

How much of the Mekong fish catch is at risk from mainstream dam development?

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In the absence of reliable data on the species composition of the catch in the Lower Mekong Basin, the authors look at three approaches to estimate the size of the region's migratory fish resources.

There are currently 11 proposals for dams to be built on the mainstream of the Mekong River in countries downstream from China (see map on page 3 and table on pages 6-7). Planning agencies need to be able to evaluate the positive and negative impacts of these proposals. The major negative impact is the potential loss of fisheries as a consequence of dams blocking fish migration routes and altering aquatic habitats both upstream and downstream of the dams. In this regard, an estimate of the catch—and ultimately the value—of fish threatened by mainstream dam development in the Lower Mekong Basin (LMB) is fundamental for effective basin development planning and balanced decision-making.

Many reviews have highlighted the exceptional importance, by global standards, of fish resources in the Lower Mekong Basin (e.g., Lagler, 1976; Jensen, 2000; Van Zalinge *et al.*, 2004; Baran *et al.*, 2007; Hurtle, 2007). However, no comprehensive field-based assessment and monitoring of fish resources basinwide has ever been undertaken. Logistically, generating such information is extremely difficult, because of the geographic spread of the fisheries, their seasonality, the abundance of species targeted by a wide range of gear, and the range of fishing practices from the family subsistence to commercial levels. Existing national statistics are not based on field studies (Coates, 2002) and are not disaggregated at the species level. This striking knowledge gap does not allow quantitative estimation of the importance of migratory fishes in the LMB: only approximations are possible.

Not all species of fish caught in the basin are at risk from mainstream dams. Some with only limited migrations over short ranges may not be impaired by dam structures. Others are highly adaptable to habitat modification including impoundment. Species most likely to be affected will be those that undertake significant passive and active migrations along the mainstream between critical spawning, feeding, and refuge habitats as part of their life histories.

In this report, we provide three different approaches to estimating the size of the migratory fish resource in the LMB. The first uses an expert panel approach, drawing on the knowledge of experienced fisheries professionals in the region. The second is based on analyses of published literature. The third categorises different species of fish into guilds based on their biology and then uses a fisher catch survey to determine the proportion of the catch that is highly threatened by dam construction.

Method 1: Surveying experts

In the first half of 2007, the MRC Fisheries Programme co-opted an expert panel to provide an estimate of the size and value of the migratory fish resource in the LMB. The expert panel consisted of 13 fisheries scientists from Lao PDR, Cambodia and international organisations operating in the LMB. The survey was conducted by email. Participants were not identified to each other to avoid peer or group pressure when answering the questions.

To estimate the size of the migratory fish resource, all participants were asked to answer and comment on the question: *What percentage of the total yield from the capture fishery in the LMB is 'white fish' (that is, those that are highly migratory)?* Responses (both estimates and comments) were compiled and sent to the respondents, giving them an opportunity to revise

their estimates based on the group's initial comments. After the second round of responses, the individual estimates were averaged to provide the overall estimate from the expert panel.

The estimate for the value of the resource in terms of first-sale price was determined using the same approach, although the question was limited to white fishes which migrate upstream and downstream of the Lao-Cambodian border. While this estimate is not strictly representative of the value of white fishes throughout the entire LMB, it is adequate for providing an indicative estimate of the value of the migratory fish resource in the LMB.

The combined results from the group indicated that migratory fish resources comprise 71% of the fisheries yield in the LMB. The first sale value of migratory fishes at the time of the survey (2007) was estimated to be US\$1.89/kg.

'First-sale value of migratory fishes was estimated to be US\$1.89/kg'

Hortle (2007) estimated that in 2000 the yield of freshwater fish in the basin, minus the aquaculture component, was approximately 1,860,000 tonnes. Combining this figure with the expert panel's estimate of size and first sale price of the migratory fish resource, the following estimates can be derived:

Size of migratory fish resource in LMB = (1,860,000 x 71%) = 1,320,000 tonnes

First sale value of migratory fish resource in LMB = (1,320,000 x 1000 x 1.89) = US\$2,500 million

Method 2: Reviewing literature

Three major migration systems have been distinguished in the Lower Mekong Basin (Poulsen *et al.*, 2002):

- (i) the Lower Mekong Migration System, characterised by its extensive floodplains and extending from the sea to the Khone Falls in southern Lao PDR;
- (ii) the Middle Mekong Migration System, from Khone Falls to Vientiane, characterised by big tributaries and local wetlands; and

(iii) the Upper Mekong Migration System, from Vientiane to China.

