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Ministry of Agriculture, Forestry and Fisheries

Department of Fisheries

CAMBODIA
NATURAL RESOURCES EVALUATION

For

World Bank Agriculture Productivity Improvement Project (APIP)

By

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NATURAL RESOURCES EVALUATION IN CAMBODIA

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1. INTRODUCTION

1.1 Geography and Resource Base

Cambodia has a land area of 181,035 km2, about 20% of which is used for agriculture. The country's capital city is Phnom Penh (Table 1.1). International borders are shared with Thailand, Lao and Vietnam. A central plain, drained by the Great Lake and the Mekong and Bassac River systems, contrasts with the Cardamon Mountains in the southeast of the country of Dangrek Mountain in the north along the Thai border. In comparison with its neighbors, Cambodia is a geographically compact country administratively divided in 19 provinces, three of which have relatively short maritime boundaries. The country has a coastline of 435 km and extensive mangrove stands, some of which are relatively undisturbed. The country has widespread forest resources, some of which have important commercial potential.

Table 1.1 Land Use in Cambodia.

Type of Land Cover	Area (km^2)
Forest	112,342
Other vegetation	25,057
Urban areas	45
Paddy fields	26,097
Receding rice fields	293
Upland crops	4,665
Sweden agriculture	1,856
Orchards	188
Plantation	746
Field crops	5,299
Water surfaces	4,111
Barren lands	336
Total	**181,035**

Source: Mekong Secretariat, data acquired during dry season 1992-1993 for UNDP/FAO/ADB Cambodia Agriculture Development Options Review.

The Mekong River is Cambodia's largest river. It runs for 486 km and dominates the hydrology of the country. The river originates in China, passes through Myanmar, Lao, Thailand, Cambodia and Vietnam, before entering the South China Sea. The Mekong River that flows through eastern Cambodia and the Tonle Sap River that originates in the lake of the same name (also known as the Great Lake) in the west cut across the country diagonally. The two rivers meet in Phnom Penh and continue to flow as the Bassac and Mekong Rivers into Vietnam. Various other smaller rivers and streams runoff this main drainage system, and are all important for fishing, transportation and provision of alluvial soils through annual flooding (Ebihana, 1968). Table 1.2 shows the areas of the various inland water systems created by the Mekong River.

Tables 1.2 Area of various types of land and water resources which support fresh water capture.

Type of land and water resource in Cambodia	Area (ha) 1985/87	Area (ha) 1992/93
Permanent water (river, lake, pond, etc.)	567 100	411 100
Flooded forest	795 400	370 700
Flooded secondary forest	28 200	259 800
Flooded grassland	80 800	84 900
Receding and floating ricefields	17 500	29 300
Seasonally flooded crop fields	366 800	529 900
Swamp	12 200	1 400
Total	**1 868 000**	**1 687 100**

Source: Ahmed et al. (1996) based on Cambodia Land Cover Atlas 1985/87-1992/93, Mekong Secretariat, Bangkok

Note: Besides an overall decline, there were significant changes in the area under different types of land and water resources which support fisheries between 1985/87 and 1992/93. The changes in the area under each type of resource can be attributed to loss of primary flooded forests and timing of the survey between the two periods.

The section of Mekong River passing through Cambodia lies within the tropical wet and dry zone. It has a pronounced dry season during the Northern Hemisphere winter, with about 80% of annual rainfall occurring during the southwest monsoon in May-October. The Mekong River's average annual flow at Kratie of 441 km3 is estimated as 93% of the total Mekong run-off discharge into the sea. The discharge at Kratie rages from a minimum of 1250 m3/s to a maximum 66 700 m^3/s.

The Mekong River swells with water during the monsoon reaching a flood discharge of 40,000 m3/s at Phnom Penh. It floods extensive adjustment floodplains for 4-7 months. Its floodwaters reserve the flow of the Tonle Sap River (about 120 km in length), which then has a maximum inflow rate of 1.8 m/s and enters the Great Lake , the largest natural lake in South Asia. When the floods subside, water start flowing out of the Great Lake, reaching a maximum outflow rate of 2 m/s. Under the impact of flowing Mekong River waters the water level in the Great Lake rises by an average 7 m, and its surface increases from, 3,000 km2 to 10,000 km2, and exceptionally to 13,000

km^2. The Great Lake then acts as a natural flood retention basin. By the time the lake water level drops to its minimum surface size, a band 20-30 km wide of inundated forest is left dry. This forest, which of great significance for fish, is now greatly reduced in size through deforestation. The area flooded around Phnom Penh and down to the Vietnamese border is about 7,000 km2.

All Cambodian lies almost entirely in the catchment area of Mekong. Excluding the provinces that mountainous or open to the sea, all provinces produce a substantial amount of fresh water fish. The DOF considers 13 (Kandal, Prey Veng, Takeo, Kompong Chhnang, Pursat Battambang BunTeay Meanchey, Siem Reap, Kompong Thom, Kompong Cham, Kratie and Stung Treng) of these provinces (including Phnom Penh) as important for commercial fresh water fish production and reports the annual catch of freshwater capture fisheries from these provinces.

At one time, most of Cambodia was covered with forest: 71% in the late 1950s and early 1960s. It was reduced to 68% in 1989 (Mekong Secretariat, 1991) and to 60 and 62% in 1991/92 (Thung, 1993; Mekong Secretariat, unpublished data).

The southern highlands and inter-riverine section of the country were covered with dense tropical woods. The northern part had open forests with deciduous trees. The remainder of the country was covered with short grass and savannah. Around the Great Lake and on both sides of the Tonle Sap, Mekong and Bassac Rivers, large areas were covered with freshwater mangroves, known as inundated forests or flooded forests. Most of grasslands and much of the open and inundated forests have been cleared for cultivation over the centuries, contributed into rice or vegetation plots or various domesticated flora (Lemasson 1949;Ebihara, 1968).

1.2 Climates

Cambodia's climate is tropical monsoon with a pronounced wet and dry season. During the wet season from May until early October, rainfall is largely derived from the southwest monsoon drawn from the Indian Ocean. The dry season, from November to April, is associated with the northeast monsoon which, sends drier and cooler air.

1.2.1 Rainfall

Most of Cambodia can be described as sub humid. High annual rainfall has a well expressed seasonally and, together with dry and flood period; it significantly affects fisheries and aquaculture activities in the country. The rise and fall of inland waters determine, inter-alia, resource availability, production, processing and marketing arrangements. The highest average monthly rainfall occurs in September/October at the end of monsoon season (Fig. 1.2). January has the lowest average monthly rainfall level. The wet season accounts for 80% of the annual rainfall. The average annual rainfall varies across the country from between 1,000 to 2,500 mm. Rainfall in the central area

covering the Tonle Sap Basin-Lower Mekong valley averages 1,200 to 1,900 mm annually. East of the Mekong River rainfall is generally between 1,800 and 3,000 mm.

The heaviest rainfall, over 3,000 mm per year, occurs along the coastal lowlands in the west. The lowest rainfall occurs in the rain shadow region of the Elephant Mountains and the Cardamome Mountains. This area is often subject to drought.

Precipitation also varies widely from year to year. From the latter part of July there may be periods without significant rainfall for ten or fifteen days or more at a time, referred to as the 'short dry season' (farmers tend to delay planting on this account to minimize the risk of damage to rice seedlings) (FAO, 1994).

1.2.2 Winds

There are few reliable records of wind speed data for Cambodia. Observations and extrapolation from neighboring Thailand and Vietnam tend to indicate that mean wind speeds are low, in the order of 2 m/s for much of the country. Between February to April there are strong winds for the south-east and these should lead to relatively strong winds in southern Cambodia. In May to July the winds move more to the southwest crossing the Thailand Coast and the Gulf of Siam before entering the south of Cambodia. From August to October generally turbulence in the upper layers leads to unstable conditions across the continent of South East Asia. In November to January the winds moves to the northeast and sometimes lead to a strong steady wind from the north.

Typhoons (tropical cyclones), which often devastate coastal Vietnam, rarely cause damage in Cambodia.

1.2.3 Temperature

Mean monthly temperature range from a minimum of 21-25^{o}C in January to a maximum of 29-33^{0}c in April. There is little spatial variation in temperatures. Temperatures higher than 32^{o}C are common, and just before the start of the rainy season they may rise to higher than 38^{o}C. The temperature rarely falls below 10^{o} C.

Relative humidity range from 65-70% in January and February to 85-90% in August and September. Annual evaporation is of the order of 2,000 to 2,200 mm, being highest in March and April at 200 mm to 240 mm, and lowest in September/October at 120 mm to 150 mm. Evapo-transpiration (EPT) varies from a monthly average of 90 mm, during the rainy season to 120 mm in the dry season.

1.2.4 Climatic Influences on Agricultural/Fisheries Activities

Cambodia is essentially an agricultural economy. Any variation in climate will influence agricultural activities and is likely to impact significantly the country's social life, development and economy.

The climate impacts agriculture/fisheries through the effect of win and rain on the rate of soil erosion. More specifically in Cambodia, agriculture/fisheries is to large extent influenced by the annual cycle inundation and recession which is triggered by the monsoon cycle with rainfall and temperature variations. The Mekong floods are crucial to crop development. Annual flooding of agricultural land has left agricultural soils to the Mekong River fertile, where as soil fertility in the rest of the country is generally poor (Saeki et al, 1959).

The waters of the river carry a heavy load of silt that is deposited during the annual flooding. This silt plays essential role in maintaining the fertility of the soil. Rained lowland rice production, which is concentrated in the flat plains surrounding the Tonle Sap/Great Lake, the Mekong and Bassac rivers, accounts for 85% of the Cambodian rice Production. Crops grown in the dry season must effectively rely entirely on irrigation and retained soil moisture. Periods of drought could easily destroy dry season crops. The lack of water through an extended dry season and period of drought restricts the production of rice crops to one per year, resulting in food shortages for 2-4 months of the year in some areas.

1.3 Population characteristics

As estimated 85-90 percent of the population lives in rural areas. Ethnically the population consist of about 90% Khmer, 5% each of Chinese and Vietnamese and small number of hill tribe (Chams and Burmese). Khmer is the country’s official language. It is spoken by more 95% of the population. French, as a second language is also spoken, mostly by older people. English is more commonly spoken by the younger generation.

Cambodia’s last national census was undertaken in 1962. At that time the population was 5.7 million. In 1998 the population was estimated to be 11.4 million (52% women) (Ahmed et al., 1998), giving a national average population density of 63 persons per km2. Information relating to population distribution through the country is scant. However, there is significant population concentrate around the country's extensive inland water systems and by comparison, relatively light distribution of population in coastal areas. Currently, the country has an estimated rate of growth of 2.8% per annum (World Bank 1998). By Southeast Asian standards this rate of population increase is high, and contrast sharply with the rate for Asia as a whole (1.85% in 1990).

Cambodia’s urban population (10-15% of the total) is principally located in two centers: Phnom Penh and Battambang. Phnom Penh has an estimated population of 1 million and annual rate of growth of 3.5%. Battambang, in the north- west of the

country, has an estimated population of 9 million and a rate of growth of 3.0% per year (World Bank, 1998).

The life expectation rate of both males and females is 50 years. Only 24% of the total population have access to safe drinking water. Infant mortality is high (117 deaths per 1000 live births). The adult literacy rate, at 70%, is also high. Malnutrition is problematic throughout the country and estimated to be 10% in urban areas and 20% in rural areas.

Existing rates of population and urbanization growth are expected to continue over the 1990s, particularly in view of the skewed population distribution (52% of the population is under 18 years of age). Moreover, the resettlement of refugees, in Thai border camps, will exacerbate rates of increase. The refugees, many of whom have been socially and economically dislocated from rural living and who have probably acquired new skills, are likely to seek employment in urban areas Resettlement, the high rate of population growth and established malnutrition levels have important implication for food security, and domestic policies and strategies relating to fisheries production, processing, marketing and distribution.

1.4 Macro-economic setting

Cambodia has fragile economy that has been devastated by more than two decades of internal conflict. In this period of rehabilitation and reconstruction efforts are being made to enhance food production, stimulate a strong and viable private sector, reduce the size and activities of public sector and re-open international trade channels.

In 1998 nominal GDP was Riels 10,750 billion ($US 2,829 million) (Ministry of Finance and Economic, 1999). As agriculture based economy, production in and export from, the agriculture sector dominate economic activities. About 84% of the country's workforce are engaged in agricultural activities (crop, livestock, fisheries and forestry). In 1998 the agriculture sector contributed 45-47% to GDP while the other sectors, industry and services, contributed 16% and 37%, respectively.

Within the agriculture sector the fisheries sub-sector is relatively small contributing, about 5-7% of GDP. Reliable estimates of the number of family units dependent on fishing as a principal source of income are not available.

Since the early 1980s Cambodia has been moving incrementally from a planned economy to market economy, and in recent years, particularly since 1989, the process has gained momentum. The benefits of this economic reform have been evident in the agricultural sector. Nevertheless, significant structural adjustment is still required to carry the process forward. This includes fundamental reorientation in production and distribution processes. It will also involve major adjustment in the public sector as its role and functions are reduced and modified to cater for a changed political and economic environment.

High rate of inflation, before 1998 national election, have made economic management in Cambodia difficult. It has discouraged longer-term investment, fostered

speculation in urban development, and substantially eroded the purchasing power of person on fixed incomes. Public servants in particular have been hard hit.

2. WATER RESOURCES

2.1 Surface water Resources

Around 86% of Cambodia lies within the catchment of the Mekong River. In terms of annual discharge the Mekong River is the tenth largest in the world (457,000 million m^3). The drainage basin covers 795,000 km^3. The average annual discharge entering Cambodia is more than 300 million m^3 and it is estimated that with the contributions of the downstream tributaries, some 500 million m^3 discharges to the China sea annually (FAO,1994). The annual rise of the Mekong River, due to the melting snow in the northern spring, influences a significant part of the country through the deposit of silt on the alluvial floodplain.

Cambodia's other great water resource is the Tonle Sap Lake which by the end of the rainy season (September-October) has an area of 10,500 km^3, and a water level of around 4m (FAO, 1994).

2.2 Groundwater Water Resources

Since there has not been a comprehensive national investigation of the ground water resources to date there is insufficient information, knowledge and understanding of this national resources. Use of the ground water for irrigation is generally limited to small scale aquaculture, vegetable and fruit gardens, mostly in the dry season (FAO, 1994). The quality of the groundwater is generally satisfactory, although high iron concentrations and increased salinity levels has been encountered in many provinces, such as Svay Rieng, Prey Veng, Kandal, Banteay Meanchey, Battambang and Kompong Speu.

3. BIODIVERSITY

The term biological diversity or 'biodiversity' refers to the total wealth of life found on earth. It encompasses the entire variety of animals, plants and microorganisms, as well as the ecosystems and ecological processes to which they belong. Biological diversity is usually reconized as having three distinct levels: genetic diversity, species diversity, and ecosystem diversity.

