977) concluded that recreationists may be clustered into groups sharing specific attitudes, values, behaviors, and preferences. Many studies (Chipman and Helfrich 1988, Kim et al. 1997, Salz and Loomis 2005, Hutt and Bettoli 2007, Beardmore et al. 2013) have since tested and refined the concept of specialization in hopes of better understanding angler behavior. Other studies have explored angler diversity in the context of motivations for fishing (Fedler and Ditton 1994, Anderson et al. 2007, Beardmore et al. 2011), management preferences (Ditton et al. 1992, Oh and Ditton 2006), and various levels of satisfaction (Holland and Ditton 1992, McCormick and Porter 2014).

Due to the declining license sales and substantial financial reliance the program has on those sales, VDGIF wishes to better understand active anglers seeking stocked trout and how

they utilize the program. The study of active stocked-trout anglers reported here was part of a larger effort, which included two mail surveys, to evaluate and develop a management plan for VDGIF's catchable-stocked-trout program. For this portion of the evaluation, we used on-site surveys to determine angler use on selected stocked-trout waters and to characterize active stocked-trout anglers. Despite heavy reliance on stocked trout to provide coldwater-angling opportunities, particularly in the Eastern U.S., no study has explored specialization, motivations, and preferences of stocked-trout anglers specifically. Evaluation of Virginia's heavily used, statewide program provides an excellent opportunity to fill this knowledge gap by conducting a focused study on anglers who actively utilize the catchable-stocked-trout program. This study sought to 1) identify, if any, unique clusters of stocked-trout anglers and 2) explore differences in anglers' attitudes, motivations, and preferences across unique clusters, fishery types, and management regions. Results from this study will increase understanding of a heretofore lightly studied group of anglers and help policymakers make more informed decisions regarding the future of the catchable-stocked-trout program in Virginia.

Methods

Study Sites and Data Collection

We sampled anglers as they fished on 17 waters throughout Virginia, U.S.A (Figure 3-1). We sampled waters from October 2013 – May 2014 and October 2014 – May 2015 in all four of the state's management regions (Figure 3-1), which included the full range of fisheries of catchable-stocked trout in Virginia (i.e., put-and-take, delayed harvest, and urban trout fisheries) (Table 3-1). On put-and-take waters, the most abundant type of stocked-trout fishery in Virginia, anglers may catch up to six trout greater than seven inches long per day regardless of species and season. The agency stocks put-and-take waters three to eight times per year depending primarily

upon water quality and angler access. Delayed-harvest waters are designated areas, where only catch-and-release fishing with artificial lures is allowed from October 1 to June 15 each year, but anglers may harvest fish for the remainder of the year. Each delayed-harvest water receives three stockings per season by VDGIF. The agency stocks urban waters, fisheries in or near urban areas, five times from November 1 to April 30 and restricts harvest to four trout per day. Virginia Department of Game and Inland Fisheries stocks combinations of Rainbow Trout *Oncorhynchus mykiss*, Brown Trout *Salmo trutta*, and/or Brook Trout *Salvelinus fontinalis*.

We conducted roving creel surveys from October 2013 – May 2014 and October 2014 – May 2015 (Malvestuto et al. 1978) on at least five days following each individual stocking of sampled waters. The surveys followed a two-stage random stratified sampling design with days as the primary sampling unit. We stratified days into five timeframes following stockings: day of stocking, day after stocking, first weekend after stocking, 7-10 days after stocking, 11-15 days after stocking, and when possible, 16-30 days after stocking (from March through May, VDGIF stocked some waters at less than 30-day intervals). We interviewed anglers from sunrise to sunset on the day of stocking and the day after stocking. We randomly selected one day in each of the remaining timeframes for each stocking. For those days, we randomly designated it as either an AM (sunrise-midday) or PM (midday-sunset) shift with equal probability.

We interviewed anglers 18 years old and older as they fished (or upon completion of fishing). We asked anglers about their catch and harvest that day and about their effort (i.e., time spent fishing). We inspected creels for number and species of trout harvested. We asked anglers questions designed to cluster anglers into groups based upon their level of specialization similar to dimensions used by Chipman and Helfrich (1988): centrality to lifestyle, experience, investment, and resource use (Table 3-2). We asked anglers about their social involvement (i.e.,

membership in fishing-related clubs, subscription to fishing-related magazines, and fishing-related vacations in the past 12 months) on a yes/no scale and their experience and avidity (i.e., days fished for stocked trout in the last 12 months and years fished for stocked trout) on a continuous scale. We also asked anglers about their investment (i.e., distance traveled to fish that day) on a continuous scale and resource use (i.e., catching fish for food and equipment preference) on yes/no and categorical scales. We chose to treat the question of catching fish for food as a specialization variable rather than a motivation because 1) of VDGIF's inquiries (S. Reeser, VDGIF, personal communication), 2) consumptive-orientation can have direct implications on management preferences (Kyle et al. 2007), and 3) multiple studies (Chipman and Helfrich 1988, Fisher 1997, Arlinghaus 2006, Ward et al. 2013) included harvest-orientation variables in cluster analysis to help describe differences between angler groups.

Beyond questions relating to specialization, on a 7-point Likert scale (i.e., 1 = strongly disagree to 7 = strongly agree), we asked anglers about their catch-related attitudes: the importance of catching something, catching many fish, and catching big fish. On the same scale, we asked anglers their level of agreement with management regulations (e.g., length of season) and stocking options (e.g., frequency of stockings). We also asked anglers about their level satisfaction with their fishing experience that day and with the program in the last 12 months on a 7-point scale (i.e., 1 = very dissatisfied to 7 = very satisfied). We asked anglers to rank their top three motivations for fishing that day and about their general demographics (e.g., employment status, gender) (Appendix A). We interviewed at least one angler per group. If we had previously interviewed an angler, we only collected creel data for that day: catch, harvest, and time spent fishing that day.

Data Analysis

We used specialization as a framework to understand heterogeneity in angler behavior. We assessed specialization of anglers who fish for stocked trout by calculating z-scores to standardized responses (O'Neill 2001) to eight questions previously correlated with specialization (Bryan 1977, Chipman and Helfrich 1988, Ward et al. 2013). Specialization studies (Chipman and Helfrich 1988, Hutt and Bettoli 2007, Beardmore et al. 2013) frequently sum multiple questions into broader dimensions (e.g., club participation and magazine subscriptions into centrality or affective systems), standardize the summed scores, and then cluster anglers based upon the broader dimensions. Other studies (Connelly et al. 2001, Ward et al. 2013, McCormick and Porter 2014) use few questions or a single question (e.g., equipment preference in McCormick and Porter 2014) as surrogates for intensive specialization questions. To our knowledge, no previous study has focused on specialization of stocked-trout anglers; consequently, we did not use surrogates. Instead, we attempted to collapse several survey questions (Table 3-2) into four specialization dimensions as described in Chipman and Helfrich (1988). However, we chose not to collapse individual questions into the four specialization dimensions due to low item reliability as indicated by low Cronbach alpha values (Vaske 2008).

We used multivariate techniques to assign individual anglers to clusters based upon standardized scores of all eight questions. We standardized scores by calculating their z-score:

$$z = \frac{x - \mu}{\sigma}$$

We used Ward's method with Euclidean distances to cluster the anglers into groups (hclust package in R version 3.0.3). We determined the optimal number of clusters to identify by comparing the Ball-Hall Index, normalized gamma coefficient, and average silhouette width (clusterCrit package in R version 3.0.3). The optimal solution(s) for the number of clusters was identified by the Ball-Hall index by maximum decrease in slope, while the optimal solution for

the normalized gamma coefficient and average silhouette width is the number of clusters with the maximum value.

We also compared anglers' demographics, catch and harvest rates (trout/angler-hr), attitudes relating to fishing and catch preferences, and levels of satisfaction among the clusters using analysis of variance (ANOVA) with Tukey's test for multiple comparisons. We then compared the motivations and management preferences among the clusters of anglers using Pearson's chi-square test. With the goal of identifying differences that could help describe the use of the fishery and ultimate support or opposition to changes in regulations and management strategies, we relaxed our alpha to $\alpha = 0.10$. We calculated the adjusted residual to explore the relationships between angler types and their motivations that contributed to a statistically significant result. We calculated the adjusted residual so we could interpret them as z-scores. Adjusted residuals (a.k.a., standardized Pearson residual) larger than 1.96 indicates that the number of observations in a cell is significantly larger than expected, while residuals less than -1.96 signifies the number of observations in a cell is significantly less than expected (Agresti and Kateri 2011, Sorice et al. 2014). We also compared angler characteristics and the distribution of the clusters across three management regions and types of fisheries using ANOVAs and Pearson's chi-square tests, depending upon the dependent variable. We only used three management regions because we surveyed only one waterbody in Region 1 (Figure 3-1). We performed all ANOVA and Pearson's chi-square tests using JMP Pro 11.

Results

Of 6,223 anglers, 157 declined the survey and 2,699 were repeat anglers. Thus, we used the remaining 3,367 surveys from the 17 waters in this analysis. Respondents to the survey ranged from 18 to 91 years old, with an average age of 48. Men comprised 92% of the anglers

interviewed and most were either employed (55%) or retired (27%). The remainder of the interviewees were either students (6%), unemployed (4%), disabled (3%), homemakers (1%), or declined to respond (1%). On average, anglers had over 25 ± 18 (mean ± SD) years of experience fishing for stocked trout and fished approximately 26 ± 38 (mean ± SD) days per year for stocked trout. Anglers traveled, on average, 24 ± 41 (mean ± SD) miles one way per fishing trip. Over 36% of the anglers fished with bait exclusively (e.g., power bait, corn, worms), 21% fished with artificial lures exclusively, 11% fished with artificial flies exclusively, and 32% fished with a combination of the three methods. Anglers caught an average of 1.4 ± 2.5 (mean ± SD) trout per angler-hr, and 67% of the anglers who caught something harvested at least one fish per trip. The fact that 33% of anglers released all of the trout they caught was greater than expected given that, in contrast to the prevalence of catch-and-release fishing in wild trout fisheries, managers of catchable-stocked-trout fisheries generally expect anglers to keep nearly all of the fish they catch (VDGIF personal communication). When asked to choose three out of seven motivation choices, anglers most commonly responded with 'to relax and/or be outside' (47%), 'I know it was stocked recently' (37%), and/or 'to catch fish for food' (35%). Angler satisfaction averaged 5.7 ± 1.7 (mean ± SD) on a 7-point scale for their experience fishing that day, implying that overall stocked-trout anglers are generally satisfied with their fishing experiences.

Specialization Clusters

The Ball-Hall Index, normalized gamma coefficient, and average silhouette width suggested that four clusters minimized within cluster variance and, hence, we identified four clusters of anglers (Table 3-2). Angler group 1 (12.5% of all anglers), specialists, most frequently used artificial flies. All specialists participated in fishing-related clubs and 70% subscribed to fishing-related magazines. Angler group 2 (44.9% of all anglers), avid anglers,

fished for stocked trout most frequently (38 days/year), had a high level of experience fishing for stocked trout (27 years), and 55% had taken a fishing-related vacation in the last 12 months, more than other angler groups. Every member of angler group 3 (17.8% of all anglers), consumptive-experienced anglers, agreed that they fished for food, typically fishing with bait. Consumptive-experienced anglers had the most years of experience fishing for stocked trout (28 years) and none of the 600 anglers in this group belonged to fishing organizations, subscribed to fishing-related magazines, or took a fishing-related vacation in the last 12 months (Table 3-2). Angler group 4 (24.8% of all anglers), casual anglers, rarely fished for food, and fished less frequently (14 days/year) than all other angler groups (lowest level of avidity). Casual anglers were least experienced (21 years) and fished with bait most commonly (Table 3-2).

We compared angler attitudes (Table 3-3), demographics, levels of satisfaction, catch and harvest rates (Table 3-4), and motivations across the four angler clusters (Table 3-5). Specialists showed less concern than other angler groups with catching their daily limit of trout and 18% of specialists thought VDGIF should decrease the daily harvest limit (Table 3-6). Specialists traveled farther than other angler groups to fish and they were more likely than expected to fish to catch-and-release fish (Table 3-5). Specialists practiced catch-and-release fishing more often than other angler groups (X^2= 87.39, df = 3, P-value < 0.0001), but they also had the slowest catch rate of any group (Table 3-4 and Table 3-5).

Forty-five percent of avid anglers fished because they knew the water was stocked recently (Table 3-5). Although this suggests that they attached great importance to high catch rates, avid anglers tended to provide intermediate responses to all other motivation questions (Table 3-5) and attitude questions (Table 3-3).

Consumptive-experienced anglers were, on average, the oldest angler group (Table 3-4). Consumptive-experienced anglers were most likely to fish for food, were less likely than expected to fish to catch-and-release fish and/or to be with family or friends (Table 3-5). These anglers were most satisfied while catching many fish and their daily limit (Table 3-4) and 22% of consumptive-experienced anglers thought VDGIF should increase the daily harvest limit (Table 3-6). They had higher harvest rates than any other group (Table 3-4).

Casual anglers had the youngest average age (Table 3-4), were most likely to fish because the waterbody was close to home, and were more likely than expected to fish to be with friends or family ($X^2 = 10.32$, df = 3, P-value = 0.016) (Table 3-5). Casual anglers preferred to see more trout stocked, even if they were smaller and were least satisfied out of the four groups if they did not catch any trout during their fishing trip (Table 3-3). Although all groups were highly satisfied with their fishing experience that day and stocked-trout fishing in Virginia in the last 12 months, casual anglers were the least satisfied of all groups for both timeframes (Table 3-4).

Regional Differences

Angler characteristics (Table 3-7) and the proportions of clusters in the three management regions varied significantly ($X^2 = 73.338$, df = 9, P-value < 0.0001, Figure 3-2). Anglers in Region 2 were least likely to fish for food and were the least satisfied with fishing that day and with stocked-trout fishing in the last 12 months (Table 3-7). Region 2 had the largest sample of avid anglers (over 50%) (Figure 3-2). Anglers in Regions 2 and 3 were similar in having the most experience fishing for stocked trout (Table 3-7).

Anglers in Region 3 had the highest catch rates, but were significantly less satisfied than anglers in Region 4 with their fishing experiences that day and with trout fishing in the last 12

months (Table 3-7). Region 3 had the fewest specialist anglers, but had larger proportions of experienced-consumptive anglers and casual anglers than any other region (Figure 3-2).

Slightly less than 50% of anglers in Region 4 fit into the avid angler cluster (Figure 3-2). They traveled the furthest to fish each trip, but had, on average, the lowest catch rates compared to anglers in other regions. Nevertheless, Region 4 anglers expressed greater satisfaction with their fishing experiences than anglers in other regions (Table 3-7).

Differences Among Fishery Types

The proportion of each cluster in fishery types varied significantly ($X^2 = 40.17$, df = 6, P-value < 0.0001). Avid anglers were most numerous in all fishery types (Figure 3-3). Consumptive, experienced anglers represented 1.3% of anglers on delayed harvest waters, but approximately 20% on put-and-take and urban fisheries. Specialists accounted for 9.3% on put-and-take fisheries, but over 30% on both delayed-harvest waters and urban waters (Figure 3-3).

Anglers on delayed harvest waters fished most frequently in the last 12 months for stocked trout (38 days) despite having the lowest catch rates (0.94 trout/angler-hr). Anglers on delayed harvest waters traveled the furthest to fish that day (41.2 miles), and not surprisingly, were the least consumptive (Table 3-7).

