# Seafood Watch
Seafood Report

MONTEREY BAY AQUARIUM®

# Farmed Pangasius
Swai (*Pangasius hypophthalmus*)
Basa (*Pangasius bocourti*)

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## About Seafood Watch® and the Seafood Reports

Monterey Bay Aquarium's Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch® defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch® makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from the Internet (seafoodwatch.org) or obtained from the Seafood Watch® program by emailing seafoodwatch@mbayaq.org. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Report. Each report synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices," "Good Alternatives," or "Avoid." The detailed evaluation methodology is available upon request. In producing the Seafood Reports, Seafood Watch® seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch® Fisheries Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch's sustainability recommendations and the underlying Seafood Reports will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling (831) 647-6873 or emailing seafoodwatch@mbayaq.org.

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Seafood Watch® strives to have all Seafood Reports reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science and aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch® program or its recommendations on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

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## Executive Summary

Commercial aquaculture production of two Pangasius species in Southeast Asia, basa (*Pangasius bocourti*) and swai (*P. hypophthalmus*), has increased rapidly in recent years. In the early 1990s imports of these species into the U.S. grew steadily until anti-dumping laws were enforced in 2003 and imports were cut by half. Basa and swai are both native to the Mekong River and Delta, and the Chao Praya River in Thailand. The two species are well adapted to low oxygen water environments and can survive on a diet low in fishmeal. Commercial aquaculture for finfish in Viet Nam continues to use relatively low technology and many operations continue to use homemade feeds, while others incorporate housing above floating cages. River catfish have a strong potential to be a sustainable aquaculture species, but the current practice of open cage aquaculture combined with little or no management of aquaculture operations raises concerns about the future sustainability of aquaculture operations for Pangasius.

## Table of Sustainability Ranks

| | **Conservation Concern** | | | |
|---|---|---|---|---|
| **Sustainability Criteria** | Low | Moderate | High | Critical |
| Use of Marine Resources | | √ | | |
| Risk of Escaped Fish to Wild Stocks | √ | | | |
| Risk of Disease/Parasite Transfer to Wild Stocks | | √ | | |
| Risk of Pollution and Habitat Effects | | √ | | |
| Management Effectiveness | | | √ | |

**About the Overall Seafood Recommendation:**

- A seafood product is ranked “**Best Choice**” if three or more criteria are of Low Conservation Concern (green) and the remaining criteria are not of High or Critical Conservation Concern.
- A seafood product is ranked “**Good Alternative**” if the five criteria “average” to yellow (Moderate Conservation Concern) OR if four criteria are of Low Conservation Concern (green) and one criteria is of High Conservation Concern.
- A seafood product is ranked “**Avoid**” if two or more criteria are of High Conservation Concern (red) OR if one or more criteria are of Critical Conservation Concern (black) in the table above.

## Overall Seafood Recommendation:

**Farmed Pangasius:** Best Choice 🟩 [✓ **Good Alternative** 🟨] Avoid 🟥

# Introduction

## Basic biology

Swai and basa are two of 28 species in the family Pangasiidae, of which the majority, including swai and basa, are in the genera Pangasius. Pangasiidae species are found primarily in freshwater in countries surrounding the Indian Ocean basin; the largest concentration of Pangasiidae diversity is found in Southeast Asia (Roberts and Vidthayanon 1991; Gustiano 2003). Both basa, *Pangasius bocourti*, and swai, *Pangasius hypophthalmus*, are native to Cambodia, the Lao People's Democratic Republic (Lao PDR), Thailand, and Viet Nam (www.fishbase.org). Additionally, swai has been introduced to freshwater systems for aquaculture throughout Southeast Asia (Roberts and Vidthayanon 1991).

Knowledge of the biology and ecology of basa and swai in the wild is scarce (Hung et al. 2003). Both species are omnivorous, and feed primarily on plant matter, fruits, and some mollusks (Vidtayanon 1993); basa consumes more fish and crustaceans than swai (Poulsen et al. 2004).

### *Swai*

The natural range of swai is limited to the lower Mekong Basin, which includes Cambodia, Lao PDR, Thailand, and Viet Nam, and the Chao Praya River in Thailand (Figure 1, Roberts and Vidthayanon 1991; Poulsen et al. 2004). In the Mekong River, upstream migration of adult swai begins in November when the water level in the river decreases and continues well into the dry season, at least until February. In the late dry season, or the start of the monsoon season, a downstream migration takes place from Khone Falls on the Lao PDR-Cambodia border to the Mekong Delta (Rainboth 1996; Sokheng et al. 1999; Kottelat 2001; Poulsen et al. 2004). During the dry season, deep pool habitats serve as important refuge for adult swai, while during the rainy season, the flood plains and tributaries provide prime feeding habitat (Poulsen et al. 2004).

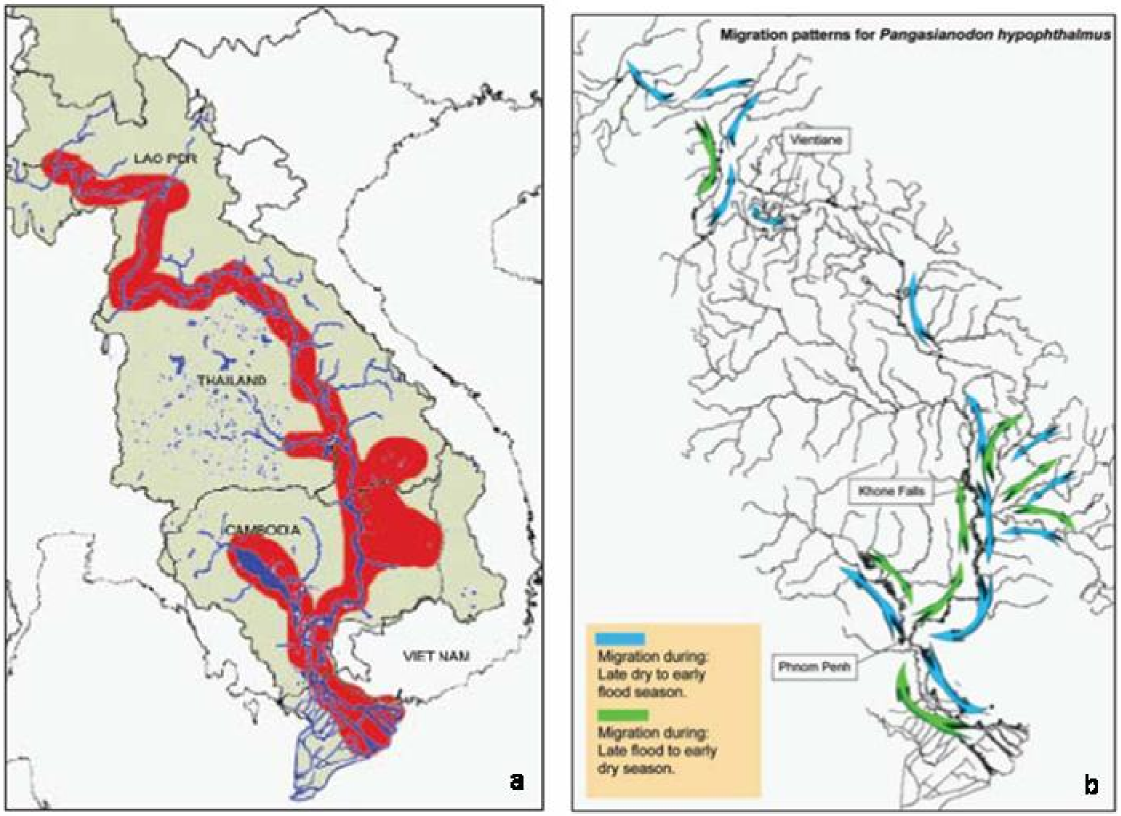


**Figure 1.** (a) Range of *P. hypophthalmus*. (b) Migration routes of *P. hypophthalmus*. Both from Poulsen (2004).

Spawning for swai occurs at the beginning of the monsoon season in the main channel of the Mekong River. Known spawning areas for the southern population of swai range from Kratie to Stung Treng in northern Cambodia, while spawning grounds for the northern population of swai remain unknown.

Sexual maturity for swai in captivity occurs at around 3 years of age, although there is no documentation of maturity for swai in the wild (Van Zalinge et al. 2002). Female swai each produce about 100,000 eggs per kilogram (kg) of body weight and spawn up to four times per year. After spawning, the early larval stage of swai drift downstream with the water current and eventually enter rearing and feeding habitats on the river's floodplains (Poulsen et al. 2004).

*Wild populations*

Over their native range, swai stocks are divided into two distinct populations: stocks in the Mekong River in Cambodia and Viet Nam belong to one population (southern stock); and stocks above Khone Falls in Lao PDR and Thailand form a separate population (northern stock) (Van Zalinge et al. 2002; Poulsen et al. 2004). The southern stock is subject to more intense fishing than the northern stock, and is larger in size (Poulsen et al. 2004).

Swai has been spread more widely outside its native range than basa. It has been introduced to China, the Philippines, Taiwan, Indonesia, Malaysia, Guam, Bangladesh, and India primarily for the purpose of aquaculture (Van Zalinge et al. 2002; Pers. Comm., Philippe Cacot, CIRAD, 2005). There is no evidence of self-sustaining populations of swai escaping from these aquaculture operations or negative ecological impacts from these operations thus far (FIGIS http://www.fao.org/figis/).

### ***Basa***

Basa ranges throughout the Mekong River as well as the Chao Phraya River system in Thailand (Figure 2). Little information is available on spawning locations or behavior for basa; however, research indicates that spawning grounds may be near the headwaters of the Mekong River in the river’s main channel. Larvae that migrate downstream and are found in Viet Nam are thought to have originated upstream (Poulsen et al. 2004).

