

Using local knowledge to inventory deep pools important fish habitats in Tonle Sap and mainstream around Great Lake in Cambodia

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ABSTRACT

The hydrology of the Mekong River has a strong influence on aquatic diversity and the fisheries of the Tonle Sap and Great Lake. The Great Lake is a large natural water body into which flows the Tonle Sap, Stung Chinit, Stung Sen, Stung Pursat, Stung Batabang rivers. The fisheries of the lake and its river system have long been considered a major source of animal protein for the population living in the river basin. The important fisheries habitats include deep pools, and floodplains and associated wetlands. Deep pools (*un loong* in Khmer) have been recognised by several researchers as important refuge habitats for fish. The definition of a deep pool is somewhat arbitrary; however, a deep pool is significantly deeper than surrounding riverbed.

Local fishers from 26 villages along the Tonle Sap and mainstreams around Great Lake were asked to identify deep pools based on water depth and importance to the local fishery, so that their location and significance might be accurately documented. Villagers identified 123 deep pools, the largest of which measured approximately 14.8 ha, and some very small pools. The depth of pools, were measured by using the Tish finder 250/250C. Fishers interviewed for this study said deep pools were important habitats for at least 77 fish species in the mainstream, and 152 fish species in Tonle Sap.

KEY WORDS: Deep pools, Local knowledge, Tonle Sap, Cambodia

INTRODUCTION

The hydrology of the Mekong River has a strong influence on aquatic diversity and fisheries in the Tonle Sap and Great Lake. The Great Lake is a large natural water body into which flows the Tonle Sap, Stung Chinit, Stung Sen, Stung Pursat, Stung Batabang rivers. The fisheries of the lake and its river system have long been considered a major source of animal protein for the population living in the river basin. During the peak flood, the level Tonle Sap and Great Lake area covers 13 000 km², and an annual maximum flood level of 9.25 masl. In the dry season the Great Lake surface area is 2,500 km² and an elevation of about 1 masl. The important fisheries habitats include deep pools and floodplains and associated wetlands. Deep pools (*un loong* in Khmer) have been mentioned by several researchers as important refuge habitats for fish. The definition of a deep pool is somewhat arbitrary; however, a deep pool is significantly deeper than surrounding riverbed. Large fish that live in these pools spawn at the start of the flood season and the rising waters carry the ensuing larvae downstream where they form the basis for recruitment for many of the floodplain fisheries.

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However, as discussions with local fishers revealed, the deep pools documented up to now represent only a fraction of those in this stretch of the Mekong. The aim of this study therefore, was to fully document and map the location and general features of deep pools in the Cambodian Mekong as a first step towards developing plans for the management of fisheries in these pools.

As previously mentioned, the definition of a deep pool is somewhat arbitrary; but it must be significantly deeper than the surrounding riverbed, retain water through the dry season (although it may become isolated from the mainstream during these times) and ecologically significant in the conservation of rare or endangered fish. Of course, there is a continuum between deep pools and the rest of the riverbed, but the concept of a deep pool is a use fill starting point for prioritising the management of those stretches of the Mekong that are known to be of great importance to fisheries and fish conservation.

STUDY AREA

The study was carried out in the main tributaries around Great Lake. There are nine main tributaries situated in five provinces (Kampong Chhnang, Pursat, Battambang, Kampong Thom, and Siem Reap) were selected for the purposes of the study (see Figure 1).

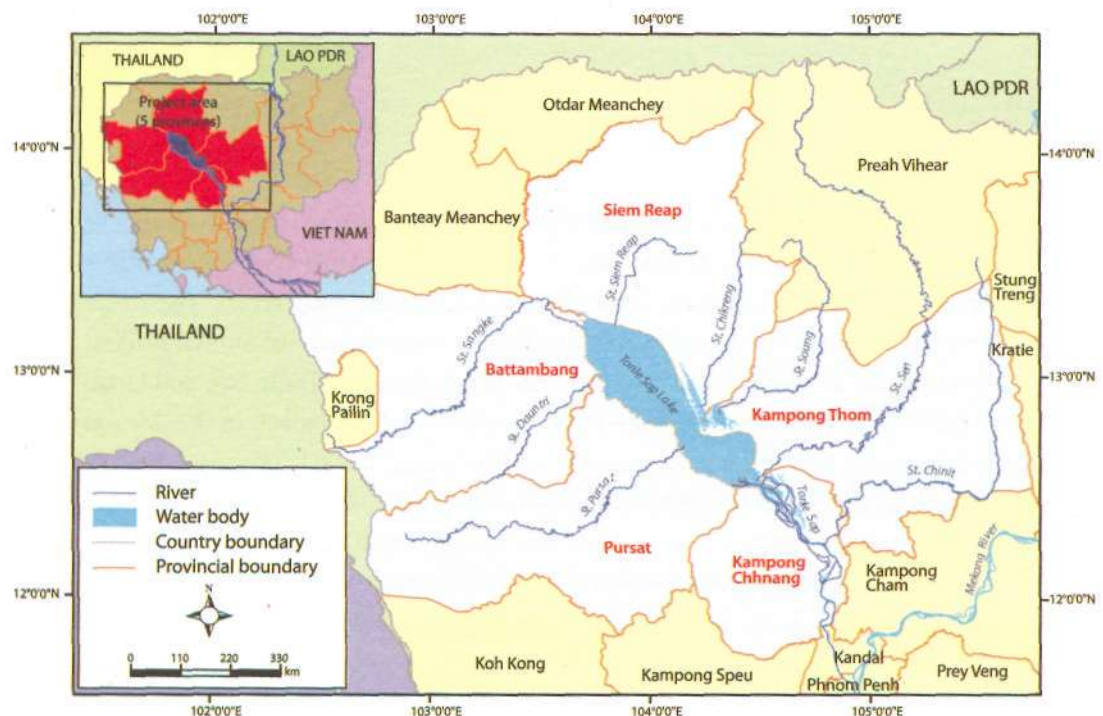


Figure 1. Map of the study area.

1. Tonle Sap (Kampong Chhnang province).

The Tonle Sap, connecting the Mekong River with Great Lake, reverses its flow with the rising of the Mekong during the wet season. The Tonle Sap-Great Lake floodplain is filled about two-thirds by the Mekong River and about one-third by the tributaries flowing into the Tonle Sap and Great Lake (MRC/UNDP, 1998)

2. Stung Pursat (Pursat province).

The Stung Pursat situated in Pursat province, it is a medium size tributary originating in the foot of Krovanh mountains, and has a catchment of about 4,480km². The catchment area is mountainous in the upper and middle reaches, and flat in the lower reaches. It flows through the Pursat town to Great Lake.

3. Stung Dauntri/ Stung Mung russey (Pursat province).

The Stung Dauntri situated in Pursat province, it is a small tributary that connects the Great Lake to other tributaries that originate in the foothills of the Krovanh Mountains.

4. Stung Sangke/ Stung Battambang (Battambang province).

The Stung Sangke situated in Battambang province, it is a medium size tributary that originates in the foothills of the Krovanh Mountains and flows into the Great Lake from the south. It flows through Battambang town is at the heart of Cambodia's 'rice bowl'.

5. Stung Siem Reap (Siem Reap province)

The Stung Siem Reap is a small tributary originating from a medium high plateau north Siem Reap town. Although it flows to the Great Lake, but on its way to the lake it loses a part of its waters because a channel connects it with the Barai Occidental.

6. Stung Chikreng (Siem Reap province).

The Stung Chikreng is a big tributary flowing into Great Lake from the north. The catchment area of this river is poorly defined in the downstream area. The rainfall of the catchment averages about 1,500 mm/year.

