

## Evaluation of stock status of *Channa micropeltes* in Tonle Sap Lake, Cambodia, by means of CPUE analysis

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**ABSTRACT:** Data collection and interview survey were conducted to evaluate stock status of a snake head, *Channa micropeltes*, which is one of the major fisheries target species around Tonle Sap Lake, Cambodia. The catch data classified by species was collected for the first time in a project cooperated with the Mekong River Commission during 1995–1999 around Tonle Sap Lake. The four provinces continued collecting individual species catch data even after the project. The catch of *C. micropeltes* decreased during 1995–2008 in the four provinces. Additionally, individual species catch data sorted by fishing lot, exclusive fishing area, were recorded in Kampong Thom province. Catch per unit effort (CPUE) of *C. micropeltes* in the fishing lot No. 3, 4 and 5, which is situated in the margin of Tonle Sap Lake, was calculated. The CPUEs rapidly decreased during 1995–2001, and the values then remained low. These results suggest the stock has been depleted in Tonle Sap Lake. We also found that the recent catch had recovered since 2006 in another smaller lake in Kampong Thom province. This may be attributed to the effect of the decrease of the illegal fishing for the fingerling in closed season according to the prohibition of the aquaculture of *C. micropeltes* since 2004.

**Keywords:** Tonle Sap Lake; fishery statistics; CPUE; *Channa micropeltes*

### 1. Introduction

It is widely recognized that scientific stock assessment is an indispensable tool for conservation and effective use of aquatic resources. However, stock assessment is often abandoned in developing countries because of budgetary restrictions and weakness in fishery statistic systems (COATES, 2002). The low quality and quantity of the fishery statistics have been also pointed out as a problem for stock assessment in developing countries (SIMPSON, 1982). Demonstrating the practical usage of their existing fishery statistics for stock assessment could

provide incentive for collecting and compiling fishery statistics and more effective utilization of fishery statistics.

In Cambodia, more than 75% of per capita animal protein intake is supplied from fisheries products (AHMED *et al.*, 1998), and approximately 85% of the total fish catch comes from inland fisheries (DEPARTMENT OF FISHERIES IN CAMBODIAN GOVERNMENT, 2007). Tonle Sap Lake, which is located in the central part of Cambodia, is the largest inland water body in Southeast Asia (Fig. 1). Around 60% of the inland fisheries products are provided from neighboring provinces around the lake (AHMED *et al.*, 1998). HORI *et al.* (2006) suggested that small-scale fishing is quite important as income sources in communities around the lake. On the other hand, deterioration of fisheries resources, especially fish stocks of large species with high price, in the lake was suggested recently (VAN ZALINGE *et al.*, 2001; HORTLE *et al.*, 2004). *Channa micropeltes* was major target

