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ARTICLE

Analysis of a Catch-and-Harvest Fishing Contest for Brown Trout Spanning 50+ Years: Long-Term Trends Influenced by Fisheries Management Actions and Angler Behavior

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Abstract

Long-term effects of evolving fisheries management, changing angler practices, and stream habitat development on stream trout fisheries in southeastern Minnesota, USA, were examined by analyzing data on >1,000 weekly winners from a single-watershed, catch-and-harvest Brown Trout *Salmo trutta* fishing contest spanning 54 years. The weights of winning fish declined significantly across the period examined. No-entry weeks increased within the past two decades, corresponding to expanding catch-and-release fishing. The streams that produced winning fish shifted as stream access increased, degraded stream habitat was improved, and various angling restrictions were instituted. Most winning fish were caught with live or preserved bait, although the proportion of winners caught with artificial lures doubled from the 1960s to the 2010s. The interpretation of contest results must consider various angling regulations (e.g., protected slot lengths, artificial lures only, catch and release only) that were placed on some reaches during and after the 1980s, increasing voluntary catch-and-release practices of contemporary anglers, and expanding stream access and habitat improvements within the watershed.

Fishing contests and tournaments are very common in marine and inland fisheries across North America (Schramm et al. 1991). These competitions range from small, local contests that are open to the general public and offer token awards to winning anglers (Olson and Cunningham 1989; Meyer et al. 2001) to large, single-day events that attract 10,000 anglers (e.g., The Brainerd Jaycees $150,000 Ice Fishing Extravaganza; Brainerd Jaycees 2022) to big-business tournaments that are restricted to sponsored, professional anglers who compete for substantial prize money (e.g., Bassmaster Elite Series; Bassmaster Elite 2022). Together, 30,000 to 50,000 fishing contests and tournaments occur in North America each year (Schramm et al. 1991).

Individual fishing competitions often have a long history, occurring annually over multiple decades (e.g., Olson and Cunningham 1989; Gilbert and Sass 2016). These long-running (>40 years) competitions may be focused on just one or a small number of related species (Gilbert and Sass 2016; www.salmon.seward.com), or they may include many species of game fish (Olson and Cunningham 1989; www.newglsf.org). With 100–1,000 of entries each year, these competitions have the potential to generate a wealth of fish data with minimal effort on the part of management agencies (Olson and Cunningham 1989; Jacobson 1992; Gilbert and Sass 2016).

Many scientific studies have examined fishing competition data to gain insights into the competitions themselves (Wilde et al. 1998), the effects of competitions on fisheries (Schramm et al. 1987; Kwak and Henry 1995), and fish abundance (Olson and Cunningham 1989; Hargrove et al. 2015), size (Olson and Cunningham 1989; Schwartz 1998; Gilbert and Sass 2016), diets (Brandt 1986; Meyer et al. 2001), and growth rates (Jacobson 1992).

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When good contest records have been maintained, data from long-term competitions have been especially useful in examining historical trends in fish size and catch rates in response to changes in angling regulations, stocking, and angler behaviors (Olson and Cunningham 1989; Gilbert and Sass 2016). These records are extremely valuable, especially when comparable data that are collected by management agencies are unavailable or incomplete.

Fishing contests for trout and salmon on inland waters are common in North America, although historically they represented <9% of competitive fishing events (Schramm et al. 1991). Contests for naturalized, stocked, and native salmonids occur throughout the Great Lakes region, in streams and rivers of the Appalachian and Rocky Mountains, and in other areas where coldwater streams or deepwater lakes and reservoirs support populations open to angling. However, contests involving trout or salmon seldom have been the focus of scientific study (e.g., Brandt 1986; Olson and Cunningham 1989; Bushong 1992), and few studies of long-term trout or salmon contests are available (Olson and Cunningham 1989; Bushong 1992).

Ongoing, long-term fishing contests and tournaments have occurred against a backdrop of changing harvest regulations; shifting angler attitudes and behaviors; enhanced public access to fishing areas; and, within many lotic systems, expanding fish habitat development. Management agencies often have mandated conservative harvest regulations for many game fishes to improve catch rates, alter population size structures, and improve trophy potential (Anderson and Nehring 1984; MN DNR 1997; Johnston et al. 2011; Sass and Shaw 2020). Additionally, individual anglers and several organized angler groups (e.g., Trout Unlimited, Muskies Inc., Bass Anglers Sportsman Society) have practiced and/or promoted voluntary catch and release to conserve fish resources and to counter perceived negative effects of fishing and fish harvest on fish populations (MN DNR 1997; Lewin et al. 2006; Snook and Dieterman 2014; Sass and Shaw 2020). Consequently, release rates for several game fish species (e.g., Largemouth Bass *Micropterus salmoides*, Muskellunge *Esox masquinongy*, Brown Trout *Salmo trutta*) have increased during the past 30 years, with anglers now releasing >95% of the fish that are caught in many lakes and streams (Snook and Dieterman 2014; Sass and Shaw 2020). Easy angler access to fishing waters has expanded via new and improved boat ramps and stream angling easements that have been purchased from private landowners (Snook and Dieterman 2014). Finally, fish habitat development projects, especially in streams and rivers, have been undertaken to increase the abundance and biomass of adult fish relative to unmanipulated reaches (Thompson and Stull 2002; Avery 2004; White et al. 2011; Snook and Dieterman 2014; Roni et al. 2015).

In the present study, I examined data on fish size, capture location, bait/lure use, and angler demographics from a long-term stream trout fishing contest in southeastern Minnesota that required fish harvest to enter. The primary goal of this study was to assess the potential influences of changing angling regulations, shifting angler behaviors, expanding angler access easements, and stream habitat development projects on the contest results across 54 years of contest records. A previous examination of the contest results (Bushong 1992) detected no trend in the average size of winning Brown Trout during the first 29 years of the contest, but numerous management actions (especially gear and harvest restrictions), expanding catch-and-release angling, and stream habitat development projects with the potential to influence contest results have occurred within the contest region since the earlier study.

