

TRADITIONAL FISHERIES AND FISH ECOLOGY ON THE MEKONG RIVER AT RHONE WATERFALLS IN SOUTHERN LAOS

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ABSTRACT

Khone (pronounced "Kawn") Falls is the site of one of the most important wildcapture riverine fisheries in tropical Asia. Khone villagers have been fishing the area for generations, and have inherited or developed an outstanding array of artisanal fishing devices based on intimate knowledge of migratory, feeding and other behavior of numerous fish species. Their traditional fisheries management system is also highly developed. Khone fishing people are confronted by the decline of many species, especially of strongly migratory ones which are the main basis for the fisheries.

The small cyprinid fish *Cirrhinus lobatus* is an ecological keystone species. It is the most abundant fish species in the Khone Falls area, and is usually the first species to migrate upstream in the December-February non-reproductive migratory period. Data on migratory *C. lobatus* during the June-July reproductive migratory period indicate that the species is a progyneous hermaphrodite. Another important cyprinid is the large species *Probarbus jullieni*, caught mainly in November-January when it is migrating to spawning sites or is actually engaged in spawning activity. The history of the *Probarbus* fisheries in southern Laos indicates that a long term decline started around 1970, with the introduction of nylon gillnets, and that it increased rapidly after 1991 when markets opened up and fisheries became increasingly capitalized and modernized. Important catfishes include *Pangasius macronema* and *P. krempfi*. *Pangasius macronema* is the object of an unusual communal fisheries practiced by the village of Ban Hang Sadam. *Pangasius krempfi* is a diadromous species, spending much of its life in coastal waters of the South China Sea, but returning to the Mekong River to spawn.

DEDICATION

This paper is dedicated to the memory of Sunton Atnakhone, master fisherman of Ban Hang Khone, who passed away on May 10, 1994, at the age of 48.

INTRODUCTION

Khone Falls is the most impressive feature of the Mekong River. Immediately below the falls occurs the most important wildcapture fisheries in Laos, and one of the most important riverine wildcapture fisheries in Southeast Asia. It is perhaps the best place to

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observe the great migrations of Mekong fishes. Fishing has been the main activity of villagers of Ban Hang Khone and other villages below Khone Falls for generations.

Khone Falls has sometimes been referred to as Lee Pee, but the latter name refers specifically to Sompamit Waterfall and should not be used to describe the whole range of waterfalls. Khone is actually pronounced as "kawn", but we retain the spelling Khone because it is so well established.

The waterfalls evidently are an impassable barrier for some fish species, especially those of secondary freshwater families (i.e. belonging to families also found in marine habitats, such as Ariidae, Polynemidae, Soleidae, Cynoglossidae). Quite a number of these species occur in the Mekong mainstream virtually up to the falls. Thus the falls represent a biogeographic boundary between the Lower and Middle portions of the Mekong basin (ROBERTS, 1993). Many of the waterfalls are impassable barriers to fish, but other falls and rapids are passable for strongly migratory and other fish species.

A general account of the migrations, seasonal cycle of fishing activities, and fish ecology of the area immediately below the falls is given in ROBERTS, 1993. That article also describes fish species and fisheries observed in June-July 1993, the migratory period dominated by nocturnally active *Pangasius* spp. and other catfishes. Most of these observations were made by Roberts and Baird at Ban Hang Khone, an important fishing village on the southern end of Don Khone (Khone Island), 4 km below Lee Pee or Sompamit Falls (Haew Sompamit).

Fisheries just above Khone Falls, including the November-January 1993-94 spawning migration of *Probarbus jullieni*, are described in ROBERTS & WARREN, 1994. That paper gives the first description of a *Probarbus* spawning ground, next to Ban Don Hee, on the west side of Don Hee (Hee Island), a few km above the falls. It also describes the December-February 1993-94 nonreproductive migrations dominated by small cyprinids, notably *Cirrhinus lobatus*. Documentation of overall decline of the fisheries at Khone Falls since the early 1970's is presented in ROBERTS (1993) and in ROBERTS & WARREN (1994).

Readers may wish to consult the two papers mentioned above in conjunction with the present account.

The present paper is based largely on observations made by the second author from November 1993 through February 1995. We give more comprehensive description and discussion of migratory pathways in the complicated system of channels (hoo) in and below Khone Falls, fishing gear and techniques used above as well as below the falls, and traditional village fisheries management systems. We also provide an account of the history of the important fisheries for *Probarbus* in southern Laos and northeastern Cambodia, and biological observations on various species, including *Cirrhinus lobatus*, an ecological keystone species.

Transliteration and pronunciation of Lao words is not a simple, straight-forward matter. We have tried to provide transliteration such that an English (American or British) speaker would be able to come fairly close to the Lao word, or at least be likely to recognize the word when it is spoken by a Lao.

Some words have given us very little trouble, others a great deal. Part of the problem arises from Lao speakers pronouncing the same word in more than one way, just as English speakers pronounce some words differently (such as the word water, occasionally pronounced "wa-ter" but more often "wada").

Among the Lao words that have given particular difficulty is the name for fishes of the genus *Probarbus*. In previous publications, this has been transliterated as "p b a uhn" (ROBERTS, 1993). But this is misleading, since English speakers would tend to pronounce "uhn" like "un" in the word unknown. The actual sound has no close equivalent in English. We now render it as "eun", with the "eu" equivalent to that in the French phrase "un peu". Even this is only an approximation, as the name pba eun has a slightly aspirated or barely voiced "r" sound, so that a more exact indication of its pronunciation might be "pba euhrn". But such a spelling would not readily guide the English speaker on how to pronounce the word, and there are limitations to transliteration. The sound occurs in several Lao place names, notably Nam Theun and Ban Weun Kahm.

We also use "eu" to transliterate other Lao words in which there is no aspirated or only a lightly voiced "r" sound. One such word is the name for *Mystus microphthalmus*, previously spelled "p b a kung" but changed here to "p b a keung" which is more accurate. Another is "p b a beuk", for *Pangasius gigas*. Pba leum, for *Pangasius sanitwongsei*, may be pronounced either as the "eu" in the French expression "un peu", or with a clearly voiced "r" sound (pba lerm).

We spell the plural of Lao words (such as lee, so, oo, hoo) the same as the singular, as in the Lao language itself. Clarity is achieved by using expressions such as "a single lee trap" or "several lee traps" or occasionally using English instead of Lao terms (e.g. "channel" or "channels" in place of hoo).

GEOGRAPHICAL FEATURES OF THE KHONE FALLS AREA

Figures 1-4, 6-9

Knowledge of numerous islands, channels, and waterfalls is necessary to achieve meaningful understanding of the migratory activity of fishes below the falls. Fishers from Ban Hang Khone, Ban Hang Sadam and other villages in Khone Subdistrict are familiar with all of these features, and have names for them, but some are inaccurately shown and very few are named on maps we have seen. We have prepared maps, based largely on information from field surveys and interviews by the second author. Most of the smaller islands and channels have been drawn in by hand. In several instances the names applied by the villagers to their villages and other features are not the same as those on previously published maps.

The great waterfalls in southern Laos have been referred to as Lee Pee ("The Spirit Trap") in ROBERTS (1993) and elsewhere, but this name more properly refers only to Haew Sompamit. All of the Khone waterfalls occur in a nearly straight line at about latitude 13° 51' N. The best term for the whole range of waterfalls is Khone (pronounced "kawn") Falls. Individual waterfalls are known as "khone" if lee and dtawn fish traps can be placed in them to catch migrating fish. It seems the name "khone" is a shortened version of the original "khone pba" or "fish waterfall." "Haew" means a high waterfall that fish probably can not go up.

Other common Lao geographical terms are "ban", village; "don" (island), "geng" (rapids), and "hoo" (channel). Two terms very often used in connection with the names

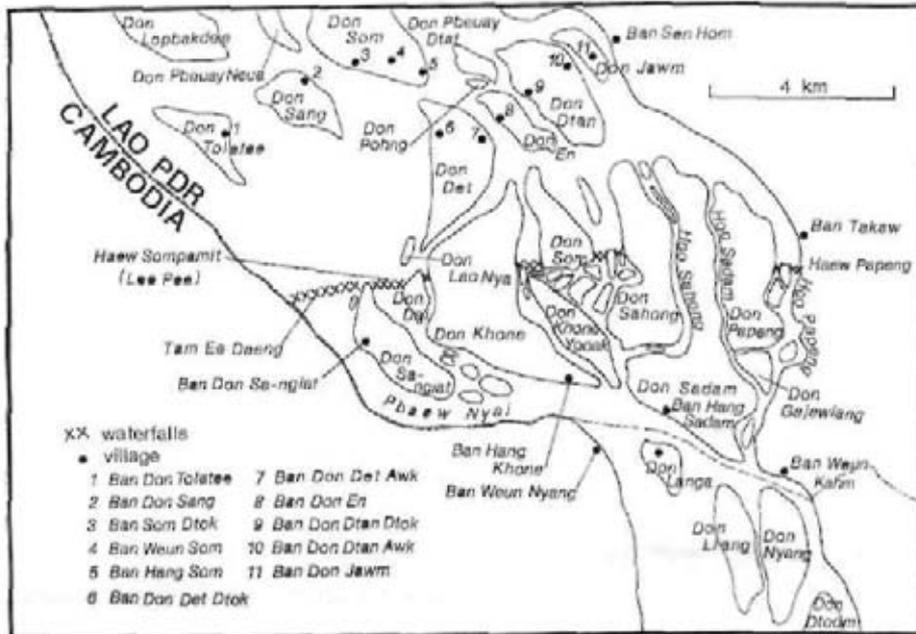


Figure 1. Map of Khone Falls area (within latitude 13°45' to 14°00'N and longitude 105°45' and 106°00'E). Note absence of waterfalls on Hoo Sahong and Hoo Sadam.

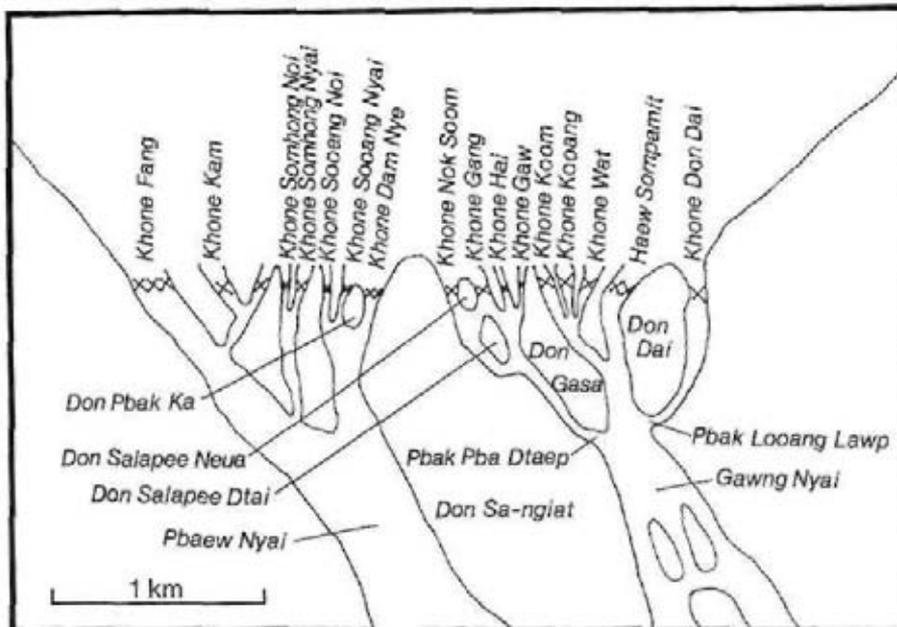


Figure 2. Map of Tam Ee Daeng-Haew Sompamit area.

of villages on islands are "hooa" (literally, at the head of the island) and "hang" (at the tail). Thus "Ban Hang Khone" means "village at the tail end of Khone [waterfall] Island".

Waterfalls

The main waterfalls comprising Khone Falls are, from west to east:

Tarn Ee Daeng (Fig. 6). Between Cambodian mainland and Don Sa-ngiat. Very large waterfalls above Hoo Khone Fang. Fish can't pass here, although nearly all migratory species except *Pangasius macronema* come up to these waterfalls before trying other channels.

The term Tarn Ee Daeng also is used for some large underwater caves located northwest of the mouth of Hoo Sompamit, between Cambodia and Don Sa-ngiat.

Haew Sompamit (Lee Pee). Large falls about 10 m high, on the west side of Don Dai (east of Don Khone). Fish can not get past this waterfall.

Khone Dta Mook. This waterfall, 2-3 meters high, is at the upper end of Hoo Khone Yooak (between Don Khone Yooak and Don Khone). Fish can not go up it.

