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Fish Assessment in the Rehabilitated Polders of Prey Nup (Cambodia)

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Abstract

Physical restoration of dykes and water gates along the shorelines of the Prey Nup area was done in 1998 to preserve rice field areas from being washed-off during high tides. The four first polders constructed resulted in the recuperation of about 5,500 ha for rice field cultivation.

Before the rehabilitation, the area was also a common dwelling place for freshwater, brackish water and marine fish species (43 species). Information regarding effects of seasonal variations on species richness and stock assessment were obtained from capture surveys of native fishermen using 11 different kinds of fishing gears from 1998 to 2001.

The influence of rehabilitating the area on the fish community species richness, stock recruitment and dynamics were investigated. Surveys showed that the marine fish species (11) were completely wiped-out from this area leaving only about 31 brackish and freshwater species. These remaining species, coming from the upstream catchment areas, colonized these rice fields especially during the rainy

season (June to October) when annual water level elevates to an average of 2 m. Annual catch is estimated to 3,467 tons for the whole area where 92% is captured using 6 main gears (gill nets, individual and line hooks, cast nets, traps, and scoop nets). Catch during the rainy season is estimated at about 79% of the total annual catch. The four main commercial fish species captured are *Channa striata*, *Clarias* spp, *Anabas testudines* and *Notopterus notopterus*.

Introduction

Cambodia is predominantly an agricultural country (Nesbitt 1998) and land ownership for subsistence agriculture is crucial, especially for alleviating rural poverty. Almost 80% of the country's population lives in rural areas and 75% are farmer-headed households that depend primarily on culture of rain-fed rice. Average rice yield, however, is considered as one of the lowest in the world due to poor soil fertility and adverse climatic conditions over the past years (Ahmed et al. 1999). Nesbitt (1998) estimated that as an average, a typical annual low-land and rain-fed rice farm's production is sufficient to sustain only about 7 -10 months of a household's consumption. Recently, efforts in increasing crop productions have been a major preoccupation of the government such that increase of annual crop production was observed from 1.7 tons in 1998 to 2.1 tons per hectare in 2002 (Lim ENSAT, pers. data.).

The Prey Nup area is a low-lying coastal zone (Fig. 1) located in the Sihanoukville province (13 N, 150 E) in Cambodia. The construction of polders was intended to protect cultivated lands from salt water intrusion (J.-P. Fontelle, GRET, pers.comm.). This technique is adopted from the Netherlands to protect lands which are rendered unproductive by salt which remains in the soils once the gulf marine waters recede. The total area comprising the four polders and adjacent small villages is estimated at 8,500 hectares. The maximum area of the floodplain is about 65% of this area (5,500 ha) and is primarily utilized for rice cultivation.

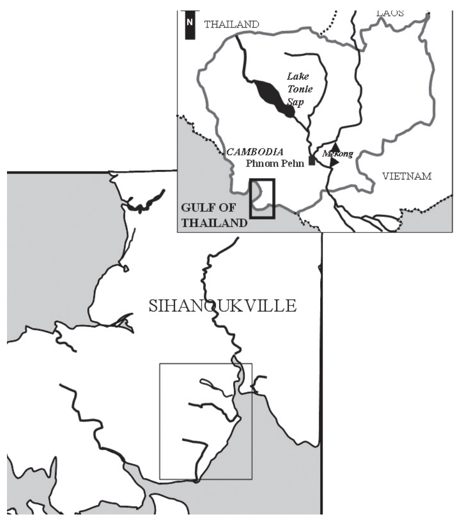

Fig. 1. Map of Cambodia showing the location of the rehabilitated polders at Sihanoukville.

The rehabilitation of these polders in 1998 aimed to recover about 10,000 -

15,000 ha of agricultural land by renovating 92 km of severely damaged dykes in the Sihanoukville province. The maintenance of these dykes will be later on taken care of by the users (39,000 inhabitants distributed in about 6,500 families). The aim is to improve existing technologies for agriculture but also to increase agriculture production by regaining land areas, controlling seawater infiltration during the rainy seasons and re-enforcing irrigation systems (Huchon and Kong 2000a; Sophal 2000; Kibler 2001).