MATERIALS AND METHODS

Study location and fishing regulations.— The Whitewater River (44°05′19″N, 92°01′04″W) is located in the Driftless Area ecoregion (Paleozoic Plateau) of southeastern Minnesota, USA, with a drainage area of 830 km^2 across Olmsted, Wabasha, and Winona counties (Figure 1). In addition to the main-stem Whitewater River, the river system is comprised of three major forks (North Fork Whitewater River [North Fork], Middle Fork Whitewater River [Middle Fork], and South Fork Whitewater River [South Fork]) and five smaller tributaries (Trout Creek, Beaver Creek, Trout Run, Logan Branch, and Crow Spring). Together, these streams comprise >100 km of fishable trout water that is accessible via public lands and purchased fishing easements on private lands. Limited creel survey data (Weiss 1999, 2000; Snook and Dieterman 2006, 2014) indicate that fishing pressure on three Whitewater River streams (North Fork, Middle Fork, and Crow Spring) has increased since the 1970s.

Trout stocking (Brown Trout, Brook Trout *Salvelinus fontinalis*, and Rainbow Trout *Oncorhynchus mykiss*) and habitat development projects helped the fishery recover from degraded conditions caused by poor land use (e.g., soil erosion caused by overgrazing, tilling hillslopes, deforestation) prior to the 1940s (Thorn et al. 1997). Some adult fish were stocked during the 1960s and 1970s, but only yearling and/or fingerling fish have been stocked since 1975. All of the streams currently support self-sustaining populations of Brown Trout, with naturally reproducing Brook Trout also present in Trout Creek, Trout Run, and Crow Spring. Catchable-size Rainbow Trout continue to be stocked at select stream sites to support put-and-take fisheries in high-use locations.

Trout harvest regulations in southeastern Minnesota have changed several times from the 1960s to the present (D. Dieterman and J. Hansen, Minnesota Department of Natural

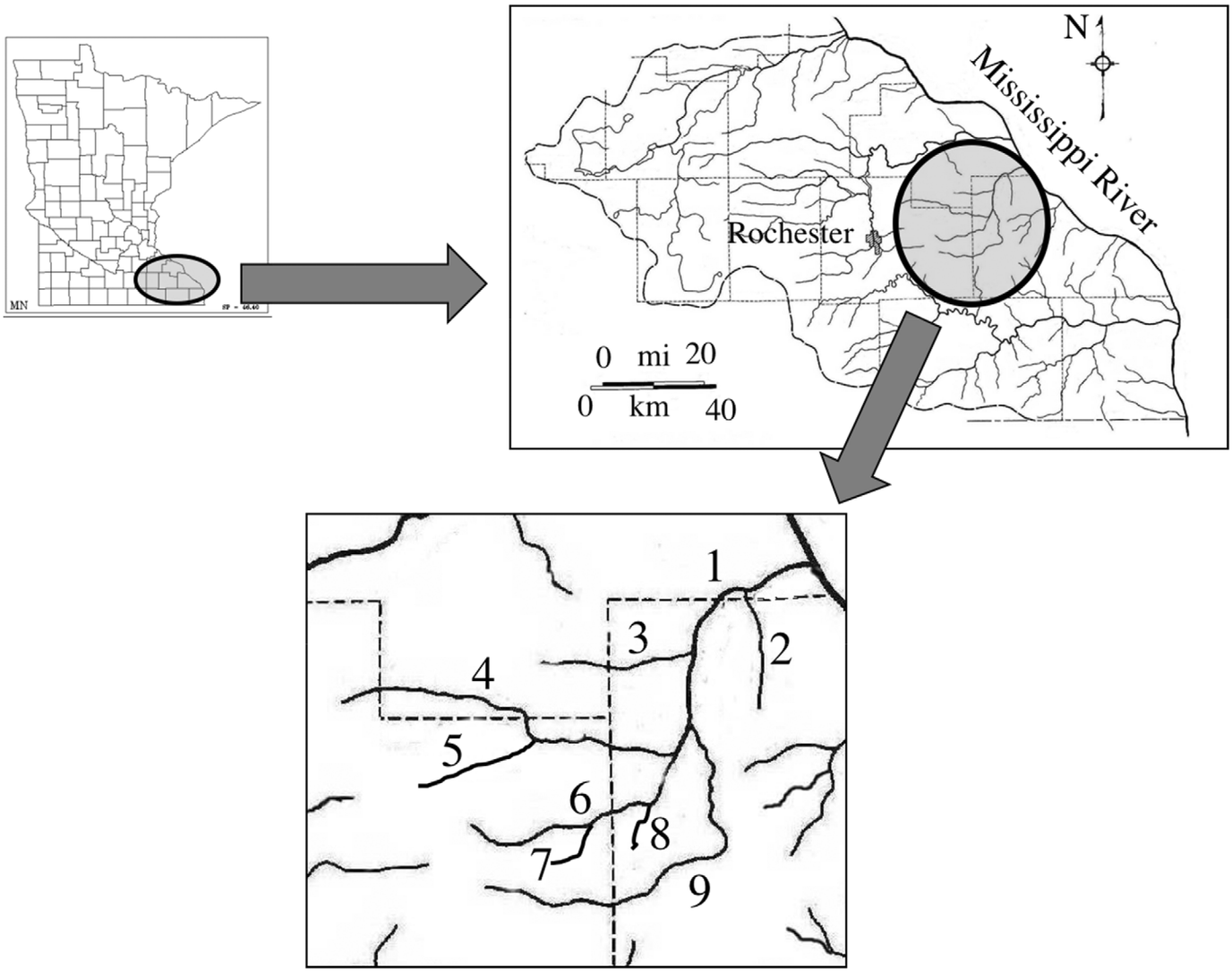

FIGURE 1. Maps showing the location of the Whitewater River in southeastern Minnesota between Rochester, Minnesota, and the Mississippi River (Olmsted, Wabasha, and Winona counties: boundaries designated by dashed lines) and the streams that comprise the Whitewater River system: **1** Whitewater River main stem, **2** Trout Creek, **3** Beaver Creek, **4** North Fork Whitewater River, **5** Logan Branch, **6** Middle Fork Whitewater River, **7** Crow Spring, **8** Trout Run, and **9** South Fork Whitewater River.