7. Stung Stoung (Kampong Thorn province).

The Stung Stoung is a big tributary flowing into Great Lake from the north. The catchment area of this stream is about 1,900 km². The rainfall in the catchment averages about 1,500 mm/year.

8. Stung Sen (Kampong Thom province).

The Stung Sen is the biggest of the tributary flowing into the Great Lake from the northeast in Kampong Thom province, north of Phnom Penh. The catchment area of this stream is about 14,000 km² at Kompong Thom. The rainfall in the catchment area averages about 1,500 mm/year.

9. Stung Chinit (Kampong Thom province).

The Stung Chinit is medium sized tributary flowing into the Great Lake from the northeast in Kampong Thom province, north of Phnom Penh. The catchment area of this stream is about 4,130 km² at Kompong Thmar. The rainfall in the catchment area averages about 1,500 mm/year.

METHODS

Surveys were carried out during the 'dry' season (April to July) in 2006, and interviews and discussions were held with fishers and provincial officers to gather some basic information about the deep pools and fish along the Tonle Sap and tributaries of Great Lake. Discussions with village leaders established where people mainly fished, and additional discussions with five or six fishers from each village provided more background information. Groups of fishers sketched maps of the tributary in their vicinity pointing out the location of deep pools. The survey team then drew preliminarily maps of the localities of deep pools based on local knowledge. Global positioning system (GPS) readings, taken from local boats, gave accurate locations for the accessible 'corners' of deep pools. The maximum depths of most of the pools were verified using Fish Finder.

During further interviews, fishers were asked to identify the species they had caught in deep pools using a photo flip chart containing 193 common Mekong River species and six exotic species found in Cambodia, as well as another ten exotic species sold in the aquarium trade in Phnom Penh. This is an updated version of the chart used by the Assessment of Mekong Fisheries Component in the four riparian countries: Cambodia, Lao PDR, Thailand and Viet Nam. The charts grouped fish species by family, and gave the local as well as the corresponding scientific names. Subsequent reports on the survey use both names. Local fishers, who we asked to monitor and record their catches, provided additional data on fish populations. Villagers also gave other, more general, information about the pools.

RESULTS

The groups of fishers, who were interviewed in 26 villages, identified 123 deep pools. The position of each has been located on maps that run in sequence from nine mainstreams to Great Lake (see Appendix 1) and the details of each pool are listed in Appendix 1. The greatest aggregation of deep pools is in a stretch of Tonle Sap River, which is also the stretch where most of the large pools are found.

During the dry season, most deep pools in the main tributaries of the Great Lake are quite small (<0.01 ha in area) with the largest pool is situated along Tonle Sap river being about 15 ha in area (Figure 2).

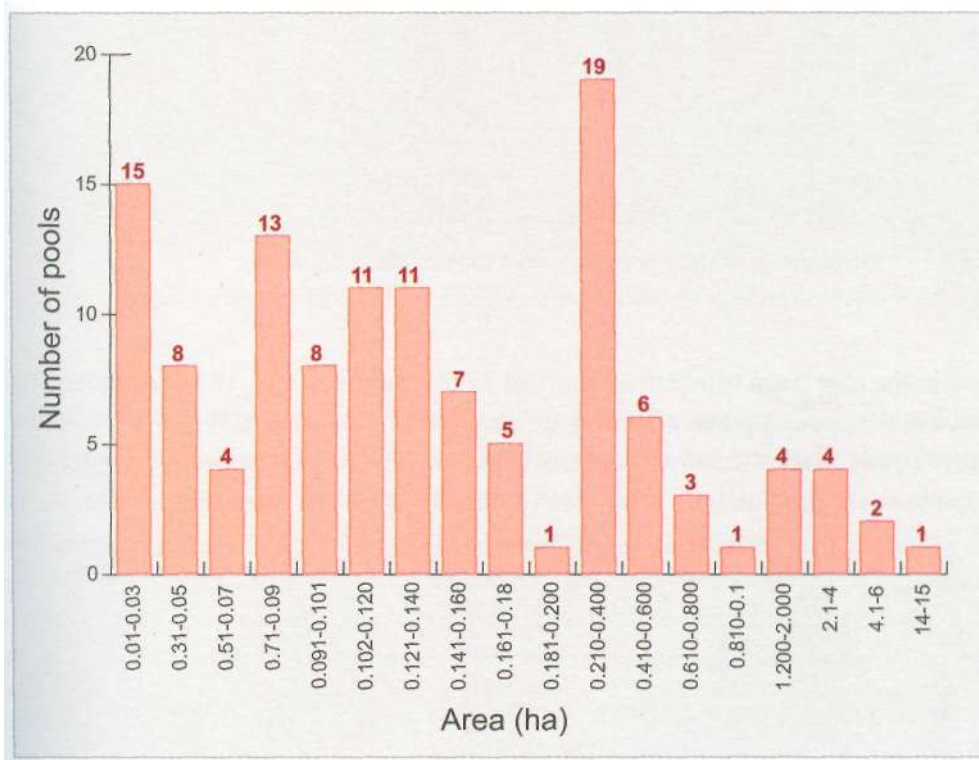


Figure 2. Distribution of deep pools by approximate area.

The maximum depth of most pools is 3-12 m, with the deepest pools about 21 m (Figure 3). However, villagers still classify some areas as deep pools (*un loong*) even though they are only 3-5 m deep, because of their depth relative to the surrounding river bed and their importance to fish.

There are a wide variety of gears in Cambodia, but the trend in recent years has been to use nylon monofilament gillnets, as well as cast nets, hook and line, and some specialised nets for the deep parts of deep pools. Other inventory assessment and monitoring that we conducted along the upper Mekong shows that now the majority of fish are being caught by gillnets, which

are very cheap and readily available. Interviews with fishers did not elaborate this point, but the increasing dominance of gillnets is obvious from their presence in villages, in local markets and set in the pools.

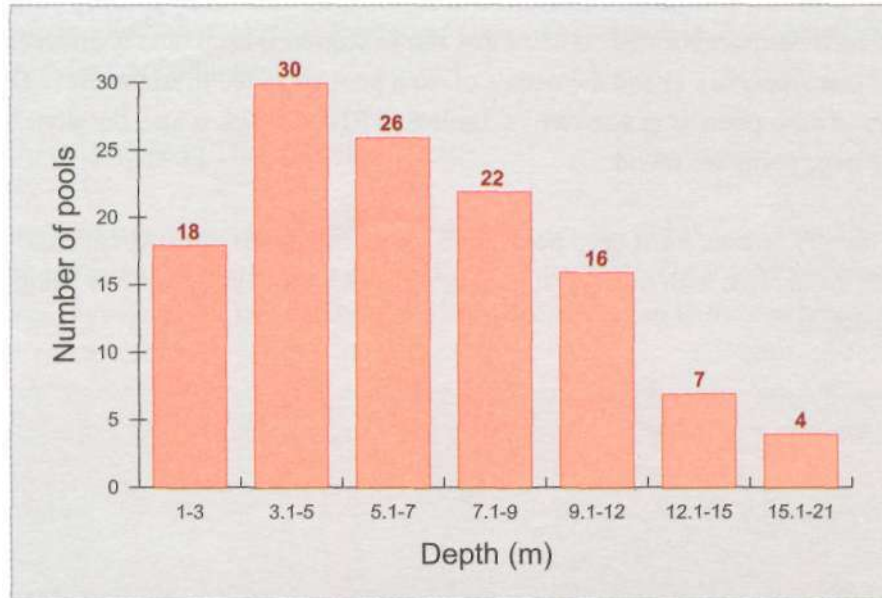


Figure 3. Distribution of deep pools by approximate maximum depth.

