

Stocking wild adult Florida largemouth bass (*Micropterus salmoides floridanus*): An additional fish management tool

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Abstract

Stocking of largemouth bass is an important management tool for fish management. The stocking of hatchery-produced fingerling or advanced-fingerling bass to supplement bass year-classes, however, has exhibited varying success. Utilizing a different approach, a multiyear stocking programme using wild adult largemouth bass was initiated at the Harris Chain of Lakes (3800 ha Lake Griffin; 1811 ha Lake Dora) in central Florida. Wild adult bass (24 781 fish), ranging in size from 200 mm total length (TL) to over 600 mm TL, were stocked in Lake Griffin (13 932 fish) and Lake Dora (10 849 fish). One month after stocking, the number of stocked bass caught in electrofishing catches in Lake Griffin and Lake Dora was ~10% and 22%, respectively. Estimates of mortality were similar to the native largemouth bass, although the movement of stocked fish into other connecting water bodies was extensive. For the Lake Griffin/Lake Dora stocking programme, bass were transferred at a cost of \$10.09–19.89 per fish, depending on how the costs of the project are calculated (\$250 000 for just the capture and transport of the fish vs. \$492 775 for the total project). Considering only capture and transport costs, conservative benefit/cost ratio estimates would be \$1.77/\$1.00 spent for replacement and \$1.85/\$1.00 spent recreational costs, although the benefit/cost ratios could exceed \$10/\$1. Based on the present study, stocking wild adult largemouth bass is a cost-effective tool for managing largemouth bass.

Key words

fish management, hatchery, largemouth bass, stocking.

INTRODUCTION

Largemouth bass (*Micropterus salmoides*) fishing has long been economically important to the State of Florida. The City of Leesburg, located on the Harris Chain of Lakes in central Florida, launched the first national bass tournament in the late-1920s, declaring it the BASS CAPITAL. Florida now has over 820 000 anglers fishing for bass, and spending more than \$1 billion annually (U.S. Department of Interior, Fish & Wildlife Service & U.S. Department of Commerce, Census Bureau 2006).

The Harris Chain of Lakes (Fig. 1) had lost a significant quantity of aquatic vegetation (habitat) by the late-1990s, and experienced a declining bass populations and increasing negative public perception regarding the quality of fish-

ing (Benton 2000). Lake Griffin and Lake Dora are the focus of this study. Rooted aquatic vegetation coverage in Lake Griffin declined from ~50% in the 1940s to virtually 0% by 1975, causing reduced bass reproduction and abundance. Total bass angling effort at Lake Griffin also declined from over 60 000 h when first measured in the 1960s to <800 h by 2003 (Benton 2000). Furthermore, the Florida Fish and Wildlife Conservation Commission (FWCC) reported the largemouth bass fishery in Lake Dora was one of the poorest in the Chain of Lakes (Harris Chain of Lakes Restoration Council 2006). Associated with the loss of vegetation and largemouth bass was the loss of a multimillion-dollar fishery, significantly impacting the economic activity and image of the city of Leesburg, Florida's BASS Capital.

The Harris Chain of Lakes Restoration Council (HCOLRC), established in 2001 by the Florida Legislature (Chapter 2001-246 F. S.), responded to the demise of

