Suckermouth Catfishes: Threats to Aquatic Ecosystems of the United States?

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In appearance and in habits, the suckermouth catfishes or "plecos" of South and Central America (Loricariidae) are markedly different from the bullhead catfishes of North America (Ictaluridae). Bullhead catfishes are terete and naked, with a terminal mouth and a spineless adipose fin. They are free-swimming predators that feed on invertebrates and other fishes. Suckermouth catfishes, in contrast, are flattened ventrally, their dorsal and lateral surfaces covered with rough, bony plates forming flexible armor (Fig. 1). Because of this armor, suckermouth catfishes are sometimes referred to as "mailed" catfishes (Norman, 1948). The mouth is inferior and the lips surrounding it form a sucking disc (Fig. 2). The adipose fin has a spine. The caudal fin is frequently longer ventrally than dorsally. Pectoral fins have thick, toothed spines which are used in male-to-male combat and locomotion (Walker, 1968). Suckermouth catfishes are benthic, adhering to streambeds and rocks with their mouths. They are vegetarians feeding on detritus and algae. Feeding is done by plowing along the substrate and using the thick-lipped, toothy mouth to scrape plant materials (filamentous algae, diatoms) from hard surfaces or to suck up fine sediments. Specimens in aquaria may live more than 10 years. Suckermouth catfishes are capable of breathing air by swallowing it and extracting oxygen through the gut lining (Norman, 1948).

With more than 550 species, suckermouth catfishes constitute the largest family of catfishes in the world (Robins et al., 1991). Popular with home aquarists because of their distinctive appearance, hardiness, and propensity for cleaning algae from all submerged surfaces (including vascular plants), suckermouth catfishes have been commonly imported into the United States since the mid-20th century (Innes, 1948) and the number of taxa imported has increased during recent decades (Robins et al., 1991). Consequently, it is not easy, at present, to precisely identify specimens of suckermouth catfishes when they are found in U.S. waters.

Taxonomy of this group has been described as "relatively primitive" and for some genera as "a mess" (Page and Burr, 1991; Armbruster, 2000). As a result, species-level identifications are tenuous. Forums exist for identifying specimens from photographs (e.g., http://www.planetcatfish.com) and some taxonomic resources are available on the Web, such as those for Loricariidae at the Auburn University Website (Armbruster, 2000), but comprehensive taxonomic keys to species are not yet readily available to resource managers. Also, taxonomists working with sucker-mouth catfishes are themselves divided into two different camps: "splitters," principally Europeans, who divide the group into multiple genera and numerous species, and "lumpers," principally Americans, who divide the group into fewer genera and fewer species.[1] Confounding the problem of taxonomic resolution is the co-occurrence of multiple species in a single location and the possibility of interspecific hybridization. For example, three recognizably distinct forms occur at a single location in the San Antonio River in Texas (Fig. 1). These conform to characteristics of three of the species known to exist in the United States, but their close abundance and cooccurrence suggest the possibility of future hybridization.[2] At present,

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[1] Personal Communication. 2003. Pete Liptrot, Bolton Museum, Art Gallery, and Aquarium; United Kingdom.

