CONSERVATION AND MANAGEMENT OF PADDLEFISH IN MISSISSIPPI WITH EMPHASIS ON THE TENNESSEE-TOMBIGBEE WATERWAY

By

Daniel Mark O'Keefe

A Dissertation
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy
in Forest Resources
in the Department of Wildlife and Fisheries

Mississippi State, Mississippi

August 2006

CONSERVATION AND MANAGEMENT OF PADDLEFISH

IN MISSISSIPPI WITH EMPHASIS ON THE

TENNESSEE-TOMBIGBEE

WATERWAY

By

Daniel Mark O'Keefe

Approved:

Donald C. Jackson Professor of Wildlife and Fisheries (Major Professor and Graduate Coordinator)	Leandro E. Miranda Professor of Wildlife and Fisheries (Committee Member)
Jeanne Jones Associate Professor of Wildlife and Fisheries (Committee Member)	Christopher M. Taylor Associate Professor of Biology (Committee Member)
Bruce D. Leopold Professor of Wildlife and Fisheries (Department Head)	George M. Hopper Dean of the College of Forest Resources

Name: Daniel Mark O'Keefe

Date of Degree: August 5, 2006

Institution: Mississippi State University

Major Field: Forest Resources

Major Professor: Dr. Donald C. Jackson

Title of Study: CONSERVATION AND MANAGEMENT OF PADDLEFISH IN MISSISSIPPI WITH EMPHASIS ON THE TENNESSEE-TOMBIGBEE WATERWAY

Pages in Study: 161

Candidate for Degree of Doctor of Philosophy

Paddlefish are long-lived large river fish which are declining in many areas of their range due to habitat modifications and overfishing. A framework for management of paddlefish in Mississippi is proposed and a case study of its application to the paddlefish population of the Tennessee-Tombigbee Waterway (TTW) is presented. The framework includes four phases: (I) distribution and stock assessment; (II) determination of limiting factors; (III) design and implementation of management actions; and (IV) review and monitoring.

Phase I of management in the TTW consisted of gill-net surveys in four impoundments. Paddlefish abundance was estimated at 1,581 to 8,851 in Demopolis Lake, Alabama. In Gainesville Lake, Alabama, CPUE was 16.8 times less than Demopolis Lake. No paddlefish were caught in Aliceville Lake, Mississippi/Alabama, or Columbus Lake, Mississippi. Demopolis Lake paddlefish grew faster than more northern

populations, but slower than more southern populations ($L_t = 971.8\ [1 - e^{-0.2844\ (t+0.6962)}]$) and had a high annual mortality rate (A = 0.406) comparable to other southern populations.

Potential limiting factors related to spawning in Demopolis Lake and stocking programs in Columbus Lake were investigated pursuant to Phase II. Paddlefish eggs were collected in the Noxubee River and a unique flowing bendway habitat in Demopolis Lake during early April when discharge was ≥2.74 m above 50% exceedance. Flow timing and magnitude in the Noxubee River was related to paddlefish year-class strength (linear regression $P = 0.089$; $R^2 = 0.830$). Radio-tagged paddlefish exhibited seasonal site fidelity and 4 of 10 translocated fish returned to their area of initial capture.

Columbus Lake provides food resources and physiochemical characteristics adequate for paddlefish survival, but depth and zooplankton density are more favorable in Demopolis Lake. Emigration of stocked juvenile paddlefish was low in Columbus Lake habitats; survival (percent after one month ± SE) was 5 ± 5 in backwaters and 28 ± 9 in the mainstem after one month. Phase III recommendations include further investigation of early life history requirements and protection of bendway and tributary habitat in Demopolis Lake. The annual stocking of 4,000 juvenile paddlefish in the mainstem of Columbus Lake and up to 1 million larval paddlefish in a tributary is recommended.

ACKNOWLEDGMENTS

Thanks to Ricky Campbell, Carl Campbell, and Corey Gullett of the Private John Allen National Fish Hatchery (United States Fish and Wildlife Service {USFWS}), and Dave Richardson of the Noxubee National Wildlife Refuge (USFWS) for their assistance with this project. Clark Young and Betsy and David Lott generously provided access to Fortson Lake and stories of paddlefish from years gone by. Johanna O'Keefe counted and identified zooplankton and assisted with telemetry and gill netting. Dr. Donald C. Jackson provided guidance and support critical to this endeavor. Funding was provided by the Mississippi Department of Wildlife, Fisheries and Parks, federal aid projects T-1 and T-5.

TABLE OF CONTENTS

APPENDIX Page

LIST OF TABLES

TABLE Page

TABLE Page

LIST OF FIGURES

FIGURE Page

FIGURE Page

CHAPTER I

INTRODUCTION

When the average human mind conjures up the image of a "fish," the shape of a paddlefish (*Polyodon spathula*) is unlikely to appear in the mind's eye. The scaleless skin, shark-like heterocercal caudal fin, tiny eyes set anterior to an immense mouth, elongated and tapered opercular flap, and almost comically-protruding paddle-shaped rostrum combine to give the impression of a fish put together from spare parts; a piscine platypus of sorts. The primarily cartilaginous skeleton, spiral valve intestine and notochord of the paddlefish bear a striking resemblance to the internal structures of chondrichthyans. Early taxonomists initially misclassified the paddlefish as a species of shark (Hoover et al. 2000). The paddlefish is now classified as a bony fish of the infraclass Chondrostei and placed in the order Acipenseriformes along with sturgeons and its only extant confamilial relative, the Chinese paddlefish (*Psephurus gladius*) (Moyle and Cech 1996; Ross 2001). It is native to large river systems of the United States which drain into the northern Gulf of Mexico, and to the Laurentian Great Lakes watershed where it is considered extirpated (Parker 1988).

Neither a shark nor a divine hoax, the paddlefish is well-suited to survival in large river/floodplain ecosystems and many aspects of its unusual morphology represent adaptations for survival in these environments. Humans are alien to the turbid, churning depths of the ever-changing rivers that meander through middle America. Our understanding of these systems is, in part, limited by the difficulty of sampling in rivers so massive and potentially dangerous as the lower Mississippi (Brown et al. 2005a). The enigmatic nature of these environments is mirrored in the shroud of mystery surrounding paddlefish, the ultimate large-river fish.

Even hypotheses regarding the function of the rostrum were speculative until a recent experiment verified its function as an “electrosensory antenna,” allowing juveniles to feed upon individual zooplankters without visual or olfactory cues (Wilkens et al. 2001). The ampullary electroreceptors that cover the rostrum are also present along the elongated opercular flaps, suggesting that the length of both structures serves to increase the electrosensory area. The function of electrosense in adult feeding and interspecies communication has not been studied, and represents one of many knowledge gaps that still persist.

Efforts to document evidence of paddlefish spawning date back to the turn of the 20th century (Stockard 1907; Hussakof 1911), but none were successful until 1960 (Purkett 1961). Capture of juvenile paddlefish remains a noteworthy event, and can serve as publishable evidence for spawning due to the extreme rarity of direct observation of spawning, eggs, or larvae (Jennings and Wilson 1993). Spawning occurs during spring over gravel bars (Purkett 1961) or in tailrace areas (Alexander and McDonough 1983; Hoxmeier and DeVries 1997) following a significant (>2.74 m) rise in water level.

found in many habitats, although oxbow lakes which are cut off from the main river under normal flow conditions can provide ideal nursery habitat (Hoxmeier and DeVries

1997). A comparison of growth rates in lentic and lotic reservoir environments revealed that growth was higher in lentic age 0 paddlefish but similar between habitats in older fish (Paukert and Fisher 2001a). As adults, paddlefish often return to mainstem environments or ascend tributaries to spawn (Hoxmeier and DeVries 1997). Adult paddlefish generally inhabit relatively deep, slow moving areas which are conducive to the production or accumulation of zooplankton, their principal prey (Rosen and Hales 1981; Zigler et al. 2003). Paddlefish are also known to feed heavily on emerging insects when available (Rosen and Hales 1981). Ingestion of fish has been noted, but only as an oddity (Fitz 1966).

Throughout their range, paddlefish are sought for their roe, which is processed into caviar that retails for up to $598.00/kg (Seattle Caviar Company 2003). Paddlefish meat also is eaten in some areas where it is sold as 'boneless cat' (Alexander and Peterson 1985). The 'Kentucky spoonfish caviar®' moniker was recently trademarked for use in conjunction with caviar produced by a company based in Louisville, Kentucky (Shuckman's Fish Company and Smokery 2005). Legal commercial and recreational snag fisheries exist in some states. Snagging is the most effective means of sport fishing for paddlefish because they do not commonly accept bait. The large size of adult paddlefish, which can reach 2.16 m TL and 74 kg (Ross 2001), requires heavy tackle and strong nerves.

Since the early 1900s, paddlefish have been declining in many areas of former abundance (Dillard et al. 1986). Overfishing has contributed to the collapse of some populations (Hoxmeier and DeVries 1996; Graham 1997), and temporary reduction of others (Jennings and Zigler 2000; Scholten and Bettoli 2005). Paddlefish are extremely vulnerable to overharvest due to their vulnerability to fishing gear and tendency to congregate during spring (Jennings and Zigler 2000), and their life history strategy, which includes longer life, older age at maturity, and lower lifetime fecundity than most commercially harvested species (Boreman 1997).

While overfishing can be detrimental to paddlefish, their widespread decline is primarily due to habitat fragmentation, destruction of spawning habitat, and alteration of natural flow regime due to dams and other water development projects (Jennings and Zigler 2000). This is especially evident in river reaches upstream from dams on the periphery of their historic range, such as the Wisconsin River, Wisconsin, above the dam at Prairie du Sac (Lyons 1993).

In 1981, the status of paddlefish in Mississippi was reported as “stable/increasing” (Gengerke 1986). In 1997, the status was reported as “stable” (Graham 1997). Both of these assessments were based on conversations with state-employed biologists who were very familiar with the fisheries, but lacking data on which to base conclusions. Paddlefish currently are listed as a species of special concern by the state of Mississippi and the American Fisheries Society (Ross 2001), and are included in Appendix AI of the Convention on International Trade of Endangered Species (CITES).

A summer-fall commercial fishery for meat exists in Mississippi, although it is primarily incidental to the catfish and buffalo fisheries (George et al. 1995). Recreational snagging is legal in Mississippi waters, with a limit of two paddlefish per day. Tailrace areas are closed to snagging from November 1 to May 31. Anglers in northern

Mississippi refer to paddlefish as "spoonbill" or "spoonbill catfish" and occasionally confuse them with flathead catfish (*Pylodictis olivaris*) if unfamiliar with paddlefish. Although harvest of paddlefish is prohibited regardless of capture method November-April to prevent the taking of roe, illegal roe harvest occurs throughout Mississippi (D. Riecke, MDWFP, personal communication 2003).

Prior to the present study, paddlefish populations in Mississippi have not been the subject of targeted large-scale sampling efforts. Existing knowledge therefore comes as bycatch records from sampling of other species, and from communication with commercial fishermen. Data from 340 paddlefish caught incidentally by a commercial fisherman in the Big Sunflower River were analyzed by George et al. (1995). That paper provides the only published information on paddlefish length-at-age, sex ratio, diet, and condition for a Mississippi population. Mortality, fecundity, and growth rates for Mississippi paddlefish populations have not been published. Graham (1997) noted that there is little information on commercial or sport harvest of paddlefish in Mississippi.

The purpose of this project is to develop a framework for research, conservation, and management of paddlefish in the state of Mississippi based on research and restoration efforts initiated during 2003 in the Tombigbee watershed of northeastern Mississippi and west-central Alabama.

Conservation and Management Framework

Fisheries management is driven by human needs and operates within a complex mosaic of belief systems, value judgments, and economic concerns. Several disparate human values are associated with paddlefish in Mississippi, and all must be taken into account.

Due to its unusual appearance, large size, ancient origins, and popularity in public aquariums, the paddlefish is a high-profile species compared to many other large-river warmwater fish. Protection of paddlefish, which have become extirpated in peripheral areas of their historic range, appeals to people who believe strongly in the protection of biodiversity. A belief in the intrinsic value of life itself and the diversity of life forms underlies some arguments for protection of biodiversity, but there are also real economic concerns associated with biodiversity loss. Under the current operation of the Endangered Species Act, the classification of a given species as "endangered" results in expensive recovery efforts and governmental oversight of habitats deemed critical to the endangered organism. Preventing species such as paddlefish from becoming endangered is the goal of the Conservation and Reinvestment Act (CARA), through which this project was funded.

Beyond aesthetic and intrinsic values, paddlefish are important to people in a utilitarian sense. Commercial harvest of paddlefish roe, which currently has a wholesale value of $110/kg (Scholten and Bettoli 2005), provides a substantial source of income for commercial fishers where roe harvest is legal. Beyond providing a living to large-scale commercial fishers and augmenting the income and food supply of artisanal fishers, paddlefish represent an important connection between humans and their surrounding environment. The reliance of people upon their own immediate surroundings is an important element of local culture, which is continually eroding as our economy becomes more global in nature.

Roe harvest is so profitable that it appeals to the darker motivations of some people. Poaching is a widespread problem not only because of the damage it does to paddlefish populations and those who would harvest the fish legally, but also because poachers typically eviscerate males and females alike and discard large quantities of carcasses in public waters. This wanton waste creates a powerful and shocking image which can fuel cynicism regarding law enforcement efforts and misplaced rage against legal commercial and sport fishers.

Snagging of paddlefish is popular among sport fishers where paddlefish are abundant. Snag-fishers do not differ markedly from other anglers in terms of their motivations, which most notably include the desire to be outdoors, catch fish, and enjoy the company of friends (Scarnecchia et al. 1996). In the Yellowstone River, Montana, snaggers rated paddlefish meat highly as table fare but did not normally use the roe (Scarnecchia et al. 1996). In Glendive, Montana, the local Chamber of Commerce capitalized on the disparity between the monetary value of the roe and the more abstract motivations of anglers by encouraging the donation of roe in exchange for fish cleaning service. The roe is processed into “Yellowstone Caviar” and sold by the Glendive Chamber of Commerce. Proceeds are used to fund fisheries research and historical and cultural community projects (Glendive Chamber of Commerce 2005). Examples such as this highlight the importance of understanding values that motivate human behavior and the potential for increasing optimum sustainable yield through non-traditional means that do not require manipulation of fish populations, habitats, or harvest regulations.

Optimal sustainable yield is a paradigm that underlies fisheries management, providing managers with the general goal of providing the maximum human benefit from fish populations and aquatic ecosystems without impairing the ability of these natural systems to replenish themselves. Paddlefish populations in Mississippi can be divided into two categories: those that can naturally replenish themselves under current conditions and those that cannot. The first step toward optimum sustainable yield is to identify distinct paddlefish stocks in Mississippi and determine the long-term prospects for each stock under current environmental and regulatory conditions. Management actions should focus on restoration and elimination of harvest for depleted stocks, whereas optimum sustained yield from abundant stocks could be realized through legalization of a carefully-managed roe fishery.

Identification of Management Units

The Mississippi Interstate Cooperative Resource Association (MICRA) concluded that currently available genetic data is insufficient for delineation of demographically independent paddlefish populations (i.e. management units) (MICRA 2005). A nationwide study under the direction of Dr. Edward Heist at Southern Illinois University, Carbondale, is currently attempting to identify management units using mitochondrial DNA microsatellites.

The best genetic information currently available suggests that paddlefish of the Mobile basin are distinct from those of the Mississippi and Pearl basins (Epifanio et al. 1996). Within the Mississippi basin, paddlefish exhibited more subtle genetic differences among major tributaries; patterns of variation between and within these tributaries were somewhat ambiguous (Epifanio et al. 1996). No genetic information is available for the Pascagoula drainage.

Within the state of Mississippi, paddlefish have been reported in the Tombigbee, Pascagoula, Pearl, Big Black, and Yazoo drainages in addition to the Mississippi River and associated backwaters. Based on the findings of Epifanio et al. (1996), the Tombigbee watershed population is clearly distinct from Pearl, Big Black, Yazoo, and Mississippi watershed populations. Genetic differences among other drainages may exist, but current information does not verify any.

Until such time that more detailed genetic information is available, it is reasonable to divide paddlefish populations according to major watersheds. Stock assessments should be conducted independently in the Tombigbee, Pascagoula, Pearl, Big Black, and Yazoo watersheds as well as the Mississippi River and adjacent backwaters. In addition to genetic differences that may exist among watersheds, differences in habitats and patterns of human interaction with paddlefish could influence stock structure, abundance, and management strategy on a watershed-specific basis. Tissue samples should be taken from at least 30 paddlefish from each watershed and preserved in 75% ethanol for future genetic stock delineation (MICRA 2005).

Phase I: Distribution and Stock Assessment

The first step in determining viability of populations in each of the identified watersheds is to collect presence/absence data at sites throughout each watershed. Sampling along the mainstem of large rivers with gill nets ranging from 101.6- to 152.7-mm bar mesh should be conducted during winter to adequately sample size structure, maximize catch, and minimize mortality (Scholten and Bettoli 2005). Where and when current velocity is slow enough to permit stationary nets set perpendicular to the flow of the river, this approach is effective. Floating gill nets can be drifted with the current at greater velocities. Drifting gill nets is a labor-intensive, but very effective, method of sampling paddlefish in large rivers with moderate current.

A "predatory" approach should be used initially to further increase efficiency in systems where the mere existence of paddlefish is questionable. A high-quality sonar device can be used to identify congregations of large, suspended fish in reduced current areas of relatively deep water before setting nets. Random or systematic sampling would be more appropriate in areas of high density. In some instances, initial presence/absence sampling may lead to identification of habitat strata relevant to paddlefish density. This could be incorporated into stratified random stock assessment sampling regimes. Some relevant strata may include time elapsed since channelization or snagging operations, distance from dam, macrohabitat type (side-channel, main channel, oxbow lake, etc.), and depth.

Communication with local landowners and fishers is an integral component of the initial investigation of a watershed. Much can be learned regarding historic trends, productive sampling sites, and local attitudes in this way. Researchers are able to obtain solid quantitative data regarding a narrow slice of time, but the people whose lives have been tied to rivers and fish through multiple generations can provide the sense of historical, cultural, economic, and emotional perspective that gives context to our work.

Concurrent to presence/absence sampling in watersheds with low paddlefish catch per unit effort (CPUE), radio transmitters should be implanted in paddlefish. In addition to providing movement and habitat use information, telemetry can aid researchers in locating seasonal congregations and increase the efficiency of stock assessment efforts. Before beginning a thorough stock assessment, it is necessary to identify male and female wintering areas. Males often congregate near spawning grounds in winter and early spring, whereas females are not as likely to do this (Lein and DeVries 1998; Stancill et al. 2002).

Design of stock assessments in each watershed will differ. In rivers where paddlefish are abundant, mark-recapture techniques incorporating random sampling or area-density methods of population estimation may be preferable. In rivers with low abundance, such a sampling scheme would be costly and impractical. The design of a stock assessment study for an individual watershed is best left to the investigator responsible for the initial presence/absence study. However, the parameters estimated should remain consistent among watersheds when possible to facilitate comparison.

Sex ratio, relative stock density, condition, age distribution, growth rate, and mortality rate are basic parameters that can be addressed for all extant populations using data from adult paddlefish sampled with gill nets. Sampling during winter (water temperature <10°C) and early spring facilitates sexing through examination of external characteristics. At this time of year, males exhibit abundant small but visible tubercles on the dorsal and lateral portions of the rostrum and head (Lein and DeVries 1998). Males frequently release milt in March and April if gentle pressure is applied to the abdomen. Females are characterized by swollen abdomens, and eggs can sometimes be felt by inserting a finger into the urogenital opening. Minute tubercles are occasionally seen on females, rendering non-lethal field sexing imperfect for a small fraction of specimens. Non-lethal sexing was used in another study of Mobile basin paddlefish (Lein and DeVries 1998).

Obtaining age distribution, growth, and mortality estimates requires ageing of paddlefish. This is somewhat problematic for two reasons. First, published paddlefish ageing studies use the dentary bone, which generally requires sacrificing the fish (Adams 1965; Reed et al. 1992; Hoxmeier and DeVries 1997). Male and female paddlefish commonly exhibit different growth rates (Reed et al. 1992), thus requiring the sacrifice of samples from representative length classes for each gender. Obtaining a sufficient sample size is not advisable in depleted populations, which can be quickly eliminated through targeted effort with gill nets. Sacrificing captured fish also inhibits the ability of researchers to conduct mark-recapture population estimates and monitor movement. In addition to requiring the sacrifice of fish, dentaries from paddlefish are difficult to age due to the presence of false annuli or 'halo bands' (Reed et al. 1992; George et al. 1995). Some authors suggest that annuli form during the summer in southern waters in response to low dissolved oxygen or supraoptimal water temperatures (Lein and DeVries 1998).

No published study has addressed the precision of paddlefish dentary ageing, making data obtained with this commonly used ageing technique subject to speculation.

Development of a non-lethal ageing technique would greatly benefit paddlefish research, especially if this new technique is more accurate or precise than ageing with dentaries. Preliminary investigation suggests that the leading rays of the pectoral fin can be removed from living paddlefish, dried, sectioned, cleared, and magnified in a manner similar to that used for sturgeons (Rien and Beamesderfer 1994; Rossiter et al. 1995). Annuli can be seen clearly on pectoral ray sections, but the accuracy and precision of this method has not been determined for paddlefish. To aid the development of pectoral fin ageing technique, fin rays and dentaries should be collected from all paddlefish sacrificed by researchers in Mississippi. Long-term monitoring of reintroduced paddlefish marked with oxytetracycline (OTC) or coded wire tags (CWT) as young-of-year provides the best opportunity to collect known-age fish for pectoral fin and dentary precision studies (Brown et al. 2005b). When recaptured, fish from these stockings should be sacrificed for ageing using both structures until a sufficient sample size is obtained.

Exploitation rate should be determined in addition to sex ratio, relative stock density, condition, age distribution, growth rate, and mortality rate for populations that support fisheries. Monitoring sport and commercial/artisanal exploitation through tag return programs can be problematic because of inconsistent or unknown rates of tag reporting by fishers, although tag returns were used to estimate mortality of paddlefish on the Neosho River, Oklahoma (Combs 1982). For a high-profile, easily identifiable, and tightly regulated species such as paddlefish, catch reporting by all successful fishers may be a viable alternative to voluntary tag returns. Establishing paddlefish check stations at the few popular tailrace snag fisheries in Mississippi would be relatively easy given the infrastructure that already exists at these locations, their limited size, and the brevity of Mississippi's month-long paddlefish snag fishery. To ensure reporting and generate interest, kill tags could be provided at no charge to paddlefish anglers at tailraces. This approach has been used successfully for a variety of wildlife species throughout the United States, and for lake sturgeon (*Acipenser fulvescens*) in Michigan.

The kill tag approach is less feasible for the primarily incidental commercial/artisanal fishery that operates throughout Mississippi during summer. To study the commercial/artisanal exploitation of paddlefish under the current regulations, it will be necessary to monitor commercial/artisanal fisheries in general. This was done on the Pearl River in 1988, and the annual paddlefish catch was a mere 55 kg (Holman 1988). Given the cost and time investment required for a thorough study of commercial/artisanal fisheries and the incidental, and potentially small, fraction of the fishery comprised by paddlefish it is likely that the information (as it pertains specifically to paddlefish management) gleaned from such a study would not justify the cost.

After the initial phase is completed, biologists should be able to determine the status of paddlefish within a watershed. If the status is extirpated or in decline, research should move into a second phase in which potential limiting factors are identified and regulations should be altered to eliminate harvest. If the status is stable but unable to sustain additional mortality through exploitation, the current regulations should be maintained. If the status is stable and stock structure and abundance indicate that additional harvest would be beneficial or harmless, regulations should be relaxed to allow for limited roe harvest or longer snagging seasons. Any liberalization of legal fishing methods should be followed with a study of exploitation rate and effects on stock structure.

Phase II: Identification of Limiting Factors

If a given stock is declining or extirpated, limiting factors must be identified before restoration efforts can begin. Habitat fragmentation, destruction of spawning habitat, and alteration of natural flow regime are commonly cited causes of stock depletion (Carlson and Bonislawsky 1981; Gengerke 1986; Sparrowe 1986; Jennings and Zigler 2000). Monitoring of recruitment, availability of suitable spawning habitat, and effects of flow regime on recruitment are complicated by lack of clear guidelines for sampling early life stages and incomplete information regarding spawning habitat requirements.

Recruitment failure is a likely indicator of early life history or spawning habitat limitations. Examination of year-class residuals along the descending limb of the catch curve produced by stock assessment efforts from Phase I can indicate variable recruitment. Direct measures of recruitment were not suggested in Phase I because of the difficult logistics associated with such a study. Assessment of spawning success and recruitment could focus on collection of wild-spawned eggs, larval paddlefish, or young-of-the-year. Researchers have used a wide variety of methods to collect paddlefish at these early life stages, but no single technique has proved effective under a wide variety of environmental conditions.

Eggs have been sampled using dredges (Purkett 1961), ichthyoplankton drift nets, and epibenthic sleds (Pasch et al. 1980). They also have been collected from gravel bars after a drop in water level (Purkett 1961). Larvae have been collected with ichthyoplankton drift nets and located visually by divers (Hoxmeier and DeVries 1997). These techniques are labor-intensive and may not be practical in the turbid, debris-rich rivers of Mississippi. The most complete long-term data sets pertaining to paddlefish recruitment are provided by studies of impingement on screens at water intakes where young-of-year paddlefish are routinely quantified (Alexander and McDonough 1983).

Gill nets are generally ineffective for sampling young-of-year paddlefish (Pasch et al. 1980). Cove rotenone application, seining, and electrofishing are not practical in pelagic impoundment habitats that young paddlefish may prefer (Pasch et al. 1980). Otter trawls have been effective in Lewis and Clark Lake, South Dakota (Ruelle and Hudson 1977), but cannot be used in most Mississippi rivers due to abundance of large woody debris. Boat electrofishing was effectively used to harvest juveniles in shallow lacustrine habitats of the Cahaba and Tallapoosa rivers, Alabama (Lein and DeVries 1997). Electrofishing may be effective in Mississippi where conductivity permits.

As paddlefish grow, they become more susceptible to gill netting. Preliminary data suggest that hobbled gill nets hung with 4.4-mm or 5.1-mm bar monofilament mesh are somewhat effective in targeting 320-390 mm eye-to-fork length (EFL) paddlefish after their first year of growth in backwater and pond environments. This method of sampling has the advantage of being easy to accomplish concurrent to adult stock assessment and the major disadvantage of substantial bycatch in certain circumstances, occasionally resulting in gear saturation by shad (family Clupeidae) within minutes. Methods for assessing recruitment are not well-developed and should be improved upon and tailored specifically to requirements imposed and opportunities available in each watershed.

Overfishing (legal and illegal) has been the cause for paddlefish decline in some aquatic systems (Jennings and Zigler 2000). Identifying the effects of overfishing should be less problematic to managers than recruitment, spawning habitat, and flow regime issues. Stock assessments performed in the initial phase should provide managers with stock structure data sufficient for identification of overfishing effects.

In watersheds where stocking is deemed necessary to augment adult spawning stock, ineffective or suboptimal stocking technique may hamper population restoration and constitute a limiting factor. The location of release and paddlefish size at release are important factors in determining survival. Stocking and monitoring programs should be designed to test competing hypotheses regarding these factors and mediating environmental factors such as water clarity and zooplankton density.

Paddlefish may display seasonal site fidelity, returning to the same general areas year after year to stage and spawn (Lein and DeVries 1998; Stancill et al. 2002). A more complete understanding of site fidelity is especially important to restore paddlefish populations in impounded rivers because (1) emigration from impoundments can be a major barrier to successful reintroduction (Pitman and Parks 1994), and (2) development of stocking protocols that encourage paddlefish to imprint on favorable spawning habitat may lead to increased natural reproduction in the future. If paddlefish display natal philopatry, stocking programs should be designed to take advantage of this behavior.

However, imprinting may occur very early in life, necessitating the development of a mark that can be applied to larvae and read five to ten years later when fish return to spawn as adults. Oxytetracycline and calcein are two chemical markers which may be suitable.

Phase III: Management Actions

Management strategy for a watershed could: (1) remain consistent with the current philosophy of roe-harvest limitation and one-month snagging season; (2) shift to mitigation of limiting factors and population restoration accompanied by a complete harvest ban in response to paddlefish scarcity; or (3) change to reflect abundance of paddlefish in liberalization of harvest regulations. In addition to considering data from earlier phases, proposed management actions should include elements of coordination with relevant state, federal, tribal, and non-governmental organizations and public participation. Discussion of proposed management actions provides the opportunity to engage local landowners and diverse agencies in paddlefish conservation efforts and develop a sense of what is possible. Implementation of management actions is ultimately at the discretion of the Mississippi Department of Fisheries, Wildlife and Parks.

In systems where paddlefish are declining, many possibilities exist to reverse this trend. Overfishing might be curtailed through increased law enforcement or more restrictive harvest regulations. Habitat and flow regime issues are more difficult to address, likely requiring coordination with the United States Army Corps of Engineers to alter discharge below flood control dams or landowners throughout the watershed to improve land-use practices.

In areas of extreme paddlefish scarcity and apparent suitability of habitat, stocking programs may be initiated under the assumption that the cause of historical decline is no longer limiting to paddlefish production. Stocking programs should proceed in accordance with the MICRA Paddlefish Genetics Plan (MICRA 2005), which suggests spawning a minimum of five unique pairs of paddlefish annually for at least five years. Paddlefish stocked as fingerlings in June or later have much greater survival rates than paddlefish stocked as larvae (Graham 1986), and the spawning of five pairs of paddlefish per year produces a number of paddlefish larvae that commonly exceeds hatchery grow-out capacity. These excess larvae can be chemically marked and stocked into a tributary stream to assess natal philopatry and mark retention. Ideally, a single tributary should be chosen for all larval stockings within a watershed because chemical markers do not effectively mark individuals or batches of larvae and will be unable to identify more than one stocking location.

In watersheds where paddlefish are underfished, liberalization of harvest regulations should include a limited and closely monitored legal roe harvest. Paddlefish roe is in high demand, and demand is likely to increase in the near future in response to recent regulations banning the import of beluga sturgeon (*Huso huso*) caviar and corresponding rise in price of other Asian imports. Management solutions that generate revenue and encourage legal exploitation of natural resources for the benefit of local fishers should be emphasized. The vast majority of illegal paddlefish harvest is conducted by wellorganized criminals who know of appropriate channels through which illicit goods flow. Opening legal channels between commercial/artisanal fishers of Mississippi and roe processors will encourage benefit to local economies and connections between people, the rivers, and the paddlefish while discouraging illegal activity by increasing roe supply and driving down prices (assuming that large underfished populations exist in Mississippi).

To reinforce the philosophy of allowing roe harvest to benefit the economy and residents of this state, licenses for commercial roe harvest should only be available to residents of Mississippi. This also would decrease interjurisdictional law enforcement problems that could result from the transport of Mississippi paddlefish into neighboring Alabama and Louisiana, where paddlefish harvest is illegal.

In watersheds where paddlefish are underfished, any regulation change that allows increased harvest should be accompanied by a thorough study of exploitation rate, catch and effort, economic impact, the effect of increased fishing mortality on stock structure, and the demographics, motivations, and values of fishers. To facilitate this, tagged fish should be present in the target river before the season begins. Initially, the roe harvest season should be short and require the purchase of a special license. The license would generate funds specifically for the management of the roe fishery and encourage accountability of fishers, who should be required to report to check-in stations where biologists can collect data on all paddlefish captured. An added benefit of this system is that it discourages wanton waste of carcasses after roe collection. Carcasses not utilized by fishers could be donated to charitable or governmental organizations by biologists.

Phase IV: Monitoring and Review

The effectiveness of restoration actions should be assessed through a second stock assessment approximately ten years after stocking or habitat/flow improvement begins. This will demonstrate the impact of restoration efforts on abundance and stock structure. Recruitment also should be investigated at this time to ensure that natural reproduction is occurring.

Review and improvement of management actions should occur continuously, with formal meetings to discuss progress at five-year intervals. As data from watersheds throughout the state are collected and analyzed, and the results of management actions are realized, a picture of what works and what doesn't will emerge. The two-tiered approach of restoring depleted populations and increasing legal harvest of underfished populations will hopefully result in healthier paddlefish populations and increased cultural and economic human benefits.

Prioritizing Watersheds

The previously outlined framework could be applied to all paddlefish populations in Mississippi, but logistic and monetary constraints may not permit simultaneous investigation of all populations. Thus, a brief discussion of the limited available knowledge pertaining to paddlefish populations in each watershed follows in addition to a suggested prioritization of research needs.

Tombigbee Watershed

The Tombigbee River is a tributary of the Mobile River and was historically isolated from the Mississippi Basin by the Tennessee Valley Divide. In 1985, the United States Army Corps of Engineers completed the Tennessee-Tombigbee Waterway, which resulted in the creation of a freshwater corridor between the two basins, fragmentation of the Tombigbee River through construction of ten dams, channelization of the river's mainstem, isolation of the mainstem from its floodplain, and impoundment of tributary and mainstem environments (Ward et al. 2005). The effect of this widespread anthropogenic impact upon the paddlefish population was not documented. Prior to the current study, no published record of paddlefish in the mainstem of the Tombigbee River in Mississippi existed. Paddlefish were collected in Mississippi waters of two tributaries where apparently suitable spawning habitat exists (Boschung 1989; Mettee et al. 1996). The Tennessee-Tombigbee Waterway represents the only freshwater corridor between the genetically distinct populations of the Mississippi and Mobile basins, raising concerns regarding integrity of stocks (Epifanio et al. 1996).

Pascagoula Watershed

The mainstem of the Pascagoula River its two major tributaries, the Leaf and Chickasawhay rivers, represent the last unregulated major river system in the conterminous United States (Dynesius and Nilsson 1994). Land in the Pascagoula basin is 59% forested, 17% wetland, and 19% pasture with only 1% urban and 2% devoted to crop production (MDEQ 2001). The Pascagoula is the second largest watershed in Mississippi and the least impacted by human activity.

Despite the lack of fragmentation and diversity of habitats available to paddlefish in the Pascagoula watershed, an anecdotal report from a commercial fisherman who has been fishing the system for over 40 years suggests that paddlefish were quite rare early in 2005 (Randy Emmons, personal communication). Commercial roe harvest from the Pascagoula River apparently decimated the paddlefish population during the early 1980s (Graham 1997) after caviar prices rose in response to the trade restrictions on Iranian caviar imports (Alexander and Peterson 1985). Anecdotal reports suggest that illegal roe harvest continued to impact paddlefish through the mid-1990s and that paddlefish never fully recovered from this period of over-exploitation (Randy Emmons, personal communication).

Hurricane Katrina resulted in the death of an estimated 60,765,808 fish in the Pascagoula River through oxygen depletion during September of 2005 (Mississippi Department of Environmental Quality {MDEQ}, unpublished data). The impact of Katrina on paddlefish is unknown, but eight paddlefish were confirmed dead and a rough estimate of 60 paddlefish mortalities was calculated by MDEQ. No historical data regarding paddlefish population trends exist. No samples from this watershed were included in studies of paddlefish genetics throughout their range (Epifanio et al. 1996), and no specimens from the Pascagoula system were reported in museum records summarized by Ross (2001).

Pearl Watershed

The Pearl River is free flowing from its confluence with the Gulf of Mexico to Ross Barnett Dam, 450 km upstream (Ward et al. 2005). Although relatively free from longitudinal habitat fragmentation, flow throughout much of the mainstem below Jackson has been impacted by construction of a diversion canal for flood control (Ward et al. 2005). Water quality has suffered because of erosion, siltation, nutrient enrichment, and input of toxins from agricultural and industrial point and non-point sources (Ward et al. 2005).

Though historical data regarding population structure and dynamics are not available, some records of paddlefish in the Pearl River exist. Sampling effort targeting Gulf sturgeon, *Acipenser oxyrhynchus*, in 1997 produced eight paddlefish, whereas comparable effort on the Pascagoula River did not result in the incidental capture of paddlefish (T. Slack, MDWPF, unpublished data). Sampling for Gulf sturgeon resulted in the capture of several paddlefish in backwaters of the lower Pearl River in 1987 near Columbia, Mississippi (D. C. Jackson, Mississippi State University, personal communication). A creel survey conducted on the lower Pearl River estimated a total commercial paddlefish harvest of 55 kg with hoop nets in 1988 (Holman 1988). The Mississippi state record paddlefish (29.5 kg) was caught below the Ross Barnett spillway in 1974.

Big Black Watershed

Free-flowing throughout the 434-km length of its mainstem, and virtually free from modification for flood-control purposes since 1955, the Big Black River retains floodplain connectivity that fuels production of ictalurids and other fish (Brown et al. 2005a). The low gradient and fine sediments of the Big Black make it unlikely to support a strong population of spawning paddlefish if they are restricted to isolated gravel deposits for egg incubation. Juvenile paddlefish were collected from the Big Black River in 2000 (D. C. Jackson, Mississippi State University, personal communication). This suggests that spawning gravel in this system may be sufficient, or perhaps that eggs adhere to and incubate upon the abundant woody debris.

Yazoo Watershed

The region of northwest Mississippi drained by the Yazoo River is colloquially referred to as "the Delta" (Smith 1954). The fertility of Delta soils led to its historic prominence in cotton production and, more recently, channel catfish aquaculture. The Yazoo watershed is the largest in Mississippi; land use is primarily agricultural (64%) with significant forest cover (17%) and wetlands (13%) remaining (MDEQ 2000). Several major tributaries (Coldwater, Little Tallahatchie, Yocona, and Yalobusha rivers) originate in uplands adjacent to the poorly-drained, low-elevation Delta region. To prevent flooding of the cultivated lands downstream, flood control reservoirs (Arkabutla, Sardis, Enid, and Grenada lakes, respectively) were built on each of these tributaries.

In the Yazoo River drainage, recreational paddlefish snag fisheries exist in tailwaters below flood control reservoirs (Gengerke 1986; Meals and Kiihnl 1993). The Sardis Lake tailrace (Little Tallahatchie River) is noted as the premier fishery (Ross 2001). Snaggers fish from the rip-rapped bank and from boats in the tailrace outlet channel and in Lower Lake, which receives effluent from the outlet channel (Meals and Kiihnl 1993). Paddlefish are only abundant seasonally at the tailrace and in Lower Lake (Meals and Kiihnl 1993). The construction of a lowhead dam at the outlet of Lower Lake was not shown to block paddlefish migration, although it was a barrier to blue sucker *Cycleptus elongatus* (Meals and Kiihnl 1993). According to Gengerke (1986), C. A. Schultz (MDWFP) reported that paddlefish numbers increased dramatically in the Yazoo River drainage from 1952 to 1981; approximately 80% of the state's commercially caught paddlefish came from the Yazoo River and its tributaries during this period.

The free-flowing Sunflower River is unique among major Yazoo River tributaries in that it has not been subject to extensive channelization and snagging operations (Brown et al. 2005a). The soil fertility index of the Sunflower River watershed is the highest of any watershed in the state of Mississippi, which is reflected in the low age of maturity observed in channel catfish, *Ictalurus punctatus* (Shephard and Jackson 2005). The Sunflower River also is the only system in Mississippi for which paddlefish data are available. George et al. (1995) reported paddlefish capture in 1-4% of hoop nets set by a commercial fisherman targeting buffalo (*Ictiobus* spp.) on the Sunflower River. Most paddlefish captures occurred in deep pools near the mouth of permanently flowing tributaries or gravel pits under stabilized or falling water level (George et al. 1995). Diet, condition, growth, sex ratio, and length-weight relationships were consistent with characteristics reported in other paddlefish populations and did not indicate a population in jeopardy (George et al. 1995). The records of commercial fisherman William Lancaster suggested that paddlefish, which were absent from his catches from 1969-1979, were increasing in abundance from 1980 to 1995 in the Sunflower River (George et al. 1995).