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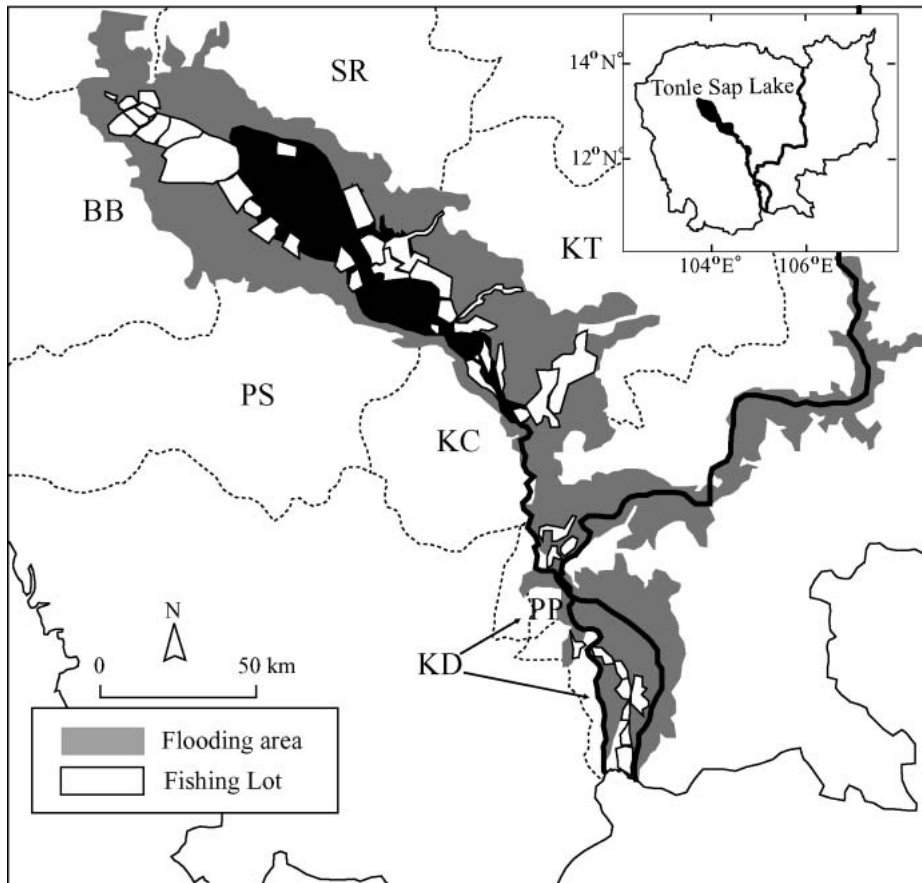


Fig.1. Map of Tonle Sap Lake with flooding areas and the 7 provinces where the catch assessment project was conducted (BB: Battambang, SR: Siem Reap, PS: Pursat, KT: Kampong Thom, KC: Kampong Chhnang, PP: Phnom Penh, KD:Kandal). Bold and dotted lines indicate rivers and boundary of provinces, respectively.

species in the inland fisheries and also one of the most highly valued commercial species (VAN ZALINGE and THUOK, 1999; RAINBOTH, 1996). The fish inhabits standing or slowly flowing waters and feeds mostly on fishes and crustaceans (RAINBOTH, 1996). Decrease in catch of *C. micropeltes* was reported in the northern part of Tonle Sap Lake (TROEUNG, 2001). The Department of Fisheries in Cambodian Government (DOF), considering this situation, has prohibited aquaculture of the species in order to prevent illegal fishing of the fingerling of the fish since 2005. However, the stock analyses of individual species, including *C. micropeltes*, have not been implemented because of several weakness and unreliability of fishery data; therefore, the effect of fisheries

management of the prohibition of aquaculture of the species could not be assessed.

The data in the total fish catch in Cambodian inland fisheries is available in statistical information such as reports by the DOF or "FAO Fish STAT." However, records of individual species catches and fishing efforts are not obtainable from these publications. Additionally, the relationship between the main fishing methods and the main target fishes are not clear. These weaknesses make it difficult to calculate the catch per unit effort (CPUE), the common indicator of fish stock fluctuation. The Cambodian government and international organizations deeply recognize the importance of freshwater resources in Tonle Sap Lake. DOF and the Mekong River Commission

(MRC) conducted a catch assessment of commercial fishing in the seven provinces adjacent to Tonle Sap Lake (Fig. 1). The project was carried out from 1995 to 1999 in order to grasp the accurate status of the quantity and value of the catch (e.g. DEAP *et al.*, 1998). In the project, catch data classified by species was collected for the first time in inland fishery and that resulted in the improvements of the routine data collection (SAM *et al.*, 2003).