Cambodia falls within the Indo-Malayan realm along with much of Laos, Vietnam and eastern Thailand. However, its importance for biodiversity is possibly greater than that of neighboring countries on account of the relative abundance of natural habitats,

particularly in the case of lowland forest and wetland formations which have been dramatically modified elsewhere.
Cambodia is fortunate to have produced a substantial number of descriptive studies on its biodiversity which were carried out before the war. In addition, the recent attempts to undertake mapping from satellite data (Mekong Secretariat 1991, 1992, UNDP/FAO, 1994) provide a more up to date analysis of the extent of forest cover. However, whilst these studies enable description of the habitats, descriptive accounts for areas above 1100 meters elevation and for wild animals appear never to have been produced.

3.1 Flora and Fauna

A wide range of descriptive studies on the flora and some aspects of the fauna were undertaken in Cambodia earlier this century. These include extensive work on nature of the freshwater ecosystems and associated fish, the development and partial review of Cambodia's flora and limited studies on selected species of wildlife.

It is believed that Cambodia features approximately 120 mammal species, 600 birds and an unknown number of reptiles, amphibians and animal groups. Over 2300species of vascular plaint have been described for Cambodia of which at least 25 percent are regularly used by rural communities for medicinal or other purposes. However many more remain to be described. A more detailed account of the diversity of plant and animal species in Cambodia is currently the subject of an IUCN project with the Ministry for Environment.

3.1.1 Flora

Cambodia possesses a diverse flora with some areas featuring numerous endemic species (Dy Phon, 1990). Five main vegetation types are to be recognised (Wharton 1968). These are humid forest, sub-humid forest, savannah forest, open savannash forest and allied grasslands, and hydrophytic communities.

The forest vegetation of Cambodia is variously dominated by the families Dipterocarpaceae, Leguminosae, Lythraceae, Fagaceae and in some place of limited extent by pinaceae or Podocarpaceae. Bamboos also occur frequently. The flora of lower altitudes is typical of the Indochinese floristic region (and so contrasts with that of the Chinese, Indo-Burman or Indo-Malayan regions) whilst that of the higher altitudes shares affinity with those of the Indo-Malayan region.

The Cambodian flora also features a number of rare and endangered tree species such as blackwood, burmese ebony and siamese rosewood. Teak (Tectona grandis) belongs to the Indo-Burman flora and does not naturally occur in Cambodia though some plantations have been established in the past (Dry Phon1970).

3.1.2 Fauna

The relatively large extent and diversity of forest cover maintains a diversity and abundance of wildlife. This fauna features a wide array of animals including carnivores, primates, bears, elephants, rhinoceros, rodents, pangolins, bats, deer and native cattle. The vast wetlands feature large numbers of water birds. Most of the species that occur in the lower Mekong basin are likely to occur in Cambodia. This includes a number of species that have declined in abundance or even become extinct in some neighboring countries. Cambodia forests have not been comprehensively surveyed for fauna so even species not yet recorded in Cambodia such as the Douc Langur (Pygathrix nemaeus) may later be found.

3.2 Freshwater wetlands

The physiography and unique hydrology of Cambodia combine to form a substantial rang of aquatic habitats which support a great diversity of fish and a number of other freshwater animals, The major habitats are as follows:

(i) River – the range of habitats include headwater and tributary streams, the extensive meandering plains tracts which feature sandy gravel bars, deep pools up to 100meters deep and several kilometers long and particularly north of the Kratie, numerous rapids. Brackish water develops seasonally in the Mekong delta.

(ii) Natural lakes and swamps – In addition to the renowned Great Lake innumerable small lake occur along the tracts of the Mekong and other rivers. These are subject to annual flooding. Although many of these may become dry in the hot season some retain water all year around.

The freshwater wetlands are the heart-lands of Cambodia society. Though they constitute a minority of the land area they provide home and sustenance to the vast majority of Cambodia whose agricultural tradition (rice and fish production) revolve around the annual flooding of these areas. In the 1960's the average annual per capita consumption of fish by Cambodians (25kg) was the highest in the region and constituted 75 percent of the animals protein in the diet (Mekong Secretariat, 1989). these water support a tremendously high diversity of fish and are legendary for their high productivity with harvest exceeding 100,000 tonnes per annum for several decades. On a per hectare basis this was nearly ten times more productive than the north Atlantic Sea fishery (Dennis 1986). The high productive capacity of these water is associated with allochthonous inputs of nutrient derived from terrestrial Production (Pantulu 1986).

Information relative to the wetland of Cambodia is compiled in the directory of Asian Wetlands (Scott, 1989). The wetlands presented in this Directory were selected on the basis of the criteria developed for the identification of wetlands of international importance and defined in the Ramsar Convention.

The Directory recognises 36,500 sq. km of wetlands of international importance in Cambodia. This figure represents 20.2% of the country's total area and 5% of Asia's total area of wetlands of international importance.

The wetlands of international importance in Cambodia can be divided into 4 areas. The descriptions below are adapted from Scott, 1989.

(i) The Mekong River and its floodplain

As the Mekong River flows between the Laos border and Phnom Penh it divides into channels at several locations creating large islands and sand banks. The river forms a fluviatile lowland landscape with high natural levees, broad floodplains and extensive backwater swamps, many of which remain flooded throughout the dry season. The Mekong Delta begins downstream of Kompong Cham and extends into Vietnam. It is a vast fertile plain covering 49,520sq km, of which 16,000sq km is situated in Cambodia. Below Phnom Penh the Mekong Delta is formed by the Mekong River and the Bassac River.

The Mekong exhibits pronounced seasonal variation in flow. Ware levels are the lowest in April and May and highest in September or October. By the end of April many water bodies are isolated and the smaller tributaries tend to dry out. with the start of the monsoon rains in late May the river starts to rise and attains its maximum in September or October.

(ii) The Great Lake and the Tonle Sap floodplain

At low water level the great Lake is about 120 km long and up to 35 km wide. The Great
Lake is surrounded by a broad belt of freshwater swamp forest, generally some 20-30 km wide but extending up to 65 km in the province of Battambang. This forest contains numerous small rivers and streams, and innumerable lakes and ponds. These forests occur naturally around the Great Lake and along the Mekong and Tonle Sap rivers. Associated with these forests is 1.2 million hectares grasslands and other swamp areas susceptible to flooding Mekong Secretariat 1991). The flooded forest is in turn surrounded by a broad belt of rice paddies, up to 25 km wide, which border on extensive forest areas.

The flooded forest are dominated by a number of small to medium-sized trees and
numerous shrubs. Important species are Barringtonia acutangula, terminalia chebula, Homalium brevidans, Hydrocarpis anthelmica, Amelia asiatica, cruedia chryshanthe and Hymenocardia wallichir and are traditional source of the nutrients necessary to sustain a large and varied aquatic biota. These forest also feature a range of other wildlife including troupes of elephants (200-300 per troupe), wild buffalo, and deer at certain times (Kol 1987). The current status of these wild animal populations is not known. Notable aquatic fauna are the three species of dolphin mentioned above, otters, fishing cats, freshwater turtles, tortoises, crocodiles, and a great rang of water birds.

The inundated forest is said to have been reduced from 1 million hectares to 614,000
hectares by the late 1960s. According to the Asian wetland Bureau they were further reduced to 564,000 hectares during the 1980s. FAO (1991) estimates them to cover only 460,000 hectares in 1990, while the Mekong Secretariat (1991) maps 361,700 hectares of flooded forest and 157,200 hectares of degraded forest and associated vegetation types

(iii) The Stung Sen

The upper reaches of the stung Sen and its tributaries are bordered by seasonally flooded
marshes and grasslands. the savannah grasslands with patches of mixed deciduous forest and dry dipterocarp forest provide excellent haritart for some large mammals.

(iv) The Coastal Wetlands

Aside from the wetlands of international importance presented in the Directory, Cambodia has a numerous other wetlands, notably numerous streams, rivers, ponds as well as extensive rice paddies. It is estimated that over 30% of the country 's area is wetlands (Nasaruddin, et al., 1993).

3.2.1 Freshwater Fish

The Mekong fisheries are supported by detritus. Pantulu (1986) notes that the silt is nutrient deficient and that it is likely that production is sustained by organic matter from terrestrial and aquatic plaints. Detritus produced upon decomposition is utilised directory by algae, aquatic plants and some fish. Central to the maintenance of these allochthonous systems has been the existence of the extensive and singular 'flooded forests'.

Over 850 species of fish have been recorded in the lower Mekong river and the Great Lake. However many are uncommon and little is known of several hundred species. More than 300 have been recorded in Cambodia of which 215 species are known from the Tonle Sap lake.
Bardach (1959) considers there to be 18 principal commercial species but notes another 36 species as being of some economic significance. these fish occupy a variety of niches including planktivory, detritivory, predators and opportunists. A range of other adoptions are also evident and enable the recognition of two ecologically complementary groups-white fish and black fish. In addition the term Trey Changva is used to describe numerous species of small fast growing species.

The white fish require water of high oxygen content and lower pH fluctuations than the black fish. white fish migrate annually to the Great Lake and floodplain areas from the mainstream and tributaries with the rise of the Mekong Floodwaters. Pantulu (1986b) details the dry season fish fauna of the plains tracts as being composed of the

following 'white'fish: carp (Cyprinidae-54%) , catfish (Siluridae, Claridae, Schilbeidae, Bargridae, Sisoridae and Akysidae-19%) and murrels (Chanidae, Ophiocephalidae-8%) families. The remaining 19% belong to the featherback (Notopteridae), herring (Clupeidae) and climbing perch (Anabatidae) families. Many of these breed within the mainstream environments.

The black fish are 'permanent residents'of the lake such as murrels, anabantids, catfish (Claria,Saccobranchus), spiny eels and Oxyeleotris. They are able to utilized atmospheric oxygen using accessory respiratory structures such as arborescent structures attached to gill arches, richly vascutarized cylindrical tubes or large supra-branchial cavities lined with convoluted vascular epithelia. Many are capable of overland travel and can thereby avoid inhospitable oxygen poor environments.

The patterns of migration and habitat utilisation by fish also depend upon the development and ebb of the flood. With the ebb of the floodwaters White fish leave the flooded forests for the open waters of the lake, mainstream or tributary channels. Many of the carps simply spawn in the proximal inundation zone and quickly move out with receding waters. Others such as tributary catfish undergo considerable lateral migration across floodplains from tributaries. Some mainstream fish spawn in the mainstream and the eggs and fry are carried into the floodplains where further development and growth occur. *Black fish* remain in peripheral forests and similar flooded

areas until the dry season advances whereupon they attempt to move back to open waters. Thus, the nature of the development of the flood in any one year had a critical impact upon the success of fish breeding. Variability in the flood regime from year to year is likely to contribute to the maintenance of the high fish diversity .

3.3 Coastal Ecosystems

The Cambodian coastline constitutes 435 km of some of the least populated areas in all of tropical Asia (Hozumi *et al.* 1969, Collins *et al.* 1991). The coastal region feature a number of closely integrated environments, viz.:

(i) Coastal watershed forests,

(ii) Mangrove and rear mangrove forests, and

(iii) Near coastal marine waters.

These three elements of a coastal ecosystem combine to maintain a diversity of biota which is not only significant for the conservation of biological diversity but also of direct economic significance to Cambodia and all other countries situated around the Gulf of Thailand. Having remained in isolation from core areas of human settlement these areas are relatively unexploited.

3.3.1 Coastal Forests

The tropical evergreen forest which occupy most of the southerly fall of the Cardemome and Elephant Ranges are amongst the most extensive and least disturbed in mainland South- east Asia and may by said to 'harvest' water from the sea particularly during the southwest monsoon. The annual rainfall which varies between 2000 and over 4000 mm is the highest in Cambodia. These forest, located in the catchments of the Meteok, Kuot, Russei Chrum, Kep, Sala Muntun , Trapeang Rung, Piphot, Sre Umbel, and Veal Ring rivers have long been important in the protection of the soil and the regulation of the flow of water and nutrients to the near coastal waters.

3.3.2 Mangrove and Rear Mangrove Forest

These two forest types together separate land from sea. The peculiar ecological characteristics of (true) mangroves are well known. These forests occur on sheltered coastal sites where sufficient muddy sediments can accumulate. Situated in the intertidal zone these forests are inundated twice daily by the tides. Mangrove forests are well known for their high biological productivity and their consequent importance to the nutrient budget of adjacent coastal waters. They also protect the shoreline from erosion. Mangrove forests are rare on Cambodia's small coastline.

In Cambodia the trees of these forest are usually arranged in four zones. From seaward to landward edge these are(i) the Avicennia-Sonneratia zon, (ii) the Rhizophora zone, (iii) the Brugieria-Kandelia-Ceriops zone and (iv), the Lumnitzera-Xylocarpus-Bruguiera zone (Vidal 1978). However, zonation patterns may not always be strongly developed. In refference to areas bordering the Bay of Kompong Som, Dy Phon (1970) notes that the regeneration of species differs from place to place according to the physical and chemical properties of the soil.

Mangrove in the Gulf of Thailand have suffered tremendous deterrioration over recent decades. Within Cambodia undistrubed mangroves now occur only in Koh kong (Larsson 1992). The total area of mangrove and rear mangrove combined in Cambodia may be estimated to be less than 60,000 ha. with much of this area in Koh Kong province where an estimated 16,000 of true mangrove occurs. FAO(1970) indicate that the coast of the Bay of Sihanouk Ville features 13,621 ha and 39,066 ha of mangrove and rear mangrove respectively , and that these areas had not been exploited commercially but were utilised by local inhabitants. However the estimate for rear mangroves may be overestimated as Hozumi et al. (1969) indicate that not all *Melaleuca* stands in this area belong to the rear mangroves formation but to another dryland formation. Smaller areas of mangroves and rear mangroves occur on the Kampot coast.

Scott (1989) identified the estuarine systems of Koah Pao and Kep rivers as wetlands of international importance. Both rivers originate in the Cardamone Range and

discharge their flow in the Kaoh Kong Bay. The bay is protected from southwest storms by the large island of Kaoh Kong. Scott (1989) describes the estuarine systems as a 'complex of tidal channels and creeks, low islands. mangrove swamps, tidal mud-flats and coastal lagoons' (see Figure A 4.1).

3.3.3 Marine Zone

The diverse Cambodian coastline possesses sandy, muddy and rocky shores, as well as seagrass flats and coral reefs similar to those off the coasts of the nearby Thai provinces of Chantaburi and Trat. These waters are likely to contain dugong and sea-turtles as well as dolphin which are becoming increasingly rare in other parts of the Gulf. Thai fishermen who used to hunt dugong of the coast of Chantaburi reportedly learnt their skills from Cambodians (Suvaluck Nateekanjanalarp *pers. comm.*).

In comparison to other parts of the Gulf of Thailand the Cambodian waters have been lightly exploited with catches-per-unit effort being reportedly ten times those in the adjacent depleted waters (Csavas 1990). The Gulf's fisheries suffered dramatic over-fishing following the mechanization of Thailand's fishing fleet in the 1960's. This resulted in a loss of biological diversity and the Gulf became dominated by invertebrates (Dennis and Woodsworth 1992, Dr. Suraphon Sudara *pers. comm.*). The importance of Cambodia's marine waters lies not only in their lightly exploited nature but also in their potential role in the rehabilitation of the depleted fish of the entire Gulf.

