ALL AQUATIC SYSTEMS HABITATS NARRATIVE

Habitat description

This habitat is comprised of all water, both flowing and stationary, habitats in Indiana.

Problems affecting species and habitats

Species threats

Respondents ranked the following threats to wildlife in all aquatic systems habitats in Indiana:

Rank	Threats to wildlife in all aquatic systems habitats
1	Habitat loss (breeding range)
2	Habitat loss (feeding/foraging areas)
3	High sensitivity to pollution
4	Degradation of movement/migration routes (overwintering habitats, nesting and staging sites)
5	Dependence on irregular resources (cyclical annual variations) (e.g., food, water, habitat limited due to annual variations in availability)
6 (tie)	Specialized reproductive behavior or low reproductive rates
6 (tie)	Invasive/non-native species
7	Bioaccumulation of contaminants
8	Viable reproductive population size or availability
9	Predators (native or domesticated)
10	Diseases/parasites (of the species itself)
11	Unintentional take/ direct mortality (e.g., vehicle collisions, power line collisions, by-catch, harvesting equipment, land preparation machinery)
12	Dependence on other species (mutualism, pollinators)
13	Regulated hunting/fishing pressure (too much)
14	Small native range (high endemism)
15	Near limits of natural geographic range
16	Genetic pollution (hybridization)
17	Species overpopulation
18	Unregulated collection pressure
19	Large home range requirements

Appendix F-2: Aggregated Aquatic Systems

Respondents offered additional threats to wildlife in all aquatic systems habitats in Indiana (not ranked):

- River otters: As adjacent states initiate harvest seasons for otters, there might be added pressure to take otters accidentally trapped in Indiana across state lines to market fur. However, I wouldn't expect this to have a significant impact at a statewide or even regional scale
- Disturbance by recreational boating.
- Commercial over-exploitation resulting in low spawner stock abundance
- Egg predators predation, nutritional requirements, early mortality syndrome
- Stream channelization
- Threats to the orangethroat darter are related to threats to the habitat
    - It prefers high-functioning, high quality riffle habitat in headwater streams. Headwater streams, are not always given as much protection or value as larger rivers downstream
    - Threats to the species colonization, such as aquatic passage problems through culverts
    - Threats to the species watersheds, such as pollution, clearing of the riparian vegetation, creek gravel mining and channelization
- High stream flows for a few months following spawning can seriously reduce year class strength. Reducing ditching in headwaters, installing grass waterways and WASCOBS and maintaining riparian corridors and cut down this threat. All of these measures will slow stream flows and reduce siltation

Respondents listed top threats to wildlife in all aquatic systems habitats in Indiana (not ranked):

- Habitat loss, degradation and fragmentation
    - Of wetlands
    - Los due to urban sprawl and other development
    - Degradation of migration routes due to development
    - Loss of feeding areas: Many reservoirs are getting very old and the once abundant standing timber is now diminishing which is reducing cover for white crappie
    - Loss or degradation of brood-rearing and foraging areas
    - Annual and seasonal variations in habitat availability
    - Losses impact northern pike survival
    - Loss of undisturbed natural lake habitat
    - Loss of large nesting trees
    - Caused by instream modifications
    - Pike have suffered a major loss of spawning habitat due to the prevalence of dredging within the watershed. This practice along with levee construction has resulted in the near elimination of in-stream and emergent wetland vegetation
    - Some wildlife species requires shallow clear water with little current in weedy areas over gravel, sand, and silt to feed on insects and lay reproduce
    - Caused by dredging (removal of aquatic vegetation and increasing depth of ditch)
    - Cleaning and dredging streams of the Kankakee drainage can result in a large amount of creek heelsplitters being lost
    - Orangethroat darter
        - Threats to migration (aquatic passage problems through stream crossing structures)
        - Threats to breeding habitat (high quality riffles). Threats to riffle habitat result from water quality degradation and loss of stream channel stability due to land management activities such as dredging, channelization, roads and clearing riparian vegetation

  - Habitat loss and degradation are serious threats to rock bass. They prefer silt free streams to reproduce and thrive. They also relate closely to structure/cover therefore any habitat loss is a threat
  - Eastern Sand darter requires sandy bottoms in fast flowing streams to bury eggs, hide from predators, ambush prey, conserve energy, and maintain position in unstable/shifting sandbars
  - Slough darter prefers a mud or silt bottom with little current velocity and vegetation to deposit eggs on

- Pollution/degradation/water quality issues
  - River otters: Reproductive performance of otters can be compromised by high levels of PCBs, heavy metals, etc. that bioaccumulate in the aquatic food chain. Direct loss of aquatic habitats such as wetlands
  - Long-term declines in water quality associated with lake eutrophication
  - Cold, clear water is critical for cisco survival; increased runoff and nutrient loading have degraded the habitat for this species in many of the 50+ lakes it once occurred in. Few lakes still have the species, and there is apparently little to no reproduction
  - Sedimentation caused by heavy spring rains
  - Nonpoint sources runoff resulting from loss of riparian buffers due to development
  - The acute effects of toxicants are recognized as a threat to organisms, but there is little knowledge on ecosystems or regional effects on chronic insults. Toxicants are more destructive to the embrolarva stages, but these are poorly documented. Pollution controls do not have definite focus on chronic effects
  - Runoff due to agricultural practices
  - Hornyhead chub are sight-feeders and mound builders for spawning; thus, muddy water will hamper their chances of survival and if the silt covers gravel and their nest, chances for successful reproduction will be limited
  - Alterations of hydrology from land-use changes
  - Pollution within the Tippecanoe River system in Indiana
  - Point source pollution, which triggers fish kills or repels rock bass from the area

- Dependence on irregular sources
  - In many reservoirs, shad is the dominant forage base for crappie. If shad are growing extremely fast, crappie can only utilize shad for a short period of time before the shad outgrow the size crappie can consume

- Habitat management issues
  - Water level control regimes at impoundments
  - Mink: Although not habitat specific, the inability to responsibly and proactively manage mink according to the wildlife conservation model, as opposed to reactive measures through nuisance practices, is a concern regarding the conservation of mink. This concern applies across the landscape, not just in urban and suburban environments
  - Fish passage problems: dams on rivers block migration

- Competition with invasive or predator species
  - Gizzard shad
  - The deliberate stocking of predator fish in cisco lakes has been a threat to this species for years; if this hasn't been stopped, it needs to
  - Round goby
  - Hornyhead chub: Competition from other species better adapted to muddy and silty stream conditions
  - Extreme depredation by overabundant raccoons (on eggs), maybe by coyotes, too

  - Potential loss of adults to road kill and to rogue raccoons (kill adults for their eggs)
  - Slough darter compete with other darters for insects and have a high mortality due to stagnation and freezing in the pools they desire to live in.

- Human disturbance and impacts
  - Over harvest and illegal harvest (This doesn't seem to be a major threat as of now)
  - Heelsplitters: Unintentional take is a threat, as well as habitat alteration by dredging
  - Commercial type fishing devices: Trot lines, branch lines, big nets, other passive fishing

- Overpopulation

- Reproductive issues/small population size
  - Year class failure related to low spawner stock abundance; competition with nonnative species for limited available food resources
  - Lack of successful spawning, possibly related to bioenergetics. Too much egg predation
  - Any factor which reduces the reproductive population size
  - Eastern sand darters: Have low reproductive rates/small populations; they reach maturity at age one, but only lives a few years
  - Possible lack of reproductive success as indicated by poor length frequency distribution
  - Low reproductive rates: Males reach sexual maturity at two while females can reproduce at one; they only have a life span of about three years
  - Hellbenders have a small geographic range and population sizes in Indiana. In many locations there is concern about low reproductive rates, but this is unknown in Indiana populations
  - Extant population (if any) far below level for unassisted recovery
  - Very low recruitment
  - Nest/embryo/hatchling loss associated with attraction to row crop land for nesting
  - Insuring that populations maintain critical larva-host connections
  - Slough darters spawn few eggs so reproduction is lower in places where vegetation is lacking

- Dependence on other species
  - Heelsplitters require fish host to reproduce; if fish populations decrease for any of a variety of reasons, then creek heelsplitter reproduction could decrease substantially

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to wildlife in all aquatic systems habitats. There were no responses.

