

Catch and Culture Environment



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Cover photo by Lor Kimsan of WWF-Cambodia is a close-up of a photo showing an Irrawaddy dolphin calf in the Mekong River in Cambodia in June. The full photo can be seen on pages 32 and 33.

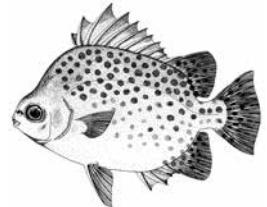
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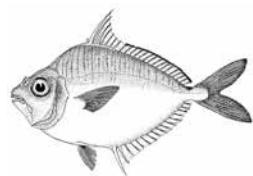
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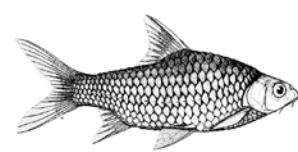


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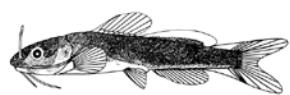
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Mekong water quality still good and even getting better in some places

Water quality for the protection of fish and other aquatic life has improved at some sites in Thailand, Cambodia and Viet Nam.

The quality of water otherwise remains ‘good’ at most of the 22 stations along the Mekong that are part of Water Quality Monitoring Network established for the Lower Mekong Basin in 1985.

With the assistance of member countries, the Mekong River Commission conducted routine monitoring of water quality at 48 stations along the Mekong and its tributaries in 2014. The monitoring included 17 sites on the mainstream and 5 on the Bassac River, the major distributary of the Mekong that flows from Phnom Penh through the southern part of the Cambodian floodplain into the Mekong Delta in Viet Nam.

Twelve water quality parameters were monitored at each station on a monthly basis (see page 9). In addition, another six parameters were monitored during the wet season between April and October (in Viet Nam, these were monitored on a monthly basis).

