DISSERTATION

ACCOUNTING FOR SPATIAL SUBSTITUTION PATTERNS AND BIOECONOMIC FEEDBACK LOOPS: AN ECONOMIC APPROACH TO MANAGING INLAND RECREATIONAL FISHERIES

Submitted by

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ABSTRACT

ACCOUNTING FOR SPATIAL SUBSTITUTION PATTERNS AND BIOECONOMIC FEEDBACK LOOPS: AN ECONOMIC APPROACH TO MANAGING INLAND RECREATIONAL FISHERIES

This dissertation consists of three papers which address separate but related issues in recreational fisheries management. Paper one estimates the economic contribution of the private, recreation-based aquaculture industry in the Western United States. Paper two presents a method for combining models of site selection with input-output models in order to better estimate the true economic impacts of augmentation or deterioration of recreational sites. Finally, paper three presents a dynamic, bioeconomic model of a recreational fishery and uses that model to simulate what would happen over time to anglers and fish populations (as well as value to anglers) if fish stocking were to be halted at a single recreational fishery. All three papers are policy relevant today given the increased pressure from (and litigation filed by) environmental groups to reduce fish stocking due to conflicts with native and endangered species.

Paper one explores the economic contribution of the private, recreation-based aquaculture industry in the Western United States. New sectors are constructed in IMPLAN input-output software using data gathered between 2007 and 2010 from producers and their direct customers (stocked fisheries). Information from a third survey

of anglers in Colorado and California is integrated to predict the short-term shocks that would occur to various industries if anglers at privately stocked fisheries were to discontinue fishing (simulating a hypothetical collapse of the industry). Accounting for both the backward and forward linkages of the private, recreation-based aquaculture industry's production, model results indicate that for every dollar of fish stocking, $36 dollars of recreational angler-related expenditures are supported, and that the total economic contribution of this industry in the Western United States is roughly $2 billion annually. This is the first study addressing the forward linkages and total economic contribution of this industry in the Western United States.

Paper two addresses a similar issue as paper one, but goes further to account for substitution patterns among anglers. Using information from a survey of anglers in 2009, a repeated nested logit (RNL) model of angler spatial substitution behavior is estimated. Then, the RNL is used to predict changes in angler days associated with changes in fishery attributes. By linking the RNL and input-output model, better insight is gained into the economic losses associated with augmentation or deterioration of stocked fishing sites. Results indicate that if a single site is closed within the region of analysis, of the 29,500 anglers that will no longer fish at that site, only 6,500 anglers will leave the region of analysis (the rest substituting to other in-region sites). Standard impact analysis would therefore *overestimate* the economic impacts of such a policy by 450%. Results are similar when catch rates are reduced by 50% at one site, with 14,000 anglers leaving that site but only 3,000 leaving the region.

The third and final paper of this dissertation presents a means by which managers may manage inland recreational fisheries from a dynamic bioeconomic perspective. A

discrete-time, discrete-space, infinite time horizon numerical model of a fishery is built in GAMS software to reflect responses of anglers to the fishery and responses of the fishery to anglers over time. A data-driven random utility model is used to inform angler response and value functions in this dynamic bioeconomic model. Results from one region in California indicate that a) current fish stocking levels may be inefficiently high, and b) elimination of fish stocking programs at popular lakes may not lead to a crash in fishery populations, since anglers will simply substitute to other nearby fisheries (rather than "fish-out" the lake). Managers who can predict the intertemporal effects of fishery management alternatives in this way will be able to better meet the demands of recreational anglers.

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DEDICATION

大学生の時、私は妻に結婚してもいいですかと聞きました。でも、妻の家族は、ドクターの後でもいいですが、今はだめですと言いました。その時とにかく結婚しましたけど、今からドクターが終わるので、全部は大丈夫です。規子、あなたの強さ、支援、積極的な態度、我慢と、あなたの人生をより広い視野から考えることができる力に、感謝しています。規子がいなかったら、このディーサーテーションをできませんでした。愛しています。

When I was an undergraduate and asked my wife to marry me, her family insisted that we wait until I finish a Ph.D. Although she married me anyways, I am happy to know that I've fulfilled the initial conditions under which our marriage would have been acceptable. Noriko, I appreciate your ongoing strength and support, your positive attitude, your patience with me, and your ability to see the bigger picture in life. I couldn't have finished this without you.

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Chapter 1: The Economic Contribution of the Private, Recreation-Based Aquaculture Industry in the Western United States

Forthcoming in the Journal of Aquaculture Economics and Management, 6/2011. Some very small differences exist between this chapter and the actual submission due to formatting and length requirements of the journal.

1. Introduction and Problem Statement

In 2006, the Center for Biological Diversity and Pacific Rivers Council filed a lawsuit against California Fish and Game, accusing the agency of failing to report the impacts of fish stocking on high mountain aquatic species (Center for Biological Diversity, 2010, PRC, 2010). Reasons for filing this lawsuit include:

"1) [Fish Stocking] *can spread disease, invasive species, or unwanted fish,*

2) Stocked fish prey on and compete with native fish and amphibians [e.g. the Critically Endangered Mountain Yellow-Legged Frog] *for food and habitat, and;*

3) Planted fish disrupt the food web and alter natural ecosystem processes to the detriment of native species." (PRC, 2010)

After several years of litigation, in September 2010, the California Department of Fish and Game (CA DFG) published an Environmental Impact Statement (EIS) which mandated that prior to fish stocking, all waters in that state must be subjected to a "Pre-Stocking Evaluation Protocol" in order to confirm that the stocking activity will have "less than significant" impacts on native and critically endangered amphibians, most notably the charismatic Mountain Yellow-Legged Frog (CDFG, 2010). The regulations also affect the private aquaculture industry, which stocks fish in many private waters, and is often contracted to stock fish in public waters in California (Deisenroth and Bond, 2010[1]). Private stocking permits will now be required and enforced, and will also expire annually, making it potentially more difficult and costly to stock fish in public and private waters (CDFG, 2010).

The outcome of this litigation is unprecedented in fisheries management, where, for the last century, stocking efforts have increased exponentially in order to meet the needs of a growing population of recreational anglers. And the negative effects of stocking are not limited to California: it has been revealed that the most widely stocked fish in the US and in the world, *Oncorhynchus mykiss* (Rainbow Trout), have detrimental effects on native species of amphibians and fish in many Western[2] states, with particular focus on native trout in the Rocky Mountains and amphibians in California (Halverson, 2010; Knapp et al., 2007; Armstrong and Knapp, 2004). As more research implicates Rainbow Trout as the culprit for species declines and even local extinctions of native species, public lands managers may begin to curtail fish stocking in order to meet the needs of the general public.

These public lands managers also realize that not only does fish stocking augment the quality of the anglers' experience, but that in some rural areas, economies may depend almost exclusively on tourism dollars generated from that fishery. In fact, much of the $45 billion in retail sales that recreational fishing generates annually in the United States (US) is supported by fish stocking programs which augment fishing quality and

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[1] Deisenroth and Bond (2010) is the final technical report to the Western Regional Aquaculture Center, and includes a lengthy and extensive review of the data collection process, more detailed state-level analysis to the extent possible, and a more detailed description of the ASRF industry in general. This report is well over 100 pages long, and most of the information in this report is irrelevant to a professional economic audience.

[2] The Western Regional Aquaculture defines the Western States as Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming. This definition is used for this paper.

encourage angler trips to local and distant fisheries (ASA, 2008). For example, Caudill (2005) found that the US Fish and Wildlife Service (USFWS) stocked 9.4 million rainbow trout in 2004 and that for each dollar of fish produced in USFWS hatcheries, $32 dollars of economic activity was generated in local and regional economies.

While most of the lay public are aware of federal and state fish stocking agencies such as the USFWS or state-level fish and game departments, few are aware of the private aquaculture businesses which supply fish for both private and public fisheries. These businesses provide fish for thousands of privately-stocked bodies of water in the Western US, including municipal, county, and state public waters, private fishing clubs and dude ranches, fee fishing ponds, and private land. Not only are privately stocked fisheries utilized by lifelong members and affiliates, but they also supplement the fishing opportunities for other anglers provided by state and federal fisheries. The stocking of fish in public and private waters encourages tourism, which in turn stimulates the economies of the rural communities adjacent to these waters. In light of recent litigation placing restrictions not only on public fish stocking, but also on *private* fish stocking, knowledge of the economic contribution of such stocking is necessary in order to inform sound policy decisions.

This study estimates the economic contribution of the private, recreation-based aquaculture industry (sometimes referred to as the aquacultural suppliers of recreational fish, or ASRF) in the Western US. These producers supply fish to both private and public recreational outlets of all types, including everything from public lakes and rivers to private backyard ponds. However, to date, no study has estimated this economic contribution and as such, little is known about the potentially detrimental economic effects of such stocking mitigation plans as suggested by the 2010 CA EIS. As such, the information provided in this paper will prove useful to policymakers and private aquaculture facilities alike.

2. Literature

There has been little research documenting the economic contributions or impacts of any portion of the private aquaculture industry in any country, and to date, no studies have investigated the economic contributions of that portion of the industry related to support of recreational freshwater fishing (although Váradi (2001) provides background of the relationship between inland aquaculture and fisheries in Europe).

Economic impacts are usually calculated using input-output (or similar) models, such as IMPLAN, which trace the backward linkages of exogenous expenditures on inputs using matrices of linked sectors calibrated to a specific region. Examples of this technique as applied to aspects of aquaculture production include investigations of the regional economic impact of the farmed-shrimp industry in India (Reddy, Reddy, and Kumar, 2004) and southern Honduras in a development context (Stanley, 2003), and the contributions of the pet turtle industry to the Louisiana economy (Hughes, 1999). Several studies have used similar regional techniques to estimate the economic impacts of entire fisheries from the demand side by using angler expenditures to trace through the impact of the fishery, including the recreational bluefin tuna fishery in Hatteras, NC (Bohnsack, et al., 2002) and a largemouth bass fishery at Lake Fork, TX (Chen, Hunt, and Ditton, 2003).

While many other economic reports refer to “economic contributions” as “economic impacts,” it should be noted here that there is a critical difference. We define economic *contribution* analysis as that which does not take into account potential substitution opportunities that may exist in the absence of an industry. Instead, economic contribution analysis simply traces the flows of expenditures stemming from ASRF production. For example, if the ASRF industry ceased to exist, producers may enter into other agricultural or industrial/commercial industries, while anglers might fish public, non-stocked fisheries or take advantage of alternative recreational opportunities. As such, economic contribution analysis will overstate potential contraction of the regional economy were an industry to simply cease to exist.

This study evaluates the economic contribution of ASRF producers for two reasons. First, other studies typically report economic contribution figures, so the economic contribution of the ASRF industry provides a consistent comparison between the ASRF industry and other industries. Second, in the short run, it is likely that ASRF producers, their customers, and anglers will have difficulty transitioning into other industries and recreational opportunities. In the very short run, the economic contribution of the ASRF industry may be a good measure of the effect of a hypothetical removal of ASRF production. As such, the economic impacts of that industry are left to future research.

This paper proceeds as follows. The following section outlines the sampling frame and data collection of ASRF producers, ASRF customers and recreational anglers. Next is a section detailing the theoretical basis and methodological approach of the economic contribution model. Summary statistics on the three surveyed groups follow, as well as results on the direct expenditures resulting from ASRF production, economic multipliers, and the total economic contribution of the ASRF industry. Finally, a brief section draws conclusions for policymakers.

3. Data Collection and Sampling Frame

In order to assess the magnitude of the forward and backward linkages associated with the private recreation-based aquaculture industry, three entities were surveyed: the potential population of the ASRF industry, a sample of their first point-of-sale customers, and a sample of anglers. All surveys were administered according to the Dillman Tailored Design Method (Dillman, 2000). These surveys, along with supplemental material including maps of survey regions, can be found in appendices 1A-1N.

In total, 418 permit-holding ASRF producers were identified in the Western US[3]. Of these, 245 producers were found to not be in the ASRF business, identified through phone calls, mail correspondence, or consultation with industry advisors. The remaining 173 potentially active producers were mailed surveys, and 52 of these producers actually completed a survey, yielding a minimum 30% response rate. This is a low estimate of response rate, since the 173 possible producers may not have all been active producers in 2007 (see Bond et al., 2011, for further discussion of response rates of agricultural producers relative to the general public). The number of producers per state, as well as the general production characteristics of these facilities, aligns with the most recent census of aquaculture (potentially mitigating concerns regarding sample selection bias),

[3] As finfish farming is illegal under Alaska Statute 16.40.210 unless farmed by a non-profit ocean-based salmon ranch, Alaska does not have any producers that fit into the for-profit ASRF category. The large scale Alaska salmon hatchery system, for example, which produces fish which are harvested by both commercial and sport fishermen, is operated by non-profit associations. As such, Alaska is excluded from the economic analysis. Initially, some surveys were distributed to Alaska producers (non-profit), but ultimately all Alaska data was excluded. A brief summary of secondary research related to the Alaska system is presented in Deisenroth and Bond (2010).

where the majority of facilities in the west exist in Washington, California, Oregon, Idaho or Colorado and the majority of facilities produce trout (USDA, 2006).

The second surveyed subpopulation was ASRF first point-of-sale customers, who were contacted by mail between November 2009 and January 2010. Since no publicly-available lists of all ASRF customers in the West are readily available, a list of 686 potential buyers was compiled through the cooperation of several ASRF producers in Colorado[4]. These customers included all identified categories of potential buyer, including private fishing clubs, dude ranches, homeowners' associations, municipalities, state parks, fee-fishing ponds, and private landowners.

Of the 686 surveys originally mailed, 74 respondents' addresses were undeliverable and 20 responded that they were no longer operating a fishery of any type and had not stocked fish recently. Of the remaining 592 potential respondents, 260 mailed their survey back for a response rate of 44%. Cross referencing survey respondents' information with industry advisor data reveals that our sample of 260 is representative of the 686 originally surveyed.

The third subpopulation was of anglers in Colorado and California. In order to generate the broadest and most representative sample possible, surveys were distributed to anglers on-site at a variety of sites in order to capture differences in expenditure patterns. Sites include many types of recreational fisheries, including private and public ponds, lakes, reservoirs, streams, and rivers. This also includes private ranches, private fishing clubs, municipalities, homeowner's associations, and other private property. Sites

[4] These firms include Cline Trout Farms, Liley Fisheries and E & J Fish Farms.

are also adjacent to both large population centers and rural areas in order to provide the most generalizable depiction of the economic effects of the ASRF industry.

During the summer and fall of 2009, anglers at 53 private and public fisheries were surveyed. Surveys were typically distributed in-person, although some surveys were distributed by mail using angler lists provided by private fishery managers (who did not wish to have surveys distributed in-person on-site). Surveys were distributed to 873 public fishery anglers and 355 private fishery anglers in Colorado, with 489 respondents to the public survey and 222 respondents to the private survey for an overall response rate of 58%. An additional 613 surveys were distributed to California public sites, with 359 surveys returned for a response rate of 58.5%. These response rates are consistent with other surveys of anglers (e.g. Loomis, 2006).

4. Methodology

4.1 General Approach

This paper includes both the forward and backward linkages of the ASRF industry in order to assess its total economic contribution to the Western US. Backward linkages are dollars generated by spending by the ASRF industry on inputs supplied by various industries (e.g., feed producers, insurance companies, automobile manufactures, etc.) and individuals (e.g., labor). Forward linkages are the dollars generated through the *usage* of ASRF products by both privately stocked fisheries and by anglers. The calculation of spending flows by this latter group is similar to the approach adopted by Caudill (2005), although in that study it was assumed that all anglers who visit a site do so as a result of fish stocking. The current study, however, accounts for the fact that many anglers would likely visit a site and spend dollars on recreation even if fish stocking did not occur. In that sense, this study generates a more conservative estimate of the economic contribution of fish stocking.

IMPLAN (IMpact Analysis for PLANning, MIG, Inc., 1997) input-output software is used in this study to account for the backward linkages of ASRF induced expenditures. IMPLAN was originally developed by the US Forest Service but was made available to the public in 1988 by the Department of Agricultural Economics at the University of Minnesota. Currently, IMPLAN is updated and distributed by Minnesota IMPLAN Group (MIG, Inc., 1997). IMPLAN uses data for industries within a region to generate linear production functions which relate the amount of final demand for a particular sector's products with the amount of inputs required to achieve that level of final demand. Formally:

(1) $$Y = (I - A) * X,$$

where Y represents the final demand for goods, I is an identity matrix, X is a vector of inputs and A is a matrix of technical coefficients which link inputs to outputs in all sectors. Solving for X yields:

(2) $$X = (I - A)^{-1} * Y,$$

which is the amount of input, X, needed to satisfy final demands, Y. $(I\text{-}A)^{-1}$ is the matrix of technical interdependence coefficients which measure direct and indirect levels of inputs needed to achieve final demand Y.

Economic contributions are often reported in the form of multipliers, which link one dollar of final demand to a certain amount of economic activity within a region. For example, an output multiplier of 1.85 for a particular sector indicates that for every $1 of goods purchased from that sector, an *additional* $0.85 cents are generated within the region. As *Y* represents final demands in equation (2), the vertical sum of a column in the $(I\text{-}A)^{-1}$ matrix represents the output multiplier for a particular sector.

For this study, *Y* represents expenditures on goods and services resulting from ASRF stocking. The matrix of technical coefficients in IMPLAN is used to calculate *X*, which is the amount of total economic activity resulting from changes in final demands of anglers in the absence of ASRF fish stocking. By simulating a cease in angler expenditures, this study essentially simulates a hypothetical removal of the ASRF industry from the Western economy, and therefore a hypothetical removal of ASRF stocking induced expenditures. The economic contribution of these expenditures is ultimately a measure of the economic contribution of the ASRF industry.

Input output modeling makes several assumptions which may not be appropriate in this instance, including Leonteif production functions, fixed prices, and a failure to account for potential substitution patterns in the absence of certain goods. However, despite these drawbacks, IMPLAN is a standard tool used to trace spending flows throughout a regional economy, and since the results of this paper will likely be compared with other similar reports, it is important to maintain consistency in order to facilitate efficient policy recommendations. For a more thorough review of input-output analysis and its major shortcomings, please see Miller and Blair (2009).

4.2 Forward Linkage Construction

In order to estimate the total economic contribution of the ASRF industry, the forward linkages of that industry’s production, coming in the form of anglers’ final demand and expenditures related to ASRF stocking, must first be estimated. Then, the *backward linkages* of these angler expenditures are traced through IMPLAN in order to estimate the amount of money generated per angler dollar spent, and thus per dollar of ASRF product sold.

The first step of the forward linkage construction (angler expenditures related to ASRF stocking) was to estimate total ASRF industry sales. This was calculated by multiplying the average sales of sampled firms by the total number of firms in the industry, which is estimated as outlined in section 2. Formally:

$$(3) \qquad S^P = P \cdot \frac{\sum_{i=1}^{p} s_i^P}{p},$$

where S^P is total industry sales, P is the estimated total number of private hatcheries in ASRF, p is the sample size and s_i^P is the sales dollars of individual firms in our sample.

Next, the number of ASRF first point-of-sale customers was estimated. While the total number of ASRF customers is uncertain, the amount that the average sampled customer spends on ASRF products is known. Using total ASRF industry sales from equation (3) above, total ASRF industry sales were divided by individual customer purchase amounts to estimate the number of ASRF customers as follows:

$$(4) \qquad C = S^P / \frac{\sum_{k=1}^{c} e_k^c}{c},$$

where C is the total number of ASRF customers, e_k^c is individual sampled customer annual expenditure on ASRF products and c is the sample size of ASRF customers.

Survey data for each ASRF customer includes annual gross sales and expenditures, the percentage of these sales attributable to fishing, and the percentage of fishing sales attributable to stocked fishing. These self-reported figures were used to estimate the amount of gross sales and expenditures attributable to stocked fishing as follows:

(5) $$S^{CSF} = C \cdot / \frac{\sum_{k=1}^{c}\left(s_k^c \cdot \zeta_k \cdot \psi_k\right)}{c},$$

where S^{CSF} is total stocked fishing related sales of ASRF customers, s_k^c is the gross sales of individual ASRF customers, ζ_k is the percentage of sales attributable to fishing and ψ_k is the percentage of fishing sales attributable to stocked fish[5].

Finally, to estimate the number of angler days generating these sales, the average amount of money that the mean angler spends on-site in a day is used. Dividing total stocked-fishing related revenue by the amount of money spent by an angler in a typical day on-site, the number of privately-stocked-induced angler days in a year at all ASRF customer sites is estimated by:

(6) $$AD = C \cdot \frac{\sum_{k=1}^{c}\left(S^{CSF} / e_k^a\right)}{c},$$

where *AD* represents ASRF-induced angler days and e_k^a represents on-site daily angler expenditure for ASRF customer *k*. This assumes that all stocked-fishing-induced sales come from anglers[6].

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[5] These calculations are based the assumption that survey respondents are able to approximate ζ_k and ψ_k with a reasonable degree of accuracy. This may be a difficult task given that many of these customers are not solely fishing-based operations; many are general dude ranches or private clubs which offer other recreation services such as scenic viewscapes, horseback riding and hunting, and may not be able to accurately estimate the appropriate shares. Still, this is likely more accurate than Caudill, 2005, where 100% of fishing revenues are assumed to come from stocked fishing.

From the models presented here, total angler expenditures are simply daily angler expenditures multiplied by the total number of angler days. Only primary-destination angler expenditures are used for this part of the analysis, since it is unknown what portion of secondary or tertiary-purpose anglers' expenditures are attributable to fishing:

(7) $$AnglerExpenditures = AnglerDays * DailyExpenditures.$$

It should be noted that all estimates were derived from sample rather than population statistics. The potential for both sample-selection bias and self-selection bias is present, and may result in either over- or under-estimation of economic contributions. Still, every effort was made to capture representative samples, and the authors believe that the results are a reasonable depiction of the ASRF industry's economic contribution to the Western US. Furthermore, the multipliers derived in the next section are within the range of other agricultural industries (MIG, 1997). If there is any bias in our estimation, it is likely to come from the *scope and size* of the industry, which is estimated rather than known. The direction of this bias, however, is unknown, but would have only linear effects on the final contribution estimates.

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[6] Some ASRF customers do not have any sales (e.g. private backyard pond owners). For these customers, we utilize a separate survey question which simply asks how many *anglers* visit the site annually. We assume here that all angler visits are due to stocked fishing and that survey respondents interpreted the annual angler question as annual angler days. This is for three reasons: 1) we have no other prior since we have no data on angler visitation patterns at private ponds with no sales; 2) it may be difficult for a non-sales fishery manager to retrospectively differentiate between two anglers coming for one day each or one angler coming for two days; and 3) the average privately stocked fishery with sales has *fewer* angler days (only 21% of total angler visitors) than stated anglers due to the fact that most angler days are not attributable to fish stocking. If we assumed that 100% of angler days were attributable to fish stocking for ASRF customers with sales, our data indicates that these producers interpreted "annual angler visitors" as "annual angler days."

5. Results

5.1 Demographic Statistics from the Surveyed Populations

Most WRAC-region producers (nearly half) are located in California. This makes sense given the climate and population of that state. Colorado, Oregon, and Washington are home to the vast majority of the remainder of potential ASRF businesses. There were no completed surveys from Arizona, and several Arizona permit holders indicated that they are in the food-fish aquaculture businesses, farming fish such as Tilapia due to the warmer weather and water. A breakdown of the number of potential producers by state can be found in table 1.

Table 1: Identified Producers By State

State	Active Permits	Not in Business	Potential ASRF Businesses	Source of Information
Alaska	77	77	0	Department of Fish and Wildlife
Arizona	15	11	4	Department of Agriculture
California	154	84	70	Department of Fish and Game
Colorado	45	22	23	Colorado Aquaculture Association
Idaho	11	1	10	Department of Agriculture
Montana	8	3	5	Department of Fish, Wildlife, and Parks
Nevada	7	4	3	Division of Wildlife
New Mexico	1	0	1	Mike Sloane, New Mexico State University Extension
Oregon	31	13	18	Department of Fish and Wildlife
Utah	24	12	12	Department of Agriculture and Food
Washington	41	18	23	Department of Fish and Wildlife
Wyoming	4	0	4	Department of Fish and Game
Total	418	245	173	

A typical ASRF business is operated by a 55-year old married man who has been in the business over 20 years. Gross sales for ASRF businesses average $330,000 annually (although sales are much higher for a few businesses but lower for a majority of businesses). Finally, income from aquaculture typically constitutes about half of household income, with many producers indicating through phone conversations that they are involved in some other agricultural activity for supplemental income. Table 2 summarizes the demographic statistics of survey respondents.

Table 2: Demographic Statistics

Variable	Average	Standard Deviation	Minimum	Maximum
Age	55	13	30	85
% Male	90%	n/a	n/a	n/a
Years in ASRF Business	22	13	1	60
Years in Aquaculture in General	23	13	4	60
Size of Household (Persons)	3.3	2	1	8
% Married	88%	n/a	n/a	n/a
% Who Live On-Site	80%	n/a	n/a	n/a
Earnings as a % of Total Income	45%	37%	0%	100%

The typical respondent to the ASRF customer survey is a 60 year old married man with a college education and 13 years of experience. He still has one child at home, and in many cases either his wife or his child are contributing to household expenses. Most live on site, with 5% of their annual income is derived from fish-stocking related services. ASRF customer demographic statistics can be seen in table 3.

Table 3: ASRF Customer Demographic Statistics

	Average	Standard Deviation	Minimum	Maximum
Age	58.51	11.49	94	24
% Male	90%	31%	0%	100%
Years of Experience	12.79	12.43	0	64
Years of Education	15.80	2.17	9	19
Household Members	2.84	1.47	1	11
Contributing Members	1.67	0.78	0	6
% Married	89%	69%	n/a	n/a
% With Home On Site	59%	49%	n/a	n/a
% of Income from Fishery	5%	18%	n/a	n/a

The survey of anglers suggests that those intercepted at private fisheries are older, more likely to be retired, and receive a higher income than their public fishery counterparts. The average age of anglers at private fisheries is just over 60, compared with 53 and 50 for Colorado public and California anglers, respectively. Anglers at private fisheries also have an average of 15.77 years of education (a 4-year bachelor's degree is 16 years), compared with 14.8 and 14.2 for Colorado and California public fishery anglers, respectively. Most of the private fishery anglers surveyed are members of a private fishing club, with only small percentages of public fishery anglers being members. Most anglers at all types of site are male. Summary statistics are provided in table 4.

