THE TECHNICAL ADVISORY BODY FOR FISHERIES MANAGEMENT (TAB)

# Fish migration triggers the Lower Mekong Basin

Mekong Fisheries Management Recommendation Nº 6

June 2007

Working towards Effective, Sustainable and Regional Fisheries Management in the Lower Mekong Basin

## INTRODUCTION

Many, if not most, of the economically important species of fish in the Mekong River undergo migration at some stage during their life cycle[1]. Indeed, many fisheries have developed specifically around the migratory behaviours of certain species of Mekong fish. However, despite the importance of migrations to the fish and the fisheries, there is apparently little knowledge about the physiological or environmental factors that trigger, or cue, these behaviours. What information there is seems to be dispersed widely and is not available from a single source or report.

It is clear, however, from both local knowledge and scientific investigations, that a number of fish species appear in great abundance at specific localities at certain times of the year. These abundances almost always relate to distinctive times in the annual flood-recession cycle. This correlation is hardly surprising as it seems most likely that the fish of the Mekong have evolved to take maximum advantage of the benefits the cycle provides, such as the abundance of nutrients on inundated floodplains during the wet season or the shelter provided by deep pools during the dry season.

Developing the water resources of the Mekong, particularly the construction of dams, will inevitably modify the natural flow of the river and thereby will have some follow-on impact on the wild fish population and the fisheries that depend on it. However, the nature and scale of these impacts is not clear, partly because of the lack of information about the factors governing fish migrations. As a consequence, the TAB (Technical Advisory Body for Fisheries Management) commissioned the WorldFish Center to undertake a review of existing information on Mekong fish migrations and to make an assessment of the consequences of flow modifications on fish populations.

**What are migration triggers?**

Fish migrate because the habitats in which they feed, shelter and spawn are geographically separated or change in character from season to season. These habitats may have dispersed for a number of geological, climatic or ecological reasons, and many fish have evolved in step with these changes.

It is important that fish arrive at the right location and the right time, and in the case of spawning it is important that large numbers of fish arrive at the right location and the right time.

However, the Mekong Basin is a large system and fish of the same species may set off from different locations. Some may travel hundreds of kilometres in the course of their migrations, others may have far shorter journeys. If this is the case the initial trigger may be different or a different aspect of the same trigger (such as a different time, or phase, in the lunar cycle).

What are often called 'triggers', or cues, may more correctly be 'correlations', that is the coincidence between fish abundance or movement and certain natural phenomenon.

The findings of this assessment, which were published by MRC in December 2006[2], form the basis of this TAB Management Recommendation. The analysis comprises two parts: (i) a qualitative review of literature on Mekong fish migrations and (ii) a quantitative interrogation of two large databases (the MRC's own *Mekong Fish Database* and the WorldFish Center's *FishBase*[3]) that hold most of the data about the fish species of the Mekong.

## REVIEW OF LITERATURE ON MIGRATION TRIGGERS

Although there are a few publications that concern fish migrations in the Mekong Basin, none deal specifically with the factors that trigger migrations. Indeed, research into migration triggers has received little attention from fish biologists working in the region. What is known about migration





triggers comes largely from interviews with fishers. As a result most of the available information relates the abundance of certain fish species to the environmental factors that are of concern to the fishers, and that can be observed by them. Practically nothing is known about the biology and physiology of triggers or the other possible environmental factors that fishers do not (or cannot) record—such as water chemistry and sediment load. Nonetheless, the literature review brings to light a number of environmental factors that clearly influence, or are associated with, migration.

- Discharge, water level and current.

  Water level is the factor most often cited as a migration trigger. This parameter, which is a feature recognised readily by fishers, correlates closely with discharge and water current. While water-level thresholds may be important, many fish seem to respond to variations, or changing water levels, rather than to specific heights of the river.

- Precipitation.

  The first rainfalls of the wet season trigger migrations associated with breeding and reproduction.

- Turbidity and water colour.

  While some migrations are known to correlate to changes in these factors, they are factors that are caused by a variety of phenomena including phytoplankton blooms and changes in the sediment load carried by the river.