During the rainy season, river floodplains provide ideal rearing and feeding habitat for juvenile basa, which feed on submerged vegetation. When waters recede at the end of the rainy season, the young fish move back to the river and migrate upstream to hold out in deeper pools. With the return of the rainy season, juvenile basa return to the flood plains to feed. This process continues until sexual maturity when the monsoon rains trigger an upstream migration to spawning habitats (Poulsen et al. 2004).

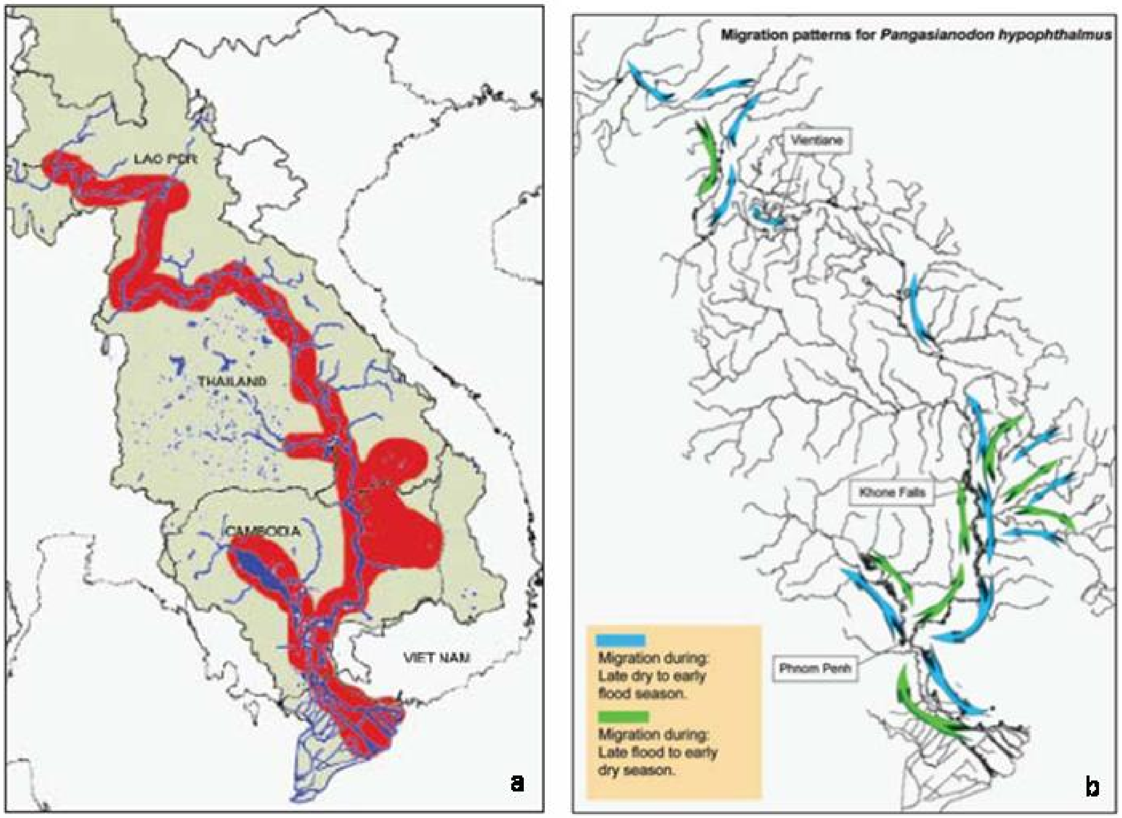


**Figure 2.** (a) Range of *P. bocourti*. (b) Migration routes of *P. bocourti*. Both from Poulsen (2004).

*Wild populations*
Two distinct populations of basa occur in the Mekong River, a northern and southern population. The northern population may be divided into two sub-populations, and some research suggests that the southern and northern populations may be two separate species (Poulsen et al. 2004).

## Wild commercial fishery

Commercial fisheries exist for both basa and swai with no effective regulation. For both species the, now illegal, fishery for larvae (fry) is still an important source of fishing mortality, although the catch is declining drastically. The fisheries supplying aquaculture operations in Viet Nam with fry are concentrated in Cambodia, although there are small fisheries for basa and swai fry in both the Mekong and Bassac Rivers in two provinces of Viet Nam. The most prevalent commercial fishery for river catfish (including basa and swai) is the bagnet, or dai fishery. This fishery is a multi-species fishery targeting fish migrating onto river floodplains (Van Zalinge et al. 2002). This fishery has been banned in Cambodia since 1994 and in Viet Nam since March 2000. However, in both countries the fishery continues to a small degree (Van Zalinge et al. 2002). In general, non-catfish landings go to human consumption and catfish landings go to fish and shrimp aquaculture feed (Pers. Comm., Philippe Cacot, CIRAD, 2005).

### *Swai*

The commercial fishery for swai fry is relatively new, with collection beginning in the early 1980s. The fishery targets only swai, but results in very high bycatch (Bun 1999). Swai comprise less than 2 percent of landings and the majority of swai landed are sub-adults (Van Zalinge et al. 2002). The fishery was outlawed in 1994 in Cambodia and in 2000 in Viet Nam, but continues illegally, still supplying a large amount of fry to aquaculture (Bun 1999; Van Zalinge et al. 2002). There is a general thought that wild-caught fry are better quality than hatchery-reared fry (Trong et al. 2002). The dai fishery exhibits high seasonality, with peaks in early June, coinciding with the May-August spawning period (Van Zalinge et al. 2002).

In addition to being caught in the dai fishery, swai are taken in other small but important fisheries by gillnet, hook-and-line gear, seines, trawls, and, to a lesser extent, traps and stunning with explosives. Fortunately extensive education programs have led to a decline in the use of explosives in recent years. In these other fisheries, swai can comprise over 6 percent of landings, the majority of which are sub-adults. Estimates show that over 2,000 tons of swai are caught annually in Cambodia alone; however, actual landings may be up to three times this amount (Van Zalinge et al. 2002).

### *Basa*

Less information is available for the basa fishery than for the swai fishery. Like swai, basa aquaculture is shifting away from wild-caught fry towards hatchery-reared fry, but aquaculturists still often prefer wild-captured fry (Bun 1999). Until recently, the aquaculture industry relied completely on the wild capture of fry and juveniles for stocking aquaculture cages (Van Zalinge et al. 2002); now only a few of the fry used in aquaculture are wild-caught (Pers. Comm., Kwei Lin, ret. Asian Institute of Technology, April 13, 2005).

A commercial fishery for adult basa occurs during the upstream migration over Khone Falls on the Lao PDR-Cambodia border, where adult basa are caught in large numbers. Additionally, basa are taken occasionally by gillnet in the main channel of the Mekong River throughout the basin (Baird 1998; Poulsen et al. 2004).

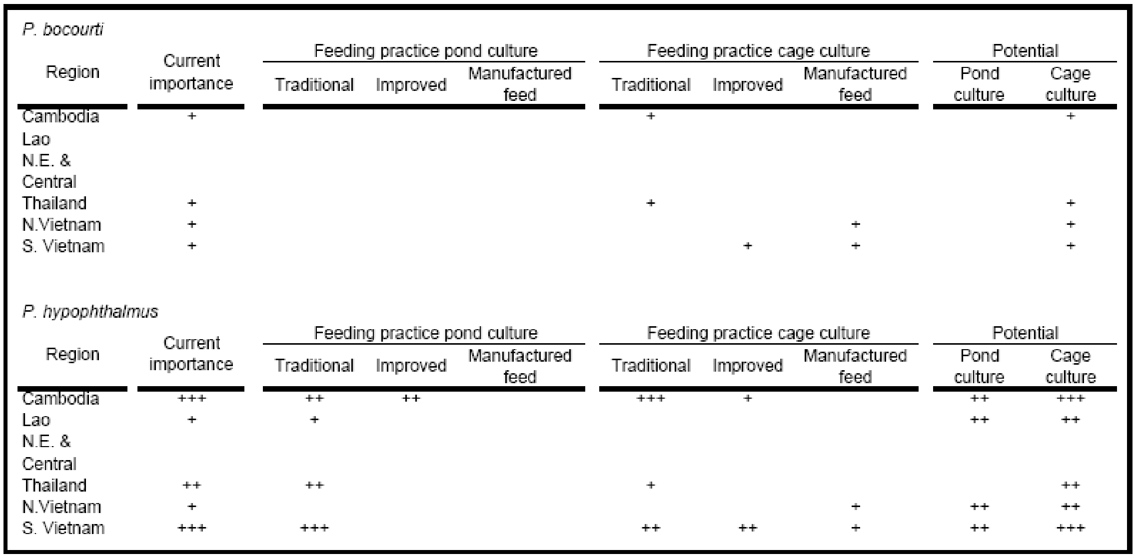
### Aquaculture systems

Aquaculture has a long history in the Lower Mekong Delta (Lazard and Cacot 1997). There are more than 30 fish and prawn species, both introduced and native species, cultured in the Lower Mekong Basin (Phillips 2002). Methods of culture vary widely from simple subsistence ponds to large, industrialized shrimp ponds. Commercial production of river catfish occurs either in earthen ponds or in cages and pens in natural water bodies (Hung et al. 2003).