Cambodian inland fishery in Tonle Sap Lake are categorized into large-, middle- and small-scale fishing, according to types of fishing gear and the difference in fishing ground defined by fishery law (DEPARTMENT OF FISHERIES IN CAMBODIAN GOVERNMENT, 1990). The large-scale fishing is a type of fishing based on the fishing law in Cambodia, which is implemented in the fishing season (1st October-31st May) in specified licensed fishing areas called "fishing lot." The lot owners obtain the exclusive fishing right in fishing lots through the payment of lot license fee to the government. Three large fishing gears were operated in the fishing lot, namely bamboo fence system, barrage, and seine net operated with motor-powered boats or many fishers (DEAP *et al.*, 2003). Lot owners have obligation to report their catch amounts to provincial fisheries office. The provincial fisheries officers sometimes confirm the accuracy of their report by checking the transportation quantities. The middle-scale fishing can be operated in the open access fishing area in fishing season. Only the registered and regulated fishing gears such as gillnet (>10 m length), seine net, round net and arrow-shape trap can be used in the middle-scale fishing. The small-scale fishing is defined as subsistence fishing wherein gill net (<10 m length), spear, hook with line and small trap are used in open access areas and rice fields. Fishers of the middle- and small-scale fishing have no obligation to report their catches, and the provincial fisheries officers conduct interviews at community or village level to estimate their catch amounts. In this study, the large-scale fishing could be analyzed because sufficient data in quality and quantity of the fishery statistics were available.

It is to our information that the collection of

individual species catch data continued in several provinces even after the project had terminated. Field surveys were made to find out and acquire the records that would provide reliable data sets of fishing effort and individual catch record around Tonle Sap Lake. The aim of this study is to examine the stock of a snake head, *C. micropeltes*, around Tonle Sap Lake using an obtainable dataset.

## 2. Materials and Methods

Data collections and interview surveys were conducted in February-April, 2005 and July-August, 2008 in the DOF and seven provincial fisheries offices (PFO) around Tonle Sap Lake, namely, Battambang, Siem Reab, Pursat, Kampong Thom, Kampong Chhnang, Kandal and Phnom Penh where the DOF and MRC Capture Fisheries Project was performed (Fig. 1). Information on the fishery statistics system and the existing fishery statistics in the large-scale fishing were also collected. In addition, the fishing operation information, such as fishing method, fishing ground and gear size, was collected through interviews of fisheries officers and fishermen.

From the collected data, individual species catch records in provincial and fishing lot level were selected and sorted out. The fluctuation of catch of *C. micropeltes* in the provinces was observed. Additionally, the catch data classified by fishing lots, where large quantity of *C. micropeltes* was harvested, were sorted out. The relation between fishing method and main target species was examined using the collected data and information; the fishing gears that mainly used for the fishing of *C. micropeltes* was identified. Difference of catch ratio of *C. micropeltes* between the fishing lots was statistically examined by analysis of variance with the Turkey-Kramer honest significant differences test using JMP version 7 (SAS Institute, Cary, NC, USA). The CPUE of *C. micropeltes* in the fishing lot was calculated by dividing the catch quantities with the fishing effort of the main fishing gear.

As the fishing season spans from October to May of the following year, annual catch data of fishery statistics were calculated through totaling the monthly data for the period. In this

paper, fishing year  $n$  was expressed as the year of the end of the fishing season.

### 3. Results

The results of field survey on data collection of individual species catch data in large-scale fishing are summarized in Table 1. In four provinces, Battambang, Siem Reab, Kampong Thom and Kampong Chhnang, data collection of individual species catch continued even after the DOF and MRC project. The catch quantities of *C. micropeltes* in the four provinces in 1995 ranged between 800 and 1200 ton. The quantities, however, decreased year by year until 2004 (Fig. 2), and since 2005, the catch volume remained low around 200 and 300 ton.

As shown in Table 1, it was possible to obtain the catch record of *C. micropeltes* in each lot in Kampong Thom province from 1995 to 2007 except for 1998. The catch record of lots in Battambang, Siem Reap and Kampong Chhnang provinces, but the duration of the record is short and old. There were 7 fishing lots in Kampong Thom (Fig. 3). The average ratios of catch quantities of *C. micropeltes* of each lot during 1995–2007 are shown in (Fig. 4); in

Kampong Thom, *C. micropeltes* was mainly caught in fishing lot No. 3, 4, 5 and 6.

