Evaluation of spillover contribution from Fish Conservation Zones (Freshwater Protected Areas) to village fishing catches in the Nam Kading River, Bolikhamxay Province, Lao PDR

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Abstract

An external tagging method was used to evaluate the Fish Conservation Zone **(**FCZ) spillover contribution to fisher catches near two different fish conservation areas in villages of Pak Kading district, Bolikhamxay province from April 2012 to March 2013. A total of 997 fish from 32 fish species were captured in two FCZs and tagged. The most common fish species captured and tagged inside the two FCZs were Pa mang, *Amblyrhynchichthys truncatus* (n=544), followed by Pa pak, *Hypsibarbus* species (n=225) and Pa vienfai, *Barbonymus schwanenfeldii* (n=75). The tagging effort was preceded by outreach in villages along the Nam Kading River to inform fishers about the study, and encourage them to returned tagged fish for a small reward. Recapture data were collected by members of the Lao Women's Union in seven villages along the Nam Kading River. After one year of participatory village research, eight fish species were reported in recapture data. The percentage of tagged fish recaptured by local fishers was 9.53% for all species combined. The results indicate that *Hypsibarbus* species (n=31, 13.77%) and *A. truncatus* (n=54, 9.93%) were most often recaptured. Fishes were generally caught at a distance of 2 km or less from the FCZ boundary, indicating that the local villages near the FCZs may benefit the most from the spillover. Of fishes that were recaptured more than 5 km from the FCZ in which they were tagged, all *A. truncatus* had moved upstream in the river to Hatsaikham and Pak Xoun villages (n=5, 100%), while more than half of the *Hypsibarbus* species migrated downstream to the Mekong confluence at Pak Kading Nuea village (n=9, 66.67%). The results of this study show that at least eight species of fishes do move outside of FCZs, and this spillover can contribute to nearby fisheries (within at least 10 km). A more detailed mark-recapture project, in which fishes are tagged throughout the year and re-captured both inside and outside of the FCZ, would clarify which species of fish are more likely to spillover into the surrounding fisheries, and which species will remain in the protected habitats.

1. Introduction

The Community Fisheries (ComFish) project is a freshwater component of the World Wide Fund For Nature (WWF)-Laos Greater Mekong Programme, which emphasizes aquatic biodiversity conservation to support community food security, household income, and sustainable livelihoods. This project is strongly supported by the national Department of Livestock and Fisheries (DLF) of the Ministry of Agriculture and Forestry (MAF) of Lao People's Democratic Republic (Lao PDR).

Since 2006, the project has created and established more than 171 freshwater biodiversity conservation zones, also called Fish Conservation Zones **(**FCZs), in 6 major tributaries and the Mekong River main stream. The project covers over 900 km of river length, from upstream reaches down to wetlands, including several FCZs on the Nam Kading River. The target sites cover 7 provinces and 29 districts from northern to southern Lao PDR. More than 100 communities and 10,000 households (roughly 60,000 people) who rely on wild aquatic resources for their daily subsistence have been involved in the ComFish project.

To date, there has not been sufficient data to assess or quantify the effectiveness of Nam Kading FCZs in terms of fishery and conservation benefits. The reserves provide conservation benefits through protecting fish from being harvested. The degree to which an FCZ functions to protect fish depends on how mobile the fish are. Fish species that are frequently coming and going from the FCZ, or only migrate through the habitat, may not benefit as much as species that rarely leave the reserve. The reserves may also have a "spillover effect," in which protected juveniles and adults that spend part of their time in the reserves move into the adjacent river habitats and are captured in the fisheries. This may occur when fish stocks are able to rebound within the reserve and resident fish or larval fish disperse outside of the reserve. Spillover effects are commonly cited as one of the benefits of FCZs to the fishing community.

