Mekong River Commission
For Sustainable Development

Recent fish migrations in Khone Falls (Lao PDR) according to local ecological knowledge

Piloting a Joint Environmental Monitoring (JEM) Programme on Two Mekong Mainstream Dams: The Don Sahong Hydropower Project and the Xayaburi Hydropower Project.

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TABLE OF CONTENTS

LIST OF FIGURES ..... **III**
LIST OF TABLES ..... **IV**
ABBREVIATIONS AND ACRONYMS ..... **V**
1. INTRODUCTION **1**
1.1. Geographic context **2**
1.2. Previous information on fish migrations in Khone Falls **3**
2. METHODOLOGY **4**
2.1. Questionnaires **4**
2.2. Target species **5**
3. RESULTS **7**
3.1. Information on species **7**
3.1.1. End of rainy season large- and medium-size cyprinids (Hypsibarbus malcolmi) 7
3.1.2. Early dry season small cyprinids (Gymnostomus. siamensis and G. lobatus) 8
3.1.3. Early dry season medium-sized cyprinids (Scaphognathops bandanensis) 10
3.1.4. Dry- to early wet season large cyprinids (*Cirrhinus microlepis* and *Cyclocheilos enoplos)* 12
3.1.5. Early wet season small Pangasiids (*Helicophagus leptorhynchus* and *Pangasius macronema*) 14
3.1.6. Early wet season large Pangasiids (*Pangasius krempfi*, *P. conchophilus*) 16
3.2. Information on channels **18**
3.2.1. End of Hoo Som Yai near Khone Phapheng 19
3.2.2. Hoo Som Pordan near Khone Phapheng 20
3.2.3. Hoo Sadam 21
3.2.4. Hoo Xang Peuak 22
3.2.5. Nyoi Koong 24
3.2.6. Koum Tao Hang 25
3.2.7. Hoo Wai 26
3.2.8. Luong Pi Teng 27
3.2.9. Hoo Don Lai 28
4. OVERVIEW AND PERSPECTIVES **30**
5. BIBLIOGRAPHY **33**
6. ANNEX 1: QUESTIONNAIRES OF THE SURVEY **36**
6.1. Upstream questionnaire **36**
6.2. Mid-falls questionnaire **41**
6.3. Downstream questionnaire **50**
7. ANNEX 2: SELECTION OF TARGET SPECIES FOR THE SURVEY **57**

LIST OF FIGURES

Figure 1-1. Map of Khone Falls main islands, channels and villages 2
Figure 1-2: Annual fish migration patterns at Khone Falls, from Baran (2006) 3
Figure 2-1. Illustration of the species selected 6
Figure 3-1. Migration of “end of rainy season large- and medium-size cyprinids” in the literature 7
Figure 3-2. Temporal migration of “end of rainy season large- and medium-size cyprinids” according to our survey 8
Figure 3-3. Spatial migration of Hypsibarbus malcolmi (end of rainy season large- and medium-size cyprinids) 8
Figure 3-4. Temporal migration of “early dry season small cyprinids” in the literature 9
Figure 3-5. Temporal migration of “early dry season small cyprinids” according to our survey 10
Figure 3-6. Migration patterns of “early dry season small cyprinids” 10
Figure 3-7: Temporal migration of “medium-sized cyprinids” in the literature 11
Figure 3-8. Temporal migration of Scaphognathops bandanensis and its group according to our survey 12
Figure 3-9. Migration patterns of “early dry season small cyprinids” 12
Figure 3-10: Temporal migration of “Dry- to early wet season large cyprinids” in the literature 13
Figure 3-11. Migration patterns of Cirrhinus microlepis and Cyclocheilos enoplos. Red marks indicate claims of total absence of species year round 14
Figure 3-12: Temporal migration of “Early wet season small Pangasiids” in the literature 15
Figure 3-13. Migration patterns of Helicophagus leptorhynchus and Pangasius macronema. Red marks indicate claims of total absence of the species year round 16
Figure 3-14: Temporal migration of “wet season large Pangasiids” in the literature 17
Figure 3-15. Temporal migration of “Pangasius krempfi and Pangasius conchophilus” according to our survey 17
Figure 3-16. Migration patterns of “wet season large Pangasiids” 18
Figure 3-17: Hoo Som Yai near Khone Phapheng, in March 2020 (left) and October 2014 (right) 19
Figure 3-18. Hoo Som Pordan (left), flowing into Hoo Som Yai, in March 2020 20
Figure 3-19. Hoo Sadam in March 2020 21
Figure 3-20. Hoo Sadam (left: upstream; right; downstream) in March 2014 22
Figure 3-21. Hoo Xang Peuak Yai and Noy (location map) 22
Figure 3-22. Hoo Xang Peuak Yai in January 2015 (left) and June 2015 (right) 23
Figure 3-23. Hoo Xang Peuak Noy in February 2015 (left) and October 1017 (right) 23
Figure 3-24. Nyoi Koong in March 2020 24
Figure 3-25. Koum Tao Hang channel 25
Figure 3-26. Hoo Wai channel (location map) 26
Figure 3-27. Hoo Wai channel in November 2019 26
Figure 3-28. Luong Pi Teng channel 27
Figure 3-29. Hoo Don Lai (location map) 28
Figure 3-30. Hoo Don Lai in January 2016 (left: downstream; middle: mid-range; right: upstream) 28
Figure 4-1. Proposed new channels improvements in Khone Fang area 32

LIST OF TABLES

Table 1-1. Khone Falls area villages surveyed 2
Table 2-1. List of migratory fish species selected for local ecological knowledge survey 5
Table 3-1 Previous information about Hypsibarbus malcolmi 7
Table 3-2 Previous information about Gymnostomus siamensis and Gymnostomus lobatus (Cyprinidae) 8
Table 3-3 Previous information about Scaphognathops bandanensis (Cyprinidae) 10
Table 3-4 Previous information about Cirrhinus microlepis and Cyclocheilos enoplos (Cyprinidae) 12
Table 3-5 Previous information about Helicophagus leptorhynchus and Pangasius macronema (Pangasiidae) 14
Table 3-6 Previous information about Pangasius krempfi and Pangasius conchophilus (Pangasiidae) 16
Table 3-7: Fish passage channels improved by Don Sahong Power Company and their location 19
Table 3-8: Hoo Som Yai characteristics 20
Table 3-9. Hoo Som Pordan characteristics 20
Table 3-10. Hoo Sadam characteristics 21
Table 3-11: Hoo Sang Peuak Yai characteristics 23
Table 3-12. Hoo Sang Peuak Noy characteristics 24
Table 3-13. Nyoi Koong characteristics 24
Table 3-14. Koum Tao Hang characteristics 25
Table 3-15. Koum Hoo Wai characteristics 27
Table 3-16. Luong Pi Teng characteristics 27
Table 3-17. Hoo Don Lai characteristics 28

ABBREVIATIONS AND ACRONYMS

AMFC	Assessment of Mekong Fisheries Component project
DSHP	Don Sahong Hydropower Project
DSPC	Don Sahong Power Company
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GPS	Global Positioning System
ICEM	International Centre for Environmental Management
MRC/MRCS	Mekong River Commission / Mekong River Commission Secretariat
PDR	People Democratic Republic
USD	US Dollar

1. INTRODUCTION

In recent years (2017-2019) the Mekong River Commission (MRC) formulated and developed a programme for the Joint Environment Monitoring (JEM) of Mekong mainstream hydropower projects. The JEM programme intends to monitor important parameters in hydrology, sediment, water quality, aquatic ecology and fisheries using a system independent from that of the hydropower project developers.

At the end of 2019 the International Center for Environmental Management (ICEM) was the commissioned by the MRC and Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) to conduct pilots for the JEM programme at two sites, the Don Sahong and Xayaburi hydropower projects, across 2020 and 2021. This is henceforth referred to as the JEM Pilot project.

For the Fisheries component, the JEM Pilot project both implements monitoring of fish abundance and diversity and, in particular at Don Sahong site, develops new methods to assess the effectiveness and efficiency of mitigation measures aimed at allowing fish migration. For the latter, the JEM pilot project is planning to use fish tagging methodologies.

To complement the migration and passage study based on fish tagging, the MRC and the JEM Pilot project conducted a survey of local ecological knowledge both to document how fish pass through the Khone Falls and to inform improvements to fish passage. This report presents the results of this survey undertaken between 10th and 30th March 2021.

Khone Falls is an area of the Mekong Basin where local ecological knowledge (LEK[1]) is very developed. It has been recognized and documented for many years through more than 15 publications, starting with the seminal work of the MRC in 1999 for the *Assessment of Mekong Fisheries Component (AMFC): Fish Migrations and Spawning and the Impact of Water Management Project*. Previous studies based on local knowledge, and confirmed by fisheries data, have in particular documented which species pass at different times of the year (Baird 2001, Baran et al. 2005, Baran 2006).

The results of this survey study contribute knowledge and design guidance for fish passage channels and the factors that are needed for optimal mitigation of dam impacts. More specifically, the study was designed to generate information on the following:

- when and how fish arrive to Khone Falls from downstream (their preferred initial migration channels);
- which channels are the most important for successful fish passage (depending on species and timing);
- physical and hydrological qualitative descriptors of channels that allow fish passage;
- recommended fish passage improvements from local residents' perspective; and
- other channels or falls that could be further managed for improved fish passage.

[1] *Local ecological knowledge* is information obtained from natural resource users, those who depend on species and ecosystems for their physical and cultural survival. This information has also been named *"fishers' knowledge"*, "*indigenous technical knowledge*" or "*traditional ecological knowledge*". The relevance of this knowledge to scientific ecology and resource management has been underlined since the 90's, in particular within the Pacific (works of Bob Johannes). Such work in the Mekong was initiated around 2000 (*Assessment of Mekong Fisheries: Fish Migrations and Spawning and the Impact of Water Management Project* at MRC).

1.1. Geographic context

Khone Falls are comprised of more than 31 large islands, 25 large waterfalls or waterfall areas and at least 52 channels individually identified. This creates a large number of corridors and dead ends through which fish attempt migration. During their migrations they are targeted by highly skilled fishers from 16 villages as listed in Figure 1-1.

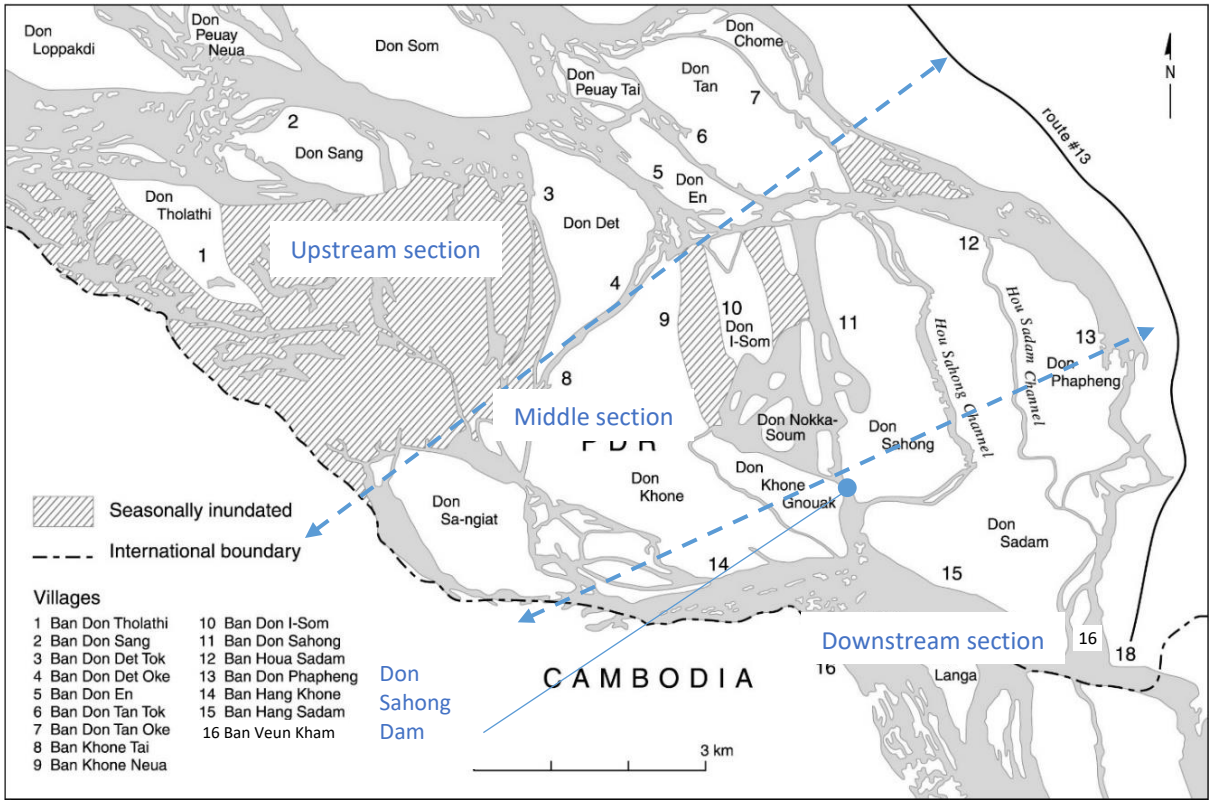

Figure 1-1. Map of Khone Falls main islands, channels and villages

The Khone Falls areas can be divided into three main zones, from south to north:

i) downstream of the falls, between the Mekong mainstream at the border with Cambodia and the main waterfalls;
ii) the middle section, corresponding to the fault line and its multiple falls and channels around 8 main islands; and
iii) the upstream area, North of the fault line, where the system of islands and channels continues but without falls.

The head difference between upstream and downstream areas reaches 10 meters. We conducted surveys in the 16 villages identified below:

Table 1-1. Khone Falls area villages surveyed

	Villages
Upstream area	#1 Ban Don Tholathi , #2 Ban Don Sang, #3 Ban Don Det Tok, #4 Ban Don Det Oke, #5 Ban Don En, #6 Ban Don Tan Tok, #7 Ban Don Tan Oke
Middle area	#8 Ban Khone Tai, #9 Ban Khone Neua, #10 Ban Don I Som, #11 Ban Don Sahong, #12 Ban Houa Sadam, #13 Ban Don Phapheng
Downstream area	#14 Ban Hang Khone; #15 Ban Hang Sadam; #16 Ban Veun Kham

1.2. Previous information on fish migrations in Khone Falls

Khone Falls is a biological hotspot, a fisheries landmark and a migration bottleneck that has attracted much attention in past decades. Its fish resources and fisheries have been detailed in multiple publication covering:

- biodiversity (Baird, 2001);
- fisheries, fish bioecology (Roberts and Baird, 1995; Baran et al., 2005); and
- local ecological knowledge (Baird and Flaherty, 2005; Baird, 2006, 2007).