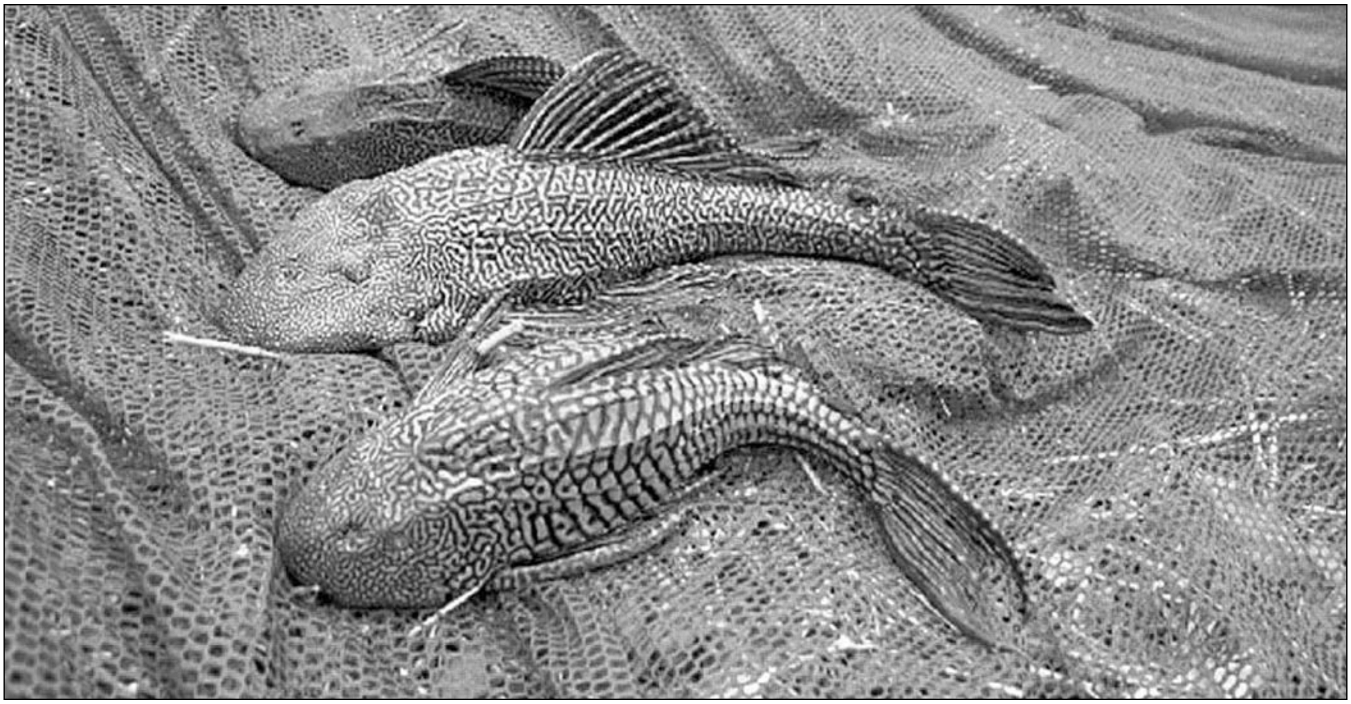

Fig. 1.
Suckermouth catfishes from the San Antonio River at Lone Star Boulevard, San Antonio, Texas. These are sailfin catfishes and are believed to represent three species: *Pterygoplichthys anisitsi* (foreground), *P. disjunctivus* (middle), *P. multiradiatus* (background).

several species, in two genera, are known to be well-established in U.S. waters (Page and Burr, 1991). Some specimens, however, have unusual pigmentation suggesting hybridization (e.g., Nico and Martin, 2001).

Hypostomus spp., Armadillo del Rio

Armadillo del rio (Fig. 3) were introduced to Texas and Florida rivers in the mid-1950s/early-1960s and other locations shortly thereafter (Nico and Fuller, 1999). Reproductive populations exist in Nevada and Hawaii and isolated specimens have been reported from at least five other states (Arizona, Colorado, Connecticut, Louisiana, and Pennsylvania). In Texas, the San Antonio River population was apparently established after individuals escaped from the San Antonio Zoo in 1962. Armadillo del rio were used in the zoo as a biological control for nuisance growths of hair algae (Barron, 1964). Other populations in the United States resulted from fish farm escapees or aquarium releases.

