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INFLUENCE OF BUILT STRUCTURES ON TONLE SAP FISH RESOURCES

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CONTENTS

INTRODUCTION

1. Fish and fisheries in many tropical river systems are strongly affected by the natural flood regimes and factors that affect these flood regimes (e.g. Welcomme and Halls 2004; Sparks 1995; Junk *et al.* 1989). These river systems are also subject to a variety of developmental pressures, including modified flow regimes, habitat loss, land use change and intensive exploitation of aquatic resources (Arthington *et al.* 2004). It is also suggested that in many cases the planning of many such developments has focused on commercial uses of natural resources, such as agriculture, and taken much less account of other uses, such as subsistence fishing (e.g. Islam and Braden 2006; Oosterbaan 1988). In order to mitigate the negative impacts of developmental activities that involve the construction, modification or removal of structures that affect the flood regime it is important therefore to better understand the effects that they have. This study has looked at three types of structures: a large scale irrigation scheme, floodplain road construction and large scale fishing gear in order to provide some insights into these structures that could inform future decision-making.

2. Built structures have the potential to impact, both positively and negatively, all fish species through the variety of effects, both direct and indirect, that they can produce. These effects, including, but not limited to, changes in hydrology, habitats and patterns of exploitation, can impact fish locally, and even result in transboundary impacts. Evidence of the impacts of built structures have mostly centered around the effects of irrigation and hydroelectric schemes and channelling of rivers (e.g. Nguyen-Khoa *et al.* 2005; Warren 2000; Halls *et al.* 1999; Bailey and Cobb, 1984; Bernacsek, 1984). These studies suggest that these types of built structures can result in a variety of impacts, often with negative impacts on the fisheries as a result of a reduction in or change to aquatic habitat (including connectivity) or changes to and on fish migration and reproduction. However, some positive effects of irrigation and hydroelectric schemes have also been described, primarily arising from associated higher dry season water levels.

3. Roads can also affect fisheries because they can also alter hydrology and sedimentation regimes, consequently affecting the nature of the aquatic habitats and the fish associated with them (Roni *et al*. 2005; Gibson *et al.* 2005; Duke *et al*. 2003; LaMarche and Lettenmaier 2001; Sidle *et al.* 1985). Finally, large-scale fishing gears can affect the movement, migration and presence of fish (by design) but may also have less direct effects on fish by affecting water movement, retention and quality (e.g. Kurien *et al.* 2006)

4. In examining the effect of built structures on fish it is important to understand the nature of the fish species that are being affected. Fish in river-floodplain systems can be categorized as belonging to one of three groups based on their spawning and migratory behavior (see also the fish bioecology-hydrology report). These are white fish (e.g. *Cyclocheilichthys* sp., *Henichorhynchus* sp. and *Paralaubuca* sp.), which migrate upstream to spawn in the main channels and whose fry drift downstream on the currents and then onto the floodplains, black fish (e.g. *Channa striata* and *Anabas testudineus*) which are largely resident on the floodplain and which spawn on the floodplain, and finally the grey fish, a group intermediate between black-fishes and white-fishes (Welcomme 2001; Lévêque and Paugy 1999). Species of this group undertake short migrations between the floodplains and adjacent rivers and tributaries and may also make similar short migrations between permanent and seasonal floodplain water bodies (Welcomme 2001).

5. White fish, because of their more complex spawning and recruitment requirements are considered to be the group that could most easily be affected by hydrological modifications as they are widely distributed, vulnerable to changes to the main channel and, along with the other types, to floodplain modifications, and, in addition, require connectivity between habitats (e.g. Poulsen *et al.* 2002).

I METHODS AND TOOLS

I.1 APPROACH AT THE BASIN AND SUB-BASIN SCALES

6. At the Mekong Basin and Tonle Sap sub-basin levels, this project did not make plans for specific fieldwork, so conclusions are based on previous work and a literature review.

I.2 APPROACH AT THE LOCAL SCALE

7. At the local level, the fisheries component has been designed to provide information that will complement the information generated from the other components and thereby contribute to the overall assessment. Based on discussions between components, the specific objectives of the fisheries surveys were identified as:
    1. Identify how built structures have modified:
        a) habitats (created/increased/reduced)
        b) fishing opportunities, including changes in access to habitats
        c) fish catches and fish populations
    2. Generate new information on fish ecology in the Tonle Sap

8. The survey has been designed to generate general information on these aspects rather than providing detailed quantitative information. Where such quantitative information is required it was suggested that supplemental questions should be integrated into the household surveys being undertaken through the livelihoods and socioeconomic components.

9. Three sites were selected for the study: an irrigation scheme at Stung Chinit, a large scale fishing gear at Prek Toal and rural roads in Pursat. Stung Chinit was selected as there are two major environmental concerns associated with such schemes: the impact of barriers on migratory fish and the impact of the use of pesticides and fertilisers in the project area. Unfortunately, because the scheme only started operating earlier this year it is too soon to be able to look at the effect of agricultural inputs and the study concentrated on the first concern. This should provide useful information that can be used by planners considering irrigation schemes.

10. Pursat is the site of many proposed developments, including irrigation developments, roads and canals. Given the relatively flat nature of the area, constructions that divert or retain water could have quite significant local hydrological effects. Studying the effect of the rural road structure at this site could provide useful insights into the effect of such potential barriers on fisheries and how these effects can be enhanced (if positive) or mitigated (if negative), which could be useful during the implementation of the planned developments.

11. The extensive fishing gears (a 35km long bamboo barrage) at Fishing Lot #2 near Prek Toal serve to concentrate the fish leaving the floodplain making them easier to catch. Given the extent of the gears it is possible that they could significantly affect local hydrological regimes, fish species and local livelihoods (e.g. Kurien *et al.* 2006). While these gears are also present at other fishing lots, the productivity of the area around Prek Toal makes this a most suitable site at which to study the effects of the structure.

12. The type of structure and its operation meant that the approach taken by the fisheries component survey team differed at each site. For Stung Chinit, a site containing a recently completed built structure, the survey concentrated on identifying the changes and effects due to the structure by comparing the fisheries situation before and after completion. For Prek Toal, where the structure has been in use for a long time, the survey team also surveyed a nearby area that was managed without a similar structure to identify differences in fishing practices and outcomes that could be attributed to the structure. Finally, in Pursat a mixed approach was taken by comparing the situation before and after with villagers who might be directly affected by the structure, and also comparing villagers nearby who were not affected by the structure.

13. A major issue that had to be carefully considered in developing the survey methodology and content was the clear trade-off between the quantity and detail of the information collected on the one hand and the needs of the participating fishers on the other. In particular the methodology was developed with the aim of keeping the respondents engaged in order to enable discussions to develop and answers to be explained. It was important that the fishers were not allowed to get bored and were not kept too long as if the respondents get bored or restless the quality of information is likely to suffer (e.g. Silver and Campbell 2005).

14. Given this approach, a methodology was developed that could generate information related to the objectives by utilizing the detailed time and place knowledge of local expert fishers. The types of information to be collected are directly related to the objectives and based on subject areas identified by the domestic fisheries specialist.

15. In accounting for the fact that the fish fauna in Cambodian inland waters comprise a mixture of black, white and grey fish, a bio-ecological review was undertaken that involved merging the FishBase and MRC Mekong Fish databases, a method similar to that employed by Baran *et al.* (2005) for Lao PDR, and using information from a number of other sources (see Annex A). The aim of this was to identify homogenous groups ("guilds") of fish species that have similar ecological conditions and that are thus likely to be similarly influenced by built structures. With regard to fish catches, populations and ecology, the methodology incorporates the materials developed by the domestic fisheries specialist from the review of bio-ecological information on Tonle Sap Lake fish species.

I.3 METHODOLOGY AT THE LOCAL SCALE

16. It is well recognized that fishers and others dependent upon natural resources have a wealth of time and place knowledge that can be valuable for management decision-making within fisheries (e.g. Jentoft 2000; Bergmann *et al.* 2004; Dubois 2005; Garaway *et al.* 2006; Wilson *et al*. 2006). The survey methodology therefore sought to access local ecological knowledge relating to each of the specific survey objectives.

17. In gathering local ecological knowledge, experiences have suggested that the use of closed, questionnaire type surveys are less appropriate and that less structured, and more visual, participatory appraisal type methodologies have been suggested (e.g. Pido *et al.* 1996). However, these methodologies require a certain level of skill and familiarity with their use if they are to be successful.

18. As a result of pre-testing of methodologies, a survey methodology was developed that was comfortable for the data collectors to use and that included elements of both formal questionnaires as well as visual methodologies, such as mapping and the use of fish picture cards for species identification (see Annex B). The actual survey at each site was preceded by a pre-survey that was intended to see if there were any additional factors that would need to be accounted for in the full survey and to identify the respondent groups who would provide the information. The results from the pre-surveys are provided in Annex C. During the pre-survey, criteria were developed that could be used at each site to identify suitable fishers and help ensure that the information that they were able to provide covered an adequate time period and geographical area. The criteria for selection of expert fishers were as follows:
    - between 40 and 60 years old;
    - having 10-15 years fishing experience;
    - currently actively fishing;
    - well-known for fishing skills in the village, and
    - fishers selected from different locations in the same village to potentially provide information on all fishing locations.

19. The local fisheries officer and village and commune headmen were asked to identify knowledgeable fishers in the survey locations who met the above criteria, and to contact them to see if they would be willing to take part in the surveys in groups of three. This provided a total of between sixty and eighty experienced and knowledgeable fishers for each study site.

20. In order to separate the effect of the built structure from other factors that have been, and are, affecting hydrological conditions and fisheries, respondent groups were asked first about aspects of the fishery, e.g. patterns in fishing effort, changes in fish size and fish prices, and what they thought were the reasons for any observed change. They were then asked what effect they thought that the built structure had had and for their perceptions of the positive and negative impacts of the built structure and how any negative impacts might be mitigated (see Annex B).

II RESULTS

II.1 MEKONG SCALE

II.1.1 Water management basinwide

21. Water coming from the Mekong (either through the Tonle Sap River or overland during floods) represents 60% of the Tonle Sap water (Koponen *et al.* 2007 and Figure 1). This means that the development of built structures upstream of the Tonle Sap sub-system would have a significant impact on the lake's hydrology.

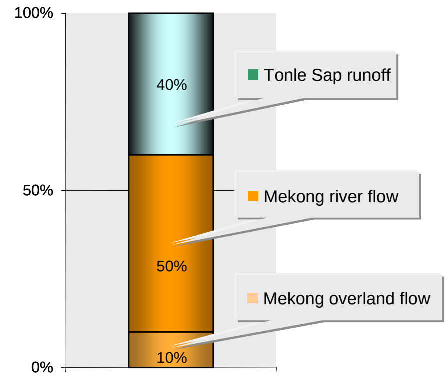

Figure 1: Contribution of the Mekong to the Tonle Sap water level (Koponen *et al.* 2007)

22. In fact Laos contributes 19 percent of Tonle Sap water, and while China and Thailand contribute 9 and 10 percent respectively. This calculation is possible knowing the contribution of each country to the Mekong annual flows (see Table I), the contribution of Mekong flows to Tonle Sap flows (see above) and the share of Mekong annual average flow at the level of Phnom Penh (i.e. 93.3 percent of the total Mekong flow).

Table I: Contribution of riparian countries to Mekong and Tonle Sap flows

	Contribution to Mekong flows (%)	Contribution to Tonle Sap flows (%)
Laos	35	19
Cambodia	18	-
Thailand	18	10
China	16	9
Vietnam	11	-
Myanmar	2	1

II.1.1.1 Mekong flows and built structure development

23. The degree of inundation in the Mekong depends on the strength of the annual monsoon, as 85-90% of the discharge is generated during the wet season. However, the average wet season discharge in the last twenty years (1979-98) appears to be at least 10% lower than in 1924-1956, while the inter-annual variations have become more extreme (Nam Sokleang 2000). The downward trend seems to be independent of fluctuations in rainfall and therefore has been linked to dam building activities that started in the late fifties in the basin (Van Zalinge *et al*. 2003). White (2000) also identified dams as the projects that pose the highest degree of systematic risk to the region, under criteria that include displacement of vulnerable people, impact irreversibility, environmental impacts on the mainstream river flow and quality, and economic impact.

24. In the Mekong Basin according to the MRC (2003), thirteen hydropower dams of a capacity higher than 10 megawatts existed in 2003: two in China on the mainstream, 5 in Laos, 4 in Thailand and 2 in Vietnam, the latter nine being on tributaries, for a total production of 4,400 megawatts (15% of the basin's hydropower potential estimated at 30,000 megawatts). Many more are under construction or being planned, including at least six in China and "a number" in Laos[1]. There is also "a positive attitude towards hydropower development" in Vietnam (MRC 2001), as attested to by the recent plans of Electricity of Vietnam to build 173 new hydroelectric power stations with a total capacity of 2,296 MW to supplement the existing 500 small and medium sized hydroelectric power stations[2]. Until recently no new major dams were planned in Thailand and Cambodia, but this is changing quickly. In Cambodia, the government "places high priority on attracting increased private sector investment and participation in electricity production and distribution"[3] and the Prime Minister of Cambodia has recently requested the Chinese ambassador in Cambodia "to attract her country's companies to invest in hydroelectric power generation"[4]

Table II: Sites with existing hydropower capacity or proposed for development in Cambodia

River/Site	Multi-site
Sre Pok	3 sites in Cambodia: 787 MW. 7 sites in Viet Nam: 841 MW
Se San	2 sites in Cambodia: 582 MW / 3042 GW; 5 sites in Viet Nam: 1516 MW
Se Kong	2 sites in Lao PDR: 390 MW / 1269 GW
O Phlai	4 sites; 21 MW / 147 GW
Stung Pursat I	4 sites: 96 MW / 485 GW
Prek Liang	3 sites: 121 MW / 581 GW
Prek Por	3 sites: 34 MW / 204 GW
Prek Ter	3 sites: 50 MW / 269 GW
Stung Battambang	3 sites: 73 MW / 384 GW
Prek Chhlong	2 sites: 31 MW / 203 GW
Prek Kam	2 sites: 8 MW / 53 GW
Prek Kreing	2 sites: 14 MW / 85 GW
Prek Rwei	2 sites: 12 MW / 128 GW
Stung Mongkulborey	2 sites: 14 MW / 97 GW

River/Site	Single site
Mekong Sambor 2	3300 MW / 14870 GW
O Chum II	1 MW / 4.4 GW
Kamchay	180 MW / 550 GW
Prek Chbar	5 MW / 32 GW
Stung Atay	110 MW / 588 GW
Stung Cheay Areng	260 MW / 1350 GW
Stung Chikreng	2 MW / 8 GW
Stung Chinit	5 MW / 23 GW
Stung Sreng	7 MW / 69 GW
Stung Staung	4 MW / 23 GW
Stung Sva Slapp	4 MW / 20 GW
Stung Tanat	4 MW / 27 GW
Stung Tatay	80 MW / 250 GW
Stung Treng	980 MW / 4870 GW
Upper Prek Ter	15 MW / 77 GW
Upper Stung Siem Reap	1.7 MW / 7 GW

Capacity installation (MW) / *Energy production* (GW)
Sources: Sources: Hydroelectricity Department, Ministry of Industry, mines and energy; MRC Hydropower development strategy 2001; Cambodge Nouveau nº 215 and 241

25. This assessment only refers to hydropower dams of medium or large size, which do not consume water but only alter the flow regime and fragment aquatic habitats. However, these dams are supplemented by thousands of small irrigation reservoirs and weirs that aim at extracting water from the river and thus reduce flow, among other impacts. These small schemes are not individually identified, although they are quite visible on remote-sensing maps, particularly in North-East Thailand (see for instance MRC 2003). In addition to existing ones, multiple smaller schemes are being considered (including 15 dams for

[1] This includes, according the Vientiane Times (28 March 2006) plans for a 240 MW dam at Khone Falls, more specifically at Don Sahong. Such dam would have a very significant negative impact on dry season migrations, since Don Sahong is the only channel that fish can use to migrate from Cambodia to Laos during the dry season.
[2] Vietnam Economic Times, 04 August 2005. This covers the whole of Vietnam, not just the share of the Mekong Basin lying within Vietnam.
[3] Rectangular Strategy, side 3, Development of the energy sector and electricity network. This approached is balanced by a commitment to "enabling a supportive fisheries and ecological system" (side 2 of the rectangular strategy).
[4] Phnom Penh Post, 1-14 December 2006

irrigation purposes, mainly in Thailand and Vietnam). The Vietnam National Mekong Committee (2003) states that currently there are 580 irrigation projects of various size within the Sesan and Srepok basins (major Mekong tributaries) in Vietnam only, servicing at least 46,180 hectares of rice paddies and coffee plantations in the central highlands. The irrigation water demand of crops in the Sesan and Srepok basins in Vietnam is estimated to grow by 36%, from 2.8 in 2001 to 3.8 billion m^3/year by the year 2010. The projected water demand in dry season represents 63% of the total runoff, an unrealistic quantity to extract without extensive water development infrastructure. Consequently, further development - and rehabilitation- of irrigation schemes are planned. About 658 irrigation works are expected to be constructed in the Gia Lai, Dak Lak and Kon Tum provinces.

II.1.1.2 Water allocation mechanisms and fisheries economics

26. To date, scientifically underpinned comprehensive water allocation mechanisms have not been set for the Lower Mekong Basin (Petersen 2003). Among the preliminary works, the model proposed by Ringler (2000, 2001) to determine the optimal allocation of water resources in the Mekong Basin should be mentioned. Unfortunately, lack of data and data unreliability hampered the predictive power of the model (Johnston *et al*. 2003). Ringler finds that artificial diversions of water from the Mekong could readily cause negative impacts on fisheries and saltwater intrusion into the Mekong Delta during the dry season.

27. Table III shows that total profits from optimal water allocation and use were estimated at USD 1.8 billion in 1990, irrigated agriculture ranking first with USD 917 million and fish catches second with USD 546 million. Vietnam obtains the greatest benefits from basin water uses, contributed chiefly by irrigated agriculture and fish production. Profits from hydropower are largest in Laos, and fish catch and wetlands are the major water-related income sources in Cambodia. One must note that this scenario is based on data available in 1999, when total Mekong fisheries catches amounted to 1 million tons, not 2.6 or 3.2 million tons as per recent estimates.

Table III: Baseline scenario profits from water use in million USD (Ringler 2001)

Country/region	Irrigation	Municipal & Industrial	Hydropower	Fisheries	Wetlands	Total
Yunnan, PRC	20	11		0.05		31
Lao PDR	38	6	33	19	5	101
Thailand	320	65	10	151	4	551
- N Thailand	52	5		10		68
- NE Thailand	268	60	10	141	4	483
Cambodia	26	7	7	188	80	301
Vietnam	513	81		188	44	825
- VN, Central Highland	29	6				35
- VN, Mekong Delta	484	75		188	44	790
Total Basin	*917*	*170*	*43*	*546*	*134*	*1,809*

28. To our knowledge no socioeconomic analysis has been done at the scale of the whole Mekong Basin. At the moment the Mekong River Commission is developing a simple resource allocation and optimization model (RAOM) similar to Ringler's model, but drawing on recent hydrological information to examine how water resources in the Lower Mekong Basin (LMB) can be allocated among various water-consuming activities and functions. The values used to run the model are simply unit estimates, and integration of environmental flow requirements is in principle possible, depending upon the progress that is made with current valuation initiatives by partners (Johnston *et al.* 2003).

29. The MRC and Halcrow Ltd. have also set up a Decision Support Framework (DSF) that consists of a suite of data analysis software and models intended to assess the magnitude and impact of changes in the water-resource system (Halcrow 2004a). These tools are supposed to allow macro-level sustainability analyses and potentially impacted population analyses. However, the nature and contents of these tools are not detailed in the sixteen volumes of documentation about the DSF, and the "*meaningful socio-economic assessment of future development scenarios will require a more detailed set of data*" than the current MRC Social Atlas, and "*significant efforts remain to assemble data sets to support socio-economic assessments*" (Halcrow 2004b and c).

30. Overall, the NSF (1998) and Smith *et al.* (in press) found that the diversity of fisheries-related livelihood strategies is poorly represented in practice by socioeconomic analyses and policies.

II.1.1.3 Water management, fisheries and livelihoods

31. In the Mekong Basin, the bulk of the catch originates from part-time and subsistence fishers rather than from those classified as full-time fishers (Dixon *et al.* 2003). According to that study, in the three Lower Mekong countries studied, the majority of full-time fishers categorise themselves as very poor, and also highly dependent on others for finance. However, they are considered relatively less vulnerable than agriculturally-based poor who are more subject to seasonal scarcity periods. The majority of part-time fishers also categorise themselves as poor or very poor. The third group of subsistence fishers includes landless labourers, women, children and small farmers. They range from very poor to rich and in most cases are not fully dependent upon fisheries for income-generation or subsistence. As such, they are less likely to be deeply impacted by a degradation of the wild resource. The fact that inland fisheries are often regarded as an activity for the poor but can also be an activity for the more wealthy was noted by Béné and Neiland (2003), which led Coates *et al.* (2004) to call for a better understanding of how fisheries and their management contribute to, or are affected by, wealth differentiation.

32. The threats to fisheries take place in a context of limited knowledge, if not ignorance, about the extent and importance of natural resources in terms of overall household livelihood strategies. The usual census approach, which consists of thinking in terms of primary and secondary occupations, conceals the importance of diversified activities and particularly of inland capture fisheries to the livelihoods of the Mekong rural poor (Dixon *et al.* 2003; Keskinen 2003)

33. Consultations with local communities (Dixon *et al.* 2003) allowed the identification of two main threats to fisheries common to the three Mekong countries: unsustainably high fishing pressure, and degradation or loss of wetlands and floodplain habitat. The latter was specified as resulting from i) increased agricultural activities (inducing deforestation and agro-chemical pollution), and ii) modification of river-flows by flood control, drainage and irrigation structures or hydropower schemes. Thus, built structures are indeed central to development options and fisheries issues in the basin.

