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Migration studies and CPUE data collection in Southern Lao P.D.R. 1994 to 2000

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Mid-Project Summary Report

Prepared for

The Living Aquatic Resources and Research Center (LARReC)
Vientiane, Lao P.D.R.

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Introduction

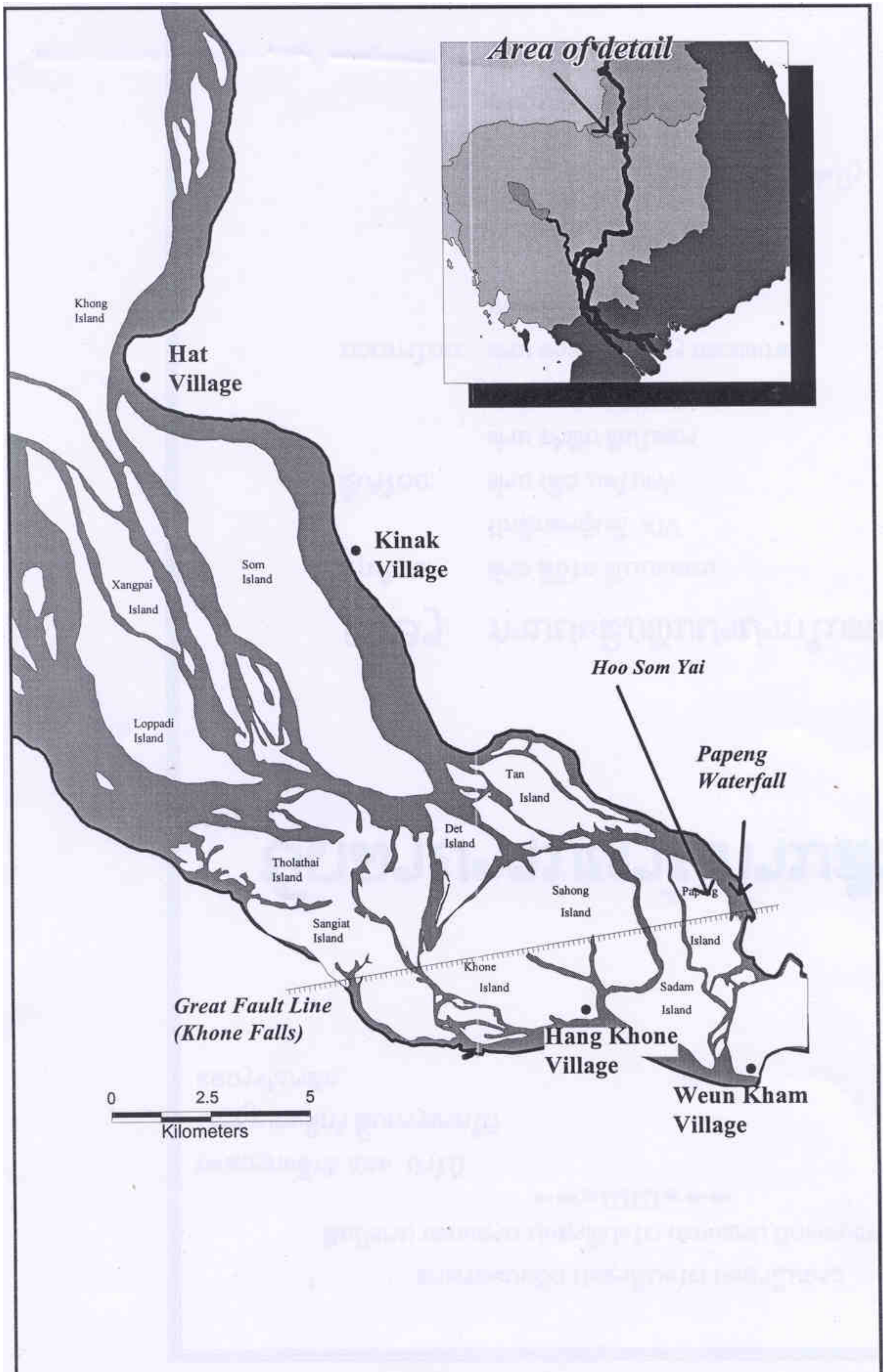
Important fish migrations take place in the Lower Mekong River of Southern Lao PDR during both the dry- and wet-season months. The riparian communities are aware of these movements and target a large number of species using a wide range of fishing gears. Cyprinid species dominate the upstream movements during the dry-season, but it is mainly catfish species of the Pangasiidae and Siluridae families that migrate upstream during the wet-season. The dry-season movements are mainly for dispersal / feeding and not for reproduction. Some of the upstream migrants in the wet-season are in reproductive condition and are on their spawning migration when they pass through Southern Laos.

Since 1993, efforts have been made to conduct basic research on these seasonal movements with the long-term objective of establishing a crude monitoring system. Technical and financial support has been provided to Provincial and District staff of the Department of Livestock/Fisheries (DLF) for this research by a number of separate projects and institutions since 1993. This is now the responsibility of the recently established LARReC institution in Vientiane.

Research into wet-season movements has been carried out in one rocky channel at the Great Fault Line since 1993. The channel is known locally as Hoo Som Yai and is located just west of the main Phapeng Waterfall just off route 13. Here, local fishers set bamboo wing traps into rapids to intercept the upstream movements of catfish during the early wet-season. The Great Fault Line represents just about the only place in the Lower Mekong where the wet-season movements can be researched and monitored effectively. CPUE data are recorded directly from fishers operating the traps from late May to the end of June. This represents the main period of movement for Pangasid and Silurid catfish; the two most important groups. Results are available in a number of project reports and a paper is currently in preparation for possible publication. Under direction from LARReC, a further data collection took place this year, and data are currently been entered, analyzed and presented in graphical form by LARReC staff.

Research into dry-season migrations has been carried out at the village of Ban Hat, just south of Khong Island and close to route 13, where the Lao Government has recently established its own research station. CPUE data have been gathered from drift gillnet fishers around the time of the lunar-orientated movements at Chinese New Year since 1994. In 1996, and again in 2000, the study was expanded to include an important fishing village (Ban Hadsalao) near to town of Pakse, some 130 km upstream from the Muang Khong site. The results of this research are available in a number of project reports and one published paper (Warren *et. al*., 1998). A fifth year of data collection took place over the Chinese New Year Period this year, and data have now been entered onto LARReC computers, analyzed and presented in graphical form.

The main objective of the research phase of the work at Ban Hat and Hoo Som Yai was to find out as much as possible regarding the nature of the migrations (species, direction, purpose, timing, variation in magnitude etc…) and to establish what external factors appear to influence them. The work has now moved into a monitoring phase whereby Provincial and District DLF staff have the capacity to be able to detect any catastrophic changes in species compositions or abundance.



Map of the Muang Khong area showing the locations where CPUE data have been gathered during the dry-season (Ban Hat) and wet-season (Hoo Som Yai).