Fishers in the nine main tributaries identified 33 fish families, with 185 (Appendix 2) of the 193 species in the photo flip chart (including 7 marine and 7 estuarine). White fish comprise 150 species (81%), and black fish only 21 species (11%) of their catches taken in deep pools. The Tonle Sap has the highest number of species (Figure 4), while the Siem Reap stream the least.

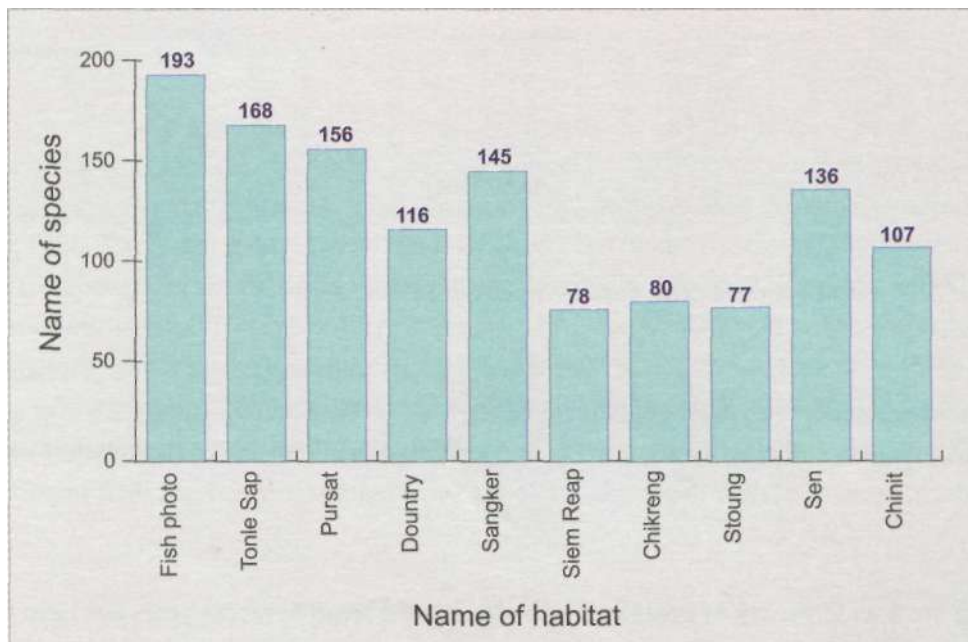


Figure 4. Species reports per habitat.

Figure 5 shows that most species (130, or 71%) were reported to occur at 1, 4, 6 and 9 locations; i.e. most species are widespread through this section of tributaries and river.

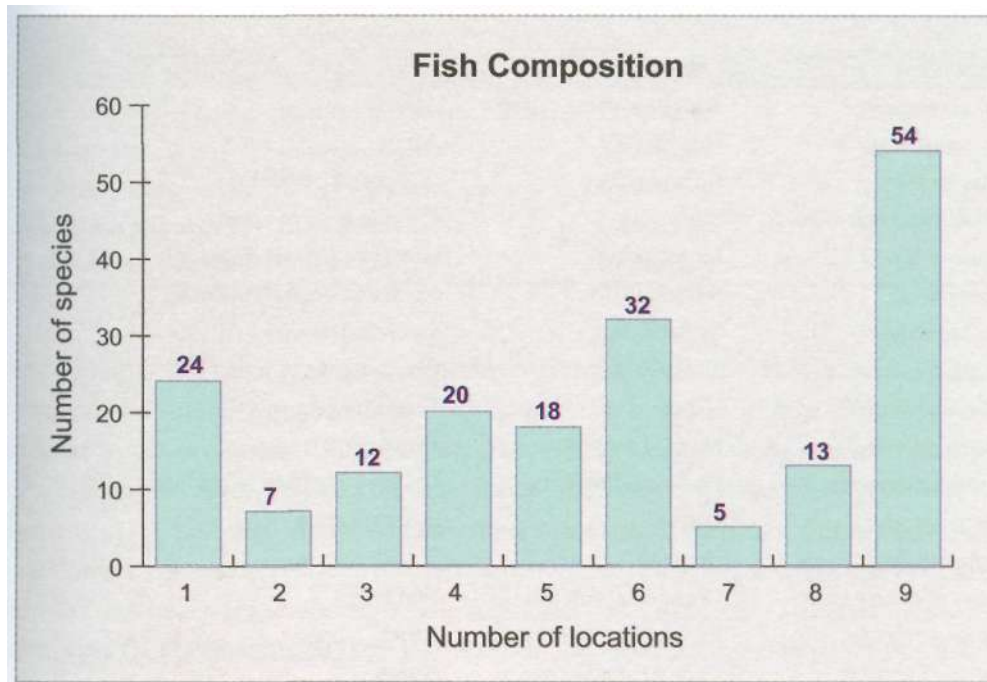


Figure 5. Species reports by location. The figure shows that 54 species occurred at all 9 locations.

The species commonly occurring were those fishes that are common in the inland fishery throughout Cambodia. These included catfishes (Pangasiidae, Bagridae and Sisoridae) and snakeheads (Channidae). The widespread occurrence of most species prevents us attaching any particular significance to particular areas for these common species. Most of the fish not recorded, or recorded at few sites, were mountain, floodplain or estuarine species, which would not be expected to be common in the tributaries of the Great Lake. Moreover the flip charts do not feature over half of the 400+ species known from the Cambodian Mekong, so the results do not provide a comprehensive species list.

The data are of more relative than absolute value in demonstrating that many species, including all common Cambodian river fishes featured on flip charts, are known to occur in the deep pools, and that most species are widespread. It is, however, likely that within individual pools particular species are more abundant, but we have not collected data on that aspect. Within the dataset we note below some points of interest on the occurrence of introduced species, the uncommon indigenous species and giant species.

Introduced species

Table 1. *The number of villages reporting introduced species in deep pools*

Scientific Name	Common Name	Origin	Records
<i>Clarias gariepinus</i>	African walking catfish	Africa	23
<i>Oreochromis niloticus</i>	Nile tilapia	Africa	9
<i>Cyprinus carpio</i>	Common Carp	West Europe to China	5
<i>Hypophthalmichthys molitrix</i>	Silver Carp	China to Eastern Siberia	5
<i>Gambusia affinis</i>	Mosquitofish	North and Central America	0
<i>Xiphophorus spp.</i>	Swordtail	North and Central America	0
<i>Puntius tetrazona</i>	Sumatra Barb	Sumatra, Borneo	0
<i>Myxocyprinus asiatica</i>	Sailfin Sucker	China, Japan	0
<i>Poecilia reticulata</i>	Guppy	South America	0
<i>Polypterus palmas</i>	Marbled Bichir	Africa	0
<i>Rasbora heteromorpha</i>	Harlequin Rasbora	Southern Thailand to Indonesia	0
<i>Symphysodon sp.</i>	Discus	South America	0
<i>Osteoglossum bicirrhosus</i>	Arowana	South America	0
<i>Carassius auratus -variety</i>	Ornamental goldfish	North Asia	0
<i>Cichlasoma hybrid A</i>	Flower Horn Variety	Africa	0
<i>Cichlasoma hybrid B</i>	Flower Horn Variety	Africa	0

Of the four introduced species reported to occur, one were widespread: the African catfish (or its hybrids) was reported at 23 villages, Nile tilapia were reported at 9 villages (Tonle Sap River and Sangke stream), and common carp and silver carp were both reported at 5 villages (Tonle Sap River), showing that these species are spreading rapidly through the mainstream and river system from sites where they have been used for aquaculture. Other aquarium species, which were not recognised by villagers, are also shown in Table 1 and these and many other exotic species are sold in Phnom Penh.

