The Case for Multi-jurisdictional Management of Ohio River Paddlefish

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Abstract: The paddlefish *(Polyodon spathula)* population in the Ohio River Basin is an inter-jurisdictional resource shared by 8 states and managed with 3 different strategies, restoration, protection, and harvest. These contrasting management strategies evolved from a historical gradient in abundance of paddlefish from the upper to lower reaches, differential impact of anthropogenic factors, and U.S. Supreme Court settlements, which changed river ownership among lower Ohio River states. Ohio River Basin states participated in a national paddlefish study during 1995–1999 verifying movement of paddlefish across state boundaries in the Ohio River. Recognition that paddlefish likely represent a single population within the Ohio River and consideration of the value and vulnerability of paddlefish as a source of caviar has created a need for comprehensive and cooperative management of paddlefish among Ohio River states.

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The Ohio River forms in Pittsburgh, Pennsylvania, at the confluence of the Allegheny and Monongahela rivers and flows 1,582 km to Cairo, Illinois. A total of 69 tributaries with drainages exceeding 2,600 km^2 enter the Ohio River as it flows through Pennsylvania, West Virginia, Ohio, Kentucky, Indiana, and Illinois (Fig. 1). The Tennessee, Wabash, and Cumberland rivers are the largest tributaries in the basin, and account for approximately 20%, 16%, and 9% of the watershed, respectively (Ohio River Valley Sanitation Commission. (2000). <http://www.orsanco.org>). Approximately 159 fish species are found within the Ohio River and 285 are found within the basin (Wallus et al. 1990). Species composition has changed dramatically during the past century due to dam construction, pollution, and pollution abatement (Pearson and Krumholz 1984).

Paddlefish *(Polyodon spathula)* are native to the Ohio River Basin of the Mississippi River drainage, a linear distance that accounts for 20,856 km or 22.3% of paddlefish habitats within the remaining distribution of their original range. Habitat degradation, exploitation by sport and commercial fishers, and poaching have impacted paddlefish in the majority of their range for the past 100 years (Graham 1997). Status and management of paddlefish in the Ohio River Basin varies among states. Paddlefish are listed as extirpated in the extreme upper river in New York and Pennsylvania, protected in the upper to mid-river reaches by threatened status in Ohio, and protected status in West Virginia and legal for sport and commercial harvest in the middle to lower-river reaches of Kentucky, Indiana, Illinois, and Tennessee (Fig. 1).

Different perspectives toward the status and management of paddlefish have developed due to historical differences in paddlefish abundance, the impact of watershed and river development, and United States Supreme Court settlements, which changed river ownership among lower Ohio River states. Paddlefish were reported to be more abundant in the lower river than the upper river prior to significant river alteration according to an 1882 account by David Starr Jordan (Pearson and Krumholz 1984). These longitudinal differences in relative abundance set the stage for the differential impact of human development on the Ohio River and the paddlefish popula-

