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Fishing Warmwater Streams with Limited Public Access: Angling Behavior, Economic Impact, and the Role of Guadalupe Bass in a Twenty-Four-County Region of Texas

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Abstract.—The Guadalupe Bass *Micropterus treculii* is a central Texas endemic black bass species occurring only in streams and rivers draining the Edwards Plateau ecoregion. It is designated the state fish of Texas and provides a popular sport fishery. In addition to being a popular sport fish, it is listed as a species of special concern due to habitat degradation and hybridization with Smallmouth Bass *M. dolomieu*. Past socioeconomic surveys of Texas black bass anglers have focused primarily on reservoir fisheries while little is known about fishing patterns, economic impact, and preferences of river and stream anglers. A Web-based open-access survey was used to determine fishing characteristics, assess attitudes and quantify the economic impact of anglers fishing rivers and streams in a 24-county region of Texas from August 20, 2011 to December 20, 2012, with a focus on anglers who specifically fished for Guadalupe Bass. A total of 700 respondents participated in the survey. More than half of respondents were paddlers targeting black bass, and 42% specifically fished for Guadalupe Bass on their trips. An additional 34% of anglers listed black bass species, which included Guadalupe Bass as their preferred species. Similar to previous surveys of Texas river and stream anglers, access was identified as the largest impediment to the future maintenance and improvement of river and stream fishing. Based on 563 surveys used in the economic impact analysis, using IMPLAN (Impact Analysis for Planning) Professional version 2 (Minnesota IMPLAN Group, Minneapolis), an estimated US$74,182,080 in direct angler expenditures was spent on fishing trips to the study region, resulting in a total economic impact (including indirect and induced impacts) of $71,552,492 and 776 full-time jobs. These findings indicate the economic value of river and stream angling to the Texas economy.

Introduction

Rivers and streams provide many vital ecosystem services to people, including the supply of water for drinking, irrigation, and hydropower generation (Postel and Thompson 2005). These services also include recreational opportunities and help support sustainable economies. Among the recreational opportunities, freshwater fishing continues to be one of the most popular and economically significant (Fisher et al. 1998). The most popular fish species among all freshwater anglers nationwide were black bass, with 10 million anglers spending 161 million days

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pursuing this species (U.S. Department of Interior, Fish and Wildlife Service, U.S. Department of Commerce, Bureau of Census 2011). Black bass angling in Texas accounted for more than 47% of the total effort expended; a total of 852,167 anglers fished over 11.3 million days (U.S. Department of Interior, Fish and Wildlife Service, U.S. Department of Commerce, Bureau of Census 2006). Among all species sought, average daily expenditures in Texas (amount spent per person per day) were highest among anglers targeting black bass species (U.S. Department of Interior, Fish and Wildlife Service, U.S. Department of Commerce, Bureau of Census 2006).

The Edwards Plateau ecoregion is the native range of the central Texas endemic Guadalupe Bass *Micropterus treculii*, which provides a popular sport fishery (Garrett 1991; Koppelman and Garrett 2002). In addition, to being a popular sport fish, Guadalupe Bass are listed as a species of special concern (Hubbs et al. 2008) due to habitat degradation and hybridization with Smallmouth bass *M. dolomieu* (Garrett 1991). The Texas population (currently more than 25 million and more than 85% urban) is expected to be more than 35 million by 2050 (Texas State Data Center 2013). As a result, the associated demand for water resources and increases in impervious cover due to expanding urbanization will negatively affect instream flow, water quality, and Guadalupe Bass habitat (Birdsong et al. 2010). In an effort to mitigate these threats, Guadalupe Bass are the subject of conservation initiatives to re-establish genetic integrity, restore degraded habitat, and protect existing intact habitat (Garrett 1991; Birdsong et al. 2010). Although Guadalupe Bass are a popular sport fish, little is known about the anglers that fish for them.

Assessment of behavior, preferences and economic impact of anglers that fish rivers and streams (many of which have low access) in central Texas and their underlying motivation will help aid future management efforts. Also, learning more about angler behaviors that target Guadalupe Bass, including expenditures made for Guadalupe Bass fishing trips, might help garner additional support for future conservation efforts, especially in communities that might economically benefit from these expenditures.

Angler expenditures and economic impacts have been assessed at national (U.S. Department of Interior, Fish and Wildlife Service, U.S. Department of Commerce, Bureau of Census 2011), regional (Schorr et al. 1995), state (Storey and Allen 1993; Kirkley and Kerstetter 1997; Southwick Associates 2007), and local levels (Chen et al. 2003; Bradle et al. 2006). There are a few components commonly examined to assess the economic contributions of anglers (Riechers and Fedler 1996; Bradle et al. 2006): (1) direct expenditures (also referred to as direct economic impact)—total dollar amount incurred during a fishing trip, and (2) total economic impact, which include direct expenditures but also indirect and induced impacts. Indirect impacts are purchases made by businesses who supply goods and services wanted by anglers (Riechers and Fedler 1996). Induced impacts are purchases of goods and services by households receiving income from businesses goods and services (Riechers and Fedler 1996).

Angler utilization and economic impact assessments of freshwater fishing in Texas have primarily focused on reservoirs (Thailing and Ditton 2000; Anderson et al. 2002). Boat and bank angling access to Texas reservoir fisheries is generally good (e.g., concrete boat ramps, fishing piers). Often, the reservoir shoreline is owned by the controlling authority and is open to the public for bank angling. Recreational fishing is frequently listed as a "purpose" for reservoir construction, and angling activity can be high (Chen et al. 2003; Schuett et al. 2012). Black bass populations in Texas reservoirs have been intensively managed using stocking and reservoir specific harvest regulations for decades (TPWD 1995).