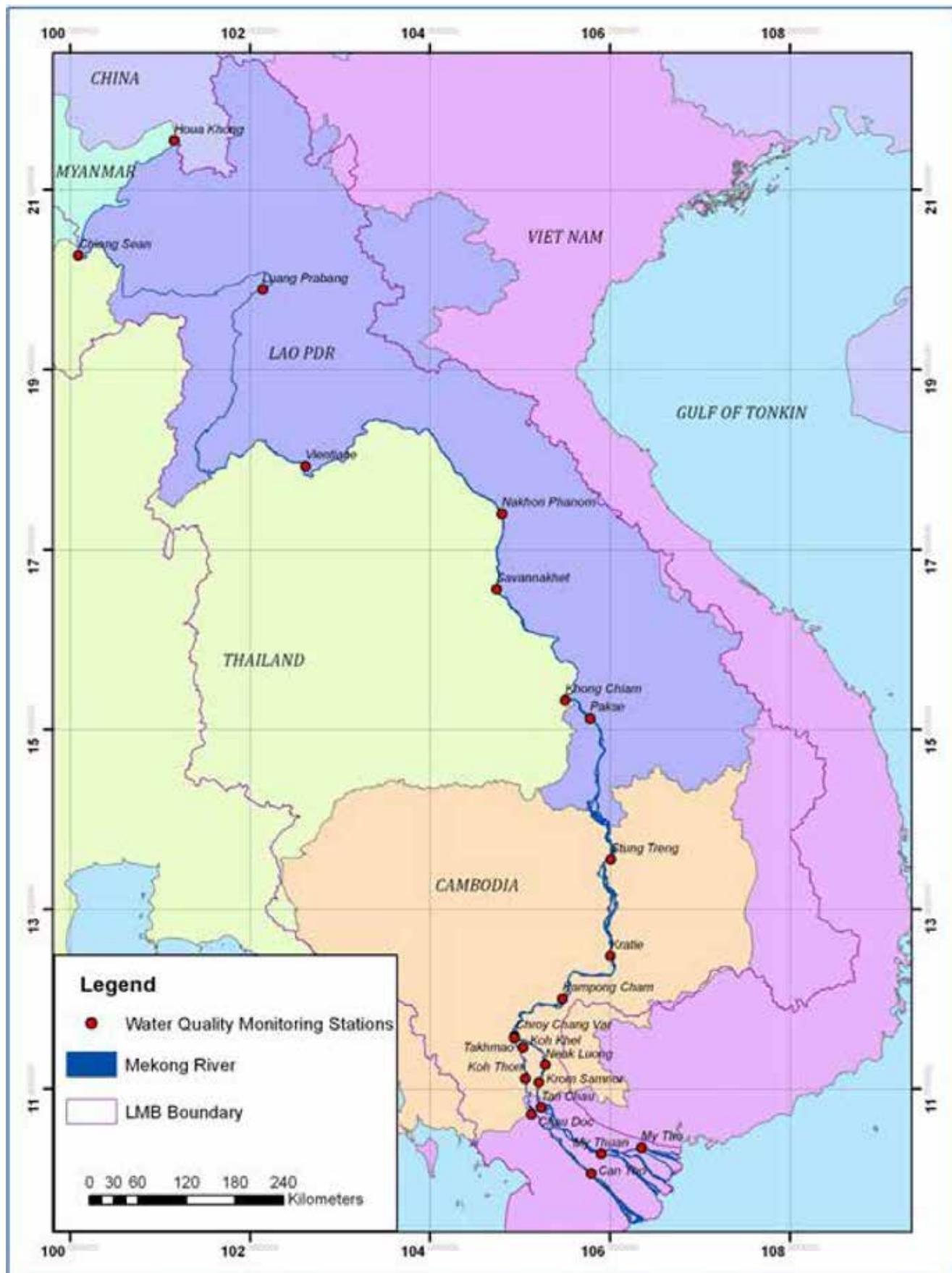
Improvement in Can Tho

Monitoring of six of the 12 parameters found that the quality of water for the protection of aquatic life remained “good” at 15 stations, unchanged from the previous year. At Can Tho – the main city in the Mekong Delta and also a centre for aquaculture production – water quality was also “good” which marked an improvement from the “moderate” levels recorded in 2013. At five stations, three in Thailand and two in Cambodia, the quality improved from “good” in 2013 to



Vietnamese laboratory workers testing the quality of water from the Mekong

PHOTO: MRC TECHNICAL PAPER No. 60



Locations of the 22 stations for monitoring water quality in the Lower Mekong Basin

MAP: MRC TECHNICAL PAPER No. 60

Water Quality Index for the Protection of Aquatic Life (2009-2014)

Water quality classes of the Mekong River (1-17) and Bassac River (18-22)

No.	Station Names	Rivers	Countries	2009	2010	2011	2012	2013	2014
1	Houa Khong	Mekong	Lao PDR	A	A	A	B	B	B
2	Chiang Saen	Mekong	Thailand	B	B	A	B	B	A
3	Luang Prabang	Mekong	Lao PDR	A	B	A	A	B	B
4	Vientiane	Mekong	Lao PDR	A	A	A	A	B	B
5	Nakhon Phanom	Mekong	Thailand	A	B	A	B	B	A
6	Savannakhet	Mekong	Lao PDR	A	A	A	A	B	B
7	Khong Chiam	Mekong	Thailand	A	A	A	A	B	A
8	Pakse	Mekong	Lao PDR	A	A	A	A	B	B
9	Stung Treng	Mekong	Cambodia	B	B	B	B	B	B
10	Kratie	Mekong	Cambodia	B	B	B	B	B	A
11	Kampong Cham	Mekong	Cambodia	B	B	B	B	B	B
12	Chrouy Changvar	Mekong	Cambodia	B	B	B	B	B	B
13	Neak Loung	Mekong	Cambodia	B	B	B	B	B	B
14	Kaom Samnor	Mekong	Cambodia	B	B	B	B	B	B
15	Tan Chau	Mekong	Viet Nam	B	B	B	B	B	B
16	My Thuan	Mekong	Viet Nam	B	B	B	B	B	B
17	My Tho	Mekong	Viet Nam	C	C	C	B	C	C
18	Takhmao	Bassac	Cambodia	B	B	B	B	B	B
19	Koh Khel	Bassac	Cambodia	B	B	B	B	B	B
20	Koh Thom	Bassac	Cambodia	B	B	B	B	B	A
21	Chau Doc	Bassac	Viet Nam	B	B	B	B	B	B
22	Can Tho	Bassac	Viet Nam	C	C	C	C	C	B