Anglers on urban waters had several distinct differences. Anglers on urban waters had fished the least for stocked trout in the last 12 months (25 days) and had the least amount of experience fishing for stocked trout (12 years). Despite their inexperience, anglers fishing on urban waters had the highest catch rate (1.91 trout/angler-hr). Urban anglers were the most consumptive, with a harvest rate of 1.61 trout/angler-hr and were the most satisfied with their fishing experience that day (6.7) and with the program in the last 12 months (6.9) (Table 3-8).

Anglers fishing on put-and-take waters typically fell in the middle between the other two fishery types on most variables. Anglers on put-and-take waters however, did have the most amount of experience fishing for stocked trout (26 years) (Table 3-8).

Discussion

With the high levels of reported satisfaction for fishing that day and for the program in the last 12 months, VDGIF should focus their efforts on maintaining a quality program and recruiting anglers from poorly represented demographics in the current angler population. Despite high levels of satisfaction among current, active anglers seeking stocked trout, trout license sales have declined drastically over the last two decades (VDIGIF unpublished data). Concurrently, the average age of trout anglers has increased on a national level (U.S Fish and Wildlife Service and U.S. Census Bureau 2011). As these trends continue, VDGIF needs to recruit more anglers. Given the demographics of their active anglers in this study, VDGIF has obvious opportunities to expand their clientele base by recruiting women, minorities, and younger anglers.

We found stocked-trout anglers differ from wild-trout anglers. Frequently, stocked-trout anglers and wild-trout anglers have been lumped into a general group of trout anglers. We found stocked-trout anglers harvest a large portion of their catch, in contrast to previous studies of trout anglers as a whole (Bryan 1977, Chipman and Helfrich 1988, Borawa et al. 1993). Although clusters of anglers in this study broadly mimicked those in previous angler-specialization work (Bryan 1977, Chipman and Helfrich 1988, Hutt and Bettoli 2007), we found one primary differences: casual anglers challenged the notion that less specialized anglers are typically more harvest-oriented than other groups.

On a broad scale, stocked-trout anglers parallel basic traits of anglers described in the seminal angler-specialization work of Bryan (1977). Bryan (1977) and numerous other researchers (Chipman and Helfrich 1988, Fisher 1997, Hutt and Bettoli 2007) grouped anglers along a continuum ranging from 'occasional anglers,' who fish infrequently and have limited fishing skills or interest in fishing, to 'advanced specialists,' who immerse themselves into leisure social worlds (Ditton et al. 1992) and will travel further than other anglers to fish (Ward et al. 2013). Among stocked-trout anglers in Virginia, specialists align with the description of the most specialized anglers in Bryan (1977), while casual anglers align with the least specialized anglers. Specialists in this study fished with artificial flies most commonly, invested the most (i.e., traveled the furthest), were trophy-oriented, and immersed themselves most into fishing social worlds (i.e., members of fishing clubs and subscribers to fishing-related magazines) (Ditton et al. 1992), typically indicators of high levels of specialization (Oh et al. 2005, Beardmore et al. 2013). Casual anglers however, most frequently fished to be with friends or family, most commonly used artificial bait, and were most satisfied while catching many trout. Avid anglers aligned with consumptive specialists described in Hutt and Bettoli (2007), who fished frequently and commonly took fishing-related vacations, but who also harvested fish regularly. Although individual groups paralleled those in Bryan (1977), consumptive-experienced anglers did not fit into the progression along the continuum described by Bryan (1977).

Stocked-trout anglers in Virginia also differed on the traditional catch- and harvest-orientation assumptions associated with varying levels of specialization, especially the notion that less specialized anglers typically harvest a higher percentage of their catch. Although casual anglers agreed most with the statement 'I would prefer to see more trout stocked, even if that

means fewer trout per stocking' and agreed least with the statement 'I would rather catch 1 or 2 larger trout than 6 smaller trout,' they also displayed the weakest consumption- and harvest-orientation among the angler groups and rated lowest on the traditional specialization continuum. Casual anglers, who account for nearly 25% of anglers in this study, differed from anglers most concerned with catching many fish in other studies, who had high levels of experience (Kyle et al. 2007). Casual anglers had much in common with anglers described by Anderson et al. (2007), who expressed greater concern with number of fish caught than they did with keeping the fish they caught.

Anglers seeking stocked trout had polarizing desires (i.e., trophy-oriented vs. number-oriented), which creates a challenge for VDGIF to manage the fishery for angler satisfaction. Specialists and avid anglers, the most (socially) invested groups who account for over 57% of anglers in this study, paralleled those found in other studies (Bryan 1977, Chipman and Helfrich 1988) that found highly specialized anglers focused on size of catch. Meeting the desires to catch many fish of casual anglers and the desires to catch large fish of specialists and avid anglers would be challenging for any agency to do on all stocked-trout waters. With such a contrast in desires between large portions of anglers, VDGIF should be cognizant of the numbers orientation of many of their anglers, possibly creating areas of high stocking density with strict harvest regulations to satisfied casual anglers, and possibly stock trophy waters to satisfy specialists and avid anglers. Virginia Department of Game and Inland Fisheries could manage for market segments of anglers and diversifying their program further, and could thereby meet their specific anglers' desires.

Urban anglers reported significantly higher levels of satisfaction than anglers did on other fishery types, perhaps because urban fisheries had significantly higher catch rates despite the

fewer years of fishing experience and lower avidity than anglers on other fishery types. With ever-growing urban populations and declining license sales, many state agencies have begun exploring characteristics of urban anglers and how they differ from rural anglers (Arlinghaus and Mehner 2004, Arlinghaus et al. 2008, Taylor et al. 2008, Wolber 2008, Hutt and Neal 2010). Paralleling our results, Hutt and Neal (2010) described urban-stocked-trout anglers as those who fished because the water was close to home and were concerned with number of bites while fishing. Arlinghaus and Mehner (2004) and Arlinghaus et al. (2008) described urban anglers in Berlin as more avid and committed, but anglers on Virginia's urban waters fished least frequently for stocked trout and had the least amount of experience, suggesting a developing niche of anglers. Currently, the urban-stocked-trout fisheries in Virginia appear successful in the context of angler satisfaction. If VDGIF wished to recruit more anglers by building upon a successful component of their catchable-stocked-trout program, expanding their urban-stocked-trout program to include more waters would be an efficient use of resources given the proximity to high population densities of urban centers and potential help with recruitment of youth and minorities.

Our results suggest that catch-orientation may play a role in daily satisfaction, while catch rates may play a role in long-term satisfaction of anglers. Virginia's stocked-trout anglers, similar to those in several previous studies, expressed high satisfaction with their fishing experiences on the days we interviewed them (Connelly and Brown 2000, Arlinghaus 2006, Hutt and Neal 2010). We found that specialist anglers, who were less concerned with catch, were similar to specialists in Germany who expressed significantly higher satisfaction than other groups of anglers (Arlinghaus 2006). We found that avid anglers and consumptive-experienced anglers however, those with the highest catch rates, reported the highest levels of satisfaction

with stocked-trout fishing in the last 12 months. For more in-depth discussion of angler satisfaction, please see chapter 4.

We found distinct differences in attitudes and proportions of anglers across the three management regions of Virginia. A similar study in British Colombia, Canada (Ward et al. 2013) also found that proportions of angler clusters varied spatially. Most notably, anglers in Region 2 reported significantly lower levels of satisfaction with their fishing experience that day and with the program in the last 12 months compared to anglers in other regions. Region 2 has fewer stocked-trout waters and even fewer waters with quality trout habitat. With limited options for changing or adding stocked-trout waters, VDGIF could focus on improving the fisheries they have (e.g., improve trout habitat by decreasing soil runoff or removing weeds from inundated ponds).

Anglers in each management region in Virginia vary. Virginia Department of Game and Inland Fisheries needs to balance locally specific management with their desire to keep regulations simple. If possible, VDGIF should attempt to manage the program on a finer scale to accommodate regional preferences instead of ubiquitous regulations and management for the entire state (i.e., diversify fishery types in each region). Our results demonstrate the complex social-ecological systems of recreational fisheries and the continued need for integrated management that incorporates and adapts to the dynamic nature of social and ecological components of fisheries (Fenichel et al. 2012, Ward et al. 2013b).

Anglers and their preferences are diverse and by understanding how anglers differ, managers can hopefully satisfy more of their clientele and ensure the longevity of their fisheries. The results from this study can help inform VDGIF how to alter stocking regimes (e.g., stocking many fish in areas with dense populations of number-oriented anglers) and management

regulations (e.g., restricting harvest by implementation of more catch-and-release only waters) to meet the desires of anglers seeking stocked trout better. This study of stocked-trout anglers can help fisheries managers to understand the motivations and drivers of satisfaction of the subgroups of stocked-trout anglers better and presumably, lead to more effective management and possibly increase the longevity of the fishery.

Table 3-1. Physical and management characteristics, including type of water, size, type of fishery, number of stockings annually, and management region, of the 17 stocked-trout fisheries studied in Virginia.

Site	Type of Water	Size[a]	Type of Fishery	No. of Stockings	Management Region
Big Stoney Creek	Stream	12.1	Put-and-take	8	3
Dorey Park	Lake	2.0	Urban	5	1
Frying Pan Creek	Stream	8.0	Put-and-take	3	3
Liberty Lake	Lake	0.7	Put-and-take	8	2
Lincolnshire Lake	Lake	8.5	Put-and-take	8	3
Locust Shade	Lake	3.2	Urban	5	4
Lake Thompson	Lake	4.0	Put-and-take	8	4
McFalls Creek	Stream	2.47	Put-and-take	3	2
Mill Creek	Stream	1.6	Put-and-take	8	2
North Creek	Stream	4.0	Put-and-take	5	2
Pandapas Pond	Lake	3.2	Put-and-take	8	3
Roanoke River	Stream	2.38	Delayed Harvest	3	2
Rose River	Stream	4.7	Put-and-take	8	4
South Fork of Powell	Stream	3.8	Put-and-take	8	3
South River	Stream	1.33	Delayed Harvest	3*	4
Stock Creek	Stream	3.5	Put-and-take	5	3
Whitetop Laurel Creek	Stream	9.0	Put-and-take	8	3

[a] for streams, size given in kilometers, for lakes, size given in hectares; * Receives supplemental stockings of Rainbow Trout from a local Fly Shop.

Table 3-2. Responses to the eight specialization questions of the four angler groups identified by the cluster analysis of the stocked-trout fishery. Within each row, means with the same lowercase letter do not significantly differ at P-value <0.0001 as determined by Tukey's test for multiple comparisons. Please reference footnote for scales.

	Angler groups (%, n)			
Question	Specialist (12.5%, n = 421)	Avid Angler (44.9%, n =1,512)	Consumptive Experienced Angler (17.8%, n = 600)	Casual Angler (24.8%, n = 835)
Are you a member of any fishing-related club or organization?[a]	100% z	3% y	0% x	0% x
Do you subscribe to any fishing-related magazine?[a]	70% z	45% y	0% x	0% x
Have you taken any fishing-related vacations in the past 12 months?[a]	47% y	55% z	0% x	0% x
Fishing is my favorite outdoor recreation.[b]	6.28 z	5.74 y	5.87 y	5.16 x
Of the days you have fished in the last 12 months, how many of those have been for stocked trout?	21.75 y	37.84 z	16.12 y	14.46 y
How many years have you fished for stocked trout?	22.83 y	26.89 z	27.91 z	21.14 y
Are you out fishing to catch fish for food?[a]	31% x	41% y	100% z	4% w
What equipment do you normally use to fish for stocked trout?[c]	34% flies 25% bait z	15% flies 42% bait y	0% flies 58% bait x	0% flies 58% bait x

[a] percent of respondents that replied yes; [b] 7-point scale, where 7 = strongly agree, 4 = neutral, and 1 = strongly disagree; [c] artificial flies = 3, artificial lures = 2, bait = 1.

Table 3-3. Catch-orientation attitudes of the four angler groups. Within each row, means with the same lowercase letter do not significantly differ at P-value <0.05 as determined by Tukey's test for multiple comparisons.

	Angler groups				ANOVA results	
Question	Specialists	Avid Angler	Consumptive Experienced	Casual Angler	df	F-value
Catch-orientation Attitudes[a]						
I would prefer to see more trout stocked even if they were smaller.	3.80 y	3.86 y	4.14 zy	4.39 z	3	7.12
I would prefer to see larger trout even if that means fewer trout.	4.74 zy	4.80 z	4.70 zy	4.45 y	3	2.85
A day of stocked trout fishing can be satisfying even when I do not catch any trout.	6.29 z	6.15 z	5.99 zy	5.79 y	3	8.37
A satisfying day of stocked trout fishing is one in which I catch many trout.	5.60 y	5.85 zy	6.03 z	5.90 zy	3	3.53
I would rather catch 1 or 2 big trout than 6 smaller trout.	5.26 z	4.89 zy	4.75 y	4.58 y	3	5.25
A satisfying trout fishing trip is one in which I reach my daily limit.	4.70 x	5.36 y	5.88 z	5.62 zy	3	22.35

[a]7-point likert scale, where 1 = strongly disagree, 4 = neutral, and 7 = strongly agree; [b] 7-point likert scale, where 1 = very dissatisfied, 4 = neutral, and 7 = very satisfied; [c] rate in trout/angler-hr

Table 3-4. Demographics, catch rates, and harvest rates of the four angler groups. Within each row, means with the same lowercase letter do not significantly differ at P-value <0.05 as determined by Tukey's test for multiple comparisons.

	Angler groups				ANOVA results	
Question	Specialists	Avid Angler	Consumptive Experienced	Casual Angler	df	F-value
Demographics and Satisfaction						
How many miles one-way did you travel to get here today?	40.5 z	24.6 y	20.1 y	18.8 y	3	16.52
What is your age?	47 xy	48 y	51 z	45 x	3	7.05
How satisfied are you with today's fishing experience? [a]	5.82 z	5.75 z	5.69 z	5.38 y	3	6.38
How satisfied are you with stocked trout fishing in Virginia in the last 12 months? [a]	5.93 zy	6.00 z	5.99 z	5.71 y		5.20
Rates[b]						
Catch Rate	1.12	1.49	1.62	1.25	3	2.35
Harvest Rate	0.73 y	0.94 y	1.29 z	0.70 y	3	6.10

[a] 7-point likert scale, where 1 = very dissatisfied, 4 = neutral, and 7 = very satisfied; [b] rate in trout/angler-hr

Table 3-5. Percent of each angler group to respond 'yes' to different motivations for fishing that day. Anglers were allowed to choose their top three motivations, hence, totals exceed 100%.

Motivation	Angler groups				ChiSquare results		
	Specialist	Avid Angler	Consumptive Experienced Angler	Casual Angler	df	X^2	P-value
To be with family or friends	35.3	34.4	29.6↓	40.1↑	3	10.3	0.0160
To catch-and-release fish	30.5↑	20.7	2.5↓	18.5	3	87.4	<0.0001
I know it was stocked recently	37.8	44.9	17.8	24.8	3	6.3	0.0981
To relax	59.0	58.9	56.6	58.1	3	0.6	0.90
It is close to home	22.1	25.0	21.41	28.1	3	6.2	0.1046
To get away from other anglers	4.4	4.9	2.5	4.0	2	5.3	0.1520

↑Adjusted Residual > 1.96; ↑ Adjusted Residual > 1.64, Number of observations in this cell is significantly larger than expected.↓ Adjusted Residual < -1.96; ↓ Adjusted Residual < -1.96, Number of observations in this cell is significantly less than expected.