Resources, personal communication; Figure 2). The harvest season ran from May through mid-September (20 weeks) from 1963 through 1969, increased to 24–25 weeks from 1970 through 1974, increased again to 29–31 weeks from 1975 through 1981, but was shortened to 24–25 weeks from 1982 through 1998 and then to 22 weeks (mid-April through mid-September) from 1999 to the present. From the 1960s through 1974, there was a daily bag limit of 10 fish (with not more than three fish >40.6 cm; Figure 2). From 1975 to 1989, the daily bag limit was five fish (with not more than three fish >40.6 cm). Since 1990, the daily bag limit has remained at five fish, but only one can be >40.6 cm.

Some sections of the South, Middle, and North forks have been subject to additional, special regulations that may have affected trout harvest (Dieterman, personal communication; Figure 2). A 1.6-km reach of the South Fork has had a 25.4-cm maximum size limit since 1986. The Middle Fork has gone through a series of changes, including catch and release and artificial lures only (no bait) during the spring/summer season on a 5.3-km reach from 1991 through 1994, allowing bait use again from 1995 through 2004 (barbless hooks only beginning in 1999), and finally expanding the special-regulations (catch and release, artificial lures only) reach to 14.8 km (including all of Crow Spring as well) and returning to artificial lures only (no bait) from 2005 to the present. The North Fork had a protected slot (30.5–40.6 cm) that was implemented in 1999 on a 19.5-km reach, with an artificial-

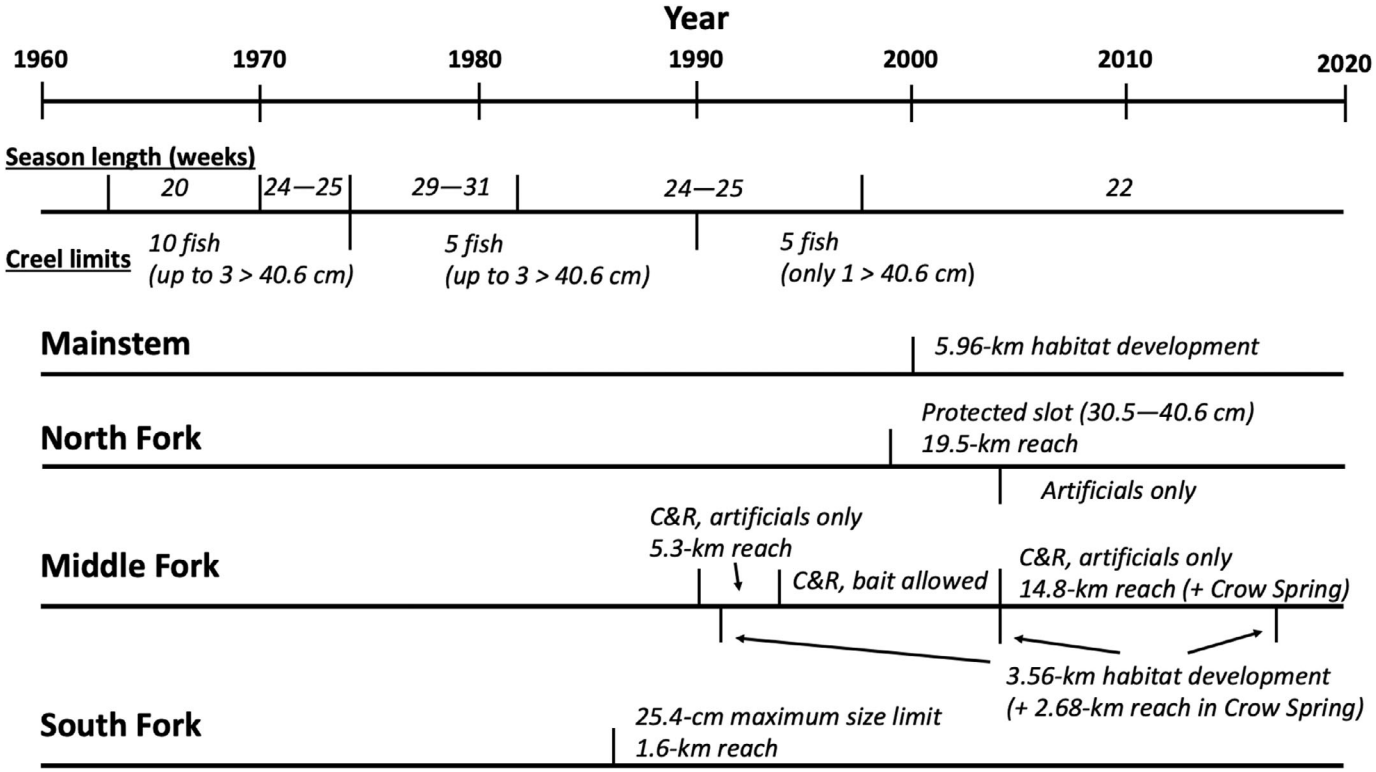

FIGURE 2. Timelines of trout management actions affecting the Whitewater River, 1960 to 2020. Separate timelines are displayed for changes in season length and regional creel/fish size limits that affected all streams within the watershed and for reach-specific management actions affecting only certain streams. The vertical lines on each timeline indicate year of change or implementation. C&R = mandatory catch and release.

lures-only (no bait) regulation added from 2005 to the present. All Whitewater River system trout streams also now have a winter catch-and-release season from January 1 through March 31, and catch and release for 2 weeks prior to and 4 weeks after the harvest season (same as all designated trout streams in southeastern Minnesota). In addition, Trout Run and the Middle Fork within Whitewater State Park and the North Fork within Carley State Park are open to continuous catch-and-release angling at all times during the nonharvest season.

Angling easements and stream habitat development projects.—Throughout the entire 54-year fishing contest period, eight of the nine streams within the Whitewater River system had angling access via public lands (state forests and wildlife management areas, state parks). Access was most extensive for the Whitewater River main stem, North and South forks, Beaver Creek, and Trout Run. In addition, public angling access has increased by >7 km since the 1990s via purchased angling easements on private lands, mostly along the Middle Fork, and Crow Spring but also including Trout Creek.