The objectives of the research study were:

1) To quantify the level of spillover contribution of the FCZ to local livelihoods.
2) To present the fish recapture data and their migration patterns for fisheries co-management
3) To strengthen local capacity through technology transfer to align with conservation goals and effective fisheries management

In order to achieve these objectives, the research project adopted a mark-recapture study as a major method for assessment. In particular, the research goals were to:

1) Tag fish inside of the FCZ and assess the level of spillover from protected areas contributing to village harvests, and to examine the spatial extent of the spillover
2) Monitor travel distance and time between tagging in the protected areas and points of recapture
3) Communicate effectiveness of freshwater protected areas to villagers, government managers, public media, and project donors
4) Develop future research plans based on results of the mark-recapture study

2. Research Methodology

Study Site

This study was conducted at FCZs in Donexay and Pak Pang villages within the Nam Kading of Bolikhamxay province, located in Central Lao PDR. This river has been identified as an important tributary of the Mekong

Figure 1. Study area with pins indicating local villages. Villages where recaptures were monitored include (from confluence upstream): Pak Kading Nuea, Pak Pang (FCZ), Donexay (FCZ), Hatsaikham, Pak Xoun, Phonesy, Phonenam

River, with an existing hydropower project and plans for additional projects in the future. ComFish has been active in this river since 2009, and 4 freshwater protected areas are currently established.

Personnel and Training

Techniques for tagging and monitoring were designed to ensure that local staff from WWF, the Provincial Agriculture and Forestry Office (PAFO), and the Pak K ading District Agriculture and Forestry Office (DAFO) could conduct the work independently after completing a training course. FISHBIO staff prepared training materials and led a 2-day training course on tagging methods and data collection procedures. Three WWF staff, one PAFO staff, and one DAFO staff participated in the course. WWF, PAFO, and DAFO staff also conducted the target site selection and community consultation. Recovery data collection and compilation was conducted through collaboration with village fishers, ComFish, PAFO, and DAFO. Two women from the Lao Women's Union in each of the 7 villages were trained to collect data on recaptures by village fishers outside the conservation zones.

Tagging Fish

Fish in each FCZ were captured, marked with a t-bar anchor tag (Hallprint, Australia) printed with a unique ID number, and returned to the same site. Between two and four gill nets of differing mesh sizes (4, 5, 7, or 8 cm mesh) were used to capture fish in FCZs during April and May 2012. Captured fishes were temporarily held in a floating cage within the river channel. Fish were removed from the cage individually, weighed using a digital scale, measured for standard length, and placed in a tagging cradle. Each fish was marked with a t-bar tag that displayed a visible color, a unique ID number, and the name of ComFish project. To assist with identifying where fish were marked a different color of tag was used for each FCZ with yellow tags used in Donexay

Table 1. Research Timeline

No.	Activities	2012												2013						
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
1	Preparing																			
2	Training																			
3	Tagging																			
4	Monitoring																			
5	Analysis & reporting																			

village and pink tags used in Pak Pang village. The tags were inserted below the dorsal fin using a manual, hand-held tagging gun. The ID number and tagging location were recorded, and the fish was returned to the location of capture. Three replicate surveys for tagging were conducted at approximately one or two-week intervals in each FCZ between April 19 and May 21 (Table 1). The objective was to tag 1,000 individuals within two conservation zones (approximately 500 fishes per zone).

Recapturing Fish

Community consultation workshops were conducted to inform villagers of the project objectives. In addition to consultation with villagers, posters were located near fishing areas to inform fishers and encourage them to participate in the study. A small reward of 3,000 kip was given for return of tags. Village fishers were instructed to note details about capture of marked individuals, including:

1) Tag ID number
2) Species (local name)
3) Type and size of fishing gear
4) Date and time
5) Location of capture or distance from the conservation zone

Fishers were asked to report sightings of tagged fish and return tags to the trained members of the Lao Women's Union who administered the survey and held tags until collection at regular intervals by project field staff. Data collection continued for one year after tagging was complete.

After one year of study, recapture data were analyzed in Excel (Microsoft, Redmond, WA, USA) to process quantitative data and graphs to address the research objectives. The percentage of fish recaptured outside of the FCZ for each species was used as a measure of the magnitude of spillover. The maximum distances travelled by a fish (based on the fisher-reported recovery locations) were used to estimate the spatial extent of the spillover. Many species of fish are presumed to migrate as the water level rises at the beginning of the rainy season. To determine whether fish showed a directional tendency to move upstream or downstream (i.e., migration) during the rainy season, the number of fish caught upstream or downstream of the release site were compared for species that were recaptured greater than 5 km from the FCZs in large enough numbers. To assess whether the length-frequency distributions differed for individuals that were recaptured compared with individuals that were not recaptured, two-sample (two-tailed) Kolmogorov-Smirnov tests were conducted in Statistica (StatSoft, Inc., Tulsa, OK, USA) comparing length distributions based on lengths measured at the time of tagging.