Fishery is one of the major occupations in most Asian countries as fish and other aquatic resources ensure a sustainable livelihood and food security to the population. Aside from rice, fish is considered as one of the major staple of Cambodian nutrition (Ahmed et al. 1999). The coastal and inland resources are currently threatened by increasing exploitation (i.e. illegal fishing) and environmental degradation (Loeung 1999). In most part of the country, however, fish is a subsistence livelihood, especially in rural provinces. It is considered as an open-access resource which is accessible to most population unlike agriculture land which is primarily held as a private ownership.

The development of the fishery sector is a part of the country's land-based reform program to alleviate rural and to improve food security (Nabasa et al. 1995). It includes the development of local aquaculture to improve the living conditions of farmers by generating incomes in addition to crops, as well as providing occupation for local residents (Guttman 1999; Gum 2000). The increase in the number of rice-aquaculture installations is due to the higher productivity of this type of system and offers not only an economic advantage but ecologic as well (Li & Pan 1992; Mai et al. 1992; Pacardo 1994). An increasing number of rice-field fisheries has already been observed in some Cambodian provinces such as Svay Rieng, Takeo and Kampong Speu (Van Zalinge et al. 1999; Vannatrn 1999).

In neighboring countries such as Thailand, rice field fish capture production may be around 25 $kg.ha^{-1}$, while in other Asian countries the range is from 1.5 to 84 $kg.ha^{-1}$ (Fedoruk &. Leelapatra 1992). A similar value may be assumed to occur in the Prey Nup area before its rehabilitation (Lim ENSAT, pers. data).

As for seasonal variations, the area comprising the Prey Nup polders experiences two main seasons : the dry season is from December to April when fish growth is quite slow whereas the rainy season is from May to November. During the dry season, the hydrographic connections, "intra-polders" (reservoirs, rivers, canal, ponds and dikes), within the floodplain, separate one polder from the other and becomes quite complex. These intra-polder water bodies are artificial reservoirs with relatively extremely varying areas. Intense water evaporation leaves only 60%, of the total submerged intra-polder area at the end of the dry season. During the rainy season, the area flooded can reach about 10,000 ha and this induces high rates of fish production and growth (Lim 2000; 2001).

Due to the significant socio-economic role of aquatic resources and production, there is a need to assess possible ecological impacts of polder restoration on the fish community of Prey Nup. This paper is a preliminary assessment of the fish community and the economic potential of fish production in the rehabilitated Prey Nup polders.

Material and Methods

Field samplings were carried out from October 2000 to September 2001. The protocol for experimental fishing adopted for this study is similar to indications of Huchin and Kong (2000b). Catch data were basically obtained from fish diversity assessment which was carried out in four selected polders where:

- Three fishermen for each polder were designated to capture fishes using the main fishing gears and record catches. Each fisherman was requested to indicate the number and weight of fish species captured on a daily basis, specifying as well the location and time of fishing and the gear utilized;
- Due to the existence of different types of traps, we considered only catches from main utilized gears. Selective gears include: gill net (*moang*), longlines (*ronong*), hooklines (*bangkai*) while non-selective gears included several kinds of bamboo-made basket traps ("*lob*", *trou*" and "*kantouy kando*r"). We called these three types as : trap type 1 (*lop*), trap type 2 (*trou*) and trap type 3 (*kantouy kandor*). The fishing effort for every specified fishing gear was studied on 20 fisherman-headed families by polder;
- Surveys of catch rates from familial fishing gears (i.e. funnel-shaped basket or "*angrout*", rattan-made basket with side-grips or "*chhneang dai*", scoop nets or "*chhip*", cast nets or "*samnang*" and dragnets or "*uons*") were carried out using the Participatory Rural Appraisal (PRA) methods (Nabasa 1995).

Catches per unit effort (CPUE) were calculated as catch per fishing gear per time unit. It was then extrapolated to the polder as explained below with an example:

Example: Polder 1: Fishing gear: gill net for a specific month (i.e. October)
CPUE (gr.100 m^{-2} gillnet.hr^{-1}): 26.6g.
407 hours per month
Number of fishermen (based on survey): 621
Surface of gillnet per fishermen: 390 m^2
Catch: 26.6g* .407hr^{-}* 621.* 3.9 = 26.2 tons.