Habitat threats

Respondents ranked threats to all aquatic systems habitats in Indiana:

Rank	Threats to all aquatic systems habitats
1	Stream channelization
2	Habitat degradation

3	Nonpoint source pollution (sedimentation and nutrients)
4	Agricultural/forestry practices
5	Commercial or residential development (sprawl)
6	Point source pollution (continuing)
7	Drainage practices (stormwater runoff)
8	Habitat fragmentation
9	Impoundment of water/flow regulation
10	Residual contamination (persistent toxins)
11	Invasive/non-native species
12	Mining/acidification
13	Counterproductive financial incentives or regulations
14	Successional change
15	Climate change
16	Diseases (of plants that create habitat)

Respondents noted additional threats to all aquatic systems habitats in Indiana (not ranked):

- Competition with round goby for near-shore habitat
- Riparian corridor destruction. Loss of shading and sedimentation
- Sand and gravel operations could destroy preferred habitat

Respondents listed top threats to all aquatic systems habitats in Indiana (not ranked):

- Habitat loss, degradation and fragmentation
    - Affects beavers: Habitat loss caused by urban sprawl
    - Loss of wetland habitats reduces amount of suitable habitat for river otters
    - Modification of stream shoreline habitats
    - Affects crappie: Natural decomposition of flooded timber and woody debris is lessening the available cover for crappie. Siltation covers root wads left in the bottom of an impoundment, which eliminates useable crappie cover
    - Residential development around lake shorelines. Degradation of aquatic plants and wetlands around lake shorelines
    - Due to development: agricultural, urbanization and residential development
    - Successional change
    - Emergent bulrush and wetland habitat loss. It has been well documented in northern states that northern pike prefer flooded vegetation for spawning during the spring. Loss of this habitat from boating and wildlife (waterfowl and muskrat feeding) may reduce reproductive habitat for northern pike in some natural lakes
    - Bulkhead seawall development reduces emergent vegetation used by northern pike for reproduction and for cover during feeding
    - Shoreline and labeled alterations
    - Dams fragmenting habitat
    - Stream channelization removing nesting sites and destroying brood habitat. It removes and/or changes the vegetative and invertebrate communities.

    - Channelization also alters the natural water flow that results in a much degraded habitat
    - Loss of bottomland hardwoods continues to be a threat. These area provide a high quality food source and nesting sites for wood ducks
    - Loss of riparian corridor
    - Channelization of many streams in the upper Kankakee watershed
    - Affects eastern sand darter
    - Impoundments
    - Drain/cut off oxbow ponds
    - Trample sandbars or remove other nesting areas along banks
    - Row crop practices: crushing nests during ground insect/weed control
    - Crushing overwinter hatchlings during harvest and early spring plowing
    - Habitat degradation may be a factor, since there are large expanses in the Wabash and East Fork White River where relic valves are common, but the living species is absent
    - Habitat degradation and stream channelization as development continues in the Ohio River drainage habitat

- Regulations
    - Beaver: Regulations that allow loss of habitat. The human/beaver interface usually results with either the habitat being eliminated or the beaver being eradicated
    - Regulation of impounded water: Extreme water fluctuations in mainly U.S. Army Corps of Engineers reservoirs can negatively effect crappie populations especially if water fluctuations occur during spawning

- Water pollution/water quality
    - River otters: Water quality not only impacts otter reproduction, but may also impact the quantity/quality of aquatic prey for otters
    - Water quality degradation that leads to cloudy water
    - Soil runoff caused by poor agricultural practices and urban development
    - Nonpoint source

- Factors that affect food availability

- Competition with invasives and predators
    - Competition with non-native species for habitat. Need a quality place to live that is not in competition with round goby

- Identification of habitat along Indiana's near-shore area

- Invasive species/predators/competition
    - Specifically round goby interactions

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to all aquatic systems habitats. There were no responses.

Additional research and survey efforts

Current body of research

<u>Species research</u>

Appendix F-2: Aggregated Aquatic Systems

Thirty-eight percent of respondents stated that the current body of science is complete, up to date and extensive/adequate for wildlife in all aquatic systems habitats in Indiana; fifty-eight percent of respondents state that the current body of science is inadequate/nonexistent.

The respondent identified the following citations (title, author, date, publisher) that would give the best overview of wildlife in ALL Aquatic system habitats in Indiana.

Title: Atlas of Breeding Birds in Indiana
Author: Castrale, J.S., E. Hopkins, C.E. Keller
Date: 1998
Publisher: IDNR

Title = Amphibians and reptiles from 23 counties of Indiana.;
Author = Robert Brodman;
Date = 2003;
Publisher = Proceedings of the Indiana Academy of Science, 112: 43-54.

Title = Ten- to eleven-year population trends of two pond-breeding amphibian species, red-spotted newts and green frogs. In Status & Conservation of Midwester;
Author = Spencer Cortwright;
Date = 1998;
Publisher = University of Iowa Press, Iowa City

Title = Mammals of Indiana;
Author = Russell E. Mumford/ John Whitaker, Jr.;
Date = 1982;
Publisher = Bloomington Indiana University Press

Title = Indiana River Otter Reintroduction Program, 2000-2001;
Author = Scott A. Johnson;
Date = November 2001;
Publisher = Internal report, Indiana Department of Natural Resources, Bloomington, IN

Title = Restoring river otters in Indiana;
Author = Scott A. Johnson and Kim A. Berkley;
Date = 1999;
Publisher = Wildlife Society Bulletin 27:419-427.

Title = Many in AFS journal of fish management and transactions of AFS

Title = Impoundments Strategic Plan;
Author = IDNR - Fish and Wildlife;
Date = 1997;
Publisher = IDNR - Fish and Wildlife

Title = Ducks, Geese & Swans of North America;
Author = Frank C. Bellrose;
Date = 1976;
Publisher = Stackpole Books

Title = Waterfowl & Wetlands an Integrated review;
Author = Theodore A. Bookout;
Date = 1979;
Publisher = LaCrosse Printing

Appendix F-2: Aggregated Aquatic Systems

Title = Preliminary Results of 2004 Ball State University Yellow Perch Research in Indiana Waters of Lake Michigan;
Author = Paul Allen and Thomas Lauer;
Date = October 2004;
Publisher = Ball State University

Title = Yellow Perch Research and Management in Lake Michigan, Evaluating Progress in a Cooperative Effort, 1997-2001;
Author = David Clapp and John Dettmers;
Date = November 2004;
Publisher = American Fisheries Society, Fisheries

Title = Lake Trout Restoration Plan;
Date = In progress

Title = Lake Trout Impediments Document;
Author = Numerous,;
Date = 2003;
Publisher = Lake Trout Task group/LMTC

Title = Cisco population status and management in Indiana;
Author = Jed Pearson;
Date = 2001;
Publisher = Division of Fish and Wildlife

Title = Northern Pike Spawning Habitat Investigations At Two Natural Lake In Indiana;
Author = Cwalinski, Tim A.;
Date = September 2001;
Publisher = Indiana Department of Natural Resources

Title = DFW largemouth bass database;
Author = Jed Pearson;
Date = unpublished;
Publisher = unpublished

Title = Largemouth bass size limits at Indiana natural lakes - a 30-year history;
Author = Jed Pearson;
Date = 2003;
Publisher = unpublished

Title = Federal Recovery Plan;
Author = USFWS;
Date = 1991;
Publisher = USFWS

Title = Life history and propagation...;
Author = Jones & Neves;
Date = 2002;
Publisher = JNABS

Title = Freshwater mussels of Tennessee;
Author = Parmalee & Bogan;
Date = 1998;
Publisher = U of Tennessee Press

Title = Freshwater mussels of the Midwest;

Appendix F-2: Aggregated Aquatic Systems

Author = Cummings & Mayer;
Date = 1992;
Publisher = INHS

Title = Wabash River Catfish Reports;
Author = Rob Columbo;
Date = 2002,2003,2004,2005;
Publisher = SIU/INDFW

Title = numerous INDFW FMR's;
Author = numerous;
Date = numerous;
Publisher = INDFW

Title = annual Ohio River sauger reports;
Author = ORFMT;
Date = annually since 1999;
Publisher = ORFMT

Title = various INDFW FMR's;
Author = various;
Date = various;
Publisher = INDFW

Title = Occurrence and distribution of freshwater mussels in the small streams of Tippecanoe County, Indiana;
Author = Myers-Kinzie, M., S. Wente, & A. Spacie;
Date = 2001;
Publisher = Proc. Ind. Acad. Sci.

Title = Naiades of Pennsylvania;
Author = Ortmann;
Date = 1919;
Publisher = Carnegie Museum

Title = Freshwater Mollusca of WI;
Author = Baker;
Date = 1919;
Publisher = WI Geol. Nat. Hist. Surv.

Title = Fisheries Survey of the East Branch of the Little Calumet River Watershed;
Author = Neil Ledet;
Date = 1978;
Publisher = IDNR Fisheries Section

Title = Stream Survey of the East Arm of the Little Calumet River;
Author = Edward Braun;
Date = 1974;
Publisher = IDNR Division of Fish and Wildlife

Title = Fishery, Habitat, and Recreational Use Surveys for the Kankakee River;
Author = Price and Robertson;
Date = 2005;
Publisher = DNR - Division of Fish and Wildlife (in review)

Title = A fishery survey of the Kankakee River in Indiana;
Author = Robertson and Ledet;

Appendix F-2: Aggregated Aquatic Systems

Date = 1981;
Publisher = DNR - Division of Fish and Wildlife

Title = Amphibians and reptiles from 23 counties of Indiana.;
Author = Robert Brodman;
Date = 2003;
Publisher = Proceedings of the Indiana Academy of Science, 112: 43-54.