Public access to Texas river and stream fisheries can be difficult (Baker 1998). Rivers and streams encompass a much more complex geographical area than reservoirs (more than 3,700 named streams and 15 major rivers flow through 200,000 mi of landscape; Samson 2011). While the public has the right to float the states' navigable rivers, ease of access is highly variable and sites are poorly defined and often remote (Baker 1998). More than 95% of land in Texas is privately owned, often resulting in conflict between river recreationists and private landowners (Baker 1998). Planning for entry and exit access points and/or overnight stays where most of the shoreline is privately owned adds an increased level of complexity to a river fishing trip. Given the hurdles that must be crossed to gain access to many Texas river and stream fisheries, fisheries managers have generally thought of them as low use, and few have received intensive fisheries management efforts. While it was assumed that fishing pressure was low on most river fisheries, relatively little is understood concerning angler behavior, motivation, preferences, and socioeconomic effects of fishing on these types of rivers.

Angler attitude and opinion and economic impact assessments of angling in Texas reservoirs have often used the intercept follow-up method (Thailing and Ditton 2000; Anderson et al. 2002). Using this method, names and addresses from anglers encountered during creel surveys are collected for the purpose of mailing a follow-up survey used to collect socioeconomic information (Ditton and Hunt 2001). Reservoirs have well-defined geographic areas and are often easily surveyed using a roving creel survey design. However, this method is not an efficient means of sampling river and stream anglers over a broad geographic area with many individual fisheries, where little or nothing is known about past spatial and temporal fishing use.

To gain a better understanding of angler behavior, preferences and economic impact of fishing on low public-access rivers and streams, and underlying motivation to fish these rivers and streams, our objectives were to (1) quantify direct expenditures to estimate the total economic impact of anglers who fished rivers and streams in our 24-county study region (including Guadalupe Bass anglers); (2) describe demographics, fishing behavior (e.g., fishing method, fishing mode), motivations, and preferences (e.g., fish species, management options) of anglers; (3) compare fishing behavior, motivations, and preferences of anglers who fished rivers and streams in our 24-county study region to Texas statewide angler surveys; and (4) identify what impediments exist to fishing rivers and streams. Objectives 2–4 provide information to help explain patterns of socioeconomic impacts and provide stream fisheries management options. We focused our study of river and stream anglers over a 24-county region of the Edwards Plateau ecoregion and collected data using a Web-based open-access survey as opposed to the intercept follow-up method. This methodology allowed a general overview of the spatial use and socioeconomics of anglers using river and stream fisheries, which can be used to justify future fisheries specific conservation, monitoring, and management actions.

Methods

Study region

The study region encompassed 24 Texas counties with 10 major rivers: Blanco, Colorado, Guadalupe, James, Llano, Medina, Pedernales, San Antonio, San Marcos, and San Saba (Figure 1). Rivers and streams in this region are characterized by wide limestone bedrock channels and have flows that are supported by springs that have constant water temperatures towards their headwaters. This region does not have much seasonality except for a few days during the year when temperatures may drop below 50° (Blair 1950). This region included most of the Edwards Plateau ecoregion and historical range for Guadalupe Bass. Some of the counties (nine) in the Edwards Plateau are sparsely populated with populations of less than 10,000 people (U.S. Census Bureau 2011c), but there are also major population centers along the eastern International Highway 35 boundary, such as Austin (current population of 820,611) and San Antonio (current population of 1.4 million; U.S. Census Bureau 2011a, 2011b). Anecdotal reports from anglers indicated that rivers in the study region had high-quality fishing opportunities for black bass species, including Guadalupe Bass. Except for portions of the Colorado and Guadalupe rivers (Magnelia et al. 2002; Bradle et al. 2006), we were unaware of any previous socioeconomic surveys conducted on rivers or streams in the study region.

Angler survey content

We used an open-access Web survey (www.surveymonkey.com) to obtain information from anglers who fished a river or stream within the study region from August 20, 2011 to December 20, 2012. The survey consisted of 36 questions that gathered information on demographics, fishing behavior (e.g., fishing method, fishing mode), motivations, preferences (e.g., fish species, management options), trip characteristics, (e.g., one-way travel distance and trip length), and trip expenditures. Respondents who answered "yes" to the question "Do you specifically fish for Guadalupe Bass in rivers and streams within the counties designated on the map?" on the survey were considered Guadalupe Bass anglers. As an incentive to participate, anglers who completed the survey were enrolled in a raffle for a rod-and-reel package valued at US$300. The survey was advertised on the Texas Parks and Wildlife Department (TPWD) freshwater fishing Web page (www.tpwd.state.tx.us/fishboat/fish/), through various media outlets such as online newspaper (e.g., Austin American Statesman and Houston Chronicle) articles, TPWD news releases, additional TPWD Web pages and publications, and angling-related forums (e.g., texasfishingforum.com, texaskayakfisherman.com). Additionally, angling clubs, service providers, and conservation organizations (e.g., Hill Country Alliance, South Llano River Watershed Alliance) were