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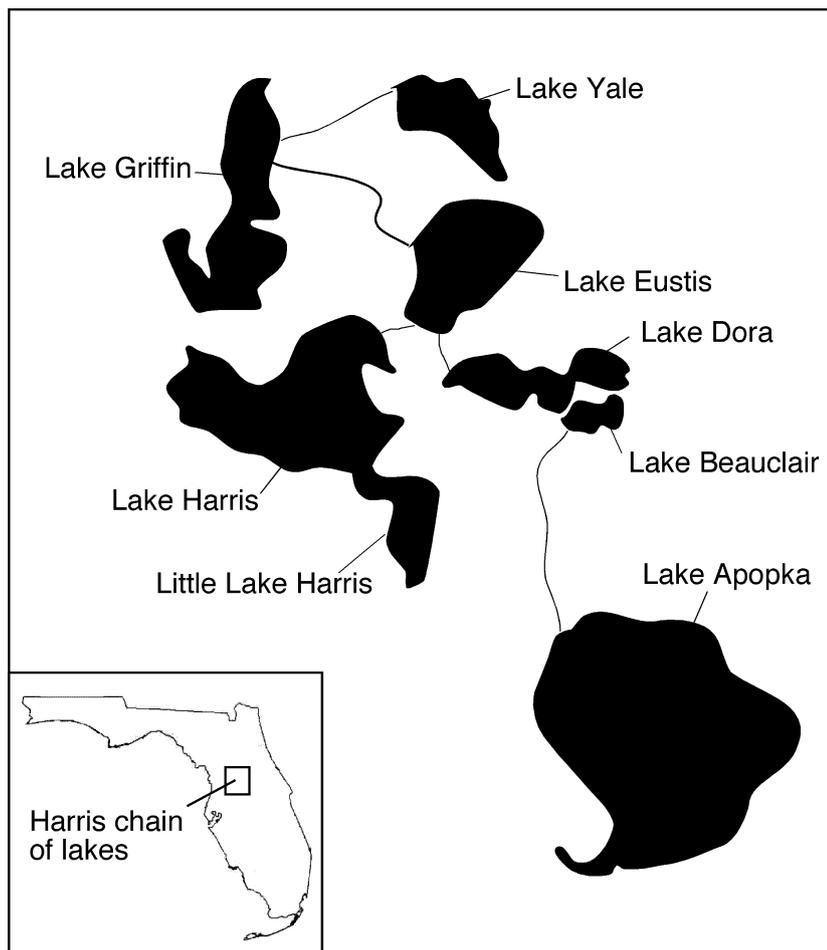


Fig. 1. The geographical location of the Harris Chain of Lakes, central Florida.

the bass fishery in 2004 by funding a wild adult largemouth bass stocking programme (HCOLRC 2005). The recommendation to do so came after due consideration of many management options, ranging from eutrophication control, water level fluctuation/drawdown and the stocking of hatchery-produced fingerling or advanced-fingerling largemouth bass.

Stocking of largemouth bass is an important management tool for fish management, with most stocking traditionally conducted with hatchery-produced fingerling or advanced-fingerling bass to supplement bass year-classes (Smith & Reeves 1986). However, stocking of hatchery-produced fingerling or advanced-fingerling bass to supplement bass year-classes has been met with varied success (Loska 1982; Buynak & Mitchell 1999; Porak *et al.* 2002; Mesing *et al.* 2008). Thus, the present study examines a multiyear stocking programme involving the movement of wild adult largemouth bass collected from non-fished nearby waters into Lake Griffin and Lake Dora, two large (>1800 ha) central Florida lakes. The present study provides the following information learned

from implementing a wild adult largemouth bass stocking programme: (i) wild adult largemouth bass stocking feasibility; (ii) angler responses; (iii) persistence of stocked fish; (iv) fish dispersal; and (v) cost/benefit analysis. This information should provide guidance to lake managers that might consider stocking of wild adult bass as a potential tool to improve/maintain a bass fishery, while long-term lake restoration programmes also are underway.

METHODS

Study lakes

The study lakes for this stocking programme were Lake Griffin and Lake Dora, with surface areas of a 3800 and 1811 ha, respectively (Shafer *et al.* 1986). Both are located in the Harris Chain of Lakes (Fig. 1). The lakes are shallow, with mean depths less than 2.7 m, and exhibiting an eutrophic status, with average chlorophyll concentrations greater than $50 \mu\text{g L}^{-1}$ (Bigham *et al.* 2009).

Fish donor sites

To begin the wild adult largemouth bass fish transfer project, a suitable (non-public fishing water) donor site, capable of producing 4000+ bass per year, was needed. Accordingly, a partnership was established with the Greater Orlando Aviation Authority, the latter offering the water systems located at the Orlando International Airport (MCO). MCO proved to be an excellent donor site because of the large number of accessible water bodies (over 85 small lakes and ponds, most <10 ha in size and interconnected by drainage canals). Several additional sites were also used as donor sites. Lake Medard (a reservoir), for example, was being drained to make dam repairs, with its fish being captured before they died because of the lack of water. Bass were collected under the auspices of a scientific collection permit from FWCC, which stipulated that only *Micropterus salmoides floridanus* could be transferred into Lake Griffin and Lake Dora.