Results

Wet-season migration studies at Hoo Som Yai

Studying fish migrations during the wet-season in a large, deep, turbid river like the Mekong is more difficult than studying the migrations during the dry-season. One reason for this is because gillnets, either fixed or drifted, which make excellent research tools because of their size and the number in use, often cannot be used during the wet-season months because water currents are too strong. In addition to this, many of the wet-season migrant species in the Mekong, particularly some catfish groups, are bottom dwelling fishes and as such are not always so vulnerable to capture as many of the mid-water to surface swimming fishes migrating during the dry-season.

Fortunately for our study, a unique geographical feature exists on the Mekong River in Southern Laos which has enabled us to study the wet-season migration. A large fault line cuts right across the river in Muang Khong district, just a few kilometers up-river from the border with Cambodia (see map). The fault line creates the Khone Waterfalls. At this point the river is very wide at approximately 10 km, and is divided up into a number of channels separated by islands. The fault line causes the river to plunge down some 20 m or so through the channels, many of which are shallow and rocky. Local artisanal fishers take advantage of this unique physical feature by constructing special traps set into the rapids in order to exploit a wide range of species that otherwise would be difficult to catch in any great numbers.

It is important to remember that the wet-season studies at Hoo Som Yai were conducted at a unique location and under atypical conditions. In this respect, our study more concerns exactly what happens to the wet-season migration specifically at the fault line. If the fault line did not exist, it seems highly likely that the migration patterns, as observed and recorded by us, would be quite different. The results of our wet-season studies in 1993, 1994, 1996, 1997 and 1998 are summarized below:

Main migratory families

GROUP 1:

Bagridae	(2 species) Pba Kot, Pba Kung
Cyprinidae	(1 species) Pba Nai
Pangasidae	(6 species) Pba Por, Pba Beung, Pba Sooai Hang Leuang, Pba Noo, Pba Nyawn, Pba Nyawn Tawng Khoom, Pba Nyawn Hang Hian.
Siluridae	(7 species) Pba Khop, Pba Nang Deng, Pba Nang, Pba Peekgai (1), Pba Peekgai (2), Pba Peekgai (3), Pba Seum.
Sisoridae	(2 species) Pba Khe (1), Pba Khe (2).

GROUP 2:

Cyprinidae	(6 species) Pba Soi Hua Lem, Pba Soi Hua Bo, Pba Lang Khon, Pba Dtep, Pba Kiang, Pba Tok Toi, Pba Wa Sooang, Pba Eun (Pba Eun juveniles only).

(See Appendix 1 for scientific names).

Timing

Movement at the fault line usually begins within the first 2 weeks after the start of the wet-season. The end of the wet-season movement in HSY is not known because the site cannot be accessed for data recording after about early July. Evidence from other channels suggest that movements of some species continue until at least August. However, the two most important groups migrating through HSY (Pangasidae and Siluridae) appear to make most of their movements during May and June.

Direction

Group 1 species move upstream. Group 1 species move downstream.

Purpose

The primary purpose of the upstream migration for some species (in certain size classes) appears to be reproduction (Pba Por, Pba Beung, Pba Sooai Hang Leuang, Pba Noo, Pba Seum, Pba Kot and Pba Nyawn Hang Hian). For at least one species (Pba Por) there appears to be a large movement of juvenile fish on a dispersal/feeding type migration. For the species moving downstream (all those except juvenile Pba Eun), all are in full reproductive condition just before, during or just after the movement. It seems likely that for most species, reproduction is followed by a downstream post-spawning movement.

Duration

Since the exact origins and destinations of the upstream migrations are not known, the total duration of the wet-season movement is also not known. Some species appear to move in very large numbers on only 2 or 3 nights over the whole migratory period (Pba Por), whereas others make regular movements over longer periods (Pba Beung, Pba Nang Deng).

Origin

The origin of the wet-season upstream movement is almost certainly in Cambodian territorial waters. One Pangasid species (Pba Sooai Hang Leuang) may be anadromous and may migrate into the Mekong from the South China Sea. Downstream movements of cyprinids likely have their origins in the mainstream and inundated areas, such as swamps and rice-paddies, bordering the Mekong River.

Destination

The destination of the upstream migration is unknown. Some species may enter tributaries, or small seasonal streams, for spawning (Pba Seum, Pba Kot) but so far, it is not clear if the larger Pangasid species do the same in any great numbers. They may remain in the mainstream and spawn at considerable distances further upstream.

Environmental, hydrological and other factors influencing the migration

Nothing is known about the factors that trigger the upstream movement from Cambodian waters. However, it seems likely that changes in water depth and velocity, water chemistry, temperature and turbidity brought about by the first rains of the season may act as external triggers. These factors may act in isolation or in consort. Movement up and over the Great Fault Line appears to be regulated mainly by water flow volume down through the fault line channels (Fig.'s 1 and 2). There appears to be a threshold flow volume that triggers the initial movement. Further movements depend on sudden increases in flow volume, but the actual number of fish migrating on any one night is also dependent on the number of fish waiting to make their ascent.

Some general observations on the wet-season movement in HSY

The most important species landed by weight in HSY is Pba Beung (*Pangasius larnaudii*). The wet-season movement over the Great Fault Line is nocturnal. Over other stretches of the river away from the fault line, there is no evidence to suggest that it is only nocturnal or only diurnal. The migration often begins with one or two large runs of fish as threshold water flow volumes are attained (Fig.1). These initial large runs may be the result of an accumulation of fish below the Great Fault Line before conditions become suitable for the ascent. Further large runs may take place, but usually only occur after a period of dry, settled weather when water levels have been decreasing. Sudden decreases in flow volume can halt the movement up and over the fault line. Sudden increases in flow volume can stimulate migratory movement, but it depends on how many fish are waiting to make the ascent. Very dark nights with heavy rainfall, particularly when water levels have been increasing rapidly during the day, often bring about the largest runs of all.

Often it is the largest specimens of each species that are observed first in HSY and also local markets. This is consistent with reports from other large floodplain rivers; the largest fish usually being the strongest swimmers. In many of the wet-season migratory populations, it appears that female fish dominate male fish by up to 100%.

Some actual and extrapolated fishery parameters and statistics from HSY

Table 1. Fishery parameters and estimated fish landings in HSY during the wet-season migrations from 1994 to 2000.