34. Participatory rural appraisal results showed that all of the above challenges and threats to inland fisheries have already reduced the livelihood base of poor people and made them

more vulnerable to hazards from drought and flooding, natural declines in the fish population, inadequate market access and high population growth. However, the study also concluded that in terms of pressing issues, access to fisheries and threats to aquatic resources come after personal and communal poverty issues such as lack of rural infrastructure (roads, clean water sources, sanitation facilities, schools), lack of land for farming rice and crop pests. Normal flooding is not a problem, only exceptional floods are.

II.1.2 Impact of large scale built structures on the basin fisheries

35. Preliminary calculations suggesting a 20% increase in demand for fish in the LMB over the next 10 years (Sverdrup-Jensen 2002), combined with a major threat that fisheries habitats will be reduced due to barriers to migration, conversion of floodplains into agricultural and urban areas, and changes in natural flow regimes due to dams and irrigation, make the future of Mekong fisheries uncertain. We detail below some of the major changes whose impacts have been at least partly documented.

36. The impacts of dams on Mekong aquatic resources have been highly debated (e.g. Roberts 1995, Siebert 2001, TERRA 2003, FEER 2004). Hill and Hill (1994) first attempted a thorough assessment of the consequences of dams on Mekong fish and fisheries. They highlighted the exceptional ecological importance of the Khone Falls area, the devastating consequences that a dam across the Tonle Sap River would have, the need to consider true “run-of-the-river” dams rather than blocking dams, and overall the absence of appropriate information. In fact their review itself is hampered by a systematic lack of data.

II.1.2.1 Gaps and flaws in assessments

37. Ten years later, specific information on the impacts of dams on fisheries is still lacking and/or of poor quality. In his review of the Economic Impact Assessment of the Nam Theun 2 dam in Laos, Wegner (1997) takes note of the high value of indigenous fish species and expresses concern that these have not been considered adequately in the impact assessment. Similarly the World Bank (in Amornsakchai *et al*. 2000) acknowledges the fact that for the Pak Mun Dam in Thailand the lack of detailed baseline studies on fisheries has made it difficult to estimate fishery losses in the cost-benefit analysis of the dam. Bernacsek (1997b) notes that aquatic impact assessments were carried out before impoundment in only seven cases out of 40 dams or reservoirs surveyed in the basin.

38. In a scenario analysis prepared for the MRC, Halcrow (2004d) estimated that the impact of five additional large dams in the Lower Mekong Basin would reduce the maximum longitudinal fish migration network by only 1.6%. However, among other flaws and biases, the distances computed include *twice* the length of large streams, with the argument that “*fishes migrate most commonly along either river bank*”! (op. cit., Appendix A). Of course, this bias minimizes the calculated impact of upstream dams on the whole river network open to migrations.

II.1.2.2 Recent breakthroughs

39. In 2004, Podger *et al.* assessed the impact of different water management scenarios on flows and on a number of indices, including a fish habitat availability index (HAI). The study concluded that the expected losses to the HAI range between 1% and 13% for the area downstream from Kratie in northern Cambodia. However, going beyond benign relative values, Barlow (pers. comm.) highlighted the fact that this is a fraction of a huge resource amounting to 2.6 million tons; it can be shown by a pro-rata calculation that this limited relative reduction would correspond, in Cambodia and Vietnam alone, to a loss of 15,000-199,000 tons with a monetary value of USD 10-135 million a year. The livelihood value of this fraction is not known.

40. Baran (2007) has recently detailed the consequences of flow modifications on the Mekong fish production. Several points are highlighted:

41. Development scenarios generally consider that dams will store water in the wet season and release it in the dry season. If dry season flows are indeed increased by infrastructure, then dry season migration thresholds or cues might never be reached, which will inhibit the migration of species sensitive to these low flows. As most migrations occurring in the dry season have a reproductive purpose, the biological impact of increased dry season flows might be on reproduction success. Another consequence would be that most artisanal gears designed to catch species migrating at low water levels could not be operated any longer or would be less efficient at higher water levels, hence a loss of catch and productivity even in the presence of fish.

42. A contrario, it is also hypothesized that significant water abstraction for irrigation might decrease flows in the dry season. Such reduction would have dramatic consequences in Southern Laos if the discharge in the Mekong main stream goes below 2000 $m^3.s^{-1}$, since no catches are recorded for such low discharge levels.

43. Dams, depending upon their operation rules, can also delay the flood onset by buffering the flood pulse. This delay might have a significant negative impact on the fish abundance as the flood onset is playing a strong trigger role in the migration of a majority of commercially important species. Several reports have documented a positive relationship between an early flood and a productive fishing year (cf. Baran *et al.* 2001). According to Welcomme and Halls (2003), in a system where the upstream movement of adults compensates for the downstream drift of larvae, a natural or artificial variation of the flow regime is likely to result in a very different distribution of fry and thus in a fluctuating production in downstream regions; this kind of perturbation has been documented in South America for instance.

44. The basinwide impact of rainy season flow modifications due to large scale built structures such as dams would be minor compared to dry season flow changes. Decreased flood peaks in the rainy season might slightly improve the catchability of fish, and delayed flood peaks might not have a major impact since they happen at a time when fish do not noticeably migrate or breed.

45. The impact of Chinese dams is also feared in the Mekong Delta, though according to Nguyen Minh Quang (2003), the hydrologic impacts of the Manwan Dam observed in Northern Laos are not perceptible in the Mekong Delta. However, the impact of reduced

flows and sediment input on the productivity of Vietnamese coastal fisheries is surprisingly never mentioned, although it was already highlighted by Chevey (1933) seventy years ago. The impacts of dams on coastal fisheries have proven very significant in a number of countries, and assessing them in the case of new damming plans is a recurrent recommendation (Vidy *et al.* 2000; Blaber 2002, Dugan *et al.* 2002; Arthington *et al.* 2004).

II.1.3 Specific impacts of hydrological changes induced by built structures

II.1.3.1 Hydrological migration triggers

46. The Mekong is the river featuring the highest hydrological variability in the world (Welcomme 1985) and its fish fauna display exceptional migratory behaviour. Since these migrations happen on a large scale and are well coordinated, the factors that trigger migrations in the basin have recently been reviewed (Baran 2007). The underlying question concerns the consequences of modifications to the hydrology and hydrodynamics of the river by infrastructure on the fish resource.

47. Migration cues have been documented for 30 out of the 165 Mekong fish species known to migrate; the cues are unknown for the remaining 82% of these migratory species. The literature review identified five major migration triggers in the Mekong: i) discharge, water level and current; ii) rainfall at the end of the dry season; iii) changes in water color and turbidity; iv) apparition of insects; and v) lunar phase (although its role remains unclear and is probably combined with hydrological factors).

48. Ninety percent of Mekong fish species for which migration cues are documented respond to a variation in water level or in discharge. Some fish families are extremely sensitive to hydrological migrations triggers, in particular Pangasiids (catfishes), of which 58% of 19 species are sensitive. In general, catfishes, which include several families, are the group most sensitive to migration triggers. Catfishes have a high value in commercial fisheries and also play a major role in the regional aquaculture sector. Since catfish fingerlings are caught in the wild to be raised in cages[5], the modification of triggers and of the reproductive success of catfishes might result in diminished supply for the whole aquaculture sector in Cambodia and southern Vietnam.

49. Khone Falls is the only stretch of the basin where long-term catch statistics can be coupled with long-term hydrological records. Analyses of the Khone Falls fisheries (Baran *et al.* 2005; Baran 2007) show that *ninety-six per cent* of the total fish biomass harvested year-round in Khone Falls is harvested between 2000 and 8000 $^{m3.s-1}$, i.e. low discharge levels corresponding to the dry season. The most “productive” discharge levels are 2000 and 3000 $m^3.s^{-1}$; they total more than 60% of the annual yield. This dependence of catches on low, dry season discharge levels is due i) to the fish migration waves that occur during the dry season; ii) to the dominance in catches of a few fish taxa that migrate at this season, and iii) to the better catchability of fish at these discharge levels.

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[5] In Cambodia, the aquaculture production of species whose cycle is mastered represents less than 5.5% of the total freshwater fish production. Ninety-four percent of the fish production thus originates from capture fisheries and from wild fingerlings – including catfishes – grown in cages.

50. The conclusion is that the impact, by dams or other built structures, of dry season flow alterations would be dramatic for fishers and food security. This importance makes it a priority area of research to better inform development options. The water allocation rules being developed and used by the MRC and the Mekong riparian countries should in particular integrate the information regarding fisheries and their dependence on low discharge levels.

II.1.3.2 Additional impacts to be considered

51. The evolution of the size of fish caught is a parameter that should be integrated into comprehensive assessments of the impact of built structures. Year after year, total catches seem to contain a higher proportion of less valuable small fish and a lower proportion of medium and big sized fish of high economic value. This evolution is mainly driven by fishing pressure, which tends to select and kill larger individuals or species (Welcomme 1995). However, hydrological changes or jaggedness tends to favour opportunistic fish species, whose reproductive strategy (early age at first maturity, lots of eggs) allows them to cope with environmental variability. These species happen to be small and short-lived (e.g. *Henicorhynchus spp.* or *Trey riel*), and they proliferate at the expense of larger species. The economic impact of this replacement of quality fish by low value fish is invisible in global statistics based on biomass and has never been assessed.

52. In Africa, detailed studies in the Niger Central Delta have shown that a reduction of 75% of the area of floodplains resulted in a 50% loss of the fish harvest, the two dams of the system contributing 10% of these losses (Laë 1992). However, these studies also highlighted that declining natural fish production was blurred by an increased concentration of fishes (hence a higher catchability) and increased fishing efficiency.

II.1.4 Mitigation measures and positive influence of dams on fisheries

53. The negative effects of dams on inland fisheries have been extensively described (WCD 2000) and alternatives or mitigation measures such as fish ladders have been proposed. Warren and Mattson (2000) expressed reservations about the efficiency of such mitigation measures in the Mekong context; Roberts (2001) confirmed the inefficiency of the Pak Mun Dam fish ladder and Baran *et al*. (2001b) showed that the intensity of migrations (e.g. 30 tons of fish caught per hour in the Tonle Sap River during the migration peak) makes fishways unrealistic in most main channels (Jensen 2001).

54. The creation of reservoir fisheries following the creation of a dam is often cited as a compensation for the loss of capture fish. However, out of 160 families living in freshwater, only 17 are fully lacustrine or able to live in lakes at one stage of their lifecycle (Fernando & Holcik 1982), most species having to return to free-flowing rivers to breed. Baran (2007) showed that in the Mekong Basin, nine species only are known to breed in reservoirs such as the ones that could be created behind dams.

55. On the positive side of dam building, additional water reservoirs increase fish production locally (Lagler 1976, Bernacsek 1997b). The latter author gives an equation predicting the catch of a new reservoir:

Catch in tons.year^{-1} = 1.877x(Reservoir area in km^2) – 12x(mean depth in m) + 0.03835x(Affluent inflow volume in mcm.y^{-1})

It should be noted, however, that i) this equation does not integrate the loss in wild fish production down the reservoir (as demonstrated in southern Laos by Lorenzen *et al.*, 2000), and ii) the biological productivity generated by this environmental modification is often concomitant with significant social changes in fisheries, particularly in terms of access rights, wealth distribution and equity (WCD 2000, Hirji and Panella 2003).

56. Among the beneficial impacts of damming are the increased dry season flows that would oppose the annual saline intrusion hampering rice culture in the delta (Feng Yan *et al.* 2004). However, the saline intrusion is also highly beneficial to fish production (abundant coastal fishes entering the delta) and shrimp aquaculture (one kilogram of shrimp being worth about 50 kg of rice), and the trade-offs between these different commodities and their underlying socioeconomic implications remain to be assessed.

II.2 TONLE SAP SCALE

II.2.1 Impact of hydrological changes driven by built structures

57. Observations on the *Dai* fishery for migrating fish in the Tonle Sap River during 1995–2002 indicate that year-to-year variations in maximum Mekong River flood levels strongly affect the yield of this fishery (Van Zalinge *et al*. 2003, Hortle *et al.* 2004), which is dominated by about 40% of short-lived opportunistic species (Baran *et al.* 2001c, van Zalinge *et al.* 2004). According to Starr (2004), very low water levels in 2003 caused the fish catch to decrease by as much as 50%, also causing fish prices to double around the Tonle Sap Lake. Among the 10 dominant taxa in Cambodia listed by van Zalinge *et al.* (2000), four are sensitive to hydrological migration cues: *Cyclocheilichthys enoplos*, *Pangasius spp.*, *Barbonymus gonionotus* and *Paralaubuca typus.* They represent 18% of the total catch and 14% of the commercial value respectively.

58. Some dramatic impact of dams on fisheries in Cambodia have been illustrated by the Yali Dam located in Vietnam on a river flowing down to Cambodia. McKenney (2001) estimated that the erratic flow release of this dam resulted in over USD 2.5 million in lost income in 1999 for 3,434 households. On average, livelihood income per household decreased from about USD 109 per month to USD 46 per month (-57%). Non-quantified impacts of this dam include deaths and illnesses, livestock losses due to suspected water quality problems, and rarefaction of some natural resources. The Fisheries Office of Ratanakiri province (Fisheries Office 2000) as well as Baird *et al.* (2002) confirmed these impacts while emphasizing the losses in fish catches and water quality and the total disruption of local livelihoods.

II.2.2 Impact of water quality and habitat losses

59. Among the threats to fisheries can be listed are chemicals that are widely used in agriculture schemes around the Tonle Sap Lake. Sixty-seven percent of the farmers surveyed used pesticides in 2000 (EJF 2002), with volumes as high as 72 l/ha/year for

vegetables, and 1.3 million litres of pesticides were used in the Tonle Sap catchment area (Yang Saing Koma *et al.* 2001). Many of them are highly hazardous chemicals (including DDT and methyl-parathion) imported from neighbouring countries and used indiscriminately, for instance to harvest fish or to preserve dry fish (FACT 2001, Touch Seang Tana and Todd 2003). Although one study of organochlorine residue levels based on 48 freshwater fishes concluded that Cambodian fishes are among the less contaminated of the region (In Monirith *et al.* 1999), the possible consequences of chemical pollution for the population's health as well as on the environment, have never been quantified on a large scale in Cambodia. These possible consequences were detailed in EJF (2000). Considering the on-going large-scale development of irrigation around the lake, this issue needs to be urgently tackled.

60. One of the issues that recently surfaced is the trapping of sediments and the reduced flow speed that results from dams, particularly those across the mainstream (Sarkkula *et al.* 2003, Kummu *et al.* 2005). Analyses detailed in Plinston and He Daming (2000) showed that about half the sediment reaching the Mekong Delta derives from the Upper Mekong in China. A scenario analysis showed, particularly through mapping of sediment concentrations and sedimentation rates, that flow reduction and sediment trapping by the Chinese dams on the Mekong would have a dramatic impact on the net sedimentation and productivity of the Tonle Sap Lake (Sarkkula *et al.* 2003, Van Zalinge *et al.* 2003, Sarkkula *et al.* 2004, Kummu *et al.* 2005).

II.2.3 Role of fishing structures

61. Several commentators on the fisheries in the Tonle Sap believe that the amount of fish in the lake is dramatically decreasing (e.g. Mak Sithirith 2000; FACT 2001). However, there is also strong evidence that fish stocks have not declined overall but on the contrary that the overall catches at the moment are higher than at any time in the past (Baran *et al.* 2001a, Van Zalinge *et al*. 2001). In fact, the population has increased much faster than the harvest. As a result, the catch per unit of effort or per fisher is falling, and medium and large-size species are becoming rare.

62. Fishing lots provide an example of changes in fishing patterns and conflicting interests: large-scale fishing includes fishing lots that are auctioned for exclusive exploitation of fish resources (Van Zalinge *et al*. 1998). In 1996, these fishing lots covered 80% of the Tonle Sap's shoreline (Gum 2000). Following social pressure, 56% of the total area of the private fishing lots was converted in 2000 into open access areas to allow the poor to benefit from the fisheries (Royal Government of Cambodia cited in Keskinen 2003). However, fishing lots are also regarded by biologists as a good way to combine exploitation, environmental protection (Chheng Vibolrith 1999), and even biodiversity conservation (Coates *et al*. 2003). Hence, there is a dilemma between a management system "socially unjust" (as the fruits of the resource are captured by a few operators) that contributes somehow to conservation, and an open access system "socially more fair" but likely to result in unrestricted exploitation levels jeopardizing the resource.

II.3 LOCAL SCALE

II.3.1 Description of the study sites

II.3.1.1 Pursat

63. The fisheries resources available to villagers in Pursat were dependent upon the local topography. While the entire area is relatively flat, the land slopes in two dimensions. The first is the slope of the floodplain from the main road (National Road number 5) down towards the Tonle Sap Lake. The second dimension is that the ground also slopes from beyond Krang Veng village on the one side and around Moat Prey village on the other down towards Chong Khlong and Doung Chua villages. On the other side of Moat Prey, the ground slopes down from around Moat Prey past Kampong Lor village. Both of the lower points were the site of canals that run between the canal parallel to National Road number 5 and the Tonle Sap. According to the fishers interviewed, higher areas are characterised by lower abundance of fish so that the area around Moat Prey, because of the relative height of the land, has relatively low fish abundance.

64. Generally fishers are permitted to fish anywhere around the villages and they are using a variety of fishing places including the nearby rice fields and canals. In addition, fishers from all the villages also fished further down the floodplain in flooded areas and small lakes as well as in the Tonle Sap Lake itself. In terms of restrictions, in Doung Chua there has also been a change in that fishers for the village no longer fish in Ka Cheng pond because this pond has now come under private ownership. Related to the built structure, there has been a regulation put in place by the village road committee that fishers should not obstruct the culverts and gates with their fishing gears.

65. In terms of location (see Figure 2) the villages in the area can be classified depending upon their location relative to the built structure that is enclosing a part of the floodplain. Thus, villages are either outside (Doung Chua and Krang Veng), inside (Moat Prey) or situated on the edge of the structure (Kampong Lor, Ou Ta Prok and Chong Khlong). In order to investigate the effects of the small floodplain road at this site it was decided that the views of fishers at each of these locations relative to the road would be sought, and this difference in location relative to the structure was used in the analysis of the context and effects of the structure.

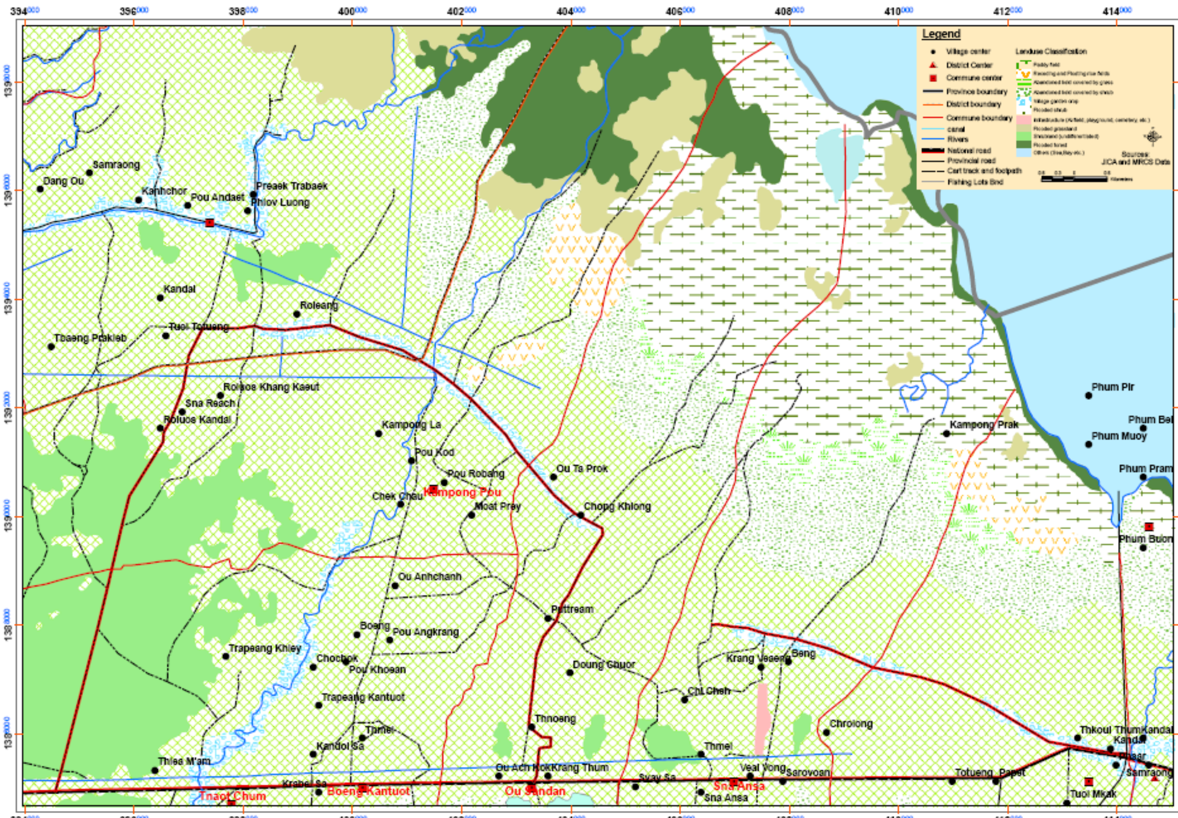

Figure 2 Location of the villages and road system at the Pursat site

II.3.1.2 Stung Chinit

66. The site is a large-scale irrigation scheme located in Santuk district of Kampong Thom Province on the Stung Chinit Tonle Sap tributary. There is a second tributary nearby: Stung Tang Krasang. The Stung Chinit irrigation scheme represents a fairly large and complex system consisting of a dam, reservoir, spillway, fish pass, a network of canals, rice fields and a number of associated roads (see Figure 3). As a result, the effects that the scheme will have on hydrology, fish and fisheries are likely to be fairly complex and spatially diverse. The scheme has been subject to quite detailed prior assessments that examined a range of aspects, including farm management, water utilisation, fisheries and navigation (e.g. OTCA 1970; MOWRAM/ADB 2003; MOWRAM/ADB 2002) and which have shown the scheme to be economically and technically feasible and developmentally desirable. The scheme has only recently started operating and for this reason the full nature of the impacts cannot yet be determined. The focus here is on the short-term impacts that have occurred during the start up of the scheme, which might serve to highlight some of the possible longer-term effects.