3. Results

A total of 997 fish (consisting of 32 different fish species) were captured in two FCZs and tagged (Table 2). A greater number of fish species were captured in Pakpang Village (n=24) compared to Donexay Village (n=15). Three tags were not useable due to tagging error (0.3%). The most common fish species captured inside both FCZs were Pa mang (*Amblyrhynchichthy struncatus*, n=544), followed by Pa Pak (*Hypsibarbus* species, n=225) and Pa vienfai (*Barbonymus schwanenfeldii,* n=75*).* The tagging process always took less than 15 seconds per individual, and all fish were released in good condition after tagging.

Table 2. Number of fish species tagged in the research study, by Fish Conservation Zone village

No	Fish species tagged	Donexay Village	Pakpang Village	Grand Total
1	*Amblyrhynchichthys truncatus*	235	309	544
2	*Hypsibarbus species*	163	62	225
3	*Barbonymus schwanenfeldii*	30	45	75
4	*Puntioplites falcifer*	19	18	37
5	*Cyclocheilichthys apogon*	28	8	36
6	*Hemibagrus spilopterus*	5	5	10
7	*Osteochilus hasselti*		10	10
8	*Cyclocheilichthys enoplos*		7	7
9	*Labiobarbus leptocheilus*		6	6
10	*Henicorhynchus species*		5	5
11	*Mystacoleucus chilopterus*		5	5
12	*Raiamas guttatus*	5		5
13	*Micronema species*	4		4
14	*Hampala species*	3		3
15	*Probarbus species*		3	3
16	*Labeo barbatulus*		2	2
17	*Notopterus notopterus*	1	1	2
18	*Osteochilus waandersii*		2	2
19	*Oxyeleotris marmorata*		2	2
20	*Pangasius pleurotaenia*	2		2
21	*Belodontichtys truncatus*	1		1
22	*Channa striata*	1		1
23	*Cirrhinus microlepis*		1	1
24	*Cosmochilus harmandi*		1	1
25	*Homaloptera confuzona*		1	1
26	*Mastacembelus species*		1	1
27	*Notopterus notopteruss*		1	1
28	*Pristolepis fasciata*		1	1
29	*Probarbus jullieni*	1		1
30	*Probarbus labeaminor*		1	1
31	*Pseudomystus siamensis*		1	1
32	*Wallago attu*	1		1
	# of Species (or Genera) Tagged:	15	24	32

Movement of Fish out of FCZs

A total of 95 tags from recaptured fish were reported to the village Lao Women's Union in 7 villages along Nam Kading River over the first year. The overall percentage of recaptures was 9.53%. Eight fish species were reported in recapture data, with recapture rates varying by species from 33% (1 out of 3) for *Hampala* spp. to 3% (2 out of 75) for *Barbonymus schwanenfeldii* (Table 3). Recaptures were reported from April through November 2012, with the majority of the recaptures reported in May shortly after the tagging effort (Figure 2). Reports of recaptures declined through the rainy period, and no tagged fish were reported between December and March.

Fish captured outside the FCZ were known to have moved out of the FCZ and survived until recapture. However, the fates of the fish that were not recaptured after one year are less clear. They could have: 1) remained in the FCZ and survived (there was no re-sampling of the FCZ), 2) remained in the FCZ and died of natural causes, 3) moved out of the FCZ and died of natural causes, 4) moved out of the FCZ and survived uncaptured, or 5) been recaptured outside of the FCZ by a fisher, but were not reported. Thus, the estimate of 9.53% of tagged fish is the minimum estimate of the percent of fish that moved out of the FCZs. The species with the highest recapture rates were species with very few tagged individuals each: *Hampala* species (n= 3, 33%) and *Henicorhynchus* species (n=5, 20%)(Table 3). The two most abundant species in the tagging effort, *Hypsibarbus* species and *A. truncatus*, also dominated the recaptures, and had 14% and 10% recapture rates respectively. While *B. schwanenfeldii* made up a large proportion of the fish tagged inside the FCZ, only 3% were recaptured outside the FCZ.

