MEKONG RIVER PANGASIIDAE CATFISH MIGRATIONS AND THE KHONE FALLS WING TRAP FISHERY IN SOUTHERN LAOS

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ABSTRACT

Laos is heavily dependent on natural resources to support the livelihoods of the bulk of its human population. Wild capture fisheries in the Mekong River and its tributaries are particularly important for providing rural Lao people with income and are their main source of protein. This article examines an important Mekong River fishery in the extreme south of Laos for migratory pangasiid catfishes and other species at the beginning of the annual rainy season. Four years of catch-effort fisheries data for a pair of large wing traps are presented. Although over 100 other species are caught in the fishery, the pangasiid catfish *Pangasius conchophilus* was by far the dominant species in catches. Peak catches for the wing trap fishery are not correlated with lunar cycles, Catch data, and 'local ecological knowledge' of fishers, suggest that these fish migrations are associated with rising river levels at the beginning of the rainy season. Changes in hydrological conditions in the Mekong River and its large tributaries caused by the construction of large hydroelectric dams could seriously impact critically important fish migrations and associated fisheries.

Key words: artisanal, Cambodia, capture fisheries, freshwater fisheries, straddling stocks, Laos.

INTRODUCTION

In Laos and throughout most of the Lower Mekong River Basin, fishing and farming in small subsistence-oriented communities remain the way of life for most people, and fish and other aquatic products are the most important source of animal protein. As Laos is a landlocked nation, the Mekong River and its tributaries are the main source of wild capture fisheries.

Many local activities and traditions—rice cultivation, fish harvesting, water festivals—are timed to the seasonal rise and fall of the Mekong. Every year around May the Mekong River begins to swell as snow melts in the Tibetan mountains and, more importantly, monsoon rains arrive in the middle and lower parts of the basin. As water levels and currents increase, many fish species become especially active, and most exhibit migratory behavior of varying degrees (BAIRD *ET AL.*, 2003; BAIRD *ET AL.*, 2001B; BAIRD, 2001; BAIRD *ET AL.*, 1999A; RAINBOTH, 1996; SINGHANOUVONG *ET AL.*, 1996; ROBERTS & BAIRD,

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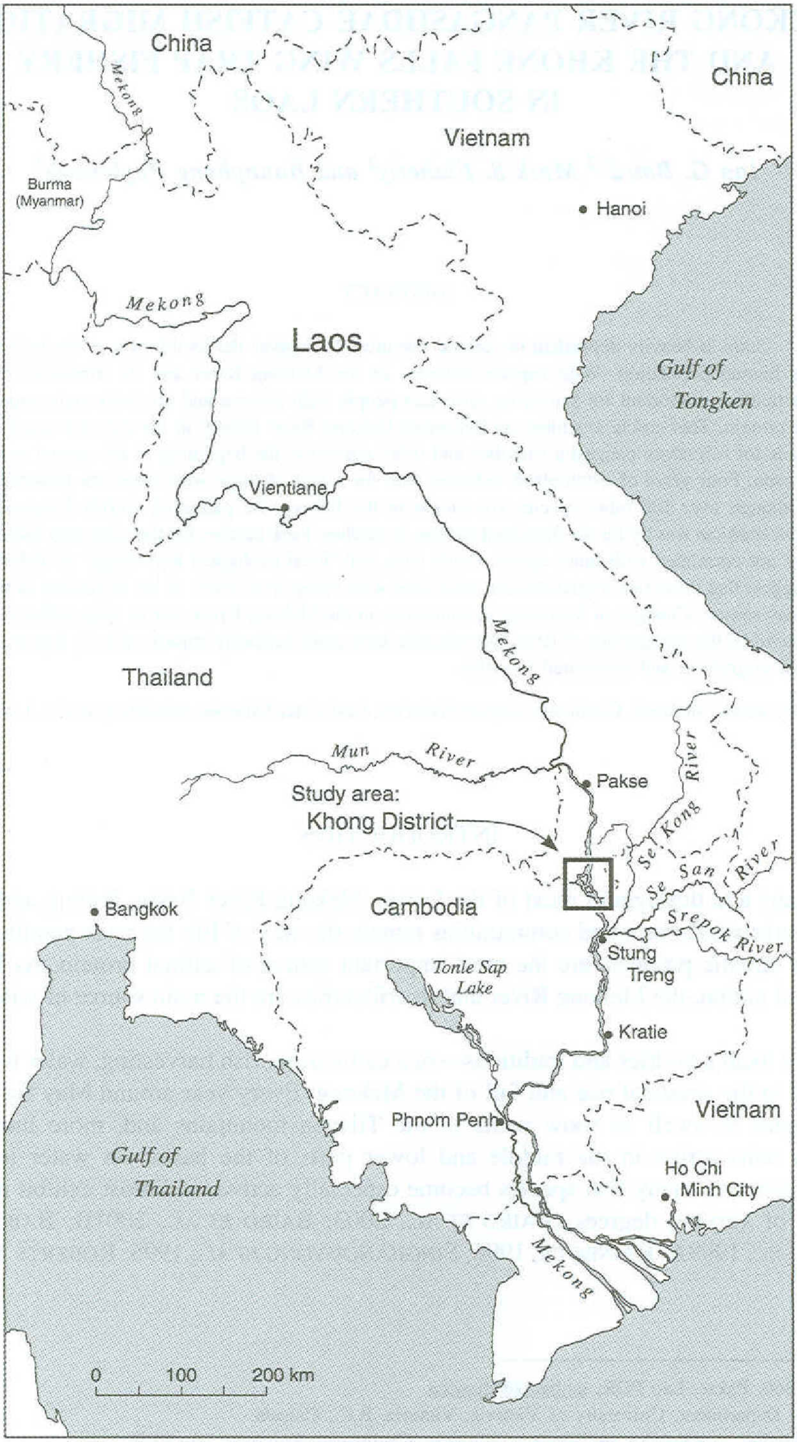

Figure 1. The study area: Khong District, Champasak Province, Southern Lao PDR

1995; ROBERTS & WARREN, 1994; ROBERTS, 1993). Rural villagers living near the mainstream Mekong River's Khone Falls (Fig. 1 & 2) have long been aware of the migratory nature of a large number of fish species. This includes, especially, the catfish family Pangasiidae, since many of the species in this family migrate past the Khone Falls at the beginning of the rainy season (BAIRD & FLAHERTY, 2004A; HOGAN *ET AL.*, 2004; BAIRD *ET AL.*, 2001B; BAIRD, 2001; BAIRD *ET AL.*, 1999; SINGHANOUVONG *ET AL.*, 1996; ROBERTS & BAIRD, 1995; ROBERTS, 1993).

Throughout the world, artisanal fishers have designed fishing gears to suit their particular set of environmental and socio-economic conditions. Over generations, the people in the Khone Falls area have developed an ingenious method for harvesting migratory catfish—the wing trap, or *'li'* in Lao. These impressive looking immovable and V-shaped wooden and bamboo structures can be up to 14 m long and 2 m wide, not including the outer wings. The Khone Falls area is the only section of the 4,200 km mainstream Mekong River where geological and hydrological conditions are suitable for building these especially designed fishing devices (BAIRD, 1998; CLARIDGE *ET AL.*, 1997; ROBERTS & BAIRD, 1995; ROBERTS, 1993), although smaller versions are used in tributaries and floodplains in the region (CLARIDGE *ET AL.*, 1997; DEAP *ET AL.*, 2003). The *li* fishery is of critical importance to people in the southern part of Khong District, and particularly the villages situated around the Khone Falls. Hundreds of families rely on wing traps to provide them with a large part of their annual income and food supplies (BAIRD *ET AL.*, 2001B; BAIRD *ET AL.*, 1999A; BAIRD, 1998; BAIRD *ET AL.*, 1998; SINGHANOUVONG *ET AL.*, 1996; ROBERTS & BAIRD, 1995; ROBERTS, 1993).

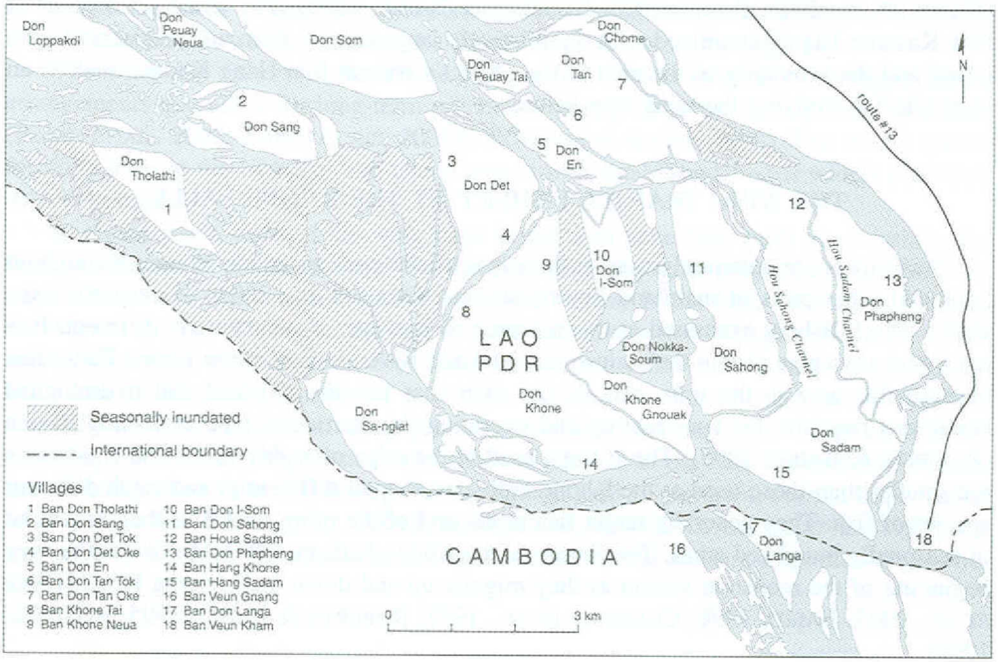

Figure 2. The Khone Falls area, Khong District, Champasak Province, Southern Lao PDR

Large rivers are some of the least known ecosystems (BROCKELMAN, 2002), and the Mekong River is no exception. In fact, very little quantitative fisheries data from the Mekong River has been published to date. This paper presents an analysis of four years (1994, 1995, 1998 and 1999) of fish catch data for two parallel set wing traps situated at the southern tip of Nok Kasoum Island, Khong District, Champasak Province, southern Lao PDR. This research is part of an ongoing effort to document the major artisanal fisheries conducted around the Khone Falls in southern Laos, and associated fish migrations (see, also, BAIRD & FLAHERTY, 2004A; BAIRD *ET AL.*, 2003; BAIRD *ET AL.*, 2001B).