PARAMETER	1994	1996	1997	1998	2000
No. of sampling days between May 24 and June 28 (main Pangasid migration period).	16	16	14	16	16
Total No.of days between May 24 and June 28.	36	36	36	36	36
Total No. of migratory fish landed based on trap samples and No. of working traps on sampling days only.	14,645	1,635	1,175	2,656	1,483
Total weight of migratory fish landed based on trap samples and No. of working traps on sampling days only (Kg).	1,622	523	198	472	288
Mean No. of traps used based on sampling days.	13.6	16.6	18.2	15.6	10.5
Mean weight of migratory species (g).	110.8	319.7	168.5	177.7	194.2*
Estimated mean No. of migratory species caught per trap/night in HSY.	67	6	5	11	9
Estimated mean weight of migratory species caught per trap/night in HSY (Kg).	7.42	1.92	0.84	1.95	1.75
Estimated mean weight of migratory species caught per night in HSY (Kg).	101.0	32.0	15.3	30.4	18.4
Estimated total landings in HSY over the 36-day main migration period from May 24 to June 28 (Kg).	3,632	1,148	551	1,094	662
Estimated total landings per trap over the main 36-day migration period in HSY (Kg).	267	32	30	70	63
Estimated income from fish sales to commercial traders if sold at 1000K/Kg (94,96), 3000K/Kg (97, 98) and 10000K/Kg in 2000.	267,100K (290.3 USD)	69,200K (75.2 USD)	90,000K (26.0 USD)	210,000K (60.0 USD)	630,000K (78.8 USD)
Estimated percentage contribution to per capita income (GDP) based on a figure of 300USD.	98%	25%	9%	20%	26%

***** Mean weight of migratory species estimated from previous data

Note: In 1994 and 1996, 1 USD equivalent to 920K
In 1997 and 1998, 1 USD equivalent to 3,500K
In 2000, 1USD equivalent to 8,000K

Table 2. Estimated extrapolated fish landings from all 18 channels traversing the Great Fault Line during the wet-season migrations from 1994 to 2000.

PARAMETER	1994	1996	1997	1998	2000
Estimated landings and value if 200 traps in operation.	1.48 Tonnes / Night (1,609 USD)	0.38 Tonnes / Night (413 USD)	0.17 Tonnes / Night (144 USD)	0.39 Tonnes / Night (334 USD)	0.35 Tonnes / Night (438 USD)
Estimated landings and value during the whole 36-night migration.	53.28 Tonnes (57,913 USD)	13.68 Tonnes (14,870 USD)	6.12 Tonnes (5,245 USD)	14.04 Tonnes (12,034 USD)	12.6 Tonnes (15,768 USD)
Estimated landings and value if 400 traps in operation.	2.97 Tonnes / Night (3,228 USD)	0.77 Tonnes / Night (837 USD)	0.34 Tonnes / Night (288 USD)	0.78 Tonnes / Night (668 USD)	0.7 Tonnes / Night (876 USD)
Estimated landings and value during the whole 36 night migration.	106.92 Tonnes (116,217 USD)	27.72 Tonnes (30,130 USD)	0.68 Tonnes (10,490 USD)	28.08 Tonnes (24,068 USD)	25.2 Tonnes (31,536 USD)

Graphical representations of the migratory patterns in HSY during the period from May 24 to June 28 in 1994, 1996, 1997 and 1998.

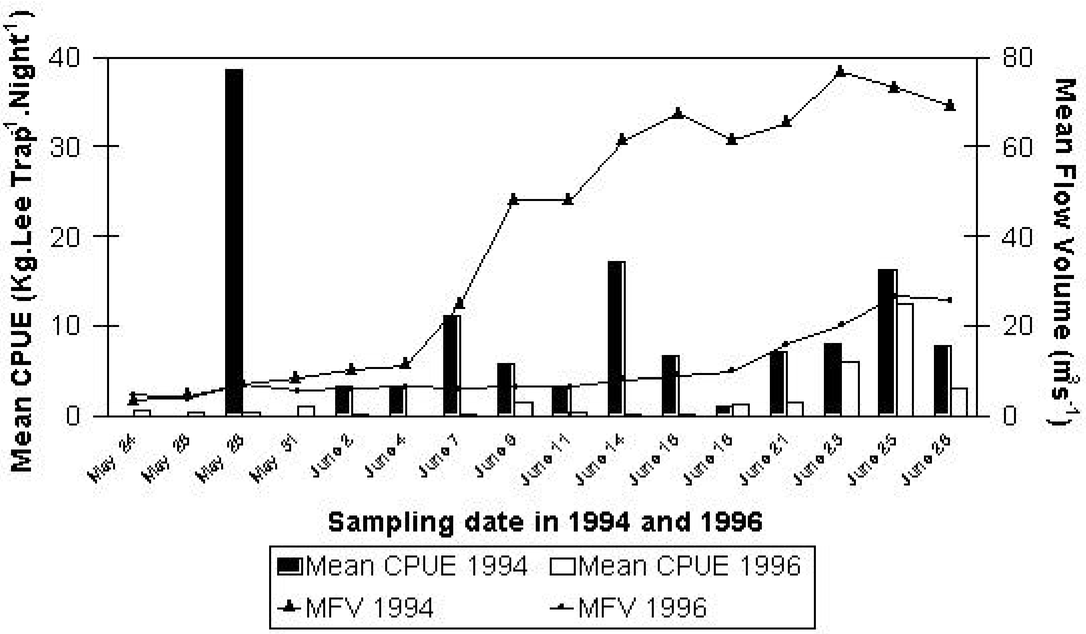


Fig.1 Migratory activity for all species together during wet-season studies in HSY in 1994 and 1996.

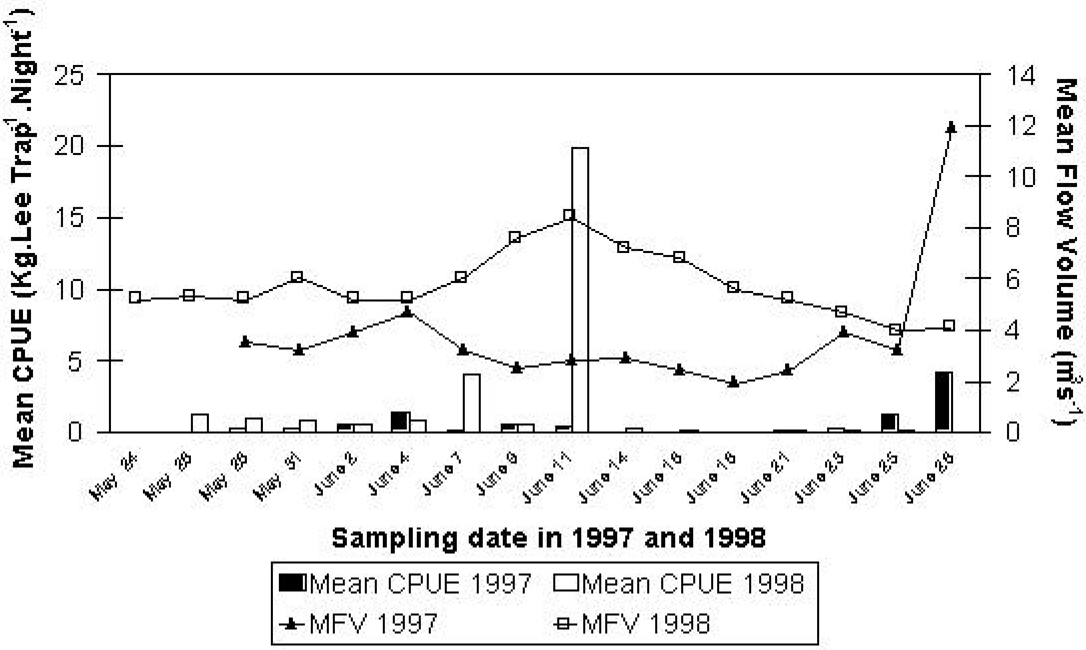


Fig 2. Migratory activity for all species together during the wet-season studies in HSY in 1997 and 1998.