Paddlefish were “much more abundant” in the Delta than other areas of Mississippi in the 1950s (Cook 1959). Historical population fluctuations have been noted in published literature (Gengerke 1986; George et al. 1995), but not corroborated with fishery-independent data. The cause of wide fluctuations reported in published literature is not clear. During the period of time when paddlefish in the Pascagoula River were reportedly declining due to overfishing and increased demand for roe, populations in the Yazoo watershed were reportedly increasing (George et al. 1995; Graham 1997). The low gradient and soft substrate of the Yazoo River and its principal tributaries downstream from flood control reservoirs may offer paddlefish limited gravel substrate for spawning; in the Sunflower River gravel occurs in small, isolated patches (George et al. 1995).

Mississippi River and Backwaters

As the largest river of the continental United States, the Mississippi River provided paddlefish access to a diverse array of main-channel, tributary, and seasonally flooded lacustrine habitats prior to anthropogenic fragmentation longitudinally (damming of upstream reaches and tributaries) and laterally (levee construction). Human disturbance has drastically altered habitat connectivity, flow regime, nutrient load, and instream habitat through agriculture, flood control, and navigation channel construction and maintenance.

Several studies have documented paddlefish movement and habitat use patterns on the upper Mississippi River (Southall and Hubert 1984; Moen et al. 1992; Zigler et al. 2003; Zigler et al. 2004). The most recent published studies pertaining to paddlefish of the lower Mississippi River are nearly a century old despite the historic importance of the commercial paddlefish fisheries of the lower Mississippi River and oxbows such as Lake Washington, Mississippi, and Moon Lake, Mississippi (Stockard 1907; Hussakof 1911). Anthropogenic habitat alteration has created some main-channel habitats preferred by paddlefish (i.e., deep pools with reduced velocities associated with bridge abutments, dikes, and wing dams) (Southall and Hubert 1984), in addition to reducing accessibility and abundance of certain habitat types through fragmentation, dredging, impoundment, and destruction of wetlands. Purkett (1961) hypothesized that destruction of shallow gravel bar habitat in the Mississippi River led to declines in the commercial paddlefish fishery.

The Mississippi River represents the epicenter of the paddlefish's historic range. The mainstem of the lower Mississippi River provides suitable feeding and, perhaps, spawning habitat in addition to a corridor for movement between productive backwater environments and major tributaries. Oxbow lakes that retain a connection to the Mississippi River are not as abundant as they once were, but those that remain in

Mississippi (including Lake Mary) could provide important insights regarding the role such backwaters play in paddlefish life history. Data from the Alabama River suggest that backwaters are primarily used by juvenile paddlefish (Hoxmeier and DeVries 1997), but the immense catches of large paddlefish from Moon Lake, Mississippi around the turn of the twentieth century indicate that adults utilize large oxbows in some situations (Stockard 1907). In 1951, the Mississippi Game and Fish Commission removed 25,057 kg of paddlefish from Moon Lake under the rubric of rough fish removal (Ross 2001). Today, such a quantity of paddlefish would be valued at $1,048,474 (Southwick and Leftus 2003).

The effects of habitat alteration on paddlefish population status and habitat use patterns in the lower Mississippi River and connecting waters has not been studied. Given the impressive historic capacity for paddlefish production, it is possible that management practices based on the outcome of such research could result in a sustainable and highly profitable paddlefish roe fishery.

Research Priorities

Based on the limited information available, paddlefish populations in two watersheds appear to be threatened. The Pascagoula system offers a diversity of habitat types and is free of fragmentation, apparently providing ideal conditions for paddlefish. The lack of available data, reported decimation through overfishing, and disastrous effect of Hurricane Katrina combine to make this a high-priority area for research. At the other end of the spectrum is the Tombigbee system, which is impacted by fragmentation and contains highly modified mainstem and tributary habitats in addition to less heavily-impacted tributaries. Lack of historical information pertaining to this system and anecdotal reports of declining paddlefish abundance led to the development of this project and initiation of population restoration efforts. The Pascagoula and Tombigbee watersheds represent top priorities due to reports of decline in paddlefish abundance and possible localized or widespread extirpation.

The Yazoo system represents the greatest potential for sustainable commercial and recreational fisheries based on limited available evidence. A thorough study following the aforementioned framework has the potential to provide guidelines for more optimal harvest within a few years. The diversity of fishing opportunities available by shore at four tailraces or by boat combined with the productivity of the watershed should result in a high level of sustainable harvest. During the period of time when paddlefish were experiencing declines due to overharvest in other watersheds, their numbers were increasing in the Yazoo system (George et al. 1995; Graham 1997). This suggests that mechanisms other than fishing mortality historically mediated population abundance in this watershed. Links between habitat availability, flow regime, and recruitment could provide a basis for more effective management actions than harvest limits.

Without current data, this amounts to mere speculation. The Yazoo system is a third priority because no evidence suggests that paddlefish populations there are declining or jeopardized in any way, but the potential for an expanded fishery may exist. Unlike the Mississippi and Pearl rivers, the Yazoo system is entirely within the borders of the state of Mississippi. The current moratorium on paddlefish harvest in bordering Louisiana would make it inadvisable for Mississippi to liberalize regulations along the Pearl and Mississippi rivers. Also, recreational tailrace snagging opportunities are not available in the Mississippi River and exist only below Ross Barnett Reservoir on the Pearl River. Finally, if contemporary stock assessment of the Yazoo basin indicates low abundance or other indicators of decline it would be cause for great concern in the light of the historical published accounts of stable and increasing abundance. A presence/absence study should include sites upstream from flood control reservoirs that are assumed, but not demonstrated, to be upstream limits of paddlefish distribution.

Due to the interjurisdictional nature of the lower Mississippi River, movements of paddlefish between states should be well-understood before pursuing a multi-agency approach to paddlefish management in the system. The Sturgeon and Paddlefish Committee of MICRA provides the coordination necessary for such discussions. A telemetry study incorporating personnel from all bordering state agencies may be necessary to adequately describe paddlefish movements and habitat use in the lower Mississippi River. Such an effort would be of much larger scale than research projects in other watersheds. Though the lower Mississippi River is potentially of greater significance than other watersheds due to its size and historic productive potential, it is placed as a fourth priority due to the amount of coordination and resources necessary for such an undertaking. Combining an initial movement study with studies of other poorly-understood large-river species such as alligator gar (*Atractosteus spatula*) and pallid sturgeon (*Scaphirhynchus albus*) would maximize the information return on such a costly investment.

The scant information available for the Pearl River suggests local abundance of paddlefish and minimal importance of fisheries in comparison to the Yazoo watershed. Virtually no published information exists regarding Big Black River paddlefish populations and fisheries. The Pearl River has more potential for human impact and benefits due to the presence of major population centers (Jackson, Mississippi) along its banks. The Pearl River is suggested as a fifth priority, and the Big Black River as sixth.

Overview of Management Strategy

The proposed management framework emphasizes a need for better information upon which management actions should be based. The current approach of two neighboring states, Louisiana and Alabama, is to completely restrict harvest until more information is available. Mississippi's current approach is to minimize harvest while retaining some forms of legal fishing. Legal roe harvest has been essentially eliminated. A primarily incidental commercial/artisanal meat fishery remains during the summer in addition to a month-long recreational snagging season at select locations in October. Mississippi's approach is probably a very successful means of eliminating overharvest statewide, and has the benefit of avoiding a complete ban in areas where paddlefish may be very abundant. It should continue to serve the purpose of preventing overharvest while maintaining limited legal fisheries until better information is available.

Applying the proposed management framework (Figure 1) to the six prioritized watersheds would provide the needed information and allow for regional modification of current statewide regulations. The ultimate purpose of the proposed framework is to protect and restore severely damaged populations while working toward sustainable use and increased human benefit from healthy or underfished populations. Data on which to base decisions are sorely needed. The potential exists for both restoration of an aesthetically valuable component of large river biodiversity and greatly increased economic and social benefit through consumptive utilization of a recreationally and commercially sought species.

Paddlefish Management in the Tennessee-Tombigbee Waterway

The management framework outlined above was developed as research on the paddlefish population of the Tennessee-Tombigbee Waterway (TTW) progressed during 2003-2005. Stock assessment on the TTW was initiated in part due to anecdotal historical reports of paddlefish in the Mississippi portion of the Tombigbee River and its tributaries. Few data regarding historical or contemporary population abundance existed, so hypotheses to explain the results of the initial stock assessment were developed concurrent with execution of the stock assessment. The TTW provides a case study for application of the proposed management framework. From the initial stock assessment, the TTW study was expanded to include the following set of objectives:

1. Determine distribution and population dynamics of paddlefish populations along the River Section of the Tennessee-Tombigbee Waterway.

2. Identify factors that limit paddlefish sustainability in two impoundments of the Tennessee-Tombigbee Waterway: Demopolis Lake and Columbus Lake.

a. Demopolis Lake: spawning and egg incubation habitat availability, spring flow duration and timing, bendway habitat use and availability
b. Columbus Lake: food resources, physicochemical factors, emigration

3. Examine site fidelity in paddlefish as it relates to the feasibility of restoration in Columbus Lake.

4. Develop an experimental paddlefish stocking program for Columbus Lake which will enable future investigation of natal philopatry and emigration rates of paddlefish stocked into tributary backwaters and mainstem habitats.

CHAPTER II

METHODS

Study Site

The 238-km long River Section of the Tennessee-Tombigbee Waterway (TTW) includes four impoundments (Figure 2). Columbus Lake (3,606 ha) is the upstream impoundment, and the only one that lies entirely within the state of Mississippi. Downstream from Columbus Lake, Aliceville Lake (3,359 ha) is situated on the Mississippi/Alabama border. Gainesville Lake (2,590 ha) and Demopolis Lake (4,047 ha), the downstream impoundment, lie entirely within the state of Alabama. Some tributaries of these lakes, including the Noxubee River, originate in Mississippi. Demopolis Lake is composed of two arms, the Tennessee-Tombigbee Waterway Arm (Tombigbee Arm) and the Black Warrior Waterway Arm. Only the Tombigbee Arm and the portion of the navigation channel downstream to Demopolis Dam are considered in this study, and references to Demopolis Lake refer only to this portion of the lake unless otherwise noted (Figure 3).

Macrohabitat types available in the River Section of the TTW include the dredged and snagged navigation channel, tailraces downstream from dams, bendways, and backwaters. Bendways were historically part of the Tombigbee River. Construction of cutoffs provided a shorter route for navigation traffic (e.g., Twelvemile Bend on Figure

3). Siltation is rapidly reducing available bendway habitat because most bendways do not carry most of the TTW discharge and are subject to the sedimentation of suspended particles at low flows. A unique ‘flowing bendway’ habitat exists between Howell Heflin Lock and Howell Heflin Dam in Demopolis Lake, where the dam discharges water from upstream Gainesville Lake into a bendway (Figure 2). Backwaters include a variety of lentic off-channel habitat types with varying degrees of connectivity to the mainstem. Some, such as flooded creek mouths, are always connected to the mainstem. Others, such as natural oxbow lakes and artificial gravel pits, are located on floodplains and connect to the mainstem only during high water periods.

Distribution and Stock Assessment

Historical Information

Federal aid freshwater fisheries reports (1950-2003) published by the Mississippi Department of Wildlife, Fisheries and Parks (MDWFP) were reviewed for material relating to paddlefish populations in Mississippi. NISC DISCover Fish and Fisheries Worldwide software (Wyman Towers, 3100 St. Paul Street, Baltimore, Maryland 21218) (June 2005) and online search engines were used to search peer-reviewed literature.

During the first year of this study, it became apparent that local residents and those who spend a good deal of time on the water are an excellent source of information regarding paddlefish in the TTW. The paucity of information that exists in the written historical record and published literature can be augmented with accounts from those who have encountered paddlefish along the waterway. Conversations were initiated with a variety of people on the waterway during sampling for stock assessment. These conversations were impromptu, informal, and un-scripted. Comments pertaining to paddlefish were recorded on data sheets if the source seemed reasonably credible. In some instances photographs were provided.

Distribution and Relative Abundance

Assessment of paddlefish distribution and abundance in the waterway focused on the 238-km River Section of the TTW, which flows from Aberdeen Lock and Dam at Aberdeen, Mississippi, to Demopolis Lock and Dam at Demopolis, Alabama (Figure 2). A sampling program was devised to allow for comparison of paddlefish catch per unit effort (CPUE: fish per five-hour net day) between fixed bendway and tailrace sampling sites in each of the four lakes in the River Section beginning in May 2003 and ending in December 2003. Sampling gear consisted of gill nets, which were 30.5 m long, 3.7 m deep, and hobbled to 2.4 m. Nets were hung with 101.6-, 127.0-, or 152.4-mm bar-mesh multifilament webbing and fished in tandem. Each of the eight fixed sampling locations (four tailraces and four bendways) was sampled once per two-month period with six nets (two of each mesh size) set for a target of five hours per net. When gear failure or lack of personnel prevented sampling on a randomly determined date an alternate date was chosen.

Bendway sites were chosen primarily on the basis of the availability of deep (>9 m) water because paddlefish often prefer the deepest water available (Zigler et al. 2003). Three groups of tandem nets were fished at each bendway site. One was set in deep (>9

m) water, one was set in mid-depth water (3-6 m) adjacent to deep water, and one was set at a creek mouth. Although actual net placement within locations was not always constant across months due to changes in current and suspended debris, locations were considered fixed as opposed to random. Tailrace net placement was nearly always identical from one sampling period to the next due to the limited area available at tailrace locations. All tailrace nets were set between 240 m and 800 m downstream of a dam. At each site, one net was fished parallel to the current flow approximately 240 m from the dam in moderate current; another was fished parallel to current flow on the edge of an eddy; and a third was set perpendicular to the current flow down a steep drop-off ending in approximately 6 m of water. Under relatively high-flow conditions, perpendicular net sets were replaced with parallel sets to avoid accumulation of debris and drifting of nets. Water with depth >6 m typically was not available at tailrace sites.

Mean CPUE at fixed locations (mean-of-ratios for sample periods calculated from mean-of-ratios for individual net sets) is reported as an index of relative abundance. Locations were chosen in the belief that they provided the best paddlefish habitat available in each of the four lakes. I originally intended to analyze these data using a split-plot analysis of variance (ANOVA) design for repeated measures, which is an ideal design for comparison of fixed locations monitored over time (Maceina et al. 1994). Violation of homogeneity of variance and normal distribution assumptions precluded ANOVA analysis. The nonparametric equivalent Kruskall-Wallis test (Conover 1999) requires independent samples. This assumption was violated due to the use of repeated measures at each site.

Supplemental nets were set in a wide variety of habitats from April 2003 to February 2004 to ensure adequate spatial coverage of the waterway and tributaries and to ensure that fixed locations were truly the best netting sites available. One tributary location (Bluff Lake spillways, Oktoc Creek, Noxubee County, Mississippi) was sampled with gear similar to that used in the TTW during March or April of 2003, 2004, and 2005 and during September and November of 2004.

Demopolis Lake Population Estimate

Paddlefish were captured in Demopolis Lake, Alabama, using gill nets during winter and spring from April, 2003 through May, 2005. Multifilament nets were 30.5 m long and 3.7 m deep (hobbled to 2.4 m). These nets were hung with 101.6-, 127.0-, or 152.4-mm bar-mesh multifilament webbing and generally fished in tandem on the surface or substrate. Monofilament nets 47.7 m long, 3.7 m deep (hobbled to 3.0 m), and hung with 127.0-mm bar-mesh were fished singly with lead lines resting on the substrate. Additional experimental mesh (101.6-, 127.0-, and 152.4-mm bar) monofilament gill nets 61 m long and 5.5 m deep were used during 2005. These nets were used to reach fish suspended in water deeper than 9 m. They were often drifted or fished oblique, with one end of the net tied to shore and the other end anchored in such a way that the deepest portion of the net fished 3 m above the substrate. Tactics were modified during 2005 in response to sonar data that indicated large concentrations of fish suspended between 3 m from the surface and 3 m from the substrate.

For 2004, a population abundance estimate was calculated using Chapman's modification of the Lincoln-Petersen mark-recapture estimator (Chapman 1951). A 95% confidence interval was calculated using the Poisson distribution due to low number of recaptures (Ricker 1975). Only those fish captured in Demopolis Lake were used in calculations. The marking period included twelve sample dates from October 17, 2003, to March 16, 2004 and the recapture period included three dates between April 9 and April 23, 2004. Gill nets were used for all initial captures. During the recapture period, fish were taken with gill nets or found dead on shore.

During 2005, a second population estimate was conducted for the entire Tombigbee Arm of Demopolis Lake using similar computations. The marking period included twelve dates from December 31, 2004 until March 21, 2005 and fish were recaptured on nine dates between March 30 and May 10, 2005. These periods were chosen based on concurrent observation of radio-tagged fish, which moved little before late-March spawning movements resulted in dispersal of paddlefish throughout the Tombigbee arm of Demopolis Lake. This dispersal satisfied the assumption of random mixing of marked and unmarked fish.

Paddlefish were captured during the marking phase using targeted gill net effort to maximize catch in the flowing bendway and Twelvemile Bend. During the recapture period, gill nets were set in two randomly-chosen river kilometers on two dates in the flowing bendway and Twelvemile Bend. Random kilometers also were chosen for sampling in the navigation channel, but conditions only allowed one net set on one chosen date. Due to the low catch rate of randomly placed nets in the flowing bendway, supplemental nets were set in productive areas to augment the catch during the recapture phase.

Demopolis Lake Population Characteristics

Demopolis Lake stock assessment was limited to winter and spring to facilitate sexing of paddlefish using external characteristics (Rosen et al. 1982) and minimize mortality in nets, which can be high when water temperatures are warm. Sampling was conducted on 3 dates during the 2003 sample season (April 2003); on 12 dates during the 2004 sample season (December, 2003 through April, 2004); and on 23 dates during the 2005 sample season (December, 2004 through May, 2005). During 2003, the flowing bendway between Howell Heflin Dam and Howell Heflin Lock (Figure 3) was the only area targeted for stock assessment. Sampling for the 2004 season included 8 nets set in Twelvemile Bend, which did not produce any paddlefish. Telemetry data from 2004 revealed more productive areas of Twelvemile Bend. Consequentially, 108 net-days were recorded in Twelvemile Bend during the 2005 season. Attempts also were made to sample the navigation channel during 2005. Only two net-days were recorded in the navigation channel due to gear damage and potentially life-threatening sampling conditions.

Nets were checked regularly in attempts to prevent mortality. Depending on water temperature, nets were checked at 20-minute to 180-minute intervals. Captured fish were measured to the nearest mm and weighed to the nearest 0.1 kg. Eye-to-fork length (EFL, a.k.a. body length) was chosen as the standard measurement for paddlefish length due to frequent rostrum abnormalities (Russell 1986). During 2003 and 2004, paddlefish were marked with Floy lock-on and Floy T-bar tags at the base of the dorsal fin, and with opercular flap notches. Paddlefish were marked with duplicate T-bar tags during 2005 in response to observed loss of lock-on tags. Tissue samples were taken from pelvic fins of most fish and preserved in 95% ethanol for genetic stock determination at the Fisheries and Aquaculture Center at Southern Illinois University, Carbondale, in the laboratory of Dr. Edward Heist. Moribund paddlefish were retained for aging using dentaries (Adams 1965).

Mature paddlefish were sexed using secondary sex characteristics (e.g., tubercles on males) when possible (Rosen et al. 1982). Gender of moribund fish was confirmed through necropsy and examination of gonads. Gender also was confirmed in paddlefish taken to Private John Allen National Fish Hatchery (United States Fish and Wildlife Service) in Tupelo, Mississippi, for use as broodstock. Injection with luteinizing hormone-releasing hormone (LHRH) stimulated the release of sperm in males and the ripening of eggs in females, allowing for positive identification of gender. Seventeen paddlefish were taken for broodstock during 2004 and 2005.

Relative stock density (RSD) was computed for paddlefish caught from Demopolis Lake during 2005 (Anderson and Neumann 1996). Minimum EFL values of 410, 660, 840, 1,040, and 1,300 mm for stock, quality, preferred, memorable, and trophy paddlefish, respectively, were used (Brown and Murphy 1993).

The chi-squared test for independence was used to test for differences in length-frequency distribution of paddlefish according to mesh size, habitat, and year (Heath

1995). All paddlefish captured in Demopolis Lake were used to test the effect of mesh size, whereas only paddlefish captured during 2005 were included in the habitat test because the Twelvemile Bend habitat was not sampled during other years. In comparing 2004 and 2005 sample seasons, only males caught in the flowing bendway were used because of small female sample size and lack of effective Twelvemile Bend sampling during 2004.

The null hypothesis that paddlefish exhibited a 50:50 sex ratio during 2005 was tested using chi-squared goodness-of-fit (Heath 1995). Sex ratios were examined separately for paddlefish caught in the flowing bendway and in Twelvemile Bend. The null hypothesis that sex ratio was independent of location was tested using the chi-squared test of independence (Heath 1995). For all chi-squared tests, groups were combined such that expected values <1 did not occur, and <20% of expected values for any test were <5 (Heath 1995).

Relative weight (*Wr*) was calculated for each paddlefish captured during 2004 and 2005 using the sex-specific *Ws* equations (Brown and Murphy 1993). Years were divided into two seasons: prespawn (December-March) and postspawn (April 16-May 10). For 2004, the effect of season on *Wr* was tested separately for males and females using two sample *t* tests (Heath 1995). A two factor analysis of variance (ANOVA) was used to test for effects of season, habitat, and interaction of season and habitat on condition of paddlefish caught during 2005 (Petersen 1985). Separate analyses were performed for male and female paddlefish. Homogeneity of variance was verified with

Lavene's test prior to performing analysis. All statistical tests were performed using SAS Version 8.2 (SAS Institute, Inc. 2001).

Four to six lateral pectoral fin rays (Mabee and Noordsy 2004), including the primary ray, were removed from 80 male paddlefish for ageing during 2005. Fin rays were not removed from females because data collected prior to 2005 suggested that few females would be captured during the 2005 sample season. Dentaries have been used by other researchers to age paddlefish (Adams 1965; Reed et al. 1992; Hoxmeier and DeVries 1997), but dentaries were not used in this study because doing so would have required the sacrifice of a large number of fish from a population of unknown size. Instead, pectoral fin rays were removed from male fish prior to their release. Pectoral fin rays have been used to age other acipenseriforms, and removal of pectoral fin rays from shortnose and Atlantic sturgeon (*Acipenser brevirostrum* and *A. oxyrinchus oxyrinchus*) does not affect growth or survival (Collins and Smith 1996). Paddlefish pectoral fin rays were removed approximately 2 mm distal from the body using wire cutters. Cutting fin rays closer to the body resulted in heavy bleeding. Fin rays were dried overnight at room temperature in scale envelopes before storing in a freezer. Five-minute epoxy was used to coat the pectoral fin rays before sectioning to prevent the rays from slippage during sectioning. The epoxy-covered fin rays were folded in paper and allowed to cure for at least one hour before sectioning to 500 μm width using an Isomet low-speed saw and diamond wafering blade manufactured by Buehler, Inc. (Evanston, Illinois).

One to three sections per sample were mounted between two 1.1-mm wide glass microscope slides and sequentially numbered. A single reader blindly selected and read each of the slides three times under a Leica S8APO stereoscope (Leica Microsystems, Inc., Buffalo, New York) at approximately 78 X magnification. Distance between the focus and each annulus was measured to 0.01 mm during the second and third reading using an ocular micrometer. If the reader assigned the same age to a given section in at least two of the three readings, that age was considered correct. A similar system was used by Hoxmeier and DeVries (1997) to age paddlefish from the Alabama River using dentaries. The presence of halo bands (false annuli) in dentaries from paddlefish in the southern portion of their range coupled with the long growing season makes age determination difficult; precision has not been quantified for any ageing method.

The Fraser-Lee method of back-calculation was used to generate mean lengths-at-age for male paddlefish after determining the intercept parameter *a* (DeVries and Frie 1996). The intercept parameter was calculated through linear regression of 110 measurements of pectoral fin ray radius and EFL at time of sampling. In addition to male paddlefish used for ageing, juvenile paddlefish caught in Demopolis Lake, juvenile paddlefish spawned from Demopolis Lake broodstock in ponds, and post-larval paddlefish raised from wild-spawned Demopolis Lake and Noxubee River eggs were used to ensure representation of all size classes. Regression was performed using SAS Version 8.2 (SAS Institute, Inc. 2001).

Mean lengths-at-age were calculated separately for male paddlefish in Twelvemile Bend and the flowing bendway and used to generate von Bertalanffy growth curves (Busacker et al. 1990). Von Bertalanffy parameters (L_∞, K, and t_0) and approximate 95% confidence intervals were calculated using all age groups present in both habitats using

Proc Nlin in SAS Version 8.2 (SAS Institute, Inc. 2001). Confidence intervals overlapped, so the two habitats were considered components of the same population, and mean lengths-at-age were calculated using combined data to generate a von Bertalanffy curve for Demopolis Lake using the above method.

A catch curve was generated by using the von Bertalanffy curve to assign ages to male paddlefish that were inconsistently aged or not sampled for ageing during 2005; and including these values with ages-at-capture for fish consistently aged using methods described above. Mortality was determined using Heincke's method and the slope of the descending limb of the log-transformed catch curve (Ricker 1975).

Potential Limiting Factors

Demopolis Lake Spawning Habitat

Wild-spawned paddlefish eggs were sampled in the flowing bendway of Demopolis Lake (Figure 3) using artificial substrates similar to those used to sample sturgeon eggs (McCabe and Beckman 1990; Marchant and Shutters 1996). Artificial substrates consisted of latex-coated hog hair filter material 63.5 cm wide by 2.54 cm deep. The material was wrapped smooth side down around a 63.5 cm square angle iron frame such that both sides of the frame were covered with the artificial substrate. Material was attached to frames using nuts and bolts. Washers were used to prevent material from slipping off bolts as holes in the material wore wider with use.

Frames were fastened to anchors with ropes and swivels to prevent twist in the current. Anchors consisted of scrap iron pieces from 9 to 23 kg. Float lines of 15 to 30 m long and 1 cm diameter were attached to anchors with a swivel. Most float lines were attached to bullet-shaped floats 35 cm long and 13.5 cm diameter, but others were tied to riparian vegetation including overhanging limbs and exposed roots.

Artificial substrates were deployed on shallow (<3 m deep at 50% exceedance) gravel bars where paddlefish were expected to spawn and at deeper sites (>3 m deep at 50% exceedance) where substrate consisted of gravel or bedrock (Figure 4). Sampling began on February 28, 2005, and concluded on April 25, 2005. Three to 12 artificial substrates were sampling effectively (i.e., deployed and retrievable) in the flowing bendway of Demopolis Lake at any given time during this period. One artificial substrate was deployed in the Noxubee River near the mouth of Bodka Creek from April 9 to April 13, 2005. Individual substrates were deployed for 4- to 8-day intervals when possible.

Upon retrieval, artificial substrates were examined for the presence of large (3-4 mm), grey, adhesive eggs (Ross 2001). Eggs of this description were removed by cutting the strands of hair to which they were attached and preserved in 80% ethanol or transported to aerated tanks for hatching. Hatched larvae were preserved in 80% ethanol upon death. Periphyton, detritus, and fine substrates that accumulated on artificial substrates were removed by thorough rinsing before substrate redeployment.

Water temperature was measured at 0.5 m below the surface on all sample dates using a Model 85 Yellow Springs Instrument (YSI, Inc., Yellow Springs, Ohio). Water velocity was measured at 0.5 m below the surface using a Flo-Mate (Marsh-McBirney, Inc., Frederick, Maryland) at successful sample sites (i.e., those at which at least one paddlefish egg was captured) on April 6 and April 13, 2005. Water level was determined using provisional stream gage height data (subject to change until published) available online from the United States Geological Survey (USGS 2005).

In addition to using artificial substrates to monitor spawning activity through time, all paddlefish captured for stock assessment were examined for evidence of spawning activity. Male paddlefish were checked for flowing milt and female paddlefish were examined to determine prespawn vs. postspawn condition (no females were depositing eggs at the time of capture). Prespawn condition was indicated by turgid abdomen and, particularly in large specimens, a swollen urogenital opening through which eggs could be felt by inserting a finger. Postspawn condition was indicated by flaccid abdomen and/or puckered and sunken appearance of skin around an inflamed urogenital opening.

Spring Flow Duration and Timing

A substantial increase in discharge is needed at the appropriate time of year to induce spawning behavior in paddlefish (Purkett 1961; Alexander and McDonough 1983; Russell 1986). To investigate effects of discharge patterns on Demopolis Lake paddlefish spawning and recruitment, three response variables collected using previously described methods were used: 1) artificial substrates to collect naturally-spawned eggs during 2005; 2) female paddlefish collected during 2004 and 2005 and examined for evidence of pre-ovulating, ovulating, or postspawn condition; 3) residuals from the descending limb of the catch curve for male paddlefish caught during 2005 were used to indicate historic year-class strength.

Provisional gage-height data (USGS 2005) from a gauging station below Helfin Dam were used to calculate exceedance values and determine the number of days during which gage height indicated a river level 2.74 m above 50% exceedance. The 2.74-m benchmark was initially chosen because Purkett (1961) noted paddlefish spawning activity following a 2.74-m rise in water level on the Osage River. Water temperature between 10 and 17° C and correct photoperiod for a given latitude also are thought to be necessary to induce paddlefish spawning (Hubert et al. 1984). Data from the Cahaba and Tallapoosa rivers (Alabama) support the suggested water temperature requirement and indicate that paddlefish at latitudes similar to those addressed in this study spawn between mid-March and mid-May (Lein and DeVries 1998). In light of this information, and observations of Demopolis Lake paddlefish addressed later in the discussion, number of days above the calculated gage height was determined for the period of April 1-May 1 during 2004, and 2005 to provide a rough estimate of the number of days during each year in which conditions were ideal for paddlefish spawning. This number will be referred to as the spawning suitability index (SSI). Capture of post-spawn females during 2004 and 2005 were compared and related to SSI. Numbers of wild-spawned eggs captured during 2005 were related to the proposed criteria for verification.

Catch-curve residuals were used as indicators of year-class strength. They were then related to SSI values. These values differed from those discussed above because tailrace data were not available prior to 1999 (USGS 2005). The SSI calculations used in year-class interpretation were based upon gage heights at two locations: (1) the Tennessee-Tombigbee Waterway above Heflin Dam, and (2) the Noxubee River at

Geiger, Alabama (USGS 2005). Linear regression was used to model the relationship between natural-log transformed SSI and catch-curve residual using Proc Reg in SAS Version 8.2 (SAS Institute, Inc. 2001). Transformed SSI values resulted in greater R^2 values and lesser P values than raw SSI values, indicating better fit.

Habitat Use and Availability

Radio telemetry was used to assess paddlefish habitat use. Most transmitters contained an internal loop antenna, weighed 40 or 145 g in air, ranged from 30.000 to 31.999 MHz, and were manufactured by Advanced Telemetry Systems (ATS), Inc. (Isanti, Minnesota). Two transmitters weighed 35 g and were manufactured by the now-defunct company Custom Telemetry. Transmitters were surgically implanted using techniques similar to those described by Hart and Summerfelt (1975). Prior to surgery, instruments and transmitters were sterilized using ethanol. During surgery, paddlefish were kept moist using damp towels and nylon mesh. Gills were aerated continuously with a pump. An incision of approximately 5 cm in length was made through the skin and ventral musculature. The transmitter was inserted and the wound was closed using a simple interrupted suture pattern. Paddlefish were docile throughout surgery and recovered quickly. Fish were relocated using a loop antenna and a R2000 scanning receiver from ATS.

Twenty-seven radio-tagged paddlefish were used to assess habitat use in Demopolis Lake. These were broken into two groups: fish that wintered in the flowing bendway and those that wintered in Twelvemile Bend. Throughout 2004, eleven fish from the flowing bendway group were at large. Prior to beginning telemetry efforts in 2005, three of these fish could not be located because of transmitter battery death or (possibly) emigration. One additional radio-tagged fish was added to the flowing bendway group before the 2005 season to bring the number of fish at large to nine, whereas fifteen fish comprised the Twelvemile Bend group during 2005.

On each sample date, the entire flowing bendway or Twelvemile Bend was searched at least twice: once during daylight hours, and once during the crepuscular period or at night. The number of fish found in the habitat of interest on each date was compared to the expected number of fish found there under the assumption of random distribution throughout the area of 'available habitat'. In the event that an individual fish was found in two different habitats on a given date, the habitat it was first located in was used.

The area of available habitat (1,357 ha) was defined as the Tombigbee Arm of Demopolis Lake from Howell Heflin Lock and Dam downstream to Demopolis Lock and Dam. Given observed movement rates up to 2 km/h for juveniles (Roush et al. 2003) and 4 km/h for adults (Paukert and Fisher 2000), paddlefish could redistribute throughout the area of Demopolis Lake they were found in (90.7 km long) between sample dates. Nearly unlimited habitats outside the defined available habitat were within reach of paddlefish through the two years of the study. Paddlefish could access the entire Mobile and Mississippi river drainages via locks in addition to Demopolis Lake tributaries. 'Available habitat' is therefore a minimum estimate used to calculate expected frequencies of paddlefish in the flowing bendway and Twelvemile Bend. The flowing bendway constitutes 6.866% of available habitat and Twelvemile Bend constitutes 13.261%.

Expected frequencies for each habitat were calculated by multiplying number of fish at large for a given group by the percentage of available habitat represented by the flowing bendway and Twelvemile Bend. For each sample date, observed frequencies were compared to expected frequencies to determine significant nonrandom habitat use. Chi-squared goodness-of-fit has been used with such data, but the low expected frequencies encountered in Demopolis Lake did not allow use of a chi-squared test (Heath 1995). Consequently, SAS Version 8.2 software (SAS Institute, Inc. 2001) was used to perform a Monte Carlo (Kalos and Whitlock 1986) analog to the chi-squared test (Appendix A). Random proportions for each fish-at-large on a given date were generated. If the proportion for a given randomly-behaving fish was less than or equal to the ratio of target habitat to total available habitat, that fish was considered present in the target habitat. Number of fish-at-large randomly present in the target habitat was thus calculated. Ten million iterations were performed with each observed frequency to calculate the probability of observing an equal or more extreme result by chance. If the resulting probability was less than α (0.05), the observed frequency of habitat use was considered significantly non-random.

Columbus Lake Translocation

Using methods discussed above, twelve paddlefish were implanted with radio transmitters after being used as broodstock at Private John Allen Fish Hatchery (Tupelo, Mississippi). Four of these fish were released near their place of capture in the flowing bendway of Demopolis Lake (Figure 3) and the remaining eight were translocated to Columbus Lake (Figure 2), where they were released near the tailrace of Aberdeen Lock and Dam. The purpose of this experiment was to compare habitat and food resources used by paddlefish in the two lakes and assess movement past lock and dam structures. Attempts were made to locate paddlefish in Columbus and Demopolis lakes once per week from June 4 to July 7, 2005 whenever possible. Additional days were spent searching adjacent impoundments for paddlefish that moved through locks or dams. Because the four paddlefish released in Demopolis Lake were not located during the June-July study period, ten paddlefish radio-tagged in conjunction with the previously described habitat use study were used to sample the Demopolis Lake population.

At each daytime paddlefish location, water depth, temperature, conductivity, and presence or absence of a visible surface eddy at the location were recorded. Zooplankton was sampled with 63-μm mesh net using vertical tows after sunset at locations where paddlefish were relocated and in tailraces. Samples were preserved in a 4% formaldehyde solution and dyed with Rose Bengal. Copepods and cladocerans were counted and identified using 20X magnification. Rotifers were subsampled and counted using 250X magnification.

Water depth, temperature, and conductivity at locations used by paddlefish in Demopolis Lake were compared to locations used by paddlefish in Columbus Lake using two sample *t* tests (Heath 1995). Eddy use was compared between the two lakes using a two sample *t* test (Heath 1995). Zooplankton density, cladoceran density, and copepod density were compared between paddlefish locations at the two lakes during the two time periods in which >1 paddlefish was located in Columbus Lake (early June and late-June/early-July) using Mann-Whitney *U* tests (Heath 1995). An α of 0.05 was used for these hypothesis tests.

Site Fidelity

Columbus Lake Translocation

Paddlefish translocated to Columbus Lake for use in the previously described study were relocated when possible to monitor movement through locks and dams and to record incidents of movement toward initial capture location in Demopolis Lake.

Oktoc Creek Translocation

Two male paddlefish radio-tagged in 2003 were captured at Noxubee National Wildlife Refuge from Oktoc Creek (a distributary of Noxubee River) at the radial gate spillway below Bluff Lake. These fish were transported to Private John Allen Fish Hatchery to be used as broodstock. No females were caught during spring 2003, so these fish were subsequently released in Demopolis Lake near the mouth of the Noxubee River. The fish were not released in Oktoc Creek because low summer water levels may prevent emigration and fish kills are common due to low oxygen. A third male paddlefish was captured at the radial gate spillway, radio-tagged, and immediately released at the spillway on March 31, 2004. Both spillways below Bluff Lake were monitored through December 2005 to record incidences of return to this location of initial capture.

Demopolis Lake Radio Telemetry

Multiple response permutation procedure (MRPP) was used to test for seasonal site fidelity (Kernohan et al. 2001) in radio-tagged Demopolis Lake paddlefish. Each paddlefish which was located a minimum of four times per season in consecutive years was used in this analysis. Seasons included winter (December through March 5), spring (March 9 through April 23), and summer (April 25 through June). Eight paddlefish were located at least four times in one or more seasons during both 2004 and 2005. Two were females, four were males, and two were of unknown gender.

The MRPP statistic (*T*) is based on within-group distances (McCune and Grace 2002). Intuitively, distance between locations must therefore be measured such that fish traveling between two locations that are measured as being close to one another must move less than fish traveling between two locations that are measured as being farther apart. Due to the sinuosity of Demopolis Lake, measuring location with latitude and longitude would not be suitable. Instead, each paddlefish location was measured in terms of its distance along the historic Tombigbee River from Howell Heflin Dam (y) and its distance from the right bank of the river if looking upstream (x). For paddlefish located in the Noxubee River (which flows into the historic Tombigbee River 3,835 m downstream from Heflin Dam from the left bank), the y coordinate is 3,835 and the x coordinate is the distance traveled up the Noxubee River plus the width of the Tombigbee at the mouth of the Noxubee River. Euclidian distance was used in MRPP calculations (McCune and Grace 2002), which were performed using PC-ORD Version 4 (MjM Software, Gleneden Beach, Oregon). Site fidelity was indicated by *P* values greater than α (0.05), representing no significant difference between paddlefish locations in consecutive years.

Stocking Program Design and Monitoring

Two stocking protocols were devised and tested. One involved stocking juvenile paddlefish into natural oxbows and anthropogenic gravel pits at a rate of 20 per surface hectare. These small lacustrine environments were adjacent to tributaries of Columbus Lake (Buttahatchie River or Tibbee Creek) and isolated from lotic environments at base flow. This protocol was devised to minimize post-stocking emigration, provide young paddlefish with a potentially food-rich environment, and allow for the possibility of imprinting on areas accessible to adult paddlefish only via streams which contain the best available spawning habitat.

The second protocol involved the more commonly used procedure: stocking juvenile paddlefish at a lesser density (1.1 per ha) into a mainstem environment. Fish were stocked at Barton’s Ferry public access, which was chosen because of its considerable distance from Aberdeen Lock and Dam and John C. Stennis Lock and Dam. This protocol had the advantage of simpler logistics. Large numbers of paddlefish can be stocked at one time in the large (3,606 ha) mainstem impoundment, whereas stocking multiple small (1.6-13.3 ha) floodplain lakes requires multiple trips from the hatchery and permission from local landowners.

Juvenile paddlefish were stocked in the mainstem and in four floodplain lakes between June 26 and June 28, 2005. All stocked paddlefish were spawned artificially from Demopolis Lake broodstock at Private John Allen National Fish Hatchery in Tupelo, Mississippi. Paddlefish were raised in raceways in either Mammoth Springs National Fish Hatchery in Mammoth Springs, Arkansas, or at Private John Allen National Fish Hatchery. Due to cooler water temperature at Mammoth Springs, paddlefish reared in the Arkansas hatchery were smaller than those raised in Mississippi (mean 25 g and 117 mm EFL vs. 60 g and 152 mm EFL). The 2,866 paddlefish from Mammoth Springs were stocked in the mainstem at Barton's Ferry whereas the 1,781 paddlefish from Private John Allen were stocked at Barton's Ferry and in four floodplain lakes. All paddlefish received a coded wire tag (CWT) manufactured by Northwest Marine Technologies (Shaw Island, Washington) prior to release.