Table 3-6. Percent of responses of each angler group that agreed that the daily bag limit in Virginia should be larger, kept the same (currently six fish per day), or smaller.

	Angler groups				ChiSquare results		
Preference for Daily Bag Limit	Specialist	Avid Angler	Consumptive Experienced Angler	Casual Angler	df	X^2	P-value
Larger	9.6	15.1	21.8	13.8			
Kept the same	72.1	76.4	73.2	79.2	6	49.5	<0.0001
Smaller	18.3	8.5	5.1	7.0			

Table 3-7. Mean values for angler characteristics and percentages of angler clusters within three management regions. Within a given row, means with the same lowercase letter do not significantly differ from each other as indicated by Tukey's test for multiple comparisons.

	Region			ANOVA results		
Question	2	3	4	df	F-value	P-value
Cluster variable						
Of the days you have fished in the last 12 months, how many of those have been for stocked trout?	29.28 z	24.17 y	28.19 zy	2	3.27	0.0383
How many years have you fished for stocked trout?	26.01 yz	26.27 z	23.70 y	2	3.87	0.0211
Are you out fishing to catch fish for food?[a]	27.0 z	43.8 y	40.9 y	2	13.50	<0.0001
Demographics and Satisfaction						
How far did you travel one-way to get here today?	22.23 y	20.01 y	34.45 z	2	23.59	<0.0001
How satisfied are you with today's fishing experience? [b]	5.07 x	5.58 y	5.99 z	2	28.64	<0.0001
How satisfied are you with stocked trout fishing in Virginia in the last 12 months? [b]	5.45 x	5.74 y	6.41 z	2	62.85	<0.0001
Rates						
Catch Rate (trout/angler-hr)	1.14 y	1.60 z	1.19 y	2	6.11	0.0023
Harvest Rate (trout/angler-hr)	0.80	1.00	0.87	2		0.2463

[a] Percentage of respondents who replied yes [b]7-point scale, where 7 = very satisfied, 4 = neutral, and 1 = very dissatisfied

Table 3-8. Mean values for angler characteristics and percentages of angler clusters within the different fishery types. Within a given row, means with the same lowercase letter do not significantly differ from each other as indicated by Tukey's test for multiple comparisons.

	Fishery type			ANOVA results		
Question	Delayed Harvest	Put-and-take	Urban	df	F-value	P-value
Cluster variable						
Of the days you have fished in the last 12 months, how many of those have been for stocked trout?	37.9 z	27.3 zy	24.9 y	2	8.5	0.0002
How many years have you fished for stocked trout?	21.9 y	26.3 z	11.7 x	2	21.6	<0.0001
Are you out fishing to catch fish for food?[a]	2.5% x	43.1% y	67.2% z	2	63.5	<0.0001
Demographics and Satisfaction						
How far did you travel one-way to get here today?	41.2 z	23.1 y	21.8 y	2	14.0	<0.0001
How satisfied are you with today's fishing experience? [b]	5.8 y	5.6 y	6.7 z	2	14.0	<0.0001
How satisfied are you with stocked trout fishing in Virginia in the last 12 months? [b]	6.1 y	5.8 y	6.9 z	2	16.7	<0.0001
Rates						
Catch Rate (trout/angler-hr)	0.94 y	1.43 zy	1.91 z	2	3.7	0.03
Harvest Rate (trout/angler-hr)	0.36 x	0.96 y	1.61 z	2	9.0	<0.0001

[a] Percentage of anglers that replied yes [b] 7-point scale, where 7 = very satisfied, 4 = neutral, and 1 = very dissatisfied

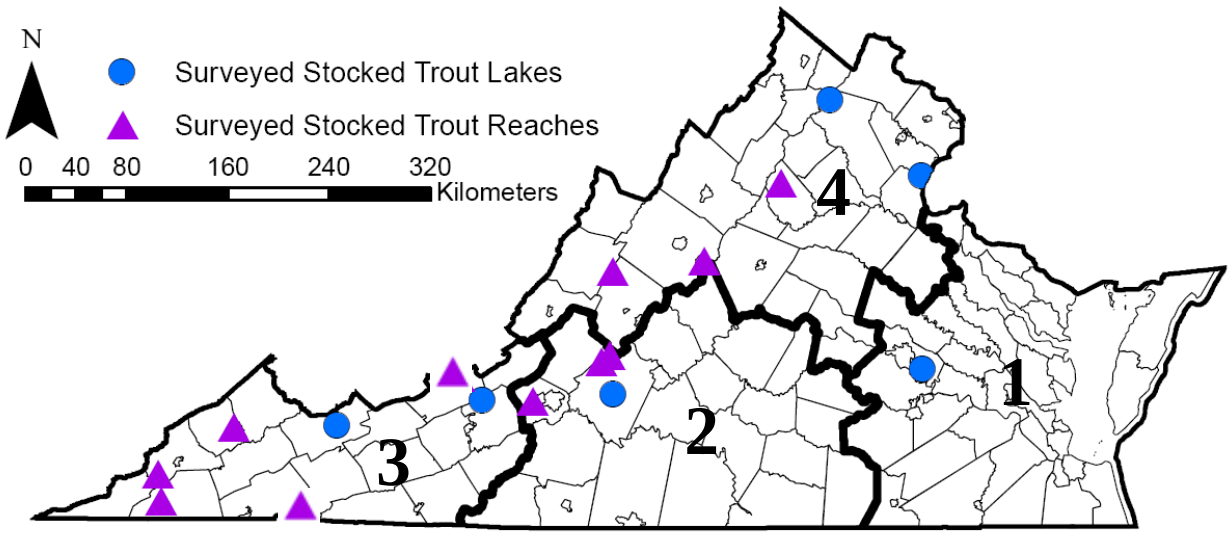

Figure 3-1. Streams and lakes studied during October 2013 – May 2014 and October 2014 – May 2015 that are stocked by Virginia Department of Game and Inland Fisheries.

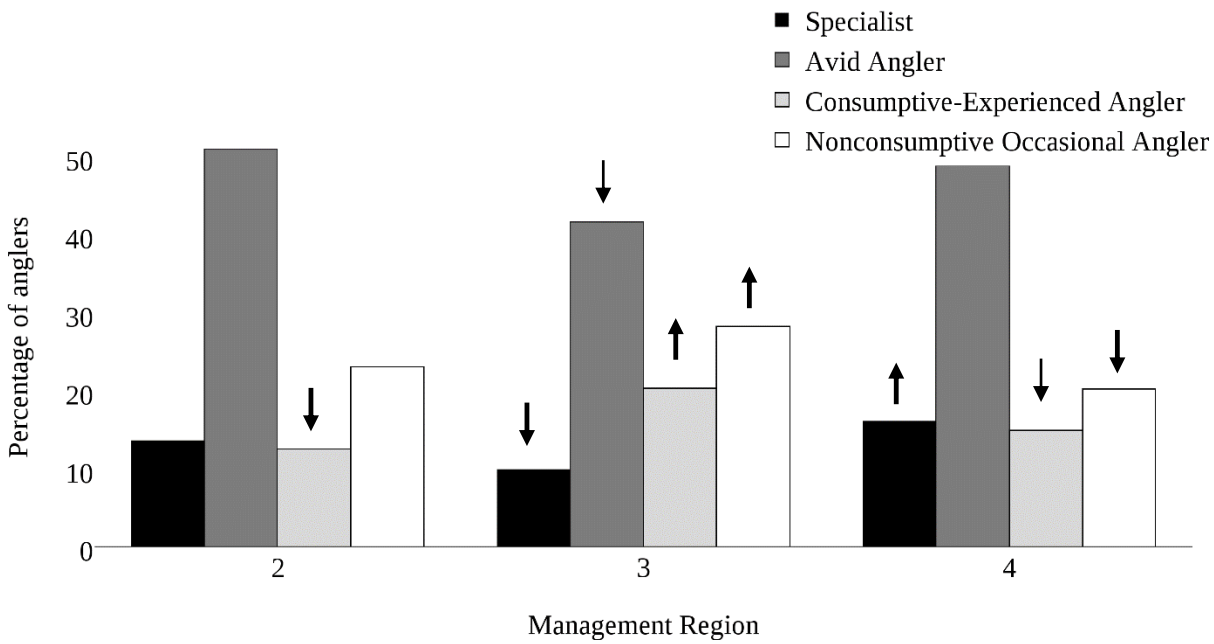

Figure 3-2. Percentage of angler clusters in each management region (X2 = 73.338, df = 9, P-value < 0.0001.

↑↑Adjusted Residual > 1.96;↑ Adjusted Residual > 1.64, Number of observations in this cell is significantly larger than expected.↓↓Adjusted Residual < -1.96; ↓ Adjusted Residual < -1.96, Number of observations in this cell is significantly less than expected.

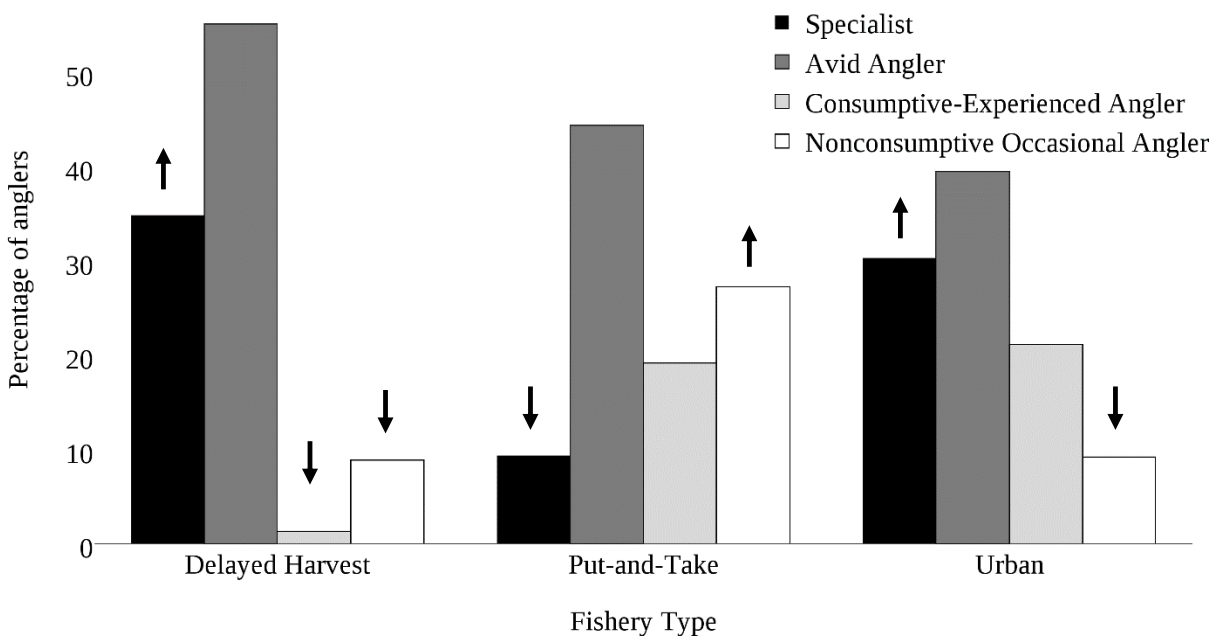

Figure 3-3. Percentage of angler clusters by type of catchable-stocked-trout fishery ($X^2 = 40.17$, df = 6, P-value < 0.0001).

↑Adjusted Residual > 1.96, Number of observations in this cell is significantly larger than expected. ↓Adjusted Residual < -1.96, Number of observations in this cell is significantly less than expected.

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Chapter 4: Effects of Catch and Angler-Specific Variables on Anglers' Daily and Annual Satisfaction

Abstract

To manage a fishery effectively for recreation, agencies need to understand what influences angler satisfaction. We sought to quantify angler satisfaction on a stocked-trout fishery and identify factors affecting angler satisfaction on both a daily and annual scale. We interviewed 3,367 anglers during their fishing trips on 17 stocked-trout waters across Virginia, U.S.A. We asked anglers questions relating to their demographics, motivations, fishing and management preferences, catch and harvest that day, level of specialization, and their level of satisfaction. We used a multinomial logistic regression to determine the effect of catch-related variables and angler-specific variables, such as fishing preferences and motivations for fishing, on angler satisfaction on multiple temporal scales. The probability of an angler reporting high levels of satisfaction on both temporal scales positively correlated with catch rate and negatively correlated with the importance anglers attached to catching something. On a daily scale, anglers on streams tended to have a higher probability of reporting a high level of satisfaction than anglers on lakes. These results can help managers establish quantifiable management objectives that will satisfy preferred percentages of anglers. These results can also help managers focus their efforts on how to recruit and retain anglers.

Introduction

Angler license sales support management of many fisheries and, hence, managers of recreational fisheries frequently emphasize improving and maintaining angler satisfaction, which leads to more license sales or renewals (Pollock et al. 1994, Hunt and Grado 2010). However, the numerous concepts that determine angler satisfaction challenge managers who wish to attain that

goal. Angler satisfaction can vary with catch-related (e.g., catch rate, size of fish caught) and non-catch-related (e.g., weather, fishing companions) aspects of a fishing trip (Spencer 1993, Arlinghaus and Mehner 2005, Hutt and Neal 2010, Patterson and Sullivan 2013, McCormick and Porter 2014). Recent studies (Patterson and Sullivan 2013, McCormick and Porter 2014) found that catch rate positively correlated with angler satisfaction. Non-catch related aspects of fishing, such as cleanliness of the site or number of other anglers, can also influence overall angler satisfaction (Holland and Ditton 1992, Hutt and Neal 2010, Hunt et al. 2012). Although non-catch related aspects of fishing affect angler satisfaction, managers, especially those of stocked fisheries, typically only have influence over catch-related aspects of fishing (Spencer 1993, Weithman 1999). Hence, understanding the correlation between fish populations, specifically abundance of fish, angler success, and angler satisfaction is critical for managers to achieve their management goals (McMullin and Pert 2010, Patterson and Sullivan 2013). The second chapter in this thesis attempts to elucidate such correlations. This chapter attempts to build upon the results of previous chapters

Angler satisfaction varies with each individual angler's motivations for fishing, attitudes toward fishing, and demographics. Anglers who fish to relax have consistently reported higher levels of satisfaction than catch-motivated anglers (Spencer 1993, Hutt and Neal 2010), and anglers frequently state that a fishing trip can be satisfying even if they do not catch any fish (Arlinghaus 2006). Catch-oriented anglers typically report lower levels of satisfaction (Spencer 1993, Arlinghaus 2006) and younger anglers tend toward higher satisfaction than older anglers (McCormick and Porter 2014). If managers wish to improve and maintain angler satisfaction, in addition to successfully retaining and recruiting anglers, they must understand who actively participates in a fishery and their expectations for fishing trips. The second chapter in this thesis

attempts to identify who actively fishes for stocked trout and how anglers vary based upon management region and fishery type.

