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Consumption and the yield of fish and other aquatic animals from the Lower Mekong Basin

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Abbreviations and Acronyms

ADB	Asian Development Bank
Danida	Danish International Development Agency
DoF	Department of Fisheries
EIA	Environmental Impact Assessment
FAO	Fisheries and Agriculture Organisation of the United Nations
FWAEs	Fresh whole animal equivalent weights: the weight of animals required to make any final product, equivalent to 'live weight' as used by the FAO
IFF	Inland fresh fish
IPF	Inland preserved fish
LMB	The Lower Mekong Basin (within Cambodia, Lao PDR, Thailand, and Viet Nam)
MPs	Marine products
MRC	Mekong River Commission
OAAs	Other aquatic animals (than fish)

Units used	
HH	Household
capita	Persons, covers all people
capita AEUs	Persons, adult equivalent units
t	Metric tonnes (1,000 kg)

Summary

The Lower Mekong River Basin (LMB), which includes parts of Cambodia, Lao PDR, Thailand and Viet Nam, supports a significant fishery that has been the subject of numerous studies on fish consumption that have been sponsored and implemented by various organizations. Unfortunately, most of the results of the studies are not generally available or synthesised, so views on the size and value of the basin's fisheries vary widely. This review attempts to estimate the yield (production) of the fishery based on data on consumption from 20 field surveys in the LMB, with some supporting analyses of complementary data.

Various adjustments were necessary so that data could be used to estimate province-level consumption and to extrapolate to provinces that have not been surveyed. Preserved fish amounts were adjusted to 'fresh whole animal equivalent weights' (FWAEs) and other adjustments were required to account for differences in coverage and units. Information on other animal products was also synthesised where available.

	Cambodia	Lao PDR	Thailand	Viet Nam	Total
Estimated per capita consumption (kg/capita/year as actual consumption) of inland fish and other aquatic animals in the LMB, based on consumption studies (from Table 25)					
Inland fish	32.3	24.5	24.9	34.5	29.3
Other aquatic animals	4.5	4.1	4.2	4.5	4.3
Total inland fish and OAAs	36.8	28.6	29.0	39.0	33.7
Estimated yield (tonnes/year as FWAEs) of inland fish and other aquatic animals in the LMB, based on consumption studies (from Table 24)					
Inland fish	481,537	167,922	720,501	692,118	2,062,077
Other aquatic animals	105,467	40,581	190,984	160,705	497,737
Total inland fish and OAAs	587,004	208,503	911,485	852,823	2,559,815

Based on the results of the 20 surveys, consumption of fish and other aquatic animals (OAAs) in the LMB is estimated to be about 2.6 million tonnes by a population of 56 million in the year 2000 as fresh whole animal equivalents. About one-fifth of this total comprises OAAs. About one-third of the fish is eaten preserved. Thailand and Viet Nam consume the most, about one-third of the total each. Cambodia consumes about one-quarter, and Lao PDR less than one-tenth. Per capita consumption of inland fish and OAAs averages 34 kg/year as actual consumption. Cambodia and Viet Nam have above-average per capita consumption, while in Lao PDR and Thailand per capita consumption is below-average. Inland fish and OAAs provide 47–80% (country range) of animal protein with an average intake of 18.3 g/capita/day of a total animal protein intake of 32.5 g/capita/day, a high intake compared with the recommended daily allowance.

Most consumption data were obtained during interviews in which people attempted to recall what they ate over extended time periods, and only two studies actually monitored consumption, both for limited periods. However, various other data tend to support the consumption-based estimates: results from one small monitoring study found very similar levels of actual consumption among some representative LMB people, catch data were generally consistent with consumption data, consumption data from elsewhere in the world indicate the LMB estimates are reasonable, and estimates based on yield per unit area provide a range of yield which supports the consumption-based estimate.

Estimates based on yield per unit area of aquatic habitat suggest a possible range of 0.7 – 2.9 million tonnes/year for the LMB. Consistent with the consumption-based estimate of 2.6 million tonnes/year, and allowing for additional wastage, exports and feed for aquaculture, it is most likely that actual yield is at the upper end of this range, because of the Mekong's high natural productivity and intensive fishing activity. Cambodia is a nett exporter to the other countries, as it has a large area of productive wetlands, intensive fisheries and moderate population. The yield estimate indicates an enormous fishery which is vital in terms of nutrition, livelihoods, food security and culture. Various data show that most of the basin's inhabitants fish at some time, and that despite significant investments in aquaculture, about 90% of consumption is derived from the wild capture fishery, justifying an increased allocation of resources to its conservation and management.

As the accuracy of the consumption surveys is unknown, future studies should be carried out using established methods with appropriate attention to quality assurance and control; detailed recommendations are provided in this report. Surveyors should take care to cover all foods of interest; data are particularly poor or incomplete for some commonly-eaten foods such as other aquatic animals (OAAs) and marine products. Further studies on yield per unit area, especially of rice-field habitats in Lao PDR and Thailand, would also refine the overall estimate of yield from the basin. Land classed as rice-fields covers most of the LMB's wetland areas, so rice-fields and related habitats make a large but poorly-quantified contribution to the total yield.

This report also highlights the inconsistencies between different data sets that are widely quoted and used for various purposes. Official national data on the yield from inland fisheries generally exclude or under-report the artisanal and subsistence fisheries that make a major contribution to yield. Official 'apparent consumption' data as provided by countries and compiled by the FAO are based on questionable data on trade figures and do not account for subsistence and the large informal or unreported economy in LMB countries. A regular basin-wide consumption survey, supported by national statistics and fisheries agencies, would greatly assist in reconciling conflicting yield estimates and in institutionalising methodologies and results for basin-wide fish yield estimates.

KEY WORDS: Fish consumption, fish yield, Lower Mekong Basin, Cambodia, Lao PDR, Thailand, Viet Nam

1 Introduction

1.1 Overview

The Mekong is one of the world's largest rivers, with a catchment area of 795,000 km^2, a mean discharge of 15,000 m^3/s, and a length of about 4,900 km (van Zalinge *et al*., 2004). The river rises in eastern Tibet and discharges into the South China Sea. The Lower Mekong Basin (LMB) lies within Cambodia, Lao PDR, Thailand, and Viet Nam (Figures 1 – 3) and is home to about 60 million people (MRC, 2003). The lower Mekong river system with its extensive associated floodplains and wetlands supports important inland fisheries (Sverdrup-Jensen, 2002). As well as the catching or growing of fish and other aquatic animals (OAAs), fisheries involve processing, transporting and marketing of fishery products and many other supporting industries. Fisheries in the LMB occupy millions of people who work full- or part-time, as individuals or in small groups, or as part of large commercial operations. Fisheries are dispersed through many environments: rivers, floodplains and natural wetlands, as well as in agricultural landscapes, and are seasonal, with catches or harvests peaking at various times in different places. Hundreds of wild fish species are caught, as well as a wide range of other aquatic animals (OAAs), including shrimps, crabs, molluscs, insects, snakes and turtles. Aquaculture is of less importance, but dozens of species are cultured commonly (Phillips, 2002).

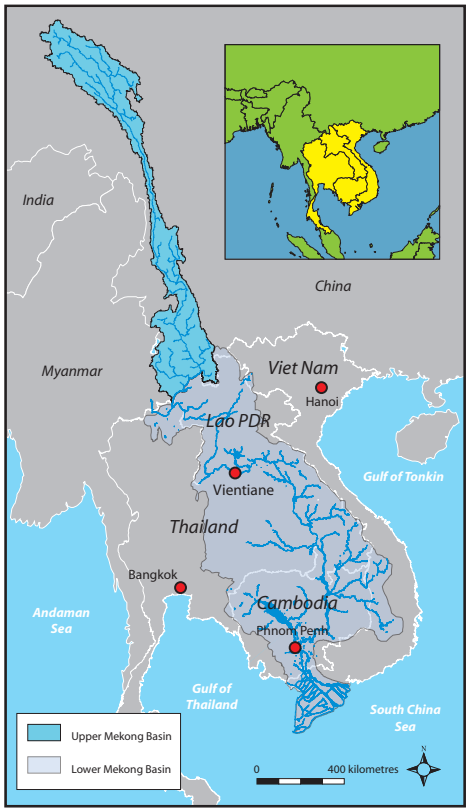

Figure 1. The Mekong Basin.

As is usual for large tropical river systems, there are no reliable basin-wide catch assessments, despite the basin's fisheries being described by the MRC as the 'linch-pin in the Basin's development' (Kristensen, 2002). Assessing the size and value of the capture fishery is difficult and complex because of the diversity of habitats and species, the seasonal variability of the yield, the dispersed geographic spread of many fisheries, and the range in scale of different types of fisheries (from solitary fishers to industrial enterprises).

The lack of accurate quantitative data on fisheries leads to relative neglect in development planning, which tends to emphasise other sectors that may compete with the fishery for use of water as populations grow and demands on the river increase. However, all sectors should be given appropriate weight in development planning, at both a basin-wide level

and when considering individual water management projects. Therefore, estimates of the yield (production) and value of fisheries are needed, so that benefits from developments in other sectors can be judged against the effects on the fishery. Various estimates of yield have been published, but as discussed below, all suffer from incomplete information or a lack of supporting evidence or analysis.

This report seeks to:

- introduce features of the importance of fisheries in the LMB, discuss basic concepts about yield and production, review published estimates of yield, and explain the basis for this review (Chapter 1);
- provide accurate estimates of the population and area of the LMB (Chapter 2);
- review terminology for fisheries products and derive conversion factors (Chapter 3);
- review studies that include consumption estimates within the LMB and extrapolate from these figures to estimate basin-wide consumption; estimate yield and the contribution from aquaculture and capture fisheries (Chapter 4);
- compare the LMB consumption and yield estimates with other data (Chapter 5);
- discuss and summarise the review and recommend directions for future work to improve yield estimates (Chapter 6).

1.2 The importance of fish and OAAs in the Lower Mekong Basin

In the LMB, fish and OAAs are eaten regularly by almost all people, providing a major source of protein and essential elements (including calcium, iron, and zinc) and vitamins—particularly vitamin A. Smaller fish generally have higher mineral content than large fish, so they are particularly important to the rural poor who tend to eat small fish and sell larger fish (Roos, 2003). People in the LMB usually eat most of the internal organs of larger fish, and small fish are often eaten whole or beheaded. Aspects of nutrition are discussed in detail by Mogensen (2001) and nutritional tables for fish and OAAs are provided by Puwastien *et al*. (1999). Fisheries contribute to livelihoods by engaging many people in direct or indirect employment and providing sustenance, so enabling people to engage in other useful employment and attain a decent standard of living. Many people in the LMB countries still depend upon local fisheries products for food security. Fisheries also link with culture and provide complementary roles for all members of the family; typically men work on gear and catch fish, whereas women sell or process the catch and fish locally for household consumption, and children assist in various ways.

1.3 Yield and production

The yield from any biological system is defined as the portion of production removed for use by humans over a given period of time. Biologists define production as the total biomass produced during a given period of time from a defined area, so production includes the biomass that is produced but not harvested by people. In national economic statistical tables (such as those compiled by the FAO) yield is usually termed production; i.e. what biologists refer to as 'yield' economists call 'production'. Yield is the term used throughout this report. The units of yield are generally kg per capita per year, or metric tonnes from a stated area per year. Yield is the best indicator of the size of the fishery, as biological production is impossible to measure in large systems. Consumption usually forms a large part of the yield in large floodplain systems such as the Mekong, where the bulk of catches are consumed locally (see also Chapter 4.6).

1.4 Estimating yield

There are four ways to estimate the yield of the LMB fishery:

- *By monitoring catches*. Larger commercial operations or catches passing through well-defined landing sites can be monitored, but the dominant small-scale subsistence or artisanal fishers are difficult to monitor directly in seasonal and geographically-dispersed fisheries. Moreover, fishers may under-report catches for various reasons, for example to avoid taxes or to avoid attracting the attention of competing fishers.

- *By monitoring trade and marketing*. In the LMB many fishery products are not marketed or traded but rather are eaten by the fishers or their families, or others who buy or barter directly with fishers, so this method neglects a large part of the yield. Licensed traders may under-report sales to avoid taxes. Illegal cross-border trade in the LMB is common but impossible to monitor.

- *By multiplying per capita consumption (i.e. food eaten) by population*. This method has the advantages that per capita consumption is within known limits (based on other studies and physical limits to each person's capacity to eat) and, as all the LMB governments conduct censuses, the error in population estimates is small. Information is also needed on imports, exports, wastage and use in animal feeds.

- *By estimating habitat area (especially flooded area), and multiplying by yield per unit area*. Studies of small well-defined areas in floodplain rivers show that fish yield depends largely upon the area and duration of seasonal flooding, as well as fishing effort. Unfortunately, there is no general relationship that could be applied basin-wide, but habitat area can be used to provide some indication of the range of yield, as is discussed in Chapter 5.3.

1.5 Previous estimates of yield

Several estimates of fish yield in the LMB have already been published.

The Netherlands Economic Institute estimated that total fish consumption in the LMB in 1970 was 492,000 tonnes/year, based on assumed per capita consumption of 16.4 kg/capita/year and a population of about 30 million (cited in Lagler 1976, p. 33). Compilation of official catch statistics from commercial operations, combined with estimates of subsistence catches (based on trial fishing and field observations), gave a range of 460–511,000 tonnes/year for LMB catches in 1973 (Lagler, 1976, p. 197), a range that encompassed the estimate based on assumed consumption.

The Mekong Basin Fishery Sector Review (Anonymous, 1992, p. 10) estimated fish consumption in the LMB was 6.5–30 kg/capita/year in 1989–90, based on assumptions about relative protein contribution from fish versus other sources. According to official production statistics the total inland fish yield at the time was 357,134 tonnes for a LMB population of 47.8 million. The official statistics were noted as 'generally unreliable' as they did not include the bulk of the catch, which is from subsistence and small-scale fishing. Moreover, official returns from licensed commercial fishers are also likely to be generally under-reported for many reasons. The review noted that a monitoring study in northeast Thailand found actual monitored consumption was 5.5 times higher than official production (Study 12 in Chapter 4, below). The total inland fish catch estimated by the Sector Review for the LMB was about 670,000 tonnes, but this total was obtained by summing the *consumption* data from northeast Thailand with official *catch* data from Cambodia, Lao PDR, and Viet Nam. If a similar under-reporting bias were to be assumed and the factor of 5.5 applied to the official catch data from the latter three countries, the total consumption estimate would be about two million tonnes for 1989–90.

Small-scale fisheries were covered in a number of surveys in the late 1980s and 1990s. Jensen (1996) quoted two of these studies (from Cambodia and northeast Thailand) and suggested that total basin production could be more than one million tonnes per year. More recently, Jensen (2000, 2001) provided some further preliminary figures from MRC-sponsored surveys in Lao PDR and Viet Nam, and he has also suggested that the capture fishery alone may be greater than one million tonnes per year, with aquaculture accounting for a further 200,000 tonnes/year.

A recent sector review (Sverdrup-Jensen, 2002) tabulated estimated consumption figures for each country based on a draft report by Sjorslev (2001). The total estimate was 2.033 million tonnes for a population of 56.259 million people in the years 1999/2000, giving a per capita estimate of 36 kg/year of fish, presumably as FWAEs.

Most recently, a summary table was presented by van Zalinge *et al*. (2004), who were then quoted by the ADB (2005) and possibly others. The summary table shows estimated total consumption in each LMB country, based on a draft report by Hortle and Bush for the year 2000. The total yield was estimated as 2.7 million tonnes/year of fish and 0.4 million tonnes/year of other aquatic animals as FWAEs. The draft report of Hortle and Bush was not

finalised, because inaccuracies were identified in the databases and new information became available. Consequently, the present report has been prepared to re-estimate the yield of the LMB and to state clearly the basis for the estimate.

In summary, published estimates for fishery production of the LMB varied between 0.5 and 3.1 million tonnes per year, between the years 1970 and 2000. Allowing for constant per capita consumption would raise the 1970s figure from 0.5 to about one million tonnes in 2000. Thus, previously published estimates, when adjusted for population, provide a range for annual yield of about 1 – 3 million tonnes for the year 2000, but the bases for the estimates have as yet not been documented properly.

1.6 Estimating basin-wide consumption and yield

Estimates for the consumption of the whole LMB were built from the 'bottom up', firstly on a province-by-province basis[1], and then on a country-by-country basis[2]. For those provinces where data were available, total consumption was derived by multiplying the province's population in the year 2000 by an estimate of its per capita consumption. For those provinces where per capita consumption figures were unavailable, total consumption was derived using per capita consumption data from nearby provinces that have similar ecology and comparable socio-economic structure.

Because individual consumption estimates were made in various years (1988 – 2002, Table 8), it was necessary to adjust the data to a common year for which population census figures were available; 2000 is the most recent of these 'common years'. It was assumed that per capita consumption was constant and that provincial consumption increased with population growth, which is about 2 – 2.5% in the LMB (MRC, 2003).

To estimate yield, additional information was sought on imports, exports, aquaculture production and use of trash fish in aquaculture.

1 A lower level of resolution (e.g. at district level) was not possible because of insufficient data.
2 Except in Lao PDR where results from a national-level census were used.

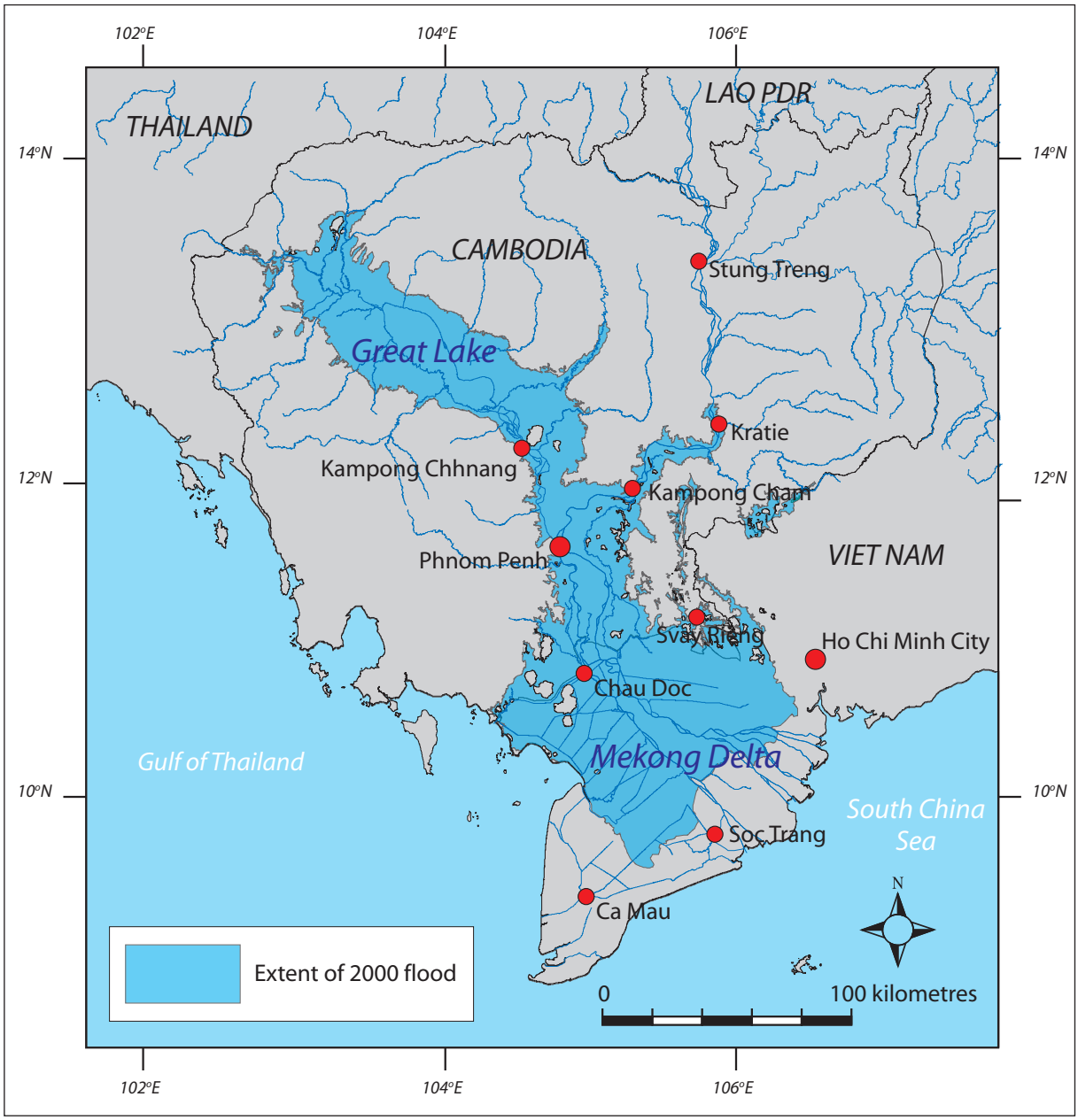

Figure 2. The extent of the flood in the year 2000 (a year with an above-average flood) in the Great Lake – Mekong Delta area.

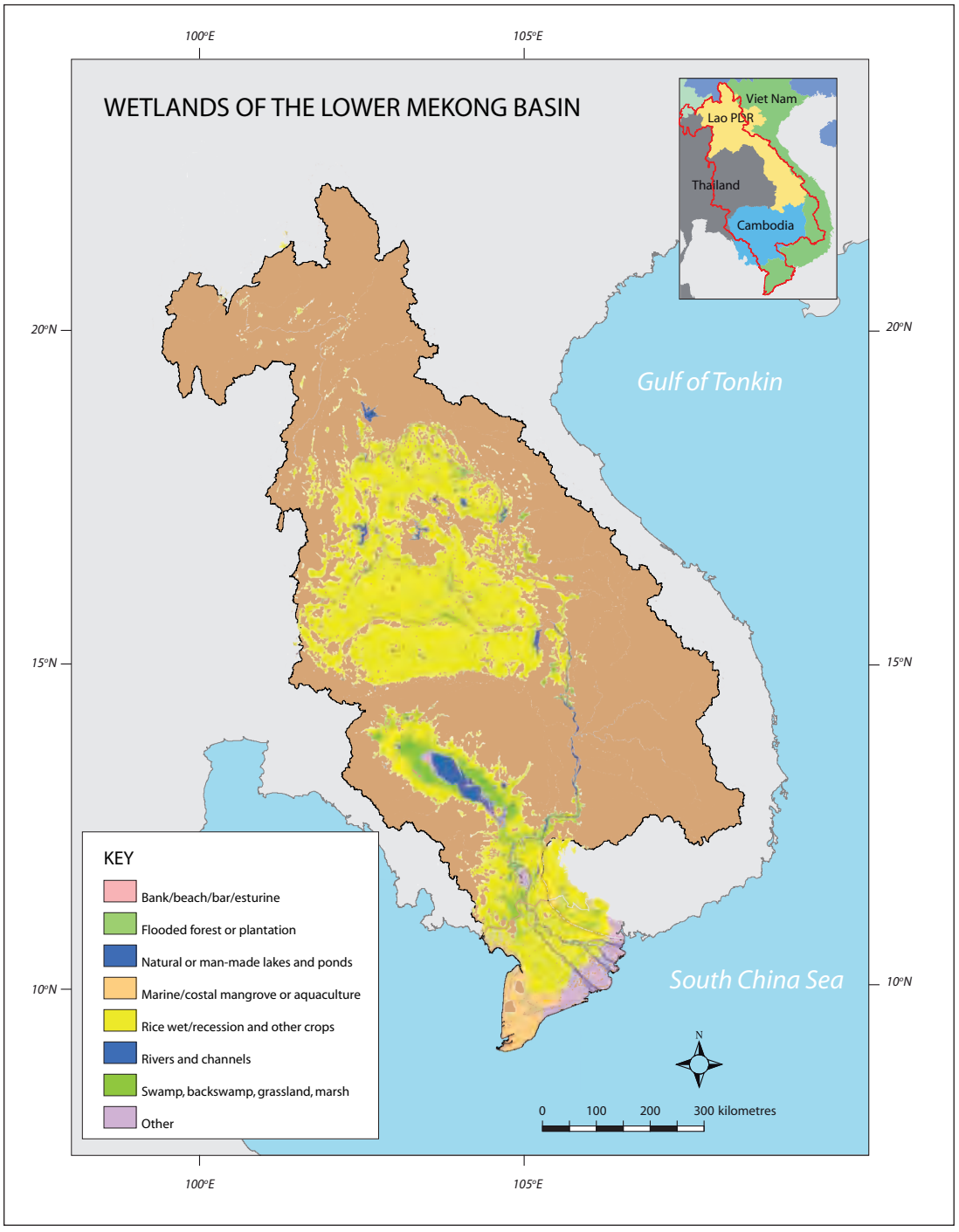

Figure 3. The extent and types of wetlands in the Lower Mekong Basin.