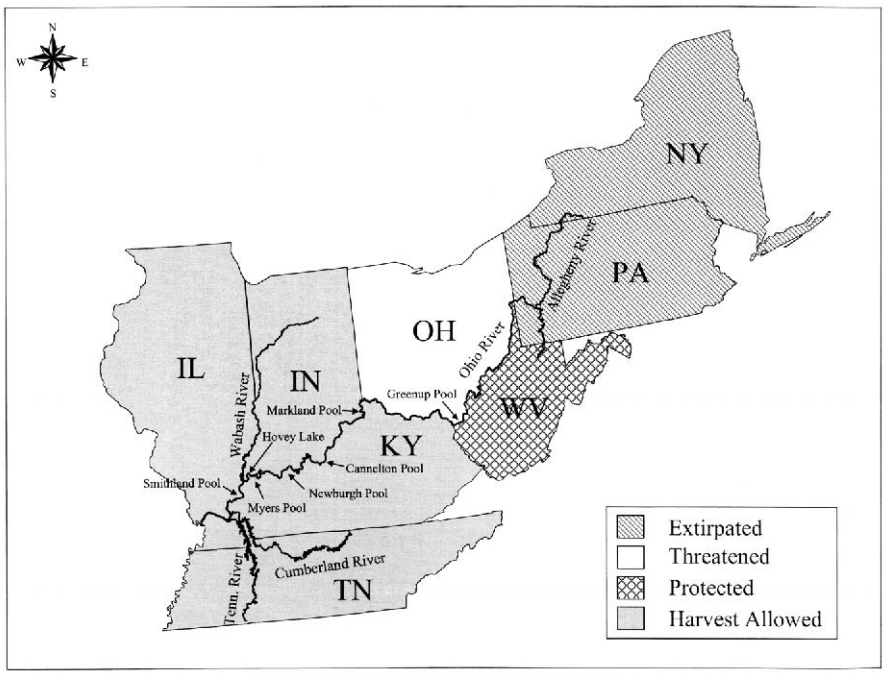

Figure 1. Eight states sharing the Ohio River Basin and current status of paddlefish within each state.

tion. Settlement of the Ohio River Valley during the following century resulted in conspicuous declines in paddlefish abundance, particularly in the upper river due to the impact of pollution, siltation, and dam construction on the mainstem and tributaries (Trautman 1981). Recent U.S. Supreme Court rulings were the final component that shaped differences in paddlefish management among border states. Prior to 1985, jurisdiction of the Ohio River belonged only to Pennsylvania (river kilometer [rk] 0–64.4), West Virginia (rk 64.4 to 510.0), and Kentucky (rk 510.0 to 1578.0). However, concurrent jurisdiction of the Ohio River was established between Ohio, Indiana, and Illinois with Kentucky along respective borders through U.S. Supreme Court decisions on 15 April 1985 (Ohio v. Kentucky, 471 U.S. 153), 4 Nov 1985 (Indiana v. Kentucky, 474 U.S. 1), and 28 May 1991 (Illinois v. Kentucky, 500 U.S. 380, No. 106, Orig.). Following these settlements, each state independently managed paddlefish based on limited information, new ownership, and different perspectives. These differences were an immediate concern among management agencies because separate management units, or stocks, are unlikely to exist in the Ohio River Basin, the Ohio River, its tributaries, or navigational pools, and paddlefish are extremely vulnerable to habitat alterations and exploitation.

Trends in paddlefish harvest during the past 20 years are unknown within the Ohio River. Carlson and Bonislawsky (1981) reported that commercial harvest of Ohio River paddlefish declined from 1950–1980 and indicated that basin harvest from the Tennessee and Cumberland rivers has historically represented a large portion of the total harvest in the United States. High egg prices during 1984 and 1985 ($110/kg) had encouraged harvest, but reintroduction of Iranian sturgeon caviar to the market in 1986 reduced egg prices to $44/kg and fishery activity declined (Hoffnagle and Timmons 1989). Timmons and Hughbanks (2000) observed improvements in the lower Tennessee River by 1992, where they estimated 3–year exploitation rates of 14.4%, a decrease in total annual mortality to 22%, and an increase in population size and age structure.

Recent Concerns

Historical trends which indicate that the demand for paddlefish roe has been inversely related to the availability of sturgeon roe since the early 20th century threaten paddlefish populations (Carlson and Bonislawsky 1981, Pasch and Alexander 1986). Several species of sturgeon throughout the world and paddlefish in North America are the source of caviar, a highly sought culinary product. Caviar producers in the United States have renewed interest in the paddlefish as a domestic caviar source since the decline and possible closure of the Caspian Sea fishery (Birstein et al. 1997, Khodorevskaya et al. 1997). Recent prices of paddlefish eggs ($200/kg wholesale; $423/kg retail) suggest that exploitation may soon increase to levels of concern without cooperative management of sport and commercial harvest throughout the range of paddlefish.

Concerns related to the reduced sturgeon stocks and paddlefish exploitation were compounded by a general lack of information about paddlefish within much of

their native range during the past decade (Graham and Rasmussen 1999). These concerns prompted international listing of paddlefish as an Appendix II species under the Convention on International Trade in Endangered Species and Wild Fauna and Flora Treaty (CITES) in 1992 (De Meulenaer and Raymakers 1996) and the development of a national paddlefish research project (Oven and Fiss 1996). The CITES treaty is an agreement among 145 nations to protect plant and animal species from unregulated international trade. Appendix II listing applies an export permit process to regulate trade in species not threatened with extinction but which may become threatened if trade goes unregulated. In 1995, the Mississippi Interstate Cooperative Resource Association (MICRA), a consortium of 28 states that shares Mississippi River Basin resource management concerns, initiated a national paddlefish study that involved 22 states in a mark and recapture project to learn more about paddlefish movement and exploitation. Biological and macro-economic factors necessitated a better understanding of paddlefish fisheries and the caviar trade, and these two approaches were the first steps.