A survey of the ecology of the Gulf of Thailand and the South China Sea Was carried out by the Naga Expeditions from 1959 to 1961 (Scripps Institution 1962), i.e. at a time when declines in fish catches were first recognised. It identifies coastal waters in general, and those off Cambodia in particular, as zones of high biological productivity and important nurseries for fish breeding in the Gulf. These zones are associated with the seasonal reversal of monsoon winds which assist the movement of nutrients to the surface, tidal mixing, land drainage and mangrove forests. They feature high plankton production. the highest counts of fish larvae (*Rastrelliger* spp., total anchovy larvae and total fish larvae), and sometimes blooms of salps which compete with fish larvae for phytoplankton and other small particulate matter that is the food of larval fish.

The ecology of *Rastrelliger* spp. highlights the importance of the Cambodian coastal waters. In Thailand during the 1950's *Rastrelliger* spp. yielded an annual catch of approximately 10,000 tons, or 60% of Thailand's total marine fish landings. Cambodia, South Viet Nam and Malaysia also utilize *Rastrelliger* during this time. There are two main populations of *Rastrelliger* within the Gulf. These are associated with the two major upwelling zones within the Gulf. One is located in the western portion near Koh Pennan and Koh Samui and enriches the western nearshore portion during the north-east monsoon. The second develops along the Cambodian cost during the transition from the Northeast to the Southwest monsoon, i.e. at a time when run-off from the coastal ranges entering the Gulf is at a maximum. *Rastrelliger* spp. breed in both of these areas according to the season and associated enrichment of the water. Both of these populations move to the upper Gulf region to feed and subsequently return to their breeding grounds in preparation for the next season.

3.3.4 Coastal Ecosystem Management

Cambodia's coastal environments are also of great regional significance. both in ecological and economic terms. They represent not only the least disturbed coastline in Asia but constitute the only site in continental South-east Asia that can be regarded as being appropriate for the establishment of a coastal biosphere reserve. There are currently no such reserves existing in continental tropical Asia.

The forested watersheds feature one of the largest extents of evergreen forest in South-east Asia and are rich in endemic flora and a host of wildlife including a number of endemic, rare and endangered species. Coastal mangrove swamps and the nearshore zones contribute to the diversity and stability of the coastal ecosystems.

Short and medium-term threats to these areas concern the instigation of inappropriate economic development. Coastal watershed and mangrove forests are currently being harvest. Various group aspire to the development of marine culture within mangrove forests, and intervention which has produced widespread ecological damage and economic failure in Thailand. Overfishing in adjacent parts of the Gulf has been disastrous and threatens to be so in Cambodia waters if not properly managed. Indeed neighbouring countries should take an interest to ensure that it does not. Coral reefs, seagrass beds and their attendant fauna should also be protected.

Longer term threats to the diversity and productivity of this ecosystem are the expansion of settlement and industry in the area and the development of mineral deposits in catchment areas. Erosion of coastal watersheds will pose great threat to the marine environment, particularly where mangrove areas have been degraded. An integrated management plan, first attending to the threats to mangrove forest, is required.

Cambodia has a great potential to conserve and develop its forest, wetland and coastal resource in a sustainable manner. In order to do so a full account of sensitive, fragile and critical species of habitats needs to be developed and integrated with the needs of institutional building and the development of protected areas. This is currently being addressed by IUCN through (i) the preparation of a National Biodiversity Prospectus describing Cambodia's biodiversity and identifying priorities for management and institutional strengthening and (ii) work of developing a strategy for the implementation of a National Protected Areas Systems Plan.

4. FISHERY STATUS AND RESOURCES

4.1 Past, present and projected fisheries production trends

At notable feature of the fisheries sector is the high degree of utilization of production (approaching 100 percent). This is despite the fact that ice and refrigeration (except on industrial vessels in the marine fisheries) is generally not used. Fish

harvested is consumed fresh, traditionally processed in various forms, and as feed for cultured fish or other animal (e.g., poultry or pigs).

Fisheries production comes from inland (river, lake and floodplain), marine and aquaculture sources. The inland fisheries are based on capture techniques in the Great Lake, its adjoining river systems and, to a lesser extent, in flood rice fields. Marine fisheries involve the exploitation of resources by coastal fishermen in inshore areas and by foreigners (eg. Thai fishermen) who operate legally, and illegally, in offshore areas. Aquaculture, based on introduced and indigenous species is practiced principally in inland areas of the country, although limited intensive and small-scale marine aquaculture is also undertaken.

The inland capture fisheries have traditionally been Cambodia's most important fishery in production and value terms and between 1982 and 1998 this dominance was apparent (Table 4.1). Ranked second over the same period was marine production and aquaculture production in third place. Between 1982 and 1998 total commercial production increased at an annual average rate of growth of 4.6%, inland fisheries production by an annual average of 0.9%, and marine fisheries production by an impressive annual average rate of 56.9%. Aquaculture production between 1984 and 1998 increased by 51.7%, on average, per year.

Total commercial fisheries production (excluding family and ricefield fisheries) between 1984 and 1990 averaged 81,570 tons; between 1990 and 1998 averaged 111,809 tons per annum (Table 2.1). Over the period of 1984-1990 annum inland production averaged 59,233 tons and accounted for 72.6% of the total and of 1991-1998 averaged 70,151 ton and accounted for 62.3% of the total; marine production averaged 18,645 tons per annum or 22.9% of the total between 1984-1990 and averaged 32,113 tons or 28.7% of the total between 1991-1998. while the annum mean production level for aquaculture was 3,693 tons or 4.5% of the total over the period of 1984-1990 and 9,545 tons or 8.5% over the period of 1991-1998. While Deap et al. (1998) and Ahmed et al. (1998) estimate that the annual inland water catch in the years from 1994 to 1998 is 130,000-180,00 kg (excluding family and ricefield fishery catch). If the family and ricefield fishery catch is included, the total annual inland water catch accounts to 290,000-430,000 tons (Table 4.2)

The production data in Table 4.1 excludes family subsistence fisheries production. As in most countries only estimates of such production are available. The Department of Fisheries estimates that family subsistence production is equivalent to 50% of commercial inland fisheries production. On the basis of this estimate in 1998 subsistence production was 37,850 tons, giving a combined commercial and subsistence inland catch for the year of 113,550 tons. According to the study of JICA (1997), the family fishing product from inland source has been extrapolated by conservative estimation from number of existing family fishing gears and their catch per unit of effort. With 66,000 unit of family fishing gears and 1 kg per unit per day, the annual production of 24,000 MT is added. While Van Zalinge and Tana, (1996) suggest that family subsistence ranges from 17,564 to 32,912 tons. The data from Siem Reap province proves that the rice-field and family fisheries are estimated as higher than 35,000 tons (Thuok et al., 1997). Based on socio-economic survey data extrapolated to

entire country, the family fisheries ranges from 115,000 to 140,000 tons (Ahmed et al., 1998, Deap et al., 1998) (Table 4.2). While the estimates of annual fish catch from ricefields by Ahmed et al. (1998) ranges from 45,000 to 110,000 tons and by Gregory et al. (1997) ranges from 50,000 to 150,000 tons.

Table 4.1 Cambodia's Commercial Fish Production (tons) by Major Fishery, 1982-1998

Year	Total*	Inland	Marine	Aquaculture	Value** (US$ million)	% of GDP	People employed
1982	68,715	65,700	3,015	-	62.2	nd	24,080
1983	68,161	58,717	9,444	-	77.5	nd	25,319
1984	64,424	55,093	7,721	1,610	70.6	nd	26,078
1985	70,578	56,400	11,178	3,000	84.3	nd	33,069
1986	73,628	64,181	7,247	2,200	76.9	nd	31,764
1987	82,071	62,154	17,417	2,500	108.7	nd	42,582
1988	86,800	61,200	21,00	4,600	121.7	nd	42,499
1989	82,088	50,500	26,050	5,538	130.5	nd	43,496
1990	111,400	65,100	39,900	6,400	187.9	9.7	48,697
1991	117,800	74,700	36,400	6,700	165.2	9.2	50,070
1992	111,150	68,900	33,700	8,550	155.1	7.5	73,622
1993	108,900	67,900	33,100	7,900	151.9	7.9	89,120
1994	103,200	65,000	30,000	8,200	140.6	5.9	92,251
1995	112,510	72,500	30,500	9,510	147.6	5.1	104,571
1996	104,310	63,510	31,200	9,600	138.9	4.5	99,836
1997	114,600	73,00	29,800	11,800	140.8	4.6	92,817
1998	122,000	75,700	32,200	14,100	152.1	5.4	111,300
1999 estimation	140,000	85,000	35,000	20,000	171.1	5.2	130,221
2000 projection	155,000	85,000	45,000	25,000	208.7	5.5	144,690
Average 1984-1990	81,570	59,223	18,645	3,693	23.6	9.7	35,287
Percent	100	72.6	22.9	4.5			
Average 1991-2000	118,947	73,121	33,690	12,136	53.0	6.1	
Percent	100	61.4	28.3	10.2			

Source: Cambodian Department of Fisheries (1999); Ministry of Economic and Finance (1999); So Nam and Nao Thuok (1999).

* Excluding subsistence fisheries production (Family fishery and ricefield fishery)
** Price of fish derived from DOF (1999) and personal communication (1999)

Table 4.2 Range of the annual inland water catch in the years from 1994-1998, Cambodia.

Cambodia. Range of the annual inland water	catch in the years from 1994-1998
	Annual catch range (tons)
• Large scale fisheries	
- Fishing lots [1]	30,000 - 60,000
- Dai (bagnets)[2]	15,000 - 20,000
• Middle scale fisheries[3]	85,000- 100,000
• Family fisheries[3]	115,00 - 140,000
• Rice field fisheries[4]	45,000 - 110,000
• **Total**	**290,000- 430,000**

Source: Deap et al. (1998) and Ahmed et al. (1998).

1. Range reflects uncertainty in actual catch levels.
2. Range shows approx. minimum and maximum value in 1994-1998.
3. Based on socio-economic survey data extrapolated to entire country.
4. Approx. 1.8 million ha x likely range of fish yields: 25-62 kg/ha.

In the 1960s the Cambodia's annual marine production was about 40,000 tons. By the early 1980s the production has fallen drastically due to a number of interrelated factors including a decline in urban demand due to the forced depopulation of urban areas, and the loss of private sector production and marketing arrangements. Since 1988 production has grown robustly to reach 32,200 tons in 1998 (Table 4.1). This growth can be attributed to a number of reasons including (1) the availability of external markets, (2) initiatives by the DOF to assist small-scale fishermen to increase their output, and (3) a focus by the administration on generating foreign exchange. Since 1992 marine catch figure included estimated or actual catches by foreign fishermen licensed to operate in the EEZ.

Consistent and increasing growth, principally from cage culture, has characterized aquaculture production. Prior to the commencement of internal conflict, the highest level of aquaculture production (approx. 5,200 tons) was recorded in 1970. This product was mainly high-value cage cultured fish destined for Phnom Penh market. This market collapsed in the mid-1970s with the forced movement of urban populations to rural areas by the Khmer Rouge. It was until 1984 aquaculture production was again recorded. Within a period of five years, aquaculture output in 1989 (5,538 tons exceeded the 1970 production level (Table 4.1). This is exponentially increased from 1984 till 1998. The production is again principally based on cage culture and geared to meet urban demand.

The value of fisheries production is difficult to assess because of a paucity of data on which to base calculations. Lagler (1976) estimated that the value of production in 1970 was between US$ 33.6 million and US$ 43.2 million. This calculation was based on a total subsistence and commercial catch of between 125,000 and 160,000. In 1992 the Mekong Secretary estimated an average' beach' price of US$ 0.3 to US$ 0.4

per kg. On the basis of this price estimate, total subsistence and commercial freshwater production in 1992 would have been valued at between US$ 43.2 million and US$ 58.2 million. According to Fisheries Department data, the value of commercial fisheries and aquaculture production was $US 70.6 million in 1984, $US 187.9 million in 1990; $US 152.1 in 1998 and $US 208.3 in 2000 (projection) (Table 4.1).

Both for preference and out of necessity, fish will remain a primary protein source for population over the 1990s and so on. To meet this demand, the country's fisheries resources, and in particularly inland resources, will continue to be heavily exploited. Over this period inland fisheries production will retain its position of prominence, though proportionally, marine and aquaculture shares should increase.

Modest production increases from inland fishery are anticipated over the 1990s but substantial gain to levels approaching those of the 1960s are not feasible because of the high level of exploitation, poor management and continuing environment degradation. Increases inland production is expected to come from floodplain fisheries, if rehabilitation efforts are successful.

By 2020 commercial inland production (large and medium scale) could reach 130,000-150,000 tons, implying a family fish catch (conventionally set at 50-60% of commercial production) and rice field fisheries of 80-100,000 tons and 50-80,000 tons, respectively. This gives an expected total annual inland production of 260,000-330,000 tons.

Substantial potential for increasing production in the marine fishery exits. Although much of the high-value production will be for export, this fishery is capable of making a large and more important contribution to meeting the country's protein needs, especially in urban areas where marketing and distribution will be easy.

The volume and value of small-scale marine production should be enhanced by provision of shore-based infrastructure, collection services and processing to increase shelf life and to reduce post-harvest loss. The private sector will continue to play a central and pivotal role in the marine fishery, though support for infrastructure development from the public sector will be necessary.

In offshore areas, the mission of FAO fisheries/aquaculture experts suggest that the policy of licensing foreign vessels as means of generating foreign exchange should be continued until Cambodian fishermen or companies (possibly using chartered vessels) have the capacity to exploit offshore resources. However, it is emphasized that the number of foreign, or subsequently domestic, vessels licensed to operate should be within sustainable bounds so as not prejudice future resources use. In licensing vessels for offshore fishing the DOF should ensure that: (1) country derive reasonable and competitive financial returns, (2) as a basis for management and future planning for fleet development, high quality (complete, true and accurate) catch data are provided, and (3) terms and conditions of access are adhered to strictly.

The production trends of the marine fishery over the 1980s and 1990s are difficult to assess because of the large number of variables involved and the options

available to the administration, especially with respect to offshore development. However, by 2010 and 2020, it is possible that the annual production could be 45,000 and 60,000 tons, respectively, though it is likely that a significant proportion (between 40-50% of the production) of high-value species will continue to be exported.

Inland and coastal aquaculture holds promise through the 2000s and 2010s. Small-scale inland pond production for subsistence purposes will continue to require strong extension inputs from the DOF and NGOs. This is because aquaculture has not been traditionally practiced in Cambodia and demonstrated aquaculture failures (which have been as high as 50%) could have long-term adverse impacts on the introduction of small and large-scale culture. By 2010 and 2020 pond culture is not expected to exceed 40,000-65,000 tons and 100,000-150,000 tons per annum, respectively.