Rare indigenous species

The giant catfish, *Pangasianodon gigas* is one of the four 'giant' Mekong species (Coates *et al.*, 2003), and is the only Mekong species currently listed as 'critically endangered' by the IUCN; the category which implies the highest risk of extinction (Table 2). It was reported at tree villages, one in Tades village of Pursat stream, and the other two in Damnak Reach and Kropeu Pul villages in Tonle Sap River, all in a relatively small area in Pursat Province and Kampong Chnang province.

Table 2. Locality records for Mekong species listed as endangered or critically endangered on the 2003 IUCN Red List (see www.redlist.org)

Scientific Name	English Name	Status	No. of Localities
<i>Pangasianodon gigas</i>	Mekong Giant Catfish	Critically Endangered.	3
<i>Himantura oxyrhynchus</i>	Marbled Freshwater Stingray	Endangered	No data
<i>Pristis zijsron</i>	Green Sawfish	Endangered	No data
<i>Probarbus jullieni</i>	Jullien's Golden Carp	Endangered	21
<i>Scleropages formosus</i>	Asian Arowana	Endangered	0
<i>Tenualosa thibaudeaui</i>	Laotian Shad	Endangered	5

Interestingly, two other giant species listed by Coates *et al.* (2003) (*Catlocarpio siamensis* and *Probarbus jullieni*) were identified as present by fishers at 21 villages, suggesting that these species are in fact still reasonably abundant, despite increasing fishing pressure. The other giant species (*Pangasius sanirwongsei*) were identified occurrence in five villages of Tonle Sap and Pursat stream. Table 2 also shows that two other endangered species featured on flip charts were not identified by fishers (*Himantura oxyrhynchus*, *Pristis zijsron*), whereas the Laotian shad which was formerly very abundant is now found only at 5 locations. The Asian arowana occurs in southwest Cambodia outside the Mekong Basin and it is unknown whether this fish actually occurs in study areas.

DISCUSSION AND CONCLUSIONS

We have identified most of the pools listed by earlier workers and further expanded the list to 123 deep pools, for which we have provided map locations, coordinates, approximate size and maximum depth. Our listing also greatly expands the number of species commonly caught by fishers in deep pools. The listing provided by Poulsen *et al.* (2002), which includes 53 species reported to use the pools as dry season habitat, greatly understates their importance as we have recorded at least 185 native Mekong species, and presumably many more species occur but were not featured on the flip charts (as Cambodia has over 400 freshwater fishes). It should also be noted that some smaller species might actually comprise more than one species, which were not discriminated by fishers. We were unable to define the spawning area, however we do know that while some species spawn in dry season (January to April; *Clupeoides borneensis*, *Corica laciniata*, and *Gobiopterus cluseo*), most of fish spawn during the flood season (May to August). The data on individual species in some cases require confirmation, as some cyprinids and some catfishes are similar to each other so misidentification from photographs is quite likely. On the other hand the use of flip charts provides an efficient way of accessing considerable knowledge on distribution, and is reliable for the larger and more distinctive species.

The pools identified provide important habitats, in particular acting as dry season refuges for large fish, which form the broodstock both for local catches and for the downstream floodplain fishery. Other data currently being collected by monitoring fishers' catches indicate that the

pools in this part of the study areas contain many more large adult fish than the river and floodplain further downstream in Cambodia and into Viet Nam.

Giant species of river barb (*Probarbus jullieni*) thought to be in serious decline are apparently still widespread, being recorded from at twenty-two villages. The giant catfish (*Pangasianodon gigas*), is considered critically endangered and was only recorded by three villages. The data on occurrence of giant and endangered species again show the importance of this area for conservation and also provide a starting point for conservation efforts on these species, as well as the interesting Mekong endemic *Aptosyax grypus*.

The fishery of the many of the deep pools identified in this study face two immediate threats.

Firstly, over-fishing of these large fish is accelerating with improved security, improved access, and better equipment. Fish were formerly relatively safe in the deepest parts of pools where traditional methods of fishing were relatively inefficient. Now boats with outboard motors can be used to travel long distances from population centres. Gillnets line the edges of many of the deep pools, so that as fish move to shallower water to feed (especially at night) where they are vulnerable to capture. Specialised nets attached to heavy weights are also now being used in the deepest parts of pools. Large fish are caught and stored in iceboxes, then sold on to traders who export them, removing this vital bloodstock from Cambodia. While hard data are lacking, all fishers agree that catches are increasing, especially of the large fish. Currently there are no effective controls on fishing periods or gears in these areas, and in fact the current closed season is during the flood (June-September), and hence does not restrict capture of the large fish when they are most vulnerable during the dry season (January-May).

Secondly, the persistence and quality of deep pools depends on the maintenance of existing hydrology and habitat conditions. If flow peak is attenuated (evened out) by dams upstream, the river and streams will lack the energy to scour out sediments in the wet season. Moreover, if sediment is trapped in upstream dams the equilibrium between deposition and suspension will be disrupted, which, for example, could increase erosion and bank-slumping leading to the infill of pools. Any dams on the Mekong mainstream in this zone would be disastrous for the fishery (note that many early feasibility studies included plans for a dam at Sambor, possibly the worst single site which could be chosen from a fisheries perspective (Anonymous, 1969). Clearing of land adjacent to the river and stream is also likely to cause bank-slumping and reduce the depth of pools.

The Mekong system is species-rich so is perhaps less vulnerable to invasion than depauperate systems. But invading species have competitive advantages if the environment is altered to suit them, if (unlike the native fishes) they are isolated from their natural enemies (parasites and pathogens), if local fishers do not target them because of their small size or unpalatability, or if escape from aquaculture supplies continuous recruits.

This paper thus serves as a starting point to clearly identify the deep pools. Now what is needed is a concerted effort to develop management of the fishery in cooperation with villagers,

to limit riparian clearing, to ensure that the EIA of upstream developments takes into account the effects in this important section of river and main streams.