The overwhelming documentation of paddlefish movement between pools of large river systems (Russell 1986), the unlikely genetic distinctions among Mississippi River Basin populations (Carlson et al. 1982, Epifanio et al. 1996), and the vulnerability of paddlefish to overexploitation (Boreman 1997) indicated the need for an inter-jurisdictional management perspective in the Ohio River Basin. The Ohio River Fish Management Team (ORFMT), a cooperative organization of fish managers from the state fish and wildlife agencies of Pennsylvania, Ohio, West Virginia, Kentucky, Indiana, and Illinois was organized in 1990 to develop shared fisheries management objectives and work on projects of mutual benefit within the Ohio River. The Team recognized the paddlefish as being vulnerable to exploitation due to the volatility of the global caviar market and became involved in the MICRA National Paddlefish Study. An ORFMT technical group was tasked with summarizing MICRA study data and developing a paddlefish management plan for the Ohio River Basin.

We thank the administrative leadership in the Ohio River Fish Management Team for the opportunity to participate in the MICRA National Paddlefish Study and to form a technical group to address paddlefish issues in the Ohio River Basin. We thank G. Conover and J. Grady, U.S. Fish and Wildlife Service (USFWS), for years of assistance with the MICRA paddlefish project database reflected in this report. We recognize K. Graham, Missouri Department of Conservation, and J. Rasmussen, USFWS, for many years of coordination of the MICRA Paddlefish-Sturgeon Subcommittee and their concern for paddlefish, sturgeon, and big-river issues. We thank D. Carlson, New York State Department of Environmental Conservation; R. Lorson, Pennsylvania Fish and Boat Commission; and R. Todd, Tennessee Wildlife Resource Agency for providing information and insights from their respective states. We are grateful for assistance from J. Field, USFWS, who provided information about the CITES permitting process, and the sport and commercial fishers who provided field data. Also, we thank D. Bunnell, Kentucky Department of Fish and Wildlife Resources, for his assistance with the Ohio River Basin figure.

Methods

Paddlefish stocking and restoration information were acquired from individual Ohio River states, whereas commercial and sport harvest data were collected from commercial fishing reports and cooperative field collections with fishers. The Kentucky Department of Fish and Wildlife Resources obtained sub-samples of sport and commercial catches from which to estimate ages of harvested paddlefish. Samples from a sport fishery were obtained from the Markland Tailwater (rk 855.2) during May 1996 and samples from the commercial fishery were obtained from the McAlpine (rk 976.3) and Cannelton (rk 1159.6) tailwaters during spring 1996. Dentary bones were sectioned and the age of each fish was determined by counting annuli with procedures described by Scarnecchia et al. (1996).

Wild paddlefish were sampled and data were collected during a multi-state, multi-basin paddlefish study from 1995 through 1999 according to protocols developed by the MICRA Paddlefish and Sturgeon Sub-committee to estimate movement and exploitation (Oven and Fiss 1996). Biologists within the Ohio River Basin collected paddlefish with electrofishing and entanglement gear, measured paddlefish weight (kg) and eye-fork length (mm), and tagged as many fish as possible in the anterior portion of the rostrum with sequential coded wire tags (CWT) to provide unique identification. Tagging location of each fish was recorded using river charts, quadrangle maps, or global positioning systems. Biologists checked all captured fish for the presence of tags during each sampling event, but additional fish were sought to test for the presence of tags through commercial and sport fishers. Fishers were encouraged to return all paddlefish rostrums from harvested fish via a reward system.

Paddlefish stocked in the Ohio River Basin during 1995–1999 were also tagged with CWT by methods described by Oven and Fiss (1996) to determine their movement, exploitation, and contribution to the fishery. These fish were tagged in the anterior portion of the rostrum similar to wild fish, but batch tags were used instead of sequentially numbered individual tags.