Cage culture of high-value fish species for urban markets and export, already established in the Great Lake and around Phnom Penh, should continue to expand over the 2000s and 2010s in line with increases in demand. It is not expected that production will increase beyond 45,000-65,000 tons by 2010 and 125,000-160,000 tons by 2020. Similarly, depending on administrative policy, intensive/semi intensive and extensive marine aquaculture for production of high-value species for export (e.g., shrimp, Artemia, seabass, grouper, etc.) might further expand through foreign private sector initiatives. The DOF and other ministries should closely monitor and regulate this development to ensure that environment degradation of the type of evident in Taiwan and Thailand does not result.

With appropriate and consistent management practices in the inland fishery and with selective and controlled development of the marine fishery and aquaculture, total fisheries production could reach 390,000-560,000 tons by 2010 and 530,000-700,000 tons by 2020 (Table 4.3). However, part of this production would be exported and therefore not be available for domestic consumption. If on the basis of the above discussion, exports totaled 50,000 tons in 2010 and 80,000 tons in 2020 (30,000-40,000 tons from marine fisheries/aquaculture and 20,000-40,000 tons from inland fishery/aquaculture); and 480,000 tons would be available for domestic consumption in 2010 and 630,000 tons in 2020. This level of fish availability implies an annual per capita consumption of 30 kg in 2010 and 2020.

Projected production of 480,000 tons and 630,00 tons available for domestic consumption in 2010 and 2020, respectively, would permit the maintenance of the 1998 annual per capita consumption of 30-kg (Table 4.3). It would not possible to maintain a per capita consumption of 48.5 kg; since projected production would only meet 61% of the total fish requirement.

Largely depending on fish export trends and the extent to which marine species are successfully marketed in the country, it should be possible to maintain current per capita consumption rates over the 2010s and the 2020 (Table 4.3). The DOF believe that new and innovative measures to sustain greater consumption of marine species and the development of pond culture in inland areas as well as rehabilitation and intensification of fish production from Mekong and Bassac floodplain, will be required. Furthermore, given production trends, the status of resources, and population growth, there does

appear to be scope to increase per capita fish consumption by more than marginal rate by 2010 and 2020.

Table 4.3 Past, Present and Projected Requirements at Different Levels of Fish Demand in Cambodia, 1982-2020.

	1982	1990	1998	2000	2010	2020
Population (million)*	6.4	8.5	11.4	12.05	15.9	20.9
Consumption per head (kg)**	-	16	-	-	-	-
Tons (thousands)		136,000				
Consumption per head (kg)***	-	-	30	30	30	30
Tons (thousands)			342,000	361,500	477,000	627,000
Consumption per head (kg)+			48.5	48.5	48.5	48.5
Tons (thousands)			552,900	584,425	771,150	1,013,650

Source: Calculated from * World Bank (1992), ** Mekong Secretariat (1992);
*** Cambodian Department of Fisheries (1999) data; So Nam and Nao Thuok (1999)

Note: A range of 2.5-3.5 percent annual population growth rate is assumed.
- Data not available.
+ Optimal fish protein requirement.

4.2 Inland Capture Fisheries

4.2.1 Resources

The inland capture fisheries in Cambodia are governed completely by the annual cycle of hydrological events, the filling up and draining of the Great Lake by Tonle Sap River, and the annual flooding of plains around and downstream of Phnom Penh. The hydrological cycles determine the longitudinal and lateral migrations and reproduction of most of the fish species. The inland fisheries are unique in a number of respects: they exploit a large density of water bodies (i.e., a natural lake, rivers with their floodplains with a high inherent productivity based on a relatively high organic carbon content). The inundated zone provides the spawning and nursery grounds which supply the bulk of the young fish repopulate most of the water bodies in the basins. The flood transfer suspended and dissolved solids onto the floodplains. Flooding also releases nutrient from the soil, vegetation and inundated organic debris, which in turn support an expansion of fish.

Over 200 fish species inhabit the inland waters of Cambodia most of which are captured and used as food. Most fish species in the Mekong are well adapted to a widely fluctuating water level, and have a wide tolerance for temperature, pH, dissolved oxygen and other environmental parameters. Some species can move over wet land which enhances survival when habitats dry up.

Inland capture fisheries can be subdivided into two main components on basis of their location: the Great Lake/Tonle Sap fishery, and the Mekong/Bassac inundation zone fishery (the latter comprising the area between Kratie and Phnom Penh and the Mekong/Bassac Delta to Vietnamese border).

The Great lake/Tonle Sap account for 60 percent of the total country inland fisheries production. Four provinces, i.e., Siem Reap, Pursat, Kompong Chhnang and Kandal, situated on the Great Lake/Tonle Sap and the Mekong River down to the Vietnamese border, contributed more than 50 percent of the total commercial production from inland fisheries in 1998 (Table 4.4).

The inundated forest of the Great Lake, and to a lesser extent the inundated forest of the Tonle Sap and Mekong rivers, are considered to be essential for maintaining the current level of inland fishery production. About 90 percent of the total freshwater fish stocks follow the inundated spawning pattern and many of fish species breeds in the inundated forests. Some fish, such as Pangasius, breed below the rapids of the Mekong River close to Lao border. They are passively carried downstream as fry and at rising or high water level enter the Great Lake through the Tonle Sap River.

The dominant fish groups of the Great Lake, as they appear in fish catch fish groups of the Great Lake, as they appear in fish catches, are carp (cyprinids) (54%), catfish (19%), murrel (9%), and the other fish. They are grouped by Cambodians into two major categories: white fish (trey sau) and black fish (trey kmao). The white fish are more important economically and include three species of carp and five river catfish. The economically important black fish are two species of murrel and a climbing perch which do not migrate from inundated forest when the water level drops, but survive in small puddles or migrate overland.

The exploitation of capture fisheries is organized at three levels: family fisheries, artisan (small-scale) fishery, and the industrial fishery. By law, each level has to follow certain regulations regarding the type and size of equipment used, the location of fishing, yield, length and width of net or fish traps, size and number of fish hooks etc. The family fishery is not regulated and is permitted year around. Unlike the other types of fisheries it has no closed season between 1 June and 31 September. It is estimated that this fishery captures an equivalent of 50% of the other two fisheries, but its catch does not appear in the statistics of the DOF, which record only commercial catches. The small-scale fishery takes place outside the fishing lots, and in the middle of the Great Lake and rivers. There exist a regulation limiting the catch but control is difficult to enforce and the distinction between family fishery and small-scale fishery is not entirely clear. Fish from small-scale fishery is sold locally, and rarely Phnom Penh markets.

The long tradition of various fisheries has led to refining a large diversity of indigenous and introduced fishing methods to their maximum capacity, resulting in a most efficient fishing system in terms of low level technology. Most recently the commercial fisheries have been transformed by an auction system.

Table 4.4 Inland capture Fisheries: Catch, Boats and CPUE

Year	Total catch (t)	CPUE* (kg)	Province (t) **			No. of boats (all provinces)		
			Siem Reap	Kompong Chhnang	Kandal	Without engine	With engine	Total
1982	65,700	2438.9	8,266	11,589	10,988	22,615	4,323	26,938
1983	58,717	1993.5	8,202	10,724	4,582	24,529	4,925	29,454
1984	55,093	1672.3	7,932	12,332	7,698	27,821	5,124	32,945
1985	56,400	1506.3	8,450	10,220	10,375	31,717	5,726	37,443
1986	64,181	1784.1	9,041	9,660	15,182	30,014	5,959	35,973
1987	62,154	1660.3	9,575	12,100	10,800	30,470	6,959	37,436
1988	61,200	1462.8	8,990	11,012	11,809	32,794	9,045	41,839
1989	50,500	1252.4	8,200	9,900	7,200	32,798	7,523	40,321
1990	65,100	1611.6	9,000	12,000	12,500	33,370	7,024	40,394
1991	74,700	1971.1	9,000	14,000	14,000	32,297	5,601	37,898
1992	68,900	1424.2	9,760	12,500	11,800	40,793	7,595	48,378
1993	67,900	2384.0	8,800	12,200	10,500	21,510	6,972	28,482
1994	65,000	1732.0	8,500	12,200	9,000	29,762	7,766	37,528
1995	72,500	2165.7	8,000	14,417	13,570	27,401	6,075	33,476
1996	63,510	1671.2	7,500	11,700	10,100	30,328	7,675	38,003
1997	73,00	2132.3	7,100	12,100	16,095	23,023	11,213	34,236
1998	75,700	2374.0	7,300	11,900	16,900	20,688	11,199	31,887

Source: Department of Fisheries Data (19982-1999)

Notes: *CPUE is measured as the catch/boat/annum (in kg); ** Provinces with the highest catch;
CPUE means: 1982-1987 period: 1842.5 kg; 1988-1993 period: 1684.3 kg ; 1993-1998 period: 2015 kg..

The industrial fishery takes place in lots, which are auctioned every second year. The lots are located at the periphery of the Great Lake and along the Tonle Sap and Mekong/Bassac rivers down to the Vietnamese border. In 1998 there were 294 lots, of which 141 were for lake-stream fishing, 63 for bag net fishing, 8 for bag net fishing for white lady cap only, 13 for fishing prawns, 31 Pangasius seed fishing, 23 for sandbank fishing, and 15 for sanctuaries. Not all lots have the same catch potential, and for this reason the auction price of lots varies widely. In the Great Lake the average size of a lot is about 15-25 km long and 5-10 km wide. This includes lots in inundated forest. Large scale fishing gear use is allowed but there are certain limits placed by DOF on each lot.

There is a belief in the DOF and elsewhere that there has been a general decline in inland commercial capture fisheries production. However, this is not substantiated by the official (DOF) statistics, which for the period since 1982, show annual commercial catch fluctuations in the vicinity of 60,000-70,000 tons. Of this total about 30% come from the Great Lake, 30% for the Tonle Sap Rive and 40% from all the other rivers and their floodplains. Since 1982 Siem Reap, Kompong Chhnang and Kandal provinces (which take about 50% of the total inland catch) there has been no decline in the overall tonnage of fish captured. The statistics give only details in terms of Grades (1,2 and 3) of fish captured, but no data on fish species. This is shown in Table 4.5.

Table 4.5 Grades of Fish (tons) from Inland Commercial capture Fishery

Fishing period	Grade 1 (%)	Grade 2	Grade 3	Total
1988	10,200 (20.20)	13,200 (26.13)	27,100 (53.66)	50,500
1989	9,600 (14.75)	15,643 (24.03)	39,778 (61.12)	65,081
1991	11,490 (16.67)	18,780 (27.25)	38,611 (56.03)	68,900
1992	11,707 (17.24)	15,910 (23.43)	40,278 (59.31)	67,900
1993	9,385 (14.43)	16,983 (26.12)	38,619 (59.41)	65,000
1994	9,040 (12.46)	14,638 (20.13)	48,818 (67.35)	72,500
1996	9,717 (15.3)	14,824 (23.34)	38,969 (61.35)	63,510
1997	9,262 (12.68)	15,632 (24.41)	48,106 (65.89)	73,000
1998	7,624 (10.07)	15,694 (20.73)	52,382 (69.19)	75,700

Source: Department of Fisheries Data (1982-1999)

Criteria for fish grading are based on the size of fish, and on the species. Grade 1 fish are 1 kg or more in weight, and this includes some 19 species (Appendix 1). Grade 2 are fish of 0.5 kg weight, Grade 3 fish less than 0.5 kg. However, some high quality of small fish may also be included in Grade 1. There is some evidence that valuable species (Grade1) are becoming less abundant, being replaced small (Grade 3) fish which form a great majority of the catch (Table 4.5). The total value of the catch is therefore declining.

The changes in fish catch could be the result of the intensification of fisheries, especially in the Great Lake and the Tonle Sap River, where the use of the most efficient and diverse fishing gears has been applied on a large scale, and the number of fishermen, as indicated by number of registered boats, has been steadily rising (Table 4.4). Intensive fishing was blamed in 1940 (Chevey and Le Poulin 1940) as a possible reason for the decline in fish stocks.

In terms of the tonnage of fish captured per boat, the CPUE has been declining since 1982 (Table 3.1). The average catch for the periods of 1982-1987, 1988-1993, and 1994-1998 of 1,842.5 kg, 1,684.3 kg and 2015 boat per annum respectively shows decline, although the value for 1993 alone still gives are relatively high CPUE of 2,384 kg. The sharp drop in CPUE in 1992, with only 1,424 kg/boat captured, should be seen as a direct result of the sudden rise in the number of fishing boats from 37,898 registered in 1991, to 48,378 in 1992. A significant conclusion from these data is that any further increase in fishing boats can be expected to further decrease the CPUE and to marginalize profits.

The decline in the Grade 1 fish species has stimulated an increase in pen and cage culture. Pen culture is confined to the Great Lake during the dry season when water levels are low. Fish are transferred to floating cage during the rainy season. In the Great Lake, Tonle Sap and Bassac Rivers, fish are also cultured in cages. Some cages built in the form of a boat, are used to transport fish to Phnom Penh for the fresh fish market.

The major indigenous cultured species, such as Pangaius sutchi, P. mcronemus and Channa micropeltes rely on the culture of wild seed. Pangasuis spawns early in the

rainy season in the Mekong River below falls close to the Lao border. Fry drift downstream, where they are captured in large quantities in the Kandal, Kompong Cham and Prey Veng provinces. In 1997/1998 the DOF auctioned 31 lots for Pangasius seed fishing (DOF, 1999). Each year not less than 100 million Pangasius fry are sold to Vietnam (Mekong Secretariat 1992). Most of the seed of Pangasius sutchi, the predominant species cultured in Cambodia, is caught in fishing lots in Tonle sap River and the Great lake during April and May as water recedes from the flooded forests. About 2-3 million 100-125 g fingerlings from these catches are sold to Vietnam. Although there is no evidence that at present such intensive capture of seed has any negative impact on fish production, the situation needs to be closely monitored to prevent any damage from over-exploitation.

4.2.2 Floodplains of the Mekong/Bassac system

Floodplain fisheries on the Mkong and Bassac Rivers have also undergone changes and a decline in catch has been reported. Again, data to support these conclusion are not available. However, the major reasons for this development can be seen in the intensive fishing pressure combined with the more difficult access to floodplain for migrating broodstock and young fish. Most of the natural connections and colmatage canal, constructed in 1920s for regulating water inflow and outflow from floodplain, have been silted over and permit flood water onto floodplains only at very high water levels. This limits the number of broodstock fish and the period of time for their entry onto the floodplain water bodies for breeding.

During their migration through the canal stocks are heavily fished. The suggested measures to remedy this situation include dredging selected canal and some natural connections and protecting brookstock against fishing during their passage through he canals. If successful, such measures should increase the number of fish in the permanent water bodies of the floodplains, which are now overfished.

4.2.3 Fish Stocks Protection

A series of measures have been introduced to protect fish stocks and it is believed that some of them have contributed to stabilized catch. The closed season (Jun - September)_ for the industrial and artisan fishing, and the 15 fish reserves (some of them in Great Lake) have been established for conservation purposes. Fishing for rare species, such as Pangasionodon gigas and catliocarpio siamensis, is prohibited. Measures to prevent illegal fishing methods (electrofishing and explosives) have been less effective, largely due to the shortage of manpower and suitable surveillance boats.