Yield and biomass estimates

The following equation expresses the relationship between fish biomass and catch:

$$Y = F * B$$

Where:

Y = Actual catch ($t.km^{-2}.yr^{-1}$);

F = Fishing mortality (yr^{-1})

B = Biomass ($t.km^{-2}$)

where $F = Z$ (total mortality) – M (natural mortality). Z is also equal to P/B, the production/biomass ratio (Allen 1971). In theoretical optimal conditions of fishing, it is admitted that the total fishing mortality $F = M = Z/2$ (Ricker 1975; Gulland 1977). In tropical areas, in which fish are characterized by small sizes related to short longevity, we have high P/B values ranging from 3 to 5 (Moreau and Sricharoendham 1999).

From our analysis it appears that fish are caught at a small size (average weight: 10 g.) meaning a very shot life span and a high total mortality. Therefore, we assume $P/B = 4$ and $F = 2$. Consequently, $B = Y/2$.

Table 1. Average seasonal variations of some limnological parameters in the polders.

	Dry season (Dec-April)	**Rainy season (May-Nov)**
Rainfall (mm)*	423	2771
Temperature (°C)	31	27
Conductivity ($\mu S.cm^{-1}$)*	2530 (δn ±3148)	271 (δn ±245)
pH*	7.1 (δn ±0.4)	7.3 (δn ±0.3)
Water level (m)*	1.30 (δn ±0.40)	1.01 (δn ±0.30)

Rainfall values per season are monthly averages from 1985 to 1999.

Results

Table 1 shows seasonal varying limnological parameters in the study area.

Table 2 shows a decline of fish species richness from the pre- to the post-rehabilitation period. After the rehabilitation, a total of 31 species were identified from the catch where 8 of which were species with brackish waters affinity (Table 2). No marine species were found in the catches, indicating their complete disappearance due to the efficiency of the polders in blocking their migration. A comparison with the results obtained by Houchon and Kong (2000a, b) shows that the species richness declined after the rehabilitation as a total of 43 species were previously observed in the ecosystem: 11 marine, 14 brackish and 18 freshwater species.

Autochtonous fish species, called “black fish”, are sedentary. Channidae, Clariidae, Bagridae and Anabantidae families are the most usual representative of this group and have high commercial values. Most are carnivorous and detritus feeders. They resist extreme conditions, especially during dry seasons when they survive even in almost dried-up swamps, canals and ponds. Migratory species are known as “white fish”. Species belonging to this group are usually from the Cyprinidae and Notopteridae families. Spawningandreproduction occurs usually from May to September when these fish species migrate and colonize flooded rice

Table 2. List of fish species identified in Prey Nup showing the species observed before and after the rehabilitation periods.