Fishes in the genus *Hypostomus* (*Plecostomus* in older references) are readily distinguished by their comparatively small dorsal fin with fewer than nine (usually seven) rays, a snout with a smooth margin, and fused opercular bones (Burgess, 1989). They frequently have patterns of spots and they range in size from 14-50 cm depending on age and species. Texas specimens have been collected that approach the maximum known size for the taxon. There are approximately 116 species (Burgess, 1989), but one, *Hypostomus plecostomus*, is the most geographically widespread, occurring in tropical South America, Panama and Trinidad; *H. plecostomus* is also the most frequently imported species (Walker, 1968). At least six other species, however, have been used as ornamental fishes and can be distinguished (and putatively identified) based on pigmentation (Walker, 1968). Taxonomic status of populations in the United States has not been determined definitively, but three morphologically distinct species are established (Page and Burr, 1991).

These fishes construct branching, horizontal burrows in stream or pond banks that are 120-150 cm deep (Burgess, 1989). Burrows are used as nesting tunnels and are guarded by the males until free-swimming larvae leave the burrow. Some species are salt tolerant. Although salinities in which they have been collected are not reported, waters have been described as “quite brackish.” Introduced populations can become locally abundant in a short period of time. Prior to

[2] Personal Communication. 2003. Larry Page, Florida Museum of Natural History, University of Florida.

Fig. 2.
Mouth of a sailfin catfish. The thick, fleshy lips form a sucking disc for attaching to rocks and grazing on algae.

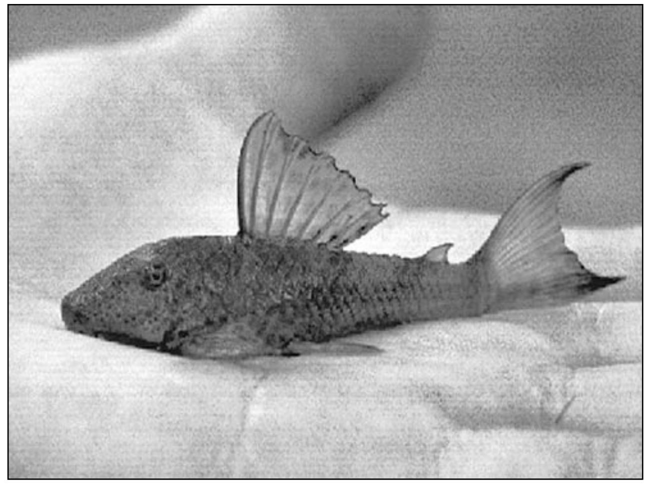

Fig. 3.
Armadillo del rio from the San Antonio River at the San Antonio Zoo. The small dorsal fin has a single spine and seven rays.

1989, the estimated number of individuals in U.S. waters was 7 million.

Pterygoplichthys spp., Sailfin Catfishes

Sailfin catfishes were confirmed from waters in Texas, Florida and Hawaii after 1970 (e.g., Ludlow and Walsh, 1991; Page, 1994; Edwards, 2001). Early introductions may have gone unnoticed because of superficial similarities to armadillo del rio. Most populations of sailfin catfishes were probably started from aquarium releases.

Fishes of the genus *Pterygoplichthys* (*Liposarcus* in some literature) are readily distinguished from the armadillo del rio by their comparatively wide dorsal fin with more than 10 rays (Fig. 4), their snout with a granular margin, and an articulated interopercular bone with evertable spines (Burgess, 1989). There are approximately 22 species (Armbruster, 1997). Pigmentation, within and among species, is highly variable. Four species are known from U.S. waters (Table 1). A fifth species, *P. gibbiceps*, the leopard pleco or acari pedra, is frequently imported but has not yet been collected in North America (Smith, 1981; Burgess, 1989; Sandford and Crow, 1991).

Like armadillo del rio, these fishes construct burrows in the banks of the rivers and lakes in which they live (Fig. 5). Burrow width approximates that of the occupant fish (i.e., width between extended pectoral fins), burrow length is typically 0.5 to 1.0 m, and shape is variable although the tunnel usually extends downward into the bank (Devick, 1988). These burrows are used for reproduction but also allow survival during drought (Fig. 6). Eggs are laid in the burrow and are guarded by males; fish can survive in the moist microhabitat even when water levels fall far below the opening to the chambers (Burgess, 1989; Sandford and Crow, 1991). The authors have observed San Antonio River fish that are, for all appearances, "dead" in the dry burrows above de-watered reaches of the river, but which are, in fact, very much alive (Fig. 7). Such fish, when returned to the water, recover after a short time and swim away. Burrows may also be used as refugia during cold weather (Nico and Martin, 2001). These traits enable sailfin catfish to thrive in their natural and in unnatural habitats.