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APPENDIX 1: DEEP POOLS LIST

No	River or Stream	Province	Village	Deep Pool name	Lth (m)	Wdth (m)	Dpth Max	Area (ha)	Area (m ²)	Position	
										X	Y
1	Tonle Sap River	Kampong Chhnang	Back Phnom	Stoeng Sngaut	20	50	11.5	0.1	1000	479663	1313798
3	Tonle Sap River	Kampong Chhnang	Chnok Tru	Dang Kom	350	50	5.5	1.75	17500	443732	1382700
2	Tonle Sap River	Kampong Chhnang	Chnok Tru	Prek Chumrov	400	50	5	2	20000	442789	1383137
4	Tonle Sap River	Kampong Chhnang	Chrum	Chrum	210	30	15	0.63	6300	481304	1318783
5	Tonle Sap River	Kampong Chhnang	Damnak Reach	Ta Lea	170	50	9	0.85	8500	485456	1370977
6	Tonle Sap River	Kampong Chhnang	Damnak Reach	Damnak Reach	530	40	10	2.12	21200	458539	1371581
7	Tonle Sap River	Kampong Chhnang	Doun Veat	Doun Veat	20	80	12.8	0.16	1600	457653	1369307
8	Tonle Sap River	Kampong Chhnang	Kan Dal	Kan Dal	1190	50	11	5.95	59500	481940	1321220
9	Tonle Sap River	Kampong Chhnang	Koh Crabey	Koh Crabey	20	50	8.5	0.1	1000	463337	1363915
10	Tonle Sap River	Kampong Chhnang	Koh Crabey	Kbal Kohcrabey	20	50	6.5	0.1	1000	463210	1364062
12	Tonle Sap River	Kampong Chhnang	Kropeu Pul	Kropeu Pul	630	45	7.6	2.835	28350	459398	1363444
11	Tonle Sap River	Kampong Chhnang	Kropeu Pul	Koh Treng	980	40	7.5	3.92	39200	460659	1363128
13	Tonle Sap River	Kampong Chhnang	Peam Chkok	Peam Chkok	105	60	6.5	6.3	63000	482952	1346749
14	Tonle Sap River	Kampong Chhnang	Peam Lunvek	Peam Lunvek	370	50	13.5	1.85	18500	475199	1314550
15	Tonle Sap River	Kampong Chhnang	Phe	Ork	30	30	13	0.09	900	476536	1335195
16	Tonle Sap River	Kampong Chhnang	Phe	Phe	40	40	15	0.16	1600	476858	1336037
17	Tonle Sap River	Kampong Chhnang	Prek Sala	Prek Sala	20	40	11	0.08	800	476330	1334234
19	Tonle Sap River	Kampong Chhnang	Prek Thmey	Chong Prek Thmey	30	50	8.5	0.15	1500	458644	1367837
18	Tonle Sap River	Kampong Chhnang	Prek Thmey	Prek Thmey	140	55	8.5	0.77	7700	458925	1367011

No	River or Stream	Province	Village	Deep Pool name	Lth (m)	Wdth (m)	Dpth Max	Area (ha)	Area (m ²)	Position	
										X	Y
20	Tonle Sap River	Kampong Chhnang	Prolay Meas	Prolay Meas	330	40	12	1.32	13200	458283	1370570
21	Tonle Sap River	Kampong Chhnang	Reusey Dongkuch	Neakta Kanval	1480	100	21	14.8	148000	482996	1345565
22	Tonle Sap River	Kampong Chhnang	Stoeng Sngaut	Stoeng Sngaut	20	50	16	0.1	1000	458151	1368779
23	Tonle Sap River	Kampong Chhnang	Tamul Krom	Tamul Krom	20	150	17.5	0.3	3000	475803	1331377
24	Tonle Sap River	Kampong Chhnang	Tamul Leu	Tamul Leu	210	130	12	2.73	27300	476014	1332436
25	Tonle Sap River	Kampong Chhnang	Tmey	Prek Chalay	30	60	7.2	0.18	1800	471565	1350002
26	Pursat Stream	Pursat	Anlung Vil	Doung	20	12	6.5	0.024	240	385689	1390457
27	Pursat Stream	Pursat	Back Trokuan	Kampong Lvea	170	20	6	0.34	3400	365562	1368246
28	Pursat Stream	Pursat	Chey Chumnas	Ancheck	20	15	7.5	0.03	300	387401	1390776
29	Pursat Stream	Pursat	Prek Kahay	Prek Kahay	40	15	3	0.06	600	375364	1382074
35	Pursat Stream	Pursat	Prek Troback	Bat Ktas	10	12	3.5	0.012	120	404086	1400379
31	Pursat Stream	Pursat	Prek Troback	Battachan	20	10	3	0.02	200	404352	1401267
37	Pursat Stream	Pursat	Prek Troback	Battangok	20	12	3.6	0.024	240	403507	1400200
36	Pursat Stream	Pursat	Prek Troback	Aloch	40	12	4.5	0.048	480	403897	1400213
30	Pursat Stream	Pursat	Prek Troback	Batponlech	50	10	4	0.05	500	404157	1401241
32	Pursat Stream	Pursat	Prek Troback	Trangol	50	15	5.5	0.075	750	404195	1401112
34	Pursat Stream	Pursat	Prek Troback	Kdam Machus	60	12	3.5	0.072	720	404157	1401032
38	Pursat Stream	Pursat	Prek Troback	Kandeang	80	12	5.5	0.096	960	399575	1397391
39	Pursat Stream	Pursat	Prek Troback	Takdam	100	15	4	0.15	1500	399204	1396616
33	Pursat Stream	Pursat	Prek Troback	Tahao	180	12	4	0.216	2160	404297	1400642
40	Pursat Stream	Pursat	Samrong Year	Kambor Sruay	110	15	10	0.165	1650	369427	1373263
42	Pursat Stream	Pursat	Sbao Reach	Kampong Takim	30	15	6	0.045	450	364801	1368199
41	Pursat Stream	Pursat	Sbao Reach	Cheu Keng	40	15	4	0.06	600	366279	1369431
43	Pursat Stream	Pursat	Svay Chan	Anlung Vil	40	10	5	0.04	400	385660	1390339
47	Pursat Stream	Pursat	Tades	Brobos	150	20	7	0.3	3000	355102	1360042

No	River or Stream	Province	Village	Deep Pool name	Lth (m)	Width (m)	Dpth Max	Area (ha)	Area (m ²)	Position	
										X	Y
46	Pursat Stream	Pursat	Tades	Pronuat	170	20	6	0.34	3400	354402	1359637
45	Pursat Stream	Pursat	Tades	Kandal	200	20	11.5	0.4	4000	353817	1359157
44	Pursat Stream	Pursat	Tades	Neakta Tvea	300	20	4.5	0.6	6000	352661	1358632
48	Pursat Stream	Pursat	Watt Loung	Svahors	390	15	2	0.585	5850	376005	1382528
49	Dauntry Steam	Battambang	Chong Samnai	Chong Samnai	20	8	3.5	0.016	160	333119	1412809
50	Dauntry Steam	Battambang	Prek Taven	Prek Taven	20	10	5	0.02	200	325809	1397887
51	Sangke Stream	Battambang	Cheu Teal	Mok Vat	20	20	7	0.04	400	302183	1439782
52	Sangke Stream	Battambang	Kam Ponchlang	Sa Thany	20	25	12	0.05	500	303612	1440612
54	Sangke Stream	Battambang	Kampong	Kampong	60	20	11	0.12	1200	299404	1431491
53	Sangke Stream	Battambang	Kampong	Trangchruk	170	15	9	0.255	2550	299135	1435609
55	Sangke Stream	Battambang	Lor Et	Phsa Leu	70	18	5	0.126	1260	305321	1446873
56	Sangke Stream	Battambang	Lor Hasaung	Koy	80	16	4	0.128	1280	310258	1457649
57	Sangke Stream	Battambang	Onlaung Tamey	Onlaung Tamey	20	10	3.5	0.02	200	301227	1438896
59	Sangke Stream	Battambang	Prek Trop	Peam Prek Trop	60	18	14	0.108	1080	316973	1461278
60	Sangke Stream	Battambang	Prek Trop	Chan Kiri	60	20	14.5	0.12	1200	315756	1461199
58	Sangke Stream	Battambang	Prek Trop	Scs	70	10	3	0.07	700	318541	1463806
61	Sangke Stream	Battambang	Prek Trop	Yei Phank	90	15	3.5	0.135	1350	314945	1460576
62	Sangke Stream	Battambang	Reach Dounkeo	Daung Mea	90	15	3.5	0.135	1350	312443	1458572
63	Sangke Stream	Battambang	Sor Pouk	Krabau	90	25	9	0.225	2250	299411	1427659
64	Sangke Stream	Battambang	Sor Pouk	Tasok	90	20	7	0.18	1800	298980	1425820
65	Chinit Stream	Kampong Thum	Barai	ToekVel	100	15	7	0.15	1500	488011	1375376
66	Chinit Stream	Kampong Thum	Kaek Sombai	Tatrao	90	15	10	0.135	1350	497292	1384292
67	Chinit Stream	Kampong Thum	Kaek Sombai	Kropet	80	15	3	0.12	1200	496848	1378506
68	Chinit Stream	Kampong Thum	Kaek Sombai	Dong	60	15	3	0.09	900	496911	1377474
69	Chinit Stream	Kampong Thum	Kaek Sombai	Sampoeu	50	16	4	0.08	800	496295	1376792
70	Chinit Stream	Kampong Thum	Kaek Sombai	Akleach	70	16	4	0.112	1120	491152	1376775
72	Chinit Stream	Kampong Thum	Kampong Sdech	Kampong Cham	100	15	5.5	0.15	1500	531253	1385125
71	Chinit Stream	Kampong Thum	Kampong Sdech	Krachal	170	15	5.6	0.255	2550	529843	1385293