Swai is the predominant finfish produced in the Mekong Delta region (Phillips 2002). Basa is produced at much lower levels due to the fact that it is less hearty, grows slower, and is more expensive to produce (Edwards et al. 2004). The fecundity of basa is also up to 10 times lower than that of swai, and basa has a much lower tolerance for poor water quality than swai (Pers. Comm., Philippe Cacot, CIRAD, 2005). In addition to a lower production cost, swai also has a higher dress-out weight than basa; 3.1 kg of swai are required to produce a 1 kg fillet, whereas 3.7–3.8 kg of basa is required to produce the same sized fillet (Edwards et al. 2004). Production of basa and swai can be unpredictable, mostly due to the lack of control of the quality and quantity of farm-made feeds (Edwards 2004). Basa was, at one time, the primary fish for export to Asian markets, as swai was thought to be dirty and of poor quality. Due to the ease of production, swai aquaculture was cleaned up and export of swai has increased under the name of basa. True basa is still preferred locally, and will sell for one third more than swai. The basa that is exported goes to a specialty market (Pers. Comm., Philippe Cacot, CIRAD, 2005).

Cage and pond aquaculture systems are used for both basa and swai; use of one system over the other depends on the country (Table 1). Fry are wild-caught or hatchery-reared, and kept in ponds until the grow-out stage (Figure 3). Fish reach marketable size at 1 – 1.5 kg (Hung et al. 2003) after about 8 months of culture, starting from fingerlings (approximately 2 months of age) (Edwards et al. 2004).

**Table 1.** Importance of farms and types of farms for *P. bocourti* and *P. hypophthalmus*. Scale ranges from +, low potential or importance, to +++, high importance. No mark means the species is not farmed in the region. Adapted from Edwards (2004).

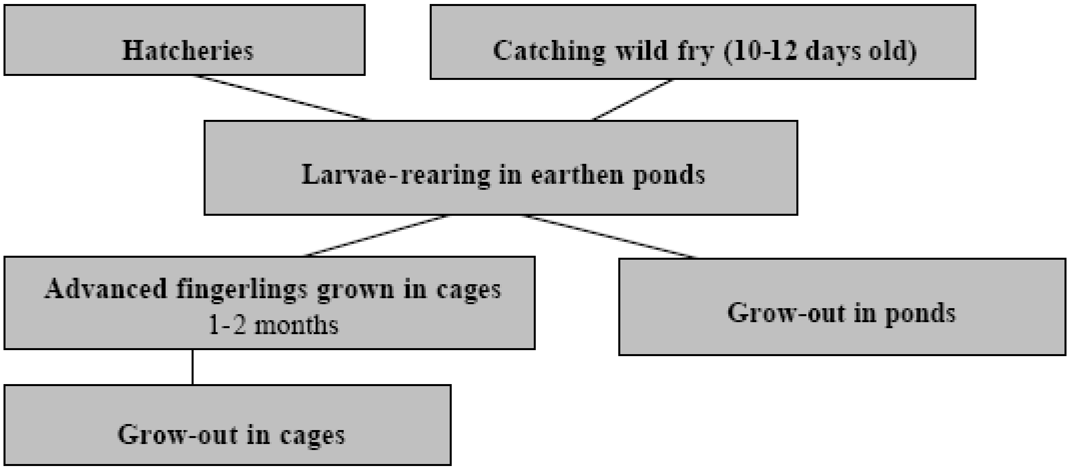


*P. bocourti*

| Region | Current importance | Feeding practice pond culture | | | Feeding practice cage culture | | | Potential | |
|---|---|---|---|---|---|---|---|---|---|
| | | Traditional | Improved | Manufactured feed | Traditional | Improved | Manufactured feed | Pond culture | Cage culture |
| Cambodia | + | | | | + | | | | + |
| Lao | | | | | | | | | |
| N.E. & Central Thailand | + | | | | + | | | | + |
| N.Vietnam | + | | | | | | + | | + |
| S. Vietnam | + | | | | | + | + | | + |

*P. hypophthalmus*

| Region | Current importance | Feeding practice pond culture | | | Feeding practice cage culture | | | Potential | |
|---|---|---|---|---|---|---|---|---|---|
| | | Traditional | Improved | Manufactured feed | Traditional | Improved | Manufactured feed | Pond culture | Cage culture |
| Cambodia | +++ | ++ | ++ | | +++ | + | | ++ | +++ |
| Lao | + | + | | | | | | ++ | ++ |
| N.E. & Central Thailand | ++ | ++ | | | + | | | | ++ |
| N.Vietnam | + | | | | | | + | ++ | ++ |
| S. Vietnam | +++ | +++ | | | ++ | ++ | + | ++ | +++ |

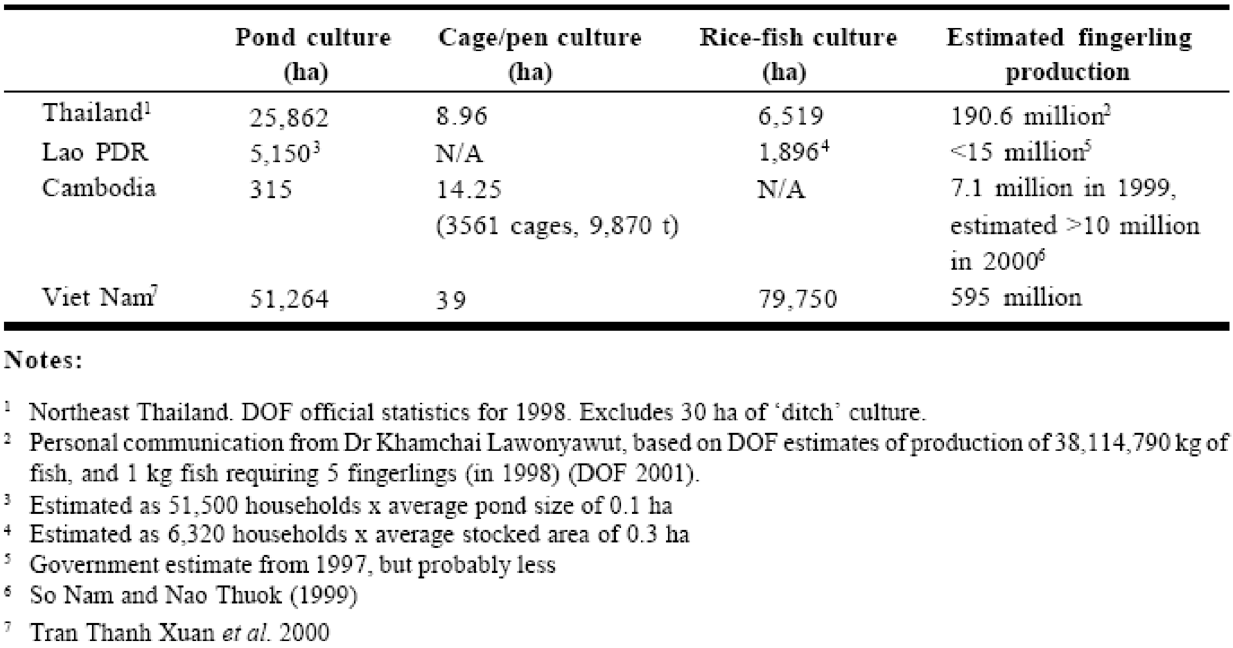


*Source:* Hung and Cacot 2000.

**Figure 3.** Aquaculture timeline for both cage and pond production. From Trong (2002).

Pond culture is the predominant method for producing swai (by area in 1999), at nearly ten-fold the production area of the next most common method. Other common aquaculture methods for swai include cage culture, ditch culture, and rice-paddy/field culture (Hung et al. 2003; Edwards 2004). Most farms in the Lower Mekong Delta are small-scale, while farms in the Bassac River in the Mekong Delta are large cage-culture operations (Phillips 2002). In Lao PDR, Thailand, and Viet Nam, river catfish aquaculture operations use more pond culture than cage culture, whereas aquaculture operations in Cambodia use primarily cage aquaculture (70% of Cambodia's total aquaculture production) (Hung et al. 2003; Edwards 2004).

**Table 2.** Aquaculture production areas and estimated fish fingerling production in the Lower Mekong Basin for all finfish cultured (based on 1998-2000 statistics). From Phillips (2002).



| | Pond culture (ha) | Cage/pen culture (ha) | Rice-fish culture (ha) | Estimated fingerling production |
|---|---|---|---|---|
| Thailand[1] | 25,862 | 8.96 | 6,519 | 190.6 million[2] |
| Lao PDR | 5,150[3] | N/A | 1,896[4] | <15 million[5] |
| Cambodia | 315 | 14.25<br>(3561 cages, 9,870 t) | N/A | 7.1 million in 1999, estimated >10 million in 2000[6] |
| Viet Nam[7] | 51,264 | 39 | 79,750 | 595 million |

**Notes:**

[1] Northeast Thailand. DOF official statistics for 1998. Excludes 30 ha of 'ditch' culture.

[2] Personal communication from Dr Khamchai Lawonyawut, based on DOF estimates of production of 38,114,790 kg of fish, and 1 kg fish requiring 5 fingerlings (in 1998) (DOF 2001).