- Lunar phase.

  Fish abundances at very specific times of the lunar calendar and the lunar phase are documented from throughout the basin. However, these are often very localised, and individual events rarely occur basin-wide. For example, the well documented 'migration wave' witnessed at Khone Falls at the time of the second new moon following the winter solstice is not observed a few kilometres further north at Pakse.

- Apparition of insects.

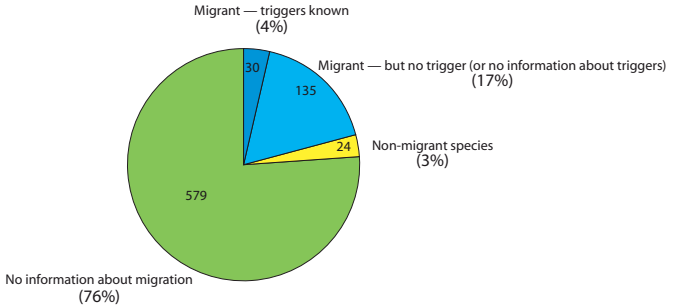
### Other related factors

While these are the primary environmental features that are known to be associated with fish migrations, the literature review also brought to light a number of important related factors.

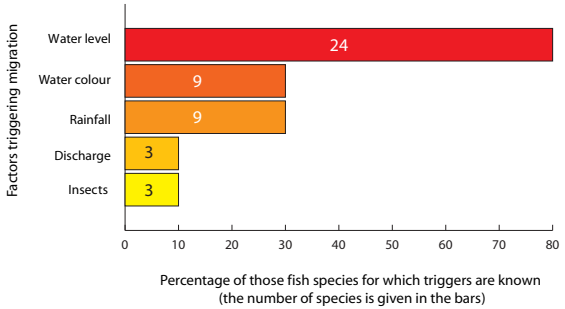
- *Fish density* may also stimulate migration, or a be complementary factor that triggers migration.
- Factors that trigger *spawning* should also be taken into account. These 'reproduction triggers' are equally important to the wellbeing of fish populations and are also important to species that are not migratory.
- The *multiplicity* and *interaction* of triggers and the role they play at different times and in different physiological mechanisms, means that triggers cannot always be reduced to a single environmental factor.

## QUANTITATIVE ANALYSIS OF MEKONG FISH MIGRATION TRIGGERS

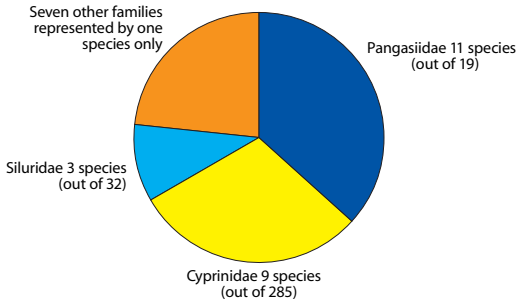
FishBase holds records on 768 fish species that have been reliably identified and documented as living in the Mekong. The migratory behaviour of nearly three-quarters of these species is unknown.




*Status of knowledge on migratory behaviours and environmental triggers*




*Percentage of species sensitive to particular types of migration triggers*




*Families most sensitive to triggers*





However, because fishers are most likely to record information on the fish that are important to their livelihoods, it seems very probable that these few numbers of species represent the bulk of the commercially important catch. (This assumption is borne out by data on specific fisheries such as that at Khone Falls.)

### Discharge and catch diversity

Where long-term and accurate data is available, such as at Khone Falls, there appears to be significant correlation between discharge and catch, both in terms of abundance and composition.