Table 4: Angler Demographic Statistics

	Average	Standard Deviation	Minimum	Maximum
% Male	89%	n/a	n/a	n/a
% Employed	71%	n/a	n/a	n/a
% Retired	35%	n/a	n/a	n/a
% Private Fishing Club Member	22%	n/a	n/a	n/a
Age	53	15	89	15
Years of Education	15	2	6	19
Income	$80,778	$38,736	$20,000	$500,000

5.2 Production Functions and Multipliers

Using sales and expenditure data from the three surveys, two new sectors are constructed in IMPLAN: one for ASRF producers and another for ASRF customers. The production functions for these sectors map a dollar of sales of a particular product into a set of expenditures on supplies, equipment and personnel. This section summarizes the production functions and multipliers of all three surveyed populations: ASRF producers, ASRF customers, and recreational anglers (expenditure patterns for the latter category). The information contained in these multipliers is used in the calculation of the total economic contribution of the ASRF industry.

5.2.1 ASRF Producers

All producer data is averaged and aggregated into a single production function which is built into IMPLAN. For every amount that is inputted into the new "ASRF Producer" sector, the "Other Animal Production" sector, which originally included ASRF producers, is reduced by that same amount in order to keep the same economy-wide output and employment levels. The specific per-producer averages (excluding food fish) used in model construction are given in table 5 Of the $330,000 in gross annual sales,

$120,000 is attributable to non-depreciated expenditures such as fish and eggs, feed, electricity, and gasoline. Labor expenditures exceed $90,000 annually, including wages, benefits and labor taxes. $75,000 is spent annually on the purchase, maintenance and lease of buildings, fish production facilities, equipment and transportation equipment. Finally, proprietors net only $45,000 annually. This makes sense, given that the average ASRF producer only derives 50% of his annual income from his ASRF operation. Note that the high standard deviations relative to the means of each expenditure category indicate a large variation in scale among ASRF producers in the region.

Using the production function above, IMPLAN traces through the backward linkages of ASRF expenditures to generate economic multipliers, which are summarized in table 6 for the ASRF industry. For every dollar spent on ASRF products, $1.85 is generated in the Western economy. This is due to the direct effect of the $1 to ASRF producers, the indirect effect of $.35 to input suppliers, and the induced effect of $.50 from spending by employees and proprietors. Likewise, every million dollars of ASRF sales results in 21.61 full-time jobs in the Western economy. Finally, for every full-time job supported by the ASRF industry directly, .37 additional jobs are supported throughout the economy.

Table 5: ASRF Production Function			
Category	Average Annual Expenditures	Standard Deviation	Absorption Coefficient*
Fish and Eggs	$23,041	$83,605	0.070
Feed	$41,439	$90,718	0.125
Electricity	$10,220	$21,596	0.031
Natural Gas/Propane	$572	$1,600	0.002
Other Utilities	$2,484	$10,498	0.008
Gasoline	$9,079	$25,831	0.027
Chemicals/Supplies and Oxygen	$6,564	$23,238	0.020
General Consumable Supplies	$2,206	$6,452	0.007
Shipping and Distribution	$9,823	$31,747	0.030
Non Labor Insurance	$4,041	$10,357	0.012
Licenses/Permits/Inspection Fees	$1,778	$4,736	0.005
Marketing and Advertising	$1,340	$4,190	0.004
Other	$2,610	$11,910	0.008
Non-Shipping Depreciated Vehicle Expenses	$2,779	$6,661	0.008
Total Non Depreciated Expenditures	$117,977		
Buildings, Fish Production Facilities, General and Transportation Equipment	$74,966	$16,383	
Labor Expenditures	$92,772	$173,915	
Proprietary Income	$45,144	$33,795	
Sales	$330,858	$40,291	
Employment	7.15	8.59	
Total ASRF Producers	173		
Aggregate Sales	$57,238,415		
Aggregate Employment	1,237		

***The percentage of total direct sales revenue that is spent on non-depreciated expenditures. The sum of all absorption coefficients is often referred to as the "gross absorption coefficient."

Table 6: ASRF Industry Multipliers					
	Direct Effect	Indirect Effect	Induced Effect	Total Effect	Type SAM[b] Multiplier
ASRF Output	1.00	0.35	0.50	1.85	1.85
ASRF Employment[a]	21.61	4.21	3.72	29.54	1.37

[a]Employment effects are reported per $1,000,000 of gross sales

[b]SAM stands for Social Accounting Matrix. This multiplier captures the direct, indirect, and induced effects of the ASRF industry.

Given the unique nature of the Western states, it is unlikely that the economic effects of the ASRF industry will be distributed uniformly across the region. Indeed, only one producer was identified in New Mexico, while 70 were identified in California. The present analysis therefore treats the Western Region as the region of analysis and makes no attempt to differentiate between states.

5.2.2 ASRF Customers

Average ASRF customer expenditure figures are used to create the ASRF customer sector in IMPLAN. As discussed in section 3, annual expenditures and sales are multiplied by the reported percentage of sales attributable to stocked fishing. Table 7 summarizes this production function. For every amount that is inputted into the new "ASRF Customer" sector, the "Other Recreation Industries" sector, which originally included ASRF customers, is reduced by that same amount in order to keep the same economy-wide output and employment levels. Most expenditures are categorized as depreciated and non-depreciated inputs. Non-depreciated inputs include fish, non labor insurance, food (for customers), feed (for fish) and electricity. Depreciated expenditures include maintenance, purchase and lease costs of buildings and facilities. In an accounting sense, the average ASRF customer takes a loss annually from his fishing operation, primarily due to the fact that half of these customers have no sales. Rather, they purchase fish for their own enjoyment and do not anticipate accounting profits from their fishing operation.

Table 7: ASRF Customer Production Function in IMPLAN			
IMPLAN Category	Annual Expenditures	Standard Deviation	Absorption Coefficient
ASRF	$2,656	$8,786	0.195360
Feed	$245	$1,981	0.018008
Chemicals	$199	$1,086	0.014654
General Supplies	$48	$378	0.003542
Electricity	$341	$1,610	0.025090
Natural Gas/ Propane	$74	$513	0.005452
Other Utilities	$194	$1,560	0.014272
Food	$982	$12,694	0.072231
Fishing Equipment	$72	$351	0.005299
Vehicle Expenses	$145	$942	0.010687
Gasoline/ Diesel	$172	$833	0.012617
Marketing	$300	$2,028	0.022091
Licenses/ Permits	$88	$477	0.006457
Non Labor Insurance	$551	$3,420	0.040513
Other	$873	$6,719	0.064217
Total Non-Depreciated Expenditures	$6,939		0.510489
Other Property Income	$6,986	$67,824	
Labor Expenditures	$2,975	$14,096	
Proprietor Income (residual)	-$3,306	n/a	
Sales	$13,593	$60,210	
Employment	0.43	1.32	
Total ASRF Customers	20,053		
Aggregate Sales	$272,588,780		
Aggregate Employment	8,658		

Multipliers for the ASRF customer sector in the Western region can be found in table 8. Every dollar spent on ASRF customer products results in $1.79 being generated in the regional economy. Furthermore, as this industry is labor-intensive, every million dollars of ASRF customer sales directly supports 32 full-time jobs annually. Due to the indirect and induced effect, every job directly supported by the ASRF customer sector implies an additional .28 jobs in the region.

Table 8: ASRF Customer Multipliers

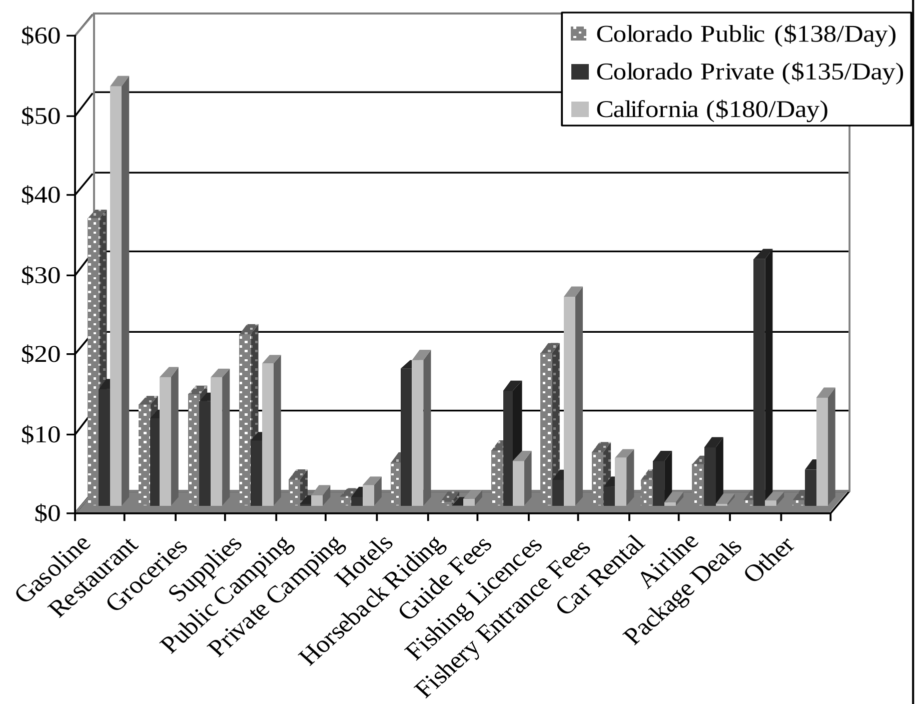
	Direct Effect	Indirect Effect	Induced Effect	Total Effect	Type SAM Multiplier
ASRF Customer Output	1.00	0.61	0.17	1.79	1.79
ASRF Customer Employment	31.76	7.76	1.27	40.80	1.28

5.2.3 Anglers

Anglers spend their money on a variety of items on a typical fishing day. The typical private fishery angler spends the bulk of his money on package deals, guide fees and hotels. Conversely, the typical public fishery angler spends most of his money on gasoline, licenses and supplies. As fishing licenses are not required at many private sites, anglers at private fisheries can enjoy fishing without the added upfront cost of $31 or $41.50 for Colorado and California, respectively (CDOW, 2010, CDFG, 2010)[7]. Although California anglers spend a bit more overall than do Colorado anglers, gasoline expenditures of California anglers dwarf those of Colorado anglers. Colorado Anglers, on the other hand, spend more money on airfare and rental cars (more Colorado anglers are from out-of-state). Figure 1 demonstrates the different types of expenditures of the three surveyed angler groups.

[7] Fishing license expenditures per day are not the same as annual license costs in that these expenditures refer to those purchases made for the most recent fishing trip (which may have been the cost of a license, or may have been zero, even for public-fishery anglers).

Figure 1. Daily Angler Expenditures by Category



Expenditures from all three angler groups are averaged and aggregated into sales categories that align with IMPLAN sectors. Table 9 gives the amount spent by the average angler in a typical day in a variety of these categories.

Table 9: Daily Angler Expenditures by Category

	Average	Standard Deviation
ASRF Customers	$38.98	$272.86
Groceries	$10.43	$26.53
Gasoline	$36.24	$155.52
Other	$16.57	$130.82
Airline	$4.22	$52.39
Rental Car	$3.08	$31.97
Horseback Riding	$19.22	$110.18
Hotel	$8.61	$52.35
Campsites	$2.61	$16.65
Restaurant	$9.63	$40.94
Total	$149.58	

With the information in table 9, IMPLAN software is used to simulate a hypothetical removal of angler dollars from the Western Region. Then, the effect of a removal of one dollar of angler expenditures is reported in the form of output and employment multipliers, just as in the previous two sections. On average, every dollar spent by anglers results in an additional $.83 cents generated in the region, and every million dollars spent by anglers directly results in 18.36 jobs (25.07 jobs when accounting for the multiplier effect).This information is summarized in table 10.

Table 10: Angler Expenditure Multipliers

	Direct Effect	Indirect Effect	Induced Effect	Total Effect	Type SAM Multiplier
Output	1.00	0.41	0.41	1.83	1.83
Employment	18.36*	3.64	3.07	1.37	1.37

5.3 Forward linkages and Total Economic Contribution of the ASRF Industry

Table 7 shows the level of sales, jobs, and expenditures at an aggregated industry level for the ASRF industry (not including the sales of food fish). These numbers are found by multiplying the average levels (from above) by the total number (173) of potential individual ASRF businesses. Average sales data in conjunction with our estimate of 173 total producers and equation (3) above results in a mean estimate of $57.2 million in ASRF direct sales annually.

Mean annual expenditures of ASRF customers on ASRF products is approximately $2656 annually. Since ASRF industry sales total $57.2 million, but only $53.2 million to non-ASRF customers (some producers buy from other producers), we predict, using equation (4), that there are approximately 20,053 ASRF customers in the Western US. Therefore, while ASRF customers purchase only $53.2 million of ASRF products, equation (5) predicts that the availability of those products is estimated to create $272.6 million in direct sales to anglers.

Using equation (6), we estimate that there are 6.99 million ASRF supported angler days in the Western US. This is in contrast to Caudill (2005) which assumes that *all* angler expenditures are due to stocked fishing. This study accounts for ASRF customers reported percentage of sales attributable to stocked fishing. Our ASRF customer survey indicates that anglers spend an average of $38.98 in a typical day at a private fishery. However, our angler survey reveals that anglers in fact spend $149.58 on a typical fishing day. This is due to off-site expenditures such as airfare, gasoline, groceries, etc. As such, there are shocks to other industries, such as petroleum refineries, which would occur as a result of a hypothetical removal of the ASRF customer industry, as seen in table 9. The direct expenditures by the 6.99 million privately stocked fish induced angler days is estimated to be $1.046 billion annually, with $272.6 million of this going to ASRF customers.

The total economic contribution of the ASRF industry is calculated by tracing the backward linkages of a complete hypothetical exodus of ASRF industry-induced angler expenditures from the region in IMPLAN. ASRF industry-induced angler expenditures amount to $1.04 billion dollars annually in the Western US, but these direct expenditures lead to many indirect and induced effects throughout the economy.

Table 11 provides estimates of the total output and employment contributions of forwardly-linked industries related to ASRF. The $53.25 million dollars of direct sales of ASRF products leads to a total of nearly $2 billion dollars in economic activity in the Western Region of the US. This translates into a “contribution multiplier” of 35.92: for every $1 of sales of ASRF products, $35.92 dollars of in-region economic activity is attributable to the ASRF industry[8]. Furthermore, 26,229 full-time jobs are supported by the presence of this industry. An employment contribution multiplier of 492 in this instance means that for every one million dollars of ASRF sales, nearly 492 full-time jobs are supported in the region.

Table 11: Output and Employment Contribution of ASRF Industry in the Western United States

	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Total ASRF Sales	$53,251,888			
Total Output[a]	$1.04 Billion	$433 Million	$434 Million	$1.91 Billion
Total Employment[a]	19,205	3,810	3,214	26,229
Output Contribution Multipliers[b]	19.64	8.14	8.14	35.92
Employment Multipliers[c]	360.64	71.55	60.35	492.54

[a]Derived from ASRF induced Angler Expenditures
[b]Dollars of economic activity per dollar of *ASRF producer* output.
[c]Jobs per million dollars of *ASRF producer* output.

Several industries are affected more significantly than others. Table 12 outlines, as an example, the top 10 industries affected in terms of output by the presence of the ASRF industry. ASRF customers rank first, but closely following is gasoline stations, grocery stores, and sporting goods stores.

[8] This is different from a traditional multiplier (see table 6), which only accounts for the backward linkages of an industry's output.

Table 12: Top 10 Output Sectors Impacted by ASRF Industry (in Millions of Dollars)				
IMPLAN Sector	Direct Effect	Indirect Effect	Induced Effect	Total Effect
ASRF Customers	$272.58	$0.00	$0.00	$272.59
Retail Stores - Gasoline stations	$253.42	$5.30	$2.51	$261.23
Other amusement and recreation industries	$134.43	$0.25	$0.86	$135.54
Retail Stores - Sporting goods- hobby- book a	$115.89	$1.67	$1.36	$118.93
Food services and drinking places	$67.33	$24.47	$19.33	$111.13
Retail Stores - Food and beverage	$72.93	$0.32	$6.85	$80.10
Hotels and motels- including casino hotels	$60.22	$1.49	$2.61	$64.32
ASRF Industry	$0.00	$57.24	$0.00	$57.24
Real estate establishments	$0.00	$33.06	$19.99	$53.05
Imputed rental activity for owner-occupied dwellings	$0.00	$0.00	$45.80	$45.80
Total	$1,046.11	$433.39	$433.57	$1,913.07

6. Conclusion

For people not native to the region, the Western United States represents the frontier of adventure. Recreational fishing is no small part of this image, with Rocky Mountain Trout, wild coastal salmon runs, and Southern California world-record largemouth bass creating opportunities for anglers to test their skills and connect with nature. This recreational industry also supports billions of dollars of sales and hundreds of thousands of jobs in that region. The private, recreation-based aquaculture industry supports a substantial portion of this economic activity.

The Aquacultural Suppliers of Recreational Fish (ASRF) producers in the Western US are typically small businesses, on average grossing only $330,000 annually in recreational fish sales. That there are no more than 173 of these small businesses may lead policymakers to overlook this industry as an insignificant component of their economy. However, these 173 producers support over 20,000 privately-stocked fisheries and nearly 7 million annual angler days. Results show that for every dollar spent on ASRF products, $36 dollars of activity and are created and that for every million dollars of ASRF sales, nearly 500 jobs are supported in the region. The aggregate contribution of this industry that sells $53.2 million worth of fish is estimated to be nearly $2 billion annually.

The challenge for Western policymakers is to weigh the costs and benefits of policies which may put a damper on ASRF production. Current legislation facing the ASRF industry involves increased regulations with regards to permitting, disease mitigation, endangered species and stocking policies. However, it is important to recognize that these regulations may have adverse effects on the regional economy. Accounting for these regional economic effects will foster enhanced efficiency and welfare not only for the ASRF industry, but for their customers, recreational anglers, and the general economy of the Western US.

There are several potential shortcomings to the analysis presented here that should be noted. First, the estimates of economic contribution reported in this study are based on primary data collected via mail survey. While every effort was made to represent the major backward and forward linkages of the ASRF industry in accordance with best practice and standard economic theory, there are a variety of potential sources of error associated with these estimates, including sampling bias (via self-selection), statistical variability, and sensitivity to outliers.

Second, the input-output models used in this paper are known to have several shortcomings. These include, but are not limited to, assumptions of constant returns to scale, no input substitutability in fish production and other industries, constant prices, etc. Several of the most common issues with input-output analysis are discussed and justified in Leonteif (1955) and Miller and Blair (2009). Most of these limitations are due to the practical realities of modeling economy-wide economic impacts, where researchers wish to make with- vs. without- comparisons, but data only exists on the with- scenario. These issues, which are prevalent in nearly all economic impact and economic contribution analyses, will tend to result in over-estimation of the economic contribution or impact of a particular sector.

Third, the Western Region is treated as the region of analysis in this study, which may thwart efforts to extrapolate these results, including multipliers, to regions or sub-regions not presented in the text. This sort of extrapolation is not advisable given differences in regional economic structure and characteristics of ASRF producers.

Fourth, we make no claim as to economic *impact* of the ASRF and supporting industries as defined above in the introductory section, as we have little to no information about the potential for substitution production activities in the case of the various industries involved, as well as the recreational substitution patters of anglers in the Western US. Rather, we simply estimate the total expenditures related to the ASRF industry, and trace their flow through the regional economy. Nevertheless, we believe that both our data collection and economic contribution methodologies are sound, and place the economic contributions of the ASRF industry in reasonable context.

Finally, although this study accounts for the total economic contribution of the ASRF industry, it should be noted that this is not the only indicator of economic importance. Economic value, often referred to as "consumer surplus," is the difference between an individual's maximum willingness to pay and what he or she actually needs to pay for some good. In the case of privately stocked fishing, anglers may derive many millions of dollars worth of satisfaction over and above what they actually paid at the ASRF customer site. This is different from the economic contribution of the ASRF industry, which merely tracks the amount of output dollars and jobs that come as a result of the presence of that industry. This economic value is a direct measure of the welfare induced by the presence of the ASRF industry, and future analysis should endeavor to account for this value in order to elucidate the true economic *benefits* of the ASRF industry to the Western US. Nevertheless, the estimates provided in the present analysis should prove useful today given the current economic climate and pressure on fish stocking from various environmental groups.

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Chapter 1 Appendices
Appendix 1A: Producer Survey Cover Letter

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FAX: (970) 491-2067
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Dear Aquacultural Producer,

In 2006, with producer support, the Western Regional Aquaculture Center sponsored a project to assess the economic contribution of the Aquacultural Suppliers of Recreational Fishing (ASRF), an industry that has not previously had its role and economic impact on the region assessed in detail. Completion of this project requires assistance from all ASRF producers during the information gathering process. It is imperative that the survey results reliably represent the broadest possible activity of ASRF producers, so your input is valuable. This project will be administered by the Department of Agricultural and Resource Economics at Colorado State University in conjunction with participation of faculty members throughout the Western United States. The participants include faculty from the University of Arizona, University of California, Davis, University of Idaho, and New Mexico State University.

The survey will examine the range of activities undertaken by ASRF producers and determine major issues facing the industry. In this survey, we ask first about the general size of your operations, and then we ask about a variety of sales outlets and locations. These questions are followed by questions regarding costs incurred within your operation and the values and purchases of a variety of assets. A clear, research-based understanding of the contribution of the ASRF industry will permit the best possible demonstration of your economic value to the Western region. All information gathered in this survey will be managed according to CSU's strict confidentiality requirements during and after the completion of this project.

While your participation in this survey research is of great importance to us, we would like to ensure you that your participation is voluntary. Your responses will be held in strict confidence and reported only in aggregated form. There are no known risks to your participation in this survey. It is not possible to identify all potential risks in research procedures, but we have taken reasonable safeguards to minimize any known and potential, but unknown, risks.

To complete the survey, please use 2007 data for your financial, marketing, and business size information. Those producers completing the survey are eligible to receive copies of the completed survey results, with appropriate disclosure and confidentiality dimensions in place. If this survey does not actually apply to you, simply write a brief explanation on the survey and return it in the enclosed pre-paid envelope.

For more information about this project, please contact Dr. Craig Bond at 970-491-6951, or by email at Craig.Bond@colostate.edu

Sincerely, Dr. Craig Bond, Principal Investigator

Appendix 1B: Producer Survey

The Economic Contribution of the Aquacultural Suppliers of Recreational Fish




How Important Are You to Your Local Economy?

Section A: General Operational Questions

Aquaculture producers vary substantially in scale and scope and may use a great variety of technologies. In order to better understand the variety of aquaculture producers in the west, we need to ask questions about your operation.

1. Please indicate your production and sales levels for <u>salmonids</u> (trout, salmon, etc.) and for your <u>warm/cool water species</u> (in terms of **sales dollars for 2007**). (If you do not produce or sell warm/cool water fish, please leave these sections blank. If you do not produce or sell Salmonids, please leave these sections blank.)

- **Salmonids**

<u>Production</u> Levels:________ (Lbs/Year) Sales $_____________
<u>Brokered</u> Levels: _________(Lbs/Year) Sales $_____________

- **Warm/Cool Water Species**

<u>Production</u> Levels:________ (Lbs/Year) Sales $_____________
<u>Brokered</u> Levels: _________(Lbs/Year) Sales $_____________

2. Which ***methods of production*** did this operation use for Salmonids and Warm/Cool Water Species in 2007? <u>This does not apply to brokered fish</u>. Please enter total water area or volume for each method used, and check the box in the species column corresponding to the species that use this technology. You may indicate one or both species for each technology.

Methods of Production

Technology	**Average Flow Rate: GPM if applicable**	**Salmonids, Warm/Cool Water Species, or both (<u>check boxes as apply</u>)**		**Size**	**Unit**
		Salmonid	Warm/ Cool Water		
Still Ponds					Surface Acres
Flow Through Ponds					
Flow Through Raceways					
Flow Through Tanks					
Cages					Total Volume Cu. Ft.
Net Pens					Total Volume Cu. Ft.
Closed Re-Circulation Tanks					Gallons
Other________________					Specify Unit___

3. How many species of Salmonid and Warm/Cool Water fish did you produce/sell in 2007?
Total # of Salmonids: _________ Total # of Warm/Cool Water Fish Species: _________

Section B: Sales Information

This section applies both to brokers and to producers. Please tell us about the sales of your Salmonids and your Warm/Cool Water Species. If you do not produce or broker warm/cool water fish, please leave these sections blank. If you do not produce or broker Salmonids, please leave these sections blank.

Salmonids			
Size Category	Amount		Sales (Dollars)
Trophy size (Over 16”)		Pounds Live Weight	$
Catchables (9-16 inches)		Pounds Live Weight	$
Sub-Catchables (less than 9 inches)		Count	$
Forage Minnows		Count	$
Eggs		Count	$
Other (Please Specify ___________________)		Other (Specify) __________	$

Warm/Cool Water Species			
Size Category	Amount (Circle pounds OR count)		Sales (Dollars)
Trophy size (Indicate Size__________________)		Pounds Count	$
Catchables (Indicate Size___________________)		Pounds Count	$
Sub-Catchables (Indicate Size_______________)		Pounds Count	$
Forage Minnows		Pounds Count	$
Eggs		Pounds Count	$
Other (Please Specify ___________________)		Other (Specify) __________	$

What percent of your production reported by species in item 1 was sold to each of the following SALES OUTLETS from January 1 through December 31, 2007? **Note: The values in each ROW should sum to 100.**

To Whom Do You Sell Your Salmonids?						
Percent of value of Salmonids sold as:	Brokers/ Consultants	Food Fish	Recreational Outlets **(Public)**	Recreational Outlets **(Private)**	Other (specify) ________	Total
Trophy size (Over 16")	%	%	%	%	%	100%
Catchables (9-16 inches)	%	%	%	%	%	100%
Sub-Catchables (less than 9 inches)	%	%	%	%	%	100%
Forage Minnows	%	%	%	%	%	100%
Eggs	%	%	%	%	%	100%
Other (Please Specify ___________________)	%	%	%	%	%	100%

To Whom Do You Sell Your Warm/Cool Water Fish?						
Percent of value of warm/cool water fish sold as:	Brokers/ Consultants	Food Fish	Recreational Outlets **(Public)**	Recreational Outlets **(Private)**	Other (specify) __	Total
Trophy size (Indicate Size___)	%	%	%	%	%	100%
Catchables (Indicate Size___)	%	%	%	%	%	100%
Sub-Catchables (Indicate Size___)	%	%	%	%	%	100%
Forage Minnows	%	%	%	%	%	100%
Eggs	%	%	%	%	%	100%
Other (Please Specify ______)	%	%	%	%	%	100%

Could you please estimate the location of your buyers? (Please estimate the percentage of sales within your state and outside of your state for each species)

1. Please indicate the percentage of Salmonids you sell in state, out of state within WRAC* and out of state outside of WRAC.