Migration patterns in Khone Falls, derived from local ecological knowledge, have been summarized in Baran (2006) (Figure 1-2).

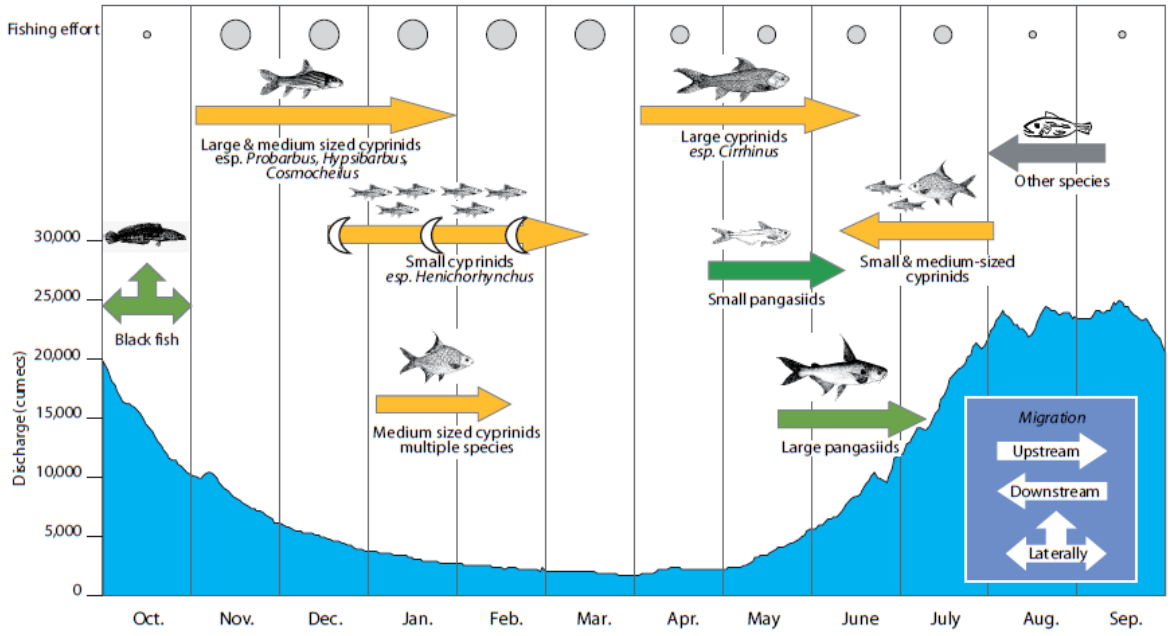

Figure 1-2: Annual fish migration patterns at Khone Falls, from Baran (2006)

Khone Falls fish bioecology is also reflected in several studies based on local ecological knowledge but developed on a larger scale (Chan Sokheng et al., 1999; Poulsen and Valbo-Jørgensen, 1999; Poulsen et al., 2000; Bao et al., 2001; MFD, 2003; Poulsen, 2003).

However, all these fisheries and ecological patterns refer to a situation that is now 15 to 25 years old. No update has been proposed in the past 15 years despite significant changes in the area, in particular the construction of the Don Sahong Dam and extensive dam development in the Lower Mekong Basin.

2. METHODOLOGY

Systematically gathering fishers' local ecological knowledge to assess ecological patterns among fish species was first developed in the Pacific (Johannes, 1981; 1989; and 1993). Comparisons of findings between local ecological knowledge surveys and scientific surveys (Poizat and Baran, 1997; Ticheler et al., 1998) led to the conclusion that gathering fishers' experience provides rapid, detailed and reliable information and is cost-effective. As a rule of thumb, local ecological knowledge can provide 70% of the information for 10% of the cost and time. This approach was subsequently taken up and promoted (Johannes et al., 2000; Rahman, 2000; Valbo-Jorgensen and Poulsen, 2000; Baird and Overton, 2001) and associated protocols were reviewed and refined (Haggan et al., 2003; 2007; Garcia-Allut et al., 2003; Moller et al., 2004; Cowie et al., 2020).

As introduced, the Mekong is one of the regions of the world where assessments based on local ecological knowledge have been extensively used (Chhuon Kim Chhea, 2000; Dubois, 2005; Baird, 2007; Chan Sokheng et al., 2008; Baran and Seng Sopheak, 2011) but the approach was also implemented in other river basins worldwide (Fishcher et al., 2015; Baran et al., 2015; Win Ko Ko et al., 2016). Most of these surveys have used - and sometimes adapted- the Mekong protocol initially described in Poulsen and Valbo-Jørgensen (1999; 2000). This protocol is also reflected in the present study.

2.1. Questionnaires

Questionnaires were developed for the 16 villages of Khone Falls based on the initial Mekong protocol, but simplified for the Cambodian and Lao context. The gathering of information was undertaken during focus group discussion (one in each village) and using questionnaires covering the following points:

- how do migratory fish arrive to Khone Falls from downstream and from upstream?
- which channels are targeted by species for initial passage?
- which channels ultimately allow species to pass the falls?
- what are the channel specificities that allow passage or not?
- in the middle section of the falls, what passage improvements could be conducted?
- are there areas of the falls of special importance in terms of passage or ecology?

Since these questions correspond to different sections of the falls, the questionnaires were tailored for upstream, middle area and downstream areas. These questionnaires are detailed in Annex 1.

In each site, interviews were organized between 10 March and 30 March 2021 by the first author and a field assistant with the guidance and support of the MRC Secretariat, and national and local fisheries-related agencies. Each focus group discussion or meeting involved five to eight fishers, and never less than three. The aim was to achieve a balance between a low number of participants that would lead to opinions not collectively validated, and a high number of participants that could result in low group dynamics. Each fisher invited had at least 10 years of fishing experience and 5 years of residence in the site surveyed. Interview with each group of fishers was done in Lao language with note-taking by a national assistant. Detailed local maps derived from Google Earth were also prepared to facilitate the discussion in each site. When fishers disagreed, the answer recorded was the consensus response agreed by most participants. In total more than 80 fishers were surveyed for the study. Completing each questionnaire required two to three hours and was followed by data entry on the same day (i.e. 1 village surveyed per day).

2.2. Target species

The survey was designed to cover abundance, size, timing, migration behaviour, passage routes and spawning, corresponding to 30-35 questions by species. Ten target species were identified for the survey as representative of large groups of other species that migrate through Khone Falls. This survey design acknowledges that that it is not possible to survey ecological knowledge about all migratory species in a place characterized by 201 fish species in 39 families, including 110 species harvested by fishers. Furthermore, our survey aimed at documenting not individual species but main passage strategies and capabilities. A final design consideration was that the questionnaire should be potentially usable as a JEM routine in future, while fitting within the time available with fishers (a few hours for each interview) and the time available for analysis. Limiting the number of species to ten provides an informative, manageable survey (10 species x 35 question = 350 questions per interview).

Criteria for species selection are detailed below:

- Species migrating through Khone Falls, with broad migration patterns already mapped (MRC Mekong Fish Database);
- Species already identified by the MRC for transboundary management (10 Priority Species identified at MRC Joint Workshop on transboundary species management in May 2016; 5 species identified and choses in 2017 as 5 Priority Fish Species for Transboundary Management);
- Species making a significant percentage of catches in Khone Falls fisheries (based on 6 years of monitoring as presented in Baran (2005));
- Clear migration patterns, to simplify the discussion with fishers;
- Migration at different times of the year, in different water levels (important for flows in fish passage and the selection of tagging methods;
- Species sensitive to discharge and flow velocity, i.e. to the conditions at fish passes (Baran, 2006); and
- Species belonging to different size groups (important in relation to the selection of swimming ability, and to tag options.

Following a selection process as detailed in Annex 2, ten following species were selected for the survey as listed in Table 2-1.

Table 2-1. List of migratory fish species selected for local ecological knowledge survey

Cirrhinus microlepis (paphone mak kok)	*Hypsibarbus malcolmi* (papak nouat/pa pak kom/pa pak)
Cyclocheilos enoplos (pa chok).	*Pangasius conchophilus* (pa pho/pa ke)
Gymnostomus lobatus (pa soi houa lem)	*Pangasius krempfi* (pa souay hang leuang)
Gymnostomus siamensis (pa soi houa po)	*Pangasius macronema* (pa gnone siap)
Helicophagus leptorhynchus	*Scaphognathops bandanensis* (pa pian)

The selected species all migrate through Khone Falls. They migrate at different times of the year, in different water levels (important for flows in fish passage and the selection of tagging methods. They belong to different size groups which is important in relation to the selection of swimming ability, and

to tag options. They also exhibit clear migration patterns. These species are representatives of the 6 main groups of species that migrate through Khone Falls as shown in Figure 2-1.

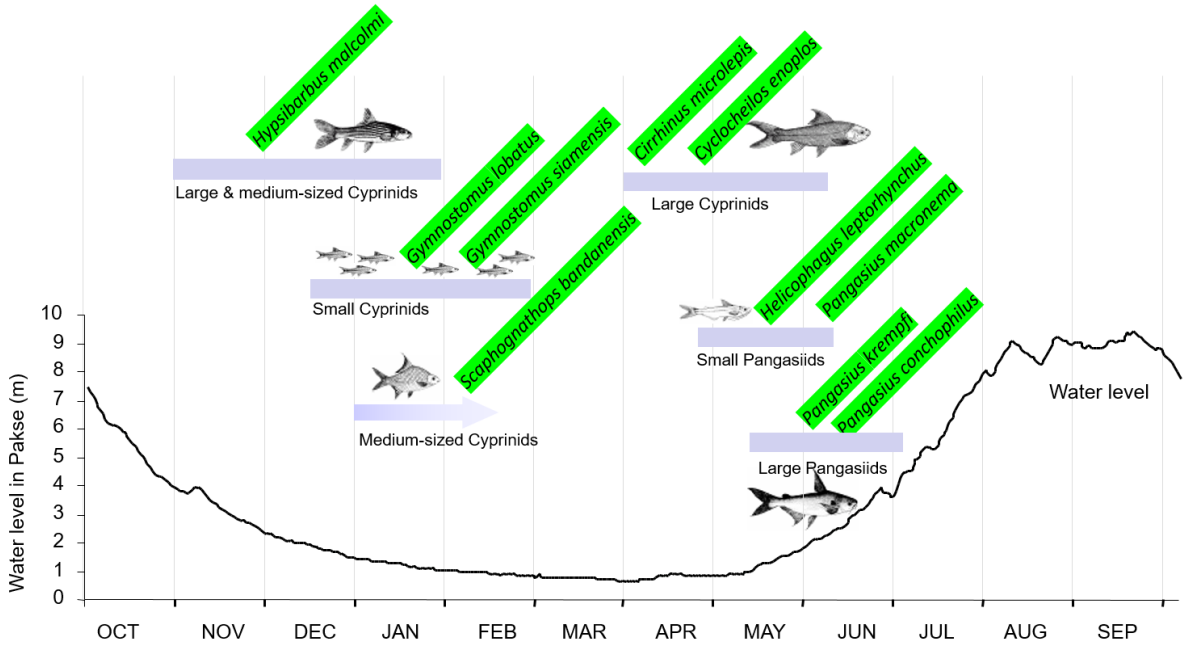

Figure 2-1. Illustration of the species selected

3. RESULTS

3.1. Information on species

The following sections present the new information gathered during this survey for each of the 10 target species representing a group of migratory fish.

3.1.1. End of rainy season large- and medium-size cyprinids (Hypsibarbus malcolmi)

Previous information about the species is provided in Table 3-1 and Figure 3-1.

Table 3-1 Previous information about Hypsibarbus malcolmi

Name	*Hypsibarbus malcolmi (*Cyprinidae)
Invalid synonym	*Poropuntius malcolmi*
Biology	Max. standard length (cm): 50; Length at maturity (cm): 29
Reproduction	Pelagic mainstream spawner that breeds in the late wet-or early dry-season
Ecology	Found in large rivers in the dry season and moves to medium-size rivers in the wet seasons.

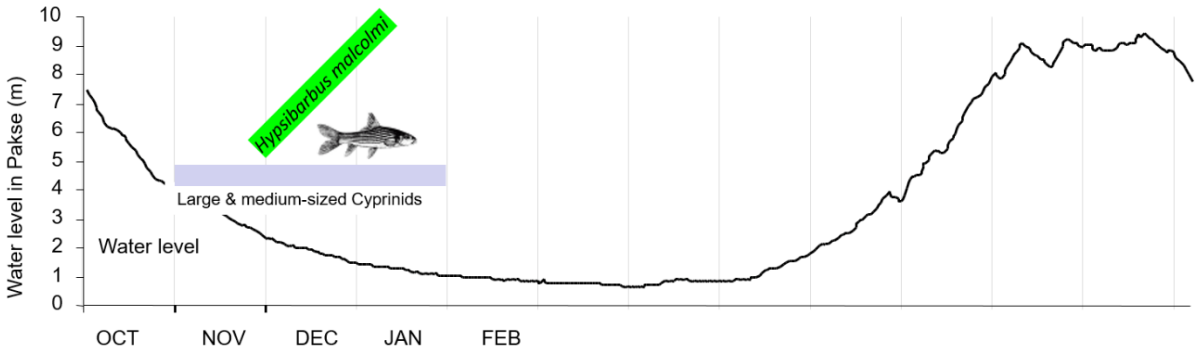

Figure 3-1. Migration of "end of rainy season large- and medium-size cyprinids" in the literature

The survey results reported the following recent trends about *Hypsibarbus malcolmi* and its group, with migration patterns as shown in Figure 3-2 and Figure 3-3:

- Schools migrating all day. Downstream migrations are unknown.
- Downstream: the species migrates upstream in December- January - February (25-30 cm long fish with eggs) but is found in the area the following months without migrating. Upstream migration channels sought are Hoo Phapheng, Li Phi and Khone Fang area.
- Mid-falls: fish now never caught in Hua Sadam (Don Sadam Island), and *never caught in Hoo Sadam*. Migration channels are Hoo Phapheng, Hoo Don Wai, Hoo Xang Pheuak and Hoo Khone Lan.
- Upstream: Species absent from around Don Tan Island (unsuitable environmental conditions). Species migrating upstream in January at Don En. Downstream migration between June and August via the Khone Fang area (Khone Fang, Khone Souang, Khone Somhong).