Title = Ecology and Management of the Wood Duck;
Author = Bellrose and Holm;
Date = 1994;
Publisher = Stackpole Books

Title = Ducks, Geese and Swans of North america;
Author = Bellrose;
Date = 1976;
Publisher = Stackpole Books

I'm am not aware of any literature on mink focused strictly to rivers and streams.

Title = Amphibians and reptiles from 23 counties of Indiana.;
Author = Robert Brodman;
Date = 2003;
Publisher = Proceedings of the Indiana Academy of Science, 112: 43-54.

Title = Naiades of Pennsylvania;
Author = Ortmann;
Date = 1919;
Publisher = Carnegie Museum

Title = Freshwater mussels of the Midwest;
Author = Cummings & Mayer;
Date = 1992;
Publisher = INHS

Title = Federal Recovery Plan;
Author = USFWS;
Date = 1993;
Publisher = USFWS

Title = Field guide to freshwater mussels of Midwest;
Author = Cummings & Mayer;
Date = 1992;
Publisher = INHS

Title = 'Clubshell';
Author = USFW, Division of Endangered Species;
Publisher = Online

Title = A survey of fish communities and aquatic habitats at Indiana's major steams with emphasis on smallmouth bass distribution and abundance;
Author = Stuart T. Shipman;
Date = 12/1997;
Publisher = DNR fisheries section

Appendix F-2: Aggregated Aquatic Systems

Title = A survey of fish communities and aquatic habitats at Indiana's major streams with emphasis on smallmouth bass distribution and abundance.;
Author = Stuart T. Shipman;
Date = December 1997;
Publisher = IDNR

Title = Surveys of the fish communties and aquatic habitats in 16 small streams in Indiana from 1996 through 1997.;
Author = Douglas C. Keller;
Date = 1999;
Publisher = IDNR

Title = The Fishes of Missouri;
Author = William L. Plieger;
Date = 1997;
Publisher = Missouri Conservation Commission

Title = Handbook of freshwater fishery biology;
Author = Kenneth D. Carlander;
Date = 1997;
Publisher = Iowa University Press

Title = fishes of Tennessee;
Author = Etnire and Starnes

Title = Fishes of Ohio;
Author = Milt Troutman;
Publisher = OSU Press

Title = FW fishes of Canada;
Author = Scott & Crossman

Title = A survey of fish communities and aquatic habitats at Indiana's major streams with emphasis on smallmouth bass distribution and abundance;
Author = Stuart Shipman;
Date = 12/1997;
Publisher = DNR/Fisheries section

Title = Surveys of the fish communties and aquatic habitats in 16 small streams in Indiana from 1996 through 1997.;
Author = Douglas C. Keller;
Date = 1999;
Publisher = IDNR

Title = Naiades of Pennsylvania;
Author = Ortmann;
Date = 1919;
Publisher = Carnegie Museum

Title = Freshwater mussels of the Midwest;
Author = Cummings & Mayer;
Date = 1992;
Publisher = INHS

Author = Minton;
Date = 2001

Author = reviewed in Minton;
Date = 2001
Title = (Numerous internet sites, including USF&W)

Title = Freshwater Mussels of the Midwest;
Author = Cummings & Mayer;
Date = 1992;
Publisher = Illinois Natural History Survey

Title = A survey of fish communities and aquatic habitats at Indiana's major streams with emphasis on smallmouth bass distribution and abundance;
Author = Stuart Shipman;
Date = 12/1997;
Publisher = DNR/Fisheries section

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the current body of science for wildlife in all aquatic systems habitats. There were no responses.

Habitat research

Twenty percent of respondents stated that the current body of science is adequate for all aquatic systems habitats in Indiana; seventy-two percent of respondents state that the current body of science is inadequate/nonexistent.

Respondents identified the following citations (title, author, date, publisher) that would give the best overview of ALL Aquatic systems habitats in Indiana.

Title = Mammals of Indiana;
Author = Russell E. Mumford;
Date = 1982;
Publisher = Bloomington Indiana University Press

Title = Soil Survey's of Indiana Counties;
Author = U.S. Dept. of Agriculture, SCS;
Date = 1990;
Publisher = U.S. Dept. of Agriculture

Title = Management of Seasonally Flooded Impoundments;
Author = Leigh H. Fredrickson, T. Scott Taylor;
Date = 1982;
Publisher = U.S. Fish and Wildlife Service

Title = Cisco population status and management in Indiana;
Author = Jed Pearson;
Date = 2001;
Publisher = Division of Fish and Wildlife

Title = Federal Recovery Plan;
Author = USFWS;
Date = 1991;

Appendix F-2: Aggregated Aquatic Systems

Publisher = USFWS

Title = Naiades of Pennsylvania;
Author = Ortmann;
Date = 1919;
Publisher = Carnegie Museum

Title = Freshwater Mollusca of WI;
Author = Baker;
Date = 1928;
Publisher = WI Geol. Nat. Hist. Surv.

Title = Ohio River Mainstem Study;
Author = USACOE;
Date = 2000?;
Publisher = USACOE

Title = Ohio River Mainstem Study;
Author = USACOE;
Date = 2000?;
Publisher = USACOE

Title = Naiades of Pennsylvania;
Author = Ortmann;
Date = 1919;
Publisher = Carnegie Museum

Title = Freshwater Molluscs of WI;
Author = Baker;
Date = 1928;
Publisher = WI Geol. Nat. Sci. Surv.

Title = Fisheries Survey of the East Branch of the Little Calumet River Watershed;
Author = Neil Ledet;
Date = 1978;
Publisher = IDNR-Fish and Wildlife

Title = Stream Survey-Little Calument River East Arm;
Author = Edward Braun;
Date = 1974;
Publisher = IDNR-Fish and Wildlife

Title = Fishery, Habitat, and Recreational Use Surveys for the Kankakee River;
Author = Price and Robertson;
Date = 2005;
Publisher = DNR - Div. of F & W

Title = A Fishery survey of the Kankakee River in Indiana;
Author = Robertson and Ledet;
Date = 1981;
Publisher = DNR - Div. of F & W

Title = Amphibians and reptiles from 23 counties of Indiana.;
Author = Robert Brodman;
Date = 2003;
Publisher = Proceedings of the Indiana Academy of Science, 112: 43-54.

Appendix F-2: Aggregated Aquatic Systems

Title = Wetlands;
Author = Mitsch & Gosselink;
Date = 1993;
Publisher = Van Nostrand Rheinhold

Title = Southern Forested Wetlands;
Author = Messina & Conner;
Date = 1998;
Publisher = CRC Press LLC

I'm am not aware of any literature on mink focused strictly to rivers and streams.

Title = Naiades of Pennsylvania;
Author = Ortmann;
Date = 1919;
Publisher = Carnegie Museum

Title = Freshwater Mollusca of WI;
Author = Baker;
Date = 1929;
Publisher = WI Geol. Nat. Sci. Surv.

Title = Federal Recovery Plan;
Author = USFWS;
Date = 1993;
Publisher = USFWS

Title = Naiades of Pennsylvania;
Author = Ortmann;
Date = 1919;
Publisher = Carnegie Museum

Title = A survey of fish communities and aquatic habitatts at Indiana's major streams with emphasis on smallmouth bass distribution and abundance.;
Author = Stuart T. Shipman;
Date = December 1997;
Publisher = IDNR

Title = Surveys of the fish communities and aquatic habitats in 16 small streams in Indiana from 1996 through 1997.;
Author = Douglas C. Keller;
Date = 1999;
Publisher = IDNR

Title = A survey of fish communities and aquatic habitats at Indiana's major streams with emphasis on smallmouth bass distribution and abundance;
Author = Stuart Shipman;
Date = 12/1997;
Publisher = DNR/Fisheries section

Title = Naiades of Pennsylvania;
Author = Ortmann;
Date = 1919;
Publisher = Carnegie Museum

Title = Freshwater Mollusca of WI;

Author = Baker;
Date = 1928;
Publisher = WI Geol. Nat. Hist. Survey

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the current body of science for all aquatic systems habitats. There were no responses.