Studies have shown angler success, i.e., catch rate, affects angler satisfaction (Spencer 1993, Patterson and Sullivan 2013, McCormick and Porter 2014). Given such a correlation, if managers seek to maximize angler satisfaction, they could logically set objectives for fishing success that maximize angler satisfaction. For example, if managers set an objective to satisfy 95% of their anglers, what catch rate do anglers need to attain to meet that objective? McCormick and Porter (2014) reported on the only study that we know of that has quantified the effects fishing success and other basic angler demographics have on the probability of an angler being satisfied. McCormick and Porter (2014), however, focused on one specific reach on a primarily wild-trout stream and did not explore the effects of angler-specific metrics (e.g., motivations, fishing preferences) on angler satisfaction.

If angler satisfaction is the primary goal of a fishery, managers need to understand what influences satisfaction. This study attempts to combine information from the first two chapters of this thesis and build upon McCormick and Porter (2014) by quantifying the probability of an angler being satisfied, both daily and annually, with their stocked-trout fishing experiences, given not only angler success, but also an array of human dimension measures in a stocked-trout fishery in Virginia. Specifically, our objectives were 1) to examine the effects of catch and angler-specific variables on angler satisfaction on a daily and annual scale and 2) to quantify the probability of an angler reporting a high level of satisfaction given varying catch and angler-specific variables. Our results will help managers set objectives for fishing success that maximize angler satisfaction and could help inform angler recruitment and retention efforts by

understanding successful aspects, aspects that positively affect angler satisfaction, of their fishery.

Methods

Sites and Data Collection

We examined angler populations on 17 stocked-trout waters within the four management regions of Virginia, U.S.A (Figure 4-1). We chose waters that exemplify the three primary types of fisheries that exist within the program: put-and-take, delayed harvest, and urban. Virginia Department of Game and Inland Fisheries (VDGIF) stocks each water three to eight times from October through May each year with varying combinations of three species of trout: Rainbow Trout *Oncorhynchus mykiss*, Brown Trout *Salmo trutta*, and Brook Trout *Salvelinus fontinalis*.

We conducted roving creel surveys (Malvestuto et al. 1978) from October 2013 through May 2014 and October 2014 through May 2015. We used a two-stage random stratified sampling design. On put-and-take waters, we stratified our sampling into timeframes based upon stocking events: day of stocking, day after stocking, first weekend after stocking, 7 to 10 days after stocking, 11 to 15 days after stocking, and when possible, 16 to 30 days after stocking. On the day of stocking and the day after stocking, we interviewed anglers the entire day from sunrise to sunset. For the remaining timeframes, we randomly selected one day within the timeframe and assigned it, with equal probability, either as an AM (sunrise to midday) or PM (midday to sunset) shift. For delayed harvest waters, we used a different sampling regime because anglers cannot harvest fish immediately after stocking and we assumed weekday verse weekend would have a greater influence than time after stocking on angler effort. Hence, we stratified sampling days as weekend or weekday. We randomly selected three days in each stratum per month and surveyed

anglers during an AM (sunrise to midday) or PM (midday to sunset) shift. We assigned each day as an AM or PM shift randomly with equal probability.

Creel clerks attempted to interview every willing angler over the age of 18 that they encountered. We asked anglers about their time spent fishing and total number of trout caught and harvested during that day of fishing. Beyond typical creel questions, we inquired about the anglers themselves (Table 4-1). We estimated catch rate for each angler as the ratio of fish caught to the number of hours they fished (Pollock et al. 1994). On a 7-point scale (i.e., 1 = strongly disagree to 7 = strongly agree), we also asked anglers questions pertaining to their catch-related attitudes: the importance of catching something, catching many fish, catching big fish, catching their daily creel limit. We asked anglers to rank their top three motivations for fishing that day. We gave the anglers 8 motivations to choose from, including 1 open-ended option if their top motivations were not listed. On a single 7-point scale, we asked anglers about their level of satisfaction both with their fishing experience that day and with stocked-trout fishing in the last 12 months. We also asked anglers about their general demographic (e.g., gender, employment status). We also asked anglers questions regarding their level of specialization, which encompassed a range of dimensions usually assessed as a part of specialization research (Bryan 1977, Chipman and Helfrich 1988) (Table 4-1). Based upon the questions regarding specialization, we clustered anglers into relatively homogenous specialization groups using Ward's method with Euclidean distances (hclust package in R version 3.0.3), employing the same methods as in Chapter 3.

Data Analysis

We used multinomial logistic regression models (McCormick and Porter 2014) to estimate the probability of an angler reporting a given satisfaction level for that day and a given

satisfaction level with stocked-trout fishing in the last 12 months. For analysis in this chapter, we used non-repeat surveys. We used a stepwise approach to determine the best-fit model using a combination of variables (Table 4-1), including catch rate, level of specialization, fishing preferences, demographics, and site characteristics. We used Akaike's second order information criterion (AICc) to evaluate candidate models and Akaike weight (w_i) to assess the plausibility of each candidate model (McCormick and Porter 2014). The optimal solution for AICc is the model with the respective minimum value. Multinomial logistic regression models express coefficients as natural log odds ratio of a given response type to the reference category. To interpret the log odds on the real number scale, we exponentiated all coefficients. We used angler satisfaction of seven (very satisfied) as the reference category. Anglers reported satisfaction on an ordinal scale, suggesting that ordinal multinomial logistic regression best suits these data. An ordinal multinomial logistic model however, assumes the relationship between each pair of outcomes is proportional (i.e., proportional odds). These data do not meet this assumption of proportional outcomes and hence, we used a multinomial logistic regression and treated angler satisfaction as nominal (McCormick and Porter 2014).

Results

Of 6,223 anglers, 157 declined the survey and 2,699 were repeat anglers. For this analysis, we used 3,367 individual stocked-trout anglers on the 17 waters. Anglers ranged from 18 to 91 years old, averaging 48 years. Anglers traveled, on average, 24 miles one way to fish that day and males represented 93% of the interviewees. . Out of the six motivation choices, anglers most commonly responded with 'to relax and/or be outside' (47%) and 'I know it was stocked recently' (37%). Sixty percent of anglers strongly agreed (i.e., reported a 7 on a scale of 1 to 7) with the statement "A day of stocked-trout fishing can be satisfying even when I do not

catch any trout (NoTrout)" (mean = 6.1 on a scale of 1 to 7). Fifty-seven percent of anglers strongly agreed (i.e., reported a 7 on a scale of 1 to 7) with the statement "A satisfying day of stocked-trout fishing is one in which I catch many trout (ManyTrout)" (mean = 5.9). Anglers, on average, caught fish at a rate of 1.4 trout per angler-hr. Fifty-seven percent of anglers caught something during their fishing trip and of those anglers 67% harvested at least one fish (i.e., 38% of all anglers harvested at least one fish). On a 7-point scale, angler satisfaction averaged 5.6 for their fishing experience that day and 6.0 with stocked-trout fishing during the last 12 months.

We identified four clusters of anglers. Angler group 1, specialists, had the highest level of social investment in fishing and used artificial flies most. Specialists and angler group 2, avid anglers, had the least concern for catching many trout, preferred catching larger trout, and agreed most with the statement that a day of stocked-trout fishing can be satisfying even when they do not catch any trout. Avid anglers took the most fishing-related vacations in the last 12 months and fished most frequently for stocked trout. Angler group 3, consumptive-experienced anglers, fished most commonly for food, typically using bait, and had the most experience with fishing for stocked trout. Consumptive-experienced anglers and angler group 4, casual anglers, were most satisfied when catching many trout. Casual anglers fished for food least and had the lowest levels of avidity, experience, and levels of satisfaction on both time scales.

Multinomal Logistic Regression Models

The most parsimonious model for predicting daily satisfaction included five variables: catch rate, age, NoTrout, specialization, and waterbody (Table 4-2). This model accounted for 89% of the w_i, meaning this model has a 89% chance of being the best model among the candidate models given our data set. The only other model that accounted for any of the w_i also included waterbody type (i.e., stream or lake, Table 4-3). Within the model however, only catch

rate, level of agreement with NoTrout, and waterbody type had a significant effect on daily angler satisfaction (Table 4-4). Anglers on streams had a consistently higher probability of responding with a level of daily satisfaction of seven (highly satisfied) than anglers on lakes (Figure 4-2). The probability of an angler responding with a seven (highly satisfied) positively correlated with catch rate and level of agreement with NoTrout (Figure 4-2). Models that included catch rate had more statistical support than models with the level of agreement with NoTrout, suggesting that catch rate was more important than the level of agreement with NoTrout for predicting daily satisfaction (Table 4-2).

The most parsimonious model for predicting satisfaction with stocked-trout fishing in the last 12 months included four variables: catch rate, age, NoTrout, and specialization (Table 4-5). This model accounted for 67% of the w_i, meaning this model has a 67% chance of being the best model among the candidate models given our data set. Two other models accounted for portions of w_i. Both of the other models included waterbody type (Table 4-5). Within the model however, only catch rate and NoTrout had significant effects on predicting the probability of anglers' satisfaction with stocked-trout fishing in the last 12 months (Table 4-7). Similar to daily satisfaction, the probability of an angler responding with a level of satisfaction of a seven positively correlated with catch rate and level of agreement with NoTrout (Figure 4-3).

Discussion

Overall, anglers actively seeking stocked trout in Virginia reported high levels of satisfaction with their short-term and long-term fishing experiences on stocked-trout waters. Other studies that examined angler satisfaction of stocked-trout fisheries have found similar results (Hutt and Neal 2010, Patterson and Sullivan 2013, McCormick and Porter 2014). These previous studies however, focus on one temporal scale, either daily or annual scales. This study

sets a baseline level of satisfaction with daily satisfaction, while elucidating what affects the probability of long-term satisfaction (and hopefully retention of anglers). For example, if VDGIF began to stock certain waters with larger trout in hopes of appeasing more anglers, they could compare daily satisfaction of anglers after the change to daily satisfaction of anglers in this study prior to the change. Managers can use the baseline data to investigate how changes to stocking or management strategies that could influence daily satisfaction and if they should continue to utilize new strategies.

To attempt to slow, if not reverse, the declining trend of fishing participation across the nation and within Virginia (U.S. Fish and Wildlife Service and U.S. Census Bureau 2011), managers must understand what influences long-term satisfaction with a program. In Virginia's stocked-trout fishery, catch rates, importance of catching something, age, and specialization all contributed to predicting long-term satisfaction. Managers can use results to understand better what influences anglers' long-term satisfaction with the intention of increasing retention and recruitment to the program. For example, our results suggests that over 85% of anglers will rate their satisfaction with that day and their satisfaction with fishing in the last 12 months as highly satisfactory if they catch, on average, one fish per hour. If managers believe this level of angler satisfaction is reasonable, managers should explore ways to reach and maintain anglers' desired catch rates. Our model suggests that anglers who place little to no importance on catching a fish have a significantly higher probability of being satisfied with their fishing experience than anglers that place importance on catching a fish. In the context of recruitment, given results, managers should attempt to promote to the public the experience of a fishing trip beyond catching fish, while reaching out to underrepresented groups (e.g., women, youth).

Our results show an overwhelmingly older, male demographic within the stocked-trout fishery in Virginia, which parallels national trends (U.S. Fish and Wildlife Service and U.S. Census Bureau 2011). The future of the program and sport depends upon recruiting younger and more diverse anglers. These results help inform managers of what satisfies current anglers, i.e., how to retain current anglers. Managers could however take this a step further by surveying lapsed anglers and then developing a similar model for lapsed anglers to determine why they stopped fishing and/or what could motivate and convince them to start fishing again. Managers could also survey underrepresented people and groups (e.g., women, youth) and then create a model that predicts the probability of the underrepresented groups to begin fishing given program changes (e.g., announced stockings, kid's fishing days).

Catch rate and the importance an angler placed on catching something (i.e., an angler's catch orientation) significantly affected the probability of an angler reporting a response of high satisfaction in both the short-term and long-term. Similar to the findings of Arlinghaus (2006), anglers who were less catch-oriented derive their satisfaction from a more diverse set of outcomes during their fishing trips and typically derived more satisfaction from their fishing experiences than anglers who placed more importance on catching something during their fishing trip (Fedler and Ditton 1994, Arlinghaus 2006). Despite varying levels of catch-orientation, rate of catch played the most significant role in reported levels of satisfaction for all anglers on either a daily or a yearly basis. All anglers have one thing in common: they want to catch fish. Angler success consistently correlates with angler satisfaction (Spencer 1993, Patterson and Sullivan 2013, McCormick and Porter 2014).

In our study, age helped to explain varying levels of satisfaction, but did not significantly affect angler satisfaction on either time scale. McCormick and Porter (2014) and Mostegl (2011)

however, found age negatively correlated with satisfaction, where younger anglers became satisfied at lower catch rates than older anglers. McCormick and Porter (2014) posit this finding is caused by changing motivations and expectations with age. McCormick and Porter (2014), however, focused on one specific stretch of stream, which has both native and stocked trout, and may have surveyed too narrow of a niche of anglers for their results to apply ubiquitously to trout fisheries.

Angler specialization contributed to the best-fit models, but did not significantly affect angler satisfaction on either time scale. Similarly, McCormick and Porter (2014) found gear type, their surrogate to specialization, did not influence angler satisfaction. More specialized anglers typically placed less emphasis than occasional anglers on the importance of catching something; hence, specialization of anglers had a similar effect on satisfaction as the level of agreement with the NoTrout statement. Specialized anglers, typically less catch-oriented than occasional anglers, found greater satisfaction in the fishing experience.

Waterbody type significantly affected short-term satisfaction, which may be due to the slower catch rate of trout on lakes than on streams. All three of the stocked species (Rainbow Trout, Brook Trout, and Brown Trout) are native to lotic systems, preferring waters ranging in temperature from 10˚C to 24˚C (Gall and Crandell 1992). Rainbow Trout acclimated to 10˚C, a temperature approximately 5˚C cooler than typical hatchery waters in Virginia, begin to experience partial to total equilibrium loss within minutes after exposure to temperatures at 24˚C and above (Luisi and Bettoli 2001). Lakes sampled during this study reached temperatures near 24˚C in April and exceed 24˚C beginning in May. Warm temperatures typically remained throughout the summer months and in some cases remained near 24˚C in October, the first month of stocking. Trout stocked in Virginia lakes may have sought deeper, cooler waters, out of

the reach of shore-bound anglers or experienced temperature-related stress, either of which could cause a decrease in catch rates in October, April and May, and less-satisfied anglers. Given the warm climate of Virginia and the preferred thermal range of the stocked trout, managers should focus their efforts on attempting to lower the catch-related expectations of anglers on lakes or shorten the stocking season to fewer months, specifically excluding April and May, when the water is cool enough for stocked trout.

Even though anglers consistently reported higher levels of satisfaction on streams, effort was consistently higher on lakes than streams. Higher levels of effort on lakes may have negatively affected the angling experience of non-catch-oriented anglers and therefore decreased their reported levels of satisfaction. Given the high use of lakes, VDGIF could focus their efforts on improving the angling experience on such popular waterbodies (e.g. from comments of anglers, clearing pervasive aquatic vegetation, providing amenities such as restrooms) or promote the benefits of fishing on streams to redistribute angling effort to their more successful waterbodies.