	Before 1999			2000-01		
Orders, Family and Species	**1***	**2***	**3***	**1***	**2***	**3***
O : Osteoglossiformes						
F : Notopteridae : *Notopterus notopterus*	+			+		
O : Clupeiformes						
F : Prstigasteridae : *Llisha spp.*		+		+	+	
F : Clupeidae : *Tenualosa thibaudeaui*		+		+	+	
Dussumieria acuta			+			
Corica laciniata		+		+	+	
O : Cypriniformes						
F : Cyprinidae : *Osteochilus hasselti*	+			+		
Esomus longimanus	+			+		
Cyclocheilichthys apogon	+			+		
O : Siluriformes						
F : Bagridae : *Mystus wolffi*	+			+		
F : Sisoridae : *Glypothorax fuscus*		+		+	+	
F : Clariidae : *Clarias batrachus*	+			+		
Clarias meladerma	+			+		
Clarias macrocephalus	+			+		
F : Ariidae : *Arius spp.*			+			
F : Plotosida : *Plosotus cantus*			+			
O : Mugiliformes						
F : Mugilidae : *Valamugil ceheli*		+		+	+	
O : Synbrachiformes						
F : Mastacembellidae : *Macrognathus spp.*	+			+		
F : Synbranchidae : *Monopterus spp.*		+		+	+	
O : Perciformes						
F : Channidae : *Channa striata*	+			+		
Channa lucius	+			+		
Parambassi wolfi	+			+		
F : Cichlidae : *Oreochromus mossambichus*	+			+		
Oreochromus niloticus		+		+	+	
F : Eleotridae : *Eleotris spp.*		+		+		
Bostrychus sinensis		+		+		
F : Gobiidae : *Glossogobius spp.*		+		+		
Oligolepis spp.		+		+		
F : Nandidae : *Pristolepis fasciata*		+		+		
F : Anabantidae : *Anabas testudineus*	+			+		
F : Helostomatidae : *Helostoma temmincki*		+		+		
F : Belontiidae : *Trichogaster tricopterus*	+			+		
Trichogaster microlepis	+			+		
Trichopsis vittata	+			+		
Trichopsis pumila	+			+		
F : Tetraponidae : *Tetrapon spp.*		+		+	+	
F : Lutjianidae : *Lutjianus spp.*			+			
F : Gerridae : *Gerres spp.*			+			
F : Sciaenidae : *Otolithes spp.*			+			
F : Centropomidae : *Lates spp.*			+			
Sardinella spp.			+			
F : Scombridae : *Rastrelliger brachysoma*			+			
Scoberomonus spp.			+			
Thunnus spp.			+			
Total species	**18**	**14**	**11**	**31**	**8**	**0**

1* freshwater species found in rainy season
2* species found in beginning of rainy season (brackishwater or freshwater)
3* marine species found in dry season (salt water is dominant)

fields where food is accessible and abundant (Lim 2000).

The migratory behavior of both freshwater and marine fish species is influenced by the season and depends on tide level. During the dry season, which corresponds to the high tide period (conductivity > 22 000 $\mu s.cm^{-1}$), the Prey Nup area is colonized by marine species most of them at juvenile stages while freshwater species migrated up to the river. During the rainy season, when the rainfall can reach up to 3 meters per year, the area is flooded and mainly colonized by freshwater fishes coming from the upstream area.

In the Prey Nup area, natural fish production is highly influenced by annual flooding of the two adjacent rivers and their tributaries, Teuk Sap and Kompong Smach, driven by the southwest monsoon (during early May).

The Fishery

Before the rehabilitation, the annual catch range in rice field fisheries (wild species) was estimated at about 25-50 $kg.ha^{-1}$ (Fisheries Department data 1998). From our results, four main species are actually dominating the actual catch: *Channa striata*, *Clarias* spp., *Notopterus notopterus* and *Anabas testudineus* (Table 3). Recent field studies by Lim (2000; 2001; 2002) of the restored polder showed significant socio-economic potentials in terms of fish production.

Table 3. Eco-physiologic descriptions of the main fish species captured in the floodplain.

Species	Local name (Khmer)	TL_{max} (cm)	Habitat	Feeding Type	Commercial Value
Channa striata	Trey Ptork	40	Strictly freshwater	Ichtyophagous	high
Clarias spp.	Trey Andeng Toun	25	Strictly freshwater	Carnivorous	high
Notopterus notopterus	Trey Slat	35	Strictly freshwater	Carnivorous	high
Anabas testudineus	Trey Kranh	15	Strictly freshwater	Carnivorous	high

Lim (2000; 2001) and Huchon and Kong (2000a) indicated that among the 11 different fishing gears utilized in the area, the most common are gill nets (*Moang*), longlines (*Ronong*), hooklines (*Bankai*) and several kinds of bamboo-made basket traps (*Lob*, *trou* and *kantouy kandor*). They contribute together to about 93% of the annual catch. Based on our observations, however, the monthly catch per gear varies according to the season (Table 4).

Fishing gears such as funnel-shaped basket (*angrout*), Rattan-made basket with side-grips (*chhneang dai*), scoop nets (*chhip*), cast nets (*samnang*) and dragnets

Table 4. Monthly catches in tons per gear in polders 1 to 4 at Prey Nup from October 2000 to September 2001.