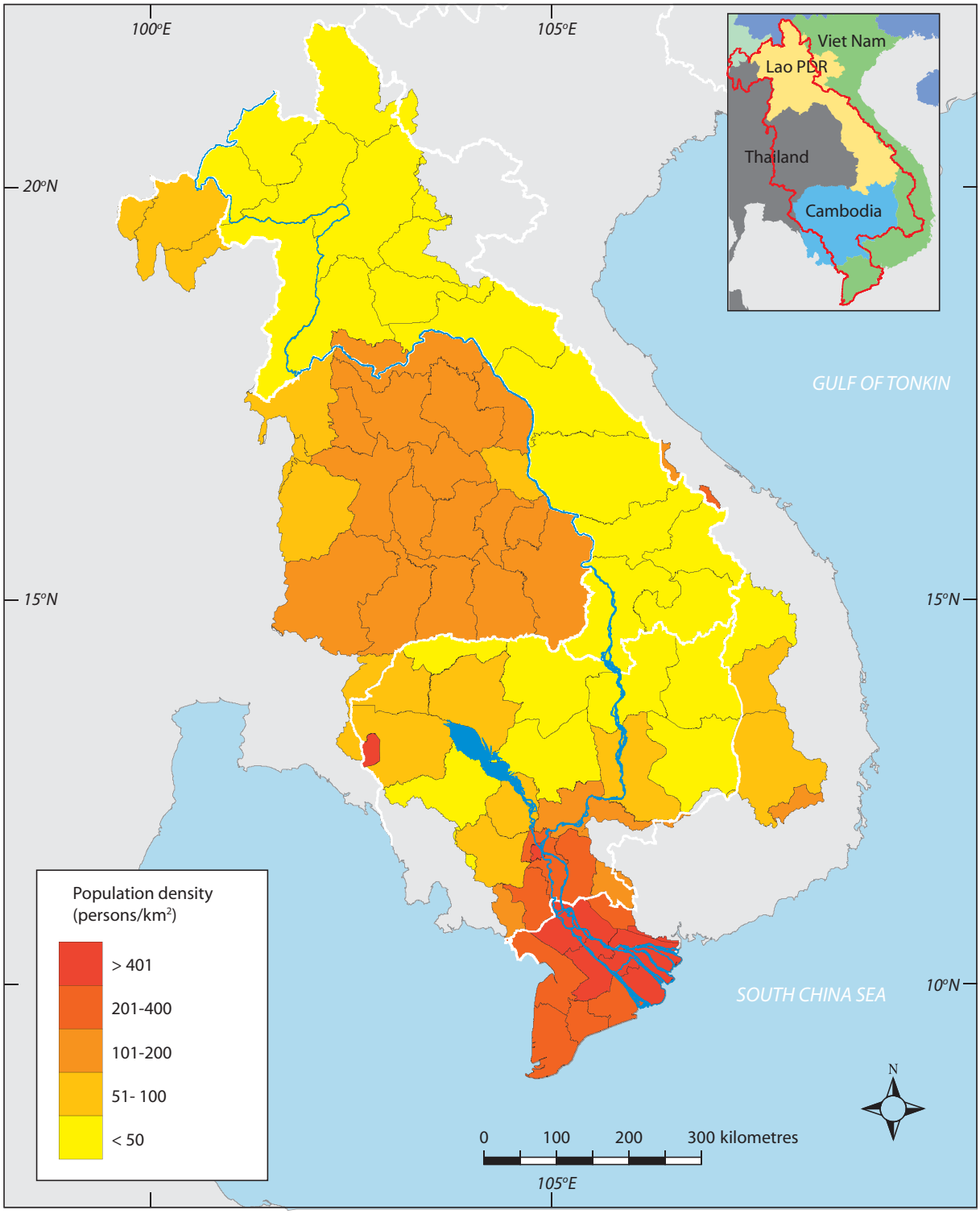

Figure 4. Distribution of population in the Lower Mekong Basin by province.
Categories are based on mean values for each province. Population density is usually higher along rivers and lower in elevated areas.

2 Population and Provinces

The Lower Mekong Basin (LMB) includes the catchments of all the Mekong's tributaries (south of China and Myanmar), and all the areas of land in the lower part of the basin that are normally flooded by Mekong waters each year or where watercourses form permanent or seasonal distributaries of the Mekong system. Population figures for each LMB province were obtained from databases held by MRC. National censuses were carried out in mid-2000 in Lao PDR, Thailand and Viet Nam. For Cambodia, the prior census was mid-1998 and figures were adjusted to equivalent mid-2000 figures by factoring by the annual growth rate (2.49%). Thus all population figures and the final consumption estimate are 'equivalent mid-2000 figures' as summarised in Table 1 and as detailed in Appendix 1.

Table 1. *Summary of surface area, population in 2000, and population density of the Lower Mekong Basin countries (based on Appendix 1).*

Surface area (km^2)				
Country	Whole country	Area in the LMB	% in LMB	% of LMB area
Cambodia	181,035	158,851	87.7%	25.5%
Lao PDR	236,800	207,313	87.5%	33.3%
Thailand	513,115	187,932	36.6%	30.2%
Viet Nam	325,490	68,489	21.0%	11.0%
Total	1,256,440	622,584	49.6%	100.0%

Population (mid-2000)				
Country	Whole country	LMB population	% in LMB	% of LMB population
Cambodia	12,014,343	11,421,458	95.1%	20.3%
Lao PDR	5,218,300	4,850,765	93.0%	8.6%
Thailand	60,617,200	22,528,171	37.2%	40.0%
Viet Nam	77,635,400	17,505,470	22.5%	31.1%
Total	155,485,243	56,305,864	36.2%	100.0%

Population density (persons/km^2)		
Country	Whole country	LMB
Cambodia	66.4	71.9
Lao PDR	22.0	23.4
Thailand	118.1	119.9
Viet Nam	238.5	255.6
Total	123.8	90.4

Note: These figures differ slightly from official national figures because GIS data were used to estimate province areas.

Censuses are meant to record people resident in on a particular night, but some residents may be living and working elsewhere. Within Cambodia and Lao PDR, which lie largely within the LMB, there would be little overall effect of this error, as short-term migration from one part of the basin would probably be balanced by gains in another part. But some people recorded in the Thai or Vietnamese parts of the LMB work outside the basin, especially in urban centres such as Bangkok or Ho Chi Minh City, so their inclusion would cause the LMB population to be overestimated. On the other hand, unrecorded LMB residents, particularly tourists, are likely to counterbalance any such effect, as all countries have a large and growing tourist industry. Allowing for these small errors, national census figures are generally accurate to within a few percent, so are not a significant source of error in the overall consumption calculation.

Table 1 and Figure 4 show that while 59% of the area of LMB lies within Cambodia and Lao PDR, these two countries contribute only 29% of its population. Thailand has the second largest proportion of the LMB area and the largest proportion of its population.

Most people in the four LMB countries are classed as rural. The censuses provide rural proportions as: Cambodia 84%, Thailand 69%, Viet Nam 75%. The rural proportion in the Lao PDR is not specified, but is probably similar to that in Cambodia.

Table 2. *Summary of province proportions within the LMB (based on Appendix 1).*

Category	No. of provinces	Area (km^2)	% of total	Estimated population	% of total
Partly within the LMB	32	200,153	32.1%	14,552,045	25.8%
Wholly within the LMB	54	422,431	67.9%	41,753,819	74.2%
Total	86	622,584	100.0%	56,305,864	100.0%

There are 54 provinces wholly within the LMB and 32 that are only partly within the LMB (Figure 5, Table 2, Appendix 1)1. Estimating the proportion of population of these 32 provinces that live in the LMB simply pro rata based on land area may introduce errors because the population is not evenly distributed. In the case of provinces lying mostly within the basin, assuming an even population distribution causes underestimates because population is denser along the rivers and floodplains of the Mekong system, i.e. away from the boundaries of the catchment, which are the most elevated parts. Conversely, for provinces lying mostly outside the LMB, populations are likely to be overestimated. The likely bias introduced by pro rata estimation based on land area can be judged from the breakdown in Table 2. This error only applies to the 26% of the total population estimate that derives from the 32 provinces partly within the basin. Of these provinces, 16 are mostly within and 16 are mostly outside the basin, so any errors from this source should approximately balance.

In summary, any errors in the population figures are likely to be small, and inconsequential in comparison to the errors in consumption estimates which are discussed further below.

1 One census area wholly within the LMB is Tonle Sap in Cambodia; it covers the Great Lake and its area is included in the figures, but it has no registered population as all residents are registered in the surrounding riparian provinces.

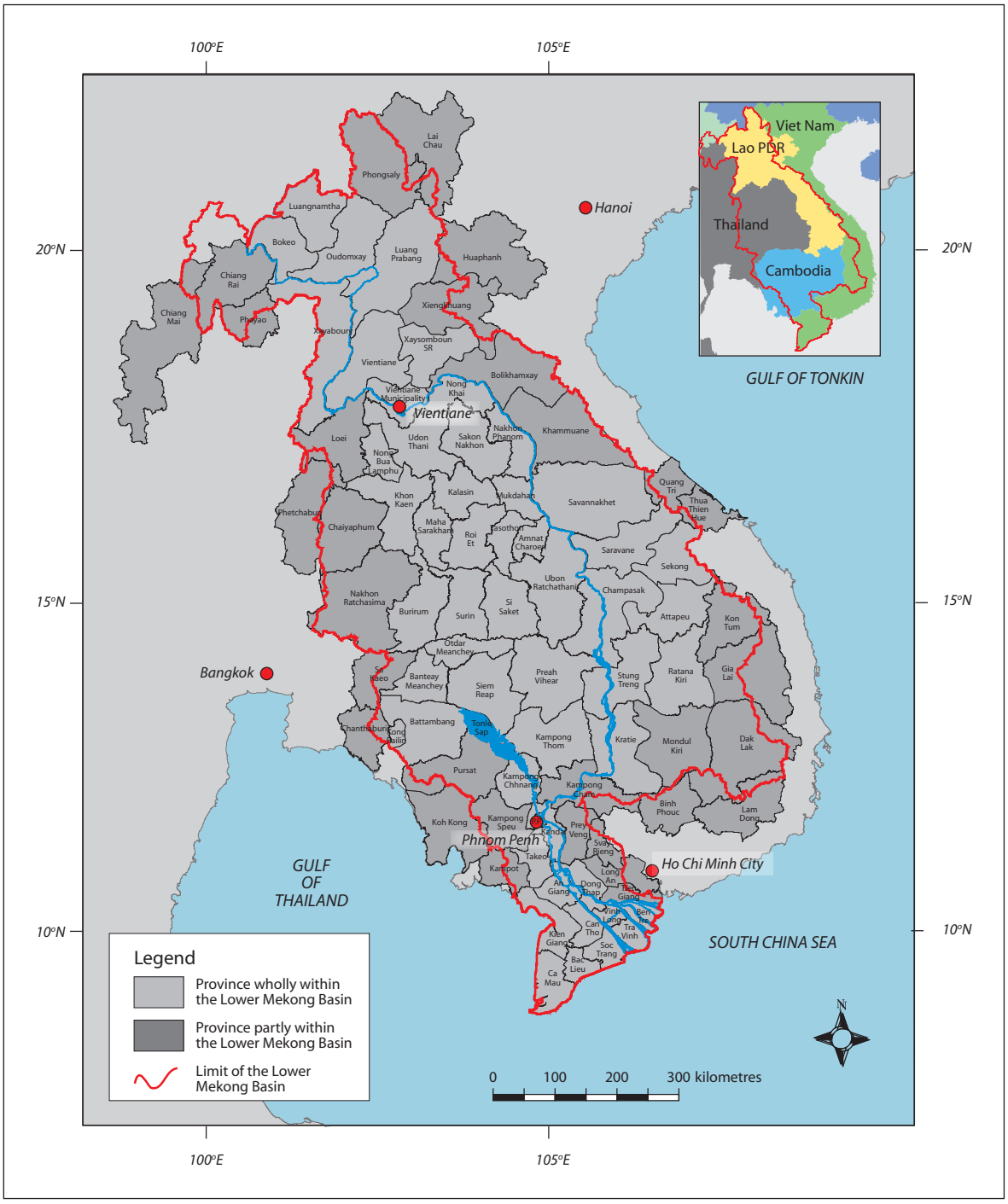

Figure 5. Provinces wholly or partly in the Lower Mekong Basin.

3 Terminology for Fishery Products

3.1 Introduction

The collective term ‘fish and OAAs’ includes four main categories: inland fresh fish (IFF), inland preserved fish (IPF), other aquatic animals (OAAs), and marine products (MPs). Many surveys of consumption do not include one or more of these categories or do not clearly state the coverage of their estimates; it is for example common to read ‘fish consumption’ without further clarification. It is therefore necessary to make some assumptions to standardise data for comparison or summation.

The surveys that were reviewed appear to refer to quantities of fresh fish and OAAs as ‘fresh whole animal equivalent weights’ (FWAEs), although definitions were not usually provided in the survey reports. FWAEs has the same meaning as ‘live weights’ as used by the FAO, i.e. the whole weight of fish or OAAs when caught. Preserved fish products are weights ‘prior to cooking’, i.e. after removal of some parts of the fish and processing. All products must either be converted to FWAEs or expressed as ‘actual consumption’, as discussed below. Actual consumption is actually less than weights ‘prior to cooking’, but the small wastage during cooking and eating has been ignored in this report.

Expressing quantities in terms of protein intake is another useful way of standardising data and comparing intakes of protein-rich foods, so is common in nutrition-focussed studies.

3.2 Inland fresh fish (IFF)

This term includes inland fish that are eaten soon after capture or that are held on ice or refrigerated prior to eating. People in the LMB will eat all parts of some small fish, but generally some portion of each fish is not eaten. Mogensen (2001) estimated that for four common fish species in a rural area of Cambodia the edible portion was between 62% and 93% of the weight of the fish. Large fish have a lower proportion of edible tissue, as their skeletons are proportionately larger. In this report, a factor of x 0.8 is used (i.e. actual weight multiplied by 0.8) to convert fish as FWAEs to edible portions (actual consumption), on the assumption that people in the LMB mostly eat small fish. Using an average protein content of 19.9% for edible portions (taken from Mogensen, 2001) a factor of 15.9% (19.9% x 0.8) can be used to estimate the edible protein content in fish as FWAEs.

For comparison, data taken from Puwastien *et al*. (1999) shows that the flesh[1] (or flesh and skin) of 22 common LMB fishes (i.e. excluding other edible parts) had an average

1 Flesh refers to muscular tissue, i.e. as normally removed in a fillet.

protein content of 17.7% (13.0–21.1%), an average moisture content when fresh of 76.6 % (65.1–80.8%), and an average fat content of 4.2% (0.2–16.5%). Thus the average protein content for **flesh** from a range of LMB fish is actually quite similar to that found by Mogensen for **edible portions**.

3.3 Inland preserved fish (IPF)

Fish catches vary seasonally throughout the LMB. At the beginning of the annual flood fish migrating upstream or onto floodplains are caught in large quantities. During the flood, fish feed and grow on inundated areas, so that large numbers of fish are caught while water levels are falling. During the dry season relatively few fish are caught. Seasonal excesses of fish have led to the development of many methods of preservation (Table 3).

Table 3. *Some local names for common kinds of preserved fish products.*

Language	Fermented fish products			Dried fish, salted/dried Fish	Smoked fish
	'Fish paste'	Fish sauce	Other fermented fish products		
Thai	*Pla Ra*	*Nam Pla*	*Ka Pi Pla, Pla Jom, Pla Som, Pla Jao*	*Pla Heng*	*Pla Yang*
Khmer	*Prahoc, Mam*	*Teuk Trey*	*Pa 'ok*	*Trey Ngiet, Trey Hal, Trey Pra Laak*	*Trey Ch'au*
Lao	*Pa Dek*	*Nam Pa*	*Ka Pi Pa, Som Pa, Pa Jao*	*Pa Heng*	*Pa Lon Fai*
Vietnamese	*Mam*	*Nuoc Mam*	*Mam (with local name of fish, eg. linh, sac, loc)*	*Ca Kho*	*Ca Xong Khoi*

Note: The words for fish paste are sometimes used generically to refer to any fermented fish.

The following section discusses the derivation of the conversion factors for preserved fish to FWAEs that are used in this report (Table 4 and Figure 3).

Preprocessing to edible portions

Conversion factors must correct for two steps, preprocessing of the fish to 'edible portions' and the subsequent process of preservation of the fish (drying, salting, smoking or fermentation). Preprocessing entails removal of some parts of the fish, with differences depending upon species and size. As the mixture of species and sizes is not known for the LMB it is necessary to assume an average loss from preprocessing. As for IFF (above) it was assumed that on average 20% of the weight of fish was discarded prior to the preservation process, with the exception

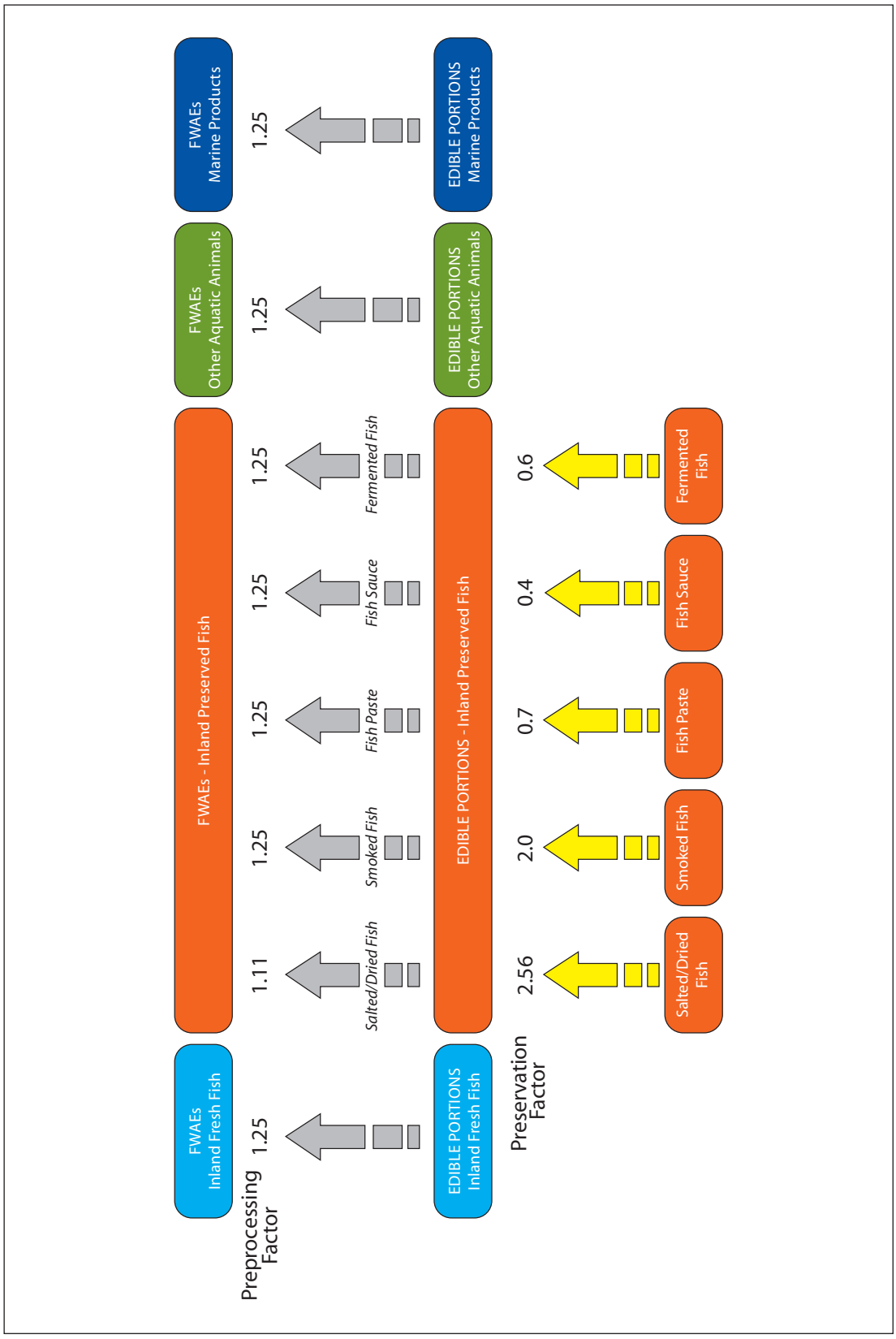

Figure 6. Conversion factors used to calculate FWAEs from preserved and edible portion weights of inland fresh fish, inland preserved fish, OAAs, and marine products.

of dried or salted/dried fish where it was assumed that only 10% was discarded, because many small fish are processed whole. The preprocessing correction factors are therefore **x 1.25** (1/0.8) and **x 1.11** (1/0.9) respectively. The average protein content of 19.9% for edible portions from Mogensen (2001) was assumed to apply to the portions used for processing (see IFF discussion above).

Dried, salted-dried or smoked fish

For dried, salted-dried or smoked fish, conversion factors could be derived based on either moisture loss or protein content. In the LMB, dried or salted/dried fish products show highly variable contents of moisture (6.6–45.9%) (Puwastien *et al*., 2000), so moisture loss is not useful for deriving general conversion factors.

Puwastien *et al*. (1999) also show that the mean (average) protein content of seven dried or dried/salted fish products from the LMB was 50.6% (range 38.5–63.0%), so the preservation factor is 2.54 (50.6/19.9), and after multiplying by the preprocessing factor (1.11) the overall conversion factor to FWAEs is **x 2.82**.

Ahmed *et al.* (1998) and Sjorslev (2000) used a factor of **x 2.5** for smoked fish, implying that less water is lost than during drying. This factor is similar to an FAO factor (2.3), so it was also used for this report (Figure 3 and Table 4). The preprocessing factor for smoked fish is assumed to be **x 1.25,** so the preservation factor is estimated as **x 2.0** (2.5/1.25) and the protein content is estimated as 39.8% (19.9 x 2.0).

Fermented fish products

Introduction

In humid tropical climates fish may dry very slowly (even in sunlight) so they begin to ferment, a natural process in which bacteria and enzymes in the fish break down the molecules that make up fish tissues (Saisithi, 1994). Fermentation involves two main reactions: firstly anaerobic decomposition of sugars in the fish, which produces lactic acid, a substance that preserves protein, and secondly, hydrolysis of protein, i.e. separation of the individual amino acids, which renders them soluble and also more digestible. This natural process is augmented by adding salt as a preservative, and has developed over many centuries in the LMB. For some products, fermentation is managed by adding a culture of micro-organisms. People of the LMB have acquired a taste for fermented fish products, and have developed many recipes by varying the types and sizes of fish used, the salt content and the processing time.

Fermented fish products can be divided into three basic groups as shown in Table 3 (Saisithi, 1994; Phithakpol *et al.*, 1995). The proportions of ingredients vary widely between different regions and producers, and the quantities of each type of product in the LMB are not known. Conversion factors for these products cannot be derived from moisture content, because

variable quantities of water are added or lost during processing. Protein content has been used for deriving conversion factors, assuming that little protein is lost during fermentation and that any protein added in other ingredients (such as rice) is negligible. An average preprocessing factor of **x 1.25** is also assumed because even small fish are not usually fermented whole (see preprocessing discussion above). Fermented fish products can be broadly classed as fermented fish, fish paste or fish sauce (Table 3), which are discussed separately below.

'Fish Paste'

Fish paste is a concentrated form of fermented fish, separately itemised in some surveys. It is not 'paste' as commonly understood, but products where fermentation has digested the fish to the point where the form of the fish is no longer discernible. Fish paste is typically made from small fish such as the common small cyprinids (*Henicorhynchus* spp.). Preprocessing varies by species, some are used whole, some are headed and cleaned, and fatty species (*Henicorhynchus* spp. in particular) are kneaded or pounded to remove fat. Fish are mixed with salt, after some time liquid is decanted and may be used as fish sauce. The mixture is fermented, typically for three months to one year. In Lao PDR and Thailand a small amount of rice or rice bran may be added late in fermentation. Inland fish pastes have highly variable protein contents of 7.9–24% (Phithakpol *et al.*, 1995) and Suntornratana (2002, *pers. comm.*) also provided a figure of 24% for a fish paste from northeast Thailand. As the proportion of different quality fish pastes throughout the LMB is not known, a mid-range figure of 14% protein was assumed. This would imply a dilution during processing of 0.70 (14%/19.9%), which after applying the preprocessing factor (1.25) gives an overall conversion factor of **x 0.88**.

Other fermented fish

Other types of fermented fish products are usually made from larger fish that are gutted, and often beheaded and scaled, salt is added, and at some stage in the process small quantities of one or more of sugar, rice, fruit, herbs or spices are added (Saisithi, 1994). Unlike fish paste, in the final product the form of the fish is discernible.

Puwastien *et al*. (1999) showed that protein contents of six kinds of inland fermented fish products varied between 5.7% and 16.2%, and Phithakpol *et al.* (1995) reported a range of 3.3 –21.2% protein content for eight inland fish fermented products. Suntornratana (2002, *pers. comm.*) reported an average protein content of 14.8% for four samples from northeast Thailand. A low/mid-range figure of 12% gives a conversion factor **x 0.75** (12/19.9 x 1.25).

Fish sauce

To make sauce, inland fish is mixed with salt and usually fermented for about 5–18 months. Liquid decanted from the mixture provides a first-grade sauce. The remaining fish-salt mixture may be further fermented and extracted several times with brine to make different grades of sauce. Fish sauce may also be made from liquid that is decanted during the making of fish paste.

The protein content of fish sauce varies widely: about 2% (Phithakpol *et al.*, 1995), 2 – 11.6% (Puwastien *et al.*, 1999), 6.2% in the Songkhram Basin of northeast Thailand (Suntornratana, 2002) and 15.8% (Saisithi, 1994, Table 5.1). Processing methods and product characteristics vary greatly, and as for fish paste, the overall proportions of different sauces in the LMB are not known. A mid-range figure of 8% protein gives a conversion factor of **x 0.5** (8/19.9 x 1.25), which has been used in this report. Mogensen (2001 p. 33) quotes one study in Cambodia that found that 10 kg of fish makes 8 L of sauce; this would give a factor of x 1.25.

Most fish sauce used in the Mekong Delta of Viet Nam and in Thailand originates from large processing plants for marine fish, but it appears that marine-derived sauce was either ignored or included within the marine fish component in field surveys, and fish sauce referred to inland fish sauce only. Only small quantities (or zero quantities) were recorded except for one inland province (An Giang, Study 15 in Chapter 4), where high usage of inland-derived fish sauce would be expected.

Summary and comparison of preserved fish conversion factors

Table 4 summarises the derivation of conversion factors for preserved fish. The figures used depend upon the assumptions made as discussed above.

Table 4. *Summary of the derivation of generic conversion factors for preserved fish to FWAEs.*
The overall factor is the weight of fish as FWAEs required to make 1kg of product.

Product	Preprocessing factor	Protein content of final product (%)	Preservation factor	Overall factor FWAEs-processed	Edible protein as % of FWAEs weight
Salted/dried fish	1.11	50.6	2.54	2.82	17.9
Smoked fish	1.25	39.8	2.00	2.50	15.9
Fish paste	1.25	14.0	0.70	0.88	15.9
Other fermented fish	1.25	12.0	0.60	0.75	15.9
Fish sauce	1.25	8.0	0.40	0.50	15.9

Note: Preprocessing factor is the ratio of FWAEs to edible portions after cleaning (beheading, gutting etc.). Preservation factor is the ratio of protein content of final product to protein content of edible portions (19.9%). The overall factor is the preprocessing factor multiplied by the preservation factor.

The overall factors are in some cases different to those used in other studies (Table 5), which causes some differences in FWAEs figures. The factors used here are generic ‘best guesses’ from limited data and should be updated if better data become available or for specific cases. Factors were used as shown and final data were rounded.

