Fisheries Productivity and its Contribution to Overall Agricultural Production in the Lower Mekong River Basin

Mohammed Mainuddin, Mac Kirby and Yun Chen

Fisheries Productivity and its Contribution to Overall Agricultural Production in the Lower Mekong River Basin

Mohammed Mainuddin, Mac Kirby and Yun Chen

This report is prepared as part of the Mekong Basin Focal Project of the Challenge Program for Water and Food

CSIRO Land and Water
Black Mountain Laboratories
GPO Box 1666
Canberra, Australia

May 2009

Summary

The Mekong River has one of the most diverse and abundant fisheries in the world. The fisheries are a major factor in the well being and livelihoods of the 60 million people who derive their livelihood from fishery and also depend on fish and other aquatic animals for food security.

Fishery production and value have been the subject of many studies and some data are available from national and international statistical databases. However, none of these offer a reliable, consistent set of data on the spatial and temporal trends, at a similar level of resolution across the basin. Because of the shortcomings in the data, there are major uncertainties in estimates of fisheries production and value in the Lower Mekong Basin. Catch surveys underestimate the production, and consumption based estimates are regarded as more reliable indicators. Nevertheless, a range of values is reported.

We combined official statistics with several consumption bases estimates to examine the spatial and temporal trends in capture fish and aquaculture production and value. The highest estimates of production are from 42 kg/capita/year in Laos to 65 kg/capita/year in Cambodia, the latter figure being comparable to consumption in Japan. Production is dominated by capture fisheries in Cambodia (where it is concentrated around the Tonle Sap and the Mekong), Laos and Thailand. In Vietnam, aquaculture dominates production, and is concentrated around the main rivers in the delta and along the coastal strip.

While there are uncertainties in the data, it appears that production from capture fisheries has not increased greatly to 2005 in all four Lower Mekong countries. In aquaculture, there is a clear, large increase in production in the Mekong delta region of Vietnam since about 2000.

The greatest estimates of value, using the consumption based estimates of production mainly from the capture fisheries, give an annual value of about $3 billion. Other estimates place the overall value somewhat lower. The value is probably not changing greatly with time. Aquaculture in Vietnam is rapidly increasing in value, to match the increase in production, and in 2005 was worth over $1 billion.

The contribution of fisheries sector to overall agricultural (crop, livestock and fisheries) production is small in Laos and Thailand, but larger in Cambodia and Vietnam, and growing in Vietnam.

The demand for fish produce will rise in the future, partly as a result of increasing population in the region and partly as a result of increasing incomes. Over and above this, there may also be a continuing rise in the export of fish products.

The Lower Mekong fisheries face threats to production from changed water availability, quality, barriers to fish migration and overfishing. If the increased demand is to be met, these threats must be managed such that developments do not reduce the production of fish, especially capture fish.

The increasing demand appears unlikely to be met through an increase in production of capture fisheries. The current rapid growth of aquaculture, if it can be maintained, appears capable of meeting the demand. However, there are no quantitative estimates of the limits to growth of this industry, nor whether it will pose risks for the capture fisheries bay taking small fish fry as feed for aquaculture fish. Therefore, whether the current growth of aquaculture can be maintained is unclear. Rice fish farming may also contribute to increased production, but again the impact appears not to have been quantified.

Table of Contents

List of Tables

List of Figures

1 Introduction

The Mekong River basin is one of the most dynamic, productive and diverse river basins in the world. It is home to approximately 65 million inhabitants, most of whom are rural poor with livelihoods directly dependent on the availability of water for the production of food. Agriculture, along with fishing and forestry employs 85% of the people living in the basin, many at subsistence level (Mekong River Commission, 2003). Whilst living standards have generally increased markedly across the basin, there remain significant areas of poverty.

The Mekong River has one of the most diverse and abundant fisheries in the World (Mekong River Commission, 2003). The lower Mekong River system with its extensive associated floodplains and wetlands supports important inland fisheries (Baran et al., 2007). The fisheries are a major factor in the well being and livelihoods of the 60 million people who live in the lower Mekong basin (Mekong River Commission, 2005). Some 40 million people or two thirds of the basin's population are involved in Mekong fisheries, at least part-time or seasonally. Not only do they derive their livelihood from fishery, they also depend on fish and other aquatic animals for food security (Mekong River Commission, 2003). Fish and other aquatic animals are the most important sources of animal protein, and thus a major support to food security, in particular of the rural population in the lower Mekong Basin (van Zalinge et al., 2003).

Fishing is important for the basin economics and productivity analysis, particularly for Cambodia and Vietnam. In Lao PDR, fish is second only to rice for food security and income (Nguyen-Khoa et al., 2005). However, increasing competition on the use of water resources and high population growth in riparian countries has increased pressure on the distribution of these resources and reduced fisheries production (Chong at al., undated).

There are many studies of fisheries of the Mekong. However, precise estimates of the total fishery production are lacking (Rab et al., 2005). There are no studies on fisheries productivity for the whole lower Mekong basin below the country level, none that compare the contribution of this sector to overall agricultural production, and few that give trends (none for the whole of the lower basin). Most of the studies provide aggregated country level information for a season or a year. Few examine to what extent the likely increase in demand for fish in future decades might be met by the fisheries of the basin. Furthermore, many estimates in the literature, such as those reviewed recently by Baran et al. (2007) appear to be for data only up to about 2000, and miss some recent developments in aquaculture production.

Here we analyse the fisheries productivity of the basin both spatially and temporally. We compare its contribution to the overall agricultural production to those of the crop and livestock sectors, and discuss the level of likely future demand and the prospects for the fisheries of the basin meeting the demand.

The report is organized into five sections. Section 1 is this introduction. In Section 2, we review the sources of literature and data including official productions statistics. In Section 3 we discuss the information on fish production and consumption, and the

spatial and temporal trends. In Section 4 we review future demand, and the threats and opportunities to fish production. Section 5 provides conclusions.

1.1 A note on definitions – production, productivity and the gross value of production

Production of fish can sometimes mean biological production, meaning the total biomass of fish and other aquatic animals, but often refers to the yield and indicating the amount of fish removed from a fishery by fishing (Hortle and Bush, 2003). Here we use production in the latter sense, to mean the amount of fish and other aquatic animals removed from a fishery.

Productivity, in general terms, is a ratio between a unit of output and a unit of input. The most encompassing measure of productivity used by economists is total factor productivity, which is defined as the value of all outputs divided by the value of all inputs. However, partial factor productivity is more widely used by economists and non-economists alike. Partial factor productivity is relatively easy to measure and is commonly used to measure the return to scarce or limited resources, such as land or labour (Barker *et al.* 2003).

In case of river fisheries, the total catch is the output which is in principle is well defined and measurable. But there is no defined or measurable input. Production from river fisheries is influenced by a number of parameters of which the most important are water level, duration of the flood, timing of the flood, and regulation of flooding, characteristics of the flooded zone, migration routes, and dry season refuges (Welcomme, 1985; Baran and Cain, 2001). For aquaculture, the input such as water, feed, land and labour are well defined and can be estimated. However, due to lack of data we are unable to estimate the water requirements and other inputs even for aquaculture production.

In this study, we define the fisheries productivity as production and gross value of production per capita. Gross value of production (GVP) can be defined as:

GVP ($) = Production of fisheries (tonne) x Landing price of fisheries ($/tonne) (1)

Fisheries comprises of both inland capture fisheries and aquaculture. We have estimated GVP of both capture river fisheries and aquaculture. All economic data are given in the report in US dollars.

Generally, three domains can be distinguished where benefits associated with river fisheries are accrued, viz., economic, social and ecological benefits (Cowx et al., 2003). Total economic value of river fisheries can be divided into direct use value and non-use/preservation value (Cowx et al., 2003). In this study, we consider only the direct use values of fisheries.

2 Data Sources

Estimates of fish production in the countries of the Lower Mekong Basin are found in statistical databases and in various reports and papers. The former give production statistics and often economic information. In the case of Cambodia and Vietnam, these also give a provincial breakdown of the data. The papers and reports, particularly the more recent ones, tend to use different methods of estimation, and give different and often much higher values of production. They generally have fewer temporal and spatial trend data (usually a single production figure for a whole country for one year), and often give production with less attention to economic data.

There are three main methods of estimation of fishery production. (Hortle and Bush, 2003):
- catch surveys (catch per fisher multiplied by the number of fishers) may give accurate estimates in fisheries dominated by single species, but in fisheries such as the Mekong, large errors result from the diversity of species, fishers and their gear, and the variability of the fishery temporally and spatially;
- trade and marketing surveys, which are problematic in the Mekong because many fish are consumed locally without being formally marketed, and traded items may anyway be under-reported;
- habitat and yield surveys (area of habitat multiplied by the yield per area), which suffer from difficulties in measuring flooded area (an important factor in fish production in the Mekong), the diversity of habitats, and confounding factors such as fishing intensity; and;
- consumption surveys, which may be accurate when wild-capture fish are all caught and consumed locally, but which require care in accounting for wastage, imports, exports, and aquaculture production (especially if fed from other fish production).

The statistical databases generally are based on catch surveys, and are thought to ignore much of the production (Coates, 2002; Hortle and Bush, 2003). According to Coates (2002) and Sverdrup-Jensen (2002) existing official statistics on inland fisheries grossly under-report catches, are often not based on field work and may not consider small-scale family fishing since these fisheries have always been considered of minor importance to the national economy. Most large-scale capture fisheries data are also inaccurate (Coates, 2002; Sverdrup-Jensen, 2002). In the case of Cambodia, Coates (2002) shows that data before 1999 are effectively meaningless. Much of the earlier literature was also based on catch surveys, often using the database information. More recent literature is based mainly on consumption surveys (eg Hortle, 2007; Hortle and Suntornratana, 2008). This has led to production estimates which are both higher than in older literature and higher than in the statistical databases.

Notwithstanding the difficulties in the available national statistics, they do give information about spatial and temporal trends, and also about economics, which are generally lacking in the published literature. Therefore, aiming to combine the better estimates of the recent literature with other information from the statistics, we present data from both sources, though we stress the difficulties with the statistics. We will use figures only from 1999 onwards from the national statistics, since figures earlier than that in the case of Cambodia at least are meaningless (Coates, 2002). We will also make two salient points with the national statistics. Firstly, they appear to be the

only source of information that demonstrates quantitatively the recent rapid and large expansion of aquaculture in the Delta. Also, while there is agreement that they are underestimates, and probably gross underestimates, of the true production, even these underestimates point to a food production that is more important than livestock production in the region. In this section, we list both principal sources of data. In the case of the statistical databases, we also describe our methods of analysing the data.

2.1 Literature sources of data

The Fisheries Program of the Mekong River Commission is a major source of information. It concentrates on knowledge generation, raising the awareness of fisheries in the Mekong and improving fisheries management, particularly promoting community involvement in management processes. It also has a strong emphasis on implementation, uptake and impact of fisheries information into planning and development decisions in the basin (http://www.mrcmekong.org/programmes/fisheries.htm). The programme researches into capture fisheries and produces papers, technical reports, development series reports, fisheries newsletters and films and Technical Advisory Body management briefs. The papers and reports are available in the MRC website (www.mrcmekong.org) and the CD 'Fisheries Information in the Lower Mekong Basin Version 1' published by the MRC. We concentrate on the subset of reports and papers that are concerned with aspects of fishery production.

There is no system in the Lower Mekong Basin for effective collection of basin-wide statistical data on fisheries and therefore very limited data are available on fisheries production. To address this, the MRC undertook socio-economic surveys (to estimate production using fish consumption) and catch assessment surveys. According to Van Zalinge (2002), the latest and most comprehensive independent data are largely based on these surveys. More recent reviews include Baran et al (2007) and Hortle (2007).

Although official production data are generally unreliable, Van Zalinge et al. (2000) estimates based on such data for the inland capture fisheries for 2000 in the Lower Mekong Basin. More recent (consumption based) estimates include Sverdrup-Jensen (2002), Van Zalinge et al. (2003) (also reported in Hortle and Bush, 2003) and Hortle (2007). Sverdrup-Jensen (2002) and Mekong River Commission (2005) give estimates of the monetary value of fisheries in the countries of the Lower Mekong Basin. Hortle (2007) reviewed estimates for the whole Lower Mekong Basin. Phillip (2002) examined aquaculture in all the countries of the Mekong Basin, based on official government statistics and household consumption surveys, and gives the estimated total production and value in 1999/2000.

Apart from those reports which discuss fish production across the Lower Mekong Basin, several studies discuss aspects in more detail in the individual countries. Phonvisay et al. (2005) and Bouakhamvongsa et al. (2005) describe fisheries in Laos in more detail, noting the importance of fish both as sources of food and of income, but do not give data on production or economic value. Coates (2002) noted the general difficulty with official statistics in Lao PDR, describing them as relatively meaningless, and reviewed evidence that the actual production was far higher than the official estimates. Bouakhamvongsa et al. (2005) describe a survey of eighteen typical fishers who recorded their daily catches over one year in 2004. However, the data of

this programme are yet to be released. Meusch et al. (2003), in a study aimed primarily at nutrition and health, reported the fish consumption in Laos of various food groups including fish. The number of farmers involved in aquaculture in Lao PDR has increased since then in recent years (Phimmachak and Chanthavong, 2005).

Khumsri et al. (2005), Sjorslev et al. (2001) and Hortle and Suntornratana (2008) discussed the importance of fish for households and communities as sources of food and income in the Songkhram Basin in NE Thailand and Sjorslev et al. (2005) estimated the catch in the basin. Nachaipherm et al. (2002) studied the fisheries activities and made a catch assessment of three reservoirs (Nam Oon, Kaeng Lawa and Huai Muk). The data were used to develop the management plans. Nakkaew et al. (2001) reported the fisheries activities and catch in Huai Luang reservoir, Udon Thani province, Thailand. Prapertchob (1989) reported fish consumption in north-east Thailand, and Coates (2002) reported both average catch per capita and the estimated total production. Mahasarakarm (2007) gave production figures based on consumption estimates, and also noted the value of fisheries in NE Thailand. Not all of fish consumed in the region are from the local production: they are also imported from other regions of Thailand and from Cambodia (often smuggled) (van Zalinge et al., 2001; Yim and McKenney, 2003a, 2003b, 2003c; Bush, 2004).

Van Zalinge and Touch (1996) and Diep et al. (1998) assessed the Cambodian inland catch based on stratified random sampling of the catch (by species and gear) and frame survey information on fishing gear. Ahmed et al. (1998) undertook a baseline socio-economic survey of households covering eight fishing provinces during 1995-1996, and provided estimates for the total inland catch of Cambodia. Petracchi (1999a), in a study aimed primarily at nutrition and health, reported the fish consumption in Laos of various food groups including fish. Navy and Bhattarai (2006) evaluated the economic cost, profitability and sustainability of small-scale inland captured fisheries of three selected fishing communities in three provinces of Cambodia. Nam (2000) studied the contribution of inland fisheries to the Cambodian economy. Hortle et al. (2004) also studied the value of the catch, and suggested that both its size and value were underestimated due to poor and incomplete figures.

Lam et al. (2002) carried out a household survey of inland fisheries activities and fish consumption in Tra Vinh province, Vietnam, as part of the MRC coordinated surveys. Tien et al. (2005) reported a study which monitored the catches of 13 fishers, carried out as a trial over a one-year period from key sites in the Mekong delta. Kaufmann (2003), in a study aimed primarily at nutrition and health, reported the fish consumption in Laos of various food groups including fish.

2.2 Official statistics

2.2.1 Capture fisheries production

As discussed in Section 2, there is uncertainty in the production of capture fisheries data published by government agencies of the respective countries, and serious doubt is cast upon them, particularly prior to 1999 in Cambodia (eg Coates, 2002). However, these sources appear to be the only source of information that demonstrates quantitatively the recent rapid and large expansion of aquaculture in the Delta. Also, even as lower bound estimates nevertheless still show a source of food that is more important than livestock. Therefore, we will present the figures from 1999 onwards,

but we caution that the actual figures are not to be regarded as reliable indicators of the true production.

