The Arizona Game and Fish Department (AGFD) prohibits discrimination on the basis of race, color, sex, national origin, age, or disability in its programs and activities. If anyone believes that they have been discriminated against in any of the AGFD's programs or activities, including its employment practices, the individual may file a complaint alleging discrimination directly to the AGFD deputy director, 5000 W. Carefree Hwy, Phoenix, AZ 85086, (602) 942-3000 or U.S. Fish and Wildlife Service, 4040 N. Fairfax Dr., Suite. 130, Arlington, VA 22203.

Persons with a disability may request a reasonable accommodation, such as a sign language interpreter, or this document in an alternative format, by contacting the AGFD Deputy Director, 5000 W. Carefree Hwy, Phoenix, AZ 85086, (602) 942-3000. Requests should be made as early as possible to allow sufficient time to arrange for accommodation.
# Table of Contents

Introduction ................................................................................................................................. 3

Materials ......................................................................................................................................... 4

Fish Habitat Structure Types .......................................................................................................... 4

  Arizona Game and Fish Arrowheads .......................................................................................... 5

  Arizona Game and Fish Crappie Condos ................................................................................... 5

  Arizona Game and Fish Department Poly Shrubs (aka spider blocks) and Trees ....................... 6

Bamboo/Native Tree Crappie Condos ............................................................................................. 6

Berkley Fish-Habs Program ............................................................................................................ 7

Catfish Houses/Condos .................................................................................................................... 8

Fathead Minnow Fortress .............................................................................................................. 8

Fishiding Reclaimed Artificial Fish Structures ............................................................................. 9

Floating Islands ............................................................................................................................... 9

Georgia Cube .................................................................................................................................. 10

Great Lakes Products Inc. AquaCribs .............................................................................................. 10

Honey Hole Cover Habitats ........................................................................................................... 11

Honey Hole Spawning Disks .......................................................................................................... 12

Mossback Racks Fish Attractors ..................................................................................................... 13

Natural Woody Structure; Christmas tree clusters, root wads, brush piles, etc. ............................... 13

Pennsylvania Black Bass nesting structure .................................................................................... 14

Pennsylvania Channel Catfish Spawning Box ............................................................................. 15

Pennsylvania Porcupine Cribs ........................................................................................................ 15

Pennsylvania Rock Rubble Humps/Reefs ...................................................................................... 15

Pisces Pyramids .............................................................................................................................. 16

Reef Balls ....................................................................................................................................... 17

Spawning Benches .......................................................................................................................... 17

Spawning Gravel ............................................................................................................................ 18

Fish Habitat Structures- Not Recommended ............................................................................... 19

  Fish-n-Trees ................................................................................................................................. 19

Conclusion ....................................................................................................................................... 19

Acknowledgements ....................................................................................................................... 20

References ....................................................................................................................................... 20
Introduction

Arizona has two natural lakes, Stoneman and Mormon lakes, and numerous man-made lakes that are important recreational fisheries. A large number of Arizona’s man-made lakes are between 50 to 100 years old and are experiencing a decline in the quality and quantity of fish habitat. As reservoirs age, primary and secondary productivity decline and complex habitat (i.e. submerged trees, brush) deteriorates resulting in little to no cover and marginal spawning habitat for important recreational fisheries. Additionally, constant water level fluctuation in reservoirs prevents establishment of shoreline aquatic vegetation whereas occasional water level fluctuation can provide additional fish habitat by submerging established shoreline vegetation. Many of Arizona’s reservoirs experience constant water level fluctuation due to drought conditions and water demands. Recent declines in target game species (i.e. largemouth bass, smallmouth bass, crappie, etc.) have shed light on the lack of quality habitat available in many aging reservoirs. Due to the decline in important sportfish fisheries, large-scale habitat enhancement projects are gaining support to reduce the effects of aging reservoirs.

Reservoir habitat enhancement is not a new theory rather it was first documented in the late 1700s in Japan and has been around for over 80 years in the United States. Brush piles were the first documented reservoir habitat enhancement in the United States that evaluated fish use by Hubbs et al. in 1931 (Tugend et al. 2002). Habitat enhancement has developed over the years from natural habitats consisting of brush piles, logs, and gravel to long-term manufactured/artificial habitat consisting of durable plastics and cement. Over the years habitat enhancements have included cars, tires, stake beds, Christmas trees, gravel, PVC pipes, steel, durable recycled plastics, and countless others. The debate on whether fish prefer natural structures (i.e. brush piles, woody debris, rock piles, etc.) or artificial (i.e. plastic, steel, etc.) is ongoing with few freshwater studies. For example, few studies, such as Jenkins and Forsythe in 1984, have noted a preference for natural structures (e.g. cedar trees) compared to artificial (e.g. polypropylene) structures (Santos et al. 2011; Richards 1996; Rold et al. 1996). While another study documented artificial structures were better at attracting and holding fish over time compared to structures made from natural materials (Baumann 2013). Regardless of the debate, natural and artificial habitat structures have been successful at improving fisheries.