Table 5. *Comparison of conversion factors for preserved fish to FWAEs.*

Product	Ahmed *et al.* (1998)	Sjorslev (2000)	FAO	This report
Salted/dried dish	2.5	3.0	3.5	2.82
Smoked fish	2.5	2.5	2.3	2.50
Fish paste	1.4	0.8		0.88
Other fermented fish	1.4	0.8		0.75
Fish sauce	0.8	0.1		0.50

Research to improve conversion factors for preserved fish should include:

- recipes for different kinds of preserved fish products;
- information on the proportions of different kinds of fermented fish products in different regions; and
- investigation of the extent to which protein is lost during preservation.

3.3 Conversion factors for inland OAAs and marine products

The term 'OAAs' includes all freshwater animals other than fish, including both vertebrates (aquatic mammals, amphibians, aquatic reptiles—including snakes, and water birds) and invertebrates (including molluscs, crustaceans and water insects).

Based on limited data reviewed in Chapter 4 (see also Table 23), it was assumed for conversion of OAAs to edible portions that frogs, shrimps and molluscs are generally eaten in about equal proportions by weight, so from the information in Table 6 it was estimated that the average edible portion of OAAs was 49% and the average protein content was 8.0% of the FWAEs weight.

Table 6. *Conversion factors for edible portions of OAAs and percent protein in edible portions.*

Taxon	% edible portions	% protein in edible portions	est. edible protein in whole animals
Frogs—*Rana* spp.	55	19.0	10.5
Shrimps—*Macrobrachium* spp.	70	15.6	10.9
Birds	71	20.6	14.6
Snakes	29	19.0	5.5
Crabs *Somanniathelphusa* spp.	38	10.7	4.1
Insects	54	12.4	6.7
Molluscs—Clams and Snails	22*	12.1**	2.7

Note: Data from Mogensen (2001), except: * factor for clams (www.fao.org), ** protein content of river snails from Puwastien *et al.* (1999).

3.4 Conversion factors for marine products (MPs)

The term MPs includes all products made from marine fish and other animals. In the LMB some common MPs are preserved fresh fish, mackerel (Scombridae), canned fish, some molluscs (including squids and octopi), and crustaceans such as prawns and crabs. Unfortunately, those studies that include reports of MPs do not also provide sufficient information to derive conversion factors for these products. Therefore, the reported weight was assumed to be FWAEs, and as for inland fresh fish, the weight actually eaten was assumed to be 80% of FWAEs weight, and the protein content was estimated as 15.9% of FWAEs.

3.5 Protein content of other foods

Some reports included data on the consumption of 'other animals', i.e. terrestrial animals, under categories as shown in Table 7, but with variable coverage of categories of 'less conventional meats'. To convert the data to protein units it was assumed that protein content was the same as in flesh; people eat other parts of animals, but the bias introduced by using protein figures for flesh depends upon which parts are consumed; as no data were provided; clearly more information is needed on this aspect. Eggs were reported as numbers eaten and it was assumed that eggs weighed 50 grams each (a small size) when converting survey results to units of weight and protein. Some studies specified hen eggs, but an equal mixture of duck and hen eggs was assumed. For wild animals, as no data were available, it was assumed that protein content was 15%, which allows for losses during dressing and wastage of some parts.

Table 7. *Protein conversion factors for other (terrestrial) animals (from Puwastien* et al.*, 1999).*

Conventional meats	% protein	Less conventional meats	% protein
Beef — average of 5 cuts	21.2	Fowl other (same as poultry)	19.0
Pork — tenderloin	21.8	Birds (same as poultry)	19.0
Chicken — matured dressed carcass	22.4	Buffalo (same as beef)	21.2
Duck — dressed carcass	15.5	Goat/sheep (same as beef)	21.2
Poultry carcass average	19.0	Dried meat (estimate)	50.0
Eggs, chicken	13.2	Reptiles/grubs (estimate)	15.0
Eggs, duck	12.6	Forest game/wildlife (estimate)	15.0
Eggs, average of chicken and duck	12.9	Insects (Mean of 13 insects)	15.0
		Others unspecified (estimate)	15.0

Only two reports included information on consumption of all foods, so this review only covers animal sources of protein. No attempt was made to convert terrestrial animal meat to FWAEs.

Plate 1. Sun-drying fish—snakehead (*Channa*) fillets in the foreground, with catfish (*Pangasius*) fillets rear right, as well as whole sheatfish (Siluridae).
No information is available on the proportions of different kinds of dried fish produced or consumed.

Plate 2. A typical complex mixture of dried fish products, with gouramies (*Trichogaster* sp.) in the foreground.

Plate 3. Smoked-dried sheatfish (*Micronema* spp.), as commonly sold.
No information is available on the proportions of fish that are smoked, nor on the species composition.

Plate 4. Smoked freshwater puffer fish in northeast Thailand.
An example of a relatively uncommon product among the many which are smoked or dried and for which no specific information is available.

Plate 5. Much of the seasonal excess of fish is processed by fermentation—here small cyprinids (*Henicorhynchus* spp.) after pre-processing and prior to addition of salt.

Plate 6. Fish are typically fermented in large earthenware pots after salt is added.

Plate 7. Examples of fish pastes (known as *pa dek*) from Lao PDR. The fish are almost completely digested in the final product, and the moisture content and quality vary greatly.

Plate 8. Examples of the many kinds of 'other fermented fish products' – *pa jao* (left) and *pa som* (right); both are from Lao PDR.

Plate 9. The diversity of some fermented fish products from the Mekong, in a market stall in Ho Chi Minh City, Viet Nam.

Top row: fermented snakehead chunks, fermented whole beheaded snakeheads, and fermented whole gouramies (*Trichogaster* spp.); lower row: fermented crabs (for which, as is usual for OAAs, there is no separately published information), and fish paste imported from Cambodia, prepared from *Henicorhynchus* spp. in this case a rather incompletely fermented type of 'fish paste'.

Plate 10. Fermented products may be stored for long periods in jars and used in small amounts.

On the left, fermented freshwater clupeids (herrings), in the centre fermented small sheatfish (Siluridae), which are classed as 'other fermented fish'. On the right is inland shrimp paste, for which, as for all preserved products made from OAAs, there is no published information on production or consumption.

Plate 11. Fish sauce from Huai Luang Reservoir inland fishery, northeast Thailand.

Inland fish sauces are common in Thailand and Cambodia and in the inland parts of the delta, but marine fish sauce is usual in coastal provinces.

Plate 12. Many species of molluscs - clams and snails - are commonly eaten, but no consumption-specific information is available on these important OAAs.

Plate 13. Molluscs are usually sold in large quantities.
Here the meat from rice field snails is on sale. Each kilogram of consumed molluscs is assumed to represent about 4.5 kg of fresh molluscs (FWAEs), including their shells.

Plate 14. Frogs and tadpoles are popular foods.
They are usually regarded as different food types so should be separately itemised in surveys.

Plate 15. Large river shrimps (*Macrobrachium rosenbergii*) left, and small rice field shrimps (*Macrobrachium ?lanchesteri*) right.
These would be regarded as different kinds of foods that should be separately itemised in surveys.

Plate 16. People in the LMB sometimes eat reptiles, but these may be overlooked in surveys.
Snakes and lizards may be regarded as terrestrial, but many are aquatic or semi-aquatic, as are the species shown. Very little specific information is available on consumption of reptiles, particularly turtles and terrapins, many of which are protected species.

Plate 17. Eels are abundant and are a popular dish throughout the LMB. Although they are fish, they are regarded as separate taxa by most people in the Mekong basin, so their consumption may have been under-estimated in most surveys. They should be separately itemised in future.

Plate 18. Rice field crabs are very often sold and eaten, but little quantitative information is available.

4 Review of Consumption Studies

4.1 Overview and data quality assessment

As discussed in Chapter 2, population data are not a significant source of error compared with consumption data, for which 20 studies were reviewed. Of these, 16 studies of particular provinces or large parts of provinces covered 34 of the 86 provinces in the LMB; two studies were at national level and two covered a district or smaller area (Table 8). Most of the studies have not been published, and it was necessary to re-analyse some databases to generate estimates of consumption.

As shown in Table 8, basic characteristics of the studies varied widely because:

- various organisations sponsored or implemented the studies;
- the studies mostly focused on fisheries, but some were primarily aquaculture-related or capture fishery-related; and
- fieldwork was carried out in different years and during different seasons.

Only in Study 19 did the authors take into account the possible effect of seasonal variability on responses, by conducting interviews at random times during the year. In other studies that were solely based on interviews, no information was provided on seasonal response biases.

Table 9 shows that the studies also varied in their sampling approaches, as their specific objectives and resources differed. Various adjustments to data were necessary to derive province-level estimates, as is discussed in each of study reviews below. In general, the large number of households covered in most studies means that the data for inland fish are likely to be representative overall; at least of 'responses to interviews'[1]. The large total sample size (10,061 households) of the province-level studies represent 'over-sampling' relative to the objective of deriving yield in the LMB, as far fewer households would suffice to represent the basin as a whole. For example, under reasonable estimates of variance and assuming a simple normal distribution, a sample population of less than 200 households would provide estimates of the mean with a relative error of less than 5%[2].

Most of the studies were based on interviews in which respondents were asked to recall foods eaten (Table 10). Consumption was actually measured in only two province-level studies (Study 10 and 12), and in Studies 4 and 5 catches were measured to estimate consumption.

1 i.e. the amounts reported to be eaten, as distinct from the actual weight eaten.

2 This estimate assumes a normal distribution and a mean consumption of 60 kg/person/year, a variance of 400, a required error of ±3 kg/person/year, so the required number of samples $n=4*400/3^2 = 178$, formula from Snedecor and Cochran (1989) p. 438.

Hence the bulk of the information for this review is from recall of foods eaten over extended periods, for which the level of bias is unknown. Consumption studies frequently rely upon recall of foods eaten in the previous 24 hours, but no LMB studies used this approach. Various units were used (Table 11), which may again lead to certain biases that were not considered in study reports.

Given the uncertainty about the accuracy of quantities recalled during interviews, it is suggested that priority should be given to standardising and validating methods for consumption studies. Indeed, this suggestion applies generally to all the interview-based methods used in sheries socioeconomic surveys if the results are to be accepted without causing a great deal of controversy.

Results for all consumption values were converted to kg/capita/year as arithmetic means for all household members. Information about consumption could not be presented by gender or age, as only one report (Study 11) provided appropriate data. Examination of available data-sets showed that—as might be expected—the per capita distribution of consumption is skewed, so in general the medians can be assumed to be less than the means shown (Figure 7). However, consumption data span a relatively narrow range compared with data on catches, which may vary over several orders of magnitude.

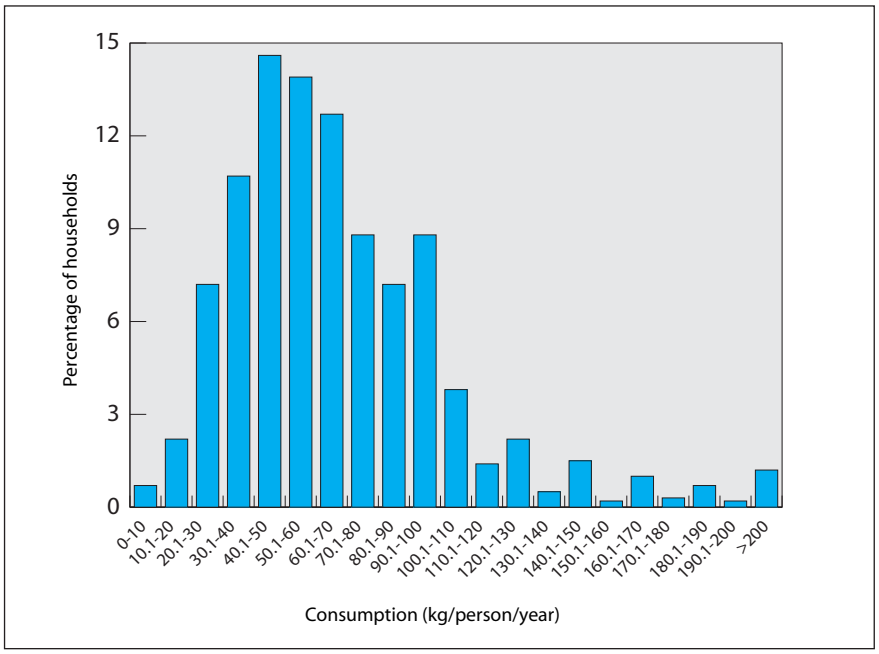

Figure 7. An example of a frequency distribution of sh consumption, from Study 13 (units are kg/person/year as FWAEs).

The median is perhaps a 'better' or more representative statistic, as 50% of people eat less than and 50% of people eat more than the median. But medians were not reported in most studies and arithmetic means are needed to calculate total provincial consumption, the main objective of this review. Con dence limits were not reported in most studies, and where

Table 8. *Basic information on the studies that were reviewed in this report.*

Studies which cover large parts of a province or provinces

No.	Study Report and Date	Study Sponsors	Country	Region	No. of provinces	Type of Study	Time of Study	Season	Number of Visits
1	Ahmed *et al*. (1998)	MRC & DoF, Cambodia	Cambodia	Tonle Sap – Great Lake	8	Capture Fisheries Baseline	Mid 1995 – early 96	Mostly Wet	Once
2	Setboonsarng *et al*. (2001)	MRC & DoF, Cambodia	Cambodia	Kandal, Prey Veng, Takeo	3	Aquaculture Baseline	March – April 1999	Dry	Once
3	Touch *et al*. (1994)	AIT	Cambodia	Svay Rieng	1	Aquaculture Baseline	February – March 1993	Dry	Once
4	Gregory *et al*. (1996)	AIT	Cambodia	Svay Rieng		Fisheries Baseline	August 1995 – April 1996	8.5 months	17
5	Mogensen (2001)	AIT	Cambodia	Svay Rieng		Nutritional Assessment	August 1997 – July 1998	Whole year	26 times/1 year
6	Funge-Smith (1999a)	FAO & UNDP	Lao PDR	Northern Lao	5	Aquaculture Baseline	November 1997 – January 1998	Late wet to early dry	Once
7	Sjorslev (2000)	MRC & LARReC	Lao PDR	Luang Prabang	1	Fisheries Baseline	May – August 1999	Wet	Once
8	Singhanouvong and Phouthavongs (2003)	MRC & LARReC	Lao PDR	Champassak	1	Fisheries Baseline	July 2002	Wet	Once
9	Baird *et al*. (1998)	EC and DoFor	Lao PDR	Khong District, Champassak	1	Fisheries Baseline	July – August 1997	Wet	Once
10	Garaway (2005)	ESRC and DFID	Lao PDR	Savanakhet	1	Fisheries related to wealth	May 1996 – April 1997	Whole Year	6 times / 1 year
11	Mattson *et al*. (2000)	MRC & LARReC	Lao PDR	Vientiane	1	Fisheries Baseline	March – April 1999	Dry	Once
12	Prapertchob *et al*. (1989)	DoF and KKU, Thailand	Thailand	Five provinces in northeast Thailand, includes Study 14 provinces	5	Fish Consumption Baseline	Three seasons in 1988	Whole year	3
13	Suntornratana (2002)	MRC& DoF, Thailand	Thailand	Lowland parts of 3 provinces	3	Fisheries Baseline	January – June 2000	Dry	Once
14	Piumsombun (2001)	Kasetsart University and FAO	Thailand	Khon Kaen, Nakhon Ratchasima to represent the northeast	2	Fish Consumption and Marketing	1988 – 89	no data	Once
15	Sjorslev (2002)	MRC and RIA2	Viet Nam	An Giang	1	Fisheries Baseline	May – June 1999	Late Dry	Once
16	Pham and Guttman (1999)	CAF Viet Nam and AIT	Viet Nam	Long An, western half	1	Fisheries Baseline	July 1997	Early Wet	Once
17	Setboonsarng *et al*. (1999)	MRC and RIA2	Viet Nam	Tien Giang	1	Aquaculture Baseline	July – August 1998	Early Wet	Once
18	Phan *et al*. (2003)	MRC and RIA2	Viet Nam	Tra Vinh	1	Fisheries Baseline	October – November 2000	Late Wet	Once
					36				

Studies which cover an entire country, not disaggregated

No.	Study Report and Date	Study Sponsors	Country	Region	No. of provinces	Type of Study	Time of Study	Season	Number of Visits
19	NSC (2004)	NSC	Lao PDR	Lao PDR	All	National Socioeconomic Survey	March 2002 – February 2003	Random over the year	Once
20	Lem and Nghia (2003)	FAO, Danida and MoF, Viet Nam	Viet Nam	Viet Nam	Not stated	National Fisheries Demand Study	2002	Not stated	Once

AIT	Asian Institute of Technology, Bangkok, Thailand
CAF	College of Agriculture and Forestry, Ho Chi Minh City, Viet Nam
DFID	Department for International Development, UK
DoFor	Dept of Forestry, Lao PDR
DoF	Dept of Fisheries
EC	European Commission
ESRC	Economic and Social Research Council, UK
FAO	Food and Agriculture Organisation of the United Nations
KKU	Kon Khaen University, Kon Khaen, Thailand
LARReC	Living Aquatic Resources Research Centre, Vientiane, Lao PDR
MoF	Ministry of Fisheries, Hanoi, Viet Nam
MRC	Mekong River Commission, Vientiane, Lao PDR
NSC	National Statistical Centre, Committee for Planning and Cooperation, Vientiane, Lao PDR
RIA2	Research Institute for Aquaculture 2, Ho Chi Minh City, Viet Nam
UNDP	United Nations Development Programme

Table 9. *Sampling details of the studies that were reviewed for this report.*

Studies which cover large parts of a province or provinces

No.	Study Report and Date	Region	Coverage of sampling (target)	Type of sampling	Sampling strata	Clustering/ randomisation of household survey	Households sampled
1	Ahmed *et al*. (1998)	Tonle Sap – Great Lake	Fishing-dependent communes within fishing districts	Clustered proportional stratified random	Weighted proportionally by strata - types of fishing and types of fishing grounds	Random households within 83 random communes	5,117
2	Setboonsarng *et al*. (2001)	Kandal, Prey Veng, Takeo	Pond-owners in fish-scarce, rainfed-rice pilot project areas; 3 pilot communes	Selective	na	50 households in each commune	150
3	Touch *et al*. (1994)	Svay Rieng	Whole province	Equally weighted clustered stratified random	Four ecozones based on soil type and rice yield	60 households per stratum, 240 hhs within 38 villages	240
4	Gregory *et al*. (1996)	Svay Rieng	Villages in one district, catchment of Saigon River.	Selective	Villages with low, medium and high access to waterbodies, 2 wealthy/3 poor households	5 households within each of 3 selected villages	15
5	Mogensen (2001)	Svay Rieng	3 of 6 districts, excludes upland and remote parts	Equally weighted stratified random	Low, medium and high trap-pond yields	About 20 households in 7-9 villages per stratum	64
6	Funge-Smith (1999a)	Northern Lao	Most of each province but only villagers interested in aquaculture	Selective	Includes both highland and lowland	Not random, clustering not stated	440
7	Sjorslev (2000)	Luang Phabang	Whole province	Clustered proportional random	na	Random households within 27 random villages	179
8	Singhanouvong and Phouthavongs (2003)	Champassak	Whole province	Clustered equally-weighted stratified representative	Ecozones, equal weighting: riparian 2, island 2 wetland 2 and highland 2	Random households within 8 representative villages	200
9	Baird *et al*. (1998)	Khong District, Champassak	Whole district	Equally weighted random households	Subdistricts	Random households equal weighting within 14 villages, one from each subdistrict	223
10	Garaway (2005)	Savanakhet	Lowland water-resource rich accessible areas	Selected for spread across wealth indicators	Rich, intermediate, poor	Equal sampling from 5 villages, linear systematic sampling of households relative to wealth	103
11	Mattson *et al*. (2000)	Vientiane	Around Nam Ngum Reservoir	Clustered random	na	Random households within 11 random villages	100
12	Prapertchob *et al*. (1989)	5 provinces in northeast Thailand	Whole provinces	Stratified random, proportional	Income, profession, education, location	Random households; 100 per province	500
13	Suntornratana (2002)	Lowland parts of 3 provinces	Lower Songkhram basin	Clustered random	na	Random households within 27 random villages	353
14	Piumsombun (2001)	Khon Kaen, Nakhon Ratchasima to represent the northeast	Whole provinces	Representative households	na	No details	99
15	Sjorslev (2002)	An Giang	Whole province, except 20% urban	Clustered, stratified random, proportional	Proximity of communes to main rivers: near-6, intermediate-2, far-2, approximately proportional	Random household within 58 random villages, within 10 selected communes	1,002
16	Pham and Guttman (1999)	Long An, western half	Mekong catchment part of the province	Stratified random, proportional	Low, medium and high income	Random households within target area , not clear if clustered	589
17	Setboonsarng et al. (1999)	Tien Giang	Whole province	Stratifed random, proportional	Five kinds of fish culture practices, including no fish culture	Random households within aquaculture categories	361
18	Phan *et al*. (2003)	Tra Vinh	Whole province	Clustered, stratified random, proportional	Villages in ecozones: urban, inland, riparian, brackish, coatal	Random households within 38 random villages proportional within strata	651

Studies which cover an entire country, not disaggregated

No.	Study Report and Date	Region	Coverage of sampling (target)	Type of sampling	Sampling strata	Sampling	Households sampled
19	NSC (2004)	Lao PDR	Whole Population	Stratified random villages, ratios between proportional and equal sampling, households systematic	Province (18) and 3 classes: urban, rural with access to road, rural with no access to road	15 households from each of 540 villages	8,100
20	Lem and Nghia (2003)	Viet Nam	Whole Population	Stratified random, proportional?	North/central/south, urban/suburban/rural	No details, assumed proportional	656

Table 10. *Methods and units used in studies that were reviewed for this report*

Studies which cover large parts of a province or provinces

No.	Study Report and Date	Region	Households	Method	Units for Fresh Fish and/or OAAs	Units for Preserved Fish	Units for Other Animal Foods	Units for Catch	Units for purchases or gifts
1	Ahmed *et al*. (1998)	Tonle Sap - Great Lake	5,117	Recall	kg/HH/week in open (Oct-May) and closed (Jun-Sept) seasons	kg/HH/month in dry and wet seasons (Nov-May and June-Oct)	kg/HH/month averaged over the year	kg/season in open (Oct-May) and closed (Jun-Sept) seasons	nd
2	Setboonsarng *et al*. (2001)	Kandal, Prey Veng, Takeo	150	Recall	kg/HH/week in wet and dry seasons	na	nd	nd	nd
3	Touch *et al*. (1994)	Svay Rieng	240	Recall	Estimated from catch	Estimated from catch	nd	kg/season (3 seasons)	nd
4	Gregory *et al*. (1996)	Svay Rieng	15	Measurement of most recent catches	kg/hh in most recent catch	nd	nd	kg/household/last trip	kg/household/7 days?
5	Mogensen (2001)	Svay Rieng	64	Measurement of most recent catches, recall of frequency	estimated from catch plus purchases	nd	kg/hh/week	kg/household/last trip	kg/household/7 days
6	Funge-Smith (1999a)	Northern Lao PDR	440	Recall	Flexible measures per week or per month	Flexible measures per week or per month	Flexible measures per week or per month	kg/harvest from ponds	nd
7	Sjorslev (2000)	Luang Phabang	179	Recall	kg/HH/week in wet and dry seasons	kg/HH/week in wet and dry seasons	kg/HH/week in wet and dry seasons	kg/month; kg/year; kg/recent trip	nd
8	Singhanouvong and Phouthavongs (2003)	Champassak	200	Recall	kg/HH/week in wet and dry seasons	kg/HH/week in wet and dry seasons	kg/HH/week in wet and dry seasons	kg/hh/season - wet or dry	nd
9	Baird *et al*. (1998)	Khong District, Champassak	223	Recall	Flexible units converted to kg/hh/2-month season	Flexible units converted to kg/hh/year	nd	kg/hh/2-month season	kg/hh/2-month season
10	Garaway (2005)	Savanakhet	103	Recall of recent acquisitions	Flexible measures, 1-day to 1-week recall, frequency of acquisition over prior period	Flexible measures, 1-day to 1-week recall, frequency of acquisition over prior period	nd	Flexible measures, 1-day to 1-week recall, frequency of acquisition over prior period	Flexible measures, 1-day to 1-week recall, frequency of acquisition over prior period
11	Mattson *et al*. (2000)	Vientiane	100	Recall	kg/HH/year	kg/HH/year	kg/HH/year	kg/HH/week in wet and dry seasons	nd
12	Prapertchob *et al*. (1989)	5 provinces in northeast Thailand	500	Measurement	kg/hh/day for three periods	kg/day for three periods	kg/day for three periods	nd	nd
13	Suntornratana (2002)	Lowland parts of 3 provinces	353	Recall	Self-chosen units/hh/week in wet and dry seasons	Self-chosen units/hh/week in wet and dry seasons	Self-chosen units/hh/week in wet and dry seasons	Self-chosen units/hh/week in wet and dry seasons	Self-chosen units/hh/week in wet and dry seasons
14	Piumsombun (2001)	Khon Kaen, Nakhon Ratchasima to represent the northeast	99	Recall	not stated	not stated	nd	nd	nd
15	Sjorslev (2002)	An Giang	1,002	Recall	kg/hh/week in wet and dry seasons	kg/hh/week in wet and dry seasons	kg/hh/week in wet and dry seasons		
16	Pham and Guttman (1999)	Long An, western half	589	Recall	kg/hh/week in each of 4 seasons	kg/hh/week in each of 4 seasons	kg/hh/week in each of 4 seasons	kg/hh/week in each of 4 seasons	kg/hh/week in each of 4 seasons
17	Setboonsarng *et al*. (1999)	Tien Giang	361	Recall	kg/HH/month, summed for annual				
18	Phan *et al*. (2003)	Tra Vinh	651	Recall	kg/hh/week in wet and dry seasons	kg/hh/week in wet and dry seasons	kg/hh/week in wet and dry seasons		

Studies which cover an entire country, not disaggregated

No.	Study Report and Date	Region	Households	Method	Units for Fresh Fish and/or OAAs	Units for Preserved Fish	Units for Other Animal Foods	Units for Catch	Units for purchases
19	NSC (2004)	Lao PDR	8,100	Recall	g/hh/week over the year	not clear	g/hh/week over the year	nd	Weekly value converted
20	Lem and Nghia (2003)	Viet Nam	656	Recall	kg/hh/month?				