Laos: Laos has a weak system of statistical data collection, with information based entirely on estimates, and is believed to under-report the catches at village level (Coates, 2002).

Country-wise fresh water historic capture fish production is available in the FAOSTAT database http://www.fao.org/figis/servlet/TabLandArea?tb_ds=Production&tb_mode=TABLE&tb_act=SELECT&tb_grp=COUNTRY.
Province-wise household level fish production (in local currency) data are available in The Lao Expenditure and Consumption Survey (LECS) (NSC, 2004b). LECS is the largest and most important survey that the National Statistical Centre undertakes. It is not only large in sample size, it also covers a wide range of subject matter areas related to household living situation, and it is conducted during a period of 12 months. The results in this report are based on data obtained from sample villages and extrapolated to provide an estimate of all households in Lao PDR.

Thailand: Coates (2002) reports that the statistical survey methods in Thailand ignore rivers and wetlands, and thus are biased towards reservoirs. In addition, even those estimates are likely to underestimate the true production.

Fresh water capture fish production for the whole country is taken from the FAOSTAT database http://www.fao.org/figis/servlet/TabLandArea?tb_ds=Production&tb_mode=TABLE&tb_act=SELECT&tb_grp=COUNTRY. The areas of Thailand within the Mekong Basin are only 36% (MRC, 2003) of the total country area. In the absence of the province-wise data, we consider the country average production per capita as equal to the production per capita of the Mekong region of Thailand.

Cambodia: Coates (2002) reports that the collection of statistics in Cambodia is inadequate, with widespread under-reporting. The problem was particularly serious before 1999, after which the extent of the underestimates reduced, but subsequent estimates are still believed to be significant underestimates.

Province-wise historical production data available in the Statistical Yearbook 2005 (National Institute of Statistics, 2005) are used in the analysis. Freshwater fisheries in Cambodia are organized at three levels: (1) family (subsistence) fishing or small-scale fishing, (2) middle-scale (artisanal) fishing, (3) large-scale (industrial fishing) (Department of Fisheries, 2001a). Family and rice field fisheries were not considered in the official statistics until 1998 (Department of Fisheries, 2001b). Therefore the reported total fish production before 1999 was significantly lower than post 1999.

Vietnam: Coates (2002) reports that the statistical surveys in Vietnam are biased strongly towards aquaculture, and mostly under-report capture fishery production. There are major discrepancies in capture fishery production figures amongst provinces, with the extremely unlikely reporting in 1999 that one province accounted for 86 % of the total national freshwater capture fish production. According to Tien et

al.. (2005), official statistics for capture fishery production cover large commercial gear, for which catches may be under-reported.

Vietnam fisheries production is available from the General Statistical Office of Vietnam (http://www.gso.gov.vn/default_en.aspx?tabid=469&idmid=3). The database includes province-wise different types of fisheries production, and their combined output value. Fisheries in Vietnam is divided into two major categories: caught aquatic product and farmed aquatic product. Total fisheries production, which is referred to as the total aquatic product is the sum of caught aquatic product and farmed aquatic product. Caught aquatic product and farmed aquatic product are further classified as follow:

Caught aquatic product = Caught fish from sea + Caught other aquatic product from sea + Inland catch (fish and others)
Farmed aquatic product = Farmed fish + Shrimp + Others (other than fish and shrimp)

Laos, Thailand and Cambodia do not have any costal provinces within the Mekong River Basin. Therefore, for cross-country comparison of the indicators, we did not consider the capture marine fisheries (caught fish from sea and caught other aquatic product from the sea) of Vietnam for the main analysis. However, we will discuss separately the contribution of marine fisheries to the overall production.

2.2.2 Aquaculture production

Laos: Few data are available on the farmed fish or aquaculture in Laos. Nonetheless, there are aquaculture farms as a large number of cultured fish are sold in the markets in Vientiane. These fish are mainly from aquaculture farms close to the city or imported from Thailand (Phonvisay et al. 2005). Data on the number of agricultural holdings engaged in aquaculture according to the first agricultural census undertaken in Lao PDR in 1998/99 (http://www.maf.gov.la/Census/Aquaculture/aquaculture.html). No other data are available on aquaculture production in Laos. In the productivity analysis, therefore, we did not consider aquaculture production.

Thailand: Aquaculture in Thailand is very well developed. However, there are no data on production.

Cambodia: Province-wise historical production data available in the Statistical Yearbook 2005 (National Institute of Statistics, 2005) are used in the analysis. Presently, small-scale aquaculture is being developed rapidly in Cambodia (Ngeth et al., 2005).

Vietnam: Aquaculture production in Vietnam is considered as the farmed aquatic products available in the website of the General Statistical Office (http://www.gso.gov.vn/default_en.aspx?tabid=469&idmid=3).

2.2.3 Fish price

We used fish price estimates to calculate the economic value (gross value of production) from the fish production data, where the gross value of production was not given directly in the data we consulted.

Laos: the National Statistical Centre of Laos publishes market price of fresh and fermented fish with the price of other commodities in the Statistical Yearbook (National Statistics Centre, 2003, 2004a and 2005).

There has never been a full study of fish market monitoring in the Lao PDR (Phonvisay, 2001). Phonvisay (2001) conducted an initial fish marketing survey in Thongkhankham and Thatluang Markets, but it only took place over one day, and was general in nature. Phonvisay (2003) further studied fish marketing operations in Luang Prabang Province, but again, this was just a 'snap shot' survey. Attempts to identify the quantities of fish sales covering periods of weeks, months or years were made on that day, but they did not obtain accurate data on fish sales. Phonvisay et al. (2005) later aimed at a more systematic approach by monitoring of fish sales at the three markets in Vientiane and Luang Prabang in 2004.

For the economic analysis of fisheries, we considered the landing price of fish not the retail market price. In estimating the total value of fisheries based on the FAO production data, we used the following assumptions:

- the average of the 8 provinces as described in the Yearbook,
- The retail or market price is 50% higher than the landing price (van Zalinge 2002).
- The landing price given by the National Statistics Centre.
- The price in 1999 was the same as that in 2000.

Thailand: Fish Marketing Organization of Thailand monitors the fresh water fish prices auctioned at the Bangkok fish market. These data are available in the Statistical Yearbooks published by the Office of the Agricultural Economics of the Ministry of Agriculture and Cooperative of the Royal Thai Government http://www.oae.go.th/English/statE.htm. The average price of the common fish species in the markets (snakehead, cat fish, white spotted fish, swamp eel, climbing perch, carp and cat fish) is considered in the analysis.

Cambodia: Unlike the production data, there are no data on fish price in the Statistical Year Books. Official statistics on average monthly market (retail) price of capture fish is available only in a report (Department of Fisheries, 2001a) published by the Department of Fisheries from January 1996 to June 2000. Some more information on fish price is available in different published papers as shown in Table 1.

Table 1. Source of capture fish price in Cambodia

Source	Description
Ngor et al. (2005)	Price of *dai trey linh* (bag-net or stationary trawl fishery) fishery on the Tonle Touch (Touch River) during the 2003 season.
Rab et al. (2006)	Landing price of capture fish in Kampong Chhnang, Kandal, Phnom Penh and Siem Reap provinces for the closed season of 2003 (August 2003) and open season of 2004 (February 2004) (see Box 1)
Khay and Hortle (2003)	Open season retail price in Phonm Penh market in 2003.
Naret et al. (2000)	Landing price of fish in Kandal, Takeo and Prey Veng provinces for 1999.
Pengbun et al. (2005)	Landing price of 2003 in Prey Veng province

Box 1: Season of operation
The fishing calendar in Cambodia is divided into two seasons: open (October-May) and closed (June-September). The small-scale fishing have an open access at all times of the year, with imposing restrictions mainly on fishing efforts. Whereas, middle and large-scale fishing are allowed only in the open season and require licenses issued by the Department of Fisheries (DoF, 2001a).

Fish price in Cambodia varies from season to season. All species sell for a higher price in the closed season than the open season (Rab et al., 2006). Among the species, larger species are generally more valuable than the smaller species (Ngor et al., 2005). However, in estimating gross value of production we used the average annual price. Using the data in all these sources, we estimated the province-wise average fish price based on the following assumptions:

- The landing price of capture fisheries 2000 were estimated from the average price from Department of Fisheries (2001a), taking the retail or market price as 50% higher than the landing price (van Zalinge 2002). Van Zalinge (2002) estimated the landing price of fish in Cambodia as $200 million and the retail price as $300 million i.e. the retail price is 50% higher than the landing price.
- The price is same in all provinces.
- The landing price of fish in Kandal, Takeo and Prey Veng provinces for 1999 was assumed to be the same as that in Naret et al. (2000). The price in the remaining provinces was considered as the average of the prices available.
- The landing price for 2003 and 2004 in Kompong Chhnang, Kompong Thom, Siem Reap and Pursat provinces was taken from Rab et al. (2006). The price in Banteay Meanchey, Battambang, Oudor Meanchey and Krong Pailin provinces were considered the same as that in Siem Reap. The price in Kampot, Takeo, and Prey Veng provinces were considered the same as that in Phnom Penh. The price in Kompong Cham was considered to be the average of that in Kompong Chhnang and Phnom Penh. The price in the remaining provinces was considered to be average of that in Kompong Chhnang and Siem Reap.

- The price in 2002 was considered as equal to the average of the 2001 and 2003 prices.

Vietnam: Details of fish production and output value of fishing are available in the website of the General Statistical Office of Vietnam. No fish price data are directly available in that site. However, our purpose is to review the total value, so we use the total value data directly.

2.2.4 Population

The provincial population of Laos was taken from the Statistical Yearbooks published by the National Statistics Centre (National Statistics Centre, 2003, 2004a, and 2005). The provincial population of Cambodia for 1998 was from the Cambodian Government website (http://www.cambodia.gov.kh/unisql1/egov/english/organ.admin.html) and for 2001 was from the Fertilizer Advisory, Development and Information Network for Asia and the Pacific (FADINAP) website (http://www.fadinap.org/cambodia/Agstat20002001/population.htm), which is maintained by UNESCAP. The population of Cambodia for other years was estimated from the data for 1998 and 2001 using equation (1) (http://web.nso.go.th/eng/stat/subject/subject.htm#cata1). The provincial population growth rate is available at the Ministry of Agriculture, Forestry and Fisheries of Cambodia (http://www.maff.gov.kh/statistics/index.html).

$$r = \frac{\ln(P_{n+t} / P_n)}{t} * 100 \qquad (11)$$

Where,

r = Population growth rate (percent per year),

P_n = Population in year n

P_{n+t} = Population in year $n + t$

The provincial population of Thailand for 1990 and 2000 and the growth rate are available from the National Statistical Office of Thailand (http://web.nso.go.th/pop2000/table/tab2.pdf). The population in other years was estimated using equation 1.

The yearly provincial populations of Vietnam were obtained from the website of the General Statistical Office of Vietnam (http://www.gso.gov.vn).

2.2.5 Currency exchange rates

The exchange rate (local currency to US dollars) of the Lao kip and the Cambodian riel were taken from the General Statistical Office of Vietnam (http://www.gso.gov.vn/default_en.aspx?tabid=491). However, the exchange rate for the Vietnamese dong was not available at that site. We obtained the exchange rates for the dong from the Economic and Social Commission for Asia and the Pacific of the United Nations (UNESCAP) (http://www.unescap.org/stat/data/statind/datatable.aspx) and from the following websites:
http://en.wikipedia.org/wiki/List_of_historical_exchange_rates#Table
http://www.jeico.com/cnc57vtn.html

The exchange rate for Thai baht was taken from the website http://fx.sauder.ubc.ca/etc/USDpages.pdf.

2.2.6 Crop and livestock productivity

We compared the fisheries productivity with the productivity of crops and livestock to see the relative contribution of different sectors to the overall agricultural production at the country level. Mainuddin et al. (2008) estimated detail province-wise crop and livestock productivity for the lower Mekong Basin. We used the results from that report to compare here with the fisheries productivity.

2.3 Concluding remarks

There are many methods of estimating fishery production based on catch surveys, consumption surveys, trade and marketing surveys, and estimates of production per unit area of different water bodies. In the Lower Mekong Basin, national statistics, which are generally based on local assessment and reporting of catches, have been shown to be very poor indicators of the total production. They are gross underestimates of the true production and often biased towards some fishing sectors, such as reservoir catch in Thailand and aquaculture in Vietnam. Coates (2002) reported in 1999 that the ratio of the best estimate to the officially reported value was 1.25-1.86 in Cambodia, 5.9-7.8 in Lao PDR, 0.5-1.4 in Thailand and 8.0-10.6 in Viet Nam. Cambodia corrected the fisheries production post 1998 with better reporting and by including the small-scale fisheries.

The better estimates based on consumption surveys are, unfortunately, available mainly based on surveys in 2000 only, and trends in production cannot be gauged from this information alone.

The situation is highly unsatisfactory. On the one hand, the trend information, the only information consistently available at province level, is highly dubious. On the other hand, the only information regarded as reasonably reliable contains little trend or spatial content.

Faced with this highly unsatisfactory situation, we have elected to consider both main sources of information, the national statistics (but only from 1999 onwards), and the literature based on consumption surveys. We will suggest that, notwithstanding the highly dubious nature of the national statistics, one or two observations emerge from them that are much harder to discern from the consumption survey based literature, in particular the recent rapid rise of aquaculture in the Delta.

The final key point to emerge simply from a survey of the methods (without even considering the data) is that the estimation of production and its trend is an area in urgent need of more survey and better information. Fisheries management and policy will both benefit from increased effort.

3 Results and Discussion

In this section, we discuss the national fisheries price, production and gross value of production estimates by country, and compare the fisheries sector to crop and livestock sector. We then compare the productivity amongst the different countries of the Lower Mekong Basin.

3.1 Fish price, production and gross value of production in Laos

According to the national statistical records, the price of fish rose more than tenfold from 1995 to 2000, since which time it has risen about another third (Table 2).

Table 2. Market price of fresh fish in Laos, average of 8 provinces (National Statistics Centre, 2003, 2004a, 2005)

Year	1990	1995	2000	2001	2002	2003	2004
Price, Kip/Kg	707.8	804.7	7887.6	8954.6	10056.3	10569	10585.5
Price, $/Kg	2.67	3.24	2.09	1.87	1.78	1.78	2.01

The survey carried out by Phonvisay et al. (2005) found that fresh fish from aquaculture were considerably more important in the urban markets than wild captured fish from rural areas and the Mekong River. However, wild captured fish are still preferred to cultured fish, as is shown by the higher price of these fish in urban markets (Phonvisay et al. 2005) (Table 3).

Table 3. Fish price in the markets of Vientiane and Luang Prabang (Phonvisay et al., 2005)

Province	Market	Price, $/kg
Vientiane	Thongkhankham	1.6
	Thatluang	1.4
Luang Prabang	Luang Prabang	1.4

Noting again that the national statistics for production are very doubtful and very likely a gross underestimate, we show in Table 4 the production and GVP per capita for Laos since 1999 (we ignore the data for earlier years) from the FAOSTAT database. The apparent decrease in the gross value of production per capita is mainly because of an increase in the US dollar with respect to the local currency.