Month	Gillnets	Longlines	Hooklines	Trap T1	Trap T2	Trap T3	Total
October	168.56	262.77	187.92	77.77	0.77	4.14	701.93
November	109.43	94.34	103.85	46.98	0.98	2.60	358.18
December	100.19	16.15	89.17	66.94	0.44	6.83	279.72
January	43.09	76.07	26.99	32.22	0.59	5.20	184.16
February	66.34	44.93	19.42	28.97	1.15	0.67	161.48
March	37.38	-	14.72	50.90	1.26	4.03	108.29
April	39.88	-	12.27	36.44	1.10	13.47	103.16
May	53.47	-	55.28	190.73	1.17	0.06	300.71
June	42.46	-	44.06	106.62	0.87	0.14	194.15
July	85.75	61.01	91.06	61.15	1.25	0.46	300.68
August	71.79	85.66	88.12	96.66	0.88	0.26	343.37
September	63.24	168.53	107.00	91.49	0.68	0.32	431.26
Total (tons)	881.58	809.46	839.86	886.87	11.14	38.18	3,467.09

(*uons*) are considered as familial gears that are poorly utilized as their contribution in the capture is quite low (approximately 275 t.yr^{-1}).

Table 5 shows the capture (in tons) from each polder. Catch in polders 1 and 4 are much higher than in polder 2 and 3. During the dry seasons, absence of fishes in the capture is observed. This is due to the migration of fishes outside the area for reproduction. Recruitment of fish stocks occurs during the rainy seasons. Increase of water level due to inflow waters from two connecting rivers at each side of the catchment area allows the migration of fishes into the polders. It should be noticed that the total catch is 3,467 tons.yr^{-1} (630 kg.ha^{-1}.yr^{-1} at the flooded water level 5,500 ha) which has to be regarded as very high. It is estimated that each of these fishing-dependent family captures about 2 kg per day (Lim 2002).

Among the 6,500 families living in the Sihanoukville vicinity, 6,322 of them consider fishing as an additional source of livelihood, aside from agriculture. The increase of the number of fisherman per household depends on the season.

For the 3,467 tons annual catch recorded in studies carried out in 2001, about 1,247 tons were considered for family subsistence whereas the rest are sold (Lim, 2002).

Table 5. Monthly captures (tons per polder) from studies made from October 2000 to September 2001.

Month	Polder 1	Polder 2	Polder 3	Polder 4	Total
October	401	33	121	148	703
November	230	16	32	80	358
December	165	15	40	60	280
January	142	2	14	26	184
February	87	34	9	32	162
March	69	15	7	17	108
April	39	13	-	50	102
May	131	20	-	150	301
June	99	24	-	71	194
July	185	17	-	99	301
August	210	23	12	98	343
September	268	26	61	76	431
Total (tons)	2,026	238	296	907	3,467

From this total catch the estimated biomass is *B* = *Y*/2 = 1.73 tons i.e. 315 $kg.ha^{-1}$ at the average maximum water level in the rice fields (5,500 ha), assuming *Z* = 4 and *F* = *M* = 2.

When fish population have high *P/B* value, such as the one expected here, it is usually assumed that fishing mortality can be higher than M (see Pauly and Moreau 1997). For instance considering a value of *F* = *M**1.5 = 3 results in a potential actual catch calculated at 945 $kg.ha^{-1}.yr^{-1}$ without significant negative effects on fish stocks.

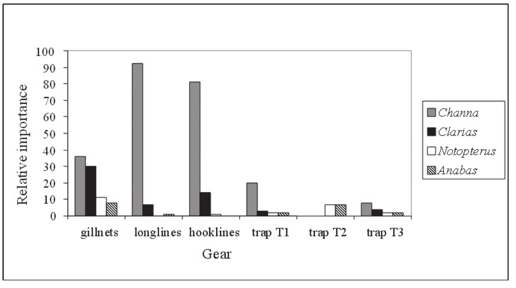

Fig. 2. Relative importance (%) of main species in annual catch per gear.

Discussion and Conclusion

As land access is still a major problem in the country and land-practice of agriculture is held at a private level, a possible strategy for rural livelihood sustainability is a rational use of resources by combining agricultural production with fish production. Since the fisheries, as well as the forests, are still considered as common property resources, capital investments in these resources are minimal as they serve only as complementary livelihood sources. Investment and management in these resources may be, however, a more suitable strategy for alleviating food deficiencies than relying on rice production intensification alone (Guttman 1999; Gum 2000).