[3] Estimated as 51,500 households x average pond size of 0.1 ha

[4] Estimated as 6,320 households x average stocked area of 0.3 ha

[5] Government estimate from 1997, but probably less

[6] So Nam and Nao Thuok (1999)

[7] Tran Thanh Xuan *et al.* 2000

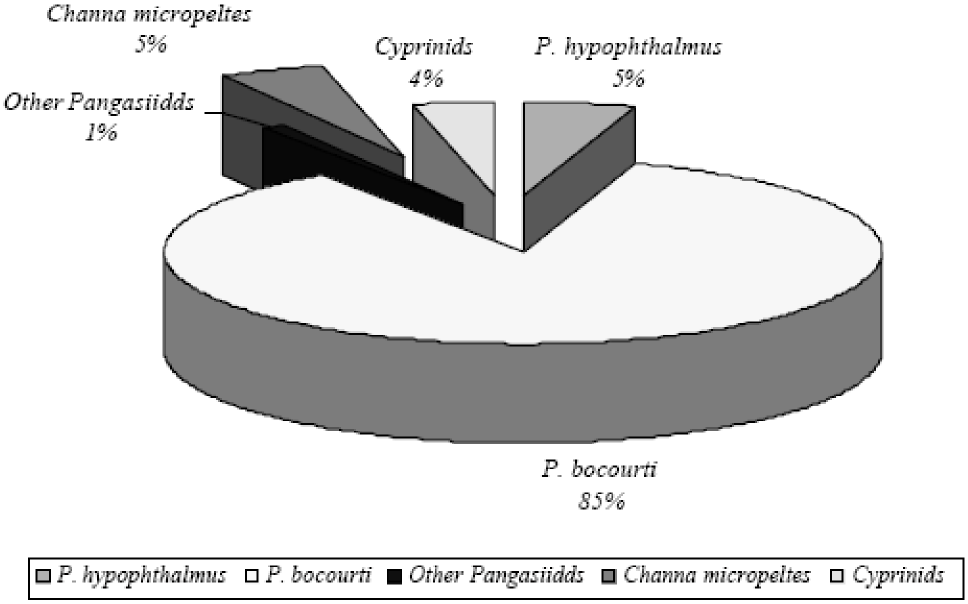
### *Pond culture*

Pond aquaculture of river catfish has been a tradition in the Mekong Delta and River Basin for several hundred years. Before more technologically advanced methods were introduced in the 20th century, farmers in Viet Nam integrated systems of gardens, ponds, and livestock quarters for combined agriculture and aquaculture, a method known in Viet Nam under the acronym VAC (Edwards et al. 2004). Pond culture tends to use less advanced technology than cage culture, and pond culturists tend to use a higher proportion of homemade feeds as well as depend on natural feeds in ponds that are fertilized with animal wastes and poly culture with other fish species, such as carps, Nile Tilapia (*Oreochromis niloticus*), and kissing gourami (*Helostoma temmincki*). These practices tend to give farmed fish's meat a muddy flavor and yellowish color. These characteristics are not favored by international markets, thus cage aquaculture is the preferred method of operation for fish being produced for export (Trong et al. 2002). Despite the higher risks of high stocking densities and poor water flow, which lead to such undesirable characteristics as yellow flesh, pond culture constitutes 50% of total river catfish aquaculture in Southeast Asia (Cacot 2004).

### *Cage culture*

In modern cage aquaculture, cages are placed and maintained in natural water bodies and consist of wood or steel frames with nylon mesh (near Ho Chi Minh City) or inox screens, and are attached to drums for floatation (Edwards 2004; Pers. Comm., Philippe Cacot, CIRAD, 2005). Cages in the Mekong River Delta range from 50 to 1600 m$^3$ in size, and larger cages commonly include living quarters for workers on the surface above the submerged cages (Phillips 2002; Pers. Comm., Philippe Cacot, CIRAD, 2005).

At one time, basa was the predominant species cultured using cages (Figure 4, Trong et al. 2002), while swai dominated total aquaculture production (cage and pond aquaculture). Currently, the culture of swai using cages has increased to surpass cage culture of basa (Pers. Comm., Philippe Cacot, CIRAD, 2005).



*Source:* Hung and Cacot 2000.

**Figure 4.** Proportion of different catfish species in the Mekong Delta in cage production, 1996. From Trong et al. (2002).

**Scope of the analysis and the ensuing recommendation:**
This analysis covers aquaculture production for basa, *P. bocourti*, and swai, *P. hypophthalmus,* in Southeast Asia, primarily in Viet Nam and Cambodia.

## Availability of Science

Numerous reports on river catfish aquaculture have been published by the Mekong River Commission in Cambodia; however, at this time, no formal stock assessments have been performed for wild populations of basa or swai. Most peer reviewed papers available on basa or swai are on nutritional needs and husbandry for aquaculture of these species.

## Market Availability

### Common and market names:

**Scientific names:** *Pangasius bocourti* (basa), previously *Pangasius pangasius*; *Pangasius hypophthalmus* (swai) (Pangasianodon hypophthalmus, Van Zalinge et al. 2002), previously *Pangasius sutchi* and *Helicophagus hypophthalmus* (Roberts and Vidthayanon 1991).

**Common names:**
Basa: bocourti catfish, basa catfish, river catfish.
Swai: basa, sutchi catfish, striped catfish, silver striped catfish, river catfish, and tra (in Vietnam).

**Market names:** white roughy, royal basa (Australia; http://www.seafoodservices.com.au, 2004), Mekong catfish, pangas catfish, basa catfish (www.house.gov, 2001), China sole, Pacific dory (Australia, Cohen and Hiebert 2001).

**Seasonal availability:**
Basa and swai are available year-round.

**Product forms:**
Basa and swai are available fresh and frozen.

**Production statistics:**
Much of the finfish produced in Southeast Asia is consumed locally, although there is a large export market. Swai is the predominant species reared for export, while basa, considered a superior product, is, for the most part, consumed domestically (Pers. Comm., Philippe Cacot, CIRAD, 2005). In 2003, production of basa was estimated to be between 10,000 and 50,000 tons and production of swai was estimated to be greater than 100,000 tons, with production steadily increasing. The government of Viet Nam hopes to increase production of basa to 50,000 – 100,000 tons by 2010 while maintaining the production of swai at its current rate (Figure 5, Edwards et al. 2004). In Viet Nam, in 2004, production of river catfish for the export market alone reached 350,000 tons, 90% of which was swai (Pers. Comm., Philippe Cacot, CIRAD, 2005).

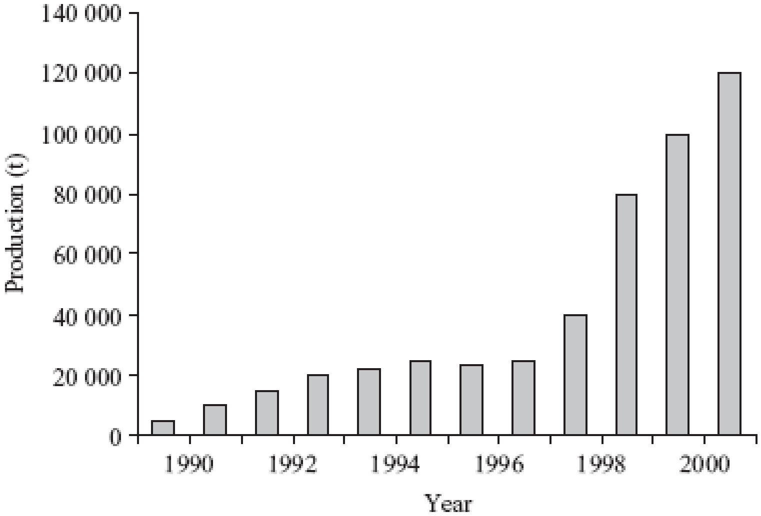


**Figure 5.** Annual production of Pangasius spp. for export in the Mekong Delta, Viet Nam. From Hung et al. (2004).

**Import and export sources and statistics:**
After normalizing trade between the U.S. and Viet Nam, imports of basa and swai to the U.S. increased to over 20 million pounds (Mydans 2002). This large increase in imports of farmed river catfish led Congressman Charles Pickering (R, Mississippi), along with Congressmen Ross (D, Arkansas) and Berry (D, Arkansas), to introduce a bill in 2003 as part of the Country of Origin Labeling that would prevent imports of basa and swai from being labeled "farm raised catfish" (HR 2439) in order to avoid confusion with U.S. farm-raised catfish. The Ministry of Fisheries in Viet Nam agreed to rename the products, and exports of swai from Viet Nam have since been required to be labeled as one of three names, Mekong catfish, pangas catfish, or basa catfish**,** while exports of basa from Viet Nam must be named basa, basa bocourti, or bocourti (www.house.gov, 2001). Following allegations of dumping by Vietnamese vessels, Congressman Ross also voted to deny Viet Nam status as a "most favored nation" (www.house.gov, 2002). In 2003, the international trade commission sided with U.S. domestic catfish producers and supported their claims that Vietnamese vessels were dumping (www.house.gov, 2003) and imposed penal duties on Viet Nam. Within a few months, imports of basa and swai from Viet Nam into the U.S. fell by about 50% (http://www.eurofish.dk).

In the U.S., basa and swai sell for about half the price of channel catfish farmed domestically, but, though they account for 90% of imported catfish, represent only a small percentage of catfish available on the U.S. market (www.seafoodbusiness.com). In 2003, the U.S. imported 46 million pounds of basa and swai combined. The Vietnamese government recently agreed to limit exports of basa and swai to the U.S. to 2002 levels, and despite decreases in the import of swai and basa, overall imports of seafood products from Viet Nam have grown substantially since trade was normalized with Viet Nam (Department of Commerce, www.commerce.gov).

## Analysis of Seafood Watch® Sustainability Criteria for Farm-raised Species

### Criterion 1: Use of Marine Resources

Feed use in Pangasius spp. aquaculture is widely varied throughout the four countries that produce the majority of farmed swai and basa (Vietnam, Thailand, Lao PDR, and Cambodia). Much of the information available on feed use in aquaculture operations in these countries is region-specific. Additionally, since half of the feed used in river catfish aquaculture is homemade, there is limited uniformity in feed use in aquaculture operations.

Until recently, in Vietnamese river catfish cage culture systems, 95 to 97% of cages used homemade feed (Phu and Hein 2003). Current estimates indicate, however, that 50% of swai and basa cages use homemade feed and 50% use manufactured feed (Pers. Comm., Philippe Cacot, CIRAD, 2005). Small-scale farmers use an integrated fisheries/aquaculture system that uses low-value fish species (trash fish), taken from marine or freshwater systems (Edwards 2004) either through bycatch or targeted fisheries, for aquaculture feed. Homemade feeds vary widely in their ingredients and nutritional value (Edwards et al. 2004), and can have low and occasionally imbalanced nutritional value, which results in low yield of marketable fishes; high fat accumulation in fish abdomens due to these low nutritional feeds reduces the proportion of fillet meat in the final, processed fish (Phu and Hein 2003).