Natural and artificial habitat enhancement projects aim to improve fisheries by concentrating fish, providing cover, and/or creating additional spawning habitat. These objectives can result in increased fish recruitment and growth, periphyton production, and angling success. Typically, habitat structures attract fish with the main goal to improve angler catch rates. Most studies have focused on this by documenting the effectiveness of different types of structure at attracting fish and increasing angler catch rates (Wilbur 1978; Prince and Maughan 1978; Timmons and Garrett 1985; Mueller and Liston 1994). Few studies have conclusively evaluated habitat structures ability to increase recruitment, spawning success, and periphyton growth (Minns et al. 1996; Siepker et al. 2013). For example, studies have found habitat enhancement structures increase bass nesting sites (Hoff 1991; Hunt et al. 2002; Wills et al. 2004) and are associated with consistently higher abundance of eggs, fry, and young-of-year lake trout (Fitzsimons 1996). However, research has not been able to quantify the enhancement structures contribution to increased recruitment and spawning success in respect to the entire population.

There are many considerations and information needs prior to implementing habitat enhancement projects. One key consideration is which type of structure will be most effective in addressing the lake management objectives and the target species. Structures target a variety of species at multiple life
stages. For example, a goal to enhance a bluegill population would benefit the most from a habitat structure with small interstices since studies have documented bluegills prefer small interstices compared to largemouth bass preference of medium interstices (Johnson et al. 1988; Lynch Jr. and Johnson 1989; Walters et al. 1991). Furthermore, the structure material plays a role in deciding on the best structure for the fishery objective. Some structures are made of materials that promote periphyton growth while other structures are made of material that is not an effective substrate for periphyton growth. If primary productivity were an additional factor limiting the fishery, choosing a structure that can benefit both the target species and promote primary productivity would be the most beneficial.

A number of additional factors will determine the type of habitat structure for a project. Cost and project scope are driving factors that can determine the type of structure used for a project. Commercial habitat structures vary in cost but for large-scale projects, the price can quickly become expensive. Large-scale projects often have limited budgets leading to a combination of commercial structures and hand-made structures using donated material. For example, donated Christmas trees, or yard clippings can decrease costs however, the downside is trees deteriorate relativity quickly decreasing long-term effects. Location is also a factor when deciding on a habitat structure. Some structures are better suited to shallow water and work better along shorelines with minimal slope. Many of the spawning structures fall into this category and become ineffective as depth increases.

With the numerous types of habitat structures available, we compiled a comprehensive list of commonly used habitat structures and general information for each structure to provide a starting point for habitat enhancement projects. As more projects and research is completed, the catalogue will be updated to include new structures, information, and experts recommendations.

**Materials**

Common habitat structure materials include concrete, rock, limestone, steel, plastics, ceramics, wood, and PVC pipes. Materials are selected based on durability, resistance to corrosion, and structure complexity. Further considerations include degradation of structures over time and any potential leaching effects that lead to harmful changes in the environment (e.g. increased pH levels).

Historically, tires were used to create artificial reefs however, they are not recommended due to concerns with petrochemical leaching and lake aesthetics especially in systems with fluctuating water levels (Kellough 1991; Day et al. 1993; Birkholz et al. 2003; Derbyshire 2006). Other harmful materials include polystyrene, which is hazardous to fish ingestion as it breaks down over time, treated wood including creosote and copper napthenate that can leach harmful chemicals into the water, and uncured cement which can increase pH to levels toxic to invertebrates for up to 12 months (Lukens and Selberg 2004, Derbyshire 2006). Overall, prior to any habitat implementation all materials need to be environmentally acceptable products that will not cause harmful effects.

**Fish Habitat Structure Types**

We assembled habitat structure information from research studies, fisheries websites, commercial habitat websites, and previous habitat projects. The catalogue of habitat structures below gives a detailed description of each habitat structure, the intended target species and benefits, materials, recommendations, average life of the structure, and informational website if available.
**Arizona Game and Fish Arrowheads**

*Description:* Arrowhead structures are comprised of three squares of PVC pipe oriented in an arrowhead/triangle shape. Brush piles are placed inside the squares and sand bags are secured to the pipes to anchor the structure to the lakebed. Squirrel baffle and safety fence is secured around the structure to contain the brush piles, and to provide shade and cover for fish.

*Target Species and Benefits:* Benefits all fish species by providing cover and protection and may increase angler catch rates. Bass and catfish both have utilized the large PVC pipes.

*Materials:* Materials consist of PVC pipes, safety fence, brush, sand bags, zip ties, and squirrel baffle.