The upstream, dry-season migration at Ban Hat, Muang Khong and Ban Hadsalao, Pakse

Dry-season migration studies were carried out in co-operation with local artisanal fishers using drift-gillnets at Ban Hat over three years from 1995 to 1997, following exploratory studies in 1994. In 1996 (and again in 2000), the study was extended to Ban Hadsalao at Pakse to provide a spatial dimension to the investigation. The village of Ban Hat at Muang Khong was chosen based on the recommendations of the local district authorities who reported exceptionally high fish landings there during annual dry-season migrations. Hadsalao village was chosen because it was one important fishing village where the methods of fishing were almost identical to those used at Ban Hat, and was conveniently positioned close to the government's departmental offices at Pakse.

The main gear in use during the dry-season months at both Ban Hat and Ban Hadsalao is the monofilament drift-gillnet. Drift-gillnets are much preferred by fishers because of the large amounts of floating algae weed in the water column during dry-season months, which causes clogging of fixed gill-nets. Mesh sizes almost always range between 5 cm and 7 cm. Although there are a number of other species migrating in the Ban Hat area during the dry-season months, gillnet fishers target 9 migratory species, which form the mainstay of the fishery. The results of our dry-season migration studies are summarized below:

Main migratory families

Cyprinidae	(8 species) Pba Pien9, Pba Pien13, Pba Geng, Pba Wa Sooang, Pba Wa Na Nor, Pba Saee, Pba Pawn, Pba Pak Nouat.
Gyrinochelidae	(1 species) Pba Ko

(See Appendix 1 for scientific names of species).

Timing

Movements usually occur as a series of waves; the first one often taking place in December. Movements are linked to the lunar cycle and take place during the last lunar cycle of the preceding year and at least the first and second lunar cycles of the new year. It is highly likely that movements take place in the third and fourth lunar cycles also.

Direction

All species, upstream.

Purpose

Of the eight migratory Cyprinid species targeted by fishers, a large proportion of Pba Pien13 and Pba Pak Nouat landed are in full reproductive condition around the December to January period. Based on data gathered in 1996, it appears that Pba Pien13 does not migrate in any great numbers to Pakse. It may migrate to Muang Khong specifically to spawn. This may be the case for Pba Pak Nouat also. The remaining 6 cyprinid species are in non-reproductive condition during the dry-season migrations, and populations are mostly dominated by small specimens which may be in either 0+ or 1+ year classes. For these six species, the primary purpose of the migration appears to be dispersal/feeding. The one Gyrinochelid species specifically migrates to rocky areas within the Muang Khong area to graze on filamentous algae.

Duration

The total duration of the dry-season upstream movement is likely to be some 4 to 5 months. However, the movements occur as a series of waves and are most intense for about 7 to 10 days at the darkest period of the month, around the time of the new moon. Migratory movements all but cease around the time of the full moon.

Origin

The origins of the dry-season movements are mostly in Cambodian territorial waters.

Destination

As mentioned above, it seems possible that two of the eight migratory cyprinids specifically migrate to Muang Khong to spawn. Apart from Pba Pien9, and perhaps Pba Saee, there is no evidence that most species continue their migratory journey much beyond the area of Muang Khong. Muang Khong may represent the destination for some species.

Environmental, hydrological and other factors influencing the migration

Our studies specifically at Ban Hat, Muang Khong, show that migratory intensity during the dry-season months is directly under the influence of the lunar cycle. The greatest movements of fish take place past Ban Hat during the darkest period of the month, around the time of the new moon (Fig's 3 and 5). One such peak occurs around the time of the lunar dependent Chinese New Year and is known locally as the "Groot Jeen", or Chinese New Year migration. The Chinese New Year coincides with the new moon phase of the second lunar cycle after the winter solstice in late December (Fig.3). Our studies in 1996 show that there is also a large movement of fishes around the time of the new moon phase associated with the first lunar cycle after the winter solstice also (Fig.5). These types of lunar-orientated movements may also take place during the 3rd and 4th lunar cycles also, but as yet we have not carried out research on these. It is important to note that this lunar-orientated movement was not recorded at Ban Hadsalao, near to Pakse where the lunar effect seems negligible or absent altogether (Fig.4).

Because of dry-season conditions, river water levels continually drop and water current velocities gradually reduce from around about November to April each year. Under these conditions, migratory activity peaks around the time of the new moon phase during each lunar month (Fig.5). However, if water levels and current velocities increase just before, or during the peak in migratory activity, the migration may be temporarily halted (Fig.3). If water levels start to decrease again, the migration may resume almost immediately (Fig.3).

Based on our limited observations over three years at Ban Hat, Muang Khong, it seems possible that water temperature may exert an influence over the overall magnitude of the migration during any one lunar cycle. Specifically concerning the Chinese New Year migration, our studies found that migratory activity for all species together was lowest when water temperatures were highest (1994); highest when water temperatures were lowest (1995) and intermediate in 1996 and 1997 when water temperatures were in between the 1994 and 1995 extremes.

Some general observations on the dry-season migration

By far the most important species caught during the dry-season migrations at Ban Hat and Ban Hadsalao is Pba Pien9 (*Scaphognathops bandanensis*). Fish movements are diurnal, and may be nocturnal also. A daytime fishery operates at Ban Hat and Ban Hadsalao. Fish are brought ashore and kept alive in special bamboo cages. The numbers of individual species migrating passed Hat Village can be highly variable from year to year. In 1995 for example, there was a massive movement of Pba Pawn past Hat Village at CNY time whereas in 1994 and 1996 the movement was very small by comparison. All species caught during the dry-season migration feed heavily on growths of filamentous algae which are attached to bottom substrates and also floating in the water column. Most of the fishes migrating during the dry-season are cyprinid species and locate their food by sight.

In 1996 a CPUE sampling program was carried out at Ban Hat, Muang Khong and Hadsalao Village, Pakse using the same sampling techniques and dates (Fig.4). The results showed that two large peaks in migratory activity at Hadsalao were not centered around the new moon lunar phase as at Hat Village, Muang Khong but were separated from the peaks at Muang Khong by periods of seven and five days respectively (Fig.4). If the peaks at Muang Khong and Pakse are related to one another, then swimming speeds would need to range between 19 km and 26 km per day in order for the fish to be able to get from Muang Khong to Pakse. These swimming speeds are consistent with figures recorded for other species on other large river systems.

Some actual and extrapolated fishery parameters and statistics from the Ban Hat and Ban Hadsalao fishery

Table 3. Fishery parameters and actual fish landings recorded during the 1994 to 2000 dry-season CNY migrations at Ban Hat and Ban Hadsalao.

