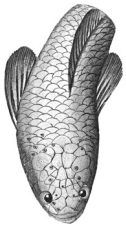
BIOLOGICAL CONTROL

There is no evidence that any species of snakehead has been suggested for use as a biological control agent in the U.S. Nevertheless, certain species of snakeheads have been investigated or utilized as biological controls abroad. For example, Kehar and others (1995) reported experiments in which spotted snakeheads, *Channa punctata*, were used at different levels of pH and salinity in controlling mosquito larvae. They concluded that this snakehead could be utilized as a potential biological control of mosquito larvae in waters up to 10 ppm salinity. Mansuri and others (1979), however, determined that this species was intolerant of salinities above 6 ppm. Nevertheless, Khora and Rao (1994) recorded the spotted snakehead from estuaries entering the Bay of Bengal. Only young spotted snakeheads feed on insect larvae before dietary changes to larger prey (Quayyum and Qasim, 1962).

Predatory teeth and jaws of a snakehead. Photo by Walter R. Courtenay, Jr. USGS.

A more common use of snakeheads in biological control has been as a predator in fish culture. Conlu (1986) and Milstein and Prein (1993) reported that chevron snakeheads, *Channa striata*, are used to control overproduction of tilapias in culture ponds in the Philippines. Wee (1982) also noted this practice, adding, as did Bardach and others (1972), that they are also used in carp culture to control unwanted "pest fish" in culture ponds. In turn, snakeheads utilized in this manner are also sold as products of culture. Similarly, African snakeheads, *Parachanna obscura*, are used to control young of tilapias in aquaculture ponds in Bénin (Bonou and Teugels, 1985).



U.S. IMPORTATIONS

Some species of snakeheads have been imported for several decades for the aquarium fish trade. In the past two decades, however, snakeheads have also been imported to the U.S. for sale in certain ethnic markets that sell live-food fishes and some restaurants that hold live fishes in aquaria for customer selection. In most states and the District of Columbia, such importation and sale is legal, but there have been violations in at least six states where possession and sale of live snakeheads is illegal. Until recently, the live-food fish pathway for potential introduction of live fishes into U.S. waters was largely overlooked. Because *Channa maculata* (misidentified as *C. striata*) and other eastern Asian food fishes (common carp, *Cyprinus carpio*; oriental weatherfish, *Misgurnus anguillicaudatus*; whitespotted clarias, *Clarias fuscus*; and swamp eel, *Monopterus albus*) were introduced from China into Hawaii before 1900, doubtlessly encouraged and perhaps initiated by Asian immigrants (Maciolek, 1984), this pathway should have been of concern.

Imports of snakeheads into the U.S. have been increasing in recent years (table 5). Importation records unfortunately report quantities either in numbers or by weight, but not both. Hence, the two columns (Number of individuals, Number of kilograms) in table 5 consist of 51,233 fish and an additional 22,208 kg of snakeheads. Furthermore, records do not provide a detailed breakdown of species imported or indication of the intended reason for importation (pet trade or live-food fish markets). Moreover, these records are probably incomplete (Marshall Myers, personal commun., 2001) and may represent only part of the total number/weight of imported snakeheads. This, coupled with not knowing how much of the weight represents small snakeheads and juveniles of larger species destined for the aquarium fish trade versus market-size, larger fish, makes projecting the total number of individuals a precarious guess at best.

Table 5—U.S. importations of live snakeheads (Channidae, all species) during 1997-2002

Year	*Number of individuals*[1]	*Number of kilograms*[2]	*Total declared $ value (individuals and weight combined)*
1997	372	892	5,085
1998	1,488	1,883	12,632
1999	6,044	8,512	27,718
2000	8,650	9,240	39,990
2001	18,991	1,681	21,185
2002[3]	15,688	--	26,077
Totals	51,233	22,208	$132,687

[1] Not included in number of kilograms.
[2] Not included in number of individuals.
[3] Data are for January–May 2002.

Sources of imported snakeheads are varied (table 6). Again, these records are probably incomplete, but China is clearly the major exporter of live snakeheads. As in table 5, there is no breakdown by species.