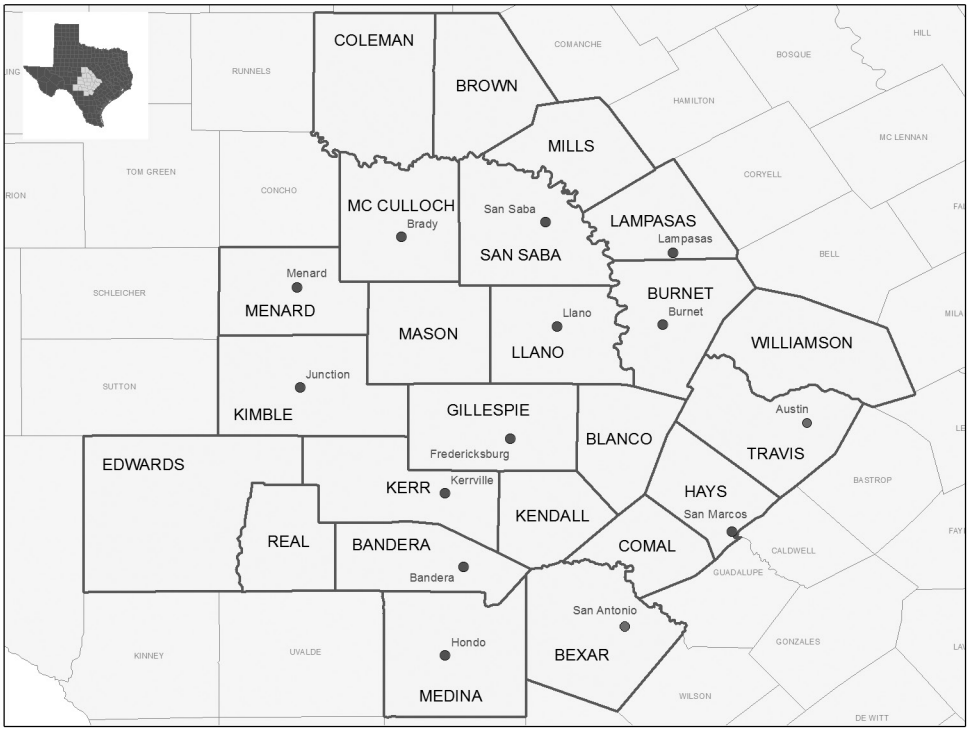

Figure 1. Twenty-four-county study region in central Texas to quantify fishing characteristics, assess attitudes, and quantify economic impact of anglers fishing rivers and streams, August 20, 2011 to December 20, 2012.

contacted through e-mail, asking for help advertising the survey. The Web-survey was closed after a 123-d period.

Trip expenditures

To estimate angler expenditures (direct economic impact) incurred on fishing trips, respondents were categorized as either nonlocal anglers (anglers that resided outside of the 24-county region of central Texas), nonresident anglers (any angler residing outside the state of Texas), or local anglers (anglers that resided within the 24-county region of central Texas. Expenditures were placed into 12 categories: (1) lodging, (2) restaurants, (3) groceries, (4) fuel, (5) equipment rental, (6) fishing tackle and supplies, (7) guide fees, (8) entrance fees, (9) fishing license, (10) launching fees, (11) airfare, and (12) miscellaneous. A median value was calculated for each expenditure category. The median value for each expenditure category was multiplied by the total number of fishing trips taken from August 20, 2011 to December 20, 2012. Using the median instead of the mean gave us a more conservative estimate of economic impact. For example, we had a few significantly higher trip totals (outliers) for some nonlocal respondents (e.g., $4,685, $3,615, and $3,075), whereas most other nonlocal respondents' trip total were less than $1,000. Each expenditure category was summed to give the total expenditures for all fishing trips. This process was repeated for nonlocal, nonresident, and local anglers.

Because the actual number of anglers who fished rivers and streams in the study region during the study period was unknown, we were unable to estimate population level trip expenditures for nonlocal and nonresident anglers. However, we were able to estimate population-level trip expenditures for local anglers using two additional sources of information in combination with the survey. Texas Parks and Wildlife Department point-of-sale freshwater fishing license data were used to estimate the total number of local freshwater anglers in fiscal year (FY) 2012 (September 1, 2011 to August 31, 2012) who resided in the 24-county study region. We assumed that anglers most likely purchased a license close to home and mainly fished within the study region. The total number of local

freshwater anglers in the study area was multiplied by the percentage (64%) of anglers who indicated on the Texas statewide angler survey (Landon et al. 2009) that they fished one or more days in a river or stream. This product gave an estimated total number of local river and stream anglers in our 24-county region. To estimate the total number of trips taken by local river and stream anglers, we multiplied the median number of trips reported by respondents on the Web survey by the total number of river and stream anglers. Finally, by multiplying the median trip expenditures reported by respondents on the Web survey by the total number of trips, we estimated the total expenditures made by local anglers during a 1-year period.

Study considerations

Determining population size of anglers is fundamental to valuating economic impact. A creel survey is the traditional method for obtaining this information. This is effective when the fishery is relatively small and/or there are defined access points (boat ramps). Because of the large size of our study region (partially defined by Guadalupe Bass distribution), the Internet-based survey was the most efficient approach for assessing anglers habits, motivations and expenditures. This approach is consistent with recommendations (National Research Council 2006) that Internet-based surveys be used as an alternative to intercept surveys for large area fisheries. We used fishing license sales to determine the angler population size for our 24-county study region. This number is likely conservative since it does not include anglers below the age of 16, but it may also have overestimated the number of anglers who actually fished in the 24-county study region as we could not confirm if anglers actually fished in the county where their fishing license was purchased. We also assumed that the 64% of anglers who responded to the last Texas statewide angler survey (Landon et al. 2009) that said they fished one or more days in rivers and streams accurately portrayed fishing habits of anglers who responded to our survey. Clearly, comparisons between Internet and intercept follow-up surveys are in need of additional evaluation. The Internet–based survey certainly has advantages that may mitigate drawbacks with this survey methodology (Dillman 2000), but the assumptions made concerning the computation of angler population size in our study area needs to be considered when interpreting results. Given the time, money, and manpower needed to conduct creel surveys on all the streams in our study region, this approach was not a reasonable option.