Table 4. Production and GVP of capture fisheries in Laos according to FAOSTAT

Year	Production (tonne)	Production value (million $)	Production per capita (kg / capita)	Gross value of production per capita ($ / capita)
1999	30041	41.82	5.90	8.22
2000	29250	40.72	5.60	7.80
2001	31000	38.57	5.77	7.17
2002	33440	39.77	6.05	7.20
2003	29800	35.36	5.25	6.23
2004	29800	39.92	5.11	6.84

According to the National Statistics Centre (2004b), the total production value of fisheries for Laos for 2002-03 was $63 million. The country average per capita production was about $12.0, and ranges from $27.33 per capita in Borikhamxay province to $6.71 per capita in Luang Prabang province (Table 5). Given the uncertainties in estimates, these values broadly agree with those in the FAOSTAT database given above. Baran et al (2007) gave a range of estimates from $48 million to $100 million.

Table 5. Province-wise production of fisheries based on the LECS survey (2002-03)

Province	Value of production, $/household	No of household, (thousands)	Household size	Total value of production, million $	Production value per capita, $/capita
Phongsaly	52.6	25	6.5	1.32	8.09
Luangnamtha	45.8	23	6.0	1.05	7.64
Oudomaxy	53.1	38	6.5	2.02	8.17
Bokeo	82.4	25	5.4	2.06	15.27
Luang Prabang	42.3	61	6.3	2.58	6.71
Huaphanh	71.1	37	7.3	2.63	9.74
Xayaboury	65.3	58	5.6	3.79	11.67
Vientiane Capital	43.3	111	5.7	4.80	7.59
Xiengkhuang	59.9	30	7.4	1.80	8.09
Vientiane Province	80.6	62	5.9	5.00	13.67
Borikhamxay	153.0	38	5.6	5.82	27.33
Khammuane	124.7	55	5.8	6.86	21.50
Savannakhet	80.2	122	6.3	9.79	12.74
Xaysomboon SR	75.7	6	5.8	0.45	13.05
Saravane	46.6	51	6.0	2.38	7.77
Sekong	46.3	12	6.4	0.56	7.24
Champasack	78.2	97	5.9	7.58	13.25
Attapeu	121.4	17	5.9	2.06	20.58
Lao PDR	72.8	868	6.1	62.54	11.93

Recent consumption based estimates yield much larger values of around ranging from 10 to 44 kg/person/year, with a probable best estimate of about 30 kg/person/year (Hortle, 2007). The upper figures give much higher estimates of total fish production of around 183,000 tonnes/year (Hortle and Bush, 2003; Van Zalinge et al., 2003). Baran et al. (2007) review estimates ranging from about 70,000 to 204,000 tonnes/year. Hortle (2007) also gives an estimate of about 208,000 tonnes/year. The gross value of production implied by the higher estimates is perhaps of order $200 million per year. On the other hand, FAO (2003) consumption estimates undertaken for health and nutrition surveys give values of about 10 kg/person/year, although this may be an underestimate (Dyg, 2006) on which we will comment further below (Section 3.5).

Figure 1 shows the comparison of gross value of production (GVP) for agriculture and livestock with the GVP from fisheries using both the lowest estimates from the national statistics and the highest estimate from the literature. The GVP from crop cultivation gradually increased over the last 5 years, while the contribution from livestock remains static. The contribution from fisheries is, according to the lowest, national figures, at least as important as that from livestock, and seemingly static. The

upper figures put the contribution from fisheries as several times that of livestock and as more important than most crops other than rice, with which it was roughly equal in 2000 (Figure 2).

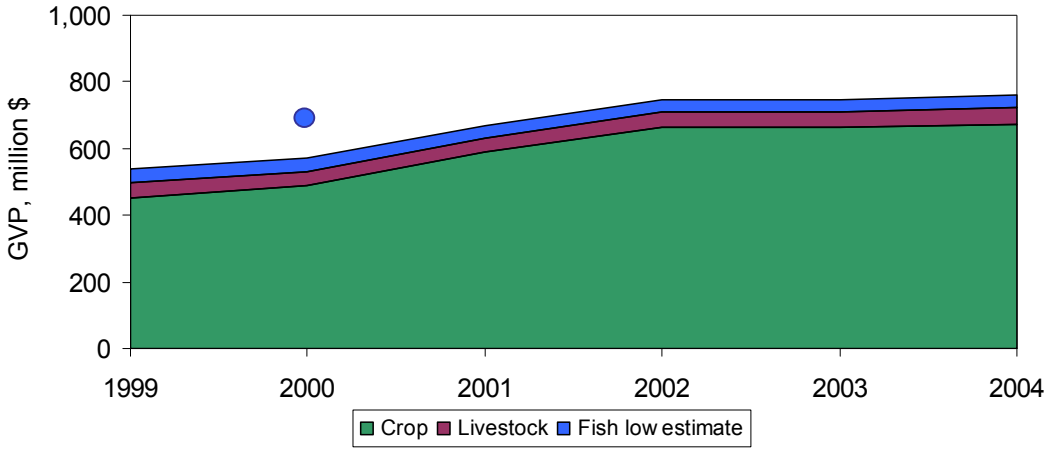

Figure 1 Contribution of different sector on overall production of Laos, using the FAOSTAT fish figures of Table 5 (Fish low estimate) and the Van Zalinge et al. (2003) fish figure (dark blue point).

Figure 2 shows the GVP per capita of inland fisheries with that of rice, other crops and livestock. There is a significant increase in per capita income from other crops while all the other sectors remained static or declined. The GVP per capita from capture fisheries is about 15% of the GVP from rice in recent years, and is similar to that from livestock.

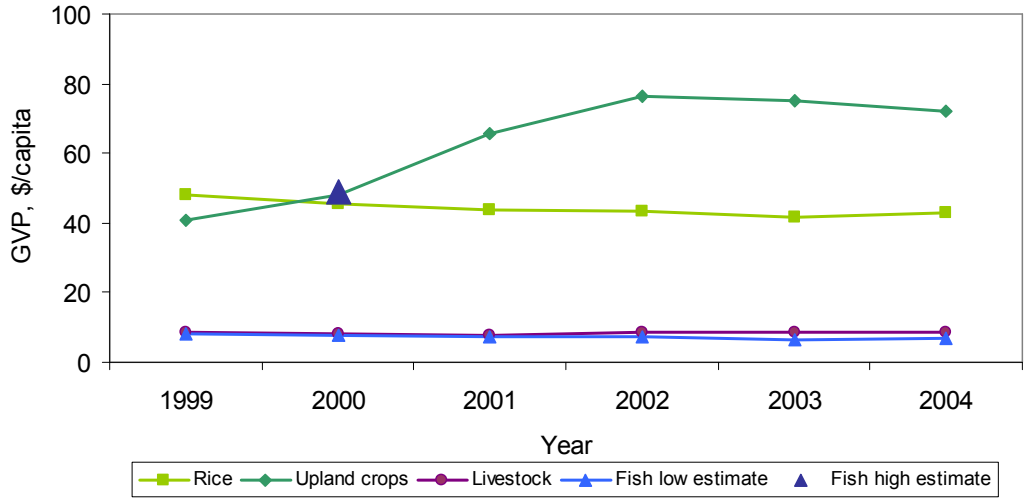

Figure 2 Comparison of GVP per capita of different production sector of Laos, using the FAOSTAT fish figures of Table 5 (Fish low estimate) and the Van Zalinge et al. (2003) fish figure (Fish high estimate).

3.2 Fish price, production and GVP in Thailand

The official Statistical Yearbooks published by the Office of the Agricultural Economics give the price of fish in Bangkok (Table 6).

Table 6. Average price of fish in the Bangkok auction market

Year	1999	2000	2001	2002	2003	2004
Price, Baht/kg	41.9	41.1	41.5	41.5	40.7	40.7

Noting again that the national statistics for production are very doubtful and very likely a gross underestimate, we show in Table 7 the production and GVP per capita for Laos since 1999 (we ignore the data for earlier years) from the FAOSTAT database. Production and GVP per capita were available only for the whole country. This leads to significant difficulties in interpreting the production in the Mekong Basin part of Thailand.

Table 7. Production of freshwater capture fisheries of Thailand, from FAOSTAT

Year	Production, tonne	Price, $/kg	Gross value of production, million $	Production, Kg/ capita	GVP per capita, $/capita
1999	206434	1.11	228.5	3.44	3.81
2000	201205	1.03	206.4	3.32	3.41
2001	202200	0.93	188.9	3.30	3.08
2002	198200	0.97	191.5	3.20	3.09
2003	197493	0.98	193.6	3.15	3.09
2004	202600	1.01	204.8	3.20	3.24

Prapertchob (1989) reported a registered production in north-east Thailand of 59,000 tonnes, but gave a consumption based estimate of 322,000 tonnes, or 5-6 times the production estimate. As with Laos, we see a consumption based estimate far higher than the official production figures. Other estimates include: Coates (2002) - annual production of 200,000 to 500,000 tonnes based on an average catching of 20 to 50 kg per capita per year by 10 million poorer rural people; Van Zalinge et al. (2003) - 932,300 tonnes, based on per capita consumption as 52.7 kg; Mahasarakarm (2007) - 795,000 tonnes, based on per capita consumption as 30-35 kg. FAOSTAT (2007) gives the consumption in Thailand as about 30 kg/person/year, little changed from 1995 to 2005, though the figure is for the whole of Thailand, and includes marine products.

At a conservative first sale price, of about $1/kg, the freshwater fisheries (both capture fisheries and aquaculture) of the Mekong in Thailand are worth about $700 million per year (Mahasarakarm, 2007). Not all of fish consumed in the region are from the local production. They are also imported from other regions of Thailand and smuggled from Cambodia (van Zalinge et al., 2001).

Figure 3 compares the GVP of freshwater capture fisheries production from 1999 with the GVP of crop and livestock for the Mekong part of Thailand. The GVP of capture fisheries for the whole of Thailand, based on the lower national statistics was less than that of livestock from the Mekong Basin areas alone. However, this estimate is both a gross underestimate and leaves out much of the fishery resource (in particular, rivers and aquaculture). The larger, more recent estimates of production in 2000 (see section 2.1.2) of between about 500,000 and 900,000 tonnes for the Thai Mekong capture fishery, and a first-sale price of about $1/kg, gives a much larger GVP of between about $500 and $900 million. With this estimate, the capture fisheries sector in the

Mekong Basin in Thailand is, in terms of GVP, be larger than the livestock sector, and perhaps about 20 – 40 % of the crop sector.

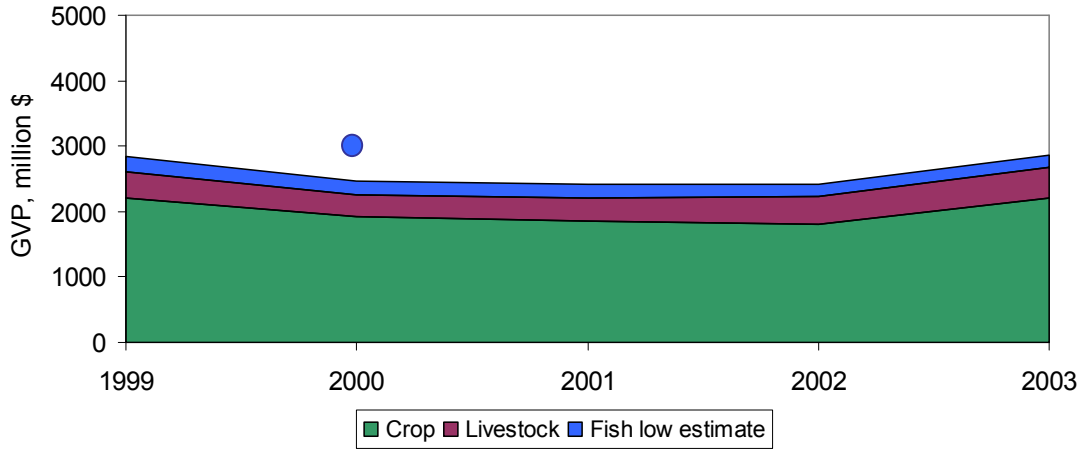

Figure 3 GVP from different sectors of Thailand (GVP of crop and livestock in this Figure is for the Mekong part of Thailand whereas the GVP of capture fisheries is for the whole of Thailand). The low fish estimate from is FAOSTAT and the high fish estimate (dark blue point) is from Van Zalinge et al. (2003).

Figure 4 compares the GVP per capita of different sectors of Thailand. The higher recent estimates of fisheries production lead to a gross value of production for fisheries greater than that of other crops, and a little less than that of rice. The higher estimate for 2000 is plotted on Figure 4.

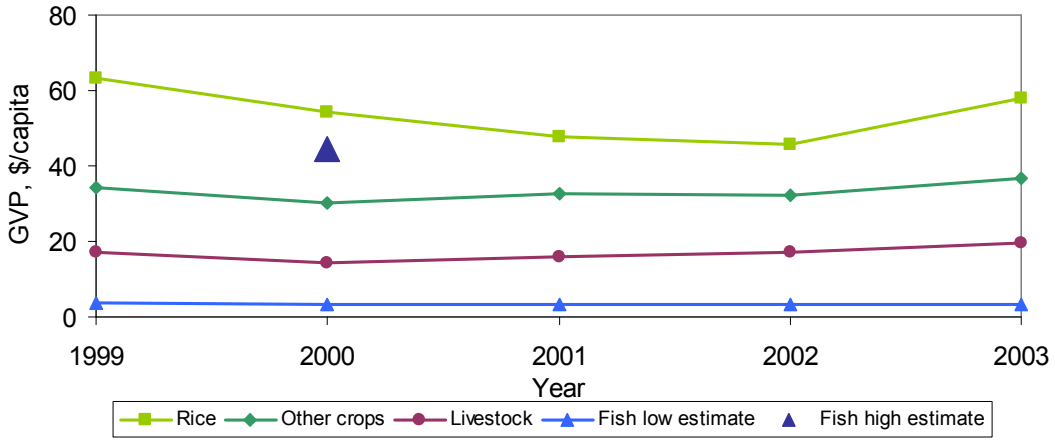

Figure 4 Comparison of GVP per capita of different production sector of Thailand. The low fish estimate from FAOSTAT and the high fish estimate from Van Zalinge et al. (2003).

Aquaculture has expanded significantly over the past 10 years in Northeast Thailand (Phillips, 2002). According to official Department of Fisheries statistics for 1998 (Department of Fisheries, 2001a), fish culture in ponds, rice fields, ditches and cages contributes over 38,000 tonnes. Phillips (2002) argues that these statistics underestimate the contribution made by large numbers of small-scale producers. There may be more than 200,000 households involved in small-scale aquaculture and

annual production from these small scale households is estimated as 30,000 tonnes or more (Phillips, 2002). This makes a total production about 68,000 tonnes per year.

3.3 Fish price, production and GVP in Cambodia

Several studies surveyed the price of fish in Cambodia (section 2.2.3). Hortle et al., (2004) reported the average price of fish as $0.75/kg. Other studies note that the price in Cambodia varies from season to season, and Figure 5 shows figures from Department of Fisheries (2001a).

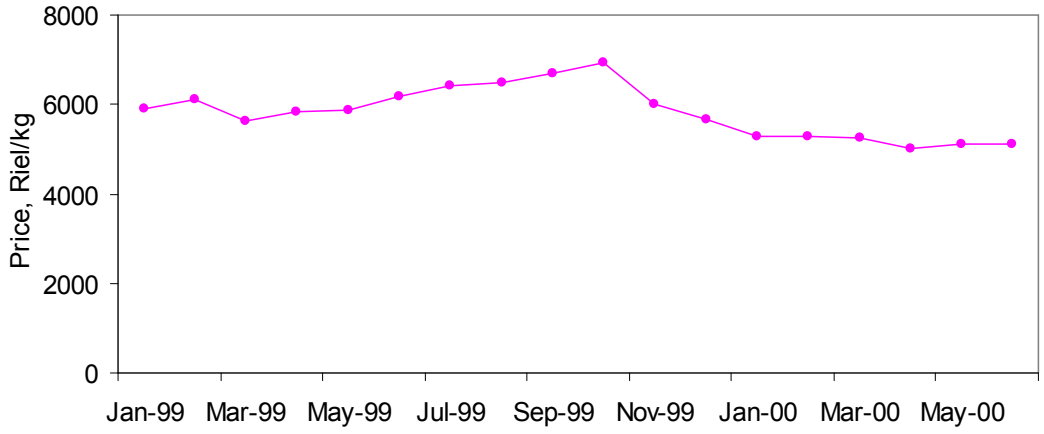

Figure 5 Monthly average catch fish price for Cambodia (constructed using the data available in Department of Fisheries (2001a)

As with Laos and Thailand, the official statistics seriously underestimate fish production. Referring to data from 1999 onwards, Coates (2002) reports that the official recorded production was about 230,000 tonnes in 1999 (a large increase on the meaningless figures of earlier years, brought about by improved survey), but the data available from the official websites show this jump to the higher figure only in 2002.