The number of species that have been imported for the aquarium fish trade or the live-food fish trade could not be determined. Nevertheless, *Channa argus* is the most widely cultured snakehead in China (Fang Fang, personal commun., 2002), and has been available for sale in ethnic live-food fish markets in New York (James Stephen Lee, personal commun., 2001) and St. Louis, Missouri (Leo Nico, personal commun., 2002). A total of 80 live individuals in transit to Seattle were confiscated in Blaine, Washington, in 2001 (Ted Pietsch, personal commun., 2001; Mike Williams, personal commun., 2003), and others were seized from markets in Houston, Texas (Howells and others, 2002), Miami and Pembroke Pines (Florida Fish and Wildlife Conservation Commission, 2001), and Orlando, Florida. Snakeheads had been illegal in California, Florida, Texas, Washington, and 10 other states for many years prior to

Table 6—Origin of snakehead shipments (Channidae, all species) during the past 5 or more years

[1997–2002; records for 2002 extend through May 31]

Country	*Number of individuals*[1]	*Number of kilograms*[2]	*Total declared $ value (individuals and weight combined)*
China	48,533	20,323	125,295
Hong Kong	2	--	50
India	572	--	1,498
Indonesia	300	--	96
Nigeria	970	--	659
Switzerland	50	--	100
Thailand	1,084	--	1,420
United States	25	--	38
Vietnam	1,079	1,435	4,265

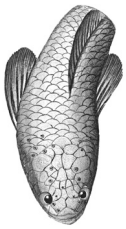
[1]Not included in number of kilograms.
[2]Not included in number of individuals.

July 2002. The first specimen of this species to have been captured from U.S. waters was taken by electrofishing in Spiritwood Lake, a reservoir north of San Bernadino, California, in 1997. Two individuals were caught by angling in the St. Johns River, below Lake Harney, Seminole and Volusia Counties, Florida, in 2001 (with three more reported as having been caught nearby); another was captured by electrofishing in Newton Pond, Worcester County, Massachusetts, in late 2001. The discovery of an established population of this species in a pond in Crofton, Anne Arundel County, Maryland, proved that this species was capable of invading U.S. waters. In July 2002 *C. argus* was being sold in a live-food fish market in Orlando, Florida. That market was raided by FFWCC agents who confiscated several specimens. Northern snakeheads were reported to be in culture in Arkansas, and this may or may not have been a source of northern snakeheads in Florida. *Channa argus* was likely available in live-food fish markets in Boston, although two snakeheads purchased there in late 2001 by Karsten Hartel were later identified as *C. maculata*. Live-food fish markets in Vancouver, British Columbia, also sold *C. argus* (Margarita Reimer, personal commun., 2002).

In conclusion, *Channa argus* is known to have been the most widely available snakehead in North American live-food fish markets, followed by *C. maculata*. *Channa marulius* was also available in New York City live-food fish markets (Leo Smith, personal commun., 2002). There have been no reports of *C. striata* being available for sale in live-food fish markets in the contiguous U.S., even though it is considered the most important snakehead used for food in southeastern Asia and is being cultured in Hawaii. Nevertheless, a freshly killed

C. striata was purchased from an oriental market in San Diego, California, on July 29, 2002 (Richard Rosenblatt, personal commun., 2002). There was no cloudiness in the eyes of the specimen, indicating that it had never been frozen and may have been kept in a live fish tank, perhaps on the premises of the market, until a very short time before being placed on ice for sale. The specimen was deposited in the fish collection of Scripps Institution of Oceanography (SIO 64-228). *Channa striata* is being sold in a market in Honolulu, Hawaii (Pam Fuller, personal commun., 2002).

Another observation from importation data shows that imports of live snakeheads from Ghangzhou and Shenzhen, both in Guangdong Province, China, began to increase in the latter part of 2001 and accounted for the majority of imports through May 2002. *Channa argus* is not native to southern China. Therefore, importation data suggest that many snakeheads imported during late 2001 well into 2002 may have been *C. maculata*, destined for the live-food fish trade.