Dense populations of sailfin catfishes (hundreds to thousands per water body) have been observed in natural parts of their range (Burgess, 1989) and in Hawaii, Puerto Rico and Florida (Devick, 1988; Nico, 1999a; Bunkley-Williams et al., 1994).[3] Growth is rapid during the first two years of life (more than 35 cm) and fecundity high (472-1283 mature eggs/female) especially in larger individuals (Devick, 1988, 1989). Consequently, introduced populations can become abundant in a very short period of time. The population of *Pterygoplichthys multiradiatus* in Wahiawa Reservoir (Oahu, Hawaii) was established in 1986 (or shortly before), was characterized by more than 2,000 burrows at three locations in 1987, and more than 10,000 burrows at those same locations in 1988 (Devick, 1989). In 1989, it was one of the more abundant fish species in the impoundment, and by 1991 had spread throughout nearby streams and reservoirs (Devick, 1991).

[3] Personal Communication. 2003. Joe Gallo, Southwind Lakes Homeowners Association, Boca Raton, FL.

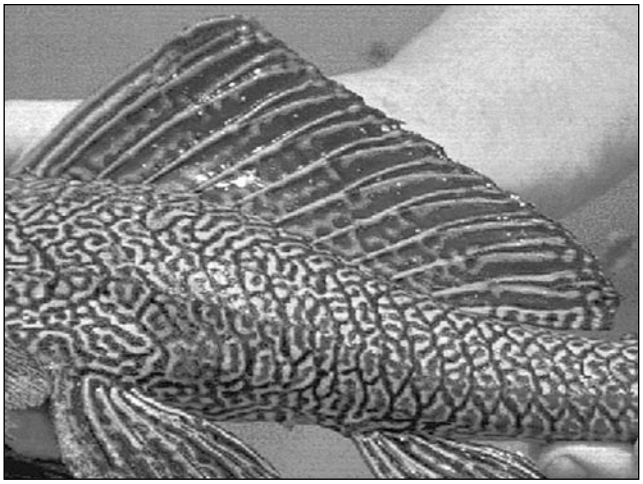

Fig. 4.
Sailfin catfish from Espada Lake, Texas.
The large dorsal fin has a single spine and 11 rays.

Environmental Effects

The distinctive feeding and reproductive behaviors of suckermouth catfishes, coupled with their large size and high population densities, constitute significant threats to native fish communities and to aquatic habitats of the United States. Potential and documented impacts of suckermouth catfishes include:

Disruption of aquatic food chains Grazing on benthic algae and detritus by suckermouth catfishes alters and reduces food and physical cover available for the aquatic insects eaten by most North American stream fishes. Feeding on mud and silt (Walker, 1968) could result in resuspension of sediments and/or changes in substrate size. In addition, nutrients are prematurely diverted from the "consumer" components of food webs and transformed into feces available only to scatophages and decomposers (i.e., bacterial, fungi). Food chain disruption is not limited to stream channels, as some species (e.g., *P. gibbiceps*, *P. pardalis*) also forage on floodplain detritus (Smith, 1981).

Impacts to native species Native herbivorous North American fishes, like the central stoneroller (*Campostoma anomalum*) and the Florida flagfish (*Jordanella floridae*), are small (less than12 cm) minnows or minnow-like fishes, with comparatively short lifespans (less than four years), low fecundity, and limited resistance to hypoxia and desiccation (Fig. 8). Consequently, they are at a competitive disadvantage when confronted by larger (greater than 15 cm), longer-lived, highly productive, environmentally tolerant species that feed on the same foods that they do. Because they are bottom feeders, suckermouth catfishes may incidentally ingest eggs of native fishes. Because they are benthic and large, they may displace smaller or less aggressive benthic fishes (e.g., darters, madtoms, bullhead catfishes). Declining abundance and restricted occurrences of the central stoneroller in the San Antonio River system, for example, were coincident with increasing abundance and expanding distributions of suckermouth catfishes believed to threaten the native minnow (Hubbs et al., 1978).