*Recommendations:* The top of the structure should be a minimum of five feet deep at all times to avoid creating a navigation hazard.

*Average life of structure/unit:* Long-term, with the brush deteriorating at varying rates depending on the type of wood used.

**Arizona Game and Fish Crappie Condos**

*Description:* Crappie Condos, invented by the US Forest Service and Arizona Game and Fish Department, are plastic snow fences contoured into multiple cylinders with a plastic hat placed on top (Warnecke 1988). Structures are anchored to the lakebed with concrete blocks to prevent movement from desired location.

*Target Species and Benefits:* Crappie Condos provide cover for juvenile panfish including crappie and baitfish, as well as, provide habitat for periphyton and zooplankton production. The structures also attract and congregate panfish including crappie, which may increases angler catch rates.

*Materials:* Materials consist of plastic safety fence tube, plastic hat, galvanized fence stays, plastic ties, and cement blocks.

*Recommendations:* Condos are most effective when linked in clusters of 10 to 20 individual structures. Structures can be deployed using a watercraft with a tilting installation structure or dropped from the side of a boat.

*Average life of structure/unit:* Long-term
Arizona Game and Fish Department Poly Shrubs (aka spider blocks) and Trees

Description: Poly Shrubs and Trees are cement bases with multiple limbs made up of flexible piping extending in all directions. Trees use a thicker pipe as the trunk with the limbs attached to the pipe. Poly Shrubs and Trees are cheap and easily assembled and reduce snagging compared to wood habitats. The branches float slightly in water providing added habitat for fish.

Target Species and Benefits: These structures are designed to attract all fish species and may increase angler catch rates. Structures provide cover for juvenile and baitfish species. The structures surfaces also promote periphyton growth.

Materials: Materials consist of cement base and polyethylene piping. Poly trees use a metal or plastic mold to hold the limbs in place until the cement dries.

Recommendations: A minimum of five structures should be placed at one location to increase effectiveness of the structures.

Average life of structure/unit: Long-term

Bamboo/Native Tree Crappie Condos

Description: Bamboo/native tree Crappie Condos consist of a cement bucket serves as the anchor to the lakebed and bamboo stalks are placed in the cement at angles creating a tree/bush structure. The structure rights itself, even on steep slopes, when dropped from a boat due to the buoyant bamboo and heavy bucket end. These structures are mainly used in Arkansas with native bamboo that is not native or present in Arizona.

Target Species and Benefits: These structures are designed to create spawning and nursery habitat for crappie and young-of-year fish species. The structure attracts juvenile crappie and may increase angler success.

Materials: Materials consist of five gallon plastic buckets, concrete, approximately 20-fresh cut bamboo stalks (about 12 feet or taller), and cement blocks if needed. Instead of bamboo, any native tree limbs present near the reservoir would work as a substitute.
**Recommendations:** In deep water, structures can be deployed from the side of a boat, whereas in shallow water, place structures horizontally on exposed bank shoreline using cement blocks to keep in desired position (see picture below).

**Average life of structure/unit:** Structures placed six years ago are still providing cover and attracting crappie for angling. Life of structure will depend on the type of wood used as branches.

**Website:** [http://www.actionfishingtrips.com/habitat.htm](http://www.actionfishingtrips.com/habitat.htm)

---

**Berkley Fish-Habs Program**

**Description:** Berkley Fish-Hab program designed a 4-foot square crib structure made from recycled fishing line and plastic. Brush can be placed in the center of the crib to provide additional structural complexity to attract juvenile fish. The structures are lightweight and easy to assemble and deploy. Structures must be anchored to the lakebed to avoid structure movement. Currently, the cost for one structure is approximately $75.

**Target Species and Benefits:** These structures are designed to attract fish and promote plant growth. The structure is large and has wide spaces to encourage larger fish to use the structure. The structure may increase angler catch rates when effective in concentrating game fish species.

**Materials:** Materials consist of recycled monofilament fishing line, line spools, and recycled consumer products like milk cartons and soda bottles.

**Recommendations:** During assembly, create additional structural complexity by filling the center with brush to increase effectiveness at attracting juvenile and young-or-year fish species. Deploying multiple structures at one location may also increase the number of fish attracted to the location.

**Average life of structure/unit:** Long-term

Catfish Houses/Condos

Description: Catfish Houses/Condos are six PVC pipes tied together in a pyramid shape. One end of each PVC pipe is plugged with cement to allow for one-way entry. The plugged ends should alternate in direction in the pyramid design. The goal is to encourage multiple catfish to use the structures and create a darker habitat inside the PVC pipe to encourage spawning.

Target Species and Benefits: These structures create spawning structure for channel catfish, as well as, provide cover for other fish species.