Indirect and induced economic impacts

IMPLAN (Impact Analysis for Planning) version 2 (Minnesota IMPLAN Group, Minneapolis) was used to estimate indirect and induced economic impacts. IMPLAN was originally developed by the U.S. Forest Service to assess economic impacts associated with land planning and resource management. In 1997, the Minnesota IMPLAN Group began modifying and expanding the scope of IMPLAN to estimate economic impacts for a wide variety of activities such as industry relocation, stadium development, and natural resources issues. In input–output models like IMPLAN, the relationship between direct, indirect, and induced impacts describes the economic importance of a fishery (Storey and Allen 1993; Chen et al. 2003). IMPLAN tracks changes in total fishing industry output (total dollar value in sales generated from angler expenditures), value added (the difference between the cost of an input and the value of fishing goods and services produced), income (wages and salaries generated by angler expenditures), employment (total full-time jobs created by angler expenditures), and state and local taxes (Storey and Allen 1993; Chen et al. 2003). IMPLAN allows users to examine economic impact at local, regional, or state levels. We used state multipliers in IMPLAN because we did not ask in what counties trip expenditures were spent.

In IMPLAN, trip expenditures (direct economic impact) are expressed in terms of fishing industry output, value added, income, employment, and state and local taxes that result from purchases by anglers (Steinback 1999; Hunt and Grado 2010). However, total economic impact also includes indirect and induced impacts. Indirect impacts are fishing industry output, value added, income, employment, and state and local taxes generated by local businesses selling goods and services to those making direct sales to visiting anglers, while induced impacts are fishing industry output, value added, income, employment, and state and local taxes generated by increased local income resulting from anglers' expenditures (Chen et al. 2003). As the initial retail purchase (direct impact) goes through several rounds of indirect and induced economic impacts, the economic impact of the initial purchase is multiplied, benefiting many individuals and businesses in an economy (Southwick Associates 2007). The summation of direct, indirect, and induced economic impacts comprises total eco-

nomic impact. To estimate the indirect and induced economic impacts using IMPLAN, fishing activity in rivers and streams of the study region was specified by six economic sectors: (1) food and beverage services, (2) food and beverage (e.g., groceries), (3) hotels and lodging, (4) transportation (e.g., gasoline stations), (5) retail services (e.g., fishing tackle), and (6) government (e.g., state and local taxes). Direct angler expenditures were allocated to the appropriate economic sector. To accomplish this, angler expenditures were separated into two categories: (1) durable goods—goods that typically last a long time and can be used more than once (e.g., boats, kayaks, fishing rods, and fishing tackle), and (2) nondurable goods—goods that are typically trip-related expenses such as lodging, gasoline, food, and beverages (Anderson et al. 1986).

Use of input–output models like IMPLAN requires some assumptions with regard to anglers' spending habits (Anderson et al. 1986). Angler expenditures serve both an export (sale of goods and services to anglers who live outside a region) and an import market (sale of goods and services to anglers who live inside a region); therefore, angler residence has an important effect on economic impact (Anderson et al. 1986). Anderson et al. (1986) suggest that nonlocal anglers travel to a region with the sole purpose of fishing, which injects new income into an economy. Therefore, most economic assessments only include nonlocal and nonresident anglers. However, Anderson et al. (1986) also argue that if a local fishing opportunity keeps local anglers from fishing elsewhere, then their expenditures would be considered new income entering an economy. Steinback (1999) also suggested that local spending helps support jobs in specific economic sectors that would not otherwise exist. We agree and analyzed the economic impacts for local, as well as nonlocal, and nonresident anglers. Inclusion of local anglers was important for several reasons: (1) rivers and streams encompass a much larger geographical area than reservoirs, (2) our local study region is the native range of Guadalupe Bass, (3) our local study region only comprised 9% of all counties in Texas, and (4) a one-way travel distance of 1–2 h is considered a hop to the local grocery store for many people in Texas, whereas this distance may seem prohibitive in other parts of the country.

Using total angler expenditures, we estimated population-level indirect and induced economic impacts for local anglers using the following approach: (1) calculated median angler trip expenditures (from Web survey), (2) allocated median angler trip expenditures to their corresponding IMPLAN producing sector, (3) expanded median sectoral expenditures to the 24-county fishing population using total number of anglers who indicated they fished a river or stream (from FY 2012 TPWD license sales and 2009 statewide angler survey data), (4) converted sectoral expenditures from purchaser prices (retailer prices) to producer prices (manufacturer prices) using IMPLAN, (5) used IMPLAN to calculate sectoral impact multipliers, (6) multiplied the results of step 4 (total expenditures) by step 5 (economic multipliers; we used state multipliers) to estimate total economic impact in terms of total fishing industry output, value added, income, employment, and state and local taxes (Schorr et al. 1995).

Results

There were 700 respondents to the survey. One-hundred thirty-seven respondents did not provide information on trip expenditures, resulting in 563 surveys for the economic analysis portion of the study.

Trip expenditures of nonlocal anglers

Because only two nonresident anglers (residing outside the state of Texas) responded, we combined them with nonlocal anglers. Thirty-four percent (n = 190) of respondents were nonlocal anglers who made 570 fishing trips to the study region. Median expenditures per trip for nonlocal anglers were $295. Nonlocal anglers spent a total of $168,150 in direct expenditures for the 570 fishing trips. Substantial categories of expenditures were fuel, lodging, and food and beverages (Table 1). Total fishing industry output as a result of direct expenditures using IMPLAN was $188,263 (Table 2).

Nearly half (42%) of nonlocal anglers (n = 80) specifically targeted Guadalupe Bass on their fishing trip. Median expenditures per trip for Guadalupe Bass anglers were $285, very similar to the median trip expenditures for all nonlocal respondents ($295). Guadalupe Bass anglers spent a total of $68,400 in direct expenditures for the 240 fishing trips, and food and beverages and fuel accounted for the majority of total expenditures (Table 1).