The average distances traveled from the FCZ for the two most abundant species, *A. truncates* and *Hypsibarbus* spp., were 2.0 km and 3.6 km respectively (Table 4); the average distance traveled for these two species was greater in June than in May (Table 5). Most fish were recaptured within 2 km of the FCZ where they were released (Figure 3), but the maximum distance for a recapture was 10.7 km (Table 4). The average number of days at large was 28 and 52, respectively (Table 4). There does not appear to be a relationship between days at large and distance from release site (Figure 4).

Two-sample Kolmogorov-Smirnov tests conducted on data from *A. truncatus* and *Hypsibarbus spp*. indicated that length-frequency distributions differed significantly for individuals of *A. truncatus* that were recaptured compared with individuals that were not recaptured (Figure 5; $D_{0.05(2),\,544} = 0.203$, $p < 0.05$), however a significant difference was not detected for *Hypsibarbus spp.* (Figure 6; $D_{0.05(2),\,225} = 0.083$, $p > 0.10$).

Table 3. Recapture data by fish species from one year research study between April 2012-March 2013

Species	# Recaptured	# Tagged	Recapture Rate:	Percent of Total Recaptures:
***Hampala* species**	1	3	33%	1%
***Henicorhynchus* species**	1	5	20%	1%
***Hypsibarbus* species**	31	225	14%	33%
Osteochilus hasselti	1	10	10%	1%
Amblyrhynchichthys truncatus	54	544	10%	57%
Cyclocheilichthys apogon	3	36	8%	3%
Puntioplites falcifer	2	37	5%	2%
Barbonymus schwanenfeldii	2	75	3%	2%
Grand Total	95	997		

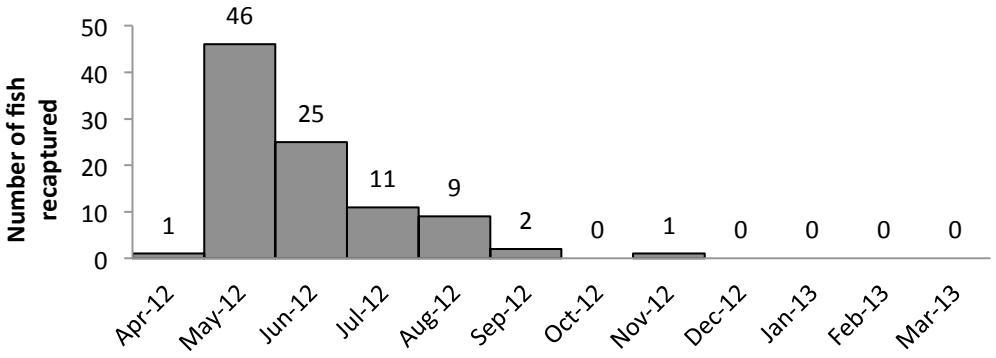

Figure 2. Recapture data collection for one-year of study (2012-2013), with peak recapture rates in May 2012.

Table 4. Distance between release and recapture and number of days at large by species

	Fish species	Count	Minimum Distance (KM)	Maximum Distance (KM)	Average Distance (KM)	Max. Days	Min. Days	Average Days
1	*Amblyrhynchichthys truncatus*	54	0.5	10.7	2.0	107	1	28.3
2	*Hypsibarbus* species	31	0.5	7.8	3.6	198	1	52.0
3	*Cyclocheilichthys apogon*	3	0.7	4.0	1.8	25	1	10
4	*Puntioplites falcifer*	2	0.7	4.0	2.4	61	2	31.5
5	*Hampala* species	1	4.0	4.0	-	10	10	-
6	*Osteochilus hasselti*	1	3.8	3.8	-	29	29	-
7	*Barbonymus schwanenfeldii*	2	0.7	0.5	0.6	30	18	24
8	*Henicorhynchus* species	1	0.5	0.5	-	2	2	-