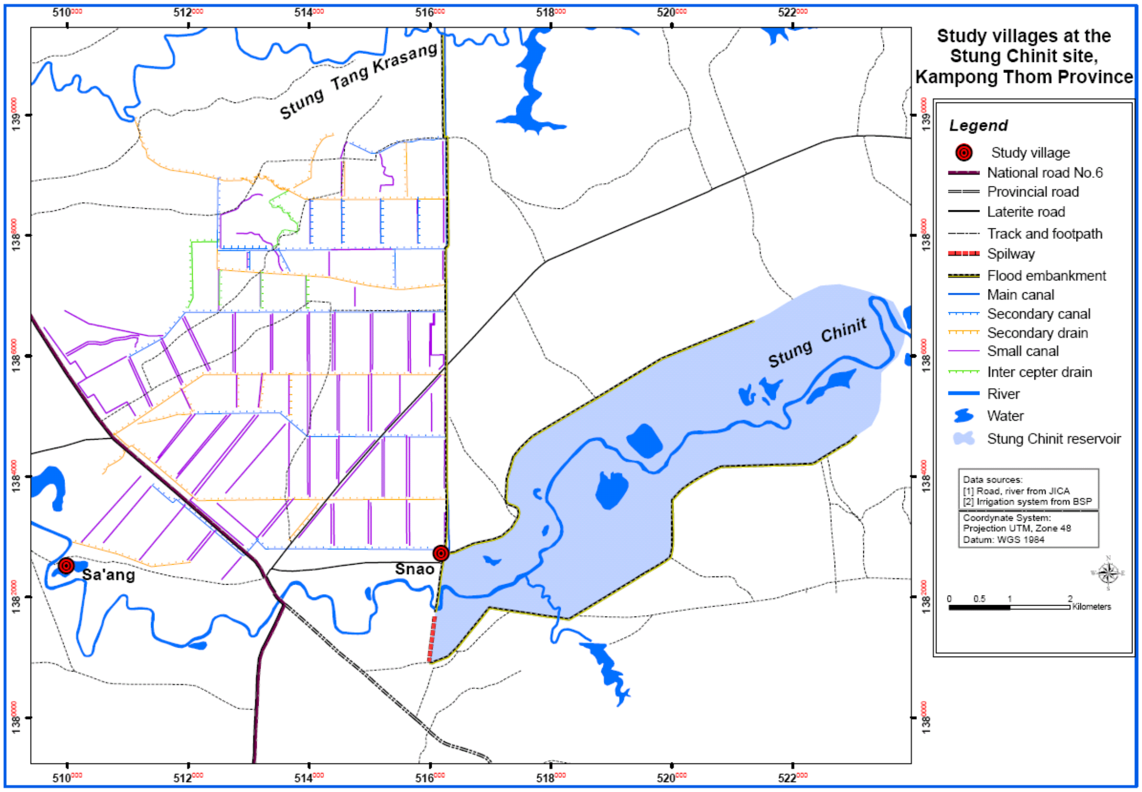

Figure 3 Location of villages and structures associated with the Stung Chinit irrigation scheme

67. Often irrigation schemes and river development plans do not take into account the effects of the development of built structures on fisheries (Grover, 1980). Destruction or alteration of the aquatic environment, the effect of flood control measures on migrations and spawning movements and triggers, and pollution of aquatic environments with sediments and agro-industrial chemicals are all commonly associated with irrigation systems. In order to capture some of this diversity, the fisheries component surveys examined the effects at villages along a transect from above the dam and main canal at the edge of the scheme to below the scheme (Figure 3). This was done as the scheme has created a large reservoir above the dam that could provide a new fishing location, a series of canals, and rice fields at the middle of the scheme, and has modified the flow of the river downstream as well as affected the connectivity to the section above the dam. Thus, villages have been classified as above the scheme (La'ak and Prey Dom), at the center of the scheme (Snao), at the lower edge of the scheme (Sa'ang), where some 30 out of 72 households will be benefiting from the access to irrigation water, and downstream from the scheme (Thnaot Chum). In addition, these locations could also be grouped as upstream or downstream based on their locations relative to the dam and main canal. Above the scheme it was also considered useful to assess the changes for villages on either side of the scheme as the availability and access to fishery resources may be particularly affected for these upstream villages.

II.3.1.3 Prek Toal

68. The site at Prek Toal consists of forest and floodplain areas that are seasonally submerged and which are managed for fishing located on either side of the Stung Sangkae, which empties into the Tonle Sap Lake. These are highly productive areas of flooded forest and floodplain that contain areas highly important to migratory birds and that have importance for fish conservation such as the Prek Toal Core Area (e.g. Davidson 2006; Goes 2005). On one side of the river along which the survey villages are located is Fishing Lot #2. This is an area that has historically been leased out on a multi-annual lease to the 'lot operator'. The conditions of the lease and area leased are described in the 'burden book' that sets out the lease conditions. During the year there is a 'closed season' from 31 May to 30 October, during which people from the surrounding area may fish in the lot using family-scale gears and methods, followed by an 'open season' from 1 November to 30 May during which access for fishing is given to the lot owner. During the open season, the lot operator may choose to sublease areas of the lot (e.g. Prek Long Ung, Prek Da, Prek Ang Krang, Prek Dem Cheu, Prek Spout, Boeung Norea and other streams and lakes, except the floodplain areas reserved for small-scale fishers). These sub-leases have been paid for in dollars but more recently the lease prices have been specified in kilograms of gold.

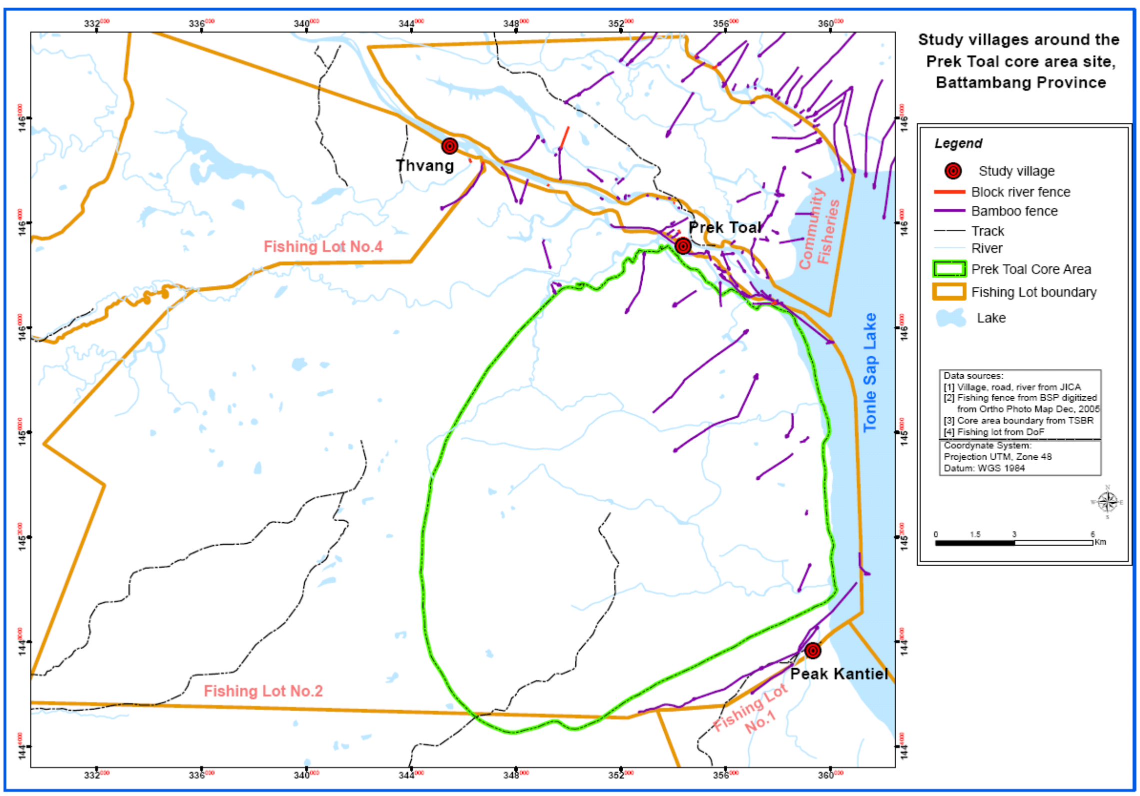

Figure 4 Location of villages, fishing lots and community fishery at the Prek Toal site

69. As one of the management measures of the fishing lot, the floodplain is enclosed from 15 November - 30 December (depending upon the flood level) until 31 May by the lot operator using a 35km long fence that is approximately 3.5m high and that runs along the edge of the floodplain, acting to channel fish into harvesting compartments. This fence has traditionally been made of bamboo but more recently fine mesh netting with a mesh size of less than 1 cm has been used. This fence is the built structure under consideration.

70. On the other side of Stung Sangkae the floodplain was managed in a similar way prior to 2001 (as Fishing Lot #3) but was considered a naturally less productive part of the floodplain. After 2001, as part of the fisheries reform process, the structure was removed and the floodplain area was given over for community management for household benefit. Exploitation within the community fishery is intended to be limited to relatively small-scale or household fishing gears.

71. The two areas of floodplain are exploited by fishers from the floating villages located along Stung Sangkae as well as fishers who migrate from Battambang and other provinces to the area to exploit the fisheries. Of the local fisher villages, closest to the edge of the lake is Prek Toal village and, moving inland along Stung Sangkae, Anlung Ta Or, Kampong Prahok and Thvang. These villages were all selected as part of the survey and interviews held with fishers in each one as well as with fishing lot workers employed to work in Fishing Lot #2, the lot operator and sub-lessees.

72. Details for each of the villages that were selected at the three sites are provided in Table 5.

Table 4 Description of the villages selected for sampling by the fisheries component at each of the sites

	Pursat					
Village	Krang Veng	Doung Chua	Chong Khlong	Ou Ta Prok	Kampong Lor	Moat Prey
Commune	Snar Ansar	Ou Sandan	Ou Sandan	Ou Sandan	Kampong Po	Ou Sandan
Location	Outside	Outside	Edge	Edge	Edge	Inside
	Stung Chinit					
Village	La'ak	Prey Dom	Snao	Sa'ang	Thnaot Chum #1	Thnaot Chum #4
Commune	Kampong Thma	Chaeng Daeng	Kampong Thma	Kampong Thma	Thnaot Chum	Thnaot Chum
Location	Upstream	Upstream	Middle	Edge	Down stream	Down stream
	Prek Toal					
Village	Prek Toal	Anlung Ta Or	Kampong Prahok	Thvang		
Commune	Kaoh Chiveang	Kaoh Chiveang	Kaoh Chiveang	Kaoh Chiveang		
Location	Lake	Inland	Further inland	Furthest inland		

II.3.2 Results of project studies

II.3.2.1 Pursat

73. As a starting point, the respondents were asked about the effect of the built structure on local hydrology. In response to this it was the universal belief among respondents was that the only effect that the built structure might have had on the water locally was a possible decrease in the rate at which water was able to move up and down the floodplain. There was no reported effect on water quality.

74. There was unanimous agreement that fish abundance had declined over time. The perception of the degree to which abundance had declined differed for the three size categories but it was again unanimous that the larger fish had declined most (see Figure 5).

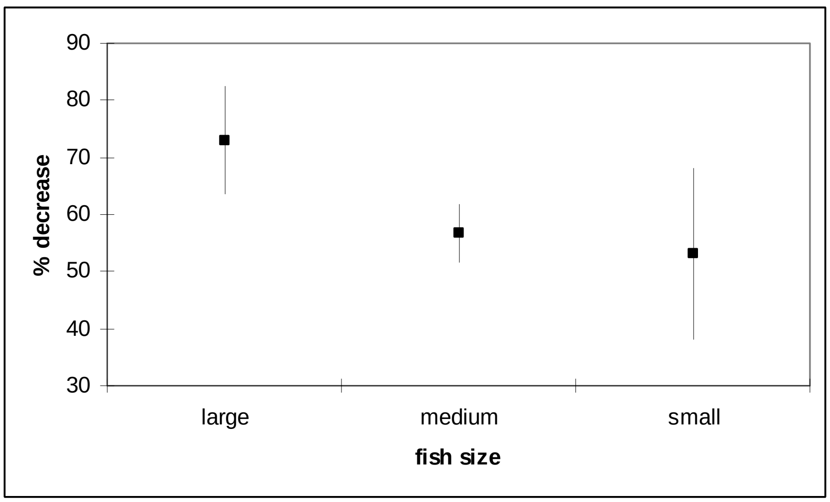

Figure 5 Mean perceived decrease in fish abundance for three size classes of fish that had decreased over time at the Pursat site (error bars indicate the standard deviation around the mean).

75. When asked what caused the changes in abundance, a variety of reasons were given for the decline in abundance that they have observed. While all the reasons given were due to human/environment interactions, the built structure was not cited as a cause by any of the respondent groups. It was stated by 42% of respondents, including 100% of those with rice fields within the boundary of the road system, that the structure had no effect because of the culverts and gates associated with it (together with the regulations related to them) as well as the presence of canals that enable fish to move up and down the floodplain. There was some variation in reasons for change by location (inside, outside and edge), although these difference do not appear to be significant (X^2, $P > 0.05$, df = 18). Considering the top two ranked reasons reported for the decline (Figure 6), it can be seen that the perception was that fishing effort, either as a result of increasing efficiency or increased numbers fishing, has been the main reason for the perceived decline.

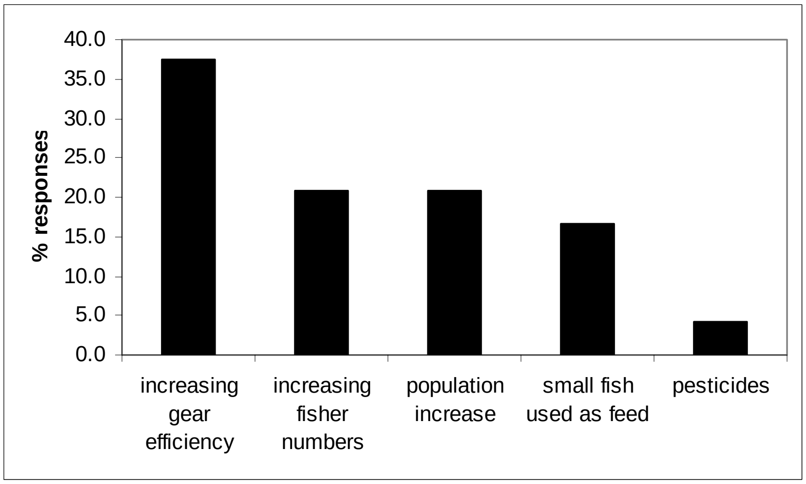

Figure 6 Top ranked reasons for the decline in fish abundance perceived by fishers at the Pursat site.

76. In relation to fishing effort, participants were asked whether the built structure was having any effect on fishing effort. There were again no significant differences in the opinions by location (X^2, $P > 0.05$, df = 4) with the road believed to have had very little effect on overall effort levels. However, patterns of effort were believed to have been affected as the canals in the area and areas around the culverts and gates were believed to have provided additional places to fish. In addition it was unanimously believed that the nature of these additional locations (i.e. deeper water and a channelling effect on fish) promoted the use of the more efficient gear types. Examples of the kinds of new and more efficient gears that were reported to be more widely used predominantly included electro-fishing and the use of fine mesh nets. At the same time the use of more traditional gears such as *angruth* and *chhneang* was widely perceived to have declined (see Figure 7). There were no significant differences in the changes in gear types used by location (X^2, $P > 0.05$, df = 8).

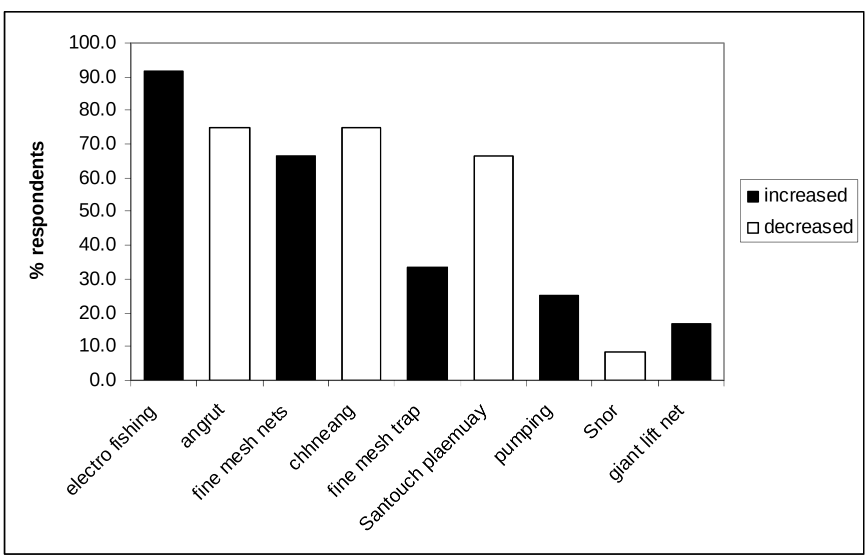

Figure 7 Perceived changes in fishing gear use reported by fishers at the Pursat site.

77. The decline in fish abundance has meant that there have been changes in the patterns of fishing effort with over 80% of respondents indicating that fishers are now travelling further from their homes in many cases and new fishing locations that had not previously been used by those villagers are being exploited. The majority of these locations are further down the floodplain towards the Tonle Sap Lake, for example Boeung Chhes, Boeung Sambok Ork, Boeung Naktavul, Trapang Khach and Boeung Kambeth Snearth and other areas including the flooded forest.

78. The decrease in abundance of fish in all categories has been accompanied by increases in price (Table 3). Interestingly, small fish had increased the most in price and also showed the greatest variation in increase. This could reflect the greater diversity in the view of the extent to which this group had declined in abundance (Figure 5) and also that the group will consist of a mixture of lower value and higher value fish species. It is also noticeable that despite large fish being perceived to have decreased the most, this was not reflected in the extent of the price increase over the period.

Table 5 Changes in fish price for three size classes of fish at the Pursat site between 2000 and 2006. Standard deviation in brackets.

	Small	**Medium**	**Large**
Mean price before (2000) (Riel/kg)	566.7 (238.7)	1833.3 (492.4)	2875.0 (979.9)
Mean price now (2006) (Riel/kg)	1958.3 (582.3)	3750.0 (891.9)	5666.7 (1557.0)
Mean difference	1391.7	1916.7	2791.7

79. A number of reasons were given for why the prices had increased and these were not significantly different between locations (X^2, $P > 0.05$, df = 12). The main reasons for the increase were high local demand (100% of respondents), decreased fish abundance and reduced fish catches (92%) and increased demand for fish for export, principally to Vietnam and Thailand (92%). The results of the socioeconomic surveys in two of the villages at the site also indicated that household catches had decreased but that the overall contribution of fishing to household income had not, likely due to the price increases.

80. The built structure was universally felt to have contributed to fish price increases by both increasing the access to the villages by middlemen (it was variously reported that visits had increased by 30-50%) and also the access to markets by villagers. This was also believed to have had a positive effect in enabling villagers to get a better price for their fish, but it was also reported that increased sales of fish meant that sometimes villagers cannot find fish to buy in their village. The main benefits of the road were, unsurprisingly, associated with better access, either access by villagers to markets and other facilities or access to the village by external agents, including traders, extension staff and NGOs. These access benefits are similar to those reported by Hettige (2006) for rural roads.

81. In terms of species, the species reported to have changed in abundance were very similar by location. There was only one species that was considered by all respondent groups to have disappeared from catches, while several others were widely believed to have declined in abundance (Figure 8). No species were reported as having increased in abundance.

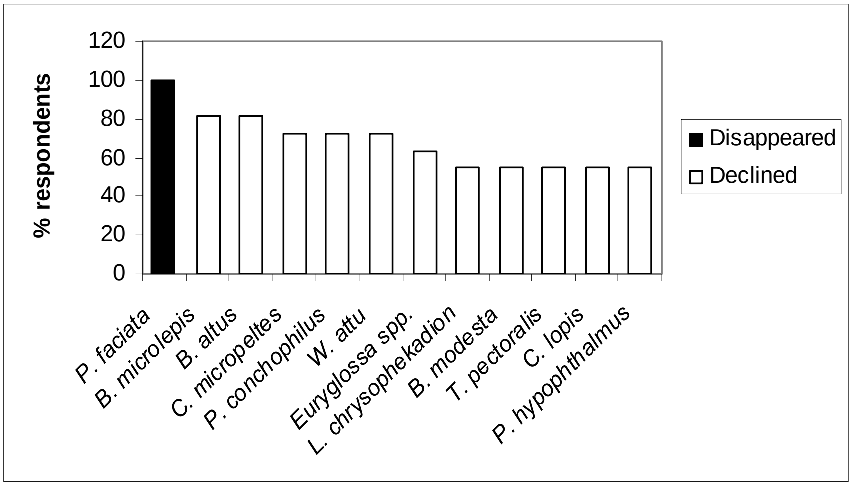

Figure 8 Changes in species abundance reported by respondents from all villages at the Pursat site.

82. In summary, the structure (road) was felt to provide benefits to locals relating to water and fisheries in that it acted as an embankment to prevent substantial flooding from water moving up the floodplain. It was also able to act to retain water in the rice fields above the road, making water available for the rice crops and for livestock. Related to fisheries, the structure was not believed to be affecting fish abundance because water connectivity has been maintained due to the presence of culverts and gates and associated regulations that enabled water and fish to move up and down the floodplain. Any blocking effect was also reported to be mitigated by the presence of canals that also enable water and fish to move up and down. The structure (and also canals in the area) has provided new fishing opportunities that have been exploited by fishers. The structure has also assisted in the marketing of the fish caught by increasing access to the villages by middlemen purchasing fish and also access of villagers to the local markets. This has had a positive effect on the prices that fishers are able to get for their catch.