Manufactured pelleted feed is of significantly higher cost that homemade feed, as manufactured feeds use imported fishmeal and soybean cake (primarily from the U.S.), instead of the local sources of “trash fish,” which are thought to be of low quality (Edwards 2004; Pers. Comm., Philippe Cacot, CIRAD, 2005). Materials for making homemade feeds, on the other hand, are locally available and cheap. The price of homemade feed is about US$0.12 – $0.13 per kilogram (kg) of feed, and the price for manufactured pelleted feed is around US$0.27 – $0.30 per kg of feed. Hence the feed cost for producing one kilogram of fish can range from US$0.31 – $0.39 for homemade feed and US$0.38 – $0.45 for manufactured pelleted feed (Phu and Hein 2003); however, these values will vary greatly depending on the feed conversion ratio (FCR), which will be affected both by protein content and rearing structure in the aquaculture operation. The recent decline in the use of homemade feeds has, in part, been due to the establishment of a feed industry, increased large-scale production of swai, and a shortage of trash fish, as well as the relationship between trash fish and pathogens such as Vibrio spp. (Pers. Comm., Philippe Cacot, CIRAD, 2005).

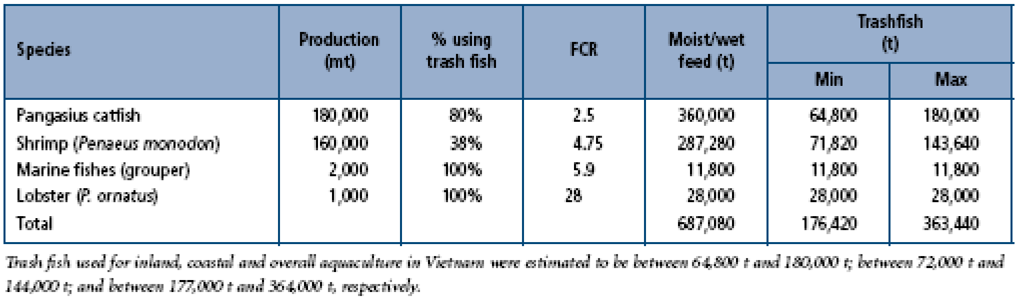
### Feed conversion ratio

The feed conversion ratio (FCR) is the amount of dry feed required to produce one unit of wet fish (Weber 2003). The FCR is a tool used by operators to measure the efficiency of the feed system, and varies with the type of aquaculture operation, the type of fish being reared, and the type of feed being used.

Due to the low-tech nature of river catfish farms, feeding may not operate at its most efficient, especially considering the common use of homemade aquaculture feeds. Feeds vary in protein content and moisture content, and homemade feeds especially vary in the type of trash fish and the amount of trash fish used in the feed (Pers. Comm., Kwei Lin, ret. Asian Institute of Technology, April 13, 2005). FCRs vary accordingly with each variation within the different types of feeds. Homemade feeds, with unknown moisture content, typically result in the highest FCRs of any type of feed. Subsequently, FCRs are typically lower for homemade feeds supplemented by manufactured feeds, depending on cost, and even lower for manufactured pelleted feeds. Phu and Hein (2003) indicate FCRs for homemade feeds range from 2.7 to 3.0 and FCRs for manufactured pelleted feeds range from 1.4 to 1.5.

FCRs also vary with stocking densities and water quality associated with the rearing structure of the aquaculture operation. In experiments done on aquaculture feed, Hung (2001) calculated FCR under a number of conditions for both basa and swai. FCRs for swai ranged from 1.34 – 1.82, with higher values for day feeding than for night feeding, while FCRs for basa had a much larger range, from 1.21 – 2.19, with the highest FCR values occurring with 1, 2, or 3 feedings during the day. Other studies have calculated an average FCR for all Pangasius catfish, under all feeding regimes, of 2.5 (Table 3, Edwards et al. 2004).

**Table 3.** Aquaculture using trash fish. From Edwards et al. (2004).



| Species | Production (mt) | % using trash fish | FCR | Moist/wet feed (t) | Trashfish (t) | |
|---|---|---|---|---|---|---|
| | | | | | Min | Max |
| Pangasius catfish | 180,000 | 80% | 2.5 | 360,000 | 64,800 | 180,000 |
| Shrimp (*Penaeus monodon*) | 160,000 | 38% | 4.75 | 287,280 | 71,820 | 143,640 |
| Marine fishes (grouper) | 2,000 | 100% | 5.9 | 11,800 | 11,800 | 11,800 |
| Lobster (*P. ornatus*) | 1,000 | 100% | 28 | 28,000 | 28,000 | 28,000 |
| Total | | | | 687,080 | 176,420 | 363,440 |

*Trash fish used for inland, coastal and overall aquaculture in Vietnam were estimated to be between 64,800 t and 180,000 t; between 72,000 t and 144,000 t; and between 177,000 t and 364,000 t, respectively.*

Comparing the FCRs from different sources (see Table 4) yields a wide range within each river catfish species and within aquaculture feed types. In general, manufactured feeds have lower feed conversion ratios that homemade feeds. In Table 4, below, both the calculated and averaged FCRs from Edwards et al. (2004) are outliers, while the empirical FCRs by Hung et al. (2001) rest in the middle of the overall ranges for FCRs from all the sources in the table and were calculated from a controlled experiment. Because this empirical finding of FCR is from a controlled experiment, the variation from consumption of naturally occurring feed or inefficient feeding technique is eliminated, so it represents the best calculation of FCR. The study of FCRs in Table 4 is based on this median. The final FCR, at the bottom of Table 4, is a weighted average of all the different estimates for FCRs (Table 4).

**Table 4.** Comparison of FCRs. FCRs less than or equal to 1 could come from high use of naturally occurring food items or over estimation of FCR from non-specific information on feed use.

| | Swai | | Basa | |
|---|---|---|---|---|
| | Homemade | Manufactured | Homemade | Manufactured |
| Empirical (Hung et al. 2001) | N/A | 1.34 – 1.82 | N/A | 1.21 – 2.19 |
| Calculated (Edwards et al. 2004)[1] | 1 | 0.933 | 1.4 | 1.267 |
| Averaged (Edwards et al. 2004) | 2.5 | 2.5 | 2.5 | 2.5 |
| (Phu and Hein 2003) | 2.7 – 3 | 1.4 – 1.5 | 2.7 – 3 | 1.4 – 1.5 |
| Pers. Comm., Cacot, [1] | 3 | 1.6 – 1.8 | 3 | 1.6 – 1.8 |
| FCR (weighted average) | 2.45 | 1.71 | 2.51 | 1.78 |

## Inclusion rate

The inclusion rate is the amount of marine, or freshwater, resources used in aquaculture feed. As with FCRs, inclusion rates vary greatly by feed type. Manufactured feed is the most consistent feed type, and optimal inclusion of fishmeal for omnivorous species, like Pangasius spp., in

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[1] Combined weight equal to one of the cited FCR studies.

manufactured feed is 4%. Fish oils are included in manufactured feed at 2 – 3% (Pers. Comm., Philippe Cacot, CIRAD, 2005). Homemade feed for swai originally consisted primarily of chopped up trash fish in Chau Doc in Viet Nam, but has been replaced by a cooked mixture of rice bran and marine trash fish at a 2:1 ratio (Edwards 2004). This method results in a much higher inclusion rate (33%) than manufactured feed (Phu and Hein 2003; Edwards et al. 2004); however, much of the trash fish in homemade feed comes from processing waste or bycatch of low-value fish (Edwards et al. 2004), and all parts of the trash fish are used in the feed. The amount of trash fish used varies seasonally and regionally, and can lead to overfeeding when trash fish are abundant, and underfeeding when trash fish are scarce. This variation in use in turn results in inefficient feed conversion. For fish farmers who can afford it, dried fish can supplement feed when trash fish are unavailable; however, the quality of this feed can be poor (Heng et al. 2004).

With increased use of trash fish for aquaculture feeds, as well as for livestock feeds, there is concern about a possible reduction in fish products available for human consumption (Phillips 2002; Edwards et al. 2004). These concerns are especially significant as much of the final aquaculture and livestock products generated in Southeast Asia are exported.

### Transfer efficiency

Transfer efficiency is the efficiency at which the fish harvested for aquaculture feed are converted from whole fish to fishmeal or fish oil. Tyedmers (2000) estimated the transfer efficiencies of wild fish from four different sources: South American fishmeal; British Columbia herring meal; Gulf of Mexico menhaden oil; and British Columbia mixed fish oil. Reduction of whole fish to fishmeal or fish oil depends on five characteristics: the species being reduced; the season during which the fish are captured and hence the condition of the fish at the time of capture; whether round fish or fish wastes are being reduced; the freshness of the fish upon processing; and the efficiency of the reduction plant. Reduction efficiencies range from 16 – 22% for fishmeal and 2 – 12% for fish oil.