Research needs

Species research

Respondents ranked research needs for wildlife in all aquatic systems habitats in Indiana:

Rank	Research needs for wildlife in all aquatic systems habitats
1	Limiting factors (food, shelter, water, breeding sites)
2	Threats (predators/competition, contamination)
3	Relationship/dependence on specific habitats
4	Distribution and abundance
5	Population health (genetic and physical)
6	Life cycle

Respondents noted other research needs for wildlife in all aquatic systems habitats in Indiana (not ranked):

- Relationship(s) between population levels and population indices
- How to produce more, larger crappie
- Harvest
- Survival/nest success
- Limiting factors and impacts of competition and predation
- Very little is known about the basic natural history, population ecology and abundance in Indiana of the lesser siren
- Research needs are not limited to river and stream habitats
- Habitat needs are not completely understood. I have seen fresh dead cylindrical papershell in channelized agricultural ditches. Other small streams with good habitat have only weathered dead fragments
- To find out why the clubshell has depopulated most of its former distribution in Indiana. Developing some sort of timeline (late Pleistocene, Holocene (usually archaeological), or historic) for relic valve distribution might narrow the possibilities of critical limiting factors (post-settlement siltation, etc.)
- Determine population-limiting factors in the Ohio River
- Cost effectiveness and periodic effective duration of local raccoon elimination
- Socio-economic impacts of terminating commercial fishing use of commercial equipment in the lower West Fork and Middle East Fork White River
  Whether genetic stock from northern Arkansas will suffice for re-introduction, or will farmed stock from Arkansas or Louisiana will suffice

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for wildlife in all aquatic systems habitats. There were no responses.

Habitat research

Respondents ranked research needs for all aquatic systems habitats in Indiana:

Rank	Research needs for all aquatic systems habitats
1	Threats (land use change/competition, contamination/global warming)
2	Relationship/dependence on specific site conditions
3	Distribution and abundance (fragmentation)
4	Growth and development of individual components of the habitat
5	Successional changes

Respondents noted additional research needs for all aquatic systems habitats in Indiana (not ranked):

- Water quality variations and impacts of land us and shoreline alterations
- Factors that limit the distribution of sirens in Indiana
- Affects of channelization on streambank communities and the affects on adjacent oxbows, bottomland hardwoods and other riparian areas
- Effects of roads and stream crossings. Is aquatic passage through culverts and other stream crossing structures adequate or are these crossings causing aquatic habitat fragmentation?
- Water quality requirements

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for all aquatic systems habitats. There were no responses.

Conservation actions necessary

Species actions

Respondents ranked conservation efforts by how well they address threats to wildlife in all aquatic systems habitats in Indiana:

Rank	Conservation efforts for wildlife in all aquatic systems habitats
1	Reintroduction (restoration)
2	Population management (hunting, trapping)
3	Translocation to new geographic range

4	Protection of migration routes
5	Habitat protection
6	Stocking
7	Culling/selective removal
8	Threats reduction
9 (tie)	Native predator control
9 (tie)	Food plots
10	Population enhancement (captive breeding and release)
11 (tie)	Limiting contact with pollutants/contaminants
11 (tie)	Public education to reduce human disturbance
11 (tie)	Regulation of collecting
12 (tie)	Exotic/invasive species control
12 (tie)	Disease/parasite management

Respondents noted other conservation practices for all wildlife in all aquatic systems habitats in Indiana (not ranked):

- Regulation of sport harvest. Closure of commercial fishery to allow spawning stock biomass to increase, thus allowing for the production of offspring that can eventually add to the spawning stock biomass
- Habitat protection if it greatly reduced the turbidity in streams for hornyhead chub feeding and breeding behaviors. Also, exotic/invasive species control would help the hornyhead population. The hornyhead chub is sensitive to pollution so limiting contact with pollutants/contaminants would benefit the species. The hornyhead chub is also a popular bait fish, so regulation of collecting would be beneficial to the species
- Habitat protection occurs in the form of the Clean Water Act, National Forest Management Act and other state and federal regulations that protect aquatic habitat and aquatic species. These regulations may or may not be enough for the sake of orangethroat darter conservation
- Wildlife species that are listed as endangered and illegal to take/"collect." People need to be reminded of this

Respondents recommended these practices for more effective conservation of wildlife in all aquatic systems habitats in Indiana (not ranked):

- Habitat management, protection and conservation
    - Protection of aquatic and riverine habitats is essential
    - Prevention of stream channelization and other (pollution) habitat factors
    - Limit disturbance in nesting/migration habitat
    - Habitat enhancement by adding more woody cover to the old impoundments where the former woody cover has decomposed
    - Needed for mallard management
    - Protect migration routes
    - Create buffer zones
    - Create hen houses

    - Create nest boxes
    - Protection of migration routes
    - Restore free-flowing systems
    - Restore aquatic passage
        - Restoring connection between the streams and the wetlands that were formerly associated with them to allow pike access to spawning areas. Current water management regimes often rely on pumping to fill restored wetlands, thus, fish passage is still restricted
        - Maintain roads and stream crossings so that stream channel function and aquatic passage are maintained
        - Remove dams when possible
    - Enhance and protect riffle habitats
    - Restore riparian vegetation
    - Protect sand and gravel habitats
    - Eastern sand darter: Reduce sedimentation covering the sand substrate that the darter needs to survive and reproduce. Current efforts to reduce sedimentation in streams is somewhat effective, but I'm not sure if it is enough to keep the eastern sand darter from disappearing

- Regulations and policy
    - Regulated trapping and nuisance animal control policies
    - Completely eliminate commercial fishing. This appears to have reduced the spawning stock to a level that could not maintain a fishery
    - Mallards: Make use of surplus numbers and regulate take (Reference: "The Mallard" by John Madson, Olin Mathieson Chemical Corporation)
    - Cisco
        - Assure there is no stocking of predator fish in cisco lakes
        - Greatly limit/mitigate any new development on cisco lakes, particularly addressing runoff from lawns and other water quality issues
        - Work to get any farmlands adjacent to cisco lakes into no-till
    - Implementation of ecozones in undeveloped areas to conserve that vegetation present
    - Implement a catch and release only regulation in lakes with low densities
    - Harvest management
    - Land use planning and regulation
    - Agricultural runoff protection through land use planning
    - Erosion controls
    - Make possession of exotic species illegal (must dispose of fish properly and not release back to stream)
    - Limit the amount of dredging that occurs in the Kankakee watershed
    - Incentives to farmers
    - Strict enforcement of laws regulating instream modification
    - Regulation of collecting
    - CREP, other incentives for BMPs
    - Limit instream modifications
    - More programs or efforts to restore lost or degraded systems would be beneficial
    - Declare moratorium on channel/drainage improvement projects that do not mitigate losses
    - End use of commercial fishing equipment
    - Provide landowner financial incentives to cease any future channelization plans and restore existing oxbow ponds

- Research and surveys
    - We need to better understand factors that limit siren abundance and distribution

    - Intensive quantitative sampling of known populations. Need to understand demography of the Clubshell. (See Strayer & Smith, 2003. AFS Monogram. 8)
    - Less intensive qualitative sampling of new or not recently surveyed areas. Need to determine distribution and status of the Clubshell. See same for protocols

- Outreach and public education
    - Mink: Outreach programs are needed to effectively and accurately educate citizens about wildlife (game and non-game), the wildlife conservation model (for game and non-game), and the need for effective mink management programs
    - Agricultural runoff protection through education
    - Educate anglers that it is illegal to use mussels as fishing bait
    - Educational programs aimed to reduce incidental take would also benefit otters especially where population densities are lower

- Invasive species/predators/competition
    - Do periodic local removal of raccoons
    - Expand and liberalize the taking of raccoons so to greatly reduce numbers associated with river cooter habitat
    - Raccoon reduction used regarding sea turtles in Florida and endangered Illinois mud turtle in Iowa, proposed for alligators in Louisiana
    - Zebra mussels

- Propagation and stocking
    - Restock, as too few if any turtles remain
    - Local restocking where raccoons reduced should hasten delisting criteria

- Pollution control
    - From waste water treatment plants and confined feeding operations
    - Protection of the habitat against pollutants and toxins

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the conservation of wildlife in all aquatic systems habitats. There were no responses.

Habitat actions

Respondents ranked conservation efforts by how well they address threats to all aquatic systems habitats in Indiana:

Rank	Conservation efforts for all aquatic systems habitats
1	Habitat restoration incentives (financial)
2	Protection of adjacent buffer zone
3	Habitat restoration on public lands
4	Cooperative land management agreements (conservation easements)
5	Habitat protection on public lands
6	Habitat protection incentives (financial)
7 (tie)	Managing water regimes
7 (tie)	Pollution reduction

7 (tie)	Restrict public access and disturbance
8	Corridor development/protection
9 (tie)	Land use planning
9 (tie)	Habitat restoration through regulation
10	Succession control (fire, mowing)
11	Artificial habitat creation (artificial reefs, nesting platforms)
12	Habitat protection through regulation
13	Technical assistance
14	Selective use of functionally equivalent exotic species in place of extirpated natives

Respondents listed other current conservation practices for all aquatic systems habitats in Indiana (not ranked):

- Limiting disturbance through the construction (DOW) permit process
- Hornyhead chub
  - Habitat protection and restoration on all lands by any means necessary would benefit all species (except those that are exotic and more tolerant than others) not just the hornyhead chub
  - Pollution reduction, protection of adjacent buffer zone, land use planning, and conservation easements would all be beneficial practices to the hornyhead chub
- Eastern sand darter
  - Habitat protection
  - Restoring floodplain would affect amount of sedimentation reaching the stream bed; managing water regimes may impact settling of sediments in streams (thus dam removal may be appropriate)
  - Protect adjacent buffer zone is key to stopping deleterious effects of erosion and sedimentation in the stream
  - Land use planning and conservation easements would also keep runoff to a minimum