To evaluate emigration and survival, 49 juvenile paddlefish reared at Private John Allen National Fish Hatchery were implanted with radio transmitters. The mainstem of Columbus Lake received 29 radio-tagged paddlefish whereas Fortson Lake and Pit 21 (Figure 2) each received ten radio-tagged fish. Radio transmitters bore whip-style antennae, weighed 1.2 g in air, broadcasted at frequencies between 30.000 and 31.999 MHz, and were manufactured by ATS.

Transmitters of such diminutive dimensions were not available with a mortality option. Determination of survival was therefore contingent upon interpretation of successive locations for an individual fish. A baseline for comparison was established by repeatedly locating a submerged transmitter hidden by a second party. Three locations were recorded using GPS before retrieving the hidden transmitter. This procedure was repeated and a 95% confidence interval was constructed using the difference between the actual transmitter location and the attempted locations. Thus, it was determined that 95% of locations were within 20.6 m of the actual transmitter location. Therefore, if successive locations for a given paddlefish were within 20.6 m of each other the fish was considered dead. Of course, differences greater than 20.6 m did not necessarily indicate a living fish. Swift current (especially at the tailrace) could have compromised accuracy. Additionally, paddlefish could have been consumed by large predators, and currents or turbulence from navigational traffic could have moved dead fish or transmitters. Because of these possibilities, differences >20.6 m but <60 m were sometimes considered indicative of mortality in light of environmental conditions.

Attempts were made to locate each tagged paddlefish a minimum of one time per week during each of the four weeks following stocking. Emigration was calculated as the proportion of paddlefish transmitters not located during the fourth week. Survival was calculated as the proportion of non-emigrant transmitters present in paddlefish considered alive using the above criteria. Standard error for emigration and survival proportions (P) were calculated using the formula: $SE=\sqrt{(P-(1-P))/(n-1)}$. The chi-squared test for independence was used to compare survival and emigration between habitats (Heath 1995).

At each paddlefish location in Columbus Lake, depth was recorded and a YSI Model 85 or Model 30 was used to measure temperature, specific conductance, and (prior to equipment failure during the fourth week) dissolved oxygen 0.5 m beneath the surface. When daylight permitted, Secchi depth was recorded.

In Fortson Lake and Pit 21, similar parameters were recorded at three fixed stations on each sample date. Due to small size and relative homogeneity, all paddlefish in these environments were assumed to experience the same conditions. Mainstem environments were sampled for abiotic parameters in the following manner. Three macrohabitats were identified: navigation channel, bendway, and tailrace. The navigation channel was broken into 1 km long segments and three were chosen randomly for sampling each week. Three of sixteen bendways also were sampled randomly weekly. Due to limited area and heavy current, the tailrace was sampled in duplicate at fixed sites. Other Columbus Lake macrohabitats (tributary streams, wetlands, canals, and flats <1 m deep) were not sampled due to logistic constraints.

CHAPTER III

RESULTS

Distribution and Stock Assessment

Historical Information

Although paddlefish were known to exist in the Mississippi component of Tombigbee River prior to the late 1950s, no museum specimens exist and no records of capture have been found in the literature. Demopolis Lake, Alabama, is the only impoundment on the entire waterway from which records of paddlefish capture have been located by the author (Mettee et al. 1996). Paddlefish also are present in the Noxubee River, a Demopolis Lake tributary which originates in Mississippi (Mettee et al. 1996; Ross 2001). Historic effort in Mississippi portion of the TTW and its tributaries includes over 4,351 hoop net sets, 90 acres of rotenone application, and 373.5 hours of electrofishing as well as seine pulls at over 87 sites and 583 larval fish light trap nights (from Mississippi Department of Wildlife, Fisheries and Parks {MDWFP} data summarized by O'Keefe et al. 2004). In the literature that was reviewed, only 31 gill net nights were recorded. These nets were set before the completion of the waterway between 1978 and 1980 (Schultz 1981). Although MDWFP records did not mention the capture of any paddlefish, their sampling efforts did not begin until 1978. Construction of the waterway began in December of 1970.

Published records do not verify presence of paddlefish in the mainstem of the historic Tombigbee River or present-day TTW, but paddlefish were recorded in a tributary of what is now Columbus Lake, Mississippi. A single record of paddlefish occurrence in the lower Buttahatchie River was reported by Mettee et al. (1996). This specimen was collected in July of 1971 where US Highway 45 crosses the river in Lowndes County, Mississippi (T16S, R18W, Sec 16). Boschung (1989) reported the occurrence of paddlefish prior to 1980 in the Buttahatchie River near Coulumbus Air Force Base in Lowndes County, Mississippi (T16S, R18W, Sec 19). Both published records of paddlefish in the Buttahatchie River came from an area where floodplain gravel mining operations intensified in the late 1970s. Present-day habitat consists of an unstable gravel-bottomed channel and a series of flooded gravel pits.

Informal conversations with commercial fishermen, anglers, local residents, and others along the waterway revealed tales of ‘spoonbill catfish’ in Mississippi waters of the TTW and pre-waterway Tombigbee River. According to a former commercial fisherman who occasionally caught paddlefish in hoop nets during the 1970s, a snag fishery once existed during spring at the mouth of Buttahatchie River. An Air Force retiree spoke of one small paddlefish he found dead below Stennis Lock and Dam in Columbus, Mississippi, “a couple of years ago.” Others remembered seeing paddlefish swimming near the surface of the Tombigbee River before construction of the waterway with their rostrums out of the water (a sign of distress). Several people witnessed the harvesting of paddlefish stranded in a pool during the construction of Stennis Lock and Dam. In Bigbee, Mississippi, local residents historically participated in a snag fishery for paddlefish at one of the many gravel pits that exist near the East Fork of the Tombigbee River. These fish probably entered the gravel pits early in life. Reports indicated that no paddlefish have been taken from the Bigbee gravel pits since 2000.

W. D. Criddle is a commercial fisherman from Columbus, Mississippi, who has fished the area since 1974. Mr. Criddle mentioned that he had heard that paddlefish were common long before 1974, and that they had declined due to industrial pollution. Former commercial fisherman James Barksdale was kind enough to provide photographic evidence of a 17.3-kg female paddlefish taken in a gill net set near Pratt Camp in Aliceville Lake, Mississippi, "approximately 4 years ago" (ca. 2001). He reported that Gene Sullivan, another local commercial fisherman, caught a smaller paddlefish a few weeks later in Aliceville Lake, Mississippi, at the mouth of Cedar Creek.

The best evidence to date of historically strong paddlefish presence in the Mississippi portion of the Tombigbee River and its tributaries comes from photographs and firsthand reports of Clark Young (West Point, Mississippi), who documented the capture of 44 adult paddlefish in one night of fishing in Fortson Lake, an 7.3-hectare backwater lake off of Tibbee Creek on which his family built a cabin in 1923 (Figure 2; Figure 5). Mr. Young reported that breaching paddlefish were a common sight before he joined the Army in 1954 and that he has not seen or heard of paddlefish being taken from Fortson Lake since his return in 1956. The lake was poisoned with rotenone to remove nongame fish in 2003 and no paddlefish were found. Several fish kills occurred in Tibbee Creek due to pollution from industry in the upstream city of West Point prior to the mid-1960s. This may have impacted paddlefish populations in the Tombigbee watershed (Clark Young and Betsy Lott, West Point, Mississippi, personal communication).

Distribution and Relative Abundance

During 2003 and 2004, 374 gill nets were set in the river section of the TTW and its tributaries to determine paddlefish distribution. This count includes net sets at fixed locations (N = 192) and net sets at supplemental locations (N = 182). Mean soak time at fixed locations was 258 min (SD = 103 min). Twenty-nine paddlefish were captured from Demopolis Lake, Alabama, and two from Gainesville Lake, Alabama, during sampling at fixed locations. Both fish captured in Gainesville Lake were juveniles (470 and 594 mm EFL). No paddlefish were captured in the Mississippi portion of the TTW, which includes Columbus Lake and most of Aliceville Lake. During sampling at fixed locations, catch-per-unit-effort was zero at all sites other than the Demopolis Lake tailrace and bendway sites and the Gainesville Lake bendway site (Table 1).

Only one paddlefish was captured during supplemental netting in the mainstem of the TTW from April, 2003 to February, 2004. This fish was taken from a gravel pit at the mouth of an unnamed tributary to Gainesville Lake (Figure 2). Low catch rates during supplemental netting suggest that fixed sites represented prime paddlefish habitat.

Twenty net sets were recorded in Oktoc Creek below Bluff Lake spillways. Two mature male paddlefish were captured during 2003, two mature males were captured during 2004 (one a recapture from 2003), and one mature male was captured in 2005. A mature female and juvenile male were found dead on July 6, 2005 following a fish kill caused by reduced water level in Bluff Lake and subsequent lack of flow over the overflow spillway, which resulted in oxygen depletion. Supplemental netting in the Buttahatchie River, Luxapalila Creek, James Creek, and McCower's Creek did not produce any paddlefish (Figure 2).

Demopolis Lake Population Estimate

During the 2003-2004 marking period, 34 paddlefish were marked in the flowing bendway of Demopolis Lake. Of 24 fish checked for marks at this location in 2004, three were previously tagged. The estimated population size was 220 gear-recruited paddlefish in the flowing bendway during spring 2004 with a 95% confidence interval of 90 to 548 paddlefish.

During the 2004-2005 marking period, 176 paddlefish were marked in the flowing bendway and Twelvemile Bend. Of 99 fish checked for marks at these sites during the 2005 recapture period, four were marked. The estimated population size was 3,541 gear-recruited paddlefish in Demopolis Lake (excluding the Black Warrior Arm) during spring 2005, with a 95% confidence interval of 1,581 to 8,851 paddlefish. This represents a density of 2.6 paddlefish/ha with a 95% confidence interval of 1.2 to 6.5 paddlefish/ha in Demopolis Lake during 2005. Density in the flowing bendway during 2004 was comparable based on the above estimates, which yield a 95% confidence interval of 0.96 to 5.9 paddlefish/ha.

Demopolis Lake Population Characteristics

Net sets recorded during the 2003, 2004, and 2005 sample seasons totaled 18, 72, and 108, respectively. Soak time averaged 194 min across years (SD = 130 min). During 2003, 29 paddlefish were captured in Demopolis Lake, although only six of these were taken during the spring sampling season for stock assessment. Sixty-three paddlefish were captured from Demopolis Lake during the 2004 season and 267 were captured during the 2005 season. A single bighead carp (*Hypophthalmichthys nobilis*) was found dead in Demopolis Lake during 2004 and two were captured in gill nets during 2005. The bighead carp is an introduced zooplanktivore which may compete with paddlefish for food resources (Schrank and Guy 2003).

Paddlefish caught in Demopolis Lake ranged from 601 to 1095 mm EFL. No paddlefish ≥ memorable size (1040 mm EFL) were captured during 2003 or 2004. Five females of memorable size were captured during 2005, although no fish ≥ trophy size (1300 mm EFL) were taken during the course of the study. Relative stock density (RSD) values for quality, preferred, memorable, and trophy fish during 2005 were 99, 73, 2, and 0, respectively.

Multifilament gill nets of differing mesh size did not catch paddlefish with significantly different length distributions (χ^2 test for independence P = 0.059; Figure 6). Average eye-to-fork length for paddlefish caught in 101.6-, 127.0-, and 152.4-mm bar mesh was 846, 869, and 870, respectively. Male paddlefish in Twelvemile Bend exhibited a different length distribution than males in the flowing bendway (χ^2 test for independence P = 0.046; Figure 7), with smaller size classes being more common and larger size classes being comparatively rare in Twelvemile Bend. Females did not exhibit a significant difference in length distribution between habitats (χ^2 test for independence P=0.126; Figure 7). Year did not affect length distribution of males in the flowing bendway (χ^2 test for independence P=0.746).

The sex ratio was highly skewed during 2004 and 2005 in the flowing bendway (χ^2 test for goodness-of-fit $P < 0.001$ in each year), with males outnumbering females more than 2:1. In Twelvemile Bend, the sex ratio differed from 50:50 (χ^2 test for goodness-of-fit $P = 0.023$), with females outnumbering males 3:2. Twelvemile Bend and flowing bendway sex ratios differed significantly (χ^2 test for independence $P < 0.001$) during 2005.

Mean gender-specific relative weight was 82 for males and females during winter 2004 and 78 during 2005. Neither female nor male paddlefish (two sample *t* tests $P >$ 0.05) relative weight was affected by season in 2004. During 2005, habitat and the interaction between habitat and season did not affect female or male *Wr* (two factor ANOVAs $P > 0.05$). However, the main effect of season was significant during 2005 for males ($P = 0.007$) and females ($P > 0.001$). During 2005, male relative weight dropped to 75 and female relative weight dropped to 72 during the post-spawn summer period.

The relationship between pectoral fin radius (r, in tens of microns) and paddlefish length (EFL, in mm) was determined through linear regression, giving the equation EFL=7.25r+52 ($R^2 = 0.963$; $P < 0.001$). The *y*-axis intercept (52 mm) was used in Fraser-Lee back-calculation of lengths-at-age to determine growth rate; which is described by the equation $L_t = 971.8\ [1 - e^{-0.2844\ (t+0.6962)}]$. This equation predicts lengths-at-age (in mm) of 372(I), 520(II), 632(III), 716(IV), 779(V), 827(VI), 863(VII), 890(VIII), 910(IX), 925(X), 937(XI), and 946(XII). Actual mean values for ages III and older were within 2% of predicted values. Of 80 pectoral fin samples taken from male paddlefish, 57 were used in back-calculation. Fin rays were not used if 1) ages did not agree in two of three ageing attempts, 2) fin regrowth or damage was evident, or 3) a lumen formed at the focus of the rays.

The catch curve (Figure 8) indicated that male paddlefish recruited to the gear at age VII. Paddlefish of age XI and over were not considered in further analysis because of small sample size (< 5; Ricker 1975) at given ages and questionable validity of extrapolating beyond the age of the oldest aged fish (age XII). The descending limb of the catch curve (age VII to X) yielded an annual mortality rate (*A*) of 0.406 and Heincke's method produced a comparable annual mortality rate of 0.382. Frequency of paddlefish in each age group was not adequately explained by the predicted mortality rate alone (linear regression R^2=0.753, P=0.132), indicating differential year-class strength.

Potential Limiting Factors

Demopolis Lake Spawning Habitat

Fertilized paddlefish eggs were collected from artificial substrates in Demopolis Lake on three dates (March 30, April 6, April 16) during 2005 (Figure 9). Of 106 paddlefish eggs collected from Demopolis Lake, 95% were taken on either April 6 or April 16. Water temperature was 18.0°C on April 6 and 19.4°C on April 16. Spawned-out females were captured on April 16 and May 6 in the flowing bendway and on April 22 and May

10 in Twelvemile Bend (Figure 9). Males began flowing milt on March 9, and 100% of mature males were flowing on all but one sample date from March 9 until April 20. The only artificial substrate set in the Noxubee River captured nine paddlefish eggs in four days and was retrieved on April 13.

Paddlefish eggs were collected under a wide variety of depth, substrate, and velocity conditions. Successful egg traps (Figure 10) were set at depths of 1.2 to 7.7 m at 50% exceedance, representing the full range of depths sampled. Eggs were collected over gravel and bedrock substrate. High flow deposited coarse sand over some gravel substrates during the study. One paddlefish egg collected from the Noxubee River hatched successfully despite the sand grains that covered it completely. On April 6, water velocity ranged from 0.39 to 1.06 m/s at successful sites in Demopolis Lake. On April 13, water velocity at the successful site in the Noxubee River was 0.99 m/s.

High discharge between April 6 and April 16 submerged floats and terrestrial tie-off points of artificial substrates, making it impossible to examine artificial substrates during this period. Five artificial substrates were retrieved on April 16, two of which were deeply buried in gravel and sand and free of eggs. These were not considered to be effectively sampling between April 6 and April 16 to determine percentage of successful effectively sampling substrates. Two others were partially covered with substrate and contained one or two eggs. These were considered to be effectively sampling, as were other partially impacted sampling devices examined on other dates. The only unimpacted substrate retrieved on April 16 contained 19 paddlefish eggs. All artificial substrates not tied to terrestrial vegetation shifted position significantly due to high water, washing into locations 1.39 to 6.57 m deeper than original locations.

Spring Flow Duration and Timing

Number of days between April 1 and May 1 in which gage height below Heflin Dam was 2.74 m above 50% exceedance was calculated for each sample season as a potential indicator of paddlefish spawning success. During 2004, zero days met these criteria, though nine days of ideal discharge occurred in early March, when water temperature (14.8-16.4°C) also appeared ideal. During February, March, and April, 2004, many of the male paddlefish captured below Heflin Dam in Demopolis Lake, Alabama, were running milt. Many females captured during this time had swollen abdomens, red swelling around the urogenital pore, and eggs that could be felt through the oviduct. No females were found flowing eggs or with sunken abdomens during 2004, which would have indicated ovulating or postspawn condition and the occurrence of spawning activity (Lein and DeVries 1998). Female paddlefish captured as late as April 23, 2004 at a water temperature of 19.7°C had not released their eggs.

During 2005, thirteen days met the criteria for gage height and photoperiod. Ninety-five percent of wild-spawned eggs found on artificial substrates in the flowing bendway were collected following dates that met proposed criteria. It should be noted that sampling effort and efficiency were less during high water due to loss of artificial substrates and sand and gravel deposition. Water temperature reached 19.4°C during peak spawning activity (Figure 9).

Catch-curve residuals for male paddlefish were not strongly related to log-transformed SSI values calculated from gage heights in the flowing bendway (linear regression P = 0.527; b = −0.366; R^2 = 0.753). The negative slope value indicates that ideal spawning conditions in the TTW may negatively affect the contribution of a year-class to future standing stock in Demopolis Lake. Log-transformed SSI values calculated from gage height in the Noxubee River at Geiger, Alabama, was conversely a strong descriptor of catch curve residuals (linear regression P=0.089; b=0.369; R^2=0.830). The positive slope indicates a direct relationship between number of ideal spawning days on the Noxubee River in a given year and the year-class contribution to future Demopolis Lake standing stock.

Habitat Use and Availability

Paddlefish that wintered in the flowing bendway group selected flowing bendway habitat on 36 of 37 sample dates (α = 0.05; Figure 11). On April 2, 2005 paddlefish from this group neither selected nor avoided the flowing bendway. Paddlefish that wintered in Twelvemile Bend showed selection for Twelvemile Bend on 11 of 13 sample dates (α = 0.05; Figure 11). On March 25 and April 2, 2005 they showed neither selection nor avoidance.

Columbus Lake Translocation

Weekly measurements of environmental variables at locations occupied by paddlefish in Columbus Lake were compared to those of Demopolis Lake between June 4 and July 7, 2005 (Table 2). Paddlefish in Columbus Lake used significantly shallower (two sample *t* test $P<0.05$) water with lesser conductivity (two sample *t* test $P<0.05$) than fish in Demopolis Lake. Surface water temperature use and use of eddy habitat did not differ between lakes. Total zooplankton, cladoceran, and copepod densities were greater at Demopolis Lake paddlefish locations than at Columbus Lake paddlefish locations (Mann-Whitney *U* tests $P<0.05$) during early June and late-June/early-July. Tailrace total zooplankton, cladoceran, and copepod densities also were greater in Demopolis Lake (Mann-Whitney *U* tests $P<0.05$). Three exotic zooplankters (*Daphnia lumholtzi*, *Leptodora kindtii*, and *Mysis relicta*) were identified in samples.

Site Fidelity

Columbus Lake Translocation

Three of the eight fish translocated to Columbus Lake died or shed their transmitters. One of these and two of the survivors made their way downstream through three locks and dams back to their lake of original capture (i.e., Demopolis Lake). One translocated fish also was recorded passing upstream through Aberdeen Lock or Dam. Of the four fish treated identically to the translocated fish and released into Demopolis Lake, all survived and none were recorded passing through lock-and-dam structures. Twenty-four other adult paddlefish tagged and released in Demopolis Lake or Oktoc Creek similarly suffered no observed mortality and were not recorded passing through locks or dams during the period 2003-2005.

Oktoc Creek Translocation

Of the two translocated males, one (# 30.320 S) wintered in the flowing bendway before traveling back to Oktoc Creek, where it stayed from March 22, 2004 until July 14, 2004. The second (# 31.151 S) was not located outside of Demopolis Lake prior to the failure of its transmitter (or possible emigration) between July 2004 and January 2005. A third paddlefish (# 30.110 D) was caught and released in Oktoc Creek on March 31, 2004 after being implanted with a radio-tag. This fish remained in Oktoc Creek until May 25, 2005, at which time its transmitter's battery presumably died.

Demopolis Lake Radio Telemetry

Six of eight paddlefish tested for site fidelity in winter exhibited this behavior whereas eight of eight paddlefish exhibited site fidelity in spring and four of six paddlefish exhibited site fidelity in summer (Table 3). All fish showed site fidelity in at least one season. Only six fish were tracked during summer because the area covered by radio-tracking in this season was limited to the flowing bendway of Demopolis Lake. During both years, two fish (# 30.050 D and # 30.110 S) left the flowing bendway during late spring or early summer, suggesting that these fish regularly spent summers elsewhere.

Stocking Program Design and Monitoring

Stocked paddlefish had low survival and emigration rates one month after stocking. Though survival appeared less in backwaters than in mainstem environments (Table 4), there was not a significant difference at α=0.05 (χ^2 test for independence P = 0.069). Juvenile paddlefish dispersed throughout Columbus Lake by the second week after stocking but tended to remain in the lake and its tributaries even though the water level was abnormally high during the study period. Emigration did not differ between habitats (χ^2 test for independence P = 0.785; Table 4).

CHAPTER IV

DISCUSSION

Research efforts on the Tennessee-Tombigbee Waterway and its tributaries did not precisely follow the proposed management framework because the framework developed as this project progressed. The initial goal of this project was to investigate population dynamics of paddlefish in the Mississippi component of the TTW through gill net sampling of adult paddlefish spawning in the Buttahatchie River and Luxapalila Creek. This evolved into an expansion of the study area to the entire River Section of the TTW and a search for remnant populations. This search incorporated a predatory approach while allowing for bi-monthly sampling at fixed sites to allow for comparison of density across sites. Subsequently, this approach was recommended as the initial component of Phase I in the management framework. Future projects should include the largest study area possible and limit the sampling season to October through May. Sampling during summer results in greater paddlefish mortality than during other seasons and may be less effective due to thermal stratification and oxygen depletion in the hypolimnion.

On the TTW, results from the first year of this study clearly indicated that stock assessment efforts should concentrate on Demopolis Lake due to the scarcity of paddlefish in the system's other impoundments. Telemetry, which was initiated during the year (2003-2004) and expanded in the second year (2004-2005), was used to locate preferred paddlefish habitat and productive netting sites. The result of this focused effort was a much larger sample size than originally anticipated. In the management framework, the stock assessment is included in Phase I. In some systems, presence/absence sampling may result in large enough sample size to conduct an adequate stock assessment during the first year, but two or three years would be a more reasonable time frame.

Investigation of limiting factors took on many forms in the TTW throughout the study. Side projects were continuously designed, implemented, and refined as the study evolved. This approach resulted in the collection of data sets that were relevant to a variety of hypotheses. Side projects produced results that collectively provided insight into paddlefish biology and management in the TTW system. Under the proposed management framework, investigation of limiting factors constitutes Phase II. In the case of the TTW, investigation of limiting factors was completed concurrent with Phase I.

Investigation of site fidelity in paddlefish was an objective of the TTW study. To facilitate this aspect of the study, paddlefish were translocated and stocked in Mississippi waters. Designing future studies to address basic questions of paddlefish biology and ecology is important because of the potentially broad management implications. Investigation of site fidelity, natal philopatry, and precision of ageing techniques was initiated, but not fully developed, during this study due to the 5- to 10-year time frame required. A follow-up stock assessment in the TTW as suggested in Phase IV should provide samples necessary to address these issues. Projects in other watersheds could use a similar approach to address other questions that require many years to answer.

Phase III of the framework involves the review and discussion of data from earlier phases and implementation of management actions. This dissertation represents the beginning of Phase III for the TTW paddlefish population. The discussion and management recommendations that follow will be reviewed by Mississippi State University faculty and employees of MDWFP and USFWS before implementation of additional management actions. Harvest of paddlefish from the Mississippi waters of the Tennessee-Tombigbee Waterway and its tributaries was suspended by MDWFP in 2005 in response to low catch rates noted in this study. A stocking program also was initiated during 2005 in response to low numbers of extant paddlefish.

Phase IV should begin in 2015 and consist of a thorough stock assessment in Columbus and Demopolis lakes. By this time, paddlefish stocked during 2005 will be age X. Paddlefish stocked during 2006-2009 will be age VI or older. Most will be mature and recruited to gill nets similar to those used in the current study, allowing for assessment of the stocking program's effect on catch rates.

Distribution and Relative Abundance

Paddlefish are extremely rare or extirpated in the Mississippi component of the TTW, though they were common (at least in localized areas) prior to the mid-1950s. Connections between Mississippi waters and the remnant paddlefish stock in Demopolis Lake include the Noxubee River system and the mainstem of the TTW. Paddlefish were not documented moving from Demopolis Lake into the Mississippi component of the TTW, but paddlefish movement upstream and downstream past locks and dams was noted in fish translocated to Columbus Lake. It is reasonable to assume that some Demopolis and Gainesville Lake paddlefish may occasionally reach Mississippi during high water events. Although several studies have documented the ability of paddlefish to pass upstream through locks and dams (Moen et al. 1992; Zigler et al. 2003), passage downstream of these structures is more common (Moen et al. 1992; Zigler et al. 2003). The ability of paddlefish to successfully pass upstream is contingent on high water in some instances (Zigler et al. 2004) and may be influenced by lock and dam design.

Construction of the TTW may not be the only cause of paddlefish decline in the watershed. Fragmentation of downstream habitat may have blocked historic runs of paddlefish from reaching spawning grounds located in Mississippi. Demopolis Dam was completed in 1955, which is about the time that people who fished the Tombigbee River and its tributaries in Mississippi noticed a decrease in paddlefish abundance. Industrial and agricultural pollution also may have contributed to the decline of paddlefish in the 1950s and early 1960s.

Further fragmentation, impoundment, instream habitat degradation, and siltation associated with construction of the TTW likely led to the further decline of any remnant population in the Mississippi component of the mainstem beginning in the 1970s. The capture of two paddlefish in the Buttahatchie River before 1980 suggests that this was a historically important spawning area. Instream and floodplain gravel mining that intensified around the area of paddlefish captures in the late 1970s may have had negative impacts on paddlefish. Juvenile paddlefish experimentally stocked in one reclaimed gravel pit near the Buttahatchie River exhibited low survival (10%) after one month.

Predation by bass (*Micropterus* spp.) and gar (*Lepisosteus* spp.), which benefit from increased availability of lacustrine habitat, may have contributed to paddlefish mortality. Although gravel mining may have had negative impacts on spawning success in the past, stable gravel-bottomed shoals that are apparently suitable for spawning are currently abundant in the area impacted by mining.

By 2003, paddlefish were nearly extirpated in Columbus and Aliceville lakes. Occasional migrants undoubtedly enter the lakes from downstream impoundments or from the Tennessee River via the Divide Cut, but none were collected during this study. The density of paddlefish vulnerable to our gear in Demopolis Lake was 1.2 to 6.5 paddlefish/ha. Assuming that CPUE is a linear index of density, and that sampling at fixed sites yielded mean CPUE representative of lakewide density, Gainesville Lake would have between 0.07 and 0.39 paddlefish/ha (16.8 times less than Demopolis Lake based on ratio of CPUE). This translates to a population abundance between 181 and 1,008 for Gainesville Lake. This technique cannot be used to compute density and abundance for other impoundments because no paddlefish were captured. A paddlefish density of 8.8/ha was reported for an unfished population in South Cross Creek Reservoir, Tennessee (Boone and Timmons 1995), whereas the density of harvestable (> 700 mm EFL) adults in a recently overfished population in Watts Bar Reservoir, Tennessee, yielded a 95% confidence interval of 0.14 to 0.42 paddlefish/ha (Alexander et al. 1987). Although these published estimates are not directly comparable to TTW estimates (the Gainesville Lake estimate is based on the capture of two juveniles and Demopolis Lake estimate results from a mark-recapture study that used all captured paddlefish), this suggests that paddlefish sparsely populate Gainesville Lake whereas the Demopolis Lake population is intermediate in density.

Demopolis Lake

The absence of trophy (>1,300 mm EFL) paddlefish in Demopolis Lake, and low RSD for memorable (>1,040 mm EFL) paddlefish, suggests a population with a naturally short life span, slow growth rate, high mortality rate, or some combination of these population characteristics. Geographic and genetic differences may result in differences in population dynamics between the historically isolated Mississippi River and Mobile River drainages (Carlson 1982; Epifanio et al. 1996).

Studies of Mobile River drainage paddlefish in the Alabama River system revealed a short life span (maximum age 11 years) and an age structure that suggested high natural mortality (Lein and DeVries 1998). The largest paddlefish from the TTW accurately aged by the author was 12 years old, and natural annual mortality based on the catch curve for this system was 41%. In the lower Alabama River, Alabama, annual mortality was 34% in 1995 (Hoxemeier and DeVries 1997). The state of Alabama imposed a moratorium on paddlefish harvest in November 1988. Most gear-recruited paddlefish in the Alabama River study were spawned before the moratorium but were not themselves subjected to fishing pressure as adults. The TTW fish in this study were spawned after the moratorium and not subject to legal, targeted fishing during their lifetime. Mortality estimates for these two Mobile River watershed populations therefore represent approximations of natural mortality. Natural annual mortality was 9% for the unfished population in South Cross Creek Reservoir, Tennessee (Boone and Timmons 1995). Natural mortality also was estimated at 9% in an exploited Missouri River (South Dakota/Nebraska) population, with a total annual mortality rate of 18% (Rosen et al. 1982). The difference noted between Mobile and Mississippi basin natural mortality rates may be due, at least in part, to latitudinal effects. Three populations in Louisiana waters of the Mississippi basin exhibited natural annual mortalities between 26% and 48% (Reed et al. 1992).

Although mortality rates for unfished populations are generally considered “natural” mortality rates, paddlefish are susceptible to other anthropogenic forms of mortality. Incidental mortality of paddlefish snagged on trotlines fished for catfish and, presumably, gill nets of commercial fishermen targeting buffalo and catfish was noted in Demopolis Lake during 2004. Two dead paddlefish were found in Twelvemile Bend on Memorial Day weekend of 2005; both bore deep wounds apparently made by outboard propellers. Of 355 paddlefish (recaptures excluded) captured with gill nets or found after death but before decomposition in Demopolis Lake, three were killed accidentally by fishermen, twenty-six (7%) had rostrum wounds or abnormalities, and an equal number bore wounds on other parts of the body (six fish had rostrum and body wounds). On the Sunflower River, Mississippi, 27 of 340 paddlefish (8%) bore evidence of scarring and six of the wounded fish were documented mortalities resulting from outboard motors (George et al. 1995). On the Missouri River, South Dakota/Nebraska, 36% of paddlefish bore scars and 10% had severed rostrums; injuries were primarily attributed to encounters with snagging hooks and powerboats (Rosen and Hales 1980). Other authors have noted injuries and mortalities resulting from propellers (Purkett 1963; Fitz 1966; Runstrom et al. 2001), but methods to estimate propeller-induced mortality rates have not been developed. In the TTW, recreational craft in all habitats and towboats in the navigation channel and deep portions of certain bendways could be a significant source of mortality. Any mortality associated with propeller wounds is reflected in the “natural” mortality estimate.

Growth rates of male TTW paddlefish were less than those of Louisiana populations, but greater than those of more northern populations. Growth in the TTW was very similar to another Mobile basin population aside from slower growth early in life for TTW paddlefish (Figure 12). Because the parameters of the von Bertalanffy curve are fairly consistent with expected values, the unvalidated and nonlethal pectoral fin ageing technique appears to yield information consistent with published data from the (also unvalidated and lethal) dentary ageing method. Length of young fish may be underestimated, however, due to the difficulty of precisely determining the position of the first two annuli. Halo bands were often visible between the origin and second annulus, but were not readily apparent between later annuli.

A non-lethal dentary ageing technique was used by Alexander et al. (1987), who removed 3-mm wide dentary sections with a Dremel tool before releasing fish. Recaptured fish showed decreased condition and evidence of reduced health (Alexander et al. 1987). I attempted to remove dentary samples using a diamond-tipped coring bit but was unable to obtain readable sections using this method. The effect of pectoral fin ray removal was not evaluated because the only recapture of a paddlefish that had been subjected to this process occurred after a mere 17 days. The wound appeared to be healing well and no negative effects were noted.

The remnant paddlefish of Demopolis Lake used two distinct habitats (the flowing bendway and Twelvemile Bend), which are isolated from one another by 67 km of TTW navigation channel. The two stocks differed in terms of sex ratio and male length frequency, suggesting that Twelvemile Bend serves as wintering habitat for juveniles and females whereas the flowing bendway provides wintering habitat primarily for adult males. This type of segregation by size or gender has been documented elsewhere. Hoxemeier and DeVries (1997) found smaller paddlefish in oxbows of the Alabama River, Alabama, than in mainstem environments. In Lake Francis Case, South Dakota, Stancill et al. (2002) found that prespawn male paddlefish were more likely to be found in staging locations than were females. Because the TTW flowing bendway served as wintering and spawning habitat, the large male paddlefish could be considered 'staging' in the deep, slow eddies of the flowing bendway throughout the winter.

The relative weight of Demopolis Lake paddlefish (78 during winter 2005) was low compared to the national average of 90 (Brown and Murphy 1993), but this is not necessarily reflective of inadequate conditions for paddlefish growth and survival. As early as 1907, researchers noted the difference between deep-bodied lacustrine paddlefish and slender riverine paddlefish (Stockard 1907; Paukert and Fisher 2001a). The national average computed by Brown and Murphy (1993), includes lacustrine and riverine populations. The flowing bendway provided a riverine environment whereas current velocity in Twelvemile Bend varied considerably according to water level. Thus, it would be expected that Demopolis Lake paddlefish would have lesser relative weight than strictly lacustrine paddlefish. A decrease in relative weight due to spawning is common to all populations and especially pronounced in females (Brown and Murphy 1993). The decrease in relative weight for both genders during 2005 in Demopolis Lake, coupled with the lack of such a decrease in 2004, suggests that spawning did not occur on a large scale during 2004. Resorbtion of eggs is thought to occur when conditions do not permit spawning (Russell 1986).

Gill nets of differing mesh size did not capture paddlefish of significantly different lengths in Demopolis Lake. However, it is possible that gear selectivity of small magnitude may have been masked by high variability in lengths of paddlefish caught in each mesh size and the relatively small sample size. Paukert and Fisher (1999) captured 728 paddlefish with two of the mesh sizes used in this study (127.0- and 152.4-mm bar) and found that significantly larger fish were captured in the larger mesh, although this difference was relatively small (60 mm).

Several reviews of paddlefish research have stressed that few spawning areas have been delineated and emphasized the need to identify and protect these areas from degradation (Carlson and Bonislawsky 1981; Dillard et al. 1986; Birsten et al. 1997; Graham 1997; Jennings and Zigler 2000). Egg sampling with artificial substrates is a promising method to identify spawning areas and test hypotheses related to spawning habitat. Artificial substrates allow researchers to sample continuously for months at a time and are reasonably effective even when used in locations having abundant debris, deep water, and high velocity.

In Demopolis Lake, paddlefish eggs were collected in habitats similar to the gravel bars described by Purkett (1961) and Pasch et al. (1980) and also were collected in large numbers from deep, high velocity areas with bedrock substrate. Purkett (1961) noted that eggs collected from deep areas downstream from gravel bars were covered with debris, implying that they came to rest in a depositional zone. In Demopolis Lake, deep bedrock runs were not sites of deposition but it is unlikely that eggs would adhere to the slick, clay-rich, marl substrate. Artificial substrates set over deep bedrock were relatively free of the leaf litter, fine substrate, and periphyton growth that accumulated at shallow sites, suggesting that eggs would experience ideal incubation conditions if they could adhere to some surface. The artificial substrates provide such a surface, as might large woody debris (present in the flowing bendway in the form of sunken, water-logged timber even in swift current). Purkett (1961) noted the attachment of eggs to water-logged wood, but implied that they were unlikely to hatch because of the accumulation of debris in depositional zones where wood was found.

Paddlefish eggs hatched in the laboratory after collection from artificial substrates despite the accumulation of periphyton, debris, and (in one instance) complete covering of the egg with coarse sand grains. The sand had evidently adhered to the egg after the artificial substrate became buried in sand and fine gravel. This egg came from a gravel bar in the lower reaches of the Noxubee River, which contains very little gravel substrate and an abundance of large woody debris and deep bedrock runs.

Documentation of paddlefish spawning in the flowing bendway of Demopolis Lake and the Noxubee River during 2005 enabled determination of environmental conditions under which paddlefish can successfully spawn and incubate their eggs. Discharge, water temperature, and photoperiod cues were apparently inadequate to induce spawning in the flowing bendway during 2004. Occurrence of poor and good spawning years during this study allowed us to evaluate published habitat suitability guidelines (Hubert et al. 1984; Crance 1987), which were not designed using data from the Mobile basin. During 2005, most spawning occurred at daytime water temperatures of 16.9°C to 19.4°C and discharges over 15.1% exceedance. This level of discharge corresponds to the 2.74 m rise observed to trigger paddlefish spawning in the Osage River, Missouri (Purkett 1961). During 2004, discharge peaked at 20.1% exceedance (1.87 m rise in gage height) for one day and large-scale spawning of paddlefish apparently did not occur.

Though paddlefish in the TTW seem to require the same increase in discharge needed to induce paddlefish spawning in the Mississippi basin, they spawn in warmer water than observed in the Osage River, Missouri, (15° C to 16°C; Purkett 1961) and Cumberland River, Tennessee (12°C to 15°C; Alexander and McDonough 1983). Suitability curves consider 12-20°C optimal (Crance 1987). Demopolis Lake paddlefish may require temperatures in the higher end of this range to trigger spawning. Between February 26 and March 11 2004, spawned out females were not captured following a period during which water level was above the 2.74-m mark for 12 of 15 days despite water temperatures of 9.7°C to 16.4°C. When spawning occurred in Demopolis Lake during 2005, temperatures were warmer than those reported from studies in the Mississippi basin and warmer than temperatures reported for Mobile basin paddlefish in the Tallapoosa

River, Alabama, where paddlefish vacated spawning grounds when water temperature exceeded 18°C (Lein and DeVries 1998).

Recruitment variability has the potential to severely impact paddlefish abundance in Demopolis Lake. If spawning fails in several consecutive years, the population could drop below a minimum sustainable level. Flow patterns in the primarily free-flowing Noxubee River currently explain most of the variation in recruitment. Links between spawning success and flow timing in regulated rivers are commonly noted in Mississippi and Mobile basins (Purkett 1961; Alexander and McDonough 1983; Hoxmeier and DeVries 1997). Paddlefish are generally considered large-river spawners. Evidence of spawning has been recorded in the Cumberland River, Tennessee, when discharge exceeds 275 m^3/s (Alexander and McDonough 1983) and in the Tallapoosa River at discharges of 100-300 m^3/s (Lein and DeVries 1998). The Noxubee River is a relatively small stream that averages 10 m^3/s discharge. Eggs were collected in the Noxubee River after a peak of 244 m^3/s, and a discharge of 132 m^3/s corresponds to the 2.74-m rise from 50% exceedance used in SSI calculation.