<u>Conclusion</u>: Hypsibarbus malcolmi *and its group migrate upstream later than previously reported (now mainly January - February); the species is not caught in Hoo Sadam anymore. It migrates downstream in June-August via the Khone Fang area.*

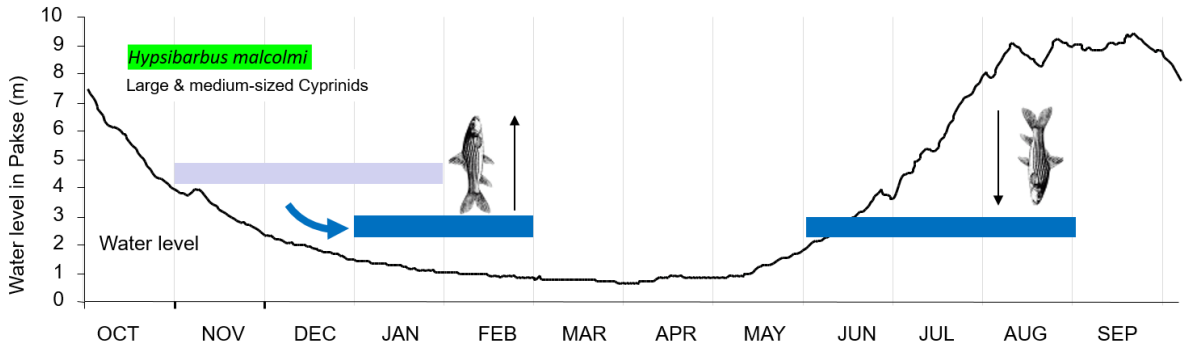

Figure 3-2. Temporal migration of "end of rainy season large- and medium-size cyprinids" according to our survey

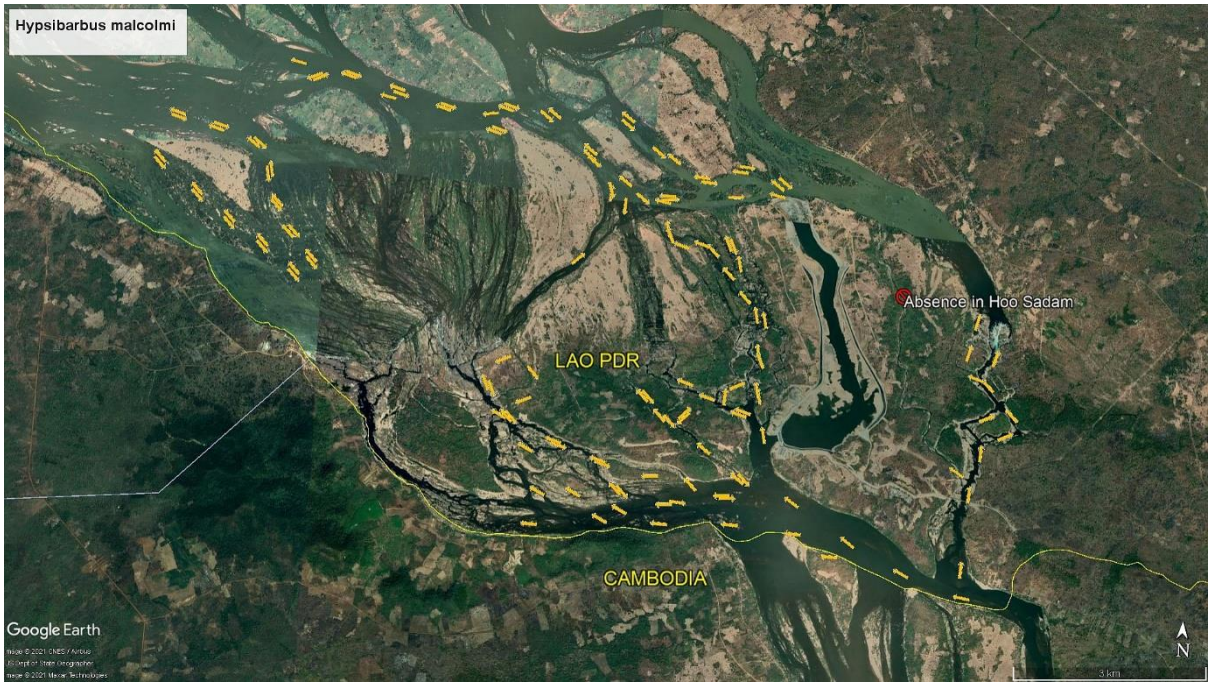

Figure 3-3. Spatial migration of Hypsibarbus malcolmi *(end of rainy season large- and medium-size cyprinids)*

3.1.2. Early dry season small cyprinids (Gymnostomus. siamensis and G. lobatus)

Previous information about the species is provided in Table 3-7Table 3-1 and Figure 3-2.

Table 3-2 Previous information about *Gymnostomus siamensis* and *Gymnostomus lobatus* (Cyprinidae)

Name	*Gymnostomus siamensis* and *Gymnostomus lobatus* (Cyprinidae)
Invalid synonym	*Cirrihinus siamensis / Henicorhynchus siamensis* and *Cirrihinus lobatus / Henicorhynchus lobatus*

Biology	Max. standard length (cm): 20 for *G. siamensis*; 15 for *G. lobatus*
Reproduction	April to July for *G. siamensis* (peak in May-June), June - July for *G. lobatus*
Ecology	Among the most abundant Mekong species, found from the Mekong Delta up to Chiang Khong. Migrates from Xayaburi to Chiang Khong. Migrates through Khone Falls between December and February and downstream in May-July. Discharge variation is a migration trigger.

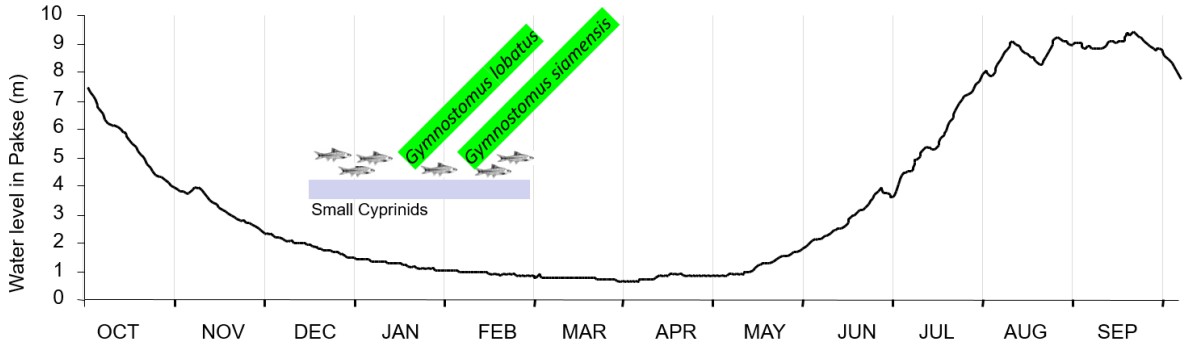

Figure 3-4. Temporal migration of "early dry season small cyprinids" in the literature

The survey results reported the following recent trends about *Gymnostomus siamensis* and *G. lobatus* and their group, with migration patterns as shown in Figure 3-5 and Figure 3-6:

- Downstream: upstream migration in January-February, by small individuals (5-10 cm). However, the catch is quite minimal, to the point that fishers in Veunkham cannot identify a migration pattern any longer for *G. siamensis.* Migration mainly through Hoo Sadam, Hoo Xang Peuak and Hoo Don Dai, but almost not through Hoo Phapheng and not any more through Khone Pa Soi, as water diversion in Hoo Sahong for Don Sahong Dam leaves too little water for attraction and passability of Khone Pa Soi - whose name meaning "Gymnostomus water fall" highlights its former central role for the migrations of these species
- Mid-falls: Several villages report the quasi-total disappearance of upstream migrations of early dry season small cyprinids; this includes Ban Don Phapheng (east of the falls) and Ban Khone Neua (north of Don Khone). Several other villages report abundance reduced by 90% and migration pulses lasting a few days only, mainly in February, by schools of immature individuals and in the day time. Downstream migrations remain observed in July-August, with schools of larger individuals bearing eggs and making noise; these migration use all central and eastern channels, in particular the Khone Lan area, Hoo Sadam and Hoo Phapheng.
- Upstream: similar patterns are observed in upstream villages, except that downstream migration is observed earlier (June-July)

Conclusions: These results underline the quasi-disappearance of species that used to be the most abundant ones, and their upstream migrations now limited to a few days a year - in particular in relation to reduced water levels in former key passages such as Khone Pa Soi.

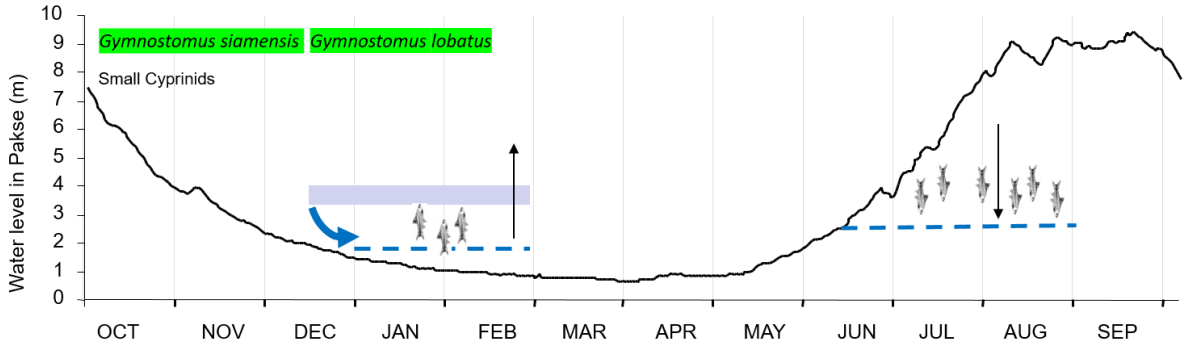

Figure 3-5. Temporal migration of "early dry season small cyprinids" according to our survey

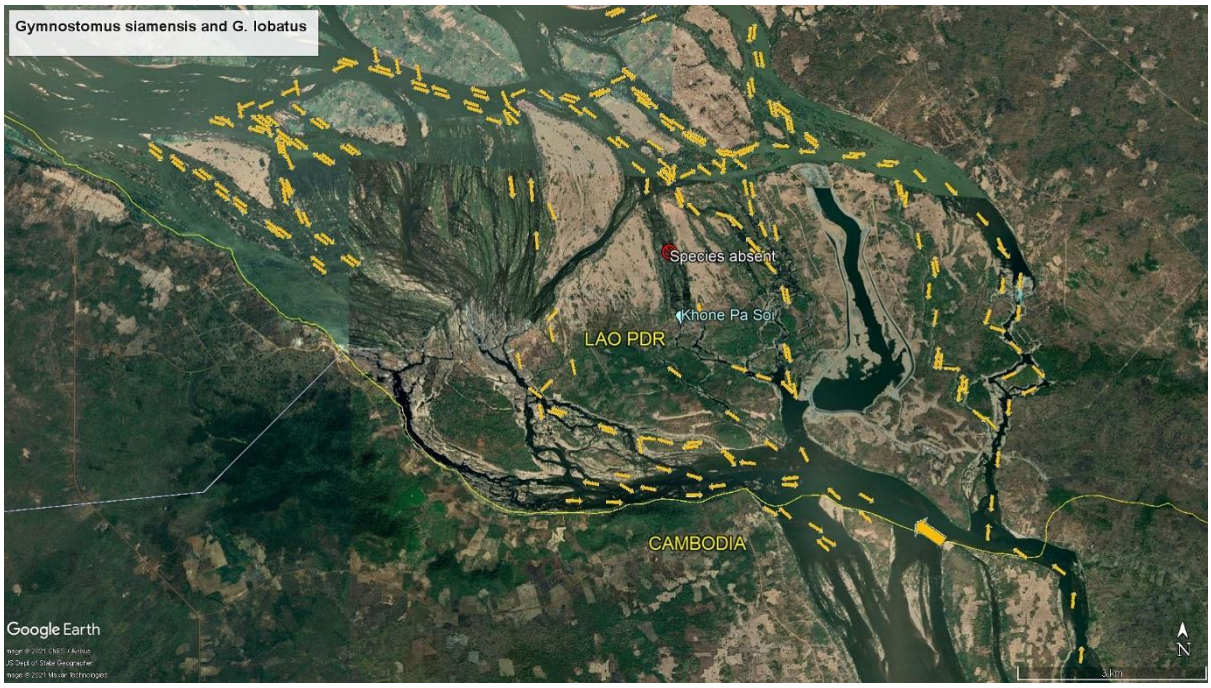

Figure 3-6. Migration patterns of "early dry season small cyprinids"

3.1.3. Early dry season medium-sized cyprinids (Scaphognathops bandanensis)

Previous information about the species is provided in Table 3-3 and Figure 3-7.

Table 3-3 Previous information about *Scaphognathops bandanensis* (Cyprinidae)

Name	*Scaphognathops bandanensis (*Cyprinidae)
Reproduction	Breeds in July-August in floodplains and streams and at the end of the rainy season in receding waters areas. Juveniles appear in catches in April.
Ecology	Found in the Middle Mekong (Xe Bangfai, Sekong, Sesan and Srepok basins). The fish migrates up from Cambodia to Lao PDR in January-February, into smaller streams and floodplains in June-July, and returns to the mainstream in November-December.

