Darwin Initiative for the Survival of Species

Final Report

Development of a conservation strategy for the critically endangered Mekong giant catfish

(Photo: Zeb Hogan)

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1 Darwin Project Information

Project title	*Development of a conservation strategy for the critically endangered Mekong giant catfish* Pangasianodon gigas
Countries	*UK, Cambodia, Laos, Thailand, Vietnam*
Contractor	*Imperial College London*
Project Reference No.	*14/053*
Grant Value	*£ 86,752*
Start/Finishing dates	*01/0405-31/03/07*

2 Project Background

Many species of freshwater fish are acutely threatened by overfishing and loss of habitat or habitat connectivity. Large and long-lived riverine species, which often migrate over long distances to complete their life cycle are particularly at risk. The Mekong giant catfish (*Pangasianodon gigas*) provides a striking case in point. Having historically supported a significant fishery, the wild population is now believed to number at best a few hundred individuals. The species has been listed as critically endangered in the 2003 IUCN Red List. Its precarious status is likely to be the result of excessive targeted and incidental harvesting over the past twenty years, and to a lesser extent habitat degradation.

A charismatic animal revered throughout the lower Mekong, the giant catfish has become the flagship species for aquatic biodiversity conservation in the Mekong river system. Given the critical state of the population, conservation and eventual recovery will require a combination of captive breeding, reduction in harvest, and conservation/restoration of critical habitat. A captive breeding programme has been instituted by the Thai Department of Fisheries, which in 2003 released 7200 juveniles into the Mekong. A buy and release scheme operated by the Mekong Fish Conservation Projects (an NGO) buys a significant share of the small number of adult catfish still caught in fisheries and releases these after tagging and tissue sampling for genetic analysis. However, significant incidental harvest of juveniles continues to be a problem. Information on giant catfish biology, habitat use and migrations has been assembled on a basin wide scale by the Mekong River Commission Fisheries Programme, and is being used to identify critical habitats. Despite of these promising initiatives, there is currently no overall conservation and recovery strategy for the giant catfish, and the effectiveness of measures taken so far is largely unknown. The Darwin project aimed to develop an integrated conservation strategy in collaboration with key regional stakeholders. The need for the development of an integrated conservation strategy follows immediately from the listing of the Mekong giant catfish as critically endangered in the IUCN 2003 Red List.

3 Project Summary

3.1 Purpose and outputs

Purpose

Effective conservation strategy for the Mekong giant catfish developed and promoted

Outputs

1. Conservation status of giant catfish assessed quantitatively
2. Scope for supportive breeding, habitat and harvest management evaluated quantitatively
3. Opportunities to improve captive breeding practices and release strategies assessed
4. Adaptive management policies developed
5. Overall strategy for conservation developed and promoted

The project LogFrame is appended to this report. This has remained materially the same, but there has been a change in emphasis with a greater focus on genetic management of the captive population, and a much reduced focus on the development of adaptive management policies for the fishery. This is a result of the strategy process, where it became evident that the threat from overfishing has largely subsided and is unlikely to re-emerge in a significant way. On the other hand, the major emerging threat of habitat degradation is difficult to quantify. Detailed adaptive management evaluations were therefore deemed less important than originally envisaged, while maintenance of the captive population as 'insurance' against large uncertainty with regards to habitat degradation was seen as more important.

3.2 Relation to articles of the Convention on Biological Diversity

The project relates directly to the following articles of the CBD:

- Article 7 (Identification and monitoring): The project synthesized, organized and analysed data on the status of the Mekong giant catfish, and processes and activities which have adverse effects on the population.
- Article 8 (In-situ conservation): The project was concerned with the regulation of fishing and the restoration of an endangered species.
- Article 9 (Ex-situ conservation): The project included the development of a breeding plan for the captive population of Mekong giant catfish, based on molecular genetic analyses.
- Article 10 (Sustainable use): The project assessed the sustainability of customary fishing for the Mekong giant catfish.
- Article 12 (Research and training): The project has promoted research on in-situ and ex-situ conservation of the giant catfish in the Mekong region.

- Article 17 (Information exchange): The project has strongly facilitated the exchange and synthesis of information on Mekong giant catfish conservation among countries in the lower Mekong region.

3.3 Success in achieving objectives

Project has been highly successful in achieving its objectives. Key achievements include:

- A science-based, integrated conservation strategy for the Mekong giant catfish developed with inputs from, and the support of all major stakeholders in the region.
- A first quantitative assessment of the status of the Mekong giant catfish population, reasons for its recent decline, and likely effectiveness of conservation measures.
- A genetic resource management plan for the captive population of Mekong giant catfish, based on molecular genetic analyses.
- Exchange and synthesis of information on the Mekong giant catfish at the regional level.
- Uptake of key elements of the conservation strategy by a major stakeholder, the Thai Department of Fisheries.
- Fundamental contributions to the understanding of regulatory processes in fish populations, and the use of hatchery fish in fisheries conservation and restoration.

Full details of project achievements are given in Section 4 below.

4 Scientific, training and technical assessment

4.1 Staff and key collaborators

4.1.1 Staff (partially Darwin funded)

Imperial College London

Dr Kai Lorenzen (Principal Investigator)

Royal Thai Department of Fisheries

Dr Naruepon Sukumasavin (Project coordinator, MGCWG Chair)

Dr Wongpathom Kamonrat (Geneticist)

Network of Aquaculture Centers in Asia-Pacific (NACA)

Dr Thuy Nguyen (Geneticist)

Kasetsart University

Professor Uthairat Na-Nakorn (Coordinator of genetics study)

Ms Srijanya Sukmanomon (Postgraduate)

Ms Kednapat Sriphairoj (Postgraduate)

4.1.2 Key collaborators (not Darwin funded)

Cambodian Department of Fisheries

Mr Em Samy

Mr Lieng Sopha

Mr Srun Lim Son

Lao Department of Livestock and Fisheries

Mr Sompanh Phanousith

Mr Kampeth Roger

Research Institute for Aquaculture No.2, Vietnam

Dr Nguyen Van Trong

Mekong Wetlands Biodiversity Program (MWBP)

Dr Zeb Hogan (Mekong giant catfish species coordinator)

Mr Alvin Lopez (Wetland ecologist)

Mekong River Commission Fisheries Program

Dr Niklas Mattson

Dr Suchart Inghamjitr

WWF Indochina

Dr Roger Mollot

Dr Chavalith Vidthayanon

4.2 Project activities

The project comprised range of separate but closely integrated studies:

- Development of a shared conservation strategy process
- Collation and evaluation of existing information
- Quantitative assessment of conservation status and management options
- Assessment of supportive breeding as a recovery tool
- Genetic resource management plan for the captive population
- Definition of a conservation strategy
- Implementation of key conservation actions

Details of the studies are given in the following sections.

4.2.1 Conservation strategy process

A diverse group of stakeholders are involved in Mekong giant catfish conservation including the government fisheries departments of Cambodia, Laos, Thailand and Vietnam, the Mekong River Commission Fisheries Program, universities, and conservation NGOs including WWF and IUCN. The project aimed to bring the different stakeholders into a joint conservation strategy process. All key stakeholders were invited to the project inception workshop, and agreed to institute a new, semi-formal working group to develop a conservation strategy: the Mekong Giant Catfish Working Group (MGCWG).

Figure 1. Participants of the project inception workshop, Bankok, September 2005. From left to right: Rob Shore (WWF), Devin Bartley (FAO), Bunchong Chumnongsittathum (TDOF), Chavalit Vidthaianon (WWF), Chumnarn Pongsri (TDOF), Niklas Mattson (MRC), Em Samy (CDOF), Nguyen Van Trong (RIA-2), Simon Wilkinson (NACA), Thuy Nguyen (NACA), Zeb Hogan (MWBP), Sompanh Phanousith (LDLF), Wongpathom Kamonrat (TDOF), Mike Phillips (NACA), Pedro Bueno (NACA), Alvin Lopez (MWBP), Uthairat Na Nakorn (KU), Kai Lorenzen (ICL).

The MGCWG outlined a medium-term process to develop an overarching conservation strategy. At the core of the process was a series of joint workshops, interspersed with specific research, policy and outreach activities by contributing organisations. It was felt that building a conservation strategy process around the informal and voluntary cooperation of existing organisations and projects would offer the best scope for developing an integrated, overarching strategy. This approach circumvented political and administrative issues between partners that had become evident early on in project. By establishing a multi-stakeholder consultative process not 'lead' by any organisation in particular, it is hoped that many organisations will be able to 'buy into' the joint strategy.