Materials: Materials consist of six 3-feet long PVC pipes with one end filled with concrete and metal straps or plastic bands to connect the PVC pipes.

Recommendations: Plastic bands have broken in the past reducing the effectiveness of the structure. Dark (black and gray) PVC pipes can help create a desirable spawning location. Furthermore, to encourage spawning place structures in shaded/darker areas. Placement should keep in mind fluctuating water levels, which can have a negative aesthetics value. For example, exposed catfish condos have been tilted upright and used as trashcans when water levels dropped due to a dam leak.

Average life of structure/unit: Unknown

Fathead Minnow Fortress

Description: Fathead minnow fortresses are a square shape built of rows of multiple cylinders. The structure design has each column of rows alternate direction with the column above and below. The goal is to increase the number nest sites for fathead minnow thus increasing recruitment of a baitfish species.

Target Species and Benefits: Specifically designed to maximize fathead minnow spawning habitat by allowing each male to claim a tube as his own territory for the season. The structure increases the number of available nesting sites and limits the visual contact between the sites decreasing the time spent of fighting.

Materials: Materials consist of corrugated tubing, electrical tap, zip ties, plastic mesh, rope, and bricks.

Recommendations: Depends on the individual lake and/or pond.

Average life of structure/unit: Long-term

Website Address: http://www.aquaticbiologists.com/equipment--tools/fisheries-equipment/fish-structure
Fishiding Reclaimed Artificial Fish Structures

Description: Fishiding structures are made from reclaimed PVC vinyl materials, mainly house siding, that is clean, safe, and stable. Each unit consists of a PVC base with numerous flat limbs of various lengths, widths, and sizes. The limbs are bent by hand to form complex aquatic fish habitat. Fishiding structures provide shade and cover for fish as well as textured and weathered surfaces that promote periphyton and algae growth. All structures come with a self-standing incorporated weight to reduce structure movement. Structures range between $25.00 to $325.00 per structure.

Target Species and Benefits: Structures are designed to provide all fish species cover in shallow, mid depth, and deep water. The limbs offer short, dense ¼” wide strands to protect fry. No tools or hardware are used to assemble the structures, just bend the limbs with your hand to the desired shape and place in lake.

Materials: Materials consist of reclaimed PVC vinyl material and cement. No additional tools or adhesives heat are needed to deploy structures.

Recommendations: Structures should be placed in clusters of three or more to improve effectiveness, with limbs just touching adjacent structures.

Average life of structure/unit: Long term (unless exposed to UV light and air)

Website Address: http://www.fishiding.com/

Floating Islands

Description: Floating islands, also called sudds, tussocks, floatons, or embalsados, typically consist of floating vegetation and/or peat with the goal of sustaining riparian vegetation, improving water quality, and/or create quality habitat for fish species. Floating islands are designed for multiple reasons such as improving water quality, providing fish habitat, and increasing aesthetics. Floating islands can also be anchored to a cove if water level fluctuation or navigation hazard is a concern. Floating islands can be costly and labor intensive. They also are a potential navigation and/or swimming hazard depending on location. Furthermore, the full lifespan of the islands is unknown.

Target Species and Benefits: Floating islands are proven effective at attracting fish, addressing
water quality problems, and benefiting other aquatic organisms. BioHavens® generate microbial activity that removes nitrate, phosphate, and ammonia (Stewart 2007), which converts nutrients into food sources for fish species. The lakebed is enhanced by the precipitation of microbes weighing out of the system and activating the sludge. They also deliver available oxygen to the benthic layer by this same process. They are also effective at reducing total suspended solids and dissolved organic carbon in waterways. Furthermore, floating islands add aesthetic value and provide habitat for wildlife species.

Materials: Materials consist of durable, non-toxic post-consumer plastics with no known leaching substances and native vegetation. BioHavens® have been proven as net absorbers of BPA from the water (BioHaven 2008).

Recommendations: Depends on the waterway and objectives of the floating island. Experts at Biohaven can custom build each floating island to the desired objective.

Average life of structure/unit: Currently, the oldest BioHaven® was launched 12 years ago and is still performing. The plastic aspect of the island will last a long time as long as it is protected from the sun.

Website Address: http://www.floatingislandswest.com/
http://www.floatingislandinternational.com/products/biohaven-technology/

Georgia Cube

Description: A Georgia Cube is a 3ft square cube frame structure made from one and a half inch PVC pipe with approximately 50ft of corrugated drainpipe attached. The bottom and sides of the pipe frame are filled with approximately 16 lbs. of gravel to anchor the structure to the lakebed.

Target Species and Benefits: To attract multiple fish species from game species to baitfish and as a result may increase angler catch rates. These structures have been documented to quickly accumulate periphyton.

Materials: Materials consist of 1 ½ PVC pipe for the cube frame with 8 of the frame pieces filled with gravel and corrugated drainpipe.