Spawning was documented through egg collection in the Noxubee River and the flowing bendway of Demopolis Lake. The lack of a positive relationship between SSI in the flowing bendway and year-class strength suggests that eggs spawned in Demopolis Lake may not contribute to future Demopolis Lake stock. It is possible that hatched larvae drift downstream into other impoundments before finding suitable nursery habitat. They may also experience high rates of predation from black basses (*Micropterus* spp.), gars (*Lepisosteus* spp.), and blue catfish (*Ictalurus furcatus*) that increased in abundance after waterway construction (Boschung 1987). In some years, gravel bars where spawning was documented in Demopolis Lake may be exposed by low flows following spawning events due to the flashiness of the TTW. Stranding of eggs was noted by Purkett (1961) in the Osage River, Missouri. Beyond spawning and egg incubation habitat, the ecology of larval and juvenile paddlefish in the TTW remains as a gap in our knowledge. Hypotheses regarding the cause of the discrepancy between Noxubee River and Demopolis Lake flow effects on recruitment are merely speculative.

Paddlefish radio-tagged in Demopolis Lake used only a small fraction of available habitat during much of the year. Similarly, in the upper Mississippi River 65% of paddlefish locations in Pool 8 were in an area that comprised only 6% of available habitat; paddlefish showed habitat selectivity in Pool 8 and Pool 5A based on depth and current velocity (Zigler et al. 2003). In Pool 12 and Pool 13, paddlefish selected tailrace and main-channel border habitats, often using areas of reduced current associated with wing dams (Southall and Hubert 1984). Paddlefish in Pool 13 avoided backwaters during 1980, but selected backwater habitat during 1980 in response to high water level (Southall and Hubert 1984), highlighting the importance of discharge and its influence on depth and habitat selection.

In Demopolis Lake, paddlefish preferred bendway habitats and did not use backwater and main channel environments regularly. Backwaters were generally <1.7 m deep during the study period, and paddlefish completely avoided water <1.7 m deep in Keystone Reservoir (Paukert and Fisher 2001b). Avoidance of main-channel habitats, including borders, was not based on depth, which ranged from 4 to 15 m during low water periods. The bendways preferred by the paddlefish of Demopolis Lake offer a more heterogeneous environment than the dredged and snagged main channel in addition to refuge from boat traffic, which causes unmeasured mortality in many paddlefish populations (Fitz 1966; George et al. 1995; Runstrom et al. 2001). Paddlefish selectivity for bendway environments cannot easily be separated from the effect of site fidelity.

Taken together, the length distribution, selectivity and site fidelity trends suggest that individual paddlefish consistently use the same summer and winter habitats from year to year, with smaller males shifting preferred habitat from Twelvemile Bend to the flowing bendway as they age. During a brief period during spring, and if conditions are ideal, paddlefish throughout Demopolis Lake move long distances, and spawn in the flowing bendway and Noxubee River (and perhaps other areas).

Fidelity to spawning areas (Lein and De Vries 1998) and segregation of paddlefish by length and gender have been noted in the Alabama River system, Alabama (Hoxmeier and DeVries 1997). Evidence provided from the present study does not directly support spawning site fidelity because locations noted during the spring do not necessarily indicate spawning locations. This is especially true for 2004, when no evidence of spawning was recorded. What is unique to this study is documentation of individual paddlefish using similar habitats in winter and summer from one year to the next.

Stancill et al. (2002) found that in Lake Francis Case, South Dakota, paddlefish that were tagged during spring in the White River were four times more likely to return to the White River in a subsequent year than were paddlefish tagged below Big Bend Dam on the Missouri River. These two groups of fish mingled during most of the year in downstream areas of Lake Francis Case (Stancill et al. 2002). Paddlefish in Keystone Reservoir, Oklahoma, were attracted to high flows in the Arkansas River and the Salt Fork River during spring 1997, but were only located in the Salt Fork River during spring 1998 when flow was low in the Arkansas River and high in the Salt Fork River (Paukert and Fisher 2001b). The Keystone Reservoir example does not suggest site fidelity, but it does not follow histories of individual fish, either.

Seven of eight paddlefish in Demopolis Lake's flowing bendway had similar distribution patterns in consecutive springs, suggesting seasonal if not spawning site fidelity. However, of these eight fish only one entered the Noxubee River during 2004 under low flow conditions while four entered the tributary at least once during 2005 under high flow. The importance of the Noxubee River to recruitment was demonstrated, and the observed relationship to flow may be a result of the reluctance of paddlefish to enter this small stream during low or moderate flow conditions. Even during the high water year of 2005, most spring locations were in the flowing bendway or Twelvemile Bend rather than the Noxubee River, which was only attractive to paddlefish during a brief period of extreme high water.

Because spawning was noted in the flowing bendway and in the Noxubee River, it could be hypothesized that spawning occurs in the flowing bendway under a wider range of current conditions than are necessary to prompt spawning in the Noxubee River. However, when spawning is limited to the flowing bendway due to low or moderate flow in the Noxubee River, it may not be successful. Similarly, Coutant (2004) noted that white sturgeon (*Acipenser transmontanus*) have been documented spawning in highly regulated rivers during years that produce no recruitment. In all likelihood, site fidelity and flow attraction play a major role in paddlefish spawning behavior. Individual fish may have a stronger tendency toward site fidelity vs. flow attraction and vice versa, as evidenced by the two Oktoc Creek fish radio-tagged and translocated to the flowing bendway of Demopolis Lake during 2003. One displayed a clear example of homing behavior, returning to the tiny Noxubee River distributary (Oktoc Creek) during the low flow year of 2004, one year after its initial capture. The other fish behaved as resident flowing bendway paddlefish did during 2004 and did not move into the Noxubee River system.

Columbus Lake

Physical and chemical parameters in Columbus Lake are appropriate for growth and survival of paddlefish. Average depths used by paddlefish were shallower in Columbus Lake (3.8 m) than Demopolis Lake (6.2 m), but similar to depths preferred by paddlefish in Pool 5A of the Mississippi River, another shallow environment. In Pool 5A, 83% of paddlefish locations were in an area that averaged 3.4 m deep, whereas the remainder of the impoundment was <2 m deep (Zigler et al. 2003). Telemetry data from Pool 5A and other areas of the upper Mississippi River system were used to define excellent habitat as >6 m deep (Zigler et al. 2003), suggesting that Columbus Lake, which has an average depth of 2 m (Pugh et al. 2001), may be suboptimal.

Published literature does not suggest that the low conductivity of Columbus Lake is detrimental to paddlefish. Paddlefish avoided areas of extremely high conductivity (>

1,275 µS/cm) in Keystone Reservoir, Oklahoma (Paukert and Fisher 2000). Literature addressing systems where specific conductance as low as observed in Columbus Lake during early summer (mean = 115.5 µS/cm; SE = 1.6) is not available. Although specific conductance was greater in Demopolis Lake (mean = 132.7 µS/cm; SE = 4.1), it was still relatively low and had no apparent negative effect on paddlefish.

Relative to Demopolis Lake, zooplankton density is low in Columbus Lake (Table 5). Other systems that support paddlefish have lesser densities than Columbus Lake, in terms of zooplankton in general and preferred taxa (Table 5). Columbus Lake does not provide the ideal depth and zooplankton density that Demopolis Lake does, but other studies suggest that Columbus Lake does provide habitat comparable to areas which support paddlefish populations. Survival of juvenile paddlefish stocked in the mainstem of Columbus Lake reinforced this conclusion.

Juveniles stocked in mainstem environments experienced greater survival and similar low rate of emigration when compared to backwaters. The difference in survival rates ($P = 0.069$) was not significant at $\alpha = 0.05$, but would have been at $\alpha = 0.10$. Given the large magnitude of the difference (26% vs. 5%) and importance of that difference from a management standpoint, I consider the mainstem stocking more successful. Post-stocking mortality accounted for greater loss of paddlefish from Columbus Lake than emigration regardless of stocking protocol. Emigration was identified as a possible impediment to paddlefish recovery efforts in B. A. Steinhagen Reservoir, Texas (Pitman and Parks 1994). Due to long-distance upstream and downstream movements noted shortly after stocking juvenile paddlefish, Pitman and Parks (1994) recommended stocking paddlefish far from dams. The stocking site at Barton's Ferry on Columbus Lake was chosen based on this criterion and appears to be ideal. Mainstem stocking locations close to dams in Columbus Lake are likely to result in greater emigration.

The seasonal site fidelity observed in Demopolis Lake paddlefish bodes well for the Columbus Lake restoration effort. Seven of eight translocated adults emigrated from Columbus Lake, and the eighth died. Four of the seven returned to Demopolis Lake where they were captured, indicating that site fidelity may have been driving the emigration as much or more than the suboptimal conditions of Columbus Lake.

Juvenile paddlefish raised in a hatchery and released into Columbus Lake were much less likely to emigrate than adults translocated to Columbus Lake. A study of stocked juvenile paddlefish movements in Lake Francis Case, South Dakota, found that they remained in upper reservoir areas for the full three years of study and showed individually distinct patterns of habitat use (Roush et al. 2003). However, these fish did not exhibit site fidelity based on stocking site within the reservoir, but rather developed patterns of habitat use independent of their stocking location (Roush et al. 2003). Their large size (340-432 mm EFL), and small stocked cohort size (16 fish at each site), also may have been factors in the observed lack of stocking site fidelity. Juvenile paddlefish are normally smaller, younger, and in the company of thousands of conspecifics when stocked for population recovery purposes.

Conclusion and Management Recommendations

The Mississippi portion of the Tennessee-Tombigbee Waterway (TTW) and its tributaries includes three distinct areas in terms of paddlefish management. The Divide Cut and Canal Section of the TTW are within Mississippi, but are not candidates for paddlefish restoration because of limited deep (>3 m depth) habitat, extreme habitat fragmentation, and lack of refugia from navigational traffic. Bay Springs Lake is the only exception to this description of the Divide Cut and Canal Section, but the possibility of emigration into the Tennessee River and subsequent mixing of genetic stocks is high. Additionally, Bay Springs Lake probably does not offer potential spawning habitat due to its lack of major tributaries.

The Noxubee River appears to be a critical spawning area for the last natural remnant of the TTW population, which resides in Demopolis Lake, Alabama. The Noxubee River probably does not have the potential to support large numbers of adults on a year-round basis, but may be important as juvenile nursery habitat due to the integrity of the floodplain.

The third area is the River Section (Columbus and Aliceville lakes in Mississippi) and associated tributaries. Paddlefish have been virtually extirpated in this area but the potential for population restoration does exist. Columbus Lake offers an abundance of bendway habitat and tributaries with apparently suitable spawning habitat (Buttahatchie River, Tibbee Creek, and Town Creek).

Noxubee River and Demopolis Lake

Historically, most Tombigbee River paddlefish probably spawned in the mainstem of the river. The Noxubee River is smaller than most rivers used by spawning paddlefish, but it remains to date free-flowing and unchannelized. Although its flow regime is natural, in some years low flow during spring is apparently not conducive to substantial paddlefish spawning. Presumably, the Tombigbee River and other tributaries historically provided adequate spawning habitat in some years when flow was low in the Noxubee River. Currently, paddlefish could be severely impacted by any further assault on their much-diminished spawning habitat: the Noxubee River and perhaps the flowing bendway.

Analyses presented here incorporated four year classes and no direct measurement of recruitment through multi-year collection of eggs, larvae, or juveniles. The data in this study indicate that recruitment is most likely the limiting factor for the remnant TTW paddlefish, but more data are necessary to explore the relationships between flow and specific early-life history responses. Specific spawning sites in Mississippi waters of the Noxubee River have not been verified, although they almost certainly exist. A minimum of three additional years of study aimed at describing spawning sites in Mississippi, quantifying their contribution to the Demopolis Lake stock, and determining the effects of flow would be a logical next step.

Artificial substrates would be a useful tool to assess spawning in the Mississippi component of the Noxubee River, but high water makes navigation and retrieval very difficult in this environment. Study design should incorporate artificial substrates and sampling for larvae and juveniles in the Noxubee River and Demopolis Lake.

Stocking known numbers of OTC-marked paddlefish larvae would aid in assessing effectiveness of larval sampling, which will probably be very low given the extreme discharge and debris load that coincides with paddlefish spawning. If larval sampling is effective, sampling at the mouth of the Noxubee River and the confluence of the flowing bendway and navigation channel in Demopolis Lake would allow calculation of the contribution of both areas in terms of larval input to Demopolis Lake. If larval fish from the Noxubee River are finding nursery habitat in the Noxubee River floodplain it would be reflected in low inputs to Demopolis Lake in spring.

Sampling for juveniles in backwater habitats of the Noxubee River and Demopolis Lake using electrofishing would be necessary to identify nursery areas, which are currently unknown. Juvenile sampling also should incorporate pelagic sampling in Demopolis Lake if an effective method can be developed.

Given the population abundance, high natural mortality, and variable recruitment of paddlefish in Demopolis Lake, suspension of the harvest moratorium in Alabama is not recommended. Assuming a 50:50 sex ratio for the population of the entire lake, females vulnerable to gill nets could number as low as 791 based on the population estimate. To put this into perspective, 361 paddlefish captures were recorded in Demopolis Lake during this study in 1,069 net-hours of effort (standardized to nets 30.5 m long and hobbled to 2.4 m). A single dedicated commercial fisherman could capture 1,134 paddlefish (567 females) in four weeks of fishing ten nets per day soaked for 12 hours at a time based on these figures. This is obviously an overestimate because of the effect of stock depletion on CPUE and the gear saturation that would occur with long soak times in prime spots, but it illustrates the potential disastrous effect of legalizing unrestricted fishing – especially in light of the increased demand on paddlefish roe that has followed the ban on importing beluga caviar. Inconsistent recruitment has the potential to deplete stocks even without the threat of overfishing.

The primary management concern in the Noxubee River and Demopolis Lake is protection of remaining suitable habitat. This requires a better understanding of spawning and nursery requirements, in part, but clearly pertains to protection of the Noxubee River watershed and the flowing bendway due to spawning that occurs there and protection of Twelvemile Bend from further siltation. No immediate threats are apparent in the Noxubee River or flowing bendway, although any proposed anthropogenic activity that could degrade these habitats should be considered in terms of its potential impact on paddlefish before proceeding.

Twelvemile Bend has been subject to sedimentation since the completion of its cutoff channel in 1976. Depth at a transect 600 m from its upstream decreased over 37 percent between 1977 and 1980 due to formation of a sand plug, implying that maximum depth in 1977 was approximately 10.7 m (Pennington et al. 1981). By 2005, maximum depths at normal flow did not generally exceed 6 m in the upstream 2.7 km of Twelvemile Bend due to the sand plug. Paddlefish did not use the shallow upper end of Twelvemile Bend (Figure 13). The deep lower end of Twelvemile Bend, which was used by towboat and barge traffic, was not extensively used by paddlefish, either. Ninety-two percent (168 of

182) of paddlefish locations in Twelvemile Bend were in the deep middle portions upstream from the barge landing and downstream of the sand plug. Given the severely altered nature of the TTW, the only viable approach to maintaining the quality of Twelvemile Bend habitat for paddlefish is periodic dredging of the upstream end.

Columbus Lake

Environmental conditions in Columbus Lake are adequate for juvenile and adult survival, but suitability of spawning and nursery habitat has not been solidly documented. Restoration efforts require stocking because no adult stock exists. For stocking to be judged successful, sufficient numbers of paddlefish must survive to adulthood and successfully reproduce. Stocking paddlefish in the mainstem was most successful in terms of juvenile survival, but may not enable paddlefish to imprint on habitats that will be suitable for spawning as adults.

If we assume the best-case scenario of paddlefish finding and using suitable spawning habitat as adults, a certain minimum number of adult spawners will be needed. If the most conservative estimate of annual natural mortality in Demopolis Lake (38%) is assumed to approximate survival of age 1 and older paddlefish in Columbus Lake, and assuming that the mortality observed in radio-tagged juvenile paddlefish of Columbus Lake (72%) is roughly equivalent to first-year mortality of tagless fish, we can roughly project future stock abundance. Given these gross approximations and the 3,993 paddlefish stocked during 2005, if 4,000 paddlefish are stocked per year for the next four years 245 adult paddlefish will comprise the Columbus Lake population in 2015. By that time, stocked fish will be age 6 to 10 and most will be mature. This corresponds to a projected adult density of 0.07/ha. To achieve a density of 1 paddlefish/ha, which is on the low side of published estimates for healthy populations, stocking 62,000 juvenile paddlefish per year for 4 years would be necessary if estimated parameters are correct. This is not feasible given the current capacity of available hatchery space.

If we substitute the least published estimate of mortality in a southern paddlefish population (26%) for the Demopolis Lake estimate and assume an optimistic 50% survival of untagged juveniles during the first year, stocking 4,000 juveniles for four years would result in a population abundance of 1,328 by 2015. Even if the projected future population size of 245 is low due to overestimation of mortality, a lack of spawning success or availability of nursery habitat may preclude establishment of a naturally sustainable population.

The money and time spent simply to restore the paddlefish population of Columbus Lake through stocking would be better spent on other systems that are not faced with the problems of habitat fragmentation, siltation of remaining suitable habitat, lack of mainstem spawning habitat, severed connection to floodplain environments, and altered flow regime that will persist in the TTW for the foreseeable future. However, Columbus Lake does provide an ideal environment to study basic questions of paddlefish behavior and strategies for restoration. Experimental stocking for research purposes should continue at the rate of 4,000 CWT-marked juvenile paddlefish per year for a minimum of four years. Up to 1,000,000 OTC-marked larvae should be stocked annually in Tibbee Creek. This will allow stock assessment efforts beginning in 2015 to provide a definitive answer regarding natal philopatry in paddlefish. Broodstock collection and stocking techniques specific to Columbus Lake have evolved to the point where such an undertaking would be possible. The proposed stocking program should be continued after four years if routine sampling by MDWFP and Mississippi State University indicate survival of stocked fish, but suspended if no evidence suggests stocking success.

The suggested stocking regime would allow researchers to compare success of juvenile and larval stocking in terms of their contribution to future Columbus Lake stock. The juvenile stocking protocol should result in establishment of a measurable (although small) population by 2015, whereas the effect of such a large-scale fry stocking in the turbid and nutrient-rich environment of Tibbee Creek is unknown. The potential does exist for the larval stocking program to be more effective than the juvenile stocking program. In that case, restoration might be feasible in Columbus Lake because the time, hatchery space, and cost of producing larval paddlefish is miniscule compared to that required for production of juveniles, and the number of larvae that could be produced yearly is almost unlimited. Of course, larval stockings are generally unsuccessful due to high mortality and are only potentially effective in areas of high food abundance and/or low predation.

Statewide Overview

Paddlefish are a high-priority species for fisheries managers in Mississippi because of the multiplicity of human values associated with them; most notably the high economic value of their roe and aesthetic/intrinsic value stemming from their unique biology, evolutionary history, and disappearance from degraded environments. For optimal sustained yield to be realized from paddlefish populations in this state, different management goals must be sought in different watersheds according to population characteristics and quality of habitat. The basis for these management goals is good information, which currently does not exist for most watersheds in Mississippi. The proposed management framework would address basic distribution and population dynamics questions before proceeding with management actions.

On the TTW, initial findings regarding distribution profoundly influenced stock assessment study design, which in turn determined some of the questions regarding limiting factors. Within the TTW system, patchiness of paddlefish was evident and the scale to which management actions apply was relatively small due to habitat fragmentation, habitat selectivity, and seasonal site fidelity. In other, less fragmented, systems with a greater abundance of suitable habitat this scale will likely be much larger. It is impossible to anticipate all of the potential management options that exist in other systems due to the dearth of available data, but it is likely that the approach to systems such as the Pascagoula and Yazoo will differ considerably from each other and the TTW.

Research projects should be initiated as soon as possible on the Pascagoula and Yazoo systems in part due to the effects of Hurricane Katrina and the recent ban on beluga caviar imports. The potential for extirpation of the Pascagoula stock is high based on what little information exists. The Yazoo is a potentially productive and sustainable roe fishery, but such a fishery might only be sustainable if monitored closely. Research should continue on the TTW despite the limited potential for population recovery in

Columbus Lake. Findings regarding stocking techniques and natal philopatry may be useful for future restoration efforts in Mississippi and elsewhere, and the role of the Noxubee River as it relates to the sustainability of the remnant Demopolis Lake population deserves further investigation.

LITERATURE CITED

Adams, L. A. 1965. Age determination and rate of growth in *Polyodon spathula*, by means of the growth rings of the otoliths and dentary bone. American Midland Naturalist 28:617-630.

Alexander, C. M. and T. A. McDonough. 1983. Effect of water condition during spawning on paddlefish year-class strength in Old Hickory Reservoir, Tennessee. Tennessee Valley Authority, TVA/ONR/WRF-83-4(a), Knoxville, Tennessee. 29 pp.

Alexander, C. M, A. I. Myhr, and J. L. Wilson. 1987. Harvest potential of paddlefish stocks in Watts Bar Reservoir, Tennessee. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 39(1985):45-55.

Alexander, C. M., and D. C. Peterson. 1985. Feasibility of a commercial paddlefish harvest from Norris Reservoir, Tennessee. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 36(1982):202-212.

Anderson, R. O. and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 *in* Murphy B. R. and D. W. Willis, editors. Fisheries techniques. Second edition. American Fisheries Society. Bethesda, Maryland.

Birstein, V. B., W. E. Bemis, and J. R. Waldman. 1997. The threatened status of acipenseriform species: a summary. Environmental Biology of Fishes 48:427-435.

Blackwell, B. G., B. R. Murphy, and V. M. Pitman. 1995. Suitability of food resources and physiochemical parameters in the lower Trinity River, Texas for paddlefish. Journal of Freshwater Ecology. 10(2):163-175.

Boone, E. A., Jr. and T. J. Timmons. 1995. Density and natural mortality of paddlefish, *Polyodon spathula*, in an unfished Cumberland River subimpoundment, South Cross Creek Reservoir, Tennessee. Journal of Freshwater Ecology 10:421-431.

Boreman, J. 1997. Sensitivity of North American sturgeons and paddlefish to fishing mortality. Environmental Biology of Fishes 48:399-405.

Boschung, H. 1987. Physical factors and the distribution and abundance of fishes in the Upper Tombigbee River System of Alabama and Mississippi, with emphasis on the Tennessee-Tombigbee Waterway. Pages 184-192 *in* W. J. Matthews and D. C. Heins, editors. Community and Evolutionary Ecology of North American Stream Fishes. University of Oklahoma Press, Norman, Oklahoma.

Boschung, H. 1989. Atlas of fishes of the upper Tombigbee River drainage, Alabama-Mississippi. Southeastern Fishes Council Proceedings 19. 104 pp.

Brown, A. V., K. B. Brown, D. C. Jackson, and W. K. Pierson. 2005a. Lower Mississippi River and its tributaries. Pages. 231-282 *in* Benke, A. C. and C. E. Cushing, editors. Rivers of North America. Elsevier Academic Press, New York, New York.

Brown, M. L. and B. R. Murphy. 1993. Management evaluation of body condition and population size structure for paddlefish: a unique case. Prairie Naturalist 25(2):93-108.

Brown, P., C. Green, K. P. Sivakumaran, D. Stoessel, and A. Giles. 2005b. Validating otolith annuli for annual age determination of common carp. Transactions of the American Fisheries Society 133:190-196.

Busacker, G. P., I. R. Adelman, and E. M. Goolish. 1990. Growth. Pages 363-387 *in* Schreck, C. B. and P. B. Moyle, editors. Methods for fish biology. American Fisheries Society. Bethesda, Maryland.

Carlson, D. M. 1982. Low genetic variability in paddlefish populations. Copeia 1982(3):721-725.

Carlson, D. M. and P. S. Bonislawsky. 1981. The paddlefish (*Polyodon spathula*) fisheries of the midwestern United States. Fisheries 6(2):17-27.

Chapman, D. G. 1951. Some properties of the hypergeometric distribution with applications to zoological sample censuses. University of California Publications in Statistics 1:131-160.

Collins, M. R. and T. I. J. Smith. 1996. Sturgeon fin ray removal is nondeleterious. North American Journal of Fisheries Management 16:939-941.

Combs, D. L. 1982. Angler exploitation of paddlefish in the Neosho River, Oklahoma. North American Journal of Fisheries Management 4:334-342.

Conover, W. J. 1999. Practical nonparametric statistics. Third Edition. John Wiley and Sons, Inc., New York, New York. 584 pp.

Cook, Fannye A. 1959. Freshwater fishes of Mississippi. Mississippi Game and Fish Commission, Jackson, Mississippi. 239 pp.

Coutant, C. C. 2004. A riparian habitat hypothesis for successful reproduciton of white sturgeon. Reviews in Fisheries Science 12:23-73.

Crance, J. H. 1987. Habitat suitability index curves for paddlefish, developed by the Delphi technique. North American Journal of Fisheries Management 7:123-130.

DeVries, D. R. and R. V. Frie. 1996. Determination of age and growth. Pages. 447-482 *in* Murphy B. R. and D. W. Willis, editors. Fisheries techniques. Second edition. American Fisheries Society. Bethesda, Maryland.

Dillard, J. G., L. K. Graham, and T. R. Russell. 1986. Symposium wrap-up. Pages 114-116 *in* J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, management, and propagation. North Central Division American Fisheries Society, Special Publication 7, Bethesda, Maryland.

Dynesius, M. and C. Nilsson. 1994. Fragmentation and flow regulation of river systems in the northern third of the world. Science 226(5186):753-762.

Epifanio, J. M., J. B. Koppelman, M. A. Nedbal, and D. P. Philipp. 1996. Geographic variation of paddlefish allozymes and mitochondrial DNA. Transactions of the American Fisheries Society 125:546-561.

Fitz, R. B. 1966. Unusual food of a paddlefish (*Polyodon spathula*) in Tennessee. Copeia 1966(2):356.

Gengerke, T. A. 1986. Distribution and abundance of paddlefish in the United States. Pages 22-35 *in* J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, management, and propagation. North Central Division American Fisheries Society, Special Publication 7, Bethesda, Maryland.

George, S. G., J. J. Hoover, K. J. Kilgore, and W. E. Lancaster. 1995. Biology of paddlefish in a Mississippi Delta river. Proceedings of the Twenty-fifth Mississippi Water Resources Conference. Mississippi State, Mississippi. 1995:163-173.

Glendive Chamber of Commerce. 2005. http://www.glendivechamber.com.

Graham, L. K. 1986. Establishing and maintaining paddlefish populations by stocking. Pages 96-104 *in* J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, management, and propagation. North Central Division American Fisheries Society, Special Publication 7, Bethesda, Maryland.

Graham, L. K. 1997. Contemporary status of the North American paddlefish, *Polyodon spathula*. Environmental Biology of Fishes 48:279-289.

Hart, L. G. and R. C. Summerfelt. 1975. Surgical procedures for implanting transmitters into flathead catfish (*Pylodictis olivaris*). Transactions of the American Fisheries Society 104:56-59.

Heath, D. 1995. An introduction to experimental design and statistics for biology. UCL Press, London, England. 372 pp.

Holman, T. 1988. Angler intercept creel surveys on Pearl, Pascagoula, Chickasawhay, and Leaf Rivers, I988. Mississippi Department of Wildlife, Fisheries, and Parks, Freshwater Fisheries Report 95 (MS 250), Jackson, Mississippi. 32 pp.

Hoover, J. J., K. J. Killgore, and S. G. George. 2000. Horned serpents, leaf dogs, and spoonbill cats: 500 years of paddlefish ponderings in North America. American Currents 26(2)1-10.

Hoxmeier, R. J. H., and D. R. DeVries. 1996. Status of paddlefish in the Alabama waters of the Tennessee River. North American Journal of Fisheries Management 16:935-938.

Hoxmeier, R. J. H., and D. R. DeVries. 1997. Habitat use, diet, and population structure of adult and juvenile paddlefish in the Lower Alabama River. Transactions of the American Fisheries Society 126:288-301.

Hubert, W. A., S. H. Anderson, P. D. Southall, and J. H. Crance. 1984. Habitat suitability index models and instream flow suitability curves: paddlefish. United States Fish and Wildlife Service Biological Services Program, FWS/OBS-82/10.80. 33 pp.

Hussakof, L. 1911. The spoonbill fishery of the lower Mississippi. Transactions of the American Fisheries Society 40:245-248.

Jennings, C. A. and D. M. Wilson. 1993. Spawning activity of paddlefish (*Polyodon spathula)* in the lower Black River, Wisconsin. Journal of Freshwater Ecology (8)3:261-262.

Jennings, C. A. and S. J. Zigler. 2000. Ecology and biology of paddlefish in North America: historical perspectives, management approaches, and research priorities. Reviews in Fish Biology and Fisheries 10:167-181.

Kalos, M. H. and P. A. Whitlock. 1986. Monte Carlo methods: volume I: basics. John Wiley and Sons, New York, New York. 186 pp.

Kernohan, B. J., R. A. Gitzen, and J. J. Misspaugh. 2001. Analysis of animal space use and movements. Pages 125-166 *in* Millspaugh, J. J. and J. M. Marzluff, editors. Radio tracking and animal populations. Academic Press, San Diego, California.

Lein, G. M. and D. R. DeVries. 1997. Boat electrofishing as a technique for sampling paddlefish. Transactions of the American Fisheries Society 126:334-337.

Lein, G. M. and D. R. DeVries. 1998. Paddlefish in the Alabama River drainage: population characteristics and the adult spawning migration. Transactions of the American Fisheries Society 127: 441-454.

Lyons, J. 1993. Status and biology of the paddlefish (*Polyodon spathula*) in the lower Wisconsin River. Transactions of the Wisconsin Academy of Science, Arts, and Letters 81:121-135.

Mabee, P. M. and M. Noordsy. 2004. Development of the paired fins in the paddlefish, *Polyodon spathula*. Journal of Morphology 261:334-344.

Maceina, M. J., P. W. Bettoli, and D. R. DeVries. 1994. Use of split-plot analysis of variance design for repeated-measures fishery data. Fisheries 19(3):14-20.

Marchant, S. R. and M. K. Shutters. 1996. Artificial substrates collect Gulf sturgeon eggs. North American Journal of Fisheries Management 16:445-447.

McCabe, G. T., Jr., and L. G. Beckman. 1990. Use of an artificial substrate to collect white sturgeon eggs. California Fish and Game 76:248-250.

McCune, B. and J. B. Grace. 2002. Analysis of Ecological Communities. MjM Software Design, Gleneden Beach, Oregon. 300 pp.

Meals, K. and R. Kiihnl. 1993. Fisheries investigations and management on north Mississippi reservoirs. Mississippi Department of Wildlife, Fisheries, and Parks, Freshwater Fisheries Report 124 (MS 297), Jackson, Mississippi. 112 pp.

Mettee, M. F., P. E. O'Neil, and J. M. Pierson. 1996. Fishes of Alabama and the Mobile Basin. Oxmoor House, Birmingham, Alabama. 820 pp.

Mississippi Department of Environmental Quality (MDEQ). 2000. Yazoo River Basin status report 2000. Jackson, Mississippi. 29 pp.

Mississippi Department of Environmental Quality (MDEQ). 2001. Pascagoula River Basin status report 2001. Jackson, Mississippi. 29 pp.

Mississippi Interstate Cooperative Resource Association (MICRA). 2005. Paddlefish Genetics Plan. http://wwwaux.cerc.cr.usgs.gov/MICRA/pfgenetics.pdf.

Moen, C. T., D. L. Scarnecchia, and J. S. Ramsey. 1992. Paddlefish movements and habitat use in Pool 13 of the Upper Mississippi River during abnormally low river stages and discharges. North American Journal of Fisheries Management 12:744-751.

Moyle, P. B. and J. J. Cech, Jr. 1996. Fishes: an introduction to ichthyology. Prentice Hall. Upper Saddle River, New Jersey. 590 pp.

O'Keefe, D. M., G. Berryhill, and D. C. Jackson. 2004. Assessment of paddlefish in the Tennessee-Tombigbee Waterway. Mississippi Department of Wildlife, Fisheries, and Parks, Freshwater Fisheries Report 235 (MS 390), Jackson, Mississippi. 52 pp.

Parker, B. J. 1988. Status of the paddlefish, *Polyodon spathula*, in Canada. Canadian Field-Naturalist 102(2):291-295.

Pasch, R. W., P. A. Hackney, and J. A. Holbrook II. 1980. Ecology of paddlefish in Old Hickory Reservoir, Tennessee, with emphasis on first-year life history. Transactions of the American Fisheries Society 109:157-167.

Paukert, C. P. and W. L. Fisher. 1999. Evaluation of paddlefish length distributions and catch rates in three mesh sizes of gill nets. North American Journal of Fisheries Management 19:599-603.

Paukert, C. P. and W. L. Fisher. 2000. Abiotic factors affecting summer distribution and movement of male paddlefish, *Polyodon spathula*, in a prairie reservoir. The Southwestern Naturalist 45(2):133-140.

Paukert, C. P. and W. L. Fisher. 2001a. Characteristics of paddlefish in a southwestern U.S. reservoir, with comparisons of lentic and lotic populations. Transactions of the American Fisheries Society 130:634-643.

Paukert, C. P. and W. L. Fisher. 2001b. Spring movements of paddlefish in a prairie reservoir system. Journal of Freshwater Ecology 16:113-123.

Pennington, C. H., J. A. Baker, F. G. Howell, and C. L. Bond. 1981. A study of cutoff bendways on the Tombigbee River. United States Army Corps of Engineers, Technical Report E-81-14, Vicksburg, Mississippi. 78 pp.

Petersen, R. G. 1985. Design and analysis of experiments. Marcel Decker, Inc. New York, New York. 429 pp.

Pitman, V. M. and J. O. Parks. 1994. Habitat use and movement of young paddlefish (*Polyodon spathula*). Journal of Freshwater Ecology 9(3):181-189.

Pugh, L., D. Franks, and C. Watts. 2001. Northeast Mississippi fisheries management investigations: District 1. Mississippi Department of Wildlife, Fisheries, and Parks. Freshwater Fisheries Report 213 (MS 367), Jackson, Mississippi. 110 pp.

Purkett, C. A. 1961. Reproduction and early development of the paddlefish. Transactions of the American Fisheries Society 90(2):125-129.

Purkett, C. A. 1963. The paddlefish fishery of the Osage River and Lake of the Ozarks, Missouri. Transactions of the American Fisheries Society 92:239-244.

Reed, B. C., W. E. Kelso, and D. A. Rutheford. 1992. Growth, fecundity, and mortality of paddlefish in Louisisana. Transactions of the American Fisheries Society 121:378-384.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada, Bulletin 191, Ottawa, Canada. 382 pp.

Rien, T. A., and R. C. Beamesderfer. 1994. Accuracy and precision of white sturgeon age estimates from pectoral fin-rays. Transactions of the American Fisheries Society 123: 255-265.

Rosen, R. A. and D. C. Hales. 1980. Occurrence of scarred paddlefish in the Missouri River South Dakota-Nebraska. The Progressive Fish-Culturist 42(2):82-84.

Rosen, R. A. and D. C. Hales. 1981. Feeding of paddlefish, *Polyodon spathula*. Copeia 1981(2):441-455.

Rosen, R. A., D. C. Hales, and D. G. Unkenholz. 1982. Biology and exploitation of paddlefish in the Missouri River below Gavins Point Dam. Transactions of the American Fisheries Society 111:216-222.

Ross, S. T. 2001. Inland Fishes of Mississippi. University Press of Mississippi, Oxford, Mississippi. 624 p.

Rossiter, A., D. L. G. Noakes, and F. W. H. Beamish. 1995. Validation of age estimation for lake sturgeon. Transactions of the American Fisheries Society 124:777-781.

Roush, K. D., C. P. Paukert, and W. Stancill. 2003. Distribution and movement of juvenile paddlefish in a mainstream Missouri River reservoir. Journal of Freshwater Ecology 18(1):79-87.

Ruelle, R. and P. L. Hudson. 1977. Paddlefish: growth and food of young of the year and a suggested technique for measuring length. Transactions of the American Fisheries Society 106:609-613.

Runstrom, A. L., B. Vondracek, and C. A. Jennings. 2001. Population statistics for paddlefish in the Wisconsin River. Transactions of the American Fisheries Society 130:546-556.

Russell, T. R. 1986. Biology and life history of the paddlefish - a review. Pages 2-20 *in* J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, management, and propagation. North Central Division American Fisheries Society, Special Publication 7, Bethesda, Maryland.

SAS Institute, Inc. 2001. Software release 8.2. SAS Institute, Inc., Cary, North Carolina.

Scarnecchia, D. L., P. A. Stewart, and Y. Lim. 1996. Profile of recreational paddlefish snaggers on the lower Yellowstone River, Montana. North American Journal of Fisheries Management 16:872-879.

Scholten, G. D., and P. W. Bettoli. 2005. Population characteristics and assessment of overfishing for an exploited paddlefish population in the lower Tennessee River. Transactions of the American Fisheries Society 134:1285-1298.

Schrank, S. J. and C. S. Guy. 2003. Competitive interactions between age-0 bighead carp and paddlefish. Transactions of the American Fisheries Society 132:1222-1228.

Schultz, C. A. 1981. Northeast Mississippi fisheries investigations: Tombigbee River basin pre-impoundment studies. Mississippi Department of Wildlife Conservation, Freshwater Fisheries Report 18 (MS 157), Jackson, Mississippi. 86 pp.

Seattle Caviar Company. 2003. Online catalog. http://www.caviar.com.

Shephard, S. and D. C. Jackson. 2005. Channel catfish maturation in Mississippi streams. North American Journal of Fisheries Management 25:1467-1475.

Shuckman's Fish Company and Smokery. 2005. http://www.kysmokedfish.com.

Smith, F. E. 1954. The Yazoo River. Rinehart and Company, Inc., New York, New York. 362 pp.

Southall, P. D. and W. A. Hubert. 1984. Habitat use by adult paddlefish in the Upper Mississippi River. Transactions of the American Fisheries Society 113:125-131.

Southwick, R. I., and A. J. Leftus, editors. 2003. Investigation and monetary values of fish and freshwater mussel kills. American Fisheries Society, Special Publication 30, Bethesda, Maryland. 176 pp.

Sparrowe, R. D. 1986. Threats to paddlefish habitat. Pages 36-45 *in* J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, management, and propagation. North Central Division American Fisheries Society, Special Publication 7, Bethesda, Maryland.

Stancill, W., G. R. Jordan, and C. P. Paukert. 2002. Seasonal migration patterns and site fidelity of adult paddlefish in Lake Francis Case, Missouri River. North American Journal of Fisheries Management 22: 815-824.

Stockard, C. R. 1907. Observations on the natural history of *Polyodon spathula*. American Naturalist 41:753-766.

United States Geological Survey (USGS). 2005. http://waterdata.usgs.gov/nwis/rt.

Ward, G. M., P. M. Harris, and A. K. Ward. 2005. Gulf Coast rivers of the southeastern United States. Pages 125-180 *in* Benke, A. C. and C. E. Cushing, editors. Rivers of North America. Elsevier Academic Press, New York, New York.

Wilkens, L. A., B. Wettring, E. Wagner, W. Wojtenek, and D. Russell. 2001. Prey detection in selective feeding by paddlefish: is the electric sense sufficient? The Journal of Experimental Biology 204:1381-1389.

Zigler, S. J., M. R. Dewey, B. C. Knights, A. L. Runstrom, and M. T. Steingraeber. 2003. Movement and habitat use by radio-tagged paddlefish in the Upper Mississippi River and tributaries. North American Journal of Fisheries Management 23:189-205.

Zigler, S. G., M. R. Dewey, B. C. Knights, A. L. Runstrom, and M. T. Steingraeber. 2004. Hydrologic and hydraulic factors affecting passage of paddlefish through dams in the Upper Mississippi River. Transactions of the American Fisheries Society 133:160-172.

TABLE 1.—Paddlefish CPUE (mean number caught per 5-hr net day ± SE) in gill nets at fixed bendway and tailrace sampling locations in four impoundments of the River Section of the Tennessee-Tombigbee Waterway May to December of 2003.