All field sampling data and tag recapture data were submitted to a central processing center and later distributed to project biologists. Length-frequency distributions were established from 127-mm mesh entanglement gear catches and summarized by four general locations. These included the Ohio River mainstem (all pools combined), Hovey Lake, a limited access backwater area in the Myers Pool, Ohio River, and the Wabash and Cumberland rivers, which are 2 major tributaries in the lower Ohio River (Fig. 1). Relative weight (Wr) was calculated for 5 length categories of paddlefish <600 mm, 600–799 mm, 800–999 mm, and >999 mm, and all lengths combined using equations proposed by Brown and Murphy (1993).

Results and Discussion

State Management Perspectives

Protection. Paddlefish are protected from harvest in the upper basin states of New York, Pennsylvania, West Virginia, and Ohio. None of these states allows har-

vest because restoration efforts are in place or they consider populations sustainable only with protection from harvest. Ohio is furthest down river among these states and does not believe that restoration is necessary given current information, whereas the upper states have initiated annual stocking to enhance or restore populations.

Restoration. Paddlefish restoration and stocking programs are management approaches used primarily in the upper Ohio River Basin. Five of 8 states in the Ohio River Basin have stocked 237,533 paddlefish since 1986. The New York State Department of Environmental Conservation initiated a recovery plan in 1998 to re-establish paddlefish. A total of 713 paddlefish were stocked in New York between 1998 and 2000 and stocking will continue through at least 2002. Paddlefish were originally present in the Upper Allegheny River, New York, before 1900. Restoration and stocking efforts began in Pennsylvania in 1991 in response to improved water quality that appeared to aid the recovery of other native fishes. The Pennsylvania Fish and Boat Commission has stocked 70,417 paddlefish in the upper reaches of the Ohio and Allegheny rivers since that time to develop self-sustaining resident paddlefish. The West Virginia Division of Natural Resources is conducting supplemental stockings to restore paddlefish to levels that will permit sport fisheries. Stocking began in West Virginia in 1992 and since then 11,537 paddlefish have been stocked in the Ohio and Kanawha rivers. These stockings are planned to continue indefinitely. In 1986, the Ohio Division of Wildlife stocked 107 paddlefish in Deer Creek and the Scioto River, tributaries of the Ohio River, but did not plan to resume stocking. The Tennessee Wildlife Resources Agency (TWRA) has stocked the largest number of paddlefish in the basin, but is the only state within the basin that stocks and permits sport and commercial harvest. During 1986–1997, TWRA stocked 154,889 paddlefish throughout the Tennessee and Cumberland river drainages.

Harvest. Both sport and commercial fisheries are sources of harvest in the Ohio River Basin. Substantial sport paddlefish fisheries exist below several dams in the Ohio River, particularly on the Kentucky border of Greenup and Meldahl pools, and both borders of the Markland, McAlpine, and J.T. Myers pools. Several smaller fisheries exist near the mouths of tributaries such as the Kentucky River in Kentucky and Laughery Creek in Indiana. Anglers caught a minimum of 504 paddlefish in the Markland Tailwater during 1997. Mean length at harvest of 57 paddlefish was 78 cm (eye-fork length). Female paddlefish lengths ranged from 58 to 94 cm (ages 5–13 years) and averaged 79 cm (10.0 years). Male paddlefish lengths ranged between 68–90 cm (ages 7–12 years) and averaged 76 cm (9.6 years).

The commercial paddlefish fishery in the Ohio River Basin is a unique artisanal fishery due to the value of paddlefish eggs as caviar, which far exceeds the value of flesh as food. Paddlefish flesh harvest from the Ohio River Basin, based on a historical price of $1.10/kg paid to commercial fishers for whole fish, was valued at $69,616 in 1999 and $175,020 in 2000 with significant variation in retail price depending upon the market. The estimated value of the egg harvest based on a historical price range of $100–200 per kg paid to fishers was $273,300–$546,600 in 1999 and $1,007,100–$2,014,200 in 2000. The retail price on 2000 of paddlefish caviar (smallest quantity of order) was approximately $423/kg (Artistoff Caviar (2000)

<http://www.aristoff.cavair.com>; Caviar Start (2000) <http://www.caviarstar.com; North Star Caviar (2000) <http://www.northstarcaviar.com>) which suggested that the market value of the harvest was approximately $1,156,059 in 1999 and $4,260,033 in 2000.