Trip expenditures of local anglers

Sixty-six percent (n = 373) of all respondents were local anglers who took 4,476 fishing trips during the study period. Median expenditures per trip for local anglers were $88. Total direct expenditures for all trips were $393,888. Food and beverages and fuel

Table 1. Direct expenditures made by nonlocal, local, nonlocal Guadalupe Bass anglers and local Guadalupe Bass anglers of a 24-county region from August 20, 2011 to December 20, 2012. All expenditures in U.S. dollars.

Expenditure category	Nonlocal anglers (n = 190)	Nonlocal Guadalupe Bass anglers (n = 80)	Local anglers (n = 373)	Local Guadalupe Bass anglers (n = 156)
Lodging	25,650	6,000	0	0
Restaurants	28,500	12,000	67,140	37,440
Groceries	28,500	12,000	44,760	22,464
Fuel	57,000	24,000	111,900	56,160
Equipment rental	0	0	0	0
Fishing tackle	11,400	5,400	44,760	28,080
Guide fees	0	0	0	0
Entrance fees	0	0	0	0
Fishing license	17,100	9,000	125,328	56,160
Launching fees	0	0	0	0
Airline ticket	0	0	0	0
Other	0	0	0	0
Total	168,150	68,400	393,888	200,304

expenditures accounted for most of the total, as it was for nonlocal anglers (Table 1).

Forty-three percent (n = 156) of local anglers indicated that they specifically fished for Guadalupe Bass. Median expenditures per trip for Guadalupe Bass anglers were $107, slightly higher than for all local anglers in general. Anglers specifically targeting Guadalupe Bass spent a total of $200,304 in direct expenditures on their 1,872 fishing trips. Similar to all angler groups, fuel and food and beverages comprised most of the total expenditures (Table 1).

Population-level trip expenditures

A total of 165,585 local anglers who fished rivers and streams in our study region purchased a freshwater fishing license in FY 2012 (September 1, 2011 to August 31, 2012; J. Taylor, TPWD, unpublished data). We estimated that these anglers made a total of 1,159,095 fishing trips to the study region (24 Texas counties with 10 major rivers) at a median cost of $88 per trip; thus, total estimated trip expenditures in our study region was $74,182,080. Direct expenditures

Table 2. Total economic impacts generated from anglers who fished rivers and streams in a 24-county region of Texas from August 20, 2011 to December 20, 2012. Indirect and induced impacts (fishing industry output, value added, income, and state and local taxes) were estimated using expenditures collected from Web survey and IMPLAN. All impacts are in U.S. dollars; employment in number of jobs.

	Angler type	
Impact	Nonlocal[a]	Local[b]
Expenditures	168,150	74,182,080
Fishing industry output	188,263	71,552,492
Value added	106,218	42,338,433
Labor income	63,863	25,757,880
State and local taxes	10,860	–
Employment	2	776

[a] Nonlocal and nonresident impact only reflects reported expenditures and the subsequent indirect and induced economic impacts of respondents who participated in the Web survey.

[b] Local impact reflects extrapolated expenditures and the subsequent indirect and induced economic impacts. Extrapolated expenditures were calculated from Texas Parks and Wildlife Department point-of-sale license vendor sales, and the statewide angler survey described in the methods.

made by local anglers resulted in a total fishing industry output of $71,552,492 and supported 776 full-time jobs (Table 2). Given that 42% of anglers answered "yes" when asked if they specifically target Guadalupe Bass in our study region, this represents 42% of these expenditures.

General angler demographics and preferences

Most respondents fished the Guadalupe (35% n = 213), Colorado (22% n = 132), and the Llano (20% n = 124) rivers. Most nonlocal anglers resided in Harris (21%; city of Houston), Tarrant (8%), and Dallas (6%; Tarrant and Dallas counties are in/or near the city of Dallas) counties, traveled an average of 309 km (one way) to the study region, and had a median trip length of 3 d. Local anglers resided predominately in Travis (34%), Bexar (16%), and Williamson (13%) counties (Travis and Williamson counties include the city of Austin, Bexar County includes the city of San Antonio) and traveled an average of 76 km (one way) to their fishing destination and had a median trip length of 1 d. Most (80%) respondents reported that fishing was the primary purpose for visiting rivers and streams in our study region. Respondents participated in fishing for a variety of generic reasons, as well as for reasons specific to fishing. The top three reasons for fishing indicated by all respondents were to enjoy natural scenery (67%), to relax (66%), and to get away from life's demands (58%) (Table 3). Two activity-specific reasons considered important by most respondents were to experience the thrill of the catch (52%), and for the challenge of the sport (43%) (Table 3). More than one-third of anglers (39%) found out about fishing opportunities and access to rivers and streams in Texas by word of mouth while others found out through other (angling forums comprised 38%) forms of communication (20%), fishing clubs

Table 3. Level of importance (%), number of respondents (n) and mean Likert score with standard error indicated by survey respondents to 14 potential motives for fishing. Means were measured on a 5-point Likert-scale, with 5 = very important and 1 = very unimportant.

Reason for fishing	Very unimportant	Somewhat unimportant	Neutral	Somewhat important	Very important	n	Mean ± SE
To enjoy natural scenery	1.5	1.2	1.8	28.1	67.4	602	4.6 ± 0.03
To relax	1.3	1.8	4.2	26.5	66.2	600	4.5 ± 0.03
To get away from life's demands	2.2	2.7	8.3	28.5	58.4	601	4.4 ± 0.04
To be close to the water	1.3	2.5	7.5	31.4	57.3	599	4.4 ± 0.03
To experience the thrill of the catch	1.5	3.2	5.9	37.4	52.0	596	4.4 ± 0.04
To explore new things and areas	1.5	2.8	10.4	39.0	46.2	597	4.3 ± 0.04
For the challenge of the sport	2.5	3.4	10.2	40.8	43.1	596	4.2 ± 0.04
To develop my fishing skills	1.7	6.0	15.5	39.8	37.0	600	4.1± 0.04
To spend time with loved ones	5.5	6.0	24.3	31.3	32.8	600	3.8 ± 0.05
To share my fishing knowledge with others	6.2	10.7	29.2	37.9	15.9	596	3.5 ± 0.04
To catch a trophy fish	13.2	19.5	29.9	22.9	14.5	599	3.1 ± 0.05
To catch many fish	10.8	15.3	28.3	31.1	14.5	594	3.2 ± 0.05
To catch fish for eating	40.2	20.1	16.6	13.9	9.2	597	2.3 ± 0.06
To exercise	17.8	14.4	28.5	31.4	7.8	589	3.0 ± 0.05

(15%), and the TPWD Web site (15%). A majority of respondents (56%) were current members of a fishing or conservation-related group.