Recommendations: Positive results have been seen in clusters and individual placement.

Average life of structure/unit: Long-term that last at least three times longer than brush piles.(10+ years)

Great Lakes Products Inc. AquaCrib

Description: AquaCrib structures are rectangular structures measuring approximately 48 inches wide by 60 inches long and 48 inches high with brush placed in the center. AquaCrib structures are durable, non-toxic post-consumer plastics with no known leaching substances and native vegetation. They have been proven as net absorbers of BPA from the water (BioHaven 2008).
connected with four supports and 44 plastic fasteners. Structures have a unique hinged top panel to allow placement and to replace deteriorated brush, as well as, the ability to insert a concrete block, if desired, to weigh down the structure. Structures are lightweight (20 pounds) and easily deployed, however, for full usefulness brush should be replaced as needed to continue to provide cover for juvenile and bait fish.

**Target Species and Benefits:** To attract multiple fish species from game species to baitfish and as a result may increase angler catch rates. AquaCrib®s are designed to encourage sportfish propagation.

**Materials:** Materials consist of corrulite (a rugged, lightweight corrugated polyethylene plastic), zip ties, and an instruction book provided by AquaCrib®s. Additional materials include concrete blocks for additional weight and brush to create additional cover.

**Recommendations:** Structures should be placed between 12 to 20 feet deep. Brush should be replaced as needed to continue to provide complex habitat for juvenile and bait fish.

**Average life of structure/unit:** Long-term with optional brush replacement as needed

**Website:** [http://www.aquacrib.com/](http://www.aquacrib.com/)

**Honey Hole Cover Habitats**

**Description:** Pond King Inc. makes all Honey Hole structures. Honey Hole Trees imitate natural fish cover and have 275 feet of flexible tubing to create a haven for crappie, bass, and catfish. Honey Hole Shrubs are domes with limbs sticking out in multiple directions. Honey Hole Logs are compact fish habitat that attracts fish in shallow or deep water by imitative natural logs. These structures are all easy to construct and install. The structures are also lightweight and easily assembled in place when water levels are low or easily deployed from a boat. Structures automatically land in an upright position when deployed from the surface. Honey Hole Trees and Shrubs include a weight that is suitable for moat locations. However, if there is wave action or current, additional weight can be added to reduce movement. Honey Hole Logs do not include weights, but can be anchored down with bricks to avoid displacement. Honey Hole habitats design and materials prevent tackle and hooks from snagging. Structures cost between $129.00 to $249.00 each. California Fish and Game and North Carolina Wildlife Resources Commission have used Honey Hole habitats to provide cover for fish.

**Target Species and Benefits:** Honey Hole habitats attract fish species potentially increasing angler catch rates. Pond King Inc. states that the structures may promote survival of juvenile fish. The structures are also designed to boost baitfish production especially species that attach eggs to vertical substrates such as fathead minnows, golden shiner, and threadfin shad.
Materials: Materials consist of environmentally friendly poly dome with polyethylene limbs. Honey Hole Trees and Shrubs include a weight. No glue is used in any of the Honey Hole products.

Recommendations: Honey Hole Trees should be placed in deep water (greater than six feet) and in a cluster of three trees in a triangle pattern. Pond King Inc. also recommended to suspend the trees off the bottom in depths greater than 15 feet otherwise place trees on points or in coves where there is a sharp contrast in water depth. Honey Hole Shrubs should be placed in shallow water between three to four feet with a maximum depth of six feet.

Average life of structure/unit: Long-term

Website Address: http://www.pondking.com/product-category/artificial-fish-habitat

Honey Hole Spawning Disks

Description: Pond King Inc. makes all Honey Hole structures. Honey Hole Spawning Disks are concave disks that are elevated off the lakebed and filled with gravel to increase spawning and hatching success for sportfish species. Structures cost $65.00 for a pack of three structures of $239.00 for a pack of 12 structures.

Target Species and Benefits: Honey Hole Spawning Disks are designed to increase fish hatching rates by 300% to 400%. Honey Hole Spawning Disks provides an elevated habitat for spawning when lakes/pond have silted lake bottoms that reduce spawning success.

Materials: Materials consist of environmentally friendly poly concave disk. No glue is used in any of the Honey Hole products.

Recommendations: Honey Hole Spawning Disks should be installed with either a PVS stake or anchored with a weight to reduce movement. Pond Kind recommends adding up to 24 disks per acre in cluster of three to eight.