The genetic makeup of bass at MCO was assessed during the summer of 2004, using allozyme electrophoresis (cellulose acetate electrophoresis method) analysis. Bass livers were tested to ensure the bass in the water bodies were *Micropterus salmoides floridanus*. All other donor sites were already designated by FWCC as *Micropterus salmoides floridanus* water bodies (i.e. Lake Medard).

Collection and transfer

Bass collected during this project were captured with the use of boat-mounted electrofishing gear. Electrofishing boats were equipped with a 5-kW generator, and either a Smithroot model VI-A pulsator or a Coefelt model VVP-15 pulsator (Smith-Root, Vancouver, Washington, USA). One individual operated the boat and pulsator, while one or two others netted fish from the bow of the boat. Bass were transferred between December 1 and May 1, when the water temperatures were below 26 °C. This thermal limit was mandated by the FWCC to minimize fish deaths attributable to handling stress. All the fish were examined for external signs of disease or parasites, with only healthy fish being transported.

Lake Griffin and Lake Dora were both stocked for 3 years, 2004–2007 and 2007–2010, respectively. Stocked fish (>200 mm) were measured to the nearest millimetre for total length (TL) and fin clipped (left pelvic) prior to being transferred. Bass >275 mm TL were implanted with either an orange or a yellow Hallprint type PDA plastic-tipped dart tag. The tag was imprinted with an individual identification number and contact telephone number to

aid in angler reporting. No reward (\$) was associated with the tag.

Evaluation of effectiveness

One month after each December–May stocking period, the potential effects of the transfer programme on the resident largemouth bass population were evaluated by collecting largemouth bass via electrofishing from nearshore waters of Lake Griffin and Lake Dora. Bass were sampled at multiple transects spaced equal distances around the perimeter of each lake. Ten minutes of electrofishing were conducted at each transect to capture bass greater than 200 mm TL. Fish were examined for pelvic fin-clips and/or Hallprint dart tags. The number of marked and unmarked largemouth bass was recorded to determine the percentage of stocked fish captured using electrofishing. This approach provided an assessment of the effects of the stocking programme on the bass populations mainly because legislative funding was not provided to conduct comprehensive pre- and poststocking bass abundance estimates. While some fisheries biologists might interpret the high percentage of stocked fish captured 1 month after stocking as evidence that the bass populations in Lake Griffin and Lake Dora were increased, this interpretation must be accepted only with great caution. The stocked fish could have replaced native fish via compensatory mortality or displacement, although the needed funding to conduct such studies was not available.

Stocked fish and native largemouth bass in Lake Griffin were collected by electrofishing between April 2007 and March 2009 for 23 sampling days (364 ten-min electrofishing transects) in the lake's nearshore waters and adjoining canals to evaluate the dispersal of stocked bass from their 50+ introduction sites in the main area of Lake Griffin (FWCC's creel zone area). This sampling effort also was used to assess the percentage contribution of stocked bass and the mortality of stocked fish. To determine whether stocked largemouth bass were exhibiting the same mortality rates as native Lake Griffin largemouth bass, two separate CPUE data groupings (2006 tags only and 2007 tags only) were plotted, and mortality estimates for the stocked bass were calculated from catch curves (Ricker 1975). The mortality calculations were then compared with a 2007 estimate provided by FWCC for Lake Griffin's native bass (Benton J, pers. comm., FWCC Eustis Laboratory).

Fish and Wildlife Conservation Commission (FWCC) annually conducts a roving creel survey at different Harris Chain lakes as part of their long-term monitoring programme. To further understand the potential impacts of stocked fish, a creel survey was conducted from June

2006 through March 2007 at Lake Griffin, in partnership with FWCC. The creel survey was conducted only on the main part of Lake Griffin and not on the many canals and other backwater/marsh areas connected to the lake. Data were analysed by FWCC using their creel analysis programme (Creel Analysis version 1.0 software: Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA).