PARAMETER	Hat 1994	Hat 1995	Hat 1996	Hat 1997	Hat 2000	Hadsalao 2000
No. of sampling days between – 4days NM to NM +15days.	13	14	14	15	15	15
Mean No. hours spent fishing per fisher per day.	3.7 SE=0.2	7.0 SE=0.2	4.3 SE=0.1	4.9 SE=0.1	5.5 SE=0.12	5.5 SE=0.3
Mean area of net used per fisher per day (m^2)	436.4 SE=5.6	548.3 SE=29.5	422.9 SE=13.9	552.6 SE=17.4	498 SE=19.6	646.3 SE=38.2
Mean TE used per fisher per day ($100m^2$ Net Hrs)	16.1 SE=0.8	39.3 SE=2.6	18.9 SE=1.0	27.2 SE=1.2	28.0 Se=1.4	37.3 SE=3.0
Mean No. migratory fish landed per fisher per day.	2.6 SE=0.4	31.8 SE=3.0	7.7 SE=1.1	7.2 SE=0.7	4.8 SE=0.6	6.8 SE=1.4
Mean weight of migratory fish landed (g).	214.4	168.7	159.1	179.6	180.5*	180.5*
Mean number of fishers out fishing per day	33.3 SD=25.6	72.9 SD=37.3	30.4 SD=37.7	38.2 SD=31.6	52.2 SD=21.4	6.8 SD=5.0
Estimated daily TE of all fishers out fishing per day ($100m^2$ Net Hrs).	536.5	2867.2	575.8	1039.0	1461.6	253.6
Mean No. of migratory fish caught by all fishers per day.	86.6	2318.2	234.1	275.0	250.6	46.2
Estimated total weight of all migratory fish caught by all fishers per day (Kg).	18.6	391.1	37.2	49.4	45.2	8.4
Estimated total No. of migratory fish landed during CNY migration (NM –4days to NM +15Days).	1,732	46,364	4,681	5,501	5,012	924
Estimated total weight of migratory fish landed during CNY migration (Kg)	371.4	7,821.6	744.8	988.0	904.7	166.8

***** Mean weight of migratory fish estimated from previous data

Graphical representations of migratory patterns at Ban Hat, Muang Khong and Ban Hadsalao Pakse

The sampling period during the Chinese New Year migration was from 4 days before the CNYnew moon to 15 days after it in all three study years.

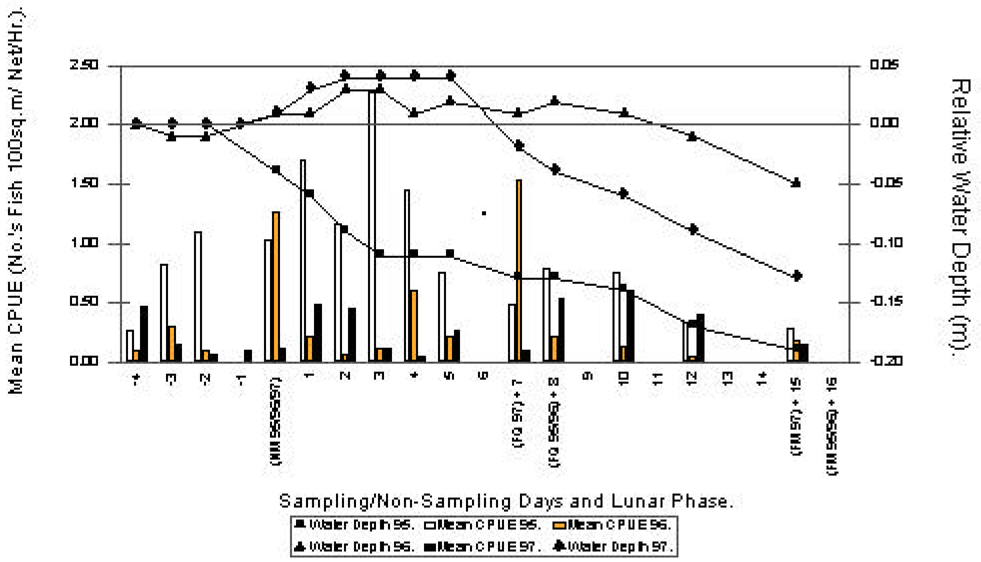


Fig 3. Migratory activity for all species together during the CNY migration studies at Hat village, Muang Khong, 1995 to 1997 (Second lunar phase after winter solstice).

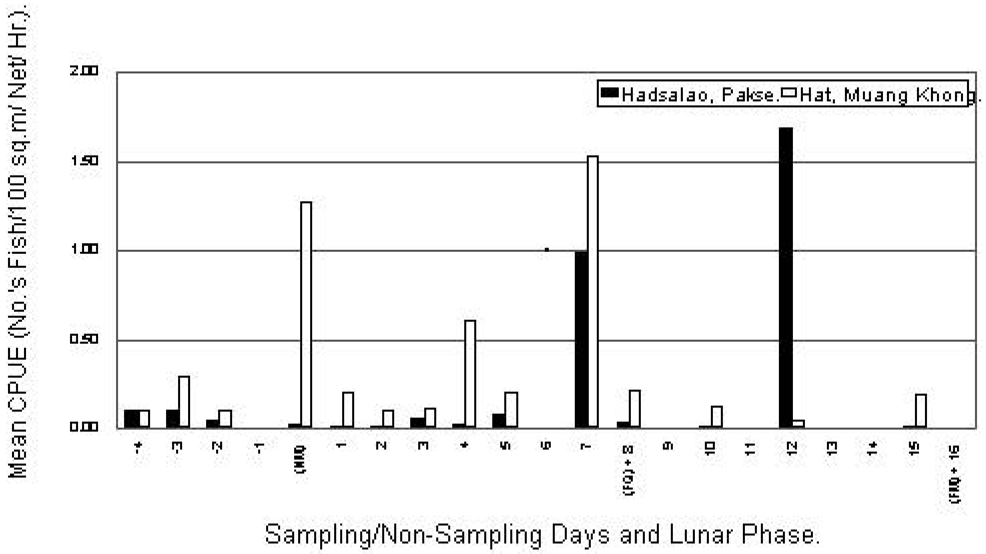


Fig 4. Migratory activity for all species together during the 1996 CNY migration at Ban Hat, Muang Khong and the study at Ban Hadsalao, Pakse (second lunar phase after winter solstice).

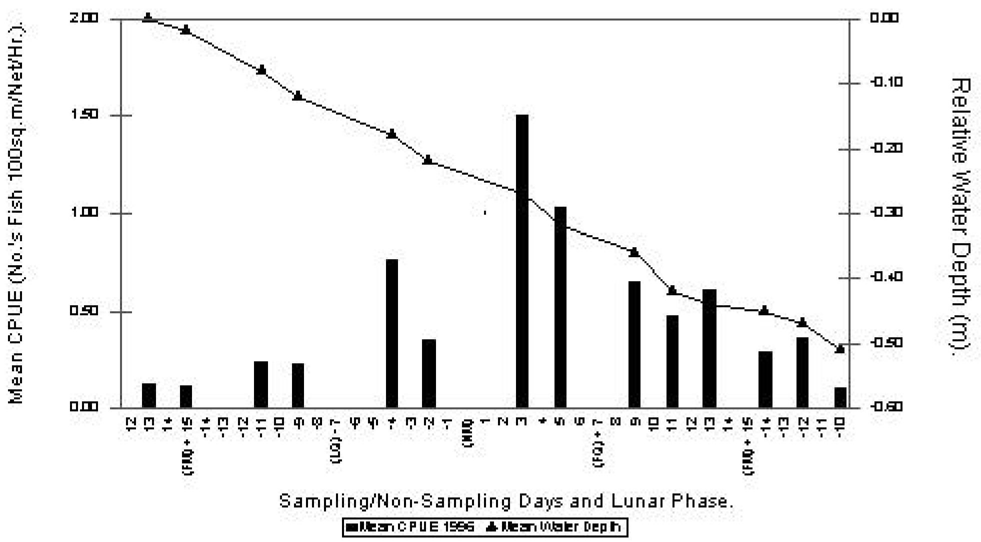


Fig 5. Migratory activity for all species together during the 1996 early dry season study at Ban Hat, Muang Khong (first lunar phase after winter solstice).