83. The negative effects of the structure were mainly indirect. There was a perception, particularly among those outside of the structure, that the water retention effect might actually contribute to flooding inside the area enclosed by the structure at times of heavy rainfall. It was also felt that the new fishing opportunities that have been created may also have enabled the use of the more efficient types of gears that are perceived to be contributing to declines in fish abundance. Finally, while the increased marketing opportunities that have been provided by the structure and price increases that have been observed have benefited fishers, they have reportedly had some negative effects on those in the villages looking to purchase fish for household consumption in that sometimes fish may not be available to those in the villages who want to buy it.

II.3.2.2 Stung Chinit

84. Asked about the hydrological changes that the scheme had brought about produced differing responses by location. Around Prey Dom, above the scheme, it was noted that development of the scheme had a negative effect in that it had led to increased flooding of the villagers' rice fields and homesteads. Prior to the scheme water could be released from the nearby lake Boeung Chork into the river through the stream Ou Chork. With the development of the scheme, an embankment was created that blocked some of this flow, and the stream was channelised to create a canal linking the reservoir to the river downstream of the dam, and that could carry the water from Boeung Chork, which received water from three other upstream streams. However, the respondents reported that the canal is unable to carry sufficient water and that this has led to the flooding problems. The respondents also noted that this canal was an important part of the scheme in relation to fisheries as it allowed fish to move upstream and downstream past the dam and embankments. The reservoir was also noted as being a major hydrological effect of the scheme and it was felt that this would benefit the fisheries by providing additional habitat that would be perennially available. While the reservoir may bring additional habitat, it can be expected that fish diversity and abundance in irrigation canals will be less than in the unmodified river. For example, following the development of the Gezira irrigation system in Sudan there was a reduction in fish diversity of some 45%, with only 19 of the 34 species of fish present in the source waters (the Blue Nile) found in the minor and field canals (Coates 1984).

85. In La'ak village, above the scheme and on the other side of the reservoir from Prey Dom, the respondents indicated that the reservoir was the main hydrological change brought about by the scheme and that this enabled them to access water for rice and that the embankment associated with the reservoir prevented flooding of the village in the wet season. At the same time though this reduced flooding effect has reduced the flow of water to the rice fields. A similar effect has been caused by the new road that was built between the two rivers Stung Chinit and Stung Tang Krasang. As a result there is less water reaching the rice field areas and this has affected fish movement and abundance in these fields.

86. In both of these locations above the scheme it was reported that the scheme had also affected water quality, primarily due to the decomposition of flooded vegetation. While respondents reported that this did not appear to affect the fish or fishing, there were reports that it had negative effects on animal (50% of respondent groups) and human (25% of respondent groups) health. In other studies it has been found that anoxic waters from reservoirs containing rotting vegetation have caused mortality in river fish (Arthington 2004). However, studies by Lim and Lek (2005) suggested that there was little variation across the site in terms of total suspended solids in the water and that, according to French standards, the water quality regarding nutrients varies between "very good" and "good" quality and that in terms of organic matter the water quality is a bit lower with a "fair" water quality. The factor affecting water quality was attributed by Lim and Lek (2005) to organic inputs from the riparian villages. The water quality descriptions provided would not seem to account for the effects described by the respondent groups.

87. At Snao village in the middle of the scheme the main hydrological effects that were noted were that the scheme had created a larger flooded area above the dam, in particular the reservoir, and that these flooded areas remained flooded for longer. They also noted, as was stated in La'ak, that the physical structures that had been created had reduced the access by fish to the rice fields. As with the locations above the scheme, respondents indicated that the development of the scheme had affected water quality. In particular, the creation of the scheme had led to some flooding in the village and there was a unanimous view that during this flood period well water in the village began to become turbid and smell bad and that again this had had negative impacts on human and animal health in the village.

88. The perception of the change in hydrology was similar for all the locations downstream of the dam and canal. Here the main effect was that there had been changes in the volume and timing of water flow, resulting in reduced water flow in the river and less flooding of the downstream floodplain areas as a result. Respondent groups also noted that the water quality had also changed with water having a 'bad smell' and being more turbid. While it is possible that this is linked to the submergence and decomposition of vegetation upstream, the perception was that this change was due to the slower current in the river. Lim and Lek (2005) noted that the total suspended solids were higher in the downstream areas and that this was possibly due to an increase of the population density and an increase of soil erosion and runoff.

89. In terms of where people can fish, there has been a traditional system of access restrictions along the river that dictated who could fish and where. This access was allocated on a household basis and this access could be leased to others. With the introduction of the scheme, the traditional system above the main dam is no longer operating and the reservoir is at present a perennial open access resource. Below the dam the traditional system is still operating along the river in the same way as before.

90. There was universal agreement among the participating fishers that the development of the irrigation system has changed where people fish. This includes both fishers fishing at new locations as well as not fishing at others that were fished prior to the scheme. This is not surprising given the scale and extent of hydrological modification that has resulted. The effect that the scheme had on patterns of fishing effort depended however on where the fishers were located in the scheme (Table 4). The greatest change has, as might be expected, been above and in the middle of the scheme where the creation of the reservoir, canal and rice fields has provided a number of new fishing locations. For the villages above and at the centre of the scheme the reservoir represents an important a dry season resource as the lakes. It has also meant that fishers in these places are no longer travelling further afield to fish (e.g. in Stung Tang Krasang and Boeung Lvea) as the reservoir is much closer. However, it has been reported, particularly by the villagers in La'ak and Snao, that the reduced connection of the rice fields to the river system due to the creation of roads and embankments has led to a decrease in the abundance of rice field fish and made rice fields a less important place to fish. This could be important as in appraisals in Lao PDR, Nguyen-Khoa *et al.* (2005) found that such fields were important sources of fish and that it was therefore important to maintain the water levels and connectivity of the fields to support production.

91. There have been some benefits from the scheme for those living in Snao village in particular as fishers from there are able to fish the section of the river just below the dam, fish pass and spillway. This is a place where fish moving upstream are reported to congregate as their way upstream is blocked and many fishers take advantage of this.

92. For villages downstream from the scheme the picture is quite different and fishers in these villages are now reporting that they are traveling further afield to fish, including to the Tonle Sap Lake, because of reduced fish abundance nearby. These villages are also being affected by other changes that are related to other resources in the floodplain, for example the release of Boeung Krai Slao, Boeung Tamun and Peam Anchanh and the restriction of access to other lakes, such as Boeung Samreth and Boeung Chhkae Khamsvar, and these changes are reported as important in the downstream locations. In addition, these villages also related that the risk of gear theft also affected where they choose to fish. Both floodplain areas far from their village and the rice fields at the southern edge of the irrigation scheme were suggested as places where gear theft was an issue.

Table 6 Changes in patterns of fishing effort described by fishers from villages around the Stung Chinit scheme.

	Above	Centre	Edge	Below
Fishing locations created	Now fishers can go fishing in the lakes that are all part of reservoir in wet season and expect to be able to in the dry season also.	Now fishers expect that they can go fishing in reservoir because this will hold water in dry season.		Fishers can go fishing at some lakes at present because these lakes were released for fishing people (after fishery reform, 2001).
	Fishers can use some lakes that are part of reservoir because they will remain full in dry season and fish are more abundant in the reservoir.			Fishers have started fishing at Tonle Sap Lake due to fewer fish in nearby rice field and lakes.
	Before some of the lakes near the village dried out in dry season. Now, with the reservoir, there is a lake in both dry and wet seasons			
Fishing locations no longer used	Fishers stopped fishing after damming because this lake was far from village (50km) and fish are more abundant in the reservoir and rice fields close to the village.	No longer fishing in the rice field area under the irrigation scheme. Recently there have been fewer fish in these rice fields due to the scheme blocking fish migrations.	Location now restricted by private control for development of livestock/fish farming.	Fishers have stopped fishing at the southern rice field area of Stung Chinit because of the risk of gear theft.
	No longer fishing in two lakes that are now very deep in wet season (after damming) and fish are now more abundant in lakes near by the village.	Fishers could not fish in rice field areas next to the village after damming in wet season due to less fish or no fish found in this type of habitat.		Now fishers cannot go fishing at a lake that has been become part of Fishing Lot #10 since 1995.

93. Within the villages around Stung Chinit there was a unanimous belief that in general there had been a decline in overall fish abundance. A number of reasons were put forward for this general decline in fish abundance (Figure 9). The reasons that were given were similar by location and there was only one notable variation, which was in the issue of barrages and electro-fishing gears strung across the river. This was considered an important cause of declining abundance in those villages below the dam but was not mentioned by fishers in villages either in the middle or above the dam. As with the other sites, the main reasons being put forward were to do with human/environment interactions. Increasing fishing effort through increasing numbers of fishers and increasing gear efficiency, for example the use of smaller mesh size nets, was unanimously cited as a reason for decreased abundance. Clearing of the flooded forest was also a widely cited reason for decreased fish abundance at the Stung Chinit site.

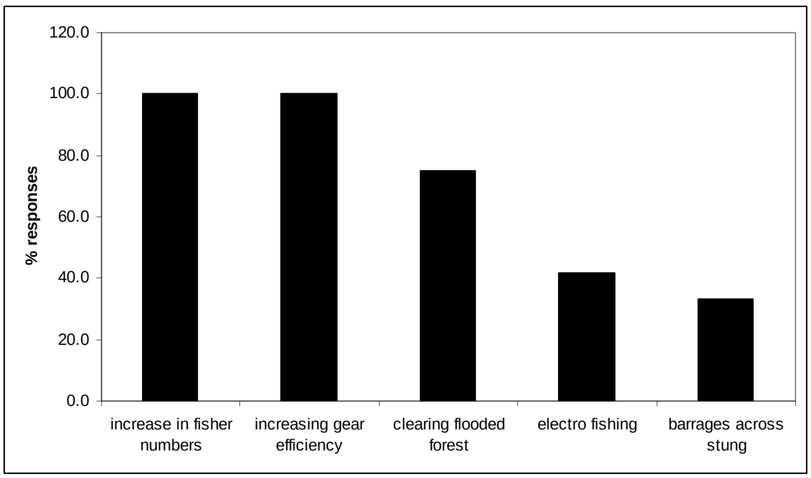

Figure 9 Top ranked reasons for the decline in fish abundance perceived by fishers at the Stung Chinit site.

94. While it was felt that there had been a general decline in fish abundance at all locations over time, it was also believed by all the respondent groups that the scheme had affected fish abundance. At the upstream locations it was stated that the scheme had led to an increase in size and abundance of fish while at the downstream locations abundance was felt to have decreased. The upstream increase was believed to be due to the increase in habitat and food availability for the fish. However, there was uncertainty as to whether the increased abundance and resulting improved catches would be maintained in the future.

95. Downstream one respondent group in Sa'ang village indicated that they felt that the reduction of fish abundance in the river was such that during the dry season in the future the river might only be used as a source of subsistence fish. The decreased abundance of fish downstream was considered by all downstream respondent groups to be due to the flow changes caused by the scheme's reduction in the number of fish that were traveling up the river from the Tonle Sap Lake. This connectedness was important, and it was also mentioned by respondents that local fish abundance was strongly correlated with the natural flooding from the Tonle Sap Lake. When there was a strong flood there would be a greater abundance of fish along the river. This is consistent with a widely found correlation between catches and flooding intensity (e.g. Baran *et al.* 2001). As well as changes in abundance it is

possible that a reduction in flow will also affect the species assemblage as the size of the stream has been identified as a potentially important factor in structuring fish assemblages (Grenouillet *et al.* 2004). Unfortunately, at this stage the structure has not been operating for long enough to be able to confirm any changes.

96. That respondents indicated that local fish abundance was dependent on fish traveling up the river, highlighting the fact that activities further downstream on the floodplain and in the main Mekong system may also be having a strong influence on fish abundance at the site. In this respect the villages at the lower edge and downstream of the scheme reported that a floodplain irrigation scheme further downstream (a structure developed during the Pol Pot time) from the Stung Chinit scheme was having a more significant effect than the Stung Chinit scheme itself. Walker (2003) has suggested that the development of such lowland irrigated agriculture often does not feature in the debate on water supply and utilization. Unfortunately, again because the structure at Stung Chinit has only started operating and because there was not enough time to also investigate the downstream structure, it was not possible to investigate this assertion.

97. The changes that the Stung Chinit scheme brought about in both hydrology and fish populations have led to changes in the patterns of exploitation with fishers in the upstream areas relating that they are now using larger mesh size nets to catch fish in the reservoir. In the downstream areas fishers relate that the reduced flow in the river due to the scheme has enabled fishers to use gears such as drift gillnets, cast nets and long lines that were used less in the past in these locations. The use of boats in the upstream and downstream area is also said to have increased with the development of the scheme.

98. There were interesting differences in the new gears that were reportedly used between the upstream and downstream locations. Downstream both electro-fishing and the use of fine mesh nets are perceived to have increased (100% of respondent groups) and it is also thought that the use of barrages across the river (50%) and the use of fine mesh traps (33%) have also increased. One group also noted that fishing with explosives was also sometimes happening. By contrast, only 50% of respondent groups upstream noted an increase in the use of electro-fishing gears or fine mesh nets. All of these gears represent an increase in gear efficiency and the differences between upstream and downstream perhaps reflect the perceived changes in fish abundance in these locations with fishers downstream increasing the use of efficient gears, such as the barrages, in pursuit of fewer fish.

99. Changes in hydrology, fish and patterns of fishing effort have also been accompanied by changes in fish price. Generally fish prices for small, medium and large fish have been increasing over time, but along with this trend there have been more local effects that were attributed to the development of the scheme. The nature of the reported local changes in fish price and the reasons for the changes also varied by location. In the downstream locations 100% of respondents reported that fish prices had increased due to the reduced catches that fishers are now getting. In the upstream locations, by contrast, 100% of respondents indicated that the development of the scheme had led to a decrease in fish price as fish were now more abundant and of a larger size (an example was given of *Channa striata* decreasing in price from Riel 7000/kg in 2005 to Riel 5000/kg in 2006). In addition it was also reported that the development of the roads associated with the scheme

meant that it was now easier for fishers to sell their catch, either by taking it to the market or selling to middlemen. In La'ak village, for example, it was reported that the roads had led to about a 30% increase in the number of middlemen coming to the village to buy fish.

100. The change in abundance in the downstream locations is also reflected through the traditional management system for the downstream locations. Decreased fish abundance downstream has meant that the price that can be charged for leasing a stretch of the river has also declined.

101. Against the backdrop of the generally perceived decrease in abundance there were some specific changes in abundance that had been observed by participants. These patterns of abundance across the Stung Chinit site were interesting. When the data on species changes was aggregated for upstream (Snao, La'ak and Prey Dom) and downstream (Sa'ang and Thnao Chum) there were significant differences between the species reported as having disappeared based on species that were reported by over 50% of respondents in either location (X^2, $P < 0.05$, df = 7). The patterns of decline in species abundance varied but not significantly (X^2, $P > 0.05$, df = 15). The spatial pattern of variation in species abundance is shown below in Table 5. These changes were attributed to the development of the scheme and in particular the dam that was constructed across the river reducing the connection between the upstream and downstream areas as well as the increase of food and habitat available upstream. In addition to the changes in abundance that had been observed it was also the view of respondents that the size of many of the species that had increased in abundance had also increased in the upstream areas. Elsewhere fish sizes were generally reported to have declined.

Table 7 Patterns of species abundance based on aggregated responses for upstream and downstream locations in relation to the dam at the Stung Chinit site.

Location	Disappeared	Declined	Increased
Upstream	*Boesemania microlepis* *Chitala lopis* *Pangasius conchophilus* *Trichogaster pectoralis* *Pangasianodon hypophthalmus* *Cirrhinus microlepis* *Amblyrhynchichthys truncatus*	*Euryglossa* spp. *Pangasius spp.* *Leptobarbus hoeveni* *Wallago attu* *Mastacembelus spp.*	*Probarbus labeamajor* *Puntioplites spp* *Barbonymus gonionotus* *Hemibagrus spilopterus*
Downstream	*Boesemania microlepis* *Chitala lopis* *Pangasius conchophilus*	*Euryglossa* spp. *Mastacembelus spp* *Pangasius* spp. *Leptobarbus hoeveni* *Trichogaster pectoralis* *Pangasius larnaudii* *Pangasianodon hypophthalmus* *Cirrhinus microlepis* *Amblyrhynchichthys truncatus* *Labeo chrysophekadion* *Channa micropeltes* *Barbonymus altus* *Hampala* spp.	

102. The species that are reported to have disappeared common to both upstream and downstream areas are predominantly white fish species. Those fish species that are reported to have increased in the upstream area are also classified as white and grey fish. As mentioned, the white fish are those that are considered most vulnerable to developments in the riverine and floodplain systems and might be some of those most affected. While it might be thought that the creation of additional upstream habitat would be likely to benefit black fish species most, it is the grey fish that have increased in abundance. There are several possible reasons for this. The first is that connectivity of the upstream and downstream has been maintained and the more migratory grey fish are still able to move up and down. Secondly, the reduced connectivity of the system to the rice fields that has been reported may have adversely affected the black fish. Finally, it may be that the blocking of the river has trapped fish in the reservoir and these fish are now being caught. The latter is possibly the most likely as fishers have reported increases in the size of these fish and also voiced concerns about the connection between upstream and downstream areas.

103. The issue of connectivity had been addressed to an extent in the design of the scheme through the inclusion of a fish pass, designed to ensure that fish could continue to move between the upstream and downstream stretches. According to MOWRAM/ADB (2002), The design of the fish pass was based on a number of ecological impact studies in the Stung Chinit site carried out by Warren (1999) and Schouten (1999), findings from successful vertical slot fish pass projects in Bangladesh (Bernacsek 1997a) and Australia (Stuart and Berghuis 1999; Mallen-Cooper 1992) where fish passes have been designed for warm-water slow-swimming fish species similar to those occurring in Cambodia. The more general aspects of the design for the Stung Chinit fishpass were prepared by using the guidelines and recommendations produced by Clay (1995) and Katopodis (1992).

104. The study by Lim and Lek (2005) suggested that the construction of fish pass will have positive impacts on migrating fish species. However, many of the fishers interviewed expressed some concern about the functioning of the fish pass and whether or not all species could easily move up and down it, particularly given the flow rates within the pass. This concern has been echoed in the report by Baran *et al.* (2001), who noted that the density of fish migrations in the Tonle Sap River means that fish passes are not realistic as a mitigation measure for dams. Respondents in the upstream areas, and in particular Prey Dom, felt that the canal that linked the reservoir and the river downstream on that side of the reservoir was in fact a more important connection between upstream and downstream for the fish and fish movement and that this connection should be maintained.

105. Respondent groups were also asked about what they felt were the effects of the scheme on fish and fisheries, how these compared with other influences and about possible mitigation measures (Table 6). This summary shows that those at the centre and upstream of the dam were the ones who were benefiting most from the development of the scheme, but that even here there were a number of concerns. Benefits to these villages (La'ak, Prey Dom and Snao) included the reservoir as a perennial fishing location and water for crops. However, there was uncertainty as to whether the benefits seen in the fisheries (larger fish and larger catches) would continue or whether the disconnection of the upstream and downstream sections of the river might affect fishing in the future. As a result most of the suggestions from these groups were about ensuring and enhancing this connection.

106. The picture downstream was less positive as while some villagers on the edge of the scheme might benefit from irrigation water in the dry season and possibly rice field fish at this time, there were no other benefits. Instead fish in the river had become less abundant and there was a fear that these would also be easier to catch and therefore vulnerable to overfishing. In addition, there was a concern within these groups that the control of the water flow in the river might also mean that their fields and villages will be more susceptible to flooding in the wet season. As a result, their suggested mitigation measures concentrated on the control of water release from the reservoir and the need to maintain flows in the river.

Table 8 Summary of the positive and negative effects of the Stung Chinit scheme on fish and fisheries, how these effects compared with others and suggested mitigation measures that could be taken to reduce the negative effects of the scheme.

	Up	**Middle**	**Edge**	**Down**
Positive effects of structure	Provides water for dry season crops. Fish are also more abundant in accessible perennial resource nearby.	Provides larger fishing locations and new fish habitats upstream. Provides water for rice field in dry season.	Will provide some households with water for dry season rice farming, and wild fish from the reservoir may become available in these dry season rice field areas.	No
Negative effects of structure	Blocks fish (including black fish) moving between river and rice field. Causes flooding in rice fields and houses close to reservoir and less water in some other rice fields. Poor water quality affects the health of humans and animals.	Affects fish migration to spawn and feed in the upstream area. Negative impacts on availability of fish in downstream areas and some rice fields. Affects flooding in rice field and houses, and poor water quality affects the health of humans and animals	Fish migrations during flood season and dry season refuge are affected. Fishers easily catch fish as they aggregate in small, shallow habitats and brood fish could be fished out.	Blocks fish migration from Tonle Sap Lake to upstream. Rice fields and houses may be flooded when the gate is opened in the wet season. Cannot travel by boat to cut wood and collect secondary forest in upstream part.
Comparison to other influences	Do not yet know.	Do not yet know.	The irrigation structure has less negative impacts on fish and fishing than unsustainable fishing methods. But the scheme may lead to increases in use of unsustainable fishing methods.	The irrigation structure has less negative impacts on fish and fishing compared to destructive fishing methods. But the scheme may lead to increases in use of unsustainable fishing methods.
Suggested mitigation measures	Enlarge the diversion canal and ensure functioning fish pass. If possible, re-establish the original fish route between Stung Chinit and Boeung Chork, as this lake has been a large and productive lake. Install technically appropriate number and size of culverts and gates along the main canal.	Ensure a route for upstream fish migration. Perhaps re-adjust fish pass position.	Gate should be managed to allow a reasonable amount of water to flow downstream.	Manage the release of water or create diversion canal to reduce possibility of flooding.

107. In addition to these suggestions regarding the scheme itself, the respondent groups also suggested that there should be a crack down on illegal fishing and that activities further downstream, including clearing of forests and operations of fishing lots, should be regulated to ensure that fish are still able to move up the river.

108. Because the effects of the built structure have been complex and spatially diverse, it is worth providing a brief summary of the outcomes as they were encountered at this early stage after the commissioning of the scheme (Table 7).

Table 9 Summary of the outcomes reported at the Stung Chinit site.