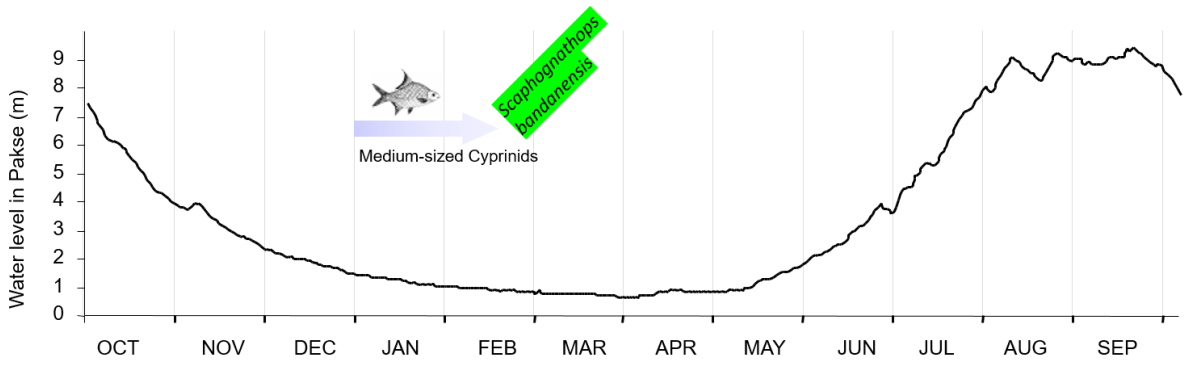

Figure 3-7: Temporal migration of "medium-sized cyprinids" in the literature

The survey results reported the following recent trends about *Scaphognathops bandanensis* and their group, with migration patterns as shown in Figure 3-8 and Figure 3-9:

- Overall, the pattern is unclear for that species.
- Downstream: the species appears in February and the upstream migration is more intense in March-April, up to June. Individuals at that time are 15-20 cm long and do not bear eggs. One site mentions a downstream migration in July. The species moves upwards towards all channels, in particular Hoo Sadam and Hoo Phapheng (the latter being impassable).
- Mid-falls: the pattern is very different from site to site, with some villages mentioning upstream migrations early in the year or in June-July. In the latter case, the direction of migration is unclear. Some sites (Ban Hua Sadam, Ban Don Phapheng) mention a quasi-permanent presence of the species in the area -during which migrations are not clearly identified- while others (Ban Don Xom, Ban Khone Neua) claim a quasi-permanent absence. During upstream migrations, most channels seem to be used (which seems in contradiction with the case of *Gymnostomus* whose channel options are said to be limited as too shallow: Scaphognathops undertakes its migration at the same period as *Gymnostomus*, and its body-size is larger).
- Upstream: In upstream sites patterns are also unclear: *S. bandanensis* is said to be almost permanently present (Ban Don Tan OK, Ban Don *Tan* Tok, Ban Don Tholathi) or almost permanently absent (Ban Don Xang). The only common feature in all villages is a downstream migration around July - but villagers do not agree about egg presence. Most channels seems to be used for movements, in particular Hoo Sadam and the Khone Lan area.

Conclusions: Patterns are unclear for Scaphognathops bandanensis and the group of Early dry season medium-sized cyprinids, suggesting a permanent residence in some sites, in particular upstream of Khone Falls. Migrations are identified mainly in January-February (upstream) and July-August (downstream)- without being common to all sites. All channels seem to be used for movements.

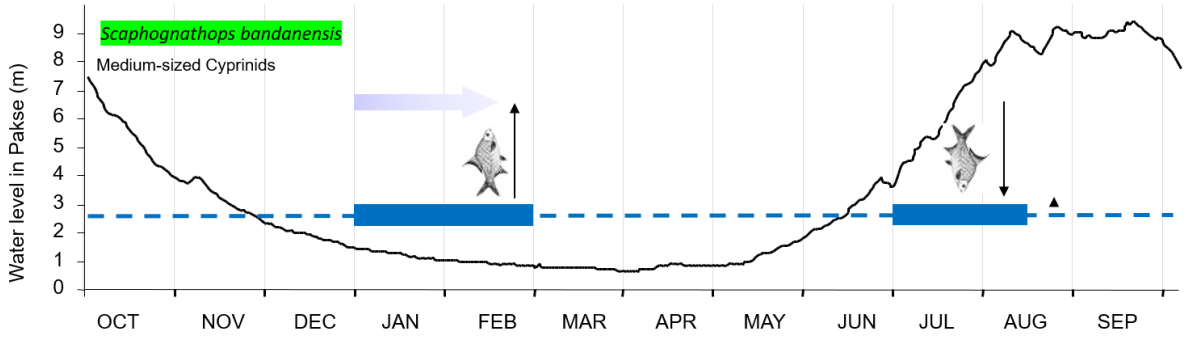

Figure 3-8. Temporal migration of **Scaphognathops bandanensis** *and its group according to our survey*

Figure 3-9. Migration patterns of "early dry season small cyprinids"

3.1.4. Dry- to early wet season large cyprinids (*Cirrhinus microlepis* and *Cyclocheilos enoplos)*

Previous information about the species is provided in Table 3-4 and Figure 3-10.

Table 3-4 Previous information about *Cirrhinus microlepis* and *Cyclocheilos enoplos* (Cyprinidae)

Name	*Cirrhinus microlepis* and *Cyclocheilos enoplos (*Cyprinidae)
Biology	Max. standard length (cm): 74; length at maturity: 41.1 (*Cyclocheilos enoplos);* Max. standard length: 65; length at maturity: 36.6 (*Cirrhinus microlepis).* The latter is a fast swimmer and a nervous "jumper".

Reproduction	Start spawning in the early flood season, July-August (*Cyclocheilos enoplos) or* May-August (*Cirrhinus microlepis*). Eggs and larvae are pelagic, and drift downstream.
Ecology	Both are found from the Mekong Delta to Bokeo or Chiang Saen. *C. enoplos* migrates upstream as a response to the first rainfalls and downstream in October - December. *Cirrhinus microlepis* seems to feature several populations.

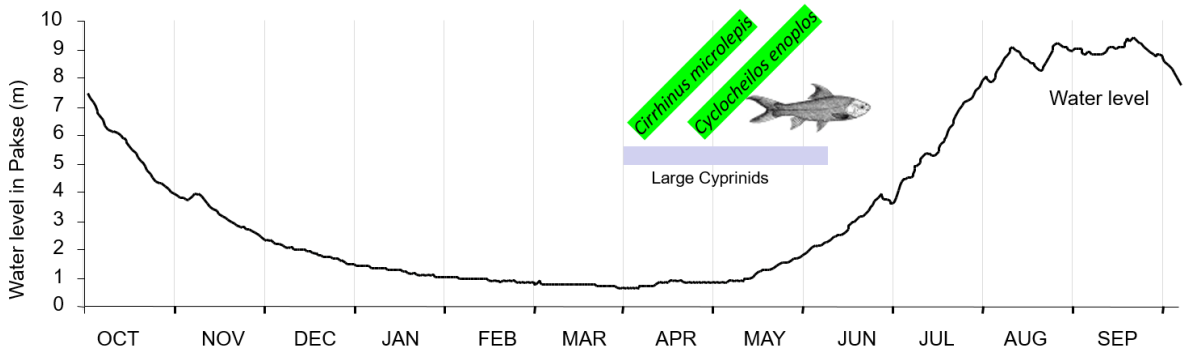

Figure 3-10: Temporal migration of "Dry- to early wet season large cyprinids" in the literature

The survey results reported the following recent trends about *Cirrhinus microlepis*, *Cyclocheilos enoplos* and their group, with migration patterns as shown in Figure 3-11:

- Downstream: Patterns are contradictory depending on species, with villages reporting upstream migrations (without eggs) for *C. microlepis* in February-March, and December for *C. enoplos*, but all agree about downstream migrations (with eggs) in June-July for C. microlepis, and limited or no downstream migration pattern for *C. enoplos*. Interestingly, fishers also identified a *Cirrhinus microlepis* breeding area on the east bank of Don Det.
- Mid-falls: All sites report a species collapse of catches, with now 10% to 0% of previous catches (no more catches of *C. enoplos* in Ban Hua Sadam, Ban Don Sahong or Ban Don Xom). Among villages with remaining catches of *C. microlepis*, the only common pattern is downstream migrations of 50-60 cm long individuals bearing eggs, between July and September - but with peaks lasting 1 to 3 days only. Among villages still catching *C. enoplos*, patterns are contradictory and also limited to 2-3 days a year.
- In this context, it is difficult to confirm the various upstream migration channels identified by fishers - among which Hoo Sadam and the Khone Lan area are mentioned a few times.
- Upstream: half of upstream villages report the total absence of *C. microlepis* and *C. enoplos* year round, in particular around Don Tan; other villages still report some migrations, but patterns are contradictory (e.g. upstream in June-July-August and downstream in July-September, with eggs or without for *C. microlepis*, and no more clear migrations, together with a tiny catch, for *C. enoplos*.

Conclusions: "Dry- to early wet season large cyprinids" seem to be vanishing from catches in the falls and upstream of them, and the remaining individuals caught are not sufficient to characterize migrations and further.

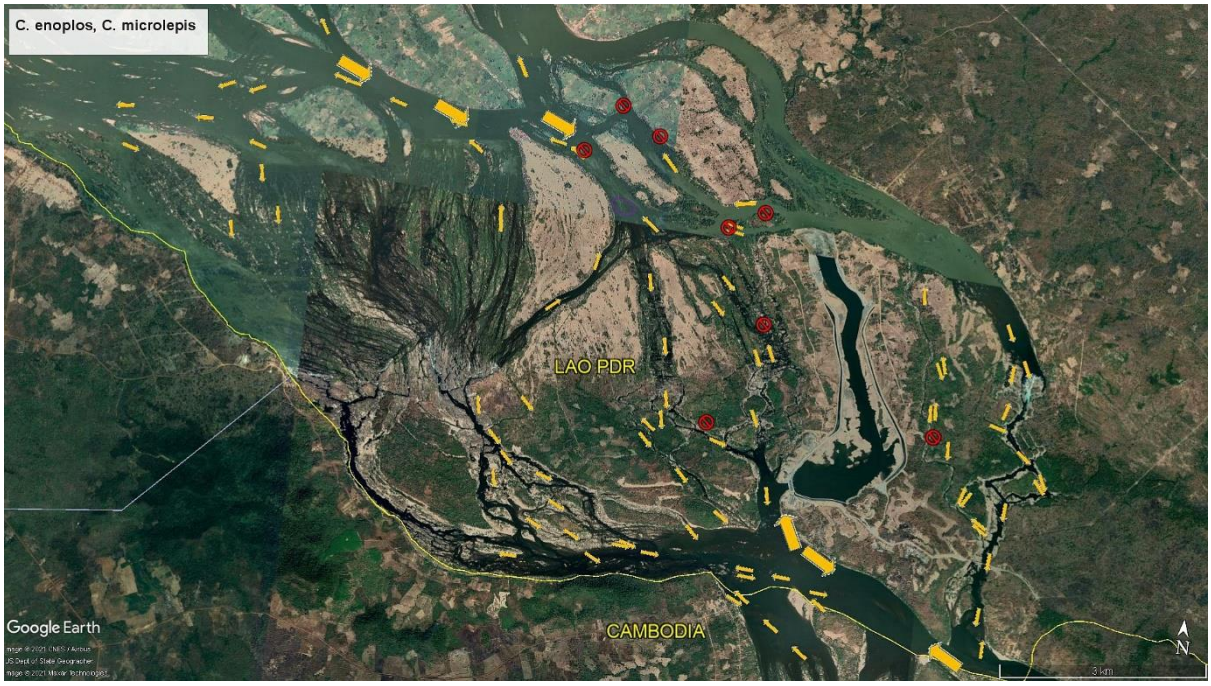

Figure 3-11. Migration patterns of **Cirrhinus microlepis and Cyclocheilos enoplos.** *Red marks indicate claims of total absence of species year round*

3.1.5. Early wet season small Pangasiids (*Helicophagus leptorhynchus* and *Pangasius macronema*)

Previous information about the species is provided in Table 3-5 and Figure 3-12.

Table 3-5 Previous information about *Helicophagus leptorhynchus* and *Pangasius macronema* (Pangasiidae)

Name	*Helicophagus leptorhynchus* and *Pangasius macronema (*Pangasiidae)
Invalid synonym	*Helicophagus waandersii* (a species from Sumatra and Malaysia only)
Biology	Max. total length (cm): 70; length at maturity (cm): 39.1 (*Helicophagus leptorhynchus);* Biology: Max. total length (cm): 30; length at maturity (cm): 18.5 (*Pangasius macronema)*
Reproduction	Eggs are observed from March to July with a peak in May-June (*Helicophagus leptorhynchus)*, or year round, but most often between April and June (*Pangasius macronema),* with some variability in both cases.
Ecology	Found basinwide. Migrates upstream at the beginning of the flood season and downstream at the end of the flood season.

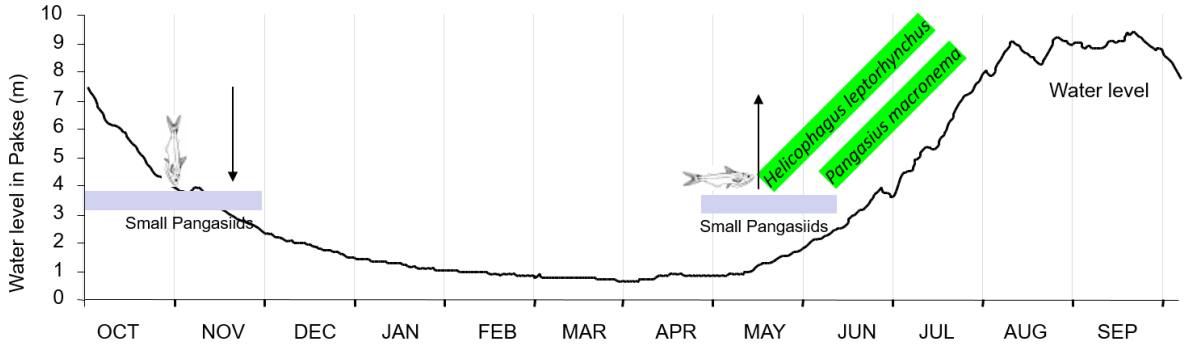

Figure 3-12: Temporal migration of "Early wet season small Pangasiids" in the literature

The survey results reported the following recent trends about *Helicophagus leptorhynchus*, *Pangasius macronema* and their group, with migration patterns as shown in Figure 3-13:

- Downstream: Some downstream villages that *H. leptorhynchus* is now present from January to July without migrating, the upstream migration happening in November-December, while others report an upstream migration (with no eggs) in July-August. The migration of *P. macronema* is only reported upwards, but timing diverges (March-May or March-July, with eggs in case of later months).
- Mid-falls: Several villages report the absence, now, of *P. macronema* year round (Ban Don Phapheng, Ban Hua Sadam) while in others the upstream migration is reported any time between March and August (very brief 2-day peaks, usually individuals with no eggs). A same low-intensity stretched pattern is reported for H. leptorhynchus, with an upstream migration spanning between June and October, but with very low peaks or even anecdotal presence during these months without migration. In all cases abundance is now extremely low, representing 30% to 0% of the former abundance.
- Upstream: villages report the presence of these species, in very low abundance, either year round without any migration pattern, or a slight upstream migration pattern in June-July.

Conclusions: Like "Dry- to early wet season large cyprinids", fishers report the progressive disappearance of "Early wet season small Pangasiids", and the remaining individuals are not enough in sufficient numbers to clearly characterize migrations any further.

***Figure 3-13. Migration patterns of H*elicophagus leptorhynchus *and* Pangasius macronema.** Red marks indicate claims of total absence of the species year round*

3.1.6. Early wet season large Pangasiids (*Pangasius krempfi*, *P. conchophilus*)

Previous information about the species is provided in Table 3-6 and Figure 3-14.