Within your state: _________% Out of State (Within WRAC) __________% Out of State (Non-WRAC) _________%

2. Please indicate the percentage of Warm/Cool Water fish you sell in state, out of state within WRAC* and out of state outside of WRAC.

Within your state __________% Out of State (Within WRAC) __________% Out of State (Non-WRAC) _________%

3. Now, please break out the categories and describe what percentage, within each category, are sold to the following outlets:

How much do you sell in state? Out of state?

Percent of value of fish sold to outlet as:	Brokers/ Consultants	Food Fish	Recreational Outlets **(Public)**	Recreational Outlets **(Private)**	Other (specify) _______
Salmonids					
Within Your State	%	%	%	%	%
Out of State (Within WRAC*)	%	%	%	%	%
Out of State (Non-WRAC*)	%	%	%	%	%
Total	100%	100%	100%	100%	100%
Warm/Cool Water Species					
Within Your State	%	%	%	%	%
Out of State (Within WRAC*)	%	%	%	%	%
Out of State (Non-WRAC*)	%	%	%	%	%
Total	100%	100%	100%	100%	100%

*The Western Regional Aquaculture Center (WRAC) is an organization of twelve states (Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming) which cooperate in order to provide quality resources for aquaculture producers in those states.

Section C: Costs

1. Labor Expenditure Information

For the following table, please indicate the number of workers in employed in each category in 2007. Please do NOT include seasonal workers:

Labor Expenditure Information					
	Number of Workers	Average Hours per Week	Total Annual Wages	Benefits (% of total Wages)	Taxes and Insurance (% of total wages)
Hired Labor (Non-Family)			**$**	**%**	**%**
Self Labor	**1**				
Family Labor					

1. Do you hire **seasonal workers**?

NO YES

2. If you answered YES to number 1, please tell us a little more about these employees:

a. Average number of Seasonal Employees hired annually
_____________employees

b. Percentage of seasonal workers who are also Family Members:
_____________%

c. Seasonal employee Average Hours Worked per week:
____________hours/week

d. Please circle the months during which you typically employ seasonal workers:

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

2. Material and Energy Expenditure Information for 2007

Please indicate your source of material purchases. The values in each Column should sum to 100.

Source of Material Purchases				
Source	Sub-Catchables/ Forage Minnows	Eggs	Feed Purchases	Fish for Resale
Producers **Within** your state	%	%	%	%
Out of State Producers (Within WRAC)	%	%	%	%
Out of State Producers (Non-WRAC)	%	%	%	%
Total	100%	100%	100%	100%

Please give us the annual, total expenditure for the following material inputs in your Aquacultural Suppliers of Recreational Fish (ASRF) business.

Non Depreciated Expenditures		
Sub Catchables/Forage Minnows	**$**	**Pounds __**
Eggs	**$**	**Count __**
Feed	**$**	**Pounds __**
Fish for Resale (Brokerage)	**$**	**Pounds___**
Chemicals/Supplies	**$**	
Oxygen	**$**	
General Consumable Supplies (e.g. nets)	**$**	
Electricity	**$**	
Natural gas/propane	**$**	
Other Utilities	**$**	
Non-Shipping Depreciated Vehicle Expenses (non-fuel)	**$**	
Gasoline	**$**	
Marketing and Advertising	**$**	
Shipping and Distribution	**$**	
Licenses/Permits/Inspection Fees	**$**	
Non-Labor Insurance	**$**	
Other_______________	**$**	

3. Depreciated Expenditures

Could you please give *annual* expenditures for 2007 on **equipment** (e.g. Feeders, Graders, Filtration, Pumps, Small Equipment, etc.), **buildings and structures** (e.g. Storage Sheds), **fish production facilities** (e.g. Ponds, Raceways, etc.), and **transportation equipment** (e.g. trucks, tanks, etc.)

Depreciated Expenditures			
	Purchase	Maintenance	Lease
Equipment	$	$	$
Buildings and Structures	$	$	$
Fish Production Facilities	$	$	$
Transportation Equipment	$	$	$

4. Water Expenditures

1. What is your source of water? (Percentages should sum to 100%).

_____% **Groundwater** (Water from closed springs, underground drainlines, or a well or wells located on this farm or another farm)

_____% **On-Farm Surface Water** (Surface supply not controlled by a water supply organization [stream, drainage ditch, lake, pond, open spring, or reservoir on or adjacent to this farm])

_____% **Off-Farm Water** (Federal supplier; irrigation district; mutual, private; cooperative, or neighborhood ditches; commercial company or municipal or community system)

2. What is the proportion of water that you used in 2007 do you own? Lease?
Own_____________%Lease_____________%

3. What are your annual non-pumping water delivery costs?
$________________

Section E: Business Information

Please answer the following questions regarding your household and personal characteristics:

1. In what year were you born? __________

2. Gender: Male_____ Female ________

3. Years in Business as Supplier of Recreational Fish: __________(years)

4. Years in Business in Aquaculture in General: __________(years)

5. Size of Household: ________ (Persons)

6. Marital Status (check one): Single_____ Married ______

7. Is your home located at the same site as your business? (Circle one)

Yes No

8. If you circled "No" in number 7, please tell us the zip code where you live:
Zip Code________

9. The earnings from your labor and profits in this ASRF business represent what percentage of your total household income? ______________________%

Thank you for taking the time to fill out this survey! If you have any comments or concerns, please contact Dr. Craig Bond at 970-491-6951, or by email at Craig.Bond@colostate.edu. You can also visit our website at http://dare.colostate.edu/wracimpact.html

Appendix 1C: Producer Survey Postcards

Thank you for your participation in our survey

We would like to thank you for participating in our survey of the Aquacultural Suppliers of Recreational Fish (ASRF). If you have not yet had a chance to fill out our survey, please take a moment to look it over and if you have any questions, please feel free to contact me at your earliest convenience.

Colorado State University

Dr. Craig Bond

Department of Agricultural and Resource Economics
Campus Delivery 1172
Fort Collins, Colorado 80523-1172

Phone: 970-491-6951
Fax: 970-491-2067
E-mail: Craig.Bond@Colostate.edu
http://dare.colostate.edu/wracimpact.html

Colorado State University

Dr. Craig Bond

Department of Agricultural and Resource Economics
Campus Delivery 1172
Fort Collins, Colorado 80523-1172

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Appendix 1D: Customer Survey Cover Letter

Department of Agricultural and
Resource Economics
Fort Collins, Colorado 80523-1172
(970) 491-6325
FAX: (970) 491-2067
http://dare.colostate.edu/

Dear Private Fishery Operator,

In 2006, with support from the aquaculture industry, the USDA sponsored a project to assess the economic contribution of the private fishing industry in the Western United States. The private fishing industry is one that has not previously had its role and economic impact on the region assessed in detail.

This project will be administered by the Department of Agricultural and Resource Economics at Colorado State University, in conjunction with participation of faculty members throughout the Western United States. The participants include faculty from the University of Arizona, University of California, Davis, University of Idaho, and New Mexico State University.

The survey will examine the range of activities undertaken by private fisheries in Colorado. The results of this project will demonstrate exactly how important you and your industry are to the economy. As stated in a previous letter, policymakers will be able to use this information in order to potentially look more favorably upon your industry. All information gathered in this survey will be managed according to CSU's strict confidentiality requirements during and after the completion of this project.

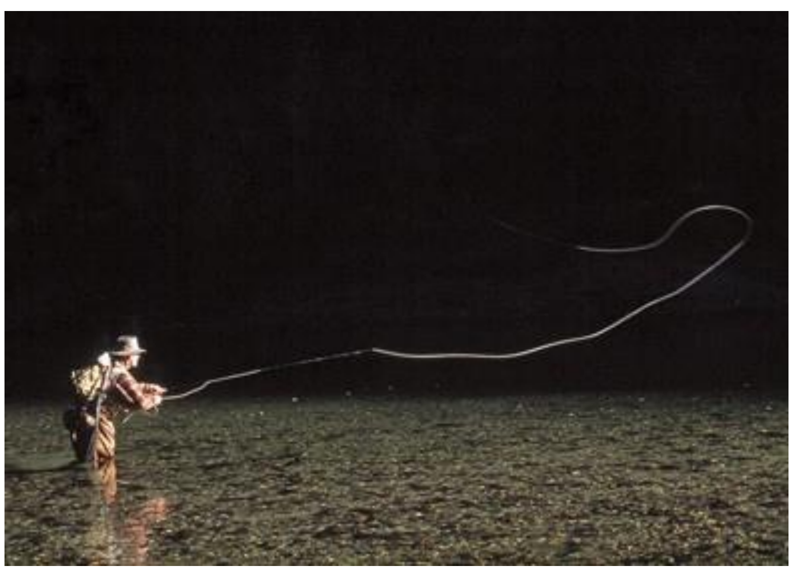
To complete the survey, please use 2008 data. If you have any questions or concerns, you can visit our website at http://dare.colostate.edu/privatefisheryimpact.aspx. If you have any additional questions, please feel free to contact our project manager, Dr. Craig Bond, at
970-491-6951, or by email at Craig.Bond@colostate.edu

Sincerely,

Dr. Craig Bond
Principal Investigator

Appendix 1E: Customer Survey

The Economic Contribution of Private Fisheries in the Western United States



How Important Are You to Your Local Economy?

Section A: General Operational Questions

Private fishing operations vary substantially in scale and scope. In order to better understand the variety of private fisheries in the west, we need to ask questions about your operation. Your responses will be held in strict confidence and reported only in aggregated (average) form.

1. Which types of Salmonid and Warm/Cool Water fish did you **stock** in 2008?

Salmonids:
□ Rainbow Trout □ Brown Trout □ Brook Trout □ Cutthroat Trout
□ Steelhead □ Other (Specify) ________________________________

Warm/Cool Water Species:
□ Bass □ Bluegill/Crappie □ Catfish □ Walleye □ Grass Carp □ Sturgeon
□ Fathead Minnows □ Mosquitofish □ Other (Specify) ____________________

2. What sort of fishing operation did you operate in 2008? Please **check all boxes that apply**, and please indicate the size of the water body/bodies at your location.

Type of Operation				
Fishing Waters	**Salmonids, Warm/Cool Water Species, or both (please *check boxes*)**		**Total Size**	**Unit**
	Salmonid	Warm/Cool Water		
Private Dude Ranch (River or Stream-Based)	☐	☐		Miles of Stream or River fished
Private Dude Ranch (Lake or Pond Based)	☐	☐		Surface Acres of Lake or Pond
Private Fishing Club (River or Stream-Based)	☐	☐		Miles of Stream or River fished
Private Fishing Club (Lake or Pond Based)	☐	☐		Surface Acres of Lake or Pond
Fee-Fishing Pond (U-Fish)	☐	☐		Surface Acres of Pond
Homeowner's Association	☐	☐		Surface Acres of Lake or Pond
Other (e.g. your own private land) Please Specify: ________	☐	☐		Specify Unit ________________

3. Approximately how many anglers visited your operation during 2008?: __________

4. What activities are typically enjoyed at your fishery (check all that apply)?:
□ Fishing from Bank/Wading □ Fishing from a Boat □ Belly Boat Fishing
□ Flyfishing □ Motorized Boating □ Rafting, Kayaking, Canoeing
□ Camping □ Horseback Riding □ Fishing with Family/Friends
□ Hiking/Backpacking □ Photography □ OHV Recreation (e.g. 4x4)
□ Viewing Scenery and Wildlife □ Biking □ Other, please describe:______________

Section B: Regional Economic Activity

The Western Region, as defined by the Western Regional Aquaculture Center (WRAC), includes the following 12 states: Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming.

Could you please estimate the percentage of your 2008 anglers that live within your state, the percentage that live out of state but within the Western Region, and the percentage of anglers that live outside of the Western Region?

How many anglers are from in state? Out of state? Out of Region?	
Angler Home Locations	Percentage of anglers from these locations
Anglers from within your state	☐ 0% ☐ 1-20% ☐ 21-40% ☐ 41-60% ☐ 61-80% ☐ 81-99% ☐ 100%
Anglers from out of State (**but within** Western Region)	☐ 0% ☐ 1-20% ☐ 21-40% ☐ 41-60% ☐ 61-80% ☐ 81-99% ☐ 100%
Anglers from out of State (**and outside** of the Western Region)	☐ 0% ☐ 1-20% ☐ 21-40% ☐ 41-60% ☐ 61-80% ☐ 81-99% ☐ 100%
Total	**100%**

Please indicate your source of material purchases. Non-applicable categories should be left blank. The values in each column should sum to 100%.

Source of Feed and Fish Purchases				
Source	Feed	Sub-Catchables/ Forage Minnows/Weed Control Fish	Catchable Fish	Trophy Size Fish
Producers from within your state	%	%	%	%
Producers from out of State (**but within** Western Region)	%	%	%	%
Producers from out of State (**and outside** of the Western Region)	%	%	%	%
Total	**100%**	**100%**	**100%**	**100%**

Section C: Sales Information

1. What was your gross revenue in 2008? _________________

2. In the table below, please indicate the percentage of sales derived from the following categories (If a particular category does not apply to you, please write an **"X".**):

Percentage of Sales from Major Categories	
Item	Percentage of Sales
Entrance Fees/Rod Fees/Guest Permits	N/A
Entrance/Rod fees or permits for Salmonid Fishing	%
Entrance/Rod fees or permits for Warm/Cool water fishing	%
General entrance fees, or fees unrelated to fishing	%
Annual Membership Dues	%
Lodging	%
Guiding Services	%
Fishing Equipment/Boat Rentals or Bait Sales	%
Food (e.g. snacks, sodas, or meals)	%
Non-Fishing Recreational Services (e.g. horseback riding)	%
Miscellaneous Retail (e.g. gift shop)	%
Other (Specify)_______________________	%
Package Deals (including any of the above activities) **(Please do not "double count" sales from above categories)**	%
Total	**100%**

1. What percentage of your operation's total sales is attributable to **fishing**? This may include fishing items such as guiding services and equipment rentals, as well as non-fishing items that only exist as a result of your fishing operation, such as lodging and food.

☐ 0% ☐ 1-20% ☐ 21-40% ☐ 41-60% ☐ 61-80% ☐ 81-99% ☐ 100% Comments?:_____________

2. What percentage of your fishing related sales is attributable to ***Stocked*** (i.e. hatchery) fish?

0% ☐ 1-20% ☐ 21-40% ☐ 41-60% ☐ 61-80% ☐ 81-99% ☐ 100% ☐ Comments?:_____________

3. On average, how much does a **typical angler** spend per day at your operation? ________________$/day

Section D: Costs

1. Water Expenditures

1. What is the proportion of water that you used in 2008 do you own? Lease? Own Access? Own_________% Lease________% Own Access_________%

2. What are your annual non-pumping water delivery costs (e.g. lease costs, ditch fees, etc.)? Pumping costs are addressed in section 3. $________________

2. Labor Expenditure Information

For the following table, please indicate for 2008 the **total** number of workers in employed in each category. This is not restricted to your fishing operation. Please do NOT include seasonal workers:

Labor Expenditure Information					
	Number of Workers	Average Hours per Week	Total Annual Wages	Benefits (% of total Wages)	Taxes and Insurance (% of total wages)
Hired Labor (Non-Family)			**$**	**%**	**%**
Self Labor	**1**				
Family Labor					

Now, please tell us a bit about your hiring of seasonal workers.

1. Do you hire **seasonal workers** (circle one)?

NO *(Skip to Section 3)* YES

2. If you answered YES to number 1, please tell us a little more about these employees:

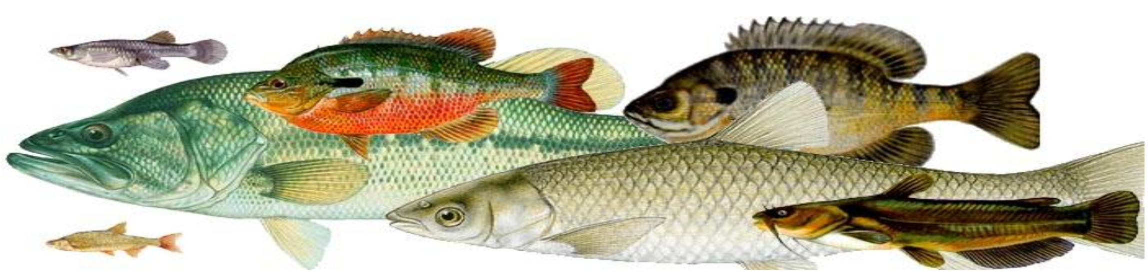
a. Average number of Seasonal Employees hired annually
____________employees

b. Percentage of seasonal workers who are also Family Members:
____________%

c. Seasonal employee Average Hours Worked per week:
___________hours/week

d. Please circle the months during which you typically employ seasonal workers:

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec



3. Material and Energy Expenditure Information for 2008

Please indicate whether or not you purchase items from the categories in the table below **for your fishing operation.** If you do purchase items within a category, please indicate the total cost of those items.

Operational (Non Depreciated) Expenditures		
Material	**Buy? Y / N (Yes/No, Circle One)**	**Total Cost**
Trophy Size Fish	**Y / N**	**$**
Catchable Fish	**Y / N**	**$**
Sub-Catchable Fish, Forage Minnows, and Weed Control Fish	**Y / N**	**$**
Feed	**Y / N**	**$**
Chemicals/Supplies	**Y / N**	**$**
Oxygen	**Y / N**	**$**
General Consumable Supplies (e.g. nets)	**Y / N**	**$**
Electricity (including pumping/aeration costs)	**Y / N**	**$**
Natural gas/propane	**Y / N**	**$**
Other Utilities	**Y / N**	**$**
Food (for customers)	**Y / N**	**$**
Equipment, bait, etc. (for customers)	**Y / N**	**$**
Non-Shipping Depreciated Vehicle Expenses (non-fuel)	**Y / N**	**$**
Gasoline/Diesel	**Y / N**	**$**
Marketing/Advertising/Mailings	**Y / N**	**$**
Licenses/Permits/Inspection Fees	**Y / N**	**$**
Non-Labor Insurance	**Y / N**	**$**
Other (Please Specify) ____________________ ____	**Y / N**	**$**
Total		**$**

4. Depreciated Expenditures

Could you please give *annual* expenditures for 2008 **for your fishing operation** on equipment (e.g. Feeders, Graders, Pumps, Small Equipment, etc.), buildings and structures (e.g. Storage Sheds), fish habitat facilities (e.g. ponds, streams, etc.) and land.

Capital (Depreciated) Expenditures			
	Purchase	Maintenance	Lease
Equipment	$	$	$
Buildings and Structures	$	$	$
Fish Habitat Facilities	$	$	$
Land	$	$	$

Section E: Business Information

Please answer the following questions regarding your household and personal characteristics. Your responses will be held in strict confidence and reported only in aggregated form:

1. What is your role at this operation (check all that apply)?

☐ General Manager ☐ Owner ☐ Other (Specify) _________

2. In what year were you born? 19____

3. Are you? ☐ Male ☐ Female

4. Years in a private fishing operation: __________(years)

5. Your highest level of formal education? (Please circle one)

Elementary School	Jr. High or Middle School	High School	Associates Degree	College (B.S./B.A) or Technical School	Graduate or Professional School

6. How many members are in your household: ________ (persons)

7. How many household members contribute to paying the household expenses? _________ (persons)

8. Marital Status (check one): ☐ Single ☐ Married

9. Is your home located at the same site as your fishing operation? (Check one)

☐ Yes ☐ No

10. If you circled "No" in number 9, please tell us the zip code where you live:

Zip Code________

11. The earnings from your labor and profits in your private fishing operation represent approximately what percentage of your total household income? ______________%

Thank you for completing the survey!

Please place your survey in the enclosed stamped return envelope and drop it in the mail. If you have any comments or concerns, please feel free to write on the back of this page.

COMMENTS?

Please feel free to write any comments you have about private fisheries in the Western United States. When you are finished, please place the survey in the stamped return envelope and mail it back to us. If you have any additional questions or concerns, please visit our website at http://dare.colostate.edu/privatefisheryimpact.aspx

Colorado State University
Department of Agricultural and Resource Economics
Campus Delivery 1172
Fort Collins, CO 80523-1172

Appendix 1F: Customer Postcards

Thank you for your participation in our survey

Last week you were given a survey asking questions about your private fishing operation.

If you already completed and returned the survey, please accept our sincere thanks. If you have not, please complete the survey and mail it back to us in the stamped return envelope.

Your responses will be very useful in our effort to demonstrate the economic contribution of your industry.

If your survey has been misplaced, please call me or email me and I will mail you a new one immediately.

Colorado State University

Dr. Craig Bond

Phone: 970-491-6951
Fax: 970-491-2067
E-mail: Craig.Bond@Colostate.edu
http://dare.colostate.edu/privatefisheryimpact.aspx

Colorado State University

Dr. Craig Bond

Department of Agricultural and Resource Economics
Campus Delivery 1172
Fort Collins, Colorado 80523-1172

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Appendix 1G: Customer Postcards with Local Private Hatchery Heading

Dear Fish Friend:

You are receiving this postcard because we at Cline Trout Farms have identified you as a business or person well-suited to participate in a new study being administered by Colorado State University.

This study, with your help, will determine the economic contribution of privately stocked and privately operated fishing opportunities in Colorado. When the study is completed, we will have data to prove what we already know - that fish farmers and privately stocked waters have a significant impact on the economy of Colorado and the west.

By doing this, we will be provided with a tool to inform policy makers in their decision making process. Presumably, with this information, their decisions may be more favorable to all of us.

You will be receiving a more detailed letter from CSU in a few days. We are looking forward to the results of this study! You can call us at any time at 303-682-1970.

Sincerely,
Ken Cline and Rebecca Cooper

Cline TROUT FARMS

RAINBOW • BROOK • BROWN • CUTTHROAT
5555 VALMONT ROAD • BOULDER, COLORADO 80301
(303) 442-2817 • FAX (303) 443-2484

PLEASE PLACE STAMP HERE

Appendix 1H: California Angler Survey Cover Letter

Department of Agricultural and
Resource Economics
Fort Collins, Colorado 80523-1172
(970) 491-6325
FAX: (970) 491-2067
http://dare.colostate.edu/

Dear Angler,
Thank you for agreeing to participate in this study. The purpose of this study is to help managers improve fishing in California. Answering the survey will only take a few minutes, but will greatly aid fisheries managers in their decisions regarding your favorite fishing areas in California.

To complete the survey, please refer to your most recent trip (where you were handed this survey). Your responses are important to us whether this is the first time you have fished here or the hundredth time. We want to hear what you think about your fishing trip here!

When you have completed the survey please mail it back to us in the enclosed postage paid stamped return envelope.

Your responses will be held in strict confidence and all results are reported only in summary form. While your responses to this survey are completely confidential and your name will NOT be associated with your survey responses, those who complete the survey will be **entered into a drawing for one of five $100 gift certificates to** Cabela's redeemable at one of their stores or their website.

The results of the survey will be posted on the Colorado State University Department website (http://dare.colostate.edu/anglersurvey.html) next fall. This website also provides answers to frequently asked questions about the survey. However, if you have any questions whatsoever, please feel free to contact one of our project managers, either Dr. Craig Bond at Craig.Bond@colostate.edu, or Dr. John Loomis at John.Loomis@colostate.edu.

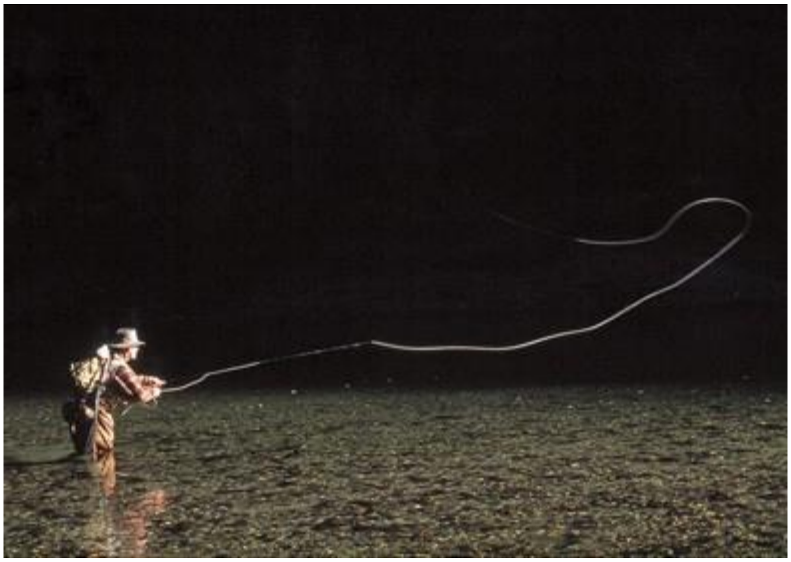
Thank you again for your willingness to complete the survey and we look forward to receiving it.

Sincerely,
Dr. Craig Bond
Assistant Professor, CSU
Project Manager

Dr. John Loomis
Professor, CSU
Project Manager

Appendix 1I: California Angler Survey

Your Fishing Trip in California



How can we make it better?

Colorado State University

UC DAVIS
UNIVERSITY OF CALIFORNIA

Thank you for agreeing to complete this survey. Your answers will be quite helpful to the groups that manage and support recreational fishing in California. In this survey, when we refer to a **trip** we mean a trip from home to the water body and back again. Thanks again, and we look forward to receiving your survey in the enclosed stamped envelope.

Section A. Please tell us about your trip to the water body (lake, reservoir, pond, river or stream) where you received this survey.

1. What was the name of the town nearest to the water body where you received this survey?

Name of town: ____________________

2. How many trips in the past 12 months did you make to the **water body** where you received this survey?

______ #Annual Trips

3. What species of fish were you targeting on **this trip** (check or list all that apply)?
□ Trout □ Bass □ Walleye □ Catfish □ Other ______________________

4. What was the total amount of time you spent on this trip visiting the water body where you received this survey (including all activities such as fishing, boating, camping, hiking, etc.)?

________# of hours or ________ # of days

4a. What was the amount of time that was spent **actually fishing** at this location on this trip?

________# of hours fished or ________ # of days fished

4b. During your **trip** to this water body, how many fish did you catch and how many did you keep?

________# of fish caught and ________ # of fish kept

4c. How many of these fish were species that you were **targeting**?

________# of **target** fish caught and ________# of **target** fish kept

4d. If you visited more than one water body during this trip, what was the total amount of time spent visiting all the water bodies on this trip from home?