Table 11. *Coverage of food categories in the studies reviewed (within 'other animals' coverage also varied).*

Studies which covered large parts of a province or provinces					Inland										Marine		Other Animals
No.	Study Report and Date	Country	Region	No. of provinces	Fresh Fish plus OAAs	Fresh Fish	Pres. Fish Aggregated	Fermented	Paste	Sauce	Smoked	Salted/dried	OAAs		Marine Fish	Marine OAAs	
1	Ahmed *et al*. (1998)	Cambodia	Tonle Sap - Great Lake	8		■		■	■	■	■	■					■
2	Setboonsarng *et al*. (2001)	Cambodia	Kandal, Prey Veng, Takeo	3		■	■								■		
3	Touch *et al*. (1994)	Cambodia	Svay Rieng	1		■		■	■	■	■	■					
4	Gregory *et al*. (1996)	Cambodia	Svay Rieng		■		1										
5	Mogensen (2001)	Cambodia	Svay Rieng			■							■				
6	Funge-Smith (1999a)	Lao PDR	Northern Lao	5		■		■				■	■		■		■
7	Sjorslev (2000)	Lao PDR	Luang Phabang	1	■			■	■	■	■	■					■
8	Singhanouvong and Phouthavongs (2003)	Lao PDR	Champassak	1		■		■	■	■	■	■	■				
9	Baird et al. (1998)	Lao PDR	Khong District, Champassak	1		■		■	■	■	■	■					
10	Garaway (2005)	Lao PDR	Savanakhet, 4 villages	1	3												
11	Mattson *et al*. (2000)	Lao PDR	Vientiane	1		■		■	■	■	■		2				
12	Prapertchob *et al*. (1989)	Thailand	Five provinces in northeast Thailand	5		■		■					■		■	■	■
13	Suntornratana (2002)	Thailand	Lowland parts of 3 provinces	3	■			■	■	■	■	■					■
14	Piumsombun (2001)	Thailand	Khon Kaen, Nakhon Ratchasima	2		■						■			■		
15	Sjorslev (2002)	Viet Nam	An Giang	1	■			■	■	■	■	■					■
16	Pham and Guttman (1999)	Viet Nam	Long An, western half	1	■		■								■		
17	Setboonsarng *et al*. (1999)	Viet Nam	Tien Giang	1		■									■		
18	Phan *et al*. (2003)	Viet Nam	Tra Vinh	1		■		■	■	■	■	■	■		■		■
				36													

Studies which covered an entire country, not disaggregated					Inland										Marine		Other Animals
No.	Study Report and Date	Country	Coverage	No. of provinces	Fish plus OAAs	Fresh Fish	Pres. Fish Aggregated	Fermented	Paste	Sauce	Smoked	Salted/dried	OAAs		Marine Fish	Marine OAAs	
19	NSC (2004)	Lao PDR	Lao PDR	18		■	■										■
20	Lem and Nghia (2003)	Viet Nam	Viet Nam	Not stated		■	■										

Notes: 1 No measurements of preserved fish which was estimated from catches
2 Mentions only frogs, no other OAAs
3 All fresh and preserved fish and OAAs were combined and shown as a single figure in FWAEs

databases were available calculation of confidence limits was usually not straightforward, because of clustering of samples (e.g. households within villages) and incomplete data on sample frames (Table 9). Because confidence limits could not be calculated for most individual studies confidence limits could not be calculated overall.

Table 11 shows the variable coverage of the main types of fishery products in each of the studies. Where studies did not provide data or where broad categories were used the approach for each study is discussed below. When studies did not state whether 'fish' referred to actual consumption or to FWAEs the figures were assumed to be FWAEs.

4.2 Review of studies

The following section discusses each study in terms of:

- background and methods used;
- consumption results;
- the way that consumption results were used to derive province estimates;
- other comparative data on catches or aquaculture, and;
- some other key findings of the study.

The studies are numbered in the same order as Tables 8 to 11 and ordered by country for ease of reference. The calculations for OAAs are presented in a single section summarised in Table 23, because of the limited amount of data.

Cambodia

Five studies were reviewed to obtain consumption estimates for inland fish for ten Cambodian provinces (Figure 8), as summarised in Table 12. The studies are discussed below.

Table 12. *Estimated consumption of inland fish in Cambodian provinces.*

Category	Study 1							
	Phnom Penh	Kandal	Kampong Cham	Kampong Chhnang	Siem Reap	Pursat	Battam-bang	Kampong Thom
Fresh Inland Fish	51.6	45.5	40.0	67.9	34.5	60.1	22.1	38.7
Salted Dried Fish	6.2	10.4	8.5	14.9	12.4	10.4	9.0	11.3
Smoked Fish	7.0	6.3	9.0	13.5	10.3	7.0	7.8	9.3
Fish Paste	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Other Fermented Fish	2.2	1.9	3.7	3.5	1.8	1.8	1.7	2.6
Fish Sauce (L)	3.1	2.8	3.2	4.5	1.5	2.4	2.0	3.1
Preserved Inland Fish	19.3	22.2	25.2	37.3	26.8	22.5	21.3	27.0
Total as FWAEs	70.9	67.7	65.2	105.2	61.3	82.6	43.4	65.7

Category	Study 2		Study 3,4,5
	Pray Veng	Takeo	Svay Rieng
Fresh Inland Fish	21.0	23.0	22.8
Salted Dried Fish	3.2	3.9	4.8
Smoked Fish	2.2	2.7	0.6
Fish Paste	0.1	0.1	3.0
Other Fermented Fish	0.2	0.3	0.6
Fish Sauce (L)	0.2	0.2	2.6
Preserved Inland Fish	5.9	7.2	11.7
Total as FWAEs	26.9	30.2	34.5

Note; All values are kg/capita/year as fresh whole animal equivalents (FWAEs), not actual consumption. Data were adjusted to province level as explained in the text so they are not the same as in the source reports. Preserved fish amounts were converted to FWAEs from factors in Table 2.

Study 1. Cambodia: eight provinces—Ahmed *et al*. (1998)

This comprehensive baseline socioeconomic study covered eight provinces along the Tonle Sap and Great Lake, the most densely populated part of Cambodia and the most productive part of the basin for inland fisheries. Large areas of each province are inundated each year, either by flood-waters or where rainfall is held in rice paddies. The total population of the eight provinces was estimated at 5.6 million (close to half the national population) of which about 4.2 million were within 'fishing districts' (those with major water bodies); within these about 2.4 million people lived in 'fishing-dependent communes' (those where there was judged to be significant dependence on fishing), and the survey only covered these communes (i.e. 43% of the population of the surveyed provinces). Both 'fishing' and 'non-fishing households' were

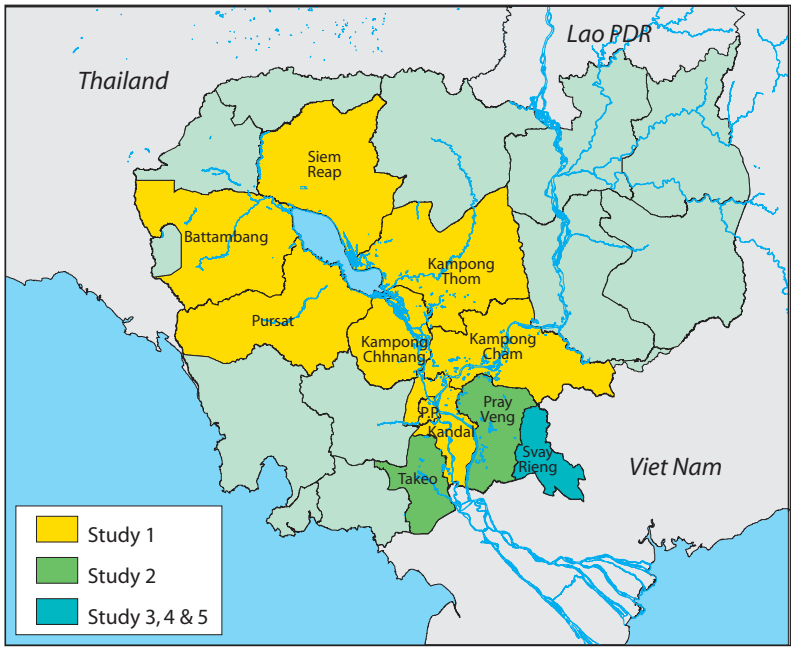

Figure 8. Provinces of Cambodia that contributed data to the consumption study.

randomly surveyed to provide weighted averages. Villagers were asked to estimate their weekly household consumption of fish in the dry and wet seasons.

Direct extrapolation from these fishing communes (i.e. from a 42% coverage of the population) to whole provinces would overestimate provincial consumption because people in non-fishing areas eat less fish. People in non-fishing households in the study's fishing districts reportedly ate 91% and 97% of overall averages for fresh and preserved fish respectively. In a separate study (Study 2) villagers in drier parts of Kandal (i.e. in selected non-fishing districts) reportedly ate only 15.27 kg/capita/year of fresh fish, i.e. 41% of the amount reportedly eaten by people in fishing communes in fishing districts in Kandal. This difference is probably greater than applies to non-fishing districts generally, which are probably in closer proximity on average to fishing districts than those surveyed in Study 2. In a useful comparison from Study 3, people living far from water bodies in Svay Rieng reported that they catch only about one-third as much fish as those living near water bodies, but that they compensate by buying more fish, especially in preserved forms. Overall in Svay Rieng those people far from water bodies reported that they ate 86% of the amount eaten by the people near water bodies. Considering these two factors (41% and 82%) it was assumed that non-fishing districts in provinces covered by Ahmed *et al*.'s study had about 60% of the consumption of fishing districts; this percentage is considered the best approximation in the absence of better data. The non-fishing districts had on average 57% of the provinces' population; therefore the overall factor that was used to adjust the estimates in Study 1 to provincial level was **x 0.8** (i.e. [0.57 x 0.6] + [0.43 x 1]).

Table 12 shows the estimated province-level means. The highest values are from Kampong Chhnang and Pursat provinces, as would be expected, because these provinces include the

most productive fishing areas around the southeast edge of the Great Lake and the Tonle Sap River–Great Lake confluence. The lowest values are from Battambong and Siem Reap, which are furthest from the most productive central parts of the Tonle Sap system.

Fish catches were also estimated based on interviews. For the fishing communes in the eight provinces the total catch from middle-scale and family fishing was estimated at 199,204 tonnes per year (Ahmed *et al*. 1998, p. 62), or about 83 kg/capita/year, a figure which is consistent with the consumption estimate of about 69 kg/capita/year[1] as a weighted average in FWAEs across the surveyed communes, allowing for some export. This consistency suggests that both estimates are reasonably accurate, as it seems unlikely that each estimate would be subject to similar biases. Accurate figures were not available for large-scale (fully commercial) operations.

This large study generally highlighted the importance of fishing and related activities around the Tonle Sap–Great Lake–Mekong floodplains of Cambodia. For example, although farming was reported to be the primary occupation of 68% of household heads, 39% of the households had one or more members actively engaged in fishing, and fishing was the primary occupation for 11% of household heads. Most (92%) of the households depended on products from common-property, open access resources either for food or income, and people exploited a wide range of water bodies, including seasonally-flooded habitats, for fish, OAAs or other products. Most (99%) of the surveyed households were engaged in family-scale fishing, with about 39% fishing for sale, but with only 1% engaged in large-scale commercial fishing.

The study did not include information on OAAs or marine fish. Other meat products were reported separately for fishing and non-fishing households. As might be expected, non-fishing households reportedly ate more pork and eggs, but consumption of other meats was reportedly little different between fishing and non-fishing households. To extrapolate to province level it was assumed that the 57% of the population who were not surveyed had the same level of 'other meat' consumption as the non-fishing households and the provincial totals were calculated accordingly (see Table 22).

Study 2. Cambodia: Kandal, Prey Veng and Takeo — Setboonsarng *et al*. (2001)

This survey was carried out to evaluate aquaculture potential in drier areas, where land-use was primarily rain-fed lowland rice (also called wet-season rice)[2] in three provinces (Kandal, Prey Veng and Takeo). The survey excluded the more densely populated areas near waterways and wetlands, where annual flooding supports highly productive aquatic environments and dry season (recession) rice cultivation, so per capita consumption of fish and OAAs was likely to be less than provincial averages. Only pond-owning villagers were surveyed, but pond fishing and aquaculture were not important relative to wild capture, so the results can be considered to apply generally to drier areas of these provinces. Villagers from 50 households in each province were asked how much fresh fish they ate on average each week in wet and dry seasons, both

1 The study report shows 75.6 kg/capita/year because different conversion factors were used for preserved fish. Confusingly, the report summary states that 'nearly 40% of the fish catch was consumed within the fishing dependent communes', a statement that does not match with the reported consumption and catch figures.

2 In Kandal 10 of 50 households were in areas of irrigated lowland rice.

fresh and preserved, but they were not questioned about OAAs. Figures from this study were used as the basis for Prey Veng and Takeo Provinces, but required adjustment as they only applied to the drier, less populated areas. The figure for consumption of fresh fish in Kandal in this study was 15.27 kg/capita/year, whereas Study 1 reported 36.4 kg/capita/year in fishing districts in Kandal, approximately 2.4 x higher; figures for fermented fish were similar: 5.9 and 5.3 kg/capita/year (Study 2 and Study 1 respectively). To obtain more realistic estimates at province level, the ratio for fresh fish was also assumed to apply to fish-poor versus fish-rich parts of Prey Veng and Takeo and it was conservatively assumed that 50% of the population lives along watercourses or floodplains (fish-rich areas); for half of each province it was assumed that yield was 2.4 x the survey result. Preserved fish was not disaggregated in results, so it was necessary to assume that the proportions of each type of preserved fish were the same as the average for Study 1 so that adjustments to FWAEs could be made.

The study highlighted the general importance of the capture fishery despite it being carried out in fish-poor areas. People reported they spent the largest proportion of their work-time on rice cultivation, followed by fish capture, with aquaculture virtually insignificant, even though pond owners were selected for the study. In Kandal, Prey Veng and Takeo 70%, 82% and 90% of the households respectively engaged in fishing, mostly in rice-fields and in household ponds, which supported wild fish populations.

Studies 3, 4, 5. Cambodia: Svay Rieng — Touch *et al*. (1994), Gregory *et al*. (1996), and Mogensen (2001)

Svay Rieng is a very dry province in southeast Cambodia, bordering Viet Nam. This province is not usually shown as within the LMB in maps, but in fact the southwest part — about half — of the province is seasonally affected by overflows from the Mekong, and drains into the canal system in the eastern part of the Mekong Delta so it is within the Mekong catchment. The northeast part of Svay Rieng is in the Saigon River catchment, which is connected to the Mekong catchment during large floods.

This province is considered poor in aquatic resources, and it is particularly affected by an extended dry season, so Study 3 was undertaken to identify areas in particular need of aquaculture development. Study 4 documented the significance of the yield from rice-field fisheries, while Study 5 focused on nutrition.

In Study 3, Touch *et al*. (1994) surveyed 240 households spread through most of the province and selected equally from four ecozones; only 200 households completed questionnaires that could be used. The ecozones were based on soil type and agricultural production, and it is likely that this selective sampling biases the results towards less productive areas, as population density is highest on the best soil types which are usually on floodplains. Results were not disaggregated according to ecozones, so could not be re-adjusted for this possible bias. During interviews in early 1993, household heads were asked about their typical catches in three seasons — cold (Dec – Jan), wet (Jul – Nov) and dry (Feb – June). They were also asked about the disposal of catches — consumption, sale, processing or given away, and about

how much fish they bought. The results were then used to estimate consumption for households classified as close to or far from water bodies. The results were not presented by catchment, so LMB data cannot be separated from Saigon River catchment data. Households near water bodies reportedly caught, processed and sold more fish whereas households far from water bodies reported they ate most of what they caught and had to buy more fish or fish products seasonally. There was limited seasonality reported in catches (Table 5 of Touch *et al*., 1994), which is rather inconsistent with actual data from Study 4 and with the pattern observed in many other studies in the Mekong. The values are also much less than those reported in Study 2 for drier areas of other provinces.

In Study 4, Gregory *et al*. (1996) carried out a more intensive survey in a floodplain area in the east of Svay Rieng in the catchment of the Saigon River. Three villages on a 7 km transect from the centre to the edge of a floodplain were studied. Selection of five houses in each village was based on their relative wealth (two wealthy, three poor) and their spacing. Study households were visited at fortnightly intervals over the 8.5-month period when fishing is significant (i.e. excluding the dry season). The species and weights of the most recent catches of 15 households were recorded and used with interview data on effort, disposal of catches, and purchases to estimate household consumption. Catches and effort were strongly seasonal in each village, peaking in November during the flood recession then falling to close to zero by April. The study stopped by mid-April 1996 when catches were close to zero, and it is likely that few fish are caught during the dry season (April – July), when preserved fish (mainly *prahoc*) is eaten instead. The study estimated the quantities of fresh fish that were processed and assumed one-third was eaten, but did not collect data on consumption of processed products, or on the disposal of fish which had been processed. Interestingly, this study showed mean catches of fish and OAAs of 72, 93, and 106 kg/capita/year over the 8.5-month period for the three villages in increasing proximity to the centre of the floodplain, with 18% of the weight on average comprising OAAs, but with no information on percentage consumed. Of the average catch of 90 kg/capita/year, 36% was eaten, 43% was sold and 21% was processed, mainly into *prahoc*. These values for catches are much greater than the mean values for fish catch — based on interviews only — in Study 3 of 20.3 kg/capita/year for households close to water bodies and 8.4 kg/capita/year for households far from water bodies. Values for consumption are also much higher. This very large discrepancy suggests that the interview data of Study 3 are under-estimates or the households studied by Gregory *et al*. were extremely 'fish-rich', or both.

In Study 5, Mogensen (2001) focused on nutritional aspects of consumption of fresh fish and OAAs, and included data from one-year study in Svay Rieng province. This intensive study covered 64 households considered representative of rural farmers in the province and classed as having trap-ponds classified as low, intermediate or high yield. The households were surveyed approximately once per two weeks for a one-year period when the most recent catch or collection of fish and OAAs was weighed. Households were also interviewed about fishing effort and provided estimates of the amounts bought, sold, processed and given away. These data were used to estimate consumption as FWAEs. Additional information on preparation and cooking methods and on nutrient content was used to estimate actual consumption and intake of nutrients. Unfortunately, quantities of preserved fish were not recorded. Mogensen's estimates

of quantities consumed are quite similar to those of Study 4 (also based on measurement of catches) but much higher than any mean estimates provided in Study 3 (based on interviews), suggesting that the results from Study 3 are underestimates.

Table 13. *Consumption figures (kg/capita/year, inland fish, all FWAEs) for Svay Rieng from Study 3, 4 & 5 showing figures used for provincial estimates.*

Category	Study 3	Study 5	Figures used	Study 4
Fresh Fish	10.5	35.0	22.8	22.7
Salted and/or Dried Fish	4.8		4.8	
Smoked Fish	0.6		0.6	
Fish Paste	3.0		3.0	
Other Fermented Fish	0.6		0.6	9.0
Fish Sauce (L)	2.6		2.6	
Preserved Fish as FWAEs	11.7		11.7	
Total fish as FWAEs	22.2		34.5	31.7
OAAs FWAEs	nd	5.2	5.2	5.0

Given the difference in consumption figures between these studies, any figures used for provincial estimates are somewhat controversial. The three studies may each be biased towards drier or wetter areas. Study 3 was an aquaculture-related survey and given the situation in Cambodia at the time, villagers may also have deliberately understated fish catches in the expectation that the government or aid agencies might provide assistance. Conversely, the subsequent studies may have—perhaps unconsciously—tended to exaggerate the role of wild fish. Although catches were recorded each fortnight, calculations of daily catches depended upon the response to questionnaires about fishing effort over each two week period, and villagers may have wanted to please interviewers who were clearly interested in fishing. Given the apparent discrepancy in the results it was decided to choose the mean of the results from Study 3 and 5 for estimating the provincial totals, as shown in Table 13. Study 4 fresh fish figures were not used given the selectivity in choice of households in that study. Note that the use of Studies 3 and 5 and exclusion of Study 4 provides a conservative estimate of consumption.

Lao PDR

Three studies provided data for seven provinces in Lao PDR, three studies provided supporting data from smaller areas, and one national study provided estimates that were not disaggregated by province. Results of province-level studies are summarised in Table 14 and then discussed below.

Table 14. *Consumption of fish and OAAs in Lao PDR as reported in studies.*

Category	Province-level Studies						
	Study 6					Study 7	Study 8
	Oudomxay	Sayaboury	Xieng Khouang	Savannakhet	Sekong	Luang Prabang	Champassak
	North	North	North	Centre	South (upland)	North	South
Fresh Fish	9.5	6.3	12.7	9.3	6.8	11.36	25.6
Salted Dried Fish	5.5	5.2	9.9	6.6	5.8	12.4	6.4
Smoked Fish	0.0	0.0	0.0	0.0	0.0	0.9	0.1
Fish Paste	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Other Fermented Fish	1.0	1.3	2.0	3.5	4.6	2.0	5.1
Fish Sauce	0.0	0.0	0.0	0.0	0.0	0.5	0.0
Preserved Fish	6.5	6.6	11.9	10.2	10.3	16.2	11.6
Total Inland Fish	16.0	12.8	24.5	19.5	17.1	27.5	37.2
Total OAAs	3.5	4.0	5.9	6.2	5.0	4.6	10.3
Inland Fish + OAAs	19.4	16.9	30.5	25.6	22.2	32.1	47.5
Canned fish marine	0.6	0.3	0.7	0.6	0.4	0.5	0.5
Total Fish	16.6	13.2	25.2	20.1	17.5	28.0	37.7

Category	Local-level Studies		
	Study 9	Study 10	Study 11
	Khong District	Savanakhet	Nam Ngum
	South	South	Centre
Fresh Fish	33.4		36.0
Salted Dried Fish			0.0
Smoked Fish			9.0
Fish Paste			0.1
Fermented Fish	9.6		4.1
Fish Sauce			0.4
Preserved Fish	9.6		13.6
Total Inland Fish	43.0	10.0	49.6
Total OAAs			
Inland Fish + OAAs	43.0	10.0	49.6
Canned fish marine	0.5	0.5	0.5
Total Fish	43.5	10.5	50.1

Note: All values are kg/capita/year as freah whole animal equivalents (FWAEs), not actual consumption. Preserved fish amounts were converted to FWAEs from factors in Table 2. Highlighted figures are estimates from Study 6.

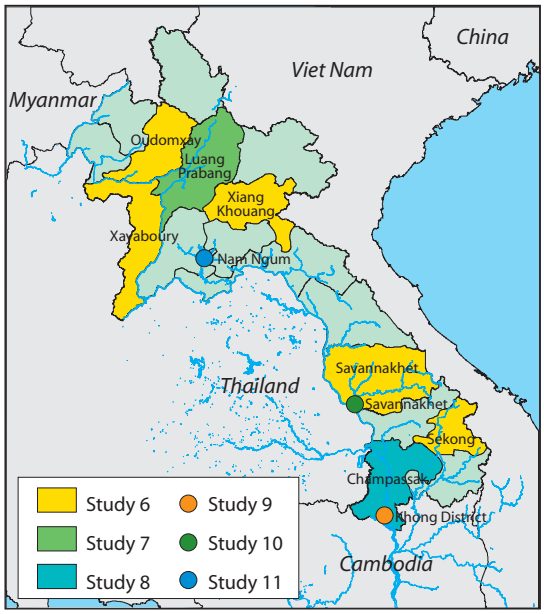

Figure 9. Provinces of Lao PDR that contributed data to the consumption study.

Study 6. Lao PDR: five provinces — Funge-Smith (1999a)

Funge-Smith (1999a), as part of the FAO/UNDP Provincial Aquaculture Development Project, conducted a survey of a cross-section of 440 rural households in Oudomxay, Savanakhet, Sayaboury, Sekong and Xieng Khouang provinces in 1997 (Figure 9). The survey targeted people who were interested in aquaculture, and although about 85% of households already had fishponds, the survey is likely to be biased towards 'low-fish' villagers (Funge-Smith, *pers. comm.*). Respondents were asked to itemise their consumption in any units they wished, both in terms of amounts (e.g. kg, buckets, plates, cans) and in any time units (e.g. days or weeks). These units were then converted to kg/year. This method avoids conversion errors from mental arithmetic by respondents or surveyors, but may introduce random errors into results from people's individual biases. The results are summarised in Table 14. As discussed under Study 19, the figures for fish appear to be generally low as compared with a national level study so they were not used directly for province-level estimates.

Study 7. Lao PDR: Luang Prabang — Sjorslev (2000)

This survey covered households in a province considered representative of northern Lao PDR. Much of Luang Prabang province is mountainous, but there are many streams and rivers and most people have access to rice-fields. People were asked how much 'fish' they eat per week in the dry season and the wet season. Fresh fish and OAAs were combined as 'fish' in the questionnaire. It was assumed that OAAs were 28.7% of total 'fish plus OAAs' (as in Study 8 in Champassak) for the purpose of separately estimating fresh fish and OAA consumption. The

report and database also included a breakdown of the previous day's catches of 286 fishers (during the early rainy season), in which 14.7% of the total weight of catches was OAAs (reptiles, amphibians, mammals and molluscs), a figure consistent with the consumption estimate, allowing for seasonality.

Consumption statistics were recalculated from the original survey databases because the figures shown in Tables 4.2.7 and 4.2.8 of Sjorslev (2000) were apparently calculated as the mean of each household's per capita consumption (household consumption divided by the number of household members). The resulting arithmetic means are generally higher than if the means are weighted correctly by dividing the total consumption of all households by the total population of all households (or by dividing mean household consumption by mean number of household members). Figure 7 illustrates how larger households tend to have lower per capita consumption, presumably because children — who eat less — form a higher percentage of the total number of people in the household, and perhaps because larger households can acquire less food per capita. This non-random relationship with household size applies to many consumption statistics and mandates caution when converting between household and per capita statistics.

People reported that 69% of their fresh fish and OAAs was self-caught; which equates to about 11 kg per year.