Combined commercial harvest of flesh and eggs for Kentucky, Indiana, and Illinois increased dramatically from 1999 to 2000. Flesh harvest increased from 63,827 kg to 159,109 kg and egg harvest increased from 2,733 kg to 10,071 kg. The estimated average size at harvest was 5.45 kg, 710 mm, and age at harvest of 8.5 years. Approximately 11,711 paddlefish were harvested in 1999, but increased dramatically to 29,194 paddlefish in 2000. A minimum of 9 age groups were represented in the catch and paddlefish fully recruited to the fishery between ages 8 and 9. The increased harvest during 2000 was a reflection of increased effort and greater catch rates compared to the previous year in the Ohio River. Ohio River fishers licensed by the Kentucky Department of Fish and Wildlife Resources harvested approximately 0.03 fish/m of net in 313,323 m of gillnets during 1999 and 0.06 fish/m of net in 419,750 m of gillnets during 2000.

Paddlefish are primarily harvested during late winter and spring. Monthly harvest records from Kentucky and Indiana identified March and April as the period of greatest harvest, although harvest was also significant during October, November, and December (Fig. 2). During 1999, 34% of the annual flesh harvest was during March and April, when 43% of the annual egg harvest was taken. The second greatest activity period during 1999 was November and December when 31% of the annual flesh harvest and 32% of the annual egg harvest were taken. In 2000, a much greater percentage of flesh (45%) and eggs (67%) were taken during March and April than in the fall and winter months compared to 1999.

Movement

Mark and recapture of paddlefish during the MICRA study indicated that paddlefish are capable of extensive inter-pool movement, movement between the backwaters and the mainstem, and movement from the backwaters to the tributaries. These results provided solid evidence that the paddlefish within the Ohio River, and likely the entire basin, should be viewed as a single population. Biologists in the Ohio River Basin tagged 4,191 wild paddlefish during 1995–1999. Forty percent of these fish were tagged in pools of the Ohio River, 27% in Hovey Lake, 24% in the Wabash River, and 7% in the Cumberland River. Less than 2% of fish within the basin were tagged in other areas. Recoveries of tags were primarily from biologists (70%) and commercial fishers (29%). Overall recapture rate during 1995–1999 was 4.6%, and was 2.6% in the Ohio River, 6.9% in the Wabash River, 5.5% in the Cumberland River, and 7.5% in Hovey Lake. All recaptures were initially captured and tagged within the Ohio River Basin, and no Ohio River Basin tagged-paddlefish have been reported from either the Mississippi River or Missouri River systems (Table 1). The majority of recovered paddlefish were captured within 2 years of initial tagging (0–1, 20%; 1–2, 44%; 2–3, 23%).

Five hatchery-reared paddlefish were recovered from among those stocked by

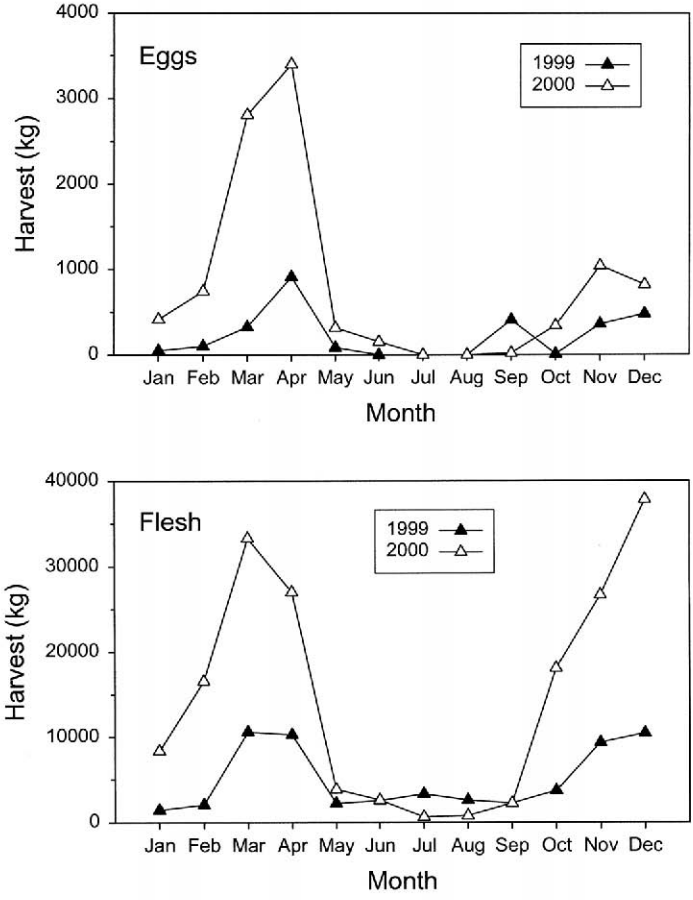

Figure 2. Monthly harvest of paddlefish eggs and flesh by commercial fishers in Kentucky and Indiana, 1999 and 2000, Ohio River Basin.