4.2.4 Environmental Degradation

Fish stocks and fisheries are adversely affected by gradual environment degradation. Increasing pressure on land, deforestation of catchments and the

conversion of such lands to agriculture, has increased soil erosion. Mining in catchments of some rivers entering the Great Lake has also increased sediment loads. Inundated forests around the Great Lake has been degraded through exploitation for various purposes. Canals and other connections between rivers and floodplains have silted over. Such environment degradation has had negative impacts on fish stocks. The current situation is further discussed as follows:

4.2.4.1 Siltation

The reported increased in rate of siltation in the great Lake from the 20 mm to 40 mm per year is speeding up aging process of the lake, with the accompanying symptoms: shallowing and narrowing, and increased water temperature during the lowest the lowest water levels. Increased siltation in southeast of lake, much of which is due to the input through Tonle Sap River, in he future may result in separation of a section of the Great Lake and formation of two water bodies instead of one. This would have unforeseeable consequences for the great lake fisheries.

Canal around the lake, dredged in the past to improve the access of fishing boats to landing sites, have silted over and can be used only part of the year when water is high. The connections between the Great Lake and the Tonle Sap River, and junction of the Tonle sap with the Mekong in Phnom Penh, have become shallow because of silt deposition. has reduced the water flow, especially during the lower water levels, impeding not only boat transporting but also possibly reduced fish migration and the drift of juvenile fish. The reduction in the water flow in the Tonle Sap River has been considered even to be the reason for mortality of sand goby in cage. High silt loads in the Mekong River after the first rains also cause mortality, closing the gills of the goby.

In the northwest of the Great Lake it is reported that it has narrowed by 5 km, from 40 km to about 35 km. Some of the increased siltation from soil erosion might have resulted from deforestation of inundated forests in catchments of several smaller rivers entering the lake in the northwest. Mining activities almost certainly aggravate the situation. Continuing degradation of inundated forests around the Great Lake, and conservation of part of them to cultivated lands, is another source of sediments, which can be - especially during the high water level in the lake- easily redeposit by wave action. An increase in fish mortality rates has been observed because of high water temperature during the lowest water level.

Unless better information is available on the significance and impact of siltation of the Great Lake on fish stocks, dredging of the Great Lake is not yet justified from the fisheries point of viewed. Dredging of the junction of the Great Lake/Tonle Sap and of the Quatre Bras, should enhance the exchange of water between the Great Lake and the Mekong River to improve the passive and active fish migrations. However, it should be recognized that the process of dredging could be temporarily detrimental for such fish stocks as it would result in high concentration of suspended solids which might clog gilled the fish and lead to a high mortality of especially fish grown in cages. The shallow canals around the Great Lake need dredging to allow better fishermen access to

landing sites. Similarly, dredging of selected colmatage canals needs to be undertaken to improve the passages for natural restocking of floodplains.

4.2.4.2 Inundated Forests

The exploitation of inundated forests has accelerated, especially since the 1950s. Inundated forests of floodplains of the Great lake and the Mekong River system have been under severe pressure for agricultural land development, for charcoal and firewood production, and also for the use of branches for brush park (fish attraction devices).

Cutting of wood for the construction of fish trap and for smoking fish has also contributed to the forest destruction. Further damage was caused by the systematic removal of forests during hostilities to destroy cover for insurgent. To assess the impact of the destruction of the level of the inundated forests belt on fish population is not easy, as no solid information exists on their significance for individual fish species. However, it is known that fish breed, spawn and feed in these forests during the high water level. Some areas of the degraded forests are now covered by regrowth of different species with a height of up to 4 m. In some areas grazing of cattle may prevent significant regrowth. It may ameliorate the detrimental impact of deforestation on fish populations which may still find such regrowth suitable for breeding and feeding.

Deforested areas, adjacent to water bodies during the low water level season and now covered in rice fields and other agricultural crops, might have significantly impacted the fish species distribution and the ecology and production of individual species. Such areas, when flooded, may release in the water pesticides and herbicides used for crops protection. Also, because of the absence of the trees and bushes, such areas are not attractive for fish breeding, as eggs and juvenile stages are vulnerable to wave action. Some fish species require a substrate for attaching their eggs. Finally, fish feeding on algae and small organisms dwelling on surfaces of tree and bushes, will also be absent for lack of food.

There is an urgent need for rehabilitation of some inundated forests to reestablish habitats which are important breeding/nursery/feeding grounds and refuges for fish. Thus rehabilitation may be achieved through replanting with different tree species on a pilot scale. The regrowth impact on fish should be carefully monitored. The results of the pilot project should be demonstrate the usefulness of replanting for fish, pave the way for implementing such rehabilitation on a large scale, and demonstrate the need for integrated environmental protection in the great Lake and on the Mekong/Bassac floodplains.

4.2.4.3 Damming

The current thinking influencing development strategies makes construction of dams on the mainstream of the Mekong River in the future less and less probable.

Nevertheless, one needs to keep in mind the potential impact of dams on the Mekong River, as already evaluated and assessed in several studies.

Feasibility studies are available for two hydroelectric dam projects at Stung Streng and at Sambur. Both locations are on the mainstream Mekong. A third project, a barrage on the Tonle sap River, proposes to regulate the seasonal reversal in flow between the Great Lake and the Mekong River. Implementation of the Mekong projects, including Pa Mong in Laos just north Cambodia, would decrease the Mekong flood discharge at Phnom Penh from 40,000 m/s to 23,000 m3/s, thereby lowering the high water level at this location by three meters. It would also result in a reduction of the maximum lake surface area by about 3,000 km2.

A reduction in flooded areas would reduce the areas available for fish breeding and feeding. The impact of the proposed Pa Mong dam in Lao has been expressed in terms of losses to Cambodia fisheries as 240 tons reduction in catches from floodplains, and 1,260 tons from the Great lake areas (NEDECO et al., 1988). However, an alternative estimate by ESCAP (1990) equates a 10 percent loss in flooded areas to a 10 percent loss of capture fisheries in Cambodia, which, at the present average levels of 150,000-tons per year from commercial and artisan fisheries and 120,000 tons from family fisheries, would equal about 27,000 tons.

If the dam projects proceed, such fish losses would have to be carefully weighted against the gains from the project. Regulation of the water level in the Great Lake resulting from the implementation of the barrage proposed for the Tonle Sap River would also certainly result in reduced fish production from the lakes and the rivers. All these projects have implications for food security.

4.2.4.4 Endangered Species and Changes in Fauna

Intensification of fisheries has led to reduction in catches of some large size fish species (Fig. 4.1)(Zalinge and Nao Thuok, 1999), such as the Giant catfish (*Pangasionodon gigas*) and *Catlocarpio siamensis*. Both species are now protected in Cambodia and it is required that when caught they will be released unharmed. Implementation of this regulation is difficult to enforce. As there are no records on individual fish species landing it is not known how many of these species are captured and returned to water. Even if species data were collected, it is unlikely that accurate reporting would occur. Successful induced breeding of *Pangasionodon gigas* in Thailand has provided seed for restocking the Thailand section of the Mekong River with this species. However, it is not clear whether the restocked fish has already entered the Mekong section of Cambodia.

4.2.4.5 Reserves and National Parks

The administration pay special attention to fish protection. There are eight fish reserves in the Great Lake (out of a total of 13), with the main purpose of protecting

broodstock. The reserves also probably provide protection for rare lacustrine fish species. Information on fish species composition in the reserves is not available, as no surveys have been undertaken.

With expanding aquaculture, exotic species (Chinese and Indian carp and tilapias) are now being cultured. Surplus production of fry/fingerlings of some exotic fish species (carp) and *Puntius gonionotus* released irregularly into the Tonle Sap River, the Great Lake, some lakes and rivers, and reservoirs from the Aquaculture Research Stations at Chraing Chamres, Bati and Toul Krasaing. Some of the adult fish from the captured in the lakes, rivers, and reservoirs. With high diversity of fish species in the Mekong River system and the Great Lake, the indigenous species can be expected to occur all available niches. Thus the introduced exotic species may only have a marginal impact on the indigenous fish stocks.

The administration proposes to introduce marine reserves and national parks, at locations yet to be determined, to provide habitats sanctuaries. These are especially need for breeding and nursing of many species. Some sites have already been identified by the provincial Fisheries authority in Sihanouk Ville. Selected areas of mangroves also need protection as they have an important role as recruitment and feeding habitats of many fish, shrimp, and mangrove crabs.

4.3 Marine Fisheries

4.3.1 Resources

The Cambodian coastal area including the exclusive economic zone (EEZ) (claimed in January, 1978) is located between latitudes 8 and 12 degrees North and logitudes 101 and 104 degrees East in the Gulf of Thailand. It is a very disadvantagous coastal area in the region, of which the claimed 200 miles EEZ covering about 16,200 sq. miles area (SEAPOL, 1990) is overlaping with claims of other countries in the Gulf of Thailand, especially Thailand and Vietnam.Cambodia coastal zone, located on the South-West, extends for 435 km which covers with 85,100 ha of mangrove forest in two provinces, Koh Kong and Kompot, and 2 cities, Sihanouk Ville and Kep. The total population is about 76,000 living in Koh Kong; 476,000 in Kompot; 120,000 in Sihanouk Ville; and 5,000 in Kep resort city.

Most of natural resources have been decreased dramatically, for instance Table 4.6 shows the change in area of resource cover land in Cambodia from the period of 1989 to 1992/1993.

For he three provinces, the Koh Kong province, adjacent to Thailand, has had the highest catch reported (13,500 tons in 1996, 12,070 tons in 1997 and 10,700 tons in 1998). The Sihanouk Ville and Kompot provinces follow, with catches in both over the last three years around the same level of 17,000-21,000 tons. The high catch in Koh Kong province can bee seen as a direct result of this province being close to Thai

markets, and may also reflect the high number of licensed Thai vessels fishing off-shore waters in this province.

Table 4.6 Status of Vegetation Cover (km²) in Cambodia

Vegetation type	1993[1]	1992[2]	1989[3]
Evergreen forest	47,633	48,192	48,160
Coniferous forest	98	83	98
Deciduous forest	43,012	42,870	60,070
Mixed forest	9,773	9,162	5,289
Secondary forest	5,170	2,572	3,582
Flooded forest	3,707	3,570	3,617
Mixed flooded forest	2,598	2,572	1,572
Mangrove forest	851	837	614
Woodlands	6,563	na	956
Natural shrublands	13,501	na	1,026
Abandoned shrubland	2,528	na	na
Grasslands	24	na	na
Grass savannash	468	na	1,290
Flooded grasslands	849	na	8,229
Abandoned grasslands	1,095	na	na
Marshes	15	na	na
Swamps	14	na	3,791

[1] : Mekong Secretariat, data acquired during dry season 1992-1993 for UNP/FAO/ADB Cambodia Agriculture Development Options Review Project

[2] : Tung, 1993

[3] : Mekong Secretariat, 1991

na : not available

Information on the fisheries resources of the Gulf of Thailand can be gleaned from records available for marine fisheries of Thailand. The Gulf of Thailand is very productive sea due to its shallowness (average 20 m deep, maximum 87 m deep) and the predominance of muddy and muddy-sandy bottom. A great diversity of fish finds these conditions very suitable.

Marine resources of the Gulf of Thailand are divided into two groups: pelagic and demersal. Among the pelagic fish, mackerels, scads, anchovies, sardines, small tunas and pomfrets are commercially important species. Sardines are caught in large quantities but they fetch a low price and must be sold to fishmeal plants. The important demersal fish species are threadfin breams, croakers, big-eyes, lizard fishes, hairtail, flatfishes, snappers, barracudas, groupers, sharks and coger eels. The overall exploitation of demersal fish resources by trawlers in the 1960s resulted in a leveling off in production, particularly in the inner region of the Gulf of Thailand. Subsequently stocks made a gradual recovery. It is believed that future development of fisheries

sector in Thailand will depend on the exploitation of pelagic fish resources (IPFC, 1991).

It is suggested that stocks in Cambodia water are in a stable state, although circumstantial evidence shows that inshore waters are under stress as indicated by the decline of larger fish in the catch and reports by fishermen and the DOF. The Thai fishery is fully exploited and further increase in catch from the Gulf of Thailand will be difficult to achieve. Thailand actively seeks joint ventures, which would allow vessels to fish in countries with underexploited resources. Cambodia is probably the only country in the Gulf with such potential.

Results of the marine fisheries research at Cambodian territorial sea during 1983-1986 conducted by USSR scientists and nationals shows that there were 435 fish species from 97 families in the off-shore (from 20 m deep up to the outer border) with a total stock of 50,000 tons/year. The same source had identified 7 shrimp species and one squid species, and two cuttle fish species. The latter stock was determined to have about 1,300 tons/year.

Many studies in the past on the composition species of the inshore catches found that there were 109 finfish species of which about 20 percent are excluded from species identifies by the research in 1983-1986.

Resulting from the above research, two major groups: Scad and Mackerel, prevailed (more than 10%) the total fish stock. Hongkul, one of the FAO researchers, studied in 1980s on spawning movement and spawning season of migratory species of the Gulf of Thailand. This researchers was also interested in the importance of these two group of fish and indicated its migratory patterns and spawning areas in the Gulf of Thailand.

Obviously, indigenous fisher's knowledge in the region had found the same thing as it was informed by the research. Skill master fishers of purse seiner (Table 4.7) are mostly originated from Koh Kong province where they had been applied this technique since 1958s.

Mackerel and scad seine was a modern fishing practice introduced to Cambodia during the above period then following by fish trawling. Operation of purse seiner at that period was definitely inshore and lasted year round the engine power of not high than 50 Hp. Total number of fishing vessels recorded before 1975 was about few hundred units, then increased up to about 4500 units in 1998 (Fig. 4.2)(Try E., 1999). The rest of fishing vessels were small rowing boast using traditional fishing technique such as fishing weir, stack trap, beach seiner and so on. Shrimp trawler was introduced after the 1970s.

Interestingly, monofilament gill net and large shrimp trawlers were heavily introduced from Thailand during the Khmer Rouge period of 1975-1978 and large shrimp trawler and mackerel purse seiner were reported to have used at the same time. Fishing operation was allowed to do only in Sihanouk Ville bay and selected fisher groups settled in two areas: one is the Thmar Sar/Chamlang Kor, Koh Kong province

and another one is in Tomnup Rolok of Sihanouk Ville. Fish catches were allocated for local consumption and supplying to fish sauce factories in Chamlang Kor (collapse now) and Tonup Rolok ((still operated by the private) while shrimp was used to export to Thailand through Thai middlemen for exchanging fuels, fishing net, medicine (main), rice (sometimes) etc.