Table 3-6 Previous information about *Pangasius krempfi* and *Pangasius conchophilus* (Pangasiidae)

Name	*Pangasius krempfi, Pangasius conchophilus* (Pangasiidae)
Biology	Max. standard length (cm): 120 (both species)
Reproduction	Sexually mature fish migrate upstream from May to September, with peaks lasting 3-5 days (*Pangasius krempfi);* spawn at various times of the year but dominantly at the beginning of the flood season until October (*Pangasius conchophilus)*.
Ecology	Anadromous species caught from the coasts of Vietnam up to Chiang Saen (*P. krempfi)* or from the Delta also up to Chiang Saen *(P. conchophilus).* Populations start migrating upstream in May until August-September. Downstream migrations in October. Water level variation is a migration trigger.

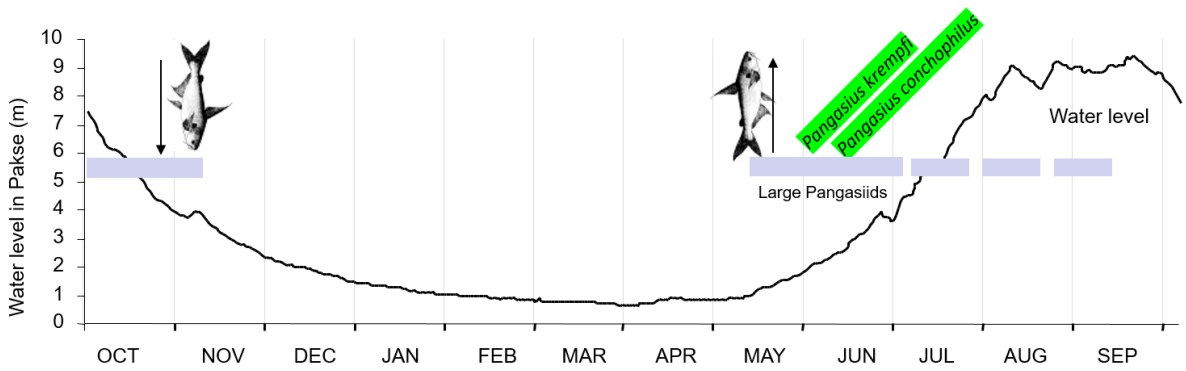

Figure 3-14: Temporal migration of "wet season large Pangasiids" in the literature

The survey results reported the following recent trends about *Pangasius krempfi, Pangasius conchophilus* and their group, with migration patterns as shown in Figure 3-15 and Figure 3-16.

- Downstream: Upstream migrations in June-August; contradictory information about September - October (either migrating up, or down).
- Mid-falls: upstream migration reported between June and August, with variability depending on sites. Eggs are visible during the flood period, but not at the beginning. Movements unanimously described as in schools, at night. Abundance reduced to 50%- 0% in all sites.
- Upstream: same patterns and trends as mid-fall villages. Permanent very low abundance presence in some sites.

Conclusions: the beginning of the migration is never reported in May, but spans mainly in June-August. Strong loss of abundance (50 to 0% remain) and, like in other groups, some permanent presence in very low abundance and without clear migration pattern is noted in several sites. Downstream migration is never reported.

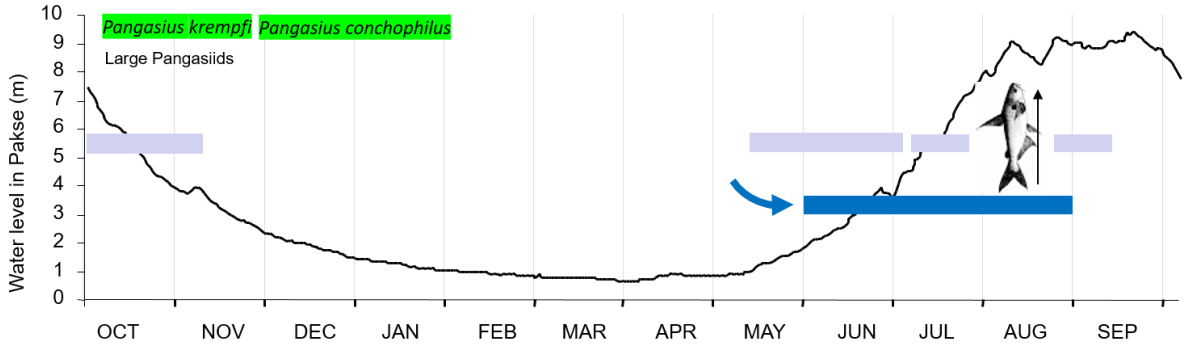

*Figure 3-15. Temporal migration of "*Pangasius krempfi *and* Pangasius conchophilus*" according to our survey*

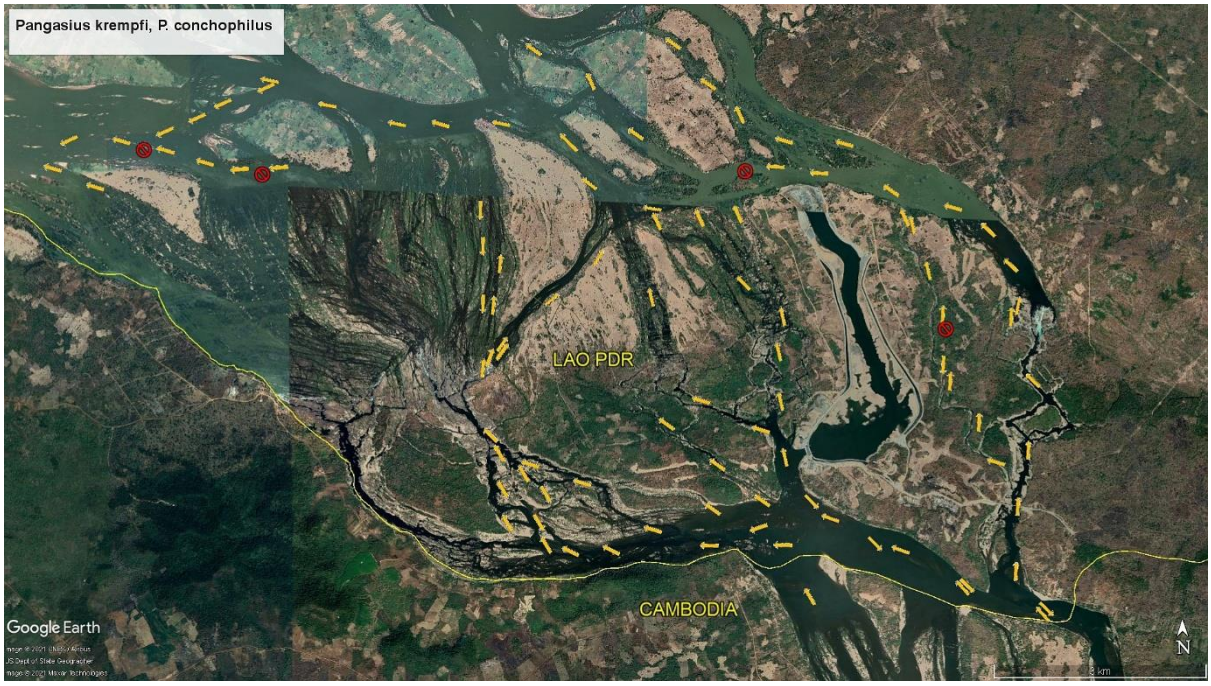

Figure 3-16. Migration patterns of "wet season large Pangasiids"

3.2. Information on channels

The local knowledge survey was also used to gather recent information about the channels used by fish for their migrations. This updated information, detailed below, reflects the hydrological changes of these past few years in a context of basin-wide dam development and climate change. Since it is impossible to detail all channels of the falls, environmental conditions are presented in nine channels identified over the years as important to fish migrations. Of particular relevance, the Don Sahong Power Company has developed activities to improve fish passage in these same nine channels. Listed from east to west, they are the following:

- Hoo Som Yai (where MRC monitored a *Lee* trap fishery for 20 years), and Hoo Som Pordan[2] next to Khone Phapheng waterfall.
- Hoo Sadam between Don Sadam and Don Papeng.
- Hoo Xang Peuak Noy, Nyoi Koong, Koum Tao Hang, Hoo Wai and Luong Pi Teng between Don Ee Som and Don Sahong; and
- Hoo Don Lai next to Lee Pee waterfall.

Coordinates for these channels are shown in Table 3-7 and the environmental terminology contained within their names is provided in Box 1.

[2] Som Pordan, the name used by the Don Sahong Power Company (DSPC), is also locally pronounced as Som Pa Lan.

Table 3-7: Fish passage channels improved by Don Sahong Power Company and their location

	Lao name (Latin script)	Lao name (Lao script)	Latitude	Longitude
1	Hoo Som Yai	ໂຮມໃຫຍ່	13°57'32.64"N	105°58'57.94"E
2	Som Pordan	ໂຮມບໍ່ດານ	13°57'46.10"N	105°58'54.24"E
3	Hoo Sadam	ຮູສະດຳ	13°58'22.51"N	105°58'10.03"E
4	Xang Peuak Noy	ຮູຊ້າງເຜືອກນ້ອຍ	13°57'27.50"N	105°57'23.13"E
5	Nyoi Koong	ຍ່ອຍກ່ຽ	13°57'4.49"N	105°57'14.79"E
6	Khoum Tao Hang	ຂຸ່ມເຕົ່າຮ່າງ	13°57'6.15"N	105°57'9.22"E
7	Luang Phi Teng	ຮູລ່ວງຜີເຕ່ງ	13°57'24.29"N	105°57'1.33"E
8	Hoo Wai	ຮູຫວາຍ	13°57'31.77"N	105°56'58.34"E
9	Hoo Don Lai	ຮູດອນໄລ່	13°57'14.40"N	105°54'59.28"E

Khone: small to medium size waterfall

Haew: high waterfall too high for fish to pass

Hoo: channel

Nyai : large*/ Noi:* small

Don: island

Ban: village

Box 1. Environmental terminology in Lao language

3.2.1. End of Hoo Som Yai near Khone Phapheng

An aerial view and photo of this channel is provided in Figure 3-17, with characteristics provided in Table 3-8.

Figure 3-17: Hoo Som Yai near Khone Phapheng, in March 2020 (left) and October 2014 (right)

Table 3-8: Hoo Som Yai characteristics

		Width
Width in dry season		6 - 10 m
Width in wet season		6 +- 15 m
	Min. depth in dry season	**Max. depth in wet season**
Now	Dry	2 m
These past 2 years, months with no water	Nov. to June	
10 years ago	80 cm	2 m
10 years ago, months with no water	Water year round	

3.2.2. Hoo Som Pordan near Khone Phapheng

An aerial view and photo of this channel is provided in Figure 3-18 with characteristics provided in Table 3-9.

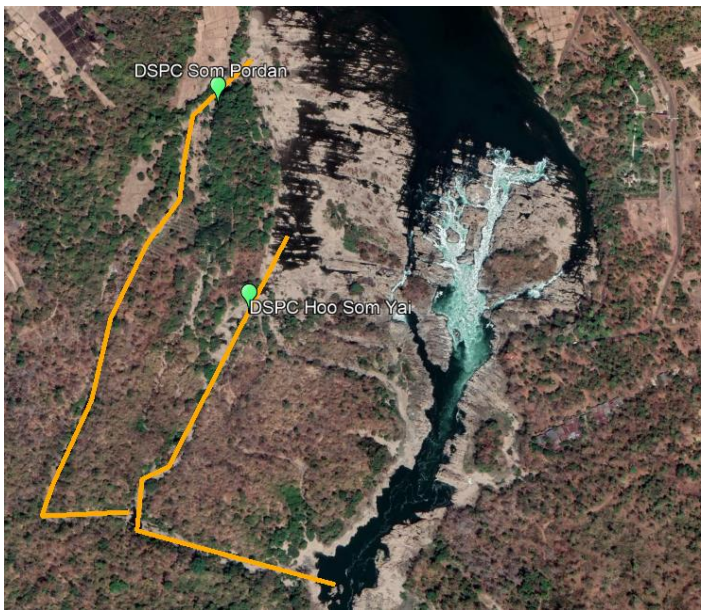

Figure 3-18. Hoo Som Pordan (left), flowing into Hoo Som Yai, in March 2020

Table 3-9. Hoo Som Pordan characteristics

		Width
Width in dry season		3 - 15 m
Width in wet season		5- 15 m
	Min. depth in dry season	**Max. depth in wet season**
In 2021 dry season	Dry	1.8 m
These past 2 years, months with no water	Dec. to early June	
10 years ago	Dry	1.8 - 2 m
10 years ago, months with no water	April to May	

3.2.3. Hoo Sadam

Hoo Sadam is located between Don Sadam and Don Papeng. An aerial view and photo of this channel is provided in Figure 3-19 and Figure 3-20 with characteristics provided in Table 3-10.

This narrow channel without waterfalls is known to be important for all migrating species during most of the year. Fishers have highlighted that this channel is special because of the presence of pools and other resting sites used by fish during their migrations (some pools reach 2m depth). In this channel, fish are also caught during the downstream migration (from May until July, after which water level is too high to catch fish).

Figure 3-19. Hoo Sadam in March 2020

Table 3-10. Hoo Sadam characteristics

	Width (m)	
Width in dry season (m)	7 - 90	
Width in wet season (m)	25 - 90	
	Min. depth in dry season	**Max. depth in wet season**
In 2021 dry season	Water not flowing. 30-50 cm depth in some places but very shallow upstream. Standing waters and disconnected pools	3 m
These past 2 years, months with no water	Dec. to June	
10 years ago	1 m	5 m
10 years ago, months with no water	Water year round	

Figure 3-20. Hoo Sadam (left: upstream; right; downstream) in March 2014

3.2.4. Hoo Xang Peuak

Hoo Xang Peuak is a major dual pathway for fish migrating upstream, with two main channels and waterfalls (Nyai = large, Noi = small) as shown in Figure 3-21.

Figure 3-21. Hoo Xang Peuak Yai and Noy (location map)

Waterfalls **Khone Xang Peuak Yai** and **Khone Xang Peuak Noy** are 3-4 m high, but not wide. In May-June migrating *Pangasius conchophilus* and *P. krempfi* pass them, while *Pangasius macronema* cannot. *Hypsibarbus spp.* can also get up these falls. In October, fish pass these falls more easily. These channels used to be the places of multiple traps catching small cyprinids in January-February.

Hoo Xang Peuak Yai is listed here as it is one of the two components of Hoo Xang Peuak channel, but was not modified by Don Sahong Power Company for improved fish passage and is currently not passable by fish (high waterfall). An aerial view and photo of this channel is provided and Figure 3-22 with characteristics provided in Table 3-11.