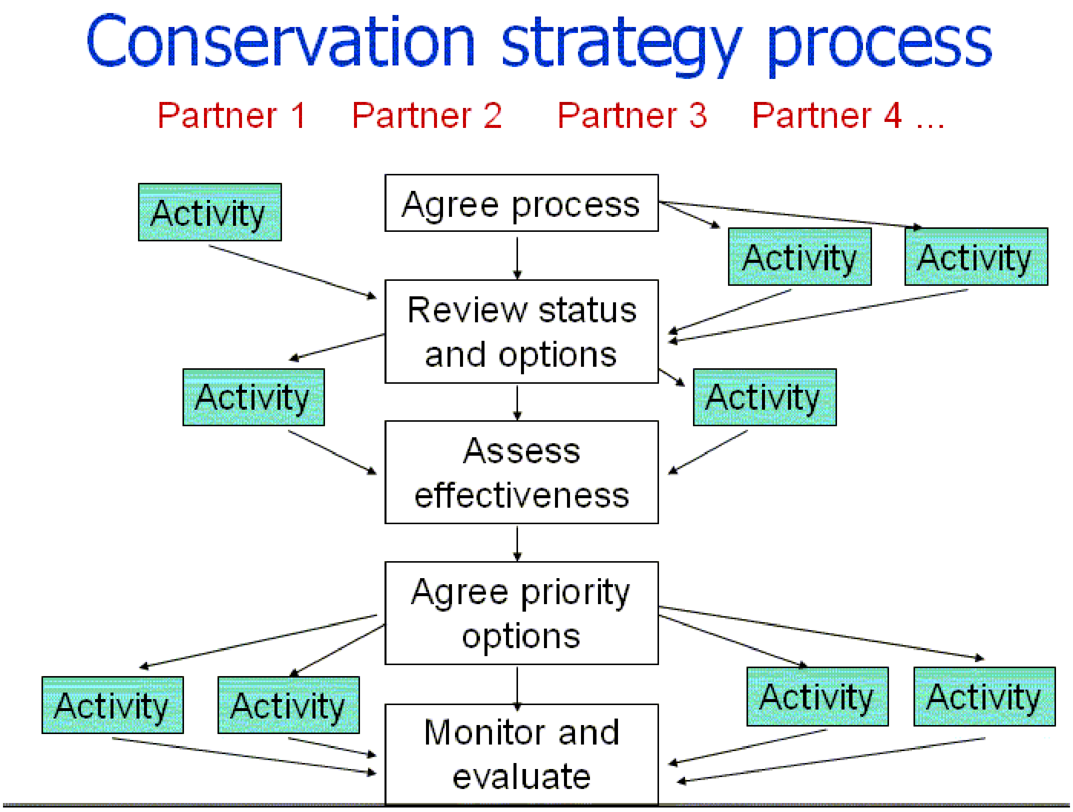

Figure 2: Outline sketch of the conservation strategy process: a core, workshop based process was supported by a wide range of activities undertaken by individual partners.

The Darwin project team provided leadership to the process and organized the majority of workshops, as well as undertaking key scientific studies on quantitative assessment of the wild population and genetic management of the captive stock. A total of 5 major workshops were held as part of the strategy process (Table 1).

<u>Further background information on the strategy process is given in:</u>

MGCWG (2005) Development of a conservation strategy for the critically endangered Mekong giant catfish: Inception workshop report. Mekong Giant Catfish Working Group, NACA, Bangkok. 31 pp. (**Annex A**).

Table 1: Major workshops held as part of the conservation strategy process.

Workshop	Purpose
Project inception workshop, Bangkok, Thailand, 23-24 August 2005	Preliminary synthesis of information, design of a conservation strategy process, formation of the MGCWG
Conservation action plan workshop, Phnom Penh, Cambodia, 12-13 December 2005	In-depth synthesis and review of information, prioritisation of conservation activities in an action plan (pending completion of the longer term strategy)
Quantitative assessment workshop, Vientiane, Laos, 10-11 August 2006	Quantitative assessment of population status and conservation/recovery measures
Captive population management and genetics workshop, Bangkok, Thailand, 22 March 2007	Review of captive stock management procedures, discussion of results from the genetic study, definition of a breeding plan
Conservation strategy workshop, Bangkok, Thailand, 23-24 March 2007	Drafting of the conservation strategy

4.2.2 Collation and evaluation of existing information

Data on fishing activities and catches of Giant catfish were assembled from historical sources and fisheries department records. The latter allowed a very detailed reconstruction of catch history since 1970 and thus provided crucial inputs for the quantitative assessment. Information from historical sources was supplemented with interviews at historically important fishing locations to cross-check information on catch levels and establish possible reasons for catch declines. Information on environmental change in the Mekong region was likewise assembled from historical sources and the scientific literature in more recent changes.

Figure 3: Harvesting Mekong giant catfish in Nong Khai, Thailand, around 1930. Information from historical sources allowed reconstruction of long-term catch patterns.

4.2.3 Quantitative assessment of conservation status and management options

The general approach to population assessment has been to confront a mathematical population model with the available data on MGC fisheries. A length-structured matrix population model was developed as the main assessment tool for this study. The recruited population is divided into length groups, and the model projects population and catch numbers at length over time. The mathematical model represents current understanding of the MGC population dynamics, and of the observation processes that underlie the available data. Some model parameters were estimated from comparative information, while others were estimated from sub-sets of giant catfish data or by confronting model predictions with long-term time series.

4.2.4 Assessment of releases of captive bred fish

The impacts of releasing captive bred fish on the abundance of the wild population and on fisheries catches was assessed using a population model for enhancement fisheries. Indicative data on survival and growth of captive bred fish released into the wild were obtained from studies on giant catfish released into reservoirs in Thailand.

4.2.5 Genetic assessment and breeding strategy for the captive population

Approximately 20,000 individuals of Mekong giant catfish (mostly juveniles) are maintained in captivity in Thailand. The captive population is a key resource for species conservation, but it needs to be managed carefully to avoid loss of genetic diversity and minimize domestication selection. The project therefore aimed to characterise the genetic resources of captive populations of MGC using molecular genetic markers, including sequences of the mitochondrial D-loop gene region, and microsatellite loci. The resulting information was used to develop a management plan for captive populations of MGC in Thailand, aiming to maximise genetic diversity and minimise inbreeding.

Figure 4: Tissue sampling from captive Mekong giant catfish broodstock maintained in a Thai Department of Fisheries Station.

4.2.6 Formulation of the conservation strategy

The conservation strategy was drafted by the project team based on MGCWG proceedings and results of the studies outlined above. It was reviewed and modified in the conservation strategy workshop.

4.2.7 Implementation of conservation measures

The conservation strategy sets out key measures for giant catfish conservation and long-term monitoring, but it is not a binding document. Uptake and implementation of key recommendations has however been promoted by MGCWG members within their own institutions, and this has led to implementation of several key measures.

4.2.8 Fundamental contributions to fish population dynamics and the use of cultured fish in population restoration

The project included two generic (i.e., not specifically giant catfish focused) studies to resolve key issues underpinning the work on giant catfish conservation. These concerned (1) the importance of different regulatory mechanisms in fish population dynamics, and (2) the process of domestication and its implications for the management of interactions between wild and captive fish.

4.3 Results

4.3.1 Historical synthesis of fisheries and environmental change data

Historically, targeted giant catfish fishing has always been a special event with spiritual associations. Exploitation seems to have been characterized by 'boom and bust' cycles. 'High' local catches of about 50 individuals followed by declines in catches and catch per unit of effort have been reported for various locations. It is unlikely, however, that catches of fish have ever been sustained.

Complete and detailed catch data are available for the fishery around Chiang Khong since 1983, with some data for Lao side reaching back to 1973. Data for other fisheries are sketchier, or cover only short time series. It was therefore necessary to reconstruct the pattern of total catches by history of decided to reconstruct total catch figures conduct a 'best

In the 1970s, catches appear to have been stable at an average of about 20-30 fish per year. Catches increased substantially, up to a maximum of 90 per year in the late 1980s, driven mainly by the high profile government-supported fishery in Chiang Khong (Northern Thailand). Catches declined again in the 1990s, dropping below 1970s 'pre-Chiang Khong fishery expansion' levels in 2000.

