



Fish passage principles to be considered for medium and large dams: The case study of a fish passage concept for a hydroelectric power project on the Mekong mainstem in Laos

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ABSTRACT

Fish passage systems may provide a means to mitigate the barrier effect of dams on migrating fish species. Even though design criteria were initially developed for the fish fauna of temperate regions, they are widely used in tropical rivers with relative success. A fish passage concept has been developed for a hydroelectric power project on the Mekong River in the absence of suitable fish passage design criteria. There are several hydropower dams proposed for development on the mainstem of the Mekong River in Cambodia, Laos, Thailand and China and the impact of hydropower on fisheries is fast becoming a big issue. Located in Laos territory, the present project is one of the promising run-of-river hydropower projects identified by the Mekong Secretariat in 1994. The feasibility study began in 2007 and the outline (basic) design is being completed in 2010. The scheme includes a comprehensive fish passage system, which provides facilities for upstream and downstream passage. The proposed fish passage concept is based on twelve principles and gives emphasis on an adaptive project management, which includes planning, implementation and operation of the fish passage system and other structures of the project. It will cater to the large number of species and high biomass and especially to the variable flow regime and the lack of biological knowledge on the behavior of migrating species.

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1. Introduction

One of the major effects of dam construction on river fish communities is the decline and possible disappearance of migrating species (Jackson and Marmulla, 2001; WCD, 2000). Dams can block or delay fish migration and thus contribute to the decline and even the extinction of species that depend on longitudinal movements along the stream continuum during certain phases of their life cycle.

Fish passage systems may provide a means to mitigate the barrier effect of dams on migrating species. They have a long history, with the earliest ones recorded almost 300 years ago in Europe (Clay, 1995). The development of their design criteria is empirical and based on experience. The ability to provide the mitigation measures seen in North America and Europe has been dependent on substantive research and development over several decades and descriptions of the design and functioning of various types of fish passage facilities have been provided by many authors (e.g. Bell,

1990; Clay, 1995; FAO and DVWK, 2002; Katopodis, 2005; Larinier et al., 2002; Orsborn, 1987).

Even though design criteria were initially developed for the fish fauna of temperate regions, they are widely used in tropical rivers with relative success (Agostinho et al., 2002; Clay, 1995; Godinho and Kynard, 2009; Quirós, 1989; Thorncraft and Harris, 2000). The performance of fish passage facilities for medium and large dams in tropical rivers has never been evaluated systematically. However, the violation of fundamental fish passage principles is regarded as one of the driving factor for poor performance (Agostinho et al., 2007; Amornsakchai et al., 2000; Godinho et al., 1991; Godinho and Kynard, 2009; Larinier, 2002; Makrakis et al., 2007; Roberts, 2001).

The Mekong River Commission (MRC), acting as the international and country-driven river basin organization of the Lower Mekong Basin, has recognized the possible barrier effect of mainstem dams on migrating fish as one of the most important questions facing the development of the Mekong River (MRC, 2010). The Lower Mekong Basin is a tropical, highly diverse and complex ecosystem, which involves an unusually large number of fish species. The fish biodiversity of the Mekong River system is second only to that of the Amazon and informed estimates suggest

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there may be up to 1200 species in total (Hortle, 2009; Rainboth, 1996). People throughout the basin depend, directly or indirectly, upon the migrating fish for food and livelihood (Baran et al., 2008).

The Mekong River is not only from an economical, social, and ecological point of view an indispensable biological resource. It also represents a large potential source of energy (MRC, 2010). There are several hydropower dams proposed for development on the mainstem of the Mekong River in Cambodia, Laos, Thailand and China and the impact of hydropower on fisheries is fast becoming a big issue (Dugan, 2008). Supporting sustainable hydropower development, the Mekong River Commission's water resources policy and strategy is underpinned by two main elements, the 1995 Mekong Agreement and the 2006–2010 Strategic Plan. These form the basis on which MRC Programs work together in an integrated structure under the Basin Development Plan (King et al., 2007). However, comprehensive fish passage design criteria have been barely addressed so far (MRC, 2009), even though the development of the mainstem projects is fast advancing.