Mortality of endangered shore birds Suckermouth catfishes, because they are large, sedentary, and palatable, are attractive prey to fish-eating birds. Their defensive erection of dorsal and pectoral spines, however, poses mortal danger to birds attempting to swallow whole fish. Twenty brown pelicans (*Pelecanus occidentalis*) are known to have strangled after feeding on *P. multiradiatus* but many more deaths are suspected (Bunkley-Williams et al. 1994).

Changes in aquatic plant communities Suckermouth catfishes "plow" the bottoms of streams, occasionally burying their heads in the substrate and lashing their tails (Walker, 1968). These behaviors can uproot or shear aquatic plants. This would impact native plant species by reducing their abundance in beds of submersed aquatic vegetation and creating mats that could shade them from sunlight. Making "cuttings" at the water's surface available for dispersal by water movement, boat propellers, and aquatic birds would benefit non-native nuisance plant species.

Bank erosion The nesting burrows of suckermouth

Table 1. Sailfin catfishes (*Pterygoplichthys* spp.) in North America. Common names are those recommended by Burgess (1989), Robins et al. (1991), and other authorities. Information from Nico (1999a, 1999b, 2000a and 2000b) unless otherwise indicated.

Scientific name	Common name	Native range	Records in the United States
P. anisitsi (=*P. ambrosettii*?)	sailfin catfish, snow pleco, snow king	tropical America	Texas
P. disjunctivus	vermiculated sailfin catfish	Amazon Basin	Texas, Florida
P. multiradiatus	butterfly sailfin catfish, radiated pleco	Venezuela	Puerto Rico (Bunkley-William et al., 1994) Florida, Hawaii, Texas (pers. obs.)
P. pardalis	acari-bodo	Amazon Basin	South Carolina (single specimen)

Fig. 5.
Burrows of sailfin catfishes in the San Antonio River, Texas.

catfishes sometimes form a large group or "spawning colony" in which several dozen occur in very close proximity to each other (Nikolsky, 1963). These colonies can compromise shoreline stability, increasing erosion and suspended sediment loads (Nico, 2000a). Siltation, bank failure, head-cutting, and elevated turbidity are likely impacts. In Wahiawa Reservoir, burrows excavated in 1988 were estimated to have displaced 150 tons of silt (Devick, 1989). In one south Florida community, erosion of catfish-infested shorelines is estimated at 0.6-1.3 m following each substantial rainfall or 4 m/yr.[4]

Systems at Risk

Based on their biology and commercial appeal, the likelihood of continued dispersal of suckermouth catfishes in North American waters is high. They are tolerant of (and likely to benefit from) eutrophication and other forms of aquatic disturbance, as evidenced by their occurrence in nutrient-rich Lake Thonotosassa and Lake Maggiore, Florida (Page, 1994; Nico, 1999b). Armadillo del rio are highly resistant to high water velocities. In laboratory swim tunnels, they can maintain station and move freely in water velocities greater than 1 m/s (personal observation). Cold tolerance is unknown but movements into thermal refugia (i.e., springs and seeps during winter) seem likely based on seasonal disappearances in the spring-fed San Antonio River, Texas (personal observation) and apparent utilization of sewage outflows in Houston area (Nico and Martin, 2001). Also, the variety of species in each of the genera suggests that certain taxa (or hybrids) in successive generations will acclimatize to subtropical and mild-temperate climates, becoming more cold tolerant over time.