Hoo Xang Peuak Noy was the first passage widened by the Don Sahong Power Company as an alternative to Hoo Sahong in the dry season. An aerial view and photo of this channel is provided in Figure 3-23 with characteristics provided in Table 3-12.

Figure 3-22. Hoo Xang Peuak Yai in January 2015 (left) and June 2015 (right)

Table 3-11: Hoo Sang Peuak Yai characteristics

		Width
Width in dry season		4 - 25 m
Width in wet season		10 - 40 m
	Min. depth in dry season	**Max. depth in wet season**
In 2021 dry season	about 1.3m	4-5 m
These past 2 years, months with no water		
10 years ago	1.3 m	4-5 m
10 years ago, months with no water	Water year round	

Figure 3-23. Hoo Xang Peuak Noy in February 2015 (left) and October 1017 (right)

Table 3-12. Hoo Sang Peuak Noy characteristics

		Width
Width in dry season		3 - 13 m
Maximum width in wet season		8 - 35 m
	Min. depth in dry season	**Max. depth in wet season**
In 2021 dry season	10 - 20 cm	2 m
These past 2 years, months with no water		
10 years ago	30 - 40 cm	2 m
10 years ago, months with no water	Water year round	

3.2.5. Nyoi Koong

Nyoi Koong is a channel located 700 m upstream of Don Sahong Dam. An aerial view and photo of this channel is provided in Figure 3-24 with characteristics provided in Table 3-13.

Figure 3-24. Nyoi Koong in March 2020

Table 3-13. Nyoi Koong characteristics

	Width
Width in dry season	4 - 40 m
Width in wet season	10 - 70 m

	Min. depth in dry season	Max. depth in wet season
In 2021 dry season	Dry	2.5 m
These past 2 years, months with no water	Dec to June	
10 years ago	40-50 cm	2.5 m
10 years ago, months with no water	Water year round	

3.2.6. Koum Tao Hang

Koum Tao Hang is another channel located 900 m upstream of Don Sahong Dam. An aerial view of this channel is provided in Figure 3-25 with characteristics provided in Table 3-14.

Figure 3-25. Koum Tao Hang channel

Table 3-14. Koum Tao Hang characteristics

	Width	
Width in dry season	13 - 37 m	
Width in wet season	22 - 40 m	
	Min. depth in dry season	**Max. depth in wet season**
In 2021 dry season	Dry	4 m
These past 2 years, months with no water	March - May	
10 years ago	50 cm	4 m
10 years ago, months with no water	Water year round	

3.2.7. Hoo Wai

Hoo Way is a major channel allowing fish to swim around the very challenging Khone Lan. It has been the place of extensive earthworks by Don Sahong Company, with in particular blocs of rocks put in place to provide shelter and break the current.

The channel is wide, moderately deep, with several steps where PIT antennas can be set. However, it is unclear whether its entrance in reverse direction compared to the main flow from Khone Lan make is at attractive option for fish. An aerial view and photo of this channel is provided in Figure 3-26 and Figure 3-27, with characteristics provided in Table 3-15.

Figure 3-26. Hoo Wai channel (location map)

Figure 3-27. Hoo Wai channel in November 2019

Table 3-15. Koum Hoo Wai characteristics

	Width	
Width in dry season	9 - 22 m	
Width in wet season	23 - 52 m	
	Min. depth in dry season	**Max. depth in wet season**
In 2021 dry season	50 cm	10 m
These past 2 years, months with no water		
10 years ago	70 cm	10 m
10 years ago, months with no water	Water year round	

3.2.8. Luong Pi Teng

Luong Pi Teng is, like Koum Tao Hang, a channel meant to complement Hoo Wai in bypassing Khone Lan. It is very shallow, with turbulent water most of the year. An aerial view and photo of this channel is provided in Figure 3-28 with characteristics provided in Table 3-16.

Figure 3-28. Luong Pi Teng channel

Table 3-16. Luong Pi Teng characteristics

	Width	
Width in dry season	5 - 8 m	
Width in wet season	Merged with Khone Lan	
	Min. depth in dry season	**Max. depth in wet season**
In 2021 dry season	Dry	2 m
These past 2 years, months with no water	March to June	
10 years ago	Dry	2 m
10 years ago, months with no water	March to April	

3.2.9. Hoo Don Lai

Hoo Don Lai channel is located next to Haew Sompamit. An aerial view and photo of this channel is provided in Figure 3-29 and Figure 3-30 with characteristics provided in Table 3-17.

This is an important channel for small cyprinids (*Cirrhinus, Paralaubuca, Crossocheilus, Labiobarbus*) but also cobitids and other species migrating in January-February. However, exiting the channel is challenging in the dry season. Fishers indicate that fish can only enter and swim in the lower part of this channel in the dry season, up to the waterfalls at mid-way. As water levels gets higher, more fish species can pass these falls.

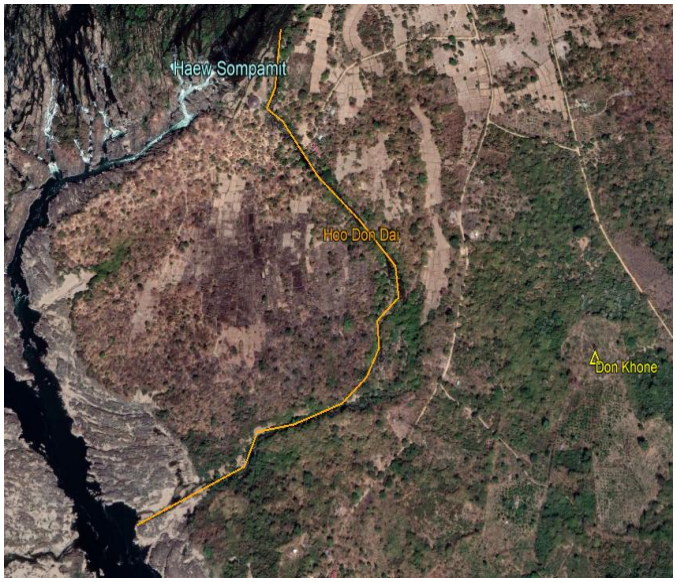

Figure 3-29. Hoo Don Lai (location map)

Figure 3-30. Hoo Don Lai in January 2016 (left: downstream; middle: mid-range; right: upstream)

Table 3-17. Hoo Don Lai characteristics

	Width
Width in dry season	3 - 28 m
Width in wet season	7 - 34 m

	Min. depth in dry season	Max. depth in wet season
In 2021 dry season	40 cm- 1 m last year 50 cm (head water)	1-2 m (head water)
These past 2 years, months with no water		
10 years ago	Dry	1 m
10 years ago, months with no water	March to April	

4. OVERVIEW AND PERSPECTIVES

A series of observations and perspectives is presented based on the survey results set out in Chapter 3.

Target migratory species caught in the zones surveyed

Among upstream villages, fishers from Ban Don Tan Tok and Ban Don Tan Oke report the lowest number of target fish caught (6-7 species) during the past 3 years. They give two reasons for this:

i) the local environment is shallow and not diverse, i.e. not attractive to fish, and
ii) the villages are close to the Don Sahong Dam reservoir inlet, with a strong current that does not allow fishing any longer.

Fishing has shifted towards the west (above Khone Lan) and fishers have started gathering snail to make a living.

In the mid-falls zone, the lowest catch of species surveyed and the lowest abundance are reported in Ban Houa Sadam and Ban Khone Nuea (6-7 species), which is explained by the fact that these villages have seen a restriction of their fishing zone (fishing now limited to Hoo Sadam). In contract to this, villages having access to Khone Pa Soi waterfalls (Ban Khone Nuea, Ban Houa Sadam, Ban Hoo Sadam) still feature a higher diversity and abundance.

Downstream villages report a high diversity of species surveyed , which fishers explain by a favorable aquatic environment (east bank of the Mekong mainstream on the east bank, Tam Ee Deng deep pool near Khone Fang).

Species passing the falls

In the past three years, among the ten target species of the survey only five have been identified as migrating through the falls (*Cirrhinus microlepis, Gymnostomus lobatus, Gymnostomus siamensis, Scaphognathops bandanensis* and *Hypsibarbus malcolmi*). Three species are reported as having upstream migration only through the falls (*Pangasius conchophilus, Pangasius macronema* and *Pangasius krempfi*). One species (*Helicophagus leptorhynchus*) was sometimes reported as having upstream migrations but without further clarity of trajectory noted. Similarly, in upstream villages *Cyclocheilos enoplos* no longer features a clear pattern due to a combination of permanent presence and very low abundance - yet upstream migration remains confirmed in downstream and mid-falls villages.

Which way do migratory fish arrive to Khone Falls?

Our survey is biased by a sampling deficit on the west bank of the Mekong downstream of the falls, since ideally Cambodian villages on the right bank should have been sampled too. However most responses indicate that fish arrive to the falls from downstream through the eastern Mekong channel (between Koh Chheu Teal Thom and the east bank) as it is much deeper than other channels (5 to 30 meter deep vs. 1 to 3 m south of Koh Lngor / Don Langa). Fish then either move north towards Hoo Phapheng, towards the central zone (Hoo Nok Gasoom, Hoo Dtat Wai), or eastwards by following the line of deepest waters (3 to 30m deep north of Koh Lngor / Don Langa) towards Khone Fang area.

Which channels are initially then successively targeted by species for initial passage? Which channels are ultimately used by species to successfully pass the falls?

In the dry season**,** 3 species (*Gymnostomus lobatus, Gymnostomus siamensis* and *Pangasius macronema*) attempt to pass upstream through:

- Hoo Kogma and Hoo Khone Souang (Khone Fang area, passable);
- Hoo Somphamit (impassable);

- Hoo Xang Peuak, Hoo Khone Lan and Hoo Wai (central zone); and
- Hoo Sadam.

However, in the latter case and in recent years lower water levels and the loss of current-related migration cues results in fish staying in Hoo Phapheng downstream of the falls, without attempting the migration through Hoo Sadam.

Hoo Nok Gasoom, Hoo Xang Peuak and Hoo Sadam are channels targeted by fish at the beginning of the rainy season, but they are not accessible before June. Fishers say that migrations start earlier in villages that have deep pools or fish conservation zones as the fish spend the dry season in these places but do not have to come from far away. Hoo Phapheng still attracts fish a lot despite reduced discharge following Don Sahong Dam flow diversion, but passage is impossible at Khone Phapheng and lateral channels (Hoo Som Yai and Hoo Som Pordan) are now dry most of the year, for the same reason.

In the wet season, June water levels are insufficient for fish to pass water falls in the Khone Fang area and fish can only pass through Hoo Xang Pheuak, Hoo Sadam and Hoo Phapheng. In Khone Fang area fish arrived earlier are said to wait in deep pools (in particular at the tip of Don Langa and at Tam Ee Deng) until July.

What are the channel specificities that allow passage?

Fishers identify several factors that attract fish and allow passage:

i) adequate discharge, i.e. strong enough to be attractive but not too strong to remain swimmable;
ii) width and depth of the channel (the more the better); and
iii) higher head producing noise, high dissolved oxygen content and lower low water temperature; iv) presence of multiple resting pools or habitat complexity, with multiple steps allowing fish to progressively jump upstream.

Due to high discharge at Don Sahong Dam site, with the attractive noise and oxygen levels, fish tend to stay in the outflow and many do not attempt to go further upstream towards Hoo Xang Pheuak or Khone Lan like they did a few years ago. This phenomenon is illustrated by the concentration of fishers in the dam outflow.

Overall, fish passage these past years is also compromised by the high number of gears set to compensate a drastically decreasing catch per unit effort, the increasing use of fine monofilament gillnets and the return of *Li* traps in several channels.

What are the passage improvements that could be further conducted?

In Khone Fang area three channels could be considered for leveling and deepening (reduction of current water head) to improve fish passage in the dry season:

i) Hoo Kokma (alternative passage 1),
ii) Hoo Khone Souang (alternative passage 2), and
iii) Hoo Khone Khouang (alternative passage 3).

In the wet season:

i) Hoo Kokma (Alt1),
ii) Hoo Khone Souang (Alt2), and
iii) Hoo Khone Khouang (Alt3), but also
iv) Hoo Sam Hoong (alternative passage 4), and
v) Hoo Khon Hai (alternative passage 5).

These proposed new channel improvements are shown in Figure 4-1. This preliminary list of options needs to be explored further, and the characteristics of each candidate passage need to be detailed.

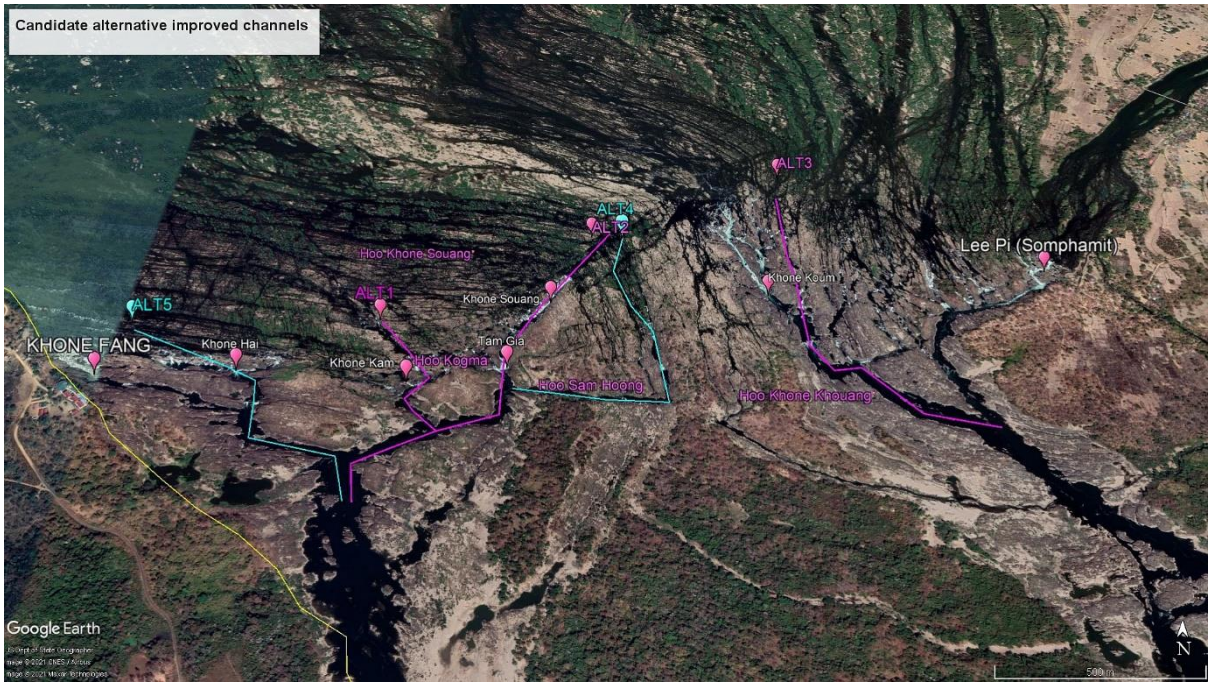

Figure 4-1. Proposed new channels improvements in Khone Fang area

Near Haew Somphamit the Don Lai channel should be improved (this is already part of DSPC's plans), in particular by deepening this channel and removing the 1.2 m high threshold limiting access after the rainy season.