### Ratio of wild fish to farmed river catfish

After obtaining values for feed conversion ratios, inclusion rates, and transfer efficiencies, the ratio of wild fish input to farmed fish output, or the amount of wild fish needed to produce 1 unit of farmed fish, can be determined through the following equation.

$$\text{manufactured}\left[\frac{1}{c_m}(i_m)+\frac{1}{c_o}(i_o)\right](FCR)+\text{homemade}\left[\frac{1}{c_m}(i_m)+\frac{1}{c_o}(i_o)\right](\text{FCR})=\text{input}:\text{output} \qquad (1)$$

In this equation, $c_m$ is the transfer efficiency from whole fish to fishmeal, $c_o$ is the transfer efficiency from whole fish to fish oil, $i_m$ is the inclusion rate of fishmeal, and $i_o$ is the inclusion rate of fish oil. To determine the average ratio of wild fish used in swai and basa aquaculture to farmed swai and basa produced, the calculation, below, uses the mean values for $c_m$ and $c_o$ of 19% and 7%, respectively, values for $i_m$ and $i_o$ for manufactured feed of 4% and 2.5%, respectively, and values for FCRs for homemade feed of 2.45 and 2.51 and for manufactured feed of 1.71 and 1.78 for swai and basa, respectively. For homemade feed, the inclusion rate for fishmeal is estimated at 36.5% and the inclusion rate for fish oil is not applicable, as no fish oil is used in homemade feeds. The transfer efficiency for homemade feed is 100%, as whole fish are used in the production of homemade feeds. Using these values, the average ratio of wild fish used to farmed swai produced is approximately:

$$0.50\left[5.263(.04)+14.286(.025)\right](1.71)+0.50\left[1(.365)\right](2.45)=0.93$$

And the average ratio of wild fish used to farmed basa produced is approximately:

$$0.50\left[5.263(.04)+14.286(.025)\right](1.78)+0.50\left[1(.365)\right](2.51)=0.96$$

**Table 5.** Coefficients to calculate wild inputs:aquaculture outputs.

| | Conversion efficiency | |
|---|---|---|
| | Homemade feeds | Manufactured feeds |
| Whole fish to fishmeal | 100% | 19% |
| Whole fish to fish oil | N/A | 7% |
| Inclusion of fishmeal | 33 – 40% (36.5%) | 4% |
| Inclusion of fish oil | N/A | 2 – 3% (2.5%) |
| Feed Conversion Ratio (swai) | 2.45 | 1.71 |
| Feed Conversion Ratio (basa) | 2.51 | 1.78 |

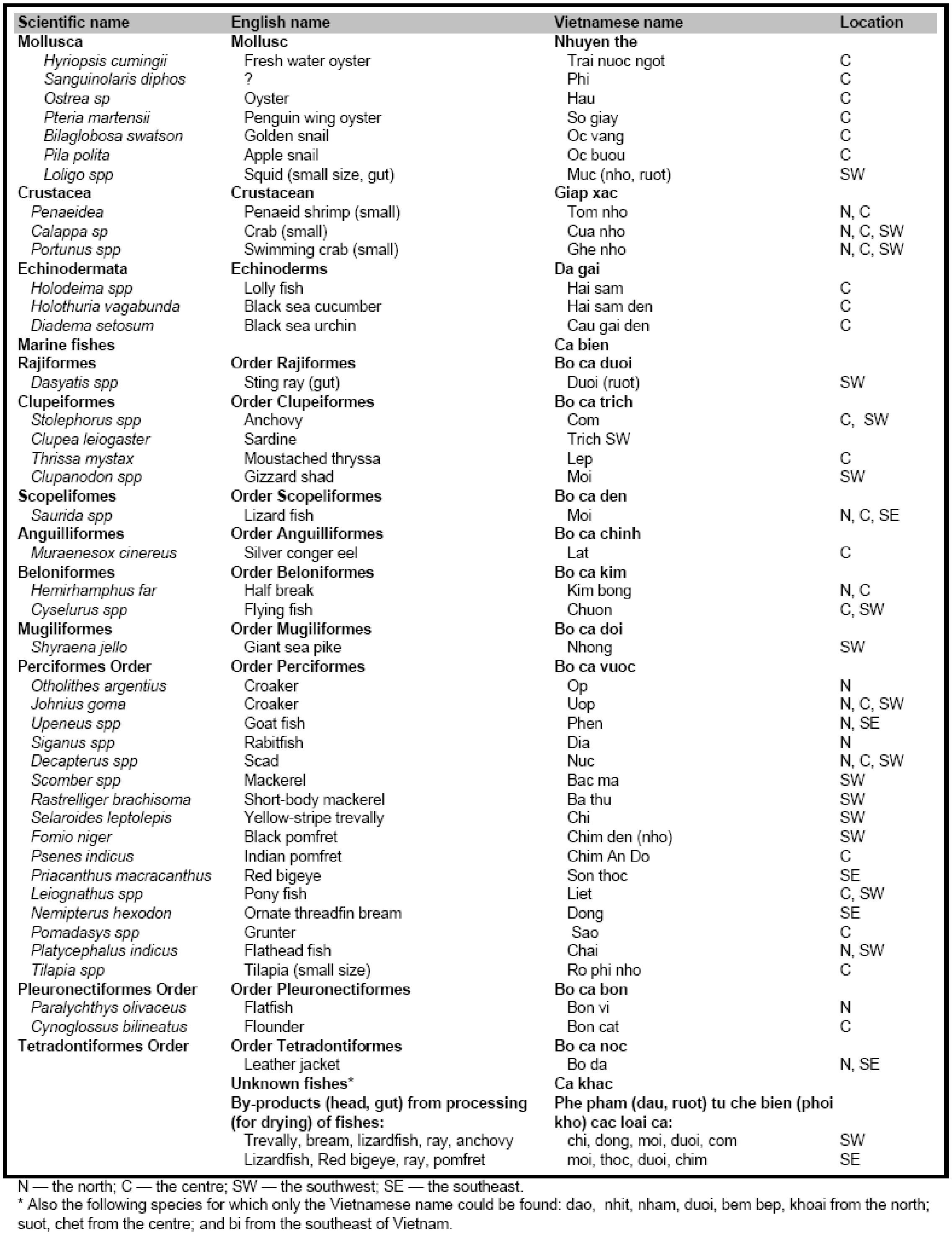
As production increases and stressors such as competition, poor water quality, and increased disease also increase, conversion efficiency decreases.

**Stock status of the reduction fishery**

The general “trash fish” designation for marine resources used in fishmeal for aquaculture feed includes a number of species of fish and invertebrates. The majority of these species are landed in the nearshore fishery (Edwards et al. 2004). Uses for trash fish include direct human uses, either as fish sauce or fish flesh, livestock feed, and aquaculture feed; the fishery for trash fish accounts for 25% of local finfish landings. Often, the human uses for trash fish are the lowest-value uses, and livestock production, as well as high value aquaculture production, such as of grouper or shrimp, are the highest value uses for trash fish (Edwards et al. 2004).

There are concerns about overfishing in the nearshore fishery (Edwards et al. 2004); however, the Mekong stingray (one of the Dasyatis spp.) is the only species captured in the fishery for trash fish that is identified by the IUCN (World Conservation Union) as a species of concern (www.redlist.org). Imported manufactured feed comes from a number of sources, so it is difficult to determine the reduction fishery providing the fishmeal used in the feed.

**Table 6.** Species comprising the "trash fish" group used in aquaculture feed. From Allen et al (2004).



| Scientific name | English name | Vietnamese name | Location |
|---|---|---|---|
| **Mollusca** | **Mollusc** | **Nhuyen the** | |
| *Hyriopsis cumingii* | Fresh water oyster | Trai nuoc ngot | C |
| *Sanguinolaris diphos* | ? | Phi | C |
| *Ostrea sp* | Oyster | Hau | C |
| *Pteria martensii* | Penguin wing oyster | So giay | C |
| *Bilaglobosa swatson* | Golden snail | Oc vang | C |
| *Pila polita* | Apple snail | Oc buou | C |
| *Loligo spp* | Squid (small size, gut) | Muc (nho, ruot) | SW |
| **Crustacea** | **Crustacean** | **Giap xac** | |
| *Penaeidea* | Penaeid shrimp (small) | Tom nho | N, C |
| *Calappa sp* | Crab (small) | Cua nho | N, C, SW |
| *Portunus spp* | Swimming crab (small) | Ghe nho | N, C, SW |
| **Echinodermata** | **Echinoderms** | **Da gai** | |
| *Holodeima spp* | Lolly fish | Hai sam | C |
| *Holothuria vagabunda* | Black sea cucumber | Hai sam den | C |
| *Diadema setosum* | Black sea urchin | Cau gai den | C |
| **Marine fishes** | | **Ca bien** | |
| **Rajiformes** | **Order Rajiformes** | **Bo ca duoi** | |
| *Dasyatis spp* | Sting ray (gut) | Duoi (ruot) | SW |
| **Clupeiformes** | **Order Clupeiformes** | **Bo ca trich** | |
| *Stolephorus spp* | Anchovy | Com | C, SW |
| *Clupea leiogaster* | Sardine | Trich SW | |
| *Thrissa mystax* | Moustached thryssa | Lep | C |
| *Clupanodon spp* | Gizzard shad | Moi | SW |
| **Scopelifomes** | **Order Scopeliformes** | **Bo ca den** | |
| *Saurida spp* | Lizard fish | Moi | N, C, SE |
| **Anguilliformes** | **Order Anguilliformes** | **Bo ca chinh** | |
| *Muraenesox cinereus* | Silver conger eel | Lat | C |
| **Beloniformes** | **Order Beloniformes** | **Bo ca kim** | |
| *Hemirhamphus far* | Half break | Kim bong | N, C |
| *Cyselurus spp* | Flying fish | Chuon | C, SW |
| **Mugiliformes** | **Order Mugiliformes** | **Bo ca doi** | |
| *Shyraena jello* | Giant sea pike | Nhong | SW |
| **Perciformes Order** | **Order Perciformes** | **Bo ca vuoc** | |
| *Otholithes argentius* | Croaker | Op | N |
| *Johnius goma* | Croaker | Uop | N, C, SW |
| *Upeneus spp* | Goat fish | Phen | N, SE |
| *Siganus spp* | Rabitfish | Dia | N |
| *Decapterus spp* | Scad | Nuc | N, C, SW |
| *Scomber spp* | Mackerel | Bac ma | SW |
| *Rastrelliger brachisoma* | Short-body mackerel | Ba thu | SW |
| *Selaroides leptolepis* | Yellow-stripe trevally | Chi | SW |
| *Fomio niger* | Black pomfret | Chim den (nho) | SW |
| *Psenes indicus* | Indian pomfret | Chim An Do | C |
| *Priacanthus macracanthus* | Red bigeye | Son thoc | SE |
| *Leiognathus spp* | Pony fish | Liet | C, SW |
| *Nemipterus hexodon* | Ornate threadfin bream | Dong | SE |
| *Pomadasys spp* | Grunter | Sao | C |
| *Platycephalus indicus* | Flathead fish | Chai | N, SW |
| *Tilapia spp* | Tilapia (small size) | Ro phi nho | C |
| **Pleuronectiformes Order** | **Order Pleuronectiformes** | **Bo ca bon** | |
| *Paralychthys olivaceus* | Flatfish | Bon vi | N |
| *Cynoglossus bilineatus* | Flounder | Bon cat | C |
| **Tetradontiformes Order** | **Order Tetradontiformes** | **Bo ca noc** | |
| | Leather jacket | Bo da | N, SE |
| | **Unknown fishes*** | **Ca khac** | |
| | **By-products (head, gut) from processing (for drying) of fishes:** | **Phe pham (dau, ruot) tu che bien (phoi kho) cac loai ca:** | |
| | Trevally, bream, lizardfish, ray, anchovy | chi, dong, moi, duoi, com | SW |
| | Lizardfish, Red bigeye, ray, pomfret | moi, thoc, duoi, chim | SE |