Other estimates of fisheries production range from similar to, to higher than, the official statistics in recent years. These include: van Zalinge and Touch (1996) and Diep et al. (1998) - 255,000 to 380,000 tonnes; van Zalinge (2002) - 400,000 tonnes in 2000, which was still believed to be an under-estimate, and of which the Tonle Sap annual catch was about 235,000 tonnes; Ahmed et al. (1998) - between 290,000 tonnes to 430,000 tonnes; van Zalinge et al. (2003) - about 680,000 tonnes for the 2000; Hortle (2007) – 590,000 tonnes. This estimate of van Zalinge et al. (2003) assumes consumption (all fish products) of about 65 kg/person/year which is within the range given by Hortle and Bush (2003). A lower estimate of consumption, of about 10 kg/person/year was given by Petracchi (1999a), based on health and nutrition surveys, but this figure is now superseded by FAOSTAT (2007) which gives consumption that varies from 17 to 29 kg/person/year for 1990-1998 and from 49 to 80 kg/person/year for 1999-2005. Although this includes all fish and all of Cambodia, it is reasonable to suppose the figure is dominated by the Mekong region and Mekong fish products, so may be taken as a broad indication of consumption of Mekong fish. Thus, the FAO figures, like other figures, have been revised upwards in recent years,

by a factor of between 2 and 3 for the late 1990s. The recent figures broadly agree with those given by van Zalinge et al. (2003).

Estimates of the gross value of production show a similar range, with upward revisions in recent years, and include: van Zalinge et al. (1998) - between $130 to 200 million at the landing sites; Jensen (2000a, 2000b) - $150-200 million, increasing in the market chain to $250-500 million; van Zalinge (2002) - $300 million; Hortle et al. (2004) - $300 million, probably an under-estimates. The official statistics gave the monetary value of the total fish catch as between $250-300 million in recent years, and the contribution of fisheries sector as 8% to 10% to the total national GDP of $2,800 million. According to Nam (2000), the inland fisheries contribution ranges from 5-7% to 9-18% of the total national GDP of $ 2,800 million. Van Zalinge et al. (2003) did not give a figure for the value of the fisheries, but the implied total value is of order $500 m.

Figure 6 shows the comparison of gross value of production (GVP) for agriculture and livestock and the GVP from fisheries using both the lowest estimates from the national statistics and the highest estimate based on van Zalinge et al. (2003). The GVP from crop cultivation shows no real trend, while the contribution from livestock has decreased. The contribution from fisheries is, according to the lowest, national figures, more important in recent years than that from livestock. The upper figures put the contribution from fisheries as several times that of livestock and as more important than most crops other than rice, with which it was roughly equal in 2000 (Figure 7).

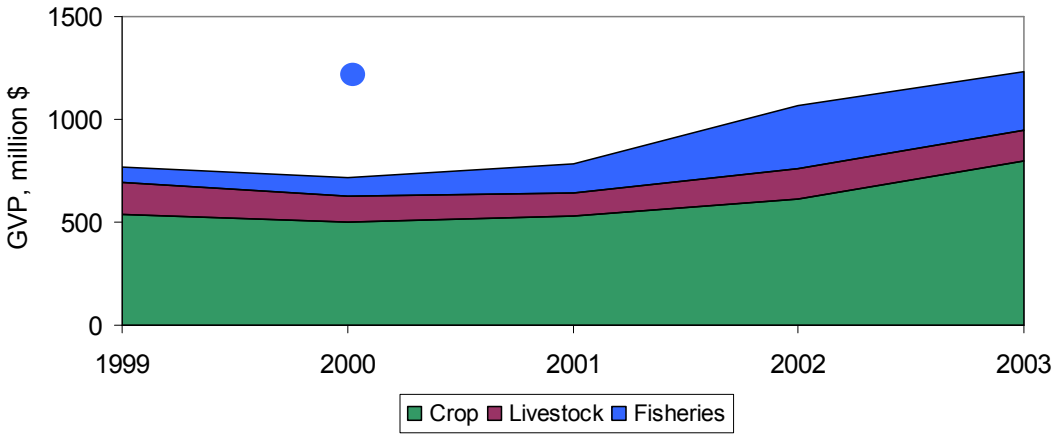

Figure 6 Contribution of different sector on overall agricultural production of Cambodia, with high estimate (blue point) of van Zalinge et al. (2003).

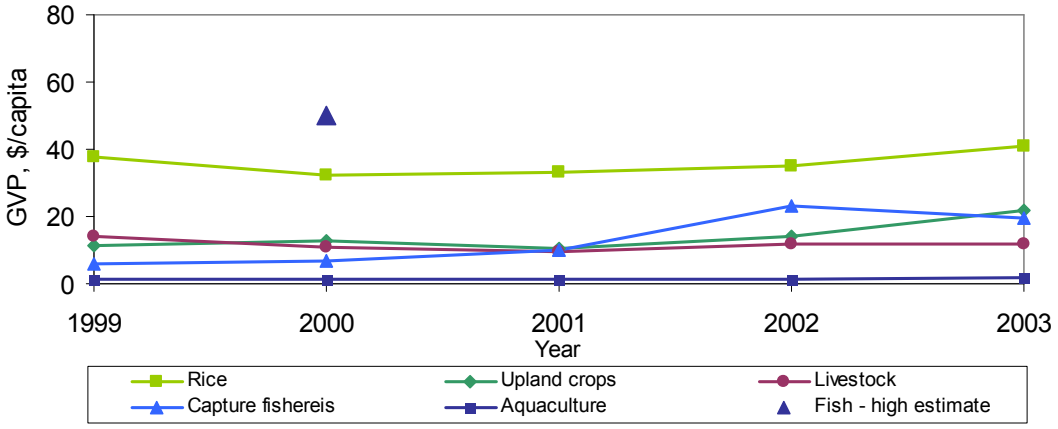

Figure 7 Comparison of GVP per capita of different production sector of Cambodia

The official statistics show the GVP of aquaculture production of Cambodia has increased from $9 million in 1993 to about $25 million in 2004. Phillip (2002) estimated value of inland aquaculture production for Cambodia as $17.2 million from 14,100 tonne of production for 1998. This gives the average price as $1.22/Kg. Sverdrup-Jensen (2002) considered the average price of aquaculture as $1.05/kg. We have considered the price reported by Phillip (2002) for all the provinces and for all years to estimate the gross value of aquaculture production.

3.4 Fish price, production and GVP in Vietnam

Fish production in the Mekong areas of Vietnam is mainly in the Mekong delta, where both capture fisheries and aquaculture are important.

The price of caught and farmed aquatic products in Vietnam is not given in official statistics, but may be estimated by the total output value by the total production. The average price so estimated is given in Table 8.

Table 8. Average fish price in Vietnam

Year	Price of caught aquatic product (million dong/tonne)	Price of farmed aquatic product (million dong/tonne)
1999	8.29	11.66
2000	8.37	13.36
2001	8.22	15.75
2002	8.04	15.51
2003	7.95	15.79
2004	7.93	15.84
2005	7.96	15.80

As with the other countries, the official statistics underestimate production and are biased towards aquaculture (Coates, 2002). Figure 8 shows the officially recorded overall production in Vietnam. Being located along the coastline, the Mekong Delta of Vietnam has an additional source of fisheries; that is marine fisheries. Marine fisheries in Vietnam are called “people’s fisheries” which develop spontaneously (Research Institute for Marine Fisheries, 2006). Its annual contribution to the total

GDP has been increasing from 1.7% in 1985 to 4% in 2004 (Research Institute for Marine Fisheries, 2006). The Mekong Delta is one of the major sources of marine fisheries in Vietnam. To show the importance of the marine fisheries in the Mekong delta part of Vietnam, it is included in Figure 8. In 1999 it was the most important part of the fishery, but by 2005 marine production had, according to official statistics, been superseded by that of the rapidly growing aquaculture sector. FAO (2008) gives a total (shrimp plus freshwater catfish) production of about 600,000 tonnes in the Delta in 2004.

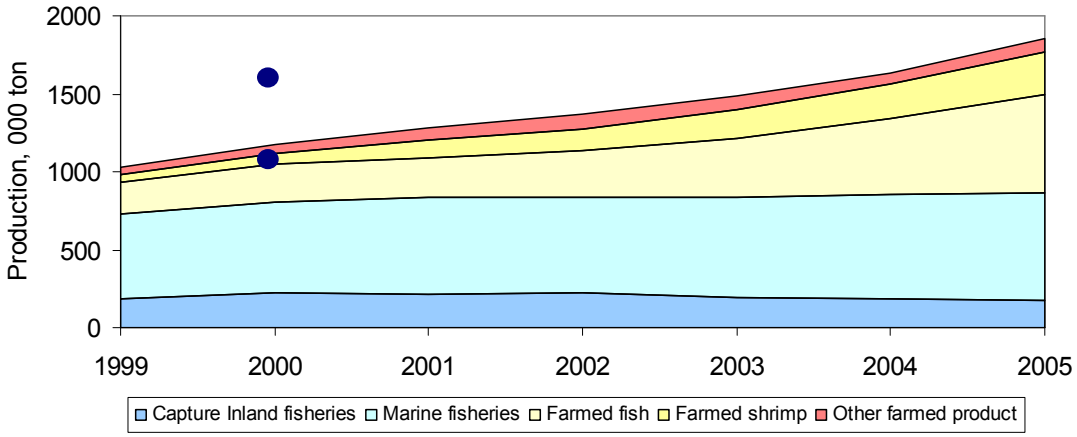

Figure 8 Production from different fisheries sectors in Vietnam. The lower dark blue point is the total production estimate, excluding marine fisheries, of van Zalinge (2003), while the upper dark blue point is the van Zalinge et al. (2003) estimate added to the official marine production value.

Other estimates of fisheries productivity show a similar divergence with official statistics to that shown in the other countries, and include: van Zalinge et al. (2000) - 190,000 tonnes from capture fisheries; van Zalinge et al. (2003) - 845,000 tonnes in 2000 from capture fisheries with aquaculture production of 171,600 tonnes, and the total fish production of just over a million tonnes being equivalent to consumption of 60 kg/person/year; Hortle (2007) – 850,000 tonnes. Lam et al. (2002), based on a household survey, estimated consumption in Tra Vinh province at 51 kg/capita/year (a fresh fish equivalent of 58 kg/capita/year), of which fresh fish (and other aquatic animals) was 42 kg/capita/year (inland fresh fish consumed was 31 kg/person/year). The FAO health and nutrition survey (Petracchi, 1999b) reported fish consumption at about 13 kg/person/year: as in Cambodia, this estimate has been superseded by more recent figures in FAOSTAT (2007) which reports higher consumption estimates rising steadily from about 30 kg/person/year in the early 1990s to 55 kg/person/year in 2003-2005. However, these figures are for the whole of Vietnam and include all fish (Vietnam has a substantial marine fishery), and so should be regarded as indicative only. The figure for 2000 of 45 kg/person/year is somewhat less than the van Zalinge et al. (2003) figure of 60 kg/person/year, but nevertheless substantially above some other estimates.

The aquaculture production reported by van Zalinge et al. (2003) of 171,600 tonnes is less than the 242,000 tonnes of farmed fish, and 372,000 total farmed aquatic produce, reported in the official statistics. This presumably arises because much aquaculture produce is raised for export, and thus does not show in consumption surveys.

Figure 9 compares the GVP of fisheries production from 1999 with the GVP of crop and livestock for the Mekong part of Vietnam using both the lowest estimates from the national statistics and the highest estimate based on van Zalinge et al. (2003). Crop and livestock production shows no trend, whereas there an increase of the contribution of the fisheries sectors from 1999-2004. This growth in fisheries sector is predominantly due to the growth in the Mekong Delta (figure 10), whereas the contribution of the Central Highlands is negligible, less than 1% of the total (figure 11). In the Central Highlands, there is an increase in the crop sector since 2001 due to the rapid increase of income from the non-rice crops (Mainuddin et al., 2008).

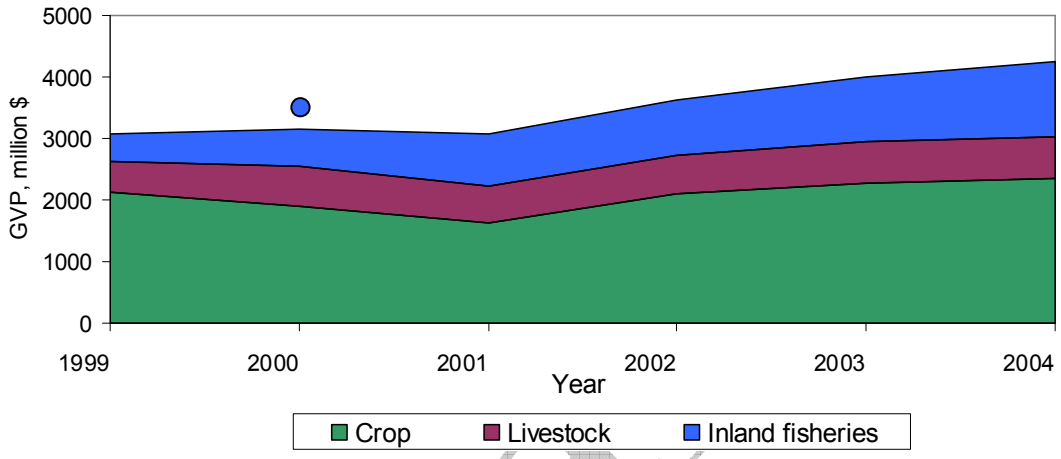

Figure 9 Contribution of different sector on overall agricultural production of Vietnam. The blue point shows the high estimate of van Zalinge et al. (2003).