Four streams within the Whitewater River system have received instream habitat development since 1990 (Figure 2): Whitewater River main stem, Beaver Creek, Middle Fork, and Crow Spring. Habitat development, totaling 13.75 km of stream reaches, focused primarily on increasing cover and pool depth for large Brown Trout while reducing bank erosion. A section of the main stem, channelized in 1958 to allow for construction of waterfowl impoundments, was "restored" in the late 1990s by placing two reaches back into 4.35 km of the original channel and connecting them with a 1.61-km, newly excavated reach. Stream habitat was developed in a single, 1.55-km reach of Beaver Creek in 1990, within three reaches of the Middle Fork, totaling 3.56 km in 1992, 2004, and 2016, and within 2.68 km of Crow Spring in 1992. The Crow Spring reach and 2.30 km of the Middle Fork were repaired in 2009 after severe flood damage.

Mauer Brothers Tavern Big Brown Trout Contest

The Mauer Brothers Tavern Big Brown Trout Contest has been conducted every year from 1963 to the present during southeastern Minnesota's stream trout harvest season (see above). To participate, anglers must harvest a Brown Trout from any of the streams that comprise the Whitewater River system and return the fish to be weighed (nearest ounce, or 28.4 g) at Mauer Brothers Tavern in Elba, Minnesota. Anglers can enter as often as they like.

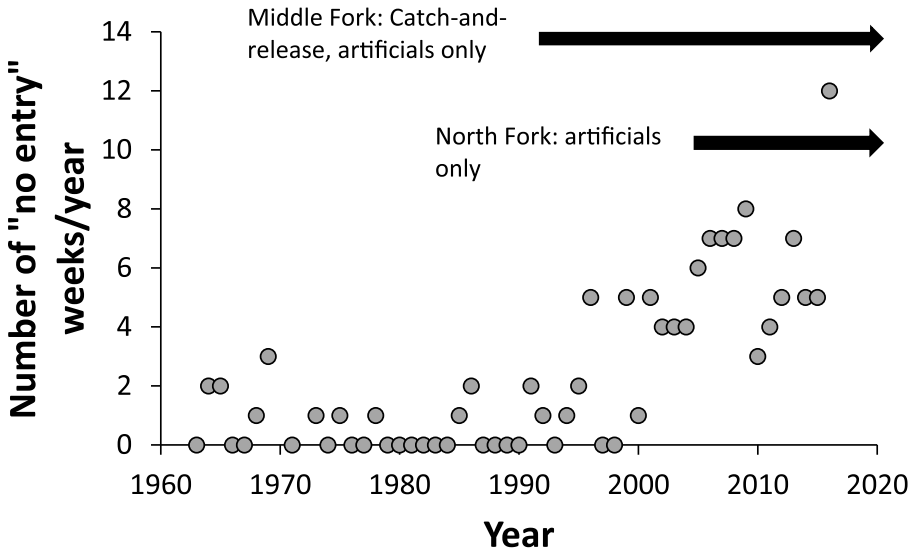

FIGURE 3. Number of "no-entry" weeks per year in the Mauer Brothers Tavern Big Brown Trout Contest, 1963–2016. The arrows indicate the onset and duration of catch-and-release and artificial-lures-only regulations (see Figure 2 for details).

During the contest period, the tavern listed the week's largest fish (by weight) on a public display board. For each fish entered, the tavern recorded fish weight, angler name, angler residence, stream where caught, and bait or lure used on the display board. Only data for the largest fish remained on the display board, with larger fish displacing smaller fish throughout the week. At the end of each week of the contest, the angler who caught the largest fish that week was declared the winner, all data for the winning entry were recorded in the contest logbook, and the winning angler was awarded a 12-pack of their preferred beverage. Yearly winners received an engraved trophy. No data for nonwinning entries or the total number of weekly entries were retained.

For the current analysis, we used contest data spanning 54 years, from 1963 through 2016. Data were missing for 1970 and 1972, so the analysis was limited to the remaining 52 years of contest results. During 1963 and 1964, angler residence was not recorded. During 1964, the stream where the winning fish was caught was not recorded. Type of bait or lure used was not recorded until 1968. In subsequent years, various data were missing (mostly stream and/or bait/lure type) for 5.1% of the weekly winners.

Data analyses.— Contest data from all years were compiled to examine patterns in winning fish weights, bait or lure use, streams where fish were caught, and residence of winning anglers. Regression analyses were used to assess potential changes in winning fish weights across contest years and across weeks of the season, and a *t*-test was used to compare the number of no-entry weeks between two periods (pre-1996, 1996 through 2016). I used single-factor ANOVA to compare (1) weights of winning fish caught using various baits or lures, (2) weights of fish from different streams, and (3) weights by decade for specific baits or lures to assess possible shifts in size over time. The fish weights were $\log_{10}$ transformed prior to the analyses to meet the normality and variance assumptions of ANOVA. Simple chi-square analysis was used to compare the proportional distribution of bait and lure types used to catch winning trout among the various streams.

RESULTS

Contest data were available for 1,289 weeks of the fishing contest from 1963 to 2016, or approximately 25 weeks/year. Over that period, there were no entries during 125 weeks (9.7%). The "no-entry" weeks were not evenly distributed among contest years, but they occurred mostly (84%) within the last 21 years analyzed (1996–2016; Figure 3). The number of no-entry weeks increased significantly ($t_{23} = 7.09$, $P < 0.001$) from before 1996 (average of 0.65 no-entry weeks/year) to during and after 1996 (average of 4.95 no-entry weeks/year). The increase in no-entry weeks beginning in the mid-1990s followed the implementation of catch-and-release-only regulations placed on the Middle Fork and protected slot regulations placed on the North Fork (Figure 2).

During the period of the contest, 33% of all weekly winners were caught in the South Fork, 21% in each of the North and Middle forks and the main stem, and the remaining 4% in Beaver Creek and Trout Run. From the 1960s through the 1990s, equal numbers of weekly winners came from the North and Middle forks combined