With one exception (McCormick and Porter 2014), previous studies have only investigated angler satisfaction with exploratory multivariate analyses, such as cluster analysis and/or analysis of variance, which can help explain differences among groups or along gradients. For example, catch rate and angler motivation may affect angler satisfaction, but previous methods did not allow for evaluation of both simultaneously. Multinomial logistic regression however, allows managers to predict the probability that an angler will be (highly) satisfied given categorical and/or continuous independent variables at the same time. McCormick and Porter (2014) presented a multinomial logistic model that focused primarily on catch-related aspects of a fishing trip with surrogates to angler specialization and limited angler-specific

components. In this study however, we explored not only angler success, but also a suite of angler and fishery characteristics effects on angler satisfaction on multiple temporal scales. Our results enables managers to set specific catch-related goals that correlate with varying percentages of satisfied anglers and simultaneously adjust stocking and management strategies to best retain and recruit satisfied anglers.

Table 4-1. Surveyed questions that we asked to stocked-trout anglers and then considered for their inclusion in multinomial logistic regressions predicting angler satisfaction.

Variable	Scale
Catch rate	Continuous
Specialization[a]	
Are you a member of any fishing-related club or organization?	Yes/No
Do you subscribe to any fishing-related magazine?	Yes/No
Have you taken any fishing-related vacations in the past 12 months?	Yes/No
Of the days you have fished in the last 12 months, how many of those have been for stocked trout?	Continuous
How many years have you fished for stocked trout?	Continuous
Are you out fishing to catch fish for food?	Yes/No
What equipment do you normally use to fish for stocked trout?	Artificial flies, artificial lures, bait
Fishing is my favorite outdoor recreation.	1 – 7, 1 = strongly disagree, 7 = strongly agree
Motivations[b]	
I know it was stocked recently	Yes/No
To relax	Yes/No
To catch and release fish	Yes/No
To be with friends or family	Yes/No
To get away from other anglers	Yes/No
Close to home	Yes/No
Expectations	
A day of stocked trout fishing can be satisfying even when I do not catch any trout (NoTrout)	1 – 7, 1 = strongly disagree, 7 = strongly agree
A satisfying day of stocked trout fishing is one in which I catch many trout (ManyTrout)	1 – 7, 1 = strongly disagree, 7 = strongly agree
I would rather catch 1 or 2 big trout than 6 smaller trout (BigTrout)	1 – 7, 1 = strongly disagree, 7 = strongly agree
Demographics	
Age	Continuous
Distance Traveled	Continuous
Site Characteristics	
Type of fishery (Fishery)	Put-and-take, Delayed Harvest, or Urban
Type of waterbody (Waterbody)	Stream or Lake
Management region (Region)[b]	

[a] Individual specialization questions were not used, but the results of clustering analysis was considered for the multinomial logistic regression; [b] Due to non-normal distribution, motivations and region created unstable models and were not considered for multinomial logistic regression.

Table 4-2. Comparison of the top multinomial logistic regression models that estimated daily satisfaction levels of anglers on the 17 stocked-trout waters in Virginia. Number of parameters (K), Akaike's information criteria (AICc), change in AIC value (ΔAIC), and Akaike weight (w_i) were used to select the top models for a set of models. Variables considered in the models included specialization, motivations, expectations, demographics, and site characteristics (listed in Table 4-1).

Model	K	AICc	ΔAICc	w_i
Catch Rate + Age + NoTrout[a] + Specialization + Waterbody[b]	42	4,919.9	0	0.89
Catch Rate + Age + NoTrout + Specialization + Fishery + Waterbody	48	4,924.2	4.3	0.10
Catch Rate + Age + NoTrout + Specialization + Fishery	42	4,933.0	13.1	0
Catch rate + Age + NoTrout + Specialization	36	4,934.5	14.6	0
Catch rate + Age + NoTrout + Waterbody	24	4,964.3	44.4	0
Catch rate + Age + NoTrout	18	4,981.9	62.0	0
Catch rate + Age + Waterbody	18	5,183.9	264.0	0
Catch rate + Age	12	5,202.9	283.0	0
Catch rate	6	5,276.0	356.1	0
Specialization + NoTrout	24	5,682.5	762.6	0
NoTrout + Age + Waterbody	18	5,693.7	773.8	
NoTrout + Fishery	12	5,728.7	808.8	0
NoTrout	6	5,732.2	812.3	0
ManyTrout[c]	6	5,852.6	932.7	0
BigTrout[d]	6	5,867.3	947.4	0
Age	6	5,951.8	1,031.9	0
Distance Traveled	6	5,971.9	1,052.0	0
Fishery + Waterbody	12	6,027.2	1,107.3	0

[a]NoTrout = Level of agreement with the statement "A day of stocked trout fishing can be satisfying even if I do not catch any trout;" [b]Waterbody = Lake or Stream; [c]ManyTrout = "A satisfying day of stocked trout fishing is one in which I catch many trout;" [d] BigTrout = I would rather catch 1 or 2 big trout than 6 smaller trout.

Table 4-3. The parameter estimates, standard errors, and 95% confidence limits for the top multinomial logistic regression model, which estimated angler daily satisfaction levels on the 17 stocked-trout waters in Virginia. Estimates are odds ratios relative to a satisfaction level of seven (i.e., the reference level).

			Confidence limits	
Variable	Estimate	SE	Lower	Upper
Satisfaction level one				
Intercept	2.33	1.67	0.84	6.28
Specialist	1.14	1.35	0.61	1.98
Avid angler	0.82	1.24	0.53	1.25
Consumptive-Experienced Angler	0.88	1.32	0.50	1.47
NoTrout	0.53	1.07	0.47	0.61
Age	1.01	1.01	0.99	1.02
Lake	1.68	1.15	1.29	2.22
Catch rate	0.95	1.05	0.85	1.04
Satisfaction level two				
Intercept	2.82	1.70	0.98	7.91
Specialist	0.71	1.45	0.31	1.37
Avid angler	0.93	1.26	0.59	1.47
Consumptive-Experienced Angler	0.96	1.35	0.51	1.68
NoTrout	0.61	1.08	0.53	0.70
Age	0.99	1.01	0.97	1.01
Lake	1.58	1.15	1.20	2.10
Catch rate	0.90	1.08	0.76	1.01
Satisfaction level three				
Intercept	1.59	1.75	0.52	4.65
Specialist	0.39	1.58	0.13	0.85
Avid angler	1.29	1.25	0.84	2.06
Consumptive-Experienced Angler	1.17	1.34	0.65	2.06
NoTrout	0.70	1.08	0.61	0.81
Age	0.99	1.01	0.98	1.01
Lake	1.03	1.14	0.79	1.33
Catch rate	0.68	1.12	0.53	0.84
Satisfaction level four				
Intercept	2.32	1.53	1.00	5.29
Specialist	0.81	1.24	0.52	1.23
Avid angler	0.95	1.15	0.72	1.26
Consumptive-Experienced Angler	1.12	1.20	0.78	1.58
NoTrout	0.72	1.06	0.64	0.81
Age	0.99	1.01	0.98	1.01
Lake	1.27	1.10	1.06	1.52
Catch rate	0.91	1.05	0.83	0.98
Satisfaction level five				
Intercept	3.38	1.47	1.59	7.15

Specialist	0.79	1.20	0.55	1.12
Avid angler	1.04	1.12	0.83	1.31
Consumptive-Experienced Angler	1.06	1.17	0.78	1.43
NoTrout	0.79	1.06	0.71	0.87
Age	0.99	1.00	0.98	1.00
Lake	1.05	1.08	0.90	1.22
Catch rate	0.80	1.05	0.72	0.88
Satisfaction level six				
Intercept	2.09	1.46	0.99	4.37
Specialist	0.68	1.20	0.47	0.97
Avid angler	1.02	1.12	0.82	1.28
Consumptive-Experienced Angler	1.13	1.16	0.85	1.50
NoTrout	0.81	1.05	0.73	0.89
Age	1.00	1.00	0.99	1.00
Lake	1.03	1.08	0.89	1.19
Catch rate	0.88	1.04	0.82	0.95

Table 4-4. The effect likelihood ratio tests of the five variables in the top model for predicting daily satisfaction.

Variable	df	P-value
Level of specialization	18	0.56
NoTrout	6	<0.0001
Waterbody Type	6	0.0001
Catch Rate	6	<0.0001
Age	6	0.06

Table 4-5. Comparison of the top multinomial logistic regression models that estimated levels of satisfaction with stocked-trout fishing in the last 12 months. Number of parameters (K), Akaike's information criteria (AICc), change in AIC value (ΔAIC), and Akaike weight (w_i) were used to select the top models for a set of models. Variables considered in the models included specialization, motivations, expectations, demographics, and site characteristics (listed in Table 4-1).

Model	K	AICc	ΔAICc	w_i
Catch rate + Age + NoTrout + Specialization + Fishery[a]	42	4,535.9		
Catch rate + Age + NoTrout + Specialization	36	4,538.3	0.00	0.67
Catch rate + Age + NoTrout + Specialization + Fishery + Waterbody	48	4,540.8	2.50	0.19
Catch rate + Age + NoTrout + Specialization + Waterbody	42	4,541.5	3.20	0.14
Catch rate + Age + NoTrout + Waterbody	24	4,594.3	56.00	0.00
Catch rate + Age + NoTrout	18	4,594.3	56.00	0.00
Catch rate + Age + Waterbody	18	4,743.9	205.60	0.00
Catch rate + Age	12	4,745.0	206.70	0.00
Catch rate	6	4,764.3	226.00	0.00
Specialization + NoTrout	24	5,174.5	636.20	0.00
NoTrout	6	5,247.5	709.20	0.00
NoTrout + Age + Waterbody	18	5,250.8	712.50	0.00
NoTrout + Fishery	12	5,251.0	712.70	0.00
ManyTrout	6	5,350.6	812.30	0.00
BigTrout	6	5,359.6	821.30	0.00
Distance Traveled	6	5,411.1	872.80	0.00
Age	6	5,416.1	877.80	0.00
Fishery + Waterbody	12	5,438.5	900.20	0.00

[a] model became unstable and was not used for further analysis

Table 4-6. The parameter estimates, standard errors, and 95% confidence limits for the top multinomial logistic regression model, which estimated angler daily satisfaction levels on the 17 stocked-trout waters in Virginia. Estimates are odds ratios relative to a satisfaction level of seven (i.e., the reference level).

			Confidence limits	
Variable	Estimate	SE	Lower	Upper
Satisfaction level one				
Intercept	0.15	2.41	0.02	0.77
Specialist	1.10	1.61	0.37	2.52
Avid angler	0.70	1.39	0.36	1.33
Consumptive-Experienced Angler	0.97	1.49	0.41	2.01
NoTrout	0.66	1.12	0.54	0.83
Age	1.02	1.01	1.00	1.05
Catch rate	1.02	1.06	0.88	1.13
Satisfaction level two				
Intercept	1.21	2.10	0.26	4.91
Specialist	0.80	1.76	0.20	2.08
Avid angler	0.79	1.41	0.39	1.57
Consumptive-Experienced Angler	1.42	1.48	0.63	3.01
NoTrout	0.57	1.10	0.47	0.70
Age	0.99	1.01	0.97	1.02
Catch rate	0.99	1.08	0.80	1.11
Satisfaction level three				
Intercept	0.39	1.95	0.10	1.37
Specialist	1.84	1.42	0.89	3.58
Avid angler	1.25	1.29	0.76	2.11
Consumptive-Experienced Angler	0.42	1.59	0.14	0.93
NoTrout	0.62	1.09	0.52	0.73
Age	1.02	1.01	1.00	1.04
Catch rate	0.99	1.06	0.87	1.09
Satisfaction level four				
Intercept	2.29	1.47	1.06	4.89
Specialist	1.05	1.22	0.71	1.52
Avid angler	0.71	1.14	0.55	0.93
Consumptive-Experienced Angler	0.91	1.19	0.64	1.26
NoTrout	0.70	1.06	0.63	0.78
Age	1.00	1.00	0.99	1.01
Catch rate	0.98	1.04	0.91	1.04
Satisfaction level five				
Intercept	3.81	1.42	1.91	7.65
Specialist	1.03	1.19	0.72	1.45
Avid angler	0.86	1.12	0.69	1.09
Consumptive-Experienced Angler	0.91	1.17	0.66	1.22
NoTrout	0.69	1.05	0.62	0.76

Age	1.00	1.00	0.99	1.01
Catch rate	0.98	1.03	0.92	1.04
Satisfaction level six				
Intercept	1.97	1.42	0.99	3.95
Specialist	0.77	1.19	0.54	1.07
Avid angler	0.98	1.11	0.80	1.20
Consumptive-Experienced Angler	1.13	1.14	0.87	1.47
NoTrout	0.77	1.05	0.70	0.85
Age	1.00	1.00	1.00	1.01
Catch rate	0.87	1.04	0.80	0.94

Table 4-7. The effect likelihood ratio tests of the four variables in the top model for predicting annual satisfaction.

Variable	df	P-value
Level of specialization	18	0.10
NoTrout	6	<0.0001
Catch rate	6	0.009
Age	6	0.19

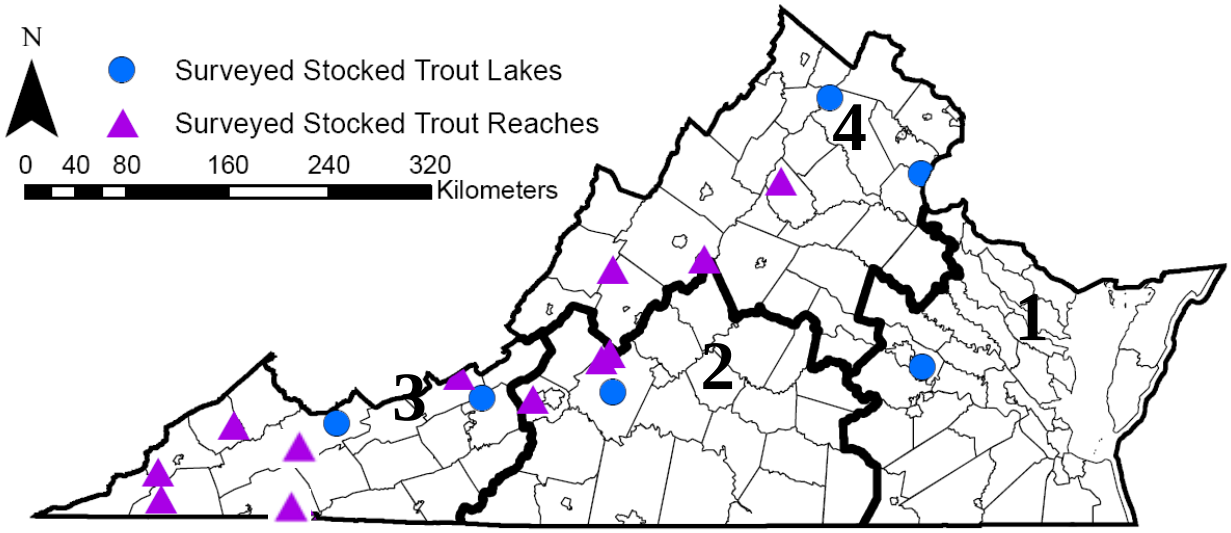

Figure 4-1. Locations of Virginia Department of Game and Inland Fisheries stocked waters that we studied from 2013 to 2015. The thick black lines denote management regions, while the thin black lines denote counties.