The present fish passage concept is based on twelve principles and has been developed because of the absence of comprehensive fish passage design criteria for mainstem dams. The concept has been an integral part of the feasibility study and the tender (basic) design of the present mainstem project and was not meant to be published separately. However, in the course of time we felt that the concept may contribute to the understanding and development of fish passage design in the Mekong Region. In our view, research on fish passage design and in particular on the biology of fish is an ongoing and probably a never ending challenge and has to be handled within an adaptive framework. Therefore, the present fish passage concept gives emphasis on an adaptive project management, which includes planning, implementation and operation of the fish passage system and other structures of the project. It will cater for the large number of species and high biomass and especially to the variable flow regime and the lack of biological knowledge on the behavior of migrating species.

2. Fish passage concept

Located in Laos territory, the present project is one of the promising run-of-river hydropower projects identified by the MRC Secretariat's predecessor, the *Mekong Secretariat* (1994). The feasibility study began in 2007 and the outline (basic) design is being completed in 2010. The scheme includes a comprehensive fish passage system, which provides facilities for upstream and downstream passage.

There are at least three possible scenarios to be distinguished from a single fish passage perspective, if a river is developed with dams for navigation, irrigation, hydropower or other purposes and fish passage criteria do not yet exist.

- *Scenario one*: before any development of the river stretch takes place, research will reveal the feasibility and will outline the design criteria of the fish passage.
- *Scenario two*: a “pro-forma” structure for fish passage is implemented, satisfying the legal requirements, but which in reality will prove useless.
- *Scenario three*: the implementation of a fish passage system based on a presumably conservative concept, which gives emphasis to an adaptive project management including planning, implementation and operation of the fish passage system and other structures of the project.

Scenario one theoretically may be applicable for small, medium and large dams. In the case of medium and large dams, research

efforts may not result in effective design criteria, since the complexity and dimensions of the structures exceed the ability for prototype testing and the so-called design criteria might lead to a false sense of security. For small dams, however, research activities including prototype testing may provide sufficient results in a relatively short period of time in order to establish consistent design criteria. Scenario two was often applied in the past, especially when responsibilities and duties among stakeholders were not clearly established. The third scenario, which is the subject of the following paragraphs, is probably the only applicable approach for medium and large dams, allowing the implementation of the project in a reasonable time frame. It takes into account fish passage engineering concerns and the time and efforts needed to collect and elaborate the data required to establish appropriate design and operation criteria.

To fully understand the application of the above third scenario to the present hydropower project, it is important to take into account that:

- The implementation of any hydropower project on the Mekong mainstem requires the approval of the Mekong River Commission and of the countries of the Lower Mekong Basin: such approval is conditional, among other requirements, on including in the scheme adequate fish passage facilities.
- The implementation of the present project is being advanced by a private developer; the financial feasibility of the project depends on energy production only, while including in the project fish passage and other (river navigation) facilities represents an additional cost, for which no additional revenues can be anticipated.
- Once the feasibility studies confirm the attractiveness of the project, the interest of the developer is to proceed to the project implementation as soon as possible. Therefore, the investigations and studies required firming up design and operation criteria for the fish passage facilities should not indefinitely delay the starting of the construction.

We suggest that the following twelve principles are to be applied to every dam development project from the very beginning, whenever guidelines on fisheries and especially fish passage design criteria are not available (Fig. 1).

2.1. Principle 1: Increase the knowledge on fish

If comprehensive fish passage design criteria are not yet established for the river stretch to be developed, one of the first tasks in fish passage design will be to increase the knowledge on the biology and the ecology of the concerned fish species. On a basin level information already exists on the fish fauna and on existing natural or artificial fish passages. On a project level, however, this process may become more complicated, whenever fisheries knowledge of a river stretch is available only through personal communication with local people or a specialist. However, in both cases the quality of the information may vary greatly and the accessibility may sometimes be difficult, if not impossible. These activities of knowledge acquisition will provide for first time information on fish migration timing, fish swimming performance, species composition and abundance. In addition to gathering such information, it is of particular importance to verify the information for the subsequent selection process of suitable fish passage devices.

2.2. Principle 2: Get to know the project

The fish passage facilities do not only represent an integral part of the overall project, but also their planning, implementation and operation will have significant implications on the different com-

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