Haew Ee Dtoot Nyai and Haew Ee Dtoot Noi. Two large, steep falls west of Don Som and east of Don Khone Lek and Don Khone. Haew Ee Dtoot Nyai is 8 m high and Haew Ee Dtoot Noi 6-7 m high. Fish go up to these falls but cannot pass them, then turn back to find another passage.

Khone Lan. A 3-4 m high waterfall between Don Sang Peuak and Don Som. Probably small cyprinids can get past here, but only with difficulty. Many can't make it up and turn around to find another passage.

Khone Sang Peuak Nyai and Khone Sang Peuak Noi (Fig. 7). These two waterfalls are at the NW end of Don Sahong. They are 3-4 m high, but not nearly so large as Haew Sompamit or Khone Papeng. Haew Sang Peuak Nyai is between Don Sang Peuak Noi and Don Sang Peuak Noi (also known as Don Jampha) and its channel is called Hoo Sang Peuak Nyai. Haew Sang Peuak Noi is between Don Sang Peuak Noi and Don Sahong and its channel is called Hoo Sang Peuak Noi or Hoo Don Jampha Noi. *Cirrhinus microlepis* and May-June migrating *Pangasius conchophilus* and *P. krempfi* can go up it; April-June migrating *Pangasius macronema* can not. *Hypsibarbus* sp. or spp. can get up these falls. In October, fish of various kinds including small cyprinids may be able to pass these falls more easily.

Haew Papeng. Large waterfalls, the only ones usually seen by tourists traveling by road, adjacent to the Lao mainland. Incorrectly referred to as Khone Papeng.



Figure 5. Suntorn making a jun trap. Ban Hang Khone, July 1993.



Figure 6. One of many large waterfalls in the Tarn Ee Daeng area. Fish cannot go up this waterfall.



Figure 7. Khone Sang Peuak. Women catching small migratory cyprinids with a gadtawng scoop net, January 1994.



Figure 8. Hoo Sahong at Dtat Po, J a n u a r y 1995.

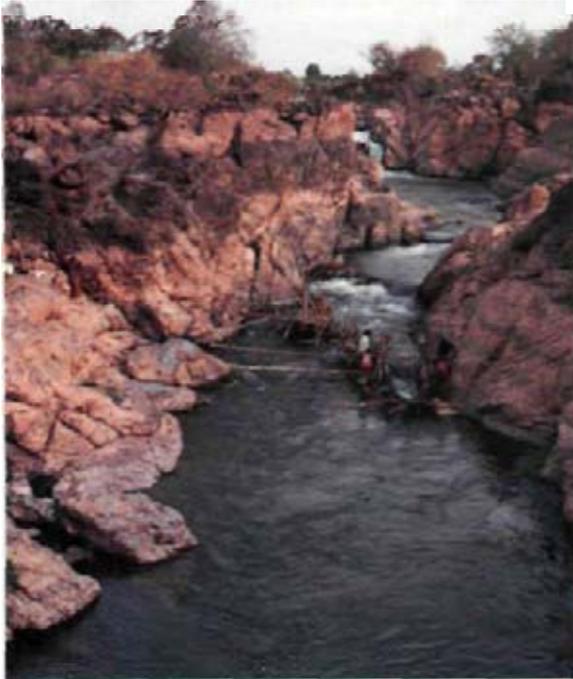


Figure 9. Hoo Khone Sooang Nyai, January 1994.



Figure 10. Suntorn's oo trap in Hoo Nok Gasoom with cylindrical gapoong basket partially visible, January 1994. Note poles lashed together in foreground used by fishermen to walk from one trap to another. This oo trap was made by modifying Suntorn's lee trap; see Roberts. 1973: fig. 13 of lee.



Figure 11. Cylindrical gapoong basket used with dtawn, oo, and lee traps.



Figure 12. Weir-like dtawn trap with 30 gapoong baskets in Hoo Sang Peuak, January 1994. Over ten families, mostly from Don En just above Khonc Falls, each owned 2 or 3 of the gapoong.

Channels

Pbaew Nyai. This is the largest and deepest channel of the Mekong River just below Khone Waterfalls. It leads to T a r n Ee Daeng.

Hoo Papeng. Between Lao mainland and Don Papeng. Fish can not pass here because they are stopped by Haew Papeng, although they try.

Hoo Sahong (Fig. 8). Between Don Sadam and Don Sahong. Large, wide channel without waterfalls. The most important channel for all migrating fish species at all times of the year.

Hoo Sadam. Between Don Sadam and Don Papeng. Narrow channel without waterfalls, important for all migrating species during most of the year.

Hoo Som Nyai. Large channel branching o f f of Hoo Papeng between Khone Papeng and Don Som Nyai. Many fish try to go up this channel. When water levels are low, very few if any fish succeed in going all the way through. Some fish are able to ascend when water levels are high. Probably very few, if any, fish get by this channel during the low water migratory periods.

Hoo Khone Gaw. Next to Don Sa-ngiat. Narrow channel branching o f f from Hoo Sompamit. In the monsoon season *Pangasius conchophilus* and *P. krempfi* go up this channel. When the waters are still relatively high in December *Scaphognathops bandonensis* and *Cirrhinus lobatus* (pba soi hooa lem or pba hooa pee) apparently can pass through this channel. Later, when water levels drop, the channel dries up (by Chinese New Year the channel usually is dry).

Hoo Sang Peuak. Major pathway for fish migrating upstream past waterfalls. Site of an unusually large weir-like dtawn trap with 30 dtawn traps with gapoong baskets (Fig. 12). Usually such weirs are much smaller than this one a n d have only 3-10 baskets. The large weir in Hoo Sang Peuak is used communally by over 10 families, each owning 2 or 3 of the baskets. Most of these families are from Don En, just above the falls. The weir catches small cyprinids migrating in January-February.

Hoo Wai or Hang Don Nok Gasoom. Site of Suntorn's two lee/oo traps at south end of Don Nok Gasoom. Also site (just below Suntorn's lee) of jip trap which targets small cyprinids in December-February, with considerable by-catch, and *Pangasius macronema* (pba nyawn) and small *P. conchophilus* (pba gae) in April-June.

Hoo Don Dai. Just below Haew Sompamit. Mouth of hoo called Pbak Looang Lawp. An important hoo for small cyprinids *Cirrhinus*, *Paralaubuca*, *Cross-ocheilus*, *Labiobarbus*, cobitid *Botia modesta*) a n d other species migrating in January-February. Fish can't get past rapids a n d waterfalls further up Hoo Don Dai and come back after finding this out. Many dtawn traps are set in this hoo and catch upstream migrating fish when they are

blocked by waterfalls and come back down stream.

Hoo Dtat Wai Nyai and Hoo Dtat Wai Noi. Some May-June migratory fish (excluding *Pangasius macronema*) get to Sang Peuak Waterfalls via these two channels.

Hoo Gajaewiang. Between Don Gajaewiang and Don Papeng. Dries out in late April or early May.

Hoo Dtat Hai. From southern tip of Don Nok Gasoom up to Haew Ee Dtoot Nyai. A dtawn trap is put at its mouth during the January-February fish migrations.

Hoo Nok Gasoom. Between Don Nok Gasoom and Don Deua. Splits into two channels at the northern end of Don Nok Gasoom. One channel runs northwest up to Khone Lan and the other northeast to Haew Ee Dtoot Noi.

Hoo Som Noi. Small channel between Don Mawk Baw Wai and Don Som Nyai.

The following hoo channels are west of Don Khone and east of the Cambodian mainland. They are separated largely by rock cliffs that get flooded in the rainy season, turning the whole area into large wide waterfalls:

Hoo Khone Wat. Hoo east of Don Sa-ngiat leading to Boong Pba Leum, with a 6-7 m waterfall. Fish cannot get up.

Hoo Khone Kooang. East of Don Sa-ngiat, with a 5-6 m waterfall. Fish cannot get up.

Hoo Khone Koom. East of Don Sa-ngiat, with a 7-8 m high waterfall. Fish cannot get up.

Hoo Khone Gaw. East of Don Sa-ngiat, with a waterfall 1-2 m high. Fish can get up in December, but the channel is dry by January or February. The width of the channel at its upper end is only a few meters, and people used to block it totally so that fish cannot go up. This practice was stopped in 1994.

Hoo Khone Hai. East of Don Sa-ngiat, with a 3-4 m high waterfall not passable by fish.

Hoo Khone Nok Soom. Similar to Hoo Khone Hai.

Hoo Khone Fang. West of Don Sa-ngiat, with a 7-8 m high waterfall. Fish cannot get up.

Hoo Khone Kam. West of Don Sa-ngiat, with a 3-4 m high waterfall. Reduced to a trickle in the dry season. No fish can pass.

Hoo Kawk Ma. West of Don Sa-ngiat, with a 3-4 m high waterfall. Dries up in the dry

season. Fish cannot pass.

Hoo Soomhong Nyai and Hoo Soomhong Noi. West of Don Sa-ngiat, both with 3-4 m high waterfall. No fish can pass.

Hoo Khone Dam Nye. West of Don Sa-ngiat, with a 2 m high waterfall. Dries up in the dry season. Fish cannot pass.

Hoo Khone Sooang Nyai (Fig. 9). West of Don Sa-ngiat, with a 7-8 m high waterfall. Fish cannot pass. Fishing with dtawn traps in January-February and May-June.

Hoo Khone Sooang Noi. Similar to Hoo Khone Sooang Nyai.

Hoo Khone Gang. West of Don Sa-ngiat, with a 5-6 m high waterfall. Fish can't pass.

Pools, Spawning Grounds, and Other Special Features

Boong Pba Gooawng. One of three large pools near Ban Hang Khone or the southern end of Don Khone. This is one of the main habitats or feeding grounds of *Orcaella brevirostris* (pba kha, Irrawaddy dolphin) below Khone Falls; February-March spawning grounds of the sciaenid fish *Boesemania microlepis* (pba gooawng). Many years ago, when large *Catlocarpio siamensis* were relatively common at Hang Khone, they also spawned in deep waters in Boong Pba Gooawng according to Suntorn and other villagers.

Boong Pba Jook. West of Boong Pba Gooawng, in front of an old French dry season boat dock. Dolphins stay there in November-December. *Hypsibarbus* sp. (pba pbak nooat or pba pbak gohm) and *Boesemania microlepis* spawning site.

Boong Hin Sang. The second large pool facing Ban Hang Khone.

Boong Ken. The deepest pool in Hoo Khone Yooak, a little over 1 km up from the mouth of Hoo Khone Yooak.

Boong Pba Leum. A very deep pool just below Khone Wat Falls, thought to be spawning ground of *Pangasius sanitwongsei*. Large *P. sanitwongsei* reportedly surface in this pool in June and July.

Tarn Ee Daeng and Gawng Nyai have deep pools below them famous for the catfishes *Micronema apogon* and *Bagarius yarrelli*. The former is much more abundant there than the latter. During the dry season gill nets (yawn mawng, 12-16 cm multifilament) are placed deep in these pools to catch *M. apogon*. This species, one of the more expensive food fish, is heavily targeted in these pools. Catches are declining.

Hin Dta Moon. A pool a little to the northwest of the mouth of Hoo Sahong where *Pangasius macronema* is caught with gillnets.

There is a *Probarbus* spawning ground between the left bank of the Mekong and Don Dtoom in Cambodia about one km below the border with Laos.

Dtat Po (Fig. 8). Site of communal fishing ground for *Pangasius macronema* on Hoo Sahong north of Ban Hang Sadam (see account under "Traditional Fisheries Management").

Hooa Kan. Hooa Kan (hooa = head, kan = rim) refers to the upper edge of all of the Khone waterfalls. Such areas, like that between Don Sang and Don Tolatee and the waterfalls usually have seasonally flooded trees and are popular fishing grounds.

Flooded Forest or Riverine Trees

The area above Don Sa-ngiat and just below Don Sang and Don Tolatee is the largest area of seasonally flooded trees in the Khone area. So far we have had only one of the species scientifically identified. The trees gohk kai, gohk kai kam, gohk kai hang nak and gohk goom (*Crateva manga* Lour. DC, Cappariaceae) are dominant just above the falls. Much of this area is exposed during the dry season, but the whole area is flooded during the wet season. There are no islands that are permanently above water.

Below the falls in Laos and into northern Cambodia the riverine trees are dominated by gohk laemsang (?*Osbeckia* sp., Melastomaceae) and gohk pee man (*Albizia* sp., Leguminosae), both rare or absent above the falls. Riverine trees are fairly abundant in Pbaew Nyai and in the upper part of Hoo Sahong.

Above Khone Lan between Don Som and Don Sahong is a lot of seasonally flooded vegetation including gohk goom, gohk kai kum and gohk kai hang nak. There are also a lot of small islands in this area which are not especially significant for fishing and for which we have not obtained place names.

Above Haew Ee Dtoot Nyai and Haew Ee Dtoot Noi and between Don Som and Don Khone is an expansive area of seasonally flooded forest dominated by gohk kai, gohk kai kum, gohk kai hang nak and gohk goom. There are no islands permanently above water in the area.