Using local knowledge to inventory deep pools important fish habitats in Cambodia

No	River or Stream	Province	Village	Deep Pool name	Lth (m)	Wdth (m)	Dpth Max	Area (ha)	Area (m ²)	Position	
										X	Y
73	Chinit Stream	Kampong Thum	Kampong Sdech	Pralau Meas	200	15	6.3	0.3	3000	533204	1385015
74	Chinit Stream	Kampong Thum	Khsach Chharos	Khsach Chharos	150	20	9.3	0.3	3000	535177	1384904
75	Chinit Stream	Kampong Thum	Prek Chrey	Apong	65	12	3	0.078	780	496876	1384845
77	Chinit Stream	Kampong Thum	Taphauk	Khsach Cheunhing	50	15	5	0.075	750	526601	1383984
76	Chinit Stream	Kampong Thum	Taphauk	Patrok	80	15	5	0.12	1200	527159	1384600
78	Chinit Stream	Kampong Thum	Taphauk	Taum	150	15	4.5	0.225	2250	531593	1384709
79	Sen Stream	Kampong Thum	Kampong Kor	Lor Sangam	90	15	12	0.135	1350	480985	1402960
80	Sen Stream	Kampong Thum	Krasang	Lat	110	20	15.5	0.22	2200	527586	1452330
81	Sen Stream	Kampong Thum	Krasang	Tuk	140	20	7.2	0.28	2800	527101	1451939
82	Sen Stream	Kampong Thum	Krasang	Kel	150	20	8.5	0.3	3000	526696	1450510
83	Sen Stream	Kampong Thum	Ksach Charos	Ta Plong	70	14	7	0.098	980	480556	1404125
84	Sen Stream	Kampong Thum	Ksach Charos	krobao Srong	80	14	8	0.112	1120	476081	1403604
85	Sen Stream	Kampong Thum	Ksach Charos	Tmar	70	14	8	0.098	980	473323	1403420
86	Sen Stream	Kampong Thum	Ksach Charos	Ruesey Te	90	14	9	0.126	1260	474856	1401704
87	Sen Stream	Kampong Thum	Ksach Charos	Pres Sneng	100	14	11	0.14	1400	478104	1404738
88	Sen Stream	Kampong Thum	Ksach Charos	Prohut	60	12	7	0.072	720	476909	1404248
89	Sen Stream	Kampong Thum	Phat Sadai	Talang	70	15	9	0.105	1050	467409	1401183
90	Sen Stream	Kampong Thum	Sandan	Tachau	90	25	9.5	0.225	2250	526467	1449675
93	Sen Stream	Kampong Thum	Srechang	Chhuk	80	25	4.5	0.2	2000	528117	1453848
92	Sen Stream	Kampong Thum	Srechang	Key	190	25	11.5	0.475	4750	527252	1456183
94	Sen Stream	Kampong Thum	Srechang	Kralok	240	25	6	0.6	6000	527586	1455260
91	Sen Stream	Kampong Thum	Srechang	Chrang Krahorn	290	25	8.5	0.725	7250	527409	1454403
95	Sen Stream	Kampong Thum	Tanuan	Tanuan	80	10	3	0.08	800	526816	1451287
97	Stoung Stream	Kampong Thum	Mit Trang	Nekta	20	10	1.8	0.02	200	446932	1431595
96	Stoung Stream	Kampong Thum	Mit Trang	Ta Young	50	10	2	0.05	500	446843	1431701
101	Stoung Stream	Kampong Thum	Piem Atet	Chruv	70	10	5	0.07	700	475586	1469389
100	Stoung Stream	Kampong Thum	Piem Atet	Tmar Kol	90	10	3	0.09	900	475629	1470355
99	Stoung Stream	Kampong Thum	Piem Atet	Kya	100	10	5	0.1	1000	475821	1470407

No	River or Stream	Province	Village	Deep Pool name	Lth (m)	Wdth (m)	Dpth Max	Area (ha)	Area (m ²)	Position	
										X	Y
102	Stoung Stream	Kampong Thum	Piem Atet	Koh Thum	130	10	5.5	0.13	1300	475271	1467965
98	Stoung Stream	Kampong Thum	Piem Atet	Piem auatet	140	10	4	0.14	1400	476257	1471071
103	Stoung Stream	Kampong Thum	Veal Kaptuk	Krabau	130	12	4	0.156	1560	475495	1456299
104	Stoung Stream	Kampong Thum	Veal Kaptuk	Chrakeng	430	12	3	0.516	5160	476024	1457970
105	Chi Kreng Stream	Siam Riep	Chek	Koh Phniev	60	15	5	0.09	900	433422	1466418
106	Chi Kreng Stream	Siam Riep	Chek	Tmar Peung	150	15	6.5	0.225	2250	433441	1466168
107	Chi Kreng Stream	Siam Riep	Dop Tnot	Sronge	70	15	5.5	0.105	1050	433593	1467923
108	Chi Kreng Stream	Siam Riep	Dop Tnot	Spien Lok	140	15	5.5	0.21	2100	433788	1467360
109	Chi Kreng Stream	Siam Riep	Kbal Damrey	Chamkar Aolech	50	15	7.4	0.075	750	432823	1464977
110	Chi Kreng Stream	Siam Riep	Kbal Damrey	Sdey	70	15	7.2	0.105	1050	432720	1464526
111	Chi Kreng Stream	Siam Riep	Kbal Damrey	Lok	150	15	8.5	0.225	2250	433312	1465925
112	Chi Kreng Stream	Siam Riep	Krieng	Damrey Slap	110	15	6.5	0.165	1650	433091	1465235
114	Chi Kreng Stream	Siam Riep	Makak	Trapeng Tmar	70	20	8.5	0.14	1400	432239	1462707
113	Chi Kreng Stream	Siam Riep	Makak	Au Tayeu	110	15	6.5	0.165	1650	432952	1465456
115	Chi Kreng Stream	Siam Riep	Makak	Rarnong	230	20	7.5	0.46	4600	432016	1462126
116	Chi Kreng Stream	Siam Riep	Samrong	Piem Srangei	70	15	7	0.105	1050	432559	1463423
117	Siem Riep Stream	Siem Riep	Banteay Srey	Anglung Tmar	10	10	1.5	0.01	100	388050	1503003
118	Siem Riep Stream	Siem Riep	Banteay Srey	Kampong Lok	10	10	2	0.01	100	388304	1502837
119	Siem Riep Stream	Siem Riep	Banteay Srey	Eay Mao	10	10	1.5	0.01	100	388512	1502623
120	Siem Riep Stream	Siem Riep	Chuk Sor	Aheong	30	15	2	0.045	450	391312	1504200