It is probable then that suckermouth catfishes will readily disperse through eutrophic waters (including those that are hypoxic and turbid), through high water velocities, and

[4] Personal Communication. 2003. Joe Gallo, Southwind Lakes Homeowners Association, Boca Raton, FL.

Fig. 6.
Sailfin catfish in de-watered burrow.

Fig. 7.
Sailfin catfish extracted from de-watered burrow. Eyes are sunken into the sockets and surface is dry to touch indicating prolonged aerial exposure. Specimen recovered, however, when returned to the river, ventilating and moving almost immediately, and swimming off into deep water several minutes later.

through brackish water. Overland travel has been reported anecdotally when environmental conditions are extreme and short terrestrial excursions seem likely if ground is sufficiently moist (Walker, 1968).[5] Inter-drainage dispersal via upland stream cross over and coastal or inter-coastal waterway migration is inevitable. Suckermouth catfishes are commercially valuable for their tasty flesh, their roe (suitable for caviar), and as live specimens for aquaria. Consequently, the risk of deliberate, anthropogenic introductions of fish into other uncontaminated drainages exists and is likely to increase as more people become aware of the species. Several geographically disparate ecosystems are at immediate risk from recent (after 1990) introductions (or discoveries) of suckermouth catfishes:

- Kissimmee River, Florida—under restoration by the Army Corps of Engineers.
- Lake Okeechobee, Florida—the perimeter of which is contained by earthen levees.
- San Antonio River, Texas—under restoration by the Army Corps of Engineers.
- Reservoirs, Puerto Rico and Hawaii—operated by the Army Corps of Engineers or other governmental resource agencies.

Unprecedented Levels of Threat

Suckermouth catfishes present a cumulative series of threats to aquatic ecosystems unprecedented in recent history. Previously introduced fishes have had significant effects on a limited number of ecosystem characteristics. Some species degrade physical habitats (e.g., common carp via turbidity, grass carp via aquatic vegetation removal). Others compete directly with native fishes for space (e.g., round goby with sculpins) or for food (e.g., bighead carp with paddlefish). A few prey on native fishes (e.g., pike killifish on native topminnows, sea lamprey on several Great Lakes fishes). Suckermouth catfishes, however, affect all of these ecosystem components and processes. They degrade physical habitats (i.e., removing algal cover, uprooting aquatic plants, altering bank topography), compete directly with native fishes (i.e., small herbivorous fishes, larger crevice-dwelling fishes), and could prey on native fishes (i.e., via incidental ingestion of demersal eggs). However, they also affect ecosystems at lower and higher trophic levels. By ingesting mud and grazing, they impact primary productivity (e.g., via changes in sediment size and algal standing crops) and secondary productivity (e.g., bypassing consumer levels of food webs). By serving as prey for aquatic birds, they threaten endangered populations of keystone predators (e.g., pelicans). Multi-level impacts of this variety and magnitude from a single group of introduced fishes have not yet been seen in this country.

Recommendations

In the early 1990s, bighead and silver carps were viewed largely as a localized and innocuous phenomenon of the lower

[5] Personal Communication. 2003. Leo Nico, USGS Geological Survey, Gainesville, FL.

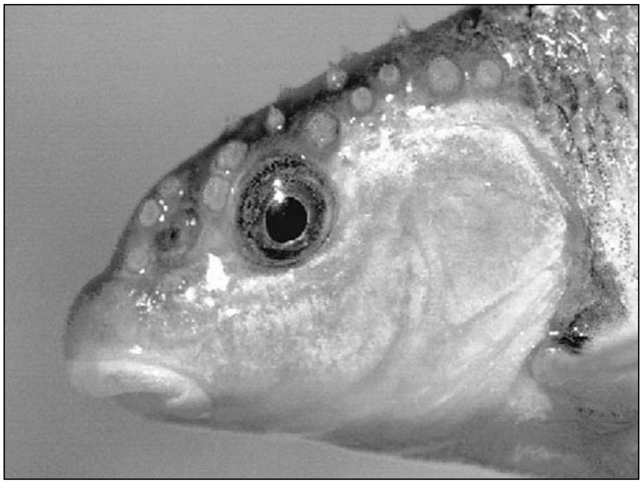

Fig. 8.
Central stoneroller, *Campostoma anomalum*, a native herbivore threatened by suckermouth catfishes. The ventrally positioned (inferior) mouth has a cartilaginous ridge on the lower jar used to scrape off attached algae on which the fish feeds. The hooked horns on the dorsal surface of the head are breeding tubercles of the male, which will be lost shortly after spawning.