Respondents recommended the following practices for more effective conservation of all aquatic systems habitats in Indiana (not ranked):

- Habitat protection, restoration and management
  - River otters: Proper land use planning, at a watershed scale, would not only benefit otters but other aquatic and riparian species
  - Water regime management for migration habitat
  - Protect nesting habitat along streams
  - Improve land use practices in watershed will reduce sedimentation in impoundments and reduce nutrient inputs
  - Restore woody debris habitats
  - Purchase more public land
  - Create and restore buffer zones
  - Habitat creation, i.e., artificial structures during lake construction projects
  - Reduce inlet and upstream degradation
  - Corridor protection
  - Eliminate or reduce stream channelization and ditches

    - Restore aquatic passage: Wetland restoration projects with connectivity to the stream or corridor development that allows passage to wetlands already restored; we need to move toward natural regulation of water levels instead of artificial means
    - Treat small streams as biological resources and not just drainage ditches
    - Culvert or stream crossing structure improvement (replace non-functioning culverts or other crossing structures and replace with ones that function and are at the right elevation/location within the stream's longitudinal profile)
    - Restore riparian vegetative communities through tree planting, etc.
    - Streambank stabilization or stream restoration (reconstructing the channel to reconnect it to its natural floodplain elevation)
    - Restore riparian zones; riffle protection/restoration
    - Encourage return to natural meander channel (within flood control)
    - Let dead trees in river stay; perhaps add some
    - Enhance natural river channel evolution including point bar development and snags (downed trees in the water); this provides basking sites and nesting habitat

- Regulation and policy
    - River otters: Strict enforcement of existing pollution regulations, and if needed, development of stricter laws would be beneficial
    - In Army Corps of Engineers impoundments alterations in water level control would benefit crappie
    - Habitat protection through regulation (only sure way to protect habitat without public ownership)
    - Habitat protection through regulation; (less intensive) cover a large geographic area. (Ducks, Geese & Swans of North America, Bellrose)
    - Habitat protection through incentives, (intensive), best landowner cooperation
    - Habitat conservation regulations
    - Land use zoning
    - Protect habitat through land use planning. Currently most headwaters areas run through agricultural areas and need to maintain riparian buffer strips
    - Implement ecozones in undeveloped areas to conserve that vegetation present
    - Restore bottomland hardwoods through Farm Bill and other incentive programs
    - Require that a mussel survey be done before dredging
    - CREP and other incentives for BMPs
    - Manage available habitat through regulation and buffer zones, increase habitat through incentives, technical assistance and restoration
    - Limit runoff through incentives or other means
    - Riparian conservation easements
    - Protect adjacent buffer zones (riparian corridor). More participation would likely occur with financial incentives
    - Rehabilitate drained oxbow ponds through conservation easement

- Pollution management
    - Reducing nutrient inputs will allow a deeper thermocline that is important for crappie growth. Crappie growth suffers when water temperatures become too high
    - Point and nonpoint pollution controls
    - Pollution reduction means improved water quality and fewer fish kills

- Public education and technical assistance
    - Increase awareness and cooperation of landowners to create better shoreline and tributary habitat
    - Provide technical assistance

- Research

- More research is needed to address the effectiveness of habitat restoration on siren conservation
- Assess riparian corridor and water quality monitoring (see Watters, 2000. Proc. 1st FMCS Symposium)

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the conservation for all aquatic systems habitats. There were no responses.

Partner agencies/organizations

The following organizations indicated that they work in Aquatic habitats.

Organization	Percent of time spent in Aquatic habitats
Aquatic Weed Control	100
Central Indiana Trout Unlimited	100
Hamilton Lake Conservancy District	100
fish lake conservancy district	90
Lake Bruce Conservancy district	90
Indiana Bass Chapter Federation	80
Indiana Smallmouth Club (ISC)	80
Northeastern Indiana Trout Association	80
Lake Lemon Conservancy District	75
Steelheaders of Northwest Indiana (Northwest Indiana Steelheaders)	70
Cordry Sweetwater Conservancy District	50
Four Rivers Resource Conservation & Development Area	50
Lake Maxinkuckee Environmental Council (LMEC)	50
Indiana Chamber of Commerce	45
Veolia Water Indianapolis, LLC	45
EnviroScience Incorporated	40
Hoosier Environmental Council	40
Sierra Club Hoosier Chapter	40
Wabash River Heritage Corridor Commission	40
St. Joseph River Watershed Initiative	36
Save the Dunes Conservation Fund	35
ACRES, Inc.	30
Arrow Head Country Resource Conservation & Development Area, Inc.	30
Indiana Environmental Institute	30
MWH Americas, Inc.	30
Valparasio Chain of Lakes Watershed Group, Inc.	30
Division of Fish and Wildlife	28
Robert Cooper Audubon Society	28
Northwestern Indiana Regional Planning Commission (NIRPC)	25
Sassafras Audubon Society	25

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Trillium Land Conservancy, Inc.	25
US Fish and Wildlife Service Ecological Services (does not include national wildlife refuges)	25
Valparaiso Lakes Area Conservancy District	25
Cinergy Corp.	20
Hoosier Heartland Resource Conservation and Education council	20
Indiana Division of the Izaak Walton League of America	20
Patoka River National Wildlife Refuge & Management Area	20
South Bend-Elkhart Audubon Society	10-20
American Consulting, Inc.	15
Pheasants Forever Inc.	15
Clark's Valley Land Trust	10
DNR Division of Nature Preserves	10
Ducks Unlimited, Inc.	10
Earth Source, Inc.	10
Indiana Deer Hunters Association	10
Indiana Association of Cities and Towns	10
Indiana Association of Soil and Water Conservation Districts	10
Indiana state trappers assoc	10
JFNew and Associates	10
Lost River Conservation Association	10
Midwest Peregrine Falcon Recovery Project	10
Summit Lake State Park	10
The Nature Conservancy	10
Wawasee Area Conservancy Foundation, Inc.	10
Whitewater Valley Land Trust, Inc.	10
Big Oaks National Wildlife Refuge, USFWS	5
Blue Heron Ministries, Inc.	5
Ducks Unlimited	5
IDNR- Division of Forestry- Cooperative Forest Management Section (Private Lands)	5
IN DNR, Division of State Parks & Reservoirs, Interpretive Services	~5
Indiana Dunes National Lakeshore	5
Indianapolis Power & Light Co.	5
Muscatatuck National Wildlife Refuge US FWS	5
Naval Support Activity Crane	5
NICHES Land Trust	5
U.S. Department of Agriculture, Forest Service Hoosier National Forest	5
Merry Lea Environmental Learning Center of Goshen College	4
Indiana Department of Natural Resources Division of Forestry, Properties Section (State Forests)	3
St. Joseph County Soil & Water Conservation District (SWCD)	3
American Society of Landscape Architects, Indiana Chapter	

amos w butler audubon society
Central Hardwoods Joint Venture/American Bird Conservancy
Federal Highway Administration (FHWA)
Fur Takers of America
fur takers of america chapter 7-E north west in.
Great Lakes Commission
Indiana Michigan Power and affiliate of American Electric Power; Land Management Department
Indiana Watershed Leadership (new initiative)with Purdue University
Indianapolis Flycasters
Kankakee River Basin Commission
LAKE MCCOY CONSERVANCY DISTRICT
Law Enforcement Division, Indiana Department of Natural Resources
National Audubon Society - Indiana Important Bird Areas Program (IBA)
U.S. Army Corps of Engineers Regulatory Branch, Louisville District (Please note this is only a part of the larger organization and while the greater organization may be involved in areas not noted below, our answers are specific to the Regulatory program.)
USDA Natural Resources Conservation Service

Proposed plans for monitoring

Current monitoring

Species monitoring

Respondents were aware of the following monitoring efforts by state agencies for wildlife in all aquatic systems habitats in Indiana:

- Statewide year-round monitoring
- Statewide once-a-year monitoring
- Periodic statewide (less than once a year but still regularly scheduled) monitoring
- Occasional statewide (less than once a year and not regularly scheduled) monitoring
- Regional or local year-round monitoring
- Regional or local once-a-year monitoring
- Periodic regional or local (less than once a year but still regularly scheduled) monitoring
- Occasional regional or local (less than once a year and not regularly scheduled) monitoring

Respondents were aware of the following monitoring efforts by other organizations for wildlife in all aquatic systems habitats in Indiana:

- Statewide year-round monitoring
- Statewide once-a-year monitoring
- Occasional statewide (less than once a year and not regularly scheduled) monitoring
- Regional or local year-round monitoring
- Regional or local once-a-year monitoring
- Periodic regional or local (less than once a year but still regularly scheduled) monitoring
- Occasional regional or local (less than once a year and not regularly scheduled) monitoring