Forty-two percent of respondents answered "yes" when asked if they specifically fished for Guadalupe Bass in our study region. In a separate question, 34% of anglers' ranked black bass *Micropterus* spp. as their most preferred species to fish for, which included Guadalupe Bass. Other popular species included Common Carp *Cyprinus carpio* (12%) and White Bass *Morone chrysops* (7%). Trout *Oncorhynchus* spp. were listed by 22% of the respondents as preferred species. A popular winter Rainbow Trout *O. mykiss* fishery exists in the lower Guadalupe River below Canyon Reservoir (Magnelia 2004), which was included in our study region. Most respondents often or always used artificial lures (63%) or fly-fished (58%). Most (61%) never or rarely used live bait (Table 4). Most respondents wade-fished (59%) or fished from kayaks, canoes, and float tubes (53%) (Table 5). Few used a motorized boat. Most respondents strongly supported efforts to maintain or improve habitat (75%) and water quality (78%), and only 39% and 34% of the respondents from our Web survey thought that increased stocking or restrictive harvest regulations were very important, respectively. Seventy-four percent of respondents thought increased access was somewhat to very important (Table 6). When asked about impediments to fishing rivers and streams, most (67%) respondents indicated that access was the largest impediment.

Guadalupe Bass angler demographics and preferences

Guadalupe Bass anglers fished the Guadalupe (29% $n = 77$), Llano (26% $n = 68$), and Colorado (20% $n = 52$) rivers most often. Similar to the response from all anglers, most nonlocal Guadalupe Bass anglers resided in Harris (25%), Tarrant (8%), Dallas (6%), and Montgomery (6%) counties, traveled an average of 317 km (one way) to the study region, and had a median trip length of 3 d. Local Guadalupe Bass anglers resided predominately in Travis (38%), Bexar (16%), and Williamson (13%) counties (counties encompassing the cities of Austin and San Antonio) and traveled an average of 74 km (one way) to their fishing destination and had a median trip length of 1 d, which again was similar to the overall response from all anglers. The majority of Guadalupe Bass anglers (87%) reported that fishing was the primary purpose for visiting rivers and streams in the study region. Guadalupe Bass anglers participated in fishing for a variety of generic reasons, as well as for reasons specific to fishing. The top three reasons for fishing indicated by Guadalupe Bass anglers were to enjoy natural scenery (75%), to relax (68%), and to be close to the water (66%). Two activity-specific reasons considered important by most Guadalupe Bass anglers were to experience the thrill of the catch (49%), and for the challenge of the sport (45%). The top three information sources for river and stream fishing opportunities and access were word of mouth (40%), fishing clubs

Table 4. Fishing method (%), number of respondents (n) and mean Likert score with standard error for anglers fishing rivers and streams in a 24-county region of Texas from August 20, 2011 to December 20, 2012. Means were measured on a 5-point Likert-scale, with 5 = always and 1 = never.

Fishing method	Always	Often	Occasional	Rarely	Never	n	Mean ± SE
Fly-fishing	33	25	12	10	21	588	3.4 ± 0.06
Artificial lures	25	38	16	11	9	570	3.6 ± 0.05
Live bait	5	19	15	30	31	551	2.4 ± 0.05

Table 5. Fishing mode (%), number of respondents (n) and mean Likert score with standard error used by river and stream anglers in a 24-county region of Texas from August 20, 2011 to December 20, 2012. Means were measured on a 5-point Likert-scale, with 5 = always and 1 = never.

Fishing mode	Always	Often	Occasional	Rarely	Never	n	Mean ± SE
Canoe, kayak, or float tube	15	38	19	11	16	587	3.3 ± 0.05
Wading	13	46	19	15	7	580	3.4 ± 0.05
Shore	9	40	21	22	8	573	3.2 ± 0.05
Boat	2	11	14	29	44	564	2.0 ± 0.05

Table 6. Importance level (%), number of respondents (*n*) and mean Likert score with standard error indicated by anglers to five types of management actions to improve Texas' river and stream fisheries. Means were measured on a 5-point Likert-scale, with 5 = very important and 1 = very unimportant.

Management action	Very unimportant	Somewhat unimportant	Neutral	Somewhat important	Very important	*n*	Mean ± SE
Increased access	6	5	16	26	48	593	4.0 ± 0.05
Restrictive harvest regulations	5	7	28	26	34	589	3.8 ± 0.05
Increased stocking	3	7	17	34	39	595	4.0 ± 0.04
Water quality improvement	2	1	3	16	78	596	4.7 ± 0.03
Habitat improvement	2	1	3	19	75	596	4.6 ± 0.03

(16%), and the TPWD Web site (12%). Most (66%) Guadalupe Bass anglers were current members of a fishing or conservation-related group, slightly more than that for all anglers (56%). Respondents who specifically targeted Guadalupe Bass (*n* = 277) predominately fly-fished (68%) and used artificial lures (58%). When fishing rivers or streams, nearly three-quarters wade-fished (70%) or used a kayak, canoe, or float tube (56%). Seventy-four percent rarely or never fished rivers or streams from a boat with a motor. Most respondents also strongly supported efforts to maintain or improve habitat (81%) and water quality (85%), a similar but higher percentage than that expressed by all anglers. A majority (78%) of Guadalupe Bass anglers indicated that they would fish rivers and streams in our study region more often as a result of the efforts to restore Guadalupe Bass populations. Only 34% thought that stocking was very important, and 36% thought that regulations were very important. More than three-quarters (76%) of respondents thought increased access was somewhat to very important. A majority (80%) also supported additional free access along rivers and streams.