Funding was not available for a comprehensive economic study for Lake Griffin. Call-ins by anglers catching tagged fish in 2007 provided information, including the angler's name, the fish tag number and size, location caught, and release or kept status of the fish. A telephone survey of anglers reporting tagged fish was then conducted to provide a crude estimate of the effects of fishing effort on the regional economic activity. Nine questions were asked, including identifying what country/state/county the angler lives in, how many largemouth bass fishing trips per year they take on Lake Griffin, how much have they heard about the stocking programme, and their best estimate on how much they (and fishing partners) typically spend (including truck/boat gas, oil, bait, tackle, lodging, launch fee, boat rental, food) for a fishing trip on Lake Griffin?

RESULTS

Wild adult bass stocking feasibility

The total number of largemouth bass >200 mm TL stocked into the Harris Chain of Lakes between December 2004 and April 2010 was 24 781 fish, with 13 932 (~4 fish ha⁻¹) transferred into Lake Griffin and 10 849 (~6 fish ha⁻¹) transferred into Lake Dora (Table 1). For all years, excepting 2009 (funding limitations; 1196 fish for Lake Dora), 4000+ bass were stocked per year.

Project personnel and volunteer-anglers surveyed the lakes (up to 2 weeks) after each stocking event, finding no large mortality events. Electrofishing surveys in May/June revealed between 10% and 13% of caught bass were stocked bass at Lake Griffin, with the corresponding number of about 22% for Lake Dora (Table 1).

Fish and Wildlife Conservation Commission's (FWCC's) creel survey results for Lake Griffin indicated that the 2002/2003 largemouth bass fishing effort was 724 ± 168 angler-hours, increasing in 2003/2004 to 2649 ± 533 angler-hours. After the first year of stocking, the angler effort in 2005/2006 was estimated to be 4034 ± 675 angler-hours and in 2006–2007, at 6443 ± 1012 angler-hours. The FWCC, however, reported low numbers of tagged bass caught by anglers.

Angler responses

Anglers that were fishing Lake Griffin placed 377 phone calls (293 calls in 2006 and 84 calls in 2007) reporting catches of tagged fish. Catch locations (326) and the kept or release status (319) of fish were recorded. These calls originated without any advertisement of the stocking programme, any public announcements requesting anglers to report tagged fish or monetary rewards for reporting tagged fish.

Largemouth bass were caught at 84 (26%) locations within the main body of Lake Griffin, where FWCC conducted their creel survey. Although most fish (65%) were caught from adjacent waters (e.g. connected canals and marshes), 30 bass (9%) were caught in other waters (e.g. Lake Harris). This evidence suggests a significant movement of stocked bass. For bass for which the kept or release status was reported, 287 (90%) fish were released and 32 (10%) fish were kept. Between December 2008 and July 2010, anglers placed 87 phone calls to

Table 1. Yearly summary of the number and size (mm TL) of wild largemouth bass stocked in Lake Griffin and Lake Dora of the Harris Chain of Lakes, central Florida (numbers in parentheses = per cent contribution estimates based on electrofishing catches 1 month after the end of each year's stocking effort)

Year	Total fish	>275 mm TL	>356 mm TL	>432 mm TL	>508 mm TL
Lake Griffin					
2004–2005	4234 (10)	1762	1314	466	163
2005–2006	5032 (10)	3586	1702	818	189
2006–2007	4666 (13)	2122	1028	371	118
Lake Dora					
2007–2008	4622 (22)	2092	1071	334	105
2008–2009	1196 (NA)	669	352	83	14
2009–2010	5031 (21)	4220	2327	839	294

report catches of tagged fish for Lake Dora. Anglers made 167 call-ins for the entire Harris Chain of Lakes. The survey anglers reported their call-ins decreased because there were no monetary rewards or they forgot to do so.

Fish dispersal

Anglers fishing adjoining canals, marshes, and the Ocklawaha River caught the majority (65%) of bass stocked in Lake Griffin. Dispersal movements of individual stocked adult largemouth bass ($N = 122$ fish) were highly variable with few (~16%) fish not leaving the immediate stocking area. The vast majority (84%) of largemouth bass, however, travelled over 0.5 km. The mean dispersal distance was 2.9 km, with minimum and maximum recorded distances of 0 and 9.2 km, respectively.