________# of hours or ________ # of days

5. Please check the activities **you** participated in during this **trip** from home at the location where you received the survey (check all that apply):

□ Fishing from Bank/Wading □ Fishing from a Boat □ Belly Boat Fishing
□ Flyfishing □ Motorized Boating □ Rafting, Kayaking, Canoeing
□ Camping □ Horseback Riding □ Fishing with Family/Friends
□ Hiking/Backpacking □ Photography □ Other, please describe:_______
□ OHV Recreation (e.g. ATV, 4x4) □ Viewing Scenery and Wildlife __________________________

5a. If you checked more than one activity, which of these activities was the most important reason for your trip to this water body? Most Important Activity_____________________

6. Was your trip to this water body: (check only one):
□ the primary purpose or sole destination of your trip from home?
□ one of many equally important reasons or destinations for your trip from home?
□ just an incidental stop on a trip taken for other purposes or to other destinations?

7. What were your primary methods of travel to this water body (circle all that apply):

Car/Truck RV Airplane Other_____________________

8. What was the one-way **travel time** from your home to the water body where you received this survey?
___________ # hours ___________ # minutes

9. What was your one-way **travel distance** from your home to this water body?

___________# one-way miles

10. Including yourself, what was the number of **adults** and **children** in your group that traveled on this trip?

___________# of **adults** in your group and ___________# of **children** in your group

11. How crowded did you think the water body was where you received this survey? Please circle one number representing how crowded it was.

Not at All Crowded 1 2 3 4 5 6 7 8 9 10 Extremely Crowded

Please tell us about the importance level of several features of the water body **where you received this survey.**

Important Aspects of Your Most Recent Trip

Please circle one number for each item	Importance for your decision to visit this water body			
	Not Important/ Not Applicable	Somewhat Important	Important	Very Important
Opportunities to catch many (large #'s) of fish	1	2	3	4
Opportunities to catch trophy-sized fish	1	2	3	4
Opportunities to catch wild fish	1	2	3	4
Enjoying peace and solitude (without crowding)	1	2	3	4
Fishing near skilled anglers/fishermen	1	2	3	4
Socializing with other anglers/fishermen	1	2	3	4
Cleanliness of site	1	2	3	4
Amenities such as restrooms and parking	1	2	3	4
Catching fish to eat	1	2	3	4
River rafting/canoeing/kayaking	1	2	3	4
Motorized Boating	1	2	3	4
Viewing Scenery and Wildlife	1	2	3	4
Camping	1	2	3	4
Horseback Riding	1	2	3	4
Fishing with Family/Friends	1	2	3	4
Hiking/Backpacking	1	2	3	4
Photography	1	2	3	4
OHV Recreation(e.g. ATV, Dirt Bike, 4x4)	1	2	3	4
Other activities: Please list __________	1	2	3	4

Section B. Most Recent Trip Expenditures (*Please skip this section if you did not travel to the site where you were handed this survey (for example, the site was on your own property or on property owned by your homeowner's association*).

Please indicate the amount you and members of your group with whom you shared expenses (e.g., other family members, traveling companions) spent on each category on the **trip** during which you were given the survey. Note: The Western Region of the United States is comprised of twelve states (Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming).

Expenses on Your Most Recent Trip

Trip Expense	**Amount spent ON THIS TRIP in California**	**Amount spent ON THIS TRIP outside of California (but still in the Western Region)**
Gas & Oil for Auto &/or Boat	$	$
Food/drink: restaurants	$	$
Food/drink: grocery stores	$	$
Supplies/fishing tackle/bait/other retail	$	$
Camping on Public Lands	$	$
Camping at Private Areas	$	$
Hotel/motel	$	$
Equipment rental	$	$
Guide fees	$	$
Fishing License	$	$
Fishing Entrance/Catch/Access Fees	$	$
Rental car	$	$
Airline ticket	$	$
Fishing Club/Dude Ranch Package Deals **(Please do not "double count" expenses from above categories)**	$	$
Other; Please List ___________________________	$	$

1. Including yourself, how many people in your group shared these expenses on this most recent trip?

__________# of persons in your group sharing expenses

2. As you know, some of the costs of travel such as gasoline, hotels and restaurant meals often increase. If your share of the **total cost** of this most recent trip had been $_____________ **higher**, would you have made this trip to the water body where you received this survey?

Circle one: YES NO

3. Did you use a motorized boat on the trip where you were handed this survey? □ Yes □No

3a. If Yes, did you rent your boat, do you own your boat, or do you borrow a boat for free?
□ Rent □ Own □ Borrow for Free

3b. If you Own a boat, do you dock your boat at a marina or did you trailer your boat to this site?
□ Marina □ Trailer

Section C: Fisheries Management and Annual Recreation Trips

Suppose managers were no longer managing this water body for recreational fishing, and catch rates were to go down by half or 50% (with everything else unchanged). Please indicate how you would respond to this change in catch rates and fill in your estimate of the change in the number of trips (if any).

Would your decision to visit this water body change if you had <u>half</u> (-50%) the daily catch rate of your targeted species that you experienced on this trip?

☐ Yes, I would **<u>decrease</u>** my fishing trips to this water body by (#) _____ fewer trips per year.

☐ Yes, I would **<u>increase</u>** my fishing trips to this water body by (#) _____ more trips per

☐

1. *During which of the following months* do you typically go fishing in a typical year (Circle all that apply)?

<u>January</u> <u>February</u> <u>March</u> <u>April</u> <u>May</u> <u>June</u> <u>July</u> <u>August</u> <u>September</u> <u>October</u> <u>November</u> <u>December</u>

2. On a scale of 1 to 10, how would you *rate your skill level* as an angler (Please circle <u>one number</u>)?

Little or No skill at all <u>1</u> <u>2</u> <u>3</u> <u>4</u> <u>5</u> <u>6</u> <u>7</u> <u>8</u> <u>9</u> <u>10</u> Extremely Skilled/Professional

For the purposes of this survey, the Western Region of the United States is comprised of twelve states (Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming).

3. About how many total *outdoor recreation* trips do you take each year to areas **within** the western US?

____________ Annual # of trips

4. About how many total *outdoor recreation* trips do you take each year to areas **outside** the western US?

____________ Annual # of trips

Section D: Season Trip Information

This information on your annual visitation is important to fishing managers in deciding how to manage your fisheries, so please enter the total number of trips from home and the number of days you spent fishing at the following freshwater water bodies during the last year. **Please refer to the enclosed map for water body locations and study region in California.** By public waters we mean county, state or federal lakes, reservoirs, ponds or rivers such as those on National Forest land, in National Parks, on National Wildlife Refuges, and on California Department of Fish and Game natural resources properties. Other private waters include waters on private land that do not fit into listed categories such as your own private property or homeowner's association (HOA) property.

How many fishing trips did you take primarily for the purpose of fishing during the last 12 months to the following locations? How much time did you spend?

Water Bodies in California, Within Study Region on Enclosed Map

	# of Trips	# of Days		# of Trips	# of Days
American River			Mammoth Lakes Basin		
Bridgeport Reservoir			Merced River		
Camanche Reservoir			Mokelumne River		
Caples Lake			New Hogan Reservoir		
Carson River			New Malones Lake		
Convict Lake			Pardee Lake		
Crowley Lake			Other Public Rivers		
Don Pedro Reservoir			Other Public Streams (Small streams, brooks, creeks, etc.)		
Donner Lake			Other Public Lakes or Reservoirs		
Hot Creek			Other Public Ponds		
June Lake Loop			Private Ranches/Dude Ranches		
Lake Amador			Fishing Clubs		
Lake McClure			Fee-Fishing Ponds (U-Fish)		
Lake Tahoe			Other Private Waters (e.g. HOA)		

Water Bodies in California, but Outside Study Region

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Water bodies in AZ, NV and OR

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Water bodies in AK, CO, ID, MT, NM, UT, WA and WY

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Water bodies OUTSIDE of these states

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Section E. Please tell us something about yourself.

These last few questions will help us in evaluating how well our sample represents visitors to the area. **Your answers will be kept strictly confidential and will only be used for the analysis of this study. Statistics will only be reported in aggregate (average) form, and <u>you will not be identified in any way</u>.**

1. Are you? ☐ Male ☐ Female

2. In what year were you born? 19____

3. Are you employed? ☐ Yes (Go to #3a.) ☐ No (Skip to #3d.)

3a. Do you work part time or full time? ☐ Full-time ☐ Part-time

3b. Do you take time off from work to participate in outdoor recreation? ☐ Yes ☐ No

3c. How many weeks of paid vacation do you receive each year? # _____ of weeks (Go to #4.)

3d. Are you retired? ☐ Yes ☐ No

4. What is your zip code? _________________________

5. Are you a member of a fishing, hunting or sportsman's organization? ☐ Yes ☐ No

6. Are you a member at a Private Ranch/ Dude Ranch or Fishing Club?☐ Yes ☐ No
   6a. If Yes, what are your <u>annual dues</u>? $_____________ Annually

7. Are you a member of a homeowner's association (HOA)? ☐ Yes ☐ No

   7a. If Yes, what are your <u>annual dues</u>? $_____________ Annually
   7b. Are you on a decision-making group for your HOA? ☐ Yes ☐ No

8. Your highest level of formal education? (Please circle one)

Elementary School | Jr. High or Middle School | High School | Associates Degree | College (B.S./B.A) or Technical School | Graduate or Professional School

9. How many members are in your household? _____ persons

10. How many household members contribute to paying the household expenses? _____ persons

11. Including these people, what was your approximate household income from all sources (before taxes) last year?

☐ less than $19,999 ☐ $20,000-$29,999 ☐ $30,000-$39,999

☐ $40,000-$59,999 ☐ $60,000-$79,999 ☐ $80,000-$99,999

☐ $100,000-$149,999 ☐ $150,000-$299,999 ☐ more than $300,000

Thank you for completing the survey!

<u>COMMENTS?</u>

Please feel free to write any comments you have about fisheries management in the western United States. When you are finished, please place the survey in the stamped return envelope and mail it back to us. If you have any additional questions or concerns, please visit our website at http://dare.colostate.edu/anglersurvey

Colorado State University

Department of Agricultural and Resource Economics
Campus Delivery 1172
Fort Collins, CO 80523-1172

Appendix 1J: California Angler Study Area Map

*Study Region is shaded

Appendix 1K: Colorado Angler Survey Cover Letter

Colorado State University

Department of Agricultural and
Resource Economics
Fort Collins, Colorado 80523-1172
(970) 491-6325
FAX: (970) 491-2067
http://dare.colostate.edu/

Dear Angler,

Thank you for agreeing to participate in this study. The purpose of this study is to help managers improve fishing in Colorado. Answering the survey will only take a few minutes, but will greatly aid fisheries managers in their decisions regarding your favorite fishing areas in Colorado.

To complete the survey, please refer to your most recent trip (where you were handed this survey). Your responses are important to us whether this is the first time you have fished here or the hundredth time. We want to hear what you think about your fishing trip here!

When you have completed the survey please mail it back to us in the enclosed postage paid stamped return envelope.

Your responses will be held in strict confidence and all results are reported only in summary form. While your responses to this survey are completely confidential and your name will NOT be associated with your survey responses, those who complete the survey will be **entered into a drawing for one of five $100 gift certificates to** Cabela's World's Foremost Outfitter®, redeemable at one of their stores or their website.

The results of the survey will be posted on our Department website (http://dare.colostate.edu/anglersurvey.html) next fall. This website also provides answers to frequently asked questions about the survey. However, if you have any questions whatsoever, please feel free to contact one of our project managers, either Dr. Craig Bond at Craig.Bond@colostate.edu, or Dr. John Loomis at John.Loomis@colostate.edu.

Thank you again for your willingness to complete the survey and we look forward to receiving it.

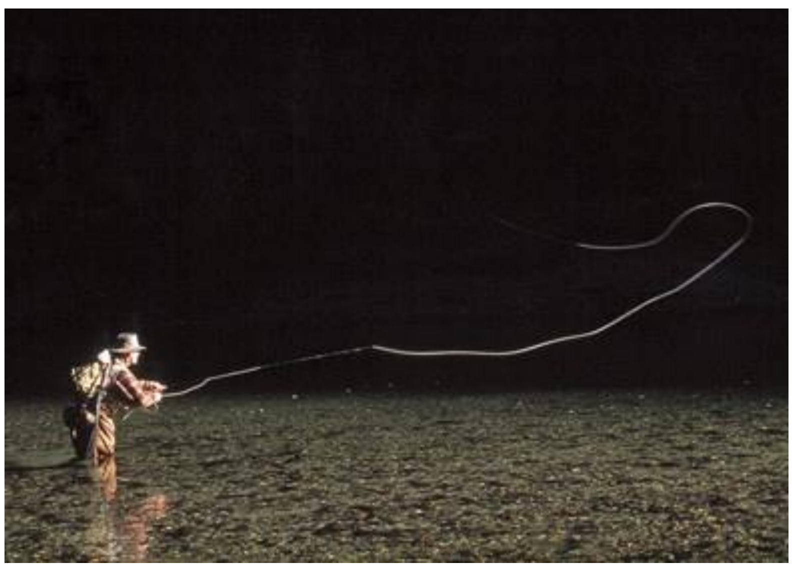
Sincerely,

Dr. Craig Bond
Project Manager

Dr. John Loomis
Project Manager

Appendix 1L: Colorado Angler Survey

Your Fishing Trip in Colorado



How can we make it better?

Colorado State University

Thank you for agreeing to complete this survey. Your answers will be quite helpful to the groups that manage and support recreational fishing in California. In this survey, when we refer to a **trip** we mean a trip from home to the water body and back again. Thanks again, and we look forward to receiving your survey in the enclosed stamped envelope.

Section A. Please tell us about your trip to the water body (lake, reservoir, pond, river or stream) where you received this survey.

1. What was the name of the town nearest to the water body where you received this survey?

Name of town: ____________________

2. How many trips in the past 12 months did you make to the **water body** where you received this survey?

______ #Annual Trips

3. What species of fish were you targeting on **this trip** (check or list all that apply)?
□ Trout □ Bass □ Walleye □ Catfish □ Other ______________________

4. What was the total amount of time you spent on this trip visiting the water body where you received this survey (including all activities such as fishing, boating, camping, hiking, etc.)?

________# of hours or ________ # of days

4a. What was the amount of time that was spent **actually fishing** at this location on this trip?

________# of hours fished or ________ # of days fished

4b. During your **trip** to this water body, how many fish did you catch and how many did you keep?

________# of fish caught and ________ # of fish kept

4c. How many of these fish were species that you were **targeting**?

________# of **target** fish caught and ________# of **target** fish kept

4d. If you visited more than one water body during this trip, what was the total amount of time spent visiting all the water bodies on this trip from home?

________# of hours or ________ # of days

5. Please check the activities **you** participated in during this **trip** from home at the location where you received the survey (check all that apply):

□ Fishing from Bank/Wading □ Fishing from a Boat □ Belly Boat Fishing
□ Flyfishing □ Motorized Boating □ Rafting, Kayaking, Canoeing
□ Camping □ Horseback Riding □ Fishing with Family/Friends
□ Hiking/Backpacking □ Photography □ Other, please describe:_______
□ OHV Recreation (e.g. ATV, 4x4) □ Viewing Scenery and Wildlife __________________________

5a. If you checked more than one activity, which of these activities was the most important reason for your trip to this water body? Most Important Activity_____________________

6. Was your trip to this water body: (check only one):
□ the primary purpose or sole destination of your trip from home?
□ one of many equally important reasons or destinations for your trip from home?
□ just an incidental stop on a trip taken for other purposes or to other destinations?

7. What were your primary methods of travel to this water body (circle all that apply):

Car/Truck RV Airplane Other______________________

8. What was the one-way **travel time** from your home to the water body where you received this survey?
___________ # hours ___________ # minutes

9. What was your one-way **travel distance** from your home to this water body?

___________# one-way miles

10. Including yourself, what was the number of **adults** and **children** in your group that traveled on this trip?

___________# of **adults** in your group and ___________# of **children** in your group

11. How crowded did you think the water body was where you received this survey? Please circle one number representing how crowded it was.

Not at All Crowded 1 2 3 4 5 6 7 8 9 10 Extremely Crowded

Please tell us about the importance level of several features of the water body **where you received this survey.**

Important Aspects of Your Most Recent Trip

Please circle one number for each item	Importance for your decision to visit this water body			
	Not Important/ Not Applicable	Somewhat Important	Important	Very Important
Opportunities to catch many (large #'s) of fish	1	2	3	4
Opportunities to catch trophy-sized fish	1	2	3	4
Opportunities to catch wild fish	1	2	3	4
Enjoying peace and solitude (without crowding)	1	2	3	4
Fishing near skilled anglers/fishermen	1	2	3	4
Socializing with other anglers/fishermen	1	2	3	4
Cleanliness of site	1	2	3	4
Amenities such as restrooms and parking	1	2	3	4
Catching fish to eat	1	2	3	4
River rafting/canoeing/kayaking	1	2	3	4
Motorized Boating	1	2	3	4
Viewing Scenery and Wildlife	1	2	3	4
Camping	1	2	3	4
Horseback Riding	1	2	3	4
Fishing with Family/Friends	1	2	3	4
Hiking/Backpacking	1	2	3	4
Photography	1	2	3	4
OHV Recreation(e.g. ATV, Dirt Bike, 4x4)	1	2	3	4
Other activities: Please list __________	1	2	3	4

Section B. Most Recent Trip Expenditures (*Please skip this section if you did not travel to the site where you were handed this survey (for example, the site was on your own property or on property owned by your homeowner's association*).

Please indicate the amount you and members of your group with whom you shared expenses (e.g., other family members, traveling companions) spent on each category on the **trip** during which you were given the survey. Note: The Western Region of the United States is comprised of twelve states (Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming).

Expenses on Your Most Recent Trip		
Trip Expense	**Amount spent ON THIS TRIP in Colorado**	**Amount spent ON THIS TRIP outside of Colorado (but still in the Western Region)**
Gas & Oil for Auto &/or Boat	$	$
Food/drink: restaurants	$	$
Food/drink: grocery stores	$	$
Supplies/fishing tackle/bait/other retail	$	$
Camping on Public Lands	$	$
Camping at Private Areas	$	$
Hotel/motel	$	$
Equipment rental	$	$
Guide fees	$	$
Fishing License	$	$
Fishing Entrance/Catch/Access Fees	$	$
Rental car	$	$
Airline ticket	$	$
Fishing Club/Dude Ranch Package Deals **(Please do not "double count" expenses from above categories)**	$	$
Other; Please List ___________________________	$	$

1. Including yourself, how many people in your group shared these expenses on this most recent trip?

__________# of persons in your group sharing expenses

2. As you know, some of the costs of travel such as gasoline, hotels and restaurant meals often increase. If your share of the **total cost** of this most recent trip had been $_____________ **higher**, would you have made this trip to the water body where you received this survey?

Circle one: YES NO

3. Did you use a motorized boat on the trip where you were handed this survey? □ Yes □No

3a. If Yes, did you rent your boat, do you own your boat, or do you borrow a boat for free?

□ Rent □ Own □ Borrow for Free

3b. If you Own a boat, do you dock your boat at a marina or did you trailer your boat to this site?

□ Marina □ Trailer

Section C: Fisheries Management and Annual Recreation Trips

Suppose managers were no longer managing this water body for recreational fishing, and catch rates were to go down by half or 50% (with everything else unchanged). Please indicate how you would respond to this change in catch rates and fill in your estimate of the change in the number of trips (if any).

Would your decision to visit this water body change if you had <u>half</u> (-50%) the daily catch rate of your targeted species that you experienced on this trip?

- ☐ Yes, I would **<u>decrease</u>** my fishing trips to this water body by (#) _____ fewer trips per year.
- ☐ Yes, I would **<u>increase</u>** my fishing trips to this water body by (#) _____ more trips per year.
- ☐

5. *During which of the following months* do you typically go fishing in a typical year (Circle all that apply)?

<u>January</u> <u>February</u> <u>March</u> <u>April</u> <u>May</u> <u>June</u> <u>July</u> <u>August</u> <u>September</u> <u>October</u> <u>November</u> <u>December</u>

6. On a scale of 1 to 10, how would you *rate your skill level* as an angler (Please circle <u>one number</u>)?

Little or No skill at all <u>1</u> <u>2</u> <u>3</u> <u>4</u> <u>5</u> <u>6</u> <u>7</u> <u>8</u> <u>9</u> <u>10</u> Extremely Skilled/Professional

For the purposes of this survey, the Western Region of the United States is comprised of twelve states (Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming).

7. About how many total *outdoor recreation* trips do you take each year to areas **within** the western US?

____________ Annual # of trips

8. About how many total *outdoor recreation* trips do you take each year to areas **outside** the western US?

____________ Annual # of trips

Section D: Season Trip Information

This information on your annual visitation is important to fishing managers in deciding how to manage your fisheries, so please enter the total number of trips from home and the number of days you spent fishing at the following water bodies during the last year. **Please refer to the enclosed map for water body locations and study region in Colorado.** By public waters we mean county, state or federal lakes, reservoirs, ponds or rivers such as those on National Forest land, in National Parks, on National Wildlife Refuges, and on Colorado Division of Wildlife or natural resources properties. Other private waters include waters on private land that do not fit into listed categories such as your own private property or homeowner's association (HOA) property.

How many fishing trips did you take primarily for the purpose of fishing during the last 12 months to the following locations? How much time did you spend?

Water Bodies in Colorado, Within Study Region on Enclosed Map

	# of Trips	# of Days		# of Trips	# of Days
Arkansas River			Poudre River		
Big Thompson River			Pueblo Reservoir		
Blue Mesa Reservoir			Ridgeway Reservoir		
Blue River			Spinney Mountain Reservoir		
Crawford Reservoir			Steamboat/Pearl Lakes		
Dowdy / Parvin / West Lakes			Yampa River		
Emerald Lakes			Other Public Rivers		
Fryingpan River			Other Public Streams (Small streams, brooks, creeks, etc.)		
Grand Lake / Lake Granby			Other Public Lakes or Reservoirs		
Grand Mesa Lakes			Other Public Ponds		
Gunnison River			Private Ranches/Dude Ranches		
Harvey Gap / Rifle Gap			Fishing Clubs		
Horseshoe Lake / Martin Lake / Lathrop State Park			Fee-Fishing Ponds (U-Fish)		
McPhee Reservoir			Other Private Waters (e.g. HOA)		

Water Bodies in Colorado, but Outside Study Region

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Water bodies in AZ, NM, UT and WY

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Water bodies in AK, CA, ID, MT, NV, OR and WA

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Water bodies OUTSIDE of these states

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Section E. Please tell us something about yourself.

These last few questions will help us in evaluating how well our sample represents visitors to the area. **Your answers will be kept strictly confidential and will only be used for the analysis of this study. Statistics will only be reported in aggregate (average) form, and <u>you will not be identified in any way</u>.**

1. Are you? ☐ Male ☐ Female

2. In what year were you born? 19____

4. Are you employed? ☐ Yes (Go to #3a.) ☐ No (Skip to #3d.)

3a. Do you work part time or full time? ☐ Full-time ☐ Part-time

3b. Do you take time off from work to participate in outdoor recreation? ☐ Yes ☐ No

3c. How many weeks of paid vacation do you receive each year? # _____ of weeks (Go to #4.)

3d. Are you retired? ☐ Yes ☐ No

4. What is your zip code? ________________________

5. Are you a member of a fishing, hunting or sportsman's organization? ☐ Yes ☐ No

. Are you a member at a Private Ranch/ Dude Ranch or Fishing Club? ☐ Yes ☐ No

6a. If Yes, what are your <u>annual dues</u>? $_____________ Annually

7. Are you a member of a homeowner's association (HOA)? ☐ Yes ☐ No

7a. If Yes, what are your <u>annual dues</u>? $_____________ Annually

7b. Are you on a decision-making group for your HOA? ☐ Yes ☐ No

8. Your highest level of formal education? (Please circle one)

Elementary School **Jr. High or Middle School** **High School** **Associates Degree** **College (B.S./B.A) or Technical School** **Graduate or Professional School**

9. How many members are in your household? _____ persons

10. How many household members contribute to paying the household expenses? _____ persons

11. Including these people, what was your approximate household income from all sources (before taxes) last year?

☐ less than $19,999 ☐ $20,000-$29,999 ☐ $30,000-$39,999

☐ $40,000-$59,999 ☐ $60,000-$79,999 ☐ $80,000-$99,999

☐ $100,000-$149,999 ☐ $150,000-$299,999 ☐ more than $300,000

Thank you for completing the survey!

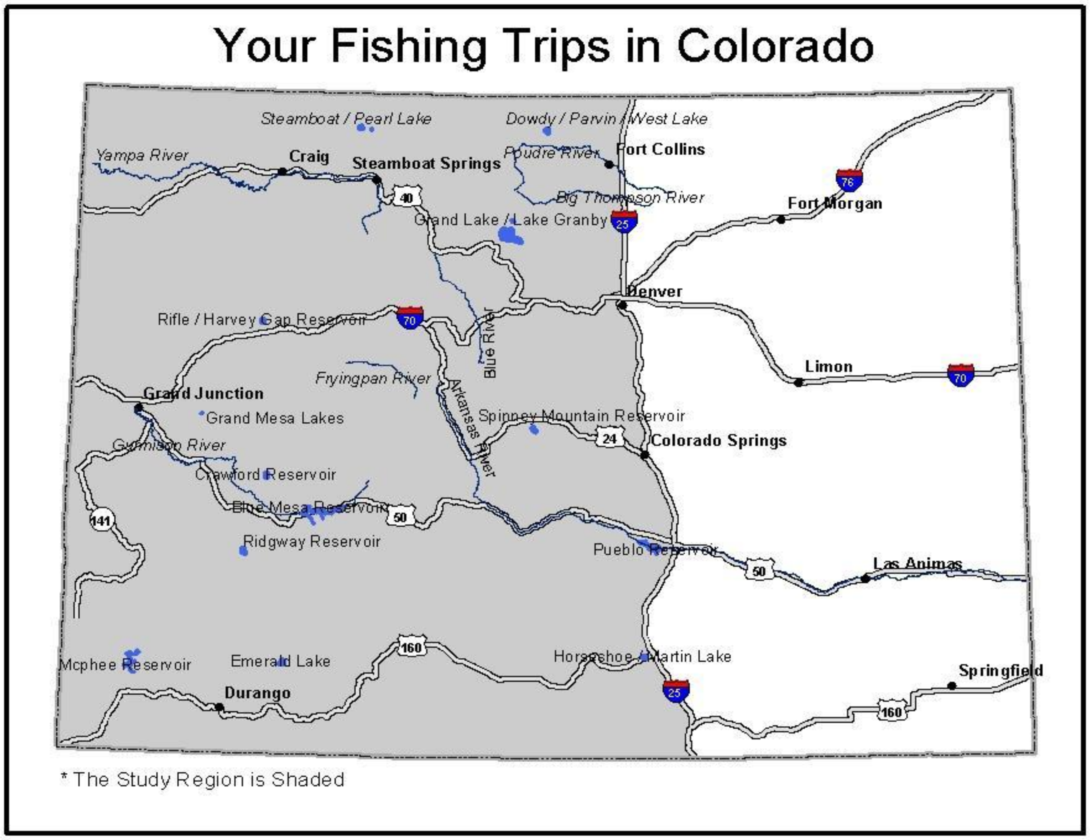
COMMENTS?