STRONGLY MIGRATORY FISH SPECIES

Virtually all of the most important species in the Khone area wildcapture fisheries are strongly migratory. The strongly migratory species in the May-July migratory period, dominated by Pangasiidae and other catfishes in reproductive condition, are identified and discussed in ROBERTS, 1993. Strongly migratory fish species during the December-February migratory period, dominated by small non-reproductive cyprinids, are listed in Table 1, and are discussed here and in ROBERTS & WARREN, 1994 (Fig. 16).

Table 1. Strongly migratory fish species observed in the Khone Falls area in December-February 1993 and 1994, with most important catching gear and socioeconomic importance on a scale of 1-5.

| Species | Gillnet | Dtawn | Importance |
|--|---------|-------|------------|
| Clupeidae (herrings) | | | |
| <i>Tenualosa thibaudeaui</i> | - | + | 5 |
| Cyprinidae (carps) | | | |
| <i>Amblyrhynchichthys truncatus</i> | + | - | 4 |
| <i>Bangana behri</i> | + | - | 3 |
| <i>Barbodes altus</i> | + | + | 3 |
| <i>Cirrhinus lineatus</i> | - | + | 5 |
| <i>Cirrhinus lobatus</i> | - | + | 1 |
| <i>Cirrhinus microlepis</i> ¹ | + | + | 1 |
| <i>Cirrhinus molitorella</i> | + | - | 4 |
| <i>Cirrhinus siamensis</i> | - | + | 3 |
| <i>Crossocheilus reticulatus</i> | - | + | 3 |
| <i>Cyclocheilichthys enoplos</i> | + | + | 3 |
| <i>Epalzeorhynchus frenatus</i> | - | + | 5 |
| <i>Epalzeorhynchus siamensis</i> | - | + | 5 |
| <i>Garra fasciacauda</i> | - | + | 5 |
| <i>Hypsibarbus</i> sp ² | + | + | 3 |
| <i>Hypsibarbus</i> sp ³ | + | - | 1 |
| <i>Labeo pierrei</i> | + | - | 2 |
| <i>Labiobarbus leptocheilus</i> | - | + | 2 |
| <i>Lobocheilos melanotaenia</i> | - | + | 2 |
| <i>Luciosoma bleekeri</i> | - | + | 4 |
| <i>Mekongina erythrospila</i> | + | + | 1 |
| <i>Osteochilus microcephalus</i> | - | + | 4 |
| <i>Paralaubuca</i> cf <i>typus</i> | - | + | 1 |
| <i>Probarbus jullieni</i> ⁴ | + | - | 1 |
| <i>Probarbus labeamajor</i> | + | - | 1 |
| <i>Puntioplites proctozysron</i> | + | + | 2 |
| <i>Scaphognathops bandonensis</i> | + | + | 1 |
| <i>Scaphognathops stejneri</i> | + | + | 2 |
| <i>Sikukia stejneri</i> | + | + | 3 |
| <i>Thynnichthys thynnoides</i> | + | + | 3 |
| Gyrinocheilidae (spiracle carps) | | | |
| <i>Gyrinocheilus pennocki</i> | + | + | 1 |
| Cobitidae (loaches) | | | |
| <i>Acantopsis</i> sp or spp | - | + | 4 |
| <i>Botia helodes</i> | - | + | 4 |
| <i>Botia modesta</i> | - | + | 2 |

¹Large and small fish in gillnet, small fish to 100 g in dtawn; ²small (juvenile?) p b a p b a k gom; ³large spawning pba pbak noat (same species as pba pbak gom according to some fishermen); ⁴juveniles only; ⁵adults only in gillnet, mostly juveniles in dtawn; large fish in spawning condition.

DIRECTIONALITY OF MIGRATIONS

From the beginning of our observations on migratory fish activity in the Khone area, we have been concerned to determine whether various fish species were migrating in the upstream or downstream direction. It is particularly difficult to determine this in the Khone area because the migratory pathways and channels there are so complicated, and because fish migrating upstream often move in large numbers down various channels when their way upstream is blocked, and thus seem to be migrating downstream when in fact their main direction is upstream.

We now present the following general observations, based on our most recent observations and interviews. During the low water season, December-February, all of the migratory fish in the Khone area appear to be migrating upstream. At this time most of the migratory fish are cyprinids, and the migrations, which occur mainly or only in the daytime, are relatively easy to observe. In the main high water migratory months, May-July, many catfishes and other groups are migrating, and the catfishes and perhaps some others migrate mainly or only at night. The most important migratory catfishes are members of the family Pangasiidae, and they evidently are all migrating upstream. Many large cyprinid species probably are also migrating upstream, including *Bangana behri*, *Cyclocheilichthys enoplos*, *Hypsibarbus* spp., *Labeo chrysophekadion*, *L. pierrei*, *Mekongina erythrospilus*, and *Scaphognathops bandonensis*. Other cyprinid species, however, including mostly smaller species, are migrating downstream: *Cirrhinus lineatus*, *C. lobatus*, *C. microlepis*, and *C. siamensis*; *Labiobarbus leptocheilus*; *Lobocheilos melanotaenia*; and *Paralaubuca typus*.

FISHING METHODS

Figures 7, 10-15, 17-19, 21

As usual in artisanal fisheries on large tropical rivers, Khone fisherfolk employ a great variety of fishing gear. Most kinds of gear, or the way they are used, depend greatly on stream flow and other water conditions and thus are highly seasonal. Many are used to target particular fish species or groups of species, whether migratory or non-migratory. Most fishing gears or the techniques employed with them involve intimate knowledge of fish behavior. This is especially but not only true of the kinds of baits used in fishing with hook and line. The kind of gear used will also depend greatly on the resources available to the fishers, including their finances, number of people fishing together, whether they have a boat and whether it is motorized, and whether they are fishing commercially or for subsistence.

A brief illustrated account of lee (large immovable traps with long wings set in rapids), lawp, kah and jun traps and other fishing gear and methods observed or recorded at Ban Hang Khone in June-July 1993 is given in ROBERTS (1993). Here we add information on fishing gear and methods currently or formerly used at various times during the year at Ban Hang Khone and other localities just above as well as below Khone Falls.

Traps

Dtawn traps (Figs. 10-15). Used in January-February in almost every channel in the Khone waterfalls and rapids area to catch small migratory cyprinids. The essential parts of dtawn are: a barrier, fence or weir of poles or sticks to restrict or direct movements of migrating fish; and an oo or gapoong basket or other device (such as a woven bamboo sheet) to catch the fish.

The baskets, which vary in shape and construction (Figs. 11-13), are also used with other kinds of fishing gear, such as lawp traps and jip bagnets.

Looang Kung (Fig. 17). A special kind of large trap, with long bamboo wings leading into a large circular bamboo enclosure, the only exit from which is a lee, oo or lawp trap. Used in January-February and in May-June. Large fish often swim around for days in the circular enclosure before slowly getting trapped in the lee or oo. In some instances an entire passageway for fish may be blocked by the wings and circular enclosure. Most people in Khone Subdistrict consider the method to be very destructive and are in favor of prohibiting this fishing gear.

Sooang, large bamboo funnel trap. Conical trap, about 3 m long, with a mouth 1 m wide facing into the current, tapering to a very narrow closed end downstream. Placed in rapids and waterfalls. When large fish enter the sooang, they are forced into the narrow end and can't turn around or get out. Traps of very similar construction are used (or were in use until quite recently) in the rapids of the Congo River above Kisangani and below Kinshasa.

Oo or gapoong baskets made of bamboo (Figs. 11-13). Placed at end of dtawn traps in October-February, catching mainly small migrating cyprinids, and at end of jip nets in April-June, catching mainly upstream migrating *Pangasius* (*P. conchophilus*, *P. macronema*). Also catches many other species. Baskets are placed in the water only when fish are migrating upstream.

So or ja-waw trap. A very old kind of fishing gear, formerly widely used, but now used mainly in rapids by villagers of Don Sahong and Ban Hang Som. Broad opening made of heavy wood or vine. The catch portion, formerly made of teuang vine, nowadays of multifilament nylon rope, woven like a net. Used mainly at night, with the fisher standing beside it for many hours (sometimes the whole night), in shallow places where the water level does not submerge the entire trap. When a big fish swims into the mouth, the front end of the ja-waw is quickly lifted. Many species but only small numbers of fish are caught by this method.

Some people tie ja-waw to flooded forest bushes at night, then check them in the morning. Used in high water season.

Saiha. An old method, rarely used now. A channel constructed of rocks led fishes into a saiha (a kind of dtoom) trap at its downstream end.

Lan, small trap. Used in April-May, baited with rice bran to catch small cyprinid fishes, mainly pba khao lan ("fish that enters lan", a species of *Puntius-like* fish), pba soi hooa lem (*Cirrhinus lobatus*) and pba soi hooa po (*C. siamensis*).

Jun, trapdoor trap. In June-July 1993 we observed only use of single jun traps set in different places (ROBERTS, 1993: 59, Fig. 15). Jun traps are also used in weirs near Hoo Sadam to catch large non-migrating fish. One stream near Hoo Sadam was totally blocked

off by a weir with 13 jun in January 1994.

Sanang. Scoop basket. One of the oldest fishing gears in the area. Used mainly by women to catch shrimp and small fish in submerged roots of trees and bushes in the flooded forest. Used in conjunction when fishing with hook and line with a simple bamboo rod or bet dteuk (q.v.) using mainly shrimp and earthworm as bait.

Oo dten. Trap consisting of a woven bamboo sheet, placed just below a waterfall mainly January-February to catch small migrating cyprinids. As fish jump up to try to pass the falls but cannot make it, they fall back into the trap ("oo dten" means the jumping or dancing trap).

Nets

Jip, stationary bagnet (Fig. 18). Set in rapids to catch migrating fish (mostly small cyprinids) and any fish moving in the area in December-February. Also used in April-June to catch small *Pangasius* (*P. macronema*, young *P. conchophilus*). An oo or gapoong basket always is placed at the catch end of the jip. When used in certain places it catches many juvenile fish.

Man, large bagnet or jip. Placed at the mouth of large streams at the end of the high water season to catch fish returning to the mainstream from the flooded forest. A particularly large jip called man has been used to completely block the mouth of Houay Talat where it flows into the Mekong mainstream in Cambodia about 20 km south of the border with Laos. The Khmer name of this tributary is O Talas.

Lai mawng, drifting gillnet. Usually made of nylon. Since 1970 this has become one of the most important fishing gears, especially above the falls. Difficult to use in rocky areas; rarely used at Hang Khone and Hang Sadam.

Mawng foo, set gillnet. Placed about a half-meter below water surface. Mainly used for *Probarbus jullieni* November-January (18-25 cm meshes) and *Pangasius krempfi* May-July (12-18 cm meshes). Not used in other seasons. Erroneously reported as drifting gillnet in ROBERTS (1993: 60).

Mawng jom, set gillnet (Fig. 19). Placed deep, near bottom. Reported as mawng loom in ROBERTS (1993: 60).

Yawn mawng, bottom gillnet. At the end of January 1994, as catches of pba sae and pba pien decreased, some Hang Khone fishers started using 5-8 cm gillnets in a different way, as yawn mawng. The nets are laid right along the bottom of the river in deep pools, like Boong Pba Gooawng, where many species retreat as the water level drops. The method results in good catches, but many people don't use it because of excessive damage to nets that get snagged on the rocky bottom. Nets get ripped apart quickly, and their life is considerably shortened. A net may be ruined in one month. Nets are left out day and night, and checked at 6:00 a.m. and 6:00 p.m.

Yawn mawng of 16-20 cm mesh are also used to target spawning *Boesemania microlepis* at Hang Khone. *Bagarius yarrelli* are also taken by large meshed yawn mawng at Hang Khone. Large meshed yawn mawng are used at T a r n Ee Daeng for *Micronema apogon* and *Bagarius yarrelli*.

Nam, drifting bagnet. A net made of pban (a kind of jute) or teuang vine operated by two canoes in May-June. The nam is allowed to drift downstream with the canoes,

suspended by only a single rope from each canoe. When a large fish (e.g. *Pangasius conchophilus* or *P. krempfi*) enters the nam, it is simultaneously lifted from both canoes. This is a very old kind of fishing gear that has almost disappeared, still used by one villager from Ban Hang Khone. Difficult to use nowadays because set gillnets block the fishing paths.

Dtong, drifting bagnet. Like a nam, but more bag like and suspended by two ropes from each canoe instead of only one. No longer in use in Ban Hang Khone, but still used in parts of Khong District above Khone Falls.