Respondents ranked monitoring efforts by state agencies based on their importance for conservation of wildlife in all aquatic systems habitats in Indiana:

Appendix F-2: Aggregated Aquatic Systems

Rank	Monitoring efforts by state agencies for conservation of wildlife in aquatic systems habitats
1	Occasional regional or local (less than once a year and not regularly scheduled) monitoring
2	Periodic regional or local (less than once a year but still regularly scheduled) monitoring
3	Regional or local once-a-year monitoring
4	Periodic statewide (less than once a year but still regularly scheduled) monitoring
5	Occasional statewide (less than once a year and not regularly scheduled) monitoring
6	Regional or local year-round monitoring
7 (tie)	Statewide year-round monitoring
7 (tie)	Statewide once-a-year monitoring

Respondents ranked monitoring efforts by other organizations based on their importance for conservation of wildlife in all aquatic systems habitats in Indiana:

Rank	Monitoring efforts by other organizations for conservation of wildlife in aquatic systems habitats
1	Occasional regional or local (less than once a year and not regularly scheduled) monitoring
2	Regional or local once-a-year monitoring
3	Periodic regional or local (less than once a year but still regularly scheduled) monitoring
4	Regional or local year-round monitoring
5	Statewide once-a-year monitoring
6	Periodic statewide (less than once a year but still regularly scheduled) monitoring
7	Statewide year-round monitoring
8	Occasional statewide (less than once a year and not regularly scheduled) monitoring

Respondents listed regional or local monitoring by state agencies for wildlife in all aquatic systems habitats in Indiana (not ranked):

- Indiana Department of Natural Resources
    - Beavers
        - State and county highway department monitor beaver activity only as flooding of roadways occur

        - IDNR property monitor and attempt to eliminate problems associated with flooding of adjacent private property
        - State furbearer biologist tracks and monitors trapping harvest data
    - River otters
        - IDNR personnel monitor otter mortality (road-kills, trap-related, etc.) at a statewide level
        - IDNR personnel conduct winter bridge/stream surveys for otter sign. These are conducted on a county basis at a statewide level
        - Patoka Lake; Hovey Lake; Dogwood Lake; Lake Sullivan; many other lakes
    - Many impoundments throughout the state have general fisheries survey conducted on them and crappie are caught during these
    - Fish and Wildlife properties in northern Indiana
    - Tri-County Fish and Wildlife Area
    - Spring assessment out of Michigan City: Fall spawning assessment, Indiana waters of Lake Michigan; 9-month creel survey for harvest information. These efforts are conducted by IDNR Division of Fish and Wildlife
    - Indiana Division of Fish and Wildlife at cisco lakes
    - Northeast Indiana by Division of Fish and Wildlife (Jed Pearson)
    - Northern pike
        - Monitored via general fish surveys conducted to update lake status. There is now monitoring of northern pike on a general schedule
        - There was a tracking study conducted in two Indiana natural lakes in the late 1990s by the IDNR to better understand reproductive habitat of northern pike
    - Division of Fish and Wildlife standardized largemouth bass sampling protocol
    - Tournament fishing monitoring by the Division of Fish and Wildlife
    - Several fish and wildlife areas perform annual wood duck banding. These properties include Hovey Lake, Glendale, Minnihaha, Willow Slough, Jasper-Pulaski, LaSalle, Pigeon River, Tri-County fish and wildlife areas; there may be others
    - Many fish and wildlife areas also conduct nest box monitoring activities on an annual basis
    - Indiana participates in the Harvest Information Program which can provide information about migration, population index and/or trends, as well as information about the amount of hunting pressure
    - Hovey Lake, Tri-county, Jasper-Pulaski, Pigeon River, Winimac, Willow Slough and LaSalle fish and wildlife areas
    - Headwater streams surveys were conducted in 2001 through 2004 by IDNR - Division of Fish and Wildlife, Lake Michigan Fisheries Office
    - State monitoring: Banding and nest box surveys
    - IDNR periodically conducts fish stream surveys
    - DNR fishery surveys are occasionally conducted on the Iroquois River, Yellow River, and Kankakee River
    - IDEM and IDNR collect fish community samples in this area; thus, they may have data on the distribution of least darters
    - IDNR non-game biologist does mussel surveys. But, he is only one person and there are thousands of miles of streams in state
    - IDEM and the DNR Nongame program also conduct monitoring during the field season, once a year for fish. These above fish surveys are not specific to the orangethroat darter, but would include the orangethroat darter
    - Periodic (usually annual) monitoring in the Tippecanoe River by IDNR
    - In early to mid-1990s, Division of Fish and Wildlife conducted fish community inventories on the major streams throughout the state
    - Indiana DNR conducts special studies on threatened and endangered species: IDNR, Brant Fisher, did a study on the population of eastern sand darters in Indiana over

the past five years. IDNR regional fish collection surveys may have collected some specimens of the eastern sand darter
    - See IDNR Fisheries Section work plans
    - In early to mid-1990s the Division of Fish and Wildlife conducted a smallmouth bass inventory
    - Five streams have been sampled every other year from 1998 to 2004 to estimate smallmouth bass populations to determine the effect of smallmouth bass population changes due to the imposition of a 12-inch black bass size limit in 1998
    - Game fish population estimates (including rock bass) have been conducted on 5 streams every other year from 1998 through 2004
    - 1999 Wabash River, 2003 East Fork White River, 2004 West Fork White River, 2004 Main Stem White River, 1993 Patoka River, 2004 Ohio River Cannelton Pool, annual commercial fish harvest monitoring
    - IDNR I believe has conducted special studies on this species
    - IDNR nongame biologist continually monitors fishes and mussels throughout the state, including yellow sandshell habitat. Two surveys have been done ten years apart and completed last year by IDNR biologists in the Wabash, Tippecanoe and East Fork White Rivers; results are pending. This is in prime yellow sandshell habitat

- Indiana Department of Environmental Management
    - Ecoregion sampling
    - Water quality monitoring
    - IDEM conducts stream health surveys using fish and invertebrates
    - IDEM monitors the Great Lakes Drainage once every five years; thus, they may have data available for hornyhead chub captured in the basin as part of the fish community assessments. IDNR may also sample fish communities in this area and have data on the hornyhead chub
    - IDEM occasionally samples fish for contaminants analysis for the annual Fish Consumption Advisory
    - IDEM and IDNR collect fish community samples in this area; thus, they may have data on the distribution of least darters
    - IDEM monitors the Kankakee River basin once every five years to determine if the stream are supporting a well-balanced warm water aquatic community. Tadpole madtoms may have been captured while sampling headwater streams
    - IDEM and the DNR Nongame program also conduct monitoring during the field season, once a year for fish. These above fish surveys are not specific to the orangethroat darter, but would include the orangethroat darter
    - IDEM monitors the health of major river basins every five years by looking at chemical, physical and biological data collected at random locations within the watershed. Southern redbelly dace have been captured in the Ohio River drainage habitat; however, specific monitoring for the species has not occurred to my knowledge by anyone state or other organization
    - Various streams throughout the region, some are sampled more regularly than others IDEM probabilistic sampling
    - See IDEM OWQ's surface water quality monitoring strategy work plans
    - IDEM has record of some wildlife species being caught in that area

- Patoka River watershed
- Maumee system
- Breeding Bird Atlas statewide every 20 years
- Random locations within the Kankakee drainage
- Wabash system
- Tippecanoe River, Maumee system
- Blue River (Harrison County); Sugar Creek (Shelby County); Indian Creek (Greene County)

Appendix F-2: Aggregated Aquatic Systems

- Blue River (Harrison County)
- Ohio River, Wabash system
- Wabash River; West Fork White River; East Fork White River; Ohio River
- Ohio, White and Wabash rivers
- Occasional stream surveys
- Ohio River, Newburgh and McApline tailwater fall/winter annual monitoring; occasional stream surveys
- Blue River (Harrison County); East Fork White River; West Fork White River

Respondents listed regional or local monitoring by other organizations for wildlife in all aquatic systems habitats in Indiana (not ranked):