Table 5. Fish recapture information for May and June 2012

Fish species	#	Minimum Distance (KM)	Maximum Distance (KM)	Average Distance (KM)	Average Water Level (m)
May 2012					
Amblyrhynchichthys truncatus	30	0.5	7.1	2.1	1.2
***Hypsibarbus* species**	12	0.5	7.8	2.8	1.1
Cyclocheilichthys apogon	2	0.7	4.0	2.4	0.7
Barbonymus schwanenfeldii	1	0.7	0.7	0.7	1.5
***Henicorhynchus* species**	1	0.5	0.5	0.5	1.7
June 2012					
Amblyrhynchichthys truncatus	12	0.5	10.7	3.0	4.0
***Hypsibarbus* species**	9	0.5	7.8	5.2	3.6
***Hampala* species**	1	4.0	4.0	4.0	2.5
Barbonymus schwanenfeldii	1	0.5	0.5	0.5	4. 8
Osteochilus hasselti	1	3.8	3.8	3.8	3.2
Cyclocheilichthys apogon	1	0.7	0.7	0.7	3.2

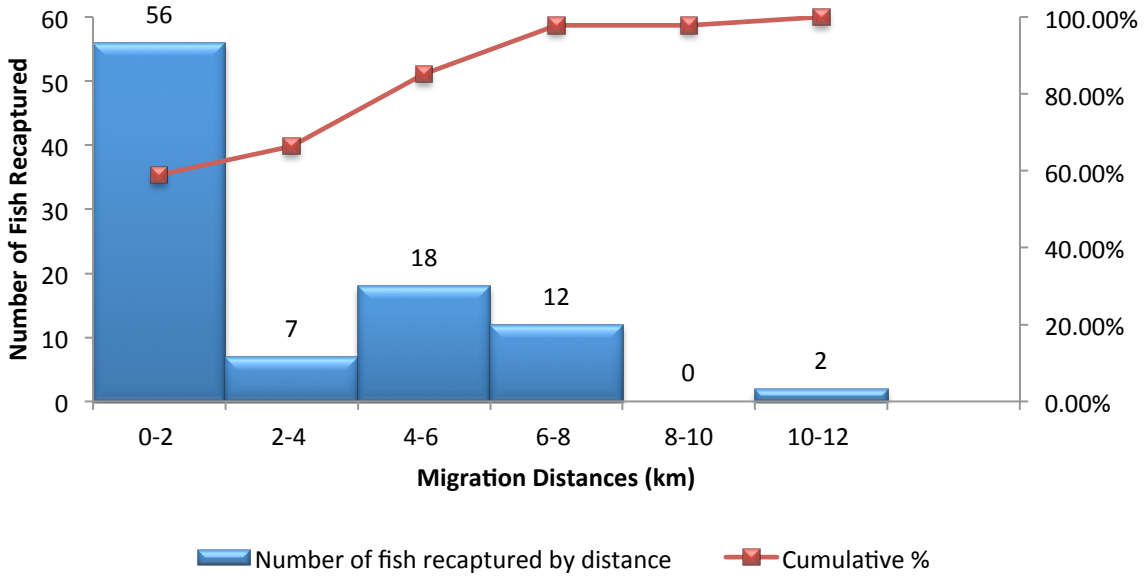

Figure 3. Fish species caught during the study, every 2 km distance from the FCZs.