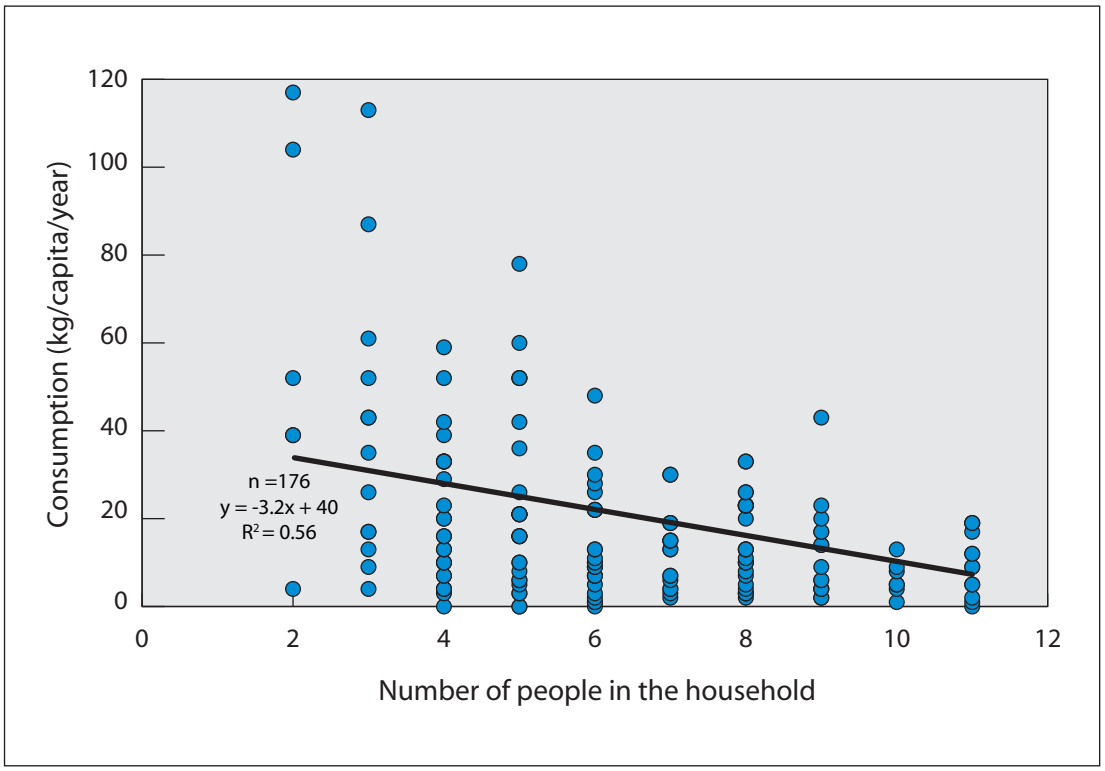

Figure 10. Household size and per capita consumption of fish and OAAs (kg/captia/year as FWAEs) in Luang Prabang (from the MRC database used in Study 7).

The survey also questioned villagers about catches. Annual catches estimated by household heads were only about 4.7 kg/capita/year (i.e. averaged across all household members), but they may have been unaware of all catches by all household members. Interviews of 286 individual fishers, gave different figures for annual catches depending on how questions were asked[1]. When based on monthly fishing trips multiplied by average catches, mean annual catches were estimated at 60.7 kg/capita/year, but when based on monthly catches by each gear type total mean catches were 34.7 kg/capita/year, with data highly variable in each case. About 35% of all people go fishing, so the individual catch estimates provide for 12–21 kg/capita/year averaged across all people. The catches reported by individuals would be large enough to cover the reported fish and OAA consumption, assuming that most preserved fish is not self-produced, but the wide range in estimates (from less than half to about two times the portion of consumption reportedly derived from catches) shows the large potential errors in quantities estimated during interviews.

The report covered many aspects of socio-economics and highlighted the importance of inland fisheries in this mountainous area, where official statistics do not cover subsistence catches. Fishing was reported as the third most important activity after rice farming and livestock rearing, and 81% of households reported that one or more household members went fishing at some time. The most important fishing habitats were rivers, streams and rice-fields. Catches were extremely diverse; the previous days' catch comprised 67 species of fish and six taxa of OAAs.

Study 8. Lao PDR: Champassak — Singhanouvong and Phouthavongs (2003)

A pilot survey of fisheries in Champassak was conducted in eight representative villages in four districts; six villages were from lowland and two from highland areas; the villages were considered reasonably representative of four zones within the province (Table 15), including Khong district (Island).

Household members were asked about their average weekly consumption in the dry and wet seasons. Portion-size estimate aids (PSEAs) were used; these were either cardboard models of fish of several sizes or containers of various sizes that the respondents could use to estimate quantities consumed. The study asked villagers to separately estimate quantities of different kinds of preserved fish and also the amounts of the main kinds of OAAs eaten. The interviewers also asked about household catches and their disposal, but the units used were total catches in dry and wet season (i.e. per 6-month season, rather than weekly catches). Some preliminary results were reported by Singhanouvong and Pouthavongs (2003), who concluded that total fish and OAA consumption for the province was 50 kg/capita/yr, about half of which comprised preserved fish. Results for catches as reported by village heads were about 57% of the results for consumption. The database from this study was re-checked for errors and re-analysed for this report as summarised in Table 15 and 16. The recalculation indicates that total fish and OAA consumption was 45 kg/capita/year. The difference from the previously published figure of 50 kg/capita/year results from weighting the data by ecozone. The high proportion of the

1 All figures were recalculated from the original databases.

province population living in the riparian zone has a large effect on the final weighted means, with high consumption in floodplain and island zones having relatively little effect on weighted means.

The order of consumption between the zones is as expected, as island and floodplain villages have highly conspicuous and productive fisheries. Fermented fish is a staple, with rather similar quantities reportedly consumed throughout the province. Less consumption of fresh fish in highland villages appears to be mitigated by greater consumption of dried fish.

Table 15. *Summary of results for consumption from the database of Study 8 in Champassak.*
In each zone, two households were sampled in each of two villages, 25 households per village.
All data is FWAEs.

Zone	Riparian	Floodplain	Island	Highland	
District	Sanasomboun	Patumphone	Khong	Paksong	
Percent of province population	68.6%	8.7%	13.3%	9.4%	
Households sampled	50	50	50	50	
People in households	323	339	300	322	
Consumption (kg/capita/year)					Weighted mean
Fresh wild fish	23.2	19.3	43.4	13.2	24.6
Eels	0.3	4.3	0.2	0.5	0.7
Fresh aquaculture fish	0.1	0.0	0.0	2.4	0.3
Total fresh fish	23.7	23.5	43.6	16.1	25.6
Dried fish	0.7	1.8	3.1	5.0	1.5
Smoked fish	0.0	0.0	0.9	0.0	0.1
Salted fish	0.5	0.8	1.4	0.9	0.7
Fermented fish	6.6	6.4	8.1	7.0	6.8
Total preserved fish	7.9	9	13.5	12.9	9.2
Total inland fish	31.6	32.5	57.0	28.9	34.8
Frogs and tadpoles	5.1	7.9	6.2	6.1	5.6
Crabs	0.2	0.3	0.1	0.6	0.2
Shrimps	0.1	1.8	1.4	0.5	0.5
Molluscs	2.6	15.5	4.6	3.2	4.0
Insects	0.0	0.1	0.0	0.0	0.0
Total OAAs	8.0	25.6	12.2	10.4	10.3
Total fish and OAAs	39.5	58.1	69.2	39.4	45.1

In this study the total quantities of OAAs were higher than in any other study, which probably shows that the effect of a reasonable level of disaggregation of the data in interviews is to increase the total estimate to a more realistic figure than where all fish and OAAs are simply lumped in one question. Interviews also specifically itemised eels (which are fish), and fish from aquaculture, so the total amount of fish is perhaps higher than if the question was simply 'fish'; again it is reasonable to disaggregate a common taxon that is perceived as different to 'fish' by villagers. The relatively high figures for fermented fish also may be a result

of the separation into three types in interviews, with the individual figures then summed. Asking separately about dried fish and salted fish may also have increased the final estimated quantities.

Household heads reported data on catches as kg per season, with the fate of catches itemised as in Table 16. Catches should approximately balance with consumption, with an excess in the island zone and a deficit in the highland zone. All zones were in apparent deficit, with the total reported catch being only 60% of total reported consumption. This deficit could indicate either over-estimation of consumption or under-estimation of catches; perhaps quantities caught and consumed are perceived differently. Alternatively, the results may simply reflect rounding-up or rounding down respectively, when people estimate quantities per week (consumption data) or per season (catch data). Clearly more investigation of this discrepancy is warranted.

Table 16. *Summary of results for household catches from the database of Study 8 in Champassak.*
In each zone two households were sampled in each of two villages, 25 households per village. All data is FWAEs.

Zone	Riparian	Floodplain	Island	Highland	
District	Sanasomboun	Patumphone	Khong	Paksong	
% of province population	68.6%	8.7%	13.3%	9.4%	
Households sampled	50	50	50	50	
Catch (kg/capita/year)					Weighted mean
Total fish and OAA catch	22.7	41.9	59.2	2.8	27.4
Eaten fresh	7.3	13.4	15.9	2.2	8.5
Dried	0.4	0.5	2.0	0.0	0.6
Fermented	5.1	9.4	13.9	0.3	6.2
Sold	8.0	16.8	25.2	0.1	10.3
Given away/bartered	1.5	1.6	2.0	0.1	1.4
Used in aquaculture	0.0	0.0	0.01	0.0	0.001
Sold in markets	0.4	0.3	0.2	0.0	0.3

Study 9. Lao PDR: Champassak, Khong district—Baird *et al*. (1998)

This rapid but thorough survey was carried out to describe the fishery of Khong Island and adjacent villages along the Mekong River in southern Lao PDR, an area well-known as having an important fishery and likely to have high levels of fish consumption. At the time of the survey there was very little documentation of capture fisheries in any part of Lao PDR. Surveyors used questionnaires and semi-structured interviewing techniques. Households were randomly selected within strata—southern/northern and mainland/island—to ensure representativeness. Fish consumption was estimated based on six 2-month seasons, and many questions were asked by interviewers to try to arrive at estimates for that season. All categories of fish were covered, but consumption of fish sauce and dried or dried/salted fish was negligible (Baird, *pers. comm.*). About 78% of meals reportedly had fish as the main animal protein and about 88% of the fish consumed was reported to be self-caught. About 98% of villagers reported that they ate fermented fish and about 90% made it themselves, showing the importance of this way of preserving seasonal excesses of fish.

Mean consumption was 43 kg/capita/year as FAWEs and of this about 9.6 kg was fermented fish. Catches were estimated at 62 kg/capita/year, a figure that matches nicely with the consumption estimate, allowing for some export from this district.

The consumption figures were about 75% of that found for 'island' villagers in Study 8 (Table 18), an acceptable match considering that the two villages sampled in Study 8 were on Khong Island where fishing is most intense.

The study found that 94% of households fished at some time, using at least 89 methods, and that the Mekong was the most important fishing habitat, with flooded rice-fields also important in the wet season. Aquaculture was of negligible importance. The most important species in catches were reportedly riverine cyprinids, primarily *pa soi* (*Henicorhynchus* spp.) and other small species. This study confirmed the great importance of river fisheries in this district. Elsewhere in the province it is likely that fisheries are also important, but presumably participation, catches and consumption are generally somewhat lower than in Khong.

Study 10. Lao PDR: Savannakhet — Garaway (2005)

Garaway studied four rural villages in a lowland district, where people had a wide range of access to aquatic resources. Representative households were selected for the survey based on wealth indicators. Data were collected six times over one year in a relatively intensive exercise. Calibrated bowls of various sizes and 'fish sticks' were used to assist respondents in quantifying their responses. Villagers were asked about their most recent fish and small shrimp 'acquisition' (caught, bought, earned and received) and fish disposal (given away or sold) over a period of one-day to one-week prior to the interview, with the period chosen by the respondent, depending on frequency of acquisition and their capability to recall. The resulting figures were then used with respondents' estimates of frequency of acquisition over the prior period to scale up the data to the prior eight-week period. Mean consumption was 17.5 kg/capita/year, all fish and shrimps combined, expressed in adult equivalent units (AEUs). Converting the figure to average per capita values would result in a figure about 30% lower, i.e. 12.3 kg/capita/year, and removing shrimps from this total would reduce the figure further; assuming OAAs are about ¼ of the total (Table 23) the fish consumption figure is about 10 kg/capita/year. This mean consumption figure is very low compared to that found in Study 8 (Table 17) in similar floodplain zones, albeit in a separate province. The study was not intended to be representative of quantities consumed across Savannakhet, and the discrepancy in estimates suggest that either the chosen villages were unrepresentative, or that the interview-based consumption estimates are too high.

Study 11. Lao PDR: Nam Ngum — Mattson *et al*. (2000)

This study covered villages around Nam Ngum reservoir, the largest man-made water body in the LMB. About 16,500 people (5% of the province's population) lived in 30 villages; from these 100 households were surveyed. Fishing was reportedly the second-most important occupation after farming and about 62% of households had one or more full-time fisher. The fishery was based on many species, caught using many kinds of gear, gillnets being the most

common. The total catch was estimated at 6,833 tonnes per year — about 143 kg/ha/year, or about 2 tonnes per fisher per year.

The questionnaire to household heads asked about average monthly consumption of fish and other meats per household over each year (i.e. not itemised by month or season). The questionnaire itemised all types of fish products except dried/salted fish, and all types of meat, but did not cover most categories of OAA. For example, shrimps, mussels and snails are common in the reservoir and are commonly eaten (based on personal observations). There were also no data for marine products, presumably because few are sold in this area. The reservoir is a significant exporter of fish, especially to other parts of Lao PDR, but also imports fish sauce from Thailand. The study report expressed results in protein units, so results were recalculated from the original database. Total fish consumption figure was 49.6 kg/capita/year of which 13.6 kg was preserved fish. These figures are consistent with those found for other fishing communities in Lao PDR, Khong — 43 kg/capita/year (Study 9) and Khong Island — 57.6 kg/capita/year (Study 8). Comparison with fishing communes in Cambodia is also of some interest, where consumption averaged around 69 kg/capita/year as FWAEs (Study 1). The difference can be partly accounted for by a reported higher consumption of other animal meat around Nam Ngum of around 18 kg/pers/year compared with about 8 kg/capita/year in Cambodia.

Study 19. Lao PDR: LECS3 — NSC (2004)

The Lao Expenditure and Consumption Study (LECS) has been carried out three times: in 1992/3, in 1997/8 and in 2002/3. It is the largest and most important survey carried out by the National Statistical Centre of Lao, so the results should be given considerable weight in official planning. In the latest (third) survey, 540 villages were selected randomly within 54 strata, based on 18 provinces and three urban/rural classes. In each village 15 households were sampled — 8,100 households in total — making this a very large and comprehensive socioeconomic study. The study also randomised villages by month of interview to remove seasonal bias. One part of the study recorded weekly expenditure on food and estimates of self-production of food; these were combined to estimate weekly intakes.

As shown in Table 17, fish consumption in the south and centre of the country was reportedly higher than in the north, as expected based on more abundant aquatic resources.

Table 17. *Reported consumption in Lao PDR in 2002/3 (kg/capita/year actual intake).*

Region	Meat	Fish	Vegetables	Fruit	Rice (cooked)
Entire Lao PDR	22.4	25.3	45.6	28.0	210.5
North	23.9	19.1	63.3	24.9	236.9
Centre	21.6	27.9	39.3	28.8	198.1
South	22.4	28.0	34.3	30.8	197.0
Urban	25.3	24.1	40.3	34.0	186.3
Rural with road access	21.8	27.7	45.6	26.9	217.8
Rural without road access	20.3	19.7	53.8	22.1	216.4

In rural areas, people with road access reportedly ate more fish and meat than those in areas without roads. Reported fish consumption increased over the last ten years, although the change was not statistically significant. Meat and fruit consumption both increased significantly as percentages, whereas consumption of rice and minor foods fell as percentages, indicating a general improvement in diet in Lao PDR. The survey reported actual consumption of food and did not separately itemise preserved fish or marine fish. To convert to FWAEs to allow comparison with other studies, it was assumed that the proportions of fresh and preserved fish were the same as the average percentages for other province-level studies (6–8) in Lao PDR (as shown in Table 14) after conversion to actual amounts eaten, and that marine fish was 0.5 kg/capita/year, the average from Study 6.

Table 18. *Estimated total inland fish consumption from LECS3 as FWAEs (kg/capita/year) compared with some other studies in Lao PDR.*

LECS values were converted to FWAEs as explained in the text.

Study	LECS3	Study 6	Study 7	Study 8	Study 9	Study 10	Study 11
Survey coverage	Lao PDR	5 provinces	Luang Prabang	Champassak	Khong district, Champassak, high-fish area	Savannakhet, small part of province	Nam Ngum, high-fish area
Region / Type	Interview	Interview	Interview	Interview	Interview	Measurement	Interview
Entire Lao PDR	34.6	18.0					
North	26.2	17.8*	27.5				
Centre	38.3	19.5				~10	49.6
South	38.3	17.1		37.2	43.0		
Urban	33.0						
Rural with road access	38.0						
Rural with no access	27.0						

Note: * mean of 3 provinces

The values for Studies 7 and 8 (in which households were selected to represent provinces) are similar to the LECS3 figures for northern and southern Lao PDR respectively. The figures for Study 9 and 11 are also quite consistent with the LECS3 figures; being from high-fish areas they are somewhat higher than regional averages. The values from Study 6 are all much less than would be expected, which suggests a bias in the selection of households in that aquaculture-focused study. Results from Study 10 were also much lower than expected, so either that study's households were not representative of the province (as they were not selected to be) or there is a bias towards over-estimation in all the other interview-based data.

The LECS3 figures are based on an excellent sampling frame so they were used for province estimates based on the grouping of provinces in the study into regions: north, centre and south.

Northeast Thailand

Three studies provide data for northeast Thailand (Figure 11), with full or partial coverage for eight provinces, as summarised in Table 19. The studies are discussed individually below, followed by an explanation of the way that provincial gures were estimated.

Table 19. *Summary of consumption data from studies in northeast Thailand.*

All values are kg/capita/year as FWAEs, not actual consumption. These are the actual data which were later corrected and adjusted to province level as explained in the text. Preserved fish amounts were converted to FWAEs from factors in Table 2.

	Study 12	Study 13	Study 14
Category	Ubon Ratchathani, Udon Thani, Khon Kaen Nakhon Ratachsima, Roi Et	Part of Nakhon Phanom, Sakon Nakhon, Nong Khai	Khon Kaen and Nakhon Ratchasima
Fresh Inland Fish	21.3	19.87	30.1
Salted Dried Fish		9.20	6.4
Smoked Fish		5.37	
Fish Paste		0.32	
Other Fermented Fish	4.0	4.78	
Fish Sauce (L)		2.80	
Preserved Fish	4.0	22.47	6.4
Total as FWAEs	25.3	42.34	36.5
OAAs	7.8	8.00	
Total	33.1	50.34	
Marine sh	5.9		1.4
Total Fish and OAAs	39.0	50.34	

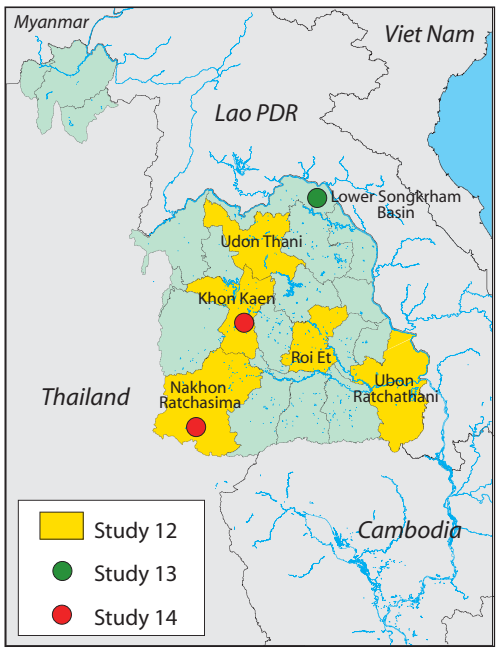

Figure 11. Provinces of Thailand that contributed data to the consumption study.

Study 12. Northeast Thailand: five provinces — Prapertchob et al. (1989)

This remains the most comprehensive study for northeast Thailand and the only large-scale study in which consumption was actually measured. The study was unique inasmuch as it focused specifically on fish marketing and consumption and on the consumption of other animal foods; it was not a general socio-economic study nor did it cover other aspects of fisheries. Households were randomly sampled within socioeconomic strata: rich, poor and medium, and results were disaggregated by categories: urban/rural and wet/dry areas. Households completed logbooks of their daily consumption in 10-day blocks at three times: April – June, July – September, both representing the wet season and October – December, representing the dry season. The study results do not include any fish paste, fish sauce, smoked fish or dried fish, which suggests these types of food were overlooked, combined with other categories, or were eaten in very small quantities. These kinds of preserved fish products are also probably commonly eaten in the season that was not surveyed (January – March), part of the dry season, when fresh fish are less common. The results for OAAs include only frogs and mussels, so under-reporting OAA consumption in this area where shrimps, insects, snails, and various other OAAs are commonly eaten.

The only IPF item recorded was fermented fish, with a value similar to that found in Study 13. Although preserved fish consumption may be lower generally in northeast Thailand than in the Songkhram Basin, the other forms of preserved fish are commonly eaten throughout the region, so this study under-reports preserved fish. Marine products were recorded by the study at 5.9 kg/capita/yr. This figure seems plausible, as it is about half of the values quoted for the Mekong Delta in Viet Nam.

The general lack of diversity in reporting of the foods that would be expected in this area — i.e. several groups are absent from the results — is usual in self-monitoring studies where respondents typically simplify their data recording or alter their diet to make the study less onerous (see e.g. Vuckovic *et al*., 2006).

Study 13. Thailand: lower Songkhram Basin — Suntornratana (2002)

The Songkhram River is the largest Mekong tributary in northeast Thailand that is not yet dammed in its lower reaches. Fish and OAAs can move freely along the river and to and from the Mekong, as well as being able to access the extensive floodplains and associated wetlands during the wet season, so the system continues to support an important wild fishery. This survey collected many kinds of data on fisheries by surveying 353 households randomly selected in 27 randomly selected villages of the lowland (downstream) part of the Songkhram Basin. The survey area covered parts of three provinces — Nakhon Phanom, Sakon Nakhon and Nong Kai — in about equal proportions. Households were asked to estimate their weekly consumption of fresh 'fish and OAAs' combined, and the various forms of preserved fish, in kg per week in both the dry and wet seasons, as well as to estimate the percentage of their consumption from different sources. In the absence of any other data it was assumed that OAAs were 28.7% of the sum of fresh fish plus OAAs, based on Champassak data in Study 8. Mean consumption and confidence limits were re-calculated from the database using the SPSS complex samples

module, and results are summarised in Table 20. Mean estimates have moderate relative errors, e.g. about ± 14% for consumption of all fish and OAAs, expressed as 95% confidence limits. The large number of households (353) would lead to very precise estimates if sampling was random, but in clustered random sampling the effective sampling size is less, as samples are drawn only from a subset of villages in the surveyed area.

Households were also asked to estimate their yearly catches in various kinds of habitat. The total annual catch of the surveyed households equated to 41.8 (±9.9) kg/capita/year, which is about 83% of the mean consumption figure of 50.3 kg/capita/year (fresh plus processed fish and OAAs as FWAEs). Aquaculture yield was estimated at only 4.5 kg/capita/year, a total which included trapping of wild fish in ponds.

Table 20. *Summary of consumption results from the lower Songkhram Basin.*

All kg/capita/year as FWAEs. Fish and OAAs calculated as percentages of Fish + OAAs.

Category	Mean	95% Confidence Interval	
		Lower	Upper
Fresh Fish and OAAs	27.87	23.45	32.29
Fresh Fish est.	19.87	16.72	23.02
OAA est.	8.00	6.73	9.27
Dried/salted Fish	9.20	6.55	11.86
Smoked Fish	5.37	4.42	6.33
Fish Paste	0.32	0.18	0.46
Other Fermented Fish	4.78	4.27	5.29
Fish Sauce	2.80	2.56	3.04
All Preserved Fish	22.47	18.91	26.03
All Fish (Fresh and Preserved)	42.34	36.63	48.05
All fish and OAAs	50.34	43.54	57.14

Marine products were not included in the study, but it can be assumed the quantities are small in this area because of the abundant inland water resources and remoteness from the sea.

The total inland fish and OAA consumption estimate is about 1.29 times the figure found in Study 12, but higher consumption of marine fish and other meat products in Study 12 compensates for this difference. Higher consumption of preserved fish in the lower Songkhram Basin is to be expected, as catches are extremely seasonal, with most fish caught over a short period each year as flood waters recede. Elsewhere in northeast Thailand, water management and fish farming have tended to even out hydrology and fish production.

Study 14. Thailand: Khon Kaen and Nakhon Ratchasima — Piumsombun (2001)

This national survey covered fish consumption and marketing by surveying markets and consumers throughout most of the country in 1988–89. Various statistical data were used to build up a picture of production and demand throughout the country. For the northeast

region, only two provinces were surveyed, both in the western (upstream) part of the Mekong catchment. The survey results were extrapolated to the northeast region in this study, but could be quite unrepresentative for the majority of the population who live towards the more easterly parts of the region, where riparian land along the Mekong, Mun, Chi and other tributary rivers is likely to be more productive of fish and OAAs, both from the wild and from aquaculture. The survey did not include OAAs and fermented fish products, both significant omissions, but found a relatively high total inland fresh fish consumption of 30 kg/capita/year as FWAEs in the two provinces. In addition, a further 6.4 kg/capita/year of dried salted fish was consumed. This study asked about consumption of individual species separately; this disaggregation may have caused a difference in estimation of quantities compared with Study 13 (which asked about total fish plus OAAs), but there is no way to determine which method of questioning produced more accurate results. The report also included official aquaculture production figures in the northeast for 1997 (Table 4 in the report) of 33,521 tonnes with a similar quantity produced from capture, according to aggregated national figures (Table 1 in the report). This estimate of around 60,000 tonnes/year for the northeast is incompatible with the consumption estimates, which if multiplied by the northeast population (about 17 million in 1999–9) give a total consumption estimate of about 500,000 tonnes for the northeast alone, i.e. about eight times the official production figures. This major discrepancy was not discussed by Piumsomboun (2001), but is readily explained by underestimation in the official production figures of the large artisanal/subsistence catch.

Province estimates for northeast Thailand

As data are missing from each study, derivation of province estimates is complicated. The five provinces of Study 12 include the two provinces of Study 14, but as Study 12 data were not disaggregated by province the data cannot be directly compared. It was decided to use Study 12 data for these five provinces, and to add an additional 6.4 kg/capita/year as dried fish to increase the preserved fish total, as a conservative increase based on the Study 14 figures.

The lower Songkhram Basin has about 18% of the population of the three provinces within which it falls. None of these provinces was covered in Studies 12 or 14. To extrapolate to province level, the Songkhram figures were used to represent 18% of the province (i.e. multiplied by 0.18) and the Study 12 figures were used to represent the remaining 82% of the provinces' populations.