- Joseph Brodman, Saint Joseph's College
- Cortwright, IUN
- Federal Breeding Bird Survey, state May Day counts, summer bird counts
- Division of Fish and Wildlife properties in northern Indiana, natural lakes, nature preserves
- Out of Michigan City and near Gary by Ball State University
- U.S. Fish and Wildlife Service and Illinois Natural History Survey complete egg and fry assessments at the Port of Indiana. This is part of a Fish and Wildlife Restoration Grant
- Newton, Jasper, Pulaski, Starke, Lake and Porter counties
- Muscatatuck National Wildlife Refuge performs wood duck banding operations
- In some cities, stream health is also assessed by fish and invertebrate surveys
- Elkhart Public Works and Utilities has a fisheries biologist who collects fish community samples from the Great Lakes Basin (one to two times in the summer). He may have data on the hornyhead chub as well
- Maumee system
- Commonwealth Biomonitoring frequently does habitat evaluations in small streams as part of watershed studies. If I happen to see a shell, I make a note of it in field notes. These are not official mussel surveys
- Wabash system
- Hoosier National Forest conducts yearly fish surveys within two or more 5th level HUCs that encompass the Hoosier National Forest, which includes the Ohio River drainage, eastern cornbelt/interior plateau ecoregions. These above fish surveys are not specific to the orangethroat darter, but would include it
- Tippecanoe River, Maumee system
- West Fork White River and tributaries (Muncie area)
- Ball State University fish sampling
- While collecting fish community samples to evaluate the community structure and ability of the stream to support a healthy fish community, these organizations may have collected eastern sand darters: Soil and Water Conservation Districts within those Ecoregions, Purdue University, Wildcat Creek Watershed Alliance. I would check with the Scientific Collectors Permit office for a list of organizations collecting in those ecoregions and also check with the IDEM Section 319 webpage for project summaries where fish or habitat in those ecoregions were studied
- U.S. Environmental Protection Agency; USGS Water Resources Division; Ohio River Valley Water Sanitation Commission; Midwest Biodiversity Institute, U.S. Army Corps of Engineers; Muncie Bureau of Water Quality; City of Elkhart Water Quality; various universities; various consulting firms
- Ohio, White and Wabash rivers

Respondents listed organizations that monitor wildlife in all aquatic systems habitats in Indiana (not ranked):

Appendix F-2: Aggregated Aquatic Systems

- Cortwright, IUN
- U.S. Geological Survey (Breeding Bird Survey) and volunteers with Indiana Audubon Society
- Indiana Department of Natural Resources - Division of Fish and Wildlife
- Audubon Society
- Ducks Unlimited
- Ball State University
- University of Michigan through a coastal program grant
- Illinois Natural History Survey
- U.S. Fish and Wildlife Service
- Bass fishing clubs who hold tournaments on Lake Wawasee and Syracuse Lake
- Robert Brodman, Saint Joseph's College
- City of Elkhart (Elkhart and St. Joseph counties)
- Indiana Department of Environmental Management
- The Nature Conservancy
- Consultants
- USDA Forest Service, Hoosier National Forest
- Muncie Bureau of Water Quality.
- Electric utilities
- Ball State University
- Purdue University

Respondents considered monitoring techniques for wildlife in all aquatic systems habitats in Indiana:

Monitoring techniques for wildlife in all aquatic systems habitats	**Used**	**Not used but possible with existing technology and data**	**Not economically feasible**
Radio telemetry and tracking	X	X	X
Modeling	X	X	X
Coverboard routes	X	X	X
Spot mapping	X	X	X
Driving a survey route	X	X	X
Reporting from harvest, depredation, or unintentional take (road kill, by-catch)	X	X	X
Mark and recapture	X	X	X
Professional survey/census	X	X	--
Volunteer survey/census	X	X	X
Trapping (by any	X	X	X

technique)			
Representative sites	X	X	--
Probabilistic sites	X	X	--

Respondents noted other monitoring techniques for wildlife in all aquatic systems habitats in Indiana (not ranked):

- Aerial surveys
- Long-term monitoring through gillnets; trawling has been conducted at three sites along the Lake Michigan lakefront since the mid-1970s by Ball State University during the summer season. Creel census has been conducted by IDNR – Division of Fish and Wildlife for approximately 20 years. Commercial monitoring was conducted until the halt of the commercial fishing industry in 1996
- Nest box surveys
- Electrofishing and seining are appropriate methods for monitoring the orangethroat darter
- Unintentional take could be monitored from fish kill cadaver counts if the officers could be trained to identify northern hog suckers instead of not counting them or just lumping them into the generic class of round bodied suckers
- Larval sampling to check for reproduction

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for wildlife in all aquatic systems habitats. There were no responses.

Habitat inventory and assessment

Respondents were aware of the following inventory and assessment efforts by state agencies for all aquatic systems habitats in Indiana (not ranked):

- Statewide annual inventory and assessment
- Statewide once-a-year inventory and assessment
- Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
- Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
- Regional or local year-round inventory and assessment
- Regional or local once-a-year inventory and assessment
- Periodic regional or local (less than once a year but still regularly scheduled) inventory and assessment
- Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment

Respondents were aware of the following inventory and assessment efforts by other organizations for all aquatic systems habitats in Indiana (not ranked):

- Statewide annual inventory and assessment
- Statewide once-a-year inventory and assessment
- Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
- Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
- Regional or local year-round inventory and assessment

- Regional or local once-a-year inventory and assessment
- Periodic regional or local (less than once a year but still regularly scheduled) inventory and assessment
- Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment

Respondents ranked inventory and assessment efforts by state agencies based on their importance for conservation of all aquatic systems habitats in Indiana:

Rank	Inventory and assessment by state agencies for conservation of all aquatic systems habitats
1	Periodic regional or local (less than once a year but still regularly scheduled) inventory and assessment
2	Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment
3	Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
4	Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
5	Regional or local once-a-year inventory and assessment
6	Statewide once-a-year inventory and assessment
7	Regional or local year-round inventory and assessment
8	Statewide annual inventory and assessment

Respondents ranked inventory and assessment efforts by other organizations based on their importance for conservation of all aquatic systems habitats in Indiana:

Rank	Inventory and assessment by other organizations for conservation of all aquatic systems habitats
1	Periodic regional or local (less than once a year but still regularly scheduled) inventory and assessment
2	Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment
3	Regional or local once-a-year inventory and assessment

4	Regional or local year-round inventory and assessment
5	Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
6	Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
7	Statewide once-a-year inventory and assessment
8	Statewide annual inventory and assessment

Respondents listed regional or local inventory and assessment by state agencies for all aquatic systems habitats in Indiana (not ranked):

- Natural lakes in northern Indiana
- Lake Michigan proper along the shoreline in nearshore area less than 30 feet in depth
- Habitat mapping and shoreline aerial imagery
- Northeast Indiana, Indiana Division of Fish and Wildlife (Jed Pearson)
- Recently the IDNR has begun sampling/mapping emergent plant species in some Indiana natural lakes. These plants may be used as reproductive habitat for northern pike
- Nearly all of the river and stream habitats in Indiana fall under state and/or federal jurisdiction, so obtaining and maintaining accurate and current information on these habitats is always occurring on a statewide basis
- Trail Creek, East Branch of Little Calumet River, Reynolds Creek, Salt Creek, West Branch of Little Calumet River, Deep River
- IDEM ecoregion surveys
- In all major tributaries of Lake Michigan
- IDEM, IDNR and City of Elkhart use the QHEI (Qualitative Habitat Evaluation Index) to assess habitat in streams
- Maumee system
- Habitat evaluations are conducted as part of general stream surveys by DNR biologists. Such surveys have been conducted on the Iroquois River, the Yellow River, and the Kankakee River
- Wabash system
- Tippecanoe River and Maumee system
- Blue River (Harrison County), Sugar Creek (Shelby County), Indian Creek (Greene County)
- Indiana Department of Environmental Management
- ORSANCO
- Blue River (Harrison County)
- Ohio River, Wabash system
- West Fork White River, East Fork White River, Wabash River
- I am assuming that the governmental division responsible for water pollution control conducts some sampling regarding organic and heavy metal toxins in the water
- IDNR primarily monitors mussel species, making habitat notations. No real habit monitors made. Indiana Department of Environmental Management, IDNR Division of Water do monitor water quality (as a component of habitat)

Appendix F-2: Aggregated Aquatic Systems

Respondents listed regional or local inventory and assessment by other organizations agencies for all aquatic systems habitats in Indiana (not ranked):

- Brodman, Saint Joseph's College, in northern Indiana
- Cortwright, IUN in Brown County
- Lake Michigan proper along the shoreline in nearshore area less than 30 feet in depth
- Newton, Jasper, Starke, Pulaski, Lake and Porter counties
- Many local zoning boards, planning commissions and drainage boards also keep and maintain their own records in regard to land use patterns within these habitats
- City of Elkhart
- St. Joseph River
- Maumee system
- Commonwealth Biomonitoring does habitat evaluations on small streams as part of watershed studies. These evaluations are not specific to mussels, but are Ohio EPA QHEI methods
- Wabash system
- Two or more 5th level HUC watersheds a year that encompass the Hoosier National Forest are sampled; a random sampling of streams found within these 5th level HUCs occurs
- Wabash system
- Tippecanoe River and Maumee system
- Muncie BWQ monitors West Fork White River and tributaries in the Muncie area
- Ohio River
- U.S. Army Corps of Engineers in Ohio River
- Occasional grants to universities

Respondents listed organizations that monitor all aquatic systems habitats in Indiana (not ranked):

- Indiana Division of Fish and Wildlife
- Ball State University
- University of Michigan
- U.S. Fish and Wildlife Service
- Robert Brodman, Saint Joseph's College
- U.S. Department of Agriculture
- Indiana Department of Environmental Management
- U.S. Army Corps of Engineers
- Environmental Protection Agency
- Local government entities (area plan commissions, zoning boards etc…)
- City of Elkhart and South Bend
- The Nature Conservancy
- Consultants
- City of Muncie
- U.S. Geological Survey/WRD
- State Board of Health

Respondents considered inventory and assessment techniques for all aquatic systems habitats in Indiana:

Inventory and assessment techniques for all aquatic systems habitat	Used	Not used but possible with existing technology and data	Not economically feasible

GIS mapping	X	X	X
Aerial photography and analysis	X	X	X
Systematic sampling	X	X	--
Property tax estimates	X	--	X
State revenue data	--	--	X
Regulatory information	X	X	X
Participation in land use programs	X	X	X
Modeling	X	X	X
Voluntary landowner reporting	X	X	X

Respondents listed additional inventory and assessment techniques for all aquatic systems habitats in Indiana (not ranked):

- Bottom mapping of habitat
- IBI and QHEI for representative sites
- QHEI; REMAP protocols for northern forested streams; stream channel cross-sections and longitudinal profiles; substrate analysis; descriptions of riparian vegetation; water quality parameters are measured using probes and Hydro-labs
- Water quality monitoring

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the inventory and assessment techniques for all aquatic systems habitats. There were no responses.