STUDY AREA

The Siphandone (or 4,000 islands) Wetland area in the mainstream Mekong River is mainly situated in Khong District, Champasak Province, and is a complex and highly diverse ecosystem (See BAIRD *ET AL.*, 2003; and DACONTO, 2001 for details regarding the geography and people of the study area). The Khone Falls represents the southern extent of Siphandone (Figs. 1 & 2).

The *li* fishery is of great importance to villagers living in Ban Hang Khone, the village where this study is based. The southern end of Nok Kasoum Island, which is less than 2 km northeast of Ban Hang Khone, is the site of several important wing traps belonging to villagers from Ban Hang Khone, Ban Khone Neua and Ban Don Som (BAIRD, 1998; ROBERTS & BAIRD, 1995) (Fig. 2). It is also the site of important fence-filter (*tone*) traps for catching migrating small cyprinids during the dry season (BAIRD *ET AL.*, 2003).

Large quantities of fish are caught during peak fishing periods at Nok Kasoum Island (BAIRD *ET AL.*, 2003; BAIRD, 1998; ROBERTS & BAIRD, 1995). The strategic location of Nok Kasoum Island, combined with the relatively large catches from areas adjacent to the island and the proximity of the area to the project's base at Ban Hang Khone, made it an ideal site for studying the wing trap fishery.

THE WING TRAP (*LI*) FISHERY AT THE KHONE FALLS

Wing traps are commonly used at the edges of rice paddies and in streams throughout Laos and other parts of mainland Southeast Asia (DEAP *ET AL.*, 2003; CLARIDGE *ET AL.*, 1997). The *li* fishery examined in this research is, however, fundamentally different. It is not found anywhere else in the mainstream Mekong River outside of the Khone Falls area, because this area is the only part of the river that has the physical and hydrological conditions requisite for constructing and operating this particular type of fishing device (ROBERTS & BAIRD, 1995). The *li* traps used at the edge of paddy fields and in streams are smaller than those used at the Khone Falls, are shaped differently, and catch different species of fish. They generally target fish at the end of the rainy season as they move out of seasonally inundated areas. The *li* traps at the Khone Falls mainly catch fish at the very beginning of the monsoon season as they migrate up and down the Mekong River (DEAP *ET AL.*, 2003; BAIRD, 1998; CLARIDGE *ET AL.*, 1997; ROBERTS & BAIRD, 1995; ROBERTS, 1993).

Each April at the height of the dry season, villagers construct wing traps of various sizes and designs using locally obtained wood, bamboo, rattan and vines. Each trap is made to fit the particular physical and hydrological conditions of the site, reflecting the significant amount of local ecological knowledge that villagers hold. These traps are built mainly to target large schools of pangasiid catfish that migrate up the Mekong River from Cambodia each year, although a wide variety of other species are also harvested (BAIRD, 1998; ROBERTS, 1993). Migrators swim up the many channels and rapids that make up the Khone Falls, but most channels cannot be easily ascended due to the impassible rapids and waterfalls. Therefore, they must move up and down the channels until they find one that they can get up. Only a few, the most notable being Hou Sahong and, to a lesser extent, Hou Sadam are easily passable year round (BAIRD & FLAHERTY, 2004A; BAIRD *ET AL.*, 2003; BAIRD *ET AL.*, 2001B; ROBERTS & BAIRD, 1995).

Villagers have determined that the most effective way of catching the migrating fish is to position the traps in the channels so that the fish can be caught when they are moving downriver. The migrating fish reverse direction when they cannot pass through a channel that has a high waterfall or steep rapid at its upper end. Some returning fish are caught in large quantities over short periods, while others conduct more protracted migrations (BAIRD, 1998; SINGHANOUVONG *ET AL.*, 1996; ROBERTS & BAIRD, 1995).

Large numbers of wing traps are operated in the Khone Falls, but it was decided that it would be most effective to concentrate the data collection efforts on one key wing trap fishing operation. Accurately monitoring more sites for the full duration of the fishing season would have required much more project labor than was available. We were fortunate in that the third author is the son-in-law of one of the co-owners of a good wing trap site on Nok Kasoum Island. His in-laws are from Ban Hang Khone while the other owner lives in Ban Khone Neua village. The two communities are situated at either end of the 5-km long Khone Island, which straddles the Khone Falls at its centre (Fig. 2).

The wing trap fishery in the Khone Falls area is subject to locally developed tenure arrangements that allow for long-term private ownership of particular trap sites by fishers (BAIRD *ET AL.*, 2003; BAIRD *ET AL.*, 2001B; ROBERTS & BAIRD, 1995). The tenure system for wing traps in the Nok Kasoum Island area is well established, and is widely respected by local people.

In recent years, most of the wing traps in the area have been built in essentially the same places and in the same ways. For the most part, the same people have operated the traps. There have been no new entries into the *li* fishery in the Nok Kasoum Island area for at least 15 years. However, the fishery experienced a period of expansion in the 1970s and 1980s, when villagers from Ban Hang Khone and other communities in the Khone Falls area established a number of new traps. Increased access to markets for fish was probably the main factor motivating people to establish new trap sites. There are a dozen or so traps of various shapes, sizes and efficiency levels in the Nok Kasoum Island area, and probably more than 100 throughout the Khone Falls. Cylindrical current traps, called '*chip*' in Lao (see BAIRD *ET AL.*, 2001B; BAIRD *ET AL.*, 1999B; CLARIDGE *ET AL.*, 1997), are also used in the Nok Kasoum area during this season, but are less important than wing traps.

METHODS

Data collection at the wing trap site at Nok Kasoum Island involved monitoring two immovable adjacent traps. Both were 14 m long and 2 m wide, not including the outer wings. The traps were built using similar materials and design, and were placed in the same location each year. Although they are used together as a single fishing operation, the trap closest to shore has two owners and the outer trap has two different owners. The owners of the outer trap, however, are closely related to one of the owners of the inner trap. Each year five or six families, two of whom are the owners, jointly operate the traps for the approximately two-month fishing season. The consistent design and operation of the fishery facilitated the collection of seasonal data that are directly comparable from year to year. Neither of the two traps were built in 1996 or 1997, however, because the Mekong River's waters rose faster than expected, and the operators were unable to complete the traps before the current became too strong for construction to continue (BAIRD, 1998). It typically takes about one month of labor by several individuals to build a single large *li* trap. Animist ceremonies are conducted after each season, as a show of respect for the spirits who are believed to determine catch levels.

The vast majority of fish caught in the *li* fishery are landed during the night. This necessitated stationing data collectors at the traps every night over the course of each fishing season. Monitors were also stationed at the traps during the daytime, since some fish are caught then. Small huts built next to the traps provide a place for the fishers to sleep during low fishing periods. The species and weights of all fish caught during each season were recorded. Data collection began around mid-May and continued until fishing ceased in June or July, depending on hydrological cycles. A season ends for a particular trap when it is either washed away by strong currents or totally submerged by rising water. Occasionally, submerged traps are not washed away, and re-emerge when water levels drop at the end of the rainy season. However, *li* trap catches are only marginal at the end of the monsoon season, even if a trap survives the rainy season.

Catch-per-unit-effort, or CPUE, is an important tool for assessing and monitoring fisheries, although the method has various weaknesses (see BAIRD *ET AL.*, 1999B; COWX, 1995). Although we rarely use the term CPUE in this paper, readers should be aware that since the two traps monitored are set in one location for the whole season, they essentially 'fish' 24 hours a day throughout the fishing season. Therefore, the CPUE for the *li* fishery at Nok Kasoum is the total catch for an hour, day or season, depending on how one wants to calculate CPUE, divided by the number of traps monitored, two, or the number of 'fishing operations' monitored, which was one. This means that the daily catch rates provided here are essentially CPUE values for the two traps.

Fish weights were recorded using the following scales:

1) Fish weighing up to 1 kg were weighed on 1-kg scales with 5 g increments.
2) Fish weighing from 1 to 5 kg were weighed on 5-kg scales with 20 g increments.
3) Fish weighing from 5 to 15 kg were weighed on 15-kg scales with 50 g increments.

Because the *li* fishery catches large quantities of fish over short fishing periods and villagers are generally anxious to either process or quickly sell part or all of their catch, lumping large numbers of fish together for weighing was sometimes necessary. One-kg random samples were taken from large batches of bulk weighed fish.

Historically, monsoon season fish catches have been preserved for use throughout the year. Preservation techniques include fermentation, pickling, drying and smoking (FAO, 1999). Small cyprinids are generally salted with bran to make fish paste (*pa dek*). Medium sized catfishes are often smoked over an open fire and later sold as *'pa yang'*, and large cyprinids and catfish are sold fresh to traders who send them on ice to market by truck or bus. Fresh and smoked fish are generally sold in the provincial capital of Pakse, which is about 130 km from the Khone Falls. *Pa dek* is either sold in clay jars outside of Khong, is sold to villagers from communities in Khong, or is consumed locally by the fishers themselves.

For the purposes of this research, migration is considered to be movements of fish that result in an alternation of species between two or more separate habitats, that occurs with a regular periodicity, and involves a large proportion of the population (NORTHCOTE, 1984). Migrations are often classified according to their trophic, reproductive and dispersal components, which differ according to species, the origin of particular populations, and size classes (SINGHANOUVONG *ET AL*., 1996).