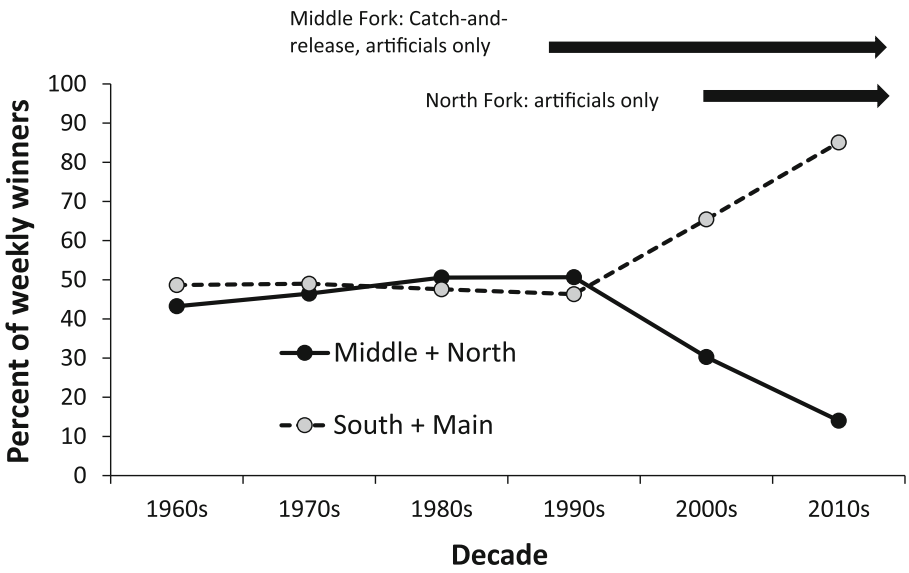

FIGURE 4. Changes in the percentages of weekly winning Brown Trout caught from the South Fork and main stem (Main) of the Whitewater River combined and from the Middle and North forks combined from the 1960s through the 2010s. The arrows indicate the onset and duration of catch-and-release and artificial-lures-only regulations (see Figure 2 for details).

and from the South Fork and main stem combined (Figure 4). However, since 2000, the percentage of winning fish coming from the South Fork and main stem (streams with very limited or no special regulations; Figure 2) have nearly doubled, whereas winners caught from the North or Middle forks (both with long reaches with catch-and-release and/or other special regulations; Figure 2) have declined by 70% (Figure 4). The decline in winners from the Middle Fork began at the same time as angler access to the Middle Fork increased due to new angling easements on private lands and as the first of >6 km of habitat development projects was initiated (Figure 2). These results suggest that changing regulations in the North and Middle forks pushed bait anglers to streams where their preferred fishing methods were still permitted (Figures 2, 4).

The sizes of weekly winning Brown Trout ranged from 113 to 6,293 g (median = 1,309 g, interquartile range = 964 to 1,899 g). Fewer than 4% of weekly winners exceeded 3 kg. The fish weights did not differ significantly (ANOVA $F_{4,\ 1,085} = 0.86$, $P = 0.487$) among streams or among four of the major bait (nightcrawlers, baitfish) or lure (spinners, crankbaits) types that were used to catch them (ANOVA $F_{3,\ 898} = 2.14$, $P = 0.094$). The weights of winning trout that were caught when using nightcrawlers as bait declined steadily and significantly (42%; ANOVA $F_{5,\ 532} = 11.49$, $P < 0.001$) across the span of six decades (Figure 5A), while weights of fish caught using spinners also differed significantly (ANOVA $F_{5,\ 208} = 2.26$, $P = 0.049$) across decades without displaying any consistent trend (Figure 5B).

Since 1963, there has been a significant (linear regression $F_{1,\ 1,162} = 7.76$, $P = 0.001$) decline in the weight of winning trout, a trend of slightly less than 10 g/year (Figure 6A). This decline was driven largely by decreased weights of fish from the main stem and South Fork, as size remained unchanged in the North and Middle forks and Beaver Creek (Table 1). In addition, the weight of the largest trout caught each year has declined significantly (linear regression $F_{1,\ 50} = 40.52$, $P = 0.007$) at a rate >20 g/year (Figure 6B). The weights of weekly and yearly winners declined by >25% over the contest period. When viewed across a typical harvest season, the weights of winning trout also exhibited significant (>40%) declines (linear regression $F_{1,\ 1,162} = 163.17$, $P < 0.001$) at a rate of approximately 34 g/week, or a total of 875 g from the beginning to the end of a 25-week harvest season (Figure 6C).

For the 1,048 weekly winners where bait/lure use was recorded, 69% was caught with bait and 31% with artificial lures. Nightcrawlers (51%) and spinners (21%) were the most commonly used bait and lure, respectively, with two other baits and one lure each used to catch from 5% to 8% of the weekly winners (Figure 7A). Although baits have consistently caught more weekly winners throughout the duration of the contest, the proportion of weekly winners that was caught with artificial lures has more than doubled (19% vs. 43%) from the late 1960s to the mid-2010s (Figure 7B). The proportional distribution of bait and lure types that was used to catch weekly winners differed significantly among streams ($\chi^2_{16} = 72.9$, $P < 0.001$),

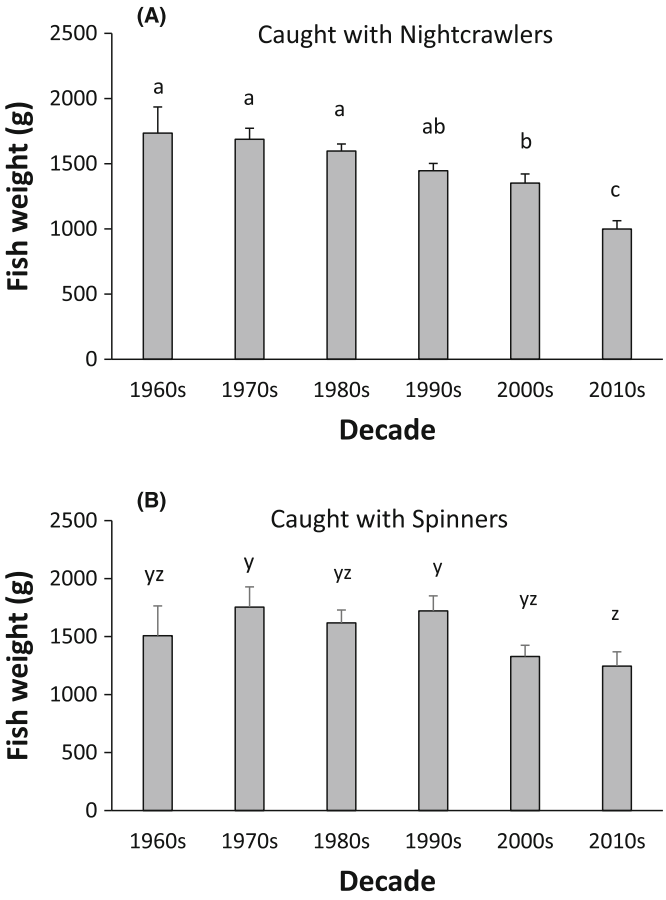

FIGURE 5. Mean (+SE) weight of weekly winning Brown Trout in the Mauer Brothers Tavern Big Brown Trout Contest caught on **(A)** nightcrawlers and **(B)** spinners across the six decades of the contest. Within each panel, the bars sharing the same lowercase letter are not significantly different.

with more winners caught with nightcrawlers and fewer winners with baitfish in Beaver Creek and the main-stem Whitewater River than in the three forks.