Environmental change in the Mekong basin has been gradual and of moderate magnitude until the very recent past. Land use has gradually become more agricultural. Hydrology has shown no marked changes since the start of systematic recording in 1960, contrary to widespread perceptions that dams have caused significant flow changes. Dams have caused loss of access to only a moderate proportion (max. 25%) of the basin. More dramatic changes may have occurred in the very recent past with 'rapid blasting' and the commissioning of several dams in the upper river, but any effects of these changes on the giant catfish population would not yet be visible in the data. It thus appears that fishing can be identified as the main driver of past changes in population abundance and structure.

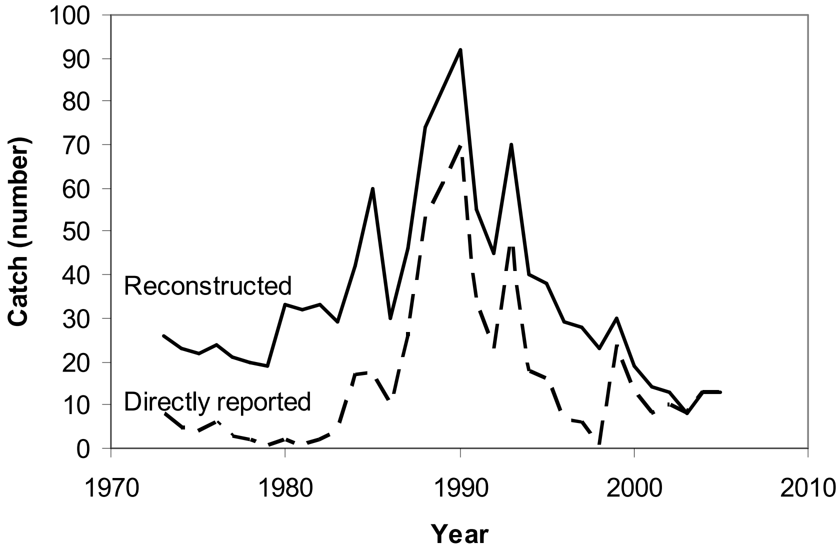

Figure 5 Directly reported catches and reconstructed catch history. The reconstructed history takes into account reported 'average' catches for locations and periods where no direct records exist.

4.3.2 Quantitative assessment of conservation status and management options

Population status

There is only moderate uncertainty about the pattern of population abundance over the past 30 years because intensive fishing in Northern Thailand and Laos has led to a strong reduction in catch per unit of effort, an index of relative abundance. Because both, the catches and the impact of those catches on relative population abundance are well documented, it is possible to estimate absolute population abundance with a high degree of confidence. However, because population changes were driven mostly by fishing rather than biological processes such as recruitment, the data provide only limited information on the latter. Therefore, although we know the current population status quite well, there is uncertainty about long-term population trends, unexploited population abundance, and maximum sustainable catches. The key biological parameters that account for much of this uncertainty are the natural mortality rate of mature fish, and the level of recruitment compensation. Comparative information suggests that the natural mortality rate of mature MGC may be about 0.06 to 0.12 per year. Juvenile survival in fish populations is subject to compensatory density-dependence, i.e. the lower the number of eggs produced by the spawning stock, the higher their survival to recruitment will be. The increase in juvenile survival with decreasing egg production can be quantified by the compensation ratio K, the ratio of juvenile survival at very low spawner population size (and thus, egg production) to juvenile survival at unexploited spawner population size (carrying capacity). On average in fish populations, K=5, but values can range from very low compensation (K=2) to very high (K=100). The higher the recruitment compensation ratio, the less recruitment declines when spawner population abundance is reduced and the more resilient the population is to harvesting or disturbances. To account for uncertainties, population analyses were conducted for mortality rates of mature fish Mr=0.06 and 0.12 per year; and compensation ratios of K=2, 5 and 100.

All analyses predicted a spawner abundance of about 250 fish at the start of the Chiang Khong fishing boom (Fig. 6). Estimates of unexploited spawner abundance varied from 355 to 2200 fish, depending on the assumed natural mortality and recruitment compensation values. Hence the abundance at the start of the Chiang Khong fishing boom represents between 11% and 71% of the unexploited abundance. The population then declines dramatically to just 50 spawners in 1995 (2-14% of unexploited abundance). The Chiang Khong fishing 'boom' thus reduced spawner abundance by about 80% in just ten years. However, the model predicts that the population has since recovered significantly. The predicted current (2006) level of spawner abundance is estimated at 145 animals (7-40% of unexploited abundance).

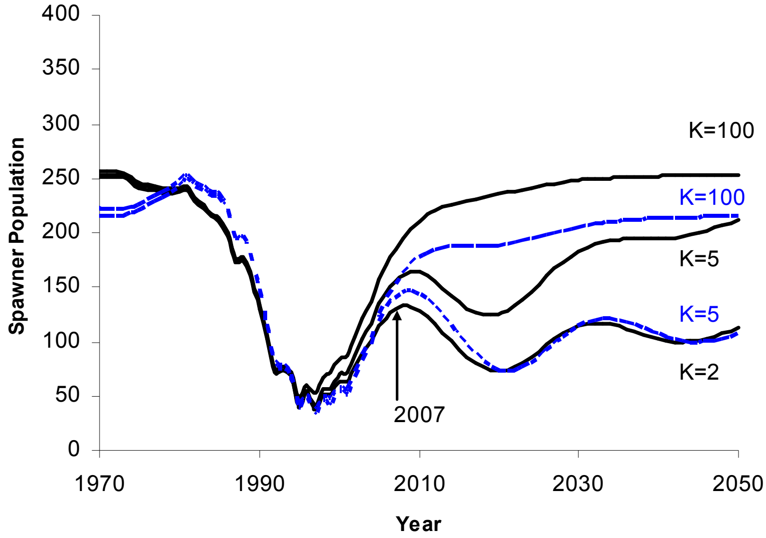

Figure 6. Spawner population abundance reconstructed by the population model. The figure shows predicted recovery trajectories for different levels of natural mortality and of density-dependence in recruitment. All three scenarios are equally consistent with fisheries data, but based on comparative data past data a recruitment compensation ratio of K=5 is most likely to be correct than K=2 or K=100.

The model-based population reconstruction also provides us with direct estimates of fishing mortality rates. The fishing mortality pattern (Fig. 4) clearly shows a dramatic increase in fishing pressure on the mature population between 1983 and the early 1990s. Fishing mortality rates then declined and returned to pre-1983 levels by 2004. Instantaneous fishing mortality rates F can be translated into proportional harvest rates H, i.e. the proportion of the available population harvested in the fishery. The fishery pre-1983 and post-2004 removed about 10% of the population per year. During 1990-2000, over 50% of the available population was harvested annually, with a maximum of 96% in 1995.

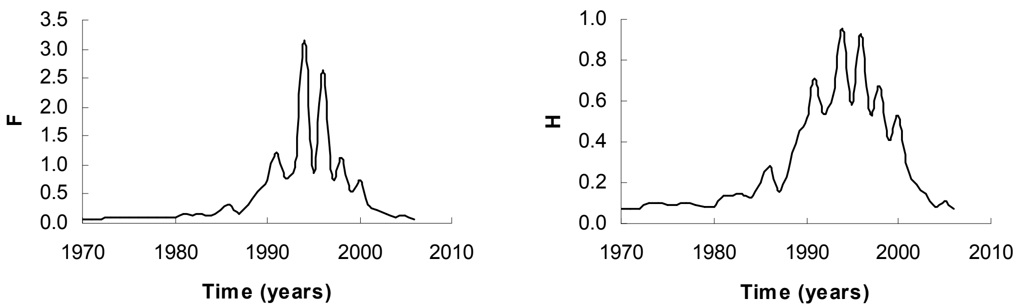

Figure 7. Reconstructed fishing mortality F (left) and the corresponding proportion of the available population harvested H (right) for the period 1970 to 2006.

Predicted development of population abundance to 2050 under different management and environmental scenarios

Future development of the population will depend on the level of fishing and on continued, successful reproduction (which could be affected by loss of spawning or nursery habitat, or Allee effects related to the very low spawner abundance in the 1990s). Possible population trajectories are shown in Figure 8, for different scenarios and levels of recruitment compensation:

- If fishing continues at a moderate, 'traditional' level and reproduction is not compromised, the population is most likely to fluctuate around the current abundance for the next 20 years but increase slowly thereafter. If the degree of density-dependence in recruitment is very high, the population may recover to its historical abundance more quickly.
- If fishing ceases completely and reproduction is not compromised, then the population will recover more quickly and to a higher level of abundance, but a significant increase is unlikely to be noticeable before 2030.
- If reproduction had failed (e.g due to habitat degradation or Allee effects) since 1990, the population would decline below the level expected for moderate fishing without reproductive failure by about 2020.