Fish and Wildlife Conservation Commission (FWCC) documented the major movement of bass from Lake Dora into upstream Lake Beauclair and Lake Carlton. The percentage tagged fish caught by FWCC during electrofishing surveys in Lake Beauclair were 1% in 2008, 4% in 2009, 14% in 2010 and 3% in 2011. Catches in Lake Carlton were 1% in 2009, 15% in 2010 and 2% in 2011.

Anglers also moved largemouth bass from Lake Griffin and Lake Dora. Tournament anglers travelling to Lake Griffin or Lake Dora from other Chain lakes (via Haines Creek or the Dora Canal) removed largemouth bass caught when bringing them to weigh-in areas at Lake Eustis and Lake Harris (Chair Goerner S, HCOLRC, pers. comm.). Anglers also reported transporting large (>2.3 kg) stocked largemouth bass in their fish live-wells to stock other water bodies in Florida, with calls regarding caught tagged bass also being received from non-connected lakes (e.g. Lake Panasoffkee) and the St. Johns River by Jacksonville.

Persistence of stocked bass in Lake Griffin

The last wild adult bass stocking for Lake Griffin occurred in March 2007. In May and June 2007, the highest percentage (13% main lake) of stocked fish was captured via electrofishing. Stocked largemouth bass were still present 2 years later, but at a reduced level (2% in main lake, with FWCC reporting 0%). A similar trend was documented in Lake Griffin canals (15% in 2007; 4% in 2009). Nevertheless, anglers were still phoning in reports of catches. Anglers from the Bass Anglers Sportsman Society (B.A.S.S) 2011 Elite Series – Sunshine Showdown on the Harris Chain of Lakes caught tagged bass from Lake Griffin in 2011 that helped place them in the earned money category (HCOLRC 2011; see report cover).

Benefits/Costs

Total expenditures for the stocking and evaluation programmes for Lake Griffin and Lake Dora since 2004 were \$492 775. This figure included University overhead (5%) and infrastructure (e.g. boat, hauling box and truck) costs. Thus, the cost was \$19.89 per fish or the 24 781 transferred bass. The total expenditure was approximately \$250 000, or \$10.09 per fish, just for their capture and transport alone (not including evaluations, infrastructure or overhead).

When assigning an aquatic damage value to fish losses from pollution, the State of Florida established a replacement (assuming no recreational value for non-fished waters) and a recreational value (public fishing waters) in 1993 for different size largemouth bass (Florida Administrative Code 62-11.001). Using these values (corrected for inflation to 2010 dollars) to assess the monetary value of the transferred fish, the total replacement value for the Harris Chain of Lakes since 2004 was \$441 634, and the recreational value was \$462 086. If only the cost of capture and transport is considered, the benefit/cost ratios would be \$1.77/\$1.00 spent for replacement and \$1.85/\$1.00 spent for recreational costs.

Angler call-in information obtained for Lake Griffin from January 2006 to December 2007 indicated that Lake County residents represented 55% of the calls, while the remaining 45% were non-county residents. Of the non-county residents, 61% were Florida residents and 39% were out-of-state residents. Although no funds were appropriated for a comprehensive economic study, an estimate of angler expenditures were made on the basis of published figures (e.g. U.S. Department of Interior, Fish & Wildlife Service & U.S. Department of Commerce, Census Bureau 2006). Exclusive of bass tournaments, total angler expenditures at Lake Griffin could range from \$3.0 million (one angler per boat) to \$6.1 million/year (two anglers per boat). For Lake Dora, the estimates ranged from \$765 600 to \$1 531 200. The phone surveys, however, indicated that only 41% of the anglers were fishing more because the stocking programme was initiated. If only 41% of the monies generated by fishing are attributed to the stocking programme, the annual dollar estimates ranged from \$1.5 million (one angler) to \$3.1 million (two anglers). The benefit/cost (capture and transport only) ratios for stocking would then range from \$6.00/\$1.00 (one angler per boat) to \$12.40/\$1.00 spent for two anglers.