Viet Nam

Four studies aimed to estimate provincial fish consumption, and these nicely encompassed the broad range of zones in the delta, from inland to coastal (Figure 12). The figures, summarised in Table 21 are consistent with the zone of the province: more inland fish are eaten in inland provinces, more marine fish are eaten in maritime provinces, and Tien Giang had intermediate reported inland fish consumption.

Table 21. *Consumption of inland fish in Viet Nam delta provinces.*

All values are kg/capita/year as FWAEs, not actual consumption. Data were corrected and adjusted to province level as explained in the text, so may not be the same as in the source reports. Preserved fish amounts were converted to FWAEs from factors in Table 4.

Category	Study 15 An Giang Inland	Study 16 Long An Inland	Study 17 Tien Giang Intermediate-coastal	Study 18 Tra Vinh Coastal
Fresh inland sh	36.8	48.1	29.6	22.7
Salted dried fish	4.2			0.1
Smoked fish	0.1			5.4
Fish paste	1.5			1.4
Other Fermented fish	0.6			6.3
Fish sauce (L)	6.3			0.3
Preserved sh	12.7	12.1		13.5
Total inland sh	49.5	60.2		36.2
OAAs	12.1			7.6
Marine sh	*	0.1	12.5	9.9
Total sh and OAAs	61.6			53.7

Note: * assumed negligible.

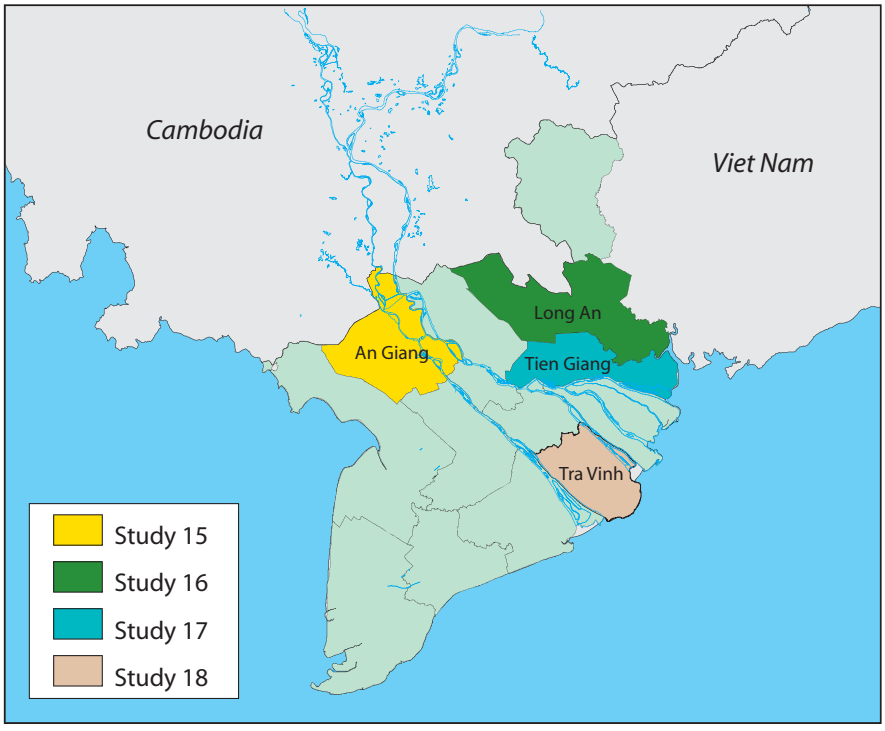

Figure 12. Provinces of Viet Nam that contributed data to the consumption study.

Study 15. Viet Nam: An Giang province — Sjorslev (2002)

An Giang is well-known as one of the most productive fisheries provinces in the LMB. Wild fish are caught throughout the province, mainly due to production on the large areas of annually flooded land, and extensive fisheries target the large seasonal migrations of fish to and from Cambodia. Aquaculture has expanded dramatically over the last decade, with *Pangasius* catfish now a major export. This socio-economic survey collected baseline information on many aspects of fisheries in nine rural districts of An Giang; i.e. excluding urban districts in which 21% of the population lives. This survey had a large coverage: 1,002 households in 58 villages that were selected to approximately represent population distribution. Within three strata about 74% of households were near the Mekong and Bassac rivers (one stratum), with others distant or intermediate from the rivers. Households were asked about many aspects of fisheries.

Respondents were asked to recall consumption of inland fish and OAAs combined, and various categories of processed fish, in the wet and dry season in kg/household/week. Marine fish were not specifically addressed, but it is assumed that consumption was negligible. The survey also asked people to rank their consumption of aquatic foods in the wet and dry seasons in terms of importance. Virtually all households eat inland fish fresh and also eat fish sauce frequently in small quantities and all households ranked fish sauce as No. 1 in terms of importance. Statistics were recalculated as the original report incorrectly reported the mean of household per capita consumption (as for Study 7), and some mistakes were corrected in databases. The survey asked individual fishers to specify the species and their weight in the most recent catch. At least 75 taxa were reported from catches, but just one taxon *Henicorhynchus* spp. (*ca linh*) made up 56% of the total catch weight, and together with other 'white fish' made up 86% of the catch weight. In consumption figures, fish and OAAs were not separately reported, so it was necessary to assume that the proportion of OAAs was 24.8%, the same proportion as in Tra Vinh province (Study 18).

Household catches averaged 783 kg/year or 139 kg/capita/year or 1.9 times consumption, a figure reasonably consistent with An Giang being a nett fish exporter.

Data on estimated catches and on production from aquaculture produced a province-level estimate of about 270,000 tonnes, of which about 36% was from aquaculture. However a significant part of the aquaculture production relied on the feeding of trash fish from both river and marine fisheries.

Study 16. Viet Nam: Long An province — Pham and Guttman (1999)

This survey covered use of aquatic resources in the six districts forming the western part of Long An province, which lies within the extensive 'Plain of Reeds' a wetland underlain by acid-sulphate soils which is seasonally flooded by Mekong overflows to about 0.5 – 3 m depth for 1 – 4 months. Flooding restricts development of secondary industries, so the province's economy is based on agriculture, forestry and fishing.

Households were selected within four strata based on economic status and interviewed using a questionnaire. People were asked about average household consumption in kg/week in each of four seasons, but were asked about catches in kg/season and about aquaculture production in kg/harvest.

Farming was the most common economic occupation reported, with fishing a primary occupation for 3% of respondents and a secondary occupation for 13% of respondents. However, 83% of households (including the 16% of economic fishers) reported fishing for household consumption. As most households own ponds (a consequence of excavating land on which to construct elevated houses) about 61% of households cultured fish, mostly *Pangasius*, tilapia and silver barb. Aquaculture production reportedly averaged 408 kg/household/year, whereas catch from wild fisheries was reported at 552 kg/household/year (Figs 21 and 22 of the report), with a skewed distribution of catches; at a household size of 5.7 persons these figures convert to 71.6 and 96.8 kg/capita/year respectively. Total consumption of inland fish was reported to be 60.2 kg/capita/year, so there was a large excess of reported production of fish (168.4 kg/capita/year) over consumption. About 47% of the catch was reportedly consumed and most of the aquaculture production was reportedly sold, so the catch and consumption figures are quite consistent.

Preserved fish was reported in the study as a total amount of 13.7 kg/capita/year. To convert this to FWAEs and to generate estimates for the components of preserved fish, it was assumed that the composition was the same as in Study 16, where the total amount of preserved fish was similar at 15.2 kg/capita/year.

Provincial production was estimated at 36,000 tonnes, of which about 42% was from aquaculture. This is probably the highest percentage for any province in the LMB, consistent with the stated importance of aquaculture and the decline of the wild fishery, which nevertheless still appeared to contribute the majority of the yield.

Study 17. Viet Nam: Tien Giang province—Setboonsarng *et al*. (1999)

This survey was carried out to assess aquaculture production and potential in this densely-populated delta province, where it was estimated that about 84% of rural households owned at least one pond and 75% were practising aquaculture. As 20% of the population was urban, about 60% of households practised aquaculture. The survey was biased towards aquaculture households (300 of 331) and households were randomly selected within the main strata of aquaculture types. Respondents were asked to list the quantities of fish harvested on each cycle over one year, and to estimate the percentages consumed, sold, restocked or given away. They were also asked to list quantities of the three main inland and marine fish species they bought for consumption in kg/month. In Tien Giang province, capture of wild fish was thought to have declined greatly due to pesticide impacts and over-fishing, so only 9.1% of households reported they caught wild fish, although quantities were not reported nor added to consumption figures. Even allowing for low catches, it seems likely that catches from small-scale fishing may have been underestimated, perhaps because households (or the surveyors) regarded them as unimportant. Mean consumption was calculated as a weighted mean based on the values

of aquaculture households (60% of the province) and non-aquaculture households, assumed to include urban dwellers. The study did not ask about preserved fish or about OAAs. For extrapolation, preserved fish was estimated as the average of Tra Vinh and An Giang figures. The main fish species bought were indigenous: snakeheads, walking catfish, climbing perch and snakeskin gouramy, all of which are floodplain/rice-field 'blackfish' species, which may have originated from capture or culture. The main cultured fish were tilapia, silver barb, giant gouramy and carp.

Aquaculture families were found to consume almost 100% more fresh fish than families with no aquaculture. Inland fresh fish consumption estimated for the province (29.6 kg/capita/year) was about 70% of the total fresh fish consumption for the province.

Inland fish consumption differed between aquaculture and non-aquaculture households by 29.7 kg/capita/yr (41.5 vs. 11.8 kg/capita/year) with an overall average of 29.6 kg/capita/yr, which was 70% of the total estimated consumption figure of 42.2 kg/capita/yr.

Study 18. Viet Nam: Tra Vinh province — Phan *et al*. (2003)

This province was selected for a socio-economic survey as coastal fishery to compare with An Giang during MRC Fisheries Programme surveys. Tra Vinh is intensively farmed and an elaborate network of canals covers the province; wild fishery production is from seasonally inundated rice-fields and from the canal system. Much of the southern coastal portion (about one quarter) of the province has been converted to brackish water shrimp ponds, as is common along the coastline of the delta.

Consumption tables were recalculated from the original databases after correction of some errors and using complex sample methods and re-weighting by strata, so figures differ from those previously published. Fresh fish and OAAs were not separated in questions about total consumption, but people were asked to estimate the percentages of their total consumption comprising marine fish, inland fish, shrimps and other OAAs. Relative errors (confidence limits/means) varied from 9% to 26% for the consumption estimates for these individual categories of aquatic foods. Table 21 shows mean consumption figures.

Reported production from inland catches and aquaculture for the province equated to about 48.7 kg/person/year, of which 26% was from aquaculture; this production figure is about 11% higher than the consumption estimate for inland fish and OAAs, an acceptable difference that allows for some export from the province or use in aquaculture feed. Calculation of a province-level production balance is complicated by a large marine catch for which only approximate estimates are available.

Study 20. Viet Nam: Lem and Nghia (2003)

This interesting study aimed to develop an economic model based on fish consumption, prices, economic growth and population growth to enable prediction of future demand as an aid to planning in the fisheries sector. The study included a survey of 656 households stratified by

region and by degree of urbanisation. The report includes limited information on the survey methods, and the make up of 'fish' is not clearly stated, so comparisons should be made with caution. Table 22 shows that reported consumption was highest in rural areas in the south of the country (52.3 kg/person/year), which would include most of the people of the Mekong delta. Results from this study were not used directly in the present report, but the figures are consistent with those for the Viet Nam delta as shown in Table 23, suggesting that responses to interview questions about fish consumption appear to be consistent across studies. The lowest consumption figure (in the rural north) was about half of the highest figure (in the rural south), indicating the likely range in reported consumption figures across the country.

Table 22. *Reported fish consumption in Viet Nam (kg/person/year).*

Stratum	North	Central	South	Total
Cities	29.2	35.6	30.4	31.8
Suburban	38.6	44.0	43.7	41.6
Rural	28.2	39.8	52.3	39.4
Total	32.0	37.7	37.0	35.6

4.3 Extrapolating consumption figures

Inland fish

Consumption figures from the above study reviews of 33 provinces were tabulated, some data were in-filled, and then figures were extrapolated for the other 53 LMB provinces to obtain total estimates of inland fish consumption, based on:

- proximity, i.e. figures were used from adjacent or nearby provinces;
- geographic similarity, especially elevation and latitude;
- averaging of data where several provinces could be used as the basis for extrapolation;
- use of conservative assumptions for drier or mountainous provinces.

Appendix 1 sets out the tabulations with notes that explain in each case how extrapolation or infilling of data was achieved. Some notes on each country follow.

Cambodia: Data were available for 11 of 23 provinces, which include 73% of the Cambodian LMB population. Extrapolation for Banteay Meanchey is uncontroversial, as it is adjacent and similar to Great Lake provinces, and includes a further 5% of the Cambodian LMB population. Extrapolation for the more mountainous and/or drier provinces, which include only 22% of the Cambodian LMB population, was derived conservatively by halving the figures from Svay Rieng, which had the lowest total fish consumption. For Kratie, Ratana Kiri and Stung Treng,

all of which have significant river and wetland fisheries, Svay Rieng figures were used, a conservative approach.

Lao PDR: Extrapolation was not necessary because consumption estimates were based on the LECS3 study which covered all provinces, and the results from LECS3 were consistent with province-level studies where comparisons were possible (Table 18).

Thailand: The eight provinces for which some information is available include about 46% of the population of the 25 LMB provinces in northeast Thailand. As data were not disaggregated by province in the original studies there is little variation seen across all provinces; therefore extrapolation was from adjacent provinces.

Viet Nam: The four sampled provinces covered only 27% of the population of the Delta, but they encompassed nicely the range of geographic variation expected through the Delta. Consumption of the other eight provinces was estimated as either the same as adjacent provinces or the average of two adjacent provinces. There were no data available for the eight highland provinces in Viet Nam which are partly within the LMB. All have significant capture and culture fisheries, and fishery products from coastal areas and the delta are widely sold. In the absence of data it was assumed that these highland provinces had 50% of the estimated fish consumption of the average for the delta provinces. Based on the national range reported in Study 20 this is a conservative assumption.

Other aquatic animals

Inland OAA consumption was reported in five of the surveys reviewed above, with data from 13 provinces (Table 23). No data were available for preserved OAAs. The studies are reviewed above in Section 4.2.

Study 8 explicitly covered (i.e. disaggregated) all main taxa of OAAs and in Studies 12 and 18 data were partly aggregated. Where some common taxa were not included data were infilled; the Svay Rieng value for molluscs was estimated as the average of other reported data, whereas the values for crabs and shrimps in northeast Thailand were infilled with the same value as reported for Champassak.

To estimate basin-wide consumption of OAAs it was assumed that the ratio of OAA consumption to inland fresh fish consumption from studies within each country was constant across each country, except that in Lao PDR different ratios were used for different parts of the country: northern (Study 6), southern (Study 8) and central (mean of Studies 6 and 8) provinces.

Table 23. *Available data on inland OAA consumption.*

Data from studies as numbered in Table 8. All values are as kg/capita/year as FWAEs. In Study 6, OAAs were classed as aquatic and amphibious and have been combined for this table, note that Study 6 was of 'low-fish' households, which were unlikely to be representative.

Country	Cambodia	Lao PDR	Lao PDR	Thailand	Viet Nam
Location	Svay Rieng	North	Champassak	NE Thailand	Tra Vinh
Study No.	5	6	8	12	18
Fresh inland fish consumption	25.7	8.9	25.6	21.3	22.7
Reported OAA consumption	5.17	4.93	10.29	7.80	7.61
Corrected OAA consumption	8.67	4.93	10.29	8.49	7.61
Ratio of corrected OAA/fresh fish consumption	0.337	0.554	0.402	0.399	0.355
As reported percent of total OAAs:					
Frogs and Tadpoles	2.74		5.57	4.80	
Crabs	0.13		0.23	0.23*	
Shrimps	1.09		0.46	0.46*	4.72
Mollusks	3.50*		4.01	3.00	
Insects			0.01		
Birds	0.89				
Snakes	0.19				
Other not specified	0.13				

Note; * values were infilled based on other studies, corrected OAA consumption includes the infilled values.

Other animal foods

Data for consumption of other animal foods were less complete than for inland fish, in terms of number of studies (7), areal coverage (22 provinces), and coverage of categories. Figure 13 illustrates how consumption of other foods appears to increase as inland fish consumption decreases, but also shows a wide scatter in the data. However, Cambodia (Study 1) does not follow this trend; over a wide range of fish consumption there is little apparent trend in the consumption of other meats.

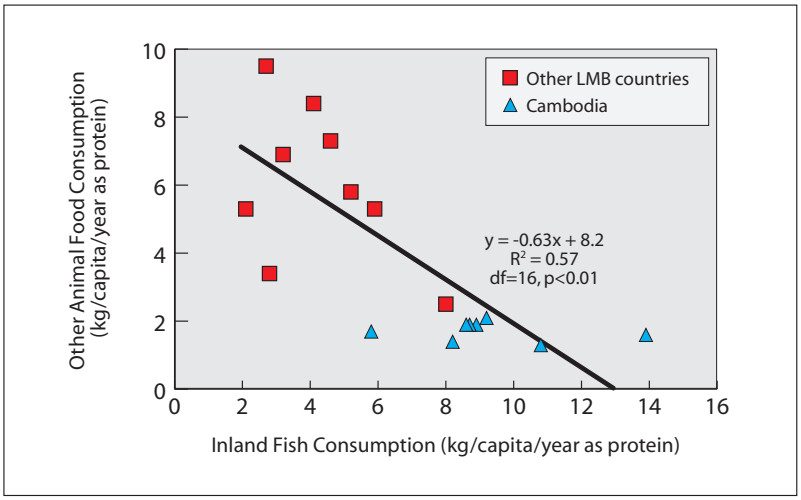

Figure 13. Relationship between other animal consumption and inland fish consumption.

In Study 1 information was only collected on conventional meat foods, ignoring wildlife and less-conventional domestic animals such as buffalo, goats, and sheep, so the intake of other animal foods is likely to be underestimated.

Nevertheless, these data were used without adjustment and extrapolated using the same general principles as for inland fish and as noted in Appendix 1.

Marine products

Only 5 studies which covered 14 provinces provided data for marine products; no data were available for Cambodia. The final extrapolated figures (Appendix 1) should be regarded as likely to be the least accurate among the categories of foods.

4.4 Summary of consumption figures

Table 24 summarises the total figures for each country and Appendix 1 provides a more detailed breakdown including the different kinds of preserved fish and consumption as actual (prior to cooking) amounts.

The consumption of inland fish in the LMB in 2000 is estimated at about 2.1 million tonnes/year as FWAEs and consumption of OAAs is estimated at about 0.5 million tonnes/year; total consumption is about 2.6 million tonnes/year as FWAEs. Actual consumption (that is flesh eaten) totals about 1.9 million tonnes. About two thirds of inland fish is eaten fresh, with the proportions and composition varying somewhat between countries, with Lao PDR for example having more salted/dried fish (see Appendix 1) and more preserved fish overall, and Viet Nam having the highest proportion of fish consumed fresh. Thailand and Viet Nam consume similar amounts of inland fish and OAAs and together account for about 69% of the total, with high total consumption being a result of moderate per capita consumption coupled with large populations. Cambodia with a large average per capita consumption but moderate population consumes about 23%, and Lao PDR accounts for only 8% because per capita consumption is moderate but its population is small.

Marine product consumption is estimated to be about 0.3 million tonnes as FWAEs, and is most important in Thailand and Viet Nam, which is consistent with their high population density and well-established marine fisheries.

Annual consumption of inland fish plus OAAs as country averages varies from 41 to 51 kg/per capita as FWAEs, or 29 to 39 kg/capita as actual consumption. When converted to protein units, aquatic foods basinwide account for about 49–82% of all animal protein consumption. Inland fish and OAAs are most important in Cambodia and Viet Nam, whereas Lao PDR and Thailand have about equal contributions from aquatic foods and other animals.

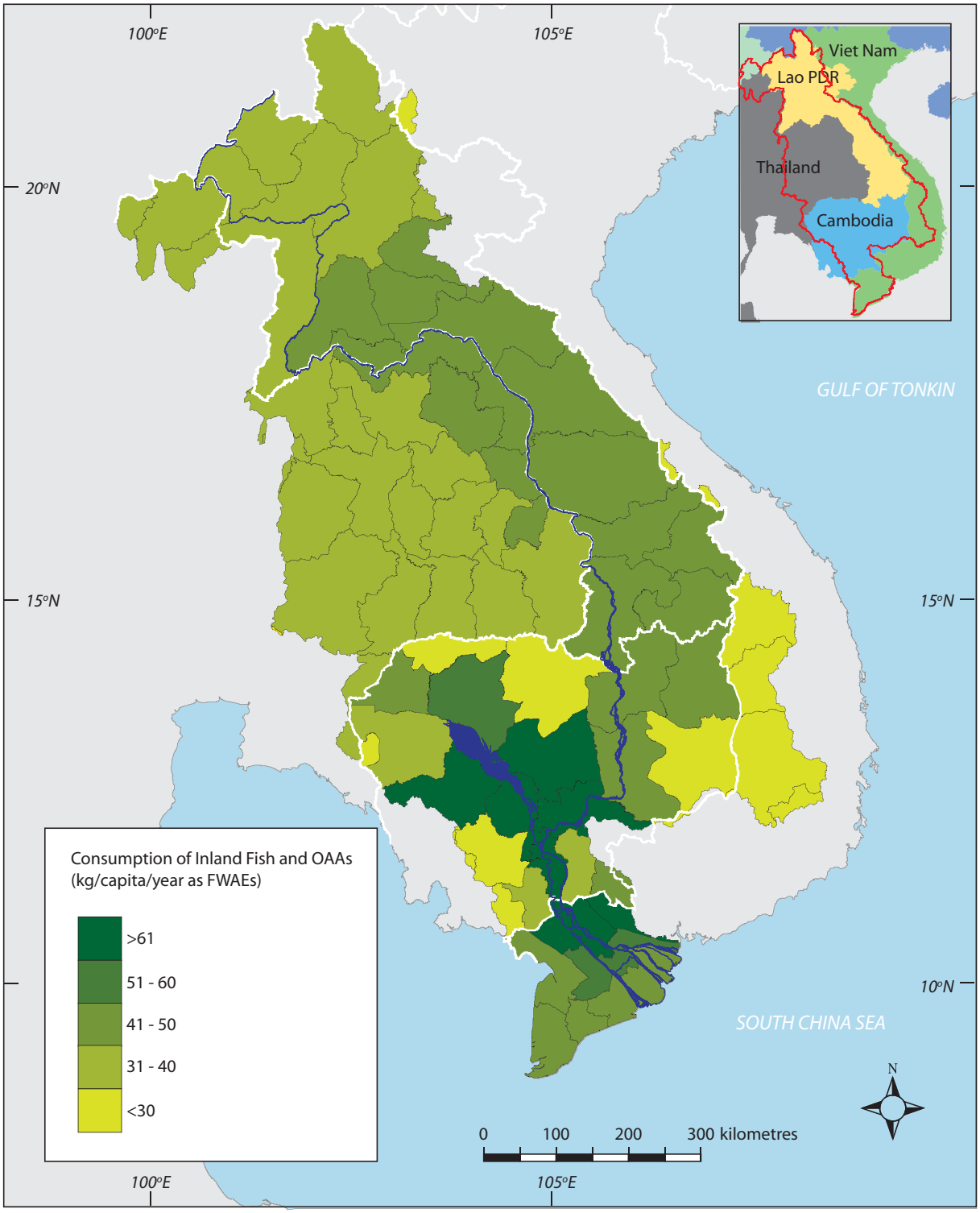

Figure 14. Distribution of per capita consumption of inland sh plus OAAs by province.
Values are mean consumption (kg/capita/year as FWAEs). Excludes marine product consumption. Values are typically lower in elevated parts of provinces, but data are not available to show variations within provinces.

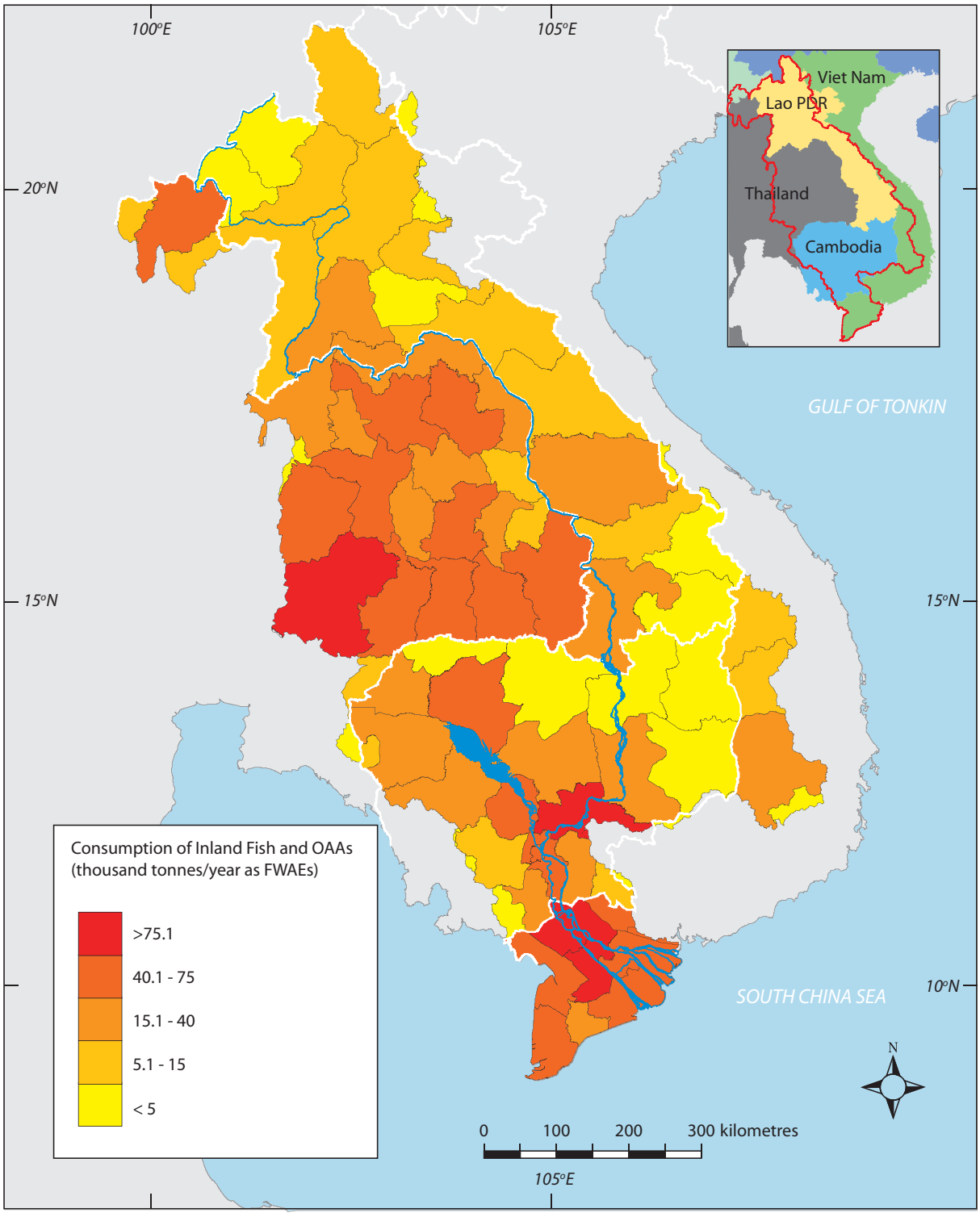

Figure 15. Distribution of total consumption of inland sh plus OAAs by province.
Values are mean consumption (thousand tonnes/year as FWAEs).