Recommended monitoring

Species monitoring

Respondents recommended the following monitoring techniques for effective conservation of wildlife in all aquatic systems habitats in Indiana (not ranked):

- Minnow traps
- Regulated trapping
- Directed surveys (canoe surveys, migration counts) most intensive; general breeding bird surveys less intensive
- Electrofishing survey
- Trap netting survey
- Gill netting surveys
- Angler creel surveys
- Reporting from harvest (angler creel surveys) to show angler exploitation
- Professional survey (fish management surveys) to show size structure, relative abundance, and provide age and growth information
- Professional surveys or counts on fish and wildlife areas during migration periods (tracts annual migration trends and is index to population levels). Harvest surveys on fish and wildlife areas (tracts annual numbers taken) ("Wildlife Investigational Techniques" by The Wildlife Society)

- Brood surveys
- Occasional gill-netting to verify presence followed by intensive netting to confirm low levels or absence
- Large fyke-nets are used in Lake Webster (Kosciusko County) to collected brood stock for muskellunge. These nets would be useful in capturing northern pike as well. This would allow biologist to capture enough fish to get a representative sample of adult fish. There is still no effective method of sampling young esocids without mortality
- Fall trawl sampling for young of the year production. Possible incorporation of hydracoustic models for the nearshore area
- Stream sampling using electrofishing techniques and seining. This should be done every five years to get a clear picture of changes that occur to habitat, water quality and invasive species introductions and distribution
- Rotational sampling at reference sites along the headwaters. Historical comparisons from the early 1980s will be compared with the sampling that was completed 2001 to 2004
- Less intensive qualitative sampling of new or not recently surveyed areas. Need to determine distribution and status of some wildlife species
- Periodic electrofishing surveys and mark recapture techniques probably provide the best information about the pike populations
- Professional surveys using timed searches, systematic sampling (Strayer and Smith 2003, A guide to sampling freshwater mussel populations American Fisheries Society Monograph 8. American Fisheries Society. Bethesda, Maryland. 103 pp)
- Intensive quantitative sampling of known populations. Need to understand demography of some wildlife species. (Strayer & Smith, 2003. AFS Monogram. 8.)
- Electrofishing streams. Take a random sampling of streams within a watershed (5th or 6th level HUC) and standardize the stream reach length for the survey, usually 15 times the stream width. Seining is also an appropriate method for sampling, especially in the riffle habitats
- River otters
  - Stream surveys for otter sign
  - Reporting (number, location, etc.) of unintentional take and biological data obtained from recovered specimens (reproductive parameters)
    - REFERENCE: Melquist, W.E., P.J. Polechla, Jr., and D. Toweill. 2003. River Otter. Pages 708-734 in Wild Mammals of North America: biology, management, and conservation. 2nd edition. G.A. Feldhamer, B.C. Thompson, and J.A. Chapman (eds.), John Hopkins University Press, Baltimore, MD, 1216 pages
- Population estimates
- Mark/recapture and banding (intensive) (Ducks, Geese and Swans of North America, Frank C. Bellrose); harvest data collection (less intensive) (Wildlife Management Volume 2, Reuben Edwin Trippensee)
- Banding
- I would like to see all the lake trout stocked in Lake Michigan to be coded wire tagged. That will allow for better understanding of survival after stocking and movement of the fish. It will also allow for better understanding of spawning site fidelity
- Tournament monitoring by the Division of Fish and Wildlife and bass clubs
- Minnow trapping and either mark recapture or telemetry
- Continued participation in HIP is perhaps the most cost effective method for monitoring the flyway population
- Representative sites or look for sites where the habitat is suitable for the least darter and seine in the vegetation over rocky substrate
- Development of trained, select volunteer core to undertake surveys at probabilistic sites, particularly occurance has not been documented in recent years

- Stream community surveys
  Rock bass population estimates
- See where populations of the darter have been captured in the past and then with seines or electrofishing equipment mark and recapture the darter to document habitat characteristics, water quality information, and land use characterization where the darters occur. You will need to target the habitat and not the exact location since the sandbars will probably shift over time. Look on the web for mark and recapture surveys as well as other eastern sand darter publications. I found many by just searching the web for eastern sand darter
- Hoop-netting by scientists and commercial fishermen
- Fall/winter Ohio River tailwater sampling and occasional stream surveys
- Occasional censusing with very large, heavily bated hoop nets left out overnight. Do not set during rising waters. Check within 12 hours.
- Search for nests in June (after determining any adults present at all) methods used in Florida and Louisiana for nests, in Arkansas and Louisiana for capturing adults
- Looking for basking individuals with a spotting scope
- Use fyke nets with big leads, or basking traps to estimate numbers after visual spotting determines presence

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for effective conservation of wildlife in all aquatic systems habitats. There were no responses.

Habitat inventory and assessment

Respondents recommended the following inventory and assessment techniques for effective conservation of all aquatic systems habitats in Indiana (not ranked):

- GIS appears to be the most feasible means for inventory and assessment of otter habitat at a statewide scale. I suspect analysis of aerial photos could be useful also, perhaps at a local scale
- GIS mapping of restored, fully connected wetland to provide an inventory of available spawning habitat
- GIS mapping (electronic data base of current habitat), aerial photography and analysis (examine changes in habitat)
- Digital satellite imagery to conduct bottom contour mapping in nearshore spawning areas
- GIS (intensive) (Wildlife Management Techniques Manual, Fourth Edition, Sanford D. Schemnitz); aerial (less intensive)
- Aerial imagery to identify and quantify habitat
- Systematic sampling would probably be best to determine the abundance of cover that is available, but could be very difficult as most of the habitat is hidden under the surface of the water
- "Wildlife Investigational Techniques" by The Wildlife Society
- Spring counts (aerial)
- Lidar mapping would help identify spawning areas within the nearshore zone along Indiana's coastline
- Emergent bulrush and wetland monitoring and protection via ecozones
- Evaluate land and water use practices to reduce in lake and upstream degradation of vegetation and shoreline
- Spring, summer, fall and winter surveys
- Sampling using electrofishing and seining in headwater areas. Completing IBI and QHEI and water quality analysis for these sites
- Assess riparian corridor and water quality

- Systematic sampling of the habitat along the length of the stream to provide baseline data for comparison across time
- Assess riparian corridor presence
- Orangethroat darter
  - Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. USDA Forest Service. General Technical Report RM-245. The reference offers useful guidance on measuring stream channel cross-sections and substrate within the stream. This information can be used to determine if a stream channel is stable and if the substrate is available within riffle habitats, which are the preferred habitat of the orangethroat darter
  - Simon, T. P. and P.M. Stewart. 1998. Standard Operating Procedures For Development of Watershed Indicators In REMAP: Northern Lakes and Forest Streams The above reference is very useful for developing a watershed level sampling design and includes useful methods for measuring stream channel and stream habitat parameters
- Water quality monitoring.
- CREP, farmer incentives for no-till, riparian corridors, etc.
- Strictly control instream modifications: mining, snagging, etc.
- Assess zebra mussel infestations. Contact P. Morrison, USFWS, Parkersburg, WV.
- Record habitat when the species is collected during a survey
- High-resolution aerial photography during low water, digitized for GIS. Goal is to locate: 1) Deep river holes with woody debris (favored by adults); 2) health/permanence of oxbow ponds; 3) nesting habitat
- Occasional site visits to assess vegetation quality for this herbivorous turtle
- To look at saturation of potential habitat using GIS construction of existing potential habitat (based upon known factors) and overlaying the current distribution of the yellow sandshell

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the inventory and assessment techniques for effective conservation for all aquatic systems habitats. There were no responses.