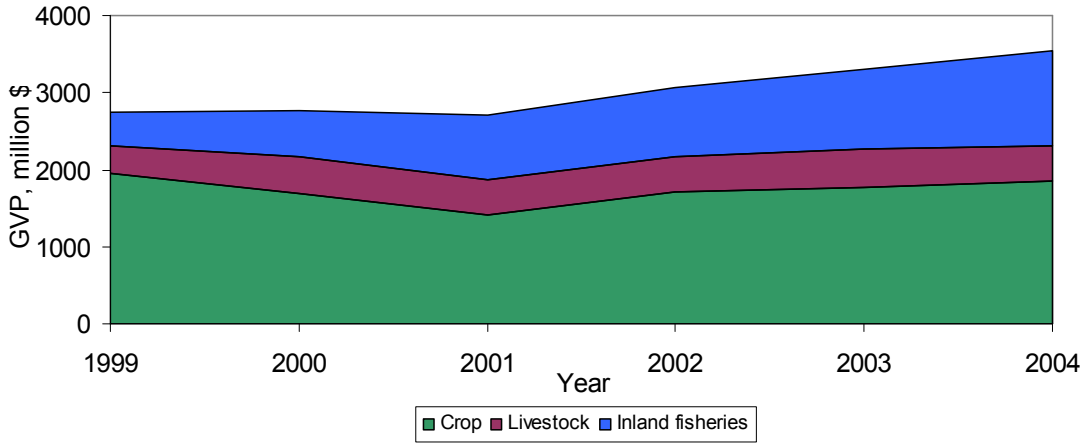

Figure 10 Contribution of different sector on overall agricultural production of the Mekong Delta of Vietnam

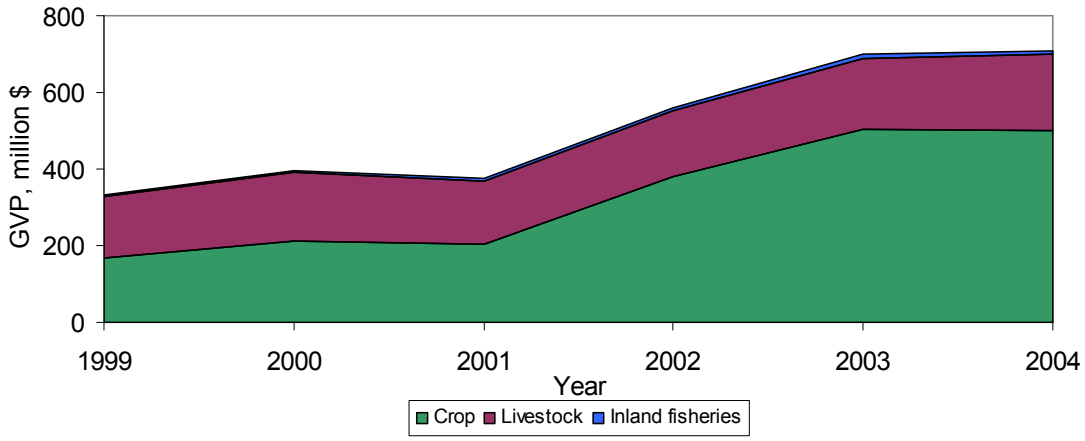

Figure 11 Contribution of different sector on overall agricultural production of the Central Highlands of Vietnam

Figures 12 to 14 show the comparison of per capita GVP of different sectors for Vietnam total (Delta plus Central Highlands), the Delta and the Central Highlands, respectively. The trend is obviously similar to that of the figures showing the contribution of different sectors. As with Laos and Cambodia, the low estimate of the official figures still places fisheries, especially aquaculture, as more important than many crops and more important than the livestock sector. The fishery figures are dominated by the production in the Delta.

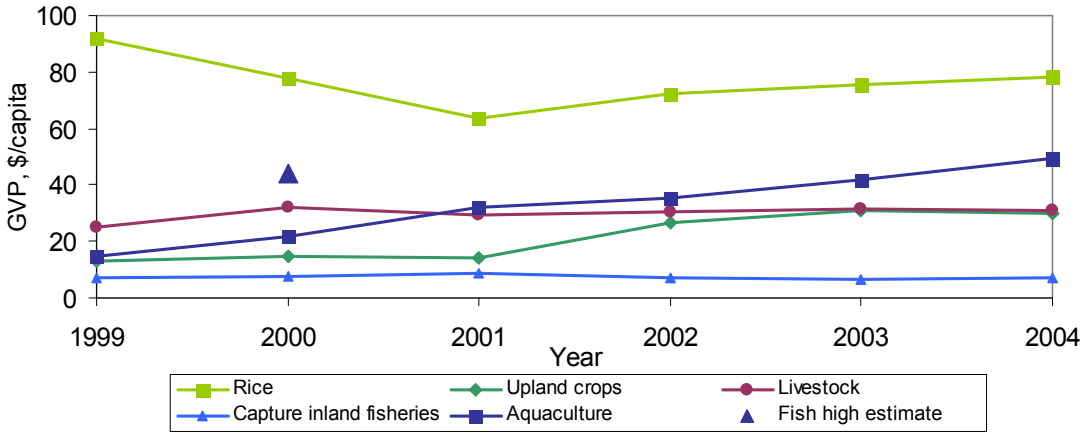

Figure 12 Comparison of GVP per capita of different production sector of Vietnam

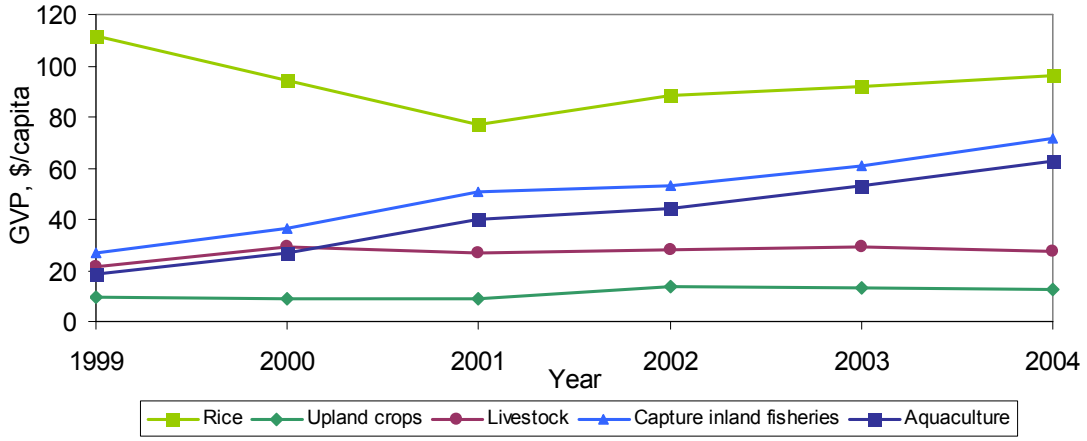

Figure 13 Comparison of GVP per capita of different production sector of the Mekong Delta of Vietnam

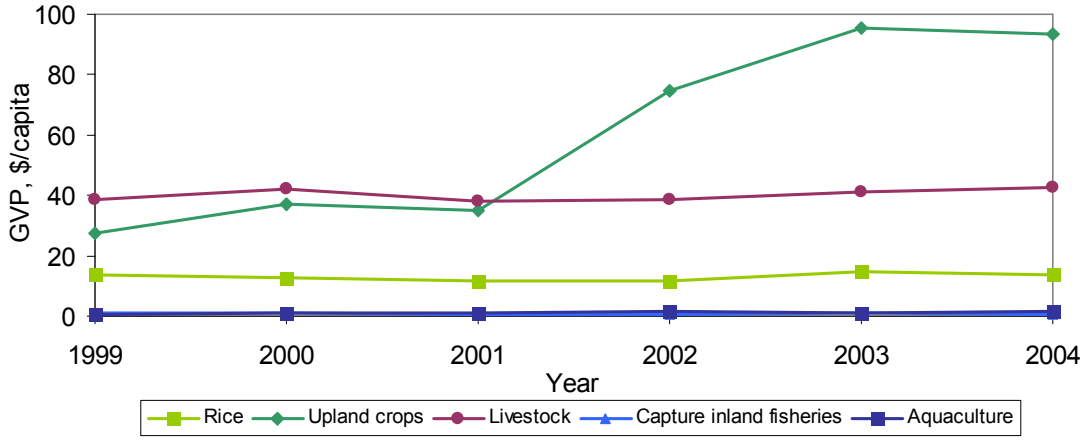

Figure 14 Comparison of GVP per capita of different production sector of the Central Highlands of Vietnam

3.5 Varying estimates of overall production

The estimates of the production and value of fisheries varies considerably. Production estimates based on national statistics are known to miss much of the catch, and provide unreasonably low estimates. Consumption based figures are believed to provide much better indications of the overall production, but estimates nevertheless vary as much as fivefold from the FAO health and nutrition surveys (Petracchi, 1999a and 1999b) to those that led to the figures reported by van Zalinge et al. (2003). The consumption based figures have been subject to upward revision, with the earlier figures reported by Petracchi (1999a, 1999b) superseded (FAO 2007). The van Zalinge estimates are the highest estimates reported for the countries of the Lower Mekong Basin, but are generally regarded as the best available (eg Baran et al., 2007). The more recent report by Hortle (2007) gives figures similar to but a little lower than those of van Zalinge et al. (2003), and higher than most other estimates. The Hortle figures may now be the best available estimates. The per capita consumption figures in Hortle (2007) are, however, somewhat lower than those given by van Zalinge et al.(2003), at 37 (Cambodia), 29 (Lao PDR), 29 (Thailand) and 39 (Vietnam)

kg/person/year (Hortle, 2007), compared to 65, 42, 53 and 60 respectively (van Zalinge et al., 2003).

Table 9 shows that the difference between the official production estimates and the consumption estimates is greatest in NE Thailand in absolute terms (about 200,000 compared to 1.2 million tonnes in 2000, a factor of six), but proportionally greatest in Cambodia (about 99,000 compared to 719,000 tonnes in 2000, a factor of about 7). The difference is proportionally less in Vietnam (factors of about 2 in 2000), but the production estimate includes exported aquaculture fish. The table also includes the production estimates for 2005 (Vietnam) or 2002-4 (average, Cambodia, Laos and Thailand), to show that in Cambodia and Vietnam these estimates increased greatly over those years, and approach the consumption based estimates. The increase in the reported production in Cambodia after 1998 results from the better surveys and inclusion of smaller scale fishing, though the increased estimates appear not to have flowed through for a few years. In Vietnam, most of the increase is due to aquaculture much of which is exported and, again, this does not figure in the consumption based estimate.

Other factors may confound these comparisons, including
- the export and import of fish (especially from Cambodia to NE Thailand),
- the consumption of marine fish especially in the Mekong delta region of Vietnam, and
- the differences between the Central Highland and Mekong Delta regions of Vietnam, with the van Zalinge et al. (2003) high estimates appearing to be for the Mekong Delta region only. The production in the Central Highlands, while it may be seriously underestimated by official figures, is nevertheless likely to be small.

Table 9 Production and per capita consumption, lowest and highest estimates. The low estimates are from official production statistics, and the high estimate is taken from van Zalinge et al. (2003). Production figures all rounded to the nearest 1000 tonnes.

Country	Year	Total production, tonnes		Capture, tonnes		Aquaculture, tonnes		Consumption, kg/person/yr		Population, million
		Low	High	Low	High	Low	High	Low	High	
Cambodia	2000	99000	719000	86000	682000	14000	14000	9	65	11
	2002-4	304000		283000		21000		23		13
Laos	2000	29000	205000	na	183000	na	5000	6	42	4.9
	2002-4	31000		na		na		5		5.8
Thailand	2000	201000	1188000	na	932000	na	68000	9	53	22.5
	2002-4	199000		na		na		8		23.5
Vietnam[a]	2000	598000	1022000	225000	845000	242000	172000	35	60	17
	2005	1170000		176000		638000		69		17
total / average	2000	928000	3133000					15	55	55.4
	2005	1704000						27		59.3

[a] The high estimate for Vietnam appears to be for the Mekong Delta alone.

Table 9 also shows the per capita consumption. Most of the estimates based on reported production give values of around 5 – 10 kg/person/year. The Cambodian consumption rises in the 2002-4 average to around 23 kg/person/year. The Vietnam

consumption figure based on the reported production is much higher, but is biased by the exported aquaculture produce. In contrast to the production estimates, the high estimate is of consumption of between 42 and 65 kg/person/year. The Cambodian consumption at 65 kg/person/year is comparable to that of Japan. FAO nutrition and health surveys (Petracchi 1999a, 1999b; Kaufmann, 2003) for Cambodia, Laos and Vietnam reported consumption generally around 12 kg/person/year, whereas FAOSTAT (2007) revises these earlier estimates and gives the higher consumption figures shown in Figure 15 for Cambodia, Thailand and Vietnam. These figures are for the whole countries and also include marine fish, but they show that FAO estimates, like other estimates in the Mekong, have risen recently. They give consumption figures approaching those of the van Zalinge et al. (2003) estimate for Cambodia, and between that implied by the reported production and the consumption survey figures reported by van Zalinge et al. (2003) for Thailand and Vietnam.

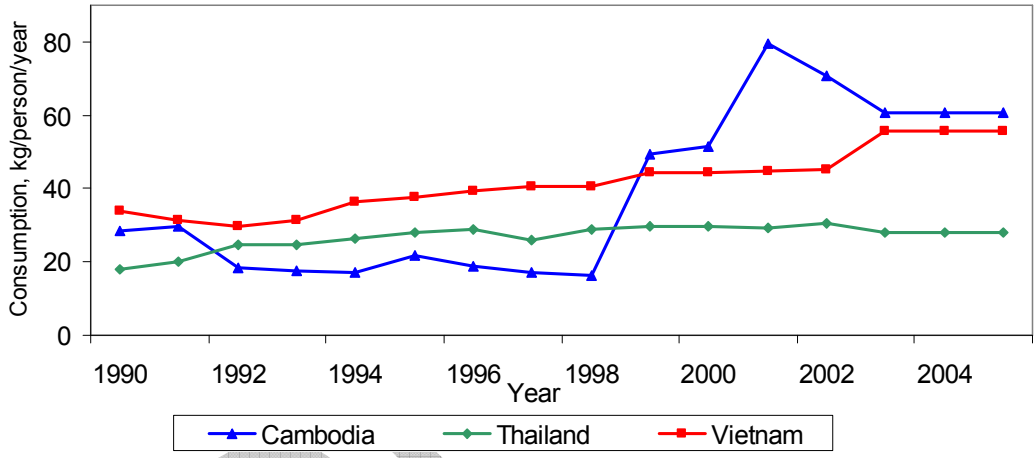

Figure 15 Consumption figures from FAOSTAT (2007)

The values reported in the high estimate of van Zalinge et al. (2003) were supported by Hortle and Bush (2003) with the following arguments.

- Small scale production and consumption surveys show reasonable agreement (no reference or data are given).
- Floodplain area yield estimates, while viewed as generally unreliable (Hortle and Bush, 2003), do lead to production estimates similar to the consumption estimates. Hortle and Bush quote a yield of 230 kg/ha/year and a floodplain area of 9.69 million ha, giving a yield of 2.23 million tonnes, which is similar to the total production estimate of 3.1 million tonnes. We will admit to not fully understanding this argument, since the bulk of the Lower Mekong floodplain is in Cambodia and Vietnam (the Tonle Sap alone expands by approximately this area when in flood), so this would imply that the production is mainly in Cambodia and Vietnam only, whereas the argument is used to support large estimated production in all parts, and particularly in NE Thailand. So, while not questioning the estimated consumption values, we find this a weak argument.
- Consumption in the four Lower Mekong countries is similar to that in some developed countries where fish is a small part of the animal protein intake, and less than that in developed countries where fish are an important part of the diet (such as Japan). Again, we do not fully understand this argument, since: 1. there is known to be a general correlation between all animal protein intake, including fish, and income and other development factors such as urbanisation (eg Huang and Bouis, 1996; York

and Gossard, 2004[1]), which might be taken to suggest that lower consumption of the Mekong countries is a reasonable expectation; 2. The suggestion that consumption is therefore comparable to Japan, which has a similar proportion of fish in the animal protein intake, is with a country that is free of many of the nutrition problems of the Lower Mekong countries, again suggesting that a lower consumption is a reasonable expectation. This does not mean the estimates are wrong, but these comparisons require much care and can point to conclusions other than those claimed.
- Expatriate LMB nationals in Washington, US, consumed quantities similar to those found in the consumption surveys. However, this does not take account of the correlation between animal protein consumption and income and other factors such as urban living. Again, while not questioning the estimated consumption values, we find this a weak argument.

Thus, we do not question the estimates of van Zalinge et al. (2003), but we think the greater arguments are in the survey work itself and in the more recent FAOSTAT estimates, not in the other evidence offered by Hortle and Bush (2003).