A point not mentioned by fishers deserves attention, which is that at Khone Lan the outlet of the Hoo Wai improved channel is characterized by a sideway and backward curve very likely to be unattractive to fish moving up towards Khone Lan. It is therefore recommended to redesign the outlet of this channel to make it straighter, so that fish can naturally engage into this channel.

5. BIBLIOGRAPHY

Baird I. G. 2001. Aquatic biodiversity in the Siphandone wetlands. Pp. 61-74 in Daconto G. (ed.). 2001 Siphandone wetlands. Publication of the project Environmental protection and community development in Siphandone wetlands. CESVI Cooperazione e Sviluppo, Bergamo, Italy. 192 pp.

Baird I. G. 2006. Conducting rapid biology-based assessments using local ecological knowledge. Nat. Hist. Bull. Siam. Soc. 54 (2);167-175.

Baird I. G. 2007. Local ecological knowledge and small-scale freshwater fisheries management in the Mekong River in Southern Laos. Pp. 227-266. In. Haggan N., Neis B., and Baird I. G. (eds.): Fishers' knowledge in fisheries science and management. Coastal Management Sourcebooks 4. United Nations

Baird I. G., Flaherty M. S. 2005. Environmental Assessment. Mekong River fish conservation zones in Southern Laos: assessing effectiveness using local ecological knowledge. Environmental Management. 36 (3);439-454.

Baird I. G., Overton J. L. 2001. Local knowledge and the conservation and use of aquatic biodiversity. Pp. 177-185. In. IIRR, IDRC, FAO, NACA and ICLARM (eds.): Utilizing different aquatic resources for livelihoods in Asia: a resource book. International Institute of Rural Reconstruction, Cavite, Philippines. 416 pp.

Bao T. Q., Bouakhamvongsa K., Chan S., Chhuon K. C., Phommavong T., Poulsen A. F., Rukawoma P, Suornratana U., Tien D. V., Tuan T. T., Tung N. T., Valbo-Jorgensen J., Viravong S., Yoorong N. 2001. Local knowledge in the study of river fish biology: experiences from the Mekong. Mekong Development Series No. 1. Mekong River Commission, Phnom Penh, Cambodia. 22 pp.

Baran E. 2006. Fish migration triggers in the Lower Mekong Basin and other tropical freshwater system. MRC Technical Paper n° 14. Mekong River Commission, Vientiane, Lao PDR. 56 pp.

Baran E., Baird I. G., Cans G. 2005. Fisheries bioecology at the Khone Falls (Mekong River, Southern Laos). WorldFish Center, Penang, Malaysia. 84 pp.

Baran E., Seng Sopheak. 2011. Fish migrations in the Sekong, Sesan and Srepok Rivers (Mekong River Basin). Report for the project "Scenario-based assessment of the potential effects of alternative dam construction schemes on freshwater fish diversity in the Lower Mekong Basin". WorldFish Center, Phnom Penh, Cambodia. 77 pp.

Baran E., Win Ko Ko, Zi Za Wah, Estepa N., Saray S., Tezzo X., Khin Myat Nwe, Maningo E. 2015. Distribution, migrations and breeding of Hilsa (Tenualosa ilisha) in the Ayeyarwady system in Myanmar. BOBLME-2015-Ecology-39. Bay of Bengal Large Marine Ecosystem project, Phuket, Thailand. 120 pp

Chan Sokheng, Chhuon Kim Chhea, Sintavong Viravong, Kongpeng Bouakhamvongsa, Ubolratana Suntornratana, Noppanum Yoorong, Nguyen Thanh Tung, Tran Quoc Bao, Poulsen A. F., Jorgensen J. V. 1999. Fish migrations and spawning habits in the Mekong mainstream: a survey using local knowledge (Basin-wide). Draft. Assessment of Mekong Fisheries: Fish Migrations and Spawning and the Impact of Water Management Project (AMFC), Vientiane, Lao PDR, November 1999. 57 pp.

Chan Sokheng, Putrea Solida, Leang Sopha. 2008. Using local knowledge to inventory deep pools important fish habitats in Tonlé Sap and mainstream around Great Lake in Cambodia. Pp. 43–63 in Burnhill T.J. and Bamrunggrach P. (eds.): Proceedings of the 8th Technical Symposium on Mekong Fisheries, 15th–17th November 2006. MRC Conference Series No. 7. Mekong River Commission, Vientiane, Laos. 238 pp.

Chhuon Kim Chhea 2000. Fisher's knowledge about migration patterns of three important Pangasius catfish species in the Mekong mainstream. Department of Fishery, Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia. 135-142.

Cowie W., Al Dhaheri S., Al Hashmi A., Solis–Rivera V., Baigun C., Chang K., Cooney R., Kamaka'ala S., Lindeman K., Louwa C., Roe D., Walker–Painemilla K., Al Baharna R., Al Ameri M., Al Hameli S., Al Jaberi K., Alzahlawi N, Binkulaib R., Al Kharusi Y. 2020. IUCN Guidelines for gathering of fishers' knowledge for policy development and applied use. IUCN, Gland, Switzerland; and Environment Agency – Abu Dhabi, United Arab Emirates. 76 pp.

Dubois M. 2005. Integrating local ecological knowledge: tools and approaches in upland aquatic resource management. Pp. 120–127 in: NAFRI, NAFES, NUOL (eds.) Improving livelihoods in the upland of the Lao PDR. Volume 2: Options and opportunities. National Agriculture and Forestry Research Institute. Vientiane, Lao PDR.

Fischer J., Jorgensen J., Josupeit H., Kalikoski D., Lucas C.M. (eds.) 2015. Fishers' knowledge and the ecosystem approach to fisheries: applications, experiences and lessons in Latin America. FAO Fisheries and Aquaculture Technical Paper No. 591. Rome, FAO. 278 pp.

Garcia-Allut A., Freire J., Barreiro A., Losada D. E. 2003. Methodology for integration of fishers' ecological knowledge in fisheries biology and management using knowledge representation [artificial intelligence]. Pp. 227-237 in Haggan N., Brignall C., Wood L. (ed)s. Putting Fisheries' Knowledge to Work. Conference Proceedings August 27-30, 2001. Fisheries Centre, University of British Columbia, Canada. 504 pp.

Haggan N., Brignall C., Wood L. (eds). 2003. Putting fishers' knowledge to work. Proceedings of a conference held at the Fisheries Centre, University of British Columbia during August 27–30, 2001. 504 pp.

Haggan N., Neis B., and Baird I. G. (eds.) 2007. Fishers' knowledge in fisheries science and management. Coastal Management Sourcebooks 4. United Nations Educational, Scientific and Cultural Organization, Paris, France. 437 pp.

Johannes R. E. 1993. Integrating traditional ecological knowledge and management with environmental impact assessment. In Inglis J. (ed.): Traditional ecological knowledge: concepts and cases. International Program on Traditional Ecological Knowledge; International Development Research Centre, Ottawa, ON, Canada. 33-39.

Johannes R.E. (ed.). 1989. Traditional ecological knowledge: a collection of essays. Johannes R. E. Ed. IUCN, Gland, Switzerland and Cambridge, UK. 77pp.

Johannes R.E. 1981. Working with fishers to improve coastal tropical fisheries and resource management. Bulletin of Marine Science.31 (3); 673–680.

Johannes R.E., Freeman M.M.R., Hamilton R.J. 2000. Ignore fishers' knowledge and miss the boat. Fish and fisheries. 1; 257–271.

MFD (Mekong Fish Database) 2003. Mekong River Commission: Mekong Fish Database. A taxonomic fish database for the Mekong Basin. Mekong River Commission, Vientiane, Lao PDR. CD-Rom.

Moller H., Berkes F., Lyver P.O, Kislalioglu M. 2004. Combining science and traditional ecological knowledge: monitoring populations for co-management. Ecology and Society. 9 (3); URL: http://www.ecologyandsociety. org/vol9/iss3/art2.

MRC 2017. Transboundary fisheries management issues in the Mekong and Sekong Rivers. Mekong River Commission, Vientiane, Lao PDR. 38 pp.

Poizat G., Baran E. 1997. Fishermen's knowledge as background information in tropical fish ecology: a quantitative comparison with fish sampling results. Environmental Biology of Fishes. 50; 435–449.

Poulsen A. F. 2003. Integration of fishers' knowledge into research on a large tropical River Basin, the Mekong River in Southeast Asia. Pp. 198-207. In Haggan N., Brignall C. and Wood L. (eds). Putting Fishers' Knowledge to Work. Conference proceedings, August 27-30, 2001, Fisheries Centre, University of British Columbia. 11 (1);198-207.

Poulsen A. F., Valbo-Jørgensen J. 1999. Survey manual for the use of local fishers' knowledge in the study of fish migrations and spawning in the Mekong River Basin. (Basin wide) Assessment of Mekong Fisheries - AMFP Technical Report 1/99 version 1. 0. Mekong River Commission, Vientiane, Lao PDR. 30 pp.

Poulsen A.F., Valbo-Jørgensen J., Chan Sokheng, Chhuon Kim Chhea, Sintavong Viravong, Kongpeng Bouakhamvongsa, Thavone Phommavong, Ubolratana Suntornratana, Noppanum Yoorong, Nguyen Thanh Tung, Tran Quoc Bao, Truong Thanh Tuan, Doan Van Tien. 2000. Fish migrations and spawning habits in the Mekong mainstream: A survey using local knowledge (Basinwide). AMFC Technical Report. Mekong River Commission. February 2000, Lao PDR. 149 pp.

Rahman A. 2000. Development of an integrated traditional and scientific knowledge base: A mechanism for accessing, benefit-sharing and documenting traditional knowledge for sustainable socio-economic development and poverty alleviation. United Nations Conference on Trade and Development (UNCTAD) Expert Meeting on Systems and National Experiences for Protecting Traditional Knowledge, Innovation and Practices. 30 October – 1st November 2000, Geneva, Switzerland. 15 pp.

Roberts T. R., Baird I. G. 1995. Traditional fisheries and fish ecology on the Mekong River at Khone Waterfalls in Southern Laos. Nat. Hist. Bull. Siam Soc. 43; 219-262.

Ticheler H.J., Kolding J., Chanda B. 1998. Participation of local fishers in scientific fisheries data collection: a case study from the Bangweulu Swamps, Zambia. Fisheries Management and Ecology. 5; 81–92.

Valbo-Jorgensen J., Poulsen A. F. 2000. Using local knowledge as a research tool in the study of river fish biology: experiences from the Mekong. Environment, Development and Sustainability. 2; 253-276.

Win Ko Ko, Zi Za Wah, Estepa N, Ouch K, Saray S, Khin Myat New, Tezzo X and Baran E. 2016. Presence, distribution, migration patterns and breeding sites of thirty fish species in the Ayeyarwady system in Myanmar. Report for the MYFish project. Yangon, Myanmar: WorldFish and Department of Fisheries.

6. ANNEX 1: QUESTIONNAIRES OF THE SURVEY

6.1. Upstream questionnaire

Use this questionnaire only in villages

#1 Ban Don Tholathi

#2 Ban Don Sang

#3 Ban Don Det Tok

#4 Ban Don Det Oke

#5 Ban Don En

#6 Ban Don Tan Tok

#7 Ban Don Tan Oke

FORM A: SURVEY DETAILS

C1. Survey form # (MonthDayQuestionnaire#): 031001

C2. Date:

C3. Who led the interview?

C4. Who entered data?

C5. Village and Village number on our map

C6. Draw on the map <u>with a pencil</u> the specific fish habitats in the area and indicate special characteristics of the environment
Cover at least one channel beyond those bordering the island surveyed

Special features may include:

- □ deep pools
- □ fish breeding sites (indicates which species breed there, and when)
- □ fish feeding areas
- □ fish resting areas (before crossing a channel, or between two bottlenecks)
- □ areas with year-round local resident species

FORM B: MIGRATORY SPECIES PRESENT

Tick □ if the species has been caught locally at least some time in the past 5 years:

C7. □ *Cirrhinus microlepis*
C8. □ *Gymnostomus lobatus*
C9. □ *Gymnostomus siamensis*
C10. □ *Scaphognathops bandanensis*
C11. □ *Hypsibarbus malcolmi*
C12. □ *Cyclocheilos enoplos*
C13. □ *Helicophagus leptorhynchus*
C14. □ *Pangasius conchophilus*
C15. □ *Pangasius macronema*
C16. □ *Pangasius krempfi*

FORM C: ABUNDANCE, MIGRATION BEHAVIOUR BY SPECIES

Species:

Tick answers below (no question about gear nor about quantities). For Size range, use sticks

Month	C17. Abundance when fishing					C18. Size range in centimeters			C19. Peak duration (days)	C20. Remarks
	High	Low	None	Don't fish	Don't know	0 – 25	25 – 50	> 50		
A. Jan										
B. Feb										
C. Mar										
D. Apr										
E. May										
F. Jun										
G. Jul										
H. Aug										
I. Sep										
J. Oct										
K. Nov										
L. Dec										

C21. Do you consider this species to be migratory? Yes ☐ No ☐ Don't know ☐

C22. How can you tell which channel(s) the fish enter the fall and which channel(s) the fish exit the falls (no channel name yet)**?**

C23. Are periods of peak occurrence <u>predictable</u> from any (natural) event? Yes□ No□

C24. If yes, which event? . .

Species:

UPSTREAM MIGRATION

C25. Which month does the migration start going upstream? . . Don't know ☐

C26. Which month does the migration stop going upstream? . . Don't know ☐

C27. Any remark about the upstream migration of this species?

C28. Show on the map the main upstream migration channels?

DOWNSTREAM MIGRATION USE THE SPECIES MAP

C29. Which month does the migration start going downstream? . . Don't know ☐

C30. Which month does the migration stop going downstream? . . Don't know ☐

C31. Any remark about the downstream migration of this species? Name of main downstream migration channels?

C32. Show on the map the main downstream migration channels?

SPAWNING

C33. Does this species spawns in Khong District? Yes☐ No☐ Don't know ☐

C34. Additional information concerning the spawning of this species?

FORM E: CONCLUSIONS

C35. Number of fishers actually interviewed (recommendation: 5-6)**:**. .