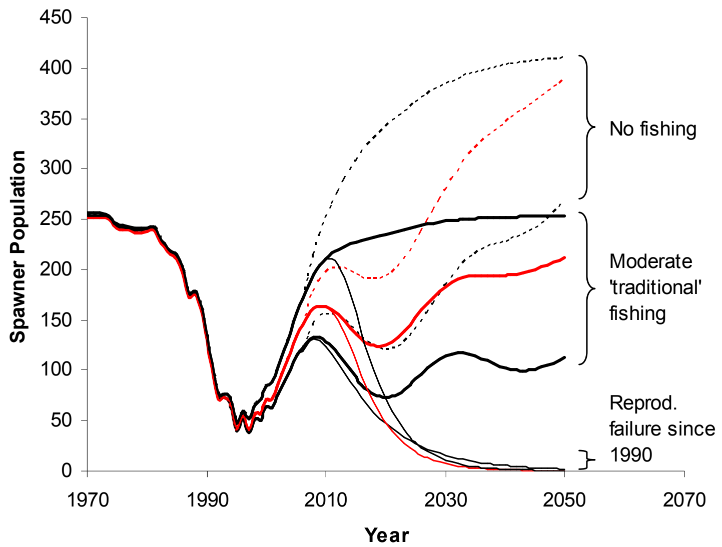

Figure 8. Predicted spawner population abundance given predicted by the population model assuming normal recruitment, or complete reproductive failure since 1995.

Full details are given in:

Lorenzen, K., Sukumasavin, N. & Hogan, Z. (2006) Development of a conservation strategy for the critically endangered Mekong giant catfish: Quantitative assessment report. Mekong Giant Catfish Working Group, NACA, Bangkok. 35 pp. (**Annex C).**

4.3.3 Assessment of releases of captive bred fish

Captive-bred and cultured fish were assumed to show the same growth and mortality patterns as wild fish, and to be reproductively competent. Most deliberate releases of captive-bred giant catfish have been of small fish of about 10-20cm length. Such fish undergo relatively high and most likely, density-dependent mortality before recruiting to the spawned population. Releases of a few hundred or thousand 20cm fish per year are predicted to have little impact on total yield, and depress wild population biomass only moderately (Figure 9). Small, e.g. ceremonial releases of small captive-bred MGC can be conducted without posing a major threat to the wild population.

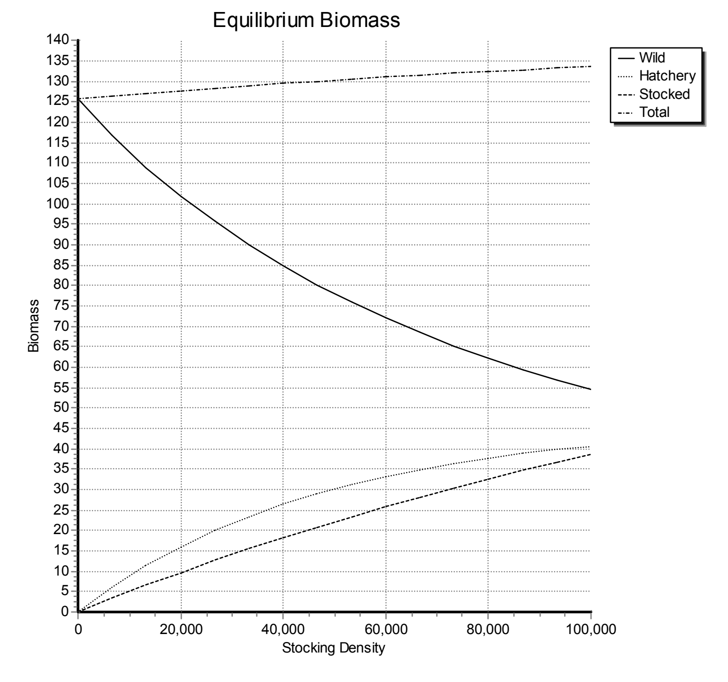

Figure 9. Impact of releasing juveniles of 20 cm length on biomass of giant catfish population components.

<u>Full details are given in:</u>

Lorenzen, K., Sukumasavin, N. & Hogan, Z. (2006) Development of a conservation strategy for the critically endangered Mekong giant catfish: Quantitative assessment report. Mekong Giant Catfish Working Group, NACA, Bangkok. 35 pp. (**Annex C).**

4.3.4 Genetic assessment and breeding strategy for the captive population

There is now a large captive population of MGC comprising some 20,000 individuals in 20 age groups, most of these first generation offspring of wild parents. Although genetic management of the captive population requires further attention, the current population is large, diverse and as yet only moderately domesticated. It is thus a key resource for species conservation, ensuring species persistence and enabling supplementation or re-introduction of the wild population.

Loss of genetic variation in the captive stocks is a common phenomenon. The consequences include loss of rare alleles accompanying by the occasional reduction of heterozygosity. However, in the present study, levels of genetic variation observed in captive stock of MGC were found commensurate with those of the wild stock based on the same sets of microsatellite loci (A= 3.91 ± 2.12; Ae = 2.49 ± 1.04; Ho = 0.60 ± 0.25; He = 0.54 ± 0.17; n=24). This may be due to the large number of founders and the brief captive history. Therefore it appears that the captive stock well represents the genetic diversity in the wild stock of Mekong giant catfish, and that it provides an effective means of conserving the species in captivity and for possible re-introduction.

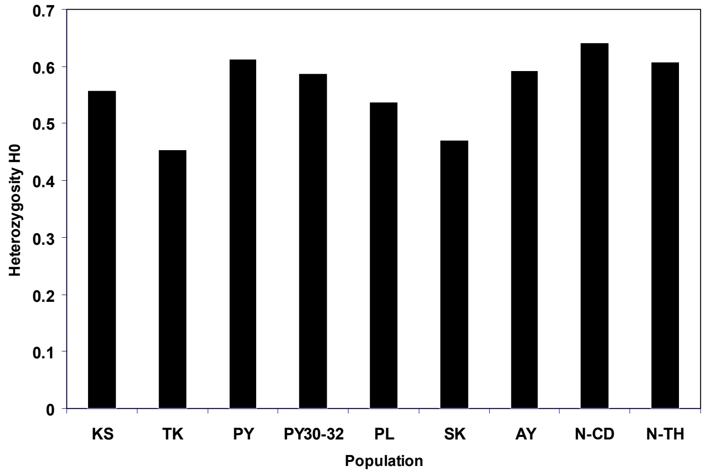

Fig. 10: Average heterozygosity in different hatchery and wild populations of MGC. Wild populations are prefixed with an N (N-CD and N-TH).

In order to avoid risks associated with unexpected catastrophes that may lead to loss of MGC broodstock, the population should be maintained at more than one facility. The four Fisheries Stations/Hatcheries Ayudthaya, Phayao, Chiangmai and Pitsanulok maintain the greatest share of genetic diversity in the captive population (relatively higher numbers of mtDNA haplotypes compared to other facilities), hence these facilities should be considered to maintain the MGC captive gene pools. A specific mating plan has been designed based on molecular genetic analysis (Na-Nakorn et al. 2008). The plan provides a basis for broodstock management for about the next five years, and should be implemented in order to maintain the greatest possible genetic diversity in the next generation of captive bred MGC.

It is important that maturation of male and female of each breeding pair according to mating plan need to be synchronized. Therefore, broodstock rearing conditions (e.g. feed, controlled environments) and enhancement of gamete development by chronic application of hormone (e.g. implantation of gonadotropin releasing hormone) should be investigated to ensure that males are ready when females could spawn. Also, cryopreservation techniques for male gametes of MGC should be refined and applied to all hatcheries. Male gametes should be cryopreserved, possibly at a central unit or share amongst hatcheries for all males in MP5. Once females are ready to spawn then cryopreserved milt of appropriate males could be used. This will reduce the risks and costs associated with transporting fish from long distance.

No further capture of wild broodfish is recommended at present, given that the captive population is diverse and is being carefully managed to maintain this diversity, and that the wild population remains in a very depleted state.