We propose below an estimate of what is at stake in each migration system if fish migrations are disrupted in the LMB. While these systems are treated independently in this analysis, it is important to appreciate that there is considerable movement of fish between the systems, particularly between the lower and middle migration systems.

In fact, the lower and middle migrations systems are not distinguished based on geography (the Khone Falls actually demarcate them, but many species migrate through the Khone Falls). Rather, the two systems are distinguished functionally. In the lower migration system, the dry season habitat is upstream of the flood plains. In the middle system, the dry season habitat is downstream of the flood plains. Consequently, at the onset of the flood season, fish migrate downstream in the lower migration system, but upstream in the middle migration system (see Poulsen *et al.* (2002) for a full explanation).

1. The Lower Mekong Migration System includes the whole of Cambodia and all the Vietnamese Mekong Basin. Fish resources in this system thus correspond to 100% of the Mekong yield in Cambodia and in Viet Nam. What is the yield in these areas? One estimate (Van Zalinge *et al.*, 2004) based on fisheries catch studies amounts to 682,000 tonnes in Cambodia and 845,000 tonnes in Viet Nam. A second estimate, based on household consumption studies (Hortle, 2007), amounts to 481,000 tonnes in Cambodia and 692,000 tonnes in Viet Nam. These estimates thus give a range for the fish production in the Lower Mekong Migration System:

- Estimate 1: (Cambodia: 682,000 tonnes x 100%) + (Viet Nam: 845,000 tonnes x 100%) = 1.53 million tonnes
- Estimate 2: (Cambodia: 481,000 tonnes x 100%) + (Viet Nam: 692,000 tonnes x 100%) = 1.17 million tonnes

Thus, the lower system produces between 1.2 and 1.5 million tonnes of fish annually, that is, 6 to 7 times more than the whole fishery sector (marine and freshwater) in Australia. Using the figure of 63% of Tonle Sap fish

being migratory white fish (van Zalinge *et al.*, 2000), the yield of migratory fish at risk if major barriers are built across the migration route amounts to 1.2 – 1.5 million x 63% = 750,000 – 950,000 tonnes. This represents more than the total fish production of France or New Zealand (around 600,000 tonnes each).

2. The Middle Mekong Migration System includes northeastern Thailand and the most productive part of the Mekong Basin in Lao PDR. Fish resources in this system correspond to 100% of the yield in the Thai Mekong basin¹, and by our estimates 80% of the yield in Lao Mekong. According to Van Zalinge *et al.* (2004) (Estimate 1), the Mekong Basin produces yearly 932,000 tonnes in Thailand and 183,000 tonnes in Lao PDR; according to Hortle (2007) (Estimate 2), Thailand produces 720,000 tonnes a year and Lao PDR 168,000 tonnes. This leads to the following estimates of fish production for the middle system:

- Estimate 1: (Thailand: 932,000 tonnes x 100%) + (Lao PDR: 183,000 x 80%) = 1.08 million tonnes
- Estimate 2: (Thailand: 720,000 tonnes x 100%) + (Lao PDR: 168,000 x 80%) = 850,000 tonnes

Thus, the middle system produces between 850,000 to 1 million tonnes annually. Assuming a similar ratio of migratory fishes as in the lower system (around 60%), that would correspond to 500,000 – 600,000 tonnes of fish resources at risk in case of dam development. In this system, the environmental impact of dams will be spread between many more tributaries than in the lower system. However, mainstream dams that disconnect floodplains from the mainstream remain a major concern for all fisheries resources in this area.

3. The Upper Mekong Migration System corresponds to the whole Chinese Lancang-Mekong area and the least productive part of the Mekong Basin in Lao PDR. Fish resources in this system correspond to 100% of the yield in the Chinese-Lancang Mekong (25,000 tonnes according to Xie and Li, 2003) and 20% of the yield in the Lao section of the Mekong basin. Hence the estimates of fish production for the Upper Mekong Migration System are:

- Estimate 1: (China: 25,000 tonnes x 100%) + (Lao PDR: 183,000 x 20%) = 62,000 tonnes
- Estimate 2: (China: 25,000 tonnes x 100%) + (Lao PDR: 168,000 x 20%) = 58,000 tonnes

The upper system thus produces around 60,000 tonnes of fish a year, which makes it the zone where there is the least to lose from hydropower development. Using again the estimate of 60% of the resource being migratory fish, we estimate the migratory stock in the upper system to be 36,000 tonnes. If we remove the Chinese portion (which is not within the LMB although it is certainly connected via migration), we have an estimate for the Lao portion of the upper system of 20,000 tonnes.