Table 24. *Summary of estimated consumption of aquatic products, tonnes/year as FWAEs and as actual consumption (conversion factors are discussed in Section 3).*

FWAEs (tonnes/year)

	Inland					Marine Products	Total Aquatic
Country	Fresh Fish	Preserved Fish	Total Inland Fish	OAAs	Inland Fish plus OAAs		
Cambodia	312,631	168,906	481,537	105,467	587,004	11,421	598,426
Lao PDR	85,076	82,846	167,922	40,581	208,503	2,480	210,982
Thailand	479,147	241,354	720,501	190,984	911,485	130,075	1,041,560
Viet Nam	479,370	212,748	692,118	160,705	852,823	129,418	982,241
TOTAL	1,356,224	705,854	2,062,077	497,737	2,559,815	273,394	2,833,209

As % of total aquatic foods from each country

	Inland					Marine Products	Total Aquatic
Country	Fresh Fish	Preserved Fish	Total Inland Fish	OAAs	Inland Fish plus OAAs		
Cambodia	52.2%	28.2%	80.5%	17.6%	98.1%	1.9%	100.0%
Lao PDR	40.3%	39.3%	79.6%	19.2%	98.8%	1.2%	100.0%
Thailand	46.0%	23.2%	69.2%	18.3%	87.5%	12.5%	100.0%
Viet Nam	48.8%	21.7%	70.5%	16.4%	86.8%	13.2%	100.0%
TOTAL	47.9%	24.9%	72.8%	17.6%	90.4%	9.6%	100.0%

As % of each category from each country

	Inland					Marine Products	Total Aquatic
Country	Fresh Fish	Preserved Fish	Total Inland Fish	OAAs	Inland Fish plus OAAs		
Cambodia	23.1%	23.9%	23.4%	21.2%	22.9%	4.2%	21.1%
Lao PDR	6.3%	11.7%	8.1%	8.2%	8.1%	0.9%	7.4%
Thailand	35.3%	34.2%	34.9%	38.4%	35.6%	47.6%	36.8%
Viet Nam	35.3%	30.1%	33.6%	32.3%	33.3%	47.3%	34.7%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

As actual consumption

	Inland					Marine Products	Total Aquatic
Country	Fresh Fish	Preserved Fish	Total Inland Fish	OAAs	Inland Fish plus OAAs		
Cambodia	250,105	118,388	368,492	51,679	420,171	9,137	429,308
Lao PDR	68,060	50,933	118,993	19,885	138,878	1,984	140,862
Thailand	383,318	176,591	559,909	93,582	653,491	104,060	757,551
Viet Nam	383,496	221,175	604,671	78,746	683,417	103,534	786,951
TOTAL	1,084,979	567,087	1,652,065	243,891	1,895,957	218,715	2,114,672

Table 25. *Estimated per capita consumption of fish and other animals (based on Appendix 1).*

As FWAEs, kg/capita/year

	Inland			Marine Products	Total Aquatic
Country	Fish	OAAs	Fish plus OAAs		
Cambodia	42.2	9.2	51.4	1.0	52.4
Lao PDR	34.6	8.4	43.0	0.5	43.5
Thailand	32.0	8.5	40.5	5.8	46.2
Viet Nam	39.5	9.2	48.7	7.4	56.1
TOTAL	36.6	8.8	45.5	4.9	50.3

As actual consumption, kg/capita/year

	Inland			Marine Products	Total Aquatic	Other Animals	Total Animal consumption
Country	Fish	OAAs	Fish plus OAAs				
Cambodia	32.3	4.5	36.8	0.8	37.6	8.5	46.1
Lao PDR	24.5	4.1	28.6	0.4	29.0	33.0	62.1
Thailand	24.9	4.2	29.0	4.6	33.6	30.2	63.8
Viet Nam	34.5	4.5	39.0	5.9	45.0	19.8	64.7
TOTAL	29.3	4.3	33.7	3.9	37.6	22.8	60.4

As protein consumption g/capita/day

	Inland			Marine Products	Total Aquatic	Other Animals	Total Animal consumption
Country	Fish	OAAs	Fish plus OAAs				
Cambodia	19.0	2.0	21.0	0.4	21.4	4.85	26.3
Lao PDR	15.8	1.8	17.6	0.2	17.9	18.69	36.6
Thailand	14.3	1.9	16.1	2.5	18.6	15.83	34.5
Viet Nam	17.5	2.0	19.5	3.2	22.7	10.31	33.0
TOTAL	16.3	1.9	18.3	2.1	20.4	12.13	32.5

As % of total animal protein consumption

	Inland			Marine Products	Total Aquatic	Other Animals	Total Animal consumption
Country	Fish	OAAs	Fish plus OAAs				
Cambodia	72.2%	7.7%	79.9%	1.7%	81.5%	18.5%	100.0%
Lao PDR	43.2%	5.0%	48.2%	0.6%	48.9%	51.1%	100.0%
Thailand	41.4%	5.4%	46.8%	7.3%	54.1%	45.9%	100.0%
Viet Nam	52.9%	6.1%	59.0%	9.7%	68.8%	31.2%	100.0%
	50.3%	6.0%	56.2%	6.5%	62.7%	37.3%	100.0%

Table 26. *Data on relative capture/culture proportion and participation in fisheries.*

No.	Study Report and Date	Country	Region	No. of provinces	%Capture %Culture	% professional fishing	%in capture fisheries	% in aquaculture	Notes
1	Ahmed *et al*. (1998)	Cambodia	Tonle Sap - Great Lake	8	No data, assumed very minor importance of aquaculture, mainly for grow-out	38.8%	99.0%	2.5%	% in capture fisheries judged by significant dependence - one or more family member Tables 3.2 and 3.45
2	Setboonsarng *et al*. (2001)	Cambodia	Kandal, Prey Veng, Takeo	3	Average 25% of own-produced fish from aquaculture, study biased to pond-owners	nd	80.7%	5.0%	Table 60, p.52 only 5% actually doing fish culture
3	Touch *et al*. (1994)	Cambodia	Svay Rieng	1	All based on wild fish, aquaculture negligible	nd	84.5%	nd	Households who fish or collect other aquatic animals
4	Gregory *et al*. (1996)	Cambodia	Svay Rieng			0.0%	100.0%	0.0%	Trap ponds important
5	Mogensen (2001)	Cambodia	Svay Rieng			0.0%	100.0%	0.0%	Trap ponds important
6	Funge-Smith (1999a)	Lao PDR	Northern Lao PDR	5	Study biased towards pond-owners, most from ponds or rice fields	nd	nd	84.5%	Survey biased to pond owners, but many not actually culturing
7	Sjorslev (2000)	Lao PDR	Luang Prabang	1	Fresh fish: 68.9% from self-capture, 1.72% from aquaculture, 29.4% purchase or gift	2.2%	81.0%	7.3%	Recalculated from databases
8	Singhanouvong and Phouthavongs (2003)	Lao PDR	Champassak	1	No data, assume virtually all is wild fishery	13.5%	96.2%	15.0%	From village (not household) survey
9	Baird *et al*. (1998)	Lao PDR	Khong District, Champassak	1	All wild capture fish	56.0%	94.2%	0.5%	56% of households sell fish
10	Garaway (2005)	Lao PDR	Savanakhet	1	Appears to be all wild capture fish	nd	98.1%	nd	Selective survey in one district
11	Mattson *et al*. (2000)	Lao PDR	Vientiane	1	Little aquaculture except grow-out of wild fish	62.0%	100%	1.2%	Professional fisher defined as main income and one or more family member□□
12	Prapertchob *et al*. (1989)	Thailand	5 provinces in northeast Thailand	5	No data	nd	nd	nd	
13	Suntornratana (2002)	Thailand	Lowland parts of 3 provinces	3	Aquaculture production 1% of total consumption	9.4%	93.6%	3.5%	Recalculated from database using weightings
14	Piumsombun (2001)	Thailand	Khon Kaen, Nakhon Ratchasima	2	No data	nd	nd	nd	
15	Sjorslev (2002)	Viet Nam	An Giang	1	Aquaculture yields about 36% of the total production, most is exported	7.1%	61.0%	14.2%	Recalculated from database, professional fishing means one or more professional fisher in household
16	Pham and Guttman (1999)	Viet Nam	Long An, western half	1	Aquaculture yields about 42% of the total production	3.4%	82.5%	61.0%	Professional fishing means household's main income
17	Setboonsarng *et al*. (1999)	Viet Nam	Tien Giang	1	Incomplete data on wild fishery	9.1%	nd	91.4%	Survey was biased towards aquaculture, 330 of 361 hhs
18	Phan *et al*. (2003)	Viet Nam	Tra Vinh	1	Aquaculture yields about 26% of the total production, most is exported	4.3%	62.2%	43.5%	Professional fishing means household's main income
19	NSC (2004)	Lao PDR	Lao PDR	All	nd	nd	nd	nd	
20	Lem and Nghia (2003)	Viet Nam	Viet Nam	Not stated	nd	nd	nd	nd	

Animal protein consumption is estimated at about 26 – 37 g/capita/day as country averages. Based on the recommended daily allowance (RDA) of 0.8 g/kg/day[1] , an 'average' LMB person 50 kg in weight needs to eat 40 g/day of protein. If correct, and assuming limited wastage during cooking and eating, the consumption figures imply a high intake of animal protein which would make up 65 – 93% of the total RDA as the range of LMB country means.

4.5 Relative contribution from aquaculture and capture fisheries

Consumption data generally cannot be used directly to discriminate the source of fish as being from capture or culture fisheries, because:

- consumers usually have no information on the origin of fish which are not self-produced;
- many aquaculture operations involve grow-out of wild-caught fish;
- some fisheries are intermediate between aquaculture and capture; for example rice-fields that are stocked where the harvest includes wild fish; and
- many indigenous species are cultured and most species of introduced aquaculture fish are also present in wild catches.

As summarised in Table 26, some production data from the reviewed reports indicate the relative yield from aquaculture and capture, as well as participation in fisheries, which also gives some indication of the relative size of the subsectors. Production figures cannot be related directly to consumption figures, as a significant proportion of the aquaculture production is exported out of the LMB, so representing additional production rather than being a component of consumption. Aquaculture is important in the delta in Viet Nam, contributing up to 42% of the total production, but most of that aquaculture production appears to be exported. Aquaculture is of less importance in Cambodia and Lao PDR, and perhaps of intermediate importance in Thailand. A portion of the aquaculture production is also supported by feeding cultured fish with inland fish trash fish, so it actually represents a large yield of wild fish.

Officially, aquaculture in the LMB accounted for about 260,000 tonnes/year in 1998 – 2000 (Phillips, 2002, p. 30). Given that a large proportion of all aquaculture is exported, and based on the limited summary data in Table 26, it can be concluded that aquaculture in 2000 produced less than 10% of the inland fish consumed in the LMB. A recent expansion is indicated by figures for 2005 (Anh Tuan & Quynh Mai, 2005); the Viet Nam delta now officially produces in excess of 600,000 tonnes per year (up from 172,000 tonnes as quoted in Phillips, 2002), much of which is *Pangasius* catfish and snakeheads, which are fed primarily on marine trash-fish.

1 RDAs are established and widely published by the Food and Nutrition Board of the US National Academy of Sciences, see also Institute of Medicine (2002)

4.6 Fishery yield

The total capture fishery yield from the LMB can be estimated as:

Yield = Consumption - Imports + Exports + Animal Feeds + Waste + Aquaculture Feed

Imports of inland fish from adjacent basins or from overseas would be very minor relative to exports. Animal feed and waste quantities are unknown, but would be certainly at least an additional 10% per year, which may approximately balance with the small component of consumption which derives from aquaculture.

Use of inland fish for aquaculture feed is insignificant in Lao PDR or Thailand (of the order of a few thousand tonnes per year) as most trash fish is marine-derived (Ingthamjitr *et al*., 2005). Inland trash fish is important in Cambodia where, based on field surveys it is estimated that about 55,000 tonnes per year is used in aquaculture (So *et al*., 2005). In Viet Nam most trash fish is marine-derived; Anh Tuan & Quynh Mai (2005) found that only 13% of fresh fish fed to catfish and snakeheads was from inland waters and almost no inland trash fish was used in pelleted feed. In the Year 2000, the use of inland trash fish in aquaculture in the Viet Nam delta was probably of the order of 55,000 tonnes/year, based on the official aquaculture yield of 172,000 tonnes/year[1]. Therefore, the total use of inland trash fish in aquaculture in the LMB during 2000 can be estimated at about 120,000 tonnes per year.

From this limited information and that discussed in the preceding section the consumption figures are likely to be less than the yield from the wild capture fishery; the figures can be summarised as follows:

1. Total consumption estimate: 2.63 million tonnes/year;
2. Assumed proportion from aquaculture: 10% or 0.26 Mt/year;
3. Proportion of consumption which is from capture fishery: 90% or 2.37 Mt/year;
4. Inland capture trash fish for aquaculture feed: 0.12 Mt/year;
5. Minimum estimate of wild fishery used for animal feed or wasted: 0.26 Mt/year;
6. Exports of capture fishery products: no reliable information, but quantities exceed imports.

Hence the consumption estimates indicate a wild capture fishery yield of at least 2.63 million tonnes per year as FWAEs from the LMB.

1 Assuming half are carnivorous species, a one-year growth period, and a feed conversion ratio of 4 for carnivorous species, and 13% from inland fish : trash fish use = 172,000/2 * 4 *0.13 = 44,720 tonnes/year; and assuming an additional 10,000 tonnes/year in omnivorous fish feeds.

5 Validation of Consumption Estimates

In this section the results from the analysis of consumption data are compared with other data: (i) a study which monitored actual consumption of some LMB residents (5.1), (iii) catches, where considered in the study reports (5.2), (iii) typical world consumption data and data from other studies (5.3), and (iv) data from areal fishery yield from floodplains (5.4).

5.1 A trial monitoring study

Garrison *et al*. (2006, and unpublished data) carried out a 12-month study (2003–4) in which consumption of all foods by 32 typical family households (8 from each LMB country) was monitored for three 2-week periods—42 days in total—by trained technicians. The households were spread between the four countries and represented equal numbers of families classed as living by aquaculture, fishing, trading and in urban jobs. The consumption recorded during this study can be considered very accurate for the families that were covered, although not necessarily representative for the LMB. It is therefore of interest to compare these actual monitoring data with the consumption estimated for the LMB in this study, which was based primarily on interviews (Table 27).

Table 27. *Comparison of consumption actually recorded for selected households and that estimated for the LMB based on regional studies.*

All data are kg/capita/year as FWAEs.

Country	Source	Type	Monitored	LMB estimate
Cambodia	Inland	Fish	41.7	42.2
		OAA	7.6	9.2
	Marine	Fish	1.1	
		OAA	4.6	1.0
	Total		55.0	52.4
Lao PDR	Inland	Fish	29.0	34.6
		OAA	2.4	8.4
	Marine	Fish	2.2	
		OAA	0.9	0.5
	Total		34.5	43.5
Thailand	Inland	Fish	38.2	31.9
		OAA	5.7	9.2
	Marine	Fish	5.0	
		OAA	1.1	5.8
	Total		50.0	47.7
Viet Nam	Inland	Fish	42.1	39.5
		OAA	6.7	10.0
	Marine	Fish	4.2	
		OAA	3.5	7.4
	Total		56.5	56.1
Total	Inland	Fish	37.7	36.6
		OAA	5.6	8.8
	Marine	Fish	3.1	
		OAA	2.5	4.9
	Total		48.9	50.3

Table 28. *Summary of data on catches.*

Studies which covered large parts of a province or provinces

No.	Study Report and Date	Country	Region	No. of provinces	Catches compared with consumption
1	Ahmed *et al*. (1998)	Cambodia	Tonle Sap - Great Lake	8	Small and middle-scale catches 20% more than consumption, allows for some sales. Large-scale catches additional.
2	Setboonsarng *et al*. (2001)	Cambodia	Kandal, Prey Veng, Takeo	3	Not separately calculated
3	Touch *et al*. (1994)	Cambodia	Svay Rieng	1	Based on catches
4	Gregory *et al*. (1996)	Cambodia	Svay Rieng		Based on catches
5	Mogensen (2001)	Cambodia	Svay Rieng		Based on catches
6	Funge-Smith (1999a)	Lao PDR	Northern Lao PDR	5	No separate data, most from aquaculture or rice-fields
7	Sjorslev (2000)	Lao PDR	Luang Prabang	1	Wide range in catch estimates; less than half to about 2 times the catch-derived part of consumption estimates
8	Singhanouvong and Phouthavongs (2003)	Lao PDR	Champassak	1	Catches only 60% of consumption, should be approximately equal
9	Baird *et al*. (1998)	Lao PDR	Khong district, Champassak	1	Data based on household catches
10	Garaway (2005)	Lao PDR	Savannakhet, 4 villages	1	Data based on household acquisition
11	Mattson *et al*. (2000)	Lao PDR	Vientiane	1	Catches much greater than consumption as expected in this commercial fishery
12	Prapertchob *et al*. (1989)	Thailand	5 provinces in northeast Thailand	5	Consumption only
13	Suntornratana (2002)	Thailand	Lowland parts of 3 provinces	3	Household catches about 80% of consumption, reasonable agreement
14	Piumsombun (2001)	Thailand	Khon Kaen, Nakhon Ratchasima	2	No data on catches
15	Sjorslev (2002)	Viet Nam	An Giang	1	Catches approx. 1.9 x consumption, consistent with nett fish export from this province
16	Pham and Guttman (1999)	Viet Nam	Long An, western half	1	Catches and aquaculture production 2.6x consumption, consistent data as excess is sold.
17	Setboonsarng et al. (1999)	Viet Nam	Tien Giang	1	Only aquaculture reported.
18	Phan *et al*. (2003)	Viet Nam	Tra Vinh	1	Catches 1.11x consumption, acceptable agreement

Studies which covered an entire country, not disaggregated

No.	Study Report and Date	Country	Coverage	No. of provinces	Catches compared with consumption
19	NSC (2004)	Lao PDR	Lao PDR	18	nd
20	Lem and Nghia (2003)	Viet Nam	Viet Nam	Not stated	nd

As shown in Table 27 there is a very good agreement between the results of monitoring and the estimates for the LMB. The results for Lao PDR are somewhat higher and for Thailand somewhat lower than the estimates, but overall the mean results are within 3% of each other. Assuming that the selected households were unremarkable (neither particularly low nor high fish eaters) this excellent concordance tends to support the LMB consumption estimates.

5.2 Catches and consumption

Households obtain fish for consumption by capture, culture, purchase, exchange or as gifts. At provincial level, a balance should be evident in production data, where capture plus culture should balance household consumption, plus exports, minus imports, plus wastage and feed. Catch data were not collected in all studies, and in some catch data were used to estimate consumption. Table 28 shows the extent to which catch and consumption figures can be compared.

In studies of provinces where there is little export or aquaculture (Studies 7, 8 and 13) there was considerable variation between catch and consumption estimates. In Study 7, catch estimates depended upon who was asked (household heads or individual fishers) and how questions were asked. In Study 8 there was a large discrepancy in input/consumption figures at the household level, perhaps due to use of different time scales in questioning. In Study 12, catches and consumption were approximately in balance, allowing for aquaculture and imports of fish.

In studies where exports were significant (Studies 1, 11, 15, 16 and 18) production data (catches plus aquaculture) always exceeded consumption, which indicates some consistency in the data. But because exports are unknown it is not possible to use the production data to precisely validate consumption estimates; i.e. exports are calculated as production minus consumption and other uses.

In summary, catch data in most cases are consistent with consumption data, so providing some level of confidence in the accuracy of the estimates.

5.3 Other consumption data

Official figures for consumption from developed countries

Based on reported trade figures, the FAO estimates annual per capita ‘apparent consumption’ figures, which are intended to include all fish and OAAs that pass through formal trade systems. National governments provide official figures on catches, imports, exports, and sales for animal feed, and the FAO uses these to derive ‘whole animal’ figures for ‘world apparent consumption of fish and fishery products’ which are updated regularly and published on www.faostat.fao.org.

For developed countries that have cash-based economies, the FAO consumption figures can be considered accurate to within a few percent, as most trade in food is accurately monitored[1].

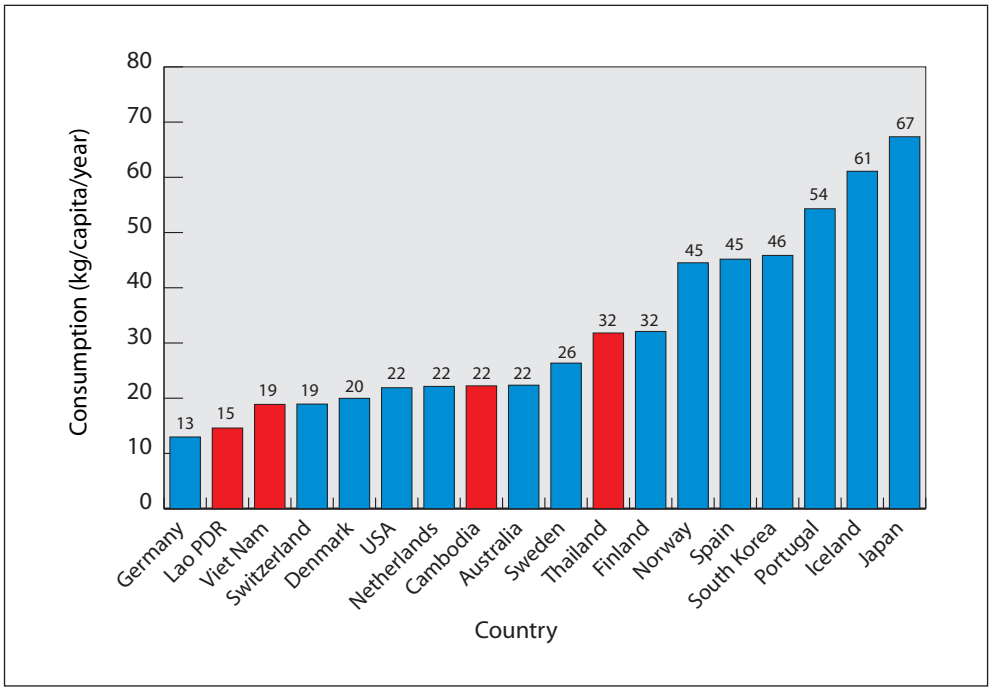

Figure 16. FAO estimates for 'apparent consumption' of all fish and OAAs for some developed countries, compared with FAO data for LMB countries (Year 2000 data from www.faostat.fao.org, updated data downloaded in 2006).

The FAO consumption figures for all fish and OAAs (marine plus inland) developed countries range from about 13 to 67 kg/capita/year, with mid-range consumers in developed countries eating about 30–40 kg/capita/year as FWAEs (Figure 16). The FAO estimates for inland fish in all LMB countries are much less than those from this study (average 23%, range 18–47%, see Table 29), and the FAO figures for inland OAAs are clearly unrealistic, being zero in three countries. Overall the FAO figures are about half of the consumption figures estimated in this study. This discrepancy is a result, at least in part, of the FAO figures excluding data from subsistence/artisanal inland fisheries as well as probable under-reporting in official trade figures.

Given that the LMB peoples are moderate to high consumers of fisheries products, we can assume from Figure 3 that a realistic range for the LMB countries (based on FAO world figures for well-monitored countries) is 40–60 kg/capita/year. The figure estimated for LMB

1 The developed-country figures are subject to two sources of error which may balance each other to some extent: wastage is not subtracted from the whole-animal figures, but consumption from recreational fisheries is underestimated or not included.

consumption in this report of 51.5 kg/capita/year as FWAEs for all aquatic foods (inland fish and OAAs as well as marine products) thus appears to be plausible from this perspective.

Table 29. *Comparison of FAO 'apparent consumption' figures with the consumption figures from this study.*

Country	Source	Type	This study, LMB estimate	FAO whole country estimate	FAO estimate / this study estimate
Cambodia	Inland	Fish	42.2	19.8	47%
		OAA	9.2	0.0	0%
	Marine	Fish and OAAs	1.0	2.5	248%
	Total		52.4	22.2	42%
Lao PDR	Inland	Fish	34.6	13.5	39%
		OAA	8.4	0.0	0%
	Marine	Fish and OAAs	0.5	1.1	219%
	Total		43.5	14.6	34%
Thailand	Inland	Fish	32.0	7.8	24%
		OAA	8.5	1.1	13%
	Marine	Fish and OAAs	5.8	23.0	396%
	Total		46.3	31.8	69%
Vietnam	Inland	Fish	39.5	7.0	18%
		OAA	9.2	0.0	0%
	Marine	Fish and OAAs	7.4	11.9	161%
	Total		56.1	18.9	34%
Total	Inland	Fish	36.6	8.5	23%
		OAA	8.8	0.4	5%
	Marine	Fish and OAAs	4.9	15.1	307%
	Total (weighted)		50.3	24.0	48%

Other tropical countries

Comparisons may also be made to studies of similar environments. Bayley and Petrere (1989) summarised results from consumption studies of inland fish from the Amazon basin; in lowland areas consumption varied from 27 – 101 kg/capita/year, and in highlands where cheap beef was available, the lowest fish consumption was 4 kg/capita/year. The LMB is more intensively exploited than the Amazon, so yields per unit area may be larger, but per capita consumption also depends upon many other factors, including population density. The LMB average is in the mid-region of the lowland Amazon range, suggesting it is of the correct order.