	Upstream	Downstream
Significant hydrological changes	Creation of reservoir; reduced connection to rice fields; reduced connection between upstream and downstream sections	Reduced flow
Water quality	Much poorer	Poorer
Fish size	Increased size of some fish	Same or decrease
Fishing effort	Fishing in reservoir; Not travelling so far to fish	Increased use of efficient gears; Fishing further afield
Fish price	Decreased	Increased
Fishing lease price	n/a	Decreased
Fish abundance	Some species increased	Declining

II.3.2.3 Prek Toal

109. It was found during the pre-survey and surveys that, while the fishing gear structures can be expected to have some effect on hydrology and fish, it is very difficult to separate the effect of the structure alone from the rules and patterns of behavior that are associated with the structure, and this should be borne in mind while reading the following sections.

110. The view was universal among the respondent groups that the structure had no effect on hydrology (in terms of flow, water retention and water quality). The same was also said of the larger *Bor* (<500 to 1000m in length) and *Nor Rav* (500 to 3-4000m in length) gears that are increasingly being used at this site. On the other hand, pumping activities and allied dyke construction by fishers, primarily by the subleasees in the fishing lots, but also in the community fishery areas, are believed by over 80% of the respondent groups to have had more significant impacts on water flow and retention. Both lakes and small streams were reported to have been emptied in this way and the result of this was a decrease in water flow in Stung Sangkae. The draining of small lakes and dyked streams is likely to reduce the available dry season habitat and this could have implications for a number of the floodplain resident species. It is also believed that this pumping affected the adjacent habitat with 100% of respondent groups saying that pumping increased the turbidity in the remaining habitat. Respondent groups also reported that the effect of this was to increase the water temperature and this was affecting fish and increasing fish mortality in refuge areas (over 80% of respondent groups) and also that the water had a “bad smell” (75%).

111. Overall, there was a unanimous view across all the villages that fish had declined in abundance in all areas with abundance estimated to have been reduced by 60-70% from levels in the past. This decline in abundance has led to changes in fishing practices in the area, and almost all of these changes to where fishers can access are due to rules and behavioral changes rather than the direct effects of the physical structure itself. There were strong differences between the community fishery and the fishing lot in terms of access to fishing grounds. The creation of the community fishery meant that villagers in all the villages (as well as migrants) now have access to fishing grounds during the dry season. In contrast, the fishing lot operation has not led to any new fishing opportunities for the villagers.

112. As well as creating opportunities, there have also been a number of examples where opportunities to fish have been reduced. In the community fishery the area of Roha Tra Num Chring was recently designed as a protected fish sanctuary where fishing is prohibited in the dry season. There was a high level of awareness of this sanctuary with over 85% of respondent groups citing it as an example of a change to where villagers can fish. This measure was taken in order to protect the fish broodstock. For Fishing Lot #2, 75% of the respondent groups related that the change in lot operator had reduced the opportunities to fish. There were three reasons for this. In the first place, the operator during the period from 1994 to 1998 allowed fishers to go fishing in many small lakes of Prek Stung Chas during open season (i.e. at a time when fish are generally more abundant), during the period of the current operator (from 1998 to present) the lot operator has stopped fishers from fishing these small lakes and instead has begun to offer them on subleases. The structure itself has had other direct effects as fishers could travel by boat to go fishing at Boeung Nob and To Tem prior to 1998 but now they cannot go fishing at these lakes because the fishing lot operator has blocked the way to these fishing locations with a long bamboo fence barrage. Finally, the fishing lot has also expanded by some 7-8 km, enclosing a larger area around Pek Kantel, making fishers' potential fishing location narrower and making it more difficult to access fishing in this area.

113. Respondents identified a number of reasons given for why abundance had decreased and many of these were common to both areas so that there was not any significant difference between the reasons given regarding the community fishery and Fishing Lot #2 (X^2, $P > 0.05$, df = 10). Common reasons, as with the other sites, were increasing numbers of fishers, an increase in the number, scale and efficiency of gears (including electro-fishing and pumping) and clearing of the flooded forest (cited by 100% of respondent groups). In addition, in the community fishery respondents also cited poor enforcement and corruption as contributing to reduced abundance (38%) by not preventing the increased use of large-scale and destructive methods, while in the fishing lot the long bamboo barrage fence (100%) and non-adherence to the conditions in the burden book (12%) were also described as contributory factors. There was also an overall perception that the activities in the community fishery, due to increased access and the use of efficient gears were having a greater impact on fish stocks than the fishing activities in the same area when it was managed as a fishing lot. An increase in the number and efficiency of the gears employed in the fisheries around the Tonle Sap has also been noted by Sithirith and Grundy-Warr (2005).

114. Respondents were asked about the changes in species abundance in the community fishery and in the fishing lot. In terms of the species that are considered to have disappeared or declined there were no significant differences between the two areas and indeed there was a high degree of correlation between the aggregated responses. Two species (*Pangassius conchophilus* and *Barbonymus altus*) are believed to have disappeared from the two areas and a number of others to have declined (Figure 10). In addition, there was one important difference between the two areas when it came to species that had increased in abundance. While no species were reported as having increased in abundance in the community fishery, there was universal agreement between respondent groups that three-spot gourami (*Trichogaster trichopterus*) had increased in abundance, or declined relatively less, in the fishing lot area.

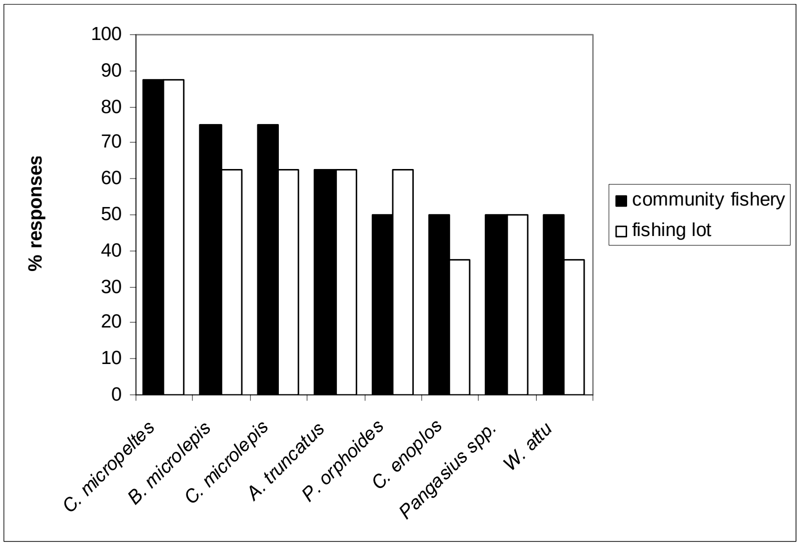

Figure 10 Declines in species abundance in both the fishing lot and community as reported by respondents from all villages at the Prek Toal site.

115. Respondents believed that the biggest local effects that were causing species-level changes were the increased fishing pressure and the destruction of fish habitat, for example through clearing of flooded forest. Gears in both areas, and particularly the structure in the fishing lot and the increasing use of *Bor* and *Nor Rav* fishing gears in the community fishery, are considered to be affecting the migration of fish from the lake to the floodplain and off the floodplain to the lake.

116. The reduction in access and perceived decline in abundance of fish has led to changes in fishing practices beyond where people fish. In all areas respondents indicated that there had been an increase in the introduction of larger-scale and more efficient gears including the nylon mesh *Bor* and *Nor Rav* gears, pumping out of sections of the floodplain, electro-fishing and giant lift nets. However, while the trends and changes were similar in the first instance there were important differences in the institutional aspects between the community fishery and fishing lot that, when combined with the structure, suggest that there may be different outcomes for the fish populations.

117. Respondents complained that in the community fishery there was a lack of enforcement and that this, combined with availability and affordability of efficient gears (e.g. the nylon mesh *Bor*) and ease of access to the fishery, meant that fishing was effectively uncontrolled. The lack of enforcement together with fishing pressure has led to conflicts between different fishers, typified by an increased incidence of gear theft. On the other hand, the fishing in the fishing lot was described as very effective and well organized and the main complaint regarding the fishing activities was that the lot owner did not always control instances of illegal fishing gear use.

118. These changes, together with the increase in demand for fish over time, have had an effect on the price of fish. Generally, the price of fish has been increasing over time and it was noted that the price of fish from the community fishery during the period when it was operated as a fishing lot was lower than it is now (see also Table 8).

Table 10 Changes in fish price of fish for three size classes of fish at the Prek Toal site between 2000 and 2006. Standard deviation in brackets.

	Small	Medium	Large
Mean price before (2000) (Riel/kg)	400.0 (115.5)	1687.5 (439.5)	2531.5 (670.0)
Mean price now (2006) (Riel/kg)	1000.0 (103.3)	3000.0 (258.2)	4250.0 (632.5)
Mean difference	600.0	1312.5	1718.8

119. As can be seen, it is the smaller fish that have increased most in price (by a factor of 2.5). One contributory factor to this increase is the reduced availability of these smaller fish locally. In the past, villagers used to be able to buy small, low value, fish from the fishing lot (Lot #2) to make *Prahok*. As the price of this fish rose the villagers changed what they did with the fish and began to sell this to fish traders at a slight profit. Most recently, in the last couple of years, the lot operator has decided to stop selling these fish species and they are instead kept by the operator to make *Prahok* himself.

120. Respondent groups all gave the same reasons for the increasing price of fish of all sizes. These were increasing demand, both locally and from Vietnam and Thailand, increasing fisher numbers and, consequently, smaller catches and lower catch rates and a general decrease in the size of fish caught. There was no difference between the community fishery and Fishing Lot #2 in terms of responses, and the structure was not considered to have any direct effect on fish prices.

121. There were interesting responses regarding the positive and negative aspects of the two management systems (Table 9). None of these related to the structure itself but centered more on issues of equity, accountability and sustainability.

Table 11 Perceptions among respondent groups of the positive and negative aspects of the two management systems at the Prek Toal site.

	Community Fishery	Fishing Lot
Positive aspects	People can access the fishery all year round and this provides opportunities for outsiders to fish (e.g. Battambang, Siem Reap, Banteay Meanchey, Pursat and Kampong Thom).	Flooded forest, birds and wildlife are better protected than in the community fishery, and fish habitat is more abundant. Fishing lot system provides better control over fishing activities than community fishery.
Negative aspects	Decline in flooded forest (suggested to be at least 60%) because of use for firewood and increase in large-scale and illegal fishing gears and activities. Corruption, limited capacity and poor accountability of managers, inability to enforce regulations and lack of support from government.	Intensive fishing, expansion in fishing lot area and blocking fishers' routes across Lot #2 to go fishing in public areas. Burden book not enforced (e.g. use of legal fishing gears, legal fishing time/periods, percentage of the fishing lot area that can be subleased)

122. Interestingly, fishers in the respondent groups indicated that they felt that the fishing lot system provided better control over the fishery than the community fishery but that the lack of accountability of the lot operator meant that illegal fishing activities, the timing of fishing activities and expansion of the effective lot area (e.g. around Pek Kantel and the exclusion of fishing activities several hundred meters outside the fence in the Tonle Sap Lake) remain unchecked.

123. Respondent groups had similar recommendations for the improved management of the two areas. Again, none of the recommendations involved the structure itself but focused on the negative aspects that were highlighted in Table 9 above. Thus over 90% of respondent groups advocated the banning of the nylon *Nor Rav* and larger, fine mesh *Bor* gears from both areas. They also wanted to see less corruption in, and increased cooperation between, the fisheries administration, police and local authorities (70% of respondent groups), better enforcement of the burden book, laws and by-laws (46%) and measures to prevent the clearing of flooded forest, including possible provision of alternative fuel sources (39%).

II.3.3 Outcomes of studies at the local scale

124. Because of the differences in the sites and in the nature of the structures, it is unsurprising that the outcomes were, in many cases, quite different. It is worth therefore dealing with each of the sites in turn before highlighting some of the common elements.

II.3.3.1 Pursat

125. The main effects of the road were on access and not directly on fish stocks. In comparison with other effects on the fishery, such as the demand for fish and use of destructive fishing methods, it was the perception of all respondents that the impacts of the road on fish abundance and species composition are insignificant. Any negative impacts attributable to the road were considered to be mitigated by the presence of gates and culverts that maintained water movement up and down the floodplain. Any impacts are also perhaps mitigated by the background trend of fishers tending to fish further down the floodplain. Respondents did indicate that the culverts and gates and canals have provided additional fishing locations but that these were often exploited using more efficient gears. It was also suggested that the road affected the hydrology locally by increasing water retention in the area enclosed by the road and that this was beneficial for rice production in that area.

II.3.3.2 Stung Chinit

126. It is too early to say what the full effects of the development at Stung Chinit will be and, from the evidence of this survey, it is likely that these will be spatially varied. Particular areas of importance would seem to be the reduced flows and connectivity of the system and the effect that this will have in the longer term on water quality and on fisheries in the main stream, reservoir and rice fields. It was also not possible at this stage to note the effects of the dry season rice culture. Increased use of agricultural inputs such as pesticides and fertilisers should help to boost agricultural production but could also very well negatively affect the fisheries (e.g. Nguyen-Khoa *et al.* 2005). The flows are an important consideration as studies have indicated that decisions related to water allocation and flow can be a primary source of conflict between fishers and farmers (e.g. Islam and Braden 2006).

127. What can be said at this stage is that at Stung Chinit there was a belief among all respondents that the structure had significantly affected the abundance, relative abundance and catches of fish. These changes had also affected local fish prices and the prices that could be obtained for leasing access to fishing in the river. However, the nature of the changes differed by location. In the downstream areas close to the dam many fish, in particular the migratory species, are reportedly aggregating as they cannot easily pass through the spillway, canal and fish ladder. While this may have negative effects for these species in the locality in the longer term, these aggregations currently provide a useful fishing opportunity. However, further downstream there are few benefits other than to those households that have access to irrigation water. Here the belief is that the structure has negatively

affected water quality, fish abundance and catches because the connection between the upstream and downstream areas has been broken and that this has had a negative impact, particularly on the migratory species. There are also concerns about the control of the release of water from the reservoir and the risk of flooding.

128. In the area above the dam, the most significant change is the reservoir and this has provided an important new fishing location, particularly as it is a perennial resource. It is too early to say what the final effects of this reservoir will be as the dam has only recently been closed but initial reports are that migratory fish species in the catches from the reservoir are larger sized. All fishers who were interviewed and who were living above the dam believed that the reservoir could become a productive fishing location as it provided a large perennial water body comprising a variety of fish habitats that could also provide more food for fish. The nature of the reservoir and the larger size of some of the fish have caused changes in the way that the resource is exploited with larger mesh nets now being used and an increase in the number of people now using boats to fish from. However, there are also a number of concerns, and among these was uncertainty over the longer-term effects of the scheme. Fishers in the upstream areas were concerned that the immediate gains in production may be a short-term effect due to the retention and growth of fish above the dam and that in the longer term the reduced connectivity to downstream areas will lead to a reduction in production. This is a very real possibility (e.g. FAO 2001; Bernacsek 1997a; Petrere 1996). The fish pass was another area that fishers highlighted during the surveys as they were not entirely convinced that it was working as it was designed to and they believed that this should be assessed.

129. Nguyen-Khoa *et al.* (2005) found in their study of irrigation systems that the reservoirs created by irrigation schemes did in fact boost fisheries production and that the increased reservoir production more than offset the reduced downstream production. However, in a scheme the size of Stung Chinit the distribution of these benefits and losses needs to be considered as it is not the same villages and households that are receiving the increased opportunities and benefits and bearing the costs.

II.3.3.3 Prek Toal

130. The situation in Prek Toal is also interesting from a management point of view. On the one hand, there is the fishing lot where there is an emphasis on productivity from the fishery and the fishing is considered by respondents to be comparatively well managed by the lot operator (although not all the management decisions favour sustainability or access) and very intensive (see also Sithirith and Grundy-Warr 2005). On the other hand there is the community fishery where access is much less of an issue but where enforcement is difficult and there is evidence that there is an increase in the use of destructive practices and in conflict between fishers and that the efficiency and, consequently productivity, is lower. A similar pattern was noted between an inland fishery in Indonesia where the fishers hold rights to fish and a more open access floodplain fishery in Bangladesh. As with the fishing lot, the fishing in Indonesia was more efficient and less competitive and, as with the community fishery, the fishing in Bangladesh involved fishers competing with one another (Hoggarth *et al.* 1999).

131. Productivity in the fishing lot comes at a cost to equity in that only those who can afford to fish there during the open season are allowed to. By contrast, in the community fishery there are, by design, fewer equity issues (this is not to say that such issues do not actually exist in practice, or that they do not actually affect the poorest to a far greater degree) but this means that there is competition for fish and, with a lack of enforcement, widespread use of illegal gears and gear theft. Thus, the community fishery is likely to be a less productive or efficient system overall than the fishing lot.

132. What cannot yet be said is how the systems compare in terms of sustainability with regard to the fish stocks. On the one hand the community fishery area would appear to be more 'porous' to fish than the fishing lot, i.e. to provide greater connectivity of the system overall, primarily because of the lack of the fence structure. On the other hand, there are considerable destructive gears and less controlled use in the community fishery, which is affecting fish and their habitats and may be affecting sustainability.

II.3.3.4 Common elements

133. The study highlighted one key aspect that is of importance and that is the common belief that fish abundance, species diversity and household catches are declining. While it may be that overall catch levels are actually remaining steady, the distribution of fish may be changing if there are increased numbers fishing (reducing individual household fish) and more export of fish (both reported by respondent groups at all locations). The effect therefore is to decrease the asset base of the rural households, potentially affecting livelihood options and strategies and increasing their vulnerability. The responses to this reported by the respondent groups have been that fishing pressure has increased though the use of larger and more effective gears (including illegal and destructive gears), exclusion of fishers from certain areas and exploitation of new fishing locations, often further from the fishers' homes. These aspects and their implications are explored in more detail in the livelihoods report.

134. The study also highlighted the importance of habitat connectivity in fisheries. The level of connectivity of riverine and floodplain habitats can have a direct effect on fish abundance and species composition (Welcomme and Halls 2004; Miranda and Lucas 2004; Berrebi-dit-Thomas *et al.* 2001; Halls *et al*. 1998). All three of the structures that were considered in this study have the potential to reduce connectivity and in the cases of Stung Chinit (water and fish) and Prek Toal (fish) this connectivity was seen to be affected. This issue of connectivity is an important consideration and should be considered at a number of scales. As the results from Stung Chinit indicate, fishers were aware that what was happening downstream of them was affecting local fish abundance. In all three cases it was also found that there were similarities in the species that were cited as having reduced abundance and that these were mainly white fish species, fish for which connectivity at larger scales is of particular importance.

135. The importance of connectivity and flows is also important to consider given the vital role of water flows as a distributor of fish larvae and juveniles through passive

drift (Poulsen *et al*. 2002). Four types of flows have been identified in relation to fish fauna in river and floodplain systems: population flows, critical flows, stress flows and habitat flows (Chea *et al.* 2006; Welcomme and Halls 2004). Population flows influence biomass through density-dependent interactions with parameters such as growth and mortality; critical flows trigger lifecycle events such as migration and spawning; stress flows endanger fish either through excessive flow rates or insufficient water, and habitat flows are needed for maintenance of environmental quality including temperature, sedimentation and nutrient levels. However, it is more difficult to identify what percentage of flow needs to be maintained. This is because the relationships between flow and ecological conditions (e.g. fish abundance) can be linear or curvilinear over a wide range and thresholds and have not been established (e.g. Acreman 2005; Sheldon *et al.* 2000; Extence *et al.* 1999).

136. Another aspect emphasized by the study sites that again highlights the importance of connectivity and flows is the issue of stress flows and the need to maintain dry season habitat because built structures can potentially affect this habitat. The dry season is a stressful period for many species and maintaining adequate water in these habitats and protecting these species from excessive fishing pressure is considered an important conservation measure (Welcomme and Halls 2004; Halls *et al.* 2001). In Prek Toal these habitats were primarily affected by the clearing of the forest and pumping. Pumping is affecting dry season habitats directly by drying out areas and indirectly by increasing the turbidity in others.

III CONCLUSIONS AND RECOMMENDATIONS

137. Development planning should consider connectivity and the maintenance of critical habitats in time and space prior to development and the introduction of mitigation measures that can preserve sufficient flows to maintain ecosystem integrity. This is a recommendation that can apply to all planned structures. This will also potentially provide more predictable outcomes as it relies on preserving existing habitat and system characteristics rather than enhancing habitats or creating new habitats (Roni *et al.* 2005; Roni *et al.* 2002).

138. This recommendation echoes the points made by Poulsen *et al*. (2002) and Coates (2001) who suggest that environmental management, and consideration of how development measures might affect water and fish, should be a prerequisite for fisheries management. Given that connectivity exists across a range of geographic scales and varies across a range of time scales, it important that the planning processes for built structures consider the wider environmental context in which they will operate. There is also a requirement that information that can support such considerations needs to be made more widely available.

139. The case studies illustrate some of the particular requirements in relation to this recommendation. For example, the Pursat case study highlighted that for roads it is important that the effects of the road on the hydrological regime are considered. In this study there were no negative impacts on fisheries attributed to the road but this was believed to be because the road design included gates and culverts that enabled water to move up and down the floodplain. However, it was also reported that these culverts and gates were being used as fishing locations and that more efficient gears were being employed in these areas. It is therefore recommended that road building should carefully consider the existing hydrological regime and how culverts and gates can best be placed to maintain this regime and preserve environmental flows. Because these locations may be exploited it is also recommended that attention be given to fisheries issues, such as the use of fishing gears in the culverts, by the road management committees that are responsible for the maintenance of the roads and culverts.

140. Water management regimes at Stung Chinit should consider the needs of fishers (across the scheme but particularly in downstream locations) and balance the flow requirements for fisheries against the water requirements for agriculture. Further information is needed on the effects of flows. At Stung Chinit maintaining environmental flows was again important for fisheries. Access and flows between the upstream and downstream sections of Stung Chinit appear to be important. These issues have been raised for irrigation schemes by a number of authors (e.g. Nguyen-Khoa *et al.* 2005; Welcomme and Halls 2004). While we know that there is a negative impact on fisheries downstream of the reduced flow, it is not possible to describe the relationship between the flows and the fisheries. The effectiveness of the connections between the downstream and upstream sections of the river should also be assessed. Access to the upstream areas by fish downstream (and *vice versa*) should take into account aspects such as water volumes and flows that will trigger or hamper movement, for example, the fact that the maximum short-term swimming speed of many fish species is less than 0.5 m/s (Clay 1995 – quoted in Nguyen-Khoa *et al.* 2005; Arthington *et al.* 2004).