The fisheries data collected at Ban Hang Khone have been entered into a relational database management system (RDMS) using Microsoft® Excel and Access. The variables recorded were weights of individual fish species, the fishing gear used to catch the fish, the number of gears used, the names of the fishers, the time periods fishing effort took place, and the number of hours that fishing took place.

RESULTS

Table 1 presents the total catch summaries by species and weight for the 1994, 1995, 1998 and 1999 wing trap or *li* fishing seasons. Table 2 combines the results of all four seasons. More species of fish were caught in the wing trap fishery at Nok Kasoum Island than in any other fishery monitored in the Khone Falls area (BAIRD, 1998). At least 106 fish species and one large crustacean species (*Macrobrachium* sp.) were recorded in catches over the four years that the fishery was monitored. Small quantities of other species may also have been caught, but were not recorded individually because of being lumped in the 'miscellaneous fish' category during peak fishing periods.

The data indicate that the pangasiid catfish *Pangasius conchophilus* (*pa pho*/*pa ke* in Lao) is the dominant species in the fishery, making up 40.8% of the combined catch for the four seasons, with annual landings ranging from between 13.7 and 58%. However, in 1995, catches of the small cyprinid *Henicorhynchus lobatus* were highest by weight. During that year, *P. conchophilus* schools apparently migrated up Hou Sadam and Hou Sahong channels (see Fig. 2), resulting in uncharacteristically disappointing catches in the Nok Kasoum Island area (Local fishers, *pers. comm*., 1995). *P. conchophilus* catches were the highest by weight during the other three seasons.

Pangasius conchophilus are caught in large quantities over very short time periods. Large catches always occur during the night, indicating that the species has a nocturnal migration pattern. Schools of fish include individuals belonging to various size classes, although members of the 0+ class are by far the most abundant. While the migrations of larger individuals may have a reproductive function, it is unclear why the sexually immature individuals migrate (SINGHANOUVONG *ET AL*., 1996). However, food stomach content studies

Table 1 Summary of 1994, 1995, 1998 and 1999 Wing Trap (*Li*) Fish Catches at Nok Kasoum Island, Khong District, Champasak Province, Lao PDR

#	Latin Name	T_weight (g)	%catch	Min (g)	Max (g)	Mean (g)	StDev (g)
	1994						
1	*Pangasius conchophilus*	1,314,590	46.13	40	2,000	341	415
2	Miscellaneous fish spp.	543,020	19.06	20	20	20	
3	*Henicorhynchus lobatus*	133,555	4.69	2	48	18	10
4	*Scaphognathops bandanensis*	117,315	4.12	10	200	41	35
5	*Puntioplites falcifer*	104,580	3.67	6	84	37	20
6	*Pangasius krempfi*	98,650	3.46	1,250	7,700	3,940	2,195
7	*Cyclocheilichthys enoplos*	79,755	2.80	50	3,950	529	804
8	*Pangasius bocourti*	74,045	2.60	1	2,143	287	564
9	*Pangasius larnaudii*	66,700	2.34	20	3,200	914	712
10	*Hemibagrus nemurus*	45,690	1.60	25	340	129	64
11	Other (73 species +)	271,553	9.53				
	Totals	**2,849,453**	**100.00**				
	1995						
1	*Henicorhynchus lobatus*	326,360	24.01	8	28	15	5
2	*Pangasius conchophilus*	185,818	13.67	50	3,400	420	647
3	*Cosmochilus harmandi*	119,690	8.81	25	6,000	1,323	1,462
4	*Pangasius krempfi*	103,450	7.61	1,500	5,500	3,277	1,198
5	*Pangasius lamaudii*	94,920	6.98	80	4,200	832	640
6	Miscellaneous fish spp.	68,000	5.00				
7	*Pangasius bocourti*	63,110	4.64	5	4,900	833	984
8	*Hemibagrus wyckioides*	54,820	4.03	200	7,900	3,005	2,139
9	*Hemibagrus nemurus*	49,550	3.65	20	1,000	235	183
10	*Pangasianodon hypophthalmus*	46,400	3.41	150	2,500	1,075	609
11	Other (61 species +)	246,962	18.17				
	Totals	**1,359,080**	**100.00**				
	1998						
1	*Pangasius conchophilus*	1,211,185	57.94	14	4,500	369	644
2	*Henicorhynchus lobatus*	304,155	14.55	6	40	18	10
3	*Cosmochilus hamandi*	80,330	3.84	10	4,600	1,236	1,211
4	*Scaphognathops bandanensis*	68,695	3.29	10	92	42	21
5	*Cyclocheilichthys enoplos*	44,010	2.11	180	3,000	1,142	887
6	*Puntioplites falcifer*	29,110	1.39	13	120	49	27
7	*Henicorhynchus siamensis*	28,007	1.34	9	54	27	11
8	*Pangasius krempfi*	27,600	1.32	2,400	5,000	3,421	965
9	*Hemibagrus nemurus*	25,380	1.21	88	450	195	105
10	*Labiobarbus leptocheilus*	23,693	1.13	10	44	22	8
11	Other (74 species +)	248,195	11.87				
	Totals	**2,090,360**	**100.00**				
	1999						
1	*Pangasius conchophilus*	653,300	33.33	188	2,200	642	710
2	*Scaphongnathops bandanensis*	379,270	19.35	3	100	47	29
3	*Henicorhynchus lobatus*	271,645	13.86	3	40	17	10
4	*Pangasius krempfi*	160,500	8.19	1,000	8,667	2,948	2,305
5	*Pangasius bocourti*	158,000	8.06	2,167	2,167	2,167	
6	*Cosmochilus harmandi*	65,990	3.37	50	3,333	1,135	892
7	*Pangasius lamaudii*	54,650	2.79	100	3,000	1,164	716
8	*Pangasius macronema*	40,400	2.06	17	50	37	16
9	*Cyclocheilichthys enoplos*	40,280	2.06	280	4,000	1,883	913
10	*Puntioplites falcifer*	27,215	1.39	7	100	67	28
11	Others (49 species +)	108,729	5.55				
	Totals	**1,959,979**	**100.00**				

Table 2 Combined Summary of 1994, 1995, 1998 and 1999 Wing Trap *(Li)* Fish Catches at Nok Kasoum Island, Khong District, Champasak Province, Lao PDR

#	Latin Name	Lao Name	T_weight (kg)	% catch	Min (g)	Max (g)	Mean (g)	StDev (g)
1	*Pangasius conchophilus*	*pa pho/pa ke*	3,365	40.76	14	4,500	397	602
2	*Henicorhynchus lobatus*	*pa soi houa lem*	1,036	12.55	2	48	18	10
3	Miscellaneous fish spp.	*pa louam*	611	7.40				
4	*Scaphognathops bandanensis*	*pa pian*	578	7.00	3	1,000	48	88
5	*Pangasius krempfi*	*pa souay hang leuang*	390	4.72	1,000	8,667	3,359	1,685
6	*Pangasius bocourti*	*pa houa mouam*	311	3.77	1	5,400	496	929
7	*Cosmochilus harmandi*	*pa mak ban*	295	3.57	10	6,000	1,062	1,204
8	*Pangasius larnaudii*	*pa peung*	221	2.68	20	4,200	927	665
9	*Cyclocheilichthys enoplos*	*pa chok/pa choke*	207	2.51	50	4,000	923	915
10	*Puntioplites falcifer*	*pa sakang*	170	2.06	6	143	55	29
11	*Hemibagrus nemurus*	*pa kot leuang*	125	1.51	20	1,000	187	138
12	*Hypsibarbus malcolmi*	*pa pak kom/pa pak nouat*	77	0.93	10	2,600		
13	*Hemibagrus wyckioides*	*pa kheung*	76	0.92	15	7,900	2,436	1,807
14	*Pangasius macronema*	*pa gnone thamada*	64	0.78	1	1,600	53	162
15	*Bagarius yarrelli*/spp.	*pa khe*	57	0.69	100	9,500	1,270	1,941
16	*Henicorhynchus siamensis*	*pa soi houa po*	55	0.67	9	100	28	14
17	*Pangasianodon hypophthalmus*	*pa souay kheo*	48	0.58	150	2,500	1,090	602
18	*Labiobarbus leptocheilus*	*pa lang khon*	44	0.53	4	500	29	56
19	*Hemisilurus mekongensis*	*pa nang deng*	43	0.52	63	1,000	429	216
20	*Henicorhynchus lobatus and siamensis*	*pa soi*	42	0.51				
21	*Morulius chrysophekadion*/*spp.*	*pa phia*	42	0.51	100	4,800	985	938
22	*Pangasius pleurotaenia*	*pa gnone thong khom*	40	0.48	5	332	74	46
23	*Belodontichthys dinema*	*pa khop*	35	0.42	75	1,800	747	452
24	*Helicophagus waandersi*	*pa nou*	32	0.39	50	1,833	241	228
25	*Probarbus jullieni*	*pa eun ta deng*	20	0.24	5	6,500	174	828
26	*Cirrhinus microlepis*	*pa phone*	19	0.23	35	3,600	687	984
27	*Wallago attu*	*pa khao*	18	0.22	100	9,400	3,058	3,357
28	*Lobocheilos melanotaenia*	*pa khiang*	18	0.22	5	200	36	27
29	*Cyprinus carpio*	*pa nai*	17	0.21	5	1,500	258	307
30	*Chitala blanci*	*pa tong kai*	17	0.21	20	2,500	745	737
31	*Paralaubuca typus*	*pa tep*	14	0.17	3	850	20	90
32	*Leptobarbus hoeveni*	*pa phong*	13	0.16	850	1,600	1,225	530

Table 2 (continued).