Please feel free to write any comments you have about fisheries management in the western United States. When you are finished, please place the survey in the stamped return envelope and mail it back to us. If you have any additional questions or concerns, please visit our website at http://dare.colostate.edu/anglersurvey

Colorado State University

Department of Agricultural and Resource Economics
Campus Delivery 1172
Fort Collins, CO 80523-1172

Appendix 1M: Colorado Angler Study Area Map



Appendix 1N: Angler Survey Postcards

Thank you for your participation in our survey

Last week you were given a survey asking questions about your recent fishing trip.

If you already completed and returned the survey, please accept our sincere thanks. If you have not, please complete the survey and mail it back to us in the stamped return envelope.

Your responses will be very useful to those individuals who manage your fisheries.

If your survey has been misplaced, please call me or email me and I will mail you a new one immediately.

Colorado State University

Dr. Craig Bond

Phone: 970-491-6951
Fax: 970-491-2067
E-mail: Craig.Bond@Colostate.edu
http://dare.colostate.edu/anglersurvey

Colorado State University

Dr. Craig Bond

Department of Agricultural and Resource Economics
Campus Delivery 1172
Fort Collins, Colorado 80523-1172

PLEASE PLACE STAMP HERE

Chapter 2: Using the Random Utility Model to Account for Substitution Effects in Economic Impact Analysis: The Case of Recreational Fish Stocking and the Critically Endangered Mountain Yellow-Legged Frog

1. Introduction and Problem Statement

As rural economies transition from commodity-based industries to service-based industries, an increased focus on the development of recreational amenities may help to maintain the livelihood of rural residents. As recreation is often considered an export to rural economies (English and Bergstrom, 1994), changes in recreation patterns not only affect the mix of economic activity, but also the extent of economic activity in a particular area.

Many natural amenities which are used for recreational purposes, such as hiking trails, scenic vistas and fishing spots, have the potential to be augmented in quality by human intervention. Hiking trails can be modified, special platforms can be constructed for roadside wildlife or mountain viewing, and fisheries can be enhanced with regulations and/or stocking programs to encourage the vitality and catchability of various species of fish. However, while the costs of making such changes to recreational resources are often well known, the benefits in terms of imported tourism dollars are not
[9].

Regional economic impact analysis, or input-output analysis, is often employed to estimate the amount of economic activity generated by a particular industry or sector of

[9] Imported tourism dollars, while often a benefit to local business owners and residents, is very different from economic *value* to recreationists, or the difference between maximum willingness to pay per trip and costs.

an economy. Several studies exist which attempt to demonstrate the economic impact of such recreational amenities as state parks (Bergstrom et al., 1990), river recreation (Cordell et al., 1990), charter and party boat fishing (Steinback, 1999), and sportfishing (ASA, 2008). However, most of these studies simply provide a snapshot of what the economic contribution of these recreational activities are, offering little information in terms of effects of potential *changes* in recreational amenity quality on economic activity[10].

In order to assess the economic activity generated from recreational amenity quality changes, an intuitive approach would be to model a rural economy with and without the proposed change and then measure the difference in economic activity (i.e. effects of imported tourism dollars) associated with that change. However, while the status quo can be used to model the "without" scenario, researchers must rely on either stated or revealed preference data to forecast what the "with" scenario would be like. To date, only a small handful of studies have adopted this approach.

At least four studies have linked contingent behavior or stated choice data with input-output models in order to estimate the economic impacts associated with changes in recreational amenities. Bergstrom et al. (1996) use a contingent behavior questionnaire to predict changes in trips associated with various aquatic plant mitigation plans, which is subsequently used to estimate changes in economic impacts. Hamel et al. (2002) and

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[10] "Economic contributions" refer to the amount of economic activity (jobs, income, etc.) that can be linked to a particular industry or sector. "Economic impacts" refer to the economic activity that is *created* by a particular industry or sector. However, even many purported "impact" analyses are simply contribution analyses, and those studies which do attempt to differentiate between impacts and contributions simply evaluate the backward linkages of imported tourism dollars. Even in the event that some sector was to be removed from an economy, some imported tourism dollars may stay within the region of analysis if there are close substitutes to the status quo. See Watson et al. (2007) for a discussion if impact vs. contribution analyses.

Criddle et al. (2003) adopt a similar approach to estimate the economic impact of an Alaskan sport fishery, and Loomis (2006) uses information from a stated-preference contingent behavior survey of anglers on to estimate the economic impacts of changes in catch rates of trout in the Smith River in Idaho and Wyoming.

Whereas those four studies use stated-preference data, Weiler et al. (2003) and Weiler and Seidl (2004) use revealed visitation patterns to predict changes in visitation to Rocky Mountain National Park and to Great Sand Dunes National Monument which would come as a result of climate and population change and from changing park designation from “National Monument” to “National Park.” The authors adopt a time-series approach in order to make these predictions. These changes in visitation are then linked with input-output models in order to estimate the economic impacts of such changes.

Although the aforementioned studies attempt to account for hypothetical changes in tourism that would come as a result of changes in recreational amenity quality, there are several shortcomings which must be addressed. First, while stated preference methodology is utilized throughout the economic literature, hypothetical bias (see Murphy et al., (2005) for a review of this literature) and a lack of understanding of the hypothetically proposed good (see Arrow et al., 1993) can result in estimates that are very different from their true value. Second, the revealed-preference methodology utilized in Weiler et al. (2003) and Weiler and Seidl (2004) is plagued by the fact that it requires many years of data. Furthermore, none of these studies explicitly address visitors *substitution* possibilities within the state or impact area. If visitors substitute from their current site within the impact area to the improved site, there may be little gain in economic activity.

A repeated nested logit (RNL), as developed by Morey (1993) and refined in Morey (1999), offers a solution to the aforementioned issues. First, the utility-theory-consistent RNL, an econometric specification of the random utility model (RUM), allows researchers to model current substitution patterns of recreationists across a multitude of sites using cross-sectional data. The RNL model estimates the probability that individuals will visit a set of sites on a particular choice occasion, and can be used to estimate the *change* in visitation probability associated with a change in amenity quality at one (or many) site(s). This is in contrast with Weiler et al. (2003) and Weiler and Seidl (2004) which use a time-series econometric model to forecast responses in visitation (to one site) to changes in national park designation. Second, unlike linked models which first estimate changes in trip frequency and then, in a separate modeling framework, predict substitution patterns across sites (see Herriges and Kling, 1999, for a further exposition of these models), the RNL incorporates a “stay home” option into recreators’ choice sets in order to allow for seamless one-step estimation of trip counts that is both straightforward and utility-theory consistent. Third, the RNL is based on revealed preference data, mitigating any potential concerns regarding hypothetical bias in stated-preference questionnaires (bias which may exist in contingent behavior studies such as Bergstrom et al. (1996), Hamel et al. (2002), Criddle et al. (2003) and Loomis (2006)). Finally, the RNL allows researchers to relax the independence of irrelevant alternatives assumption which plagues many other models, in particular the often-used multinomial logit model (Herriges and Kling, 1999)[11,12].

In his dissertation, Bastian (2004) uses the RNL to predict substitution patterns of snowmobilers in response to site closure in Yellowstone National Park, and then links these predictions with input-output models of the northwestern Wyoming regional economy. However, the only policy proposal in that study was site closure: no consideration was given to the potential economic impacts of changes in site *quality*. As most outdoor recreation management decisions involve changes to site quality, evaluating the economic impacts of such changes will be of general interest to researchers and policymakers alike.

In order to address this gap in the literature, the present study links information from the RNL to input-output models in order to estimate the economic impacts of both site closure and changes to influences of site attributes on substitution and participation decisions of recreationists. As a case study, this paper focuses on recreational fishery management in California. Recent endangered species litigation (see Center for Biological Diversity, 2010, and PRC, 2010, for a discussion of the litigation) has resulted in new policies which curtail fish stocking in that state, because studies have shown that

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[11] The independence of irrelevant alternatives assumption, commonly referred to as the IIA assumption, plagues multinomial logit and probit models often adopted for this type of research. In these site-selection models, the IIA assumption implies that the *ratio* of probabilities of visiting two sites must stay constant as long as the attributes of those to sites stays constant. For example, assume the probabilities of visiting site A and site B are .05 and .05, respectively. Now assume that a third site, say site C, is augmented in quality, encouraging visitors to substitute away from sites A and B and toward site C. IIA assumes that they will substitute away from A and B proportionally so that the probability ratio between A and B remains 1:1.

[12] The Mixed Logit model, described by Haab and McConnell (2002) and Train (2003), may offer a similar solution. However, the Mixed Logit model does not offer a closed form solution, and although it too relaxes the IIA assumption, since the model is completely flexible, many distributional assumptions are required. Furthermore, the RNL described in the next section addresses the research questions appropriately, and more generally the nested logit model has been used throughout the literature and is widely accepted as a means to answer the *types* of questions addressed by this paper.

stocked fish harm native and now critically endangered Mountain Yellow-Legged Frog populations. However, the short "Recreation and Economics" section in the environmental impact statement published by the California Department of Fish and Game (which was used to inform policy creation) made strong assumptions about anglers' economic behavior in the absence of fish stocking at several sites. For example, ICF Jones and Stokes[13] (2010) assumed that a) "People will no longer fish in water bodies where stocking has ceased" p. 7-15, b) substitution to alternate fishing sites will not occur, and c) expenditures for any one angler day at any site are equal to the CA state average of $49 (our data indicate these expenditures to be closer to $150 in high-sierra fisheries). The EIS also only evaluates economic "impacts" (which are actually contributions) on a statewide basis, ignoring the economic implications to smaller communities or counties which are tourism-dependent. To the best of the author's knowledge, no academic study exists linking *revealed* angler behavior to economic impacts of fishery management, and no study of any sort exists which links changes in fishery management strategies to economic impacts in California.

This study contributes to this literature in several ways. First, this will be only the second study which links the revealed preference RUM (in this case the RNL) to input-output models to forecast changes in economic activity. As this methodology is both utility-theory-consistent and based on revealed preferences, it should advance the literature regarding tourism and regional economic development. Second, this will be the first study to use the RNL to forecast changes in economic activity coming from changes in site *quality*. As many management regimes involve quality changes rather than

[13] The consulting firm hired to complete the Environmental Impact Report/Environmental Impact Statement

outright closures, this approach should prove useful to resource managers and economists alike. Third, this paper empirically compares several with- vs. without-substitution scenarios in order to assess the importance of accounting for substitution, which is important for any researcher considering adopting this approach.

This paper proceeds as follows. The next section provides a theoretical exposition of the models used in this paper. Next, information about the data collected and the specific region of analysis is provided. Finally, sections summarizing the results of the models are provided, followed by a brief section to conclude and summarize the implications of this study.

2. Theoretical Models

2.1. Regional Economic Model

Typically, an input-output (IO) model is used to assess the effect of changes in spending by those residing outside an impact area. IO models are the source for estimating the multipliers commonly used in regional economics. In the case of this study, IMPLAN IO software is used (MIG INC., 1997). IMPLAN uses pre-existing data of industries within a region to generate linear production functions which relate the amount of final demand for a particular sector's products with the amount of inputs required to achieve that level of final demand. Formally:

(1) $Y = (I - A) * X$,

where *Y* represents the final demand for goods, *I* is an identity matrix, *X* is a vector of inputs and *A* is a matrix of technical coefficients which link inputs to outputs in all sectors. Solving for *X* yields

(2) $$X = (I - A)^{-1} * Y,$$

which yields the amount of input, *X*, needed to satisfy final demands, *Y*. $(I\text{-}A)^{-1}$ is the matrix of technical interdependence coefficients which measure direct and indirect levels of inputs needed to achieve final demand *Y* (see Miller and Blair, 2009, for an excellent explanation and exposition of IO models).

2.2. Revealed Preference Recreation Model

Solving for the economic impact of some recreational activity, in this case fishing, requires accounting for the indirect and induced effects (*X*) of angler expenditures (*Y*) with and without that recreational activity. However, in the case of fishing, closure of one site, or changes in quality attributes of that site will not necessarily result in anglers' refraining from fishing. In fact, while some anglers will elect to "stay home"[14] in the event that a particular site closes, other anglers will simply visit a nearby site, making similar in-region expenditures as they would have made in the absence of such a closure.

The random utility model (RUM) can be utilized to model substitution patterns across various sites (in this case fishing sites). The RUM can be derived as follows, as seen in Haab and McConnell (2002) and Parsons (2003). Individuals derive utility from either recreating or from some alternate activity. While the individual decision maker (in this case the angler) has full knowledge of his/her indirect utility function, the researcher only observes behavior and as such there is a random or unobserved component. The indirect utility associated with recreating at a particular site *j* for an individual *i* is

[14] "Staying home" implies not fishing. Although some of the non-fishing activities may occur inside of the region of analysis, due to the small size of this region, and lack of information about specific substitution options, individuals are assumed to participate in these activities outside of the region of analysis. This, of course, will result in an *overestimate* of economic impacts since many of the individuals who elect to "stay home" in the model will actually participate in an alternate in-region activity.

(3) $$v_{ij} = \underline{\beta}_{tc} * tc_{ij} + \underline{\beta}_{Q} * \underline{Q}_{j} + \varepsilon_{ij}, \quad j = 1,...,J$$

where tc_{ij} represents the travel cost for individual *i* associated with site *j* and Q_j represents a vector of other attributes associated with site *j* (which, in the case of a fishery, include catch per unit effort). Notation denoting choice occasion is suppressed for convenience, with the underlying assumption being that the β s, (coefficients for the independent variables) are identical across choice occasions. The indirect utility of an alternate activity is

(4) $$v_{i0} = \underline{\alpha}_{i0} \cdot \underline{\lambda}_{i0} + \varepsilon_{i0}$$

where $\underline{\lambda}_{i0}$ represents a set of individual attributes (not specific to a particular fishery), and $\underline{\alpha}_{i0}$ represents the vector of coefficients on these variables. Then, an individual maximizes his current-period utility by choosing the site which yields the highest utility:

(5) $$u_i = \max(v_{i0}, v_{i1}, v_{i2}, ..., v_{iJ})$$

The RNL discussed in the previous section of this paper is one particular econometric specification of the RUM. In the RNL estimated for the present analysis, individuals are assumed to maximize utility by deciding whether to participate in fishing and if so, in which region to fish (each of these choices is considered a "nest"). Then, if the decision is to fish, the angler decides at which site to fish. For this model, the probability of visiting a particular site on a particular choice occasion is:

$$p_{m*}\, p_{j|m}$$

which is the probability of selecting nest *m* (fishing in-region, out-of-region, or not at all) multiplied by the conditional probability of selecting site *j* given the selection of nest *m*. The specific functional forms of these probability statements are as follows:

(6) $$p_m = \frac{e^{\ln\left[\sum_{j=1}^{J_m} e^{X_j'\beta}\right]\cdot\theta_m}}{\sum_{m=1}^{M}\left\{e^{\ln\left[\sum_{j=1}^{J_m} e^{X_j'\beta}\right]\cdot\theta_m}\right\}}$$

and

(7) $$p_{j|m} = \frac{e^{X_j'\beta}}{\sum_{j=1}^{J_m} e^{X_j'\beta}}$$

as detailed in Hensher et al (2005), where $m \in M$ (nests) and $j \in J$ (choices within a nest), and J_m represents the total number of sites within nest *m*. The parameter θ, sometimes referred to as an Inclusive Value or IV parameter, essentially indicates the level of dissimilarity of choices between nests. $X_j'\beta$ (in the econometric model) is equivalent to V_{ij} (in the theoretical model), or the indirect utility function from equation (3) for site *j* within nest *m*. This probability statement is actually fairly intuitive: the numerator is the weight placed on each individual site, while the denominator is the weight (inversely) placed on all sites.

The expected number of angler days in a particular time period is:

(8) $$E(AnglerDays) = A \cdot C \cdot p_m \cdot p_{j|m}$$

where *C* is the total number of available choice occasions, *A* is the total number of potential anglers (e.g. anglers with fishing licenses), and the right hand side is the probability that a particular angler visits the site on a particular choice occasion.

In order to link the RNL and input-output models, “with” and “without” scenarios must first be constructed. The RNL is used to predict how many angler days will take place in a particular region with and without a particular management alternative, which in this case is fish-stocking-augmented catch rates (catch rates enter the model through the $X_j'\beta$ function for each site). Then, each of the two scenarios' economic contribution of angler days is simulated in IMPLAN input-output software. The difference between the two scenarios' economic contribution of angler days is the marginal effect of the management action on economic activity (i.e. the true economic *impact* of that management action). Formally:

(9) $$\Delta X = (I - A)^{-1} * \Delta Y$$

as in Bastian (2004), where ΔY represents the change in overall expenditures by anglers within the region (simulated with the RNL), and ΔX represents the total change in in-region output resulting from the change in angler expenditures. Equation (9) allows for the estimation of the true economic impact of a management action by measuring the difference in economic activity with and without that management action. This is in direct contrast to an economic *contribution* analysis, which merely traces the flow of dollars associated with a particular economic activity.

3. Data and Study Region

Mono County is a destination that contains some of the best fishing in California (Stienstra, 2008). What makes Mono County fisheries unique, aside from the aesthetic beauty of the area, is that the fish contained in its lakes and rivers are large and plentiful. Much of the fishing is supported by heavy stocking programs, both by the California Department of Fish and Game and by private industry (Fish and Game, 2010). Finally, Mono County's population is only 12,927 (US Census, 2009), but there are an estimated 337,807 visiting angler days spent in that region (see next section). As such, potential changes to fish stocking policy may have large economic impacts on the region.

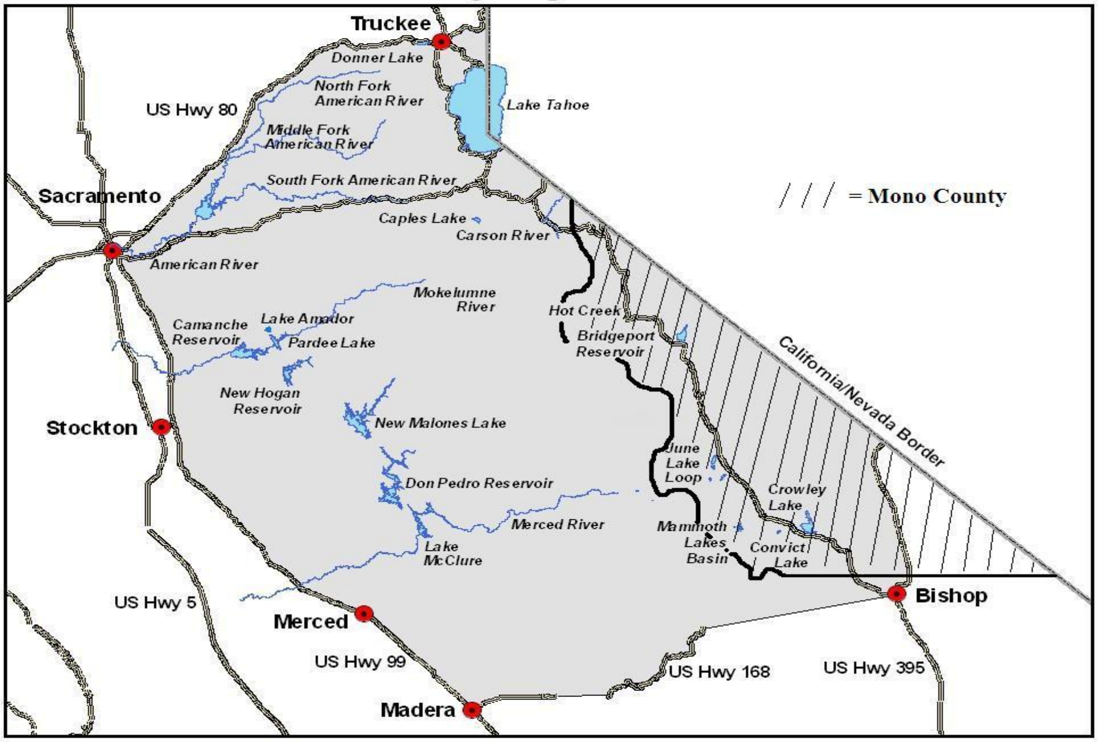
Although Mono County hosts some of the best fishing in California, and Mono County fisheries receive heavy stocking from both the private and public sector, three of the six surveyed fisheries are within the historic range of the critically endangered Mountain Yellow-Legged Frog (Convict lake, Hot Creek and Mammoth Lakes) (Parker, 1994). In the future, policies to mitigate the adverse effects of introduced fish on native frogs may include closure of the fishery and removal of fish, or simply halting of the trout stocking program (see Armstrong and Knapp, 2004, Knapp et al., 2007, ICF Jones and Stokes, 2010[15]). In subsequent sections, the models described in section 2 are used to predict angler substitutions, and resulting economic impacts, that come as a result of such fish stocking policies.

During the summer and fall of 2009, anglers at 17 public fisheries in and around Mono County were surveyed in order to obtain a representative sample of anglers at a variety of location types (study region illustrated in figure 1). Surveys were distributed in person on site in most cases. Anglers were asked for their address and told that their participation would automatically enter them into a raffle for gift certificates to Cabela's (an outdoor equipment retailer). They were handed a survey and a pre-stamped return envelope. A thank you/reminder postcard was mailed 10 days after the first contact, and a second survey was mailed a week later for any who had not yet responded. For more information about the survey distribution process, see Deisenroth and Bond (2010).

Figure 1: California Survey Region

[15] The recent California EIS (2010) does not suggest trout *removal* as an alternative, but Knapp et al. (2007) demonstrates that trout removal is feasible and can lead to recovery of frog populations.

Your Fishing Trips in California



*Study Region is shaded

The angler survey asks how much anglers spent on their most recent trip in a number of expenditure categories within and outside of the western region. Anglers were also asked about the number of trips they had taken to a variety of sites within the past year (Appendix 2A). In total, 613 surveys were distributed to anglers at California public sites, with 359 surveys returned for a response rate of 58.5%.

Although there are many small streams and rivers in Mono County, six major fisheries were selected for analysis in this study (Bridgeport Reservoir, Convict Lake, Crowley Lake, Hot Creek, June Lake Loop and Mammoth Lakes). It is assumed, for the purpose of this study, that these bodies of water harbor *all* angler activity in the region. As such, the estimates provided in subsequent sections may not be as precise as they could have been had data been collected about all fishing sites in Mono County. However, the six aforementioned fisheries likely occupy a majority of angler days, rendering this simplifying assumption defensible. The present model assumes 100 recreational choice occasions per year to coincide with the period of highest fishing activity (Memorial Day through Labor Day)[16].

4. Results

4.1. Status Quo Angler-Tourism and Economic Contributions

Mono (2009) provides information which can be used to estimate the number of primary-purpose angler days spent each year by visitors to Mono County. Their survey asked visitors to indicate the average number of individuals in a group, as well as the primary purpose of the trip. That study also indicates the total number of occupied lodging sites[17] on an annual basis. Using this data, annual angler days is estimated formally as follows:

(9) $A = \varphi \cdot \gamma \cdot \eta \cdot \iota \cdot \kappa \cdot o,$

where φ represents total annual sites occupied, γ represents average persons per group, η represents the percentage of visitors whose primary travel purpose was to visit Mono County, ι represents the percentage of visitors whose primary purpose of visiting Mono County was to experience the outdoors, and κ represents the percentage of primarily

[16] The fishing season in Mono County (the region of analysis for this study, see next section) is from April 30th – November 15th, allowing for a potential angler to fish for 195 days. However, it is extremely unlikely (as corroborated by our data) that any angler would fish for this many days due to employment and other constraints, so it is *assumed* that he or she chooses whether or not to fish on a maximum of 100 days. There are many warm-water fisheries in California with year-round fishing access, in which case the 100 days represents the roughly 100 weekend days The few anglers who indicated that they fished for more than 100 days at any site during the year (i.e. some respondents indicated that they fished for 365 days because they lived on-site) were eliminated from the sample. This was only 30 out of the 359 total anglers sampled in California. In fact, the number of days in an angler's choice set is largely endogenous, depending on a number of factors, but likely depending primarily on employment status. For this study, all anglers were assumed to have 100 choice occasions available on which to choose whether or not to fish.

[17] A "site" may be a campsite, hotel, motel, or condominium.

outdoor travelers who engaged in fishing on their trip. o is an additional parameter representing the fraction of group members who engaged in fishing, which is *assumed* to be 50% for this analysis[18]. Finally, although Mono (2009) did not indicate whether fishing was a primary purpose of travel, the assumption here is that all anglers whose primary purpose of travel was to visit Mono County and experience the outdoors were also primarily visiting in order to fish. Given the nature of the destination fisheries in Mono County, this is a defensible assumption.

By equation (9), there are an estimated 337,807 visitor angler days per year in Mono County[19]. Table 1 illustrates the average daily spending patterns of anglers surveyed in this study. The largest expenditure category is gasoline, of which half is *assumed* to be spent in region[20]. Other major categories include guide fees, restaurant meals and groceries, and hotels. This information is used to shock the appropriate industries in IMPLAN input-output software in order to estimate the regional economic impact of sportfishing in Mono County, California.

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[18] This represents the possibility that a family visits Mono County, and only a fraction of that family fish (e.g. father and son fish, mother and daughter participate in other activities). This is an assumption that will have only a *linear* effect on final results.

[19] This uses overnight stays as a proxy for the number of days spent in Mono County by anglers. However, only individual day trips are used to calculate angler substitution patterns in the next section.

[20] Many anglers may not purchase any gasoline in Mono County, whereas others spend *more* in Mono County than what would be required for the round trip from home to the fishery (i.e. a fill-up). Still, on average, 50% makes sense due to the round-trip nature of anglers' trips.