<u>Full details are given in:</u>

Na-Nakorn, U., Sukmanomon, S., Sriphairoj, K., Kamonrat, W., Sukumasavin, N. & Nguyen, T.T.T (2008) Development of a conservation strategy for the critically endangered Mekong giant catfish: Conservation of genetic resources of captive stock. Mekong Giant Catfish Working Group, NACA, Bangkok. 25 pp. (**Annex D)**.

4.3.5 Conservation strategy

Conservation vision and goals

The core conservation vision or goal of the Mekong Giant Catfish Conservation Group is the maintenance of a viable wild population of Mekong giant catfish and the restoration of its historical distribution. Maintenance of a genetically representative captive population is crucial as 'insurance' against possible (if not likely) extinction in the wild. Maintenance of critical habitats and ecosystem processes in the Mekong basin is clearly important if a wild population is to be maintained. The presumed transboundary migrations and reliance on a variety of habitats of the MGC make it an ideal flagship species for ecosystem conservation in the Mekong. In this context, maintenance of the MGC's social and cultural importance is in itself a goal of conservation initiatives.

Factors affecting the population:

Habitat and environmental change in the Mekong basin has been gradual and of moderate magnitude until the very recent past, and it is unlikely that this has been a significant factor in past population change. More dramatic changes may have occurred in the very recent past (with 'rapid blasting' and the commissioning of several dams in the upper river), and this trend is likely to continue in the future. ***Fishing*** can be identified as the main driver of past changes in population abundance and structure. The exceptionally intensive Chiang Khong fishery in the 1980s and 90s in particular is likely to account for the dramatic population decline observed over this period. However, the previously moderate level of traditional targeted and incidental harvesting is likely to be sustainable***. Interactions with other species***, either native or non-native, are unlikely to have played a significant role in past population change, and there are no known issues in this regard for the future. ***Interactions with cultured*** fish are unlikely to have played a significant role in past population change, but may become a major issue in the future due to both intentional and accidental releases. At present the cultured population is likely to exceed the wild population in abundance.

Conservation strategy:

Fishing. Fishing mortality on the recruited population should be maintained at very low levels. For the next two decades, catches should not exceed 10 mature fish per year in order to allow some population recovery. The legal mechanisms for harvest regulation are in place in Cambodia and Thailand, but need to be strengthened in the Lao PDR. ***Habitat conservation***. Maintaining the overall Mekong ecosystem (flows, physical habitats and connectivity) clearly is important to ensuring the long-term survival of the species in the wild. Given that habitat use and migration patterns of the species are largely unknown, no essential habitat can be identified except for the spawning area. The spawning area is very likely to be located within some 50 miles north of Chiang Khong, and it can be clearly identified as essential habitat. An immediate priority should be to protect this habitat. ***Captive breeding***. The captive population of MGC maintained by the Thai Department of Fisheries provides a vital 'insurance', safeguarding the survival of the species should it become extinct in the wild. The captive population should be managed carefully so as to conserve its genetic diversity, should re-introduction become necessary. For the time being, captive-bred fish should not (or only in very low numbers) be released into the Mekong or its tributaries because the wild population is likely to recover naturally. Releases would have no net benefit but could compromise this process through ecological and genetic interactions with captive-bred fish. ***Aquaculture*.** Escapes of MGC grown in commercial aquaculture could pose a significant threat to the wild population. Measures should be taken to minimize the risk of such escapes occurring. It should be noted that, because the wild population carrying capacity appears to be quite low, releases of even low numbers of captive-bred fish can have significant impacts on the wild population.

Monitoring, research and adaptive management

Monitoring should encompass factors affecting the wild population, the status of the wild population, and the status of the captive population. Monitoring of factors affecting the population is particularly important because it will allow identifying and alleviating risks well before population impacts would become measurable. Monitoring of the population itself is possible only on the basis of fisheries data from traditional targeted and incidental fisheries (principally in Chiang Khong and the Tonle Sap River, respectively). There is thus a tradeoff between minimising harvest and maximising monitoring information, but maintenance of a low level of traditional harvesting is deemed not to pose a great risk to the population. Monitoring of the captive population should cover its demography and breeding practice in relation to the genetic management plan. Further molecular genetic analysis will be required approximately every 5 years in order to extend the breeding plan to newly maturing fish. Further ***research*** is required on habitat use and movement of wild and released captive-bred fish with a view to identifying key habitats and supporting a re-introduction programme should this become necessary. ***Adaptive management*** entails responding to new monitoring information in a way that promotes long-term persistence of the wild population.

Full details are given in:

MGCWG (2007) Conservation strategy for the Mekong giant catfish. Mekong Giant Catfish Working Group, NACA, Bangkok. 30 pp. (**Annex B**).

4.3.6 Implementation of the strategy and key conservation measures

The strategy will be implemented by multiple institutions. The MRC Technical Advisory Board for Fisheries (MRC-TAB) will assume a coordinating function and conduct annual reviews and assessments of monitoring information. The Royal Cambodian Fisheries Administration will continue to restrict harvesting of the giant catfish and minimise its incidental capture. The Lao Department of Livestock and Fisheries, and LARReC will strive to increase legal protection of the species from unsustainable harvesting. The Royal Thai Department of Fisheries will maintain its captive population of giant catfish and apply improved breeding protocols based on molecular genetic analysis. It will also continue to regulate the harvest of giant catfish with a view to conserving the wild population while also providing population monitoring data and maintaining the indicator value of the species.

Three conservation measures have been highlighted by the strategy and implemented by the Thai Department of Fisheries:

- Targeted fishing is being restricted by a maximum total allowable catch of 10 fish per year.
- A breeding plan for the captive population has been developed, supported by molecular genetic data generated by the project. The plan involves flexible use of the data to obtain the best possible pairings of the fish maturing at any one time.
- Releases of captive-bred fish into the Mekong river and its tributaries have been discontinued in order to protect the small wild population from introgression of partially domesticated types.

4.3.7 Fundamental contributions to fish population dynamics and the use of cultured fish in population restoration

Population regulation in fish

Most fisheries models assume that population regulation occurs exclusively in the pre-recruit phase of the life cycle. However, there is increasing evidence that density-dependent body growth in the recruited phase and its interaction with size-dependent reproductive development can play an important role in regulation, and that this can have significant management implications. Comparative analyses and population modelling were used to explore the respective role in regulation, and interactions between density-dependent processes in pre- post-recruitment phases of the life cycle. Of 16 study populations, 14 show significant density dependence and thus regulation in either (9) or both (5) phases. When standardized by habitat area, the density-dependent parameters of both phases are correlated, but the density-dependent growth parameter is a better predictor of average biomass density than the equivalent parameter of the spawner-recruit relationship. Population modelling shows that in absence of exploitation (i.e. near carrying capacity), 11 of the 16 populations respond most strongly to relaxation of pre-recruit density dependence, while 5 respond most strongly to relaxation of density-dependence in post-recruit growth. Growth regulation is less important when population density is reduced below carrying capacity. Fishing erodes compensatory reserve in the recruited phase by truncating the age and size distribution. The spawner-recruit relationship thus dominates compensation in heavily exploited populations, but growth-mediated regulation in the recruited phase is likely to be important when populations are closer to carrying capacity, e.g. in the context of harvest reserves, stock rebuilding, and fisheries enhancement. This study informed the representation of density dependence and carrying capacity in the Mekong giant catfish population model.

Full details are given in:

Lorenzen, K. (in press) Beyond ‘stock and recruitment’: density-dependent growth in recruited fish and its role in population regulation. Bulletin of Marine Science. (**Annex F**).

Domestication and cultured-wild fish interactions

Aquaculture for food, ornament, research, fisheries enhancement and conservation is expanding throughout the world. Many species are being cultured and have entered a process of domestication with consequences for their morphology, physiology, behaviour, ecology and evolution. The process of domestication involves plastic developmental responses as well as natural and artificial selection and may be divided into an initial, and two alternative advanced modes. Initial domestication is characterized by modification of the culture environment to best meet the requirements of the organism, and biological responses of the organism to these modifications. Advanced domestication involves targeted manipulations of the organism's biology to promote either, traits of commercial interest in fish culture or the maintenance of wild genotype and phenotype within the culture environment. Controlled domestication can yield benefits for all forms of aquaculture, but inadvertent or poorly managed domestication can be detrimental to aquaculture as well as wild stocks. Accidental and intentional releases of cultured fish are widespread and interactions between cultured and wild fish pose new challenges as well as opportunities for the conservation of wild stocks. Ecological and genetic interactions of cultured and wild fish can be significant and are closely linked. On the whole, cultured fish perform less well in natural ecosystems than their wild conspecifics. Nonetheless ecological and genetic interactions between the two groups can be significant, particularly where wild populations are small, and/or highly adapted to local conditions, and/or declining. Impacts of fish released accidentally or for fisheries enhancement tend to be negative for the wild populations involved. Captive breeding and supplementation can play a positive role in restoring threatened populations, but the biology of threatened populations and the potential of culture approaches for conserving them remain poorly understood. Research for a better understanding of fish domestication and the ecological and genetic consequences of cultured fish released into the wild will also provide key insights into fundamental biology of diverse organisms.