3.6 Regional and temporal trends in production and value

Notwithstanding the different estimates of production and consumption, the overall picture is of greater and increasing per capita production and consumption in Cambodia and Vietnam (around 55 and 50 kg/capita/year respectively if we take the FAOSTAT (2007) estimates as compromise figures, bearing in mind the possible whole-country and marine fish bias). In Thailand and Laos, the amounts are somewhat lower and more static with time (perhaps around 30 kg if again we take the FAOSTAT (2007) estimates as compromise figures, bearing in mind the possible whole-country and marine fish bias). The absolute figures change in the different estimates, but all estimates find this broad regional trend. In Cambodia and Vietnam, consumption appears to have increased, whereas in Thailand it appears to have remained fairly static. Estimates of consumption over several years in Laos are not available. The whole country (and, for Vietnam and Thailand, therefore possibly unreliable) FAOSTAT figures are the only consistent evidence for this.

Reported production estimates are not reliable but, to the extent that they help build the picture, they show that the overall production of caught fish is large in the Mekong delta, Cambodia and Thailand, and smaller in Laos and the Central Highlands of Vietnam, and not increasing greatly with time (Figure 16). The figure for Thailand is for the whole country. Aquaculture production is dominated by the Mekong delta region and is small elsewhere (Figure 17). Aquaculture production has grown dramatically in the Delta in recent year (Mekong River Commission, 2007; also USDA, 2007, though the figures given here are for the whole of Vietnam). Vietnam anticipates continued rapid growth, and expected catfish production alone to exceed 1,000,000 tonnes by 2007 (Mekong River Commission, 2007). The total production (caught product plus aquaculture) is greatest in the Mekong delta (Figure 18). The great growth since 2000 is generally missed by other publications including Baran et al. (2007), and only mentioned in passing by Hortle (2007).

[1] Hortle (personal communication) disputes the correlations described by York and Gossard as being based on flawed fish consumption surveys, and suggests that the correlations are an artifact of the surveys.

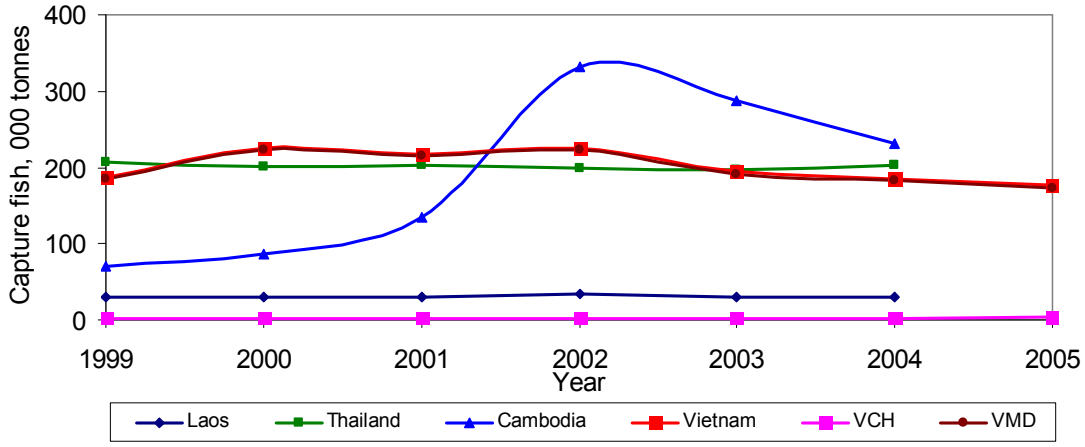

Figure 16 Capture fish production from official statistics.

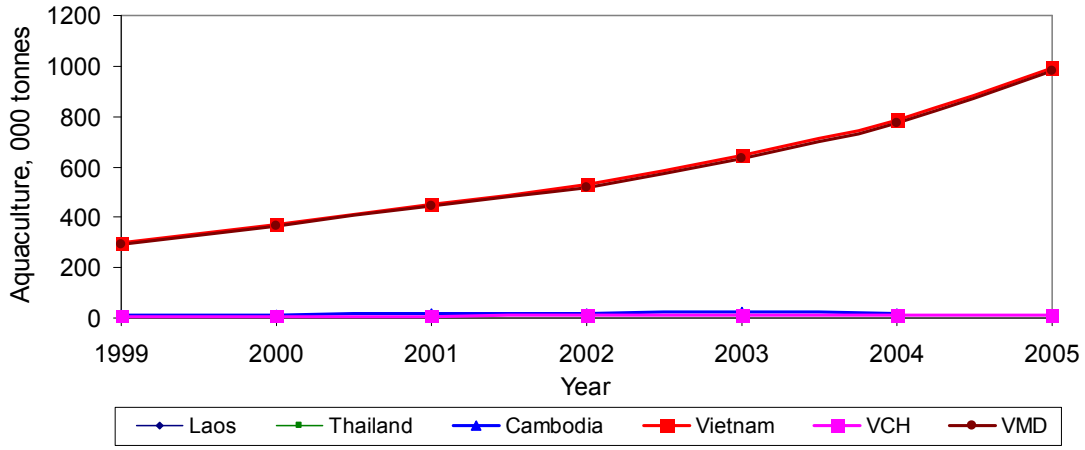

Figure 17 Aquaculture production from official statistics.

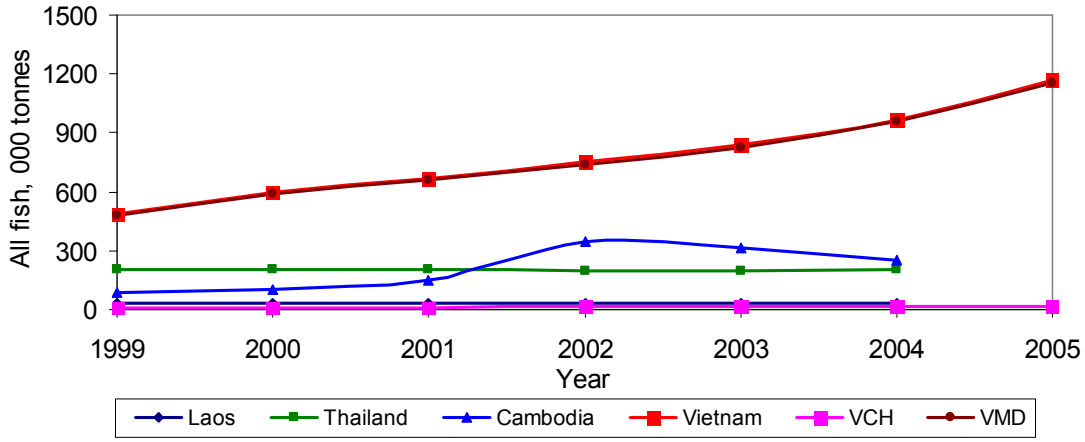

Figure 18 Total fish production from official statistics.

The gross value of production calculated from the reported production estimates are also not reliable but, again to the extent that they help build the picture, they show that the overall value of fish is large and increasing in the Mekong delta, mainly because of high value (and largely exported) aquaculture production (Figure 19). Cambodia and Thailand have smaller production, increasing (probably mainly a reporting

artefact) in Cambodia, and static in recent years in Thailand. Note that the figure for Thailand is for the whole country. The value is smaller in Laos and the Central Highlands of Vietnam, and not increasing greatly with time.

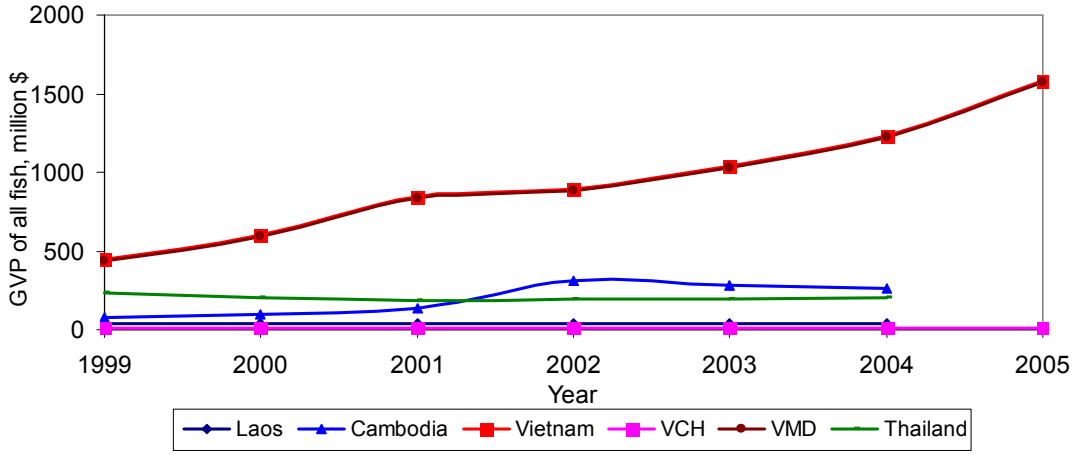

Figure 19 Value of total fish production from official statistics.

Van Zalinge et al. (2003) gave the total value in 2000 as exceeding $1.7 billion. According to MRC (Mekong River Commission, 2005), the total value of fish was in the order of $2,000 million in 2000, at about $800 million in Thailand, $750 million in Vietnam, $500 million in Cambodia and $150 million in Laos. This puts the total value at about two to three times that shown in the figures above.

Figure 20 shows the gross value of fisheries production as percentage of the gross value of rice production. Since 1999, the gross value of fisheries production has increased significantly compared to the gross value of rice production. As a result the contribution from fisheries sector to the total (crop, livestock and fisheries) agricultural production has also increased (Figure 21). The value as a proportion of the rice value or total agricultural and fish value is greater in Cambodia and Vietnam. Using the higher figures of van Zalinge et al. (2003) and Mekong River Commission (2005), the value relative to rice, or total agricultural and fish production, would be significantly greater. The value of fish would be greater than that of rice in both Cambodia and Vietnam in recent years.

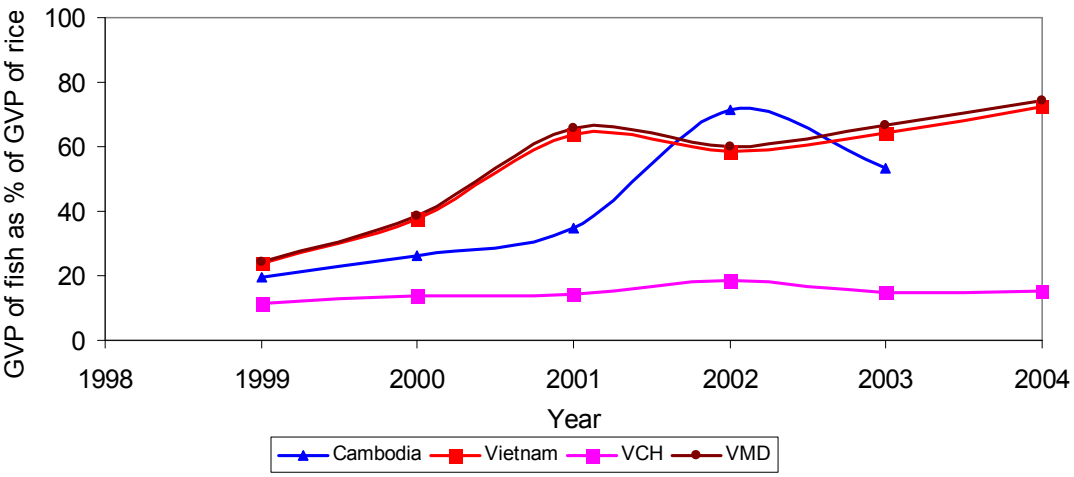

Figure 20 GVP of fisheries as percentage of GVP of rice

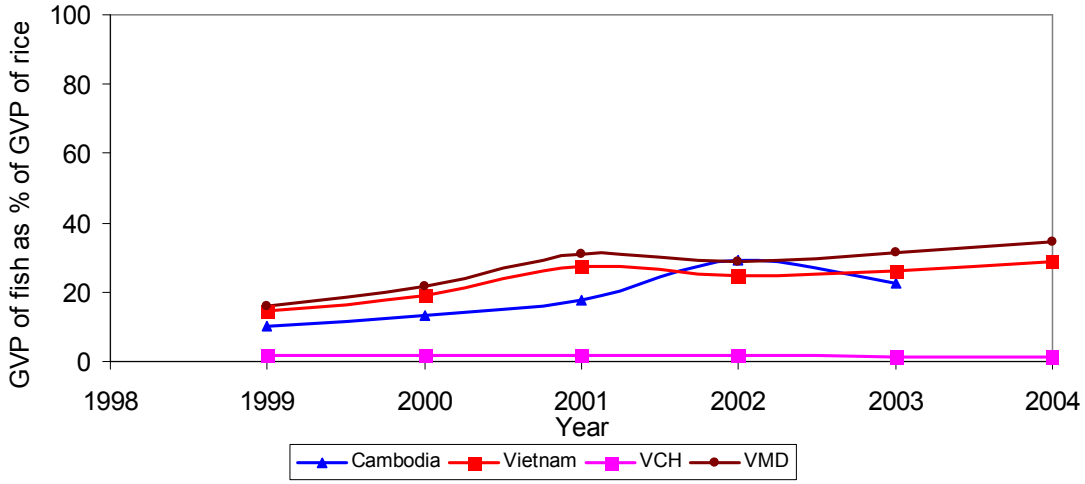

Figure 21 GVP of all fisheries as % of GVP of crops, livestock and fisheries

While the available data appear sufficient to establish broad trends, there is clearly much uncertainty. Fish as food and income are very important in the Mekong, as are the rivers and wetlands where they breed and grow. There is a clear need for more and better estimates of production (including production for export) and consumption.

4 Threats and Opportunities in Mekong Fish Production

The population of the Lower Mekong Basin is likely to rise from the present 60 million or so to perhaps 80 million or more by 2020 and greater than 90 million by 2050 (based on medium variant projection, UN Population Division, 2006). Delgado et al (2007) suggest that fish consumption in SE Asia to 2020 will grow at between 1.4 and 1.7 % per annum, partly because of rising population and partly because of improving diets with increasing development (York and Gossard, 2004). Sokhem and Sunada (2006) suggest that an increase of between 0.4 and 1.6[2] million tonnes/year will be required by 2050, based on a production of 3.1 m tonnes in 2003. These increases are roughly proportional to the expected increase in population, and therefore appear not to anticipate increase in fish in the diet. A growth rate of 1.4 % per annum, as suggested by Delgado et al. (2007), from the 3.1 m tonne base figure in 2003 would lead to an increase in demand of 0.8 and 2.9 million tonnes/year to 2020 and 2050, respectively, and a growth rate of 1.7 % per annum would lead to increases of 1.0 and 3.7 million tonnes/year.

At the same time, there are concerns about several threats to the capture fisheries of the Lower Mekong Basin (Sverdrup-Jensen, 2002; Mekong River Commission, 2003; Vanhan, 2004; Mollot et al. 2005; Baran et al. 2001a, Baran et al, 2007).

- Removal of rapids, siltation, changes to vegetation, etc., results in the destruction of spawning grounds and dry season fish refuges.
- Dam construction and increased diversions change the quantity and timing of flows for sensitive habitats and especially the annual flooding (which is associated with a large increase in fish populations). Dam development will alter the timing and magnitude of flows, in particular flood peaks will decrease (Podger et al., 2004), hence the seasonal expansion of the Tonle Sap and flooding of seasonal wetlands elsewhere in the basin will be reduced. This will in turn jeopardise fisheries production, since the production is correlated to the magnitude of the flood (eg Baran et al., 2001b, 2007). Although the change in flows may not be great, the impact on fisheries could nevertheless be considerable (Baran et al., 2007).
- Sediment trapping in completed hydropower dams in the upper Mekong has led to reduced sediment transport downstream leading to concerns that this will limit the supply of fresh nutrients for ecosystems and streams in the lower basin, and hence to fish production (Kummu and Varis, 2007). Water quality may also be affected by increased sediment load due to deforestation, etc.
- Dams and weirs present physical barriers which limits migration. Declines in fish production in the lower Mun River after the development of the Pak Mun dam was largely due to the constraint on migration (Amornsakchai et al., 2000). The proposed Don Sahong dam appears likely to repeat this experience (Baran and Ratner, 2007).