Table 1: California Angler Daily Expenditures[21]			
	Amount Spent/Day*	Amount Spent in Mono County on a Day Trip	Accounting for Retail Margins
Gasoline	$52.79	$26.39	$4.33
Restaurant Meals	$16.21	$16.21	$16.21
Groceries	$16.15	$16.15	$4.75
Camping	$4.02	$0	$0
Hotels	$18.36	$0	$0
Guide and License Fees	$32.98	$32.98	$32.98
Fishery Entrance Fees	$6.69	$6.69	$6.69
Car Rentals	$0.53	$0.00	$0.00
Airlines	$0.28	$0.00	$0.00
Other	$31.49	$31.49	$12.53
Total	$179.51	$129.92	$77.49

*Per-day expenditures given in Deisenroth and Bond (2010), but day-trip expenditures are assumed here.

IMPLAN input-output software is used to find that for every dollar spent by anglers in Mono County (accounting only for retail margins, as opposed to gross retail sales), 1.285 dollars are generated *within* Mono County (all export dollars). The high amount of leakages, and thus low multiplier, is due to the small region size. Given this multiplier, the economic contribution per angler day is $99.56. Assuming 337,807 anglers in that region per year, the economic contribution of sport fishing to Mono County, in terms of total output, is $33.6 million annually (all export dollars)[22].

4.2. Angler Substitution Patterns

The model presented in section 4.1 assumes that in the absence of sport fishing in Mono County, anglers would simply leave and spend their dollars elsewhere. However,

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[21] Hotels and campsites are excluded for this part of the analysis in order to align with day-trip estimation results in subsequent sections. However, this does result in an underestimate of the economic impacts of sportfishing to Mono County. The multiplier found when including hotel and campsite spending is 1.273, which could be used to calculate the economic impacts of sportfishing to Mono County including overnight stays. Another key assumption is that all guide and license fees, fishery entrance fees and "other" occur inside of Mono County. The survey questionnaire contains no questions regarding expenditures inside vs. outside Mono County.

[22] Traditional economic "impact" analysis would stop here.

in the event that one fishery (or several fisheries) in Mono County were to be closed, or in the event that catch rates at one fishery (or several fisheries) were to fall, the model presented above cannot predict what sorts of impacts may accrue to the region from these changes.

In order to capture the potential substitution patterns that anglers may exhibit when presented with varying fishery characteristics, surveyed anglers were asked about the number of days spent at a variety of sites within the past year (see appendix 2A)[23]. Then, a RNL of angler preferences for fishery attributes (see section 2.2) was estimated. This model captures both angler preferences for various site attributes as well as demographic factors which would change anglers' likelihood of going fishing. In the present RNL, anglers are assumed to choose whether to fish in Mono County, fish elsewhere, or do something else (outside of Mono County). If the decision is to fish, the angler decides which fishery to visit. The decision does not need to be sequential: the "decision tree" appearance of the model is only to allow for differences in variances across nests, but not within nests (figure 2) (Hensher et al., 2005).

[23] This model assumes that the visitation proportions reported by surveyed anglers are an accurate reflection of the proportion of anglers visiting each site throughout the year. In other words, zero weight is placed on any site by the researchers. Although this may bias the results towards one site or another, no other information is available regarding annual visitation at the study sites. However, since anglers report *annual* trips to all sites, rather than just their most recent trip (which would be very biased by sampling on-site), the bias may be somewhat mitigated.

Figure 2: 2-Level Repeated Nested Logit Model of Anglers' Decision Process

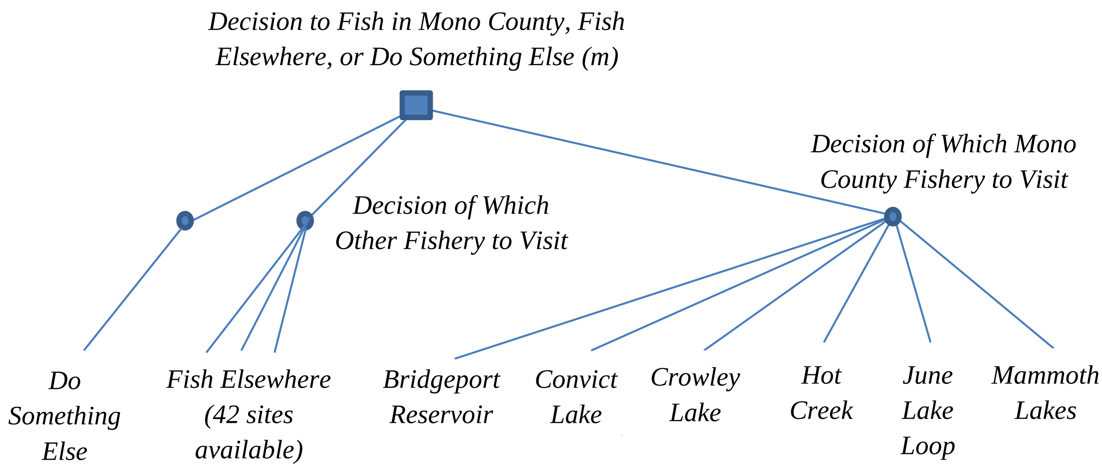

Table 2 presents the variables used in the RNL, along with their definitions, and table 3 presents summary statistics for the six Mono County sites. Variables were included to capture differences across fisheries, as well as across anglers (i.e. different travel costs for different anglers). These variables capture elements of fishing quality and scenic beauty, as well as access costs, and generally coincide with the literature (e.g. Johnson et al., 2006, Morey et al., 2003).

Table 2: Variable Descriptions

Variable	Description
Utility Function for "Fishing" Nests	
Travel Cost	Round trip travel distance indicated by linear distance from zip code center of site to home zip code center. This linear distance is then divided by .78, which is the average fraction of total distance (as indicated by questions about anglers' most recent trip) that the linear distance measures. Finally, this new distance is multiplied by *individual* anglers' per-mile expenditures, which averages to be $.37 per mile.[24]
Expected Catch Per Unit Effort	Using data collected at 17 sites, model individual catch rates as a function of average catch rates, self-reported skill, hunting/fishing club membership status. Use this model to predict individual expected catch rates at all sites.
Lake	Whether the site was a lake or not. Other site types include ponds, rivers, and streams.
Private	Whether the site was privately owned.
Stienstra Ranking	Independent ranking based on fish abundance, fish size, and overall quality of fishery (including scenic beauty, etc.) Scale is from 1-10.
Elevation	Elevation, in feet, above sea level, added as a proxy for scenic beauty.
Elevation*Travel Cost	Simply elevation (in feet) divided by travel cost. This variable allows for a different travel cost coefficient for varying elevation levels.
Surface Acres	Only applicable to lakes and reservoirs, this measures the surface area of the water body in acres. The utility functions for rivers and streams does not include this variable.
Fishery Constant	Separate constant for each fishery from which data was collected.
Utility Function for "Staying Home" Nest	
Home Constant	Constant for whether or not the site was a non-fishery.
Education	Reported years of education.
Inclusive Value (IV) Parameters (θ)	
Fishing Elsewhere	Dissimilarity of "fishing elsewhere" nest from other nests. Significantly different from other IV parameters means more dissimilar.
Mono County	Dissimilarity of "Mono County fishing" nest from other nests. Significantly different from other IV parameters means more dissimilar.
Staying Home	Fixed at 1.

[24] Opportunity cost of time is not included. Individuals' time spent on-site at all sites is unknown, most sampled individuals who did report income (many did not) report full-time (i.e. inflexible) salaries, and many individuals are retired. Although assumptions could be made, for example ignoring time spent on-site (or assuming 8 hours per day spent on-site), 1/3 of the wage rate for wage earners, given the extrapolation inherently necessary in this site-choice model, these assumptions would be broad and strong. The result, however, of ignoring the opportunity cost of time, is that subsequent welfare estimates are likely an *underestimate* of the welfare derived from a day trip. See Parsons (2003) for a discussion of including the opportunity cost of time in recreation demand models.

Table 3: Variable Averages for Mono County Sites						
Variable*	Bridgeport Reservoir	Convict Lake	Crowley Lake	Hot Creek	June Lake Loop	Mammoth Lakes
Travel Cost[25]	$189.35	$189.19	$189.19	$189.19	$188.71	$189.19
	($242.67)	($235.10)	($235.10)	($235.10)	($238.42)	($235.10)
Expected Catch Per Unit Effort	0.75	0.85	0.84	0.96	0.81	0.86
	(0.23)	(0.24)	(0.24)	(0.25)	(0.25)	(0.24)
Lake	1	1	1	0	1	1
Private	0	0	0	0	0	0
Stienstra Ranking	10	10	10	8	7	6
Elevation *(feet)*	6453	7850	6781	6844	7654	8900
Surface Acres	2914	168	650	n/a	n/a *Consists of many lakes.*	n/a *Consists of many lakes.*

*Standard Errors in Parentheses

One variable which deserves a bit of attention, as it is the focus of any policy regarding fish stocking, is catch per unit effort (or fish caught per hour). The survey questionnaire asked questions about an angler's *most recent* trip, as well as questions about their trips within the last year. However, catch rate information was only collected from the recent trip. In order to simulate anglers' *expected* catch rates at all other sites, in the spirit of McConnell et al. (1995)[26], the present analysis uses ordinary least squares (OLS) to model individual anglers' catch rates as a function of other anglers' average catch rates,

[25] The average travel cost is nearly identical for all sites, since all sites reside in Mono County and only zip code distances were used. However, travel costs vary widely across individuals (although for any individual, travel costs are the same for any Mono County site). Furthermore, these are average travel costs to the site for all individuals, not only those who visited.

[26] McConnell et al. (1995) model numbers of fish caught as a function of average fish caught and individual-specific variables. Since their dependent variable is always an integer, they adopt a count data *poisson* model (*poisson* means "fish" in French). The present analysis uses catch *rates*, and as such uses a standard OLS regression.

individual anglers' self-reported skill level and individual anglers' membership status in a hunting or fishing organization. Expected catch per unit effort model results are displayed in table 4. A discussion of OLS models is omitted here, but Greene (2003) offers an excellent exposition.

Table 4: Expected Catch Per Unit Effort

Variable	Coefficient	Standard Error
Constant	0.19	0.20
Average CPUE	0.23	0.14*
Hunting/Fishing Club Member	0.35	0.14***
Self-Reported Skill	0.06	0.03**
R-squared	0.05	
F-statistic	6.59	
Prob(F-statistic)	0.0002	

*** Significant at the 1% Level
**Significant at the 5% Level
*Significant at the 1% Level

The low R-squared statistic may raise a red flag regarding omission of key variables. However, fishing success is inherently random, where even skilled anglers will often catch no fish. Although there are obviously causes of this variability, the causes may be truly random from the perspective of the angler. Furthermore, using this model provides more information than simply applying average catch rates to all anglers' expectations. Finally, predicted catch rates are within one standard deviation of reported catch rates for 308 of 353 (87%) anglers whose data was used for this model. This model is used to generate *expected* catch rates for all anglers at all sites which, along with the site-specific variables described in table 4, is used in a RNL of angler site choice (table 5).

Table 5: RNL Model Results

Variable	Coefficient	Standard Error	
Travel Cost	-0.005	0.0002	***
Catch Per Unit Effort	1.424	0.105	***
Lake	0.184	0.050	***
Private	-2.483	0.079	***
Stienstra Guidebook Ranking	-0.298	0.029	***
Elevation	0.0004	0.00004	***
Elevation*Travel Cost	-0.000003	0.0000001	***
Logged Surface Acres	0.201	0.028	***
Bridgeport Reservoir Dummy[a]	-2.699	0.612	***
Camanche Reservoir Dummy	-0.202	0.123	*
Caples Lake Dummy	-0.936	0.250	***
Carson River Dummy	-0.296	0.180	*
Convict Lake Dummy[a]	-2.536	0.611	***
Crowley Lake Dummy[a]	-1.524	0.598	**
Don Pedro Reservoir Dummy	0.754	0.105	***
Donner Lake Dummy	-0.974	0.216	***
Hot Creek Dummy[a]	-1.659	0.589	***
June Lake Loop Dummy[a]	-1.642	0.588	***
Lake Amador Dummy	0.463	0.148	***
Lake McClure Dummy	-0.290	0.111	***
Lake Tahoe Dummy	-2.398	0.334	***
Mammoth Lakes Basin Dummy[a]	-2.552	0.618	***
Merced River Dummy	0.090	0.152	
New Hogan Reservoir Dummy	-0.447	0.111	***
Pardee Lake Dummy	0.616	0.106	***
Home Constant	1.824	0.154	***
Education Level (years)	0.135	0.006	***
Mono County IV Parameter (θ)	0.011	0.001	***
Other Fishery IV Parameter (θ)	0.029	0.001	***
Stay Home IV Parameter	0.050	Fixed Parameter	
Number of Observations	16,122		
McFadden Pseudo R-Squared	0.4542323		
Restricted Log Likelihood	-53540.24		

*** Significant at the 1% Level
**Significant at the 5% Level
*Significant at the 1% Level
[a]Mono County Sites

The RNL results generally conform to predicted angler preferences (a priori). First, a higher travel cost is a deterrent to fishing at a particular site, while higher catch rates are an attractant[27]. Surveyed anglers prefer fishing at lakes as opposed to rivers, potentially due to the fact that larger fish tend to grow lakes. Surveyed anglers also prefer public sites to private sites, which could be due to the expense of private fishing, or to the fact that anglers were only intercepted at public sites in California, potentially biasing the sample. Higher elevation sites are preferred to lower elevation sites (likely due to scenic beauty), but higher elevation sites also imply a larger travel cost coefficient. Larger lakes are preferred to smaller lakes, potentially due to the fact that larger lakes often contain larger fish. Larger lakes are also sometimes considered more beautiful than smaller lakes, and may imply less crowding. A popular California fishing guidebook (Stienstra, 2008) has a ranking of all major California fisheries which incorporates the author's observed catch rates, fish size, and scenic beauty. However, results indicate a *negative* and significant response to the variables proxied in aggregate by this ranking system. This may be due to the fact that other variables in the model already capture some of the characteristics in this ranking. The ranking system may also be wrong. Finally, one variable, education, was included to allow for variation across individuals for the "stay home" option. More highly educated individuals prefer to spend fewer days fishing.

Although the log-likelihood statistic of the RNL model in table 5 indicates overall model significance, there is still some question regarding the predictive success of the model. Table 6 compares the predicted vs. reported probabilities of visiting several sites. Although there is some variability between predicted and reported percentages of days

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[27] One fish is assumed to be just as good as another fish from an angler's perspective, with no attention paid to size or species. There are two reasons for this. First, the survey instrument did not ask about specific size class of catch, nor species. Second, most anglers indicated that they were "targeting" rainbow trout, and the size range of this fish is typically fairly narrow, although "lunkers" are sometimes caught and harvested.

spent fishing overall, the predicted percentage of days spent in Mono County (the relevant region for this study) is within .46% of the reported percentage.

Table 6: Predicted vs. Reported Probabilities of Visitation

	Percentage of Choice Occasions Spent at This Site	
	Predicted	Reported
Mono County	1.46%	1.92%
Other Fishing Total	13.43%	14.73%
Non-Fishing Total	85.03%	83.35%
Specific Mono County Site Predictions		
Bridgeport Reservoir	0.23%	0.13%
Convict Lake	0.09%	0.22%
Crowley Lake	0.50%	0.62%
Hot Creek	0.11%	0.30%
June Lake Loop	0.35%	0.26%
Mammoth Lakes	0.12%	0.38%

4.3. Linking Substitution Behavior with Economic Impact Analysis

Results from the RNL model described in section 4.2 can be used to simulate hypothetical alterations in fishery characteristics in Mono County. For example, a site closure can be simulated by raising travel cost to infinity for that site. Convict Lake is within the historic range of the critically endangered Mountain Yellow-Legged frog, and also receives the least visitation among the six surveyed sites. Convict Lake may, therefore, be the first major site which is targeted for re-establishment of the endangered frog. Table 7 illustrates what would happen to visitation patterns after such a closure. 29,500 angler days will be lost from Convict Lake, but of those angler days, 23,000 are predicted by the model to be substituted to other Mono County sites. As such, instead of losing 29,500 angler days, only 6,500 angler days will substitute out of the Mono County region. The economic *impact* of losing 29,500 angler days to Mono County would be -

$2.9 million (as standard economic impact analysis would predict), but when accounting for substitution, the economic impact to Mono County is only -$650,000 per year.

Table 7: Policy Scenario - Shut Down Convict Lake

	Baseline Angler Days	After Policy Angler Days	Difference	Economic Impact to Mono County
Bridgeport Reservoir	45,815	49,238	3,423	$340,762
Convict Lake*	**29,518**	**0**	**-29,518**	**-$2,938,815**
Crowley Lake	120,062	129,032	8,969	$892,999
Hot Creek	50,781	54,575	3,794	$377,701
June Lake Loop	61,533	66,130	4,597	$457,670
Mammoth Lakes	30,097	32,346	2,248	$223,857
Net to Mono County	337,807	331,320	-6,487	-$645,827
Other Fishery Days	3,812,579	3,814,047	1,468	n/a
Non Fishing Days	13,034,946	13,039,965	5,019	n/a
Days Spent Outside Mono County	16,847,525	16,854,012	6,487	n/a

*Closed or Reduced-Stocking sites indicated with **bold** in tables 7-10.

What if, in response to pressure from environmental groups, stocking were to cease at Convict Lake? Armstrong and Knapp (2004) found that at certain water bodies, elimination of stocking programs did not affect populations of fish[28]. In other words, even though fish are not *native* to many lakes that are currently stocked, the lakes still provide adequate habitat and food supply to sustain breeding populations of fish. At a lake like Convict Lake, which receives weekly stocking, it is likely that catch rates would fall if stocking were to stop. Table 8 illustrates the effect of a 50% reduction in catch

[28] The authors did not actually count fish, but instead verified that lakes held self-sustaining populations of fish in the absence of fish stocking. The authors also show that catch rates are relatively unchanged before and after halting of the stocking programs.

rates at Convict Lake[29]. Nearly half of the angler days originally spent at Convict Lake will be spent elsewhere, but of the 14,000 angler days lost at Convict Lake, 11,000 are substituted to other Mono County sites. Accounting for this substitution, the economic impact to Mono County is only -$300,000 per year (as compared with a -$1.3 million per year impact when failing to account for substitution).

Table 8: Policy Scenario - Reduce Catch by 50% at Convict Lake

	Baseline Angler Days	After Policy Angler Days	Difference	Economic Impact to Mono County
Bridgeport Reservoir	45,815	47,305	1,490	$148,367
Convict Lake	**29,518**	**16,593**	**-12,925**	**-$1,286,798**
Crowley Lake	120,062	123,968	3,905	$388,810
Hot Creek	50,781	52,433	1,652	$164,450
June Lake Loop	61,533	63,534	2,001	$199,269
Mammoth Lakes	30,097	31,076	979	$97,467
Net to Mono County	337,807	334,910	-2,897	-$288,435
Other Fishery Days	3,812,579	3,813,234	656	n/a
Non Fishing Days	13,034,946	13,037,188	2,241	n/a
Days Spent Outside Mono County	16,847,525	16,850,422	2,897	n/a

In an extreme case, policymakers may elect to shut down all fisheries which are within the historic range of the Mountain Yellow-Legged frog (Convict Lake, Hot Creek and Mammoth Lakes). Nearly 120,000 angler days are spent at these sites each year, yielding an economic contribution of $12 million per year to Mono County. However, shutting down these sites does not imply an economic impact of -$12 million to Mono

[29] Chapter 3 of this dissertation demonstrates that a 50% reduction in catch rates is possible if stocking programs are eliminated.

County. In fact, since there are other sites available for fishing, the actual loss of angler days will be only 27,000, yielding an economic *impact* of -$2.7 million per year (table 9).

Table 9: Policy Scenario - Shut Down Convict Lake, Mammoth Lakes, and Hot Creek

	Baseline Angler Days	After Policy Angler Days	Difference	Economic Impact to Mono County
Bridgeport Reservoir	45,815	62,575	16,760	$1,668,618
Convict Lake	**29,518**	**0**	**-29,518**	**-$2,938,815**
Crowley Lake	120,062	163,983	43,921	$4,372,762
Hot Creek	**50,781**	**0**	**-50,781**	**-$5,055,789**
June Lake Loop	61,533	84,043	22,510	$2,241,079
Mammoth Lakes	**30,097**	**0**	**-30,097**	**-$2,996,481**
Net to Mono County	337,807	310,601	-27,206	-$2,708,626
Other Fishery Days	3,812,579	3,818,735	6,157	n/a
Non Fishing Days	13,034,946	13,055,996	21,049	n/a
Days Spent Outside Mono County	16,847,525	16,874,731	27,206	n/a

Finally, what if stocking were to cease at all three sites that are within the historic range of the Mountain Yellow-Legged Frog? Anglers will tend to gravitate towards sites with higher catch rates, which are sometimes outside of the Mono County region. However, most anglers stay within Mono County, and the loss of angler days and economic impact to Mono County in such a scenario would be 12,000 and -$1.2 million, respectively.

Table 10: Policy Scenario - Reduce Catch by 50% at Convict Lake, Mammoth Lakes, and Hot Creek

	Baseline Angler Days	After Policy Angler Days	Difference	Economic Impact to Mono County
Bridgeport Reservoir	45,815	52,324	6,509	$648,021
Convict Lake	**29,518**	**18,354**	**-11,164**	**-$1,111,536**
Crowley Lake	120,062	137,119	17,057	$1,698,197
Hot Creek	**50,781**	**29,264**	**-21,518**	**-$2,142,296**
June Lake Loop	61,533	70,275	8,742	$870,341
Mammoth Lakes	**30,097**	**18,606**	**-11,491**	**-$1,144,073**
Net to Mono County	337,807	325,941	-11,866	-$1,181,347
Other Fishery Days	3,812,579	3,815,264	2,685	n/a
Non Fishing Days	13,034,946	13,044,127	9,180	n/a
Days Spent Outside Mono County	16,847,525	16,859,391	11,866	n/a

5. Conclusion

This paper demonstrates how a RNL model of substitution behavior can be used to augment results from input-output models in order to better inform economic impact analysis. Results indicate that failure to account for substitution patterns in anglers will result in an overestimation of economic impacts of both site closure and of changes in site quality.

Several implications can be drawn from the results above. First, future studies should be cautious when assuming that closure of a particular site will result in a complete exodus of all economic activity that accrued to that site. This could be important in impact analysis of recreational activities such as hiking, biking, or off-highway vehicle recreation. This could also be important in impact analysis of changes in transportation options, such as road closure (since individuals can substitute to other roads at a higher cost) or road widening.

Second, very few studies exist which evaluate the regional economic impacts of changes in site attributes. As many recreation management policies involve changes in quality (e.g. policies regarding inland fisheries involve bag limits, terminal tackle restrictions and/or fish stocking), the ability to measure the economic impacts of such changes is critical. The model presented here could have provided useful input in, for example, the estimation of the economic impacts of recent curtailing of fish stocking in all of California that have resulted from endangered species litigation and management (prior to actually implementing the management alternatives).

Although the RUM can be used to augment traditional impact analysis, one major shortcoming of this model is that the estimated coefficients indicate the effects of *marginal* changes in attributes on the overall likelihood of visiting a site (this is true for any cross-sectional specification of the RUM). However, the estimation of, for example, a 50% reduction in catch rates may have very different implications than a simple expansion of the effects of a 1% change in catch rates. As such, future researchers may consider estimating random utility models for data that is collected at different times in order to reflect the varying marginal effects of attributes at varying levels (see Loomis and Cooper, 1990).

Another shortcoming, more general to input-output analysis, is that statements regarding the economic "impact" of a certain policy action are more or less statements of a new static equilibrium. Over time, even if an industry (or a fishery) is shut down, individual *producers* can substitute to new business activities. The present analysis evaluates substitution in final demand, but does not account for dynamic substitution in production. Furthermore, substitution in production may lead to new in-region demand, which the present analysis also does not address. As such, the present analysis is more appropriate for short-run impacts than long-run impacts.

Still, the method presented in this study provides a straightforward way to incorporate site substitution and make predictions about visitors' response in a timely manner without requiring a large time series of data. Furthermore, the results of this case study should prove useful to policymakers in California who are currently grappling with the tradeoffs between the existence values of endangered species and the use values and regional economic impacts of recreational fisheries. Specifically, management which curtails fishing at any one site may not have large economic impacts to rural areas such as Mono County, but closure of all sites, of course, could come as a detriment to the community.

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Chapter 2 Appendices

Appendix 2A: Site Selection Survey Question

How many fishing trips did you take primarily for the purpose of fishing during the last 12 months to the following locations? How much time did you spend?

Water Bodies in California, Within Study Region on Enclosed Map

	# of Trips	# of Days		# of Trips	# of Days
American River			Mammoth Lakes Basin		
Bridgeport Reservoir			Merced River		
Camanche Reservoir			Mokelumne River		
Caples Lake			New Hogan Reservoir		
Carson River			New Malones Lake		
Convict Lake			Pardee Lake		
Crowley Lake			Other Public Rivers		
Don Pedro Reservoir			Other Public Streams (Small streams, brooks, creeks, etc.)		
Donner Lake			Other Public Lakes or Reservoirs		
Hot Creek			Other Public Ponds		
June Lake Loop			Private Ranches/Dude Ranches		
Lake Amador			Fishing Clubs		
Lake McClure			Fee-Fishing Ponds (U-Fish)		
Lake Tahoe			Other Private Waters (e.g. HOA)		

Water Bodies in California, but Outside Study Region

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Water bodies in AZ, NV and OR

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Water bodies in AK, CO, ID, MT, NM, UT, WA and WY

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Water bodies OUTSIDE of these states

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Chapter 3: A Bioeconomic Approach to Managing Inland Recreational Fisheries

1. Introduction and Problem Statement

"As for fish, both of fresh and saltwater, of shellfish, and others, no country can boast of more variety, greater plenty, or of better in their several kinds…In the spring of the year, herrings come up in such abundance into their brooks and fords to spawn that it is impossible to ride through without treading on them…. Thence it is that at this time of the year,…the rivers…stink of fish." (Robert Beverly, describing the New World in 1705, Quoted in Wharton, 1957, and Nielsen, 1999).