The Migration / CPUE studies in Southern Lao PDR 1993 to 1998

Very large numbers of people in Southern Lao PDR and Cambodia rely on the annual mainstream fish migrations to support their subsistence level livelihoods. Anecdotal evidence from local artisanal fishers suggests stocks are declining in numbers, but hard data to support this are lacking. In the absence of more quantitative data on fish stocks, all but generic management options are reduced to guesswork and speculation.

The Migration/CPUE studies have for the most part met their intended objectives. These studies were one of the first of their kind on the Mekong mainstream and have provided much needed baseline information on what is a highly complex and vital resource. Our study results should be viewed in the light of how little information was available to begin with. Whereas definitive management strategies are often the ultimate goal of such studies, the sheer size, complexity and dynamic nature of multi-species fisheries in large river systems inevitably means that many years of research are needed before effective management options can be formulated.

One major benefit of these studies is that they have provided a grounding on which larger, more extensive studies can be planned and implemented. They have provided fisheries researchers in the Lao PDR with a practical tool to monitor annual fish migrations and hopefully identify catastrophic declines over time. They have shown that fish landings, recorded as standardized catch (CPUE), are sensitive to changes in environmental and hydrological factors.

Year 2000 studies in Muang Khong and at Pakse

Following a resumption of migration / CPUE studies at both the above sites in 2000, under the direction of LARReC, an external advisor (Mr. Terry Warren) provided training in methods of data collection, data storage, analysis, graphical presentation and interpretation to LARReC and Provincial and District DLF staff. Details of the two separate training workshops (and names of the participants) are provided in Appendix 2 of this report. In summary, LARReC and Provincial and District DLF staff have been provided with the following:

- Background slide presentations covering the dry-season and wet-season studies
- An explanation of the main purposes and objectives of the studies
- An explanation of the methodologies used during the studies and practical demonstrations of the technical calculations involved
- A practical session on making up field data forms
- A practical session on how to enter the data onto computer spreadsheets
- A practical session on how to analyze, graph and interpret the data recorded

The data from the wet and dry-season studies at Ban Hat, Ban Hadsalao and Hoo Som Yai have now been entered, analyzed and graphed and appear over page. It is anticipated that another data collection will take place next year (2001). LARReC, PLF and DLF staff are now in a position to undertake the research themselves with perhaps only a minimal input from an external advisor.

Graphical representations of the dry-season CPUE studies at Ban Hat and Ban Hadsalao 2000, and wet-season studies at Hoo Som Yai 2000.

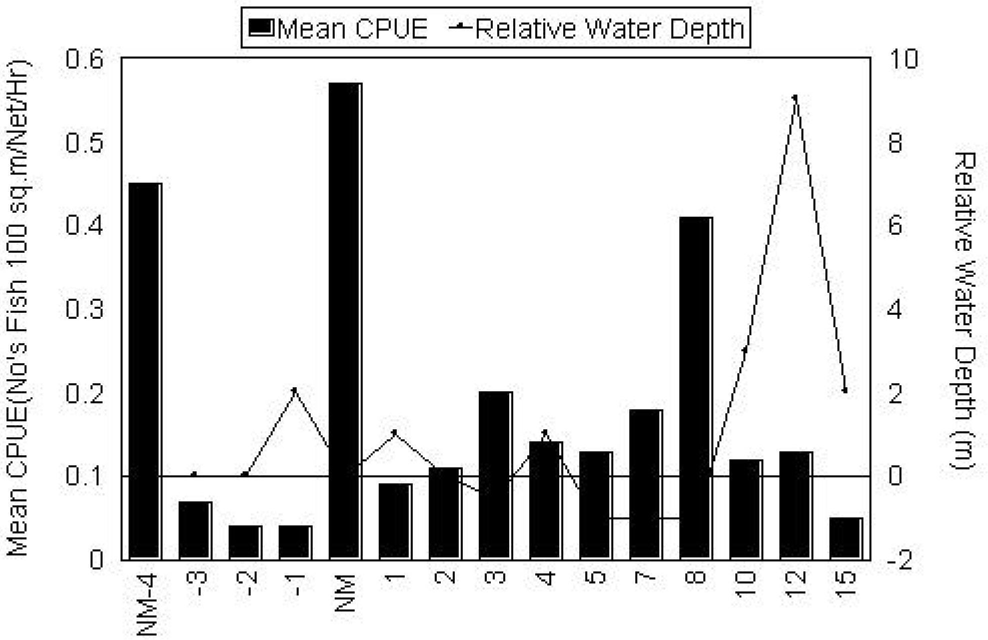


Fig 6. Migratory activity for all species together during the dry-season study at Ban Hat in 2000.

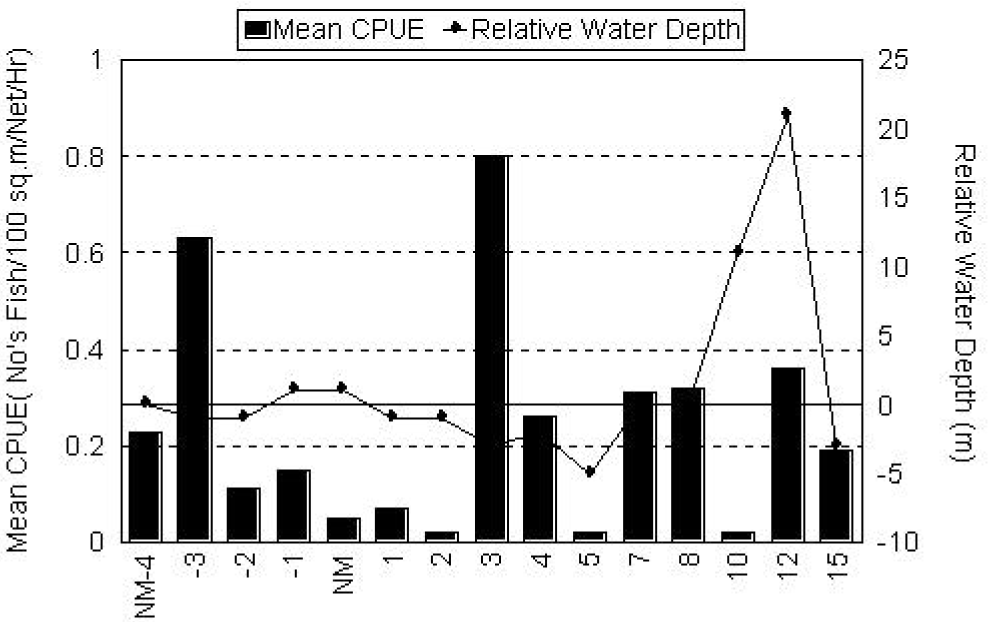


Fig. 7. Migratory activity for all species together during dry-season studies at Ban Hadsalao, Pakse in 2000.