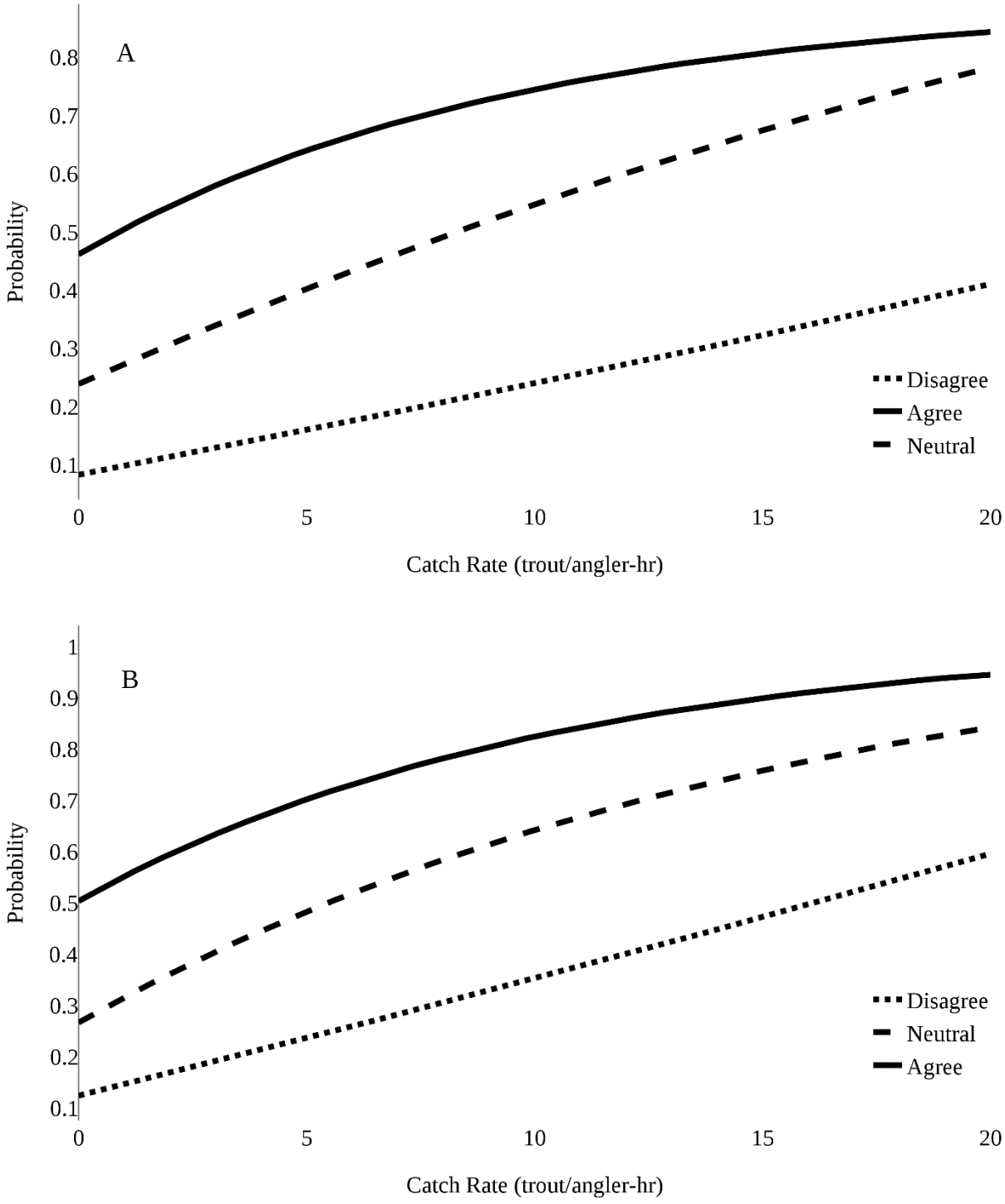

Figure 4-2. Predicted probability that an angler would report a satisfaction level of seven on lakes (A) and streams (B) given the calculated catch rate (trout/angler-hr) and reported level of agreement with the statement "A trout fishing trip can be satisfying even when I do not catch any trout," where 7 = strongly agree (solid line), 4 = neutral (dashed line), and 1 = strongly disagree (dotted line).

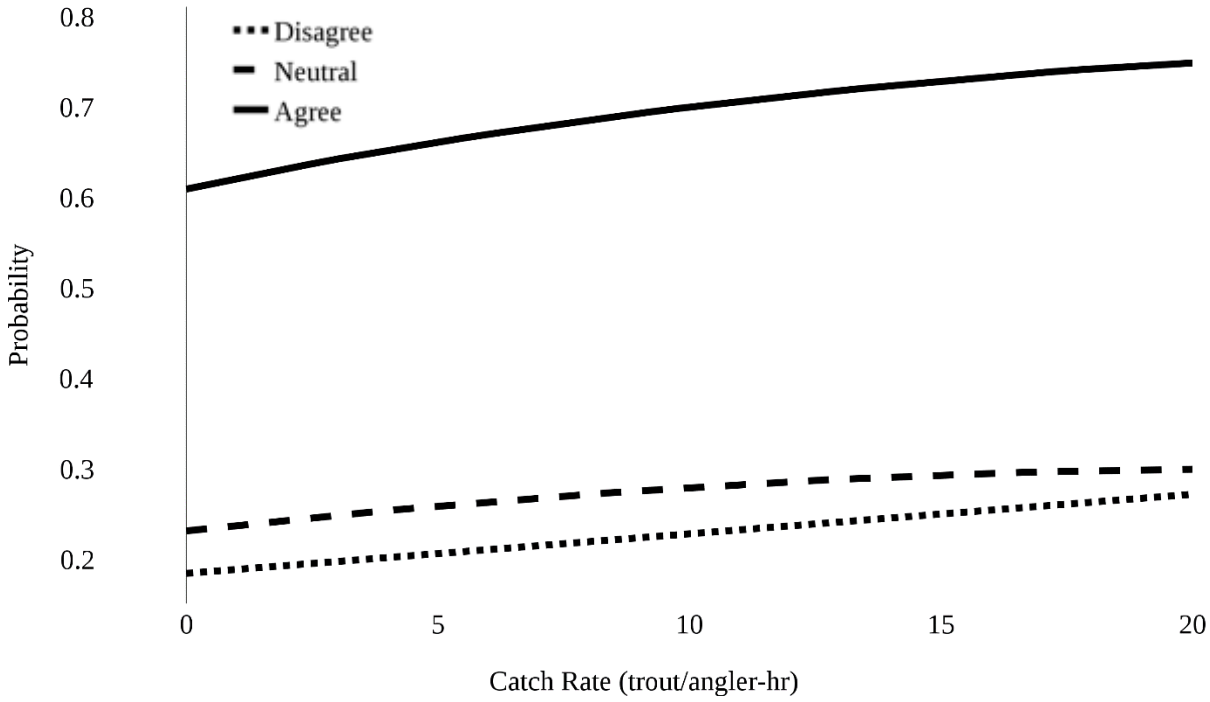

Figure 4-3. Predicted probability that an angler would report a satisfaction level of seven for stocked-trout fishing in the last 12 months given the calculated catch rate (trout/angler-hr) and reported level of agreement with the statement "A trout fishing trip can be satisfying even when I do not catch any trout," where 7 = strongly agree (solid line), 4 = neutral (dashed line), and 1 = strongly disagree (dotted line).

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Chapter 5: Summary and Conclusions

Assessment of Catch Rate on Stocked-Trout Fisheries in Virginia

Stocking rate showed no correlation with catch rate on either lakes or streams. A previous study (O'Bara and Eggleton 1995) found similar results on other lotic systems. In other lentic systems however, previous research (Patterson and Sullivan 2013, Hunt et al. 2014) found stocking rates positively correlated with catch rate. The other waterbodies had similar physical characteristics and were stocked with similar-sized fish, but the research focused on stocking rates significantly lower than the rate at which Virginia Department of Game and Inland Fisheries (VDGIF) stocks. We propose three mechanisms that explain the lack of relationship between stocking rates and catch rates on stocked-trout waters: 1) VDGIF could be saturating systems by stocking at high densities, 2) fish could disperse beyond legal fishing areas and/or the reach of shore-bound anglers (Cresswell 1981, Helfrich and Kendall 1982), and 3) more experienced and proficient anglers fish when and where fish densities have declined (Ward et al. 2013a). If overstocking is the cause, VDGIF may be able to achieve management objectives by stocking fewer fish and still satisfy and retain anglers.

Prior to and throughout this study, many anglers suggested that excessive harvest of stocked fish by "truck followers" severely reduced opportunities for anglers who could not fish on the day of stocking. At current stocking rates, we found that although anglers did catch fish quicker on stocking day than any day following a stocking event, catch rates remained at or near 1.0 trout/angler-hr up to a month following stocking events. Stable catch rates following stocking events could result from saturation of the system due to high stocking rates and frequent stockings, especially in the spring when VDGIF regularly stocks more than once a month.

Furthermore, anglers released 33% of the trout they caught, far more than expected for a presumably harvest-oriented program. This "recycling" of stocked trout may contribute to the persistence of catch rates that meet management objectives up to 30 days after stocking.

With the decline of license sales across the nation and in Virginia (U.S. Fish and Wildlife Service and U.S. Census Bureau 2011, unpublished VDGIF data), declining revenue may force VDGIF to seek cost-saving measures in the stocked-trout program. Reducing the number of trout stocked could help VDGIF reduce their expenses, given the high cost of raising a catchable-sized trout (in Virginia, estimated at $2.00 per trout, VDGIF 2015). Our results suggest that VDGIF could decrease not only their rate of stocking, but also their frequency of stocking and still maintain desirable fishing experiences. Decreasing the rate of stocking may allow VDGIF to stock fish in additional waters. Decreasing the frequency of stockings could help alleviate associated costs (e.g., gas for hatchery trucks, maintenance of hatchery trucks, personnel needed to complete stockings).

Diversity and Preferences of Anglers Seeking Stocked Trout

We identified four distinct clusters of anglers based upon eight specialization questions: specialists, avid anglers, consumptive-experienced anglers, and casual anglers. Each cluster differed in their motivations for fishing, fishing preferences, and levels of satisfactions. Anglers also differed based upon management region. Anglers in Region 2 reported significantly lower levels of satisfaction for both timeframes than anglers in other regions.

We inquired about anglers' management preferences. Anglers strongly support the current, year-round stocking system and strongly oppose an opening-day system. Anglers however, were split on their preference for the timing of announcements of stocking dates and locations. Only 31% of anglers preferred the currently announcement timing.

Given the heterogeneity of anglers utilizing the stocked-trout program and across management regions, we suggest diversifying the stocking regimes (e.g., stocking many fish in waters frequented by many casual anglers, stocking larger fish in waters fished by many specialists) and management regulations (e.g., creating more opportunities to catch-and-release stocked-trout waters by converting more waters to the delayed-harvest strategy in areas with many non-harvest-oriented anglers). We recommend diversifying the timing of the announcements (e.g., leaving a few waters in each region completely unannounced, while announcing stockings for a few waters in advance).

Synthesis of Human Dimensions and Catch-Related Variables on Angler Satisfaction

We found that catch rate, the importance an angler places on catching something, age, and level of specialization contribute to the best model fit for predicting angler satisfaction on both daily and annual scales. Catch rate consistently correlates with angler satisfaction (Spencer 1993, Patterson and Sullivan 2013, McCormick and Porter 2014), yet anglers who are less catch-oriented (typically more specialized anglers) regularly report higher levels of satisfaction (Arlinghaus 2006). Although age contributed to the best-fit models, it did not significantly affect angler satisfaction. Previous studies (Mostegl 2011, McCormick and Porter 2014) however, found age negatively correlated with satisfaction.

This model can help managers set quantifiable management goals. For example, if managers set an objective to satisfy 85% of their anglers, what catch rate do anglers need to attain to meet that objective? Our model suggests over 85% of anglers will report high satisfaction with that day and with fishing in the last 12 months if they catch one fish per hour, on average. If managers believe this level of angler satisfaction is reasonable for the context of retention, mangers should explore ways to reach and maintain catch rates of one fish per hour.

The best-fit model may help managers predict angler satisfaction, but we found that anglers currently seeking stocked trout already are highly satisfied. Despite high levels of reported satisfaction, license sales have declined in the last decade. To add to the concern, stocked-trout anglers represent an aging and almost exclusively white-male demographic. To address these trends, VDGIF could alter their recruitment efforts to focus on non-catch aspects of a fishing trip that likely would appeal to a broader audience. The future of this program relies upon retaining existing anglers and recruiting younger and more diverse new anglers.

Appendix A: On-site Stocked-Trout Angler Data Sheet, Interview Script, and Survey

Stocked Trout Daily Creel Form

Interviewer's name: _____ Site: _____ Date: _____ Day type: _____

Survey start time: _____ Time frame: _____ Shift length: _____

Angler's not interviewed: _____

	Start Time	Angler or Car Count
Count #1 Total		
Count #2 Total		
Count #3 Total		

Weather: _____

Notes: _____

Stocked Trout Angler Survey

Interviewer's name: _____ Date and time: _____ Site: _____ Interview #: _____

Hello, my name is _____. I am working with Virginia Tech and the Virginia Department of Game and Inland Fisheries. We are trying to learn more about fishermen and their preferences and opinions on the management of the stocked trout program. I would like to ask you a few questions; it should only take a few minutes. Are you willing to answer a few questions? **If they decline, note how many people in the vehicle. Declined interview: _____**

Have you been interviewed for this project before? . . . . . ❑ Yes ❑ No

How many people are in your group today? #Adults #Youth . . . _____ What time did you start fishing today? . . . _____

What species of trout do you prefer to fish for? . ❑ Brook trout ❑ Brown trout ❑ Rainbow trout ❑ No preference

What equipment do you normally use to fish for stocked trout? . . . . . ❑ Artificial flies ❑ Artificial lures ❑ Bait

How many days in the last 12 months have you gone fishing in Virginia? . . . . . _____

Of the days you have fished in the last 12 months in Virginia, how many of those have been for stocked trout? . . . . . _____

How many years have you been fishing? . . . . . _____

How many years have you fished for stocked trout in Virginia? . . . . . _____

When do you prefer to fish for stocked trout?

❑ On or near day of stocking ❑ Stocking day doesn't matter to me ❑ I avoid days on or close to stocking

When do you most often fish for stocked trout? . . . . . ❑ Weekdays ❑ Weekends and holidays ❑ No preference

Where do you prefer to fish for stocked trout?

❑ Ponds and lakes ❑ Large streams ❑ Small streams ❑ No preference

Which are the three most important reasons for your decision to fish here today?

❑ I know it was stocked recently	❑ To catch and release fish	❑ To get away from other anglers
❑ To relax and/or to be outside	❑ To be with friends or family	❑ The weather
❑ To catch fish for food	❑ It is close to home	❑ Other_____

Do you subscribe to any fishing-related magazines?	❑ Yes ❑ No
Are you a member of any fishing-related club or organization?	❑ Yes ❑ No
Have you taken any fishing-related vacations in the past 12 months?	❑ Yes ❑ No

Please indicate to what level you agree or disagree with each of the following statements regarding stocked trout fishing by selecting a number from 1 to 7, where 7 = strongly agree, 1 = strongly disagree, and 4 is neutral.