Using local knowledge to inventory deep pools important fish habitats in Cambodia

No	River or Stream	Province	Village	Deep Pool name	Lth (m)	Wdth (m)	Dpth Max	Area (ha)	Area (m ²)	Position	
										X	Y
121	Siem Riep Stream	Siem Riep	Prey	Piem Steongdach	10	15	3	0.015	150	383981	1498880
122	Siem Riep Stream	Siem Riep	Prey	Doun Ao	10	15	4	0.015	150	382780	1497764
123	Siem Riep Stream	Siem Riep	Prey	Tapil	20	15	3	0.03	300	383342	1498139

APPENDIX 2: LISTS OF SPECIES OCCURRENCE

No	Scientific Name	Family name	Classification	Villages occurrence
1	<i>Acanthopsis sp. 1</i>	Cobitidae	White	25
2	<i>Acanthopsis sp.5</i>	Cobitidae	White	26
3	<i>Acanthopsoides delphax</i>	Cobitidae	White	26
4	<i>Acanthopsoides gracilentus</i>	Cobitidae	White	24
5	<i>Achiroides leucorhynchus</i>	Soleidae	White	18
6	<i>Albulichthys albuloides</i>	Cyprinidae	White	15
7	<i>Amblyrhynchichthys truncatus</i>	Cyprinidae	White	24
8	<i>Anabas testudineus</i>	Anabantidae	Black	25
9	<i>Anguilla marmorata</i>	Anguillidae	White	5
10	<i>Arius caelatus</i>	Ariidae	White	5
11	<i>Arius maculatus</i>	Ariidae	Marine	5
12	<i>Arius sona</i>	Ariidae	Marine	5
13	<i>Bagarius bagarius</i>	Sisoridae	White	20
14	<i>Bagarius suchus</i>	Sisoridae	White	13
15	<i>Bagarius yarrelli</i>	Sisoridae	White	8
16	<i>Bagrichthys obscurus</i>	Bagriichthidae	White	21
17	<i>Bangana behri</i>	Cyprinidae	White	10
18	<i>Bangana sp.</i>	Cyprinidae	White	3
19	<i>Barbonymus altus</i>	Cyprinidae	White	26
20	<i>Barbonymus gonionotus</i>	Cyprinidae	White	5
21	<i>Barbonymus schwanenfeldi</i>	Cyprinidae	White	26
22	<i>Belodontichthys truncatus</i>	Siluridae	White	21
23	<i>Boesemania microlepis</i>	Sciaenidae	White	10
24	<i>Botia helodes</i>	Cobitidae	White	21
25	<i>Botia modesta</i>	Cobitidae	White	26
26	<i>Botia morleti</i>	Cobitidae	White	26
27	<i>Botia sidhimunki</i>	Cobitidae	White	18
28	<i>Botia sp. cf. beauforti</i>	Siluridae	White	18
29	<i>Botia sp. cf. lecontei</i>	Siluridae	White	21
30	<i>Brachirus harmandi</i>	Soleidae	White	20
31	<i>Brachirus orientalis</i>	Soleidae	White	21
32	<i>Catlocarpio siamensis</i>	Cyprinidae	White	13
33	<i>Channa gachua</i>	Channidae	Black	20
34	<i>Channa grandinosa</i>	Pongasiidae	Black	12
35	<i>Channa lucius</i>	Channidae	Black	25
36	<i>Channa maruloides</i>	Channidae	Black	10
37	<i>Channa melasoma</i>	Channidae	Black	20
38	<i>Channa micropeltes</i>	Channidae	Black	24
39	<i>Channa striata</i>	Channidae	Black	25
40	<i>Chitala blanci</i>	Notopteridae	White	20
41	<i>Chitala lopis</i>	Notopteridae	White	18
42	<i>Chitala ornata</i>	Notopteridae	White	21
43	<i>Cirrhinus cirrhosus</i>	Cyprinidae	White	10
44	<i>Cirrhinus jullieni</i>	Cyprinidae	White	18
45	<i>Cirrhinus microlepis</i>	Cyprinidae	White	15
46	<i>Cirrhinus proseion</i>	Cyprinidae	White	17
47	<i>Clarias batrachus</i>	Clariidae	Black	23
48	<i>Clarias gariepinus</i>	Clariidae	Black	23
49	<i>Clarias macrocephalus</i>	Clariidae	Black	26
50	<i>Clupeichthys aesarnensis</i>	Clupeidae	White	17
51	<i>Clupeichthys goniognathus</i>	Clupeidae	White	23
52	<i>Clupeoides borneensis</i>	Clupeidae	White	20
53	<i>Clupisoma sinensis</i>	Schilbeidae	White	26

Using local knowledge to inventory deep pools important fish habitats in Cambodia

No	Scientific Name	Family name	Classification	Villages occurrence
54	<i>Corica laciniata</i>	Clupeidae	White	15
55	<i>Cosmochilus harmandi</i>	Cyprinidae	White	18
56	<i>Crossocheilus atrilimes</i>	Cyprinidae	White	21
57	<i>Cyclocheilichthys enoplos</i>	Cyprnidae	White	26
58	<i>Cyclocheilichthys furcatus</i>	Cyprnidae	White	18
59	<i>Cyclocheilichthys repasson</i>	Cyprinidae	White	21
60	<i>Cyclocheilichthys tapiensis</i>	Cyprnidae	White	26
61	<i>Cynoglossus feldmanni</i>	Cynoglossidae	White	18
62	<i>Cynoglossus microlepis</i>	Cynoglossidae	White	21
63	<i>Cyprinus carpio</i>	Cyprinidae	White	5
64	<i>Dasyatis laosensis</i>	Dasyatidae	White	4
65	<i>Datnioides undecimradiatus</i>	Datnioididae	White	19
66	<i>Ellochelon vaigiensis</i>	Mugilidae	Estuarine	5
67	<i>Gambusia affinis</i>	Poeciliidae	Black	4
68	<i>Garra fasciacauda</i>	Cyprinidae	White	23
69	<i>Gyrinocheilus pennocki</i>	Gyrinocheilidae	White	26
70	<i>Hampala dispar</i>	Cyprnidae	White	25
71	<i>Hampala macrolepidota</i>	Cyprinidae	White	25
72	<i>Helicophagus waandersi</i>	Pangasiidae	White	12
73	<i>Hemarius stormii</i>	Ariidae	Marine	17
74	<i>Hemibagrus spilopterus</i>	Bagridae	White	26
75	<i>Hemibagrus wycki</i>	Bagridae	White	21
76	<i>Hemibagrus wyckioides</i>	Bagridae	White	23
77	<i>Hemipimelodus borneensis</i>	Ariidae	Marine	5
78	<i>Hemipimelodus intermedius</i>	Ariidae	Marine	5
79	<i>Hemisilurus mekongensis</i>	Siluridae	White	26
80	<i>Henicorhynchus lobatus</i>	Cyprinidae	White	25
81	<i>Henicorhynchus siamensis</i>	Cyprnidae	White	26
82	<i>Heterobagrus bocourti</i>	Bagridae	White	26
83	<i>Hypophthalmichthys molitrix</i>	Cyprinidae	White	5
84	<i>Hypophthalmichthys nobilis</i>	Cyprinidae	White	13
85	<i>Hyporhamphus limbatus</i>	Hemiramphidae	Estuarine	26
86	<i>Hypsibarbus lagleri</i>	Cyprinidae	White	21
87	<i>Hypsibarbus malcolmi</i>	Cyprinidae	White	21
88	<i>Hypsibarbus vernayi</i>	Cyprinidae	White	26
89	<i>Hypsibarbus wetmorei</i>	Cyprinidae	White	25
90	<i>Kryptopterus kryptopterus</i>	Siluridae	White	23
91	<i>Labeo chrysophekadion</i>	Cyprinidae	White	26
92	<i>Labeo dyocheilus</i>	Cyprinidae	White	12
93	<i>Labeo rohita</i>	Cyprinidae	White	22
94	<i>Labiobarbus lineata</i>	Cyprinidae	White	21
95	<i>Labiobarbus siamensis</i>	Cyprinidae	White	26
96	<i>Laides longibarbis</i>	Schilbeidae	White	21
97	<i>Leptobarbus hoeveni</i>	Cyprinidae	White	26
98	<i>Lobocheilos melanotaenia</i>	Cyprinidae	White	26
99	<i>Luciosoma bleekeri</i>	Cyprinidae	White	23
100	<i>Lycorhissa crocodilus</i>	Engraulidae	Estuarine	17
101	<i>Macrobrachium sp.</i>	Palaeomonidae	White	17
102	<i>Macrochirichthys macrochirus</i>	Cyprinidae	White	20
103	<i>Macrogathus circumcinctus</i>	Mastacembelidae	White	21
104	<i>Macrogathus siamensis</i>	Mastacembelidae	White	26
105	<i>Mastacembelus armatus</i>	Mastacembelidae	White	26
106	<i>Megalops cyprinoides</i>	Megalopidae	Black	18