141. Managing flows between the upstream and downstream sections should explicitly address the balance of benefits from water management to the upstream rice farmers and downstream fishers. In the first place, management that will benefit the downstream fisheries will require that water flows account for past natural hydrological variation as much as possible by releasing appropriate amounts of water at the right times. However, determining the appropriate amount is not straightforward as water releases potentially come at a cost to agricultural production or to fisheries in the reservoir upstream. Given that the downstream villages appear to have borne a number of costs of the scheme and received fewer benefits, at least in terms of the fishery, these trade-offs need to be carefully considered.

142. Within the upstream area flows between the main channel and reservoir and the rice fields have been identified as important. While it is still rather too early to conclusively determine, the rice field fisheries appear to have suffered from poor flows, and modifications to water management practices may be able to improve the production potential of these fisheries.

143. The level of sustainability of the fishing practices in Fishing Lot #2 and the community fishery is uncertain and should be established to inform management decision-making. At Prek Toal there were issues with both maintenance of flows and maintenance of critical habitats (flooded forest and dry season refuges). While the structure did not appear to affect the environmental flows in terms of the hydrological regime, there was a clear effect on fish movement. What is less clear in this case is the overall effect on fish and levels of escapement of fish and fish larvae that would provide an indicator of the sustainability of current management practices. It is therefore a recommendation for the Prek Toal site that the relative sustainability of the fishing systems used in the Tonle Sap Lake in terms of their effect on fish recruitment and escapement be investigated.

144. In terms of dry season habitats, pumping in both the community fishery and the fishing lot appears to be a particular issue as far as illegal or intensive gears are concerned in that it seems to be a fairly destructive method. Habitat being modified to facilitate pumping, i.e. through the creation of dykes and dams across streams, and pumping also has wider effects, including increased turbidity in other water bodies and reduction in dry season habitat. These dry season habitats provide important refuge areas, particularly for grey and black fish, and structures and associated management measures that effectively reduce dry season habitats can result in a decline in fish production, as has been suggested by the respondents in this study and the results of Halls *et al.* (1999).

145. Flows and fisheries are not just a result of the physical structures but also of how these structures are managed and utilised. It is therefore important to examine the associated institutional arrangements. This is highlighted by examples from each of the study sites.

146. In Prek Toal there is a need to ensure the accountability of the management decision-makers and to improve the contact and collaboration between the various actors including fishers, management committees and the Fisheries Administration. In the fishing lot there has been an increase in activities such as pumping and expansion of the effective area of the fishing lot that require some form of control. At

the same time, there is a good deal of unregulated activity within the community fishery and an intensification of fishing as well as conflicts between fishers. There is a need also to develop a cost-effective enforcement system within the community fishery area. This will require cooperation and collaboration between the main fisheries stakeholders in the area and will be a challenge.

147. At the Stung Chinit site there was also clear evidence of the potential for conflict. Downstream villages are concerned about water management and how this will affect the fisheries and flood regimes and evidence from the pre-survey has highlighted that there have been conflicts between water use for agricultural use and for maintaining fisheries and this had been given as one reason that the scheme fell into disuse in the past. The potential for these water use conflicts has also been highlighted in other studies elsewhere (e.g. Nguyen-Khoa *et al.* 2005 and Huq 2005). Because of this potential, as well as the issue of how the increase in agricultural intensity and inputs affects fish production, it will be important to revisit the site in the future in order to assess the relative agricultural production gains and changes in fisheries.

148. The situation in Pursat was that the introduction of the road, gates and culverts provided new fishing opportunities. While there have been rules introduced by the road management committees that prohibit the blocking of these culverts by fishing gears these were not always adhered to and more intensive fishing gears have been deployed in these places.

149. Access to fisheries and to the benefits from fisheries is likely to become an increasingly contentious issue and requires an explicit consideration of what benefits are required from fisheries and how these should be shared within society. The investigation into built structures also highlighted some wider questions that it is worth drawing attention to. The almost unanimous response from respondent groups is that fishing effort is increasing through a combination of the increasing numbers of people fishing and the increasing scale and efficiency of the gears being used. The use of efficient gears, and in particular those classified as illegal such as electro-fishing, is reportedly widespread and there have been calls by many of the respondent groups for improvements in enforcement and clamp downs on illegal fishing. While this again highlights the issues around enforcement and how this can be achieved, there are some broader implications for decision-makers in this trend.

150. Clearly the fish resources themselves cannot sustain ever-increasing pressure and still maintain biological integrity. There are already concerns over a number of species including the giant river catfish and giant carp. However, there are also a great many people who are dependent on the resources for food and/or income. Thus, maintaining the productivity of the fishery and ensuring an equitable, or at least acceptable, sharing of the benefits is also a key consideration. Even so, increasing fishers chasing possibly fewer wish will mean lower individual catches, increasing the individual pressure to use more effective gears and raising the potential for conflict. At some point decisions will have to be made about access to fisheries. This point is highlighted by the contrast between the two fisheries in the case of Prek Toal.

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ANNEX A: AN EVALUATION OF FISH SPECIES AND GENETIC DIVERSITY OF THE TONLE SAP GREAT LAKE

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Summary

Fish has long been critical to all Cambodians. It is a major source of nutritious food in the daily diet, a primary source of income and has strong cultural and religious significance. Fisheries matter a great deal to the millions of people who live on the banks of the country's rivers, particularly those living in and around the Tonle Sap Great Lake. Cambodians are considered one of the highest per capita consumers of freshwater fish in the world (a recent estimate of 67 kg per person per year from household surveys). Freshwater fisheries contribute 10 to 12% of Cambodia's GDP accounting for 31% of the GDP contribution of the primary sector. Since 2000 Cambodian freshwater capture fisheries rank fourth in the world in terms of total catch (i.e. 400,000 tons per year). This is considerable as the country is rather small (181,035 km^2) and its population is also small (13.6 million in 2005). Actually, with an average 30 kilograms of freshwater fish caught per Cambodian per year, the country has the most intense freshwater fisheries in the world.

The contribution of various ecotones to global biodiversity in Southeast Asia reaches the status of hotspot. The Indo-Burma region, including the Mekong River Basin, is no exception. The aquatic resources of the basin represent enormous biodiversity with at least 1,200 fish species. Its extremely diverse fish community reflects past climatic and geological processes, which have brought together the fauna of several river systems, and places the Mekong among the top three rivers in the world (after the Amazon and the Zaïre/Congo). Cambodia's Mekong River Basin harbors approximately 500 fish species, of which, about 200 fish species are found in the Tonle Sap Great Lake (the largest and most productive lake in Southeast Asia, being formed by subsidence about 5,700 years ago). The Tonle Sap Great Lake is the center of Cambodian fish production and it is globally significant ecologically, being nominated as a Biosphere Reserve in 1997 under the Man and Biosphere Program of UNESCO.

Fisheries from the Tonle Sap Great Lake contribute over 60% of the total freshwater fish catch in Cambodia. The Tonle Sap Great Lake has some of the smallest and largest freshwater fishes in the world, from the minute carp *Oreichthys parvus* (maximum length 2.5 cm), to huge species such as the Mekong giant catfish *Pangasianodon gigas* (maximum length 300 cm) and the giant barb *Catlocarpio siamensis* (maximum length 200 cm). The more familiar fish groups comprise carps (Cyprinidae – 39%), catfishes (Akysidae, Ariidae, Bagridae, Clariidae, Pangasiidae, Siluridae and Sisoridae – 24%), herring (Clupeidae – 3%), snakeheads (Channidae – 2%), featherbacks (Notopteridae – 2%), gouramis (Osphronemidae – 2%), and climbing perch (Anabantidae – 1%). The remaining 27% consists of needlefishes or garfishes, tongue fishes, soles, leaf fishes, archerfishes, drums, threadfins, snooks, anchovies, eels and many other fish species. A very recent first research result is that "white" fish species constitute about 37% of the total number of Tonle Sap Lake fish species, "grey" fish species 50%, and "black" fish species 13%. The catch composition of "white" fishes and "grey" fishes is about 60% of total

catch, while "black" fishes contribute about 40% to total fish catch. The previous estimates of composition of catches of top ten fish species (i.e. *Henicorhynchus lobatus/siamensis*, *Channa micropeltes, Cyclocheilichthys enoplos*, *Labiobarbus spp.*, *Osteochilus spp.*, *Cirrhinus microlepis*, *Pangasianondon hypophthalmus*, *Barbonymus gonionotus*, *Paralaubuca typus*, and *Channa striata*) in commercial fisheries (i.e. large- and middle-scale fisheries) by the Mekong River Commission – Fisheries Program reveal that "white" fishes (i.e. six of the top ten fish species) contribute about 45% of total catch and 27% of total value, "grey" fishes (i.e. two of the top ten fish species) 7% of total catch and 4% of total value, and "black" fishes 11% of total catch and 25% of total value.

The many fish species of the Tonle Sap Great Lake encompass 90 genera and 32 families with a diversity of form, feeding habits and modes of reproduction. As a result of the high diversity in the Tonle Sap Great Lake, fish occupy all available aquatic habitats and exploit many kinds of foods. Biodiversity is a crucial element in high fishery production, providing to some extent a natural "safety-valve" each season, so that loss of any species (e.g. from a disease or over-fishing) will be compensated for by increased production of other species. The high diversity of species, the great range of habitats, and the variation in catches over time and space make wild freshwater fish available to a wide range of people, thus a high degree of participation in Cambodian fisheries.

Within fish species, diversity might be partitioned into variation within and among populations. It is necessary to maintain both types of variation to minimize the frequency of extirpation of local populations and to sustain species stability since genetic diversity is a requisite for evolutionary adaptation to a changing environment. So far, genetic stock structure and differentiation at the population levels has proven to be the best method to manage the conservation of species, including fisheries. However, their application, particularly in tropical regions, is still in its infancy. In Cambodia, there is very little scientific knowledge of fish population genetics (i.e. genetic diversity and stock structure). The first research study is on population genetics of the two large migratory Pangasiid catfish species *Pangasianodon hypophthalmus* and *Pangasius bocourti* in the Mekong River (including Cambodia, Laos, Thailand and Vietnam) using both mtDNA and microsatellite markers by Cambodian DoF/KULeuven. The recent study on mtDNA stock structure of the two small migratory Mekong River carp species *Henicorhynchus siamensis* and *H. lobatus*, collected throughout Cambodia, Thailand and Vietnam, was conducted by MRC/QUT/ACIAR. In addition, there is an on-going mtDNA phylogenetic study on the Mekong giant catfish *Pangasianodon gigas* by NACA.

So far in the Mekong region, there are nine microsatellite markers in the SE Asia catfishes *Pangasianodon hypophthalmus* (4) and *Claria batrachus* (5) developed in 1999, twenty-seven microsatellites for the migratory Asian catfish family Pangasiidae (i.e. five species: *Pangasius krempfi*, *P. bocourti*, *P. conchophilus*, *P. pleurotaenia*, and *Helicophagus waandersii*) developed in 2002, and recently twenty-four microsatellites in the captive Mekong giant catfish *Pangasianodon gigas* developed in 2006. In the past decade, there have been several studies on population and phylogeographic structure in SE Asia fish, i.e. the catfish *Hemibagrus nemurus* in SE Asia using mtDNA markers published in 1995, the climbing perch *Anabas testudineus* in Thailand using allozymic markers in 2000, Pangasiidae catfishes in SE Asia using both allozymic and mtDNA markers in 2000 and using mtDNA markers in 2003, the four species of the catfish genus *Clarias* (i.e. *C. batrachus*, *C. macrocephalus*, *C. gariepinus*, and *C. meladerma*) in Thailand using allozymic markers in 2002, the river catfish *Hemibagrus nemurus* in Malaysia using microsatellite DNA markers in 2003, and the cyprinid fish *Barbonymus gonionotus* in SE Asia using mtDNA and microsatellite markers in 2004.

To date, the genetic approach for identifying discrete gene pools (i.e. stocks or populations) of fish, and hence effective management units, has not been trialed in Cambodia and so the basis for developing management principles and practices is limited. Therefore, population genetics programs are needed to (1) demonstrate the utility of molecular population genetic data for fisheries and aquaculture management in Cambodia, particularly in the Tonle Sap Great Lake and (2) develop both human (expertise) and physical (DNA laboratory) capacity in Cambodia in undertaking and interpreting such programs. This approach will provide a major boost to the level of scientific knowledge available to managers for developing successful long-term management plans for Tonle Sap Great Lake fish species. In parallel it will develop expertise in Cambodia in the practice and interpretation of such data sets in fisheries and aquaculture management where previously it was largely absent. Together this should provide a powerful impetus to develop and apply similar technologies more widely on Lower Mekong River Basin fish species and ultimately promote the level and quality of fish stock management in the region.

ANNEX B. SURVEY FORMS

Built Structures Fisheries Survey Form

COMPLETE 1 FORM FOR EACH INTERVIEW

Section A. - DETAILS OF THE INTERVIEW

			Respondents	Gender/Age
Date				
Location				
Structure type				
Village name				
Commune				
District		Who identified them?		
Province				

Section B. - TYPE OF INVESTIGATION

	Yes/No?
B1. Is this a before/after investigation?	

If answer to B1 is "Yes" then fill in sections	C, **D**, E and F
If answer to B1 is "No" then fill in sections	C, E and F

Section C. - MAPPING THE CURRENT SITUATION

Guidelines:

We get the respondents to draw a map of the area as it is now (use large piece of paper).
Important aspects to include are:
1. types of habitat (e.g. canals, paddy fields, ponds, rivers, streams, swamps etc.) that might be important for fish and/or fishing. Highlight which ones are new or have changed. Location name
2. Distances, estimated areas and depths and seasonality of the resource (mark these on map)
3. Any rules that are in place regarding access to and use of resources. Mark these with the letter private or protected areas on the map.
4. Gear and main gear types in each fishing location.
Now **go to section D or E.**

Section D. - MAPPING THE SITUATION BEFORE THE BUILT STRUCTURE

Guidelines:

We get the respondents to draw a map of the area as it was before the built structure was put in place (use large piece of paper). Important aspects to include are:

1. types of habitat (e.g. canals, paddy fields, ponds, rivers, streams, swamps etc.) that might be important for fish and/or fishing. Local name
2. Distances, estimated areas and depths and seasonality of the resource (mark these on map)
3. Any rules that were in place regarding access to and use of resources. Mark these with the letter private or protected areas on the map.
4. Gear and main gear types in each fishing location.

Now **go to section E** and to ask about changes.

	Yes/No?
D1. Is there anywhere that you are fishing now that you were not fishing before?	

If D1 = yes then describe why?

	Yes/No?
D2. Is there anywhere that you were fishing before that you are not fishing now?	

If D2 = yes then describe why?

Section E. - CHANGES IN THE FISHERY

E2. For each of the locations that are still being fished, what changes have there been in catches and fishing and why, e.g. change in depth, number of fishers, gear types, scale of the gear, species etc.

1. total catch - how much changed in %? overall, small- and big- sized fish groups and why changed?

Did/does the built structure affect catches? What level?

2. fish size - how much changed in %? overall, small- and big- sized fish groups and why changed?

Did/does the built structure affect fish size? What level?

Section E continued

3. catch composition -how much changed in %? overall, small- and big- sized fish groups, by species and why changed?

Did/does the built structure affect catch composition? What level?

4. fish movement and migration - why changed? (white, grey and black fishes)

Did/does the built structure affect movements and migrations? What level?

Section E continued

5. fishing effort - why changed?

Did/does the built structure affect fishing effort? (gear types used)

6. fish price - how much in %?: overall, small-sized fish group and big-sized fish group. Why changed?

Did/does the built structure affect fish prices?

Section F. - EFFECT OF THE BUILT STRUCTURE ON HYDROLOGY & HABITATS

F1. How do the fishers feel that the built structure has affected/affects the water flow and water quality? For examples: extent and uration of flooding, amount of fish disease, water colour and turbidity.
1. How water flow affected?   2. How water retention affected?   3. How flooding areas affected?   4. How water quality affected? (e.g. fish disease, water collour and turbidity)

F2. How do the fishers feel the built structure has affected/affects the habitats or fishing locations?

For example: new habitats or fishing locations created, change in size/area, acess to fishing locations

1. New habitat or fishing location created?

2. In the past could you access to many locations easily?

F3. Is there any other information about the built structure or the fishery that the fishers would like to share with us?

Recommendations/suggestions for protecting your fisheries resources

Are built structures having positive or negative impacts on fisheries resources? Why?

In case of negative impact, how do you minimize it?

Form completed by:

Fisheries Ecology Survey Form

COMPLETE 1 FORM FOR EACH INTERVIEW

Section A. - DETAILS OF THE INTERVIEW

Date	
Location	
Structure type	
Village name	
Commune	
District	
Province	

Respondents	Gender/Age

Who identified them?

Section B. - MAPPING THE CURRENT SITUATION

Guidelines:

We get the respondents to draw a map of the area as it is now (use large piece of paper).
Important aspects to include are:
1. types of habitat (e.g. canals, paddy fields, ponds, rivers, streams, swamps etc.) that might be important for fish and/or fishing. Highlight which ones are new or have changed. Location name
2. Distances, estimated areas and depths and seasonality of the resource (mark these on map)
3. Any rules that are in place regarding access to and use of resources. Mark these with the letter private or protected areas on the map.
4. Gear and main gear types in each fishing location.
Now **go to section C.**

C1: For each location records gear and main gear used by season, scale and mesh size of the gear, species caught (see pictures), and catch per day

Location	Main gear	W/D season	Scale	mesh size	Species caught	kg w sea	kg d sea	kg total

C2: Record the fish species caught by season, catch per season and average size of the fish in that season

Species	Wet season (6-10)		Dry season (11-5)		Total	
	kg	cm	kg	cm	kg	cm
Riel						
Andetchhkae						
Chhkaok						
Pra Thom						
Kae						
Po						
Chhveat						
Kros						
Changva						
Prual						
Kambot Chramos						
Brama						
Ros						
Chhdau						
Srakakdam						
Kantrop						
Slat Srae						
Kanhchos Chnot						
Khman						
Ta Aon						
Linh						
Kanhchrouch						
Sanday						
Sleuk Reusei						
Ka Ek						
Kahae						
Chpin Prak						
Proloung						
Kranh						
Kantho						
Kray Sre						
Kampleanh Sre						
Chhlounh						
Kcheng						
Angdeng						
Khman						

Section D - LOCAL MIGRATIONS AND SPAWNING

D1. Use the local map and transparencies to show the location and timing of migrations
and where the fisher perceives the source of young fish to be (e.g. local, tributary or Mekong).

Species	Where the young fish come from
Pra Thom	
Prual	
Riel	
Chhpin	
Ta Oan	
Kanh Chos	
Kanthou	
Kray Srae	
Proloong	

D2. Have there been any changes in migrations and movements because of the built structure?
If yes, which species and why do they think this has happened?

Section E. - NEW INFORMATION ON FISH ECOLOGY

H1. Ask fishers for which species they have knowledge of spawning, nursing, feeding and migrations within the basin. For those fish that they have knowledge, complete the following table.
For the ecology type (black/white/grey) you will need to identify this yourself.

Species name	Type of Spawning habitat	Name of Spawning location	Type of Feeding habitat	Type of nursing habitat	Ecology type
Andet Chhkae					
Kanhchos Bay					
Kanchras Thom					
Bandoul Ampov					
Reus Chek					
Kasan					
Phtoung					
Chlaing					
Ka Ek					
Angkot Prak					
Dorng Khteng					
Chunteas Phluk					
Ampil Tum					
Stuk					
Kra Morm					
Ka Uk					
Krum					
Chunluanh Moan					
Kantrang Preing					
Kampleav					
Khlaing Hay					
Kes					

Form completed by:

ANNEX C. PRE-SURVEY REPORTS

Kampong Thom Province

Objective of the trip: To select sampling locations and test the fisheries component questionnaire at Stung Chinit site in Kampong Thom province

Duration of the trip: 3 days (21-23 August 2006)

Persons involved: Dr. So Nam, Dr. Robert Arthur, Mr. Leng Sy Vann, Mr. Prum Sitha, and Miss. Pom Sok Hort.

The site:

The site at Stung Chinit in Kampong Thom Province represents an irrigation scheme comprising a number of built structures that include a barrage across a river (Stung Chinit River), sluice gates, canals (including channelised rivers), embankments, roads, a fish pass, an irrigation reservoir and paddy fields. This is an example of a development that has rehabilitated an existing, but disused, irrigation scheme that dates from the Khmer Rouge period. From the available information it seems that the scheme was in use (gates closed) between 1981/982 and 1989/90 after which the barrage was broken (gates open). There have been a number of reasons given for this including conflict between fishers and water users but the true reason remains unclear. The scheme remained out of operation until June 2006 when the present, renovated and extended, scheme came into operation (gates closed once more).

Progress report:

1. Consulting with Provincial Fishery Officers

The team met with provincial fishery officers to inform them about the purpose of the visit to Kampong Thom. This was also an opportunity to get additional information from them regarding the built structure at Stung Chinit, especially about the patterns of fishing activity for the villagers who fish in the affected river. From discussions with the livelihoods component team and with the provincial fishery officers, it was decided that the team would visit four communes: Chaeng Daeng, Kampong Thmor, Boeung Lvea and Thnoat Chum commune. Within these four communes six villages[6] were identified that would be visited:

- Tek La'ak, Snao, and Sang village in Kampong Thnor commune,
- Prey Dom village in Chaeng Daeng commune, and
- Thnoat Chum village 1, 2, 3, or 4 in Thnoat Chum commune,

1. Consulting with commune/village head and commune council members

We met with the chiefs of three communes (Kampong Thmor, Thnoat Chum) to consult with each of them about fishery situation around the irrigation scheme at Stung Chinit. This information was given by representative of each commune through mapping and interview techniques.

[6] Tek Laak, Snao and Sang villages were identified based on discussions about an earlier visit by the livelihoods component.