#	Latin Name	Lao Name	T_weight (kg)	% catch	Min (g)	Max (g)	Mean (g)	StDev (g)
33	*Tenualosa thibaudeaui*	*pa mak phang*	12	0.15	3	120	17	20
34	*Micronema apogon/M. micronema*	*pa nang khao/pa sa ngoua*	10	0.12	8	2,000	533	567
35	*Barbodes altus*	*pa vian fai*	9.8	0.12	11	300	63	43
36	*Cirrhinus mrigala*	*pa nang chan*	9.0	0.11	150	3,200	1,129	1,182
37	*Labeo erythropterus*	*pa va souang*	8.9	0.11	60	1,000	371	284
38	*Wallago leeri*	*pa khoun*	8.0	0.10	8,000	8,000	8,000	
39	*Hypsibarbus wetmorei*	*pa pak thong leuang*	8.0	0.10	80	1,200	655	447
40	*Notopterus notopterus*	*pa tong na*	7.6	0.09	60	300	144	61
41	*Osphronemus exodon*	*pa men*	6.8	0.08	20	1,200	456	324
42	*Micronema bleekeri*	*pa nang ngeun*	5.4	0.07	10	1,200	461	297
43	*Osteochilus melanopleurus*	*pa khang lai*	5.3	0.06	10	2,300	240	562
44	*Kryptopterus* spp.	*pa pik kai*	4.9	0.06	10	150	41	25
45	*Chitala ornata*	*pa tong khouay*	4.7	0.06	2,650	2,650	2,650	
46	*Amblyrhynchichthys truncatus*	*pa ta po*	4.2	0.05	5	310	69	61
47	*Crossocheilus reticulatus*	*pa toke thoi*	3.9	0.05	5	65	13	8
48	*Bangana behri*	*pa va na no*	3.5	0.04	50	725	160	202
49	*Gyrinocheilus pennocki*	*pa ko*	3.2	0.04	10	260	125	79
50	*Probarbus labeamajor*	*pa eun khao*	2.8	0.03	60	640	271	246
51	*Sikukia gudgeri*	*pa khao na*	2.7	0.03	4	100	32	26
52	*Botia modesta*	*pa mou man*	2.7	0.03	8	50	17	8
53	*Laides hexanema/spp.*	*pa gnone thong*	2.5	0.03	10	100	28	17
54	*Mekongina erythrospila*	*pa sa-i*	2.4	0.03	10	85	43	20
55	*Hypsibarbus lagleri*	*pa pak pe*	2.3	0.03	25	400	223	141
56	*Thynnichthys thynnoides*	*pa koum*	2.1	0.03	20	400	129	154
57	*Bagrichthys macracanthus*	*pa mak khan mak kheu*	2.0	0.02	50	320	145	88
58	*Hemibagrus wycki*	*pa kot mo*	1.9	0.02	950	950	950	0
59	*Scaphognathops stejnegeri*	*pa pian*	1.9	0.02	50	200	107	42
60	*Mystus singaringan/spp.*	*pa kha gneng*	1.6	0.02	20	100	53	26
61	*Channa striata*	*pa kho*	1.5	0.02	50	900	363	373
62	*Ompok bimaculatus*	*pa seuam*	1.2	0.01	20	300	112	87
63	*Cyclocheilichthys repasson*	*pa doke ngieu*	1.2	0.01	20	150	48	34
64	*Hampala macrolepidota*	*pa sout*	1.0	0.01	5	460	39	98

Table 2 (continued).

#	Latin Name	Lao Name	T_weight (kg)	% catch	Min (g)	Max (g)	Mean (g)	StDev (g)
65	*Pangasius polyuranodon*	*pa gnone hang hian*	0.80	0.01	250	300	267	29
66	*Cirrhinus molitorella*	*pa keng*	0.80	0.01	20	500	114	173
67	*Xenentodon cancila*	*pa kathong*	0.78	0.01	7	40	21	10
68	*Macrochirichthys macrochirus*	*pa hang pha*	0.75	0.01	250	500	375	177
69	*Channa marulius*/spp.	*pa kouan*	0.68	0.01	260	420	340	113
70	*Pseudomystus siamensis*	*pa khi hia*	0.64	0.01	8	67	34	18
71	*Pristolepis fasciata*	*pa ka*	0.59	0.01	5	80	21	21
72	*Osteochilus microcephalus/waandersii*	*pa khang lai gnai*	0.57	0.01	20	45	28	12
73	*Osteochilus hasselti*	*pa mak bouap*	0.44	0.01	10	50	26	14
74	*Hampala dispar*	*pa sout*	0.36	0.00	10	220	63	89
75	*Botia helodes*	*pa kheo kai*	0.35	0.00	10	45	24	7
76	*Glyptothorax* spp.	*pa kon*	0.34	0.00	5	15	7	3
77	*Garra fasciacauda*	*pa khiko*	0.33	0.00	3	20	8	4
78	*Mystacoleucus marginatus*	*pa lang nam*	0.33	0.00	7	25	12	5
79	*Coius undecimradiatus*	*pa seua*	0.32	0.00	320	320	320	
80	*Macrobrachium* sp. *(large shrimp)*	*koung gnai*	0.30	0.00	300	300	300	
81	*Luciosoma bleekeri*	*pa mak vai*	0.28	0.00	25	100	47	30
82	*Raiamas guttatus*	*pa sanak noi*	0.28	0.00	10	70	31	21
83	*Mastacemblus armatus*/spp.	*pa lat*	0.25	0.00	250	250	250	
84	*Cyclocheilichthys armatus*	*pa doke ngieu*	0.25	0.00	10	50	27	18
85	*Cirrhinus jullieni*	*pa doke ngieu pa*	0.24	0.00	35	65	50	12
86	*Setipinna melanochir*	*pa meo*	0.21	0.00	10	200	105	134
87	*Mystus multiradius/mysticetus*/spp.	*pa kha gneng khang lai*	0.21	0.00	15	80	41	24
88	*Amphotistius laosensis*	*pa fa hang/pa fa lai*	0.20	0.00	200	200	200	
89	*Rasbora* spp.	*pa sieu ao*	0.19	0.00	5	20	9	4
90	*Poropuntius deauratus*	*pa chat hang leuang*	0.17	0.00	7	80	25	28
91	*Systomus orphoides*	*pa pok*	0.16	0.00	10	30	22	8
92	*Osteochilus waandersi*	*pa khang lai*	0.10	0.00	20	80	50	42
93	*Clarias batrachus*/spp.	*pa douk*	0.10	0.00	100	100	100	
94	*Onychostoma* cf. *elongatum*	*pa khiang fai*	0.10	0.00	10	20	14	5
95	*Toxotes microlepis*	*pa mong*	0.09	0.00	20	25	23	3
96	*Opsarius pulchellus*	*pa sieu ao*	0.09	0.00	4	10	7	3

Table 2 (continued).

#	Latin Name	Lao Name	T_weight (kg)	% catch	Min (g)	Max (g)	Mean (g)	StDev (g)
97	*Kryptopterus cryptopterus*	*pa pik kai*	0.05	0.00	50	50	50	
98	*Tetraodon leiurus*/spp.	*pa pao*	0.05	0.00	50	50	50	
99	*Mystacoleucus atridorsalis*	*pa lang nam*	0.03	0.00	5	10	7	3
100	*Crossocheilus siamensis*	*pa khang lai noi*	0.03	0.00	5	20	13	11
101	*Acantopsis* spp.	*pa hak kouay*	0.02	0.00	5	10	8	4
102	*Tor tambroides*	*pa koua*	0.02	0.00	20	20	20	
103	*Botia caudipunctata*/spp.	*pa mou man*	0.02	0.00	20	20	20	
104	*Trichogaster* spp.	*pa kadeut*	0.01	0.00	10	10	10	
105	*Parambassis wolffi*/spp.	*pa khap khong*	0.005	0.00	5	5	5	
	Totals		8,257	100.00				

conducted in the Khone Falls area indicate that this species changes its diet considerably by season (BAIRD & PHYLAVANH, 1999). Therefore, migrations may have a trophic component. SINGHANOUVONG *ET AL.* (1996) suggested that many of the larger migrating *P. conchophilus* probably only exhibit gonadal development after reaching their intended spawning ground. BAIRD & PHYLAVANH (1999) have found individual *P. conchophilus* in various stages of reproductive condition in March, June and August, indicating that spawning patterns may be complicated, and spawning may occur more than once a year.

SINGHANOUVONG *ET AL.* (1996) found that *Pangasius conchophilus* constitutes a large proportion of the *li* catch from Hou Som Gnai channel, a steep gradient channel on the east side of the Khone Falls. We believe that the species is the most abundant caught by *li* traps throughout the Khone Falls. LIENG *ET AL.* (1995) recorded *P. conchophilus* as the 12th most common fish species in the bag-net (*dai*) fishery in the Tonle Sap River in central Cambodia, albeit only making up 0.18% of the catch. However, it is unclear how far this species migrates or if there is any relation between the populations targeted by the *dai* fishery in Cambodia and those targeted by the *li* fishery in Laos.

The cyprinid minnow *Henicorhynchus lobatus* (*pa soi houa lem*) was the second most abundant species in catches by weight, constituting an average of 12.5% (range 4.7–24%) of catches. In fact, the actual total catch for this species may be slightly underestimated, since some of the fish in the 'miscellaneous fish species' and '*Henicorhynchus lobatus and siamensis*' categories were *H. lobatus*, along with other small cyprinids, including *H. siamensis* (*pa soi houa po*), *Labiobarbus leptocheilus* (*pa lang khon*), *Crossocheilus reticulatus* (*pa toke thoi*), *Paralaubuca typus* (*pa tep*) and *Lobocheilus melanotaenia* (*pa khiang khang lai*). Most *H. lobatus* were caught during the day. There were apparently fewer *H. lobatus* caught in *li* traps in Hou Som Gnai compared to the traps located near Nok Kasoum Island (BAIRD, 1998; SINGHANOUVONG *ET AL.*, 1996).

Unlike pangasiid catfishes, which are migrating upriver when they are caught in wing traps, *Henicorhynchus lobatus* are caught as they move downriver to spawn in the Great Lake and other seasonally inundated wetlands in Cambodia. SINGHANOUVONG *ET AL.* (1996) and ROBERTS & WARREN (1994) reported that villagers from Khong District believe that this species spawns above the Khone Falls. The many villagers with whom we have spoken, concur with these authors that *H. lobatus* make grunting sounds when they are still above the Khone Falls. However, they assert that the vast majority of *H. lobatus* spawn downriver in Cambodia. This claim is backed up by our field observations that no spent *H. lobatus* are caught in fish attractant baskets that target *H. lobatus* and other small cyprinids at Ban Hang Khone below the Khone Falls in June and July (BAIRD, 1998).