[2] Sokhem and Sunada give the increase to 2050 as 1.29 million tones, but in two places state that 4.7 million tones will be required, which is an increase of 1.6 million tonnes over the 3.1 million tonne base in 2003. The 1.29 million tones is obviously an error.

- Overfishing, of large species in particular and also of the whole assemblage (Allan et al., 2005). Baran et al. (2007) suggests that illegal fishing and overfishing is a problem in the Tonle Sap and Delta regions.

In addition, concern is expressed about the ability of international institutions and agreements to deal with these issues, and the inadequacy of environmental impact assessments in respect of aquatic habitat and biodiversity (eg Sokhem and Sunada, 2006; Hirsch, 2005; Campbell and Parnrong, 2001).

Notwithstanding the threats, there has been considerable growth in aquaculture in the Lower Mekong Basin, particularly in the Delta in Vietnam. It is the only growth in production that can reliably be established from all the estimates discussed in section 3. The growth was about 400,000 tonnes/year in aquaculture in the Mekong delta over the five years from 2000. Aquaculture in the Delta is thus currently increasing production at a rate sufficient to cope the anticipated future demand. It is reasonable to suppose that further growth is likely. However, much of the production was for export: continued growth in export increases further the pressure on future production. Furthermore, the growth in aquaculture cannot be expected to increase indefinitely and does carry an environmental cost. Aquaculture growth depends on wild fish fry or trash fish as a feed and also on the introduction of exotic species (Vu and Bach, 2005; Baran et al., 2007), so the growth may be limited and may also pose an additional threat to capture fisheries. Baran et al. (2007) argue that therefore the emphasis should be on the protection of the current wild fish resources. Coates (1996) viewed opinions about the prospects for aquaculture growth as being over-optimistic, but having some justification, and also argued for the preservation of current resources.

Rice fish farming systems offer prospects for improved production and livelihoods, but they must be managed with considerable care as integrated systems so that rice farming and pesticide use does not affect the fish production (Berg, 2002; Nguyen-Khoa et al., 2005; Frei and Becker, 2005). In addition, the reservoirs for irrigated rice production yield extra fish (Sverdrup-Jensen, 2002), and the total fish from a reservoir and rice-fish paddy system may be greater than the loss of fish due to irrigation infrastructure (Nguyen-Khoa et al., 2005). Baran et al. (2007), on the other hand, caution that aquaculture production is likely to be less than the loss of production from capture fisheries. What is not clear from these studies is how much rice production is accompanied by fish production, though the implication of the studies is that current levels are low. Nor is the potential level of production quantified. How much current rice production could be accompanied by fish production? What would be the production of fish if it all were so managed?

Given these competing factors, what are the prospects for increasing fisheries productivity to meet the likely increased demand to 2020 and 2050? The available information appears inadequate to fully answer this question but we may note that:

- if overfishing is beginning to change the size and composition of the catch, that capture fisheries may not be able to meet the increased demand;
- in addition, there is no indication of growth in the capture fishery production estimates, with the national statistics being unreliable and the consumption based figures being just for one year, again indicating that capture fisheries may not be able to meet the increased demand;

- nevertheless, since capture fisheries are the largest sector of fisheries production, the prospects of meeting demand will be seriously jeopardised by any reduction in the current capture fishery resulting from dams and other developments and consequent changes to hydrology, so it is crucial that developments be sustainable and not impact river ecology and fisheries;
- the reservoir catch may offer scope for increased production, though presumably not at a scale to meet the demand;
- rice-fish systems may also offer scope for increased production, though the impact basin-wide has not been quantified;
- aquaculture has grown dramatically in recent years, at a rate far above that required to meet future demand (it is nearly doubling every year). It therefore appears in principle to be well capable of meeting the demand. However, we are not aware of any study that quantifies the physical, social or other limits to aquaculture production. As mentioned by Baran et al. (2007) growth that relies on wild fish fry may be limited, but the implications of this are not quantified.

So will fishery production meet the anticipated demand? As shown, the current estimates give no means of quantitatively answering the question, and we enter the realms of speculation and opinion. We offer as speculation four scenarios: no doubt more are possible. They are not mutually exclusive.

1. Decline of the capture fishery. As demand rises, there is unchecked overfishing and illegal fishing of the capture fishery resource, combined with changed flow regimes resulting from upstream dam development and irrigation diversion. The fishery for a while yields extra production with change in size of individuals and species in the catch, but ultimately declines greatly. This is similar to the experience in Bangladesh (eg World Bank, 2006, Chapter 4), and for a similar mix of physical and institutional reasons.

2. Maintenance of the capture fishery. Many dams are built, but mostly well upstream on the main channel and in the tributaries, and the management of releases limits the impact on flows; the Don Sahong and other high impact dams are not built. The trans-boundary agreements are struck to bring this about. In the main downstream fisheries, the institutions (especially community management and a system of enforced access and property rights) are put in place. Cambodia experimented with community access in 2000, though the system was incomplete and not very successful (Ratner, 2006).

3. Unchecked, export driven rise in aquaculture. The current growth in aquaculture in the Delta continues, and spreads to areas upstream. While the growth in production is sufficient to satisfy the growing demand, most of it goes to export. The benefits are thus mainly income, and confined to those directly and indirectly employed in the sector and those who own production and marketing facilities. The rural poor outside this sector benefit little, and indeed are disadvantaged by competing for fish at higher prices. In addition, there is largely unchecked adverse impacts on the environment, ranging from destruction of other habitats (including mangroves and wetlands), pollution, pressure on capture fisheries to provide feed, and disease pressures from farmed fish.

4. Regulated rise in aquaculture. The current growth in aquaculture is maintained, but the emphasis shifts to rice-fish and small pond systems (as in Bangladesh), with much of the increase being for local consumption. This scenario will only be realised with considerable local extension and education, backed by research into local management factors, species, and social uptake. This scenario, coupled with maintenance of the capture fisheries, is the only one which copes with the projected increase in future local demand.

Our main point in describing these scenarios is to emphasise that there are choices, and not all lead to outcomes that will maintain the current level of fish in the local diet.

5 Conclusions

There are major uncertainties in estimates of fisheries production and value in the Lower Mekong Basin. Catch surveys underestimate the production, although recent catch survey estimates in Cambodia report production since 2001 greatly larger than in earlier years probably as a result of taking non-commercial catch into account. Consumption surveys generally result in higher estimates of production, but nevertheless a range of values is reported. The highest estimates are from 42 kg/capita/year in Laos to 65 kg/capita/year in Cambodia. However, the data and methods supporting the higher estimates appear not to be readily publicly available.

Fisheries production is dominated by capture fisheries in Cambodia (where it is concentrated around the Tonle Sap and the Mekong), Laos and Thailand. In Vietnam, aquaculture dominates production, and is concentrated around the main rivers in the delta and along the coastal strip.

The uncertainties over production estimates make other conclusions tentative, but it appears that production from capture fisheries increased relatively little from about 1995 to 2005 in all four Lower Mekong countries. A large reported increase in Cambodia in recent years appears to be a change in estimation methods rather than a true increase in production. In aquaculture, there is a clear, large increase in production in the Mekong delta region of Vietnam since about 2000. Probably, much of the increased production is exported.

The value of the fisheries is, like the production, somewhat uncertain. The greatest estimates of value, using the consumption based estimates of production, put the value of the 2000 catch at about $3 billion. Other estimates (including those using other consumption figures) place the overall value somewhat lower. The value is probably not changing greatly with time, though again the range of estimates and poor data mean that this conclusion is tentative. Aquaculture in Vietnam is rapidly increasing in value, to match the increase in production, and in 2005 was worth over $1 billion. Aquaculture is also growing in Cambodia but the practice is probably still in its infancy.

The contribution of fisheries sector to overall agricultural (crop, livestock and fisheries) production is significantly small in Laos and Thailand. The crop sector is the biggest contributor in all countries. The contribution from fisheries is smaller than that of livestock in Laos and Thailand and bigger than that in Cambodia and Vietnam. However, whereas there is growth in the fisheries sector in recent years in Vietnam the growth in crop and livestock sector remains more or less static.

The demand for fish produce will inevitably rise in the future, partly as a result of increasing population in the region and partly as a result of increasing incomes. Over and above this, there may also be a continuing rise in the export of fish products.

The Lower Mekong fisheries face threats to production from changed water availability, quality, barriers to fish migration and overfishing. If the increased demand is to be met, these threats must be managed such that developments do not reduce the production of fish, especially capture fish.

The increasing demand appears unlikely to be met through an increase in production of capture fisheries. The current rapid growth of aquaculture, if it can be maintained, appears capable of meeting the demand. However, there are no quantitative estimates of the limits to growth of this industry, nor whether it will pose risks for the capture fisheries bay taking small fish fry as feed for aquaculture fish. Therefore, whether the current growth of aquaculture can be maintained is unclear. Rice fish farming may also contribute to increased production, but again the impact appears not to have been quantified.

References

Ahmed, M., Navy, H., Vuthy, L., and Tiongco, M., 1998. Socio-economic assessment of freshwater capture fisheries of Cambodia: Report on a Household Surveys. Mekong River Commission, Phnom Penh, Cambodia. 186p.

Allan, J.D., Abell, R., Hogan, Z., Revenga, C., Taylor, B.W., Wellcome, R.L. and Winemiller, K., 2005. Overfishing of inland waters. Bioscience, 55, 1041-1051.

Amornsakchai, S., Annez, P., Vonvisessomjai, S., Choowaew, S., Kunurat, P., Nippanon, J., Schouten, R., Sripapatrprasite, P., Vaddhanaphutri, C., Wirojanagud, W., Watana, E., 2000. Pak Mun Dam, Mekong River Basin, Thailand. World Commission on Dams Case Study, final report. Secretariat of the World Commission on Dams, Cape Town. Available at: http://www.dams.org/docs/kbase/studies/csthmain.pdf (accessed July 2008).

Baran, E. and Cain, J., 2001. Ecological and modelling approach to flood-fish relationships in the Mekong river basin. Contribution to the National Workshop on Ecological and Environmental Modelling (ECOMOD 2001), 3-4 September 2001, Universiti Sains Malaysia, Penang, Malaysia. 6 pp.

Baran E., Jantunen T. and Chong C. K., 2007. Values of inland fisheries in the Mekong River Basin. WorldFish Center, Phnom Penh, Cambodia. 76 pages.

Baran, E. and Ratner, B., 2007. The Don Sahong dam and Mekong fisheries: a science brief from the WorldFish Centre. The WorldFish Centre, Penang.

Baran E, Van Zalinge N, Ngor, P. B. (2001a). Floods, floodplains and fish production in the Mekong basin: present and past trends. Contribution to the Asian Wetlands Symposium 2001, 27-30 August 2001, Penang, Malaysia. 11 pp.

Baran E., Van Zalinge N., Ngor Peng Bun, Baird I.G., Coates D. (2001b). Fish resource and hydrobiological modelling approaches in the Mekong Basin. ICLARM, Penang, Malaysia and the Mekong River Commission Secretariat, Phnom Penh, Cambodia. 60 pp.

Barker, R., Dawe, D. and Inocencio, A., 2003. Economics of Water Productivity in Managing Water for Agriculture. In: Water Productivity in Agriculture: Limits and Opportunities for Improvement, Kijne, J. W., Barker, R. and Molden, D. (eds), Comprehensive Assessment of Water Management in Agriculture Series, No 1. International Water Management Institute, Sri Lanka.

Berg, H., 2002. Rice monoculture and integrated rice-fish farming in the Mekong Delta, Vietnam—economic and ecological considerations. Ecological Economics, 41, 95-107.

Bouakhamvongsa, K., Viravong, S., and Hortle, K. G., 2005. Monitoring river fishers along the Mekong River in Lao PDR. In: Burnhill, T.J. and Warren, T.J. (Eds). Proceedings of the 7th Technical Symposium on Mekong Fisheries, MRC Conference Series, No 6, Mekong River Commission, Vientiane, Lao PDR.

Bush, S.R., 2004. Scales and sales: changing social and spatial fish trading networks in the Siiphandone fishery, Lao PDR. Singapore Journal of Tropical Geography, 25, 32-50.

Campbell, I.C. and Parnrong, S., 2001. Limonology in Thailand: present status and future needs. Verhandlungen der Internationale Vereinigung fur Theoretische und Angewandte Limnologie 27: 2135-2141.

Chong, C. K., Ahmed, M., Valmonte-Santos, R. A., and Balasubramanian, H., (undated). Review of Literature on Values of Inland Capture Fisheries and Dams Construction at the Lower Mekong and Ganga Basins. Available at http://www.iwmi.cgiar.org/assessment/files_new/research_projects/Paper_Chong%20et%20al_ICLARM.pdf

Coates, D., 1996. Inland fisheries and food security. Catch and Culture: Mekong Fisheries Network Newsletter, 2 (1).

Coates, D., 2002. Inland Capture Fishery Statistics of Southeast Asia: Current Status and Information Needs, FAO RAP publication 2002/11, 114 pp.

Cowx, I. G., Almeida, O., Bene, C., Brummett, R., Bush, S., Darwall, W., Pittock, J. and van Brakel, M., 2003. Session 2 Review: Value of River Fisheries. In. Welcomme, R. L., and Petr, T. (eds.) Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries: Sustaining Livelihoods and Biodiversity in the New Millennium, 11th-14th February, 2003, Phnom Penh, Cambodia.

Delgado, C.L., Wada, N., Rosegrant, M.W., Meijer, S., and Ahmed, M., 2007. Fish to 2020: Supply and Demand in Changing Global Markets. International Food Policy Research Institute, Washington, DC, and WorldFish Center, Penang, Malaysia

Department of Fisheries, 2001a. Trade, Marketing and Processing of Fisheries and Fisheries Product Review. Technical Report No. 6, MoF, Phnom Penh, Cambodia. http://www.maff.gov.kh/pdf/TradeMarketingandProcessingReview.pdf

Department of Fisheries, 2001b. Internal Fisheries Review. Technical Report No. 2, MoF, Phnom Penh, Cambodia. http://www.maff.gov.kh/pdf/InlandFisheriesReview.pdf

Diep, L., S. Ly and N.P.van Zalinge, (Eds.), 1998. Catch statistics of the Cambodian Freshwater Fisheries. Mekong River Commission, 146p.

Dyg, P.M., 2006. Understanding malnutrition and rural food consumption in Lao PDR. Journal of Food Composition and Analysis 19. 763–764.

Frei, M., and Becker, K., 2005. Integrated rice-fish culture: Coupled production saves resources. Natural Resources Forum, 29, 135–143.

FAO, 2003. Nutrition Country Profile – LAOS. FAO, Rome.

FAO, 2008. National aquaculture sector overview, Vietnam. http://www.fao.org/fishery/countrysector/naso_vietnam,

FAOSTAT, 2007. http://faostat.fao.org/

Hirsch, P., 2005. The politics of fisheries knowledge in the Mekong River Basin. Australian Mekong Resource Centre, University of Sydney.

Hortle, K.G. and Bush, S.R., 2003. Consumption of fish and other aquatic animals in the Lower Mekong Basin. MRC Technical Series, in preparation.

Hortle, K.G., S. Lieng and J. Valbo-Jorgensen., 2004. An introduction to Cambodia's inland fisheries. Mekong Development Series No. 4. Mekong River Commission, Phnom Penh, Cambodia. 41 pages. ISSN 1680-4023.

Hortle, K.G., 2007. Consumption and the yield of fish and other aquatic animals from the Lower Mekong Basin. MRC Technical Paper No. 16, Mekong River Commission, Vientiane. 87 pp.