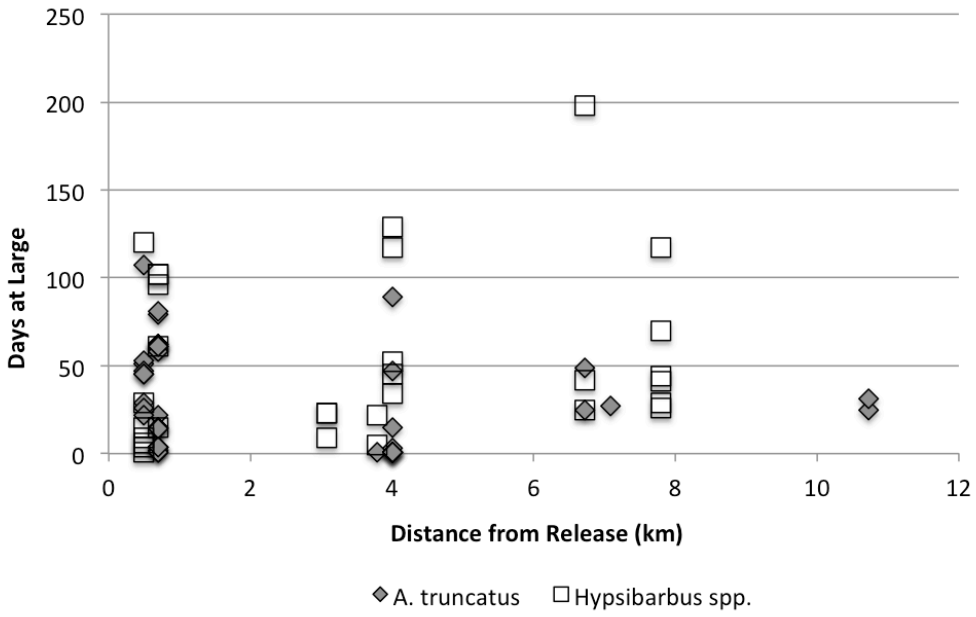

Figure 4. Re-captured fished graphed by days at large and the distance from release site for *A. truncatus* and *Hypsibarbus* spp.

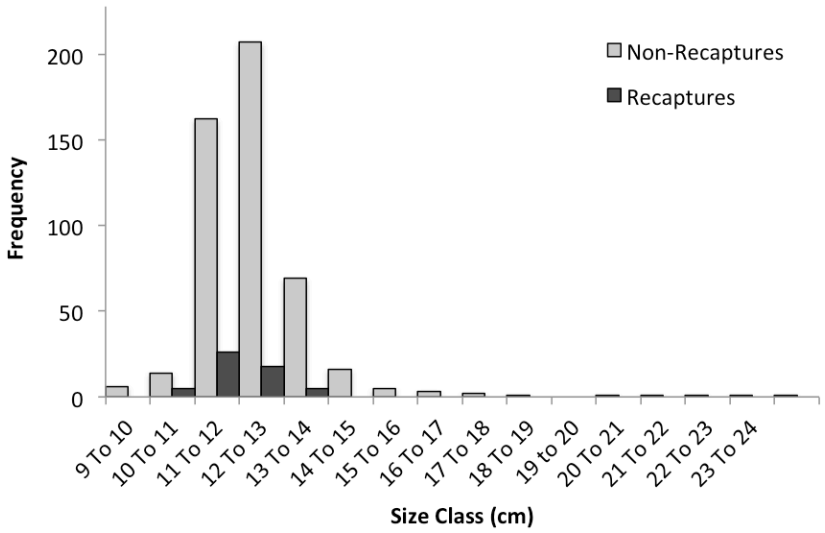

Figure 5. Size frequency distributions for recaptured and non-recaptured *A. truncatus*, based on measured length at tagging.

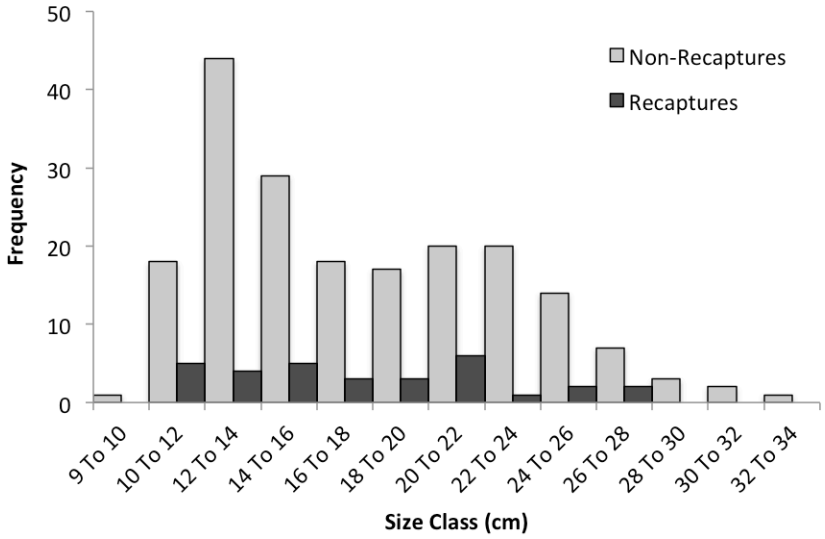

Figure 6. Size frequency distributions for recaptured and non-recaptured *Hypsibarbus spp.*, based on measured length at tagging.