Average life of structure/unit: Long-term

Website Address: http://www.pondking.com/shop/artificial-fish-habitat/honey-hole-fish-spawning-disks

Photos courtesy of Pond King Inc.
**Mossback Racks Fish Attractors**

*Description*: Mossback Fish Habitat products are natural looking fish habitat comprised of a main trunk with up to 32 flexible branches. The design aims to provide fry and bait fish cover, ambush cover for larger game fish, easy assembly and deployment, and to minimize snagging. All surfaces are designed to promote periphyton growth. Base platforms are available to aid with vertical product placement and may be filled with either gravel to create additional spawning habitat or an alternative weight of your choice for stability. Mossback Fish Habitat manufactures a variety of products with numerous configurations to help achieve your ultimate habitat goals. Prices vary ($30 and up) depending on number of structures and size.

*Target Species and Benefits*: These structures are designed to attract fish and may increase angling success. Structures also provide cover for baitfish and game fish. Due to the realistic bark like texture, aquatic plant growth attaches quickly providing a food source for juvenile fish.

*Materials*: Materials consist of recycled material, PVC pipes, and stainless steel.

*Recommendations*: For best results, cluster three or more structures together to create a habitat community.

*Average life of structure/unit*: Long-term


**Natural Woody Structure; Christmas tree clusters, root wads, brush piles, etc.**

*Description*: Natural woody structure can have a variety of designs and types; however, they are all made of woody debris with a structure to anchor them together and to the lakebed. For example, Christmas tree clusters are a group of 10 to 20 Christmas trees tied together and anchored to the bottom of the reservoir. Brush piles, a pile of tree limbs, were the first habitat enhancement structure documented in the United States. Woody structures are proven very effective at attracting fish and are beneficial to other aquatic organisms. Structures can be built in place or deployed from a boat. Woody structures are inexpensive and provide cover for fish; however, they are relatively short-term depending on the type of wood. There is also potential for displacement and movement if not secured properly and as structure degrades over time.

*Target Species and Benefits*: Structures provides cover for panfish and bass. Clusters also congregate fish and may lead to an increase in angling success.
**Materials:** Materials consist of multiple types of wood and trees such as evergreen and oak. Structures are anchored to the lakebed with cement blocks or buckets filled with cement and piles are tied together using a natural fiber rope.

**Recommendations:** Trees placed vertical in the water column may be more effective for longer periods than those lying horizontal. Snags can become an issue in heavily fished structures. One solution for limiting snags is tying multiple trees together in the vertical position forming rows of trees. This allows anglers to cast between rows and avoid snagging. In heavily silted areas and reservoirs with fluctuating water levels, trees should be suspended off the bottom to increase effectiveness. It is also important to consider the type of tree (i.e. cedar, pine, etc.). Smaller fish congregate on trees that provide dense cover, such as cedar, whereas larger fish congregate around trees that provide less dense cover, such as oak (Cofer 1991).

**Average life of structure/unit:** On average structures average between 3 to 9 years depending on type of wood and water level fluctuations.

**Pennsylvania Black Bass nesting structure**

**Description:** Small, complex wooden structures that have a table appearance and use concrete blocks to anchor to the lakebed. Due to the small height of the structure (15 inches high), it is great in shallow water and doesn’t create a navigation hazard. Structures can be built in place or deployed from a boat.

**Target Species and Benefits:** These structures are designed to increase nest sites and spawning success for bass. The structures also provide cover for young-of-year and juvenile bass. The structures aim to improve young-of-year survival and increase spawning sites for largemouth and smallmouth bass.

**Materials:** Materials consist of wood (fresh cut hemlock or poplar), cement blocks, 16d common nails, nylon banding, and a steel buckle.

**Recommendations:** Structures should be placed in shallow water (less than 10 feet) with an average of five to ten structures per acre. Deploy structures in an alternating row pattern.

**Average life of structure/unit:** Dependent on type of wood. If the structure is exposed during annual draw down 3 to 5 years compared to submerged year round 20+ years.

**Website:** [http://fishandboat.com/water/habitat/lake_fish_hab.pdf](http://fishandboat.com/water/habitat/lake_fish_hab.pdf)
Pennsylvania Channel Catfish Spawning Box

Description: Channel Catfish Spawning Boxes are a hollow wooden box with a dark interior and one round opening to allow catfish to enter and exit the structure. The top of the structure can be designed with a hinge to evaluate spawning success in the field. A concrete patio block placed inside the structure decreases the likelihood of movement.

Target Species and Benefits: Designed to propagate channel catfish in impoundments and provide protection for young-of-year.

Materials: Materials consist of rough-cut wood, 3-inch screws, and concrete patio blocks.
Recommendations: Structures should have a dark interior or be placed in well-shaded areas. During reservoir drawdowns, structures should be placed in trenches and covered with substrate to provide secure habitat from wind and wave action. Placement should occur in areas with minimal silt and in shallow areas (3 to 5 feet deep). Channel catfish will use the structures placed as close as 10 feet apart. Boxes should be placed with the hole facing away from shore.