Across the 1,164 contest weeks with winning fish, 710 different anglers were weekly winners. Of those anglers, 548 (77%) won only once. The remaining 162 anglers collectively won 616 (53%) weekly contests, with the top four anglers combining to win 114 weekly contests (18, 25, 33, and 38 weeks, respectively). These four anglers' wins spanned the years 1989 to 2016, 1981 to 1998, 1981 to 2016, and 1964 to 1990, respectively. Two of these top anglers ended participation during the 1990 s as special regulations were being implemented (Figure 2) and no-entry weeks began increasing (Figure 3), but the other two continued successful participation through the end of contest records. Most (82%) weekly winners lived within the three-county region of the watershed, although winners represented seven different U.S. states (Minnesota, Wisconsin, Iowa, Pennsylvania, Missouri, North Dakota, and Washington) and one foreign country (Spain). Over 56% of multiweek winning anglers caught all their winning fish by using only a single bait or artificial lure type, whereas 29% used both baits and artificial lures to catch their winning fish.

DISCUSSION

The Big Brown Trout fishing contest in southeastern Minnesota has been a small tournament that has been dominated by local anglers throughout its contest history, unlikely to attract anglers from outside the area due to a lack of advertising and nominal prizes. However, the 50-year record of contest results displayed patterns of change in winning trout size, capture location, and participation rates that coincided with changes in resource management and shifting attitudes of recreational anglers, a pattern likely repeated in many geographical regions and across a variety of different fisheries (Sass and Shaw 2020).

The primary goal of this study was to compare any changes observed in the data that have been archived from a long-running stream trout fishing contest to the timing of changing angling regulations, shifting angler behaviors, and increasing angler access and stream habitat development. I found three major trends in the contest results: (1) a steady, long-term decline in the size of winning fish throughout the history of the contest; (2) waning participation in the contest coinciding with increased catch-and-release angling (both mandated by regulation and by personal choice); and (3) a shift in the streams producing winning trout concurrent with new angling regulations, improved angler access, and stream habitat development projects.

Across the 54 years of trout contest data that were analyzed, the average weights of weekly winners declined by >500 g and the weights of yearly winners declined by >1,100 g (a 25–30% reduction over 54 years). This finding partially supports the perceptions among some anglers that the size and abundance of large trout have been declining in southeastern Minnesota streams, even as fishery management agency personnel have demonstrated through regular population assessments and creel surveys that trout abundance and the angling experience have improved dramatically (total biomass has increased 5% annually and adult abundance has increased 7% annually over a 48-year period) throughout the southeastern Minnesota region (Snook and Dieterman 2014; Dieterman et al. 2020). However, the abundance of large (>355 mm TL) Brown Trout and the probability of sampling a larger (>406 mm TL) fish have not changed significantly, not even in streams with mandatory catch-and-release regulations in place (Dieterman et al. 2020). In addition, two of the most frequent winning anglers, who together