As the American population grew and moved west, development encroached upon watersheds in which many fisheries had once thrived. Anadromous runs were shut down by reclamation projects, logging and its waste polluted rivers, and an ever-increasing population of recreational anglers brought many fisheries to extinction (Nielsen, 1999). In 1871, as a means to offset the effects of population expansion and development, the US government created the US Fish Commission, which in its early days functioned to culture and stock fish around the country. Today, every state in the Union stocks fish for the benefit of recreational anglers, and coupled with efforts from the US Fish and Wildlife Service, an estimated 2.5 *billion* individual sport fish are stocked in United States freshwater fisheries every year (Heidinger, 1999). Furthermore, fish stocking policy is not limited to the US; Rainbow Trout, for example, have been distributed to over 100 countries on six continents (Halverson, 2008, 2010).

In spite of these numbers, policymakers often pay little attention to specific economic criteria in fish stocking policy. For example, some of the general "goals" of fish stocking include "Maximiz[ing] the sustainable supply of fish…Maximizing the species diversity…Maintaining 'quality' of fisheries…Ensuring the satisfaction of user groups through equitable allocation…Meet[ing] the demand for angling opportunities" (Stroud, 1986, p.147-148). Stocking policy may also involve rules such as "stocking until the phone stops ringing" or "when fish populations are low, stock more."[1] From an economic perspective, inland (freshwater) recreational fisheries management is more or less ad hoc.

Accounting for economics in stocking policy is particularly important today, due to recent pressure from environmental groups to *curtail* fish stocking. The focus of this pressure has been on Rainbow trout, which is stocked more widely than any other fish (Halverson, 2010). Rainbow trout which are introduced into ecosystems which did not formerly contain this fish often compete with native species. For example, in Colorado, Rainbow trout compete with native Cutthroat trout, and in California, Rainbow trout compete with (and eat) many aquatic amphibians, including the now critically-endangered Mountain Yellow-Legged Frog (*Rana muscosa*) (Halverson, 2010).

In response to pressures placed on native species by introduced recreational fish, the Pacific Rivers Council and the Center for Biological Diversity filed lawsuits in 2006 to attempt to curtail both public and private fish stocking efforts in California [PRC, 2010, Center for Biological Diversity, 2010]. This led to the California Department of Fish and Game releasing an environmental impact statement which included several alternatives for managing recreational fisheries with an eye towards endangered species management [ICF Jones and Stokes, 2010]. New policies involve site inspection prior to stocking to ascertain the suitability of a fishery for stocking (versus no stocking and management for

[1] Revealed through conversations with fisheries biologists at Colorado State University.

endangered species). Some sites that have received fish stocking for many years will no longer receive stocking.

What would be the economic implications of eliminating stocking programs? Recent experimental halting of fish stocking of certain high mountain backcountry lakes in California showed that fish populations, or at least angler catch rates, are relatively unaffected by halting of fish stocking programs (Armstrong and Knapp, 2004). Natural reproduction supported angler and fish populations. However, this was purely experimental and measured only fishery characteristics: no information was collected on angler behavior, or, more importantly, benefits to anglers. Specifically, the authors find only that halting of stocking programs does not affect *catch rates*.

This finding is consistent with the literature in terms of *introduction* of fish stocking programs as well. The general problem, however, is that this sort of analysis does not account for the fact that fish stocking (or halting of fish stocking programs) that augments (reduces) catch rates will also influence changes in behavior among anglers (Moring, 1979). Butler and Borgeson (1965), for example, find that

"The generalization may be made that the yearly average catch per angler hour from individual waters is unaffected by changes in the annual allotment of catchable-sized trout because angling effort adjusts proportionally." p.43.

This general result implies that models which place value on *marginal* changes in catch rates (and thus fish stocking) may lead to erroneous policy prescriptions since fish stocking may result in an equilibrium number of anglers that is greater than the status quo, leaving catch rate unchanged. Even recent empirical biological studies (e.g. Li et al., 1996) find empirically that fish stocking has no affect on catch rates and as such, *recommend* reduced fish stocking (failing to account for increased angler benefits to or increased numbers of anglers).

Another approach, adopted by many economists, is to estimate the dollar value of fish stocking to anglers. However, of the over 400 value of fish stocking studies published to date (see Johnston et al., 2006 for a review of this literature), all evaluate either the marginal benefits of an additional fish (e.g. Johnson, 1989, and Harpman et al., 1993)[2] or the marginal benefits of increasing catch rates (e.g. Loomis, 2006; Englin and Lambert, 1995; Milon, 1988). This marginal analysis is likely inappropriate for the aforementioned reasons, especially since stocking actions are not "marginal" (i.e. 2.5 billion individuals stocked every year). Furthermore, as with any natural resource, the actions taken today in recreational fishery management will have a direct effect on the choices made in the future, since stocked fish often grow and reproduce, and since angler harvest has a direct affect on this growth. To date, no study exists in either the economic or biological literature that accounts for the dynamic bioeconomic relationship between recreational fisheries and recreational anglers in order analyze the economic (or biological) implications of various fish stocking policies.

Two studies have addressed similar issues. Johnson and Carpenter (1994) analyze the complex nature of the fishery-angler system by tracking angler numbers, catch rates and fish stocking over time. However, this study only offers a rough estimate of the relationships between fish populations, fish stocking, and angler levels, and offers neither predictions nor prescriptions for managing recreational fisheries through fish stocking. Furthermore, this study does not address *alternatives* for anglers, nor does it address the

[2] These values are then multiplied by an assumed percentage of stocked fish that are caught (often 60%) in order to infer the marginal value of a *stocked* fish.

economic value of a fishing day to anglers (the augmentation of which is, presumably, the underlying purpose of recreational fish stocking).

Smith and Wilen (2003) address a similar problem in commercial fisheries, namely marine reserves, using random utility models (RUMs) to model fisherman substitution patterns in response to catch rates. That study models the optimal management of the Northern California red sea urchin fishery, and compares the economic efficiency of managing with and without accounting for bioeconomic feedbacks (influence of the fishery on angler behavior and visa versa). However, the management alternative prescribed involves closure (or no closure) of fishing zones, and addresses neither fish stocking nor recreational fisheries.

In order to help bridge these gaps in the literature, the present study uses data collected from recreational anglers at a multitude of fisheries in California which are within the historic range of *R. muscosa*, the poster-child of the recent environmental movement to curtail fish stocking in California. Then, using current angler substitution patterns across these fisheries, anglers' preferences and responsiveness to changes in catch rates are modeled in a random utility framework. Finally, this random utility model of angler behavior is combined in a dynamic, bioeconomic framework with a model of fishery population growth at a single fishery which is within the historic range of *R. muscosa*. This model is used to forecast how the angler-fishery system would evolve at this one water body in the absence of fish stocking. Finally, net benefits to anglers are compared under this with vs. without simulation in order to ascertain the implicit cost to anglers of failing to stock fish.

This study contributes to the literature in several ways. First, this will be the first study to forecast the effects of inland recreational fishery management from a dynamic, bioeconomic perspective. As this is a more holistic approach, in the sense that it accounts for relationships of which both economists and biologists are aware but for which neither have accounted, results will help to inform policy which has historically been created in the absence of such models. This is of particular importance today, when environmental groups are pushing to reduce or eliminate fish stocking. Second, in the spirit of Smith and Wilen (2003), this paper dynamically links a revealed preference random utility model (RUM) of spatial angler behavior with a model of fishery population growth in order to prescribe optimal management of a recreational fishery. To the best of the author's knowledge, this approach has never been adopted in recreational fishery management, has only been adopted once before in any natural resource economics research, and should prove useful to future researchers who wish to inform optimal resource management.

This paper proceeds as follows. The following section outlines the conceptual framework for the bioeconomic model. This is followed by a mathematical exposition of both the theoretical and empirical models to be used. Next, a brief section is included to summarize the data collection process and the region of analysis for the empirical model. The following section includes results from an integrated, data-driven bioeconomic model of a fishery in California. Finally, a section is included to conclude and discuss some of the implications of the results.

2. The Bioeconomic Model

2.1. General Bioeconomic Model of a Recreational Fishery

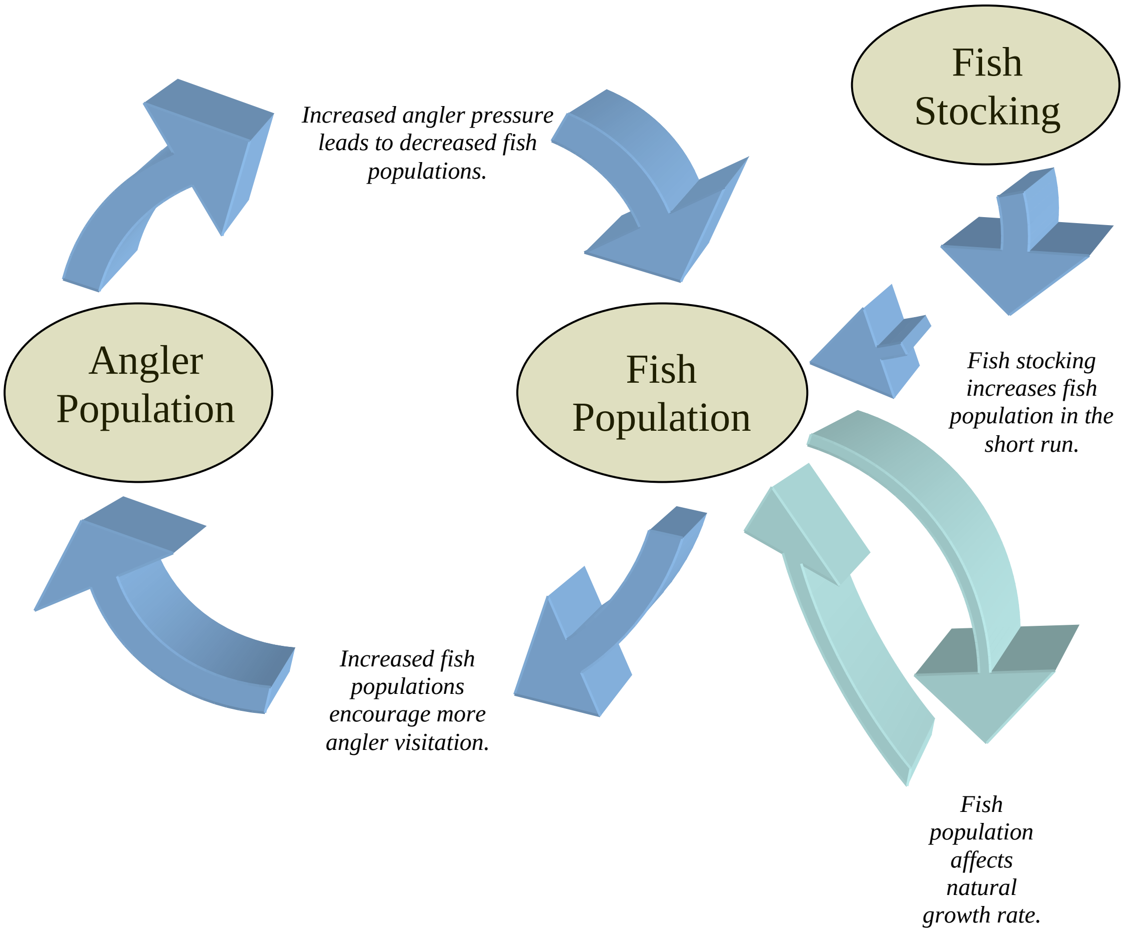
The following is a conceptual outline for a bioeconomic model which incorporates both angler-to-fishery and fishery-to-angler feedbacks. Angler-to-fishery feedbacks are those responses in fish population levels to changes in numbers of angler days. For example, if an exogenous decrease in angler pressure occurs, it would be expected that the reduced angling pressure would lead to higher fish population levels, thereby increasing catch rates for each remaining angler over time.

Fishery-to-angler feedbacks are those responses in angler population to changes in fishery quality. For example, a particular fishery may have been in equilibrium for many years in terms of number of angler days per time period. However, if the fish population levels, and thus catch rate, were to suddenly decrease exogenously due elimination of fish stocking, the number of angler days would also likely decrease.

Accounting for both feedback loops allows for the dynamics of the fishery to affect angler behavior, and it allows for angler behavior to affect fishery dynamics. In other words, if there are more fish, more anglers will come, but when there are more anglers, fish populations should gradually fall (figure 1).

Figure 1: Full Bioeconomic Feedback Loop[3]

[3] This simplified model of a fishery does not account for the many other factors which affect fish growth including water temperature and quality, seasonality, etc. However, this simplified model is adopted since the research questions addressed here are only concerned with the interaction between anglers and fish at a single fishery. All other variables are held constant over time.



In a dynamic bioeconomic model of a single recreational fishery, it is assumed that there are some benefits associated with fish harvest (either catch and keep or catch and release):

(1) $B = B([x(t) + s(t)], a(t); \underline{\alpha})$

where *x(t)*[4] represents fish population in a particular time period, *s(t)* represents fish stocking levels (the control), *a(t)* represents angler population levels, and $\underline{\alpha}$ is a vector of parameters.

There are also generally some costs associated with fish stocking:

(2) $$C = C(s(t);\underline{\delta})$$

where $\underline{\delta}$ is a vector of parameters.

In the case of inland recreational fishery management, the state space is assumed to be limited to the number of anglers and the population of fish, and the control space is limited to fish stocking. There are many other variables, of course, that affect angler benefits. However, these are assumed to be constant at this one fishery over time. In order to conform to general economic theory, it is assumed that

$B_z > 0, B_a > 0, B_{zz} < 0, B_{aa} < 0, B_{za} = B_{az} < 0,$

where $z=x+s$. Furthermore,

$C_s > 0, C_{ss} > 0$[5]

Fish and angler populations are assumed to evolve over time and with respect to each other, which can be represented with the following differential equations[6]:

(3) $$\dot{x} = G(x(t);\underline{\eta}) + s(t) - H([x(t)+s(t)], a(t);\underline{\omega})$$

(4) $$\dot{a} = R([x(t)+s(t)];\underline{\varsigma})$$

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[4] It is assumed that a stocked fish is identical to a non-stocked fish from an angler's perspective. This simplifying assumption may not always be true, but is likely true in the study region in California, since that region has historically received very heavy stocking.
[5] A single subscript represents first partial derivatives, a double subscript represents either second or cross partial derivatives.
[6] In the discrete-time model implemented here, stocked fish are assumed to start reproducing only if they survive the period in which they were stocked. In other words, there is a 1 time period delay for reproduction.

where *G(•)* is the natural growth function of the population of fish and is angler harvest of fish. In the case of a logistic growth function, it is assumed that $G_z > 0$ for some *z* and $G_z < 0$ for other *z*. $G_{zz} < 0$. $H_{za} > 0$ and $R_z > 0$, since more fish is assumed to be better for anglers. *R(•)* is a response function of anglers to the conditions of the fishery, and $\underline{\eta}$, $\underline{\omega}$, and $\underline{\varsigma}$ are parameter vectors[7].

2.3. Specific Angler Response and Benefits Functions

A key link that is missing in some previous studies which attempt to measure the marginal value of a fish in inland recreational fisheries is *R(•)*, or the response of anglers to changes in fishery characteristics (in this case the only change in fishery characteristics is fish population levels). The random utility model (RUM) offers a straightforward solution. The RUM allows researchers to evaluate anglers' current substitution patterns across sites and, controlling for the attributes at these sites, predict how anglers would re-distribute themselves in the event that some characteristic or characteristics were to change at any one (or many) site(s).

Haab and McConnell (2002) and Parsons (2003) provide a straightforward explanation of the RUM, which is summarized here in the context of recreational fishing. On a particular choice occasion (e.g. a summer Saturday), an angler faces a set of choices from which he will derive utility:

$$(5) \qquad v_{ij} = \underline{\beta}_{tc} * tc_{ij} + \underline{\beta}_{Q} * \underline{Q}_{j} + \varepsilon_{ij}, \quad j = 1,..., J$$

[7] Recreational anglers maximize their own utility by fishing at a particular site on a particular day. However, anglers *do not* account for the effects they have on the fishery. In that sense, their planning is myopic.

where v_{ij} is the indirect utility derived from site *j* for individual *i*. The subscript for choice occasion is dropped for convenience since all choice occasions are assumed, from the researcher's perspective, to be identical. Differences across choice occasions, if any, are captured by the error term. tc_{ij} is that individual's travel cost to site *j*, and β is the marginal effect of travel cost on utility (the marginal utility of income). $\underline{Q}_j$ represents a vector of site attributes, and $\underline{\beta}_Q$ represents the marginal effect of these attributes on utility. ε_{ij} represents information which is known to the angler, but not to the researcher. The maximum utility derived from an alternative activity (i.e. non-fishing) is:

(6) $$v_{i0} = \underline{\alpha}_{i0} \cdot \underline{\lambda}_{i0} + \varepsilon_{i0}$$

where $\underline{\lambda}_{i0}$ is a vector of individual-specific variables and $\underline{\alpha}_{i0}$ is a vector of coefficients for those variables. An individual maximizes his utility on a particular choice occasion by selecting the activity and site which gives him the highest level of utility:

(7) $$u_i = \max(v_{i0}, v_{i1}, v_{i2}, ..., v_{iJ})$$

Although there are many econometric specifications of the RUM, for the present analysis, a Repeated Nested Logit (RNL) model is adopted because it offers several advantages over other specifications, particularly the multinomial logit model (see Morey et al., 1993 and Morey, 1999 for a more detailed discussion of the RNL model). The RNL is one variant of the more general nested logit model that allows for the inclusion of a no-fishing nest in the estimation. Anglers decide whether or not to fish and then, if the decision is to fish, which site to visit. Within the fishing nest, further nests can be built based on region (one county vs. another), fishery type (rivers vs. lakes), targeted fish species (trout vs. bass), etc. These "nests" are created for purely econometric purposes, namely to allow for differences in variances across nests (Hensher et al., 2005). However, it can be *instructive* to think of the decision process as a decision tree, where anglers first make one decision, then another. In its most simple form, the RNL probability of visiting a particular site is the conditional probability of visiting that site *given* fishing in that region ($p_{j|m}$, with m indexing nests and j indexing sites) multiplied by the unconditional probability of going fishing in that region (p_m):

$p_{m*}\, p_{j|m}$

The specific functional forms of these probability statements are as follows:

$$(8) \qquad p_m = \frac{e^{\ln\left[\sum_{j=1}^{J_m} e^{X_j'\beta}\right]\cdot\theta_m}}{\sum_{m=1}^{M}\left\{e^{\ln\left[\sum_{j=1}^{J_m} e^{X_j'\beta}\right]\cdot\theta_m}\right\}}$$

and

$$(9) \qquad p_{j|m} = \frac{e^{X_j'\beta}}{\sum_{j=1}^{J_m} e^{X_j'\beta}}$$

as detailed in Hensher et al (2005). J_m is the total number of sites in a given nest m, θ is an inclusive value (IV) parameter indicating the level of dissimilarity across nests. $X_j'\beta$ is the maximum utility derived from visiting site j (equivalent to v in equation (6)).

Expected angler days at a given site is:

$$(10) \qquad E(AnglerDays) = A \cdot C \cdot p_m \cdot p_{j|m}$$

where A is the total population of anglers and C is the total number of choice occasions (assumed constant across anglers).

Finally, the compensating variation (CV) of an angler day at a particular site is

$$(11)\quad CV = \frac{\left\{\ln\left(\left[1 - p_{i|m}\right]^{\theta}\right) \cdot p_m + \left[1 - p_m\right]\right\}}{\beta_{tc}}$$

as derived in Haab and McConnell (2002). The formulation for CV is quite intuitive: the probability of visiting a particular site going up indicates an increase in value to anglers. This RNL model is used to construct equations (1) and (4) in the dynamic bioeconomic model.

3. Data and Study Region

The specific site selected for this analysis is Convict Lake in Mono County, California. Convict Lake is of particular interest since this lake a) receives heavy angler pressure in the summer months, b) receives heavy fish stocking from both public and private sources, and c) is located in the historic range of the critically endangered Mountain Yellow-Legged Frog (*R. muscosa*). The Center for Biological Diversity and Pacific Rivers Council filed a lawsuit in 2006 against California Fish and Game, accusing the agency of failing to report the impacts of fish stocking on high mountain aquatic species (Center for Biological Diversity, 2010, PRC, 2010). The reason for filing this lawsuit is that there are several environmental problems with fish stocking, including:

"1) It can spread disease, invasive species, or unwanted fish;
2) Stocked fish prey on and compete with native fish and amphibians for food and habitat, and;
3) The planted fish disrupt the food web and alter natural ecosystem processes to the detriment of native species." (PRC, 2010)

As a result of the subsequent Environmental Impact Report, stocking in California waters requires a "Pre-Stocking Evaluation Protocol," whereby bodies of water are evaluated for sensitivity of organisms to stocking (ICF Jones and Stokes, 2010). Convict Lake may be directly affected by this new policy, and the absence of any studies of fish stocking in this lake render it an excellent case study.

Data was collected from anglers at 17 public fisheries in California, including Convict Lake, during the summer and fall of 2009 (prior to changes in fish stocking policy). Anglers were asked about the number of day trips they took to these, as well as a number of other sites inside and outside of California (see appendix 3A). 359 surveys were returned (nearly 60% response rate), and each angler indicated his visitation patterns at each of 48 fishing sites (and one "non-fishing" site). After removing individuals with omitted variables, there are a total of 16,122 observations in the sample. These data are used with the equations described in section 2.2 to model angler response to changes in catch rate and daily angler net benefits at Convict Lake (see chapter 1 of this dissertation for individual angler summary statistics and chapter 2 for site-specific summary statistics in Mono County).

4. Results

4.1. Revealed Angler Response Function

The specific RNL estimation is identical to that in chapter 2 of this dissertation. Tables 1 and 2 are variable descriptions and estimation output, respectively, and are *reproduced* here for convenience. Further discussion, however, is omitted here to avoid excess redundancy.

Table 1: Variable Descriptions (Reproduced from Chapter 2)

Variable	Description
Utility Function for "Fishing" Nests	
Travel Cost	Round trip travel distance indicated by linear distance from zip code center of site to home zip code center. This linear distance is then divided by .78, which is the average fraction of total distance (as indicated by questions about anglers' most recent trip) that the linear distance measures. Finally, this new distance is multiplied by *individual* anglers' per-mile expenditures, which averages to be $.37 per mile.
Expected Catch Per Unit Effort	Using data collected at 17 sites, model individual catch rates as a function of average catch rates, self-reported skill, hunting/fishing club membership status. Use this model to predict individual expected catch rates at all sites.
Lake	Whether the site was a lake or not. Other site types include ponds, rivers, and streams.
Private	Whether the site was privately owned.
Stienstra Ranking	Independent ranking based on fish abundance, fish size, and overall quality of fishery (including scenic beauty, etc.) Scale is from 1-10 (Stienstra, 2008).
Elevation	Elevation, in feet, above sea level, added as a proxy for scenic beauty.
Elevation*Travel Cost	Simply elevation (in feet) divided by travel cost. This variable allows for a different travel cost coefficient for varying elevation levels.
Surface Acres	Only applicable to lakes and reservoirs, this measures the surface area of the water body in acres. The utility functions for rivers and streams does not include this variable.
Fishery Constant	Separate constant for each fishery from which data was collected.
Utility Function for "Staying Home" Nest	
Home Constant	Constant for whether or not the site was a non-fishery.
Education	Reported years of education.
Inclusive Value (IV) Parameters (θ)	
Fishing Elsewhere	Dissimilarity of "fishing elsewhere" nest from other nests. Significantly different from other IV parameters means more dissimilar.
Mono County	Dissimilarity of "Mono County fishing" nest from other nests. Significantly different from other IV parameters means more dissimilar.
Staying Home	Fixed at 1.

Table 2: RNL Model Results (Reproduced from Chapter 2)

Variable	Coefficient	Standard Error	
Travel Cost	-0.005	0.0002	***
Catch Per Unit Effort	1.424	0.105	***
Lake	0.184	0.050	***
Private	-2.483	0.079	***
Stienstra Guidebook Ranking	-0.298	0.029	***
Elevation	0.0004	0.00004	***
Elevation*Travel Cost	-0.000003	0.0000001	***
Logged Surface Acres	0.201	0.028	***
Bridgeport Reservoir Dummy[a]	-2.699	0.612	***
Camanche Reservoir Dummy	-0.202	0.123	*
Caples Lake Dummy	-0.936	0.250	***
Carson River Dummy	-0.296	0.180	*
Convict Lake Dummy[a]	-2.536	0.611	***
Crowley Lake Dummy[a]	-1.524	0.598	**
Don Pedro Reservoir Dummy	0.754	0.105	***
Donner Lake Dummy	-0.974	0.216	***
Hot Creek Dummy[a]	-1.659	0.589	***
June Lake Loop Dummy[a]	-1.642	0.588	***
Lake Amador Dummy	0.463	0.148	***
Lake McClure Dummy	-0.290	0.111	***
Lake Tahoe Dummy	-2.398	0.334	***
Mammoth Lakes Basin Dummy[a]	-2.552	0.618	***
Merced River Dummy	0.090	0.152	
New Hogan Reservoir Dummy	-0.447	0.111	***
Pardee Lake Dummy	0.616	0.106	***
Home Constant	1.824	0.154	***
Education Level (years)	0.135	0.006	***
Mono County IV Parameter (θ)	0.011	0.001	***
Other Fishery IV Parameter (θ)	0.029	0.001	***
Stay Home IV Parameter	0.050	Fixed Parameter	
Number of Observations	16,122		
McFadden Pseudo R-Squared	0.4542323		
Restricted Log Likelihood	-53540.24		

Please see chapter 2 of this dissertation for a discussion of these results.

4.2. Bioeconomic Calibration

Using the models developed in section 2 of this paper, a discrete time, discrete space, infinite time horizon model of optimal fish stocking is programmed and simulated using GAMS software[8]. Although the specific functional forms for angler response and net benefits are given by the RNL model, the specific nature of the dynamics of the fishery (i.e. growth rate, carrying capacity, harvest rate, etc.) are not known[9]. However, catch rates are given from angler survey data, and total angler days at Convict Lake is estimated in Chapter 2 of this dissertation. The fish biology and harvest functions in the bioeconomic model are therefore parameterized such that model results align with observed data.

Information that is known (or can be estimated) about Convict Lake includes stocking levels, catch rates, annual angler days, and % of fish kept (vs. released). The RNL from section 4.1 predicts that roughly 29,000 angler days will be spent at Convict Lake[10]. The California Department of Fish and Game stocks between 60,000 and 70,000 individual fish in Convict Lake each year[11]. Anglers at convict lake have expected catch rates of .853 fish/hour (see chapter 2 for discussion of this estimation), and keep 85% of the fish they catch.

Unknown information includes carrying capacity (of fish), how harvest rates relate to fish and angler population levels, and fish population growth rates at Convict Lake. These parameters are calibrated so that the bioeconomic model simulates a steady

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[8] Although the functional forms from the RNL are continuous, these functions are rounded to the nearest integer and modeled in discrete space to mitigate computational burden.