At Khone Falls, 96% of the catch is taken at discharge rates of between 2,000 and 8,000 cumecs (cubic metres per second), and that rates between 2,000 and 5,000 cumecs are the most important for fishers. Five species make up almost half of the catch. These are all species that are known to be sensitive to hydrological triggers.[4]

Elsewhere in the basin the size and composition of the catch also correlates closely to the seasonal hydrograph. For example, the largest catch at the *dai trey linh* fishery on the Tonle Touch (a distributary of the Mekong in southeastern Cambodia) is taken on or just before the maximum flood with a series of smaller peaks occurring at intervals later on during the flood recession.[5]

This is in contrast to the Khone Fall fishery where the peak catch is taken when the flow is at or close to the dry season minimum, and shows that the correlation between flow and abundance varies depending on the geographic location, the hydrological setting, and the stage individual fish have reached in their life cycle. At Khone Falls fish migrating upstream arrive at a time when the volume of water over the falls is at its lowest and passage across this difficult natural barrier is presumably at its easiest. On the other hand the large numbers of fish caught moving downstream in the Tonle Touch comprise either adult fish migrating back into the river after spawning (early season) or juvenile fishes migrating off feeding grounds on inundated floodplains (later in the season).

## CONSEQUENCES OF FLOW MODIFICATIONS ON MEKONG FISH AND FISHERIES

The most significant modifications to the flow regime of the Mekong will most likely result from the impoundment of water behind dams during the wet season and its release for generating hydropower and/or agricultural irrigation during the dry season. The major overall impacts are: (i) increased dry season flow, (ii) reduced flood season flow, and (iii) modifications to the timing of the onset of the seasons[6].

### Increased dry season flow

The biological implications of increased dry season flow could be that migration thresholds relating to current and water level are not reached, thereby disrupting the life cycle of fish that are known to be sensitive to these factors. Damage to the fisheries that target fish migrating at these times could result from reduced numbers of fish undergoing migration and the unsuitability of fishing gears that were designed to operate at low discharge levels.

### Reduced flood season flow

The major implications of reduced flood season flows come about from a reduction in the area inundated during the flood. Changes of this type would diminish the size of important feeding grounds and thereby reduce fish productivity. Another possible consequence of reduced flood season flow could be the retardation, or even the elimination, of the type of 'reverse flow' that contributes to the inundation of the floodplains around the Great Lake/Tonle Sap and other

wetlands. While changes of this magnitude are unlikely to occur, any alteration of the 'flow reversals', in scale or timing, will have unpredictable impacts on the migration of those species that have adapted their life histories to accommodate this rare hydrological setting.

**Modifications to the timing of the onset of the seasons**

Statistical analysis of historical hydrological data reveals that the onset of the flood is one of the most tightly constrained features of the annual cycle[6]. Each year it occurs within a narrow time window of about two weeks, and it is seemingly less variable than either the flood volume or the height of the peak flood. Given that the onset of the flood is so predictable it seems likely that the life cycles of migratory fish have evolved in tune with the timing of this event. Storage dams, which are 'recharged' at the beginning of the wet season will retard the onset of the flood significantly (by a matter of days or weeks). This in turn may disrupt the fishes' 'highly tuned' migration behaviour and shorten the length of the feeding/growing season (the end of the wet season remains unchanged) thereby reducing productivity—particularly if the delay in the onset is accompanied by a reduction in the area of flooding.

Many of the impacts described above relate to the basin-wide changes resulting from one or more development activities. This analysis does not however include localised impacts on fish and fisheries that can result from poorly conceived and badly implemented projects. These impacts may occur at some distance up- or downstream of the site.

## RECOMMENDATIONS

1. Discharge appears to correlate closely with times of great fish abundance (although whether this is an actual migration trigger is unclear). Data from fisheries where information on the daily catch is recorded reliably (such as Khone Falls, the Tonle Touch, and the Tonle Sap) should be analysed in conjunction with daily discharge to shed more light on the nature of this correlation. This type of detailed temporal analysis may well help clarify the role and importance of other environmental factors such as the lunar cycle.

2. Migration triggers and fish abundances that correlate with the annual hydrograph should be taken into account in the assessment of the impact of development activities.

3. The review of literature on migrations reveals a number of important gaps in our knowledge of migration triggers and processes. These gaps include:

- Knowledge on the migratory behaviour of 75% of the Mekong fish species—albeit that the behaviour of the commercially important fish is better understood;
- An understanding of the biochemical and physiological processes that trigger migration and other import stages in the life cycle of fish, including spawning;
- Information on other possible environmental triggers (water chemistry, sediment load, etc.), particularly those that fishers do not, or cannot, observe.
- Information on the timing of migration and on migration routes, particularly at specific localities with different physical geography and river settings.