Table 6. The upstream or downstream movement of fish species that were recaptured more than 5 km from the release location.

Fish species	Number of fish species caught in villages upstream of the FCZs			Number of fish species caught in villages downstream of the FCZs	
	Hatsaikham	Pakxoun	Percent of total	Pa Kading Nuea	Percent of total
Amblyrhynchichthys truncatus	1	4	100%	0	0%
Hypsibarbus species	0	3	33.33%	6	66.67%

The majority of fish were captured less than 2 km from the site where they were tagged, although 35 of the 95 recaptures occurred more than 3 km from the tagging site. However, most of these recaptures were either fish tagged in Pakpang and recaptured in Donexay, or tagged in Donexay and recaptured in Pakpang. Movement analysis of fish that were recaptured over 5 km from the FCZ in which they were tagged focused on the species (or genera) of which more than one fish was recaptured at that distance, which greatly reduced the sample size to 14 fish (Table 7). All five *A. truncatus* that traveled more than 5km moved upstream in the river to Hatsaikham and Pak Xoun village (n=5, 100%), while more than half of the *Hypsibarbus* species migrated downstream to the Mekong confluence at Pak Kading Nuea village (n=9, 66.67%). Sample sizes are too small to analyze with chi-square goodness of fit test, because the test assumes that the categories do not have expected frequencies of less than 5.

4. Conclusions

This one-year research study using mark and recapture methods to assess the spillover effects of two FCZs was a successful example of capacity building for people from different sectors who learned together from the implementation and results of the study. Previously, there were no studies to inform effective FCZ co-management, and this study is a good step in quantifying the importance of FCZs for fish production and contribution to the local fishers in the Nam Kading River.

The results of this research study indicate that at least eight species of fish do move beyond the boundaries of FCZs ("spillover") and can contribute to local fisheries within at least 10 km. A minimum of 10% of the fish tagged in the FCZ contributed to the local fisher catch. This is a minimum estimate, since the data do not clearly describe the fates of the fish that were not recaptured. The return rate was typical for this type of mark-recapture study. The species with the largest numbers of individuals tagged tended to have the most recaptures. However, the recapture rate (% recaptured) for each species was unrelated to the initial number tagged, indicating that there may be species-specific differences in contributing to spillover. For example, the recapture of one out of three tagged *Hampala spp*. (33%) indicates that recaptures were possible from small numbers of tagged fish. Most fish were recaptured within 2 km of the FCZ, indicating that while the maximum distance traveled was just over 10 km, the majority of the spillover occurred in villages near the FCZ. Therefore, the benefits of the spillover appear to be more localized to the communities nearest to the reserves, although communities within at least 10 km may also benefit.

Because the fish tagging focused on a transitional period at the beginning of the rainy season, it is possible that the fish captured and tagged were just briefly passing through the FCZ, and were not typical inhabitants of the FCZ habitat. The FCZ would still provide them with protection from fishers during their passage, but this would not meet the standard concept of "spillover effect." A more detailed mark-recapture project, in which fishes were tagged over a longer period of time and re-captured both inside and outside of the FCZ, would be necessary to clarify to what extent different species of fishes are utilizing the FCZ habitat or just passing through it.

Very few fish were recaptured more than 5 km from the FCZ, but those that were showed interesting patterns. Based on the limited re-capture data from the rainy season, it appears that *A. truncatus* may be migrating upstream in Nam Kading during this time. Little is known about the migrations of *A. truncatus*.

Rainboth (1996) reports that *A. truncatus* "moves into inundated forests during the flood season and returns to the rivers in October and November as floodwaters recede." Roberts and Baird (1995) state that the species was "formerly very common in the January-February migration at Hang Khone" in the Si Phan Don region of Southern Laos. The length frequency distribution of recaptured fish was significantly different than that of the non-recaptured fish, and generally consisted of smaller individuals. However, this may be an artifact of the skewed size distribution of tagged fish and the small proportion of recaptures (i.e., we were unlikely to capture the few larger fish that were tagged). Additional mark and recapture studies with a greater number of fish tagged over a longer period could be used to verify whether *A. truncatus* is migrating during this period.