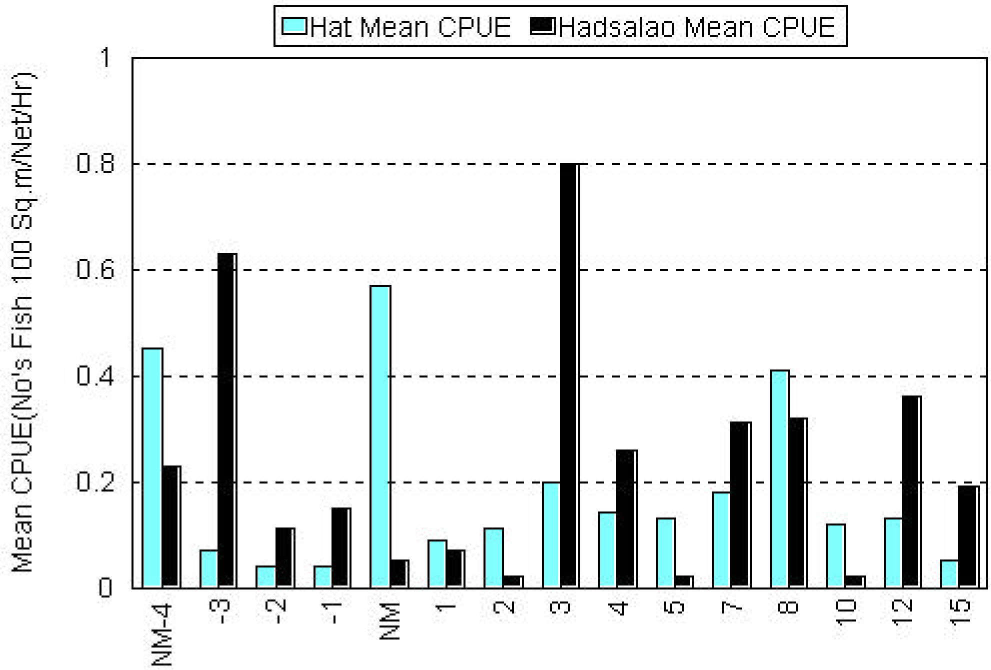


Fig. 8. Migratory activity for all species together during studies at Ban Hat and Ban Hadsalao in 2000.

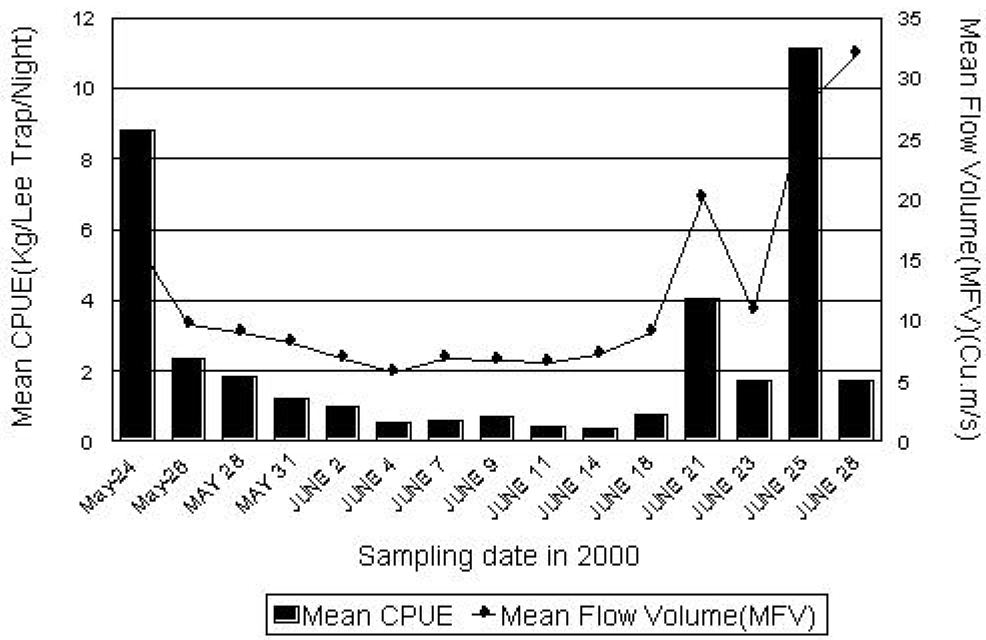


Fig. 9. Migratory activity for all species together during wet-season studies in HSY in 2000.

Discussion of results in 2000

The results from the studies at Ban Hat in 2000 are consistent with some previous studies in that the highest CPUE was recorded during the darkest time of the lunar cycle (Fig. 6). However, the constant rising and falling of the river level (with associated changes in flow volume and current speeds), produced a predictable distortion to the level of migratory activity over what remained of the complete lunar cycle up to full moon (at day NM +15). In general, a rise in water level caused a decrease in migratory activity, whilst a decrease in water level brought about an increase in migratory activity (Fig. 6). This is consistent with previous studies and is a phenomenon also reported anecdotally by local fishers.

At Ban Hadsalao, Pakse migratory activity also appeared to be associated with a rise in water level, but the relationship was less clear (Fig. 7). In addition, there was no peak in migratory activity on the day of the new moon as observed at Ban Hat, Muang Khong. This is consistent with studies carried out on 1996, where migratory activity at Pakse did not appear to be under the influence of the lunar cycle as observed at Muang Khong (Fig. 4). Some theories and hypotheses to possibly account for these observations are provided by Warren *et al*., (1998).

It is not known if the groups of fish that pass the village of Ban Hat in Muang Khong, eventually reach Pakse and move beyond. Previous studies in 1996 attempted to associate the peaks in migratory activity observed at Muang Khong and Pakse (Fig. 4). Although pure speculation at present, if there is an association between the peaks, the fish would need to have swum between 19 and 26 km per day in order to travel the distance from Muang Khong to Pakse within the time period. The peaks in migratory activity during the 2000 studies may, or may not be associated (Fig. 8). Certainly, the NM-4 peak at Hat village and the NM-3 peak at Hadsalao village cannot be linked (Fig. 7). There is a remote possibility that there is some link between the NM peak at Ban Hat, and the peak on NM+3 at Ban Hadsalao, Pakse. However, given that the two villages are some 130 km apart, the fish would need to swim at a rate of approximately 43 km per day (1.8 km per hour) in order to reach Pakse after passing Muang Khong. This seems unlikely, but swimming speeds are unknown for any Mekong species at present. A tagging study planned for February 2001 at Ban Hat and Ban Hadsalao may reveal more information.