I would prefer to see more trout stocked even if they were smaller.	Strongly Disagree 1 2 3 4 5 6 7 Strongly agree
I would prefer to see larger trout stocked even if that means fewer trout per stocking.	Strongly Disagree 1 2 3 4 5 6 7 Strongly agree
I would prefer the stream to be stocked more often with fewer trout per stocking.	Strongly Disagree 1 2 3 4 5 6 7 Strongly agree
I would prefer the stream to be stocked less often with more trout per stocking.	Strongly Disagree 1 2 3 4 5 6 7 Strongly agree
A day of stocked trout fishing can be satisfying even when I do not catch any trout.	Strongly Disagree 1 2 3 4 5 6 7 Strongly agree
A satisfying day of stocked trout fishing is one in which I catch many trout.	Strongly Disagree 1 2 3 4 5 6 7 Strongly agree
I would rather catch 1 or 2 big trout than 6 smaller trout.	Strongly Disagree 1 2 3 4 5 6 7 Strongly agree
A satisfying trout fishing trip is one in which I reach my daily limit.	Strongly Disagree 1 2 3 4 5 6 7 Strongly agree
Fishing is my favorite outdoor recreation.	Strongly Disagree 1 2 3 4 5 6 7 Strongly agree

The current daily bag limit is 6 fish. Would you prefer it to be smaller, larger or kept the same? . . . . . ❑ Smaller ❑ Larger ❑ Same

Where do you usually get information, including stocking dates and locations, about Virginia's trout stocking program?

❑ VDGIF webpage ❑ VDGIF hotline ❑ Other VDGIF publication
❑ Social Media e.g., facebook, twitter ❑ Family or friend ❑ Other

Currently, stocking date and location are announced at 4pm the day of stocking. Do you prefer to have the stocking date and location unannounced, announced in advanced, or announced at 4pm?

❑ Advanced announcement ❑ Delayed annoucement ❑ Unannounced ❑ No preference

Please indicate to what level you support or oppose each of the following statements regarding stocked trout fishing in Virginia by selecting a number from 1 to 7, where 7 = strongly support, 1 = strongly oppose, and 4 is neutral.

To what level do you support or oppose the current regulations that allow year-round trout fishing with stockings from October to May?	Strongly Oppose 1 2 3 4 5 6 7 Strongly Support
To what level do you support or oppose having a defined opening day in March or April, with stockings only from March to May?	Strongly Oppose 1 2 3 4 5 6 7 Strongly Support

Please indicate to what level you agree or disagree with each of the following statements regarding your satisfaction with stocked trout fishing in Virginia by selecting a number from 1 to 7, where 7 = very satisfied, 1 = very dissatisfied, and 4 is neutral.

How satisfied are you with the availability of information about the stocked trout program in Virginia?	Very Dissatisfied 1 2 3 4 5 6 7 Very Satisfied
How satisfied are you with today's fishing experience?	Very Dissatisfied 1 2 3 4 5 6 7 Very Satisfied
How satisfied are you with stocked trout fishing in Virginia in the last 12 months?	Very Dissatisfied 1 2 3 4 5 6 7 Very Satisfied

How many fish have you caught today? ___ Of the fish you have caught, how many have you kept? _____

We have marked some of the fish stocked here to determine how many fish from one stocking are caught and how quickly they are caught. Is it OK if I look at your fish to see if any of them are marked? **If they decline, continue with other questions from survey. Declined fish check:_____**

Location and # of clipped fish: _____ Species and # of harvested fish: _____

How many miles one-way did you travel to get here today? . . . . . _____ What is your age? . . . . . _____ Gender ❑ Male ❑ Female

What is your employment status? . . . . . ❑ Employed ❑ Unemployed ❑ Homemaker ❑ Retired ❑ Student

The Department of Game and Inland Fisheries is interested in knowing which types of licenses trout anglers purchase. I do not need to see your license, but we would like to know, do you have any of the following?:

❑ Lifetime Trout License ❑ Military Leave ❑ Trout License ❑ Freshwater Fishing License ❑ Disability ❑ Non-resident ❑ None of the above

Do you have any other comments about the stocked trout program?

_____

_____

Thank you for your time. Would you be interested in receiving a summary of the results of this study when it is completed? **If yes, have them fill out their name and address or email on a notecard.**

. . . . . ❑ Yes ❑ No

Appendix B: On-site Survey Addendum for the Delayed-Harvest Section of the South River, Virginia, U.S.A.

South River Delayed Harvest Angler Creel Survey

Date _____ Time _____ Interview # _____

What type of tackle/gear is the angler fishing with? . . . . . ❑ Spinfishing gear/lures ❑ Flyfishing gear/flies ❑ Bait

Can you tell me the current regulations for this section of the South River? . . . . . ❑ Correct ❑ Incorrect

Correct regulations: **Delayed Harvest.** October 1 through May 31 - Fishing with artificial lures only. No trout may be in possession. June 1 - September 30 - Fishing with bait is allowed and 6 fish per day can be harvested. A trout license is required October 1 through June 15.

Please indicate to what level you agree or disagree with each of the following statements regarding stocked trout fishing by selecting a number from 1 to 7, where 7 = strongly agree, 1 = strongly disagree, and 4 is neutral.

I am fishing here today because this section of South River is managed under Special Regulations.	Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
I would prefer to see this section of Sourth River to be managed as an Artificial lure/Delayed harvest water (Current Regulations).	Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
I would prefer to see this section of South River to be managed as a Flyfishing only/Catch-and-Release water.	Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
I would prefer to see this section of South River to be managed as an Artificial lure/Catch-and-Release water.	Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

How many days in the past 12 months did you fish general put-and-take stocked-trout waters? . . . . . _____

How many days between June 1 - September 30, 2014 did you fish this section of South River? . . . . . _____

Appendix C: On-Site Heritage Day Survey

Heritage Day Stocked Trout Angler Survey

Interviewer's name: _____ Date and time: _____ Site: _____ Interview #: _____

Hello, my name is _____. I am working with Virginia Tech and the Virginia Department of Game and Inland Fisheries. We are working on evaluating the stocked trout program and I would like to ask you a few questions; it should only take a few minutes. Are you willing to answer a few questions? **If they decline, note how many people in the vehicle. Declined interview: _____**

How many people are in your group today? #Adults #Kids .... _____ What time did you start fishing today? ... _____

Is this the first day you have fished for stocked trout this season? ..... ❑ Yes ❑ No

How many days in the last 12 months have you gone fishing in Virginia? ..... _____

Of the days you have fished in the last 12 months in Virginia, how many have been for stocked trout? _____

How many years have you been fishing? ..... _____

How many years have you fished for stocked trout in Virginia? ..... _____

Have you participated in Heritage Day in the past? ..... ❑ Yes ❑ No

Why are you fishing today on Heritage Day?

❑ I know it was stocked today ❑ To catch and release fish ❑ It is a Saturday
❑ To relax and/or to be outside ❑ To be with friends or family ❑ Other_____
❑ To catch fish for food ❑ It is close to home

Please indicate to what level you agree or disagree with each of the following statements regarding stocked trout fishing by selecting a number from 1 to 7, where 7 = strongly agree, 1 = strongly disagree, and 4 is neutral.

I would prefer more Heritage Days.	Strongly Disagree 1 2 3 4 5 6 7 Strongly agree
I would prefer additional waters to be stocked on Heritage Day.	Strongly Disagree 1 2 3 4 5 6 7 Strongly agree
I would fish more for stocked trout if more waters were stocked on Saturdays and Sundays.	Strongly Disagree 1 2 3 4 5 6 7 Strongly agree

Currently, stocking date and location are announced at 4pm the day of stocking. Do you prefer to have the stocking date and location unannounced, announced in advanced, or announced at 4pm?

❑ Advanced announcement ❑ Delayed annoucement ❑ Unannounced ❑ No preference

Please indicate to what level you agree or disagree with each of the following statements regarding your satisfaction with stocked trout fishing in Virginia by selecting a number from 1 to 7, where 7 = very satisfied, 1 = very dissatisfied, and 4 is neutral.

How satisfied are you with today's fishing experience?	Very Dissatisfied 1 2 3 4 5 6 7 Very Satisfied
How satisfied are you with stocked trout fishing in Virginia in the last 12 months?	Very Dissatisfied 1 2 3 4 5 6 7 Very Satisfied

How many fish has your group caught today? ____ Of the fish you have caught, how many have you kept? ____

How many miles one-way did you travel to get here? _____ What is your age? _____

What is your employment status? ..... ❑ Employed ❑ Unemployed ❑ Homemaker ❑ Retired ❑ Student ❑ Disabled

The Department of Game and Inland Fisheries is interested in knowing which types of licenses trout anglers purchase. I do not need to see your license, but we would like to know, do you have any of the following?:

❑ Lifetime Holder ❑ Military Leave ❑ Trout License ❑ Freshwater Fishing License ❑ None of the above

Do you have any other comments about the stocked trout program?

_____

_____

_____

_____

Appendix D: Summary Results from On-site Stocked-Trout Survey

Table D-1. Locations of Virginia Department of Game and Inland Fisheries stocked waters, and their physical and managerially characterisitics that we studied from 2013 – 2015.

Site	Size[a]	Type of fishery	No. of Stockings	Management Region	Year Sampled
Big Stoney Creek	12.1	Put-and-take	8	3	2013 – 2014
Dorey Park	2.0	Urban	5	1	2014 – 2015
Frying Pan Creek	8.0	Put-and-take	3	3	2013 – 2014
Liberty Lake	0.7	Put-and-take	8	2	2014 – 2015
Lincolnshire Lake	8.5	Put-and-take	8	3	2013 – 2014
Locust Shade	3.2	Urban	5	4	2014 – 2015
Lake Thompson	4.0	Put-and-take	8	4	2014 – 2015
Mill Creek	2.47	Put-and-take	3	2	2014 – 2015
North Creek	1.6	Put-and-take	8	2	2014 – 2015
Pandapas Pond	4.0	Put-and-take	5	2	2013 – 2014
Roanoke River	3.2	Put-and-take	8	3	2013 – 2014
Rose River	2.38	Delayed Harvest	3	2	2014 – 2015
Stock Creek	4.7	Put-and-take	8	4	2014 – 2015
South Fork of Powell	3.8	Put-and-take	8	3	2014 – 2015
South River	1.33	Delayed Harvest	3*	4	2014 – 2015
Whitetop Laurel Creek	3.5	Put-and-take	5	3	2013 – 2014

Table D- 2. Average responses of surveys on the 17 waters.

Question	Response
How many adults are in your group today?	1.26
How many youth are in your group today?	0.13
What species of trout do you prefer to fish for?	16.4% Brook 16.8% Brown 26.5% Rainbow 40.3% No preference
What equipment do you normally use to fish for stocked trout?	12.5% Artificial flies 40.8% Artificial lures 46.5% Bait
How many days in the last 12 months have you gone fishing in Virginia?	45.2
Of the days you have fished in the last 12 months in Virginia, how many of those have been for stocked trout?	26.0
How many years have you been fishing?	34.6
How many years have you fished for stocked trout in Virginia?	25.3
When do you prefer to fish for stocked trout?	17.2% I avoid days near stocking 40.5% On or near stocking day 42.3% Stocking day does not matter
When do you most often fish for stocked trout?	23.4% Weekday 29.6% Weekend 46.9% No preference
Where do you prefer to fish for stocked trout?	31.1% Large Streams 32.0% Small Streams 18.2% Ponds and Lakes 18.7% No preference
Which are the three most important reasons for your decision to fish here today?	36.6% I know it was stocked recently 46.5% To relax 34.4% To catch fish for food 13.1% To catch and release fish 24.4% To be with family or friends 19.2% Close to home 2.7% To get away from other anglers 6.7% Good weather
Do you subscribe to any fishing-related magazines?	16.5%
Are you a member of any fishing-related club or organization?	7.1%
Have you taken any fishing-related vacations in the past 12 months?	15.4%
Would you prefer the bag limit to be smaller, larger, or kept the same?	15.4% Larger 8.6% Smaller 75.9% Keep the same

Where do you usually get information, including stocking dates and locations, about Virginia's trout stocking program?	62.2% VDGIF webpage 10.7% VDGIF hotline 15.9% Family or Friend 1% Social Media 1% Other VDGIF publication 6.6% Other
Do you prefer to have the stocking date and location unannounced, announced in advanced or announced at 4 pm?	33.7% Advanced announcement 31.2% Announcement at 4pm 15.3% Unannounced 19.8% No preference
How many miles on-way did you travel to get here today?	24
What is your age?	48
Gender	93% male
What is your employment status?	Employed 55.1% Retired 27.5% Unemployed 4.4% Student 6.0% Disabled 2.7% Homemaker 1%
License type	69.3% Trout and Freshwater License 21.9% Lifetime Trout License 1% Disability License 1% Non-resident License

Table D-3. Distribution of levels of support for given programmatic options, levels of agreement with fishing-preference statements, and levels of satisfaction for specific timeframes. All responses are on a 7-point likert scale.

	Level of Support [a]						
Question	1	2	3	4	5	6	7
To what level do you support or oppose the current regulations that allow year-round trout fishing with stockings from October to May?	2.1%	1.6%	1.2%	7.3%	5.2%	14.3%	68.4%
To what level do you support or oppose having a defined opening day in March or April, with stockings only from March to May?	46.8%	10.5%	4.4%	13.7%	4.0%	5.8%	14.9%
	Level of Agreement [b]						
I would prefer the stream to be stocked more often with fewer trout per stocking.	12.0%	6.8%	6.4%	22.1%	9.8%	15.5%	27.5%
I would prefer the stream to be stocked less often with more trout per stocking.	24.6%	10.7%	9.7%	24.7%	7.5%	8.1%	14.6%
I would prefer to see more trout stocked even if they were smaller.	22.3%	11.0%	8.5%	14.7%	10.6%	10.2%	22.6%
I would prefer to see larger trout stocked even if that means fewer trout per stocking.	12.9%	7.9%	6.7%	17.1%	10.4%	14.1%	30.9%
A day of stocked trout fishing can be satisfying even when I do not catch any trout.	4.3%	1.3%	1.9%	5.8%	9.7%	17.0%	60.0%
A satisfying day of stocked trout fishing is one in which I catch many trout.	3.0%	2.2%	3.6%	14.0%	8.6%	11.9%	56.7%
I would rather catch 1 or 2 big trout than 6 smaller trout.	15.2%	7.4%	5.3%	13.3%	8.2%	11.3%	39.4%
A satisfying trout fishing trip is one in which I reach my daily limit.	5.9%	4.0%	4.1%	19.6%	9.1%	10.8%	46.7%
Fishing is my favorite outdoor recreation.	3.5%	3.3%	4.9%	12.1%	11.6%	13.8%	50.8%
	Level of Satisfaction [c]						
How satisfied are you with the availability of information about the stocked trout program in Virginia?	1.9%	1.2%	2.5%	8.8%	10.3%	21.3%	54.0%
How satisfied are you with today's fishing experience?	5.4%	3.6%	4.5%	9.8%	14.9%	15.2%	46.7%

How satisfied are you with stocked trout in Virginia in the last 12 months?	1.6%	1.5%	2.4%	11.0%	14.5%	19.3%	49.7%

[a] 7-point likert scale, where 1 = strongly oppose, 4 = neutral, and 7 = strongly support; [b] 7-point likert scale, where 1 = strongly disagree, 4 = neutral, and 7 = strongly agree; [c] 7-poing likert scale, where 1 = highly dissatisfied, 4 = neutral, and 7 = highly satisfied

Table D-4. Average responses on all 17 waters by waterbody type.