These gaps in our knowledge of fish biology should be the topics of future research.





## END NOTES

1. Poulsen, A. F. *et al.*, (2002) Fish migrations in the Lower Mekong Basin: implications for development, planning and environmental management. *MRC Technical Paper No. 8*. Mekong River Commission, Phnom Penh.

2. Baran, E. (2006) Fish migration triggers in the Lower Mekong Basin and other tropical freshwater systems. *MRC Technical Paper No. 14*. Mekong River Commission, Vientiane.

3. The Mekong Fisheries Database (MFD) provides detailed ecological information, while FishBase provides a number of life history parameters such as age at first maturity, diet, and the estimated life span, for each species.

4. Top-ten most abundant species in the Khone Falls catch and their sensitivity to discharge rates.

| | | Discharge ranges (thousand cumecs) and corresponding % of the catch of individual species | | | | |
|---|---|---|---|---|---|---|
| Species or taxon | % of the overall catch | 1-5 | 6-10 | 11-15 | 16-20 | > 21 |
| *Henicorhynchus* spp. | 20.0 | 94 | 5 | 1 | 0 | 0 |
| *Pangasius krempfi* | 14.4 | 76 | 23 | 1 | 1 | 0 |
| *Pangasius conchophilus* | 11.8 | 70 | 29 | 1 | 0 | 0 |
| *Paralaubuca typus* | 11.7 | 100 | 0 | 0 | 0 | 0 |
| *Pangasius macronema* | 8.1 | 100 | 0 | 0 | 0 | 0 |
| *Probarbus jullieni* | 4.5 | 93 | 7 | 0 | 0 | 0 |
| *Cosmochilus harmandi* | 4.5 | 83 | 15 | 2 | 1 | 0 |
| *Scaphognathops bandanensis* | 3.5 | 99 | 1 | 0 | 0 | 0 |
| *Labiobarbus leptocheilus* | 1.8 | 95 | 4 | 1 | 0 | 0 |
| *Botia modesta* | 1.5 | 100 | 0 | 0 | 0 | 0 |

5. Ngor, P. *et al.* (2005) The *Dai Trey Linh* fishery on the Tonle Touch (Touch River), southeastern Cambodia. In: *Proceedings of the 6th Annual Technical Symposium on Mekong Fisheries*. T.J. Burnhill and M.M. Hewitt, eds. *MRC Conference Series No. 5.* Mekong River Commission, Vientiane. pp 57-76.

6. A detailed analysis of historical hydrological data going back nearly 80 years can be found in the MRC publication *Annual Mekong Flood Report 2006*. This report also contains hydrologically based definitions of the onset of the seasons. The onset of the flood season is defined at the time when the flow at a given locality exceeds the mean annual discharge at that location.

Other publications available in this series:

Mekong Fisheries Management Recommendation Nº 1: The status of Mekong *Pangasianodon hypophthalmus* resources, with special reference to the stock shared between Cambodia and Viet Nam

Mekong Fisheries Management Recommendation Nº 2: Mekong giant fish species: on their management and biology

Mekong Fisheries Management Recommendation Nº 3: Deep pools as dry season habitats in the Mekong Basin

Mekong Fisheries Management Recommendation Nº 4: Gender and fisheries in the Lower Mekong Basin

Mekong Fisheries Management Recommendation Nº 5: Livelihoods approaches and fisheries management in the Lower Mekong Basin

*Printed by the MRC Secretariat to promote and support the TAB – June 2007*
*Series editor Dr Tim Burnhill*
Mekong River Commission
P.O. Box 6101, 184 Fa Ngoum Road, Unit 18, Ban Sithane Neua
Sikhottabong District, Vientiane 01000 Lao PDR
Telephone: (856) 21 263 263 Facsimile: (856) 21 263 264
E-mail mrcs@mrcmekong.org Website www.mrcmekong.org