REGULATIONS AS OF JULY 2002

At least 14 states specifically prohibited possession of live snakeheads (table 7) prior to the discovery of an established population of northern snakeheads in a pond in Crofton, Anne Arundel County, Maryland, which was eradicated in September 2002. Since then, the states of Arkansas, Connecticut, Illinois, North Carolina, Rhode Island, Pennsylvania, South Carolina, Tennessee, and Virginia have made possession of live channids illegal (fig. 5). Indiana Department of Natural Resources approved emergency fisheries regulations on November 22, 2002, that bans possession of snakeheads effective December 1, 2002. Kansas Department of Wildlife and Parks prohibited possession of snakeheads in early 2003.

Table 7—States prohibiting snakeheads as of July 2002

Alabama	Idaho
Arizona	Mississippi
California	Nevada
Colorado	Oregon
Florida	Texas
Kentucky	Utah
Georgia	Washington

The U.S. Fish and Wildlife Service published a proposed rule to list the family Channidae (snakehead fishes) as injurious wildlife in the Federal Register on July 26, 2002 (67 FR 48855) under the Lacey Act (18 U.S.C. 42). The final rule banning importation and interstate transport of live snakeheads was published in the Federal Register on October 4, 2002 (67 FR 62193). This ruling does not affect possession or sale of live snakeheads in states that do not specifically prohibit them, or importation of dead snakeheads refrigerated or frozen for sale as food fishes into states where possession of live snakeheads is illegal. Nevertheless, despite the Federal rule and a long-standing state prohibition, several live *Channa argus* were confiscated by U.S. Fish and Wildlife Service Inspectors in California as recently as July 2003.

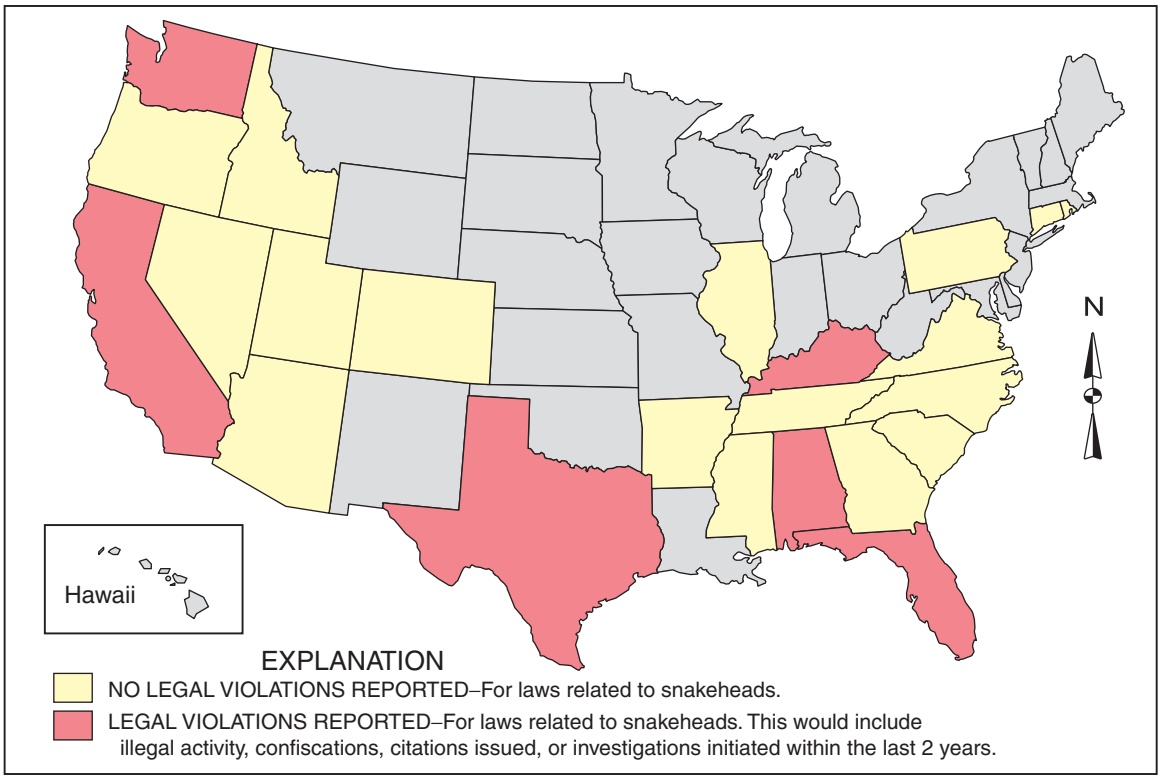
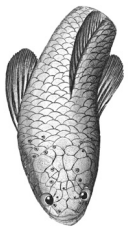


Figure 5—States prohibiting possession of live snakeheads as of November 2002.