Average life of structure/unit: Dependent on type of wood. If the structure is exposed during annual draw down 10 to 15 years compared to submerged year round 20+ years.

Website: http://fishandboat.com/water/habitat/lake_fish_hab.pdf

Pennsylvania Porcupine Cribs

Description: Large complex wooden structures built with multiple pieces of wood layered on top of one another in a pyramid design. Structures use concrete blocks to anchor to the lakebed. Structures can be built in place or deployed from a boat.

Target Species and Benefits: The cribs main purpose is to provide a refuge for panfish and other sportfish instead of attract fish for angling. These structures are designed to create cover for juvenile fish and improve recruitment for panfish and other sportfish species in reservoirs.

Materials: Material consists of wood (fresh cut hemlock or poplar), concrete blocks, 16d common bright nails, nylon security banding, and a steel buckle.
Recommendations: Place structures in deep water (10-15 feet) with 10 to 20 structures per acre. Arrange structures in rows or alternating rows with four to eight foot spaces between each structure.

Average life of structure/unit: Dependent on type of wood. If the structure is exposed during annual draw down five to 15 years compared to submerged year round 25+ years.

Website: http://fishandboat.com/water/habitat/lake_fish_hab.pdf

Pennsylvania Rock Rubble Humps/Reefs
**Description:** A pile of rock, stone, and/or concrete that can range in type and size. Humps are generally one to three cubic yards while reefs are between three and ten cubic yards. Structures can be built in place or deployed from a boat. However, high piles can cause a navigation hazard especially in reservoirs with fluctuating water levels.

**Target Species and Benefits:** These structures attract fish species to a localized area and provide a food source for baitfish in reservoirs lacking structure. Structures also promote periphyton growth and provide forage for aquatic insects. Rock piles also have the potential to increase angling success by congregating fish.

**Materials:** Materials may consist of sandstone, limestone, and concrete blocks, varying in size from fine to riprap.

**Recommendations:** Structures can be placed during low water levels and/or using a specially equipped watercraft. Structure density is usually 20 two-ton humps per acre.

**Average life of structure/unit:** Long-term

**Website:** [http://fishandboat.com/water/habitat/lake_fish_hab.pdf](http://fishandboat.com/water/habitat/lake_fish_hab.pdf)

---

**Pisces Pyramids**

**Description:** Pisces Pyramids are three pallets tied together in a triangle shape with trees attached to two of the sides of the pyramid. The structures are anchored to the bottom using cement blocks or an equivalent heavy object. Pisces pyramids are easy to construct and very inexpensive. They can be built in place during drawdowns or low water levels. Pisces pyramids used in Arizona were shown to be effective at attracting multiple fish. However, they are relatively short-term and need to be built on dry lakebed. There is also some potential for movement as structures degrade.

**Target Species and Benefits:** Pisces pyramids provide cover for structure-seeking fish such as bass, crappie, sunfish, and catfish. These structures also congregate fish, which may increase catch rates.

**Materials:** Structures consist of wooden pallets, trees, cement blocks, and zip ties.

**Recommendations:** For increased effectiveness, place structures in a line or clusters along the shoreline.

**Average life of structure/unit:** ~ 10 years
**Reef Balls**

*Description:* Reef Balls are a 3x4 structure with each ball comprised of approximately 0.75 yards of concrete and other environmentally safe ingredients that will not negatively affect water quality. The structures create a hollow 1/2 sphere with numerous holes varying in size that create fish habitat. The structures are durable and resistant to wave action and currents. In addition, after purchasing the mold, the cost to make a reef ball is relatively inexpensive. However, reef balls can be a potential hazard to recreational boaters if exposed during reservoir water level fluctuations. Reef balls are also extremely heavy and labor intensive to construct and install. Due to the reef ball design, structures deployed from the water surface will automatically right themselves.

*Target Species and Benefits:* Reef balls, in reservoir systems, provide cover for fish species and provide habitat for periphyton and zooplankton growth. Reef balls attract fish species and may increase angler catch rates.

*Materials:* Materials consist of cement (with microfibers to increase strength and powdered densified microsilica to promote periphyton growth), metal pipes and bars, PVC pipes, fiberglass mold, wooden pallet, sand, and rubber balloon of varying sizes.

*Recommendations:* To deploy from a boat, fill the balloon inside the mold and drag the reef ball behind the boat. Deflate the balloon at the desired location and the structure will automatically right itself. Reef balls should only be deployed from the surface when the lakebed substrate is soft (e.g. sand) to prevent the structure from breaking upon impact.

*Average life of structure/unit:* Structures are thought to last between 100 and 500 years.