	Columbus Lake	Aliceville Lake	Gainesville Lake	Demopolis Lake	Mean
Tailrace	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.09 ± 0.66	0.27 ± 0.26
Bendway	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.05	0.25 ± 0.15	0.08 ± 0.05
Mean	0.00 ± 0.00	0.00 ± 0.00	0.04 ± 0.03	0.67 ± 0.35	

TABLE 2.—Characteristics of habitat (mean ± SE) used by radio-tagged adult paddlefish (six in Columbus Lake and ten in Demopolis Lake) June 6 through July 7, 2004. Variables which significantly differ between lakes are denoted with asterisks (two sample *t* test; α=0.05).

	Columbus Lake	Demopolis Lake
Depth (m)*	3.8 ± 0.4	6.2 ± 0.7
Temperature (C)	27.4 ± 0.4	27.8 ± 0.3
Specific Conductance (µS/cm)*	115.5 ± 1.6	132.7 ± 4.1
Use of Eddy Habitat (%)	39 ± 15	65 ± 5%

TABLE 3.—Results from multi-response permutation procedure (MRPP) analysis for site fidelity of paddlefish radio-tagged in the flowing bendway of Demopolis Lake; $P < 0.05$ indicates significantly different spatial distribution between 2004 and 2005.

Fish # (Sex)	Season	2004 *N*	2005 *N*	*P*	Site Fidelity
30.050 D (Male)	Winter	6	11	0.018	No
	Spring	12	8	0.103	Yes
	Summer	0	0	NA	NA
30.030 S (Female)	Winter	4	11	0.534	Yes
	Spring	8	14	0.577	Yes
	Summer	14	7	0.828	Yes
30.090 S (Unknown)	Winter	5	12	0.517	Yes
	Spring	14	15	0.089	Yes
	Summer	14	5	0.002	No
30.110 S (Male)	Winter	6	9	0.376	Yes
	Spring	12	6	0.439	Yes
	Summer	2	0	NA	NA
30.130 S (Unknown)	Winter	6	11	0.123	Yes
	Spring	10	13	0.617	Yes
	Summer	14	4	0.062	Yes
30.150 S (Female)	Winter	5	11	0.080	Yes
	Spring	9	9	0.725	Yes
	Summer	14	7	0.011	No
30.190 S (Male)	Winter	6	10	0.043	No
	Spring	9	10	0.390	Yes
	Summer	14	7	0.326	Yes
30.921 S (Male)	Winter	5	11	0.058	Yes
	Spring	13	15	0.064	Yes
	Summer	15	7	0.696	Yes

TABLE 4.—Survival, and emigration (± SE) of juvenile paddlefish stocked into backwater and mainstem habitats of Columbus Lake and radio-tracked from June 30 to July 21, 2005. Abiotic environmental variable means are shown with standard errors.

	Backwater		Mainstem		
Survival	0.05 ± 0.05		0.28 ± 0.09		
Emigration	0.05 ± 0.04		0.07 ± 0.05		
N	20		29		
	Fortson Lake	Pit 21	Channel	Bendway	Tailrace
Depth (m)	2.7 ± 0.1	3.2 ± 0.1	4.7 ± 0.3	4.5 ± 0.2	3.6 ± 0.2
Temperature (C)	29.3 ± 0.7	32.1 ± 0.5	28.9 ± 0.2	29.3 ± 1.2	29.1 ± 0.6
Specific Conductance (μS/cm)	46 ± 1	29 ± 1	133 ± 19	146 ± 34	108 ± 9
Dissolved Oxygen (mg/L)	8.5 ± 0.3	7.4 ± 0.5	7.5 ± 0.5	8.5 ± 1.1	5.2 ± 1.8
Secchi Depth (cm)	60 ± 2	143 ± 10	45 ± 10	50 ± 7	29 ± 5

TABLE 5.—Zooplankton densities (mean or mean ± SE when available) in systems which support paddlefish populations or have been reported as suitable for paddlefish restoration in this study and others.

Water Body	Time of Year	Cladocerans per Liter	Cope-pods per Liter	Copepods and Cladocerans per Liter	Zoo-plankters per Liter
Columbus Lk., MS (tailrace)	June-July	8 ± 2	11 ± 2	18 ± 2	105 ± 40
Demopolis Lk., AL (tailrace)	June	43 ± 9	18 ± 2	61 ± 8	400 ± 166
Trinity River, TX[a]	May-Sept.	1	6	7	33
Missouri River, SD[b]	Spring Summer			5 to 35 2 to 10	
Alabama River, AL (tailrace)[c]	Annual				30

[a] Blackwell et al. 1995
[b] Rosen and Hales 1981; Spring = April to mid-June; Summer = mid-June to early Sept.
[c] Hoxmeier and DeVries 1997

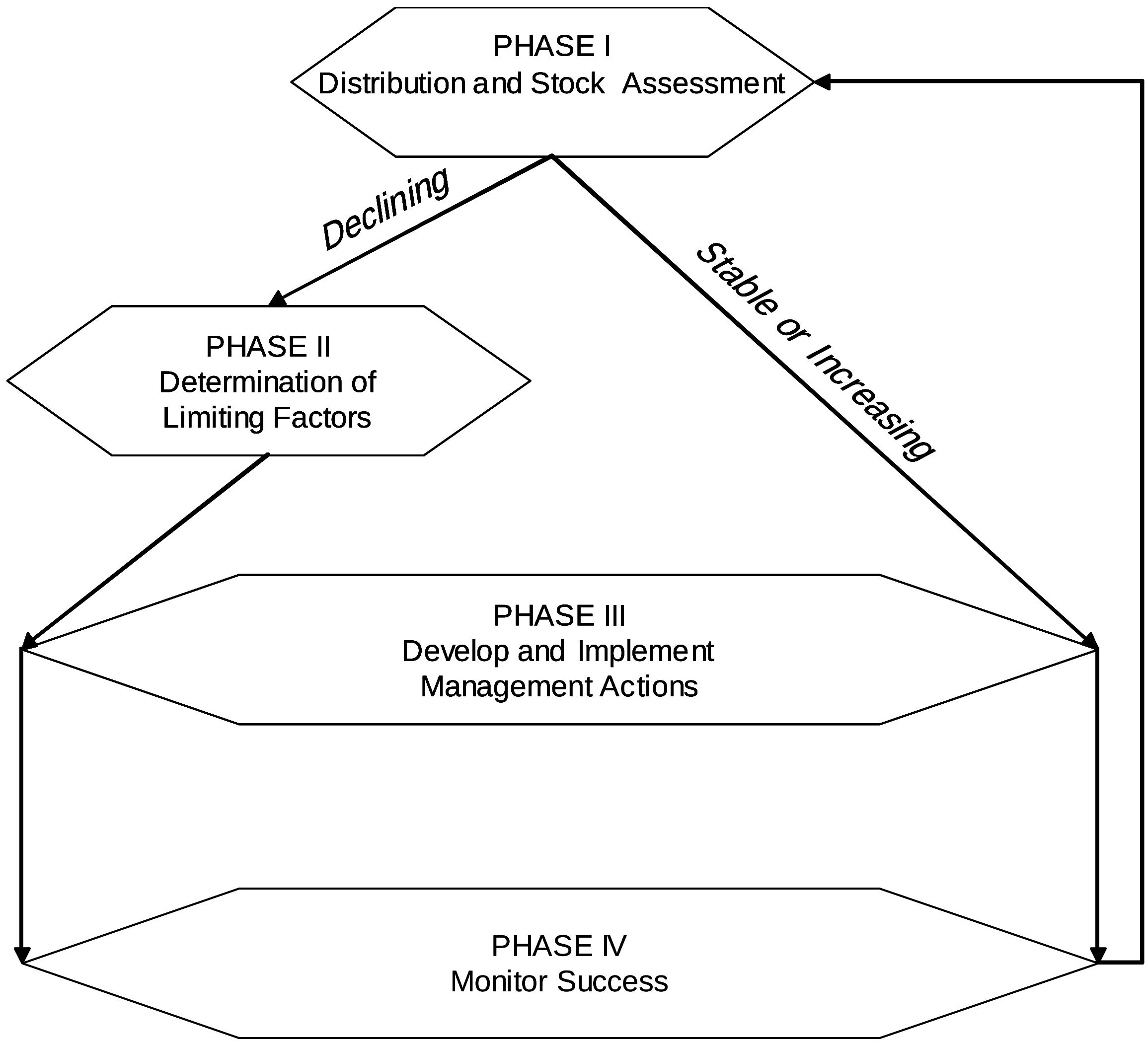


FIGURE 1.—Proposed framework for management of paddlefish in Mississippi.

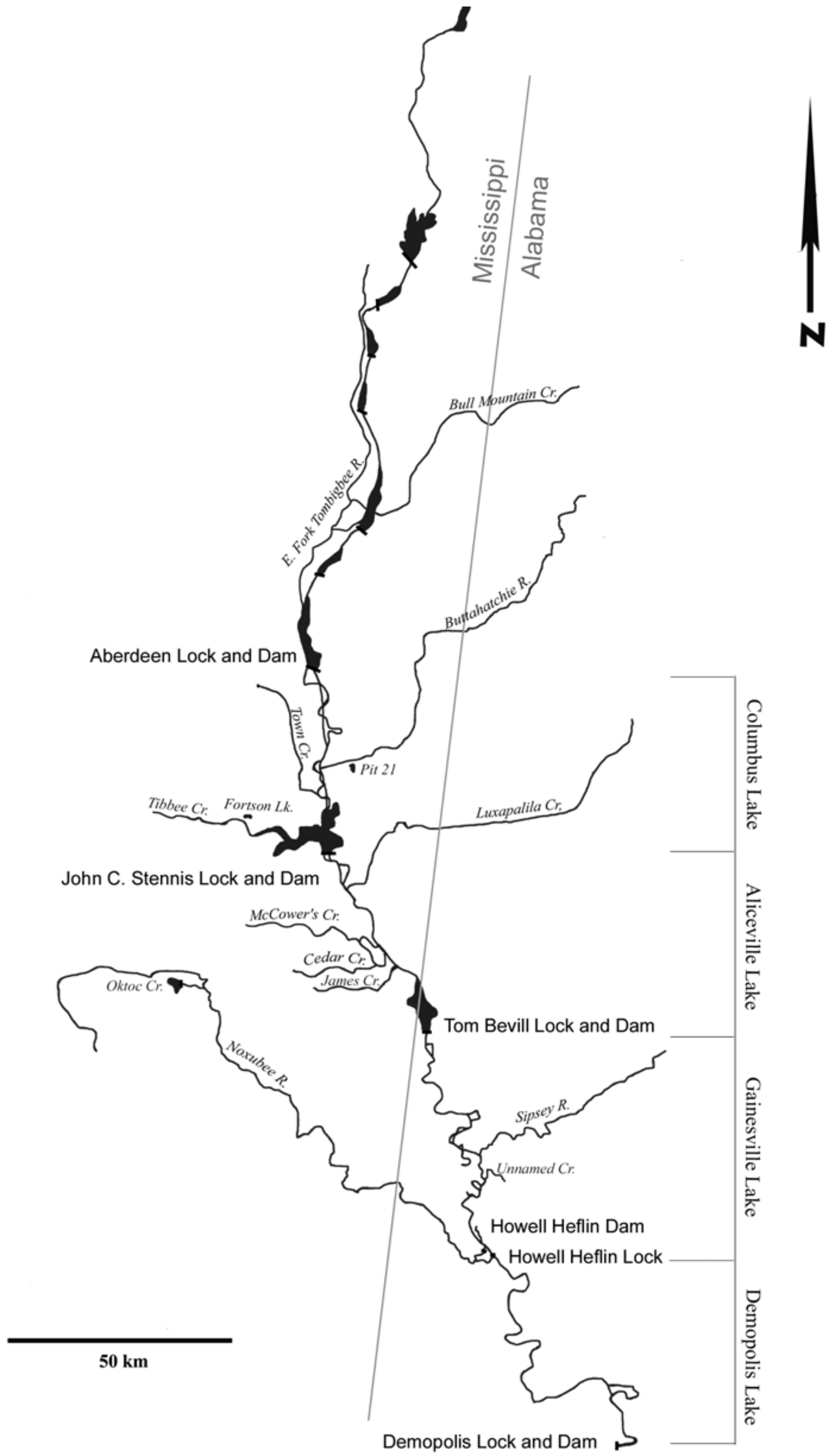


FIGURE 2.—Tennessee-Tombigbee Waterway with selected tributaries.

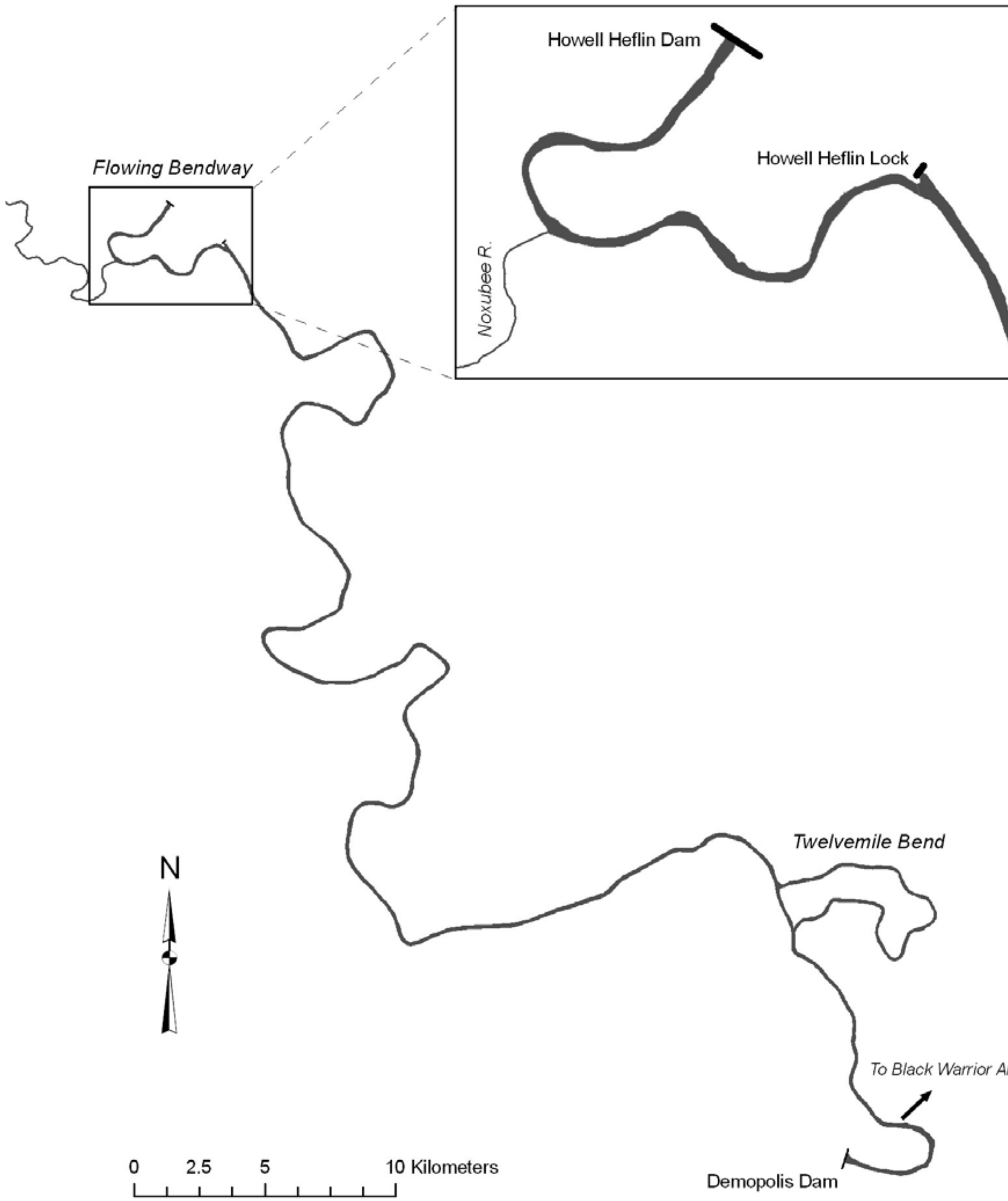


FIGURE 3.—Tennessee-Tombigbee Waterway arm of Demopolis Lake showing two locations used for stock assessment: the flowing bendway between Howell Heflin Lock and Howell Heflin Dam, and Twelvemile Bend.

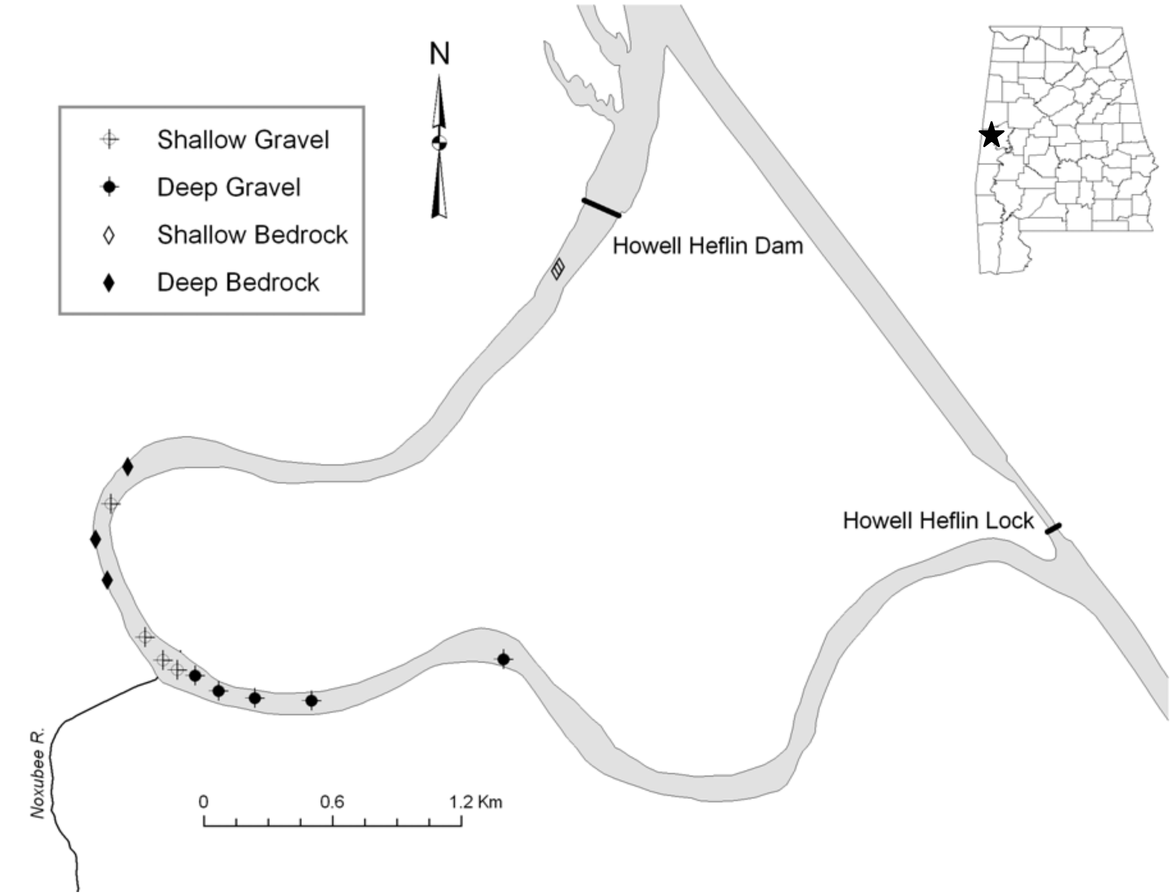


FIGURE 4.—Locations of artificial substrates used to sample paddlefish eggs at shallow (<3 m) and deep (≥3 m) sites in the flowing bendway of Demopolis Lake below Howell Heflin Dam during spring 2005.

FIGURE 5.—Paddlefish taken from Fortson Lake, a backwater of Tibbee Creek. Photograph provided by Clark Young.

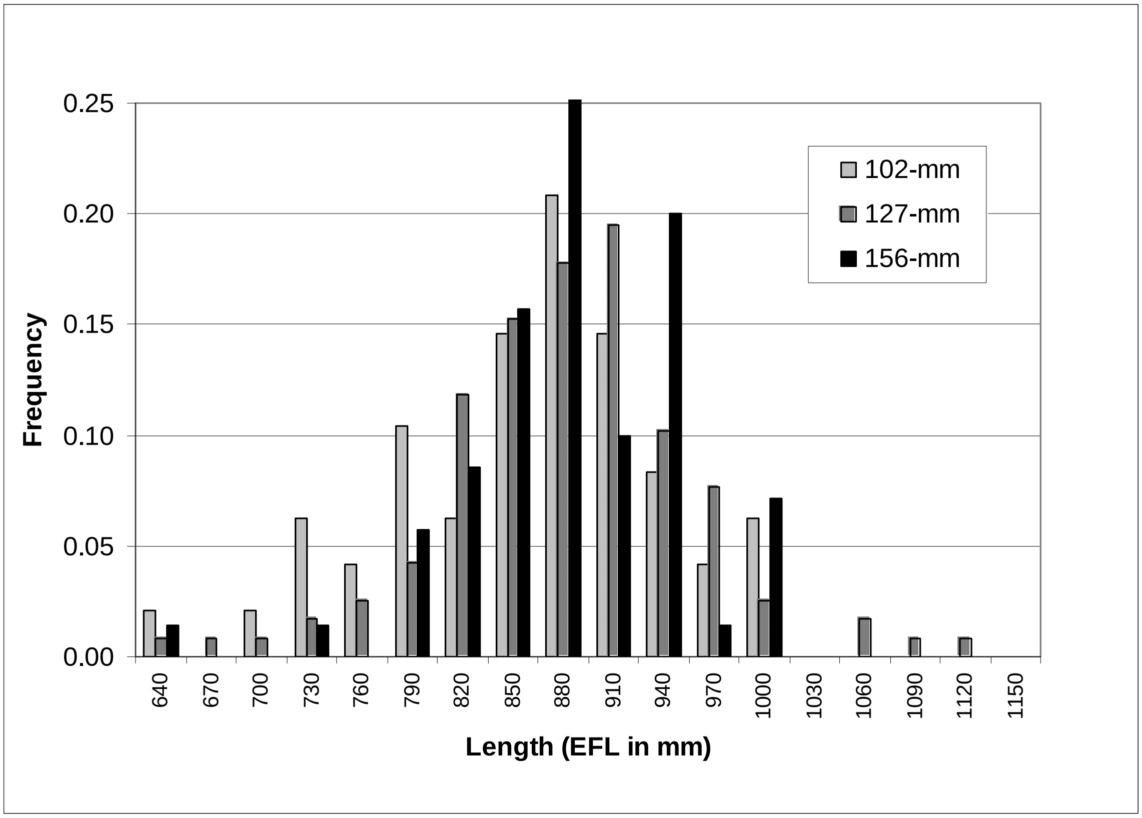
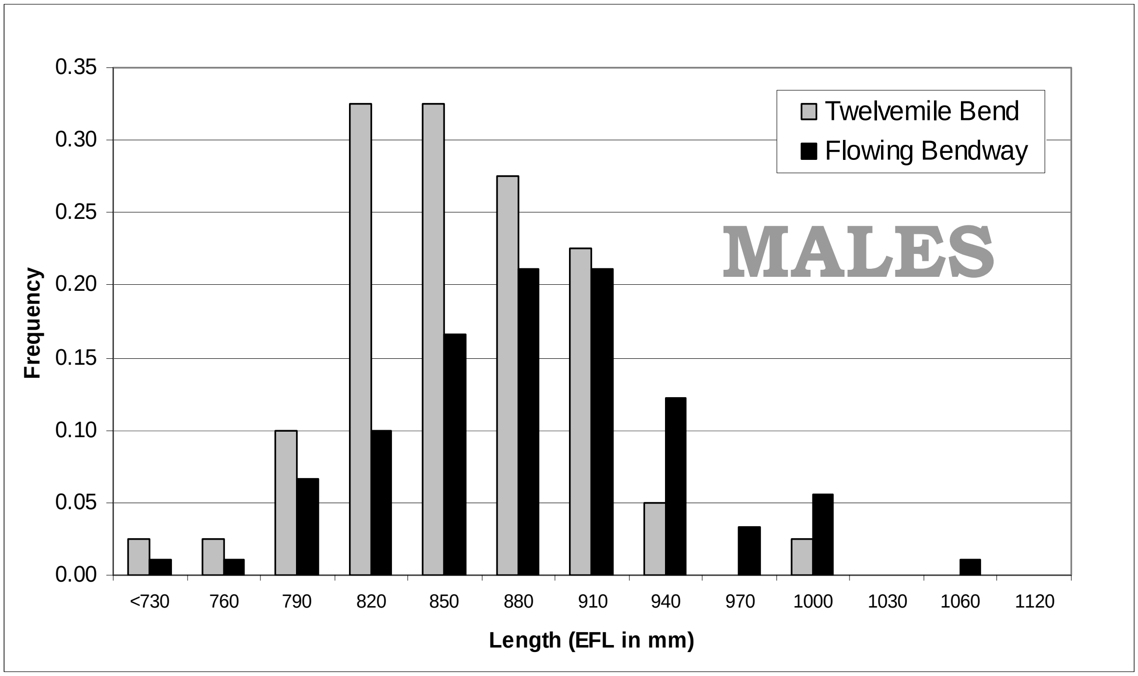


FIGURE 6.—Comparison of paddlefish caught in Demopolis Lake 2003-2005 using three sizes of multifilament gill net mesh (102-, 127-, and 156-mm bar; N = 48, 117, 70 respectively).



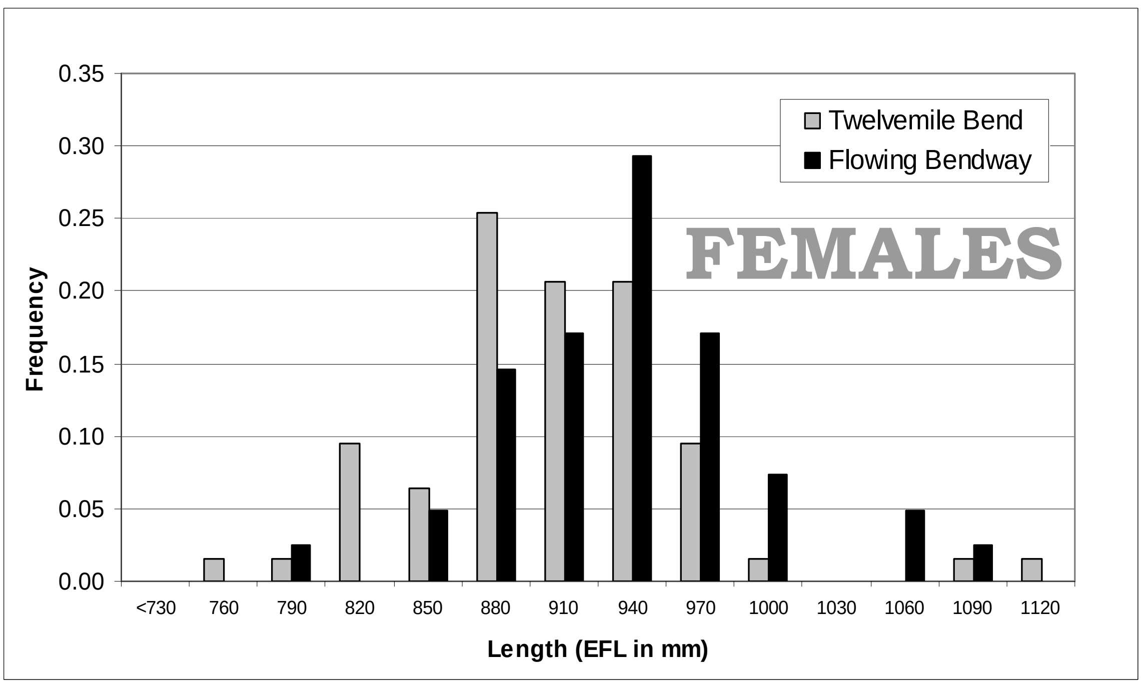


FIGURE 7.—Length frequency histogram for paddlefish caught in gill nets set in Demopolis Lake during the 2005 sample season in Twelvemile Bend (*N* = 55 males, 63 females) and the flowing bendway (*N* = 90 males, 41 females).

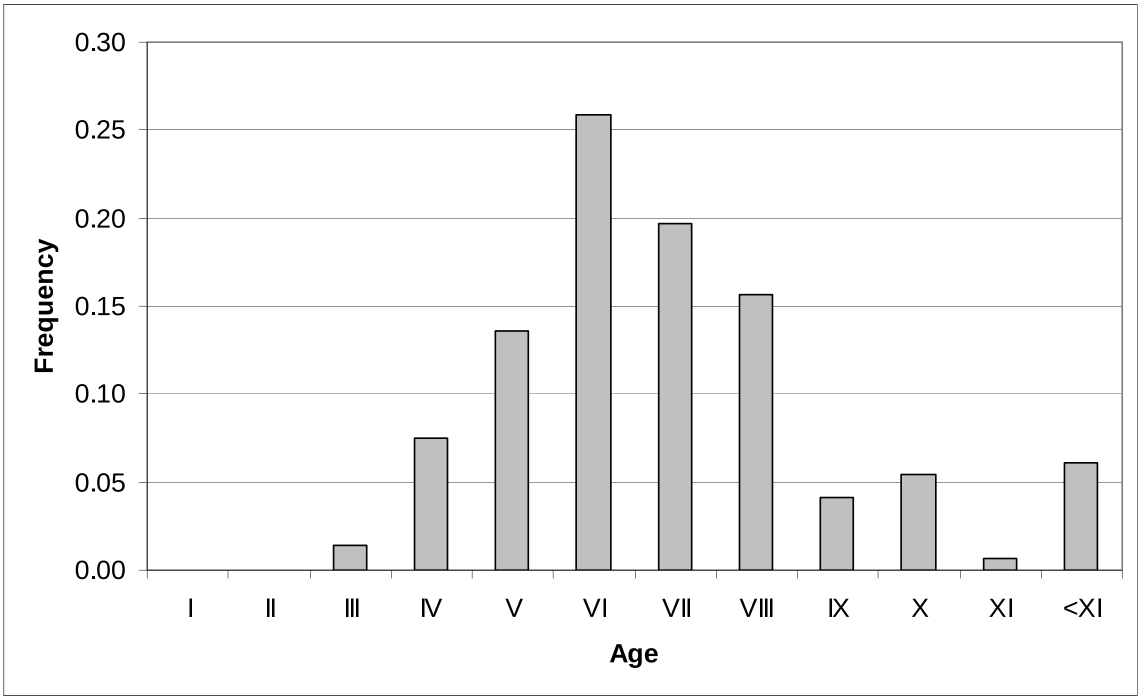
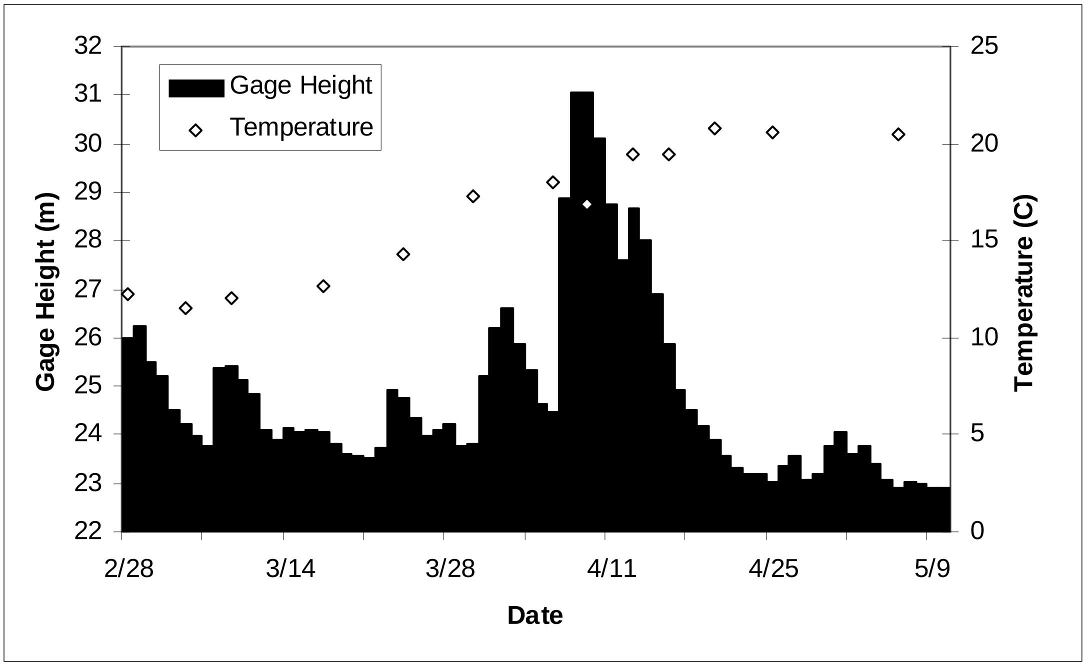


FIGURE 8.—Catch curve for male paddlefish (N = 145) caught during the 2005 sample season in Demopolis Lake.



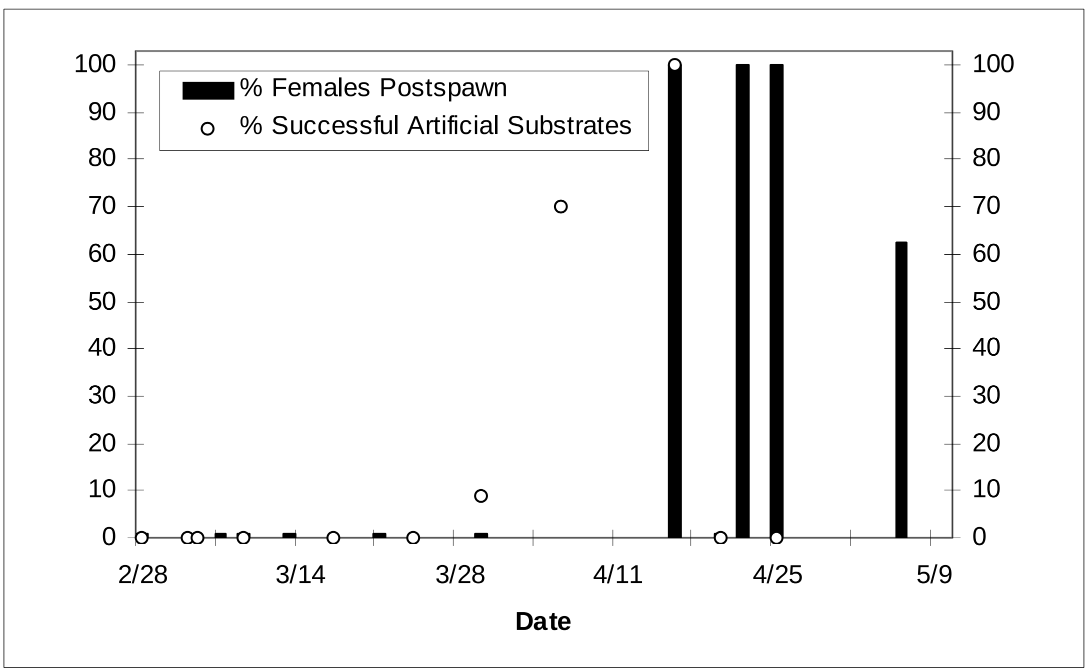


FIGURE 9.—Gage height and water temperature in the flowing bendway of Demopolis Lake during spring 2005 and two indicators of spawning activity. Female paddlefish were captured in the flowing bendway or Twelvemile Bend. Capture of one or more paddlefish eggs on an artificial substrate was considered a success.

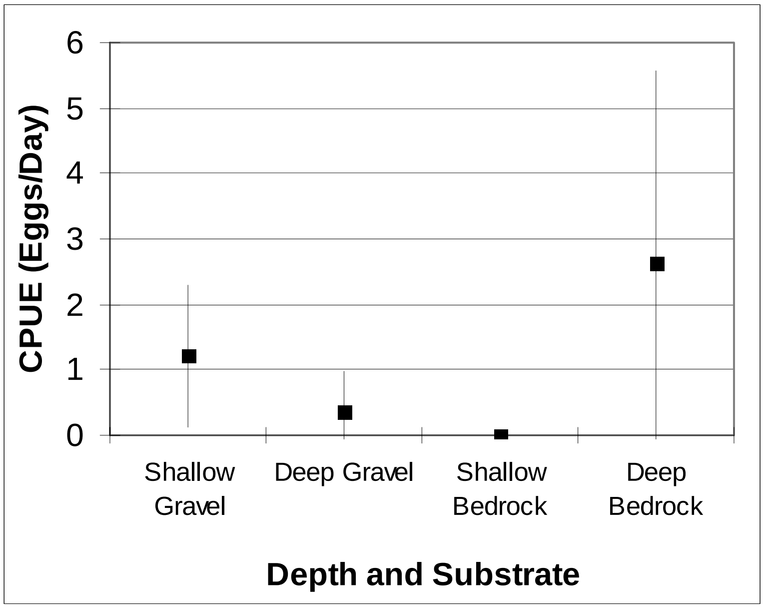


FIGURE 10.—Artificial substrate CPUE (paddlefish eggs per day) at shallow gravel (depth <3 m; N =4), deep gravel (depth >3 m; N =3), shallow bedrock (N =1), and deep bedrock (N =2) locations in the flowing bendway of Demopolis Lake between March 30 and April 6, 2005. Error bars represent 95% confidence interval where N >1.

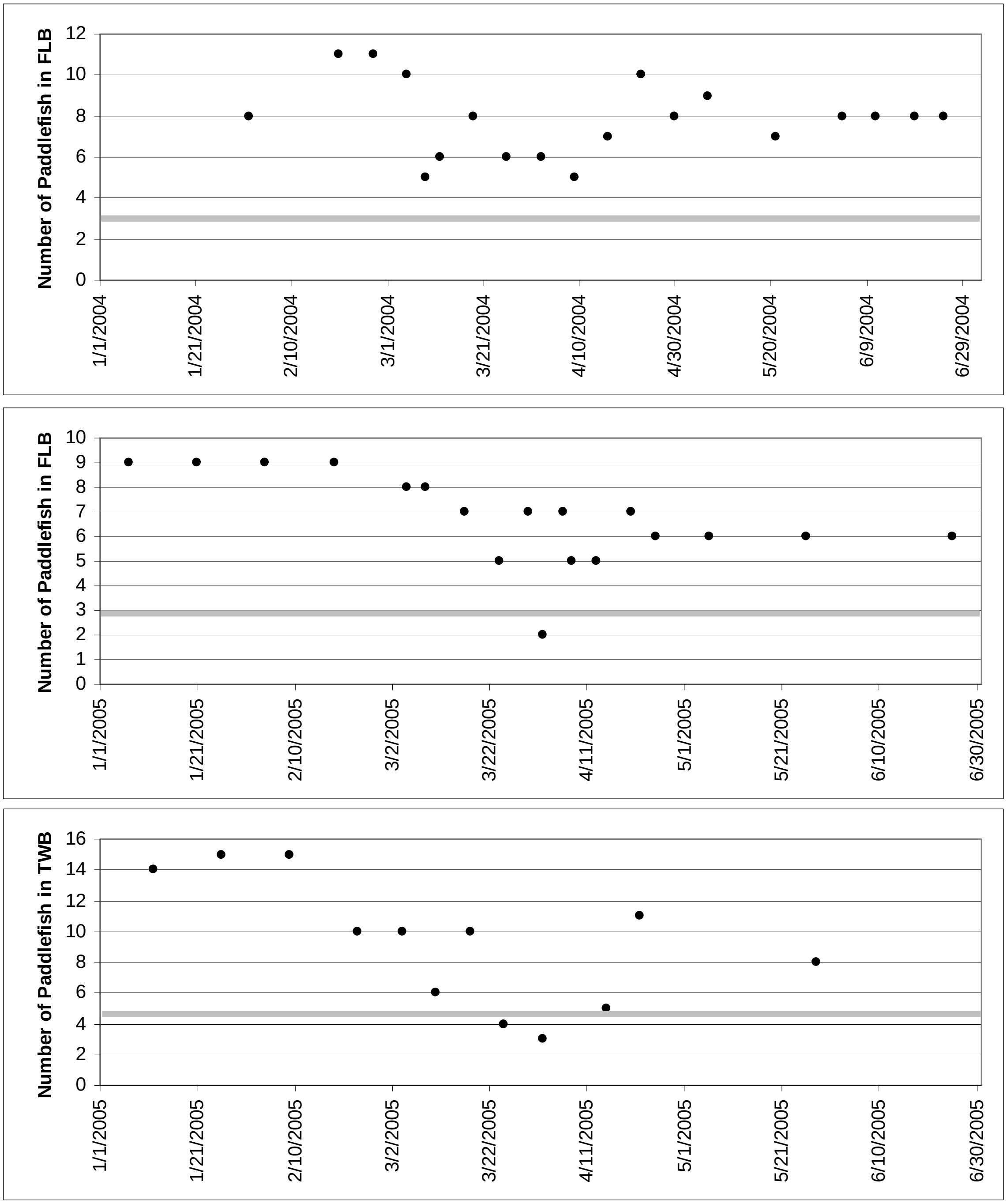


FIGURE 11.—Selectivity of flowing bendway (FLB) habitat during 2004 (*N* = 11) and 2005 (*N* = 9) and Twelvemile Bend (TWB) habitat during 2005 (*N* = 15) by paddlefish which wintered in respective Demopolis Lake habitats. Values above grey lines represent non-random selection (α=0.05).