In summary, our calculations provide estimates of the migratory fish resource in the three migration systems of the LMB of:

- Lower Mekong Migration System (Viet Nam to Khone Falls) = 750,000 – 950,000 tonnes
- Middle Mekong Migration System (Khone Falls to Vientiane) = 500,000 – 600,000 tonnes
- Upper Mekong Migration System (Vientiane to China) = 20,000 tonnes (36,000 tonnes if Chinese fisheries are included).
- Entire LMB excluding China = 1,270,000 – 1,570,000 tonnes

Method 3: Combining information on fish migrations with catch survey data

As part of a recent modelling exercise to explore the barrier effects of dams on migratory fish populations in the LMB, Kshatriya and Halls (in prep.) determined which groups of fishes are likely to be susceptible based on their biology. Ten 'migratory guilds' or groups of species sharing similar migratory behaviour were identified based upon the degree to which the mainstream acts as a conduit or migration corridor for their movement (as eggs, larvae, juveniles and adults) between habitats. These represent variants or aggregations of the environmental guilds proposed by Welcomme *et al.* (2006).

¹ While there is some fish production in the Thai section of the Upper Mekong Migration System, for this analysis it is considered negligible compared with production from the Songkhram and Mun-Chi systems in the Middle Mekong Migration System

The migrations, and therefore the viability, of populations of species belonging to four guilds ('main channel resident', 'main channel spawner', 'semi-anadromous' and 'catadromous') were identified as being most threatened by mainstream dam development. One guild (floodplain spawner) may be partially impacted, while the other five guilds are unlikely to be affected by mainstream dams (Table 1).

Species of fish caught in the LMB were assigned to each guild on the basis of their presence or absence as adults and larvae/juveniles within the main habitats of the basin (rithron², main channel and tributaries, deep pools, floodplains and estuary) as recorded in MRC monitoring programmes and *ad hoc* surveys, as well as on the basis of information contained in the Mekong Fish Database (MFD) and wider literature.

A survey conducted by the MRC Fisheries Programme in 2003-04 identified 233 species of fish belonging to 55 families as present in the main channel, floodplains and estuary. The whitefish or highly migratory fishes comprised 150 species belonging to guilds 1-5, 8 and 9.

Fifty-eight species were assigned to the highly vulnerable guilds (2, 3, 8 and 9). They include 5 of the 11 Mekong fish species threatened by extinction

according to the IUCN 'Red List' (<http://www.redlist.org>) including the Mekong giant catfish (*Pangasianodon gigas*), the Mekong stingray (*Dasyatis laosensis*) and Jullien's barb (*Probarbus jullieni*). A further 26 species belonging to the 'floodplain spawner' guild were identified as being at medium risk of impact.

The 58 very species belonging to the highly vulnerable guilds (2, 3, 8 and 9) contributed to 38.5 % of the total weight of all 233 species recorded in the fisher catch survey in 2003/04 (Kshatriya and Halls, in prep.).

We can combine this estimate of the proportion of the highly vulnerable fish groups in the LMB catch with the figure provided by Hurtle (2007) for the total fish yield of 1,860,000 tonnes in the LMB to estimate the overall size of the highly vulnerable migratory fish groups in the LMB. That is, (1,860,000 x 38.5%) = 744,000 tonnes.

Method 3 was primarily undertaken to identify species of fish whose migrations are likely to be impacted by mainstream dam development as part of a recent modelling exercise undertaken by the MRC and the WorldFish Center. Whilst the fisher catch survey data provide some objective basis for determining the relative importance of the threatened species in the basin, the

Table 1. Species in the main channel, floodplains and estuary

Numbers of species assigned to each guild and their contribution to total catch recorded by MRC fisher-catch survey (Nov 2003-Dec 2004)

	Guild Name	Mainstream Dam Threat Level	Number of Species	Catch (kg)	Catch (%)
1	Rithron resident	Low or no threat	6	190	0.16
2	Main channel resident	Very high	38	18,694	15.37
3	Main channel spawner	Very high	14	26,160	21.51
4	Floodplain spawner	Medium	26	17,945	14.76
5	Generalist	Low or no threat	56	43,203	35.53
6	Floodplain resident ('black fish')	Low or no threat	22	6,251	5.14
7	Estuarine resident	Low or no threat	42	5,773	4.75
8	Semi-anadromous	Very high	3	80	0.06
9	Catadromous	Very high	3	1,865	1.53
10	Marine	Low or no threat	19	1,290	1.06
	Unknown	-	4	155	0.13
	Grand Total:		233	121,607	100

Source: Kshatriya and Halls, in prep.