Kampong Thmor commune

We went to meet the Chief of Kampong Thmor commune accompanied by Kampong Thmor Fishery Inspector (Mr. Keo Sitha, phone number: 012 716 339). The head of the commune (Mr. Men Chin, phone number: 012 596 235) provided information regarding the location of fishing villages and his views on the fisheries situation at Stung Chinit.

- La'ak village is a village where villagers fish in both Stung Tang Krasang and Stung Chinit irrigation reservoir. Snao and Sang villagers go fishing mainly in the irrigation reservoir.
- Regarding the fishery situation in Stung Chinit, before the closure of the gate following rehabilitation of the irrigation scheme there were many fish in Stung Chinit upstream of the dam and fishermen could at this time catch large fish, including species such as *Mystus wyckioides*, *Wallago Leerii*, *Probarbus jullieni*, and *Catlocarpio siamensis*. These species are now rarely caught.
- The head of the commune relates that there are still many fish both below and above the gate that can easily be caught (more above than below). Some parliamentary people came recently to see how the abundance of fish had increased but he is not sure whether the abundance is due to an actual increase or just fish concentrating at these sites.
- The fish ladder is considered to be beneficial if it allows fish to get up but there is no evidence for this.
- Before any irrigation scheme was created there were many pools in the upstream area that were an important source of fish as a lot of fish congregated in these deep pools. During the period when the gate was open the pools silted up. The reason given for this was that the forests were being cleared along the river. The larger trees are prized for their wood and because the roots make good plowing implements. Removing the trees has a big effect in making the river and pools shallower and both water temperature and turbidity increase.
- Regulation of the water using the gate means that the forest downstream no longer gets inundated in the same way. This makes it easier to exploit. Development of the irrigation scheme has had an effect on trees with a lot of palm trees around Snao village being removed.

After discussions with the commune head, the team went to see the heads of each of the three villages within the commune and to discuss with groups of three fishers from each in order to get a more detailed picture of the fishing activities, and changes in fishing activities in each village.

La'ak village

La'ak represents a village upstream of the irrigation scheme, in particular the dam across Stung Chinit. According to respondents at La'ak village fish were abundant during the time when the dam of Stung Chinit was not broken (i.e. was closed). After the dam was broken in 1989/90, the number of fish declined too. With the dam closed large aggregations of fish such as *trey rie*l are seen below the dam, where they can easily be caught. Everyone from the downstream areas fishes just below the dam as the fish get stuck there and cannot pass. Fish from upstream are also less able to move downstream and some have been observed spawning at the edges of the irrigation reservoir. This is a benefit for the fishers upstream. It is also good because in the dry season there were not so many places to fish but now they can fish easily because there is water in the reservoir.

Villagers have been fishing in both Stung Tang Krasang and Stung Chinit. With the dam closed again the fishers use the reservoir more because it is closer. In La'ak village there are five or six households that go to fish all the time, the others just fish occasionally with cast nets or with gillnets set overnight. Over time there have been changes in fishing with the number of fishermen increasing; in some places there is even fishing in rotation. There were two, interrelated, reasons given for this. The first is that people see that there are fish and that more fish are being caught so they also want to go fishing. Also, after planting rice, farmers have more free time so the opportunity is there and the numbers of fishers increase. The fishing gears have also changed with mesh sizes decreasing. In the past nets with 3-4 cm mesh sizes were used but now 2.5 cm mesh sizes are common and fishers are catching many more small fish.

There have been some differences identified between the two rivers with fishers mostly catching black fish species in Stung Tang Krasang. They report that *Wallago attu* is present in both rivers: Stung Tang Krasang and Chinit. There have also been changes in the composition of fish in the rivers over time; particularly notable is the decline in snakeheads, especially *Channa mircopeltes*. However, this is due more to harvesting for aquaculture than the dam. The fishers weren't able to catch much in the reservoir this year because there is a larger area of water and the fish are less concentrated so more difficult to catch. They hope to catch more next year because the broodstock were not caught this year and the increase in fish will mean that they can use larger mesh sizes and not have to set gillnets overnight. In the wet season (May/June) fish (i.e. black and grey fish) move and migrate from the stream (i.e. both rivers) to rice fields, lakes, and other floodplain areas though canals and tributaries to feed and spawn (an upstream migration according to local knowledge). In the dry season (November/December) fish move from the rice fields, lakes, and other floodplain areas to the stream through canals and tributaries (a downstream migration according to local knowledge) in order to find refuge (e.g. in deep pools) where the fish can hide and feed. When the dam was open fish (i.e. white fish) moved and migrated down the river to feed in the floodplain and lake.

Snao village

Snao village is adjacent to the irrigation scheme dam and therefore represents a village in the middle of the scheme. Fishers from the village fish for household consumption and have generally been fishing below the dam. This is a general thing that people downstream of the dam do not really fish above the dam and the fishers report that there is some sort of unofficial regulation that if you are from downstream you fish downstream and if upstream you stay upstream. (According to the fishers, there was also an allocation of fishing locations along the river with traditional family locations that were all identified a long time ago. This was all along the river and this fishing location system is still in place in the downstream areas). The main fishing gear used in this village was the cast net.

When the dam was closed this changed as there became a large area upstream to fish all year and fewer opportunities downstream. The fishing downstream was affected as there was less water and the fishing was only good while there was water, particularly from November to January, while fishing upstream could continue all year round. It is the opinion of the fishers that fishing will become better upstream compared to down for this reason and already they say that there are generally more people fishing upstream compared to down. The effect of the closure was that the larger area upstream meant that there were no longer regulations there and fishers from downstream could fish in the reservoir. However, the restrictions remain in place downstream where there is still partitioning and it can get quite crowded but where the catches can be quite good for the few months that there is sufficient water. Fishers from upstream are still not allowed to fish in this area.

They were also able to inform us that there were more fish upstream than downstream when the dam was not broken, with bigger fish, for example a *Walago lerri* of up to 20 to 30 kg, and more fish at this time compared to when the dam was open. When the dam was broken (opened, the fishers say through natural erosion of the base of the dam), there were fewer fish and catches were smaller but they could catch more in the downstream areas. However, in the future they do not expect catches to return to the levels they experienced before when the dam was closed because of the modern, smaller mesh, fishing gears, the increase in numbers of fishermen and the clearing of the flooded forest. Before in Snao village some people used to buy fish and about a third went fishing after rice planting; now they all fish. In addition, before it was just adults who fished but now younger people from Snao are also fishing using hooks and line.

In the wet season the catches were lower than those in dry season because at this time the river was full of water and very deep, making it difficult to fish. In the dry season villagers always went fishing in the river's deep pools and in the irrigation reservoir, and especially in October to November they could catch a lot of fish. The reason given for people not catching much in the upstream areas at the moment is that when the dam was closed the fish in the reservoir were quickly caught. After the dam was closed, the water downstream was reduced and so fewer people were able to go and fish there at that time.

Regarding the structure, it was the opinion of the fishers that some fish are able to get up the fish ladder but these are larger fish and that smaller species such as *trey riel* cannot move up the pass as they are not strong enough.

The above information is the first information obtained from the village head only. This information may be different from that obtained from experienced fishers.

Sang village

Sang village is downstream from the Stung Chinit dam and represents a village at the edge of the irrigation scheme. Fishers at the village informed us that before the Khmer Rouge dam on Stung Chinit had been broken, there were many fish species in Stung Chinit. At that time the majority of the people living in the village always went fishing upstream below the dam where fish congregated and a few (the minority) fished around the irrigation reservoir. At this time many fish species were caught (e.g. *Morulius chrysophekadion*, *Osteochilus melanopleurus, Micronema micronema, Pangasius larnaudii, Henicorhynchus siamensis, Thynnichthys thynnoides, Barbonymus gonionotus, Mystus wyckioides, Wallago attu, Hampala spp, Channa striata, and Channa micropeltes*).

Fishers report that they are now catching less and using more gears or fishing for longer.

After the dam was broken, some fish species were no longer caught (e.g. *Mystus wyckioides and Channa micropeltes*) and some were caught in smaller numbers than before (such as *Wallago attu, Hampala spp., Channa striata, Henicorhynchus spp., and Thynnichthys thynnoides*). Overall fish abundance is believed by the fishers in this village to have declined since the time before the dam was broken. Reasons given for why fish abundance has declined included: increasing numbers of fishermen, increasing fishing effort (i.e. time spent fishing and number of gears), and new and potentially unsustainable fishing gears (including gears made from filamentous mesh net).

The fishers were also able to provide some information on fish movements and migrations, reporting that there are two peak periods of fish migration: (1) upstream migration in November/December and (2) downstream migration (May/June). Interestingly, according to them, the migration patterns in Stung Chinit are completely different from the patterns in Stung Tang Krasang due to its different water regime.

Boeung Lvea village/commune

We met with the chief of the commune to consult with him about the general situation in the commune. He told us that this commune started out as a single commune but is now divided into two parts (Old Boeung Lvea (in the upland area) and New Boeung Lvea (this village). New Boeung Lvea was established around 1980 and is situated along the main irrigation canal leading from the irrigation reservoir and, as such, represents a village in the middle of the scheme. According to the commune chief, the main occupations of villagers are related to collecting secondary wood and non-timber products from the upland areas around Old Boeung Lvea and rice cultivation around New Boeung Lvea. The reason for this is that they do not have much land. According to him only about 30% of households are engaged in fishing activities and mostly in Stung Tang Krasang although they also use the reservoir area of Stung Chinit when the dam is closed as anyone can fish there. The villagers thus split their time between the two locations and, according to the chief of the commune, would continue to do so even with the operation of the irrigation scheme. Because there was not a high degree of reliance on fishing in the village and villagers did not have long fishing experience it was decided not to include Boeung Lvea as a study location for the fisheries component.

Chaeng Daeng commune

We met first with the vice-chief of the commune and the secretary of the commune at the commune office. We informed them of the purpose of our visit and asked for information about the commune, especially about villages within the commune that were particularly dependent on fishing or were recognized as having particular knowledge about fish and fishing. We were informed that Prey Dum village is an active fishing village and that this village was located about one kilometer from the river. Because it is also a lowland village, the village is at risk from flooding due to the dam that can affect the rice fields every year. Before the new scheme was developed, there was a large natural canal that allowed water to escape from the land around the village to the river downstream of the dam. During the renovation of the scheme the canal was channelised and when the water is high this canal does not transfer the water away sufficiently and local flooding occurs affecting both the village and surrounding rice fields.

When the dam was not broken (post Khmer Rouge period), there was a high abundance of fish and many big fish also. For example, a *Wallago leerii* could weigh o to 20 kg. Since the dam was broken fish abundance has declined strongly and some fish species were not found in some places, in particular they mentioned *Barbonymus gonionotus* and *Hampala spp*. The commune officials thought that with the reconstruction of the scheme fish stocks may recover in the future.

Prey Dum village

Prey Dum is similar to La'ak village in being upstream of the dam. However, it is located on the other side of the river and irrigation reservoir, away from Stung Tang Krasang, and instead near the channelised canal. The village is comprised of 182 households according to the village chief. He complained that his village and the nearby rice fields get flooded due to the dam because the new channelised canal is not able to take away sufficient water. Last year households in the village lost some rice through flooding and this year it has been much worse and they expect that this will be the case also in the future. The canal used to be a tributary that ran from a lake in the flooded wetland area to the river downstream of the dam and water would move quickly down this tributary. With the development of the scheme this tributary became a canal that now acts as a link between the irrigation reservoir upstream and the river below the dam. The villagers would like to enlarge the canal so that it is able to remove the water more effectively to reduce the flooding and, according to the village chief, the MoWRAM is considering this. However, the MoWRAM had also apparently agreed to compensate villagers between 1000 (productive lowland areas) and 500-700 (less productive areas) US dollars per hectare for the damage that might result to their fields from the renovation of the scheme. Up to this point the villagers complain that they have not received this money from the MoWRAM.

The village chief considers that the overall the scheme provides more benefit for people living downstream because they can do 2-3 crops from their rice fields, but upstream people get less benefit from their rice fields, which are irrigated by rain water rather than from the reservoir, and indeed suffer from the flooding. During the dry season there is some irrigated rice cultivation with water pumped from the reservoir but not much. The general feeling is that the scheme provides very little benefit.

In this village people go fishing mainly for subsistence purposes rather than commercially, although they may sell a small amount at the local market. Traditionally many in the village have been growing rice and collecting forest products and making baskets. There are also some who move down to the lake and who either fish in the fishing lot after the lot owner, work as fishing a lot owner or take the opportunity to buy cheap fish there. When the dam was open there were many small water bodies around the village (including many lakes such as Chung Keang, Takeng, Ambeksrov, Rolouch, Tangbang and Ptachas). These water bodies were easy to fish and gears used in them included small scale fishing gears such as cast nets, gill nets, hooks and lines and bamboo traps. When the dam is closed these water bodies become part of the irrigation reservoir and in the dry season villagers go fishing mainly in the irrigation reservoir where the fishing gears used were similar to those in the water bodies and the upstream river. In the wet season fishing is mainly in rice fields and the flooded wetland areas that are created. Most of the villagers do not like fishing in the reservoir because they can catch less fish. However, there are two families (with boats) who have to go fishing there a lot because they have little or no land for rice fields.

Most of the fish that villagers catch are black/grey as they move and migrate. In general there was a perception that fish abundance has been declining over time. The village headman thought that when the dam was closed in the past this resulted in plenty of fish in the upstream area because the flooded forest provided habitat for the fish. However, while he thinks that this will also be the case in the future he believes that it will be less because a lot of the flooded forest has become rice field. He thinks that perhaps after the dam has been closed for two or three years the fish will have become more abundant. However, species diversity has decreased over time and now the diversity of fish species is less than it was in the past. This, and the decline in abundance, is due to two factors: firstly, there is illegal fishing activity using electro-fishing, dynamite and small mesh nets and, secondly, there has been the effect of the changes in hydrology over time. Before the dam fish could move freely. When the dam was closed the upstream area benefited, while fish from downstream could not move up. When the dam was broken, the fish could move again and there was also a benefit to the people downstream.

Related to the current irrigation scheme, the headman informed us that almost all fish species can continue to move upstream and down because of the canal, particularly important for upstream movement. The canal, which is always open, means that fish can get to the irrigation reservoir as well as to the wetlands around the village and to the deep pools further upstream. In the rainy season fish migrate down from the river to rice fields, floodplains (also through the network of irrigation canals) and lakes. These species include the climbing perch (*Anabas testudineus*), *Mystus wyckioides*, *Channa striata*, *Hemibagrus spilopterus*, *Henicorchynchus siamensis*, *Dangila spp.*, *Barbonymus gonionotus*, and *Clarias spp*. Fish moving upstream reach the dam and either aggregate below the dam or else move up through the canal. This aggregation effect is a benefit to those downstream who have more fish to catch during this period. Generally, the village is not worried about the fish but is concerned at the loss of rice production.

Thnot Chum commune

We met with the chief of the commune and Thnot Chum villages to consult with him about the fishery situation in Thnot Chum commune and impacts of the irrigation scheme in Stung Chinit. This is a commune located downstream of the dam and outside the irrigation scheme. Thnot Chum itself is made up of four villages (1st, 2nd, 3rd, 4th Thnot Chum village) and consists of a total of 550 households. There is a researcher from the GRET project to monitor the fish catch in the village. Some 40% of people from these villages fish regularly (either part-time or full-time) and 20% fish all year round. Fishing is generally local and fishers don't go downstream very much. As with Snao village, it was reported that in the past the fishing area downstream of the dam was subject to access restrictions. Households had their own particular fishing areas that were passed down and spots where people fished, using cast nets and gill nets, were often signposted. As the numbers of fishers has increased over time (due to population increases) this system has stopped. As a general rule the number of fishers increases as one moves downstream. Before, when the dam was closed, households also used to fish above the dam, but not much as it is quite a long way away. At present, with the dam closed again, they are not sure whether the fish are very abundant in the reservoir yet so they have not started fishing there again yet. Generally, the river is preferred as flowing water is different to standing water and the river is nearby and has fish in it.

The dam broke in 1985/86. Before this, when the dam was not broken, fishing in the river was better than when the dam became damaged because the water level was lower and the river was narrower, making it easier to catch fish. There were not really any problems with the fishery then because the upstream area had enough water for spawning fish. Fish in the river generally came from upstream although there was also another dam lower down in the floodplain that kept water in the floodplain and which meant that fish could travel upstream to Thnot Chum. After the downstream floodplain dam broke there were fewer fish traveling upstream.

The river at Thnot Chum provides something of a nursery area and there are usually plenty of *Wallago attu* because of the many small fish in the area. This year there has been a lot of *trey riel* in the river, more than last year although in general the abundance of *trey riel* has been declining over time. The reason for the abundance this year is not clear but someone has suggested that it is because there are fewer predators and another reason that has been suggested is reduced fishing with mosquito netting that has allowed more of the fry to survive.

Regarding this, the DoF patrols have meant that there is less illegal fishing but if the patrols were to stop there would be lots. They have wanted to try to create a community fishery for conservation and to improve production. There are a number of small water bodies near the villages and they have created some regulations to help manage these resources. While it is still allowed for people to fish in these there are regulations such as conservation zones in place.

On the 20th of January 2006, the southern embankment was broken and at that time water was shallow, making the water very turbid. As a result, a lot of fish, especially *Wallago attu* (with a single fish of 5-8 kg) died and could be found with silt in their gills. There are many deep pools and they are 4-12 m of depth in the downstream part of the village (e.g. Ta Ouk, Ta Tra and Prek Ampov deep pools), and deeper than 12 m in the upstream part (e.g. Thnot Chum deep pool with 15 m in depth). These pools represent important refuges because they are difficult to fish (depth and water eddies) even in the dry season.

In terms of the effect of the built structures for Thnot Chum the downstream dam had a larger effect for fisheries as it made the floodplain area larger and so more fish would come into the river. The upstream dam did not affect the fish abundance so much but when it was closed it affected the river and also meant that fish would concentrate in the river. There will always be water in the river and fish will still be able to move up and down the river when the dam is closed so they expect that there will be no negative impact on the fishery in Thnot Chum. With the closure of the dam this year the village will benefit from the concentration of fish but they will not benefit from the irrigation. However, it is planned that another canal will be built during a second phase and they expect to benefit from this.

Battambang (Prek Toal)

<u>Objective of the trip</u>: To select sampling sites for the project area of Prek Toal and pre-test the questionnaires in Prek Toal village of Battambang province

<u>Duration of the trip</u>: Two days (24-26 August)

<u>Persons involved</u>: Dr. So Nam, Dr Robert Arthur, Mr. Leng Sy Vann, Mr. Prum Setha, and Miss. Pom Sok Hort.

<u>Progress report:</u>

<u>The site:</u>

The site at Prek Toal village of Battambang province provides a different sort of built structure from the other sites. Here the structure is a fishing gear consisting in a large part of a large bamboo fence (36 km long) that is in place from January to June in order to channel fish returning to the lake from the floodplain area as the water recedes into fishing gears. This type of structure is associated with the fishing lot system where the enclosed area of the lake and floodplain is leased for fishing. This lot system and the fence gear is a traditional system of management. Prek Toal provides an opportunity to examine an operational fishing lot (Lot #2, the largest (50,134 ha) and most productive lot in Cambodia) and a fishing lot (Lot #3) where the structure was removed and the management system changed to a ‘community fishery’ system that has fewer access restrictions in 2001 in order to examine the effect of the structure. This is slightly complicated by the fact that the management system and structure are so closely related, making it difficult to clearly separate the impacts of the two.

1. Consulting with Provincial Fisheries Officers, Village Heads and Commune Council Members

We met and discussed Prek Toal with the local Fishery Inspectors: the First Vice-chief of Koh Chivang commune (Mr. Kuy An, his phone number, 016 715 986) and heads of Kampong Prohok (Mr. Keo Sovann) and Prek Toal (Mr. Pum Chin, his phone number, 016 328 721) at the Prek Toal Fishery Inspection Unit in order to discuss our plans for information collection, introduce ourselves, distribute the criteria for the selection of fishers for the interviews we would be conducting and also gather some general information regarding the fishery situation around Prek Toal. At this site there are four floating villages along the Stung Sankae: Prek Toal village, Anlung Taour, Kampong Prahok, and Khvang. In addition, there is a further village, Prek Kanteal, that is not officially recognized and which is located on the other side of Fishing Lot #2. During the discussions they were able to inform us that:

- This source of water around Prek Toal village is from the Stung Sangkae and Mekong River during the wet season. At the start of the wet season (June to August), the standing water in the floodplain area also starts being described as having a bad smell. The water's smell is reduced as fresh water flows into the floodplain area as the flood level rises. The bad smelling water is also described as being present again in November and December when the inflow of fresh water stops. This spoiled or bad smelling water in June and August results from flooded water from Stung Sankae and the rain over grasslands, and the water's smell is reduced when the Mekong River arrives.
- The Mekong River is a major factor relating to the abundance of fish in the Prek Toal area. When flooding from the Mekong River arrives late, i.e. starting in July/August, the abundance of fish is low. In contrast, when the flooding arrives early (June/July) then the abundance of fish in the area is much greater.
- There are a variety of fishing locations in the Prek Toal area but these can be summarized as being Fishing Lot #2, the community fishery (formerly Fishing Lot #3), the Tonle Sap Lake and the Stung Sankae main channel. Where people go fishing is not fixed and is instead related to the gear and resources of the fishers, access to the fishing lot and the flood level (see Table 1). Small-scale fishers are allowed to fish in the fishing lot area up to 15th October, after which access is restricted and the area comes under the control of the holder of the lease. The area controlled by the lease-holder includes the floodplain and also the lake area adjacent to the built structure (bamboo/nylon net fence) extending some 1 km into the lake. Within the fishing lot and community fishery fishers gradually move inland across the floodplain from the lake with the rising water and movement of the fish. Areas within the lot are subleased after 15th October so there is still some fishing activity within the fishing lot after this date. In the wet season fishers go fishing in the lake from May to July, and in the four community fisheries (previously Fishing Lot #3) and Fishing Lot #2 from August to the middle of October. Fishing is much more difficult during the months of November and December because in those months there is the bad smelling water from the Tonle Sap Lake that affects the fish and the water level is still high, making it difficult to fish. The bad smelling water causes fish to die, especially white fish and grey fish. In the dry season (in particular from January to May) they go back fishing in the Tonle Sap Lake and Stung Sankae main channel.