Discussion

Angler behavior, motivation, and socioeconomics

The total economic impact reported from our survey was much higher than reported from two of Texas' most popular trophy Largemouth Bass M. salmoides reservoir fisheries (Chen et al. 2003; Schuett et al. 2012). Direct expenditures resulting from Lake Amistad anglers in 2007–2008 were estimated at $14.6 million, which resulted in a total economic impact of $14.9 million and 110 full-time jobs (Schuett et al. 2012). Chen et al. (2003) reported an estimated $14.5 million in total direct expenditures from nonresident Lake Fork anglers in 1994–1995, resulting in a total economic impact of $18.6 million and 367 full-time jobs. However, to understand the magnitude of economic impact of fishing in our study region, one needs to understand the spatial scale of this study relative to reservoir economic studies. A reservoir represents only one water body and encompasses a few counties at most. For example, Lake Fork is located in only three counties (Chen et al. 2003). In contrast, our study region encompassed 24 counties and 10 major rivers. For comparison, fishing in our study region ($2.9 million per county at the state level) was lower in total economic impact than in the Lake Fork region ($6.2 million per county for local good and services and $3.2 million per county at the state level). Our total economic impact was conservative in that we were unable to estimate population level trip expenditures for nonlocal and nonresident anglers. Also, our analysis focused only on the economic impact of nondurable goods and services; it did not include angler expenditures associated with the purchase of boats, trailers, paddle craft, fishing clothing, and fishing equipment (Chen et al. 2003). Thus, our total economic impact was conservative in that it only included consumables associated with specific fishing trips to rivers and streams in our study region. Yet, in another context, the $71 million in total economic impact may provide significant local economic benefits to the nine sparsely populated (<10,000 people) counties in the study region.

There are several factors that help explain differences in expenditures between reservoir and river anglers. First, differences in geographical scale explained different expenditure patterns between reservoir and river anglers. Rivers and streams encompass a much more complex and broader geographical area than reservoirs. Many rivers span hundreds of miles through numerous counties, whereas most reservoirs are located within a few counties. Consequently, the size of the local area surrounding a river or reservoir affects angler expenditures in several ways. Local anglers traveled an average of 76 km (one way) within our 24-county study region and spent a median of $88 per trip to fish a river or stream. In comparison, Lake Fork (a Texas trophy bass fishery) is located in only three counties (Chen et al. 2003) and local anglers spent an average of $51 per fishing trip (Chen et al. 2003). At Georgetown Reservoir in Williamson County, Texas, local anglers resided within five counties (Williamson, Travis, Burnet, Milam, and Bell counties) and spent an average of $69 per trip (Magnelia and De Jesus 2006). Thus, geographical differences in terms of local fishing destination affect travel distances of anglers and their corresponding trip expenditures. Rivers and streams are characterized by length. Most central Texas rivers where Guadalupe Bass distribution occurs are headwater streams and tend to be located farther from population centers than many reservoirs, which are better characterized by area.

The quality of a fishery or the way it is managed (i.e., trophy fishery versus general statewide regulations) may also affect spending habits. Some fisheries seek to promote a trophy fishery, offering a greater opportunity to catch a large fish (Chen et al. 2003; Schuett et al. 2007). This trophy opportunity often attracts more anglers (especially out of state) who are willing to pay more in travel costs and bypass fishing destinations closer to home (Chen et al. 2003). At Lake Amistad, a Texas fishery noted for trophy-size bass, 90% of anglers were nonlocal (including out of state) and averaged $656 per trip to the reservoir (Schuett et al. 2007). In comparison, 34% of the anglers from our Web survey were from outside our 24-county study region and spent a median of only $295 per trip to a river or stream. The Guadalupe River trout fishery below Canyon Reservoir was the only fishery in our study region that had harvest regulations that differed from statewide regulations (454 mm minimum length and one trout daily bag limit), and the ability to potentially catch a large trout may also have been responsible for its popularity among our survey respondents.

The margin between nonlocal expenditures may also be attributed to the average length of fishing trips, where nonlocal (including out of state) Lake Amistad anglers spent an average of 5.9 d (Schuett et al. 2012). Nonlocal anglers from our Web survey averaged 3 d per trip and only two nonresident anglers responded to the survey. Thus, the number of nonlocal anglers and the length of a fishing trip may also account for differences in nonlocal expenditures.

So why is the economic impact associated with fishing rivers and streams in our study region relatively high given the previous assumption that use of these fisheries was low? Other than the large spatial scale of our study region, the basis for this impact is the large number of anglers and fishing trips and may be related to the underlying motivations for fishing rivers and streams in our study region, and specifically for Guadalupe Bass.

Fisheries resource reasons may have contributed to the high number of anglers and fishing trips to our study region and subsequent economic impact. Black bass were a preferred fish species similar to results for freshwater anglers from previous Texas statewide angler surveys (Tseng et al. 2006; Landon et al. 2009). In statewide surveys where black bass preference was specified, most (50–53%) anglers preferred Largemouth Bass to other fish species (Bohnsack and Ditton 1999; Tseng et al. 2006), whereas 42% of our survey respondents specifically fished for Guadalupe Bass. Differences in distribution, abundance, and habitat of Largemouth Bass and Guadalupe Bass underlie angler black bass preferences. Most (81%) anglers in the statewide survey spent their time fishing in reservoirs (Landon et al. 2009) where Largemouth Bass are well adapted (Thomas et al. 2007). In contrast, Guadalupe Bass are adapted for rivers and streams, have a propensity for fast-moving water, and are not a large component of reservoir fisheries (Garrett 1991).