The third most abundant species was the medium-sized cyprinid *Scaphognathops bandanensis* (*pa pian*), which made up an average of 7% (range 0.9–19.4%) of catches. Villagers believe that these fish are moving upriver when they are caught. Large runs are usually landed at the very beginning of the wing trap fishing season, before peak *P. conchophilus* runs begin. For example, over 100 kg of the species were landed on May 26, 1994. Migrations apparently take place during the daytime, as this is when the fish are caught in the *li* traps (BAIRD, 1998). Large runs were caught in 1994, 1998 and 1999, but only a few fish were recorded in 1995. The migrating schools of this species may not have passed Nok Kasoum Island in 1995, or they may have migrated upriver before the *li* traps at Nok Kasoum began operating. SINGHANOUVONG *ET AL.* (1996) did not record this species in *li* catches at Hou Som Gnai, and it is not found in the lower stretches of the

Mekong River in Central Cambodia. It is believed to conduct annual migrations between the Sekong, Se San and Sre Pok basins, and in the Mekong River, in northeast Cambodia and southern Laos (BAIRD & FLAHERTY, 2004A; BAIRD *ET AL.*, 1999A; ROBERTS & BAIRD, 1995). However, migratory patterns are apparently complex (BAIRD & FLAHERTY, 2004A) and are not fully understood (BAIRD & FLAHERTY, 2004A; BAIRD *ET AL.*, 2003; BAIRD *ET AL.*, 2001B; BAIRD *ET AL.*, 1999A; WARREN *ET AL.*, 1998).

The pangasiid catfish *Pangasius krempfi* (*pa souay hang leuang*) is believed to be an anadromous species that migrates up from the Mekong Delta in Viet Nam to the Khone Falls and beyond (BAIRD, 1998; SINGHANOUVONG *ET AL.*, 1996; ROBERTS & BAIRD, 1995). Recent examination of *P. krempfi* olitoths ('ear stones') and stable isotopes have confirmed that fish caught at the Khone Falls migrate from the South China Sea and the Mekong Delta estuary in Viet Nam (HOGAN *ET AL.*, 2004). It was the fourth most abundant species by weight in catches, making up an average of 4.7% (range 1.3–8.2%) of total landings. It appears that only individuals in spawning condition migrate up to the Khone Falls (HOGAN *ET AL.*, 2004; BAIRD *ET AL.*, 1999A; BAIRD, 1998; ROBERTS & BAIRD, 1995). The largest individual landed in the *li* traps was 8.7 kg, the smallest was 1 kg, and the mean weight was 3.4 kg. BAIRD & PHYLAVANH (1999) examined 79 specimens of adult *P. krempfi* caught near Ban Hang Khone at the beginning of the rainy season and found that 56% were females with immature eggs. The rest were males. 94% of the specimens examined had empty stomaches and large amounts of body fat, a condition common for anadromous fishes, which typically do not feed in freshwater environments and derive energy for migration and gonadal maturation from fat deposits distributed throughout the tissues and viscera (BERNATCHEZ & DODSON, 1987). Although this species is important to wing trap and large-meshed gillnet fisheries near Ban Hang Khone (BAIRD *ET AL.*, 1999A; BAIRD, 1998; ROBERTS & BAIRD, 1995), SINGHANOUVONG *ET AL.* (1996) observed only two specimens at Hou Som Gnai between 1993 and 1996.

Pangasius bocourti (*pa houa mouam*) is another pangasiid catfish believed to migrate upriver during this season (BAIRD, 1998; RAINBOTH, 1996, SINGHANOUVONG *ET AL.*, 1996). It was the fifth most abundant species by weight in catches, making up 3.8% (range 0.8–8.1%) of total catches. Although most of the fish caught are medium-to-large size, very small pangasiid juveniles tentatively identified as *P. bocourti* were also caught in the wing trap fishery at Nok Kasoum. However, fingerlings of *Pangasius hypophthalmus, Pangasius larnaudii, Pangasius conchophilus* and *Pangasius djambal* are sometimes mistaken for *P. bocourti* in Viet Nam (LENORMAND, 1996). Nevertheless, RAINBOTH (1996) reported that *P. bocourti* spawns at the outset of the flood season, and that juveniles reach about 5 cm by mid-June. No other juvenile pangasiids were found in catches.

The cyprinid carp *Cosmochilus harmandi* (*pa mak ban*) was the sixth most abundant species by weight, making up 3.6% (range 1.0–8.8%) of catches. ROBERTS (1993) suggested that this species migrates downriver at the beginning of the rainy season, but the first author has observed *C. harmandi* unsuccessfully attempting to jump up the Somphamit Falls, which is on the west side of Khone Island (Fig. 2), at the beginning of the rainy season. This indicates that at least some are trying to move upriver at that time of year, but we do not believe that *C. harmandi* is a long distance migrator (BAIRD *ET AL.*, 1999A).

The pangasiid catfish *Pangasius larnaudii* (*pa peung*) was the seventh most abundant species in catches, making up 2.7% (range 0.23–7%) of the total landings. This nocturnal migrator is believed to be moving upriver when caught. Catches are much more protracted compared to those of *Pangasius conchophilus*. (See, also, SINGHANOUVONG *ET AL*., 1996). BARDACH (1959) wrote that some species of *Pangasius*, including *P. larnaudii* and *Pangasius hypophthalmus*, migrate up the Mekong River during the low water dry season before spawning in the Stung Treng and Khone Falls area in June and July. However, little is known about the spawning grounds of this species near the Khone Falls, and fingerlings have not been observed there.

The cyprinid carp *Cyclocheilichthys enoplos* (*pa chok/pa choke*) was the eighth most abundant species in catches at 2.5%, and the cyprinid *Puntioplites falcifer* (*pa sakang*) was the ninth most abundant at 2.1%. ROBERTS (1993) suggested that *C. enoplos* migrates downriver at the Khone Falls at the beginning of the rainy season. However, we now believe that both species are moving upriver when they are caught in wing traps at the beginning of the rainy season. The first author has observed both species trying unsuccessfully to jump up the Sompamit Falls in May, indicating that they are trying to move upriver at that time of year. SINGHANOUVONG *ET AL*. (1996) did not record either species at Hou Som Gnai.

The bagrid catfish *Hemibagrus nemurus* (*pa kot leuang*), the tenth most abundant species in catches, made up 1.5% of landings. While SINGHANOUVONG *ET AL*. (1996) proposed that this species is probably caught when migrating upriver, we believe that that at least some move downriver at the beginning of the rainy season. This hypothesis is based on the occurrence of an important '*kasone*' funnel trap fishery just above the Khone Falls, which specifically targets schools of *H. nemurus* when they move down the Khone Falls at the beginning of the rainy season (BAIRD *ET AL*., 1999A).

The cyprinid carp *Hypsibarbus malcolmi* (*pa pak kom/pa pak nouat*) was the eleventh most abundant species, constituting 0.9% of the catch. While ROBERTS (1993) suggested that the species migrates downriver at the beginning of the rainy season, the first author has observed it unsuccessfully attempting to jump up the Somphamit Falls at the beginning of the rainy season, indicating that the species migrates upriver at the beginning of the rainy season.

The large bagrid catfish *Hemibagrus wyckioides* (*pa kheung*), the twelfth most abundant species (0.9% of the catch) is not believed to be highly migratory, but probably disperses short distances at the beginning of the rainy season (BAIRD *ET AL*., 1999; SINGHANOUVONG *ET AL*., 1996).

The pangasid *Pangasius macronema* (*pa gnone thamada*) (thirteenth most abundant species with 0.8% of catches) migrates mainly in April before the *li* traps at Nok Kasoum begin operating (BAIRD *ET AL*., 2001B; ROBERTS & BAIRD, 1995). BAIRD *ET AL*. (2001B) documented the fisheries in the Hou Sahong channel of the Khone Falls that specifically target migrating schools of this species.

Migrations of large sisorid catfish *Bagarius yarrelli/spp.* (*pa khe*) are not well known, but the species may conduct short distance migrations with dispersal and trophic components (BAIRD *ET AL*., 1999A). SINGHANOUVONG *ET AL*. (1996) hypothesized that the species migrates up the Khone Falls through Hou Som Gnai, although they acknowledged that local fishers do not consider the species to migrate long distances.

Pangasius hypophthalmus (*pa souay kheo*) is another pangasiid catfish believed to move up the Mekong River from Cambodia to the Khone Falls at the beginning of the rainy season. While it made up only 0.6% of the total catch, the fish constituted 3.4% of landings 1995. None were caught in 1994 and 1999, and only one in 1998. Zeb Hogan tagged a number of *P. hypophthalmus* caught in the bag-net fishery near Phnom Penh in November 2001, and was later able to recover the tag of 17-kg specimen two months later, in Stung Treng, Cambodia, 300 km up the Mekong River and not far south from the Khone Falls. Since then tags attached to a number of other *P. hypophthalmus* caught in the bag-net fishery have also turned up near Stung Treng (HOGAN *ET AL.*, 2004).

The migratory status of three more pangasid catfish caught in smaller numbers in the *li* fishery remains unclear. *Pangasius pleurotaenia* (*pa gnone thong khom*) may conduct short distance migrations, such as one in 1994 documented by SINGHANOUVONG *ET AL.* (1996) from Hou Som Gnai, but we believe that they do not migrate long distances like some other pangasiid catfishes (BAIRD *ET AL.*, 1999A). *Helicophagus waandersi* (*pa nou*) may also participate in short migrations, but we think it unlikely that they migrate long distances (BAIRD *ET AL.*, 1999A). *Pangasius polyuranodon* (*pa gnone hang hian*) is not believed to move long distances (BAIRD *ET AL.*, 1999A), and since the species is only rarely found above the Khone Falls (ROBERTS, 1993), it is highly unlikely that large numbers move up the Falls.