No	Scientific Name	Family name	Classification	Villages occurrence
107	<i>Mekongina erythrospila</i>	Cyprinidae	White	8
108	<i>Micronema apogon</i>	Siluridae	White	14
109	<i>Micronema bleekeri</i>	Siluridae	White	26
110	<i>Micronema cheveyi</i>	Siluridae	White	26
111	<i>Monopterus albus</i>	Synbranchidae	Black	26
112	<i>Monotrete barbatus</i>	Tetraodontidae	Estuarine	21
113	<i>Mugil cephalus</i>	Mugilidae	Estuarine	5
114	<i>Mystus albolineatus</i>	Bagridae	White	26
115	<i>Mystus atrifasciatus</i>	Bagridae	White	21
116	<i>Mystus multiradiatus</i>	Bagridae	White	21
117	<i>Mystus mysticetus</i>	Bagridae	White	26
118	<i>Mystus singaringan</i>	Bagridae	White	26
119	<i>Mystus wolffii</i>	Bagridae	White	18
120	<i>Neolissochilus blanci</i>	Cyprinidae	White	9
121	<i>Netuma thalassinus</i>	Ariidae	Marine	5
122	<i>Notopterus notopterus</i>	Notopteridae	White	26
123	<i>Ompok bimaculatus</i>	Siluridae	White	26
124	<i>Ompok hypophthalmus</i>	Siluridae	White	26
125	<i>Ophisternon bengalense</i>	Synbranchidae	Black	21
126	<i>Oreochromis niloticus</i>	Cichlidae	Black	9
127	<i>Osphronemus exodon</i>	Osphronemidae	Black	11
128	<i>Osphronemus goramy</i>	Osphronemidae	Black	11
129	<i>Osteochilus hasselti</i>	Cyprinidae	White	26
130	<i>Osteochilus lini</i>	Cyprinidae	White	21
131	<i>Osteochilus melanopleura</i>	Cyprinidae	White	26
132	<i>Osteochilus microcephalus</i>	Cyprinidae	White	21
133	<i>Osteochilus schlegeli</i>	Cyprinidae	White	21
134	<i>Osteochilus waandersii</i>	Cyprinidae	White	21
135	<i>Osteogeneiosus militaris</i>	Ariidae	Marine	12
136	<i>Oxyeleotris marmorata</i>	Eleotridae	White	26
137	<i>Pangasianodon gigas</i>	Pangasiidae	White	3
138	<i>Pangasianodon hypophthalmus</i>	Pangasiidae	White	17
139	<i>Pangasius bocourti</i>	Pangasiidae	White	20
140	<i>Pangasius conchophilus</i>	Pangasiidae	White	10
141	<i>Pangasius djambal</i>	Pangasiidae	White	17
142'	<i>Pangasius krempfi</i>	Pangasiidae	White	15
143	<i>Pangasius larnaudiei</i>	Pangasiidae	White	16
144	<i>Pangasius macronema</i>	Pangasiidae	White	15
145	<i>Pangasius mekongensis</i>	Pangasiidae	White	13
146	<i>Pangasius micronemus</i>	Pangasiidae	White	15
147	<i>Pangasius pleurotaenia</i>	Pangasiidae	White	20
148	<i>Pangasius polyuranodon</i>	Pangasiidae	White	15
149	<i>Pangasius sanitwongsei</i>	Pangasiidae	White	10
150	<i>Pangasius siamensis</i>	Mastacembelidae	White	17
151	<i>Pangasius siamensis</i>	Pangasiidae	White	26
152	<i>Paralabuca harmandi</i>	Cyprinidae	White	26
153	<i>Paralabuca typus</i>	Cyprinidae	White	24
154	<i>Parambassis wolffi</i>	Chandidae	White	18
155	<i>Plotosus canius</i>	Plotosidae	Estuarine	23
156	<i>Polynemus longipectoralis</i>	Polynemidae	Estuarine	18
157	<i>Poropuntius deauratus</i>	Cyprinidae	White	26
158	<i>Pristolepis fasciata</i>	Nandidae	White	17
159	<i>Probarbus jullieni</i>	Cyprinidae	White	21

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No	Scientific Name	Family name	Classification	Villages occurrence
160	<i>Probarbus labeamajor</i>	Cyprinidae	White	26
161	<i>Pseudomystus siamensis</i>	Bagridae	White	26
162	<i>Puntioplites falcifer</i>	Cyprinidae	White	20
163	<i>Puntioplites proctozysron</i>	Cyprinidae	White	26
164	<i>Puntius orphoides</i>	Cyprinidae	White	17
165	<i>Puntius rhombeus</i>	Cyprinidae	White	11
166	<i>Raiamas guttatus</i>	Cyprinidae	White	20
167	<i>Rasbora dorsinotata</i>	Cyprinidae	White	5
168	<i>Rasbora paviei</i>	Cyprinidae	White	5
169	<i>Rasbora spp. Thai Catch/Mkt</i>	Cyprinidae	White	18
170	<i>Scaphognathops bandanensis</i>	Cyprinidae	White	18
171	<i>Scaphognathops stejneri</i>	Cyprinidae	White	3
172	<i>Scatophagus argus</i>	Scatophagidae	White	5
173	<i>Tenuulosa thibaudeaui</i>	Clupeidae	White	5
174	<i>Tenuulosa toli</i>	Clupeidae	White	26
175	<i>Thynnichthys thynnoides</i>	Cyprinidae	White	4
176	<i>Tor laterivittatus</i>	Cyprinidae	White	5
177	<i>Tor sinensis</i>	Cyprinidae	White	5
178	<i>Tor tambroides</i>	Cyprinidae	White	5
179	<i>Toxotes microlepis</i>	Toxotidae	White	26
180	<i>Trichogaster microlepis</i>	Osphronemidae	Black	21
181	<i>Trichogaster pectoralis</i>	Osphronemidae	Black	26
182	<i>Trichogaster trichopterus</i>	Osphronemidae	Black	26
183	<i>Wallago attu</i>	Siluridae	White	11
184	<i>Wallago leerii</i>	Siluridae	White	26
185	<i>Xenentodon cancila</i>	Belonidae	White	17