Wet-season studies at Hoo Som Yai in 2000 showed a good positive relationship between flow volume and migratory activity (Fig. 9). In general, a decrease in flow volume caused a cessation of fish movement, whereas an increase in flow volume stimulated an immediate further upstream movement of fish (Fig. 9). However, observations and data from previous studies suggest that there may not always be a direct cause and effect relationship. It appears that although there is a relationship between flow volume and migratory activity, the degree of fish movement is also governed by the numbers of fish waiting to move below the fault line. This in itself is dependent on the level of movement during the period immediately before the day of recording.

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Appendix 1.

Lao vernacular names, scientific names and families of the species investigated during the migration / CPUE studies.

Lao vernacular name	Species scientific name	Family
Wa Sooang	*Labeo erythropterus*	Cyprinidae
Geng	*Cirrhinus molitorella*	Cyprinidae
Pien 13	*Scaphognathops stejnegeri*	Cyprinidae
Pien 9	*Scaphognathops bandanensis*	Cyprinidae
Saee	*Mekongina erythrospila*	Cyprinidae
Pawn	*Cirrhinus microlepis*	Cyprinidae
Pak Nouat	*Hypsibarbus* sp.	Cyprinidae
Eun	*Probarbus jullieni*	Cyprinidae
Wa Na Nor	*Bangana behri*	Cyprinidae
Nang Deng	*Hemisilurus mekongensis*	Siluridae
Soi	*Henichorynchus* sp.	Cyprinidae
Lang Khon	*Dangila* sp. cf *cuveri*	Cyprinidae
Khao	*Wallago attu*	Siluridae
Khop	*Belodontichthys dinema*	Siluridae
Dtaep	*Paralabuca typus*	Cyprinidae
Kiang	*Lobocheilus melantaenia*	Cyprinidae
Kot	*Mystus nemurus*	Bagridae
Kung	*Mystus wyckiodes*	Bagridae
Sooai Hang Leuang	*Pangasius krempfi*	Pangasidae
Beung	*Pangasius larnaudiei*	Pangasidae
Nyawn Hang Hian	*Pangasius polyuranodon*	Pangasidae
Por	*Pangasius chonchophilus*	Pangasidae
Nyawn Tong Khom	*Pangasius pleurotaenia*	Pangasidae
Nyawn	*Pangasius siamensis*	Pangasidae
Noo	*Helicophagus waandersi*	Pangasidae
Peek Gai	*Krytopterus* sp.	Siluridae
Ko	*Gyrinocheilus pennocki*	Gyrinocheilidae
Seum	*Ompok bimaculatus*	Siluridae
Nai	*Cyprinus carpio*	Cyprinidae
Tok Toi	*Crossochelus* sp.	Cyprinidae
Khe	*Bagarius yarreli*	Sisoridae

Appendix 2
Tentative schedule for training in migration studies / CPUE data collection and related bio-statistics

Living Aquatic Resources and Research Center

April 26 to 28, 2000

Date: Wednesday April 26
Timing: 13:30 to 16:00 hrs
Topic: Introduction to migration / CPUE studies in Southern Lao PDR
Detail:

- Background and objectives of migration studies
- Slide presentation of the studies carried out so far
- Overview of the main results obtained and current state of knowledge
- The need for time-series data
- Review of known major fish movements in Lower Mekong Basin
- Familiarization with the main species involved

Date: Thursday April 27
Timing: 09:15 to 12:00 hrs
Topic: Collecting and entering CPUE into computers. Calculating CPUE.
Detail:

- Deciding on what questions to ask and what data should be collected
- Making up data entry forms
- CPUE data entry
- Long-hand calculation of CPUE without computers
- Worked examples and calculation excersizes

Timing: 13:30 to 16:00 hrs
Topic: Introduction to basic bio-statistics
Detail:

- Mean, standard deviation, standard error
- Normal distribution
- Logarithmic conversion
- One-way ANOVA
- Length-weight data and simple regression

Date: Friday April 28
Timing: 09:15 to 12:00 hrs
Topic: Analyzing, graphing and interpreting CPUE data
Detail:

- Using the computer to analyze and graph CPUE data
- Interpretation of CPUE data
- Other factors affecting CPUE

Timing: 13:30 to 16:00 hrs
Topic: Reviewing experiences from data collection in Mekong tributaries
Detail:

- The continuing migration / CPUE data collection in the Sedone
- CPUE data collection in the Nam Theun and Hinboun
- Slide presentation
- Open discussion on CPUE data collection and ways of improvement

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August 21 to 23, 2000

Date: Monday August 21
Timing: 09:00 to 12:00 hrs
Topic: Review of migration / CPUE studies in Southern Lao PDR
Detail:

- Background and objectives of migration studies
- Slide presentation of the studies carried out so far
- Review of dry and wet-season data collection programs

Timing: 13:30 to 16:00 hrs
Topic: This year's data from Ban Hat
Detail:

- Analyzing this year's data from Ban Hat using STATISTICA software (data already entered onto LARReC computers)
- Graphing and interpreting this year's data using HARVARD GRAPHICS 4 software

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Date: Tuesday August 22
Timing: 09:00 to 12:00 hrs
Topic: This year's wet-season data from Hoo Som Yai
Detail:

- Setting up spread sheets to enter wet-season data
- Data entry into EXCEL software

Timing: 13:30 to 16:00 hrs
Topic: Historical wet and dry-season CPUE data
Detail:

- Loading of all historical CPUE data onto LARReC computers
- Demonstration of analysis of historical wet-season CPUE data
- Graphing and interpretation

Date: Wednesday August 23
Timing: 09:00 to 12:00 hrs
Topic: Continuation of any topics outstanding from first two days
Detail:

- Further explanations / clarifications
- Trouble-shooting

Timing: 13:30 to 16:00 hrs
Topic: Optional (only necessary if required. Otherwise finish at 12:00 hrs)
Detail:

- Reserved for more explanation / discussion if required

List of workshop participants

Mr. Vannaxay Soukhaseum – LARReC (Officer)
Ms. Souvanny Phommakone – LARReC (Officer)
Mr. Saleumphone Chanthavong – LARReC (Officer)
Mr. Somboon – LARReC (Officer)
Mr. Phosavath Vongphasouk – Provincial Livestock and Fisheries (Officer)
Mr. Somboun Chanrya – LARReC (Officer)
Ms. Homchane Vongchampa – SWIM Project (Officer)
Mr. Serd Nanotham – SWIM Project (Officer)
Ms. Davanh Sysavath – Provincial Livestock and Fisheries (Officer)
Mr. Kongpheng Bouakhamvongsa – LARReC (Technical Officer)
Mr. Sisommouth Sichan – LARReC (Technical Officer)
Mr. Khamla Phommachanh – LARReC (Technical Officer)
Mr. Chanthone Phomitay – LARReC (Technical Officer)
Mr. Thavone Phommavong – LARReC (Technical Officer)
Mr. Sommano Phounsavath – LARReC (Technical Officer)

LARReC Data and Information Unit

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