Labeo erythropterus (*pa va souang*) made up only 0.1% of catches, and only small sized individuals of this large cyprinid were landed. SINGHANOUVONG *ET AL.* (1996) suggested that *L. erythropterus*, *Bangana behri* and *Cirrhinus microlepis* were probably moving downstream at the beginning of the rainy season, but they were unsure, and presented an alternative hypothesis that *L. erythropterus* may be moving both upriver and downriver in order to reach suitable spawning environments within the Khong District area. ROBERTS (1993) also reported that *L. erythropterus* migrates downstream at the beginning of the rainy season. While we agree that *C. microlepis* probably moves downstream at the onset of the rainy season, we believe that *L. erythopterus* and *B. behri* move upriver at that time of year, although we are not sure where they move later in the rainy season. The first author observed *L. erythopterus* and *B. behri* unsuccessfully attempting to jump over the Somphamit Waterfalls in May, indicating that they were trying to move upriver. ROBERTS & BAIRD (1995) also suggested that *L. erythopterus* migrations at the beginning of the rainy season are upriver.

Like SINGHANOUVONG *ET AL.* (1996), we recorded a number of *Probarbus jullieni* (*pa eun ta deng*) fingerlings weighing about 5 to 10 g each in wing trap catches. However, only a few large individuals of this cyprinid carp were recorded. No migratory behavior during this season has been noted for the species (BAIRD *ET AL.*, 1999A; RAINBOTH, 1996).

SINGHANOUVONG *ET AL.* (1996) reported that various silurid and bagrid catfishes such as *Ompok* spp., *Kryptopterus* spp., *Hemisilurus mekongensis*, *Belodontichthys dinema* and *Micronema* spp., probably migrate up the Khone Falls at the beginning of the rainy season. ROBERTS (1993) had suggested that *Hemisilurus mekongensis*, *Micronema* spp., and *Belodontichthys dinema* were upriver migrators in the Khone Falls at the beginning of the rainy season.

We found very few *Ompok bimaculatus* in *li* catches, and *Kryptopterus* spp. was not abundant either. *Li* catches at Nok Kasoum provided us with little information about these species. However, most silurid and bagrid catfishes are more active at night, when they are all primarily caught.

The silurid catfish *Micronema micronema* and *Micronema apogon* made up only 0.1% of catches for the four years, and it seems unlikely that either undertakes long distance migrations (BAIRD *ET AL.*, 1999A). The same goes for *Micronema bleekeri*, which made up just 0.07% of catches. However, *Micronema micronema* is known to migrate up medium to large streams to spawn at the beginning of the rainy season (BAIRD *ET AL.*, 1999A).

Another silurid catfish *Hemisilurus mekongensis* (*pa nang deng*) made up 0.5% of the catches for the four years. This species spends most of the low-water season in deep-water pools in the Mekong River (BAIRD *ET AL.*, 1999A), but may migrate out of those areas at the beginning of the rainy season. However, this primarily nocturnal species is unlikely to migrate long distances (BAIRD *ET AL.*, 1999A). Nevertheless, SINGHANOUVONG *ET AL.* (1996) reported that many *H. mekongensis* migrated up Hou Som Gnai channel of the Khone Falls during the rainy season.

The silurid catfish *Belodontichthys dinema* (*pa khop*) may migrate up and down the Khone Falls, but it is unlikely to move long distances (BAIRD *ET AL.*, 1999A). It made up 0.43% of *li* catches. SINGHANOUVONG *ET AL.* (1996) suggested that it conducts upriver migrations through the Khone Falls during the rainy season. In December 1994, villagers in the Khone Falls area were surprised to catch, for the first time in memory, a number of individuals of the species over a short period in '*chip*' cylindrical traps targeting schools of migrating *Scaphognathops bandanensis* below the Khone Falls (ROBERTS & BAIRD, 1995).

From the four years of catch data available, it has not been possible to detect any significant trends in catch declines or increases for the *li* fishery at Nok Kasoum Island. The largest catches were recorded in 1994, the lowest in 1995, and moderate catches were documented in 1998 and 1999. However, since only a set of two traps at one fishing site were monitored, albeit one of the most important single wing trap sites in the Khone Falls area, it is likely that our fish catch data are not representative of the overall wing trap fishery (BAIRD, 1998).

Like BAIRD *ET AL.* (2003), we compared daily total fish catches for each year against lunar phases. However, unlike the catches for the fence-filter trap fishery in the Nok Kasoum Island area, which are closely associated with lunar periods (BAIRD *ET AL.*, 2003), no association between lunar phases and peak catch periods for the wing trap fishery was found.

Fig. 3 compares water discharge in the mainstream Mekong River at Pakse (approximately 130 km upriver from the Khone Falls) and weekly total catches for the two wing traps at Nok Kasoum Island. The data indicate that peak wing trap catches occur shortly after water levels begin to rise from their lowest points in the year. Fig. 4 compares water discharge and total *Pangasius conchophilus* catches. The results are similar to those shown in Fig. 3.

Fig. 5 compares the daily total catches for the two wing traps monitored in 1994 and daily total catches of *Pangasius conchophilus, Pangasius bocourti, Pangasius krempfi* and *Pangasius larnaudii*. Large quantities of *P. conchophilus* were caught on May 29, while relatively small amounts were caught the days before and after the peak fishing period.

Fig. 6 presents the same type of data included in Fig. 5, except for 1995. Unlike 1994, there were no major catch periods for *Pangasius conchophilus* during the 1995 wing trap fishing season at Nok Kasoum Island. However, wing traps situated in other channels in the Khone Falls area caught large amounts of *P. conchophilus* in 1995.

1998 and 1999 data are presented in Figs. 7 and 8. Unlike 1995, but similar to 1994, large quantities of *Pangasius conchophilus* were caught in 1998 over the two nights of June 13 and 14.

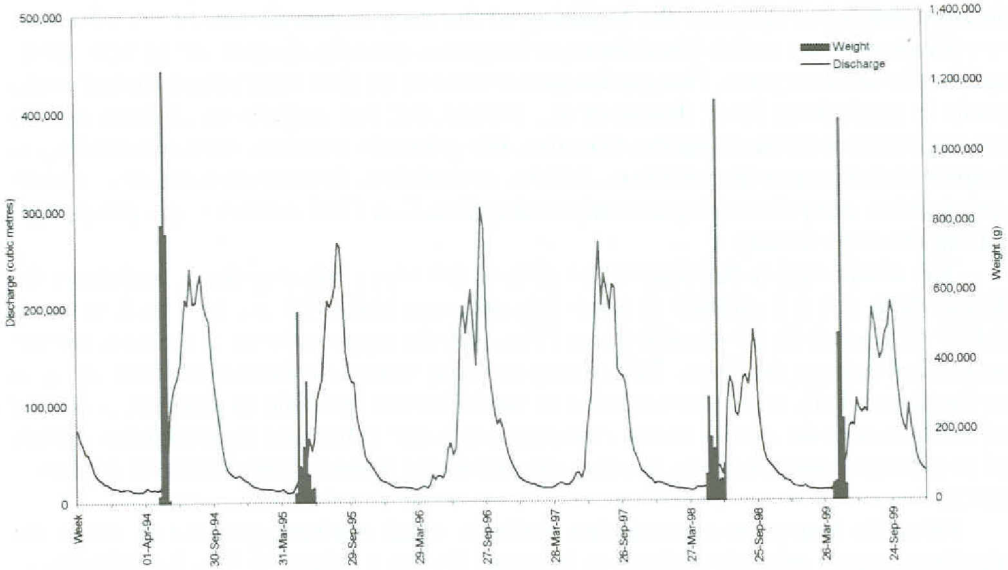

Figure 3. Total 1994 to 1999 fish catches for the wing trap *(li)* fishery at Nok Kasoum Island, Khong District, Champasak Province, Lao PDR against Mekong River water discharge

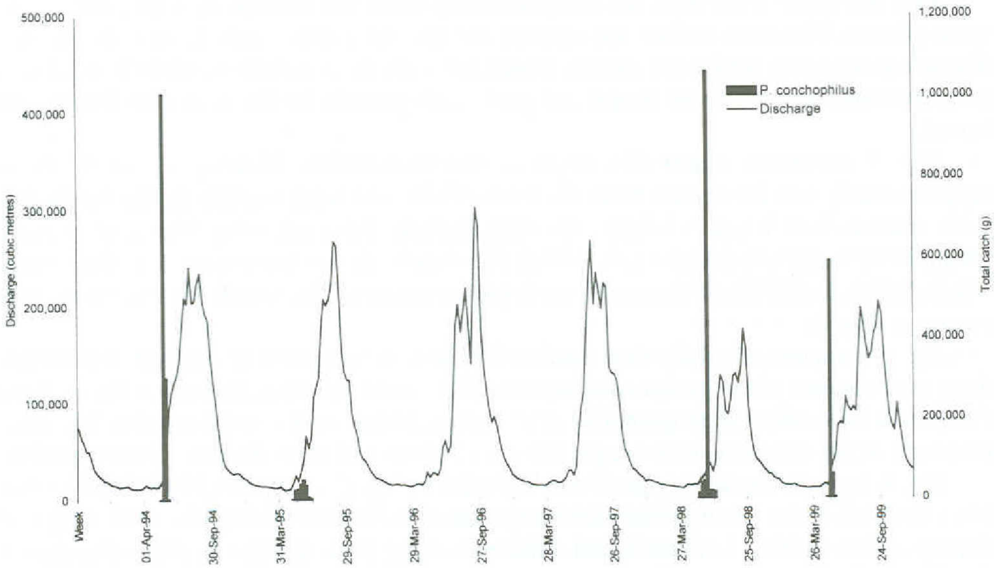

Figure 4. Total 1994 to 1999 *Pangasius conchophilus* catches for the wing trap *(li)* fishery at Nok Kasoum Island, Khong District, Champasak Province, Lao PDR against mainstream Mekong River water discharge