Gadtawng, scoop net (Fig. 7). One of the oldest and simplest fishing gears used in the Khone area. Formerly popular, now used only by a few people in a few places such as Sang Peuak Fall. Used mainly by women, it is placed in the falling water to scoop out a few small cyprinids (*Cirrhinus lobatus*, *C. siamensis*, *Paralaubuca* cf. *typus*, *Crossocheilus reticulatus*, *Lobocheilos melanotaenia*) every 20 or 30 seconds. These species are caught as they try to jump up the falls.

Sawn (Fig. 21). Two bamboo poles about 2 m long with a net attached between the upper ends of the poles. During use, the fisher crosses the lower ends of the poles, causing the upper ends with the net stretched between to form a V-shaped opening. The upper end is then scooped through the water to catch fish. Used only to catch migratory fish: small cyprinids January-February; *Pangasius macronema* April-May; and *Cyclocheilichthys enoplos*, *Hypsibarbus* spp., *Pangasius conchophilus*, and others May-July.

Hook (bet) and Line, Baits.

Hook and line are used around the year above and below the falls. In the Hang Khone area most popular during the rainy or monsoon season, when gill nets can't be used widely. A wide variety of baits and techniques are used to target particular species.

Pba gadao (small sun-dried cyprinids) and mak deua (figs of *Ficus variegata* Bl.) are mixed together and used as bait mainly for catfish.

Mak hoon (fruits of *Crayratia trifolia* (L.) Dom. var. *cinerea* (Lmk.) Gagnep., Vitaceae), keegadeuan (earthworms) and maeng keenai (nymphs of mole crickets, *Grylotalpa* sp.) are used as bait on small hooks on long lines (bet piak) during the high water season to catch various kinds of cat fish at Hang Khone. The lines are set at midwater, with rocks as sinkers to keep them from floating to the surface.

Mak gabao (fruits of *Hydnocarpus anthelminthica*, Flacourtiaceae) is put on hooks in September-November to catch pba gooa (*Tor* cf. *tambra*) and pba pohng (*Leptobarbus hoeveni*). The method is used at Hang Khone, but is not popular there. It is commonly used in the southern Lao provinces of Se Kong and Attapeu. For discussion of this plant-fish relationship see below under notes on individual taxa for *Tor* cf. *tambra* and ROBERTS, 1993: 38.

Frogs are put on hooks and leaders and put in water waist deep to catch *Mystus microphthalmus*. The same gear placed in shallow water near shore catches *Channa* spp.

Live pba kaw (*Channa striata*) are put on large hooks on long lines in deep water in February-May to catch large *Mystus microphthalmus*.

Live pba dook (*Clarias* spp.) are put on large hooks (bet ken) 3 m below the surface in deep water in the rainy season, September-November, to catch *Mystus microphthalmus*.

The baitfish is kept alive by attaching the hook to a string tied around its body.

Mak gan leuang (a fruit not yet scientifically identified) is put on hooks in October-November to catch large *Pangasius* spp. (*P. bocourti*, *P. conchophilus*, *P. krempfi*, *P. larnaudei*) in October-November. This method is known in the Khone area, but is not popular there. It is commonly used on the Se Kong and its tributaries in Se Kong and Attapeu provinces of southern Laos.

Leaves of the tree gohk goom (*Crateva manga* Lour. DC, Cappariaceae) are put on single hooks to catch *Pangasius bocourti*. This method is used during rising water in June-August. After observing that some submerged leaves already have been eaten by the fish, fishers tie a leader to the tree with one or two hooks baited with leaves floating on the surface. *Crateva manga* is fed on by many fish species entering the flooded forest, including *Osphronemus exodon*. It was previously reported as *Crateva nurvala* in ROBERTS (1993: 51); ROBERTS (1994: 74, Fig. 8).

Dawk kai. In March-April when gohk kai blooms, villagers from Ban Don Tolatee, Ban Don Sang, and other villages bait small hooks with the flowers, dawk kai. The lines, with single hooks, are tied to gohk kai bushes with branches hanging over the water so that the hooks float on the surface. Fishes caught include *Pangasius pleurotaenia* (notorious for feeding on dawk kai), and several species of *Hypsibarbus* (pba pbak gohm, pba pbak pbeh, and pba pbak tawng leuang).

Rotten meat (dog, fish or chicken) is put on a special large hook (bet pba leum) on a rope 20-30 m long set in deep water during the rainy season (July-October) to catch *Pangasius sanitwongsei*. It is considered bad luck to let anyone know you are putting this kind of hook out, or to let anyone see you baiting it. Villagers believe in this custom very much, which applies only to this kind of hook.

Mak hoon (fruit of *Crayratia trifolia*) and mak deua (figs of *Ficus variegata*, Moraceae) are put on single hooks with 0.5 m leaders attached to floats made of bamboo sections. The floats and hooks (bet dtao) are allowed to drift over deep water for a half hour or so (10 or 20 may be put out at a time). This method, frequently used at Hang Khone, catches a single species, *Pangasius polyuranodon* (pba nyawn hang hian), which apparently is active near the surface much of the time.

Pba soi (*Cirrhinus lobatus*, pba soi hooa lem, and *C. siamensis*, pba soi hooa po) and other small cyprinids are put on long lines in May-June to catch migrating *Pangasius conchophilus* and other fish.

Hoi joop (bivalve mollusk) are put on long line hooks placed on the river bed to catch *Helicophagus waandersii* (pba noo).

Crabs (ga pboo) are put on hook (single or longline) set about 1 m above the bottom to catch *Probarbus* spp. This method is seldom used.

Medium sized (half-kilogram) *Chitala* spp. and *Boesemania microlepis* are put on large hooks set at the bottom of deep pools (wang) with floats at the surface to catch giant stingrays (*Himantura chaophraya*). This method is used at Don Sang and other places above Khone Falls.

Bet dteuk. Simple rods with line and single hook, baited with shrimp, used to catch *Mystus*, *Kryptopterus*, *Chitala*, and other species. Rod is held by fisher, usually women. Especially popular in November-February, and used by many people. Shrimp is caught with a special basket called sanang (q.v.).



Figure 13. Close-up of gampoong baskets on dlawm in Hoo Sang Peuak, January 1994.



Figure 14. Dlawm in Hoo Don Dai just below Hacw Som p a m i t, January 1994.



Figure 15. Dlawm at Hang Don Nok Gassom, just south of Suntorn's lee/oo site, January 1995.



Figure 16. The most important fish species caught in dtawn and oo traps, January 1994. From top: *Crossocheilus reticulatus*, *Cirrhinus lobatus*, *Paralaubuca cf. typus*, *Lobocheilos melanotaenia*, *Labiobarbus leptocheilus*, *Cirrhinus siamensis*, *Gyrinocheilus pennocki*, *Bolia modesta*.



Figure 17. Looang Kung in Hoo Nok Gasoom, January 1994.

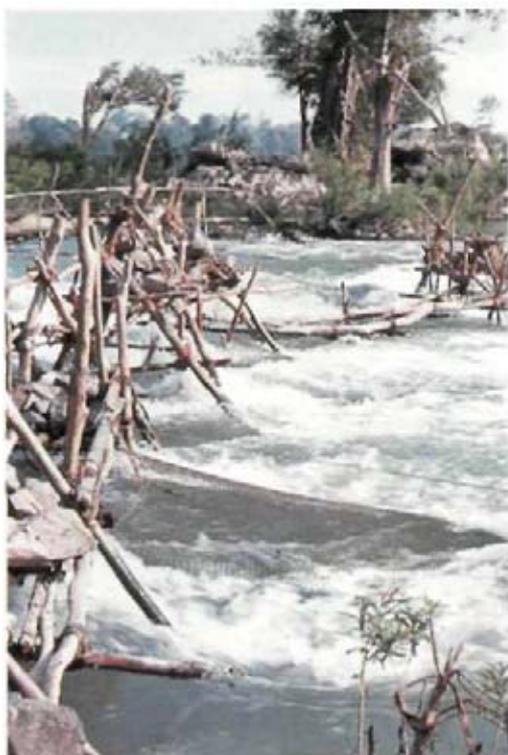


Figure 18. Jip bagnets in January 1994.



Figure 19. Mawng jom (2.5 cm mesh) with deepwater catch of *Pangasius macronema*, April 1994.



Figure 20. *Pangasius macronema* being sun-dried to make p b a dte. April 1994.



Figure 21. Fishing with sawn in Hoo Sahong, January 1995.

Bet sit. Simple rods with hook and line similar to bet sit, but only baited with the bodies and eggs of large red ants. Catches mainly *Hypsibarbus* spp., *Paralaubuca* cf. *typus*, *Hampala*, and *Osphronemus exodon*. Used only in the dry season, when red ants with eggs can be found; not very popular at Hang Khone.

Bet kan or bet tawt. Hook and line attached to a bamboo rod a half meter long. Hooks are baited with earthworm, rods struck part way into mud near shore of larger rivers. Catches mainly *Channa striata* at night. Gear moved daily. Method popular at Hang Khone during rainy season.

Bet leuam. Casting hook and line with an artificial lure made of "kee gooa" (a soft metal, possibly a zinc alloy). Catches mainly *Hampala macrolepidota* (not commonly used at Hang Khone).

Bet boom. Single hook and line baited with live fish such as *Clarias* sp. (pba dook), *Mastacembelus armatus* (pba lot).

Bet pba kae. Single large hooks and line with 5-10 m leaders baited with small cyprinids (pba soi) or earthworms. Put in deep rocky places in rainy season (August-November) to catch large pba kae, *Bagarius yarrelli*.

Bet pba goht. Hooks on longline used in dry season for *Mystus nemurus*. Baited with earthworms or small cyprinids and placed in water about 1 m deep. In wet season same method used to target other catfishes, mainly *Pangasius conchophilus*, *Pangasius macronema*, *Bagarius yarrelli*, and *Micronema apogon*, but lines are placed in deeper water. Few *Mystus nemurus* caught then, as most have moved into tributaries where the gear is not used.

Bet pba keung. Large single hook and line or longline baited with live fish. Hooks are placed through the back of the bait fish so it won't die soon. Used mainly in the dry season, with *Gyrinocheilus pennocki* as the preferred bait. Hooks set near rocks in deep pools catching mainly *Mystus microphthalmus* (pba keung).

In March-April 1994 a number of large (1-25 kg) *M. microphthalmus* were caught using this method by Ban Hang Khone fishers and Cambodian fishers living on Don Langa and Ban Weun Yang across the river from Ban Hang Khone. *Mystus microphthalmus* was the only species observed or reported to be caught.

Bet ken. Large single hook and line with a 2-m leader baited with fish, worms or mole cricket nymphs. Tied above water to submerged tree branches or used with long wood or bamboo pole extending from shore.

A special longline is used at Don Tolatee (just above Khone Falls) to catch *Micronema apogon*. It is set in deep water with leaders 3 m long spaced 5 m apart baited with live fish. The hooks are put through the dorsal fins so the baitfish won't die. In November the baitfish is pba dook (*Clarias batrachus* and in December-January pba soi and pba kao (small cyprinids including *Cirrhinus* spp. and *Puntius* spp.). The baitfish swim around rocks in deep pools where the longline is set. This method is not used much anymore.

Miscellaneous

Sa-nohng, harpoon. Up to the early 1970's harpoons with 20-30 m lines made of pban or teuang vines (neither plant species scientifically identified) were used to catch very large fish. Fishers waited in rapids and harpooned large catfishes such as *Pangasius*

sanitwongsei and *Bagarius yarrelli* as they came up or down deeper channels in the rapids, particularly in Hoo Sadam and Hoo Papeng. Due to the recent scarcity of large fish, the method is no longer used.

Ngiang pba. Spears with 3-4 barbed tines used to catch fish at night, with the aid of spotlights attached to the forehead to see fish. Used only in the first half of the year when the water is low. Large *Channa*, *Chitala*, *Cyprinus carpio* and other species are caught. A relatively new method, used mainly near Don Khong and Kinnak above Lee Pee Waterfalls, not yet adopted below the falls.

Some people feel the use of modern lamps is wrong and that the method is unduly destructive when used on a commercial basis. Some users in Khong district are known to steal agriculture products and to tie up fish in the water when using this method. This is one of the reasons people oppose the method. Users fish mainly at night and can not be easily watched by others.

Jahp pba gap meu. Fishing by hand. In June-July, as the Mekong rises quickly, Ban Hang Khone villagers (mostly women and children) sometimes go and catch fish with their bare hands, especially small cyprinids that stay in shallow water close to shore and can be easily scooped up. The main species caught is *Lobocheilos melanotaenia*; *Cirrhinus lobatus*, *C. siamensis*, *Crossocheilus reticulatos*, and *Labiobarbus leptocheilus* are also caught. The season only lasts for 2-3 weeks.

Pbeun nying pba. Shooting fish. Automatic rifles (M-16 and AK 47) are used to shoot fish that come close to shore, mainly large *Channa* including *C. cf. marulia*. (Automatic rifles also are used by Karens to shoot large *C. cf. marulia* in the Tenasserim and Moei rivers). Some people disagree with this method.