Table 4.7 Number of fishing effort of Koh Kong province

Fishing gear	Target resource	Capacity	Number	Fishing ground
Purse seiner Trawler	Mackerel, scad Anchovy Shrimp	<50Hp >50Hp >50Hp <50Hp	8 15 33 257	inshore inshore inshore inshore/off-shore
Drift gill netter	Spanish Mackerel	<5,000m	28	inshore/off-shore
Set gill netter	Mullet Seabass Mackerel Crab	<5,000m	141 18 259 208	inshore/off-shore
Trap Stake trap	Crab Squid <50Hp >50Hp	Rowing boat	87 80 2	inshore
Long liner	Shark/stingray Snapper/grouper	<50Hp	42 10	inshore/off-shore reef areas
Engine boat push netter	Fish/shrimp	<50Hp	34	inshore
Portable push net		Rowing boat	20	inshore
Beach seine	Fish/squid	Rowing boat	6	inshore

Source: Koh Kong Fisheries Office (1997)

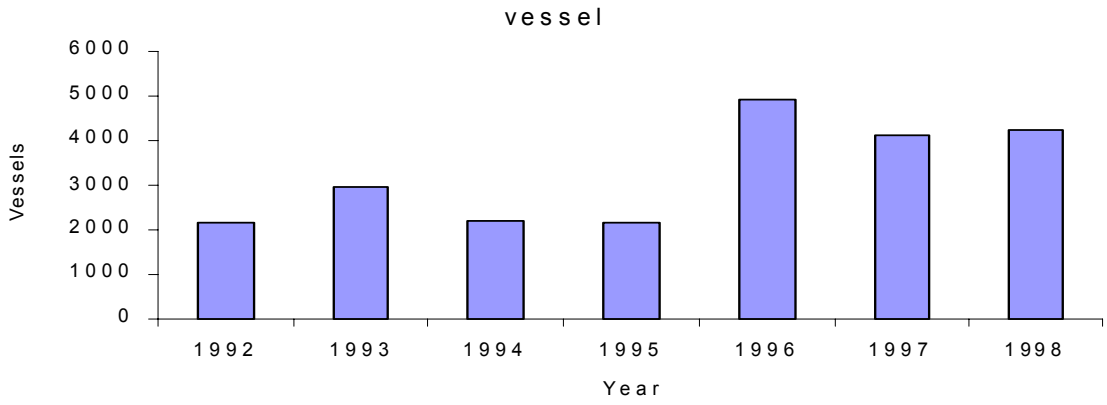

Figure 3.2. Number of fishing vessel used in Cambodia Sea.

The shrimp catch in Koh Kong province, using modern gear has been rapidly developed since 981, duet o economic interest of the species, which lead to the dramatic decrease in almost all the purse operation and traditional fishing, such as fishing weir, stack trap. The target species of Koh Kong's fishers to satisfy the Thai market are shrimp, crab, squid, tuna, spanish, mackerel and stony fish. Surplus of scad, mackerel and other low value fish are also exported to Thailand.

The depletion of marine fisheries resources, especially shrimps stock since 1989 has led to gradual change of shrimp catch practice. The shrimp gill production, which has been recorded since 1990s are not higher than 6,000 tons/year and trends to be decreased if this situation still continue. Table 4.7 and Table 4.8 show the number of fishing efforts currently operated under the jurisdiction of Koh Kong province and catches-effort, while Table 4.1 shows the total marine fish catch production.

The marine fisheries production in Cambodia amounts to 33,7000 tons annually; it is 28 percent of the total fishery production, although the tendency of marine production decreases. According to the National Environment Action Plan (NEAP, 1998), the annual catch may be higher because the figures do not include the harvest of foreign fishing fleets that land their catch out of Cambodia, illegal commercial boats, and subsistence fishers.

It is important to note that production statistics and estimates of the value for fisheries, aquaculture and other uses of natural resources in Cambodia is not corresponding to the real situation. This is especially obvious in the case of fisheries where household surveys and other estimates shows that the real figures might be as much as ten times more than the common used figures.

Catches by shrimp gill net and crab gill net should also be doubled if considering to the number of these efforts that have not registered tax payment.

4.3.2 Crabs

There are about 9 crab species known by local fishermen but only 3 species are economically targeted (Tana, 1997). They are:

- Land hermit crab, Coenobita perlatus;
- Shore crab, Graspus albolineatus (local name Kdam Chuor), an economic species. People used to process dried crab;
- Soldier crab, Mictyris sp.
- Swimmer crab, Charibdis sp. (Pontunidae), an economic species (local name Kdam Ses);
- Swimmer crab, Lissoarcius laevis (pontunidae), an economic species (Kdam Ses);
- Trapezia crab, Tapezia rufopunctata (Trapeziidae);
- Reef crab, Etisus splenditus;

Table 4.8 Catch - Effort

Fishing effort	Catch (tons)
Mackerel purse seine	1,420
Anchovy purse seine	958
Shrimp trawl	1,340 + 5,897 trash fish
Shrimp gill net	1,797
Fish gill net	1,890
Crab gill net	390
Crab trap	210
Squid trap	498
Fish stake trap	210
Hook and line	295
Push net	680
shellfish collector	123
Beach seine net	48

Source: Koh Kong Fisheries Office (1997)

- Reef crab, Zosimus aeneus (Xanthidae); and
- Mangrove mud crab, Scylla serrata, and economic species (local name Kdam Thmar)

The shore crab is available in mangrove forest of Kompot coast in the past but now is drastically depleted due to mangrove degradation in that area. The mangrove mud crab and swimmer crab to be caught by trawling, gill netting and trapping are complained by the local fisher that there are also dwindling especially at the fishing ground near to the mangrove forest due to the same problem and impact of acidified water drained from shrimp farms.

4.3.3 Shrimps

The commercial shrimp species (Penaeus sp.) is found a few more species than that of the research done in 1983-86 or may be the 2 unidentified by former research. They are:
P. silasis, P. longistylus and P. cannaliculatus is also found in Cambodia sea water. The two latter species and also P. latisucatus so called locally as Kong Lay and Che Buoy, respectively, are the deep water species (according to fisher). Metapenaeus species was found only one Metapeaeus intermedius species in the past but now some more species occur in the catch from coastal water trawling, push netting and other small scale traditionally fishing. The very common species of this group are: M. anxchistus, M. lysianassa, M. dobsoni, M. brevicrnis, M. tenipes, M. ensis, M. affinis, M. conjunctus, and M. moyebi.

The shrimp was yielded high of more than 10,000 during the last 10-16 year. Since 1980s the shrimp production was drastically decline due to degradation of its

habitats (mangrove) and over inshore fishing (about 333 large shrimp trawler, >50Hp-350Hp), 200 small shrimp trawler (<50Hp), 900 small gill nets and about100 small and medium push net operate regularly The average catch of this species during the last five years was about 3-4 thousand tons inwhich Penaeus meruiensis is a dominant economic important species. Metapaeus species which shared large part (about 60%) of the total shrimp production now is also claimed to have a drastic decline that may seriously affects the subsistent fisheries of the rural coastal communities.

4.3.4 Shellfish (mollusk)

Molluscs species consisted of bivalves, Gastropods, strombs, vase shells, hard shells, coweries, murex shells, mitre shells and cone shells are very diversified in Cambodia sea of which major species of them are properly identified (Tana, 1997)

4.3.5 Mangrove Forest

The Mekong Remote Sensing Landsat, 1992 shows that the total area of mangrove in Cambodia is 83,600 ha, of which 63,200 ha in Koh Kong, 13,200 ha in Sihanouk Ville and the remaining 7,300 ha in Kompot province.

The Important mangrove forest areas are located in the large estuaries of Peam Krasob/Koh Sralao in Koh Kong province. These areas are reputed to be some of the best pristine mangrove forest left in the region. There are also may other estuaries with mangrove flora such as at Koh Por, Koh Yor, Dong Tong, Anduong Tuk and Sre Ambel but they cover small areas.

The mangrove flora in Peam Krosob/Koh Sralao is reported to have 74 related species from 35 families and 53 genera (Chun Sareth, 1993). A recent study in 1995 conducted by IDRC and the Ministry of Environment identified 17 families and 34 species in the field.

Exploitation of these resources for domestic fuel is traditional but charcoal production for export was taken place around 1920-1930 during the French protectorate with a very appropriated management and conservation program of which zoning area for exploitation, reforestation and protection were well planned. The red mangrove (Rhizophora spp.), so called locally as Kong Kang Nhe/Chmuol, is the most favorable for firewood and charcoal production.

At the present, exploitation of mangrove for all purposes is illegal except a special license issued by the Department of Fisheries. Despite that there was the enforcement operation of both central and provincial fishery surveillance units, the illegal exploitation of mangrove for all purposes still continued and clandestinely intensified which result the present serious degradation of this pristine resource. Other cause of mangrove degradation is officially recorded to have operated on the area of

about 500 ha of the 1,000 ha licensed by the DOF (Wetland International & ICLAM, 1998).

4.3.6 Coral Reefs

Coral reefs can be found rarely around Koh Daung but abundant around Koh Karang in Kompot, Koh Sdach in Koh Kong and many small inshore islands zones. This zone covers on a large and clean seawater area at the inshore which wipes on rocky and several white sandy beaches of the coastline. Almost at all islands, the coral reefs are reportedly to be abundant. This resource is assumed to have threat of the increase of shrimp trawling and push netting operation. The Cambodia coral is similar to those of the coast near by Thai provinces of Chanburi and trat.

Other marine resources such as plankton, sea grass, sea star, sea urchins, jelly fish, sea turtle, dolphin and whale are described in the report on Marine Biology in Cambodia water (Tana T.S., 1997)

4.4 Aquaculture

4.4.1 Inland Aquaculture

4.4.1.1 Cage and Pen Culture

Cage culture system seems to have originated in the Great Lake, presently 77% of the cages are located in the Tonle Sap, Mekong and Bassac Rivers, only 23 % in the lakes itself.. Cage culture system was reportedly introduced a century ago through ethnic Chinese and later became very popular among ethnic Vietnamese. The extent of freshwater aquaculture production by species and systems, ranging from 1984 to 1998, in Cambodia is shown in Table 3.9 and Table 3.10. Cage culture of fish still dominates Cambodian aquaculture since ranging from 90%-80% during 1984-1991 to 80%-70% of aquaculture production during 1992-1998 came from these systems, while the rest was from pond culture (Tana, 1995; Savanary, 1997, DOF, 1999). The production and areas of cage culture increased from 1,449 tons and 0.72 ha in 1984 to 9,870 tons and 4.94 ha in 1998, respectively (Table 3.11). The major cultured species from cage and pen systems *are Pangasius hypophthalmus* (73%) followed by *Channa micropeltes* (21%). Other species produced include *Puntius sp., Clarias batrachus, Oxyeleotris marmorata, Cirrhinus sp., Puntius altus* and *Leptobarbus hoevennii* which fishermen used to stock for a couple of months for fattening during abundant catches and then sell when fish were scarce.

Many of the cages are constructed of bamboo, the cheapest locally available construction materials, although bamboo cages do not last longer than two years. Wooden cages have a longer life span, but their cost is getting prohibitively for smaller fishermen/fish farmers. While square cages of small and medium sizes are common over the country, the most typical cages in Cambodia are the relatively large, boat-shaped ones with the house of the owner/operator built over it. Many of these boat-

shape cages have also pigsties on their desk. Floating households tend to crow together in floating villages along the riverside and used to be towed to the live fish landing place of Phnom Penh when the stock is ready for marketing.

Supply of Inputs: seed supply for cage culture depends on the seasonal wild seed availability in the natural water. Fish seed were collected from fishing lots, bag net (Dai) and other small scale fishing ground in the Great Lake, Tonle Sap, Mekong and Bassac rivers. Stocking densities vary as widely as sizes and shapes of cages. For Pangasius catfish culture, stocking densities range from 20 fish to 50 fish/m3 (4 kg-10kg/m3) (Sovannary, 1997; Nandeesha, 1994), which increases up to 60kg/m3 (FAO, 1993) by the end of the culture period twelve month later, a production of 70-80 kg/m3 is obtained. Snakeheads are generally cultured in smaller cages of less than 1,000 m3, while pangasids are cultured both in small and bigger cages which could be as big as 3,000 m3. With a stocking density of 10-40 kg fish/m3, a production of up to 150 kg/m3 has been obtained in snakehead culture during a culture period of one year. With these stocking densities it is no wonder that fish mortality is rather high, especially during the hottest months (April and May), particularly when cages are crowed together. Mortality is estimated to be around 10% of
the stock over the culture period. Feed is the most important input in cage culture operations in Cambodia, representing more than 70% of total operational costs. In dry season, especially from December to May, the important source of feed is trash fish. There are 20 fish species caught during the open fishing season were used as trash fish to feed cage culture fish (Sovannary, 1997) (Table 4.13). In rainy season (July-December), feed ingredient use is from plant source such rice bran (different qualities), broken rice, morning glory and other aquatic plants and mixed with few amount of trash fish from family fishing, dried waste fish or fish oil. FCR varies among cages in Cambodia according to the feeding strategy adopted of different farmers. Sovannary (1997) found that FCR ranges from 1.9 to 2, based on dry matter of trash fish (29%) and Nandeesha et al. (1997) ranges from 3 to 4.5, based on wet weight of total feed fed.

Pen culture is a technique practiced in some parts of the Great Lake and in the rivers and lakes around the capital. Young fish (primarily Pangasius catfish species) are stocked into bamboo pen at low water level (1-3 m in depth) and are usually marketed as fingerlings/juveniles or transferred to floating cages when water starts to rise. The size of the pens may vary from 500-5,000 m^2 (FAO, 1993); they are smaller in the rivers and bigger in lakes. Fish volume cultures in pens (1984-1990) does not exceed 1,500 tons annually or some 18% of total aquaculture production in 1992 and vary from 20% in 1991 to 25% of total aquaculture production in 1998 (DOF, 1999).

Cage and pen farmers are facing some problems such as the lack of inputs, fish seed, feed, technology, feed formulation and feeding and management of cages; and lack of capital to operate the whole crop cycle.