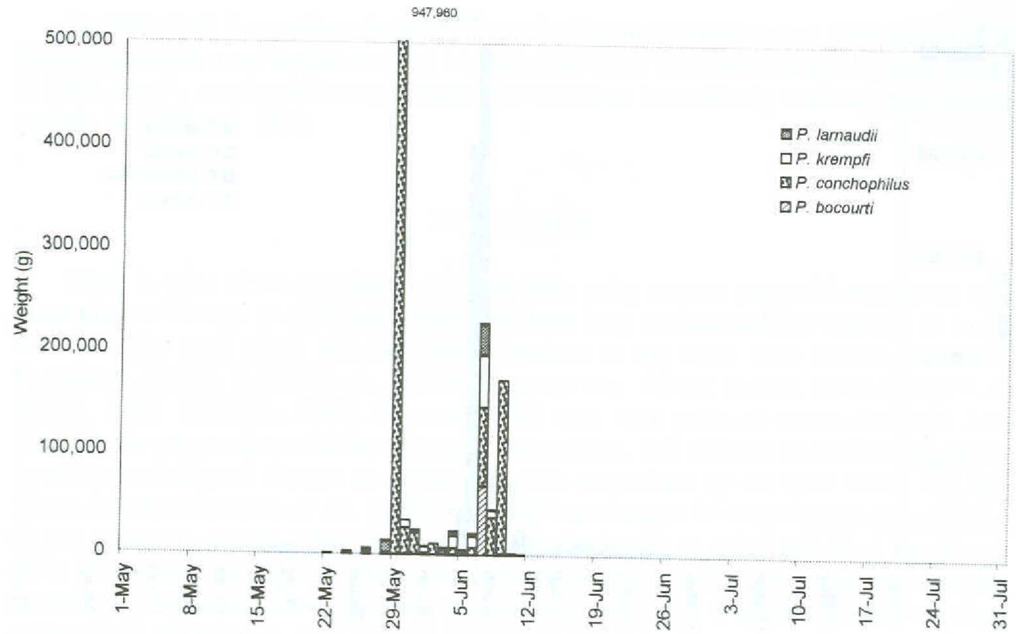

Figure 5. 1994 total daily fish catches and total catches of selected *Pangasius* species for the wing trap (*li*) fishery at Nok Kasoum Island, Khong District, Champasak Province, Lao PDR

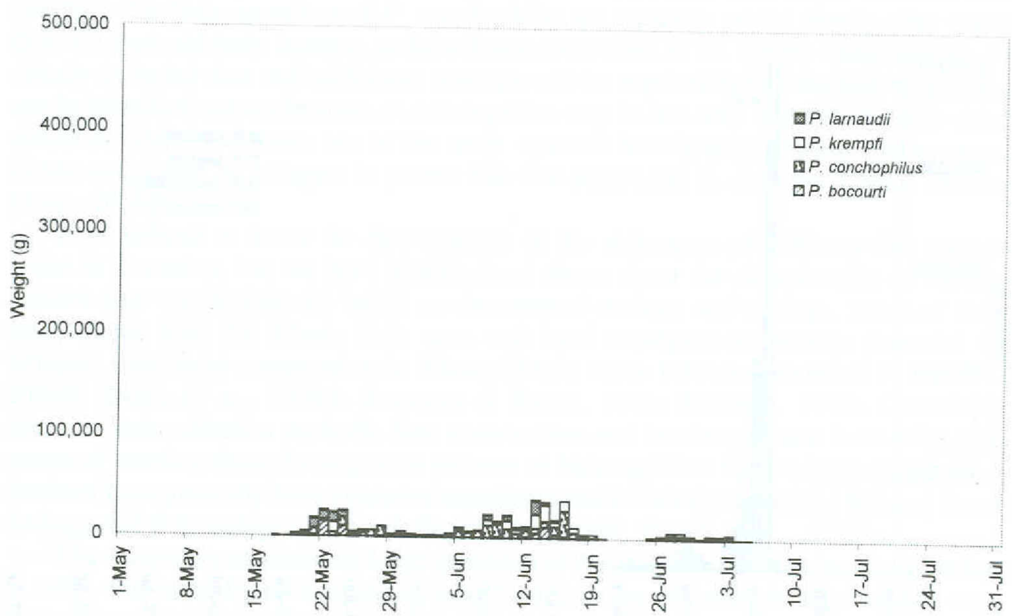

Figure 6. 1995 total daily fish catches and total catches of selected *Pangasius* species for the wing trap (*li*) fishery at Nok Kasoum Island, Khong District, Champasak Province, Lao PDR

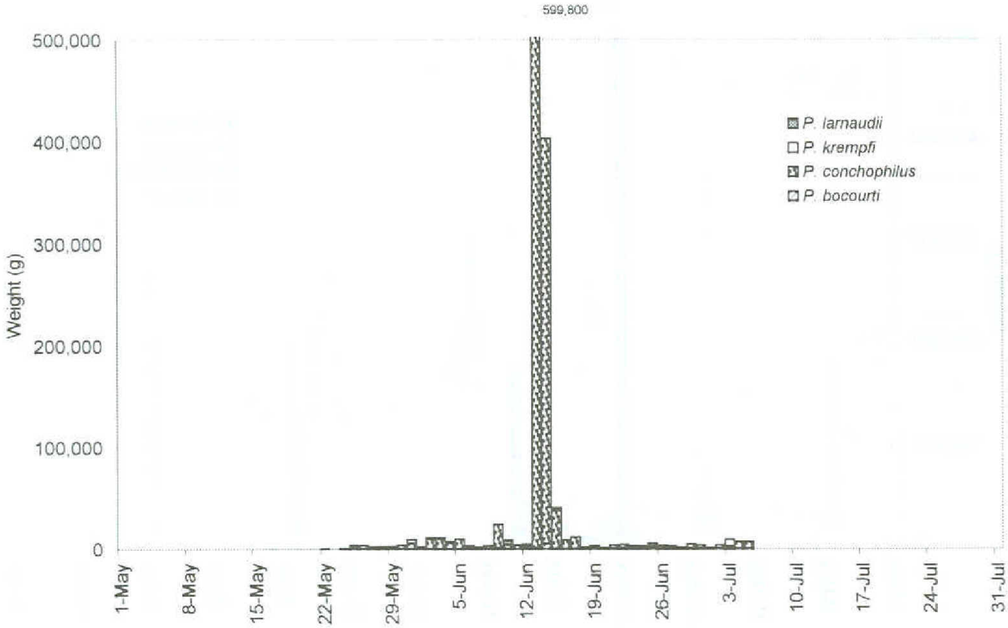

Figure 7. 1998 total daily fish catches and total catches of selected *Pangasius* species for the wing trap (*li*) fishery at Nok Kasoum Island, Khong District, Champasak Province, Lao PDR

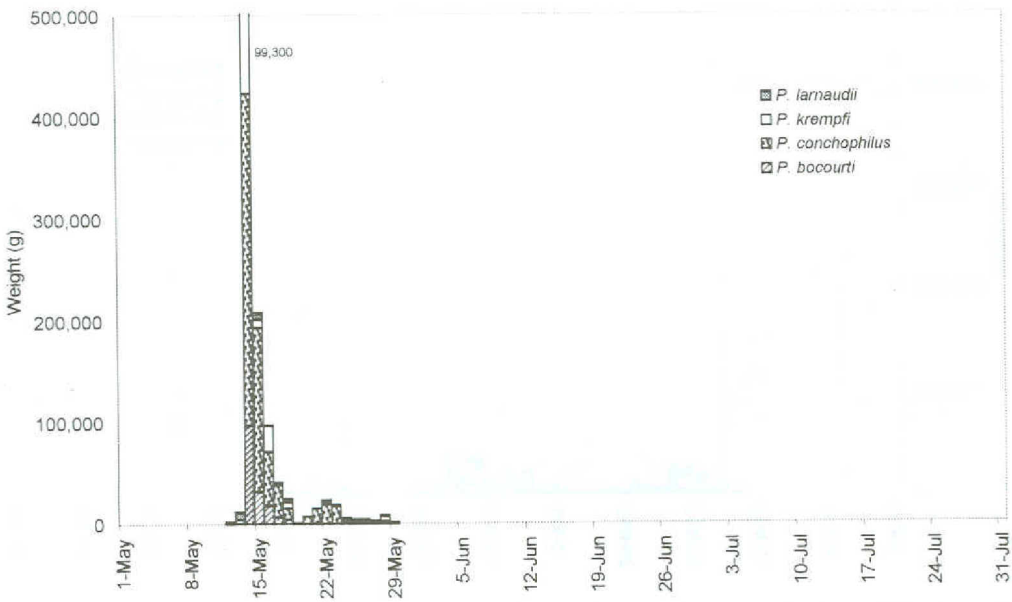

Figure 8. 1999 total daily fish catches and total catches of selected *Pangasius* species for the wing trap (*li*) fishery at Nok Kasoum Island, Khong District, Champasak Province, Lao PDR

In 1999, peak *Pangasius conchophilus* catches again occurred over a short period. The largest quantities were landed on May 14, and there were moderate catches on May 15. As in 1994, few *P. conchophilus* were caught just before or immediately after the peak fishing periods in 1998 and 1999.