Roos *et al*. (2003) in a rather intensive study in Bangladesh of typical poor rural people found that they ate 16 – 36 kg/capita/year of fish as FWAEs. This figure fits well with the LMB estimates, allowing for some substitution of fish in Bangladesh by pulses (peas, beans, etc.). The study was based on five-day recall, which is probably less accurate than 24 hour recall.

Consumption by expatriate LMB country people

Sechena *et al*. (1999) used quality-assured standardised interview protocols among expatriate Asians in Washington State (USA) and found high annual seafood consumption among people from LMB countries, as summarised in Table 30. In this study, older respondents reportedly ate more seafood than younger respondents, perhaps indicating retention of original eating habits as is also suggested by the low consumption rates among highland Hmong and Mien people.

Table 30. *Consumption of fish and seafood by expatriate Asians in the USA. Estimated actual intakes in people living in King Country, Washington State, (from Sechena* et al*., 2002). Seaweed/kelp was subtracted from totals and an average body weight of 62 kg was used for converting these figures from g/kg/day.*

Ethnicity	Reported actual consumption (kg/capita/year)			
	N	Total	Shellfish	Fish
Cambodian	20	32.2	20.8	11.4
Laotian	20	43.5	20.3	23.1
Mien	10	13.1	7.7	5.5
Hmong	10	13.2	5.6	7.6
Vietnamese	26	59.1	35.7	23.4

These figures for reported actual consumption should be increased to derive FWAEs. They are then much higher than the figures for LMB people and for US citizens generally, suggesting that LMB people do indeed have an above-average tendency to consume seafood given the opportunity. Although this study does not support any particular figures for LMB people, it does suggest that consumption of fish and OAAs in the LMB is likely to be higher than world averages.

5.4 Yield calculations based on floodplain area x production/ha

Yields from large tropical floodplain rivers are thought to depend mainly on the area of land that is flooded and the duration of flooding each year. Welcomme (1985) reviewing world data suggested that 70% of the production in large river systems is predictable from floodplain area alone. In the LMB the size of the flood each year has a direct effect on the production and subsequent yield of fish, as shown by monitoring data from the Cambodian *dai* fishery (Hortle *et al*., 2005). While many fish and OAAs are caught in rivers or streams, much of their biomass actually originates from growth during the time that they were feeding on productive flooded areas during the wet season.

Sverdrup-Jensen (2002) estimated a yield of fish of 230 kg/ha/year of floodplain, which he multiplied by a floodplain area in the LMB of 96,900 km^2 to estimate a yield of 2.23 million tonnes for the LMB. The figure of 230 kg/ha/year was derived from a very approximate estimation of yield from the entire Cambodian floodplain area by Baran *et al*. (2001), which

Table 31. *Areal estimates for LMB fishery yield.*

Mekong System — Floodplains

Study Area	Habitats	Yield (kg/ha/year)	Composition	Comment	Source
Mekong Delta Floodplain, deep water flooded areas	Rice fields, black water area	42 – 63	Fish 46.9% OAAs 53.1%	Intensive monitoring at one site	de Graaf and Chinh (2000)
Mekong Delta Floodplain, deep water flooded areas	Rice fields, non-acid area	80 – 119	Fish 88.9%, OAAs 11.1%	Intensive monitoring at one site	
Battambong, near Great Lake, Cambodia	Rice fields, single crop rain fed	67 – 162, mean 119	Fish 76.6%, OAAs 23.4%	Yields from 10 plots of 25 ha each, monitoring of all catches	Troeung *et al*. (2005)
Mekong Delta, Viet Nam	Rice fields, stocked with fry	95 – 619 per 10 months	Fish, mostly exotic	Yields from 50 trial farms, double or triple rice-cropping, fish not fed	Nguyen *et al*. (2002) Table 13
Northeast Thailand	Rice fields, wild fish Rice fields, wild and stocked	25 – 125 56 – 303	Fish	Range from one study in Khu Khat Range from two sites	Little *et al*. (1996)
Uplands, Lao PDR	Rice fields, stocked with fry	31 – 640 per crop	Fish, mostly exotic	Range from several studies, approximate	Funge-Smith (1999b)
Prey Veng, Cambodia	Rice fields, single-crop, former forest	55	Fish	Includes only large and middle-scale fisheries catches in fishing lots, does not include artisanal catch	Troeung *et al*. (2003)
Prey Veng, Cambodia	Degraded forest 31% cover and rice fields, single crop	92	Fish		
Battambong, near Great Lake, Cambodia	Flooded forest	95	Fish		
Tonle Sap Floodplain, Kampong Chhnang	Natural grassland	113 kg/ha	Fish 95% OAA 2%	Standing crop of 13 sites	Lieng *et al*. (2006)
Tonle Sap Floodplain, Kampong Chhnang	Natural swampland	84 kg/ha	Fish 90% OAA 3%	Standing crop of 20 sites	Lieng *et al*. (2006)

Mekong System — Reservoirs

Study Area	Habitats	Yield (kg/ha/year)	Composition	Comment	Source
Sirindhorn Res., NE Thailand	Reservoir	21	Fish only	Stabilised catch	Sricharoendham *et al*. (2000)
Ubolratana Res., NE Thailand	Reservoir	23 – 64	Fish only	Initial rise then fall, 1965-1993	Pholprasith and Sirmongkonthaworn (1999)
Nam Ngum, Lao PDR	Reservoir	40 – 185	Fish only	Indigenous species, fishery not yet stabilised	Mattson *et al*. (2000)
Ea Kao, Highlands of Viet Nam	Reservoir	400 – 450	Fish only	Mainly stocked exotic species, euthrophic reservoir	Phan and De Silva (2000)
7 tropical countries	Asian Reservoirs	15 – 576	Fish?	Mixed species	de Silva and Amarasinghe (1996)

Other rivers — Floodplains - wild fish

Study Area	Habitats	Yield (kg/ha/year)	Composition	Comment	Source
Africa, South America, Asia	Tropical floodplain rivers	typically 40 – 60, range 7 – 143	Fish?	Review of data	Welcomme (1985) p. 214 and Table 7.13
Bangladesh	Unregulated Floodplains 8 studies	51 – 215	Fish	Intensively fished	Ali (1997) Table 31
Bangladesh	Floodplain enclosed by levees	77 – 102	Fish	Intensively fished	Ali (1997) Table 33 - non-stocked yield only
Bangladesh	Open floodplain	423 – 574	Fish	Intensively fished	Ali (1997) Table 33 - non-stocked yield only
Bangladesh	Floodplain - low-lying areas with permanent water bodies	165	Fish	Intensively fished	de Graaf *et al*. (2001)
Bangladesh	Floodplain seasonally inundated	83	Fish	Intensively fished	
Bangladesh	Rivers and riparian land	102 – 157	Fish	Intensively fished	
Bangladesh	Floodplain – Natural	104 – 130	Fish	Intensively fished	Halls *et al*. (1999)
	Floodplain – Modified	51 – 81	Fish	Intensively fished	

Other systems — rice fields

Malaysia	Rice fields, wild fish	68 – 140	Fish	Double rice cropping, artisanal fishery	Tan *et al*. (1973), cited in Fernando (1993) Table 3
Northeast India	Rice fields, stocked	907–1,282 per 120 days	Fish and Shrimp	120 day rice crop, heavy organic fertiliser, no feeding	Mohanty (2003)

Crude Estimates from the LMB, not based on exact areas or measured yields

Tonle Sap System	Floodplain, total	230	Fish?	Crude estimate, see text	Baran *et al*. (2001)
Tonle Sap Floodplain	Floodplain, total for 1995 – 99	139 – 190	Fish?	Crude estimate, see text	Lieng and van Zalinge (2001)
Prey Veng, single rice rain fed, low-moderate yield	Rice fields	50 – 100	Fish?	Estimates based on catches, villages may not be representative, approximate area	Guttman (1999)

was itself partly based on consumption figures of Ahmed *et al*. (1998), so it cannot be used to validate consumption estimates. Moreover, Cambodian floodplains are generally more productive than those in Thailand and Lao PDR, where land is inundated for shorter periods.

A wide range of yields has been reported from floodplain river systems elsewhere (from <100 to >1,000 kg/ha/year), and Welcomme (1985 p. 214) believed a range of 40–60 kg/ha/year was typical for floodplain river systems. Data from other areas of the world may not be applicable to the LMB because of differences in productivity of the systems, differences in level of exploitation, and inaccuracies in the methods used. A preferred approach is to use the results from studies in the LMB where catches and areas were accurately estimated, and to use these to extrapolate for the LMB.

Table 31 shows the range of relevant reliable areal yield estimates in the LMB. It should be noted that many studies under-estimate yields to some extent as not all catches can be monitored. Yields from rice-fields of fish and OAAs combined are 42–165 kg/ha/year, with one quarter typically comprising OAAs, a proportion consistent with the limited consumption data (see Table 23). Stocking of rice-fields shows how natural yields can be augmented (Little *et al*., 1996; Nguyen *et al*., 2002) and perhaps provides some indication of the upper limits to yield (around 700kg/ha/year) for wild fish in very productive rice-fields. Middendorp (1992) reported a maximum wild fish yield of 1,199 kg/ha in rice-fish culture systems in northeast Thailand, but his very high figures suggest that his study sites might have included some drain-in from upstream rice paddies (i.e. from a larger area than that used to calculate yield). In floodplains, Troueng *et al*. (2003) showed that partly- or well-forested areas may produce 1.7 times as much fish as unforested areas; note that their study does not include artisanal and subsistence catch which would increase the yield figures. If this ratio of 1.7 is applied to the more complete data from rice-fields (i.e. including all fish and OAAs), the range for forested floodplains could be 71–281 kg/ha/year (i.e. the rice-field range multiplied by 1.7). Figures for standing crop show a minimum estimate for yield of 84 and 113 kg/ha for natural swamp and grassland as the figures are based on a single harvest (Lieng *et al*., 2006). Data for typical rice-fields or other aquatic habitats in Lao PDR and Thailand are limited (Little *et al*., 1996). However, it is reasonable to expect that the yields in these countries would be lower than in Viet Nam and Cambodia where rice-field habitat includes most of the large areas seasonally flooded by the Mekong (Figure 3).

Floodplains in Bangladesh have a similar fauna to the LMB and appear to have similar yields, but in some cases yields are higher, perhaps as a result of more intense fishing pressure. The yield from rice-fields in other systems appears to be similar to yields from LMB rice-fields (Fernando, 1993), and heavy stocking with fry and fertilisation may lead to yields greater than 1,000 kg/ha/year.

Table 31 also shows the various levels of yield that can be expected in reservoirs in the LMB; yields are high when reservoirs first fill and then decline to around 20 kg/ha/year of reservoir surface after some decades, except where nutrients are constantly added to the reservoir as can be seen for Ea Kao.

The total area of the Lower Mekong Basin is 622,584 km^2, and of this about 193,896 km^2 (24.8%) is classed as wetlands, a figure much higher than that used by Sverdrup-Jensen (2002) in his estimate of basinwide production. A breakdown of the wetland area (Table 32) shows that most is classed as rice-fields, although much of this may actually be other land uses (e.g. scrub, other agricultural fields, idle land or small water bodies) that are in blocks that are too small to be discriminated. For comparison, Cambodia officially has about 23,000 km^2 of rice-fields (McKenney & Prom, 2002) which is 77% of the area classed as rice-fields under the GIS system. Thailand has the largest share of the LMB wetland (and rice-field) area, but flooding has been limited in extent and duration by water management schemes, so capture fisheries production (per unit area) is likely to be less than in Viet Nam and Cambodia.

Table 32. *Estimates of area of wetland areas in the Lower Mekong Basin from MRC GIS databases.*
Broad categories follow Figure 3 and these may include small blocks of other habitats.

	Area (km^2)					% of total
Wetland type	Cambodia	Lao PDR	Thailand	Vietnam	Total	
Bank/Beach bar/Estuarine	24	22			46	0.02%
Flooded Forest or Plantation	52			120	172	0.09%
Lakes or Ponds, Man-made or Natural	3,086	602	1,757		5,445	2.81%
Marine/Coastal Mangrove and Aquaculture	515			16,034	16,549	8.53%
Rice: Wet/Recession and Other Crops	31,494	7,186	82,846	18,068	139,594	71.99%
Rivers and Channels	1,446	1,126	569	730	3,871	2.00%
Swamp, Backswamp, Grassland, Marsh	10,426	1,260	1,562	1,156	14,404	7.43%
Others	2,350			11,465	13,815	7.12%
Total	49,393	10,196	86,734	47,573	193,896	100.00%
% of Total	25.5%	5.3%	44.7%	24.5%	100.0%	

Note: Figures from the MRC GIS database, based on data from 1992 – 1998

Because rice-fields forms such a large proportion of the total wetland area, a basin wide estimate of yield depends largely upon the yield estimate (per unit area) that is used for rice-fields. All LMB studies are from Cambodian or Vietnamese rice-fields, so in the absence of field data it was assumed that areal yields in Lao PDR and Thailand are on average 50% of areal yields in Viet Nam and Cambodia.

Three levels of yield were assumed — 'low', 'medium' and 'high': 50, 100 and 200 kg/ha/year respectively — as shown in Table 33 and based on data in Table 31. The 'high' level allows for possible underestimation in studies in which all the yield was not recorded. These areal yield estimates were then multiplied by the estimated wetland areas to derive total yield estimates. Table 33 shows that under these assumptions the estimated yield from Cambodia is the highest among the four countries, while Thailand and Viet Nam have similar but slightly lower yields; the lower areal yield in Thailand is compensated for by its larger total area of wetland habitat. Lao PDR yields relatively little because of its small wetland area and assumed low areal yield.

Table 33. *Estimated fisheries yield from the LMB based on yield per unit area, compared with consumption estimates.* *OAAs estimated as 25% of fish.*

	Cambodia	Lao PDR	Thailand	Viet Nam	Total
Total wetland area (km²)	49,393	10,196	86,734	47,573	193,896

Estimated yield (kg/ha/year)	Cambodia	Lao PDR	Thailand	Viet Nam	Weighted Total
Low estimate	50.0	25.0	25.0	50.0	37.5
Fish	40.0	20.0	20.0	40.0	30.0
OAA	10.0	5.0	5.0	10.0	7.5
Medium estimate	100.0	50.0	50.0	100.0	75.0
Fish	80.0	40.0	40.0	80.0	60.0
OAA	20.0	10.0	10.0	20.0	15.0
High estimate	200.0	100.0	100.0	200.0	150.0
Fish	160.0	80.0	80.0	160.0	120.0
OAA	40.0	25.0	25.0	50.0	37.5

Estimated yield (tonnes/year)	Cambodia	Lao PDR	Thailand	Viet Nam	Total
Low estimate	246,965	25,490	216,835	237,865	727,110
Fish	197,572	20,392	173,468	190,292	581,688
OAA	49,393	5,098	43,367	47,573	145,422
Medium estimate	493,930	50,980	433,670	475,730	1,454,220
Fish	395,144	40,784	346,936	380,584	1,163,376
OAA	98,786	10,196	86,734	95,146	290,844
High estimate	987,860	101,960	867,340	951,460	2,908,440
Fish	790,288	81,568	693,872	761,168	2,326,752
OAA	197,572	20,392	173,468	190,292	581,688

Consumption Estimates (tonnes/year)					
Fish plus OAAs	587,004	208,503	911,485	852,823	2,559,815
Total Inland Fish	481,537	167,922	720,501	692,118	2,062,077
Inland OAAs	105,467	40,581	190,984	160,705	497,737

Consumption Estimates as percentage of low yield estimates					
Fish plus OAAs	238%	818%	420%	359%	352%
Total Inland Fish	244%	823%	415%	364%	354%
Inland OAAs	214%	796%	440%	338%	342%

Consumption Estimates as percentage of medium yield estimates					
Fish plus OAAs	119%	409%	210%	179%	176%
Total Inland Fish	122%	412%	208%	182%	177%
Inland OAAs	107%	398%	220%	169%	171%

Consumption Estimates as percentage of high yield estimates					
Fish plus OAAs	59%	204%	105%	90%	88%
Total Inland Fish	61%	206%	104%	91%	89%
Inland OAAs	53%	199%	110%	84%	86%

The estimated range for yield of 0.7 – 2.9 million tonnes/year is only indicative, because it depends upon various estimates and assumptions. It should also be noted that yield from year-to-year would vary depending upon the extent and nature of flooding and the intensity of fishing pressure. The differences between countries only apply to the **source** of yield rather than the point of capture, because fish and OAAs may migrate and be caught hundreds of kilometres away across international borders (Poulsen *et al*., 2004), moreover some fish are transported and consumed away from the point of capture. The yield estimate of Sverdrup-Jensen (2002) is at the upper end of the range suggested here, because his use of a much lower wetland area was balanced by a much higher areal yield estimate.

The estimate of consumption is towards the upper end of the estimated range for yield, which is to be expected because the Mekong is a productive system and is intensively fished.

Assuming a high level of yield in the LMB, in both Viet Nam and Thailand the yield approximately balances with consumption. In Cambodia, yield greatly exceeds consumption, a finding consistent with its position as a nett exporter of fish to the other LMB countries. Conversely, Lao PDR in particular appears to be in deficit as it probably imports a significant part of its total consumption. Lao PDR's imports are likely to be primarily preserved fish, in particular salted/dried fish (see Table 14), which would be consistent with limited availability of fresh fish during the extended dry season in this part of the LMB.

6. Conclusions

This report reviews a range of consumption studies which were based primarily on interviews. From these studies, it is estimated that about 2.6 million tonnes per year as FWAEs of fish and OAAs were eaten by a LMB population of about 56 million in 2000; about one quarter of this figure is estimated to comprise OAAs. The consumption estimate leads to *per capita* estimates for animal protein intake which would indicate that an average LMB resident eats more than the recommended daily allowance intakes once additional vegetable protein is taken into account. Other data (a trial monitoring study, catches, and comparative data from elsewhere in the world, and yield estimates) together provide support for the validity of the consumption figures. Information on sampling precision in two studies suggests a relative error of about 10% is likely, and given possible bias in the data the general agreement between the overall estimates and the validation data is very encouraging.

Table 34. *Official figures for inland fisheries yield compared with the estimates for LMB consumption and medium-level yield estimates.*

Consumption estimate is fish only. The yield estimate for the LMB is the official national yield multiplied by the proportion of that country which is within the LMB, from Table 1. This table differs from some others; it is not always clear what 'official' yield is. For Long An and Tien Giang official production was estimated pro-rata based on LMB area as in Appendix 1.

Country	Official Yield (production) tonnes/year					Consumption comparison		Areal yield comparison	
	Official Yield	Origin	Year	Reference	Assumed from LMB	Consumption estimate, tonnes/year (Table 24)	Discrepancy	Medium Areal Yield Estimate, tonnes/year (Table 33)	Discrepancy
Cambodia	385,000	Whole Country	2001	Sam *et al*. (2003) consumption and catch estimates	337,645	587,004	174%	493,930	146%
Lao PDR	71,316	Whole Country	2000	Souvanaphanh *et al*. (2003) areal yield times areas of habitat	62,402	208,503	334%	50,980	82%
Thailand	206,900	Whole Country	1999	Pawaputanon *et al*. (2003) commercial figures, mainly reservoirs	75,725	911,485	1204%	433,670	573%
Viet Nam	703,360	Delta, whole 12 provinces	2000	GSO (2003) Production minus sea catches	681,653	852,823	125%	475,730	70%
				TOTAL	1,157,425	2,559,815	221%	1,454,220	126%

Available data on yields per unit area suggest a possible range of 0.7-2.9 million tonnes/year of fish and OAAs from the LMB. To the consumption-based estimate (2.6 million/tonnes/year) must be added exports from the LMB and wastage, certainly an additional 10-20% of the consumption estimate, as well as trash fish used in aquaculture, which amounts to about

120,000 tonnes/year. The estimated overall yield in the LMB therefore appears to be close to the upper end of the possible range, a finding which seems reasonable, because the Mekong is a highly productive system with intensively exploited fisheries.

Various data suggest that most (>90%) of the yield is from capture fisheries, with relatively little production from aquaculture in the Year 2000, despite large investments in the sector. A high level of participation in capture fisheries is evident throughout the basin, consistent with high areal and total yields.

The consumption and areal-based yield figures are somewhat at odds with the official production (yield) figures within each LMB country (Table 34). The best match is for Viet Nam and the largest discrepancy is for northeast Thailand, where the consumption figures are close to 10 times the official production figures. The difference between official and estimated consumption figures for Thailand may be partly caused by this region importing fish from Lao and Cambodia, but even allowing for imports and a possible overestimation of consumption the official yield figures are clearly too low, as even the medium areal yield estimate is more than five times the official figure.

Most of the wetland area in the LMB is classed as rice-fields (i.e. rice-fields as well as smaller areas of habitat not discriminated by GIS), so it is likely that rice-fields and related habitats make a large contribution to the total yield. There are no representative data for large areas of rice-field habitat, so further studies on yield per unit area, especially in Thailand and Lao PDR, would also refine the overall estimate of yield from the basin.

Although the exact size of the LMB fisheries will continue to be debated, the importance of wild capture fisheries is undeniable and clearly under-recognised. More attention should be focused on accurately assessing the size and value of capture fisheries and on measures to maintain and where possible increase their yield. While stocking has been a common response, environmental management is likely to be more cost-effective. In the Mekong context, it follows that rice-fish production systems in particular should receive a higher priority for environmental management for fisheries production.

This report shows the inconsistencies between different data sets that are quoted widely and used for various purposes. All official data of fisheries yield are less than estimates derived from consumption data. National data exclude or under-report the important artisanal and subsistence fisheries which make a major contribution to yield. The FAO's 'apparent consumption' figures — compiled from data provided by countries — are based on questionable data on trade figures and also do not account for subsistence and the large informal or unreported economy in LMB countries. Users of such 'official' figures may draw incorrect conclusions about the relative importance fisheries. A regular basinwide consumption survey, supported by national statistics and fisheries agencies, would greatly assist in reconciling conflicting yield estimates and in institutionalising methodologies and results for basinwide fish yield estimates.

The studies reviewed for this report suffer from a general lack of quality assurance, a problem compounded for this review by their poor comparability in terms of approach,

coverage and units. Most of the surveys were based on interviews, during which biases may have been introduced, and most provided no information on precision. Given the lack of consistency in methods and the uncertainty as to the accuracy of results it is important to consider some approaches for collecting better data to produce a more precise estimate of yield.

Consumption survey design

The surveys were not designed with the aim of producing an estimate of yield for the LMB, so the survey design is far from optimal. A random survey of households from the entire basin would provide a much more accurate overall consumption estimate with far less effort on data collection; far fewer households would be required than in studies where highly variable statistics (such as catch) are investigated. As the range of individual consumption estimates is not wide compared to the range of individual catch estimates (which span several orders of magnitude), a stratified sampling approach (which adds to cost and complexity) may not be necessary. If individual estimates are required from each country or from any particular region, the number of samples to be taken should be increased.

Data quality

The quality of surveys should be improved, with adequate attention to the main data quality indicators (DQIs): bias, precision, representativeness, completeness and comparability. Surveys that cover these indicators are likely to be generally less controversial and so of more value for management.

Sampling to estimate consumption

Food consumption is usually assessed by either retrospective (recall) or prospective (measurement) methods (Seaman, 1995; Anderson, 1995). Virtually all retrospective surveys are based on recall of consumption during the previous 24 hours, so any future studies in the LMB should also follow this standardised approach. For validation, direct methods based on daily weighed food inventories are considered accurate, but still subject to some bias: if people weigh their own foods they will simplify their diet or simplify their records; if investigators keep records their presence will affect the behaviour of subjects. Nevertheless, many investigators refer to daily food records as the ‘gold standard’ against which other methods should be validated. Hence a reasonable approach is to use interviews to achieve coverage of sufficient households and to measure consumption in a subset of the interviewed households to calibrate the interview data. Portion-size estimation aids (PSEAs) are widely used elsewhere and should be standardised and incorporated in future consumption surveys.

Consumption coverage and units

Surveys have used various units with varying degrees of coverage of food types with the result that many data are difficult to compare. A minimum list of food types is suggested in

Appendix 2. This list aims to avoid overestimation of quantities during interviews caused by disaggregation (or decomposition) (see Belli *et al*., 2006). A more detailed list could be formulated during monitoring. Units should be standardised; for most foods, kilograms or grams per household per day would match the recommendation to base surveys around 24-hour recall and weighed daily food records. Surveys are usually based on households, but because household size varies, per capita estimates are necessary for comparison or compilation of survey results. Surveyors should take care to record actual numbers of people present at meals (rather than household members) and should correctly weight data when converting between household and per capita units.

Survey implementation

Future large-scale surveys could be part of the routine work of national statistics agencies, as they could be readily incorporated in rural and agricultural censuses (e.g. GSO, 2003) or national household censuses (e.g. NSC, 2004). Such surveys are probably beyond the expertise and mandate of fisheries agencies.

More intensive surveys can be successfully carried out by fisheries agencies, but should involve statistics agencies to ensure that methods and results are broadly accepted.

Areal-based yield estimates

This review highlights the importance of the large areas of habitat classified as rice-fields. Studies of yield in representative habitats in Thailand and Lao PDR, as well as more data from Viet Nam and Cambodia would greatly improve yield estimates based on area. Such studies are properly the purview of fisheries agencies and complement consumption data.

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Appendix 1 Consumption summary tabulations

Appendix 1 is a large Excel workbook that contains all the key data that was used in the compilation of this report. The table is too large to be presented in this report but is available in the CD-ROM that is included in the back of this document.

Appendix 2 Recommended minimum categories for consumption surveys

FRESH FISH
Itemise the main species
Eels
PRESERVED FISH
Fermented Fish
Separately itemise the different types
Fish Paste
Fish Sauce (L) marine
Fish Sauce (L) inland
Smoked Fish
Salted and/or Dried Fish
MARINE FISH
MARINE OAAs

OTHER AQUATIC ANIMALS (OAAs)
Tadpoles
Small Frogs
Big Frogs
Crabs
Shrimps
Molluscs (bivalves & gastropods)
Aquatic Insects
Snakes
Turtles
Birds

OTHER ANIMAL FOODS
Beef
Buffalo
Goat/Sheep
Pork
Chicken
Duck
Other poultry
Eggs
Dried meat
Fowl other
Wild land animals
Wild birds
Reptiles
Forest game/wildlife
Insects—terrestrial

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