The geographic condition and the fishing gears used differed among fishing lots as shown in Table 2. The fishing lots No. 3, 4 and 5 are located in the lake, while lot No. 6 is located at the mouth of a river. Bamboo fence

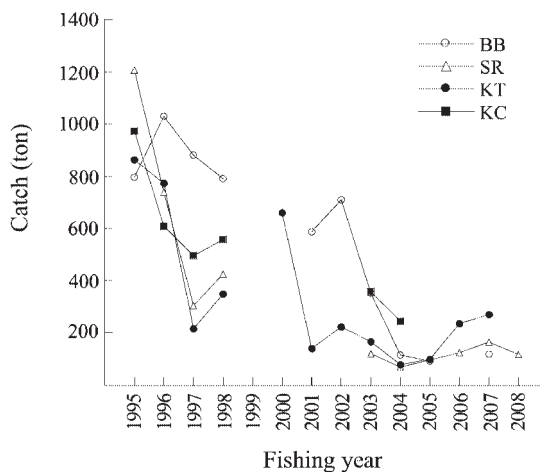


Fig. 2. Time series of catch in the four provinces, Battambang, Siem Reap, Kampong Thom and Kampong Chhnang during 1995–2008.

Table 1. Collected catch data sorted by species of large-scale fishing in the 7 provinces

Province	Period	Data contents	Data source
Battambang	1995–1997	Annual catch sorted by fishing lot	DEAP <i>et al.</i> , 1998
	1998	Annual catch sorted by fishing lot	THOR <i>et al.</i> , 1999
	2000, 2002, 2006–2007	Annual catch in fishing lot No.2	Stored at POF
	2001–2007	Total Annual catch	Stored at POF
Siem Reap	1995–1997	Annual catch sorted by fishing lot	DEAP <i>et al.</i> , 1998
	1998	Total Annual catch	THOR <i>et al.</i> , 1999
	2003–2008	Total Annual catch	Stored at POF
Pursat	1995–1997	Annual catch sorted by fishing lot	DEAP <i>et al.</i> , 1998
	1998	Total Annual catch	THOR <i>et al.</i> , 1999
Kampong Thom	1995–1997	Annual catch sorted by fishing lot	DEAP <i>et al.</i> , 1998
	1998	Annual catch sorted by fishing lot	THOR <i>et al.</i> , 1999
	2000	Annual catch sorted by fishing lot	Stored at POF
	2001–2007	Annual catch sorted by fishing lot	Stored at POF
Kampong Chhnang	1995–1997	Total Annual catch	DEAP <i>et al.</i> , 1998
	1998	Total Annual catch	THOR <i>et al.</i> , 1999
	2003	Annual catch sorted by fishing lot	Stored at POF
	2004	Total Annual catch	Stored at POF
	2005–2007	Total Annual catch of middle- and large-scale fishing.	Stored at POF
Kandal and Phnom Penh*	1995–1997	Annual catch sorted by month	DEAP <i>et al.</i> , 1998
	1998	Total Annual catch	THOR <i>et al.</i> , 1999

\*The catch data of Phnom Penh and Kandal were summed up into one unit in the catch assessment project by DOF and MRC (DEAP *et al.*, 1998).