C36. Was the quality of this interview? Good☐ Average☐ Poor☐

C37. If good, contact of a person for coming back:

C38. Other remarks concerning the interview:

6.2. Mid-falls questionnaire

Use this questionnaire only in villages
#8 Ban Khone Tai
#9 Ban Khone Neua
#10 Ban Don I Som
#11 Ban Don Sahong
#12 Ban Houa Sadam
#13 Ban Don Phapheng

FORM A: SURVEY DETAILS

B1. Survey form # (MonthDayQuestionnaire#):
B2. Date:
B3. Who led the interview?
B4. Who entered data?
B5. Village and Village number on our map

B6. Draw on the map <u>with a pencil</u> the specific fish habitats in the area and indicate special characteristics of the environment
Cover at least one channel beyond those bordering the island surveyed

Special features may include:
- □ deep pools
- □ fish breeding sites (indicates which species breed there, and when)
- □ fish feeding areas
- □ fish resting areas (before crossing a channel, or between two bottlenecks)
- □ areas with year-round local resident species

FORM B: MIGRATORY SPECIES PRESENT

Tick □ if the species has been caught locally at least some time in the past 5 years

B7. □ *Cirrhinus microlepis*
B8. □ *Gymnostomus lobatus*
B9. □ *Gymnostomus siamensis*
B10. □ *Scaphognathops bandanensis*
B11. □ *Hypsibarbus malcolmi*
B12. □ *Cyclocheilos enoplos*
B13. □ *Helicophagus leptorhynchus*
B14. □ *Pangasius conchophilus*
B15. □ *Pangasius macronema*
B16. □ *Pangasius krempfi*

Survey form #(MonthDayQuestionnaire#): ……

FORM C: ABUNDANCE, MIGRATION BEHAVIOUR BY SPECIES

Species:

Tick answers below (no question about gear nor about quantities). For Size range, use sticks

Month	B17. Abundance when fishing					B18. Size range in centimeters			B19. Peak duration (days)	B20. Remarks
	High	Low	None	Don't fish	Don't know	0 – 25	25 – 50	> 50		
A. Jan										
B. Feb										
C. Mar										
D. Apr										
E. May										
F. Jun										
G. Jul										
H. Aug										
I. Sep										
J. Oct										
K. Nov										
L. Dec										

B21. Do you consider this species to be migratory? Yes ☐ No ☐ Don't know ☐

B22. How can you tell the fish are migrating and the direction of the migration?

B23. Are periods of peak occurrence <u>predictable</u> from any (natural) event? Yes□ No□

B24. If yes, which event? . **.**

Species:

<u>UPSTREAM MIGRATION</u> USE THE SPECIES MAP

B25. Which month does the migration <u>start</u> going <u>upstream</u>? . . Don't know ☐

B26. Which month does the migration <u>stop</u> going <u>upstream</u>? . . Don't know ☐

B27. Any remark? Day/night swimming? Surface/bottom? New / full moon? Female/male first? Waiting phase before moving up?

B28. Towards which channels are fish attracted for initial passage upstream? (attractive channels, not necessarily passable channels)
Use the map. Number channels in blue on the map by order of preference (if any preference among fish)

<u>DOWNSTREAM MIGRATION</u> USE THE SPECIES MAP

B29. Which month does the migration <u>start</u> going <u>downstream</u>? . . Don't know ☐

B30. Which month does the migration <u>stop</u> going <u>downstream</u>? . . Don't know ☐

B31. Any remark about the downstream migration of this species? Name of main downstream migration channels?

A32. Does the species pass downstream through impoundment of Don Sahong dam?

Yes☐ No☐ Don't know ☐

SPAWNING

B33. Does this species spawns in Khong District? Yes☐ No☐ Don't know ☐

B34. Additional information concerning the spawning of this species?

Survey form #(MonthDayQuestionnaire#): ……

FORM D: FISH PASSAGE

USE THE SPECIES MAP

B35. Which channels are ultimately used by this species to successfully pass the falls on the way up?
Draw a circle in green around triangle on the channels passable by the species
For each channel where fish passage is possible (red triangle) indicate minimal water depth or month

B36. Any remark?

What are the channel specificities that make passage for this species possible or impossible?
Tick answers. Open answers are possible in G., H., I. and P., Q., R.

B37 Passage possible because	
A. Limited fall height	
B. Limited flow speed	
C. Multiple steps	
D. Deep water	
E. Resting sites	
F. Micro-channels along the main channel	
G.	
H.	

B38 Passage impossible because	
J. Fall too hight	
K. High flow speed	
L. No progressive steps	
M. Shallow water	
N. No resting sites	
O. No micro-channels	
P.	
Q.	

I.	

R.	

B39. Any remark?

B40. In the middle section of the falls, what are the passage <u>improvements</u> (fish passes) that could be further conducted?
Name the channel of the passage for each recommendation

B41. Are there falls or channels not considered so far that could be candidates for passage facilitation (opening passage by removing obstacles)?
Name:

FORM E: CONCLUSIONS

B42. Number of fishers actually interviewed (recommendation: 5-6)**:**. .

B43. Was the quality of this interview? Good☐ Average☐ Poor☐

B44. If good, contact of a person for coming back:

B45. Other remarks concerning the interview:

6.3. Downstream questionnaire

Use this questionnaire only in villages
#14 Ban Hang Khone in Don Khone
#15 Ban Hang Sadam in Don Sadam
#16 Ban Veun Kham on the left bank

FORM A: SURVEY DETAILS

A1. Survey form # (MonthDayQuestionnaire#):
A2. Date:
A3. Who led the interview?
A4. Who entered data?
A5. Village and Village number on our map

A6. Draw on the map <u>with a pencil</u> the specific fish habitats in the area and indicate special characteristics of the environment
Special features may include:

- □ deep pools
- □ fish breeding sites (indicates which species breed there, and when)
- □ fish feeding areas
- □ fish resting areas (before crossing a channel, or between two bottlenecks)
- □ areas with year-round local resident species

FORM B: MIGRATORY SPECIES PRESENT

Tick □ if the species has been caught locally at least some time in the past 5 years

A7. □ 01 *Cirrhinus microlepis*
A8. □ 02 *Gymnostomus lobatus*
A9. □ 03 *Gymnostomus siamensis*
A10. □ 04 *Scaphognathops bandanensis*
A11. □ 05 *Hypsibarbus malcolmi*
A12. □ 06 *Cyclocheilos enoplos*
A13. □ 07 *Helicophagus leptorhynchus*
A14. □ 08 *Pangasius conchophilus*
A15. □ 09 *Pangasius macronema*
A16. □ 10 *Pangasius krempfi*

FORM C: ABUNDANCE, MIGRATION BEHAVIOUR AND SPAWNING BY SPECIES

One form per species

Species:

Tick answers below (no question about gear nor about quantities). For Size range, use sticks

Month	A17. Abundance when fishing					A18. Size range in centimeters			A19. Peak duration (days)	A20. Remarks
	High	Low	None	Don't fish	Don't know	0 – 25	25 – 50	> 50		
A. Jan										
B. Feb										
C. Mar										
D. Apr										
E. May										
F. Jun										
G. Jul										
H. Aug										
I. Sep										
J. Oct										
K. Nov										
L. Dec										

A21. Do you consider this species to be migratory? Yes ☐ No ☐ Don't know ☐

A22. How can you tell the fish are migrating and the direction of the migration?

A23. Are periods of peak occurrence <u>predictable</u> from any (natural) event? Yes□ No□

A24. If yes, which event? . .

Species:

UPSTREAM MIGRATION USE THE SPECIES MAP

A25. Which month does the migration start going upstream? . .

Don't know ☐

A26. Which month does the migration stop going upstream? . .

Don't know ☐

A27. Which way do fish arrive to Khone Falls from downstream? From which bank, going where, why?
Use the map. Draw patterns on the map and use 3 types of arrows:
1) Large thick arrows: most of the fish (main trajectory) if there is a large clear pattern
2) Small thin arrow: if some of the fish only

A28. Any remark? Day/night swimming? Surface/bottom? New / full moon? Female/male first? Waiting phase before moving up?

A29. Towards which channels are fish attracted for initial passage?
Use the map. Number channels in blue on the map by order of preference (if any preference among fish)

A30. Any remark? Khone Fang first? Khone Phapheng first? Progressive moves? Different fish groups have different strategies?

A31. Are there falls not considered so far that could be candidates for passage facilitation (opening passage by removing obstacles)?
Name:

Species:

DOWNSTREAM MIGRATION USE THE SPECIES MAP

A32. Which month does the migration start going downstream? . . Don't know ☐

A33. Which month does the migration stop going downstream? . .Don't know ☐

A34. Any remark about the downstream migration of this species? Name of main downstream migration channels?

A35. Does the species pass downstream through impoundment of Don Sahong dam?

Yes☐ No☐ Don't know ☐

SPAWNING

A36. Does this species spawn in Khong District? Yes☐ No☐ Don't know ☐

A37. Additional information concerning the spawning of this species?

FORM C: CONCLUSIONS

A38. Number of fishers actually interviewed (recommendation: 5-6)**:**. .

A39. Was the quality of this interview? Good☐ Average☐ Poor☐

A40. If good, contact of a person for coming back:

A41. Other remarks concerning the interview:

7. ANNEX 2: Selection of target species for the survey

Process: species reviewed, criteria used, selection and justifications

Species	Migration pattern (Baird 2001)	Migration mapped (MFD 2003)	Percentage of catches in Khone Falls fisheries over 6 years (Baran et al. 2005)	Sensitivity to discharge (Baran 2006)	One of the 10 MRC Priority Species identified in May 2016[3]	Priority Fish Species for Transboundary Management (MRC 2017)	Family and size	Conclusion
Barbonymus altus	Big migration peak in Dec-March, small one in June	No	-	Very high	X	-	Small -medium cyprinid	**Not selected**
Cirrhinus microlepis	two peaks (dry and wet season respectively)	Yes	0.6	Very high	x	x	Medium-large cyprinid	**Selected**
Cyclocheilos enoplos	Peak at the beginning of the rainy season	Yes	1.2	High	-	-	Large cyprinid	**Selected**
Gymnostomus lobatus	Two peaks, Dec-Feb upstream, June-July downstream	Yes	17.3	Low	x	-	Small Cyprinid	**Selected**
Gymnostomus siamensis	Two peaks, Dec-Feb	Yes	2.2	Low	x	-	Small Cyprinid	**Selected**

[3] MRC Joint Planning Workshop on transboundary species management, Pakse, Lao PDR, May 2016.

Species	Migration pattern (Baird 2001)	Migration mapped (MFD 2003)	Percentage of catches in Khone Falls fisheries over 6 years (Baran et al. 2005)	Sensitivity to discharge (Baran 2006)	One of the 10 MRC Priority Species identified in May 2016[3]	Priority Fish Species for Transboundary Management (MRC 2017)	Family and size	Conclusion
	upstream, June-July downstream							
Helicophagus leptorhynchus	-	No	-	-	x	x	Medium size cyprinid	**Selected**
Hemibagrus spilopterus	-	No	-	-	x	-	Medium size Bagridae	**Not selected**
Hypsibarbus malcolmi	Two peaks in December and May	No	0.9	High	x	-	Medium-large cyprinid	**Selected**
Hypsibarbus wetmorei	Two peaks in December (small) and May (large)	No	-	-	x	-	Medium-large cyprinid	**Not selected**
Labeo chrysophekhadion	Two peaks in December (small) and May (large)	No	-	Medium	X	-	Large cyprinid	**Not selected**
Labiobarbus leptocheilus	-	No	1.7	-	X	-	Medium size cyprinid	**Not selected**
Mekongina erythrospila	-	No	1.4	-	x	x	Small Cyprinid	**Selection not recommended by Dr So Nam**
Pangasius conchophilus	Peak in May-June	Yes	11.5	High	x	x	Large Pangasiid	**Selected**
Pangasius krempfi	Peak in June	Yes	14	High	-	-	Large Pangasiid	**Selected**

Species	Migration pattern (Baird 2001)	Migration mapped (MFD 2003)	Percentage of catches in Khone Falls fisheries over 6 years (Baran et al. 2005)	Sensitivity to discharge (Baran 2006)	One of the 10 MRC Priority Species identified in May 2016[3]	Priority Fish Species for Transboundary Management (MRC 2017)	Family and size	Conclusion
Pangasius larnaudii	Peak in May-June	No	0.8	High	x	x	Large Pangasiid	**Selection not recommended by Dr So Nam**
Pangasius macronema	April-July, peak in June	Yes	7.9	High	X	-	Small Pangasiid	**Selected**
Paralaubuca typus	Peak in Jan-March	-	11.4	Very high	X	-	Small Cyprinid	**Selection not recommended by Dr So Nam**
Puntioplites falcifer	Small peak in Jan-Feb, high peak in May	-	0.5	Medium	x	-	Medium size cyprinid	**Not selected**
Scaphognathops bandanensis	2 peaks in January and May	-	3.4	Very high	x	-	Medium size Cyprinid	**Selected**

Final result: 10 species selected

Cirrhinus microlepis (paphone mak kok)	*Hypsibarbus malcolmi* (pa pak nouat/pa pak kom)
Cyclocheilos enoplos (pa chok).	*Pangasius conchophilus* (pa pho/pa ke)
Gymnostomus lobatus (pa soi houa lem)	*Pangasius krempfi* (pa souay hang leuang)
Gymnostomus siamensis (pa soi houa po)	*Pangasius macronema* (pa gnone siap)
Helicophagus leptorhynchus	*Scaphognathops bandanensis* (pa pian)

References cited:

Baird I. G. 2001. Aquatic biodiversity in the Siphandone wetlands. Pp. 61-74 in Daconto G. (ed.). 2001 Siphandone wetlands. Publication of the project Environmental protection and community development in Siphandone wetlands. CESVI Cooperazione e Sviluppo, Bergamo, Italy. 192 pp.

Baran E. 2006. Fish migration triggers in the Lower Mekong Basin and other tropical freshwater system. MRC Technical Paper n° 14. Mekong River Commission, Vientiane, Lao PDR. 56 pp.

Baran E., I.G. Baird and G. Cans. 2005. Fisheries bioecology at the Khone Falls (Mekong River, Southern Laos). WorldFish Center. 84 p.

MFD (Mekong Fish Database) 2003. Mekong River Commission: Mekong Fish Database. A taxonomic fish database for the Mekong Basin. Mekong River Commission, Vientiane, Lao PDR. CD-Rom.

MRC 2017. Transboundary fisheries management issues in the Mekong and Sekong Rivers. Mekong River Commission, Vientiane, Lao PDR. 38 pp.

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