Mississippi Basin. Little effort was made to study, contain, and manage those species. Today they threaten the upper Mississippi Basin and the Great Lakes. In recent years, suckermouth catfishes have appeared in a greater number of locations and in greater taxonomic diversity than ever before. Failure to promptly contain and manage them could result in a similar range expansion with potential for disastrous environmental consequences.

To effectively control these species, innovative barriers, management techniques, and public awareness programs are required. Electrical barriers, effective at containment of some other fishes (Stokstad, 2003), may not be effective on suckermouth catfishes, the adults of which are capable of sudden bursts of speed carrying them substantial distances in seconds (personal observation). Hydraulic barriers provide natural containment of many fishes and can be used to contain some exotic species (Hoover et al., 2003), but may be difficult to create for this group of fishes. Suckermouth catfishes are specially adapted for resisting high water velocities, both behaviorally (via substrate appression and rapid swimming) and morphologically (via suctorial mouths, winglike pectoral fins, rough surfaces, and flattened bellies).

Turbulence, bubbles, or sound, however, may provide some level of containment due to the fishes' sensitivity to underwater vibrations and sounds. Suckermouth catfishes, like all catfishes and minnows, possess a series of bones (i.e., the Weberian apparatus or Weberian ossicles) connecting the inner ear to the swim bladder and providing better sound discrimination and perception than other fishes (Burgess, 1989). Pulses or curtains of such disruptive stimuli will be avoided by fish, but the threshold levels and habituation responses of suckermouth catfishes have not been determined.

Bank stabilization (e.g., to minimize nesting), water diversion (to minimize contamination of uninfested waters), population augmentation of native herbivores, and removal of suckermouth catfishes can also be implemented proactively or as damage control techniques. Burrows of sailfin catfishes in south Florida are sometimes clumped, suggesting that certain substrates, or locations within water bodies are preferred. If these areas were stabilized (e.g., bank armor), erosion would be reduced and nesting discouraged simultaneously. Likewise, if infested water bodies could be isolated during periods of fish movement (e.g., flap gate culverts), some level of containment could be achieved. Native fish communities could be enhanced by stocking waterways with native herbivores (minnows, killifishes, tadpoles). They could also be enhanced by the promotion of fishing for suckermouth catfishes. Suckermouth catfishes are larger than most species of native freshwater fishes and in some streams (e.g., San Antonio River), they may be the largest fishes present. Commercial fishermen could be contracted (and could generate additional revenue for contractors from the sale of meat and eggs). Recreational fishermen could participate in fund-raising "rodeos" or "roundups' sponsored by local governments (and could be eligible for cash prizes or bounties).

Educational materials (e.g., CDs, Webpages, flyers, posters), similar to those used for other aquatic nuisance species and for endangered species, could be developed to inform people of the dangers posed by these seemingly innocuous fishes. The United States Geological Survey produces detailed species "fact sheets" for all exotic fishes in U.S. waters (e.g., Nico 1999a, 1999b, 2000a, 2000b) and the U.S. Army Corps of Engineers has a Web page devoted to its own Aquatic Nuisance Species Research Program: *www.wes.army.mil/el/ansrp/ansrp.html*. These, or similar materials, could be incorporated into public outreach programs (e.g., for schools, youth groups), news coverage (e.g., in newspapers, local publications), and in science-oriented events (e.g., at nature centers and natural history museums, at meetings of aquarium societies).

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