DISCUSSION

There is not a close association between early rainy season pangasiid migrations and lunar phases. Fishers in the Khone Falls area have long maintained that changes in water levels are the main factor affecting fish migrations in the early rainy season (BAIRD & FLAHERTY, 2004A; BAIRD *ET AL.*, 2001B; BAIRD *ET AL.*, 1999A; BAIRD, 1998; ROBERTS & BAIRD, 1995; ROBERTS, 1993). However, with only four years of water discharge data available for comparison with the wing trap fish catches, it is difficult to confirm the extent to which hydrological factors are influencing fish migrations up the mainstream Mekong River. SINGHANOUVONG *ET AL.* (1996) reported that changes in temperature and turbidity do not appear to greatly affect migrations at the beginning of rainy season at the Khone Falls. We believe, as they do, that a combination of changes of water levels and currents are probably the main factors affecting migrations. However, it is unclear whether absolute water levels are the key, or if relative changes in water levels are more important. Local fishers at Nok Kasoum state that large migrations of *Pangasius conchophilus* migrate upriver when water levels reach a certain height, which fishers mentally mark with the location of the roots of certain seasonally inundated trees near their traps. We have also observed that large quantities of *P. conchophilus* are typically caught shortly after water flow volumes suddenly increase, as have SINGHANOUVONG *ET AL.* (1996). More analysis of already collected data and additional research will be required before the fish migrations can be identified and understood. *P. conchophilus* may in fact only migrate relatively short distances. They have been one of the main reported beneficiaries of Fish Conservation Zones established by villagers to protect fish that congregate in deep-water areas (BAIRD *ET AL.*, 2004B)

It is difficult to know the directionality of the migrations of different fish species found in *li* catches, but we have hypothesized above about the directionality of various species. Our conclusions are based on documented biology and ecology, years of field observations from the Khone Falls area, and local ecological knowledge provided by villagers from many communities in Khong District since 1993 (see BAIRD & FLAHERTY, 2004B; BAIRD *ET AL.*, 1999A; ROBERTS & BAIRD, 1995; ROBERTS, 1993). Combining scientific data collection methods, field observations and local experience is an invaluable means of learning about the migration patterns of Mekong River fish, as local people from southern Laos generally have extensive experience and knowledge regarding Mekong River ecology and fish biology (BAIRD & FLAHERTY, 2004B; BAIRD *ET AL.*, 1999A).

The occurrence of relatively large quantities of *Pangasius hypophthalmus* in *li* catches in 1995, with virtually no individuals being landed during the other three years data were collected, provides some important clues potentially useful for the management of juvenile *P. hypophthalmus* in Cambodia. BARDACH (1959) reported that *P. hypophthalmus* fingerlings are caught south of Phnom Penh over a short period in June and July, and sometimes in August, to supply cage and pond culture operations in Vietnam, and Cambodia to a lesser extent in Cambodia (NGOR, 1999). NGOR (1999) reported that in 1994 the Cambodian government banned the collection of juvenile *P. hypophthalmus*, which are collected near Phnom Penh, and in Kandal and Kampong Cham provinces, Central Cambodia (NGOR, 1999), using bag nets made of mosquito netting. However, the ban has apparently not been enforced and has been largely ineffective (Fisheries Officials, Department of Fisheries, pers. comm., 2000).

According to Cambodian fisheries officials, however, a number of junks carrying quantities of live juvenile *P. hypophthalmus* to Vietnam were sunk or damaged in August 1994 near Neak Luong, resulting in the release of large numbers of fish into the lower Mekong River. NGOR (1999) was unsure of the biological impact of banning the fishery. However, the occurrence of significant numbers of 0+ year class *P. hypopthalmus* in 1995 *li* catches indicates that the release of large numbers of juveniles into the Mekong River in 1994 (basically the equivalent of reducing the fishing effort on the juveniles) may have resulted in more larger fish migrating up to the Khone Falls during the following year. The lack of *P. hypophthalmus* in *li* catches during 1998 and 1999 also fits with this hypothesis, since no barges carrying fish have apparently been sunk since 1994.

BARDACH (1959) suggested that capturing fry and fingerlings of *Pangasius hypophthalmus* (listed by him as *Pangasius sutchi*), *P. larnaudii* and *Pangasius* sp. (listed as *Pangasius micronema*) was not destructive because their collection actually kept fish alive that would have died of natural mortality in the wild anyway. He expected that natural mortality for fry at the stage in life that they were being collected was 90 to 95%. BARDACH (1959) also reported that *P. hypophthalmus* migrate upriver from central Cambodia to the northeast Cambodian province of Stung Treng and onto the Khone Falls at the beginning of the rainy season, where they spawn. As described above, HOGAN *ET AL.* (2004) have recently provided solid evidence that these migrations occur. However, we know little about spawning activities for this species around the Khone Falls. More research should be devoted to this important regional management questions related to *P. hypophthalmus*.

Several methodological issues arose during this study. At the outset, several decisions were made regarding the most appropriate strategy for data collection. Collecting too much data is a waste of limited resources, while collecting too few data can leave researchers with an inadequate basis for answering questions important for making management decisions (COWX, 1995). This data collection program was largely exploratory in nature, and sampling was therefore done on a daily basis, rather than on days randomly selected or spaced over some interval of time. In contrast, SINGHANOUVONG *ET AL.* (1996) decided to sample the *li* fishery at Hou Som Gnai three days a week. While staggered fishery sampling is very cost-effective, our investigation of the *li* fishery suggests that daily sampling is preferable owing to the nature of the fishery. The bulk of the fish caught in the *li* fishery are often landed during a single night, or over two nights. For example, on 28 May 1994, 950 g of *Pangasius conchophilus* were caught at the traps at Nok Kasoum, but on 29 May 1994, the catch increased almost 1,000-fold to 947,960 g. The catches of *P. conchophilus* were just 26,100 g on 30 May 1994. Had our data collection been spaced at some interval of time, it is quite possible that we would have missed the main run of *P. conchophilus*. This, in turn, would have resulted in a significant under estimation of catches.

Figure 9. The third author adds a funnel basket to one of the two *li* traps at Nok Kasoum Island, just below the Khone Falls, monitored during this study. These baskets are only added when large quantities of *Henicorhynchus lobatus* are being caught during the daytime.

Figure 10. One of the many *li* traps used in the Khone Falls area of the mainstream Mekong River in southern Laos.

Figure 11. It takes about a month to build a single *li* trap out of wood, bamboo, rattan, vines and sometimes nails in the Khone Falls area.

Figure 12. *Li* traps are often situated in places with strong rapids and currents, or just below major waterfalls in the Khone Falls area.

Figure 13. Cyprinids collecting in a *li* trap at Nok Kasoum Island during the daytime. The Pangasiid catfish, the mainstay of the fishery, are mainly caught at night.

Figure 14. A woman collects small fish from a *li* trap at Nok Kasoum Island. All slides by Ian G. Baird

CONCLUSIONS

This study was undertaken to better understand the wing trap fishery in the lower reaches of the Mekong River, and to investigate whether a relationship exists between pangasid migrations and lunar cycles and/or hydrological cycles in the Mekong. There is some evidence that water discharge levels and associated changes in current regimes are the primary triggers for many of the bi-directional migrating fish that have been documented from the *li* fishery at the Khone Falls. Yet, much is still unknown about the biology and life cycles of the many species caught in *li* traps. Current information on the main characteristics of Mekong mainstream migrations is highly fragmented and often only qualitative in origin. The fact that the taxonomy of many Mekong fish species is confused adds further to difficulties in the documentation process (ROBERTS, 1997; SINGHANOUVONG *ET AL.*, 1996).

The pangasiid catfishes, including *Pangasius conchophilus*, *P. larnaudii*, *P. bocourti* and *P. krempfi* are the main highly migratory species targeted by this fishery at Nok Kasoum Island, but highly migratory minnows and carps such as *Henicorhynchus lobatus*, *Henicorhynchus siamensis*, *Labiobarbus leptocheilus*, *Lobocheilus melanotaenia*, *Crossocheilus reticulatus*, *Paralaubuca typus* and *Scaphognathops bandanensis* are also caught in large quantities. Other cyprinid carps, such as *Cosmocheilus harmandi*, *Cyclocheilichthys enoplos*, *Puntioplites falcifer* and *Hypsibarbus malcolmi*, make up significant proportions of the catch. Bagrid, silurid and sisorid catfishes like *Hemibagrus nemurus*, *Hemibagrus wyckioides*, *Bagarius yarrelli*, *Micronema* spp. and *Hemisilurus mekongensis* are also important in catches, but unlike the first groups, these carps and catfishes are unlikely to be long distance migrators, and may only disperse short distances at the beginning of the rainy season.

Considering the importance of the wing trap and other fisheries in the Khone Falls area to the welfare of local subsistence communities, it is critical that wise management decisions be made at local, national, and regional levels. Without considering various scales, it will be difficult to achieve effective management. In the face of growing development pressures, many of which promise short-term economic gains, it is essential to ensure that this important resource is protected and managed for the long-term. While there are many crucial management issues to consider in relation to the fish populations that the *li* fishery depends upon, the construction of large hydroelectric dams and water diversion projects on the mainstream Mekong River and her large tributaries are the most worrying. Dams could block important fish migrations, and fundamentally alter the ecology of rivers near the dam, and also downstream areas affected by changes in hydrology caused by dam construction and operation.

There are many planned dams in the Mekong basin that are viewed with grave concern by the international environmental community (HIRSCH & WYATT, 2004; BAIRD *ET AL.*, 2003; BAIRD *ET AL.*, 2001B; INTERNATIONAL RIVERS NETWORK, 1999; CLARIDGE *ET AL.*, 1997; MCCULLY, 1996; ROBERTS & BAIRD, 1995). However, the ten dams formerly envisioned by the Mekong River Commission for the mainstream Mekong River (MEKONG SECRETARIAT, 1994), as well as dams planned in the Sekong, Se San and Sre Pok basins in Viet Nam, Cambodia and Laos (HALCROW & PARTNERS, 1998), are of greatest concern to the future welfare of fishing-dependent rural communities in Laos. Already, the Yali Falls dam on the Se San River in Viet Nam has caused dramatic changes in river hydrology and water quality that have seriously negatively impacted riverine habitat and associated fisheries in the Cambodian provinces of Ratanakiri and Stung Treng (HIRSCH & WYATT, 2004; BAIRD & FLAHERTY, 2004A; BAIRD *ET AL.*, 2002). Artisanal fishing provides the backbone for local food security and contributes heavily to the village economies in communities scattered throughout the reaches of the Mekong River and its tributaries. Large dams constructed on the mainstream Mekong River or her larger tributaries, including in China, could devastate fisheries in a number of countries in the basin (BAIRD & FLAHERTY, 2004A; BAIRD *ET AL.*, 2003; BAIRD *ET AL.*, 2001B; BAIRD *ET AL.*, 1999A; ROBERTS & BAIRD, 1995). With so many people's livelihoods at stake, great caution is required before proceeding with these projects.

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