Hortle K.G. and Suntornratana, U., 2008. Socio-economics of the fisheries of the lower Songkhram River Basin, northeast Thailand. MRC Technical Paper No. 17. Mekong River Commission, Vientiane. 85 pp.

Huang, J., and Bouis, H., 1996. Structural changes in the demand for food in Asia. International Food Policy Research Institute, 2020 Brief 41.

Jensen. J, 2000a. Save the Fish or lose the food security. MRCS in Mekong Fish Catch and Culture, Vol. 6 (1), p 1-2, September 2000, Phnom Penh.

Jensen, J., 2000b. Food security and inland fisheries. In SEAFDEC Fish Regional Technical Consultation on Fisheries Management for the Conference on Food security – Fish for the People. November 2000, Penang, Malaysia.

Kaufmann, S., 2003. Nutrition Country Profile of Laos Nutrition Country Profiles – LAOS July, 2003 FAO, Rome, Italy.

Khay, D. and Hortle, K. G., 2003. Monitoring sales of fish and other aquatic animals at retail markets in "Phnom Penh, Cambodia. Proceedings of the 6th Technical Symposium on Mekong Fisheries, 26-28 Nov 2003, MRC Conference Series No. 5, MRC.

Khumsri, M., Sriputtnibondh, N., and Thongpun, W., 2005. Fisheries co-management in Lower Songkhram River Basin: problems and challenges. In: Burnhill, T.J. and Warren, T.J. (Eds). Proceedings of the 7th Technical Symposium on Mekong Fisheries, MRC Conference Series, No 6, Mekong River Commission, Vientiane, Lao PDR.

Kummu, M. and Varis, O., 2007. Sediment-related impacts due to upstream reservoir trapping, the Lower Mekong River. Geomorphology, 85, 275-293.

Lam, P. T., Phuong, P. M., Visser, T., Sjorslev, J. G. and Hortle, K. G., 2002. Inland fisheries activities and fish consumption in Tra Vinh province, Viet Nam. 5th Technical Symposium on Mekong Fisheries, 11th – 13th December 2002, Mekong River Commission.

Mahasarakarm, O. P. N., 2007. An Introduction to the Mekong Fisheries of Thailand. Mekong Development Series No.5, Mekong River Commission, Vientiane, Lao PDR. 54 Pages.

Mainuddin, M., Kirby, M. and Chen, Y., 2008. Spatial and Temporal Pattern of Land and Water Productivity in the Lower Mekong River Basin. Basin Approach. Basin Focal project Working Paper No. 5, CGIAR Challenge Program on Water and Food. http://www.waterandfood.org/fileadmin/CPWF_Documents/Documents/Basin_Focal_Projects/BFP_Publications/Spatial_Temporal_Pattern_Land_Water_Productivity_Mekong_BFPWP5_pgs1-21.pdf

Mekong River Commission, 2003. State of the Basin Report. Mekong River Commission, Phnom Penh, Cambodia.

Mekong River Commission, 2005. Fisheries Program Phase 2, 2006-2010. August 2005, Mekong River Commission, Viantiane, Lao PDR.

Mekong River Commission, 2007. Catfish processing takes off in delta as global demand soars. Catch and Culture, 13, 2, September 2007. MRC, Vientiane, Lao PDR.

Meusch, Eric, Jintana Yhoung-Aree, Richard Friend, Simon Funge-Smith, 2003. The role and nutritional value of aquatic resources in the livelihoods of rural people: A participatory assessment in Attapeu Province, Lao PDR. Food and Agriculture Organization RAP publication 2003/11. FAO Rome.

Mollot, R., Phothitay, C. and Kosy, S., 2005. Hydrology, habitat and livelihoods on the floodplains of southern Lao PDR. In. Burnhill T.J. and Hewitt M.M. (eds). Proceedings of the 6th Technical Symposium on Mekong Fisheries, 26th – 28th November 2003. MRC Conference Series No.5. Mekong River Commission, Vientiane. 194 pp.

Nachaipherm, J., Nuengsit, S., Rukaewma, P., Taruwan, W., Nakkaew, S. and Sinsoontorn, S., 2002. Fisheries Activities and Catch Assessments of three Reservoirs: Nam Oon in Sakon Nakhon Province, Kaeng Lawa in Khon Kaen Province and Huai Muk in Mukdahan Province, Thailand. 5th Technical Symposium on Mekong Fisheries, 11th – 13th December 2002. Mekong River Commission, Phnom Penh, Cambodia.

Nakkaew, S., Nuengsit, S., Nachaipherm, J., Taruwan, W., Rukaewma, P. and Sinsoontorn, S., 2001. Preliminary fisheries activities and catch in Huai Luang reservoir, Udon Thani province, Thailand. 4th Technical Symposium on Mekong Fisheries, Phnom Penh, 10th-11th December 2001.

Nam, S., 2000. Geographic analysis of poverty status and aquatic resources use-focusing especially on the livelihoods of the poor- in Cambodia. Consultancy report for DFID. Department of Fisheries, Phnom Penh.

Naret, K., Viryak, S. and Griffiths, D., 2000. Fish price monitoring in Kandal, Prey Veng and Takeo Provinces of Cambodia. Proceedings of the 3rd Technical Symposium on Mekong Fisheries, Phnom Penh, 8-9th December 2000.

National Institute of Statistics, 2005. Statistical Yearbook 2005. National Institute of Statistics, Ministry of Planning, Kingdom of Cambodia.

National Statistics Centre NSC, 2003. Statistical Yearbook 2002. Committee for Planning and Investment, National Statistics Centre, Vientiane, Laos.

National Statistics Centre NSC, 2004a. Statistical Yearbook 2003. Committee for Planning and Investment, National Statistics Centre, Vientiane, Laos.

National Statistics Centre, NSC, 2004b. The Household of Lao PDR: Social and Economic Indictors. Lao Expenditure and Consumption Survey 2002/03, LECS 3. Committee for Planning and Investment, National Statistics Centre, Vientiane, Laos.

National Statistics Centre NSC, 2005. Statistics 1975-2005. Committee for Planning and Investment, National Statistics Centre, Vientiane, Laos.

Navy, H. and Bhattarai, M., 2006. Economic Assessment of Small-Scale Inland Fisheries and Wetland Livelihoods in Cambodia, Paper prepared for presentation at International River Symposium, Brisbane, Australia, 4-7, September, 2006.

Ngeth, L., Koun, S., Vibul, O., Cans, G. and Mattson, N., 2005. Economic evaluation of small-scale aquaculture of indigenous fish in Cambodia. In: Burnhill, T.J. and Warren, T.J. (Eds). Proceedings of the 7th Technical Symposium on Mekong Fisheries, MRC Conference Series, No 6, Mekong River Commission, Vientiane, Lao PDR.

Ngor, S., Deap A. L. and Hortle, K.G., 2005. The dai trey linh fishery on the Tonle Touch (Touch River), southeast Cambodia. In. Burnhill T.J. and Hewitt M.M. (eds). Proceedings of the 6th Technical Symposium on Mekong Fisheries, 26th – 28th November 2003. MRC Conference Series No.5. Mekong River Commission, Vientiane. 194 pp.

Nguyen-Khoa, S., Smith, L., and Lorenzen, K., 2005. Impacts of Irrigation on Inland Fisheries: Appraisals in Laos and Sri Lanka. Comprehensive Assessment Research Report 7. Colombo, Sri Lanka: Comprehensive Assessment Secretariat.

Pengbun, N., Sinath, A. and Hortle, K. G., 2005. The Dai Bongkong fishery for giant river prawns, Macrobrachium rosenbergii, in southeastern Cambodia. In: Burnhill, T.J. and Warren, T.J. (Eds). Proceedings of the 7th Technical Symposium on Mekong Fisheries, MRC Conference Series, No 6, Mekong River Commission, Vientiane, Lao PDR.

Petracchi, C., 1999a. Nutrition Country Profile of Cambodia. Nutrition Country Profiles -CAMBODIA-24 February 1999, FAO, Rome. Available at: ftp://ftp.fao.org/es/esn/nutrition/ncp/CMB.pdf

Petracchi, C., 1999b. Nutrition Country Profile of Vietnam. 2 March 1999, FAO, Rome. Available at:. ftp://ftp.fao.org/es/esn/nutrition/ncp/vie.pdf

Phillips, M.J., 2002. Fresh water aquaculture in the Lower Mekong Basin. MRC Technical Paper No. 7, Mekong River Commission, Phnom Penh. 62 pp. ISSN: 1683-1489.

Phimmachak, S. and Chanthavong, S., 2005. A survey of aquatic animal health problems affecting small-scale aquaculture production and fisheries in Lao PDR. In. Burnhill T.J. and Hewitt M.M. (eds). Proceedings of the 6th Technical Symposium on Mekong Fisheries, 26th – 28th November 2003. MRC Conference Series No.5. Mekong River Commission, Vientiane. 194 pp.

Phonvisay, A., 2001. Fish Marketing Study in Vientiane, LARReC Technical Report No. 0003, LARReC, Vientiane.

Phonvisay, A., 2003 The study of fish market channels in Luangprabang and Oudomxay Province, AMCF, Vientiane.

Phonvisay, A., Bualaphanh, V., Sichanh, S., Singhanouvong, D., and Hortle, K. G., 2005. Monitoring of fish markets in Vientiane and Luang Prabang Province, Lao PDR, using logbooks. In: Burnhill, T.J. and Warren, T.J. (Eds). Proceedings of the 7th Technical Symposium on Mekong Fisheries, MRC Conference Series, No 6, Mekong River Commission, Vientiane, Lao PDR.

Podger, G.M., Beecham, R.E., Blackmore, D., Stein, R. and Perry, C. 2004. Modelled Observations on Development Scenarios in the Lower Mekong Basin, Mekong Water Resouces Assistance Strategy, World Bank, Nov. 2004, Vientiane.

Prapertchop, P., 1989, Summary Report on Analysis of Freshwater Fish Consumption and Marine Product Marketing in North-East Thailand. Report No.9, Parts 11/111. Thailand-Canada North-East Fishery Project, DOF/CIDA, 8906/11415.

Rab, M.A., H. Navy, M. Ahmed, K. Seng and K. Viner., 2006. Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac area; Results from a sample survey in Kampong Chhnang, Siem Reap and Kandal Provinces, Cambodia. WorldFish Center Discussion Series No. 4. 98p.

Rab, M.A., Hap, N., Ahmed, M., Keang, S.L., and Viner, K., 2005. Socioeconomics and Values of Resources in Great Lake, Tonle Sap and Mekong - Bassac Area: Results from a Sample Survey in Kampong Chhnang, Siem Reap and Kandal Provinces. WorldFish Center, Penang, Malaysia. (Available at www.ifredi.org).

Ratner, B.D., 2006. Policy Review: Community Management by Decree? Lessons From Cambodia's Fisheries Reform. Society and Natural Resources, 19:79–86

Research Institute of Marine Fisheries, 2006. Marine Resources and Fishing Situation in Viet Nam's waters: Current State of Resources and Fisheries Development Trends. Available at http://www.fistenet.gov.vn/details_e.asp?Object=2112463&news_ID=7263407. (Accessed on October 2007).

Sokhem, P., and Sunada, K. 2006. Key Fisheries Issues in the Mekong Region Draft Paper for Mekong Region Waters Dialogues, Fisheries Session 230606 Available at: http://www.sea-user.org/UserFiles/File/docs/Sokhem&Sunada_Fisheries_Session_draft_270606(1).pdf

Sjorslev J.G., 2001. Assessment of consumption of fish and aquatic animals in the Lower Mekong Basin. Draft report for the Mekong Development Series. 35 pp.

Sverdrup-Jensen, S., 2002. Fisheries in the Lower Mekong Basin: Status and Perspectives. MRC Technical Paper No. 6, Mekong River Commission, Phnom Penh. 103 pp.

Tien, D. V., Chau, L. N., Chi, T. T., and Hortle, K. G., 2005. Trial monitoring of fishers in the Mekong Delta, Viet Nam. In: Burnhill, T.J. and Warren, T.J. (Eds). Proceedings of the 7th Technical Symposium on Mekong Fisheries, MRC Conference Series, No 6, Mekong River Commission, Vientiane, Lao PDR.

USDA, 2007. Vietnam Fishery Products Shrimp Report 2007. USDA Foreign Agricultural Service. Available at: http://www.thefishsite.com/articles/307/vietnam-fishery-products-shrimp-report-2007

Vanhan. H, 2004. Agriculture in the wetlands of Cambodia. In Magnus Torell, Albert M. Salamanca and Blake D. Ratner (eds.) 2004. Wetlands Management in Cambodia: Socioeconomic, Ecological, and Policy Perspectives. WorldFish Center Technical Report 64,p 17-21

Van Zalinge, N, Nao, T. Touch, S. Tana, Deap, L., 2000. Where there is water, there is fish? Cambodian fisheries issues in a Mekong River Basin perspective. p. 37-48. In M. Ahmed and P. Hirsch (eds.) Common property in the Mekong: issues of sustainability and subsistence. ICLARM Studies and Reviews 26, 67 pp.

Van Zalinge N. P., Nao T. & Sam, N., 2001. Status of the Cambodian inland capture fisheries sector with special reference to the Tonle Sap Great Lake. Inland Fisheries Research and Development Institute of Cambodia, Fisheries Technical Paper Series, Volume III. pp. 10-17.

Van Zalinge, N. P., 2002. Update on the status of the Cambodian inland capture fisheries sector with special reference to the Tonle Sap Great Lake. Catch and Culture, Mekong Fisheries Network Newsletter, Vol. 8, No. 2, December 2002.

Van Zalinge, N., P. Degan, C. Pongsri, S. Nuov, J.G. Jensen, V.H. Nguyen, X.Choulamany, 2003. The Mekong River System. In. Welcomme, R. L., and Petr, T. (eds.) Proceedings of the Second International Symposium on the Management of

Large Rivers for Fisheries: Sustaining Livelihoods and Biodiversity in the New Millennium, 11th-14th February, 2003, Phnom Penh, Cambodia.

van Zalinge, N., Thuok, N., and Tana, T. S., 1998. Where there is water, there is fish? Fisheries issues in the Lower Mekong Basin from a Cambodian perspective. Contribution to the Mekong Panel at the Seventh Common Property Conference of the International Association for the Study of Common Property, Vancouver, Canada, 10 - 14 June 1998 Mekong River Commission. Available at http://www.indiana.edu/~iascp/Final/zalingeo.pdf

Van Zalinge, N.P. and T.S. Touch, 1996. Cambodia National Environmental Action Plan. Fisheries management in the Tonle Sap. Contribution to the Workshop on the "Management of the Tonle Sap Ecosystem". Siem Reap, 11 - 14 September 1996.

Welcomme R.L., 1985. River fisheries. FAO fisheries technical paper No.262. 330 pp.

World Bank, 2006. Bangladesh Country Environmental Analysis. Bangladesh Development Series Paper no. 12. The World Bank Office, Dhaka.

Yim Chea and McKenney, Bruce, 2003. Great Lake fish exports: an analysis of the fee system. Cambodian Development Review, Cambodian Development Resource Institute, 7, 1-6.

Yim Chea and McKenney, Bruce, 2003. Fish Exports from the Great Lake to Thailand: An Analysis of Trade Constraints, Governance, and the Climate for Growth — Working Paper 27. Cambodian Development Resource Institute, Phnom Penh.

Yim Chea and McKenney, Bruce, 2003. Domestic Fish Trade: A Case Study of Fish Marketing from the Great Lake to Phnom Penh — Working Paper 29. Cambodian Development Resource Institute, Phnom Penh.

York, R., and Gossard, M. H. 2004. Cross-national meat and fish consumption: exploring the effects of modernization and ecological context. Ecological Economics 48, 293– 302