West Virginia. These fish were recaptured near the original release sites. Two of the recaptures were collected within 30 days of release, and 1 was collected within 5 months of release. The remaining 2 fish were recaptured 1.5 and 2.5 years following release and within the same reach of river.

Recaptured paddlefish were not consistently found either upstream or downstream of tagging sites, although tagging results provided only endpoints of movement rather than movement histories. Of the 192 paddlefish recovered, 32 moved upstream, 14 moved downstream and 133 were recovered near original tagging locations (Table 1). Thirteen recaptured paddlefish were of unknown tagging or recapture locations. Two recaptured individuals showed extensive movement. One

Table 1. Tagging and recapture locations for paddlefish in the Ohio River, Hovey Lake, Wabash River, and Cumberland River, Ohio River Basin, 1995–1999.

	Location Tagged									
Location recaptured	Smithland	Newburgh	Cannelton	Markland	Greenup	Hovey Lake	Wabash River	Cumberland River	Unknown	Total
Ohio River										
—Smithland						2				2
—Newburgh	2	7	1			17				27
—Cannelton		3	5	2	1	3				14
—Markland	1		3	36					1	41
Hovey Lake	2	1	2	3		56	1			65
Wabash River						2	24			26
Cumberland River								5		5
Unknown	1		3	3		1		4		12
Total recaptured	6	11	14	44	1	81	25	9	1	192

paddlefish was tagged in the Smithland Pool and was recovered 5 pools upstream in Markland Pool having traveled a minimum of 483 km and passing through 5 high-lift navigation dams. Another paddlefish was tagged in the Greenup Pool and was subsequently recovered 5 pools downstream in the Cannelton Pool, an estimated distance of 526.2 km. Eighty-one paddlefish originally tagged in Hovey Lake were later recovered. Fifty-six of these fish were recaptured in Hovey Lake, but 20 displayed upstream movement and 2 moved downstream. Two of these fish were recaptured in the Wabash River.

Paddlefish are known to move through navigation dams and are capable of traveling great distances. Of the 192 paddlefish recaptured in this study, 46 were found outside the original tagging pool and 70% of these fish had moved upstream through navigation structures. This contrasted markedly with several telemetry studies that found paddlefish in large rivers moving downstream through partially closed dam gates, yet limited upstream movements during high-flow conditions when dam gates were completely open (Southall and Hubert 1984, Johnson et al. 1997). Moen et al. (1992) noted that paddlefish under low flow conditions moved downstream but did not move upstream even when a lock and dam was fully opened for 10 days. However, most of the upstream movement in this study occurred in the lower area of the Ohio River (Kentucky portion). Dam gates are frequently lifted during high-water events (run of the river) which allows paddlefish movement. The dam gates further up the Ohio River (from West Virginia upstream) are less frequently raised, thus restricting paddlefish movement.

Paddlefish had been tagged in 6 major Ohio River tributaries, but recaptures occurred from only 3 systems (Table 1). All fish recovered from the Cumberland River system were initially tagged within that system and within close proximity of the tagging site. Wabash River tagged paddlefish were recovered primarily within that system (24 of 25) with 1 fish recaptured in Hovey Lake.

Length Frequency

The length frequency of paddlefish differed among the 4 primary sampling areas, but given the movement results from our tagging data, we believe that differences represent different habitat use patterns related to fish size rather than distinct populations. Fish were consistently largest in Hovey Lake and smallest in the Wabash River (Fig. 3). Combined length-frequency distributions from 1995–1999 suggested that paddlefish size structure was not severely truncated after recruitment to the gear in the Ohio or Cumberland rivers, but few larger fish were apparent in the Wabash River. However, annual length-frequency distributions of paddlefish captured with 127–mm mesh within the Ohio River became progressively more truncated from 1995 to 1999 (Fig. 4). The frequency of large fish captured was lowest during 1999. Likewise, the size structure of paddlefish captured with 127-mm mesh within the Ohio River, and a sub-set of Ohio River data that included only Hovey Lake, indicated similar patterns. Sufficient data were not available from the Wabash or Cumberland River for similar comparisons.