Table 4.9: Aquaculture Production (tons) in Cambodia, 1984-1998

Province/municipal	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Bantey Meanchey	-	-	-	-	-	-	2	2	10	7	5	5	7	2	20
Battambang	152	6313	350	252	450	800	850	750	1,300	1,000	500	273	470	2,285	1,200
kampot*	-	100	-	1	25	-	21	-	31	30	15	83	43	50	80
Kandal	638	495	600	570	1.020	965	899	937	1,813	750	1.136	1.045	1,245	1,450	2,300
Krung Keb*	-	-	-	-	-	-	-	-	-	-	-	-	2	3	4
Koh Kong*	-	-	-	-	60	60	10	-	70	500	560	740	15	266	1,493
Kompong Cham	28	36	35	80	100	200	336	400	326	357	250	480	420	410	450
Kompong Chhnang	20	180	150	130	450	540	1,212	500	800	605	1,218	1,600	1,710	1,826	1,800
Kompong Speu	-	37	-	5	10	10	-	-	7	10	20	54	29	10	15
Kompong Thom	-	70	28	50	150	238	260	380	980	1,200	1,050	1,010	940	1,550	1,800
Kratie	96	115	125	130	240	130	93	108	107	101	70	124	150	100	105
Phnom Penh	419	740	629	782	1,110	1,050	1,007	1,050	1,193	1,000	1,150	1,103	1,210	1,050	1,285
Prey Veng	134	28	53	40	60	69	50	102	136	98	110	362	385	400	450
Pursat	-	92	80	80	275	300	460	736	550	650	856	1,380	1,450	1,226	1,600
Siem Reap	9	472	150	374	580	1,008	913	1,410	1,143	1,372	1,070	1,050	750	900	1,200
Sihanouk Ville*	28	-	-	-	15	50	57	30	13	15	35	22	35	26	23
Stung Treng	-	-	-	-	-	8	10	-	6	5	5	27	19	15	15
Svay Rieng	14	4	-	5	10	10	-	-	5	50	60	61	90	100	110
Takeo	-	-	-	-	45	100	215	295	60	150	90	81	30	80	100
Total (tons)	1,610	3,000	2,200	2,500	4,600	5,538	6,400	6,700	8,550	7,900	8,200	9,510	9,600	11,709	14,100
Value(US$ million)	1.0	1.8	1.3	1.5	2.8	3.3	3.8	4.8	6.0	11.4	12.1	14.6	13.8	13.6	17.2
Production as % of GDP	nd	nd	nd	nd	nd	nd	0.2	0.3	0.3	0.6	0.5	0.5	0.4	0.5	0.6
People employed	1,293	3,015	2,633	2,807	2,842	3,156	3,979	4,613	8,544	6,667	10,149	11,203	9,600	10,628	12,024

Source: Cambodian Department of Fisheries Data (1999); Nandeesha et al. (1997); So Nam et al. (1996); Ministry of Economy and Finance (1999)
* Coastal Aquaculture

4.4.1.2 Pond Culture

Pond culture of fish is the least developed technique in Cambodia. Its contribution to the total is estimated slightly below 1000 tons/year, or some 10% of the total aquaculture production (1984-1992) (DOF, 1993; FAO, 1993) and some 15-20% of total cultured fish volume in 1993-1998 (DOF, 1999). There were two fish pond culture systems in Cambodia. Intensive fish culture, mainly Pangaius catfish, which contributed less 10% of the total aquaculture production (Table 4.10). This was found around Phnom Penh and Kandal province. There are a number of farmers who have undertaken these activities in smaller ponds ranging from 300-1,500 m2. Seeds collected from the wild are stocked at 4-10 fish/m2 and grown to more than 1 kg over a period of one year. Fish are fed with cooked rice bran during most part of the year, though during glut fishing season, they are fed with trash fish (Table 4.12)). Depending on the management strategies adopted, the production is as high as 30-100 tons/ha/year (Nandeesha, 1994; Nandeesha et al., 1997).

However, low input pond, rice/fish and other integrated fish/animals/vegetable culture techniques, so called extensive/semi-intensive system, of tilapia (*O. niloticus*), silver *barb (P. gonionotus*), pangasius catfish (*P. hypophthalmus*), silver carp (*H. nolitrix*), common *carp (C. carpio),* grass carp (*C. idallus*), big head carp (*Aristichthys nobilis*), catla (*Catla catla*), rohu (*L. rohita*), *mrigal (C. mrigala*), small scale mud carp (*C. micropeltes*), giant barb, (*Catlocarpio siamensis*), walking catfish (*Clarias macrocephalus and batrachus*) and other minor specie (Table 4.10) are promoted through Fisheries Department, Fisheries stations, provincial Fisheries office and various NGOs (i.e. AIT, MRC, PADEK, SAO, APHEDA, ect.,). It contributed about 10% of the total aquaculture production in 1984-1992 and about 15-20% in 1993-1998. With the stocking densities ranging from 2-6 fish/m2, a production of 2-5 tons/ha/8 months has been obtained.

In 1992 only about 12% of the total number of ponds in Cambodia were used for culturing fish (FAO, 1993). Many of them did not hold water due to their permeable soil and the majority of families preferred competing use of water (e.g., watering vegetable, domestic use, etc.) over aquaculture at that time. Moreover, fish seed and professional advice were not readily available, especially in distant provinces.

In 1998, the estimated number of ponds used for fish culture is about 35% of the total number of ponds in the whole country. Total fish production exponentially increased from 1,610 tons in 1984 to 14,100 tons 1998 (Table 4.10)). The number of cages and ponds used for aquaculture increased from 288 (0.72 ha) and 1,297 (36.01 ha) in 1984 to 1,976 (4.94 ha) and 29,704 (568.05 ha) in 1998, respectively (Table 4.10). From 1993 till date activities of aquaculture development in Cambodia is considered to be blooming. National, provincial and various international (NGOs) aquaculture organizations put very strong effort to produce as much family fish production as possible in order to improve food security and generate family income. This indicate that aquaculture is the main source to increase the total fish production and can fill the gap of fish requirement of Cambodian people. Thus there is now a solid basis in the country on which significant expansion of low-input fish culture systems can be achieved.

4.4.1.3 Cultured Species

In line with national preferences and the urban up-market orientation of aquaculture in Cambodia, dominant culture species are carnivorous fishes, like pangasius catfishes, clariid

catfish and introduced Clarias gariepinus (Table 4.11). There are no data available on the share of carnivorous species in the total volume of cultured fish, however the ratio in Cambodia is quite high (60-70% by estimation), as opposed to other developing countries of the region, where carnivores represent only 3% of the total cultured finfish volume (Csavas, 1992), and with respect to world aquaculture production, carnivorous fish contribute only 15% (FAO, 1994).

Another special feature in Cambodia is the high number of cultured indigenous fish, reflecting also the population' s strong predilection for the tradition. Common carp, Chinese carp, Indian carp and tilapia were introduced and bred successfully since one or two decades in Cambodia, but public acceptance of these fish species (at least at urban market) is still low. Some demands for introduced carp species may exist among ethnic Chinese, who contribute about 5% of population, but marketability of exotic species is not good. This, however, may not be the case in rural areas, where public acceptance of tilapia and common carp seem to be improving.

Aquaculture is now apparently at a crossroads, as the demand of urban up-market for high quality of fish is more or less satisfied. Further increase in such demand is not likely to be fast, although declining catches of high quality fish and improving living standards may further boost the need for expanding fish production. On the other hand, the rapidly increasing rural population in areas most suitable for agricultural production is already resulting in a significant drop in the per kaput catch of subsistent fishing. This increases the need to produce cheap fish fort the poorer segments of the population through low-input culture systems. Nutritional requirement in this case will counterbalance traditional preferences. One can see that acceptance of tilapia and common carp is already improving. Some indigenous species, most notably *Puntius*, but also *Trichogaster and Anabas spp*., are suitable for low-input for pond, rice/fish or other integrated fish farming systems and more may be brought under culture once systematic research and development work is done.

4.4.1.4 Supply of Inputs

Seed Supply

As it was already mentioned, Pangasid catfish is the most important group of cultured species, in both cage/pen and pond. Large number of Pangsius seed are caught by bagnets in river north from Phnom Penh or trapped in the fishing lots in the Great Lake as the water recedes from the flooded forest. Bigger fingerlings are also caught by hook and lines in the river south of capital. *Pangasius hypophthalmus* fingerlings are usually stocked in cage/pen and pond in Cambodia, *P. pangasius* seed is exported to Vietnam directly or after being nursed further in cage/pen.

The second most important cultured fish in Cambodia is snakehead. Mainly *Channa micropeltes* is collected on the floodplains by scoopnets in July and August. Similarly, Clariid catfish and *Oxyeleotris marmorata* seed are also caught in a large number. While capturing wild seed still provides the cheapest way of obtaining stocking material for cage/pen and pond culture operations, strong dependence on wild stocks limits optimal species selection, stocking rate, size of the stocking material, etc.

Table 4.10: Freshwater Aquaculture Production (tons) in Cambodia, 1984-1998*

Farming Systems	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1. Cage/Pen:															
■ Number (No.)	288	540	396	500	828	996	1,152	1,072	1,368	1,264	1,312	1,332	1,344	1,652	1,976
■ Areas (ha)	0.72	1.35	0.99	1.25	2.07	2.49	2.88	2.68	3.42	3.16	3.28	3.33	3.36	4.13	4.94
■ Production (t)	1,449	2,700	1,980	2,250	4,180	4,984	5,760	5,360	6,840	6,320	6,560	6,657	6,720	8,260	9,870
2. Pond Culture:															
■ Extensive/Semi-intensive:															
Number (No.)	1,278	2,388	1,722	2,000	3,650	4,394	5,078	10,634	13,567	12,538	11,387	20,311	20,000	24,584	29,377
Areas (ha)	33	53	41	48	70.7	89.1	91.4	251.4	270.2	275.7	215	395.6	390	442.5	528.8
Production (t)	96.6	180	132	150	276	332	384	804	1,026	948	984	1,427	1,440	1,770	2,115
■ Intensive															
Number (No.)	19	36	30	32	38	61	53	181	241	236	250	267	277	270	327
Areas (ha)	3.01	5.75	4.75	5.13	5.75	7.92	8.0	21.75	31.37	30.75	32.5	34.77	36.0	35.5	39.25
Production (t)	64.4	120	88	100	184	221	265	536	684	632	656	951	960	1,180	1,410

* Department of Fisheries data (1984-1999); Personal Communication (1999); Estimation (1999); Tana, 1995

Table 4.11 Freshwater fish production by species and system (tons), 1998+

Species	Cage/Pen	Pond	Total	Value (000$US)
Indigenous species				
Pangasius hypophthalmus (striped catfish)*	5,332	987	6,319	5,055
Pangasius larnaudi (black ear catfish)*	144	423	567	709
*Pangasius conchophilus**	108		108	162
*Pangasius pangasius**	100		100	100
*Pangasius micronemus**	72		72	65
Channa micropeltes (giant snakehead)*	1,969		1,969	3,938
Channa striatus (striped snakehead)*	104		104	156
Cirrhinus auatus (small scale mud carp)*	174		174	261
Clarias batrachus (walking catfish)	nd	52.5	52.5	79
Clarias macrocephalus (gunther walking catfish)		32	32	48
Leptobarbus hoeveni (hoeven's slender carp)*	nd			
Notopterus chitala (spotted featherback)*	nd			
Oxyeleotris marmorata (sand goby)*	nd	21	21	168
Puntioplites proetozysron (smith barb*)	nd			
Puntius altus (red tail tinfoil barb)	nd			
*Puntius gonionotus (*silver barb)		423	423	432
Trichogaster pectoralis (snakeskin gourami)*		32	32	32
Catlocapio siamensis (giant barb)*		11	11	16.5
Introduced species				
Cyprinus carpio (common carp)		212	212	212
Hypophthalmichthys molitrix (silver carp)		225	225	225
Aristichthys nobilis (big head carp)		42	42	42
Ctenopharyngodon idella (grass carp)		2.5	2.5	2.5
Clarias gariepinus (African catfish)		nd		
Labeo rohita (rohu)		nd		
Catla catla (catla)		nd		
Catla mrigala (mrigal)		nd		
Oreochromis niloticus (Nile tilapia)		635	635	635
Oreochromis mosambicus (Java tilapia)		22	22	22

* Seed supply from the wild
\+ Fisheries Department data (1999) and Estimation (1999)

Moreover, some of the most suitable species for low-input pond and rice/fish culture systems are exotic ones, which may not reproduce in the wild or in the pond at all. This was one of the most important constrains of aquaculture development in Cambodia at that time.

In 1980 the first Chinese-type fish hatchery in the country was established with Vietnamese assistance at the Chraing Chamres fisheries station, about 12 km north of Phnom Penh. In 1982, another Chinese hatchery was constructed with the assistance from Japan at Chak Angre fisheries station, also close to Phnom Penh. Combined capacity of the two hatcheries could produce above 4 million fingerling per year, but due to technical, managerial and marketing problems actual peaked in 1990 at 3.5 million and did not exceed 2.7 million in 1992 (Table 4.13). The two hatcheries could produce about 40 % of *Puntius goninotus*, 30% of *Cyprinus carpio*, 20 % of Chinese

carps (*Hypophthalmichthys molitrix, Ctenopharyngodon idella, Aristichthys nobilis) and the rest tilapia, Orechromis niloticus).*

The main purpose of Chak Angre fisheries station is to produce market fish and fish seed. The Chraing Chamres fisheries station also uses several of its ponds for their financially more lucrative market fish production. They also keep broodstock of more than 20 species, including not only the introduced species but also breeders of indigenous ones with potential for aquaculture (Nandeesha, 1991b). Till date the Chraing Chamres only has got 28 indigenous species (DOF, 1999). Most of them are mature. But they do not successfully reproduce those fish in Cambodia due to technical, managerial, capital and water supply constrains, but several most species were induced to breed in captivity in neighboring counties such as Vietnam, Thailand or Laos. These indigenous species include *Puntius gonionotus*, *P. altus, Leptobarbus hoeveni*, *Cirrhinus auratus*, *Oxyeleotris marmoratus*, *Notptoterus chitala*, *Osteochilus microcephalus*, *Probarbus julieni*, *Catlocarpio siamesis, Puntioplites protoczysron*, *Cryptopterus apogon*, *Mystus nemurus*, *Clarias batrachus*, *C. macrocephalus* and all the local *Pangasius species*.

In order to produce and distribute fish seed to distant provinces, in 1990 the government pursued a policy of establishing local fish breeding centers in key provinces to promote aquaculture development. Several NGOs provided assistance to this program, but the process is slow. In 1991-1992, The Bati Fisheries Research and Fish Seed Production station was established with assistance of PADEK (Nandeesha 1991a). Fingerlings and table fish production, training and research conductance on fish biology, breeding, larval rearing, feed and feeding method and nutrition have been going on at this station. In Kandal province SAO established a fish hatchery in 1992-1993 (SAO, 1993). Then various freshwater fishery/aquaculture stations were constructed with the sponsorship of international organizations and Non-Government organizations such as Prasaut fishery station in Svay Rieng province sponsored by EU/PRASAC; Ksoeng fishery station in Takeo by JICE; Kompong Speu fishery station by JICE, Battambang, Pursat and Banteay Meanchey fishery station by CARERE; Siem Reap fishery station by CIDSE/ADRA/CARERE; Kompot fishery station by APHEDA; and Preak Leap and Chamkar Dong by AIT aqua-outreach (DOF, 1999b). The above mentioned fishery stations have been starting the production of fingerlings of exotic species such as tilapia, Chinese carps, common carp, Indian carps and African catfish. Few indigenous species, silver barb*, Clarias macrocephalus* and *batrachus* were also successfully reproduced. Moreover, Bati fisheries research and fish seed production station is experimenting on the reproduction and rearing of *Pangusius hypophthalmus* larvae. Hatching and survival rates of larvae are still very low. The results of the research are not published yet. The station is further planning to continue with this type of research in order to produce as much fingerling of *P. hypophthalmus* as possible to meet the fish seed demand both inside and outside the country. The fourteen fishery/aquaculture stations produced fingerlings up to 5.06 million heads (DOF,1999a) (Table 4.12). In 2000, some 10-15 million fingerlings will produced by the fishery stations.