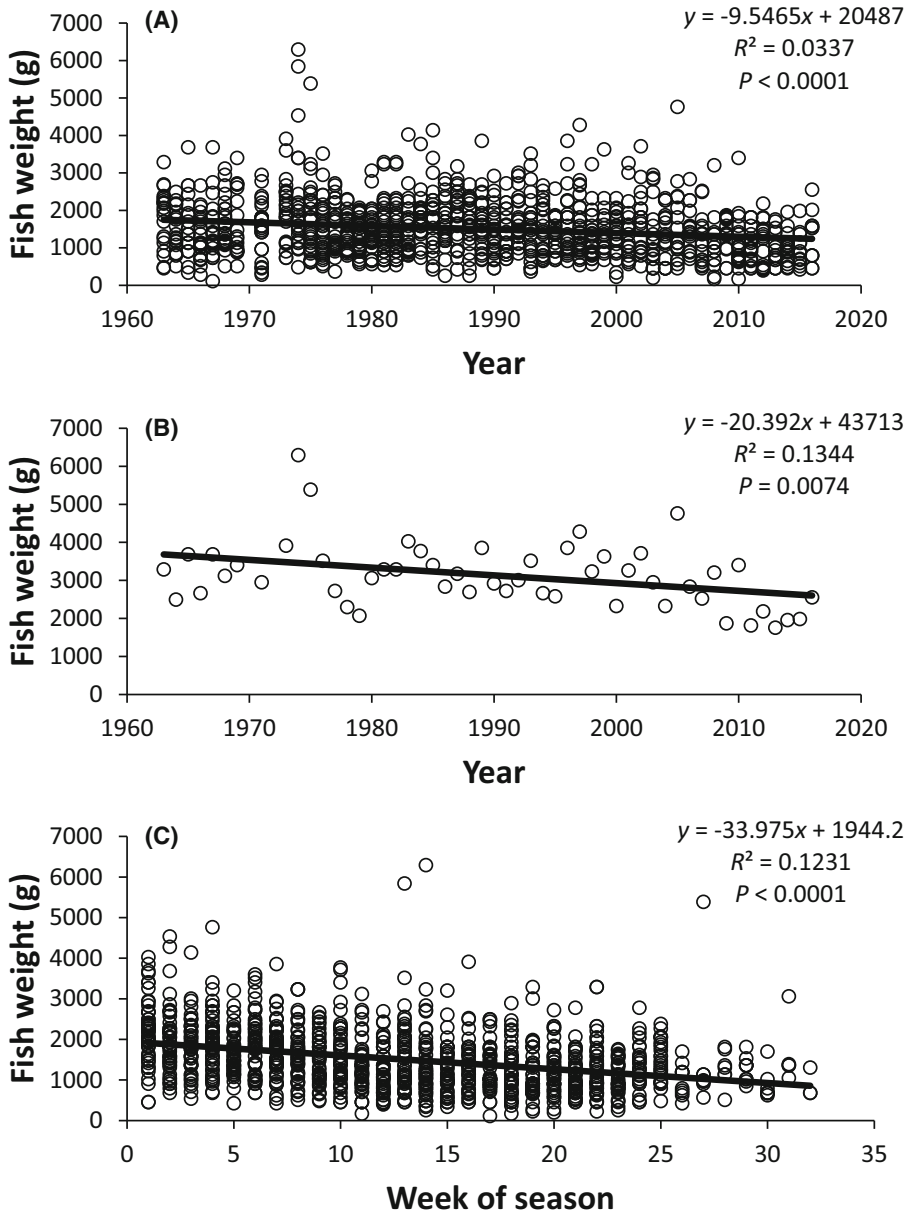

FIGURE 6. Change in weight of **(A)** weekly winning Brown Trout in the Mauer Brothers Tavern Big Brown Trout Contest, 1963–2016, **(B)** yearly winning Brown Trout, 1963–2016, and **(C)** weekly winning Brown Trout throughout the 25–32 weeks of the harvest season.

accounted for slightly over 5% of all winning fish during the contest period examined, ended their contest participation during the 1990s. It is possible that their departure from the contest as anglers skilled at catching rare, large fish may have resulted in other, more average anglers winning weekly awards by catching smaller trout. However, two other frequent winning anglers (who won >4% of all weekly contests) continued their success through to the end of the contest period that was examined, suggesting that skilled anglers filled the void that was left when the others ceased entries. Taken together, these data do not support the anglers' perception of declining abundance of large trout, but we currently lack management data on the sizes of large fish within streams in southeastern Minnesota to compare with the declining sizes that we observed in contest results. Future examination of historical data on large Brown Trout in southeastern Minnesota, dating back to the 1920s and 1930s, hopefully can be used to determine if the size of large fish has changed within this region (Dieterman, personal communication).

A decline in the size of contest-winning fish is not unusual, having been observed for several species in other

TABLE 1. Simple linear regression statistics for relationships between Brown Trout weight and year for weekly winners caught in five streams within the Whitewater River system, 1963–2016.

Stream	n	Slope	r^2	P
Main stem	229	−13.6	0.076	<0.0001
North Fork	228	−4.9	0.008	0.180
Middle Fork	226	2.0	0.001	0.594
South Fork	368	−16.7	0.087	<0.0001
Beaver Creek	39	−1.7	0.001	0.840

long-term fishing contests within the upper Midwestern United States (Olson and Cunningham 1989; Gilbert and Sass 2016). Such declines have been attributed to changes in catchability of larger fish, angler reluctance to enter trophy fish, density-dependent constraints on the growth rates of larger fish, overexploitation of large fish, shifting population size structures, and more restrictive harvest regulations (Olson and Cunningham 1989; Gilbert and Sass 2016). It is not known whether (and to what extent) any of these factors may have played a role in the size decline of winning trout in the Whitewater River-based contest.

The significant decline in size of winning Brown Trout in the Whitewater River contest could be an artifact resulting from a combination of managed gear restrictions, mandated and/or voluntary catch-and-release angling that is directed at promoting an improved trophy fishery, and fewer contest entries through time. However, it also may be, in part, the result of management efforts that have led to increased trout densities within the region (Dieterman et al. 2020). Biomass and abundance of juvenile and adult Brown Trout have increased significantly in southeastern Minnesota streams over the past 50 years, especially in stream reaches with catch-and-release regulations and those where stream habitat development has occurred (Dieterman et al. 2020). Angler catch rates have also increased 50% to 450% since the 1980s (Snook and Dieterman 2014), suggesting that Brown Trout population size structures may have shifted toward more abundant and smaller trout (Dieterman et al. 2020). Increased trout

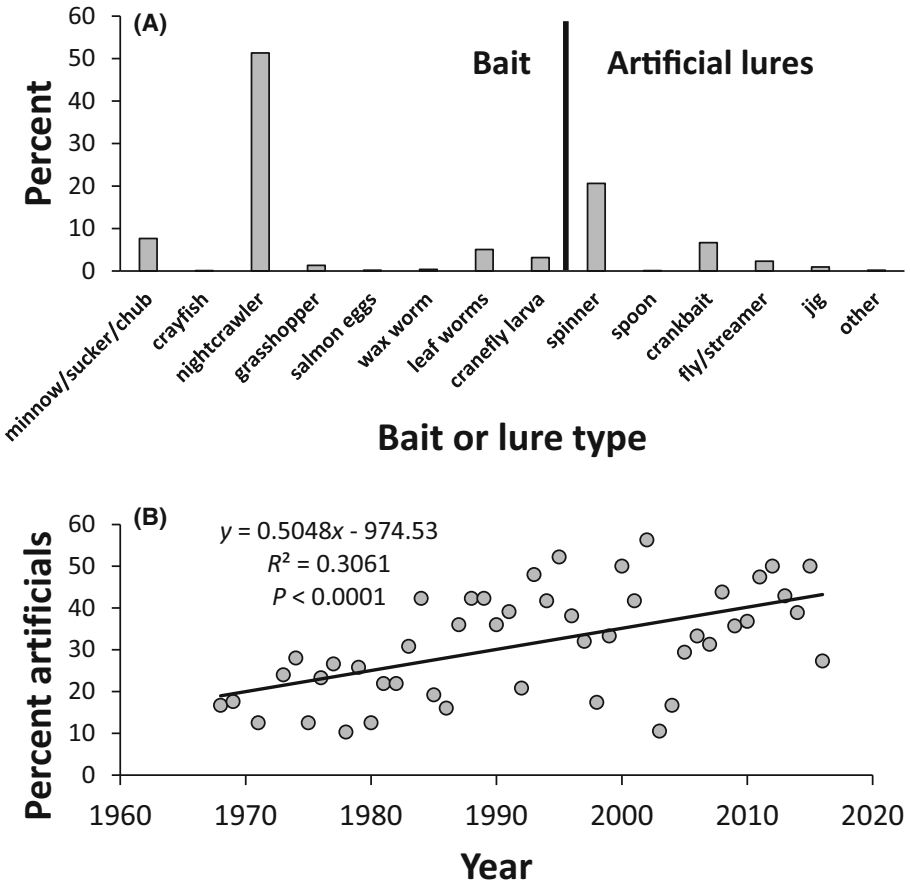

FIGURE 7. **(A)** Percentage of weekly winning Brown Trout in the Mauer Brothers Tavern Big Brown Trout Contest, 1968–2016, caught with different baits and artificial lures, and **(B)** change in the percentage of weekly winners caught with artificial lures, 1968–2016.