There are several species of *Hypsibarbus* that may occupy the Nam Kading, but species are difficult to identify in the field, and thus were grouped for the purposes of this study. Six species are described in Rainboth (1996) and five in Kottelat (2001). Poulsen and Valbo-Jørgensen (2000) describe contradictory information regarding Hypsibarbus migratory patterns with the onset of the rainy season (both upstream and downstream reports), indicating that species within the genus may behave differently. April to June is presumed to be the peak spawning period, based on observed gravid females. In this study, *Hypsibarbus* spp. were recaptured both upstream and downstream of the FCZs, with the majority of the fish re-captured upstream. There was no indication of a size difference between fish that were recaptured outside of the FCZs and fish that were not.

A greater diversity of fish species were initially captured in Pak Pang Village compared to Donexay Village, which may be a reflection of differences between the two FCZs. Pak Pang FCZ has a greater diversity of habitats, with many rapids and deep water pools. The fish in the FCZ in Donexay village are often fed with pellets, which may alter their natural behaviors and movements. Additional studies of fish diversity and habitat use in these two FCZs may help to inform decisions about placement of future FCZs.

5. Lesson learned

There are many factors that can lead to an underestimate of the spillover effect, such as: fishers did not report tags to village surveyors (discard data), possible fish deaths caused by injuries from tagging, loss of tags over time, and the capture probability (less than 100% probability of capture in fishing gear). These factors make it challenging to draw conclusions from the results. For example, a relatively large number of *Barbonymus schwanenfeldii* were tagged inside the FCZ, but only 3% were recaptured outside the FCZ. There are many possible explanations for this: it may be due to the behavior of the fish (e.g., it is not migratory and is unlikely to move outside of the FCZs), or this may be because the species is unusually sensitive to handling and did not survive after tagging. If the low recapture rate is due to the fish behavior, then this may be an indication that the FCZ may offer great benefit to *B. schwanenfeldii* by protecting it throughout the year. Thus, the FCZ should also be re-sampled periodically to estimate the number of tagged fish that remained in the FCZ. This would clarify the fate of the fish that were not recaptured, and can indicate whether some species (e.g., *B. schwanenfeldii*) are less likely to leave the reserve (spillover) and be susceptible to the fishery until their densities reach a threshold at which point some individuals may move out of the FCZ.

6. Future Recommendations

- When possible, the recapture data record should include more associated data like weather condition, seasonal gear types used for catches, water depth records, and water turbidity.
- This study focused on tagging fish during a transition period between the dry and wet seasons. It would be informative to contrast this by applying tags to fish during the dry season (or just before the dry season), when fish are thought to be less likely to migrate. These are the periods when the FCZs may provide the most protection to fishes, but also may provide the least spillover benefits.
- The FCZ should also be re-sampled periodically to estimate the number of tagged fish that remained in the FCZ. This can be done carefully, with very short gill-net soak times to minimize harm to the protected fish. All fish could be released after capture.
- The study can be repeated over time in the same villages to provide a quantitative fisheries management index of spillover.
- The results of the research study should be presented to relevant sectors, including participants in villages near the Nam Kading River.

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8. References

Kottelat, M. 2001. Fishes of Laos. p. 198. WHT Publications (Pte) Ltd., Colombo, Sri Lanka.

Poulsen, A. F. and J. Valbo-Jørgensen (Ed.). 2000. Fish migrations and spawning habits in the Mekong Mainstream – a survey using local knowledge. AMFC Technical Report. Mekong River Commission. Vientiane, Lao PDR.

Rainboth, W. J. 1996. FAO Species Identification Field Guide for Fishery Purposes - Fishes of the Cambodian Mekong. Food and Agriculture Organization of the United Nations. Rome, Italy.

Roberts, T. R. and I. G. Baird. 1995. Traditional fisheries and fish ecology on the Mekong River at Khone waterfalls in southern Laos. The Natural History Bulletin of the Siam Society 43:219–262.