Condition

Relative weight differed very little among primary sampling locations within the Ohio River Basin during the survey period and supported the notion of a single population. Paddlefish of all sizes were in good condition based upon our results and mean relative weight consistently exceeded 95 for all sizes of paddlefish and locations. Within locations, Wr ranged from 95–99 among all size categories and indicated no consistent size-related trends.

Conclusions

Contrasting perspectives of paddlefish management evolved from a historical gradient in abundance of paddlefish from the upper to lower reaches, differential impacts of watershed and river alteration on paddlefish abundance, and river jurisdiction among Ohio River states. However, information collected by states in the Ohio River Basin during the MICRA National Paddlefish Study indicated that paddlefish within the basin should be managed as a single population. Tagging verified movement of paddlefish across state boundaries in the Ohio River and reinforced the importance of a multi-jurisdictional perspective of paddlefish management. Additional information provided by length-frequency distributions and condition factors within the basin also infers that separate management units or stocks are unlikely to exist. The ORFMT recognizes the paddlefish as a shared resource by the states of the Ohio River Basin. Each state is aware of the vulnerability of paddlefish to over-exploitation and habitat degradation. Efforts are being made by the ORFMT to address these varied management perspectives, i.e., protection, restoration, and harvest, to ensure the viability of paddlefish in the Ohio River Basin.

The need for inter-jurisdictional management in the Ohio River Basin prompted the ORFMT to develop a comprehensive paddlefish management plan. The plan ana-

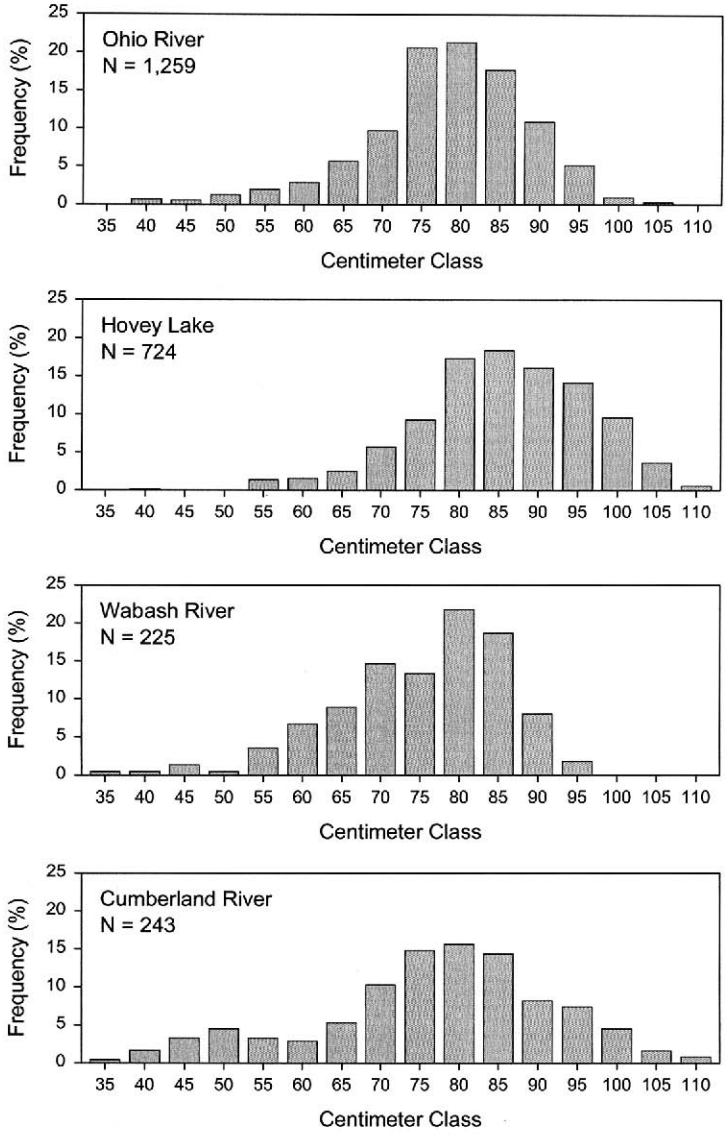

Figure 3. Length-frequency distributions of paddlefish sampled with 127–mm mesh gillnets in the Ohio River, Hovey Lake, Wabash River, and Cumberland River, Ohio River Basin, 1995–1999.