Labert pba. Bombs. The use of explosives (mainly land mines from the civil war in Cambodia) in the Khone area by Cambodian fishers is described in ROBERTS (1993). Villagers believe this practice has contributed substantially to declining fish catches. They are strongly against the practice and have been trying to prevent it. In 1993-94 the use of bombs seems to have lessened compared to previous years, especially along the Lao-Cambodian border. Further south in Cambodia, however, bombing for fish is reportedly still largely uncontrolled and remains a major problem.

FISH MIGRATIONS BELOW KHONE FALLS, DECEMBER-FEBRUARY 1993-94

Migrations in the Mekong near Khone Falls during the low water season of December-February involve mainly cyprinids in non-reproductive condition. Only the large cyprinids of the genus *Probarbus* (*P. jullieni* and *P. labeamajor*) and perhaps only one species of *Hypsibarbus* have reproductive migrations during the low water season. Almost none of the catfishes migrate at this time (with the notable exception of *Pangasius pleurotaenia*).

During the low water season fish migrating up the Mekong from Cambodia towards Khone Falls pass mostly between Don Dtoom and Don Nhang and the left bank (eastern bank) of the Mekong, and then between Don Sadam and Don Langa and on up the Pbaew Nyai. (During the high water season migrating fish pass mainly to the right (western) side

of Don Dtoom, Don Liang, and Don Langa and thus more directly into the Pbaew Nyai). The narrow channel between Don Liang and Don Nhang is dry during the low water season, and is not an important pathway for migrating fish or fisheries at any time.

Fish arriving at Tarn Ee Daeng and Haew Sompamit or Haew Papeng are unable to get past these waterfalls and after a short delay turn back and head up other channels, some of which they can go all the way up and get above the waterfalls. The main pathways that permit fish to get above the waterfalls, in approximate order of their importance are Hoo Sahong; Hoo Sadam; Khone Gaw; Khone Lan; Hoo Sang Peuak; and Hoo Khone Hai.

In January-February 1994 the second author and several local helpers walked all of the channels in the Khone waterfalls/rapids area and found the following fishing gear in use: about 30 jip nets; 15 large oo traps; 17 sai traps; 34 pba soi lawp traps; and 138 dtawn looang with about 282 "mouths" including bamboo sheets (like lee traps) and small baskets. The traps were concentrated at Hoo Sahong, Hoo Sadam, Khone Gaw, Khone Lan, Hoo Sang Peuak, Khone Sooang, small channels running into Hoo Sompamit, Hoo Don Dai, Hoo Dtat Wai Nyai, Hoo Dtat Wai Noi, Hoo Som Yai, Hoo Gajaewiang, Hoo Haew Ee Dtoot Nyai, Hoo Haew Ee Dtoot Noi, and Hoo Don Wai (also known as Hoo Nok Gasoom).

The 34 pba soi lawp traps were all on Hoo Sadam and Hoo Som Nyai (17 on a single weir at the head of Hoo Sadam next to Ban Hooa Sadam). The 17 sai traps also were all on one weir in Hoo Sadam.

The beginning of each year is the time of daytime, upstream, non-reproductive migrations dominated by small cyprinids collectively known as pba soi. These migrations apparently occur in waves, with the strongest wave occurring on or about Chinese New Years day (ROBERTS, 1993; ROBERTS & WARREN, 1994). The earliest wave (known as pba hooa pbee or "fish at the head of the year") usually occurs in December. The lead fish species in these migrations or migratory waves usually is pba soi hooa lem, sharp headed pba soi, which we now identify as *Cirrhinus lobatus*. Other species are pba soi hooa pbo, large headed pba soi, *Cirrhinus siamensis*; pba kiang, *Lobocheilos melanotaenia*; pba soi or striped pba soi, *Cirrhinus lineatus* (local fishers apparently do not distinguish this species from other pba soi); pba dtep, *Paralaubuca cf. typus*; pba lang kohn, *Labiobarbus leptocheilus*; and pba dtawk toi, *Crossocheilus reticulatus*. Medium- and larger-sized cyprinids that have non-reproductive migrations at the same time include *Scaphognathops bandonensis* and *S. stejnegeri*, *Bangana behri*, *Mekongina erythrospila*, *Labeo pierrei*, and *Cirrhinus molitorella*. Species in other families that migrate non-reproductively at this time include *Gyrinocheilus pennocki* (Gyrinocheilidae), *Botia modesta* (Cobitidae), and *Pangasius pleurotaenia* (Pangasiidae) (Table 1).

The present account of migrations in and below Khone Falls should be compared with an account of migrations above the falls during February 1994 (ROBERTS & WARREN, 1994: 90-92).

The first small cyprinids or "pba hooa pbee" of the 1993-94 Chinese New Year migrations arrived at Ban Hang Khone on 12 December 1993. These were a single species, pba soi hooa lem (*Cirrhinus lobatus*), and they were swimming upstream. At first, they passed Hang Khone and proceeded up Pbaew Nyai, the righthand mainstream Mekong channel leading to Tarn Ee Daeng. Large numbers were caught in dtawn traps below Tarn Ee Daeng and Khone Gaw on 13 December. Some fish were able to get past

Khone Gaw channel and rapids but most ran into various waterfalls like Sompamit, and turned back towards Hang Khone after finding no way up. On 15 December 3 kg of pba soi hooa lem were caught in a jip net set in Hoo Khone Yooak, the small channel separating Don Khone and Don Khone Yooak (Khone and Khone Yooak Islands). These evidently were fish that had turned back from Tarn Ee Daeng. On 16, 17 and 18 December, respectively, 7, 3 and 4 kg were caught in the jip, and from then on less than a kg per day. (This jip had been monitored daily for an entire month before 15 December, when it did not catch a single pba soi hooa lem). Fish started going up Hoo Sahong, Hoo Sadam, and other channels that they had previously bypassed, and were able easily to get by the rapids in these channels and so continue on above Khone Falls.

Villagers are all familiar with this pattern, and there is an old saying that "migrating fish must first go to Tarn Ee Daeng to be stamped onwards before they are allowed to continue up the Mekong." (The main exception to this general rule is pba nyawn, *Pangasius macronema*. This species always goes up Hoo Sadam and Hoo Papeng (following left bank of the Mekong) without first going to Tarn Ee Daeng. Perhaps the only other migratory species that does not go up to Tarn Ee Daeng first is *Cirrhinus microlepis*. For further discussion of these two species see individual accounts below).

Cirrhinus lobatus can be observed easily when migrating because schools travel upstream in long processions, sometimes tens of thousands passing a single point in a few hours.

Just as *Cirrhinus lobatus* started to be caught in the jip on 15 December, so did a large number of the catfish pba nyawn tawng kohm, *Pangasius pleurotaenia*. Villagers believe these fish were not migrating, but that they came out of deep pools nearby to feed on the pba soi hooa lem. On 16 December, when the pba soi hooa lem migration peaked, 15 kg of *P. pleurotaenia* were caught. The *C. lobatus* and *P. pleurotaenia* catches dropped simultaneously. A few pba nyawn tawng kohm were caught in the jip on most days during the month before the pba soi arrived, and the species was recorded in gillnet and longline catches throughout the monsoon season. However, on 16 December their numbers increased by 10 to 20 times compared to previous days that month.

On 15 December, four days after *Cirrhinus lobatus* were first seen passing Hang Khone on their way to Tam Ee Daeng, the first few deep-bodied cyprinids of the genus *Scaphognathops* (pba pbian) were caught in 5-9 cm gillnets set in front of the Cambodian Island Don Langa, directly across the Mekong from Hang Khone. On 17 December, 10 or 20 more were caught in the same nets. After this, the catches dropped off sharply, and the fishers removed their nets. According to Suntorn, there are three distinct runs of *Scaphognathops*. This first run is small (about 10% as large as the peak run). The second run, usually one or two weeks later and just before the first pba soi hooa lem run, is about 60% as big as the peak run. The peak run usually occurs on or about Chinese New Years day. These runs are very short, lasting only 2-5 days each.

On 20 December 1993 Suntorn started using his dtawn or lee trap with a long round basket tied to the catch end. About 20 kg of pba soi hooa, 20 young *Cyclocheilichthys enoplos*, of about 300 gm each and 7 *Pangasius pleurotaenia* of about 80 gm each, were caught, all during the daytime. According to the villagers the pba jawk (young *Cyclocheilichthys enoplos*) were migrating upstream. Suntorn's dtawn was used throughout the season, which lasted until about 18 February, and hardly any fish were caught at night.

As the second pba pbian (*Scaphognathops*) wave passed, a big run of pba saee (*Mekongina erythrospila*) arrived, along with a smaller numbers of pba geng (*Cirrhinus molitorella*), pba wa sooang (*Labeo pierrei*), and pba wa na naw (pba wa na hak), *Bangana behri*. The species caught the most, and apparently most abundant, was pba saee. All of these fishes first passed Hang Khone headed towards T a r n Ee Daeng. Some m a d e i t p a s t Khone Gaw, but most turned back to find other routes through the rapids.

During the first half of January 1994 *Mekongina erythrospila*, *Labeo pierrei*, *Bangana behri*, *Cirrhinus molitorella*, and *Scaphognathops bandanensis* were caught in large numbers. By the end of January the main runs had passed. All of these species were still being caught but in smaller numbers, except *C. molitorella*, which almost disappeared.

By the end of January large numbers of a single species of pba gaw, *Gyrinocheilus pennocki* began to arrive, and it was the most commonly caught species throughout February. Gillnets used to catch *Scaphognathops*, *Mekongina*, *Labeo pierrei*, *Bangana behri*, a n d *Cirrhinus molitorella* are put in deep channels to cut migratory routes gillnets used to catch *Gyrinocheilus* are put close to submerged rocky areas where the fish are very abundant.

Not a single *Gyrinocheilus* was caught in the Hang Khone area between June and December 1993. Some people say this is because they stay around rocky areas all year round and can't be caught in the highwater rainy season, when gillnets are not used. On the other hand, Suntorn observed that for each of these species, including *Gyrinocheilus*, the leading migrators are caught at localities increasingly upstream from Stung Treng during the migratory period. We suspect *Gyrinocheilus* is moderately or very abundant everywhere in deep rocky habitats throughout the d r y season, a n d that when it migrates, it does so in large numbers and tends to keep to the same rocky habitats as much as possible.

CIRRHINUS LOBATUS: ECOLOGICAL KEYSTONE SPECIES, MIGRATORY FISH LEADER, PROTOGYNOUS HERMAPHRODITE

Figures 22-24

Cirrhinus lobatus or pba soi hooa lem (sharp-headed pba soi) (Figs. 22-23) clearly is an ecological keystone species, however one defines the concept. Previously reported as *Cirrhinus* sp. in ROBERTS, 1993 and ROBERTS & WARREN, 1994, the species is now identified as *Cirrhinus lobatus* (Smith, 1945) based on results of a systematic revision of the genus *Cirrhinus* being prepared by the first author. This species occurs only in the Mekong basin.

In terms of absolute number of individuals, *C. lobatus* almost certainly is the single most abundant fish species in the area below the falls during the two migratory periods, December-February and May-July. During the high water season of August-November the species appears to be absent from the Khone area (pers. obs., second author). Although data is minimal, observations of fish stomach contents indicate it probably is the single most important forage or prey species of many predatory fish species, especially among the catfishes. People fishing just below the falls catch more *C. lobatus* than any other fish.

Particularly noteworthy, *Cirrhinus lobatus* is the lead species in almost all of the major migrations of cyprinids moving up the Mekong in December-January (ROBERTS, 1993;

ROBERTS & WARREN, 1994; present obs.). From our present observations, it appears that the lead migrators find their way upstream by trial and error. This is not a conclusion that we predicted or expected. It is even conceivable that the species finds pathways followed by other small cyprinid species commonly associated with it, but we lack direct observations on this point and it is no more than an hypothesis at present.