[9] The California Department of Fish and Game occasionally conducts gill net surveys and surveys of anglers to determine fishery and angler characteristics at some sites, but these surveys are conducted sporadically. No specific information is available regarding the biology of Convict lake, nor any other lakes in Mono County. However, ICF Jones and Stokes (2010) indicates that Convict lake depends somewhere between 75-99% on fish stocking, indicating that there is some natural growth and reproduction of fish, although it is unlikely that the lake could support current angling pressure without supplemental stocking.

[10] This is slightly less than the estimate in chapter 2 because while that chapter aggregates individual visitation probabilities, this chapter assumes a homogenous angler in order to minimize computational burden in the dynamic, bioeconomic model.

[11] Convict Lake also receives roughly 600 pounds of privately stocked fish each year, as revealed through a phone conversation with Convict Lake Resort. It is assumed, therefore, that a total of 70,000 fish are stocked each year in Convict Lake by private and public organizations.

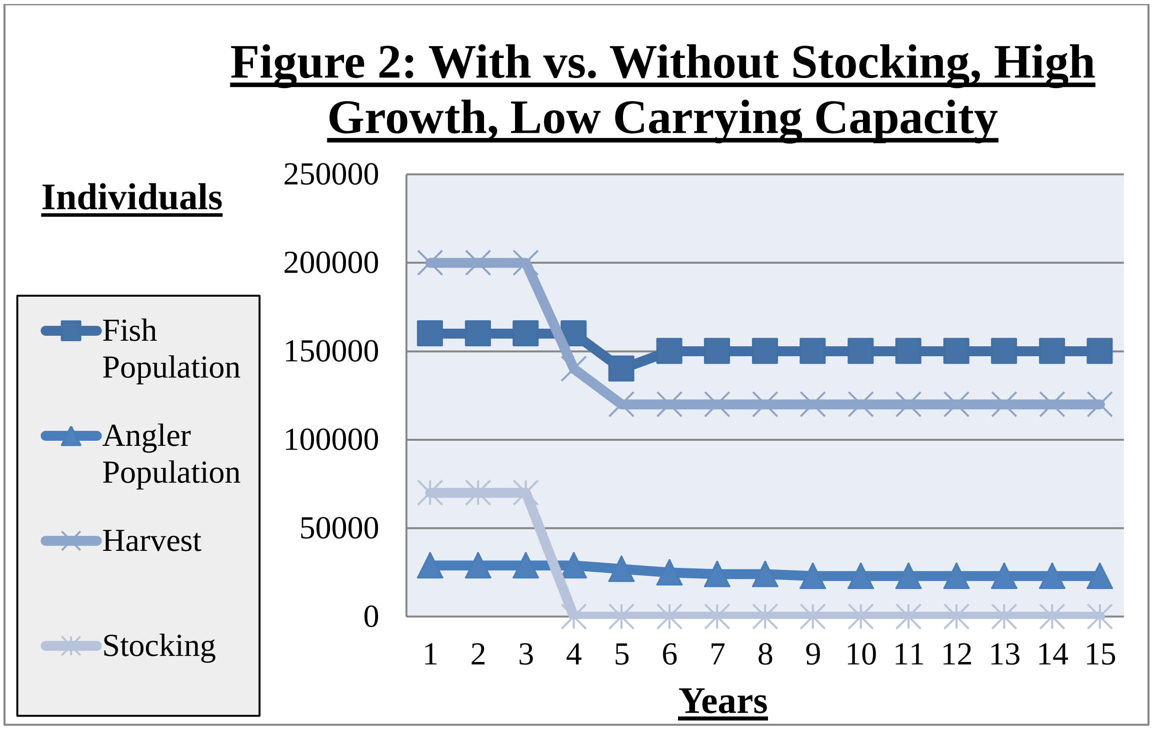
state which matches the aforementioned known statistics. However, the most challenging element of this calibration is that there are multiple parameters which can be altered in order to give the steady state equilibrium that matches existing data. For example, in a standard logistic-growth model of a fishery, carrying capacity *and* growth rates can be changed. Which parameterization is adopted has an affect on the prediction of angler levels without stocking.

Furthermore, since there is more than one unknown parameter, there are an *infinite* number of potential parameterization schemes available to calibrate the model to the existing data. In order to calibrate the model for the present analysis, the harvest function parameterization is *assumed*, and the fishery population model is then calibrated. Since there are two parameters available for calibration in the fishery population model, two calibrated parameterizations are presented and then these two models are used to simulate the effects of halting fish stocking in Convict Lake. Comparing the outcomes of these models lends insight into the effect that various calibration techniques have on final results. Specific functional relationships and parameterization schemes can be found in appendix 3C.

4.3. Stocking vs. No Stocking

4.3.1. Low Carrying Capacity, High Growth Rates

Although the specific biology of the fishery at Convict Lake is unknown, this section illustrates the effect of eliminating fish stocking programs if the fishery is calibrated to have a low carrying capacity for fish (~230,000 fish), but a high growth rate. Figure 2 illustrates a scenario in which managers were to halt fish stocking due to conflicts with endangered species. The first three years represent the status quo: 70,000 fish stocked per year, catch rates of .85 fish/hour, 29,000 angler days/year. Then, in year 4, stocking is eliminated permanently (for all subsequent years).

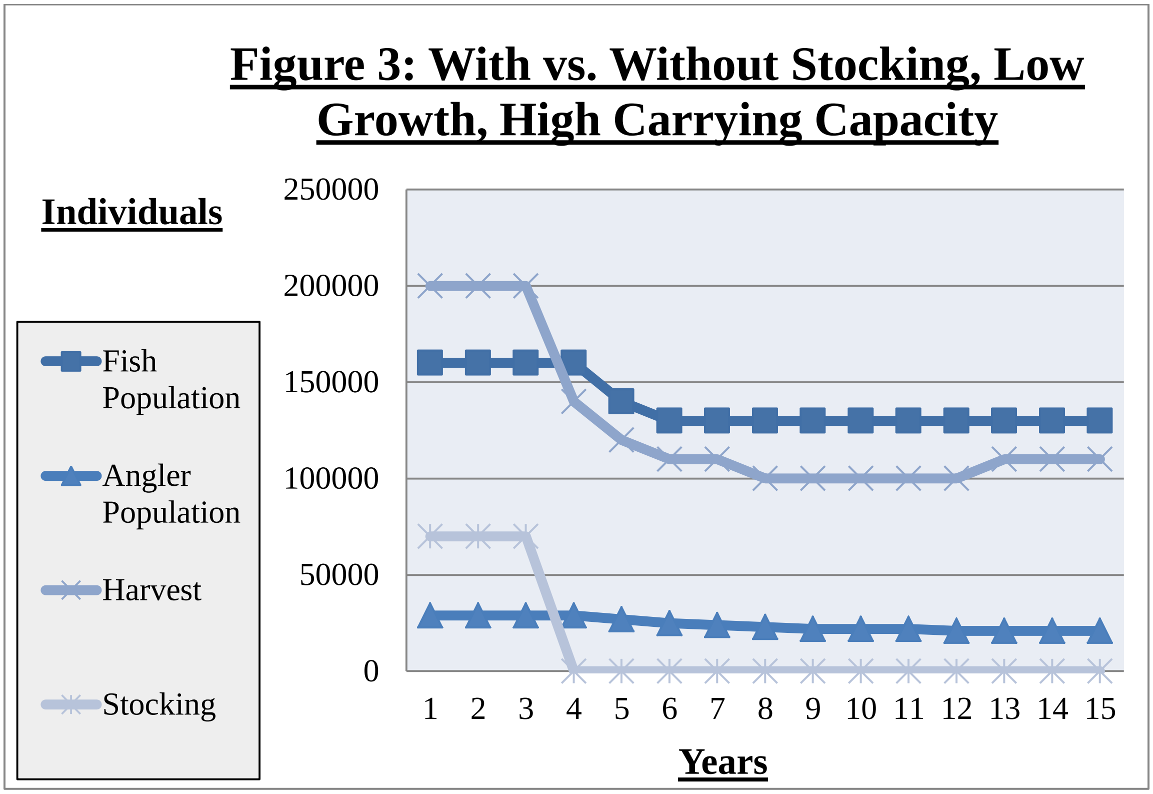


Initially, fish populations fall since they are no longer supported by annual stocking. However, over time, as a result of these lower fish population levels, angler catch rates fall as well. This fall in catch rates drives anglers at Convict Lake to seek other fishery alternatives. After angler levels fall to roughly 23,000 angler days per year, fish population levels, and catch rates, rise slightly, reaching a new equilibrium after this adjustment period[12]. Final equilibrium catch rates are .67 fish/hour (down from .853 fish/hour).

4.3.2. High Carrying Capacity, Low Growth Rates

[12] The "adjustment period" length depends on an assumption regarding angler response time. The final equilibrium is *unaffected* by this assumption, only the length of time between the initial and final equilibria. An adjustment period makes sense since anglers are likely to formulate *beliefs* about a fishery which may not change instantaneously.

This section illustrates the effect of eliminating fish stocking programs if the model is calibrated using a high carrying capacity (450,000 fish) and low growth rates. Figure 3 illustrates the same removal of stocking program scenario as figure 2 with this different parameterization.



As before, eliminating fish stocking programs results in a drop in catch rates and angler populations. However, as the growth rate is lower in this case, fish populations are less able to support angler levels without supplemental stocking. Angler days fall to 21,000 per year (vs. 23,000 in the previous parameterization) and equilibrium fish population levels fall to 130,000 (vs. 150,000). Although these results appear to indicate that the model is relatively insensitive to the specific parameterization of the logistic growth function of fishery population, there are an infinite number of more extreme parameterizations which could calibrate the model to the actual data. These results indicate, however, that lower growth rates in fish populations imply more sensitivity to reduced fish stocking.

4.3.1. Lost Angler Benefits

The reduction in angler days at Convict Lake is an indicator of a loss in angler benefits at that fishery. However, the *value* of access to Convict Lake is only $.0109 per angler per day under the baseline (current stocking) scenario. In other words, the *additional* consumer surplus per day for anglers who elect to fish at Convict Lake is $.0109. This value seems unreasonably low relative to other studies on recreational per-day value (see Shrestha and Loomis, 2001, for examples of per-day recreational surplus estimates). However, typically values of recreational fishing are reported in terms of value of an *angler-day*, or the value of being able to fish at all. However, the present analysis is only concerned with *one water body*. There are many other comparable water bodies in the state of California and even within minutes of the Convict Lake. Table 3, adapted from the models and tables presented in chapter 2 of this dissertation, demonstrates the substitution patterns of anglers faced with a reduction in catch rates at Convict Lake from .853 fish/hour to .67 fish/hour. The low lost value here is the value of Convict Lake to anglers that originally choose to visit Convict Lake, *assuming* that the conditions at other lakes remain constant Table 3 indicates that this *ceteris paribus* assumption is defensible.

Table 3: Angler Substitution to Other Fisheries Given Reduction in Convict Lake Catch Rates from .85 fish/hour to .67 fish/hour

	Baseline Angler Days	After Policy Angler Days	Difference
Bridgeport Reservoir	45,815	46,554	739
Convict Lake	29,518	23,088	-6,430
Crowley Lake	120,062	121,999	1,936
Hot Creek	50,781	51,600	819
June Lake Loop	61,533	62,525	992
Mammoth Lakes	30,097	30,583	485

*Substitution to any one non-Mono County fishery is negligible

As a result, the reduction of stocking from 70,000 to zero fish at Convict Lake will come at a total cost of $126 per year (in terms of lost angler benefits). On the other hand, will save the California Division of Wildlife (and concessionaires' contracting of private hatchery stocking) roughly $126,000 per year[13]. In other words, the halting of fish stocking will come as a net *benefit*, even when ignoring the benefits from an endangered species management perspective.

These results assume that other sites' catch rates are not affected by the additional angler pressure (from ex-Convict Lake anglers). 6,000-8,000 anglers are unlikely to have a large affect on the other fisheries in California to which they substitute, but eliminating stocking programs at *multiple* fisheries would likely result in greater substitution of anglers and an inability to hold characteristics of other fisheries constant. The multiple-fishery simulation model that this scenario would require is beyond the context of the present study, but would be an interesting extension.

5. Discussion

[13] A catchable trout costs roughly $1.80 to stock (CDOW, 2010).

This paper presents a data-driven dynamic bioeconomic model of a single recreational fishery in Northern California (Convict Lake) in order to explore the implications of recent endangered species litigation that has led to curtailing of fish stocking. Results indicate that if fish stocking is eliminated at one site, anglers will respond to lower catch rates by substituting to other fisheries, and that there will be a new equilibrium between anglers and the recreational fish population which includes both positive fish and positive angler populations. Furthermore, lower catch rates at this fishery imply reduced benefits to anglers, but the loss in benefits to anglers is far outweighed by the cost savings of fish stocking. The reason is that there are many very close substitutes to Convict Lake that are either near Convict Lake or even closer to anglers' residences.

A simple marginal benefit-cost study of fish stocking at Convict Lake would have revealed that fish stocking here, from a net benefits to society perspective, is likely inefficient. However, the dynamic, bioeconomic model presented here allows for simulation of changes in angler and fish populations over time. Angler distribution may be relevant to local businesses that depend on angler visitation, and fisheries enthusiasts may wish to know whether or not a fishery will remain viable in the absence of stocking. These questions, answered in this paper, could not be answered using standard marginal analysis.

To the author's knowledge, this is the first study to evaluate inland recreational fishery management policy from a dynamic, bioeconomic perspective. As this approach is a more holistic approach, in the sense that the general framework reflects fishery-angler relationships more accurately than static, marginal analysis, the methods presented here also offer a tool for future researchers to evaluate the implications of various fish stocking policy alternatives. Specifically, the RUM offers a unique solution to predicting angler behavior in that it a) is consistent with standard economic theory, b) can predict spatial angler distribution across a multitude of sites under various hypothetical management scenarios, and c) can utilize data that is collected at a relatively low cost. Furthermore, data need not be time series and thus can be collected in a short amount of time.

There are, however, several caveats to the present analysis. First, the results presented here are not necessarily true at all fisheries, and are certainly not true if *multiple* major fisheries were to be affected by the new reduced fish-stocking policy. The present analysis assumes that the conditions at all other fisheries remain constant over time and that only Convict Lake receives reduced fish stocking. If anglers who substitute away from this fishery ultimately create pressure at other fisheries and reduce *those* fisheries' catch rates significantly, then the predicted substitution patterns among anglers in the present analysis would be erroneous. Future studies could model the effects of stocking policy at multiple fisheries using the methods presented here, but this is outside of the context of the present analysis.

A second caveat is that the present study makes several assumptions that could be empirically explored if biologists were to collect data and estimate fishery population growth models at Convict Lake. In order to calibrate the model presented here to empirical data, carrying capacity, harvest rates, carrying capacity *and* growth rates of the fish population needed to be altered simultaneously, since none were estimated empirically. Furthermore, even the fundamental functional relationship between fish population levels and growth was assumed to be logistic: whether or not this is realistic is unknown (although logistic growth is often assumed in the literature). Unfortunately, estimating these biological relationships would be both expensive and time consuming, and is left to future research.

Finally, the cross-sectional RNL only estimates marginal response rates to changes in catch rates, and although these are not linear, they may be functionally different at different catch rate levels. Since the no-fish-stocking model equilibrates with catch rates that are far lower than the status quo, it is unknown whether or not the resulting angler levels are realistic (see Loomis and Cooper, 1990).

Still, the model presented here provides a good step in the direction of modeling and managing recreational fisheries from an integrated bioeconomic perspective. Furthermore, the results show that even ignoring benefits to endangered species enthusiasts, eliminating stocking programs at Convict Lake may be a net benefit to society, since there are many very close substitutes for anglers. Finally, results corroborate many years of biological research which has suggested that anglers do respond to changes in fish stocking policy, but which could not address exactly how anglers would respond and thus could not make appropriate recommendations about fish stocking levels. The present analysis provides a framework within which biologists can evaluate fish stocking policy from an *economic* perspective, accounting for specific angler response rates and, more importantly, *value* to anglers.

Chapter 3 References

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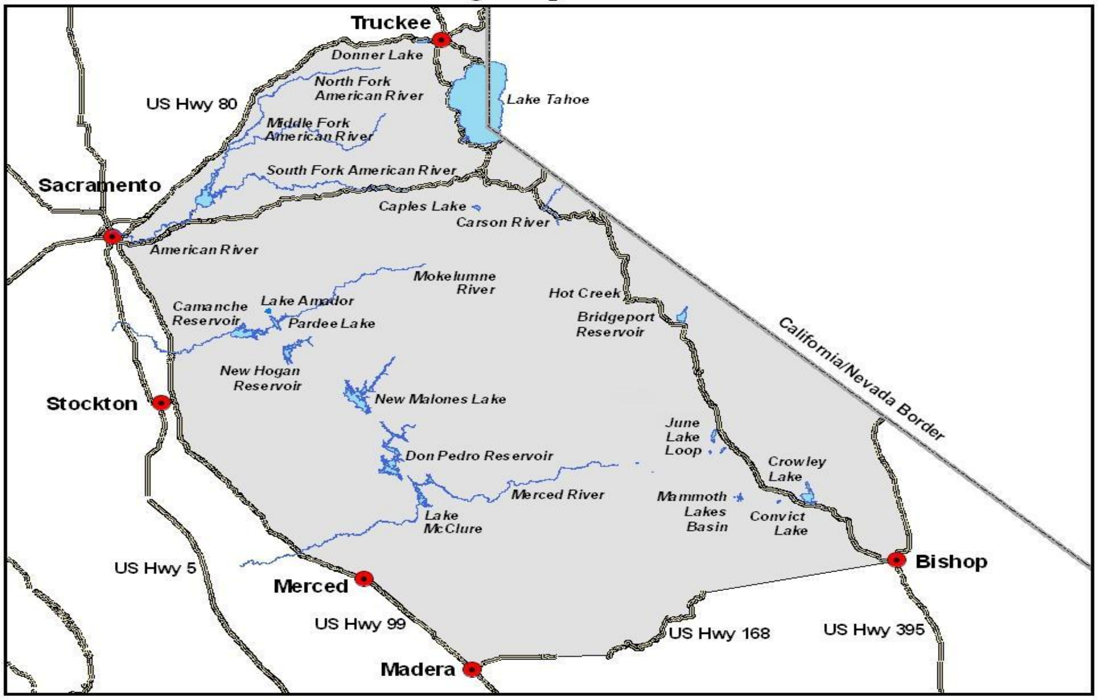
Chapter 3 Appendices
Appendix 3A: California Survey Region

Your Fishing Trips in California



*Study Region is shaded

Appendix 3B: Site Selection Survey Question

How many fishing trips did you take primarily for the purpose of fishing during the last 12 months to the following locations? How much time did you spend?

Water Bodies in California, Within Study Region on Enclosed Map

	# of Trips	# of Days		# of Trips	# of Days
American River			Mammoth Lakes Basin		
Bridgeport Reservoir			Merced River		
Camanche Reservoir			Mokelumne River		
Caples Lake			New Hogan Reservoir		
Carson River			New Malones Lake		
Convict Lake			Pardee Lake		
Crowley Lake			Other Public Rivers		
Don Pedro Reservoir			Other Public Streams (Small streams, brooks, creeks, etc.)		
Donner Lake			Other Public Lakes or Reservoirs		
Hot Creek			Other Public Ponds		
June Lake Loop			Private Ranches/Dude Ranches		
Lake Amador			Fishing Clubs		
Lake McClure			Fee-Fishing Ponds (U-Fish)		
Lake Tahoe			Other Private Waters (e.g. HOA)		

Water Bodies in California, but Outside Study Region

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Water bodies in AZ, NV and OR

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Water bodies in AK, CO, ID, MT, NM, UT, WA and WY

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Water bodies OUTSIDE of these states

	# of Trips	# of Days
Public Waters		
Private Ranches/Dude Ranches		
Fishing Clubs		
Fee Fishing Ponds (U-Fish)		
Other Private Waters (e.g. HOA)		

Appendix 3C: Bioeconomic Model Parameterization

A discrete time, discrete state, discrete control infinite time horizon model is constructed using GAMS software. The model conforms to the following assumptions.

(A1) $$H([x(t)+s(t)],a(t);\underline{\omega}) = \kappa \cdot \left[(x(t)+s(t)) - (x(t)+s(t)) \Big/ ((1+\omega_1 * a(t))) \right]$$

and

(A2) $$G([x(t)+s(t)];\underline{\eta}) = \eta_1 * (x(t)+s(t)) * \left[1 - \frac{(x(t)+s(t))}{\eta_2} \right]$$

ω_1, η_1 and η_2 are captured by "calibrating" the bioeconomic model. As described in the results section of this paper, an infinite number of calibration combinations exist. Depending on how the model is calibrated, the effects of eliminating stocking programs will be different. For the present analysis, ω_1 is assumed to be 0.1 and η_1 and η_2 are adjusted to calibrate the model. κ is the percentage of caught fish that are harvested or killed.

From the RNL, angler populations are assumed to respond to changes in site attributes such as travel cost, catch per unit effort, and type of site (e.g. lake, river, etc.):

(A3) $$R([x(t)+s(t)],a(t);\varphi) = \varphi * (a(t)) * \left[1 - \frac{(a(t))}{\mathrm{A}(\bullet)} \right]$$

and $$\mathrm{A}(\bullet) = \varsigma * p_{i|m}([x(t)+s(t)],a(t)) * p_m([x(t)+s(t)],a(t)) - a(t)$$

In this case, A represents the predicted number of anglers (from the RNL) and φ controls the rate at which angler levels will approach that predicted number. This prevents anglers from instantaneously doubling (or growing ten fold) in population in one time period, and makes sense given the fact that expectations about the fishery are likely change slowly. Still, φ is assumed and could only be estimated with time-series data. ς represents the possible angler days (total anglers multiplied by total choice occasions) for this site. Basically, this says that the change in angler days is total angler population, multiplied by the probability of a visit to this site, minus the original angler days at this site.

The probability of selecting a particular "nest" in the RNL model is as follows:

(A4) $$p_m([x(t)+s(t)],a(t)) = \frac{e^{\ln\left[\sum_{i=1}^{J} e^{X_j'\beta}\right] \cdot \theta_m}}{\sum_{m=1}^{M} \left\{ e^{\ln\left[\sum_{j=1}^{J} e^{X_j'\beta}\right] \cdot \theta_m} \right\}}$$

where *i* indexes sites within a nest and *m* indexes nests. Although there are many other variables that affect the probability of choosing a nest besides *x(t), s(t),* and *a(t)* for any particular site, the only things that are assumed to change over time are fish and angler populations, both of which affect catch per unit effort (one of the independent variables in the RNL). θ is the Inclusive Value (IV) parameter for each nest that is estimated with the RUM. In this case, the nest to be selected is "fishing in Mono County," the region in which Convict Lake:

$$\text{(A5)} \quad p_{j|m}(x(t),a(t),s(t)) = \frac{e^{X_j'\beta}}{\sum_{j=1}^{J_m} e^{X_j'\beta}}$$

This is the probability of selecting site *j* given the selection of the "fishing" nest. Thus, multiplying $p_m(\bullet)$ by $p_{i|m}(\bullet)$ gives the unconditional probability of visiting site *i*.

The specific parameterization is given from the RNL output described in table 2[43]:

$$\text{(A6)} \quad p_m(x(t),a(t),s(t)) = \frac{e^{\ln\left[\left(e^{-6.25+1.42*CPUE(x(t),a(t),s(t))}\right)+.07\right] .22}}{\left\{e^{\ln\left[\left(e^{-6.25+1.42*CPUE(x(t),a(t),s(t))}\right)+.07\right] \cdot .22}\right\}+\left\{34.87\right\}}$$

$$\text{(A7)} \quad p_{i|m}(x(t),a(t),s(t)) = \frac{e^{-6.25+1.42*CPUE(x(t),a(t),s(t))}}{\left(e^{-6.25+1.42*CPUE(x(t),a(t),s(t))}\right)+.07}$$

In spite of the fact that there are 49 separate alternatives in two nests, the model collapses to the relatively simple form seen above, with catch per unit effort, or CPUE, remaining as the only variable[44].

Catch per unit effort, or *CPUE*, is found as follows:

$$\text{(A8)} \quad CPUE(x(t),a(t),s(t)) = \frac{H(x(t),a(t),s(t))}{\left(1+a(t)*hours\right)}$$

where *hours* represents the number of hours in a day, and one "unit of effort" is an angler hour. The 1 in the denominator prevents CPUE from becoming undefined in GAMS.

From Haab and McConnell (2002), the benefits of an angler day, measured in dollars, is represented as follows:

$$\text{(A9)} \quad B(x(t),a(t),s(t)) = \frac{a(t)\cdot\left\{\ln\left(\left[1-p_{i|m}(\bullet)\right]^{\theta}\right)\cdot p_m(\bullet)+\left[1-p_m(\bullet)\right]\right\}}{\beta_{tc}}$$

---

[43] The constant term in the exponential functions, which is -6.25, is actually an aggregate term consisting of all other coefficients multiplied by their means. The reason for this is that in the dynamic, bioeconomic model, the only variable that is assumed to change from the anglers' perspective is catch rates at the site of analysis.

[44] The RNL collapses to this only if a homogeneous angler is assumed.

where β_{tc} represents the coefficient on travel cost from the RUM, which for this site is -.028, and θ represents the IV parameter from the RUM, which in this case is .21 for the "fishing" nest.

Finally, a general cobb-douglas cost function is assumed:

(A10) $C(x(t), a(t), s(t); \underline{\delta}) = \delta_1 \cdot s(t)^{\delta_2}$

In this case, it is assumed that there is a constant cost for stocking (δ_1 = 1) to be consistent with CDOW (2010).

Table A1: Parameter Values and Explanation

Parameter	Value	Explanation
η_1	2.0 or .95	Calibrated to match empirical data. If 2.0, then η_2 is calibrated to 230,000. If .95, then η_2 is calibrated to 450,000.
η_2	230,000 or 450,000	Calibrated as indicated above.
κ	.85	Average from Convict Lake angler data.
hours	8	8 hours in a fishing day.
ω_1	0.1	Entirely unknown, but assumed. Then, both η_1 and η_2 are calibrated accordingly.
ω_2	29,000	Starting angler value, estimated using RNL.
δ_1	$1.80	CDOW (2010)
δ_1	1	Constant Cost Function.
e^{-rt}	.9	Commonly assumed discount factor.