Full details are given in:

Lorenzen, K., Beveridge, M. & Mangel, M. (submitted) Aquaculture, domestication, and interactions between wild and cultured fish. Biological Reviews. (**Annex G**).

4.3.8 Conclusions

Key conclusions of project research and planning activities are:

(1) A science-based, integrated conservation strategy for the Mekong giant catfish developed with inputs from, and the support of all major stakeholders in the region. Key elements of the strategy, including the use of quantitative assessment results in determining harvest permits, improved genetic management of the captive MGC population, and discontinuation of captive releases in the Mekong basin while the wild population is undergoing natural recovery have already been taken up.

(2) A first quantitative assessment has been carried out of the status of the Mekong giant catfish population, reasons for its recent decline, and likely effectiveness of conservation measures. The assessment shows that the MGC is likely to be naturally rare. A stable population of about 250 mature fish in the 1960s/70s has been depleted by intensive fishing in the 1980s/90s to no more than 50 mature fish in the 1990s. The population is now likely to be recovering naturally, and number around 145 mature fish. A moderate level of 'traditional' fishing for MGC is sustainable in principle, but the population is still in a depleted state and only a very low harvest of up to 10

mature fish per year should be allowed over the next 10-20 years. While fishing was the primary cause of MGC population decline in the past and remains a significant threat, habitat degradation is likely to be the most important (and largely unquantifiable) threat to population persistence at present.

(3) The captive population of MGC is a vital 'insurance' for species survival in the face of large uncertainties about future habitat degradation. The captive population is large, diverse and as yet only moderately domesticated. A molecular genetic study has shown that levels of genetic variation in the captive stock of MGC are commensurate with those of the wild stock based on the same sets of microsatellite loci. A genetic resource management plan for the captive population has been defined, based on molecular genetic analyses.

5 Project impact

The project purpose has been accomplished: an effective conservation strategy for the Mekong giant catfish has been developed and promoted. This has been achieved by initiating and facilitating a systematic and cooperative conservation planning process, and by providing key scientific inputs to the process including a quantitative assessment of population status and conservation measures, and the development of a genetic resource management plan for the captive population.

The project has effectively assisted the host countries in meeting their obligations under the CBD in particular with regards to:

- Article 7 (Identification and monitoring): The project synthesized, organized and analysed data on the status of the Mekong giant catfish, and processes and activities which have adverse effects on the population.
- Article 8 (In-situ conservation): The project has provided quantitative information on biological limits to exploitation of the wild MGC population.
- Article 9 (Ex-situ conservation): The project has developed a genetic resource management plan for the captive population of MGC, based on molecular genetic analyses.
- Article 10 (Sustainable use): The project has assessed the sustainability of exploitation of the Mekong giant catfish, and defined biological limits for management.
- Article 17 (Information exchange): The project has strongly facilitated the exchange and synthesis of information on Mekong giant catfish conservation among countries in the lower Mekong region.

Project outputs have already been taken up by the Thai Department if Fisheries, which has primary responsibility for managing both, the main targeted fishery for MGC (at Chiang Khong) and the captive breeding programme. Quantitative assessment results are being used to determine special permits for harvesting of the protected species. Harvesting of MGC is a highly political issue in Thailand, and availability of well defined biological limits to exploitation enables the Department to deal with such requests on a rational, transparent and fair basis. For the captive breeding programme, the Darwin project has provided a genetic management plan to maximise conservation of genetic resources.

The Darwin project has fostered close collaboration between UK and Cambodian, Lao, Thai and Vietnamese scientists, government officials and NGO representatives throughout the conservation strategy process. Virtually all core activities have involved close cooperation of MGCWG members from a variety of backgrounds. The UK Principal Investigator (Dr Kai Lorenzen) visited most partner institutions for joint activities in the course of the project, and the Thai Research Officer and Chair of the MGCWG (Dr Naruepon Sukumasavin) visited Imperial College London for two weeks to continue joint work on population assessment. The project has also succeeded in enhancing cooperation between governmental institutions and NGOs, in particular with regards to managing the MGC fisheries.

6 Outputs

Complete lists of outputs are given in the appendices. The quantity and quality of outputs is in line with the original agreement. Due to the dynamic nature of the project, where research activities were strongly influenced by workshop outcomes and the availability of information, some outputs are different from those originally envisaged. In particular, the genetic management plan for the captive population has replaced the originally envisaged, more explicit adaptive management strategy for the MGC fishery. This reflects the importance of the captive population as 'insurance' in the face of uncertainty about future habitat degradation, and the fact that fishing is likely to be less of a threat to the population's future than originally assumed. Several publication outputs are not yet publicly available or accepted for publication, these outputs are not quantified in Appendix II, but listed in Appendix III.

Figure 11: Discussing the conservation strategy during the 4th MGCWG regional meeting, Bangkok, 23 March 2007.

7 Project Expenditure

Project expenditure is summarized in Table 3. Expenditure has remained in line with the agreed budget. Some variation has occurred in the research partner (NACA) subcontract as a result of the inclusion of the molecular genetics study.

Table 3: Project expenditure

Item	Budget	Expenditure
Salaries (specify)		
Dr Kai Lorenzen		
Rent, rates heating lighting etc		
Office administration costs		
Capital items/equipment		
Others		
Travel		
NACA Subcontract		
Coordinator		
Genetics study honoraria		
Consumables etc		
Overheads		
Total	86,752	86,752

8 Project operation and partnerships

The project was implemented with the Network of Aquaculture Centers in Asia-Pacific (NACA), Bangkok, Thailand as the lead partner. NACA established formal links/subcontracts with the Thai Department of Fisheries and the Faculty of Fisheries of Kasetsart University in order to achieve part-time secondment of the Project Officer and Chair of the MGCWG and to conduct the genetic resource management study of the captive MGC population. The project established the MGCWG as a semi-formal, open but purpose-driven working group to which all major stakeholders could send delegates and contribute information or resources. This setup has proved highly effective in bringing together expertise and information, and in developing a shared understanding of issues, conservation vision and strategy. In addition to the directly contracted parties described above, the following organisations participated in the MGCWG: Mekong River Commission Fisheries Programme; the Mekong Wetlands Biodiversity Program; the government fisheries departments of Cambodia, Laos, and Vietnam; FAO Fisheries Department; WWF; IUCN; the Giant Catfish Club of Chiang Khong, and Thai Senator Ms Tuenchai Deetes.

9 Monitoring, Evaluation and Lessons

Project objectives and outputs had been defined mostly in terms of research products. These products have been achieved as demonstrated by the results reported here and in the annexed papers and reports. Most of the work has been extensively scrutinized in the MGCWG, and key publication outputs have been or will be fully peer reviewed. There has been some time (but not cost) overrun, largely due to the complex nature of the conservation strategy process that relied so heavily on the voluntary collaboration of many institutions and individuals.

The MGCWG and its conservation strategy process were set up with the aim of providing a neutral forum where information could be synthesized and analysed, and conservation measures assessed and prioritized. Creation of a new, neutral and time-limited entity was important because Mekong giant catfish conservation is championed by may players with different agendas, values and preferences. The MGCWG has worked very effectively in terms of synthesis/analysis and strategy development and as such, has achieved its main purpose. The group has proved less effective at coordinating concrete conservation actions, largely because these often spring from short-term opportunities, are driven by individual stakeholder's interests, and/or rely on external funding from a variety of sources. Experience has shown that MGCWG members base longer-term considerations and initiatives on working group outputs, but will continue to take short-term opportunities as they arise and without recourse to the group. Most importantly, the working group outputs including the conservation strategy provide science-based guidance on a number of controversial issues including the level of allowable catch and the questions of whether captive bred fish should be released into the wild population.

One key lesson to be drawn from this project is that small projects such as those supported by the Darwin Initiative can achieve big impacts by integrating and assessing work carried out by larger initiatives and organisations.