Prior to 2002, there were illegal activities involving snakeheads in states that prohibited their sale or possession. A total of 80 live *Channa argus*, destined for markets in Seattle, was discovered in 2001 on a truck from British Columbia. Specimens of *C. micropeltes* and *C. marulius* were confiscated from pet shops in the Los Angeles area, southern California, in the past 2 years. *Channa argus* was confiscated from live-food fish markets in Miami, Orlando, and Pembroke Pines, Florida, and Houston, Texas, in 2001. Illegal traffic in pet snakeheads, involving mostly *C. bleheri*, was discovered in Alabama and Kentucky in the past 2 years. It has been suggested that these snakeheads came from a distributor in Atlanta, Georgia, a state where snakehead possession is also illegal.



POTENTIAL RANGE

Temperature is the most important environmental factor that would determine potential range of snakeheads in the United States. Because there are few data providing thermal tolerance ranges for snakeheads, potential range must be inferred from distribution within native ranges (fig. 6).

The family Channidae contains 10 species that are strictly tropical and, if introduced, would survive in only the warmest waters, such as extreme southern Florida, perhaps parts of southern California and Hawaii, and certain thermal spring systems and their outflows in the American west. Another four species can be considered

tropical to subtropical, indicating a similar potential range of distribution as for tropical species, but with a greater likelihood of survival during cold winters and more northward limits. One is subtropical. Another 11 snakeheads (3 that appear to be species complexes) can tolerate tropical or subtropical to warm temperate conditions, indicative of species that could survive in most southern states. One is warm temperate, and another is warm temperate to cold temperate (*Channa argus* has a temperature range of 0-30 ºC). In summary, there are no waters in the United States that, based on temperature, would preclude some member(s) of the family Channidae from becoming established.

RISK ASSESSMENT PROCESS

Snakehead fishes have had a modest following among U.S. aquarists for several decades. Nevertheless, they are more popular in the Japanese and European aquarium fish trade (Ralf Britz, personal commun., 2002). It is only within the past two decades that snakeheads, limited to a few species, have been imported and marketed in the U.S. as live-food fishes. Thus, pathways for introduction into U.S. waters have been through importations and releases by aquarists and introductions of market-size snakeheads, the latter typically at or near sexual maturity. Release or introduction of snakeheads out of both of these pathways has been documented in open waters of the U.S. All snakeheads prey on other aquatic organisms, most showing a preference for fishes, and many are regarded as thrust predators, hiding and attacking prey by surprise. As with any introduction of a nonindigenous aquatic species, there is always the possibility that they may host parasites or diseases that could spread to native species. Some might host human parasites, and one snakehead species has been found to be a carrier for gnathostomiasis. The fact that one species has been shown as a carrier indicates that there are others which could present a similar threat to human health, yet to be investigated.

There are seven rating elements in the risk model (Risk Assessment Management Committee, 1996). Each element is assigned an estimated level of risk, rated as high, medium, or low. Uncertainty codes after each element rating are as follows (with descriptions): Very Certain (as certain as we are going to get); Reasonably Certain (reasonably certain); Moderately Certain (more certain than not); Reasonably Uncertain (reasonably uncertain); and Very Uncertain (a guess).