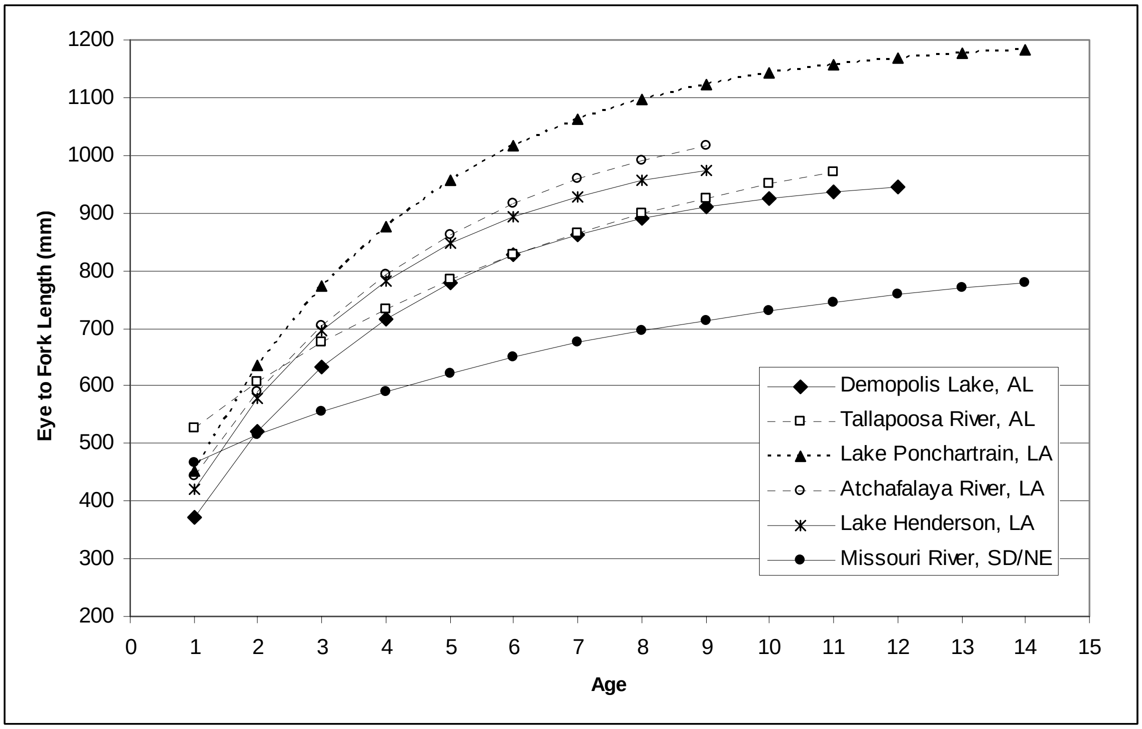


FIGURE 12.—Comparison of Von Bertalanffy growth curves for paddlefish in Demopolis Lake, the Tallapoosa River (Lein and DeVries 1998), Lake Ponchartrain, Atchafalaya River, Lake Henderson (Reed et al. 1992), and the Missouri River (Rosen et al. 1982). Curves shown are for males only with the exception of the three Louisiana populations, which did not show sexual dichotomy in growth rates.

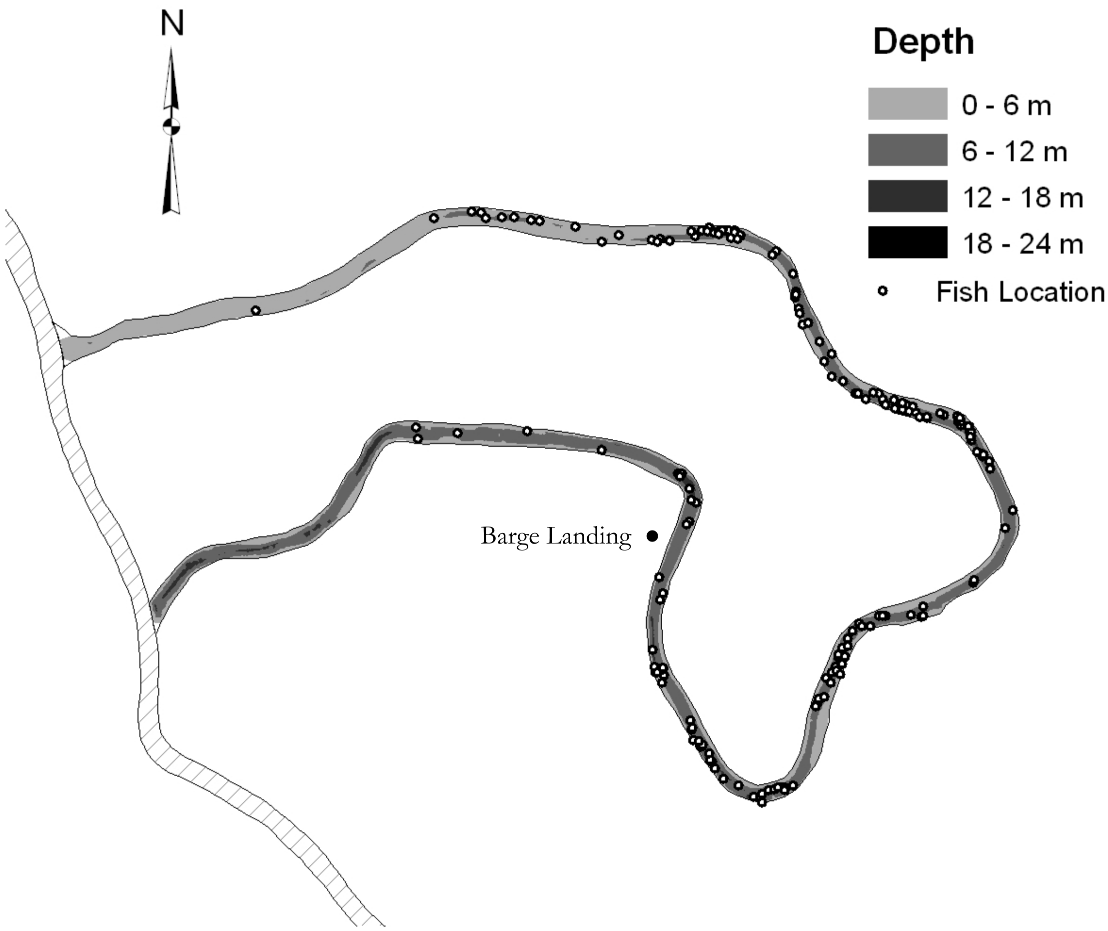


FIGURE 13.—Paddlefish locations in Twelvemile Bend, Demopolis Lake, during 2005. Navigation channel habitat is shown with hatch marks. The upstream (northern) intersection of Twelvemile Bend and the navigation channel has been decreasing in depth since 1977.

APPENDIX A

SAS CODE FOR MONTE CARLO HABITAT SELECTIVITY TEST

```
DATA a;
do sample = 1 to 10000000; *
  do i = 1 to 11 by 1; **
  random=ranuni(0);
  output;
  end;
end;
stop;
RUN;
DATA b; set a; if random le 0.068663; ***
PROC SORT; by sample;
PROC MEANS noprint N; by sample;
output out=c N=fish;
RUN;
PROC SORT; by fish;
RUN;
DATA d; set c; if fish ge 2; ****
PROC MEANS noprint N; output out=e N=ct;
RUN;
DATA f; set e; P=ct/10000000; *
RUN;
PROC PRINT;
RUN;
```

* Number of iterations is 10,000,000.

** Number of fish at large is 11.

*** Target habitat represents 6.8663% of available habitat.

**** Resultant *P*-value gives probability that 2 or more fish will be present in the target habitat assuming random habitat use.

APPENDIX B

RADIO-TELEMETRY LOCATIONS FOR PADDLEFISH

IN THE TENNESSEE-TOMBIGBEE

WATERWAY

TABLE B1.—Radio-telemetry locations for paddlefish in Demopolis Lake and tributaries. "HAB" indicates habitat type; "FLB"= flowing bendway; "NC"= navigation channel; "NOX"= Noxubee River or Oktoc Creek; "TWB"= Twelvemile Bend. "TEMP" indicates temperature in degrees Celsius. "DAM" indicates distance from dam in meters. "BANK" indicates distance from right bank of Demopolis Lake in meters. Latitude and longitude reported in decimal degrees (datum: WGS 1984).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
6/30/2003	1340	31.151 S	FLB	30.3	410	74	-88.1593882	32.8454895
10/18/2003	1520	31.151 S	FLB	21.5	905	25	-88.1622600	32.8417100
11/4/2003	1338	30.090 S	FLB	20.5	4880	89	-88.1674200	32.8281500
11/4/2003	1426	31.151 S	FLB	20.2	1310	133	-88.1656700	32.8395200
12/17/2003	911	30.320 S	FLB	7.2	5215	49	-88.1643930	32.8298841
12/17/2003	919	30.090 S	FLB	7.5	5355	23	-88.1630300	32.8306700
12/17/2003	927	30.130 S	FLB	7.5	5300	32	-88.1635996	32.8303681
12/17/2003	933	31.151 S	FLB	7.4	5420	105	-88.1622700	32.8299300
1/11/2004	900	30.190 S	FLB	7.4	5475	69	-88.1616830	32.8301000
1/11/2004	902	30.320 S	FLB	7.4	5495	19	-88.1612800	32.8304300
1/11/2004	903	30.010 S	FLB	7.4	5410	68	-88.1623700	32.8302800
1/11/2004	904	30.050 D	FLB	7.4	5465	50	-88.1617300	32.8303000
1/11/2004	905	30.110 S	FLB	7.4	5380	58	-88.1627300	32.8303700
1/11/2004	908	30.130 S	FLB	7.4	5450	25	-88.1618000	32.8305700
1/11/2004	910	30.921 S	FLB	7.4	5365	54	-88.1628500	32.8304000
1/11/2004	946	30.090 S	FLB	7.5	2845	88	-88.1806700	32.8372300
1/11/2004	1011	31.151 S	FLB	7.5	1330	30	-88.1650200	32.8387300
2/1/2004	1425	30.010 S	FLB	8.9	5365	29	-88.1629079	32.8306237
2/1/2004	1425	30.030 S	FLB	8.9	5375	34	-88.1627996	32.8305842
2/1/2004	1425	30.050 D	FLB	8.9	5425	82	-88.1622106	32.8301329
2/1/2004	1425	30.110 S	FLB	8.9	5465	91	-88.1618758	32.8299469
2/1/2004	1425	30.130 S	FLB	8.9	5370	31	-88.1628370	32.8306047
2/1/2004	1425	30.150 S	FLB	8.9	5425	52	-88.1622175	32.8304105
2/1/2004	1425	30.190 S	FLB	8.9	5395	48	-88.1625292	32.8304651
2/1/2004	1425	30.320 S	FLB	8.9	5330	33	-88.1633300	32.8304604
2/1/2004	1425	31.151 S	FLB	8.9	2680	119	-88.1791493	32.8381980
2/20/2004	1103	30.090 S	FLB	8.0	5925	123	-88.1587067	32.8269663
2/20/2004	1127	30.130 S	FLB	7.9	6270	42	-88.1554500	32.8253989
2/20/2004	1156	30.190 S	FLB	8.0	5345	16	-88.1632075	32.8306691
2/20/2004	1205	30.010 S	FLB	8.0	5370	18	-88.1628537	32.8307290
2/20/2004	1211	30.030 S	FLB	8.0	5400	29	-88.1624790	32.8306291
2/20/2004	1214	30.110 S	FLB	8.0	5410	37	-88.1623811	32.8305614
2/20/2004	1223	30.921 S	FLB	8.0	5410	31	-88.1623632	32.8306097
2/20/2004	1227	30.050 D	FLB	8.0	5375	31	-88.1627703	32.8306064
2/20/2004	1232	30.150 S	FLB	8.0	5350	57	-88.1630345	32.8303364
2/20/2004	1237	30.320 S	FLB	8.0	5360	21	-88.1629411	32.8306954
2/20/2004	1301	31.151 S	FLB	8.0	2695	126	-88.1793236	32.8382170
2/20/2004	1405	30.110 S	FLB		5385	49	-88.1626342	32.8304498

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
2/20/2004	1409	30.050 D	FLB		5385	58	-88.1626376	32.8303763
2/20/2004	1413	30.150 S	FLB		5410	67	-88.1623772	32.8302865
2/20/2004	1417	30.190 S	FLB		5385	12	-88.1626697	32.8307816
2/20/2004	1421	30.921 S	FLB		5345	45	-88.1631334	32.8304196
2/20/2004	1424	30.320 S	FLB		5355	14	-88.1630349	32.8307509
2/20/2004	1435	30.010 S	FLB		5355	70	-88.1629871	32.8302274
2/20/2004	1443	30.090 S	FLB		5850	108	-88.1592312	32.8275124
2/20/2004	1452	30.130 S	FLB		6520	42	-88.1530635	32.8244864
2/27/2004	1028	30.921 S	FLB	9.7	5410	47	-88.1623367	32.8304684
2/27/2004	1034	30.010 S	FLB	9.7	5415	26	-88.1622845	32.8306506
2/27/2004	1039	30.110 S	FLB	9.7	5350	51	-88.1630597	32.8303834
2/27/2004	1046	30.150 S	FLB	9.7	5375	23	-88.1628156	32.8306855
2/27/2004	1049	30.190 S	FLB	9.7	5370	30	-88.1628618	32.8306126
2/27/2004	1053	30.050 D	FLB	9.7	5365	25	-88.1629136	32.8306556
2/27/2004	1057	30.320 S	FLB	9.7	5355	11	-88.1631072	32.8307604
2/27/2004	1129	31.151 S	FLB	9.9	2660	139	-88.1790380	32.8384201
2/27/2004	1137	30.030 S	FLB	9.9	2680	107	-88.1790938	32.8380947
2/27/2004	1144	30.090 S	FLB	9.9	2665	139	-88.1790747	32.8384055
2/27/2004	1201	30.130 S	FLB	9.9	2515	132	-88.1771848	32.8386743
3/5/2004	639	30.090 S	FLB	14.8	5405	36	-88.1624178	32.8305670
3/5/2004	648	30.150 S	FLB	14.8	5355	17	-88.1630243	32.8307297
3/5/2004	706	30.030 S	FLB	14.9	5460	63	-88.1618091	32.8301995
3/5/2004	711	30.921 S	FLB	14.8	5515	29	-88.1610922	32.8302469
3/5/2004	743	30.050 D	FLB	14.9	3495	24	-88.1800851	32.8317349
3/5/2004	755	31.151 S	FLB	14.9	2660	145	-88.1790619	32.8384752
3/5/2004	806	30.010 S	FLB	14.9	2590	130	-88.1780840	32.8385841
3/5/2004	810	30.130 S	FLB	14.9	2505	136	-88.1771174	32.8387123
3/5/2004	827	30.110 S	FLB	14.9	4625	66	-88.1701105	32.8276686
3/5/2004	1633	30.190 S	FLB	14.9	3355	27	-88.1807711	32.8328481
3/9/2004	1024	30.150 S	FLB	16.3	6265	15	-88.1552700	32.8256517
3/9/2004	1048	30.010 S	FLB	16.4	5355	12	-88.1630640	32.8307633
3/9/2004	1118	30.921 S	FLB	16.6	3860	156	-88.1783494	32.8284962
3/9/2004	1128	31.151 S	FLB	16.6	3805	14	-88.1778502	32.8298231
3/9/2004	1159	30.090 S	FLB	16.6	2660	143	-88.1790551	32.8384580
3/9/2004	1252	30.030 S	NOX	16.8	3835	888	-88.1837759	32.8247331
3/9/2004	1459	30.130 S	NC	16.4	15385	102	-88.0894263	32.7993134
3/9/2004	1512	30.320 S	NC	16.4	17500	113	-88.0711742	32.8013869
3/12/2004	702	30.921 S	NC	14.4	9020	22	-88.1323168	32.8334011
3/12/2004	756	30.110 S	NC	14.4	20540	120	-88.0742482	32.7784500
3/12/2004	845	31.151 S	NC	14.3	26735	110	-88.1073849	32.7545710
3/12/2004	959	30.150 S	FLB	14.5	6240	15	-88.1556467	32.8256311
3/12/2004	1020	30.030 S	FLB	14.5	5415	103	-88.1623074	32.8299531
3/12/2004	1026	30.130 S	FLB	14.5	5425	94	-88.1622341	32.8300275
3/12/2004	1033	30.010 S	FLB	14.5	5395	46	-88.1625309	32.8304802

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
3/12/2004	1319	30.050 D	FLB	14.6	3580	71	-88.1800946	32.8308526
3/12/2004	1326	30.090 S	FLB	14.6	2685	122	-88.1791902	32.8382190
3/19/2004	1020	30.130 S	FLB	16.2	8290	89	-88.1398296	32.8333283
3/19/2004	1041	30.030 S	FLB	16.1	5445	32	-88.1618752	32.8305172
3/19/2004	1047	30.921 S	FLB	16.1	5430	52	-88.1621157	32.8303882
3/19/2004	1051	30.150 S	FLB	16.1	5415	66	-88.1623355	32.8302934
3/19/2004	1058	30.010 S	FLB	16.1	5270	31	-88.1639215	32.8302730
3/19/2004	1100	30.190 S	FLB	16.1	5290	34	-88.1637399	32.8303068
3/19/2004	1103	30.050 D	FLB	16.1	5295	62	-88.1635804	32.8300854
3/19/2004	1200	30.090 S	FLB	16.1	2700	115	-88.1792960	32.8381246
3/19/2004	1340	30.110 S	NC	16.3	31320	22	-88.0810526	32.7209846
3/19/2004	1808	31.151 S	NC	16.7	28990	50	-88.0975690	32.7365739
3/22/2004	1330	30.320 S	NOX		3835	73703	-88.7775025	33.2710437
3/26/2004	817	30.320 S	NOX	17.2	3835	73703	-88.7775025	33.2710437
3/26/2004	1104	30.110 S	FLB	17.6	5860	103	-88.1590913	32.8274767
3/26/2004	1117	30.090 S	FLB	17.6	5470	73	-88.1617706	32.8300893
3/26/2004	1121	30.921 S	FLB	17.6	5500	42	-88.1613432	32.8302232
3/26/2004	1130	30.010 S	FLB	17.6	5285	21	-88.1638158	32.8304098
3/26/2004	1148	30.130 S	FLB	17.6	5395	103	-88.1625691	32.8299699
3/26/2004	1200	30.050 D	FLB	17.6	4165	45	-88.1749788	32.8279398
3/26/2004	1317	30.030 S	NC	17.8	13480	54	-88.1062081	32.8002427
3/26/2004	1342	30.190 S	NC	17.8	16630	144	-88.0777564	32.8043299
3/26/2004	1350	30.150 S	NC	18.2	16570	37	-88.0786590	32.8050407
3/26/2004	1753	31.151 S	NC	18.0	9615	62	-88.1287892	32.8287577
3/31/2004	2028	30.320 S	NOX		3835	73703	-88.7775025	33.2710437
4/2/2004	429	30.110 S	FLB	17.6	4965	69	-88.1666738	32.8286012
4/2/2004	443	30.050 D	FLB	17.6	4315	58	-88.1734721	32.8276500
4/2/2004	502	30.921 S	FLB	18.0	2470	40	-88.1766975	32.8378440
4/2/2004	510	30.190 S	FLB	18.0	1590	24	-88.1674156	32.8374694
4/2/2004	517	30.010 S	FLB	18.0	1430	55	-88.1659939	32.8382693
4/2/2004	525	30.090 S	FLB	18.0	75	47	-88.1569372	32.8477554
4/2/2004	735	30.050 D	FLB	17.6	5390	69	-88.1625891	32.8302767
4/2/2004	751	30.110 S	FLB	17.6	4375	76	-88.1728186	32.8274329
4/2/2004	802	30.921 S	FLB	17.6	2435	63	-88.1763399	32.8380606
4/2/2004	810	30.190 S	FLB	18.0	1530	40	-88.1668547	32.8377784
4/2/2004	814	30.010 S	FLB	18.0	1535	54	-88.1669495	32.8378820
4/2/2004	820	30.090 S	FLB	18.0	160	43	-88.1574397	32.8470908
4/2/2004	1049	30.050 D	FLB	18.2	4250	42	-88.1741199	32.8278527
4/2/2004	1109	30.110 S	FLB	18.2	3575	77	-88.1801890	32.8308784
4/2/2004	1118	30.921 S	FLB	18.2	2765	109	-88.1799587	32.8378663
4/2/2004	1126	30.190 S	FLB	18.2	2290	64	-88.1747427	32.8381081
4/2/2004	1139	30.010 S	FLB	18.2	1400	14	-88.1654289	32.8381979
4/2/2004	1148	30.090 S	FLB	18.2	185	68	-88.1578314	32.8470538
4/2/2004	1822	30.150 S	NC	18.2	41230	117	-88.0683535	32.6868976

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
4/2/2004	1858	30.130 S	NC	18.2	29900	103	-88.0901634	32.7312691
4/2/2004	2030	30.921 S	FLB	17.9	6830	53	-88.1497981	32.8243796
4/2/2004	2047	30.110 S	FLB	17.9	4450	75	-88.1720066	32.8274390
4/2/2004	2056	30.010 S	FLB	17.9	3530	73	-88.1803831	32.8312647
4/2/2004	2117	30.050 D	FLB	17.9	75	64	-88.1571014	32.8478309
4/2/2004	2118	30.090 S	FLB	17.9	50	100	-88.1573557	32.8482085
4/5/2004	1031	30.320 S	NOX	18.8	3835	73696	-88.7774235	33.2710259
4/5/2004	1210	30.110 D	NOX	18.8	3835	73699	-88.7764914	33.2719828
4/8/2004	850	30.110 D	NOX	18.1	3835	73699	-88.7764914	33.2719828
4/8/2004	850	30.320 S	NOX	18.1	3835	73696	-88.7774235	33.2710259
4/9/2004	1438	30.110 S	FLB	19.1	3530	56	-88.1802106	32.8313159
4/9/2004	1448	30.050 D	FLB	19.1	3765	39	-88.1784199	32.8298430
4/9/2004	1505	30.090 S	FLB	19.1	2560	63	-88.1776730	32.8380265
4/9/2004	1601	30.190 S	FLB	19.3	4570	62	-88.1707137	32.8276410
4/9/2004	1611	30.010 S	FLB	19.3	5395	114	-88.1625500	32.8298666
4/9/2004	1638	31.151 S	NC	19.4	12185	88	-88.1144890	32.8092898
4/9/2004	1717	30.921 S	NC	19.4	24740	119	-88.1094458	32.7722831
4/9/2004	1750	30.130 S	NC	19.4	29935	86	-88.0897629	32.7311756
4/9/2004	1846	30.110 S	FLB	19.3	5280	65	-88.1637255	32.8300074
4/9/2004	1856	30.190 S	FLB	19.2	3395	57	-88.1809040	32.8324351
4/9/2004	1930	30.090 S	FLB	19.2	1610	35	-88.1676644	32.8375084
4/9/2004	2037	30.050 D	FLB	19.1	5510	83	-88.1614280	32.8298422
4/9/2004	2144	30.110 S	FLB	19.1	4330	59	-88.1732878	32.8276238
4/9/2004	2200	30.050 D	FLB	19.1	3520	53	-88.1802396	32.8314245
4/15/2004	1720	30.110 D	NOX	16.9	3835	73699	-88.7764914	33.2719828
4/15/2004	1730	30.320 S	NOX	16.9	3835	73696	-88.7774235	33.2710259
4/16/2004	1049	30.030 S	FLB	16.8	5460	21	-88.1616623	32.8305551
4/16/2004	1059	30.090 S	FLB	16.8	5455	30	-88.1617884	32.8305125
4/16/2004	1104	30.921 S	FLB	16.8	5455	32	-88.1618054	32.8305051
4/16/2004	1110	30.010 S	FLB	16.8	5430	39	-88.1620923	32.8305118
4/16/2004	1123	30.150 S	FLB	16.8	5260	55	-88.1639380	32.8300433
4/16/2004	1202	31.151 S	FLB	17.3	2460	94	-88.1766017	32.8383351
4/16/2004	1210	30.130 S	FLB	17.3	2475	97	-88.1767655	32.8383581
4/16/2004	1821	30.030 S	FLB	17.3	5460	22	-88.1616580	32.8305516
4/16/2004	1829	30.090 S	FLB	17.3	5515	19	-88.1610319	32.8303191
4/16/2004	1838	30.010 S	FLB	17.3	5560	55	-88.1608835	32.8297607
4/16/2004	1851	30.921 S	FLB	17.3	5665	49	-88.1600893	32.8290558
4/16/2004	1905	30.150 S	FLB	17.3	4870	64	-88.1676255	32.8283199
4/16/2004	1919	30.130 S	FLB	17.2	2655	108	-88.1788057	32.8382028
4/16/2004	1927	31.151 S	FLB	17.2	2540	97	-88.1775233	32.8383576
4/23/2004	818	30.110 D	NOX	21.8	3835	73726	-88.7768364	33.2720166
4/23/2004	827	30.320 S	NOX	21.8	3835	73688	-88.7772248	33.2711128
4/23/2004	1048	30.010 S	FLB	19.7	5635	4	-88.1599883	32.8295309
4/23/2004	1118	30.110 S	FLB	19.7	5595	48	-88.1606184	32.8295413

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
4/23/2004	1127	30.030 S	FLB	19.7	5445	21	-88.1618673	32.8306183
4/23/2004	1146	30.050 D	FLB	19.7	5355	34	-88.1630495	32.8305488
4/23/2004	1153	30.090 S	FLB	19.7	5380	52	-88.1627241	32.8304236
4/23/2004	1202	30.921 S	FLB	19.7	5305	77	-88.1634546	32.8299797
4/23/2004	1207	30.130 S	FLB	19.7	5220	31	-88.1644225	32.8300596
4/23/2004	1215	30.150 S	FLB	19.7	5475	34	-88.1615895	32.8304078
4/23/2004	1232	30.190 S	FLB	19.7	2525	109	-88.1772917	32.8384626
4/23/2004	1238	31.151 S	FLB	19.7	2490	75	-88.1769291	32.8381557
4/23/2004	1921	30.010 S	FLB	20.1	5565	96	-88.1611073	32.8293958
4/23/2004	1931	30.050 D	FLB	20.1	5540	17	-88.1607681	32.8302057
4/23/2004	1937	30.090 S	FLB	20.1	5465	65	-88.1617662	32.8301694
4/23/2004	1944	30.030 S	FLB	20.1	5400	59	-88.1624571	32.8303645
4/23/2004	1958	30.921 S	FLB	20.1	5475	132	-88.1619009	32.8295543
4/23/2004	2011	30.150 S	FLB	20.1	5270	98	-88.1637128	32.8297009
4/23/2004	2014	30.110 S	FLB	20.1	4395	98	-88.1725780	32.8272362
4/23/2004	2040	30.130 S	FLB	20.1	3925	96	-88.1774740	32.8285703
4/23/2004	2058	31.151 S	FLB	20.1	2785	63	-88.1799221	32.8374060
4/23/2004	2116	30.190 S	FLB	20.1	2595	95	-88.1780980	32.8382542
4/30/2004	1301	30.090 S	FLB	21.4	5460	19	-88.1616620	32.8305794
4/30/2004	1325	30.921 S	FLB	21.4	5455	34	-88.1617965	32.8304800
4/30/2004	1508	30.110 S	FLB	22.0	2405	76	-88.1760011	32.8381801
4/30/2004	1515	30.190 S	FLB	22.0	2445	48	-88.1764962	32.8379235
4/30/2004	1527	30.130 S	FLB	22.0	2270	46	-88.1745779	32.8379364
4/30/2004	1602	30.030 S	FLB	22.0	2425	88	-88.1761796	32.8382879
4/30/2004	1622	30.150 S	FLB	22.0	165	107	-88.1580217	32.8474021
4/30/2004	1647	31.151 S	FLB	22.0	2585	108	-88.1779737	32.8383969
4/30/2004	1750	30.010 S	NC	22.0	13495	71	-88.1063190	32.8000487
4/30/2004	1940	30.010 S	NC	21.5	9185	74	-88.1315615	32.8318574
4/30/2004	2006	30.090 S	FLB	21.5	5360	39	-88.1629379	32.8305287
4/30/2004	2019	30.921 S	FLB	21.5	4685	47	-88.1695273	32.8279418
4/30/2004	2036	30.130 S	FLB	21.4	2115	31	-88.1731410	32.8372392
4/30/2004	2045	30.030 S	FLB	21.4	1555	39	-88.1671258	32.8376752
4/30/2004	2053	30.190 S	FLB	21.4	1035	56	-88.1634249	32.8410876
4/30/2004	2059	30.110 S	FLB	21.4	1035	92	-88.1637440	32.8412705
4/30/2004	2107	30.150 S	FLB	21.4	300	66	-88.1585929	32.8462512
4/30/2004	2110	31.151 S	FLB	21.4	200	66	-88.1579040	32.8469446
5/1/2004	1139	30.320 S	NOX		3835	73713	-88.7775522	33.2711413
5/1/2004	1144	30.110 D	NOX		3835	73729	-88.7767708	33.2721144
5/7/2004	1244	30.320 S	NOX	26.9	3835	73698	-88.7774178	33.2710550
5/7/2004	1249	30.110 D	NOX	26.9	3835	73736	-88.7767803	33.2722085
5/7/2004	1627	30.010 S	FLB	22.0	1385	88	-88.1658898	32.8387459
5/7/2004	1643	30.130 S	FLB	22.0	385	53	-88.1590610	32.8455781
5/7/2004	1652	30.030 S	FLB	22.0	350	38	-88.1586809	32.8457614
5/7/2004	1700	30.921 S	FLB	22.0	315	64	-88.1586875	32.8461250

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
5/7/2004	1705	30.190 S	FLB	22.0	175	68	-88.1577754	32.8471072
5/7/2004	1716	30.090 S	FLB	22.0	125	93	-88.1576355	32.8475764
5/7/2004	1725	30.150 S	FLB	22.0	105	66	-88.1572376	32.8476012
5/7/2004	1742	31.151 S	FLB	22.0	20	86	-88.1571189	32.8484160
5/7/2004	1922	30.010 S	FLB	22.6	5375	87	-88.1627254	32.8301031
5/7/2004	1941	31.151 S	FLB	22.4	1820	60	-88.1699339	32.8374941
5/7/2004	1953	30.030 S	FLB	21.8	860	49	-88.1620444	32.8421661
5/7/2004	1957	30.130 S	FLB	21.8	800	74	-88.1617594	32.8426802
5/7/2004	2003	30.921 S	FLB	21.8	415	45	-88.1591356	32.8453229
5/7/2004	2017	30.090 S	FLB	21.8	150	92	-88.1577780	32.8474323
5/7/2004	2021	30.150 S	FLB	21.8	100	70	-88.1572641	32.8476460
5/7/2004	2024	30.190 S	FLB	21.8	70	66	-88.1570904	32.8479066
5/7/2004	2114	30.010 S	FLB	22.4	5480	36	-88.1615309	32.8303612
5/7/2004	2147	30.921 S	FLB	21.9	1720	62	-88.1688449	32.8375312
5/7/2004	2158	30.090 S	FLB	21.9	1275	80	-88.1650733	32.8393819
5/7/2004	2206	31.151 S	FLB	21.9	1090	50	-88.1636839	32.8406113
5/7/2004	2214	30.030 S	FLB	21.9	585	42	-88.1599374	32.8439079
5/7/2004	2231	30.150 S	FLB	21.9	465	89	-88.1597747	32.8450727
5/7/2004	2241	30.190 S	FLB	21.9	370	57	-88.1590118	32.8456933
5/7/2004	2247	30.130 S	FLB	21.9	1545	42	-88.1670167	32.8377267
5/7/2004	2343	30.921 S	FLB	22.2	6310	107	-88.1554309	32.8246042
5/21/2004	800	30.320 S	NOX	25.8	3835	73713	-88.7775522	33.2711413
5/21/2004	804	30.110 D	NOX	25.8	3835	73729	-88.7767708	33.2721144
5/21/2004	1006	30.030 S	FLB	26.4	5490	40	-88.1614339	32.8302874
5/21/2004	1057	30.090 S	FLB	27.7	2205	41	-88.1739601	32.8376374
5/21/2004	1101	30.130 S	FLB	27.7	1730	15	-88.1689432	32.8371010
5/21/2004	1103	30.010 S	FLB	27.7	1635	16	-88.1678724	32.8372844
5/21/2004	1111	30.190 S	FLB	27.7	1115	60	-88.1638849	32.8404962
5/21/2004	1246	30.921 S	FLB	27.7	2695	107	-88.1792073	32.8380655
5/21/2004	1330	30.150 S	FLB	28.4	5230	41	-88.1643268	32.8300055
6/4/2004	1153	30.110 D	NOX	27.1	3835	73714	-88.7766573	33.2720227
6/4/2004	1200	30.320 S	NOX	27.1	3835	73672	-88.7772010	33.2709119
6/4/2004	1440	30.090 S	FLB	27.1	2590	99	-88.1780147	32.8383060
6/4/2004	1447	31.151 S	FLB	27.1	2595	122	-88.1780999	32.8385022
6/4/2004	1505	30.130 S	FLB	27.1	2165	79	-88.1734601	32.8377992
6/4/2004	1516	30.190 S	FLB	27.1	1350	25	-88.1651325	32.8385729
6/4/2004	1519	30.921 S	FLB	27.1	1370	31	-88.1653132	32.8384948
6/4/2004	1524	30.010 S	FLB	27.1	1415	45	-88.1657846	32.8383033
6/4/2004	1530	30.150 S	FLB	27.1	1315	26	-88.1648730	32.8388306
6/4/2004	1800	30.030 S	FLB	26.8	5345	21	-88.1632217	32.8306170
6/4/2004	2148	30.030 S	FLB	25.9	5265	90	-88.1637959	32.8297520
6/4/2004	2227	30.921 S	FLB	26.1	2885	72	-88.1808594	32.8368995
6/4/2004	2250	30.130 S	FLB	26.1	2525	113	-88.1773011	32.8385035
6/4/2004	2258	30.090 S	FLB	26.1	2500	108	-88.1770216	32.8384571

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
6/4/2004	2327	30.190 S	FLB	26.1	1575	31	-88.1672841	32.8375672
6/4/2004	2346	30.010 S	FLB	26.1	1560	17	-88.1671007	32.8374741
6/5/2004	25	30.150 S	FLB	26.1	1625	12	-88.1677278	32.8372795
6/5/2004	45	31.151 S	FLB	26.1	1445	38	-88.1659942	32.8380735
6/11/2004	1653	30.190 S	FLB	29.2	1410	15	-88.1655587	32.8381114
6/11/2004	1703	30.010 S	FLB	29.2	1310	30	-88.1648617	32.8388866
6/11/2004	1723	30.150 S	FLB	29.2	1555	25	-88.1670886	32.8375520
6/11/2004	1740	30.090 S	FLB	29.6	2480	123	-88.1768118	32.8385932
6/11/2004	1742	30.130 S	FLB	29.6	2470	128	-88.1766923	32.8386362
6/11/2004	1747	31.151 S	FLB	29.6	2380	55	-88.1757871	32.8379981
6/11/2004	1752	30.921 S	FLB	29.6	2445	77	-88.1764103	32.8381872
6/11/2004	1832	30.030 S	FLB	29.0	5625	13	-88.1601342	32.8295417
6/11/2004	2102	30.130 S	FLB	27.0	2270	31	-88.1746374	32.8378083
6/11/2004	2149	30.150 S	FLB	26.9	635	17	-88.1600975	32.8434086
6/11/2004	2208	30.190 S	FLB	27.0	1285	41	-88.1648010	32.8391063
6/11/2004	2211	31.151 S	FLB	27.0	1305	41	-88.1649437	32.8389683
6/11/2004	2213	30.010 S	FLB	27.0	1305	41	-88.1649400	32.8389677
6/11/2004	2246	30.090 S	FLB	26.8	2295	65	-88.1748346	32.8381169
6/11/2004	2325	30.030 S	FLB	26.9	5395	35	-88.1625237	32.8305763
6/12/2004	15	30.921 S	FLB	26.6	1405	38	-88.1656846	32.8382895
6/16/2004	1830	30.110 D	NOX		3835	73714	-88.7766573	33.2720227
6/16/2004	1841	30.320 S	NOX		3835	73672	-88.7772010	33.2709119
6/19/2004	1630	30.921 S	FLB	29.8	190	62	-88.1577961	32.8469953
6/19/2004	1654	30.190 S	FLB	29.8	1165	58	-88.1641587	32.8401103
6/19/2004	1700	30.010 S	FLB	29.8	1305	93	-88.1653392	32.8392947
6/19/2004	1707	31.151 S	FLB	29.8	1450	55	-88.1661684	32.8381631
6/19/2004	1720	30.150 S	FLB	29.8	1640	74	-88.1680830	32.8377770
6/19/2004	1732	30.130 S	FLB	29.8	2185	66	-88.1736594	32.8377544
6/19/2004	1752	30.090 S	FLB	29.8	2595	123	-88.1781059	32.8385093
6/19/2004	1819	30.030 S	FLB	29.6	5370	57	-88.1628186	32.8303747
6/19/2004	2025	30.030 S	FLB	29.0	5450	103	-88.1620535	32.8298904
6/19/2004	2055	31.151 S	FLB	28.7	2270	61	-88.1745340	32.8380657
6/19/2004	2107	30.090 S	FLB	28.7	2260	70	-88.1744236	32.8381306
6/19/2004	2121	30.130 S	FLB	28.7	1570	63	-88.1673328	32.8378504
6/19/2004	2134	30.190 S	FLB	28.7	825	86	-88.1620583	32.8425918
6/19/2004	2149	30.010 S	FLB	28.8	215	67	-88.1580350	32.8468293
6/19/2004	2157	30.921 S	FLB	28.8	170	60	-88.1576386	32.8471214
6/19/2004	2203	30.150 S	FLB	28.8	150	57	-88.1574685	32.8472468
6/25/2004	1725	30.090 S	FLB	28.4	2200	36	-88.1739100	32.8375656
6/25/2004	1807	30.010 S	FLB	28.4	1950	33	-88.1712874	32.8372209
6/25/2004	1814	30.190 S	FLB	28.4	1385	35	-88.1654834	32.8384093
6/25/2004	1837	30.150 S	FLB	28.4	240	95	-88.1584593	32.8467965
6/25/2004	1838	30.921 S	FLB	28.4	240	93	-88.1584559	32.8467821
6/25/2004	1907	30.130 S	FLB	28.4	2395	107	-88.1758381	32.8384594