abundance can result in greater intraspecific competition, reducing growth rates in southeastern Minnesota streams (Mundahl 2017; Dieterman et al. 2020) and potentially limiting the size and abundance of trophy fish (Gilbert and Sass 2016). If monitoring surveys in southeastern Minnesota reflect what is happening within the Whitewater River system, the probability of encountering a large (>40.6 cm TL) trout likely remains unchanged since 1970 (Dieterman et al. 2020), and angling regulations on most Whitewater basin waters still allow for harvest of one fish >40.6 cm per day. The same suite of gear restrictions and mandatory catch-and-release angling implemented on some streams in the Whitewater River system is used successfully in many different streams to produce higher densities of larger-sized Brown Trout that support higher catch rates (Arlinghaus et al. 2007; Zorn 2018). Consequently, the factor(s) responsible for the decreasing size of winning trout in the Whitewater River contest remains elusive. Interestingly, a long-term fishing contest in northern Minnesota reported no change in weights of either Brown Trout or Brook Trout from the 1960s through the 1980s (Olson and Cunningham 1989), even as winning Brown Trout weights were declining in the Whitewater-based contest.

Participation in the catch-and-harvest trout contest in the Whitewater River began declining in the mid-1990s, as catch-and-release regulations were applied to some streams within the contest area and angler behaviors began shifting (Sass and Shaw 2020). While some fisheries have remained harvest oriented as voluntary catch-and-release angling has increased in popularity, others have exhibited a dramatic shift away from harvest (Sass and Shaw 2020). The shift toward more catch-and-release angling has been documented in southeastern Minnesota trout streams where trout harvest is permitted, increasing from 40% to 60% during the early 1980s (Hirsch 1989) to >80% by 2005 (Snook and Dieterman 2006) and >92% by 2013 (Snook and Dieterman 2014). The same pattern in catch-and-release angling also has been observed in Michigan streams (Zorn 2018). In general, the reduced participation that we observed in the Whitewater River trout fishing contest in recent decades parallels the dramatic decline in trout harvest rates in southeastern Minnesota, even as catch rates have increased dramatically (Snook and Dieterman 2006, 2014). Two of the frequent winning anglers who ended their contest participation during the 1990s potentially contributed to, but did not account for, the significant increase in no-entry weeks that began in that decade.

Mandatory catch-and-release regulations were instituted on the Middle Fork Whitewater River starting in 1991, and this change had an immediate effect on the trout fishing contest. From the 1960s through the 1980s, the Middle Fork was a go-to stream for winning trout, producing nearly 30% of weekly winners just prior to implementation of the angling restrictions. New angling easements on private lands improved angler access, and large sections of stream received habitat development for trout. However, following the implementation of the catch-and-release mandate, the numbers of winning trout from the Middle Fork plummeted, as most of the publicly accessible waters were covered by the catch-and-release regulation. Mandatory catch-and-release regulations often are employed to reduce harvest and improve the size structure of fish populations, especially increasing the potential for trophy-sized fish (Anderson and Nehring 1984; Johnston et al. 2011; Sass and Shaw 2020). In the Middle Fork, those trophy-sized fish were still available to anglers but could not be harvested for entry into the contest, likely displacing harvest-oriented anglers to other nearby waters (e.g., main stem, South Fork) in search of potential contest entries (Johnston et al. 2011).

Coincident with the voluntary and mandatory catch-and-release angling in the Whitewater River system, shifts in the types of terminal tackle that was used to catch winning trout were evident through the decades. Although live bait (mostly nightcrawlers and baitfish) caught more than twice as many winning trout as did artificial lures (mostly spinners and crankbaits) throughout the entire contest period analyzed, the proportion of winning fish that was caught on artificial lures doubled over the contest period. This shift may have been driven, in part, by tackle restrictions on contest-eligible streams where harvest was permitted (e.g., North Fork Whitewater River). The shift also may have reflected widespread change in recreational angling in general, with anglers who practiced catch-and-release fishing switching from live bait to artificial lures to reduce angling mortality (Clapp and Clark 1989; Payer et al. 1989; Pauley and Thomas 1993; Arlinghaus et al. 2008; Sass and Shaw 2020). However, the trend toward increasing proportions of winning fish caught on artificial lures more likely resulted from a combination of bait anglers either "aging-out" of the sport or giving up on fishing streams where their preferred angling method was no longer an option (Shetter and Alexander 1962; Johnston et al. 2011).

MANAGEMENT IMPLICATIONS

Records from long-term fishing contests can provide a wealth of data on the history of various fisheries, which in turn can help researchers assess patterns and trends associated with changing regulations and angler behaviors (Olson and Cunningham 1989; Gilbert and Sass 2016; present study). However, the interpretation of these data sources may be complicated and should be done with caution due to the number of differing fishery management actions (creel limits, size limits, gear restrictions, and

habitat development projects) that have been implemented over long periods, superimposed on a background of other angling changes (e.g., angler attitudes, gear improvements, advancing technology, social media communications). Stream trout fisheries in southeastern Minnesota and elsewhere are managed in many different ways to protect and enhance the trout resources and maximize the quality of the angling experience (Thorn et al. 1997; Unther and Pinter 2018; Zorn 2018; Dieterman et al. 2020). These different management actions are designed to have differing effects on a fishery (Zorn 2018), but when they are conducted simultaneously, the outcomes from one action may limit or mask the expected outcomes from another actions (Gilbert and Sass 2016; Sass and Shaw 2020). Despite these caveats, long-term fishing contests provide valuable historical records of changing fisheries that may be impossible to obtain in any other way. Greater effort should be expended to access and analyze fishing contest and tournament data to obtain a perspective on long-term fishery status and characteristics that may differ from what might be obtainable via typical agency monitoring activities (Olson and Cunningham 1989; Gilbert and Sass 2016).

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