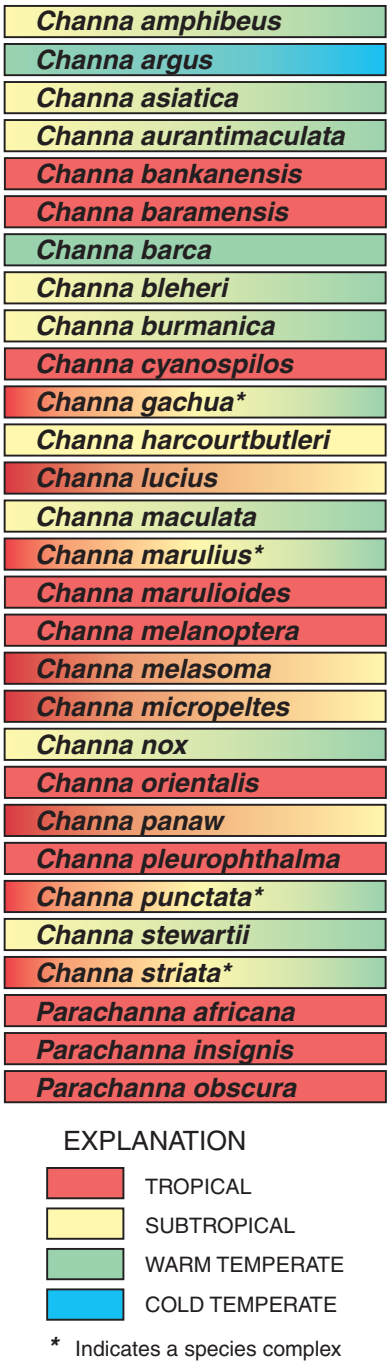


Figure 6—Thermal range of snakeheads (Channidae) based largely on native range of distribution.

RATING ELEMENTS OF RISK MODEL

• 1 • Estimate probability of the exotic organism being on, with, or in the pathway.
High—very certain

Four species of snakeheads have been recorded as reproducing in waters of the United States. These are *Channa argus* in Crofton, Maryland (isolated population, eradicated in September 2002), *C. maculata* in Oahu, Hawaii, *C. marulius* in southeastern Florida, and *C. striata*, being cultured in confined waters in Oahu, Hawaii, since the early 1990s. Specimens of *C. micropeltes* have been collected from waters of four states, the earliest records being from Maine and Rhode Island from the 1970s. Snakeheads have had a limited market in the aquarium fish trade for several decades and, more recently, four species of snakeheads (*C. argus, C. maculata, C. marulius,* and *C. striata*) were being sold in live-food fish markets within the U.S. Therefore, snakeheads have been and are in the United States pathway.

• 2 • Estimate probability of the organism surviving in transit.
High—very certain

Snakeheads are capable of breathing air, many being obligate airbreathers, and easily transported by air or land vehicle without water as long as they are kept moist. They have survived importation from overseas as well as interstate truck transportation.

• 3 • Estimate probability of the organism successfully colonizing and maintaining a population where introduced.
High—very certain

Appropriate habitats and climate are found throughout most of the United States. This does not infer that all species of snakeheads could become established in most of the U.S., but that there are habitats in all states, with the possible exception of Alaska, where one or more species could establish a reproducing population. Preferred food of snakeheads (that is, fishes, crustaceans, insects and insect larvae) is locally abundant.

Several species of snakeheads have established in waters outside their native ranges of distribution in the Eastern Hemisphere. These include *Channa argus* in Japan, Czechoslovakia, Russia for a period of time, the Aral Sea basin (Amu Dar'ya, Syr Dar'ya, Kaska-Dar'ya, Sarysu, Chu, and reservoirs on the Talus rivers); *C. asiatica* in Taiwan; *C. maculata* in Taiwan, several prefectures of Japan, Madagascar, and Hawaii; *C. melasoma* on Palawan, Philippines; *C. orientalis* in Kalimantan and Greater Sunda Islands; and *C. striata* in many Pacific Islands and most recently (early 1990s) in confined waters of Oahu, Hawaii.

Within the continental U.S., two species of snakeheads have been recorded as established. *Channa argus* was established in a pond in Crofton, Anne Arundel County, Maryland, for at least 2 years before being eradicated in September 2002. There remains some concern that the species may have escaped into the Little Patuxent River during that period of occupancy. In addition, specimens of this species have been collected from the St. Johns River, Seminole and Volusia Counties, Florida,

a pond in Shrewsbury, Worcester County, Massachusetts, and from a reservoir serving Los Angeles, located just north of San Bernardino, California, in 1997. There was a reported capture of two individuals of the same species from a reservoir near Charlotte, Mecklenburg County, North Carolina. Subsequent sampling of that reservoir by North Carolina Wildlife Resources Commission biologists did not reveal the presence of additional specimens. *Channa marulius* has been established for several years in a series of interconnected artificial lakes and canals in Tamarac, Broward County, Florida. This system of waterways is connected to the gridwork of flood control canals of southeastern Florida.