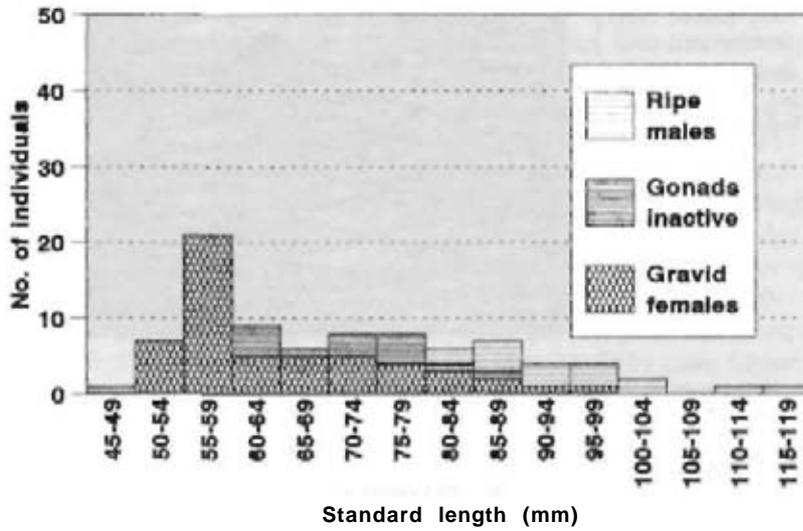
The consociation of several small species of cyprinid fishes with *C. lobatus* during the migratory periods of May-July and December-January was pointed out by ROBERTS, 1993: 49; and by ROBERTS & WARREN, 1994 but has not received sufficient comment. The species most commonly found together are pba soi hooa lem, *Cirrhinus lobatus*; pba soi hooa pbo (largeheaded pba soi) or pba mohk (for larger individuals), *Cirrhinus siamensis*; pba dtawk toi, *Crossocheilus reticulatus*; pba kiang, *Lobocheilos melanotaenia*; p b a lahng kohn, *Labiobarbus leptocheilus*; and pba dtaep, *Paralabuca* cf. *typus*. Various combinations of these species occur at different times and places throughout the migratory periods. Much of the time several of the species are moving more or less together, in what may be true mixed schools. *Paralabuca* cf. *typus*, which differs from the others in having a strongly compressed rather than moderately compressed body, tends to swim slightly more offshore and nearer the surface, but still in close association.

Pba soi migrating in June-July reportedly vocalize in many places below Khone Falls. Apparently they are not necessarily spawning when they do so, because pba soi are not known to spawn in the immediate area below the falls. Villagers from Ban Don Tolatee, Ban Hang Khone, and Ban Ta Kahm claim that *Cirrhinus lobatus* is the only species that vocalizes, and that it does so to call conspecifics to migrate to the spawning grounds. Villagers say that the vocalizations last about one month until all of the *C. lobatus* have migrated south. At this time they still have eggs in them. The mechanism of sound production is unknown.

So far as known, except for one species, all of the migratory cyprinids (and indeed, all of the other fish species at Lee Pee) have normal or standard sexual differentiation, with males and females maturing at approximately the same age and in a ratio approaching 1:1. The single exception noted thus far is *Cirrhinus lobatus*, which appears to be a protogynous hermaphrodite. This tentative conclusion is based on two samples of fish in spawning condition collected and analyzed by the first author in June-July 1993. Sex of cyprinid fish in spawning condition is readily determined by applying slight pressure to the abdomen of live or freshly dead fish. Ripe females and males readily exude eggs and milt.

Sex distribution was analyzed in two population samples of *C. lobatus* obtained from kah catches in June-July 1993 (Fig. 23). All of the migrating fish from 45 to about 60 mm standard length are gravid females, and only a few of the fish over 60 mm are males. The conjunction of the three properties, keystone species: lead migrator: early-maturing protogynous hermaphroditism (or whatever other sexual phenomenon is involved) is highly significant.

22 June 1993
 N=83, 47-115 mm SL



1 July 1993
 N=302, 47-115 mm SL

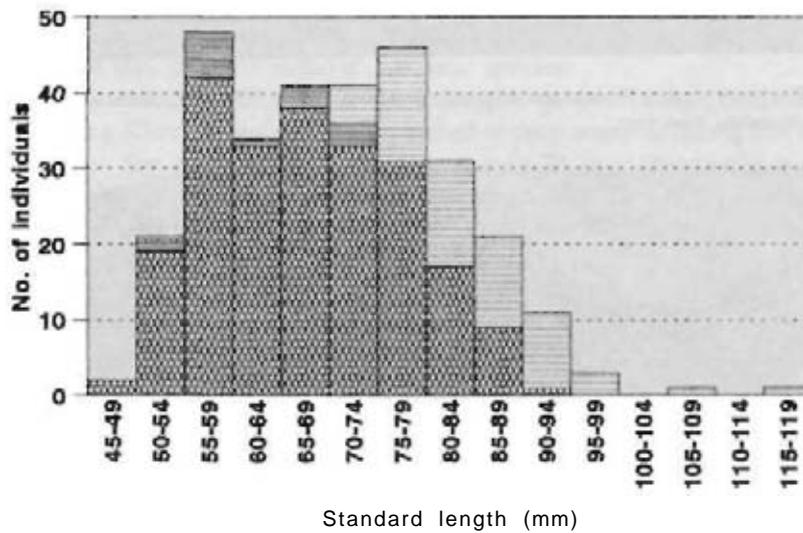


Figure 22. *Cirrhinus lobatus*. Frequency of gravid females, ripe males, and individuals of undetermined sex in two population samples of migrating fish from hatcheries. Ban Heng Khone, June-July 1993.

Figure 23. *Cirrhinus lobatus*, population sample from Kah catches, Hang Khone, July 1993 (left three rows females, middle row sex undetermined, last row males).

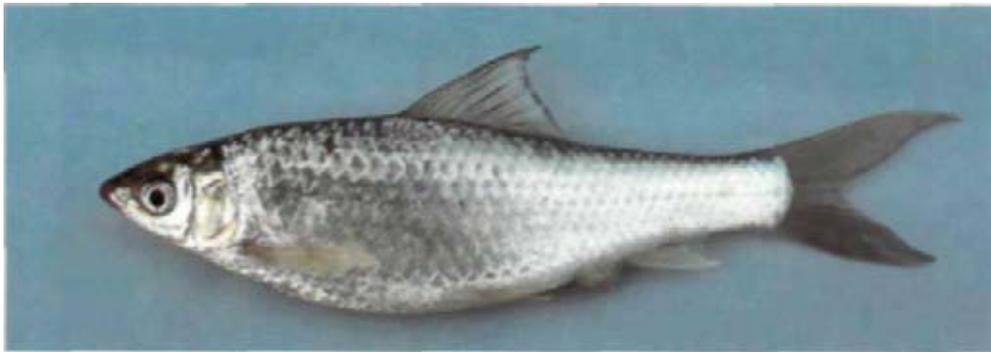


Figure 24. *Cirrhinus lobatus*, 70 mm gravid female, Ban Hang Khone, July 1993. Note pale greenish eggs protruding from vent.



Figure 25. *Callocarpio siamensis*, 3.7 kg. Caught near Boong Pba Gooawng, Hang Khone, December 1994.

FURTHER NOTES ON FISH TAXA

Clupeidae

Tenulosa thibaudeaui. Pba m a k pang, Mekong herring. The first author previously reported that Suntorn, the most successful fisher in Hang Khone, caught 400 or 500 kg of pa mak pang daily during upstream migrations in February and downstream migrations in June-July in the 1970s, and that for 10 days in February about 10 years ago (1984?) he caught 20-30 kg/daily ROBERTS, 1993: 37. This statement was subsequently rechecked with Suntorn, and found to be in error. Suntorn caught 400-500 kg yearly during the entire January-February migratory period in the 1970s, and 20-30 kg over a 10-day period in February about 10 years ago (1984?). Nevertheless, it remains true that this species has declined perhaps more markedly than any other at Hang Khone since the 1970s. Only four specimens were observed during 15 days of the migratory period in June-July 1993 (ROBERTS, 1993: 37), and only a few individual fish were caught by Hang Khone fishermen in November-January 1993-94.

Data on the overall decline of fisheries at Hang Khone based on Suntorn's May-July total lee fish catches since 1991 also was rechecked with Suntorn and require slight modification. His catches for 1991, 1992, and 1993 were reported as 7000, 5000, and 3,500 kg, respectively (ROBERTS, 1993: 55). His catches were actually somewhat greater: 9000, 7000, and 5,500 kg.

Cyprinidae

Amblyrhynchichthys truncatus. Pba d t a pbo (big-eyed fish), pba dta jon, pba jon. Formerly very common in the January-February migration at Hang Khone, it is now uncommon, and may be more reduced than most species.

Catlocarpio siamensis (Fig. 25). Pba gaho, pba gaman. Large *Catlocarpio* were common at Hang Khone in the past, and spawned in deep water in Boong Pba Gooawng. In 1993-94 very few fish were seen, the largest only 70 kg. The species is extremely susceptible to gillnets. Pba gaho also used to be common at Don Lek Fai, above Khone Falls near Don Khong) but is now very seldom seen there according to villagers. It may still enter the Se Lam Pow (river forming western border between Laos and Cambodia) but is also rare there.

The scientific identification of p b a gaman, evidently referring to a cyprinid fish attaining 100 kg, mystified us for some time, because some fishermen insisted that it was different from pba kaho. We now are confident that pba gaman is a Lao name for *Catlocarpio siamensis* used in the Khone area and elsewhere in Lao PDR.

Cirrhinus microlepis. Pba pawn. Large *C. microlepis* to 4-5 kg migrate upstream during the lowest water months of March-April and share the migratory behavior with *Pangasius macronema* (q.v.) of n o t going up to T a r n Ee Daeng, presumably due to the low water levels. However, small *C. microlepis*, called pba pawn mak gawk, come up even earlier and do go to T a r n Ee Daeng before turning back to search for another way up past the rapids. In some years when water levels are higher than usual large *C. microlepis* have also been seen going to T a r n Ee Daeng first, but they generally just go up Hoo Sahong,

where they are targeted by large lawp traps.

In late January 1995 large numbers of *C. microlepis* of approximately 100 g were caught in the Khone area. Suntorn's dtawn trap caught over 80 kg (about 800 fish) in a single day. In 1994 hardly any small fish of this species had been caught in Suntorn's dtawn.

Macrochirichthys macrochir. Pba hang pa. This highly specialized predatory species is widely distributed but greatly reduced in numbers probably throughout its range. It is extremely sensitive to gillnetting and perhaps also to pollution. It may have disappeared from the Chao Phraya, and is rare in the Middle Mekong. Several were caught at Hang Khone in 1993-94.

Tor cf. tambra. Pba gooa. Two large cyprinid fishes caught by fishermen in the Khone area pba pohng (*Leptobarbus hoeveni*) and pba gooa (not then scientifically identified) were reported as becoming poisonous to eat after feeding on the fruits m a k gabao, *Hydnocarpus anthelminthica* Pierre ex Lanessan (Flacourtiaceae) and mak ngoan, *Quassia harmandiana* (Pierre) Nooteboom (Simaroubaceae) (ROBERTS, 1993: 38, 52). Specimens of pba gooa were collected subsequently and have been identified as *Tor cf. tambra* (for discussion of taxonomy of this and other Southeast Asian *Tor* species, see ROBERTS, 1994a). For color photos of m a k gabao and mak ngoan, see ROBERTS, 1993, Figs. 5, 20, 21).

Paw Jankoon, an older fisher and renowned traditional medicine practitioner living in Ban Hang Sadam, provided the following information on *Tor* and *Leptobarbus*. The poisonous condition is not seasonal but may occur at any time, and fruits of *Hydnocarpus* and *Quassia* are not the only poisonous fruits eaten by these two fish species. When *Tor* (but not *Leptobarbus*) is poisonous it has red eyes and whiter scales (the scales usually are dark). Suntorn, Sit, and several other fishers and fish sellers at Ban Hang Khone and at Stung Treng in Cambodia also reported *Tor* has red eyes when it is poisonous. People can eat *Tor* (even when it has red eyes) and *Leptobarbus* if the head and viscera are discarded, and the meat is dried in the sun or marinated.

Local fishers also report that the cyprinids pba wian fai (*Puntius* or *Barbodes altus*) and pba pbak kam or pba pbak tawng leuang (*Hypsibarbus* sp.) occasionally (not commonly) are poisonous (causing vomiting) due to fruits they have eaten.

Pangasiidae

Pangasius krempfi. Pba sooay hang leuang or pba sooay mak mai. *Pangasius krempfi* apparently is unique among pangasiid species in the Mekong in spending a major part of its life in marine coastal waters. It apparently migrates into the Mekong River (but not into any other rivers) in order to reproduce. Spawning apparently occurs in late June or early July, but the spawning grounds are unknown. The species forms an important part of fish caught in the Hang Khone area in May-June (ROBERTS, 1993: 45).

The second author found two large (about 4 kg) fish on 4 January 1994 at Vung Tau fishing port on the south coast of Viet Nam. They had been caught more than 10 km offshore in 7 km long gillnets fishing mainly for medium sized scombroid fishes: Spanish mackerel (*Scomberomorus* spp.), tongol or longfin tuna (*Thunnus tonggol*), and black skipjack (*Euthynnus* sp.). Vietnamese fishermen say the *Pangasius* are caught mainly

between December and April, when many are also caught on longlines. The species shows up at Hang Khone during the May-July migratory season dominated by *Pangasius*, and remains in Laos until November. The rest of the year it is absent or very rare at Hang Khone.

Almost every female *P. krempfi* caught at Hang Khone in May 1994 was full of eggs, while those caught in July 1994 had no eggs. Young *P. krempfi* are never seen at Hang Khone. Migrating fish observed at Hang Khone always have empty stomachs but their bodies are full of fat. Large fish apparently enter the flooded forest during high water in September-November where they feed heavily on leaves.