[http://www.reefball.com/whatsball.htm](http://www.reefball.com/whatsball.htm)

**Spawning Benches**

*Description:* Spawning benches are a slab of wood laid across three wooden or concrete blocks relatively low to the ground. Tie wood to the concrete blocks with a natural fiber rope to ensure durability. Research has shown that spawning benches built on rocky points are the most utilized by smallmouth bass.
**Target Species and Benefits:** Spawning benches provide additional spawning habitat for smallmouth bass. They have been used in several deep reservoirs in Tennessee to provide covered areas under which smallmouth build their nests.

**Materials:** Materials consist of wood, concrete, natural fiber rope, and nails.

**Recommendations:** Place structures near the shoreline at a depth between four and ten feet. To increase smallmouth bass use, place structures on rocky points.

**Average life of structure/unit:** Dependent on type of wood and water level fluctuations.

**Website Address:** [http://www.state.tn.us/twra/fish/Reservoir/habitat/habitat.html](http://www.state.tn.us/twra/fish/Reservoir/habitat/habitat.html)

---

**Spawning Gravel**

**Description:** Coarse gravel is applied to a large section of lake bed to create more spawning habitat. Spawning gravel is relatively inexpensive, easy to install, and does not pose a hazard to recreational boaters. However, gravel can become ineffective over time due to sedimentation and water flow displacement.

**Target Species and Benefits:** Spawning gravel creates additional spawning habitat that can boost reproductive success of nest building species (i.e. trout).

**Materials:** Materials consist of coarse gravel and buckets or heavy equipment.

**Recommendations:** Spawning gravel recommendations vary by site and watershed.

**Average life of structure/unit:** Dependent on sedimentation and currents.

---

**Vegetative Planting**

**Description:** Vegetative planting used to increase fish habitat consists of planting native vegetation around the shoreline of a reservoir to reduce bank erosion and provide habitat during occasional flooding and planting submerged vegetation in shallow water to provide additional fish cover. Vegetative planting is an effective tool to increase cover habitat and thus increase recruitment of fish to adult size. Costs associated with vegetative planting is relatively inexpensive, especially when volunteers assist with labor. Additional vegetation is beneficial to multiple fish and many other aquatic organisms. However, planting vegetation is not likely to be effective in reservoirs with continual water level fluctuations.
**Target Species and Benefits:** All fish species benefit from shoreline vegetation, especially juvenile and young-of-year fish. Vegetative planting also provides additional cover for fish species.

**Materials:** Materials consist of native vegetation and any equipment necessary for planting.

**Recommendations:** Vegetative planting is unique to each environment and recommendations vary.

**Average life of structure/unit:** Long-term

---

**Fish Habitat Structures- Not Recommended**

**Fish-n-Trees**

**Description:** Structures look similar to plastic trees with large palm-like leaves that are buoyant and rotate freely. The structure stems are filled with plastic foam bars that vertically suspend the trees off the lakebed. Fish-n-Trees are easy to construct, install, and deploy from a boat or build in place. Arizona Game & Fish have previously used Fish-n-Trees and they have been effective at attracting fish. Additionally, due to the plastic buoyant free-floating leaves lure snagging and potential boating hazards are uncommon. However, the structures are expensive and were found to move after installation and degrade over time. In addition, the plastic leaves may sag from periphyton and silt accumulation and are prone to vandalism. The company that provided the plastic leaves says they are no longer available as of June 2012 (Wagner 2012).

---

**Conclusion**

Angling success is a main goal of recreational fisheries management agencies and habitat enhancement is one method to improve angling catch rates. Additional strategies to combat recreational fisheries decline in aging reservoirs include nutrient supplementation, stocking programs, harvest regulations, regulating water levels, sediment removal, and/or watershed-scale management approaches depending on the conditions in a specific reservoir. Frequently, fisheries improvements require multiple approaches, such as habitat enhancement, supplemental stocking, and regulation changes.

Reservoir habitat enhancement projects are becoming more prominent to address recreational and commercial fishery declines in reservoirs with lacking natural habitat. As more research is conducted, habitat structures are evolving to increase their efficiency and durability. This catalogue will be updated as needed with new habitat structures and recommendations as lessons are learned and more information becomes available.

---

*Photo courtesy of Arizona Game and Fish*
Acknowledgements

The authors would like to thank all the companies; Action Fishing Trips, Aquatic Biologists Inc., Berkley Fish-Hab, Floating Island International, Great Lakes Products, King Outdoor Enterprises, and Pond King Inc. along with fellow agencies; Pennsylvania Fish and boat Commission, Tennessee Wildlife Resource Agency, and Kansas Wildlife, Parks and Tourism that allowed us access to their product information and assisted in verifying the information provided in the catalogue was accurate.

References


Stewart, F. 2007. Biomimetic floating islands that maximize plant and microbial synergistic relationships to revitalize degraded fisheries, wildlife habitats, and human water resources. Grant Agreement Number 06-02, 61 pp.