Channa maculata has been established since before 1900 on Oahu, Hawaii. Although the species was once widely distributed on Oahu, it is now largely confined to Wahiawa Reservoir and adjoining canal systems. Yamamoto and Tagawa (2000) reported the largest snakehead captured from waters of Oahu was "over 5 feet in length," and that species had to have been *C. maculata.* Two specimens were also reported to have been captured by an angler from the Charles River, Boston, Massachusetts, in 2002. Since the early 1990s, *C. striata* was imported into Hawaii and it is now being cultured.

Channa micropeltes, a species largely sold through the pet fish trade, has been collected from open waters of Maine, Massachusetts, Maryland, Rhode Island, and Wisconsin. This tropical/subtropical species could not survive winters in those states. Nevertheless, these releases, likely made by hobbyists, is indicative of what could happen if similar introductions of this or other tropical/subtropical snakeheads were made in states, such as Florida or Hawaii, or into thermal springs and their outflows in western states.

Joe Hennessey with a giant snakehead (*Channa micropeltes*) caught in a Wisconsin river, September 4, 2003, undoubtedly after being released by an aquarium enthusiast. Fortunately, this species will not survive the winter (see fig. 6). Photo by Mike Sorge, Wisconsin Department of Natural Resources, Bureau of Fisheries Management and Habitat Protection.

- 4 • Estimate probability of the organism to spread beyond the colonized area.
  High—reasonably certain

Appropriate habitats (rivers, streams, lakes, reservoirs, ponds, canals) and climate are suitable for establishment of snakeheads in U.S. waters. Suitable habitat for subtropical/tropical species exists in southern Florida, Hawaii, perhaps southern Texas, and thermal springs and their outflows in several western states. Several snakehead species can exist in warm temperate conditions that exist in southern states. Both *Channa argus* and *C. maculata*, especially the former, can tolerate cold climates,

making the likelihood of their becoming established a probability even in some northern states if released. Introductions into rivers, streams, or canal systems would likely spread whereas releases into lakes or ponds could be more restrictive as to range expansion. Nevertheless, people move fish; considering that larger species of snakeheads are popular with anglers in several locations within their native and introduced ranges abroad, the likelihood of anglers moving snakeheads to novel waters from colonized areas is reasonably great.

Because most snakeheads build nests in aquatic vegetation, some might argue that these fishes would be incapable of colonizing waters devoid of macrophytes. Nevertheless, at least three snakeheads, *Channa gachua, C. marulius,* and *C. punctata*, have successfully reproduced in waters lacking vegetation. The same may be true for *C. argus* that has colonized reservoirs on the Talas River of Kazakhstan. This suggests that there is likelihood that other species of snakeheads have the potential to establish in waters lacking vegetation. Predictions as to where or under what environmental conditions a nonindigenous aquatic species might or might not become established have been proven unreliable in several instances.

- 5 • Estimate economic impact if established.
  Medium—moderately certain

The predatory nature of snakeheads indicates that their introduction could negatively impact populations of native fishes through direct predation, competition for food resources, and alteration of food webs. Larger species of snakeheads are considered to be "top predators" in their native ranges. Unlike U.S. highly predatory native fishes, snakeheads are very protective of their young, thus enhancing survival beyond early life history stages and suggesting the possibility of eventual dominance in suitable waters. To predict what the economic impact could be to the recreational fishing industry or to sport fishing is difficult to assess, but could prove to be substantially detrimental over time.

The economic cost of eradication efforts would be high. Introduction of the northern snakehead, *Channa argus*, to a single pond in Crofton, Anne Arundel County, Maryland, serves as an example. The original purchase of the snakeheads that were eventually introduced at least 2 years ago was likely no more than $40. A recent estimate of the costs to the State of Maryland during 2002 in personnel, creating and conducting two meetings of the Maryland Snakehead Scientific Advisory Panel, application of herbicides and rotenone, and disposing of dead fish was about $110,000 (Steve Early, personal commun., 2003). Introduction of non-native aquatic species is illegal in Maryland, but the perpetrator must be found and charged of such action within a 2-year period. In this instance, the time limitation had expired before the individual making the introduction was identified. Had that person been charged before the limitation expired, the fine would have been $40. At present, no state requires a liability bond before an intentional introduction is made by individuals or an agency, and there are no laws that hold an individual (or individuals) responsible for the costs of eradicating or controlling an unintentional introduction should the species involved become established.