Table 1: Fishing location of Community Fisheries Members by Season

Community Fisheries	Closed Season May-October		Open Season October-May	
	% of CF members	Fishing location	% of CF members	Fishing location
Khvang	- 20 - 30 - 50	- CF's fishing domain (ex-Fishing Lot No.3) - CF's fishing domain (ex-Fishing Lot No.4) - Fishing Lot No.2	- 80 - 20	- CF's fishing domain (ex-Fishing Lot No.3) - Open access around the village, including Stung Sangkae
Kampong Prahok	- 70 - 30	- CF's fishing domain (ex-Fishing Lot No.3) - Fishing Lot No.2	- 80 - 20	- CF's fishing domain (ex-Fishing Lot No.3) - Open access around the village, including Stung Sangkae
Anlung Taour	- 50 - 50	- CF's fishing domain (ex-Fishing Lot No.3) - Fishing Lot No.2	- 50 - 30 - 20	- CF's fishing domain (ex-Fishing Lot No.3) - Go fishing at the lake - Leasing fishing location of Fishing Lot No.2 (Dong) from middle of December to May
Prek Toal	- 50 - 50	- CF's fishing domain (ex-Fishing Lot No.3) - Fishing Lot No.2	- 30 - 40 - 30	- CF's fishing domain (ex-Fishing Lot No.3) - Go fishing at the lake - Leasing fishing location of Fishing Lot No.2 from middle of December to May

Source: field trip, August 2006

The fishing gears that are used in the floodplain areas are *Bor* (small or big barrage with mesh net), gill net, and long hook and line. Over 90% of the gears used are *Bor*, and gill nets and long lines make up the rest. This *Bor* gear can be divided into three categories based on the scale of the gear: small scale (100-500 m); medium scale (>500-1000 m); and large scale (>1000 m). Table 2 provides a summary of fish catches by gear and location.

Table 2: Fish catch by *Bor* gear around the Lake and Fishing Lot No.2

Scale of *Bor* Fishing Gear (m)	Fishing Location		
	Total catch/day In TS Lake (Kg/time)	Total catch/day In Fishing Lot Number 2 (Kg/time)	
	May-July	August	Sept.-middle October
100-500	10-20	20	100-200
>500-1000	50-60	50	300-500
>1000	400	100	500-1000

Source: field trip, August 2006

A wide range of fish species are caught at the Prek Toal site including from the three ecological groups (i.e. black, grey and white fish, for the details see Table 4). When these fish species are caught depends on the season (see Table 3). During the closed season (particularly from May to July), grey and white fish are caught in the lake while black fish are caught in Fishing Lot #2 and the community fishery from August to October. White fish are again caught in the open season from the middle of October to November and grey fish are also caught from November to December. Fish species from all the ecological groups are caught from December to May, both in the floodplain areas and in the lake.

Table 3: Fish Species Caught by Season and Location

Closed season		**Open season In fishing lot No.2 and lake**		
Lake	Fishing Lot #2/CF	Fishing Lot #2/CF	Fishing Lot #2/CF	Lake and floodplain
May-July	August-October	Middle October-November	November-December	December-May
Grey and white fish	Black fish	White fish	Grey fish	Mixed fish species

Source: field trip, August 2006

In addition to fishing, some of villagers also go to work for the lease-holder of Fishing Lot #2 from February to May.

2. Discussing with knowledgeable fishermen

Two groups, comprising a total of six fishers, were convened to discuss local fish ecology and their perception of the effect and impact of the built structure. This discussion was held in Prek Toal village and the information was obtained through a combination of interviews based on the fisheries survey form and mapping.

Prek Toal village has been in existence for a long time and the fishing lots themselves were developed during the French regime. Within the fishing lots, as the water starts receding, the lease-holder of the fishing lot starts subleasing fishing locations along natural canals and lakes within the lot (from the middle of October to December/January). Other locations along the edge of the Tonle Sap Lake are similarly subleased from January/February to June. The reason for this subleasing is that the fishing lot lease holder does not have enough labor to be able to fish all these locations himself. However, fishing lot operators also go fishing with bamboo fences (i.e. a fence barrage of > 30 km long) installed at the Tonle Sap Lake from February to June. The fishing lot lease-holder starts putting up the fence barrage from middle of January and this remains in place until June. In Lot #2 the fence has a length of 36 km, stretching from Koh Chinuk (10 km), along the edge of the Tonle Sap Lake (20 km) and up to Pak Kanteal (6 km).

The people in the Prek Toal area informed us that they face serious problems in fishing. During the closed season (June-October), the provincial fishery officer does not allow them to fish in both the floodplain and the fishing lot, and in the open season (middle of October-June) the owners of the fishing lots do the same too within and around the boundary of their fishing lots. Several fishing gears are used in this area and these gears are classified into 3 types based on their fishing scale. Members of the community fishery use fishing gears such as gill nets, long hooks and lines, cast nets, *Lae*, *Bor*, *Samras*, and giant dip nets as well as various illegal gears, including electro-fishing. Lessees (*Dong*) always use middle-scale barrages, long gill nets, *Bor*, pumping machines, and electro-fishing. Fishing lots use large-scale barrages and electro-fishing.

A wide range of important fish species were caught in both seasons in Fishing Lot #2 and the community fisheries (before 2001 called fishing Lot #3 adjacent to Lot #2). They include white, grey and black fish species (for details see Table 4). On average, fish catch by species varied from 0.5 kg to 8 kg per day per household.

Table 4: Fish species caught at Prek Toal

Scientific name	**Khmer name**
Henicorhynchus siamensis	Riel Top
Henicorhynchus cryptopogon	Riel Angkam
Euryglossa spp.	Andetchhkae
Cyclocheilichthys enoplos	Chhkaok
Pangasianodon hypophthalmus	Pra Thom
Pangasius conchophilus	Kae
Pangsius larnaudii	Po
Pangasius spp.	Chhveat
Osteochilus waandersi	Kros
Labocheilos melanotaenia	Changva Ronoung
Rasbota tornieri	Changva Moul
Cirrhinus microlepis	Prual
Amblyrhynchichthys truncatus	Kambot Chramos
Boesemania microlepis	Brama
Channa striata	Ros
Channa micropeltes	Chhdau
Cyclocheilichthys apogon	Srakakdam
Pristolepis faciata	Kantrop
Notopterus notopterus	Slat Srae
Mustiid spp.	Kanhchos Snot
Hampala macrolepidota	Khman
Ompok hypophthalmus	Ta Aon
Thynnichthys thynnoides	Linh
Botia modesta	Kanhchrouch Krahorm
Wallago attu	Sanday
Paralaubuca typus	Sleuk Reusei
Morulius (Labeo) chrysophekadion	Ka Ek
Barbonymus altus	Kahae
Barbonymus gonionotus	Chpin Prak
Leptobarbus hoeveni	Proloung
Anabas testudineus	Kranh

Trichogaster pectoralis	Kanto
Chitala lopis	Kray Sre
Trichogaster trichopterus	Kampleanh Sre
Macrognathus siamensis	Chhlounh
Mastacembelus favus	Khcheng
Clarias batrachus	Angdeng Reung
Clarias macrocephalus	Angdeng Tun
Hampala dispar	Khman

Source: field trip, August 2006

Fishers informed us that fish catch and size drastically declined due to an increase in fishers, more gears, including small, medium and large-scale barrages bamboo/nylon net fences and illegal fishing gears such electro-fishing, filamentous nets and pumping, new gears (i.e. *Bor*, mosquito net fence traps), and good security (no fear of Khmer Rouge soldiers). Some fish species have not been seen in the catch such as *Amblyrhynchichthys truncates, Puntius orphoides, Belodonthichthys dinema,* and *Dasyatis laosensis*. The giant snakehead *Channa micropeltes* declined very much in the catch because of an increase in the use of electro-fishing and collection of its juvenile for stocking the floating cages; however, there was an increase in the murrel snakehead *C. striata* due to its proliferations and multiple spawning, and difficulties from catching in the wet season, and clarrid catfishes because currently its juveniles have not been collected for aquaculture. It was stated that the number of fishers increased in the past years because of a lack of job opportunities and alternative livelihoods for the floating village households, and these people have to depend solely on fishing as their main occupation. The price of all fish species has dramatically increased in the recent years due to an increase in demand for household consumption and both internal and external markets, and in price of other goods.

Lots of flooded forests have been cleared to create new fishing locations by both small- and medium-scale fishers, and large-scale fishers (fishing lot operators). In past years fishers did not go fishing in many small natural lakes, in which, they are fishing now due to the increase in the number of fishers and fish demands, and the decrease in fish productivity in Fishing Lot #2. They complained that some locations particularly in the core zone areas were restricted to fish in the wet season by the environmental sector due to biodiversity conservation. Moreover, fishers informed us that there is a complaint from Fishing Lot #2 that core zone areas within the lot were also restricted to fish in the dry season (i.e. open season) by the environmental sector.

Regarding the fishers' perceptions of the effect and impact of the built structure (i.e. large barrage or bamboo/ nylon net fence) on:

(1) fish migration, this gear had a significant impact on fish migration and spawning of all groups of fish species (i.e. black, grey and white fish) to the lake during the early dry season when water recede to the lake from the floodplain and from the lake during early wet season when the water enters the floodplain from the lake. This leads to retarding the spawning and foraging time of the adult fish and rearing/nursing time of the young of black and grey and white fish species. However, the level of such an impact cannot be measured.
(2) water flow, the barrage had little effect on water flow at Prek Toal.
(3) flooding areas, furthermore the pumping method accompanied by partitioning of the tributary (another type of built structure made by lessees) to harvest fish, especially in Fishing Lot #2 has a significant effect on the level of flooding by preventing water flow

into the floodplain in the early wet season, and fish migration into the lake in the early dry season.

(4) water quality, harvesting fish by the pumping method causes many fish, particularly small fish species, to die due to water turbidity as silt is sealed their gills. Bad-smelling water caused by rain water is found in the floodplain (dry grassland in dry season) in the wet season (May/June); this water does not cause fish to die as grey and white fish can stay in the lake, tributaries, and floodplain lakes away from the bad-smelling water on the floodplain and can enter the floodplain when the Tonle Sap Lake water enters the floodplain or mixes with floodplain water to remove the bad smell (i.e. buffering). Bad-smelling water entering from the Tonle Sap Lake is found in the floodplain in the dry season (November/December); such light brown colored water causes fish to die, particularly grey and white fish.

Interestingly, fishers provided their perceptions of the advantages and disadvantages of the built structure (i.e. Lot #2) and community fisheries management system as follows.

Fishing Lot # 2

- Advantage:
  - Flooded forest, fish and other aquatic animals and plants, and birds in the lot were well protected by the lot as the lot operator can hire may guards to patrol the lot;
  - Fishers can have access to some far distant fishing locations to fish if they ask the lot for permission to fish there; and
  - Prevents fishers from using electro-fishing method to fish in the lot.

- Disadvantage:
  - The lot harvested fish using pumping method;
  - The lot owner expanded the boundary of the lot;
  - The lot harvested fish using large-scale bamboo/nylon net fence trap (i.e. barrage); and
  - The lot fished with electro-fishing device.

Community Fisheries

- Advantage:
  - Small-scale fishers had more freedom to fish.

- Disadvantage
  - During the transitional period, fishers fished with illegal fishing gears such as electro-fishing, filamentous nets and brush park fishing, and other most effective fishing gears, e.g. the *Bor*; and
  - Fishers had too much right to use all types of new and unsustainable fishing gears.

Pursat

Technical Assistance Built Structures Project
TA 4669-CAM
Fisheries Components

FIELD TRIP PRESURVEY REPORT
31 August to 1st September 2006 at Pursat site, Pursat province

Objective of the trip: To select sampling sites for the project area and test the questionnaires in Ou Taprok and Chong Khlong village of Pursat province.

Duration of the trip: 2 and half days.

Persons involved: Dr. So Nam, Dr Robert Arthur, Mr. Leng Sy Vann, Mr. Prum Setha, and Miss. Pum Sok Hourt.

Activities of the trip:

1. Consulting with Provincial Fishery Office

We met with provincial fishery officer to inform him of the purposes of our visit to Pursat province and then we consulted with PFOs to select the sites within the project area through the map of Pursat province. Six villages within three communes were selected that would be visited during the field trip. All the villages are located close to National Road No. 5 in the south of Pursat province. They consist of:

- Ou Sandan commune, Ou Tabroak, Chong Khlong, and Doung Chhua villages);
- Snar Ansar commune, Krang Veng village; and
- Kampong Po commune, Moat Prey and Kampong Law village.

2. Consulting with Commune Council

We went to meet the chiefs of each of the three communes to consult with them and get information about general situation in each commune. This information was given using mapping combined with interviews:

Ou Sandan commune

We met and consulted with the chief of Ou Sandan commune as well as the head of all the three villages in the commune. The villages within this commune are Chong Khlong (158 HH), Ou Taprok (195 HH), and Daung Chhua (99 HH). They provided general information about Ou Sandan commune:

- Ou Sandan is a commune located 150 m from National Road No. 5 and consists of seven villages.

- In this commune there are plenty of small streams, lakes, canals, track roads and cow roads and these structures have existed since ancient times. There are two main canals that are used for rice field irrigation, as fishing locations, and as a route for fish migration from the mountains during the wet season, getting water from Stung Thlea Ma-orm. These canals have water in the wet season with 1 m depth and are dried up during the dry season.
- The commune is divided into two parts. The top part is in the upland area and the living standard of people in this area is lower than the bottom part (lowland) because people in the lowland area are able to cultivate rice in both wet and dry seasons and are getting high rice production. In addition, they are able to fish in both the dry and wet season. People in the upland areas go fishing in the wet season and the majority of their fishing locations are in the rice fields.
- In the wet season, approximately 30% of villagers go fishing around the rice fields, 20% of them go fishing along the small streams and canals, and the other 50% go fishing in the floodplain areas and in the lakes. In the rice fields, canals and small streams the fishing gears being used are similar and are small-scale fishing gears such as cast nets, gill nets, long line hooks, and bamboo traps. But there are different gears used in the floodplain and lakes where they use small barrages, electro-fishing, gill net with big mesh net (5-10 cm), and trawls.
- In the dry season, there is fishing in the lake (10%) and Tonle Sap River (90%) only.
- Fish species caught along the canal include *Barbonymus gonionotus, Notopterus notopterus, Henicorchynchus siamensis, Hemibagrus spilopterus*, and many other fish species.
- The built structure (road) does not affect fish migration because fish can migrate through the gates and the culverts (holes of cement) along the road. These gates are not allowed to be blocked and people are not allowed to fish with nets or bamboo barrages. This has been prohibited by the commune council.

Snar Ansar commune

The team met with the first vice chief of the commune as well as the head of Krang Veng village to consult with them about the general situation, especially fishery resources in the commune. This information was obtained through mapping. Krang Veng village has 162 HH. Then they informed us that:

- Snar Ansar is a commune located along National Road No. 5 bordering the west of Ou Sandan commune, the east of Anlung Thnaot commune, and the north of the Tonle Sap Lake.
- This commune is not different from other communes where there are canals, small streams, and roads from ancient times. Some roads were renovated in 2002 and 2005. There was also a new canal dug in 2002. This canal dries out in the dry season and in the wet season it has a depth of 1.5 m.
- Besides cultivating rice and fishing, they have other jobs such as collecting palm juice, collecting vines, making bamboo baskets, weaving mats, and raising livestock.
- In this commune, there are three villages that are professional fishing villages both dry and wet season. These villages are Beng, Krang Veng, and Kampong Prak (floating house). However, if we compare ethnic villages (i.e. Cham or Islamic villages) they are still lower than these villages in terms of fish caught. For example, in the dry season Beng village went buying *Prohok* (fermented fish paste) from ethnic villages but Ou Taprok and Chung Chlong village went back buying palm sugar from Beng village. In other words, ethnic villages also become suppliers for livestock to other villages and their living standard is better than other villages.

- In the dry season villagers go fishing at small streams, canals, floodplains, and the lake but especially rice fields. They use different fishing gears in the different fishing locations. In rice fields they always use cast nets, bamboo traps, and long line hooks, but at the lake and floodplain they use cast nets, gill nets, and barrages with bamboo traps.

Kampong Po commune

We met with the secretary of Kampong Pou commune and the head of Moat Prey and Kampong Lor. We consulted with them through asking and mapping in the commune. In this sense two villages are proposed for the survey: Moat Prey (183 HH) and Kampong Lor (264 HH). They informed us that:

- This commune is located along National Road No. 5 and borders the west with Anlung Vil commune, the east with Ou Sandan commune, and the north with the Tonle Sap Lake.
- The east area of this commune is better than the west area because the east is a lowland area. This lowland area gets higher rice production and can also produce more fish because it is closer to the Tonle Sap.
- This commune has three primary canals (Prolay 17 Mesa), which get water from either Stung Pursat or Stung Thlea Ma-orm. These canals were built during the Pol Pot regime (1976). So far they are still useful for irrigation and fish migration from upstream and are a fishing location for the villagers during the wet season. But they are dried out during dry season. Moreover, Kampong Lor commune has a new canal that was dug in 2000 crossing Prolay 17 Mesa from Stung Thlea Ma-orm and it gives more benefits for rice farming and fishing, especially fish migration from upstream. In May through June fish migrate upstream, and they migrate downstream from October.
- The commune also has some big lakes and a lot of small lakes. These lakes are not dried out during dry season and they are advantageous for villagers fishing there because they can be used in both dry and wet seasons.
- The main occupations of people in Kampong Lor are rice field cultivation and fishing. Fifty percent of Kampong Lor villagers do both rice farming and fishing, and the other 50% do fishing only. As for Moat Prey village, the majority of villagers make their living both fishing and rice farming, but the minority do fishing only.
- Villagers in this commune always go fishing during the wet and dry season. In the wet season, they go fishing at rice fields, small streams, streams, canals, floodplains, and the Tonle Sap Lake with small-scale fishing gears. However, these gears are used in a different manner depending on the fishing location. Rice field gears consist of long line hooks, cast nets, and bamboo traps. Cast nets, bamboo traps, and small barrages with bamboo traps are used in streams and canals. Gill nets, cast nets, and small barrages with bamboo traps are used at the floodplain areas and Tonle Sap Lake. During the dry season, they go fishing in the lakes, Ou Taprok stream and the Tonle Sap Lake with different fishing gears based on fishing locations. *Samras*, bamboo traps, cast nets, circular seine nets and small barrages with bamboo traps are used in floodplain lakes. Cast nets, gill nets and bamboo traps are used in streams. Circular seine nets, *Samras*, cast nets, and long barrages with bamboo traps are used in the Tonle Sap Lake.
- For fishing gears, they bought them from Cham villages (Ou Taprok and Chung Chlong villages) and sometimes they went to buy fishing gears in Pursat town.
- They thought that before there were plenty of fish, but now there is a dramatic decline in both the quantity and size of fish. Moreover, some fish species have disappeared, especially larger fish.

3. Discussing with fishermen groups

We have two groups (a total of six fishermen) to discuss fish ecology and fishing information related to the build structure in their villages. The first group is in Chong Klong village, talking about the built structure, and another group is in Ou Taprok, talking about fish ecology. This information is detailed as below:

Chong Klong village

This village is a village close to Ou Taprok village, which is in the east of Ou Taprok. This village has some primary and secondary canals which were built during the Pol Pot regime and they were renovated in 1996 and 2003. In addition, there are some rural roads that were built in 1994 and renovated in 2002 due to the flooding from 2000 to 2002. Another road linking Ou Sadan road was underwater during the flood from 2000 to 2003.

Chong Khlong village is a village that favors fishing because of the many floodplain lakes. These are Boeung Tro Chek, Veng Tun, Pro Lakva, Charb Kul, Kbal Skouv, Tys Peay, Tro Borklun, Kouch, Locheung, Tro Pengkros, Tro Pengksarch, Pseurt Knung, Chhes, Dach Krolech, and Boeung Bath Pdil. In the wet season villagers always go fishing in rice fields, small streams, canals, and floodplain areas with family-scale fishing gears and their fishing gears are different owing to fishing location. At rice fields they like to use gill nets and hooks and line. Cast nets and bamboo traps are used in small streams and canals. Gill nets, bamboo traps, and circle grill nets, electro-fishing (September to November) is used in floodplain areas. But in the dry season villagers go fishing in floodplain lakes and the Tonle Sap Lake only and their fishing gears consist of cast nets, circular seine nets, electro-fishing, and *Samras*.

Ou Taprok village

Ou Taprok village is next to Chong Khlong village and is also a professional fishing village. This village also has many floodplain lakes, and these lakes have permanent water. Villagers always go fishing in rice fields and canals in the wet season, and the floodplain and Tonle Sap Lake in the dry season. The fishing gears they are using are not different from Chong Khlong village in both dry and wet seasons.

Fishers' perceptions of fish and fishing in Chung Khlong and Ou Taprok villages

In general, there has been a dramatic decline (i.e. 50-70% from the past catch rate) in either fish abundance or fish size in both villages. Several similar reasons for the decline are (1) use of illegal fishing gears such as electro-fishing, fine mesh nets and brushparks, (2) clearing flooded forests, and (3) illegal fishing activities such as collection of snakehead eggs. It was reported that there is an increase in the abundance of other aquatic animals such as small shrimp (i.e. *Kampeus*) and mollusks. However, amphibians (i.e. frogs) similar to all fin-fish species had declined. It is clearly reported that the price of fish is increased over time due to a decline in fish abundance, high market demand, and population growth. Interestingly, the price of small-sized fish has dramatically increased compared to big-sized fish.

Fishers' perceptions of the effect of the built structures (i.e. roads and canals) on hydrology, fish, and fishing in Chung Khlong and Ou Taprok village

It is strongly believed that the built structure (i.e. road) has no negative effect on water flow and water quality in the villages as water gates and culverts have been installed along the roads.

Fish can move up and down the floodplain through these gates and culverts. The structure provides more fishing opportunities in terms of new fishing locations and different fishing gears used, especially around water gates and culverts. Canals are another type of built structure that could create new fishing locations, fish habitats and/or migration routes.