Thus our information indicates that *P. krempfi* is an anadromous fish with a life history resembling that of salmon. It belongs to a primary freshwater family of catfishes, Pangasiidae, of which most other species are strictly confined to fresh water. *Pangasius polyuranodon* often occurs in brackish water but has not been found in the sea. The only other species known to occur in the sea is *Pangasius pangasius*. This species although previously reported from the Mekong basin and even Indonesia, is restricted to the Indian subregion (ROBERTS & VIDIHAYANON, 1991). It does occasionally occur in the Andaman Sea and perhaps elsewhere in the Indian Ocean, but virtually nothing is known of the migratory and reproductive activities of the sea-going population or populations. Most *P. pangasius* probably pass their entire lives in fresh water. *Pangasius krempfi*, on the other hand, appears to have only a single population, with a single migratory pattern and anadromous life history, including spawning in fresh water. It is unclear what happens to the adult *P. krempfi* after spawning. We have no evidence that they die after spawning (as in the case of salmon), so presumably they return to brackish or coastal waters after spawning, and may migrate more than once during their lifetime into freshwater for spawning. Possibly many of them remain in brackish waters in the Mekong delta without going out to sea. Much more research is needed on the biology and ecology of this unique species.

Pangasius macronema has been mentioned as one of the few strongly migratory fish species in the Khone area that does not go to T a r n Ee Daeng. This may be because it migrates upstream at a time when waters are lower (April-early May) than when other species migrate. Since all the migratory species appear to migrate upstream close to the deepest channels, villagers believe that the low water levels in April-early May change the relationship between deep water channels and make the channel up Hoo Sahong more attractive for migrating fish than the channel that goes to T a r n Ee Daeng. *Pangasius macronema* only goes as far upstream as Boong Pba Jook (across from Hang Khone) before turning back and going up the channel to Hoo Sahong. In the past, the species reportedly migrated up in April and again in late May each year, but only the April migrants arrived in 1994. The species normally is caught in April in Hoo Sahong and Hoo Gajaewiang. It goes up Hoo Papeng to get to Hoo Gajaewiang. In May, in previous years, it reportedly has been caught mainly in these two channels as well as in Hoo Sadam, Hoo Dtat Wai Nyai, Hoo Dtat Wai Noi, Hoo Sang Peuak Nyai, and Hoo Sang Peuak Noi.

Pangasius macronema migrations last for about one week. Villagers know that the schools of "p b a nyawn noot" or "p b a nyawn siap" migrate up at night, returning to deep pools in the daytime if they can not get up in the night. Some villagers use 2.5-cm mesh gillnets or mawng jom (set deep) to catch them in the pools in the daytime (Fig. 19). Large

catches taken this way were observed in April 1994. The fish were caught in a deep pool near the mouth of Hoo Sahong between Don Khone Yooak and Don Sadam. Cambodians also are familiar with these habits of *P. macronema* and have been known to throw explosives into the deep pools on the Cambodian side of the border in the daytime during migration periods, reportedly killing up to 500 kg with a single blast. In April 1992 the second author observed Cambodians using explosives to target *P. macronema* on the Cambodian side of the border across from Ban Weun Kahm.

Pangasius sanitwongsei. Pba leum. Used to be relatively abundant. About twenty years ago Suntom's father used large hooks baited with rotten meat to catch up to 4 or 5 big ones each year. Now big ones are rare, and none were caught at Hang Khone in 1993 and 1994. Many young of about 40 g were seen in November-December 1993, as well as in other months. Villagers have seen large fish with eggs in June-July, and think that they spawn in Boong Pba Leum, where large fish have been seen surfacing each June and July (seen in 1993). This is a very deep pool just below some falls in Hoo Khone W a t with such strong current and deep rock cliffs surrounding it that no one is able to catch the big fish in it. Previously many were caught with hooks in Hoo Sadam, too, but they are now seldom seen or caught there.

Siluridae

Belodontichthys sp. For the first time in the memory of villagers in the Khone area, large numbers of individuals of this species (mostly around 200 g) were caught in jip bagnets in December 1994. The nets were targeting migrating *Scaphognathops* spp. when dozens of the *Belodontichthys* (pba kohp) were caught. These mysterious catches continued for a few days, and involved several channels in the Khone area. Prior to this, no one had seen so many of these fish at one time, and no one regarded the species as migratory.

Sciaenidae

Boesemania microlepis, pba gooawng. Large fish in spawning condition are caught at Hang Khone in February-March. They are thought to spawn in Boong Pba Gooawng and Boong Pba Jook, just in front of Ban Hang Khone. They vocalize at mid-afternoon every day in February-March, producing a deep "oot-oot" sound. This is similar to the "oot" of *Hypsibarbus* sp. but is a deeper sound.

This is thought to be one of the fish species that has declined most seriously at Hang Khone, perhaps to 10% of its former abundance. Suntom formerly caught up to 700 kg yearly in gillnets. Relatively few large fish were caught at Hang Khone in 1993-94, but juveniles are still regularly seen in catches.

Belontiidae

Osphronemus exodon, pba men. Specimens of *Osphronemus* from Ban Hang Khone previously reported as the widespread giant gouramy species *O. goramy* (ROBERTS, 1993: 35) have been reidentified as *Osphronemus exodon* Roberts, 1994, a new species apparently endemic to the Mekong basin. The giant gouramy present in Ngam Ngum

Reservoir and commonly marketed in Vientiane is also *O. exodon*. *Osphronemus goramy* probably does not occur naturally in the Mekong basin. It does occur in parts of the Mekong delta in Vietnam, where it presumably has been introduced relatively recently. For an account of the species of *Osphronemus*, see ROBERTS, 1994b.

HISTORY OF *PROBARBUS* FISHERIES IN SOUTHERN LAOS SINCE 1970

A large number of Lao, Cambodian, and Thai traders deal in large freshwater fish in southern Laos. One of the most important species in this trade is *Probarbus jullieni* (Lao pba eun, Cambodian tray trawsawk, Thai pbla yesok). This species attains 70 kg or more, but most marketed fish nowadays are 5-20 kg. While the species may be caught at any time of the year, most are caught during the November-January spawning migration, when it is by far the most important species in fisheries catches. There are two other species of *Probarbus* in the Mekong basin (ROBERTS, 1992). *Probarbus labeamajor* is of fisheries significance in southern Laos and northeastern Cambodia; *P. labeaminor* is only known from the Middle Mekong mainstream from That Phanom to Mukdahan or Savannakhet and is apparently of little or no fisheries significance.

The second author and his assistants interviewed a large number of traders and fishers on numerous occasions at Hang Khone, Hang Sadam, Weun Kham (just below Khone Falls), and at Pakse (capital of Champasak Province, Lao PDR, and principal market town in southern Laos) during the *Probarbus* fishing season of 1993-94. Detailed information was obtained about economics, history of the trade, trade routes, quantities of fish marketed, markets for the fish in Thailand, and related issues. Additional detailed information regarding the trade and Lao regulations relating to it was obtained from Dr. Hatsadong, Director, and other members of the Agriculture and Forestry Division, Champasak Province.

People in southern Laos and northeastern Cambodia have been catching and eating *Probarbus* and other wild fish for as long as they can remember. *Probarbus jullieni* always has been one of the favorite food fishes in Thailand, Laos, and Cambodia. While the meat is considered excellent, the eggs are especially prized. Lao and Cambodian villagers have traditionally enjoyed making "som kai pba eun", in which one part of fish eggs with salt and ground rice added is mixed with 15 parts of meat (either of *Probarbus* or some other species). The uncooked mix is put in earthen jars to ferment for a number of days before eating. It has long been one of the most prized of Laotian foods. In the past, som kai pba eun was consumed mainly in the villages where it was made, or occasionally sold at local festivals and celebrations. A 30-kg spawning *P. jullieni* or *P. labeamajor* usually has 5 or 6 kg of eggs, so that about 70 to 90 kg of som kai pba eun can be made from just one female if caught just before spawning. In fact, many *Probarbus* are caught on the spawning grounds in the act of spawning (ROBERTS & WARREN, 1994).

Before the early 1970's local fishers and farmers in southern Laos, and especially in northeastern Cambodia (where fishing is traditionally less popular) did not heavily target migrating and spawning *Probarbus*. This was because 1) nylon gillnets were uncommon; 2) fish had very little, if any, monetary value, so most fishing was for subsistence; 3) transporting fish to market was difficult; and 4) there was no refrigeration or ice to keep

fresh fish from spoiling. Fishing families caught only a few large *Probarbus* each year, using castnets and gill nets made of local plant fibers (pban and teuang) and longlines with 1.5 m leaders and #5 hooks baited with pboohin (rock crabs).

Villagers in southern Laos recall nylon gillnets arriving in their villages in the early 1970's. At the time there were still lots of fish in the Mekong, and fish had little commercial value. Moreover, nylon gillnets were (and still are) very expensive for local people, and only better-off villagers were able to afford even a few gillnets each. The fishing effort in southern Laos and northeastern Cambodia was generally light and subsistence based throughout the 1970's and most of the 1980's.

When the Lao Revolutionary Party came to power and created the Lao People's Democratic Republic (LAO PDR) in 1975, *Probarbus* and other large fish were very abundant in southern Laos. The Khmer Rouge's draconian policy against fishing put a stop to most fishing in northeastern Cambodia. At the same time, cross-border trade of all kinds between Cambodia, Laos, and Thailand virtually ceased in 1975 due to ideological differences, and in 1975 the Lao Revolutionary Party banned the export of all fish from Laos, in order to make sure that there was sufficient supply for local needs. Villagers believe that for these reasons populations of many economically important fish species increased in the mid to late 1970's. Throughout much of the 1980's there was virtually no trade in fish between southern Laos, Cambodia, and Thailand. Only a small amount of smoked, dried, and salted fish was traded domestically between fishing communities in Khong District (just above Khone Falls) and larger centers like Pakse.

The Khmer Rouge were against fishing because they were so much in favor of agriculture. They felt that agriculture was the key to success. People were not spending enough time growing rice, and were wasting time fishing. Moreover, fishing was for local family use, and traditional patterns of fishing did not fit well into the commune concept. Once communes were set up people were assigned specifically to catch fish for the whole commune. However, it was difficult for the few people assigned to catch enough fish to feed hundreds of people in each commune, and fish consumption went down during that period.

The food fish trade between Thailand and Lao PDR started growing in the late 1980's as relationships between the two countries improved. The border crossing at Chong Mek (between Laos's Champasak and Thailand's Ubon Ratchathani provinces) was opened in 1989. Fresh and iced fish from Laos began to be smuggled into Ubon on a commercial scale. The trade was centered on large, high-priced species, including *Pangasius gigas*, *P. sanitwongsei*, and *Probarbus*. With improved roads, more vehicles, and ice it was easier to get fish to market. Modern fishing gears including nylon gillnets, and longtailed motorboats became increasingly common. As the trade in food fish increased in southern Laos, so did fishing effort. And as fishing effort increased fish stocks declined precipitously. It is estimated that the overall fisheries in 1993-94, with greatly increased fishing effort and shifts to less desirable species, was only about 20% of that in the early 1970's. Among the stocks that diminished most strongly were those of *Probarbus*. Many villagers who previously had been fishing turned to fish trading (ROBERTS, 1993).

Hang Khone villagers estimate that despite increased fishing effort for *Probarbus*, their 1993-94 catches decreased by about 30-50% from those in 1992-93, and that catches have decreased to just 10 or 20% of what they were in the mid 1970's. Villagers living

above Khone Falls have reported even greater decline in *Probarbus* fisheries. At Don Lopbakdee and Don Tolatee, where large numbers of *Probarbus* were caught in the 1970's, hardly any were caught in 1993-94. At Don Sai, another locally well-known *Probarbus* fishery has crashed. Villagers reported that they caught approximately 60 fish weighing over 5 kg in 1992-93 and none in 1993-94. The steady decline of the *Probarbus* fisheries at Ban Don Hee has been documented by ROBERTS & WARREN, 1994.

In 1990 the first Lao fish traders, consisting only of local villagers, began to take longtailed motorized boats from just below Khone Falls into northeastern Cambodia to buy fresh fish. These traders resold the Cambodian fish to bigger Lao traders, who sent the fish (packed with ice) by boat or bus to places where they could be smuggled into Thailand. A smaller quantity of fish was also resold in Pakse and elsewhere in southern Laos.

In 1991 the Lao government decided to permit Champathong Company, owned by Thai and Lao business people, to import fresh fish from Cambodia to Laos. The imported fish was transported by bus to Pakse, before being re-exported to Thailand via Ban Dan or Ban Huai Pai, on the Lao side of the border. A 5% import tax was collected on Cambodian fish that entered Lao PDR, and if the company paid this tax, the fish were exempt from export taxes when they were sent to Thailand. Later another company, the Lao-Australia Agriculture Cooperative Company, also started buying Cambodian and Lao fish for export to Thailand.