DISCUSSION

When it was initially proposed to stock wild adult bass into the 3800 ha Lake Griffin, it was unclear whether or

not a sufficient number of bass could be obtained to significantly increase the number of bass in the lake. Unfortunately, as there was no money appropriated for pre- and poststocking population estimates, it was decided that an increase in the percentage of tagged fish caught during electrofishing around the perimeters of the large lakes could provide some insight. The Lake Griffin/Lake Dora study clearly demonstrated that stocked adult bass could contribute significantly to electrofishing catches of bass (>10%) in a large (>1000 ha) water body (Table 1), and that the angling community immediately utilized these fish (as shown by the large number of angler calls). The impact of using this stocking approach clearly would be even greater if smaller (<500 ha), heavily fished water bodies, often identified by agencies as stocking candidates, were chosen for stocking large numbers of wild adult bass. Whether the stocked fish increased the bass populations in Lake Griffin and Lake Dora, or the stocked fish replaced resident fish via compensatory mortality or displacement, cannot be determined. Considerable public support was generated, however, if for no other reason because anglers were aware that quality-sized (>400 mm TL) fish were being stocked and that they could catch them.

The success or failure of any stocking programme will ultimately be judged on the basis of economics. For the Lake Griffin/Lake Dora stocking programme, the 24 781 bass were transferred at a cost of between \$10.09 and \$19.89 per fish, depending on how the project costs are calculated (i.e. \$250 000 for just the capture and transport of the fish or \$492 775 for the total project). Opponents of the Harris Chain of Lakes stocking pointed to the high cost per fish as the reason for not supporting such a programme. In fact, it is difficult to estimate the true economic impact that an adult fish-stocking programme might have on a fishery without conducting detailed economic study. Nevertheless, maintaining sufficient catchable fish to draw angling tournaments will definitely provide economic benefit to the surrounding communities. The 3-day 2011 Elite Series – Sunshine Showdown tournament at the Harris Chain of Lakes, for example, generated a direct economic input of \$553 000 for the City of Tavares and Lake County, and an indirect and induced impact of more than \$1.65 million (Tavares Economic Development Department, Director Bill Neron).

In a perfect world, managers strive to maintain a high-quality environment, including habitat, to perpetuate a quality fishery. Unfortunately, many environments become degraded, resulting in a loss of fisheries, an example being the Harris Chain of Lakes, once considered the BASS CAPITAL of the world. The first step in

correcting the problem, via the eyes of the scientific community, is the restoration of optimal environmental conditions. Most environmental restoration programmes cost millions of dollars, however, and could not produce noticeable effects for decades. Furthermore, a recommended fish management programme (e.g. lake draw-down) cannot be accomplished sometimes because of political opposition. When such situations arise, the stocking of hatchery-raised, as well as perhaps wild adult fish now, is an additional fisheries management tool that might help mitigate economic losses to surrounding communities.

The results of the present study demonstrate that transferring wild adult largemouth bass from non-fished waters represents a viable fish management strategy for large Florida waters, and undoubtedly for waters elsewhere. Federal, state and local fish management agencies typically have electrofishing boats and fish-hauling equipment. Thus, the cost of adult bass transfer-programmes should be less than the costs generated during the Harris Chain of Lakes' wild adult bass transfer demonstration projects. Private, unfished waters (e.g. MCO Airport), and waters where restoration/management programmes were underway (e.g. Lake Medard), were used in the present study as sources for the bass transfer programme. Such water systems, however, could not always be readily available. Another possible source of fish would be public waters for where fish management agencies have established slot limits to improve 'quality' fishing (Bonds *et al.* 2008).

Moving to public waters will require working directly with the public to explain why professionals want to remove smaller bass to improve the size distribution of largemouth bass in a given water body. The fish managers must explain why anglers, by themselves, typically have had little or no success in removing sufficient numbers of fish. The managers, however, most likely will also have to conduct studies to evaluate the effects/sustainability of this type of effort.

Finally, the stocking of hatchery-raised and wild adult bass can bring economic benefits to the surrounding communities that exceed the costs of the stocking programme. An important issue to be addressed by managers, however, is the true costs of stocking hatchery-produced fingerling, advanced-fingerling and wild adult bass. Specifically, all survival rates need to be understood, as well as determining how long it will take for the hatchery-produced fish to reach catchable legal size. If the survival rates of hatchery-produced fish are low, the cost per hatchery-produced fish will probably exceed the cost per fish generated with a wild adult stocking pro-

gramme. Although it is clear that hatcheries have been, and still are, important for fish management, the stocking of wild adult fish also should be considered as an additional largemouth bass management tool.

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