N — the north; C — the centre; SW — the southwest; SE — the southeast.

* Also the following species for which only the Vietnamese name could be found: dao, nhit, nham, duoi, bem bep, khoai from the north; suot, chet from the centre; and bi from the southeast of Vietnam.

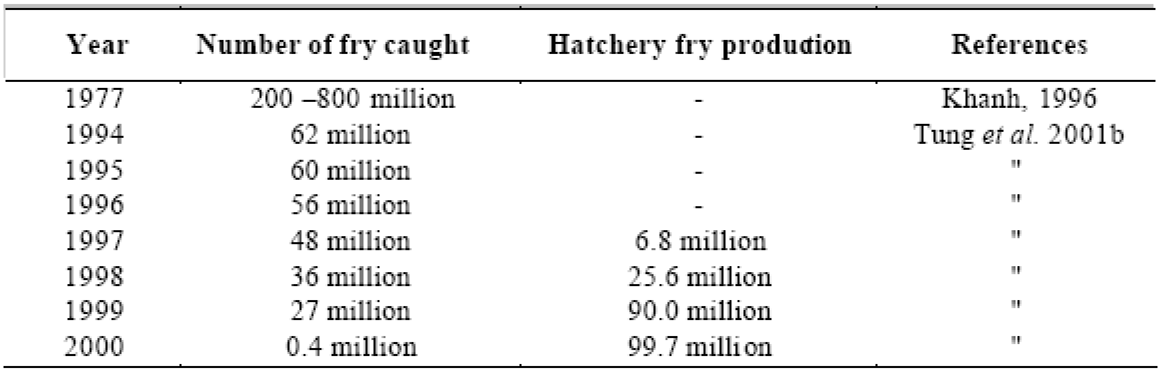
### Source of seed stock

Supply of seed stock for swai and basa aquaculture has traditionally been dependent on collection of wild Pangasius spp. fry from rivers (Cacot et al. 2003; Edwards et al. 2004). Most of the spawning grounds for both basa and swai are located within the borders of Cambodia (Poulsen et al. 2004). Fishers usually target swai fry; however, they are often unable to identify fry at the species level and some fish farmers have reported a mixture of Pangasius species in their ponds. In the wild fishery, non-Pangasius species are thrown back or used as fish feed (Bun 1999; Van Zalinge et al. 2002); an estimated 5 – 10 kg of fish of species other than swai or basa are killed for each kilogram of river catfish fry caught (Phuong 1998). Bycatch of non-target fry is much higher in Viet Nam than Cambodia, most likely due to the lower numbers of fry within Viet Nam's waters. Furthermore, the average size of fry in Viet Nam is larger than in Cambodia (Van Zalinge et al. 2002).

The fishery for river catfish fry was outlawed in Cambodia in 1994 and in Viet Nam in 2000, but continues illegally, still supplying fry to aquaculture (Bun 1999; Van Zalinge et al. 2002). It is unclear the extent to which this practice is still in use; however, the increase in hatchery production and enforcement indicates that capture of wild river catfish fry is declining; a 1000-fold decrease in wild-caught fry has been observed in the An Giang province in Viet Nam (Van Zalinge et al. 2002). Anecdotally, the number of wild-caught fry has dropped to almost zero, with hatchery fry dominating the supply to aquaculture operations (Pers. Comm., Kwei Lin, Asian Institute of Technology, ret., April 13, 2005).

There are many small scale nursery hatcheries for swai and basa fry in Viet Nam (< 1 ha in area) that now provide seed stock to Vietnamese river catfish farms. These hatcheries produce enough fry for the local market and for export to Cambodia (Edwards et al. 2004). The first artificial propagation of Pangasius spp. catfish occurred in Thailand in 1959 and has since expanded throughout Southeast Asia (Trong et al. 2002). In 1999, more than 270 million swai and basa fry and fingerlings were produced by a number of state and private hatcheries (Van Zalinge et al. 2002).

**Table 7.** Estimated numbers of swai fry caught in the dai fishery in Viet Nam, An Giang province. From Van Zalinge et al. (2002).



| Year | Number of fry caught | Hatchery fry production | References |
|---|---|---|---|
| 1977 | 200 –800 million | - | Khanh, 1996 |
| 1994 | 62 million | - | Tung *et al.* 2001b |
| 1995 | 60 million | - | " |
| 1996 | 56 million | - | " |
| 1997 | 48 million | 6.8 million | " |
| 1998 | 36 million | 25.6 million | " |
| 1999 | 27 million | 90.0 million | " |
| 2000 | 0.4 million | 99.7 million | " |

### Synthesis

The use of marine resources in aquaculture operations for basa and swai ranks as a moderate conservation concern. Feed conversion ratios for aquaculture feed for these omnivorous species are relatively high, and the inclusion of trash fish in feeds is moderate. The high use of homemade feed, while it results in a worse feed conversion ratio for both swai and basa feeds, also results in a low input of wild fish because whole fish are used; the transfer efficiency for homemade feed is 100%. Some concerns exist, however, about the source of the trash fish used in homemade and manufactured aquaculture feeds. Primarily composed of bycatch, trash fish used in aquaculture feed comes from nearshore and riverine fisheries, which are considered fully exploited. The source of seed stock for swai and basa aquaculture varies by operation. While capture of wild fry for seed stock is now illegal, it continues at low levels. High levels of bycatch and decreased catch per unit effort (CPUE) of wild swai and basa raise concerns about the continued illegal fishing for river catfish fry. Thanks to enforcement and increased hatchery production of fry, the amount of wild-caught fry in the marketplace is continuously declining.

**Use of Marine Resources Rank:**

Low 🟩 **Moderate** 🟨 High 🟥 Critical ⬛

## Criterion 2: Risk of Escaped Fish to Wild Stocks

### Frequency and impact of escapes

Aquaculture systems in Southeast Asia are typically enclosed or semi-enclosed structures, like ponds, rice fields, or cages suspended in natural bodies of water. Cage culture is the most common large-scale type of aquaculture system in Southeast Asia and the most common type for river catfish in Viet Nam (Phillips 2002). In cage culture, water is free to exchange between the cage and the natural water body in which the cage is suspended. Despite the cage system being open to the environment, it seems unlikely that escapes occur very frequently because the cages are situated in calm water; however, there are no data documenting the frequency or infrequency of escapes of farmed fish from cage culture.

Hatchery programs for swai and basa are still nascent, with focuses on milt management, egg production, and larval rearing (Hung et al. 1999; Cacot et al. 2002; Hung et al. 2002; Cacot et al. 2003; Hung et al. 2003), as opposed to selection for certain traits. Furthermore, most of the research on husbandry and larval rearing focuses on higher value basa, rather than swai. Additionally, a small fraction of the supply of swai and basa fry and fingerlings for aquaculture still comes from wild sources (Bun 1999; Van Zalinge et al. 2002), thus farm-reared swai and basa are still genetically similar to their wild counterparts.

There are concerns regarding hybridization between basa and swai, and hybrids have been observed in local markets. No studies on hybridization, particularly female swai/male basa crosses, were available for this report. Reportedly the Vietnamese government has effectively controlled the production of hybrids (Pers. Comm., Philippe Cacot, CIRAD, 2005).

### Synthesis

The open cages that dominate river catfish aquaculture are open to the surrounding water bodies in which they are suspended, and are thus inherently susceptible to escapes by farmed swai and basa. In the case of Pangasiid aquaculture in Southeast Asia, however, the impact of escapes is minimal, as swai and basa are native to the region. In addition, the early stages of artificial hatcheries, which engage in minimal artificial selection for genetic traits, means that fish produced in aquaculture are still ecologically and genetically similar to wild stocks. That being said, as husbandry techniques improve, and hatcheries begin selecting for traits favorable to aquaculture, escapes may become a concern.