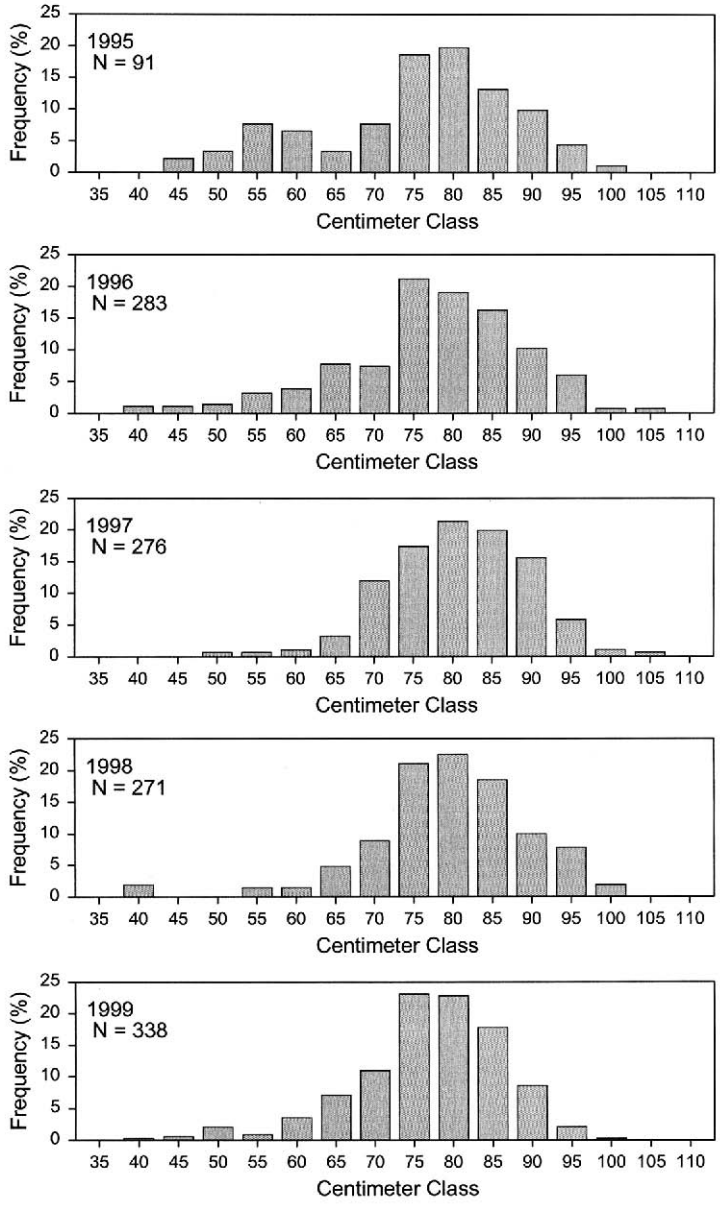

Figure 4. Length-frequency distributions of paddlefish sampled with 127–mm mesh gillnets, Ohio River, 1995–1999.

lyzes the current situation and scopes a course of action for paddlefish management within the basin. Recommendations of the management plan calls for states to establish full cooperation in the managing and monitoring of paddlefish throughout the Ohio River Basin, continued participation in the MICRA National Paddlefish Study, encourage states stocking paddlefish to use Ohio River broodstock to protect the genetic integrity of the stock, improve procedures for oversight and assessment of commercial fisheries, align sport harvest regulations among states permitting fisheries, and to monitor retail and wholesale prices of caviar and CITES exporting permits for paddlefish. Through this management plan, the ORFMT states hope to restore, enhance, and protect paddlefish in the Ohio River Basin by ensuring restoration and protection of paddlefish in the upper basin and providing sustainable sport and commercial use of paddlefish in the lower basin.

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