Feed Supply

The major foods used in cage/pen culture systems are rice bran and trash fish (Table 4.13), while dried trash fish is used in pond culture systems. Rice bran is mainly supplied from the rice mill factory, while the trash fish (third grade fish) captured from the wild was either fresh (in the fishing season) or dried (in off-season). Sun-dried fish heads, the by-products of fermented, were also traditionally used in intensive pond culture systems. With the recent rapid increase of population, however, demand for third grade fish for human nutrition increases at a time, when aquaculture production reached an all-time high. According to Nuov and Nandeesha (1992) to produce one kilogram of cage culture fish, 4 kg of fresh trash fish has to be used as feed during the

Table 3.12 Fingerling production in Cambodia, 1984-1998

Year	Annual Production
1984	148,000
1985	182,000
1986	208,000
1987	559,000
1988	1,174,000
1989	2,983,000
1990	3,500,000
1991	2,406,000
1992	2,700,000
1993	990,000
1994	5,600,000
1995	5,096,000
1996	5,100,000
1997	4,124,000
1998	5,060,000

Source: Fisheries Department data (1999a).

fishing season. In 1992 as much as 8,450 t of fish was produced by aquaculture, out of which not more than 10 % belonged to species not fed with fish. Thus theoretically, 30,000 tons of third grade fish had to be used for feeding fish, or 44% of the total inland fish catch in that year. In 1998 about 20% of the total aquaculture belonged to species not fed with fish.

The same as in several Asian countries, slaughter wastes such as poultry viscera, pig and cattle offal, blood, rumen contents, etc. were used in fish culture. Rapid urbanization provides an increases amount of kitchen wastes (restaurant wastes), which are efficiently used to feed pangasid catfishes through the region.

Like in other tropical countries, rice bran and broken rice are the most important fish feeding ingredient of plant origin and available over the country. The available amount of rice bran is estimated to be 200-300,000 tons annually (Nuov and Nandeesha, 1992), but for this resource there is a strong competition between cultured fish and

livestock, primarily pigs. Presently cultured fish consume well about 15% of the total rice bran volume. Oilseed cakes, important fish feed ingredient in several Asian countries, are not available in significant quantities because there is no commercial oil extraction in Cambodia as yet. During the closed season, when fresh fish is not available and even dried fish and rice bran have been run out, as a last resort pangasid catfishes used to be fed with aquatic vegetation eg., Lemna, Azolla and morning glory. Snakehead, however, do not accept feed of plant origin and thus they stave when fish is not available anymore.

Scarcity of suitable feed ingredients, due to strong competition for them, is certainly the most important constraint of producing more cultured fish in Cambodia. A further problem is the seasonal availability of fresh fish for feeding, which causes a glut in fishing, mainly in December-February, that results in overfishing in animal protein and consequently considerable wastage of this valuable ingredient. During the rest of the year (from June to September, during the close season), fish are fed sparingly, primarily with carbohydrate and fibre-rich feed ingredient of plant origin, or not at all, and this considerably retards their growth.

Small scale aquaculture systems which are compatible with the existing farming systems have been developed using on-farm resources. Wastes of ten types of vegetables grown on pond dike and nine types grown in vegetable plot were used for feeding cultured fish. Aquatic vegetation, wastes from kitchen and slaughter house and wild and cultured earth worm were also used in this semi-intensive fish culture systems. These on-farm feed resources used for cultured fish competed with pig raising. A proper management of the on-farm resources should help to reduce this competition.

4.4.2 Coastal Aquaculture

Cambodia coastal zone, located on the South-West, extends for 435 km which covers with 85,100 ha of mangrove forest in three provinces, Koh Kong, Sihanouk Ville and Kompot (Landsat, 1994).

Coastal aquaculture in Cambodia was negligible before 1988, although there were few traditional extensive shrimp farms in Kompot province. Until one or two decades ago, this commodity was still generally considered as a secondary crop in aquaculture practice. In recent years, because the world demand for shrimp has increased, the shrimp business has become attractive and profitable among agro-business in the local and international markets. The production and value of coastal aquaculture since 1988 is shown in Table 4.14. Since 1989, one modern extensive shrimp farm in Koh Kong was established, but the production recorded was very poor.

In early 1991, the case studies conducted by consultant in the three provinces (Kompot, Koh Kong and Sihanouk Ville) of Cambodia indicated that there were lots of potentials, possibilities and feasibility for shrimp and finfish farming in the coastal zone. There were approx. 10,000-50,000 ha where shrimp farming activities could be operated (DOF, 1992). The status of shrimp/fish farming was evaluated as semi-

intensive culture systems. Most of the shrimp farms located at the coast, on the bank of estuaries or in mangrove forests. The soil is sandy with an average pH of 6.0 (San vanty, 1994). The salinity of the water during the cultured period ranged from 20 to 30 ppt. In semi-intensive culture with providing the paddle wheel aerators, daily water exchanges of 30% of pond/field water and stocking density of 300,000 to 500,000 seed /ha, the production rate of shrimp was 6-9 tons/ha/4 months.

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Besides pond/field culture, the pen/cage culture of shrimp is carried out by Mr. Team who is the only Cambodia farmer engaged in the in pen/cage of P. monodon using 85 x 14 meter areas in Smach Ngam (San vanty, 1994). With 100,000 seeds of P. monodon, after four months of cultured period he has reported that production of about 10 tons of shrimp was harvested from his farm. Total production cost of inputs for construction and operation was about $US 24,000. The harvested shrimp were directly exported to Thailand.

In mid 1991, intensive shrimp farming systems were introduced to Koh Kong province by Thai shrimp farmers and businessmen in the form of a clandestine joint venture with provincial citizen. All inputs for construction and operation of shrimp farms were imported from Thailand. Allegedly, the harvested shrimp were exported to Thailand after paying tax to the customs, and the Cambodian private partners received 5% of the income from the venture. Several small and mid-sized shrimp farms are owned by private Cambodian individuals. The types of shrimp culture system, location and production are shown in Table 4.15.

Intensive shrimp farming in 1994 covered an area of 850 ha with production of 560 tons a year (DOF, 1995). According to consultants from the Department of Fisheries and all concerned ministries (1995), there were lots of potentials for shrimp farming development in Koh Kong where 450.13 ha were under shrimp farming operation and some 2,800 ha were estimated to be potential for shrimp farming. The shrimp yields were reported to be high, up to 7-9 tons/crop for the new staring farms and profit were attracting further investment. A survey by NACA in early 1996 has placed the value of the industry at $US 42 million a year. But due to the disease outbreaks and self-pollution have reduced the culture area to 20%, and estimate of national losses amounted to 28.6 million. As results, the local government and concerned ministries have placed a moratorium on further licensing of shrimp farms. It is unfortunate that other restrictions - (1) shrimp farms must not encroach on mangrove forest, (2)

Table 4.13 Fish Feed Availability and Use Types in Cambodia, 1998

Input sources	Fish feed cage/pen	pond1	pond2	Consumption
Fish species from the wild				
1. *Channa micropeltes* (Juv. trey diep & chhdaur)				**
2. *Cyclocheilichthys enoplos* (trey chhhok)	**	**		**
3. *Hampala dispar* (trey khmann)				**
4. *Puntius gonionotus* (trey chhpin)	**	**		**
5. *Pseudambassi notatus* (trye kanhchanh chras touch)	*	*		
6. *Clupeichthys aesamensis* (trey bandol ampoev)				
7. *Henicorhynchus cryptogon* (trey riel awngkam)	*	*		
8. *Mystus cavasius* (trey kanchos bay)	*	*		
9. *Puntoplites waandersi* (trey chrawkaing)	**	**		**
10. *Cyclocheilichthys lagleri* (trey srawkakdam)	*	*		
11. *Osteochilus waandersi* (trey kros)	*	*		
12. *Thynnichthys thynnoide* (trey linh)	**	**		
13. *Paralaubuca barroni* (trey sleukreusey)	*	*		
14. *Trichogaster microlepis* (trey kawmphleanh phluk)	*	*		
15. *Mystus multriradiatus* (trey kanchos chhnouk)	*	*		**
16. *Henicorhynchus siamensis* (trey riel, trey riel top)	*	*		**
17. *Puntius brevis* (trey awngkat prak)	**	**		**
18. *Xenentodon cancial* (trey phtoung)	**	**		
19. *Botia lecontei* (trey kanchrouk loeung)	*	*		
20. *Coilia lindmani* (trey chunlunh moin)	**	**		
21. *Carnotetraodon lorteti* (trey kompot)	*	*	*	
	**	*	**	**
	**	**	*	**
On-farm resources				
1. Rice bran	**	**	*	*
2. Broken rice	**	**	*	
3. Aquatic vegetation (Lemna, Azolla, morning glory, wolfia, hyacinth,….)	**	**	*	
4. Vegetable (cabbages, sweet potatoes, casava, soya bean, corn, egg plant, banana,…)			*	
5. Kitchen wastes			*	
6. Slaughter house wastes			*	
7. Wild and cultured earth worms		**		
8. Termites				
9. weed fish				
10. Animal manure (pig, cattle,…)				
Restaurant wastes				

Source: Keosovannary (1997); Nandeesha et al. (1997); So Nam et al. (1996).

Note: pond1 = intensive pond culture systems
pond2 = semi-intensive pond culture systems
* mostly used
** occasionally used

Table 4.14 Production of Coastal Aquaculture in Cambodia, 1988-1998.

Species Group	Production and value	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Shrimp	Production (tons)	2	5	3	50	1,500	500	560	731	600	266	197
	Value (000 $US)	8	20	15	250	7,500	3,000	3,360	4,386	4,200	2,128	1,970
Finfish	Production (tons)	4	8	16	9	35	3.5	6.75	17.5	18.5	15	24
	Value (000 $US)	24	48	96	54	210	28	54	140	148	150	240

treatment of wastes from shrimp ponds before discharging to the sea, (3) construction of ponds must be 150 m from the shoreline- are not respected and enforced even through shrimp farmers are aware of negative impact to the environment.

Table 4.15 Shrimp farming Systems in 1993.

Farming Systems	No of Farms	Location	Area (ha)	Species cultured	Production (tons)
traditional/extensive	2	Kompot	20	P. merguensis/ local	5
Modern extensive	2	Koh Kong	10		5
Intensive				P. monodon	
small (<5ha)	6	Koh Kong	23		190
Medium (5-20ha)	15	Koh Kong	164	P. monodon	1,300
Large (>20)	3	Koh Kong	76	P. monodon To be stocked in 1994	

Source: Tana, 1995 and DOF (1995)

Finfish (seabass, grouper and snapper) cage culture was operated mainly in Kompot and Koh Kong province. The production and economic value of marine fish culture is shown in Table 4.15. It collapsed during late July-August in 1993 due to the impact of freshwater runoff during heavy rainfall. Other activities such as oysters and green mussel culture are not significant in term of production and economics.

4.4.3 Crocodile Farming

Crocodile farming had an impressive breakthrough in Cambodia. Based on Thai experience, production of about 30 cm long, one-month juveniles started in 1987/1988 with very good survival rates. The production was drastically increased since 1989, although its market

Apparently collapsed in 1992 when less than 3,700 juveniles were export (Table 4.16). By 1998 production reached 40,700 juveniles, which were exported to Thailand for further raising. As crocodile farming provides high returns against moderate feeding

Table 4.16 Crocodile Juvenile Production (numbers) in Cambodia, 1989-1998

Province	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Banta Meanchey	32	2	32		-	62	-	10	134	70
Battambang	1,300	2,381	1,800	1,752	804	973	1,529	2,828	3,920	7,550
Kandal	-	-	-	-	-	-	-	117	115	100
Kompong Chhnang	925	803	1,620	85	1,500	1,363	1,500	2,140	1,750	1,750
Kompong Thom	115	61	-	-	-	75	-	-	1,165	1,088
Phnom Penh	-	188	163	50	235	235	3,200	816	1,050	1,000
Pursat	-	56	70	-	70	486	599	180	340	464
Siem Reap	2,000	2,126	2,408	1,770	2,200	3,000	7,858	14,020	8,267	28,029
Sihanouk Ville	-	7	7	7	7	6	5	-	130	540
Total	**4,372**	**5,654**	**6,100**	**3,664**	**4,816**	**6,200**	**14,691**	**20,200**	**17,000**	**40,700**

Source: Department of Fisheries Data (1999)

costs, adaptation of technologies for raising market sized individuals and exporting the skins deserves consideration by the private sector.

4.4.4 Fish Disease Outbreak

Cambodia was among the first countries in Southeast Asia affected seriously in the early 1980s by an epizootic fish disease (EUS) that spread across the region from the south to north/northwest. The first reports on a hitherto unidentified disease that affected both natural and cultured fish stocks and caused severe mortality in all major fishing areas in Cambodia were received in 1983/1984 (Tonguthai, 1995). As it turned out, most severely affected species were snakeheads (primarily *Channa striata*) and other air breathing that inhabit marginal habitats over certain period of the year (eg. *Clariid catfishes*, *Trichogaster pectoralis, Anabas testudineus, Heteropneustes fossilis, and Fluta alba*). Several economically important Cyprinid species were also seriously affected (e.g., *Puntius gonionotus*, *Cirrhinus* species and Indian carps). Chinese carp and tilapia species have shown some resistance against the disease (Lilley et al., 1992).

The list of sensitive species includes almost all of the indigenous cultured species (except for economically most important pangasid catfishes, that were only moderately affected). Similarly, most of the floodplain species, that inhabit rice fields and canals and play the most significant role in family fishing, are highly susceptible. High mortality caused by disease outbreaks in subsequent years caused a significant decrease both in the fish catch and cultured volume. Production recovered only by 1986, as fish stocks developed some natural resistance against disease. The EUS (causative agent of which has not yet been satisfactorily established) is still recurring every year in Cambodia, although with diminishing severity, during the dry season and the symptoms disappear with the onset of the rain. According to FAO consultants (1993), the snakeheads harvested from the cage/pen in the Great Lake were showing typical, albeit not severe, EUS ulceration. The EUS was also found on *Channa striata* growing in trap ponds in Svay Rieng province, S.E Cambodia (Racy et al., 1999: unpublished).

5. CONCLUSIONS

Cambodia has rich natural heritage. This heritage has historically been an important element in Cambodia's development. However, like other countries in the region, Cambodia's biodiversity is becoming under threats as the country is being developed. Habitat destruction has already been acknowledged as a serious problem and the impacts of fertilizers and pesticides used for rice and crop cultivations are being investigated.

Exploitation of natural resources (especially wildlife) for domestic and export has reached critical level in Ratanakiri and other parts of Cambodia. Main centers of trade include Phnom Penh, Nak Loeung and Sre Ambil. The current policy of the Government to ban all taking and trading of wildlife and wildlife products is laudable given the lack of reliable population data for most species in Cambodia. However, a more realistic system allowing for the taking and trading of non-endangered species needs to be developed as does an improved system of hunting and border control.

The Government needs to develop a comprehensive framework for utilizing and protecting Cambodia's terrestrial, marine and freshwater flora and fauna. Such a framework would help to ensure that natural resources are utilized in a sustainable fashion and continue to contribute to the development of the Kingdom.

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