The fisheries serve both subsistence and commercial scales. Although a large portion of the catch is usually sold, a considerable proportion (about 40%) is also consumed within the fishing communities. In 1996, the per capita consumption of fish-dependent communities was estimated at 75.6 $kg.yr^{-1}$. This shows that, apart from rice, fish and other aquatic products contribute significantly to Cambodia's food security (Ahmed et al. 1999).

The development and sustainable management of the fisheries is crucial as almost 60% of Cambodia's estimated population has substantial access to fishing grounds since most households are land-based, especially the households situated near the water bodies, and depend on the fisheries as an additional source of livelihood aside from agriculture (Guttman 1999; Gum 2000).

In the Svay Rieng province, the average fish production can reach up to 80 $kg.ha^{-1}.yr^{-1}$ and the production from rice-aquaculture installations is therefore about 40% higher than obtained from a simple rice-cultured field (Guttman 1999).

Fish species captured are usually wild fish entering rice fields during the flooding period without fish management inputs. Predominant species are usually predators such as snakehead (*Channa strata*) and walking catfish (*Clarias batrachus*) and other air-breathers (e.g., climbing perch *Anabas testudineus*). The production from this capture fishery has never been investigated. Unsubstantiated claims, however, indicate that past yields were higher than current ones. The reason may be the decline of wild stocks which is associated with agricultural pollution, as well as waste and water management projects which have impeded natural fish migration. Fish production in a rain-fed closed-water dike, comprising introduced fish species, can range from 30 to 900 $kg.ha^{-1}$ (Feroduk at al. 1992).

For the villagers of Sihanoukville, the opportunity-cost of fishing is low due to the abundance of species captured with high turnover rates. In the Prey Nup polders, any individual is free to harvest as many fish as possible provided that fishermen use authorized fishing equipments.

Based on our estimations, the current fish production appears to be relatively high and the socio-economic potential is significant, especially in providing substantial resources to local communities. Increased access to common properties, especially widening the access to fisheries and water resources, can improve the plight of the poor families with access to land as it provides livelihood source when agricultural harvest is low. It can be the main source of livelihood for those without access to agricultural land. Recent studies by Lim (2002) estimated that about 97% of poor families are considered as fishing-dependent households. This may be due to the fact that total revenues gained from the fisheries exceeds the invested capital. This may explain the increase in number of fishery-dependent families in the area. A similar trend has been observed in other fishing lot boundaries that have been reserved for local establishment of community-based fisheries schemes.

A disadvantage may be an overexploitation of fish resources that can lead to species extinction that might eventually limit the socio-economic potential of this activity for the villagers. Illegal fishing has already been noticed in some aquatic ecosystems by the Cambodian Fisheries Department (pers. comm.).

Although the first results obtained here seem promising in terms of developing fish stock production due to its high capacity of sustaining an increase in the actual fishing rate, further investigations should be carried out in order to assess if the stability of the system and the sustainability of it's resources can be warranted on a long-term basis. Although such open-access fishing practices contribute to increase the annual catches, other factors should be considered such as possible detrimental effects for the fisheries resources of the destruction of habitats (i.e. development and construction of dams) which can lead to declines in fish production and growth (Van Zalinge et al. 1999). A better comprehension of the trophic state dynamics of the ecosystem and fisheries is required to optimize water and resources utilization (Van Zalinge et al. 1999; Dudgeon et al. 1994; Dugan 1994).

The benefits of Prey Nup polders management schemes, especially with regard to fisheries, are difficult to identify and to measure in monetary terms, whereas the costs are easier to quantify. The risk is to overlook these benefits in the future decision-making process. Short or long-term term profits of improving fisheries through proper management of ecosystem resources and conservation need to be carefully evaluated since any management choice has both biologic and economic implications in terms of costs and benefits (Sensereivorth et al. 1999). Economic sustainability and environmental conservation management schemes, however, are not easy to obtain and posses inevitable trade-offs (Dudgeon et al. 1994; Degan and Leng 1999).

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