10 Darwin identity

Project staff and collaborators made every effort to publicise the Darwin Initiative. The Darwin logo has been used on all project material and displayed prominently at the collaborator's premises and at workshops.

The workshops have been extremely well attended by conservation professionals from the Mekong region, and have done much to promote knowledge of the Darwin Initiative. The fact alone that most of the region's key aquatic resources and conservation professional attended the workshops at their own institution's expense shows that the project was regarded as an important contribution to the field.

Although the project was closely integrated with other, larger initiatives in fisheries management and conservation of the giant catfish, it maintained a distinct identity due to its leadership of the conservation strategy process, the conceptual advances and the integrated, quantitative analyses carried out by the project.

11 Leverage

The MGCWG and its conservation planning process have been made possible by Darwin base funding for the PI and Project Officer, but has relied very heavily on contributions of time, funds, expertise, data etc. from the project partners. The fact alone that so many organisations and individuals have voluntarily contributed to the endeavour shows that the project had very strong leverage. Major financial contributions have been made by MRC and MWBP in the form of honoraria and travel cost payments for many of the delegates from Cambodia, Laos, and Vietnam; and by the Thai DoF for its own research and management staff.

12 Sustainability and legacy

Project achievements are likely to endure in various forms. Most importantly, a science-based conservation strategy for the Mekong giant catfish is now available to guide practical conservation action. Three conservation measures highlighted by the strategy have already been taken up by the Thai Department of Fisheries: targeted fishing is being restricted in accordance with biological limits identified in the strategy; a breeding plan for the captive population has been developed and is being used; and releases of captive-bred fish into the Mekong river and its tributaries have been discontinued. Other stakeholders and initiatives will continue to draw on the strategy. The strategy itself is being reviewed annually in the light of new information under the auspices of the MRC Technical Advisory Body for Fisheries.

13 Value for money

The project has provided excellent value for money. With limited funding, it has:

- orchestrated a participatory, science-based, regional conservation strategy process for one of the world's most endangered fish species
- synthesized and analysed ecological, genetic and management information on the wild and captive populations of the species
- provided the first quantitative assessment of the species' conservation status and options
- developed a genetic management plan for the captive population
- developed an integrated conservation strategy
- successfully promoted the uptake of key strategy elements

Author(s) / Date

Dr Kai Lorenzen, 27 February 2008

LOGICAL FRAMEWORK

<table>
<tr><td>Project summary</td><td>Measurable Indicators</td><td>Means of verification</td><td>Important Assumptions</td></tr>
<tr><td colspan="4">Goal:

To draw on expertise relevant to biodiversity from within the United Kingdom to work with local partners in countries rich in biodiversity but poor in resources to achieve
• the conservation of biological diversity,
• the sustainable use of its components, and
• the fair and equitable sharing of benefits arising out of the utilisation of genetic resources</td></tr>
<tr><td>Purpose
Effective conservation strategy for the Mekong giant catfish developed and promoted</td><td>Strategy document available and taken up by target institutions</td><td>Project reports and publications</td><td>Target organisations remain committed to, and are adequately resourced to implement conservation programme</td></tr>
<tr><td>Outputs
1. Conservation status of giant catfish assessed quantitatively
2. Scope for supportive breeding, habitat and harvest management evaluated quantitatively
3. Opportunities to improve captive breeding practices and releases strategies assessed
4. Adaptive management policies developed
5. Overall strategy for conservation developed and promoted</td><td>1. Conservation status, threats and opportunities identified
2. Assessments of target populations using new population models available
3. Captive breeding procedures reviewed, and improvements identified
4. Adaptive management policies defined, and at least partially adopted
5. Strategy document available</td><td>1. Conservation status assessment reports
2. Population assessment workshop reports and publications
3. Captive breeding practices reports and publications
4. Reports on adaptive policies and preliminary experimental results
5. Strategy published and copies sent to Darwin Initiative</td><td>1. Existing data sufficiently informative
2. Target institutions embrace integrated strategies
3. Captive breeding practices can be improved within given resource constraints
4. Target institutions implement adaptive policies
5. Strategy taken up within and beyond partner institutions</td></tr>
</table>

Activities	
1.1 Collation of existing information from collaborating institutions 1.2 Model development and quantitative analysis of data to estimate parameters and test hypotheses about population status and threats 2.1 Projections of population development under alternative scenarios of future fishing pressure, environmental state, and conservation measures 2.2 Discussion of projected recovery scenarios with collaborating institutions 2.3 Consolidation of scenarios, incorporation of results from captive breeding study 3.1 Review of broodstock management 3.2 Review of hatchery production and release strategies 3.3 Molecular genetic analysis and definition of breeding strategy 4.1 Identification of key uncertainties pertaining to recover strategy 4.2 Development of monitoring strategy 4.3 Definition of alternative pathways and decision rules for review of strategy in the light of monitoring results 5.1 Project inception workshop 5.3 Conservation strategy workshops with partner institutions 5.3 Policy workshop with wider target institutions	

List of Annexes

A) MGCWG (2005) Development of a conservation strategy for the critically endangered Mekong giant catfish: Inception workshop report. Mekong Giant Catfish Working Group Report 1. 31 pp.

B) MGCWG (2007) Conservation strategy for the Mekong giant catfish. Mekong Giant Catfish Working Group Report 5. 45 pp.

C) Lorenzen, K., Sukumasavin, N. & Hogan, Z. (2006) Development of a conservation strategy for the critically endangered Mekong giant catfish: Quantitative assessment report. Mekong Giant Catfish Working Group Report 3. 25 pp.

D) Na-Nakorn, U., Sukmanomon, S., Sriphairoj, K., Kamonrat, W., Sukumasavin, N. & Nguyen, T.T.T (2008) Development of a conservation strategy for the critically endangered Mekong giant catfish: Conservation of genetic resources of captive stock. Mekong Giant Catfish Working Group Report 4. 31 pp.

E) Lorenzen, K. & Sukumasavin, N. (2007) A conservation strategy for the Mekong giant catfish. Catch and Culture – The Mekong River Commission Fisheries Newsletter 13(1) 22-25.

F) Lorenzen, K. (in press) Beyond 'stock and recruitment': density-dependent growth in recruited fish and its role in population regulation. Bulletin of Marine Science.

G) Lorenzen, K., Beveridge, M. & Mangel, M. (submitted) Aquaculture, domestication, and interactions between wild and cultured fish. Biological Reviews.

Appendix I: Project Contribution to Articles under the Convention on Biological Diversity (CBD)

Project Contribution to Articles under the Convention on Biological Diversity		
Article No./Title	**Project %**	**Article Description**
6. General Measures for Conservation & Sustainable Use	-	Develop national strategies which integrate conservation and sustainable use.
7. Identification and Monitoring	15	Identify and monitor components of biological diversity, particularly those requiring urgent conservation; identify processes and activities which have adverse effects; maintain and organise relevant data.
8. In-situ Conservation	20	Establish systems of protected areas with guidelines for selection and management; regulate biological resources, promote protection of habitats; manage areas adjacent to protected areas; restore degraded ecosystems and recovery of threatened species; control risks associated with organisms modified by biotechnology; control spread of alien species; ensure compatibility between sustainable use of resources and their conservation; protect traditional lifestyles and knowledge on biological resources.
9. Ex-situ Conservation	20	Adopt ex-situ measures to conserve and research components of biological diversity, preferably in country of origin; facilitate recovery of threatened species; regulate and manage collection of biological resources.
10. Sustainable Use of Components of Biological Diversity	15	Integrate conservation and sustainable use in national decisions; protect sustainable customary uses; support local populations to implement remedial actions; encourage co-operation between governments and the private sector.
11. Incentive Measures	-	Establish economically and socially sound incentives to conserve and promote sustainable use of biological diversity.
12. Research and Training	10	Establish programmes for scientific and technical education in identification, conservation and sustainable use of biodiversity components; promote research contributing to the conservation and sustainable use of biological diversity, particularly in developing countries (in accordance with SBSTTA recommendations).
13. Public Education and Awareness	-	Promote understanding of the importance of measures to conserve biological diversity and propagate these measures through the media; cooperate with other states and organisations in developing awareness programmes.