² Residing in the riffle and pool zone in headwaters

estimates may be biased given that the majority of the reported landings contained in the database were for gillnet fishers targeting mainstream habitat.

It does not, for example, include landings from industrial-scale or specialised fisheries such as the Cambodian bagnet fishery in the Tonle Sap river that targets migratory species seeking refuge habitat (believed to be located near the border with Lao PDR) during the falling water period.

Nor does it include the *ly* trap fisheries of Khone Falls in southern Lao PDR that target the upstream spawning migrations of fish. Including such fisheries would likely raise the estimate of the proportion of the basin's catch threatened by dam development. However, at the same time, the fisher catch survey is unlikely to have representatively sampled landings of floodplain-resident species or generalists from floodplain systems such as the Songkhram system in Thailand which would have the converse effect on the estimates.

'The migratory fish resource at risk is 0.7-1.6 million tonnes per year'

A more accurate assessment of how much of the catch from the LMB is threatened by mainstream dam development will require unbiased estimates of the relative contribution of the threatened species to the entire landings within the basin. This will require a carefully designed basin-wide and species-wise household or fisher-based catch assessment survey

with appropriate stratification to account for temporal, spatial and habitat-dependent variation in fish catches.

It should also be borne in mind that the estimate of the proportion of the basin's catch that is at risk from mainstream dam development derived using the fisher catch survey data above relates only to the barrier effects of dams on fish migrations. It does not include the potential additional effects of changes to water quality, flow and sediment transport on fish abundance and landings arising from dam construction. It is therefore likely to be a conservative estimate of potential loss.

Conclusions

The results from the three methods indicate that the migratory fish resource at risk from mainstream dam development in the Mekong is in the range 0.7 – 1.6 million tonnes per year (Table 2). In more familiar terms, that amount of fish is equivalent to 1.6-3.5 times the entire beef production of Cambodia, Lao PDR, Thailand, and Viet Nam; or 0.9-1.8 times the entire pork production of Cambodia, Lao PDR, and Thailand (FAO statistics, <http://faostat.fao.org>).

The size of the migratory fish resources in the Lower and Middle Migration Systems (between the delta and Vientiane) is far larger than the resource in the Upper Migration System (northern Lao PDR) (Table 2). Therefore, dams built in the Lower and Middle Migration Systems are likely to have a greater impact on fisheries production in the LMB than dams built in the Upper Migration System. However, the calculation of local

Table 2. Estimates of migratory fish resources in the Lower Mekong Basin

Method	Estimate Derived	Annual Yield (tonnes)	Annual Value (US\$ million)
1	Highly migratory fish resource in the LMB	1,320,000	2,500*
2	Highly migratory fish resource in the LMB		
	(i) Lower Mekong Migration System (Viet Nam to Khone Falls)	750,000 – 950,000	1,400 – 1,800*
	(ii) Middle Mekong Migration System (Khone Falls to Vientiane)	500,000 – 600,000	950 – 1,100*
	(iii) Upper Mekong Migration System (Vientiane to China border)	20,000	37*
	LMB	1,270,000 – 1,570,000	2,400 – 3,000*
3	Highly vulnerable migratory fish groups in the LMB	744,000	1,400*

* the values for first-sale price are derived using the unit value for fish (\$1.89/kg) estimated in Method 1

yields at risk does not include far-reaching impacts, such as sediment retention in upstream dams and its impact on overall fish and river productivity. Furthermore, the Mekong River in northern Lao PDR is very specific in terms of aquatic biodiversity, with a number of local species characteristic of headwaters, rapids and high streams.

The analysis also indicates a first sale value for the resource of US\$1,400-3,000 million per year. This is actually a conservative estimate, because it does not take into account the economic benefits that flow from the trade and processing of fish products. Nor does it include the very considerable indirect values of the Mekong fisheries, such as their contribution to the nutrition, employment and well-being of millions of rural people in the LMB, who generally have few other livelihood options.

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