Psychological motivations may have also attracted anglers to our study region. The fishing experience for Guadalupe Bass is often compared to those shared by trout enthusiasts (Garrett 1991)—Guadalupe Bass are known as the "Texas trout," and the size of the fish caught is not as important as the overall fishing experience. Thus, the opportunity to target Guadalupe Bass may have contributed to the high number of anglers and fishing trips in our study region.

The motivation to develop specific angling skills or paddle may have contributed to the high

number of anglers and fishing trips to our study region. Most respondents wade-fished or fished from a kayak or canoe using artificial lures, and many fly-fished. Most of the rivers and streams in our study region have clear water, which is ideal for sight-casting using flies and light tackle, and are shallow, making fishing more accessible by wading or paddling. Only 12.9% of respondents in our study fished from a boat with a motor compared to 77.8% of respondents in the Texas statewide survey (Landon et al. 2009). Access to most rivers and streams in the study region by motorboat can be difficult compared to paddle craft, and on many rivers in the study region, their use is not practical due to shallow depths, boulders, low water dams, and low water crossings. Paddle craft are easily maneuverable, especially in shallow water, and provide access where it is difficult to wade-fish (Quam 2014). This finding is not surprising given that paddle sports are one of the fastest-growing outdoor recreation activities in the nation (Cordell 2008), including among anglers. In 2008, the National Survey on Recreation and Environment reported that more than 40% of the national population participated in paddle sports (NSRE 2010). In Texas, paddle sports have grown from 2 million participants in 1994–1995 to nearly 4 million in 2006–2009, with kayaking leading the way (G. Green, University of Georgia, personal communication). Furthermore, with the increased cost of gasoline and the significant expense involved in the maintenance, transportation, and use of motorboats for fishing, some anglers are resorting to paddle craft fishing as a lower-cost alternative (Birdsong 2013).

Angler-induced economic impact can be used to justify conservation (Riechers and Fedler 1996) and fisheries management actions (Schorr et al. 1995). Fishing in central Texas rivers and streams generated surprisingly high economic impact given the previous assumption that angler use was low. Most river and stream fisheries in Texas are not the focus of intensive fisheries management efforts (i.e., stocking, customized harvest regulations, habitat improvement, and improved angler access). Like many river fisheries throughout the United States, they are likely not managed in proportion to their economic value (Fisher et al. 1998). Angler expenditures to specifically fish for Guadalupe Bass reported in this study help justify continuing efforts for restoring, improving, and protecting instream and riparian habitat, as well as efforts to enhance the genetic integrity of this species. Habitat improvement was identified by respondents in this survey as important to the future maintenance of river and stream fisheries, and Guadalupe Bass anglers indicated that they would fish rivers and streams in our study region more often as a result of ongoing Guadalupe Bass restoration efforts. The Texas Parks and Wildlife Department has initiated 16 restoration projects in the South Llano River watershed. These efforts currently encompassed 53,000 acres and 35 mi of rivers and streams (G. Garrett, TPWD, personal communication).

While it is understood that there are many contributing factors that have led to a decline in fishing participation, access is one of the most consistently identified (Responsive Management 2010). If anglers do not have access to places to fish, they may choose to fish elsewhere or may even decide to not fish at all (Responsive Management 2010). Consequently, lack of public access may be a factor that explains differences between reservoir and river angler economic impact. Lack of access was identified as the largest impediment to anglers fishing rivers and streams in our study and will likely need to be improved before more anglers use this resource. Leased angler access programs, where private property is leased so anglers have a path to enter and exit the fishery without trespassing on private property is one solution TPWD has just started to explore (TPWD 2013a). Seven new fishing areas opened to the public through this program in 2013, including locations on the Colorado and Guadalupe rivers in central Texas, with expansion to other fisheries expected in the future (TPWD 2013a). The Texas Paddling Trails program, which currently provides access points and a platform for local communities and landowners to promote sustainable economic opportunities and participate in the conservation of wildlife and aquatic resources (TPWD 2013b), might also be utilized to expand river fishing opportunities. Fisheries management actions (e.g., customized harvest restrictions) could be made to protect and improve fisheries in these segments of river and could be marketed specifically for river and stream anglers. In addition, improved public outreach identifying current access sites would help communicate to the public not only what TPWD is doing to improve access, but also to conserve and enhance Guadalupe Bass populations. Many anglers found out about fishing opportunities and access to rivers and streams in Texas through online angling forums. Thus, it is recommended that fishing opportunities and access to rivers and streams be marketed on online angling forums.

River and stream fishing is a potential growth area for TPWD and other fish and wildlife agencies across the country (Fisher et al. 1998). Fishing, although important and economically significant, is not the only ecosystem service that freshwater ecosystems provide people (Fisher et al. 1998). Human demand for ecosystem services will require consideration of sociological, biological, and economic concerns to maintain ecologically sustainable rivers and streams (Richter et al. 2003). State fish and wildlife agencies charged with managing rivers and streams should consider a broad spectrum of values (e.g., fish production, esthetics, and other recreation; Angermeier et al. 1991) to determine what resources should be allocated to their conservation and management. While economic impact of recreational fishing can be used as a surrogate for other values that freshwater ecosystem services provide and to show the need and benefits of ecologically sound river management. Failure to recognize these services and incorporate them into decisions about the management of rivers and streams will reduce the net benefit not only for anglers, but also for society (Postel and Thompson 2005).

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