**Risk of Escaped Fish to Wild Stocks Rank:**

[✓ **Low** 🟩] Moderate 🟨 High 🟥 Critical ⬛

## Criterion 3: Risk of Disease and Parasite Transfer to Wild Stocks

In 2002, a study by Crumlish (2002) identified the bacteria *Edwardsiella ictaluri*, a disease native to channel catfish in North America, in farmed swai cultured in the Mekong River Delta. This was the first instance of this disease being observed in Pangasiids. The study makes no comment about where the disease originated. In a study by Yuasa et al. (2003), this same disease was also identified in farms in Indonesia. Again, the study did not attempt to explain the source of the bacteria, but Yuasa et al. (2003) did mention that the strain infecting Indonesian swai is more similar to the strain infecting Vietnamese swai than that infecting channel catfish (*Ictalurus punctata*) in the U.S. Transmission of the disease may have been vertical, from hatchery seed stock, or horizontal, from wild fish, but ultimately its source is unknown. It also remains unclear as to whether the bacteria were introduced from abroad or were present locally but previously unidentified.

Although it seems as if a new disease is emerging, there have been no data to show that wild swai stocks have been affected by new diseases. Additionally, no evidence exists for amplification or retransmission of native diseases from farmed stocks to wild stocks or vice versa.

### Synthesis

While there have not been any documented cases of the newly introduced *E. ictaluri* in wild populations, there is no reason to suggest that transmission from farmed fish to wild fish is not likely. Due to this uncertainty, along with the dominance of the open cage system in Pangasiid farms and uncertainty about the health of wild Pangasiid populations, the risk of disease transfer to wild swai and basa stocks ranks as moderate.

**Risk of Disease Transfer to Wild Stocks Rank:**

Low 🟩 [✓ **Moderate** 🟨] High 🟥 Critical ⬛

## Criterion 4: Risk of Pollution and Habitat Effects

### Effluent effects

While both pond and cage aquaculture systems are used for swai and basa, cage aquaculture is the more technologically advanced method, thus it is utilized more for the export market. The cages utilized are essentially open net pens placed within the Mekong River Delta, so effluent from the aquaculture operations is not treated before flowing out of the cages into the surrounding environment. Some polyculture for cage culture exists, where river catfish are reared with carps, Nile tilapia (*Oreochromis niloticus*), or kissing gourami (*Helostoma temmincki*), but this is not common in larger scale production (Trong et al. 2002).

There is concern regarding pollution from cage effluent, as well as regarding deterioration of water quality and an increase in observed fish disease outbreaks (Phillips 2002). Combined with high water temperatures, ammonia, nitrates, and organic matter released in fecal wastes lead to rapid growth of algae and aquatic plants, and can result in severe algal blooms and eutrophication of water bodies. Low levels of dissolved oxygen in natural water bodies resulting from the decomposition of plants and other organic matter could have affects on local fisheries, water quality, and other local resources (Pers. Comm., Philippe Cacot, CIRAD, 2005). The Mekong River Delta, however, could be at a lower risk to effluent effects than reservoirs or coastal areas, as in the Mekong River Delta the water is already polluted by activities other than aquaculture (Phillips 2002). Additionally, due to the six-month flood season, leftover aquaculture feed and wastewater is periodically flushed out to sea (Edwards et al. 2004). The Vietnamese government also suggests that the carrying capacity of the Mekong River is high if factories are prohibited from discharging effluents into the river (Edwards et al. 2004), while others observe that the impact of fruit and rice production contributes significantly more to environmental degradation than does aquaculture (Pers. Comm., Philippe Cacot, CIRAD, 2005).

### Habitat effects

Siting and locations for cage production in the Mekong River Delta is relatively benign. The environment in this region is already highly degraded from non-aquaculture sources, and the area is heavily used by a large human population. Additionally, large-scale cage aquaculture serves a dual purpose when combined with housing, which is built above submerged aquaculture cages (Phillips 2002). This method may aid in reducing impacts on land from development.

In the Mekong River Delta, typical stocking densities of basa and swai are 200 – 300 fish/$m^3$ (Phillips 2002) or 100 kg/$m^3$ (Trong et al. 2002), which are considered intensive production levels. Ponds with low flow must be stocked at much lower levels to maintain fish health. Typical low-flow pond stocking densities are 18 fish/$m^3$ (Cacot 2004). Flow in cage and net pen operations is highly variable due to strong seasonal affects, so intensive aquaculture, relative to flow, during the dry season may be minor during the rainy season. Feeding rates vary with the availability of feed (Heng et al. 2004), meaning that the quantity of wastes also varies, further contributing to high variability in effluent. Other variations in effluent come from variability in feed type and quality. Homemade feed is less stable than manufactured feed, and typically has a higher feed conversion ratio than manufactured feed, thus the use of homemade feed can also lead to increased water pollution (Edwards 2004).

**Synthesis**
The predominance of cage culture for farming basa and swai and the high stocking densities within cages means that there is a clear risk of pollution and habitat effects. This risk is tempered, however, by characteristics of the Mekong River Delta. The degraded state and high flow of the river means that effluents have less of a total impact on the region. Overall, therefore, the risk of pollution and habitat effects from swai and basa aquaculture is deemed moderate.

**Risk of Pollution and Habitat Effects Rank:**

Low 🟩 **Moderate** 🟨 High 🟥 Critical ⬛

## Criterion 5: Effectiveness of the Management Regime

The rapid growth of finfish aquaculture in the Mekong River Delta has highlighted the need for clear and effective management of aquaculture operations and supporting fisheries. In general, the government of Viet Nam has acted in a pro-aquaculture manner, supporting the industry as a means to develop impoverished regions and alleviate hunger. Viet Nam has adopted a plan to build aquaculture capacity and has shifted resources from research to farm assistance (Phillips 2002).

**Regulation and BMPs**
Best management practices (BMPs) have not yet been built into management of swai and basa aquaculture. There are no requirements for starting an aquaculture system, and home ponds are quite common, though such ponds do not result in large-scale production (Edwards 2004). The rapid growth of aquaculture in Southeast Asia has prompted increasing discussion about environmental impacts. The Mekong River Commission (MRC), in its publications, repeatedly states the need for regulating feed, siting, brood stock, and pollution (Phillips 2002; Trong et al. 2002; Commission 2003).

Increasing exports of swai and basa from Southeast Asia have meant that international regulations must be met. In order to meet European Union (EU) and Japanese import regulations, 125 Southeast Asian companies have banned the use of antibiotics and drugs that are regulated in those markets. These companies are subject to regular inspections by independent parties and processors exporting to international markets, which require that fish be free from chemical residues before harvest. Furthermore, 175 out of 300 processors in Southeast Asia now adhere to Hazard Analysis and Critical Control Point (HACCP) regulations (http://www.eurofish.dk).

**Synthesis**
Currently, management of finfish aquaculture in Southeast Asia is weak. Most regulation comes from import regulations in other countries. The lack of management for siting of farms and BMPs to control escaped fish and pollution are a concern for the long-term sustainability of

aquaculture of river catfish. Due to the poor state of management on all levels, effectiveness of management of swai and basa aquaculture in Southeast Asia ranks ineffective.

**Effectiveness of Management Rank:**

Highly Effective 🟩 Moderately Effective 🟨 [✓ **Ineffective** 🟥] Critical ⬛

## Overall Evaluation and Seafood Recommendation

Pangasius have many qualities that are conducive to sustainable aquaculture, including: a low need for fish protein; high feed conversion; rapid growth; the ability to thrive in poor water quality; and low risk of harm from fish escapes in the regions where they are farmed, due to ecological and genetic similarity with wild stocks. However, current aquaculture operations for Pangasius are of moderate conservation concern. Despite laws that prohibit the capture of wild Pangasius fry for stocking aquaculture operations, the practice continues to the detriment of wild stocks. Additionally, emerging diseases, like a new strain of *E. ictaluri*, raise concern about increased infection amongst wild fish. The sources of infection and current wild infection rates are unknown, however, thus there is great uncertainty surrounding this risk. Furthermore, treatment options, such as antibiotics added to feed, are undesirable because fish are farmed in open systems, however some import markets ban the use of certain antibiotics and drugs. With regards to pollution, the open systems of cage culture, the most common aquaculture method used for farming Pangasius, are less of a concern because cages are typically placed in highly environmentally-degraded areas. The Mekong River Delta is a large drainage with numerous urban areas within its watershed, which contribute many pollutants and nutrient sources to the river. This combined with annual flushing of the river system by monsoon floods means that the net impact of aquaculture on the river is relatively low. However, excess aquaculture feed and feces from farmed fish, reared at a range of stocking densities, still do flow freely into the surrounding environment. Finally, finfish aquaculture is poorly regulated. Aside from requirements put on production and processing by importing countries, no management plan for Pangasius aquaculture exists. Generally poor management and moderate concerns over several other criteria results in an overall seafood recommendation of “Good Alternatives” for farmed Pangasius. Should additional evidence of environmental impacts arise or should production techniques become less sustainable over time, farmed Pangasius may warrant a recommendation of Avoid to consumers and businesses.

## Table of Sustainability Ranks

|  | Conservation Concern |  |  |  |
|---|---|---|---|---|
| **Sustainability Criteria** | Low | Moderate | High | Critical |
| Use of Marine Resources |  | √ |  |  |
| Risk of Escaped Fish to Wild Stocks | √ |  |  |  |
| Risk of Disease/Parasite Transfer to Wild Stocks |  | √ |  |  |
| Risk of Pollution and Habitat Effects |  | √ |  |  |
| Management Effectiveness |  |  | √ |  |

## Overall Seafood Recommendation:

**Farmed Pangasius:** Best Choice 🟩 **Good Alternative** 🟨 Avoid 🟥

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*Scientific review does not constitute an endorsement of Seafood Watch® on the part of the reviewing scientists. The Seafood Watch® staff is solely responsible for the conclusions reached in this report.*

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