The northern snakehead introduction in Maryland was a rare instance where the fish was confined to a single pond from which it could be eradicated. The costs of eradicating an introduced species in an isolated small lake would be greater and could be substantial in a larger lake. Eradication from flowing waters or large lakes with connecting drainages is physically and fiscally impossible, and the same applies to control measures.

Some species of snakeheads are capable of short overland migrations. This presents a potential economic threat to fish culture interests if those species enter culture facilities from adjacent waters, such as occurred with another introduced airbreathing predator, the walking catfish, in Florida (Courtenay and Miley, 1975).

- 6 • Estimate environmental impact if established.
  High—very certain

Because snakeheads do not occur naturally in the U.S., there is no possibility of introduced snakeheads hybridizing or interbreeding with native fishes. Conversely, competition for food resources is probably high. Competition for habitat is probably low except during spawning seasons. Moreover, potential to cause habitat degradation and/or destruction is low.

All snakeheads are predators, particularly on fishes. Therefore, negative impacts to populations of native fishes could be quite high, as well as predation on crustaceans. Predation on other invertebrate species would be moderate to low, based

A blue tilapia (*Oreochromis aureus*), an introduced species in Thailand, was sheared in half by a giant snakehead (*Channa micropeltes*). Photo courtesy of Jean-Francois Helias, Fishing Adventures Thailand.

on literature references supplied in individual species accounts. Larger snakeheads, however, are known to also feed on birds (particularly young waterfowl), amphibians, small reptiles (snakes, lizards), and small mammals.

Potential to transfer pathogens (parasites, diseases) is largely unknown. Nevertheless, all snakehead species are hosts to at least several species of parasites (see table 2). At least two snakehead species utilized in intense aquaculture, *Channa punctata* and *C. striata*, are susceptible to epizootic ulcerative syndrome (EUS), a disease believed to be caused by several species of bacteria, a fungus, and perhaps a retrovirus. EUS is not specific to snakeheads and has affected other fishes, such as clariid catfishes, bagrid catfishes, two cyprinid genera, mastacembalid eels, a nandid fish in India, and giant gourami and climbing perch in Thailand. There have been no studies undertaken to examine transfer of parasites or diseases to native North American fishes.

Adverse impacts on native wildlife and wildlife resources would likely be few, other than through predation. Ecosystem balance, however, could be substantially modified should snakeheads become established in waters with low diversity of native fishes and low abundance or absence of native predatory species.

Adverse impacts on threatened and endangered species would likely be high. Of all the taxa listed as endangered or threatened in U.S. aquatic habitats, 16 amphibians, 115 fishes, and 5 of the 21 crustaceans (surface dwelling crayfish and shrimp), would be the most likely to be affected. Based on habitat requirements and life history, amphibians and surface dwelling crustaceans would generally be less likely to be affected by introduced snakeheads than would fishes. The possibility of a nonindigenous predator in the aquatic community with any listed amphibian or crustacean would constitute a threat.

Likelihood and magnitude of the effect on designated critical habitats of threatened or endangered species would be significant on the living component of the aquatic ecosystem. Depending on the habitat, snakeheads have the potential to detrimentally alter aquatic communities. The most likely scenario would be an alteration of the fish and crustacean community structure through predation. For listed fishes there could be competition for food in addition to direct predation. Like amphibians, fishes and crustaceans listed as threatened or endangered species, candidate taxa of these three groups or aquatic organisms would likewise be at risk.