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
6/25/2004	1934	30.030 S	FLB	28.3	5375	27	-88.1627762	32.8306463
6/25/2004	2132	30.010 S	FLB	28.3	5510	80	-88.1614195	32.8298770
6/25/2004	2154	30.030 S	FLB	28.3	5435	39	-88.1620085	32.8304883
6/25/2004	2231	30.090 S	FLB	28.0	2535	116	-88.1774882	32.8385296
6/25/2004	2251	30.130 S	FLB	28.0	2590	115	-88.1780404	32.8384473
6/25/2004	2332	30.190 S	FLB	28.0	1315	13	-88.1647818	32.8387291
6/25/2004	2342	30.150 S	FLB	28.0	1335	9	-88.1648911	32.8385719
6/25/2004	2352	30.921 S	FLB	28.0	1320	22	-88.1648682	32.8387750
6/26/2004	2	31.151 S	FLB	28.0	1435	15	-88.1657663	32.8379571
7/14/2004	840	30.110 D	NOX	30.2	3835	73714	-88.7766573	33.2720227
7/14/2004	841	30.320 S	NOX	30.2	3835	73672	-88.7772010	33.2709119
9/7/2004	1700	30.110 D	NOX	29.0	3835	73729	-88.7767708	33.2721144
9/17/2004	1750	30.110 D	NOX	29.0	3835	73729	-88.7767708	33.2721144
10/19/2004	1010	30.090 S	NC	22.5	8995	10	-88.1324881	32.8337827
10/19/2004	1033	30.030 S	FLB	22.2	5355	44	-88.1630479	32.8304594
10/19/2004	1052	30.130 S	FLB	22.2	2315	36	-88.1750789	32.8378628
10/19/2004	1100	30.190 S	FLB	22.2	1445	51	-88.1660869	32.8381645
10/19/2004	1120	30.921 S	FLB	22.2	165	96	-88.1579262	32.8473481
10/19/2004	1124	30.010 S	FLB	22.2	95	103	-88.1575541	32.8478348
10/19/2004	1128	30.150 S	FLB	22.2	50	49	-88.1568543	32.8480178
11/4/2004	1400	30.110 D	NOX	21.5	3835	73729	-88.7767708	33.2721144
11/13/2004	1036	30.211 D	TWB	18.8	83500	65	-87.8524005	32.5964211
11/13/2004	1208	30.130 D	TWB	18.2	78710	94	-87.8647491	32.6210021
11/13/2004	1251	30.050 S	TWB	18.2	78225	26	-87.8699293	32.6217118
11/13/2004	1742	30.010 D	TWB	18.1	76055	86	-87.8914050	32.6167865
11/13/2004	1757	30.050 S	TWB	18.1	78985	65	-87.8618429	32.6212703
11/13/2004	1806	30.130 D	TWB	18.1	80265	91	-87.8530947	32.6141337
11/13/2004	1819	30.211 D	TWB	18.1	84805	29	-87.8602634	32.5909121
12/2/2004	1700	30.110 D	NOX	5.7	3835	73729	-88.7767708	33.2721144
12/30/2004	1126	30.050 D	FLB	5.7	5520	30	-88.1610387	32.8302069
12/30/2004	1140	30.090 S	FLB	5.8	5385	67	-88.1626462	32.8302886
12/30/2004	1206	30.921 S	FLB	5.8	2790	80	-88.1800622	32.8375119
12/30/2004	1316	30.030 S	FLB	5.8	5390	49	-88.1625572	32.8304518
12/30/2004	1320	30.070 S	FLB	5.8	5435	53	-88.1620412	32.8303658
12/30/2004	1325	30.110 S	FLB	5.8	5385	67	-88.1626462	32.8302886
12/30/2004	1332	30.190 S	FLB	5.8	5280	45	-88.1638129	32.8301799
12/30/2004	1335	30.150 S	FLB	5.8	5410	54	-88.1623620	32.8304013
12/30/2004	1338	30.130 S	FLB	5.8	5515	48	-88.1612002	32.8300959
12/30/2004	1415	30.190 D	NC	6.1	14020	137	-88.1032779	32.7959717
12/30/2004	1605	30.190 D	NC	6.1	14400	65	-88.0993000	32.7962042
1/3/2005	1035	30.211 D	TWB	8.1	85025	10	-87.8616807	32.5924915
1/3/2005	1138	30.130 D	TWB	7.6	80605	98	-87.8503063	32.6120352
1/3/2005	1144	30.010 D	TWB	7.6	80925	79	-87.8469223	32.6113248
1/3/2005	1150	30.050 S	TWB	7.6	81200	53	-87.8440197	32.6107889

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
1/5/2005	1103	30.712 D	TWB	8.1	82385	45	-87.8429426	32.6016211
1/5/2005	1120	30.211 D	TWB	8.1	85025	10	-87.8616807	32.5924915
1/5/2005	1200	30.010 D	TWB	8.1	78765	87	-87.8641966	32.6210731
1/5/2005	1203	30.682 D	TWB	8.1	78825	100	-87.8635363	32.6209503
1/5/2005	1207	30.682 S	TWB	8.1	79095	39	-87.8606610	32.6214801
1/5/2005	1213	30.130 D	TWB	8.1	79515	26	-87.8563745	32.6204333
1/5/2005	1220	30.691 D	TWB	8.1	79900	74	-87.8548499	32.6171580
1/7/2005	1200	30.921 S	FLB	11.5	5510	48	-88.1612340	32.8301161
1/7/2005	1208	30.030 S	FLB	11.5	5470	63	-88.1617344	32.8301778
1/7/2005	1215	30.050 D	FLB	11.5	5430	54	-88.1621074	32.8303675
1/7/2005	1219	30.070 S	FLB	11.5	5505	33	-88.1611761	32.8302443
1/7/2005	1223	30.110 S	FLB	11.5	5500	49	-88.1613501	32.8301586
1/7/2005	1227	30.130 S	FLB	11.5	5420	62	-88.1622567	32.8303270
1/7/2005	1255	30.150 S	FLB	9.8	2200	53	-88.1738876	32.8377217
1/7/2005	1258	30.090 S	FLB	9.8	2200	27	-88.1739733	32.8374973
1/7/2005	1304	30.190 S	FLB	9.8	1570	19	-88.1672140	32.8374676
1/7/2005	1719	30.130 S	FLB	10.7	5685	22	-88.1597369	32.8290881
1/7/2005	1730	30.070 S	FLB	10.5	5405	93	-88.1624571	32.8300583
1/7/2005	1733	30.921 S	FLB	10.5	5335	70	-88.1631787	32.8301491
1/7/2005	1735	30.110 S	FLB	10.5	5300	91	-88.1634354	32.8298480
1/7/2005	1739	30.030 S	FLB	10.5	5435	68	-88.1620892	32.8302360
1/7/2005	1746	30.050 D	FLB	10.5	5635	16	-88.1600848	32.8294571
1/7/2005	1829	30.190 S	FLB	9.9	1665	18	-88.1682050	32.8372087
1/7/2005	1834	30.090 S	FLB	9.9	2435	98	-88.1763268	32.8383784
1/7/2005	1836	30.150 S	FLB	9.9	2480	113	-88.1768201	32.8384974
1/12/2005	1309	31.044 D	TWB	13.2	81270	25	-87.8432865	32.6105047
1/12/2005	1317	30.682 S	TWB	13.2	81100	47	-87.8449960	32.6111772
1/12/2005	1322	30.050 S	TWB	13.2	80855	46	-87.8475502	32.6117371
1/12/2005	1326	31.044 S	TWB	13.2	80710	67	-87.8490998	32.6118961
1/12/2005	1336	30.010 D	TWB	13.2	80005	101	-87.8545525	32.6162330
1/12/2005	1340	30.752 S	TWB	13.2	80145	47	-87.8533987	32.6153093
1/12/2005	1349	30.130 D	TWB	13.2	79135	32	-87.8602669	32.6215358
1/12/2005	1445	30.211 D	TWB	13.1	85510	36	-87.8641233	32.5963927
1/12/2005	1451	30.691 D	TWB	13.1	85475	61	-87.8637410	32.5961738
1/12/2005	1458	30.190 D	TWB	13.1	84970	47	-87.8610647	32.5922300
1/12/2005	1508	30.712 D	TWB	13.1	83710	87	-87.8533561	32.5946831
1/12/2005	1513	30.682 D	TWB	13.1	83455	58	-87.8521482	32.5967740
1/12/2005	1553	30.691 S	TWB	13.1	81225	61	-87.8438315	32.6105464
1/12/2005	1608	30.712 S	TWB	13.1	79225	42	-87.8592810	32.6213517
1/12/2005	1628	30.130 D	TWB	13.1	79175	24	-87.8598036	32.6215697
1/12/2005	1635	30.752 S	TWB	13.1	79685	25	-87.8552415	32.6191154
1/12/2005	1640	30.010 D	TWB	13.1	79925	81	-87.8547671	32.6169110
1/12/2005	1647	31.044 S	TWB	13.1	80700	52	-87.8491481	32.6120558
1/12/2005	1653	30.682 S	TWB	13.1	81080	48	-87.8452443	32.6112401

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
1/12/2005	1656	31.044 D	TWB	13.1	81285	39	-87.8432588	32.6102599
1/12/2005	1700	30.050 S	TWB	13.1	81315	48	-87.8431676	32.6100046
1/12/2005	1711	30.712 D	TWB	13.1	83475	42	-87.8520788	32.5965378
1/12/2005	1716	30.682 D	TWB	13.1	83680	86	-87.8532776	32.5949229
1/12/2005	1724	30.190 D	TWB	13.1	84980	35	-87.8612316	32.5922572
1/12/2005	1729	30.691 D	TWB	13.1	81290	41	-87.8432467	32.6102201
1/12/2005	1733	30.211 D	TWB	13.1	85510	22	-87.8642588	32.5963463
1/12/2005	1754	30.691 S	TWB	13.1	81300	32	-87.8431283	32.6102145
1/12/2005	1809	30.712 S	TWB	13.1	79240	25	-87.8591066	32.6214843
1/21/2005	1025	30.190 S	FLB	8.6	2755	93	-88.1797700	32.8377671
1/21/2005	1033	30.090 S	FLB	8.6	2420	82	-88.1761517	32.8382341
1/21/2005	1037	30.130 S	FLB	8.6	2370	85	-88.1756019	32.8382735
1/21/2005	1126	30.030 S	FLB	8.3	5415	55	-88.1623360	32.8303955
1/21/2005	1135	30.070 S	FLB	8.3	5340	86	-88.1630880	32.8300278
1/21/2005	1139	30.110 S	FLB	8.3	5365	88	-88.1628115	32.8300937
1/21/2005	1146	30.150 S	FLB	8.3	5255	46	-88.1640245	32.8301017
1/21/2005	1152	30.921 S	FLB	8.3	5400	60	-88.1624970	32.8303545
1/21/2005	1211	30.050 D	FLB	9.0	7815	24	-88.1443724	32.8314868
1/21/2005	1639	30.050 D	FLB	8.9	7820	18	-88.1443706	32.8315770
1/21/2005	1728	30.090 S	FLB	8.4	1430	30	-88.1658172	32.8380993
1/21/2005	1739	30.130 S	FLB	8.4	2510	87	-88.1771517	32.8382665
1/21/2005	1744	30.090 S	FLB	8.4	2740	98	-88.1796317	32.8378611
1/21/2005	1755	30.150 S	FLB	8.2	5255	98	-88.1638741	32.8296411
1/21/2005	1801	30.070 S	FLB	8.2	5350	77	-88.1630086	32.8301507
1/21/2005	1807	30.110 S	FLB	8.2	5355	39	-88.1630339	32.8305057
1/21/2005	1813	30.921 S	FLB	8.2	5440	30	-88.1619278	32.8305512
1/21/2005	1816	30.030 S	FLB	8.2	5395	59	-88.1625435	32.8303659
1/26/2005	1054	30.050 S	TWB	8.6	84460	4	-87.8570205	32.5890070
1/26/2005	1107	30.130 D	TWB	8.6	84410	70	-87.8566032	32.5896642
1/26/2005	1113	30.682 S	TWB	8.6	84255	37	-87.8549361	32.5899762
1/26/2005	1122	30.691 D	TWB	8.6	84375	73	-87.8562092	32.5897447
1/26/2005	1130	30.752 S	TWB	8.6	85085	32	-87.8618269	32.5930741
1/26/2005	1139	30.211 D	TWB	8.6	85510	68	-87.8638061	32.5964993
1/26/2005	1145	30.712 D	TWB	8.6	85100	44	-87.8617737	32.5932156
1/26/2005	1154	30.190 D	TWB	8.6	86500	81	-87.8620554	32.6049626
1/26/2005	1234	30.682 D	TWB	8.6	84455	57	-87.8570582	32.5894849
1/26/2005	1251	31.044 D	TWB	9.3	80825	76	-87.8479515	32.6115346
1/26/2005	1259	31.044 S	TWB	9.3	80880	89	-87.8474389	32.6113246
1/26/2005	1304	30.010 D	TWB	9.3	80815	80	-87.8480944	32.6115231
1/26/2005	1309	30.691 S	TWB	9.3	80960	107	-87.8466523	32.6110147
1/26/2005	1314	30.712 S	TWB	9.3	80815	63	-87.8480147	32.6116648
1/26/2005	1545	30.752 D	NC	8.4	59905	71	-88.0434008	32.5970007
1/26/2005	1645	30.752 D	NC	8.4	60885	76	-88.0333045	32.5991779
1/26/2005	1814	30.691 S	TWB	8.6	81445	48	-87.8424219	32.6089781

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
1/26/2005	1825	30.010 D	TWB	8.6	80820	89	-87.8480375	32.6114324
1/26/2005	1851	31.044 S	TWB	8.6	80435	71	-87.8517819	32.6130302
1/26/2005	1904	31.044 D	TWB	8.6	82820	51	-87.8470889	32.5997577
1/26/2005	1910	30.712 S	TWB	8.6	83020	72	-87.8492512	32.5996580
1/26/2005	1919	30.691 D	TWB	9.0	84300	54	-87.8554952	32.5898498
1/26/2005	1924	30.752 S	TWB	9.0	84325	65	-87.8557461	32.5898371
1/26/2005	1928	30.050 S	TWB	9.0	84315	51	-87.8556114	32.5897576
1/26/2005	1933	30.682 D	TWB	8.8	84510	31	-87.8576259	32.5892957
1/26/2005	1940	30.130 D	TWB	9.0	84845	42	-87.8604183	32.5912699
1/26/2005	1947	30.682 S	TWB	9.0	84905	56	-87.8606404	32.5917374
1/26/2005	1958	30.190 D	TWB	9.1	86620	79	-87.8616356	32.6060259
1/26/2005	2008	30.712 D	TWB	9.1	86470	70	-87.8622662	32.6047747
1/26/2005	2050	30.211 D	TWB	9.0	84865	39	-87.8605722	32.5913907
2/4/2005	1322	30.030 S	FLB	8.6	5425	41	-88.1621626	32.8305063
2/4/2005	1328	30.050 D	FLB	8.6	5285	47	-88.1637341	32.8301812
2/4/2005	1332	30.090 S	FLB	8.6	5405	31	-88.1623958	32.8306095
2/4/2005	1349	30.070 S	FLB	8.5	2735	106	-88.1796298	32.8379397
2/4/2005	1401	30.110 S	FLB	8.5	2460	128	-88.1766368	32.8386433
2/4/2005	1406	30.130 S	FLB	8.5	2500	107	-88.1770425	32.8384459
2/4/2005	1411	30.150 S	FLB	8.5	2635	102	-88.1785440	32.8382353
2/4/2005	1423	30.921 S	FLB	8.5	1370	41	-88.1654009	32.8385603
2/4/2005	1426	30.190 S	FLB	8.5	1375	25	-88.1653148	32.8384270
2/4/2005	1640	30.030 S	FLB	8.5	5400	45	-88.1624575	32.8304900
2/4/2005	1644	30.050 D	FLB	8.5	5590	5	-88.1603350	32.8298939
2/4/2005	1647	30.090 S	FLB	8.5	5355	15	-88.1630659	32.8307317
2/4/2005	1657	30.150 S	FLB	8.5	4530	44	-88.1711477	32.8277690
2/4/2005	1706	30.070 S	FLB	8.1	2775	54	-88.1797698	32.8373930
2/4/2005	1712	30.130 S	FLB	8.1	2465	74	-88.1766355	32.8381499
2/4/2005	1716	30.110 S	FLB	8.1	2485	106	-88.1768746	32.8384351
2/4/2005	1721	30.190 S	FLB	8.1	1350	17	-88.1650743	32.8385199
2/4/2005	1724	30.921 S	FLB	8.1	1335	32	-88.1650704	32.8387185
2/9/2005	1151	30.682 S	TWB	9.8	81425	71	-87.8427492	32.6090458
2/9/2005	1212	30.010 D	TWB	9.8	81270	27	-87.8433220	32.6105113
2/9/2005	1216	30.050 S	TWB	9.8	81170	23	-87.8441087	32.6111178
2/9/2005	1224	31.044 D	TWB	9.8	80840	80	-87.8477926	32.6114717
2/9/2005	1230	31.044 S	TWB	9.8	80535	93	-87.8509563	32.6123440
2/9/2005	1242	30.712 D	TWB	9.8	80250	28	-87.8526194	32.6145781
2/9/2005	1252	30.712 S	TWB	9.8	79215	25	-87.8593672	32.6215140
2/9/2005	1310	30.682 D	TWB	10.1	82985	63	-87.8488418	32.5996602
2/9/2005	1314	30.691 S	TWB	10.1	83000	69	-87.8490114	32.5996780
2/9/2005	1319	30.190 D	TWB	10.1	83540	86	-87.8527790	32.5961175
2/9/2005	1328	30.211 D	TWB	10.1	84340	77	-87.8559754	32.5898722
2/9/2005	1337	30.130 D	TWB	10.1	85530	28	-87.8642992	32.5966055
2/9/2005	1342	30.752 S	TWB	10.1	85960	76	-87.8639994	32.6004685

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
2/9/2005	1606	30.752 D	TWB	10.3	78400	104	-87.8681463	32.6208887
2/9/2005	1708	30.752 S	TWB	10.1	86830	71	-87.8628457	32.6076893
2/9/2005	1716	30.211 D	TWB	10.1	86015	81	-87.8638342	32.6008899
2/9/2005	1721	30.130 D	TWB	10.1	85540	23	-87.8643804	32.5966614
2/9/2005	1729	30.691 D	TWB	10.1	84725	37	-87.8596680	32.5903183
2/9/2005	1741	30.682 D	TWB	10.1	82765	27	-87.8464081	32.5996463
2/9/2005	1744	30.691 S	TWB	10.1	82735	82	-87.8462648	32.6002404
2/9/2005	1755	30.682 S	TWB	10.3	81215	45	-87.8438323	32.6107713
2/9/2005	1803	31.044 S	TWB	10.3	80900	51	-87.8471141	32.6116215
2/9/2005	1809	30.050 S	TWB	10.3	80665	28	-87.8494142	32.6123746
2/9/2005	1816	30.010 D	TWB	10.3	80360	106	-87.8525911	32.6132931
2/9/2005	1821	31.044 D	TWB	10.3	79825	63	-87.8550648	32.6178217
2/9/2005	1827	30.712 S	TWB	10.3	79195	20	-87.8595664	32.6215796
2/9/2005	1837	30.752 D	TWB	10.3	77625	31	-87.8762791	32.6224847
2/18/2005	1246	30.050 D	FLB	13.1	7525	33	-88.1458598	32.8291442
2/18/2005	1304	30.030 S	FLB	13.1	5505	44	-88.1612694	32.8301788
2/18/2005	1312	30.150 S	FLB	13.1	5405	92	-88.1624254	32.8300622
2/18/2005	1315	30.090 S	FLB	13.1	5450	42	-88.1618778	32.8304253
2/18/2005	1317	30.190 S	FLB	13.1	5445	54	-88.1619621	32.8303348
2/18/2005	1322	30.110 S	FLB	13.1	5360	54	-88.1629271	32.8303970
2/18/2005	1326	30.921 S	FLB	13.1	5455	47	-88.1618177	32.8303601
2/18/2005	1341	30.130 S	FLB	13.1	2490	107	-88.1769218	32.8384451
2/18/2005	1349	30.070 S	FLB	13.1	2425	96	-88.1762085	32.8383560
2/18/2005	1713	30.030 S	FLB	12.6	5380	41	-88.1626999	32.8305209
2/18/2005	1716	30.090 S	FLB	12.6	5380	42	-88.1627066	32.8305175
2/18/2005	1721	30.110 S	FLB	12.6	5375	55	-88.1627715	32.8303914
2/18/2005	1725	30.190 S	FLB	12.6	5480	52	-88.1615892	32.8302336
2/18/2005	1728	30.921 S	FLB	12.6	5505	60	-88.1613479	32.8300492
2/18/2005	1732	30.150 S	FLB	12.6	5225	29	-88.1644075	32.8300932
2/18/2005	1758	30.070 S	FLB	12.3	2500	92	-88.1770384	32.8383151
2/18/2005	1803	30.130 S	FLB	12.3	2600	100	-88.1781597	32.8382905
2/18/2005	1819	30.050 D	FLB	12.3	7585	7	-88.1458310	32.8296984
2/23/2005	1117	30.691 D	TWB	14.2	81005	99	-87.8461260	32.6109968
2/23/2005	1129	30.050 S	TWB	14.2	79505	60	-87.8566345	32.6202043
2/23/2005	1146	30.691 S	TWB	14.2	77655	60	-87.8759600	32.6221849
2/23/2005	1201	30.712 S	TWB	14.2	79230	18	-87.8592071	32.6215608
2/23/2005	1209	30.130 D	TWB	14.2	80005	65	-87.8541962	32.6163521
2/23/2005	1229	30.682 S	TWB	14.5	83150	81	-87.8506320	32.5992283
2/23/2005	1238	30.682 D	TWB	14.5	83330	66	-87.8517133	32.5978102
2/23/2005	1302	30.211 D	TWB	14.3	85505	34	-87.8641257	32.5963484
2/23/2005	1307	31.044 S	TWB	14.3	85525	76	-87.8637807	32.5966490
2/23/2005	1317	30.752 S	TWB	14.3	86100	32	-87.8640519	32.6017854
2/23/2005	1428	30.190 D	NC	14.0	71680	59	-87.9279351	32.6323661
2/23/2005	1513	30.712 D	NC	14.0	60980	48	-88.0323610	32.5995551

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
3/4/2005	1352	30.691 D	TWB	12.2	79270	40	-87.8587933	32.6212872
3/4/2005	1403	30.712 S	TWB	12.2	79235	25	-87.8591865	32.6214970
3/4/2005	1444	30.752 S	TWB	12.5	86635	48	-87.8619353	32.6061877
3/4/2005	1501	31.044 S	TWB	12.5	84965	30	-87.8612092	32.5921234
3/4/2005	1507	30.211 D	TWB	12.5	84970	50	-87.8610412	32.5922418
3/4/2005	1518	30.050 S	TWB	12.5	83725	98	-87.8535072	32.5945118
3/4/2005	1522	30.190 D	TWB	12.5	83560	46	-87.8524497	32.5958232
3/4/2005	1526	30.682 D	TWB	12.5	83390	69	-87.8519989	32.5973156
3/4/2005	1537	30.682 S	TWB	11.8	81850	21	-87.8403126	32.6057695
3/4/2005	1546	31.044 D	TWB	11.8	81465	55	-87.8423950	32.6088290
3/5/2005	1204	30.050 D	FLB	11.5	6265	38	-88.1554489	32.8254372
3/5/2005	1219	30.712 D	FLB	11.5	5435	68	-88.1621043	32.8302393
3/5/2005	1227	30.921 S	FLB	11.5	5375	65	-88.1627731	32.8303041
3/5/2005	1234	30.030 S	FLB	11.5	5445	53	-88.1619371	32.8303405
3/5/2005	1239	30.130 D	FLB	11.5	5365	61	-88.1628528	32.8303388
3/5/2005	1247	30.150 S	FLB	11.5	5285	108	-88.1635373	32.8296571
3/5/2005	1303	30.090 S	FLB	11.7	2655	135	-88.1789725	32.8384080
3/5/2005	1313	30.190 S	FLB	11.7	2410	92	-88.1760211	32.8383204
3/5/2005	1317	30.130 S	FLB	11.7	2325	57	-88.1751753	32.8380476
3/5/2005	1327	30.070 S	FLB	11.7	1795	59	-88.1696225	32.8374921
3/5/2005	1612	30.752 D	NC	11.5	11440	23	-88.1194581	32.8145138
3/5/2005	1645	30.050 D	FLB	11.5	7800	25	-88.1444802	32.8313803
3/5/2005	1709	30.712 D	FLB	11.5	5455	129	-88.1620860	32.8296573
3/5/2005	1716	30.090 S	FLB	11.5	5425	44	-88.1622009	32.8304808
3/5/2005	1720	30.030 S	FLB	11.5	5355	46	-88.1630466	32.8304323
3/5/2005	1725	30.190 S	FLB	11.5	5220	20	-88.1644828	32.8301484
3/5/2005	1731	30.150 S	FLB	11.5	5060	59	-88.1657938	32.8290581
3/5/2005	1741	30.130 D	FLB	11.5	4040	62	-88.1763224	32.8282305
3/5/2005	1801	30.070 S	FLB	11.3	1365	42	-88.1653623	32.8385951
3/5/2005	1803	30.921 S	FLB	11.5	5490	32	-88.1613999	32.8303481
3/5/2005	1807	30.130 S	FLB	11.3	2425	97	-88.1761993	32.8383700
3/5/2005	1826	30.752 D	NC	11.3	10910	22	-88.1222253	32.8185232
3/9/2005	1251	30.150 S	FLB	12.0	6290	22	-88.1551651	32.8255120
3/9/2005	1302	30.110 S	FLB	12.0	5645	66	-88.1603954	32.8290891
3/9/2005	1309	30.030 S	FLB	12.0	5360	37	-88.1629269	32.8305481
3/9/2005	1313	30.090 S	FLB	12.0	5410	62	-88.1623691	32.8303305
3/9/2005	1345	30.130 D	NOX	12.4	3835	243	-88.1794619	32.8283989
3/9/2005	1356	30.712 D	FLB	12.0	3330	40	-88.1809911	32.8330294
3/9/2005	1407	30.921 S	FLB	12.0	2570	116	-88.1778604	32.8384859
3/9/2005	1409	30.190 S	FLB	12.0	2570	124	-88.1778399	32.8385620
3/9/2005	1414	30.070 S	FLB	12.0	2450	111	-88.1764540	32.8384863
3/9/2005	1451	30.010 D	FLB	12.1	7660	101	-88.1446166	32.8299794
3/9/2005	1809	30.150 S	FLB	11.8	6320	59	-88.1551209	32.8249555
3/9/2005	1820	30.030 S	FLB	11.8	5425	29	-88.1621857	32.8306158

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
3/9/2005	1832	30.090 S	FLB	11.6	4030	108	-88.1765789	32.8278619
3/9/2005	1852	30.921 S	FLB	11.6	2445	99	-88.1763927	32.8383817
3/9/2005	1858	30.070 S	FLB	11.6	2290	71	-88.1747573	32.8381747
3/9/2005	1905	30.712 D	FLB	11.6	1900	31	-88.1707535	32.8372225
3/9/2005	1945	30.050 D	FLB	11.6	3745	100	-88.1791485	32.8295463
3/9/2005	1951	30.130 D	NOX	11.7	3835	2581	-88.1913937	32.8148814
3/9/2005	2024	30.010 D	FLB	11.6	7560	90	-88.1451279	32.8292409
3/11/2005	1109	30.130 S	NC	12.4	12105	92	-88.1151807	32.8097634
3/11/2005	1209	30.190 D	NC	12.4	25705	75	-88.1084424	32.7636094
3/11/2005	1234	30.712 D	NC	12.4	30760	42	-88.0841802	32.7254751
3/11/2005	1249	31.044 D	NC	12.4	33730	72	-88.0950283	32.7043751
3/11/2005	1408	30.682 D	NC	12.4	53105	66	-88.0795761	32.6360694
3/11/2005	1441	30.691 S	NC	12.4	61865	118	-88.0228624	32.5992776
3/11/2005	1456	30.050 S	NC	12.4	63820	58	-88.0026936	32.6031699
3/11/2005	1553	30.712 S	TWB	12.7	80830	44	-87.8477833	32.6118041
3/11/2005	1629	31.044 S	TWB	12.7	80795	85	-87.8483244	32.6115142
3/11/2005	1640	30.682 S	TWB	12.7	81555	51	-87.8418882	32.6081105
3/11/2005	1655	30.691 D	TWB	12.3	84310	45	-87.8555428	32.5897230
3/11/2005	1703	30.211 D	TWB	12.3	85440	31	-87.8638455	32.5957629
3/11/2005	1711	30.752 S	TWB	12.3	86715	47	-87.8621086	32.6068627
3/17/2005	1341	30.090 S	FLB	12.8	2445	107	-88.1763855	32.8384552
3/17/2005	1342	30.070 S	FLB	12.8	2445	110	-88.1764067	32.8384764
3/17/2005	1349	30.921 S	FLB	12.8	2640	114	-88.1786490	32.8383175
3/17/2005	1426	30.110 S	FLB	12.7	4170	92	-88.1750769	32.8275228
3/17/2005	1441	30.190 S	FLB	12.7	5365	36	-88.1628740	32.8305637
3/17/2005	1446	30.030 S	FLB	12.7	5450	79	-88.1619771	32.8301027
3/17/2005	1450	30.050 D	FLB	12.7	5370	75	-88.1628030	32.8302159
3/17/2005	1751	30.070 S	FLB	12.8	2450	96	-88.1764481	32.8383567
3/17/2005	1758	30.090 S	FLB	12.8	2695	135	-88.1793669	32.8382862
3/17/2005	1818	30.921 S	FLB	12.8	2690	114	-88.1792191	32.8381298
3/17/2005	1838	30.030 S	FLB	12.8	5420	39	-88.1622334	32.8305279
3/17/2005	1840	30.110 S	FLB	12.8	5370	22	-88.1628255	32.8306924
3/17/2005	1844	30.190 S	FLB	12.8	5420	48	-88.1622733	32.8304538
3/17/2005	1848	30.050 D	FLB	12.8	5515	89	-88.1614323	32.8297849
3/18/2005	1236	30.150 S	NC	12.8	26195	35	-88.1063831	32.7594396
3/18/2005	1312	30.010 D	NC	12.8	32955	45	-88.0875838	32.7073826
3/18/2005	1324	31.044 D	NC	12.8	35445	140	-88.1128221	32.7024121
3/18/2005	1346	30.691 S	NC	12.8	37770	30	-88.1034603	32.6880667
3/18/2005	1452	30.682 D	NC	13.6	60380	68	-88.0386566	32.5985140
3/18/2005	1500	30.110 D	NOX	11.5	3835	73729	-88.7767708	33.2721144
3/18/2005	1559	30.752 D	TWB	13.7	77940	38	-87.8728887	32.6220847
3/18/2005	1609	30.752 S	TWB	13.7	78745	107	-87.8643878	32.6208903
3/18/2005	1623	30.691 D	TWB	13.7	79215	67	-87.8594293	32.6211374
3/18/2005	1630	30.050 S	TWB	13.7	79800	45	-87.8550098	32.6181125

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
3/18/2005	1632	30.190 D	TWB	13.7	79810	56	-87.8550612	32.6179640
3/18/2005	1639	30.130 S	TWB	14.0	80730	79	-87.8489670	32.6117382
3/18/2005	1647	30.682 S	TWB	14.0	81335	64	-87.8431470	32.6097220
3/18/2005	1650	30.712 D	TWB	14.0	81515	32	-87.8419120	32.6085285
3/18/2005	1700	31.044 S	TWB	14.0	83265	66	-87.8513617	32.5983771
3/18/2005	1708	30.712 S	TWB	14.0	85005	34	-87.8613575	32.5924348
3/18/2005	1729	30.211 D	TWB	14.0	88260	78	-87.8777179	32.6099310
3/24/2005	1200	30.921 S	FLB	14.3	6415	34	-88.1541289	32.8247134
3/24/2005	1215	30.030 S	FLB	14.3	5355	28	-88.1630028	32.8306269
3/24/2005	1227	30.050 D	FLB	14.3	4380	24	-88.1727873	32.8279048
3/24/2005	1240	30.070 S	FLB	14.5	2710	125	-88.1794819	32.8381675
3/24/2005	1243	30.090 S	FLB	14.5	2685	126	-88.1792047	32.8382453
3/24/2005	1713	30.090 S	FLB	14.5	2710	121	-88.1794327	32.8381393
3/24/2005	1714	30.070 S	FLB	14.5	2740	108	-88.1796949	32.8379421
3/24/2005	1723	30.921 S	FLB	14.4	4315	63	-88.1734697	32.8276046
3/24/2005	1737	30.030 S	FLB	14.4	5395	41	-88.1625309	32.8305260
3/25/2005	1011	30.211 D	TWB	14.7	85650	34	-87.8644835	32.5976670
3/25/2005	1038	30.691 D	TWB	14.7	81315	54	-87.8432013	32.6099431
3/25/2005	1051	30.752 S	TWB	15.2	79160	26	-87.8599888	32.6215724
3/25/2005	1054	30.712 S	TWB	15.2	79025	33	-87.8614340	32.6215543
3/25/2005	1215	30.050 S	NC	15.4	51295	70	-88.0642221	32.6409379
3/25/2005	1255	31.044 S	NC	15.4	37260	32	-88.1081581	32.6901782
3/25/2005	1315	30.682 S	NC	15.4	30870	37	-88.0834528	32.7246258
3/25/2005	1325	31.044 D	NC	15.4	28740	72	-88.0997866	32.7378855
3/25/2005	1340	30.130 S	NC	15.4	20125	131	-88.0720826	32.7817632
3/25/2005	1403	30.752 D	NC	15.4	18870	56	-88.0643027	32.7905988
3/25/2005	1601	30.752 D	NC	15.4	22135	98	-88.0863449	32.7770064
3/25/2005	1605	30.682 D	NC	15.4	22040	53	-88.0858105	32.7761830
3/25/2005	1611	30.712 D	NC	15.4	23380	66	-88.0990449	32.7802576
3/25/2005	1618	30.130 S	NC	15.4	23930	107	-88.1044361	32.7783854
3/25/2005	1635	31.044 D	NC	15.4	29835	111	-88.0907687	32.7316134
3/25/2005	1647	31.044 S	NC	15.4	33100	51	-88.0890280	32.7068756
3/25/2005	1707	30.050 S	NC	15.4	42570	113	-88.0565429	32.6935160
3/25/2005	1825	30.712 S	TWB	15.2	78960	37	-87.8621061	32.6215154
3/25/2005	1828	30.752 S	TWB	15.2	79135	50	-87.8602852	32.6213712
3/25/2005	1834	30.691 D	TWB	15.2	80635	40	-87.8497427	32.6123837
3/30/2005	1056	30.921 S	FLB	17.6	8675	74	-88.1361722	32.8339947
3/30/2005	1105	30.691 S	FLB	17.6	8770	54	-88.1351986	32.8337129
3/30/2005	1126	30.090 S	FLB	17.4	5425	28	-88.1621387	32.8306186
3/30/2005	1130	30.030 S	FLB	17.4	5390	36	-88.1626079	32.8305752
3/30/2005	1133	30.070 S	FLB	17.4	5395	46	-88.1625371	32.8304785
3/30/2005	1136	30.130 D	FLB	17.4	5325	24	-88.1633906	32.8305224
3/30/2005	1159	30.050 D	FLB	17.4	5095	17	-88.1656821	32.8295422
3/30/2005	1209	30.110 S	FLB	17.5	3850	137	-88.1783140	32.8286909

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
3/30/2005	1219	30.010 D	FLB	17.5	3575	43	-88.1798647	32.8310191
3/30/2005	1229	30.130 S	FLB	17.4	2305	72	-88.1749045	32.8381833
3/30/2005	1607	30.010 D	NOX	17.8	3835	348	-88.1808306	32.8278109
3/30/2005	1752	30.921 S	FLB	17.5	7595	52	-88.1453432	32.8296209
3/30/2005	1759	30.030 S	FLB	17.5	5470	57	-88.1616826	32.8302095
3/30/2005	1803	30.090 S	FLB	17.5	5435	23	-88.1619400	32.8306251
3/30/2005	1811	30.050 D	FLB	17.5	5215	27	-88.1644896	32.8300670
3/30/2005	1822	30.110 S	FLB	17.4	3800	76	-88.1783960	32.8294539
3/30/2005	1831	30.070 S	FLB	17.4	2745	110	-88.1797813	32.8379279
3/30/2005	1835	30.130 S	FLB	17.4	2535	92	-88.1774365	32.8383113
3/30/2005	1919	30.010 D	NOX	17.8	3835	408	-88.1815263	32.8275589
3/30/2005	1933	30.130 D	NOX	17.8	3835	207	-88.1790828	32.8284721
3/30/2005	1950	30.691 S	FLB	17.8	8145	38	-88.1414654	32.8332264
4/2/2005	1249	30.211 D	TWB	18.7	85145	62	-87.8618771	32.5936427
4/2/2005	1348	30.712 S	TWB	18.7	79070	10	-87.8609184	32.6217518
4/2/2005	1400	30.691 D	TWB	18.7	81420	70	-87.8427726	32.6090955
4/2/2005	1516	30.190 S	FLB	18.2	7580	57	-88.1453556	32.8295098
4/2/2005	1533	30.130 S	FLB	18.0	3685	74	-88.1794851	32.8300365
4/2/2005	1600	30.752 S	FLB	17.9	7860	59	-88.1437201	32.8315975
4/2/2005	1621	30.050 S	NC	18.0	16345	59	-88.0808023	32.8039523
4/2/2005	1745	30.752 D	NC	17.9	17640	55	-88.0698893	32.8005680
4/6/2005	952	30.752 S	FLB	18.0	5405	50	-88.1624342	32.8304382
4/6/2005	954	30.030 S	FLB	18.0	5400	59	-88.1624977	32.8303603
4/6/2005	958	30.090 S	FLB	18.0	5430	38	-88.1620693	32.8305160
4/6/2005	1000	30.150 S	FLB	18.0	5375	55	-88.1627766	32.8303938
4/6/2005	1001	30.070 S	FLB	18.0	5410	53	-88.1623662	32.8304109
4/6/2005	1037	30.190 S	FLB	18.0	2275	56	-88.1745872	32.8380300
4/6/2005	1041	30.921 S	FLB	18.0	2360	70	-88.1755370	32.8381427
4/6/2005	1044	30.130 S	FLB	18.0	2315	69	-88.1750420	32.8381654
4/6/2005	1049	30.712 D	FLB	18.0	2535	92	-88.1774147	32.8383076
4/8/2005	1139	30.090 S	FLB	16.9	5355	28	-88.1630486	32.8306063
4/8/2005	1142	30.150 S	FLB	16.9	5365	13	-88.1628881	32.8307654
4/8/2005	1158	30.921 S	FLB	16.9	3595	60	-88.1798999	32.8307808
4/8/2005	1215	30.070 S	FLB	16.9	975	127	-88.1635979	32.8418660
4/8/2005	1254	30.030 S	FLB	16.9	4130	55	-88.1754199	32.8279327
4/8/2005	1309	30.752 S	NOX	17.1	3835	3096	-88.1963777	32.8161253
4/8/2005	1322	30.130 S	NOX	17.1	3835	4921	-88.1941691	32.8273337
4/8/2005	1348	30.752 D	NOX	17.1	3835	13362	-88.2312279	32.8630212
4/8/2005	1542	30.190 S	NOX	17.1	3835	6806	-88.2116709	32.8296016
4/8/2005	1549	30.752 S	NOX		3835	5307	-88.1979900	32.8286169
4/8/2005	1554	30.130 S	NOX		3835	3986	-88.1902623	32.8210967
4/8/2005	1602	30.030 S	NOX		3835	650	-88.1832236	32.8266343
4/8/2005	1627	30.050 S	NC	17.1	16610	66	-88.0781721	32.8049407
4/8/2005	1815	30.050 S	NC	17.1	16615	77	-88.0780971	32.8048675