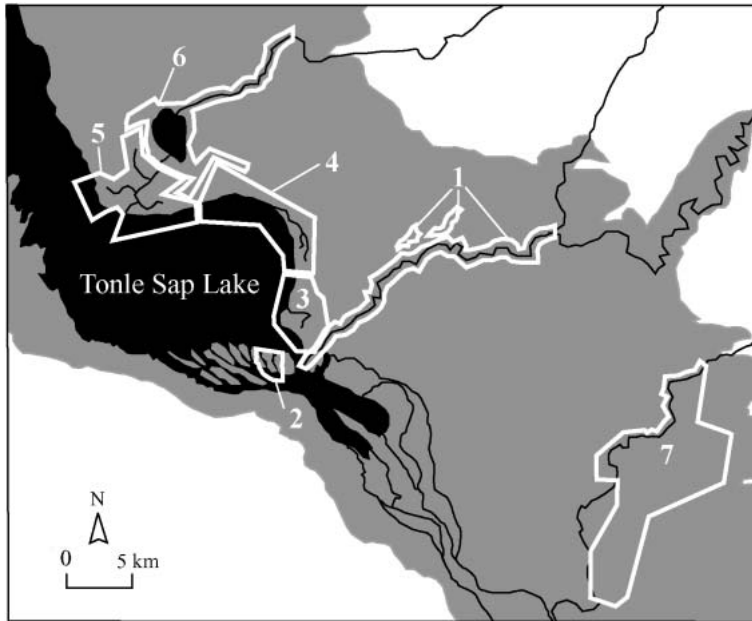


Fig. 3. Map of 7 fishing lots in Kampong Thom province. Black area indicates lake area and gray area indicates flooding areas in rainy season. Solid lines and white lines show rivers and boundaries of the fishing lots, respectively. Numeric character indicates fishing lot number.

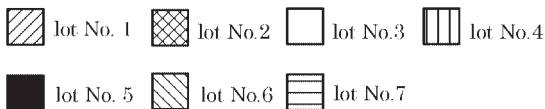
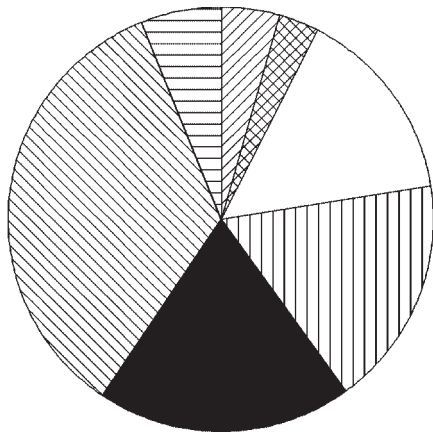


Fig. 4. Average catch ratio of *C. micropeltes* in seven fishing lots in Kampong Thom province during 1995-2007.

Table 2. The fishing area and fishing gear in each fishing lot in Kampong Thom province

Fishing lot No.	Fishing area	Fishing gear
1	River	barrage, seine net
2	River	barrage, seine net
3	Lake	bamboo fence system
4	Lake	bamboo fence system, seine net
5	Lake	bamboo fence system, seine net
6	River, Lake	barrage, bamboo fence system, seine net
7	River	barrage, seine net

system is a structure to enclose fishes in flooding area, and the long bamboo fence is set up along the fringe of the lake. Fishers catch the fish in late dry season, when the water depth and the flooding area decrease. Fishing lots No. 3, 4, 5 and 6 had a bamboo fence system. Seine nets were used in fishing lots No. 4 and 5 at the end of fishing season. In lot No. 6, a bamboo fence system, seine nets and a barrage (a setting net in the river) were used.

In order to examine the relationship between

catch of the bamboo fence system and the length of the bamboo fence, the total catch amount of *C. micropeltes* in lot No. 3, 4 and 5 and the share of each lot in the total during 2001–2007 were calculated. The catch ratios of fishing lot No. 4 and 5 were statistically higher than that of fishing lot No. 3 (Turkey-Kramer test,  $P < 0.01$ ) (Table 3).