Introduction of a small number of snakeheads (for example, less than five) into isolated spring habitats could result in extinction of endemic spring-adapted fishes or crustaceans. Introductions of fishes considered to be far less aggressive than snakeheads (that is, guppies, *Poecilia reticulata*) in such habitats have had major negative impacts (Courtenay and others, 1985). Snakeheads would not have to establish a reproducing population to reduce or eliminate a fish or crustacean species confined to a small section of a stream or isolated spring habitat. A small number of snakeheads introduced, but not established, in a stream or lake would likely have less of an impact. Nevertheless, any snakehead that becomes established in a water body would represent a significant threat and could potentially put any listed amphibian, fish, or crustacean at risk of local extinction.

There is a likelihood that damage to ancillary wildlife resources through control measures could be substantial. Netting and/or electrofishing would be too selective on size classes to remove a population of snakeheads, even in an isolated situation. Despite preliminary fears that rotenone would be ineffective against airbreathing snakeheads, the Crofton, Anne Arundel County, Maryland, eradication program on *Channa argus* in September 2002 proved to be effective. Young northern snakeheads captured from the pond were exposed experimentally to several different ichthyocides, and rotenone did kill the fish. Nevertheless and as expected, when rotenone was applied to the three adjacent ponds in Crofton, it also killed all other fishes. An estimated 500 kg of native fishes died and were disposed of (Bob Lunsford and Steve Early, personal commun., 2002). Control methods in a nonisolated pond or lake, or in flowing water (streams, rivers) situations would be ineffective in eliminating snakeheads whether or not they were established.

- 7 • Estimate impact from social and/or political influences.
  Low—moderately certain

Snakeheads have been in the U.S. aquarium fish trade and hobby for several decades. Due to their predatory nature, compounded by the high costs of housing and feeding larger snakehead species, they have had a limited following by hobbyists. Therefore, snakeheads have never represented more than a very minor component of the U.S. aquarium fish trade. Consequently, economic impact to the aquarium fish trade through prohibition of importation or interstate transport of live snakeheads would be minor.

Importation of snakeheads for the live-food fish market in the mainland U.S. is a more recent trend, to our knowledge dating back to the most recent decade or two. Although snakeheads have been available in live-food fish markets in Hawaii for a far longer period of time (likely several decades), only one market (in Honolulu) was selling live snakeheads for food purposes as of 2002 (Mike Yamamoto, personal commun., 2002). Markets that sell live freshwater food fishes also sell species other than snakeheads, including catfishes, tilapias, carp, eels, hybrid striped bass, and sometimes swamp eels. These are typically Asian ethnic food markets, and they frequently carry a large variety of frozen, imported marine and freshwater food fishes. Therefore, as in the aquarium fish trade, snakeheads are only a minor component of live-food fish sales.

Economic impact to the live-food fish trade would be minor following a ban on importation and interstate transportation of live snakeheads, as these fishes can be imported frozen or dead on ice for sale. Until Arkansas passed an emergency rule banning importation, possession, and sale of live snakeheads in late July 2002, only three fish farmers in that state were reported to be culturing snakeheads (*Channa argus*) for the live-food fish market. There were no other culture facilities in the mainland U.S. known to be raising snakeheads. There is, however, one aquaculture facility on Oahu, Hawaii, that has been rearing *C. striata* since the latter part of the 1990s.

Fish produced by that facility can be shipped for sale either dead on ice or frozen to any state or U.S. territory, or sold within Hawaii. As a result, Federal prohibition of importation and interstate transport of live snakeheads would not present a significant negative impact to most U.S. aquaculture interests. Although political entities could be negatively impacted by the costs of eradication or attempts to control introduced snakeheads, no political entity is known to support importation, culture, sale, or any other use of live snakeheads.

ORGANISM RISK POTENTIAL

Probability of establishment	Organism within pathway **HIGH**	→	Entry potential **HIGH**	→	Colonization potential **HIGH**	→	Spread potential **HIGH**	→ ***HIGH***
Consequence of establishment	Economic **LOW**	→	Environmental **HIGH**	→	Perceived **HIGH**	→	***HIGH***	
Organism risk potential	Probability of etablishment **HIGH**	→	Consequences of establishment **HIGH**	→	***HIGH***			

LOW	= acceptable risk	=	organisms of little concern (does not justify mitigation)
MEDIUM	= unacceptable risk	=	organisms of moderate concern (mitigation justified)
HIGH	= unacceptable risk	=	organisms of major concern (mitigation justified)