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
4/8/2005	1855	30.090 S	FLB	16.9	5355	8	-88.1631480	32.8307764
4/8/2005	1903	30.030 S	FLB	16.9	4515	1	-88.1713416	32.8281500
4/8/2005	1907	30.150 S	FLB	16.9	3940	98	-88.1773450	32.8284643
4/8/2005	1915	30.070 S	FLB	16.9	2300	20	-88.1749843	32.8377167
4/8/2005	1934	30.921 S	NOX	16.9	3835	966	-88.1837354	32.8240108
4/13/2005	1240	30.190 S	FLB	19.4	7980	74	-88.1427613	32.8322525
4/13/2005	1257	30.050 D	FLB	19.4	7755	54	-88.1445833	32.8309496
4/13/2005	1319	30.921 S	FLB	19.4	4535	36	-88.1710813	32.8278462
4/13/2005	1336	30.090 S	FLB	19.4	2540	48	-88.1774381	32.8379163
4/13/2005	1347	30.712 D	FLB	19.4	2460	108	-88.1766089	32.8384601
4/13/2005	2012	30.090 S	FLB	17.2	2415	112	-88.1760776	32.8385082
4/13/2005	2030	30.921 S	FLB	17.2	3365	44	-88.1808988	32.8326940
4/13/2005	2039	30.712 D	NOX	17.2	3835	204	-88.1790596	32.8284982
4/13/2005	2058	30.150 S	FLB	19.4	7730	132	-88.1440647	32.8303707
4/13/2005	2102	30.190 S	FLB	19.4	7720	62	-88.1447518	32.8306398
4/14/2005	1400	30.110 D	NOX		3835	73729	-88.7767708	33.2721144
4/15/2005	1350	30.752 S	TWB		81195	30	-87.8439139	32.6109725
4/15/2005	1400	30.712 S	TWB		79065	35	-87.8610200	32.6215280
4/15/2005	1414	30.682 S	TWB		82755	29	-87.8462818	32.5996769
4/15/2005	1420	31.044 S	TWB		83420	31	-87.8517496	32.5969483
4/15/2005	1424	30.190 D	TWB		83490	14	-87.8518589	32.5963251
4/15/2005	1715	30.050 D	NC		16750	89	-88.0766948	32.8050680
4/15/2005	1720	31.044 D	NC		15355	70	-88.0899072	32.7993953
4/15/2005	1737	30.752 D	NC		9420	20	-88.1296096	32.8304525
4/15/2005	1846	30.070 S	NC		23830	123	-88.1037836	32.7791054
4/15/2005	1852	30.130 S	NC		24380	121	-88.1075583	32.7752106
4/20/2005	1702	30.190 S	FLB	20.7	1210	62	-88.1644717	32.8397491
4/20/2005	1718	30.921 S	FLB	20.7	2415	75	-88.1761223	32.8381711
4/20/2005	1721	30.130 S	FLB	20.7	2445	113	-88.1763771	32.8385060
4/20/2005	1725	30.150 S	FLB	20.7	2655	131	-88.1789398	32.8383837
4/20/2005	1736	30.030 S	FLB	20.8	5290	52	-88.1636415	32.8301589
4/20/2005	1740	30.090 S	FLB	20.8	5545	49	-88.1609449	32.8299277
4/20/2005	1835	30.110 S	FLB	20.4	8195	59	-88.1408401	32.8332357
4/20/2005	2027	30.090 S	FLB	20.1	6225	13	-88.1558160	32.8256566
4/20/2005	2034	30.030 S	FLB	20.1	5540	21	-88.1608074	32.8301829
4/20/2005	2054	30.150 S	FLB	20.2	1915	12	-88.1709113	32.8370395
4/20/2005	2101	30.190 S	FLB	20.2	1410	20	-88.1655727	32.8381575
4/20/2005	2105	30.921 S	FLB	20.2	1325	37	-88.1650542	32.8388035
4/20/2005	2113	30.130 S	FLB	20.2	475	58	-88.1595168	32.8448427
4/20/2005	2140	30.130 D	FLB	19.1	3855	162	-88.1784213	32.8284704
4/22/2005	1418	30.752 D	TWB	24.3	77260	-269	-87.8813275	32.6245928
4/22/2005	1430	30.752 S	TWB	21.3	77995	39	-87.8723394	32.6220089
4/22/2005	1649	30.190 D	TWB	23.0	83145	54	-87.8504116	32.5990707
4/22/2005	1652	30.682 D	TWB	23.0	83090	28	-87.8498289	32.5990955

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
4/22/2005	1705	31.044 D	TWB	22.5	81460	45	-87.8423343	32.6089038
4/22/2005	1727	30.712 D	TWB	22.5	80770	36	-87.8483941	32.6119781
4/22/2005	1730	30.010 D	TWB	22.5	80545	83	-87.8507809	32.6123738
4/22/2005	1740	30.712 S	TWB	22.5	78500	54	-87.8670019	32.6212753
4/22/2005	1753	30.682 S	TWB	22.5	80885	84	-87.8473664	32.6113611
4/22/2005	2124	30.130 D	TWB	20.6	87825	102	-87.8730703	32.6100280
4/22/2005	2132	30.211 D	TWB	20.6	88510	33	-87.8803941	32.6095445
4/25/2005	1409	30.921 S	FLB	20.6	2475	99	-88.1767504	32.8383787
4/25/2005	1415	30.030 S	FLB	20.6	1280	55	-88.1648642	32.8392316
4/25/2005	1423	30.190 S	FLB	20.6	205	50	-88.1578043	32.8468294
4/25/2005	1426	30.130 S	FLB	20.6	270	32	-88.1580838	32.8462994
4/25/2005	1428	30.090 S	FLB	20.6	275	39	-88.1581826	32.8462973
4/25/2005	1430	30.150 S	FLB	20.6	135	67	-88.1574834	32.8473681
4/25/2005	2055	30.130 S	FLB	20.6	965	48	-88.1628391	32.8414794
4/25/2005	2100	30.190 S	FLB	20.6	885	72	-88.1624152	32.8421731
4/25/2005	2106	30.921 S	FLB	20.6	250	61	-88.1582164	32.8465726
4/25/2005	2110	30.030 S	FLB	20.6	155	59	-88.1575317	32.8472176
4/25/2005	2112	30.090 S	FLB	20.6	125	127	-88.1579205	32.8477724
4/25/2005	2114	30.150 S	FLB	20.6	75	81	-88.1572514	32.8479308
5/6/2005	1051	30.030 S	FLB	20.5	5520	50	-88.1611526	32.8300552
5/6/2005	1107	30.070 S	FLB	21.5	2485	92	-88.1768532	32.8383111
5/6/2005	1110	30.130 S	FLB	21.5	2490	58	-88.1769089	32.8380000
5/6/2005	1114	30.921 S	FLB	21.5	2225	45	-88.1741231	32.8377549
5/6/2005	1126	30.190 S	FLB	21.5	1095	115	-88.1642706	32.8409342
5/6/2005	1134	30.150 S	FLB	21.5	115	71	-88.1573501	32.8475634
5/6/2005	1850	30.190 S	FLB	20.3	260	83	-88.1584802	32.8466184
5/6/2005	1854	30.130 S	FLB	20.3	130	68	-88.1574420	32.8474308
5/6/2005	1856	30.150 S	FLB	20.3	130	104	-88.1577377	32.8476340
5/6/2005	1912	30.070 S	FLB	20.3	2925	79	-88.1812527	32.8366324
5/6/2005	1938	30.921 S	FLB	20.5	5355	39	-88.1629919	32.8305260
5/6/2005	1942	30.030 S	FLB	20.5	5530	109	-88.1614383	32.8295691
5/10/2005	1219	30.682 D	TWB	27.0	83370	28	-87.8515171	32.5973381
5/10/2005	1229	30.712 D	TWB	24.5	84620	72	-87.8586282	32.5899410
5/10/2005	1243	31.044 S	TWB	26.5	86815	83	-87.8626136	32.6077114
5/10/2005	1301	30.130 D	TWB	24.8	88525	104	-87.8805358	32.6102088
5/10/2005	1342	30.712 S	TWB	23.9	77835	31	-87.8740415	32.6222570
5/26/2005	1010	30.110 D	NOX		3835	73729	-88.7767708	33.2721144
5/26/2005	1347	30.090 S	FLB	27.6	70	10	-88.1565714	32.8476497
5/26/2005	1356	30.150 S	FLB	27.6	155	44	-88.1573996	32.8471322
5/26/2005	1449	30.070 S	FLB	27.6	1970	45	-88.1714958	32.8373198
5/26/2005	1452	30.921 S	FLB	27.6	2320	26	-88.1751816	32.8377682
5/26/2005	1456	30.190 S	FLB	27.6	2895	64	-88.1808684	32.8367960
5/26/2005	1557	30.030 S	FLB	30.2	5435	47	-88.1620433	32.8304222
5/26/2005	1948	30.050 S	NC	28.6	16770	84	-88.0764810	32.8051557

TABLE B1 (continued).

DATE	TIME	FISH #	HAB	TEMP	DAM	BANK	LONGITUDE	LATITUDE
5/26/2005	2054	30.030 S	FLB	27.7	5680	22	-88.1597559	32.8291130
5/26/2005	2057	30.921 S	FLB	27.7	5260	58	-88.1639522	32.8300083
5/26/2005	2110	30.070 S	FLB	27.0	2335	61	-88.1752415	32.8380774
5/26/2005	2123	30.190 S	FLB	27.0	105	38	-88.1570151	32.8474346
5/26/2005	2125	30.090 S	FLB	27.0	35	18	-88.1565084	32.8480117
5/26/2005	2126	30.150 S	FLB	27.0	20	8	-88.1563563	32.8481096
5/28/2005	1326	30.712 S	TWB	29.6	77330	48	-87.8794261	32.6221155
5/28/2005	1419	30.682 D	TWB	29.6	83310	42	-87.8513782	32.5979192
5/28/2005	1605	31.044 S	TWB	28.3	77565	25	-87.8769256	32.6225500
5/28/2005	1615	30.712 D	TWB	28.3	79270	35	-87.8587841	32.6213385
5/28/2005	1624	30.691 S	TWB	28.3	81005	94	-87.8461182	32.6110391
5/28/2005	1634	31.044 D	TWB	30.3	83380	74	-87.8519937	32.5974528
5/28/2005	1652	30.691 D	TWB	30.3	86810	58	-87.8627316	32.6075141
5/28/2005	1934	30.691 D	TWB	29.3	87340	30	-87.8680275	32.6089818
5/28/2005	1952	30.682 D	TWB	30.2	83655	61	-87.8529383	32.5950562
5/28/2005	2000	31.044 D	TWB	30.2	83205	70	-87.8510136	32.5987936
5/28/2005	2005	30.691 S	TWB	29.2	82370	55	-87.8428693	32.6017510
5/28/2005	2007	30.712 D	TWB	29.2	81965	79	-87.8407895	32.6047109
5/28/2005	2019	30.752 S	TWB	29.2	79255	63	-87.8590228	32.6211254
5/28/2005	2025	30.712 S	TWB	29.2	77755	42	-87.8748853	32.6222419
6/25/2005	1900	30.921 S	FLB	28.4	160	107	-88.1579862	32.8474307
6/25/2005	1904	30.150 S	FLB	28.4	140	94	-88.1577241	32.8475111
6/25/2005	1914	30.190 S	FLB	28.4	970	35	-88.1627703	32.8413847
6/25/2005	1918	30.090 S	FLB	28.4	1160	80	-88.1643297	32.8402477
6/25/2005	2008	30.070 S	FLB	28.9	5375	53	-88.1627693	32.8304154
6/25/2005	2016	30.030 S	FLB	28.9	5225	77	-88.1642137	32.8296890

APPENDIX C

PADDLEFISH CAPTURED WITH GILL NETS

IN THE TENNESSEE-TOMBIGBEE

WATERWAY

TABLE C1.—Paddlefish caught in the Tennessee-Tombigbee Waterway and a tributary using gill nets. "HAB" indicates habitat type; "FLB"= flowing bendway; "NOX"= Oktoc Creek in the Noxubee River sytem; "TWB"= Twelvemile Bend. "MESH" indicates bar measurement of mesh size in mm. "TYPE" indicates mesh type; "mono"= monofilament; "multi"= multifilament. Age is given in years; asterisks denote ages estimated with von Bertalanffy growth curve; ages without asterisks were determined from pectoral fin rays. "EFL" indicates eye-to-fork length in mm. Weight is given in kg.

DATE	LAKE	HABITAT	MESH	TYPE	AGE	EFL	WEIGHT	SEX
3/17/2003		NOX	127	mono		900	9.7	m
3/17/2003		NOX	127	mono		970	14.1	m
4/15/2003	Demopolis	FLB	127	mono		745	6.7	
4/15/2003	Demopolis	FLB	127	mono		800	7.7	
4/22/2003	Demopolis	FLB	127	mono		730		m
4/22/2003	Demopolis	FLB	127	multi		780	7.9	m
4/22/2003	Demopolis	FLB	127	multi		803	6.8	m
4/22/2003	Demopolis	FLB	127	multi		820	10.2	m
6/30/2003	Demopolis	FLB	127	multi		840	8.9	
8/10/2003	Gainesville		152	multi		834	11.3	
8/23/2003	Demopolis	FLB	102	multi		789	7.5	
8/23/2003	Demopolis	FLB	102	multi		830	9.0	
8/23/2003	Demopolis	FLB	152	multi		860	9.6	
8/23/2003	Demopolis	FLB	152	multi		870	9.3	
8/23/2003	Demopolis	FLB	152	multi		875	10.8	
8/23/2003	Demopolis	FLB	102	multi		875	9.8	
8/23/2003	Demopolis	FLB	127	multi		936	13.3	f
10/14/2003	Gainesville		102	multi		470	1.5	
10/17/2003	Demopolis	FLB	152	multi		863	9.8	
10/17/2003	Demopolis	FLB	102	multi		900	11.1	
10/17/2003	Demopolis	FLB	152	multi		908	12.6	
10/17/2003	Demopolis	FLB	152	multi		914	11.8	
10/17/2003	Demopolis	FLB	102	multi		940	13.4	
10/17/2003	Demopolis	FLB	127	multi		993	16.0	
10/18/2003	Demopolis	FLB	102	multi		722	5.4	
10/18/2003	Demopolis	FLB	127	multi		842	9.8	
11/9/2003	Gainesville		152	multi		594	3.7	
12/17/2003	Demopolis	FLB	127	multi		800	8.6	m
12/17/2003	Demopolis	FLB	127	multi		806	7.7	
12/17/2003	Demopolis	FLB	127	multi		845	9.3	m
12/17/2003	Demopolis	FLB	127	multi		853	11.3	f
12/17/2003	Demopolis	FLB	152	multi		918	13.0	m
12/17/2003	Demopolis	FLB	152	multi		927	15.0	m
12/19/2003	Demopolis	FLB	152	multi		856	8.7	
1/11/2004	Demopolis	FLB	127	multi		827	7.8	m
1/11/2004	Demopolis	FLB	127	multi		833	8.0	m

TABLE C1 (continued).

DATE	LAKE	HABITAT	MESH	TYPE	AGE	EFL	WEIGHT	SEX
1/11/2004	Demopolis	FLB	152	multi		845	9.2	m
1/11/2004	Demopolis	FLB	152	multi		870	9.5	m
1/11/2004	Demopolis	FLB	127	multi		915	12.1	f
1/11/2004	Demopolis	FLB	127	multi		948	14.3	f
1/11/2004	Demopolis	FLB	152	multi		982	14.0	m
2/27/2004	Demopolis	FLB	102	multi		632	3.4	
2/27/2004	Demopolis	FLB	102	multi		823	7.0	
2/27/2004	Demopolis	FLB	102	multi		840	8.2	m
2/27/2004	Demopolis	FLB	102	multi		842	9.0	f
2/27/2004	Demopolis	FLB	102	multi		860	9.0	m
2/27/2004	Demopolis	FLB	102	multi		861	8.6	m
2/27/2004	Demopolis	FLB	102	multi		877	8.6	m
2/27/2004	Demopolis	FLB	102	multi		881	9.6	m
2/27/2004	Demopolis	FLB	102	multi		986	12.0	f
3/5/2004	Demopolis	FLB	127	mono		647	4.1	
3/5/2004	Demopolis	FLB	102	multi		820	7.3	m
3/5/2004	Demopolis	FLB	152	multi		871	9.4	f
3/12/2004	Demopolis	FLB	102	multi		789	6.6	m
3/12/2004	Demopolis	FLB	152	multi		860	10.5	f
3/12/2004	Demopolis	FLB	127	mono		890	8.8	m
3/12/2004	Demopolis	FLB	102	multi		905	9.5	m
3/16/2004	Demopolis	FLB	102	multi		690		
3/16/2004	Demopolis	FLB	102	multi		742	6.6	m
3/16/2004	Demopolis	FLB	102	multi		771	5.5	m
3/16/2004	Demopolis	FLB	102	multi		793	7.1	m
3/16/2004	Demopolis	FLB	102	multi		803	7.9	m
3/16/2004	Demopolis	FLB	102	multi		828	8.3	m
3/16/2004	Demopolis	FLB	127	mono		830	7.9	m
3/16/2004	Demopolis	FLB	102	multi		852	8.9	m
3/16/2004	Demopolis	FLB	127	mono		860	8.3	m
3/16/2004	Demopolis	FLB	102	multi		913	11.6	m
3/16/2004	Demopolis	FLB	127	mono		923	11.6	f
3/16/2004	Demopolis	FLB	102	multi		942	13.2	f
3/16/2004	Demopolis	FLB	102	multi		970	16.3	f
3/31/2004		NOX	127	multi		881	12.4	m
4/2/2004	Demopolis	FLB	152	multi		892	15.6	f
4/9/2004	Demopolis	FLB	152	multi		601	2.9	
4/9/2004	Demopolis	FLB	152	multi		720	5.6	
4/9/2004	Demopolis	FLB	152	multi		835	8.6	m
4/9/2004	Demopolis	FLB	127	mono		864	10.3	
4/9/2004	Demopolis	FLB	152	multi		872	11.2	f
4/9/2004	Demopolis	FLB	152	multi		914	10.8	m
4/16/2004	Demopolis	FLB	152	multi		912	9.9	m
4/16/2004	Demopolis	FLB	127	multi		1035	16.6	f

TABLE C1 (continued).

DATE	LAKE	HABITAT	MESH	TYPE	AGE	EFL	WEIGHT	SEX
4/23/2004	Demopolis	FLB	152	multi		790	6.9	m
4/23/2004	Demopolis	FLB	152	multi		817	7.7	m
4/23/2004	Demopolis	FLB	152	multi		818	7.5	m
4/23/2004	Demopolis	FLB	152	multi		855	8.3	m
4/23/2004	Demopolis	FLB	152	multi		859	7.9	m
4/23/2004	Demopolis	FLB	152	multi		912	10.5	m
4/23/2004	Demopolis	FLB	152	multi		916	9.8	m
4/23/2004	Demopolis	FLB	152	multi		926	12.3	m
4/23/2004	Demopolis	FLB	152	multi		936	12.1	m
4/23/2004	Demopolis	FLB	152	multi		990	15.6	f
12/31/2004	Demopolis	FLB	152	multi		830	7.5	f
12/31/2004	Demopolis	FLB	127	multi	6*	839	7.7	m
12/31/2004	Demopolis	FLB	127	multi	6*	845	9.2	m
12/31/2004	Demopolis	FLB	152	multi	6*	849	8.9	m
12/31/2004	Demopolis	FLB	127	multi		873	10.0	f
12/31/2004	Demopolis	FLB	152	multi	7*	876	11.1	m
12/31/2004	Demopolis	FLB	152	multi	7*	879	9.3	m
12/31/2004	Demopolis	FLB	152	multi	7*	884	10.1	m
12/31/2004	Demopolis	FLB	127	multi	8*	909	12.0	m
12/31/2004	Demopolis	FLB	152	multi		937	13.5	f
12/31/2004	Demopolis	FLB	152	multi	12*	979	11.6	m
12/31/2004	Demopolis	FLB	152	multi		986	14.2	f
1/3/2005	Demopolis	TWB	102	multi	4*	740	5.0	m
1/3/2005	Demopolis	TWB	102	multi	4*	778	6.7	m
1/3/2005	Demopolis	TWB	127	multi	5*	792	7.0	m
1/3/2005	Demopolis	TWB	127	multi	7	821	8.0	m
1/3/2005	Demopolis	TWB	102	multi	6*	855	7.5	m
1/3/2005	Demopolis	TWB	127	multi		876	9.9	f
1/3/2005	Demopolis	TWB	127	multi		895	10.9	f
1/3/2005	Demopolis	TWB	102	multi		895	10.2	f
1/3/2005	Demopolis	TWB	127	multi		897	10.2	f
1/3/2005	Demopolis	TWB	127	multi		953	12.0	f
1/5/2005	Demopolis	TWB	152	multi	5*	812	7.9	m
1/5/2005	Demopolis	TWB	152	multi		820	7.9	f
1/5/2005	Demopolis	TWB	152	multi	6*	840	8.5	m
1/5/2005	Demopolis	TWB	102	multi	6*	853	8.0	m
1/5/2005	Demopolis	TWB	152	multi	6*	857	8.8	m
1/5/2005	Demopolis	TWB	102	multi		880	10.4	f
1/5/2005	Demopolis	TWB	102	multi		880	10.0	f
1/5/2005	Demopolis	TWB	127	multi		890	10.3	f
1/5/2005	Demopolis	TWB	127	multi		900	10.7	f
1/5/2005	Demopolis	TWB	152	multi	8*	902	11.0	m
1/5/2005	Demopolis	TWB	127	multi		909	10.8	f
1/5/2005	Demopolis	TWB	102	multi		909	12.0	f

TABLE C1 (continued).

DATE	LAKE	HABITAT	MESH	TYPE	AGE	EFL	WEIGHT	SEX
1/5/2005	Demopolis	TWB	102	multi		916	11.7	f
1/5/2005	Demopolis	TWB	127	multi		970	13.4	f
1/5/2005	Demopolis	TWB	102	multi	12*	979	13.5	m
1/5/2005	Demopolis	TWB	127	multi		1074	20.5	f
1/18/2005	Demopolis	FLB	127	mono	4*	740	4.9	m
1/18/2005	Demopolis	FLB	127	mono	5*	794	7.0	m
1/18/2005	Demopolis	FLB	102	mono	6*	829	7.8	m
1/18/2005	Demopolis	FLB	102	mono	6*	847	8.4	m
1/18/2005	Demopolis	FLB	102	mono		885	9.3	f
1/18/2005	Demopolis	FLB	152	mono		890	10.2	f
1/18/2005	Demopolis	FLB	102	mono	8*	892	10.0	m
1/18/2005	Demopolis	FLB	152	multi		911	9.4	f
1/18/2005	Demopolis	FLB	102	mono	9*	914	11.6	m
1/18/2005	Demopolis	FLB	102	mono		930	11.8	f
1/18/2005	Demopolis	FLB	152	mono	10*	934	10.6	m
1/18/2005	Demopolis	FLB	127	mono	10*	935	12.7	m
1/18/2005	Demopolis	FLB	127	mono		960	14.1	f
1/18/2005	Demopolis	FLB	127	mono		970	14.5	f
1/18/2005	Demopolis	FLB	127	mono	12*	972	16.0	m
1/18/2005	Demopolis	FLB	152	mono		973	12.8	f
1/22/2005	Demopolis	TWB	102	multi		720	5.4	
1/22/2005	Demopolis	TWB	127	multi	5*	788	7.0	m
1/22/2005	Demopolis	TWB	152	multi	6	816	7.6	m
1/22/2005	Demopolis	TWB	152	multi		826	8.7	f
1/22/2005	Demopolis	TWB	152	multi	6*	842	8.1	m
1/22/2005	Demopolis	TWB	127	multi	6*	850	8.7	m
1/22/2005	Demopolis	TWB	152	multi	7	851	9.1	m
1/22/2005	Demopolis	TWB	102	multi		855	8.4	f
1/22/2005	Demopolis	TWB	127	multi		866	9.9	f
1/22/2005	Demopolis	TWB	152	multi	7*	867	8.7	m
1/22/2005	Demopolis	TWB	127	multi	8*	901	10.7	m
1/22/2005	Demopolis	TWB	127	multi		901	10.9	f
1/22/2005	Demopolis	TWB	152	mono	8*	907	9.0	m
1/22/2005	Demopolis	TWB	127	multi	8*	908	11.2	m
1/22/2005	Demopolis	TWB	127	multi		911	11.8	f
1/22/2005	Demopolis	TWB	152	mono	9*	916	10.9	m
1/22/2005	Demopolis	TWB	152	multi		934	13.2	f
1/22/2005	Demopolis	TWB	102	multi		940	13.8	f
1/22/2005	Demopolis	TWB	127	multi		948	13.6	f
1/22/2005	Demopolis	TWB	102	multi		990	14.0	f
1/22/2005	Demopolis	TWB	127	multi		1095	23.0	f
1/24/2005	Demopolis	FLB	152	mono		767	6.1	f
1/24/2005	Demopolis	FLB	102	mono	4*	769	5.9	m
1/24/2005	Demopolis	FLB	127	mono	5	792	7.3	m

TABLE C1 (continued).

DATE	LAKE	HABITAT	MESH	TYPE	AGE	EFL	WEIGHT	SEX
1/24/2005	Demopolis	FLB	102	mono	6	831	8.4	m
1/24/2005	Demopolis	FLB	127	mono	6*	842	8.5	m
1/24/2005	Demopolis	FLB	102	mono	6*	852	8.5	m
1/24/2005	Demopolis	FLB	127	mono	8	854	8.5	m
1/24/2005	Demopolis	FLB	127	mono	6*	862	8.5	m
1/24/2005	Demopolis	FLB	152	mono	6*	862	8.2	m
1/24/2005	Demopolis	FLB	127	mono		876	8.2	f
1/24/2005	Demopolis	FLB	127	multi	7*	883	8.7	m
1/24/2005	Demopolis	FLB	102	mono	9	885	9.3	m
1/24/2005	Demopolis	FLB	152	mono		888	10.7	f
1/24/2005	Demopolis	FLB	127	multi	7*	891	9.8	m
1/24/2005	Demopolis	FLB	127	mono	8*	894	9.8	m
1/24/2005	Demopolis	FLB	152	mono	8*	900	10.0	m
1/24/2005	Demopolis	FLB	127	multi		901	10.2	f
1/24/2005	Demopolis	FLB	127	multi	8*	910	10.4	m
1/24/2005	Demopolis	FLB	127	mono	11	920	11.2	m
1/24/2005	Demopolis	FLB	127	mono	10*	932	10.6	m
1/24/2005	Demopolis	FLB	127	multi		940	11.2	f
1/24/2005	Demopolis	FLB	152	mono		1052	19.4	f
2/2/2005	Demopolis	TWB	127	mono		661	4.0	
2/2/2005	Demopolis	TWB	127	mono	4*	761	6.2	m
2/2/2005	Demopolis	TWB	152	mono		809	7.7	f
2/2/2005	Demopolis	TWB	102	mono	5*	810	6.7	m
2/2/2005	Demopolis	TWB	127	mono	6*	834	7.5	m
2/2/2005	Demopolis	TWB	152	mono	6*	841	8.6	m
2/2/2005	Demopolis	TWB	152	mono	7	851	9.6	m
2/2/2005	Demopolis	TWB	152	mono		865	10.8	f
2/2/2005	Demopolis	TWB	152	mono	7*	888	10.9	m
2/2/2005	Demopolis	TWB	127	mono		908	11.0	f
2/2/2005	Demopolis	TWB	102	mono		920	11.4	f
2/2/2005	Demopolis	TWB	102	mono		951	11.6	f
2/28/2005	Demopolis	FLB	102	mono	6	798	6.8	m
2/28/2005	Demopolis	FLB	102	mono		841	8.3	f
2/28/2005	Demopolis	FLB	127	mono	7*	874	9.4	m
2/28/2005	Demopolis	FLB	102	mono		920	11.0	f
2/28/2005	Demopolis	FLB	102	mono		927	12.7	f
2/28/2005	Demopolis	FLB	127	mono		952	13.2	f
3/7/2005	Demopolis	TWB	152	multi		918	12.0	f
3/9/2005	Demopolis	FLB	127	multi	7*	876	9.0	m
3/9/2005	Demopolis	FLB	127	multi		938	13.2	f
3/13/2005	Demopolis	FLB	127	mono	4*	776	6.2	m
3/13/2005	Demopolis	FLB	127	mono	5*	780	5.8	m
3/13/2005	Demopolis	FLB	152	multi	5*	781	6.8	m
3/13/2005	Demopolis	FLB	102	mono	4	792	6.4	m

TABLE C1 (continued).

DATE	LAKE	HABITAT	MESH	TYPE	AGE	EFL	WEIGHT	SEX
3/13/2005	Demopolis	FLB	127	mono	5*	819	7.0	m
3/13/2005	Demopolis	FLB	152	multi	5*	820	8.0	m
3/13/2005	Demopolis	FLB	152	multi	6*	830	7.1	m
3/13/2005	Demopolis	FLB	102	mono	7	840	8.0	m
3/13/2005	Demopolis	FLB	127	mono	7	843	9.2	m
3/13/2005	Demopolis	FLB	152	multi	6*	859	8.0	m
3/13/2005	Demopolis	FLB	102	mono	7*	868	8.6	m
3/13/2005	Demopolis	FLB	127	mono	8	878	8.6	m
3/13/2005	Demopolis	FLB	102	mono		880	11.4	f
3/13/2005	Demopolis	FLB	102	multi	10	884	8.8	m
3/13/2005	Demopolis	FLB	127	mono	7	885	10.2	m
3/13/2005	Demopolis	FLB	102	multi	8	885	9.5	m
3/13/2005	Demopolis	FLB	127	multi	7*	888	8.7	m
3/13/2005	Demopolis	FLB	152	multi	10*	929	10.2	m
3/13/2005	Demopolis	FLB	127	mono	12*	955	11.4	m
3/13/2005	Demopolis	FLB	152	multi	9	991	12.8	m
3/13/2005	Demopolis	FLB	127	mono	12*	998	13.4	m
3/13/2005	Demopolis	FLB	127	mono		1048	20.1	f
3/21/2005	Demopolis	TWB	127	mono		654	3.2	
3/21/2005	Demopolis	TWB	127	mono		804	7.7	f
3/21/2005	Demopolis	TWB	127	mono	5*	806	7.2	m
3/21/2005	Demopolis	TWB	127	mono	5*	811	7.3	m
3/21/2005	Demopolis	TWB	127	mono		816	7.6	f
3/21/2005	Demopolis	TWB	127	multi	5	817	7.7	m
3/21/2005	Demopolis	TWB	127	mono		820	7.9	f
3/21/2005	Demopolis	TWB	152	multi		822	8.2	f
3/21/2005	Demopolis	TWB	127	multi		823	8.8	f
3/21/2005	Demopolis	TWB	127	mono		835	8.8	f
3/21/2005	Demopolis	TWB	127	mono	6*	846	7.4	m
3/21/2005	Demopolis	TWB	127	mono	7*	849	7.6	m
3/21/2005	Demopolis	TWB	127	mono		851	9.4	f
3/21/2005	Demopolis	TWB	127	mono		858	10.1	f
3/21/2005	Demopolis	TWB	127	mono		860	10.2	f
3/21/2005	Demopolis	TWB	127	mono	6*	861	7.9	m
3/21/2005	Demopolis	TWB	127	multi		861	9.9	f
3/21/2005	Demopolis	TWB	127	mono	7*	864	8.3	m
3/21/2005	Demopolis	TWB	127	multi	7*	872	9.0	m
3/21/2005	Demopolis	TWB	127	mono	8	882	9.6	m
3/21/2005	Demopolis	TWB	127	mono	8	897	9.7	m
3/21/2005	Demopolis	TWB	127	mono		898	11.1	f
3/21/2005	Demopolis	TWB	127	mono	10	912	10.0	m
3/21/2005	Demopolis	TWB	127	mono		912	10.7	f
3/21/2005	Demopolis	TWB	127	mono		915	11.8	f
3/21/2005	Demopolis	TWB	127	mono		932	10.8	f

TABLE C1 (continued).

DATE	LAKE	HABITAT	MESH	TYPE	AGE	EFL	WEIGHT	SEX
3/21/2005	Demopolis	TWB	127	mono		933	11.8	f
3/21/2005	Demopolis	TWB	127	mono		935	12.2	f
3/21/2005	Demopolis	TWB	127	mono		939	14.0	f
3/21/2005	Demopolis	TWB	127	mono		942	11.2	f
3/30/2005	Demopolis	FLB	152	mono	5	808	6.7	m
3/30/2005	Demopolis	FLB	102	mono	5*	817	6.7	m
3/30/2005	Demopolis	FLB	152	mono	5	834	7.0	m
3/30/2005	Demopolis	FLB	127	mono		869	9.7	f
3/30/2005	Demopolis	FLB	127	mono	7	892	8.6	m
3/30/2005	Demopolis	FLB	102	mono		910	10.6	f
3/30/2005	Demopolis	FLB	102	mono		940	14.5	f
3/30/2005	Demopolis	FLB	152	mono		964	14.4	f
3/30/2005	Demopolis	FLB	152	mono		1078	19.5	f
3/31/2005		NOX	102	mono		982	14.5	m
4/6/2005	Demopolis	FLB	102	mono	8	876	8.9	m
4/6/2005	Demopolis	FLB	102	mono	7	880	8.5	m
4/16/2005	Demopolis	FLB	152	mono		883	8.9	f
4/16/2005	Demopolis	FLB	102	mono	9*	915	10.2	m
4/20/2005	Demopolis	FLB	127	multi	5	771	6.3	m
4/20/2005	Demopolis	FLB	127	multi	6*	853	6.9	m
4/20/2005	Demopolis	FLB	102	mono	8	865	8.9	m
4/20/2005	Demopolis	FLB	152	multi	7	874	8.1	m
4/20/2005	Demopolis	FLB	127	multi	8*	895	8.5	m
4/20/2005	Demopolis	FLB	102	mono	10*	930	9.0	m
4/20/2005	Demopolis	FLB	102	mono		931	12.4	f
4/20/2005	Demopolis	FLB	127	multi	10*	934	9.0	m
4/22/2005	Demopolis	TWB	152	mono	3	648	4.0	m
4/22/2005	Demopolis	TWB	127	multi		651	3.7	
4/22/2005	Demopolis	TWB	127	multi		680	4.0	
4/22/2005	Demopolis	TWB	127	multi	5*	791	6.6	m
4/22/2005	Demopolis	TWB	127	multi	4	811	8.3	m
4/22/2005	Demopolis	TWB	127	multi	6	813	7.2	m
4/22/2005	Demopolis	TWB	127	multi		820	6.8	f
4/22/2005	Demopolis	TWB	127	multi	6	840	7.3	m
4/22/2005	Demopolis	TWB	127	multi		854	7.2	f
4/22/2005	Demopolis	TWB	127	multi		856	9.4	f
4/22/2005	Demopolis	TWB	152	multi	8	880	9.3	m
4/22/2005	Demopolis	TWB	127	multi	7	883	8.0	m
4/22/2005	Demopolis	TWB	127	multi		898	9.8	f
4/25/2005	Demopolis	FLB	127	multi	6	836	7.5	m
4/25/2005	Demopolis	FLB	127	multi	8	850	8.0	m
4/25/2005	Demopolis	FLB	127	mono		872	8.7	
4/25/2005	Demopolis	FLB	127	multi	8	872	10.0	m
4/25/2005	Demopolis	FLB	127	multi		903	10.5	f

TABLE C1 (continued).

DATE	LAKE	HABITAT	MESH	TYPE	AGE	EFL	WEIGHT	SEX
4/25/2005	Demopolis	FLB	127	multi	7	928	9.4	m
4/25/2005	Demopolis	FLB	127	multi	12	953	10.6	m
4/25/2005	Demopolis	FLB	127	multi	12*	970	12.1	m
4/25/2005	Demopolis	FLB	127	multi	12	974	12.0	m
4/25/2005	Demopolis	FLB	127	multi		990	13.8	f
5/6/2005	Demopolis	FLB	102	multi		716	4.7	
5/6/2005	Demopolis	FLB	127	multi	4	730	4.9	m
5/6/2005	Demopolis	FLB	127	multi		745	5.8	
5/6/2005	Demopolis	FLB	152	multi		765	6.1	
5/6/2005	Demopolis	FLB	152	multi		768	6.1	
5/6/2005	Demopolis	FLB	102	multi	4	790	5.4	m
5/6/2005	Demopolis	FLB	127	multi	5*	804	6.7	m
5/6/2005	Demopolis	FLB	102	multi	7	834	7.3	m
5/6/2005	Demopolis	FLB	127	multi	6*	843	8.2	m
5/6/2005	Demopolis	FLB	127	multi		856	9.6	f
5/6/2005	Demopolis	FLB	152	multi	6	856	8.5	m
5/6/2005	Demopolis	FLB	127	multi		860	7.7	f
5/6/2005	Demopolis	FLB	127	multi	6	875	8.4	m
5/6/2005	Demopolis	FLB	127	multi	7*	885	10.1	m
5/6/2005	Demopolis	FLB	152	multi	8*	896	9.2	m
5/6/2005	Demopolis	FLB	152	multi	8*	900	9.6	m
5/6/2005	Demopolis	FLB	127	multi	8*	906	10.2	m
5/6/2005	Demopolis	FLB	127	multi		912	9.6	f
5/6/2005	Demopolis	FLB	127	multi		914	9.2	f
5/6/2005	Demopolis	FLB	102	multi		918	10.4	f
5/6/2005	Demopolis	FLB	127	multi	9	920	10.0	m
5/6/2005	Demopolis	FLB	127	multi		952	11.9	f
5/6/2005	Demopolis	FLB	127	multi		960	13.5	f
5/6/2005	Demopolis	FLB	152	multi		963	12.3	f
5/6/2005	Demopolis	FLB	127	multi	12*	1034	14.9	m
5/10/2005	Demopolis	TWB	127	multi		639	3.9	
5/10/2005	Demopolis	TWB	127	multi		717	5.2	
5/10/2005	Demopolis	TWB	127	multi		745	5.8	
5/10/2005	Demopolis	TWB	127	multi		751	6.1	f
5/10/2005	Demopolis	TWB	127	multi	4*	775	6.8	m
5/10/2005	Demopolis	TWB	127	multi		782	7.0	f
5/10/2005	Demopolis	TWB	127	multi	6	805	7.1	m
5/10/2005	Demopolis	TWB	127	multi	6	813	7.7	m
5/10/2005	Demopolis	TWB	127	multi	7	820	7.3	m
5/10/2005	Demopolis	TWB	127	multi	6	822	8.0	m
5/10/2005	Demopolis	TWB	127	multi	6	845	7.9	m
5/10/2005	Demopolis	TWB	127	multi		846	10.2	
5/10/2005	Demopolis	TWB	152	multi	6	849	8.4	m
5/10/2005	Demopolis	TWB	152	multi	7	850	8.4	m

TABLE C1 (continued).

DATE	LAKE	HABITAT	MESH	TYPE	AGE	EFL	WEIGHT	SEX
5/10/2005	Demopolis	TWB	127	multi		852	9.9	f
5/10/2005	Demopolis	TWB	127	multi		860	9.3	f
5/10/2005	Demopolis	TWB	127	multi		868	8.9	f
5/10/2005	Demopolis	TWB	127	multi		873	8.5	
5/10/2005	Demopolis	TWB	127	multi	7	876	9.2	m
5/10/2005	Demopolis	TWB	127	multi		880	8.6	f
5/10/2005	Demopolis	TWB	152	multi		882	9.0	f
5/10/2005	Demopolis	TWB	127	multi	6	888	8.6	m
5/10/2005	Demopolis	TWB	127	multi		910	10.0	f
5/10/2005	Demopolis	TWB	127	multi		914	10.1	f
5/10/2005	Demopolis	TWB	127	multi		955	12.8	f