The place of the bamboo fence system was basically fixed in each lot, and there were little changes in the length of the bamboo fence. However, there seemed to have a little change in the length of the lot No. 3 in 2001. The fluctuations of the CPUEs in fishing lots No. 3, 4 and 5 are calculated by dividing the catch by the length of the bamboo fence (Fig. 5). The fluctuation patterns of the CPUEs were exactly similar among those fishing lots. The values of CPUE were between 6 to 9 in 1995 and 1996 in the lots, but in 1997 it was reduced to a value between one-fourth and half. The CPUE relatively increased much in 2000, but it decreased again in 2001, and since 2002 it maintained between 0.5 and 2.

It is impossible to calculate CPUE in lot No. 6, because *C. micropeltes* in the lot were caught by both bamboo fence system and barrage, and hence, the quantity of the catch by bamboo

fence system in lot No. 6 could not be separated. Fig. 6 shows the fluctuation of the catch quantity of *C. micropeltes* in lot No. 6. The fluctuation of the catch in lot No. 6 was similar to the CPUEs of lots No. 3, 4 and 5 during 1995–2005 although the fluctuation was obviously different from CPUEs in lots No. 3, 4 and 5 in 2006 and 2007.

**4. Discussion**

Data collection of catch was continued in the four provinces around Tonle Sap Lake, Battambang, Siem Reap, Kampong Thom and Kampong Chhnang. The catch fluctuation of *C. micropeltes* during 1995–2007 had negative trends in the all provinces (Fig. 2). This indicated a possibility that the fish stock was largely depleted around Tonle Sap Lake.

Table 3. Length of the bamboo fence and catch ration during 2001–2007 in fishing lot No. 3, 4 and 5 in Kampong Thom province

Fishing lot No.	Length of the bamboo fence (km)	Catch ratio (%)	n
3	20.7	22.1±5.0	7
4	24.6	37.1±7.7	7
5	25.6	40.8±6.5	7

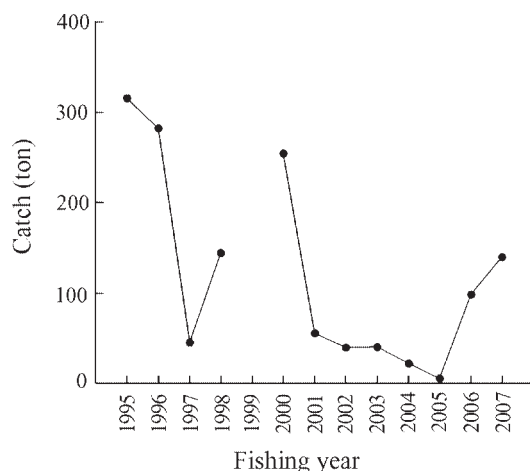


Fig. 6. Time series of catch in fishing lot No. 6 in Kampong Thom province during 1995–2007.

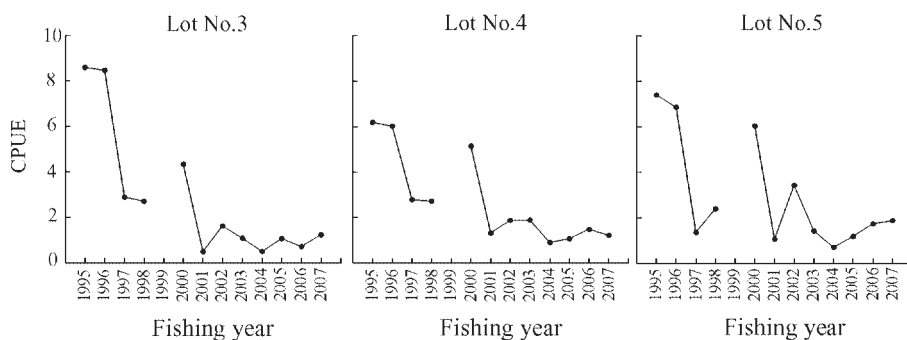


Fig. 5. Time series of CPUE in fishing lot No. 3, 4 and 5 in Kampong Thom province during 1995–2007.