Question	Response	
	Lake	**Stream**
How many adults are in your group today?	1.4	1.5
How many youth are in your group today? [a]	0.12	0.14
What species of trout do you prefer to fish for?	12.5% Brook 16.6% Brown 30.5% Rainbow 40.4% No preference	21.3% Brook 17.0% Brown 23.6% Rainbow 38.1% No preference
What equipment do you normally use to fish for stocked trout?	9.3% Artificial flies 41.9% Artificial lures 48.8% Bait	21.6% Artificial flies 32.6% Artificial lures 45.8% Bait
Of the days you have fished in the last 12 months in Virginia, how many of those have been for stocked trout?	22.9	28.2
How many years have you fished for stocked trout in Virginia?	21.7	27.8
When do you prefer to fish for stocked trout?	16.3% I avoid days near stocking 39.7% On or near stocking 44.1% Stocking day doesn't matter	17.8% I avoid days near stocking 41.0% On or near stocking day 41.1% Stocking day doesn't matter
When do you most often fish for stocked trout?	21.1% Weekday 31.6% Weekend 47.2% No preference	25.2% Weekday 28.1% Weekend 46.7% No preference
Do you subscribe to any fishing-related magazines?	28.6% Yes	33.8% Yes
Are you a member of any fishing-related club or organization?	15.0% Yes	12.7% Yes
Have you taken any fishing-related vacations in the past 12 months?	27.5% Yes	31.7% Yes
Would you prefer the bag limit to be smaller, larger, or kept the same?	15.9% Bigger 77.3% Keep the same 6.8% Smaller	15.1% Bigger 74.9% Keep the same 10.0% Smaller
Do you prefer to have the stocking date and location unannounced, announced in advanced or announced at 4 pm?	33.9% Advanced 35.7% 4pm 14.2% Unannounced 16.1% No preference	34.9% Advanced 29.5% 4pm 17.1% Unannounced 18.6% No preference
How many miles on-way did you travel to get here today?	18.8	28.4
What is your age?	46	48
What is your employment status?	3.1% Disabled 54.2% Employed 5.1% Unemployed	2.4% Disabled 57.8% Employed 4.1% Unemployed

	26.7% Retired 10.0% Student 1.0% Homemaker	30.2% Retired 5.1% Student 0.4% Homemaker
License type	69.7% Trout License 22.3% Lifetime License	71.8% Trout License 23.6% Lifetime License
I would prefer the stream to be stocked more often with fewer trout per stocking. [b]	4.7	4.7
I would prefer the stream to be stocked less often with more trout per stocking. [b]	3.5	3.7
I would prefer to see more trout stocked even if they were smaller. [b]	4.1	4.0
I would prefer to see larger trout stocked even if that means fewer trout per stocking. [b]	4.6	4.8
A day of stocked trout fishing can be satisfying even when I do not catch any trout. [b]	6.1	6.1
A satisfying day of stocked trout fishing is one in which I catch many trout. [b]	5.7	6.0
I would rather catch 1 or 2 big trout than 6 smaller trout. [b]	4.8	4.8
A satisfying trout fishing trip is one in which I reach my daily limit. [b]	5.5	5.4
Fishing is my favorite outdoor recreation. [b]	5.8	5.6

[a] number of youth was only collected during the second year of the study; [b] 7-point likert scale, where 1 = strongly disagree, 4 = neutral, and 7 = strongly agree

We asked the anglers their opinions on management options. Anglers supported the current year-round season and opposed the opening-day season (Table X). Anglers believed the frequency of stockings was sufficient, remaining neutral on increasing or decreasing the frequency (Table X). To find information regarding recent stocking locations and dates, anglers most frequently used VDGIF's webpage (62%), contacted a family member or friend (16%), or used VDGIF's hotline (10%). Anglers were split on their preference for timing of announcement; 34% of anglers preferred advanced announcement, 31% preferred a delayed announcement at 4 pm, 15% preferred no announcement, and 20% had no preference. The majority of the anglers had a regular trout license (69%), while 22% had a Lifetime Trout License.

Table D-5. Average level of support or opposition for current year-round season and an opening-day season from anglers in each region. Responses on a 7-point likert scale, where 1 = strongly oppose, 4 = neutral, and 7 = strongly support.

	Region			Overall Mean	ANOVA results		
Question	2	3	4		df	F-value	P-value
To what level do you support or oppose the current regulations that allow year-round trout fishing with stockings from October to May?	6.1 y	6.1 y	6.7 z	6.3	2	34.65	<0.0001
To what level do you support or oppose having a defined opening day in March or April, with stockings only from March to May?	2.7 y	3.3 z	2.4 y	2.9	2	36.29	<0.0001

Table D-6. Announcement preferences of anglers in each region.

	Region			ChiSquare Results		
Announcement Preference	2	3	4	df	ChiSquare	P-value
Unannounced	12.1	17.3	16.1	8	77.4	<0.0001
Delayed announcement	27.9	33.1	30.9			
Advanced announcement	41.1	37.6	25.7			
No preference	18.9	12.0	27.3			

Table D- 7. Number of youth, repeat anglers, and total number of anglers interviewed for waterbody types, management regions, and fishery types.

Variable	Number of Youth*	Number of Repeat Anglers	Number of Anglers
Lake	129	1,709	3,156
Stream	103	963	2,733
Region 2	46	435	816
Region 3	72	1,564	3,454
Region 4	102	527	1,395
Put-and-take	182	2,248	5,059
Delayed Harvest	4	74	310
Urban	46	350	520

*Number of youth results from year 2 surveys only.

Table D- 8. Average miles traveled, one-way, to fish that day by waterbody type, management region, and fishery type.

Variable	Miles Traveled
Lake	18.8
Stream	28.4
Region 2	22.2
Region 3	20.0
Region 4	34.4
Put-and-take	23.1
Delayed Harvest	41.2
Urban	20.8

Table D- 9. Differences in average number of days fished for stocked trout in the last 12 months and average number of years fished for stocked trout given anglers' employment statuses.

						ANOVA results		
Question	Disabled	Employed	Un-employed	Retired	Student	df	F value	P-value
Days fished for stocked trout in the last 12 months	25.7 zy	24.3 y	36.8 z	28.2 zy	26.7 zy	6	2.32	0.04
Years fished for stocked trout	31.8 z	21.7 y	20.5 y	37.0 z	6.9 x	6	111.9	<0.0001

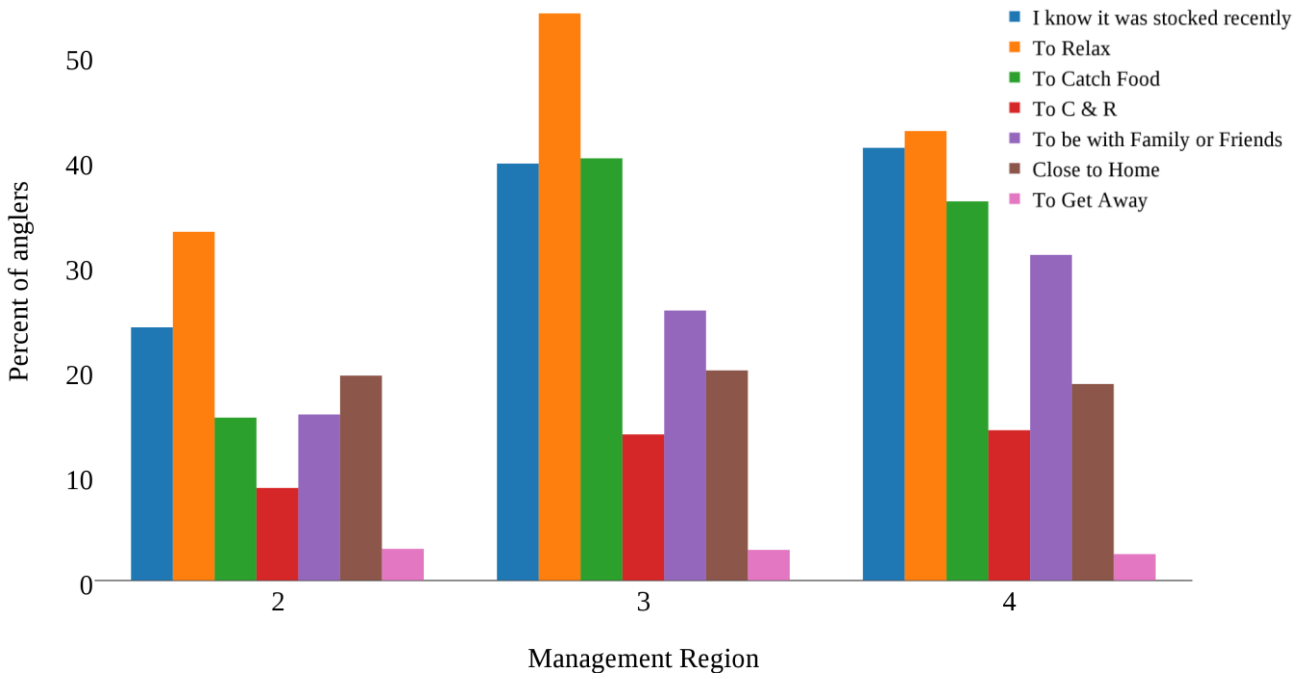

Figure D-1. Percent of anglers in each management region that responded ‘yes’ to different motivations for fishing that day. Anglers were allowed to choose their top three motivations, hence, totals exceed 100%.

Appendix E: Site-Specific Catch, Harvest, and Effort Analysis

Table E- 1. Effort calculations, stocking data, and harvest and catch calculations for surveyed waters.

Site	Effort[a]	No. trout stocked[b]	Avg. Catch Rate[c]	Avg. Harvest Rate[c]	Total Catch[d]	Percent of stock caught[d]	Total Harvest[e]	Percent of stock harvested[f]
Big Stoney Creek	77.3	13,495	1.17	0.85	5,891	0.44	3,937	0.29
Dorey Park	47.9	3,485	0.46	0.32	1,789	0.51	1,322	0.38
Frying Pan Creek	46.0	4,095	1.72	1.54	1,559	0.38	1,469	0.36
Liberty Lake	88.5	2,359	0.38	0.30	2,427	1.03*	1,888	0.80
Lincolnshire Lake	118.7	5,988	0.94	0.50	7,431	1.24*	3,227	0.54
Locust Shade	74.1	7,424	1.41	0.92	6,163	0.83	4,355	0.59
Lake Thompson	66.1	5,028	0.67	0.57	2,496	0.50	2,166	0.43
Mill Creek	27.3	3,479	1.06	0.86	1,415	0.41	1,275	0.37
North Creek	52.5	4,352	0.66	0.63	1,427	0.33	1,306	0.30
Pandapas Pond	117.0	4,540	0.60	0.40	3,628	0.80	1,921	0.42
Roanoke River	8.45	1,749	0.49	N/A	1,329	0.76	N/A	N/A
Rose River	37.0	6,585	1.30	1.17	2,171	0.33	1,980	0.30
Stock Creek	15.7	2,895	1.25	1.08	629	0.22	541	0.19
South Fork of Powell	81.0	6,257	1.40	0.75	6,641	1.06*	3,730	0.60
South River	28.8	2,777	1.11	N/A	4,745	1.71*	N/A	N/A

Whitetop Laurel Creek	76.1	12,197	1.78	1.12	8,652	0.71	5,633	0.46

[a] average angler effort in hours per day; [b] total for all stocked species: Brown Trout, Brook Trout, and Rainbow Trout; [c] average catch rate per day calculated using Mean of Ratios (Polluck et al. 1994); [d] calculated as number caught divided by number stocked; [e] Totals for 8-month stocking season; [f] calculated as number harvested divided by number stocked; *values over 1, imply that on average, all stocked fish were caught at least once

Table E-2. Range and mean cohorts remaining after the first weekend following a stocking event for each site and the range and mean of the total number of trout stocked at a site remaining after the first weekend following a stocking event.

Site	Percent of Cohort Remaining Range for season (mean)	Percent Stocked Remaining Range for Season (mean)
Big Stoney Creek	64.1 – 94.5 (78.8)	72.4 – 84.4 (77.4)
Dorey Park	84.9 – 96.1 (92.3)	71.9 – 94.6 (82.8)
Frying Pan Creek	43.1 – 76.6 (64.3)	64.9 – 76.6 (72.2)
Liberty Lake	-79.6* – 85.0 (33.2)	16.6 – 73.5 (32.5)
Lincolnshire Lake	-5.1* – 85.8 (58.3)	48.0 – 70.3 (56.2)
Locust Shade	44.0 – 88.8 (69.0)	45.7 – 88.8 (70.9)
Lake Thompson	32.9 – 91.0 (63.0)	57.0 – 83.3 (73.0)
Mill Creek	19.8 – 83.2 (62.5)	61.5 – 83.2 (70.4)
North Creek	25.4 – 94.2 (65.3)	66.3 – 79.2 (71.8)
Pandapas Pond	37.6 – 98.7 (70.5)	58.6 – 76.3 (64.8)
Rose River	49.2 – 99.2 (72.6)	70.0 – 77.2 (72.9)
Stock Creek	62.2 – 100 (78.0)	70.7 – 78.5 (73.8)
South Fork of Powell	-1.5* – 69.9 (42.3)	41.2 – 66.7 (51.7)
Whitetop Laurel Creek	39.2 – 74.2 (61.6)	54.4 – 72.6 (61.0)

* negative value attributed to harvest of trout from previous cohorts still remaining in the water

Appendix F: Summary Results from South River Survey

Table F- 1. Summary results by angler gear type from South River Addendum Survey. Within a given column, means with the same lowercase letter do not significantly differ from each other as indicated by Tukey's test for multiple comparisons.

Gear Type Used	Correct Regs	Special Reg	Artificial lure as DH	Flyfishing only with CAR	Artificial lure with CAR	Days On PNT	Day On South River
Bait	47.4% correct	3.1 x	4.6	1.4 y	2.1 y	37.0 z	5
Fly	50% correct	6.7 z	4.6	6.0 z	4.4 z	13.5 y	3.3
Spin	63.6% correct	4.9 y	5.5	2.3 y	3.3 zy	34.9 z	8.2
Overall	51% correct	6	4.7	4.9	3.9	19.5	4.1

Table F- 2. Summary results by harvest regulation from South River Addendum Survey. Within a given column, means with the same lowercase letter do not significantly differ from each other as indicated by Tukey's test for multiple comparisons.

Regulations (months)	Correct Regs	Special Reg	Artificial lure as DH	Flyfishing only with CAR	Artificial lure with CAR	Days On PNT	Day On South River
Put-and-take (June)	15 z	35 y	50 z	44.7	4.1 y	5	2.7 y
Catch-and-release (Oct. – May)	7.1 y	92.9 z	0 y	54.3	6.9 z	5.4	6.1 z
Overall	51% correct	6	4.7	4.9	3.9	19.5	4.1

Appendix G: Summary Results from Heritage Day Survey

Table G- 1. Summary results of the Heritage Day Survey.

Question	Response
Have you participated in Heritage Days in the past?	72.3%
Average catch rate (trout/angler-hr)	0.69

Table G-2. Summary results of management preferences of anglers interviewed on Heritage Day in 2014 on 11 Heritage Day waters.

	Level of Support						
Question	1	2	3	4	5	6	7
I would prefer more Heritage Days.	9.8%	1.3%	3.6%	16.0%	10.5%	9.5%	49.3%
I would prefer additional waters to be stocked on Heritage Day.	4.2%	2.6%	2.0%	8.8%	6.8%	8.5%	67.1%
I would fish more for stocked trout if more waters were stocked on Saturdays and Sundays.	5.9%	3.3%	1.6%	13.4%	6.2%	10.2%	59.3%