In September-October 1991, 4,000 kg of *Probarbus* were caught at the mouth of Houay Talat. This is a large stream with extensive flooded forest entering the Mekong mainstream on the right bank in Cambodia about 20 km below the border with Laos. Such a large catch was possible only because the mouth of the stream was entirely blocked by large nets and stacks of lawp traps so that almost no fish could not get by or continue on into the Mekong without getting caught. Exceptionally large catches of *Probarbus* caught in similar circumstances reportedly have occurred at other places in northeastern Cambodia.

The Champasak Provincial Government, alarmed by drastic decline of fish catches in southern Laos and fish shortages in Pakse, banned the sale of Laotian and imported Cambodian fish to Thailand on 1 January 1994. At the same time, the government banned further imports of fish from Cambodia.

At the present time, *Probarbus jullieni* may be caught out of the spawning season for local consumption, but cannot legally be caught in the spawning season or traded on a commercial basis at any time (Lao Ministry of Agriculture and Forestry decree 118/MC 1989, updated 1991).

TRADITIONAL FISHERIES MANAGEMENT

Local people have been using lawp, dtawn, and lee traps to target migrating fish in the Khone Falls area for many generations. They have always considered the sites where the traps are placed, just like the land on which their houses and paddy fields are located, as family property.

In the past there were no land deeds, and villagers just respected the fact that land used by others could not be taken from them. This also applied to traditional sites of fish traps. Land titles have since been issued, but the Lao government has never fully recognized the

traditional rights for fish trap sites and the waters around them. Without exception, however, villagers in the Khone area still strongly respect these rights. They never try to take over the spot traditionally used by another villager. An owner can, of course, give permission for others to use the site for one or more seasons, rent or may give or sell it to another villager.

Villagers also normally do not put new traps in places that interfere with older traps. Although this has happened a few times in recent years, social pressure usually has forced offenders to remove the traps or reposition them so they don't interfere with the older sites. For example, in 1994 a new trap placed in Hoo Dtat Wai Nyai was removed after a villager claimed that it had split the water that normally flowed into his trap into two parts, one of which flowed into the new trap.

The traditional ownership system for trap sites targeting migrating fish is so strong in the Khone area that even if a site has not been used for many years by a family, the family can still come back and reclaim it. This is still valid even if putting a trap there will interfere with new sites that might have been used for a number of years while the older site was in disuse. Moreover, while the traditional ownership system is not officially recognized, most government officials from the local area do unofficially recognize the right of villagers to put fish traps in spots that have been used by their families for a long time. Officials as well as villagers may not uphold the right if the trap has been enlarged or changed from one kind to another, especially when the change is viewed as interfering with fish migrations or with the ability of other people to catch fish.

Most long-term resident families in the Khone area own one or more fish trap sites. In many instances, particular sites are owned by more than one family. In most such cases two or three families own and operate a site, but as many as 8 or 9 families may be co-owners. On the other hand, some newcomers and long-term resident families don't own any sites.

The problem of some people not owning any fish trap sites has been dealt with traditionally in two ways to ensure that everybody can get enough fish to eat. The first way is for the owner(s) of a trap site to allow other people to build and operate the trap together with them. This common practice lets the traditional owner(s) retain exclusive ownership of a site, but those who work with them are treated fairly. They expend an equal amount of effort to build and operate the trap as the owners, and they get an equal share of the catch. The only advantage to the owner(s) is that they can choose who they want to work with, and they retain the right to change their workers each year for whatever reason. Sometimes extra labor is needed when fish are caught in large amounts. This system creates partnerships rather than a boss/employee relationship.

The second way in which the problem of equitable distribution of the migratory fish resource is solved in Khone communities is by other forms of traditional sharing and social pressure. Those with traps who get a lot of fish are customarily obliged to give a portion of their fish to others who have no traps or whose traps have done poorly. Although this system is gradually deteriorating due to the increasingly high monetary value of fish, it is still strong in the Khone area. Such giving is rewarded by obligations to return the favor in some other way. Thus villagers have a saying that "getting something for free is more expensive than paying for it." Those who are stingy about giving fish to others who don't have enough are in for heavy criticism.

If a family wants to own another family's fish trap site, or become a full owning partner of a site, they will have to pay for it. For example, Suntorn's old dtawn site was in Dtat Wai Noi, where Ban Hang Khone villagers have many sites. But about six years ago he decided that a site at the lower end of Don Nok Gasoom would be better for catching fish. The site he desired was owned by two villagers from Ban Khone Neua. One of them was very old and wanted to sell his share of the site, which Suntorn bought for gold worth about U.S. \$1000. This is a considerable investment for local people, but Suntorn felt he got his share of the site for a good price because his family would have the fishing rights in perpetuity.

At present five families operate the site in Don Nok Gasoom of which Suntorn purchased a share. They include the families of the two owners (one of which is Suntorn's family) and the families of the three sons-in-law of the original founding owner who did not sell his share. All five operating families get an equal share of the fish caught, and all contribute the same amount of labor. It might seem strange to some that Suntorn's family receives only a fifth of the catch even though they own half of the trap site, but in fact that is the way the system has always worked, and nobody seems to worry about it or to want to change it. Villagers call these trap sites "looang moon" (inherited sites). This system provides just one example of how Lao Loom communities traditionally distribute resources equitably and unselfishly amongst each other.

Villagers from Ban Hang Sadam operate a traditional community fishery for *Pangasius macronema* unlike any other fisheries in the Khone area. They set up oo traps at the edge of Hoo Sahong in an area of rapids called Dtat Po. This old system permits all members of the community to get an equal share of the fish caught. In other words, the entire village owns the fish traps, not just certain families as is normally the case with dtawn and lee traps in the area. Every family that wants a share of the catch on a particular day goes to the traps in the early morning to pick up the fish which had been migrating during the night. The catch is divided by the villagers so that everyone gets about the same amount of fish. If a family does not send a member to get a share, they may still get fish by asking those who did go for some fish after they return to the village. In 1994 some 3000 kg of *P. macronema* was caught at Dtat Po by Ban Hang Sadam villagers, and the fishery is of considerable economic importance. The fish are not gravid or in spawning condition when caught (at least not in April).

Each year the owners and other operators of a trap site pay dtawn and lee taxes to the government, but they don't pay for the right to use their sites. They only pay tax for the number of cubic meters of wood used to make their traps, and therefore those with smaller traps pay much less. The tax is never based on the amount of fish caught. Most of the lee and dtawn trap sites are registered by the Khong District government in the owner's names.

Apart from the looang moon fish trap sites, there are a number of looang moon gillnet sites in the Khone area. These sites are especially good for catching certain migratory species in particular seasons. Most of those near Ban Hang Khone are for catching *Pangasius krempfi* in May-July. Although the looang moon tradition for gillnet sites is not so strong as for the one for trap sites, and many of the sites have been established in recent years, at least a few of the spots are very old and date back to the time when gillnets were still made out of pban and teuang vines.

In May 1994 Suntorn rented a looang moon gillnet site near the mouth of Hoo Sahong for a single fishing season. He paid the owner, another Ban Hang Khone villager, 10,000 kip (about US \$14) for the right to put two 14 cm gillnets at the site for two months.

The traditional fisheries management system of villagers in the Khone area requires that none of the channels used by migrating fish are totally blocked. Thus many fish are able to find their way safely through openings between various kinds of fishing gear. It is generally agreed that nobody should be allowed to get many fish while leaving villagers upstream with none or only a few. Major management problems are worked out by village to village consultations, often lasting many hours or even several days.

The traditional system probably worked well in the past, when fish were extremely abundant and most fishing was subsistence level. In most instances the system still works well. But with decline in fish stocks and increasing market demand, conflict has increased. Villagers consider that people have become greedy due to the greatly increased monetary value of fish. It should also be noted that fishers must increase their effort if catches are to be maintained in the face of a diminishing fisheries resource. Some have resorted to using gear that was formerly outlawed, fishing in areas formerly protected, etc. Communities are responding actively to these problems and to the entire question of overfishing.

In 1993-94 there were conflicts when some people blocked streams completely. In these cases, villagers from upstream came down and got the offenders to open up the channels. There were also many complaints about jip bagnets disturbing migratory fish, since many were placed in the water as the fish were coming up. Villagers also complained that new dtawn traps were placed where they had never been before.

A trap called looang kung is considered to be very destructive and most villagers would like it to be strictly banned. It consists of three elements: a large funnel-like structure, with two wings made of bamboo fence, facing downstream; the funnel opens narrowly into a large circular bamboo fence enclosure, which may almost totally block a channel; and the circular fence opens downstream into a lee or oo trap. This gear is illegal in Muang Khong, Champasak Province. It was first used in the Khone area about 20 years ago. There were about 20 in Hoo Sahong and Hoo Sadam in May-June 1994.

Lawp pba pawn is a special type of lawp trap used to catch *Cirrhinus microlepis* (pba pawn) during its February-April migrations. Sometimes 40-50 large fish are caught in a single trap in one day, but in the past catches were bigger. Many of these traps are used in Hoo Sahong and other channels that are most important for migrating pba pawn. Sometimes this gear is used with bamboo weirs and fences (peuak) to such an extent that migrating pba pawn may be almost completely cut off, leading to disputes with other villagers because channels were not caught off this way in the past even though the gear has long been in use.

Other fishing gear and methods that many villagers would like to see regulated or banned include jip and man bagnets, nightfishing with spear and headlamp (ngiang pba), shooting fish with automatic rifles, electrofishing, fishing with agricultural pesticides and other chemicals, and fishing with explosives. Fishing with electricity, chemicals, and explosives has been banned in Laos. Fishing with electricity and with chemicals is not being done in the Khone area at this time. Lao people in the Khone area also do not fish with explosives, but this is still being done by some Cambodians.

DISCUSSION

The Mekong Secretariat has long maintained that there is no scientific documentation for long term decline of Mekong fisheries, the implication being that it has not occurred and is not occurring now. According to the Secretariat, claims of former abundance of fish in the Mekong basin are largely or entirely anecdotal, and hence unreliable. To a certain extent this is true. But claims that the Mekong did not formerly have more abundant fisheries do not have any basis at all (not even anecdotal), and are mere wistful thinking on the part of bureaucrats.

If any organization has had the opportunity and means to gather data on Mekong wildcapture fisheries it is the Mekong Secretariat. Let us hope that the newly formed Mekong Commission will not be so remiss in its treatment of wildcapture fisheries.

Stream flow in the Mekong River apparently has been decreasing since 1970 (ROBERTS, 1993: 56; HILL & HILL, 1994: 32-35). Whether this represents merely repetition of a long term cyclical phenomenon (as suggested by HILL & HILL) or is due to negative human impacts of recent origin is an open question. Analysis may indicate that both are involved, i.e., that recent homogenic impacts and long-term cyclical events have coincided. In this case, the overall effect may be much greater and of longer duration than at any time in the recent past.

It is suggested that decline of Mekong fisheries since the early 1970's may be largely due to the decreased stream flows, or that declining stream flow and overfishing have acted synergistically to reduce catches (HILL & HILL, 1994: 35). The main concern is that decreasing stream flow might be the harbinger of destabilization or desiccation of the Mekong basin, and that this could lead, in a relatively short time (perhaps only a few decades) to increasingly arid conditions in the Mekong basin. This is most likely to happen if the watershed is extensively deforested in Laos and Cambodia, as has happened already in Thailand and Yunnan and is now happening in the Myanmar portion of the basin.

Data on trend analysis of annual flows in the Mekong River at Vientiane 1970-1992 are presented and discussed by HILL & HILL, 1994: 32-35, fig. 4). On this basis they suggest that the decrease in stream flow is due entirely to a normal cyclical event. A more relevant analysis, based on monthly or daily fluctuations, however, might reveal that the stream flow of the Mekong mainstream is currently much more irregular than it has been in the past. This could indicate that present decline in stream flows is due mainly to human impacts. Presumably the Mekong Commission has inherited adequate data from the Mekong Secretariat to address this problem.

In a wide-ranging evaluation of so-called run-of-the-river hydropower projects recently proposed by the Mekong Secretariat, the following observations were made concerning Khone Falls: "Khone Falls is an ecologically unique area that is essentially a microcosm of the entire lower Mekong River. It is a remarkable natural laboratory that would allow researchers to focus on one small area of the river, yet be able to describe much of the ecology of the fisheries throughout the entire river. Such a site is so rare in nature that every effort should be made to preserve all of Khone Falls from any development" (HILL & HILL, 1994: 90). We heartily concur with these remarks. In particular, we strongly advise against any projects that would alter natural conditions in any of the channels used

by migratory fish, including but not limited to Hoo Sahong, Hoo Sadam and Hoo Papeng.

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