Catch records of each fishing lot after 1999 were obtained only from Kampong Thom. Kampong Thom was selected as target areas because the catch data of *C. micropeltes* in each fishing lot were available, and an estimate of the main fishing gear used to catch the fish was possible. There were 7 fishing lots in Kampong Thom as shown in Fig. 3, and *C. micropeltes* was the main species harvested in the lake and the river mouth fishing area (Fig. 4). Among the 7 fishing lots, No. 3, 4 and 5 were located in lake fishing area wherein bamboo fence system and seine net were operated. In the bamboo fence system, the fences were set along the boundary of a fishing lot in the lake side and prevented the fish from going out of flooded area to the lake. The fish was captured by several traps installed inside and along the boundary of the fishing lot. Seine net was used at the end of the fishing season in bamboo fence system to catch the fishes that remained in fishing lots No. 4 and 5. The water depth in fishing lot No. 3 was shallow and fishers do not need seine net for the harvest at the end of fishing season. Hence, the catch by seine net in the lake fishing lot should be considered and included as a catch by bamboo fence system. If the catch by seine net in fishing lots in the lake is presumed and accepted as a part of the catch by the bamboo fence system, overall the fish harvested in fishing lot No. 3, 4 and 5 are considered to be caught by the bamboo fence system. This means the main fishing gear that captures *C. micropeltes* in fishing lot No. 3, 4 and 5 can be identified, and CPUE analysis using proper unit of the fishing effort is possible. It was anticipated that the length of the fence could be used as the unit of the fishing effort; therefore, to examine this hypothesis, the shares of the catch among these three fishing lots in each year was calculated. The catch ratios of fishing lot No. 4 and 5 with the longer fence were higher than that of fishing lot No. 3 with the shorter fence (Table 3). The results suggest that the catch quantities of *C. micropeltes* in the lots depend on the length of the fence, and therefore the length could be used as fishing effort.

In the CPUE analysis, the fluctuations were basically synchronized with small differences

in magnitude of the value among fishing lot No. 3, 4 and 5 (Fig. 5). From this, it could be said that the *C. micropeltes* in the fishing lots constitutes a population and that the stock of this population was drastically decreased between 1995 and 2001.

We screened out the CPUE analysis in fishing lot No. 6 because we could not estimate strength of fishing effort in the lot. Generally, place of the bamboo fence system and barrage was restricted by land form, and changes in the numbers of the gears are supposed to be little. When we presume there was no change in fishing effort in lot No. 6, the fluctuation pattern in the catch amount is similar to the pattern in CPUE. The catch fluctuation of the lot during 1995–2001 was very similar to the CPUE in fishing lot No. 3, 4 and 5. However, the catch largely increased during 2006–2007 (Fig. 6). This increase would be derived from the prohibition of capture of the seedling for aquaculture of the *C. micropeltes* since 2004. The illegal fishing activity for the fingerling was punished in several provinces (DEPARTMENT OF FISHERIES IN CAMBODIAN GOVERNMENT, 2006). It could be explained that fishing lot No. 6 was located in a separated lake and river and thus the controlling the illegal fishing would be easier than the lots inside Tonle Sap Lake. On the contrary, the fisheries management for decreasing fishing pressure in closed season would be more difficult in Tonle Sap Lake. The delay in the recovery of the stock may be derived from the incomplete regulation of capture of the fingerling.

This study revealed that stock assessment by CPUE analysis for *C. micropeltes* in Tonle Sap Lake is possible using catch record data of bamboo fence system. Moreover, by the CPUE analysis, the stock depletion of the fish in Tonle Sap Lake from 1995 to 2008 is confirmed. This study also suggested that the recent catch recovery in an adjunct small lake may be due to the prohibition of capture of fingerlings for aquaculture since 2004.

It is concluded that the bamboo fence system is a highly quantitative fishing method when length of the fence is used as fishing efforts, and that CPUE analysis for major target fish of bamboo fence system will provide accurate

information of stock status and proper evaluation of stock management.

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