14. Impact Assessment and Minimizing Adverse Impacts	10	Introduce EIAs of appropriate projects and allow public participation; take into account environmental consequences of policies; exchange information on impacts beyond State boundaries and work to reduce hazards; promote emergency responses to hazards; examine mechanisms for re-dress of international damage.
15. Access to Genetic Resources	-	Whilst governments control access to their genetic resources they should also facilitate access of environmentally sound uses on mutually agreed terms; scientific research based on a country's genetic resources should ensure sharing in a fair and equitable way of results and benefits.
16. Access to and Transfer of Technology	-	Countries shall ensure access to technologies relevant to conservation and sustainable use of biodiversity under fair and most favourable terms to the source countries (subject to patents and intellectual property rights) and ensure the private sector facilitates such assess and joint development of technologies.
17. Exchange of Information	10	Countries shall facilitate information exchange and repatriation including technical scientific and socio-economic research, information on training and surveying programmes and local knowledge
19. Bio-safety Protocol	-	Countries shall take legislative, administrative or policy measures to provide for the effective participation in biotechnological research activities and to ensure all practicable measures to promote and advance priority access on a fair and equitable basis, especially where they provide the genetic resources for such research.
Total %	**100%**	**Check % = total 100**

Appendix II Outputs

Code	**Total to date (reduce box)**	***Detail (←expand box)***
	Training Outputs	
1a	*Number of people to submit PhD thesis*	
1b	*Number of PhD qualifications obtained*	
2	*Number of Masters qualifications obtained*	
3	*Number of other qualifications obtained*	
4a	*Number of undergraduate students receiving training*	
4b	*Number of training weeks provided to undergraduate students*	
4c	*Number of postgraduate students receiving training (not 1-3 above)*	
4d	*Number of training weeks for postgraduate students*	*20* Training in genetic analysis for graduate students of Kasetsart University, conducted as part of research on the genetic management plan
5	*Number of people receiving other forms of* ***long-term*** *(>1yr) training not leading to formal qualification(i.e not categories 1-4 above)*	
6a	*Number of people receiving other forms of* ***short-term*** *education/training (i.e not categories 1-5 above)*	
6b	*Number of training weeks not leading to formal qualification*	
7	*Number of types of training materials produced for use by host country(s)*	
	Research Outputs	
8	*Number of weeks spent by UK project staff on project work in host country(s)*	*9* Visits to Cambodia, Laos and Thailand by PI, also visit to the UK by Thai project officer
9	*Number of species/habitat management plans (or action plans) produced for Governments, public authorities or other implementing agencies in the host country (s)*	*1* Conservation strategy (Annex B)
10	*Number of formal documents produced to assist work related to species identification, classification and recording.*	

Code	Total to date (reduce box)	*Detail (←expand box)*
11a	*Number of papers published or accepted for publication in peer reviewed journals*	*1* Lorenzen, K. (in press) Beyond 'stock and recruitment': density-dependent growth in recruited fish and its role in population regulation. *Bulletin of Marine Science*. (Annex F)
11b	*Number of papers published or accepted for publication elsewhere*	*1* Lorenzen, K. & Sukumasavin, N. (2007) A conservation strategy for the Mekong giant catfish. Catch and Culture – The Mekong River Commission Fisheries Newsletter 13(1) 22-25. (Annex E)
12a	*Number of computer-based databases established (containing species/generic information) and handed over to host country*	
12b	*Number of computer-based databases enhanced (containing species/genetic information) and handed over to host country*	
13a	*Number of species reference collections established and handed over to host country(s)*	
13b	*Number of species reference collections enhanced and handed over to host country(s)*	
Dissemination Outputs		
14a	*Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work*	*5* MGCWG Meetings (Table 1)
14b	*Number of conferences/seminars/ workshops **attended** at which findings from Darwin project work will be presented/ disseminated.*	*2* British Ecological Society Annual Conference 2006, Oxford, UK SCB2007: Annual Conference of the Society for Conservation Biology, Port Elizabeth, South Africa
15a	*Number of national press releases or publicity articles in host country(s)*	*2* Press releases associated with project inception and conservation strategy workshops
15b	*Number of local press releases or publicity articles in host country(s)*	
15c	*Number of national press releases or publicity articles in UK*	
15d	*Number of local press releases or publicity articles in UK*	
16a	*Number of issues of newsletters produced in the host country(s)*	

Code	Total to date (reduce box)	Detail (←expand box)
16b	Estimated circulation of each newsletter in the host country(s)	
16c	Estimated circulation of each newsletter in the UK	
17a	Number of dissemination networks established	
17b	Number of dissemination networks enhanced or extended	
18a	Number of national TV programmes/features in host country(s)	
18b	Number of national TV programme/features in the UK	
18c	Number of local TV programme/features in host country	
18d	Number of local TV programme features in the UK	
19a	Number of national radio interviews/features in host country(s)	
19b	Number of national radio interviews/features in the UK	
19c	Number of local radio interviews/features in host country (s)	
19d	Number of local radio interviews/features in the UK	
Physical Outputs		
20	Estimated value (£s) of physical assets handed over to host country(s)	
21	Number of permanent educational/training/research facilities or organisation established	
22	Number of permanent field plots established	
23	Value of additional resources raised for project	£ 40,000 approx.

Appendix III: Publications

The following publications are publicly accessible at present.

Type	Detail	Publishers	Available from	Cost £
Working group report	MGCWG (2005) Development of a conservation strategy for the critically endangered Mekong giant catfish: Inception workshop report. Mekong Giant Catfish Working Group, NACA, Bangkok. 31 pp.	MGCWG	http://www.aquaticresources.org/mekongcatfish.html	-
Working group report	MGCWG (2005) Development of a conservation strategy for the critically endangered Mekong giant catfish: Conservation action plan (SCAP) workshop report. Mekong Giant Catfish Working Group, MWBP, Vientiane, Lao PDR. 31 pp.	MGCWG	http://www.aquaticresources.org/mekongcatfish.html	-
Working group report	Lorenzen, K., Sukumasavin, N. & Hogan, Z. (2006) Development of a conservation strategy for the critically endangered Mekong giant catfish: Quantitative assessment report. Mekong Giant Catfish Working Group, NACA, Bangkok. 35 pp.	MGCWG	http://www.aquaticresources.org/mekongcatfish.html	-
Working group report	Na-Nakorn, U., Sukmanomon, S., Sriphairoj, K., Kamonrat, W., Sukumasavin, N. & Nguyen, T.T.T (2008) Development of a conservation strategy for the critically endangered Mekong giant catfish: Conservation of genetic resources of captive stock. Mekong Giant Catfish Working Group, NACA, Bangkok. 25 pp.	MGCWG	http://www.aquaticresources.org/mekongcatfish.html	-
Conservation strategy	MGCWG (2007) Conservation strategy for the Mekong giant catfish. Mekong Giant Catfish Working Group, NACA, Bangkok. 25 pp.	MGCWG	http://www.aquaticresources.org/mekongcatfish.html	-
Newsletter article	Lorenzen, K. & Sukumasavin, N. (2007) A conservation strategy for the Mekong giant catfish. Catch and Culture – The Mekong River Commission Fisheries Newsletter 13(1) 22-25.	Mekong River Commission	http://www.mrcmekong.org/programmes/fisheries/catch_culture.htm	-

The following manuscripts have been, or will be submitted in due course:

Lorenzen, K. (in press) Beyond 'stock and recruitment': density-dependent growth in recruited fish and its role in population regulation. *Bulletin of Marine Science.*

Lorenzen, K., Beveridge, M. & Mangel, M. (submitted) Aquaculture, domestication, and interactions between wild and cultured fish. *Biological Reviews*.

Lorenzen, K., Sukumasavin, N. & Hogan, Z. (in prep.) Quantitative assessment of the population status of the critically endangered Mekong giant catfish. Target: *Biological Conservation.*

Lorenzen, K., Sukumasavin, N. Na-Nakorn, U., & Hogan, Z. (in prep). Development of a conservation strategy for the critically endangered Mekong giant catfish. Target: *Oryx.*

Appendix IV: Darwin Contacts

To assist us with future evaluation work and feedback on your report, please provide contact details below.

Project Title	**Development of a Conservation Strategy for the Critically Endangered Mekong Giant Catfish *Pangasianodon gigas*.**
Ref. No.	**14/053**
UK Leader Details	
Name	**Dr Kai Lorenzen**
Role within Darwin Project	**PI**
Address	**Division of Biology** **Imperial College London** **Silwood Park** **Ascot SL5 7PY**
Phone	
Fax	
Email	
Partner 1	
Name	**Dr Naruepon Sukumasavin**
Organisation	**Royal Thai Department of Fisheries**
Role within Darwin Project	**Project Officer**
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Fax	
Email	