SOURCE: MRC TECHNICAL PAPER No 60

A	High	B	Good	C	Moderate	D	Poor	E	Very Poor
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“excellent” in 2014. Only one of the 22 stations was rated as “moderate” in 2014. This was in the Vietnamese city of My Tho, the furthest downstream station on the Mekong mainstream. Its rating was unchanged from 2013.

In June this year, the commission published the results of the monitoring in *MRC Technical Paper No. 60*. At the three Thai stations where water quality improved from “good” in 2013 to “excellent” in 2014, the paper points to “significant reduction in levels of chemical oxygen demand and total phosphorous.” These stations were Chiang Saen – in the uppermost part of the Lower Mekong Basin in the Golden Triangle between Laos, Myanmar and Thailand – along with Nakhom Phanom and Khong Chiam in northeast Thailand. Similar improvements were seen at Cambodian stations in Kampong Cham on the Mekong and Koh Thom on

the Bassac. At these two stations, the ratio of total phosphorous data above the threshold level of 0.13 mg/L fell from more than 40 percent in 2013 to 25 percent in 2014.

‘Minor degree of threat or impairment’

“Between 2009 and 2014, the water quality of the Mekong and Bassac Rivers remained relatively unchanged and was suitable for all aquatic life with a only minor degree of threat or impairment observed,” the paper said. The authors reached similar conclusions on the quality of water for the protection of human health during the same period. In 2014, the paper said 13 of the 22 stations had “high” quality water for the protection of human health while six were ranked as having water of “good” quality. The three sites with “moderate” quality water for human health were the Cambodian city of Takhmao,

Parameters and Ratings for Protecting Aquatic Life

The six parameters for calculating scores and target values (left) and the five classes of ratings for protecting aquatic life (right)

Parameters	Target Values
pH	6 – 9
EC: Conductivity (mS/m)	< 150
NH ₃ : Ammonia (mg/L)	0.1
DO: Dissolved Oxygen (mg/L)	> 5
NO ₂₋₃ – N (mg/L): Total Nitrite and Nitrate	0.5
T-P: Total Phosphorous (mg/L)	0.13

Rating Score	Class
9.5 ≤ WQI ≤ 10	A: High Quality
8 ≤ WQI < 9.5	B: Good Quality
6.5 ≤ WQI < 8	C: Moderate Quality
4.5 ≤ WQI < 6.5	D: Poor Quality
WQI < 4.5	E: Very Poor Quality

SOURCE: MRC TECHNICAL PAPER No 60

located downstream from Phnom Penh on the Bassac River, along with Houa Khong on the Lao-Myanmar border and the central Lao city of Savannakhet. All three locations were affected by elevated levels of chemical oxygen demand. The Lao DR sites were also affected by low levels of dissolved oxygen.

Since its inception in 1985, the Water Quality Monitoring Network has provided a continuous

record of water quality in the Mekong and its tributaries. Routine monitoring has become one of the key environmental monitoring activities of the MRC and supports Water Quality Procedures adopted by ministers of Cambodia, Lao PDR, Thailand and Viet Nam in Ho Chi Minh City in 2011.

Further reading

Kongmeng Ly, Henrik Larsen (2016) 2014 Lower Mekong Regional Water Quality Monitoring Report, MRC Technical Paper No. 60, Mekong River Commission, Vientiane, 56 pp.

Analytical Methods for All Parameters

The analytical methods for the 18 parameters monitored in the Lower Mekong Basin (12 on a monthly basis and 6 from April to October) follow the *Standard Methods for the Examination of Water and Wastewater* published in 1998 or nationally accepted methods, as agreed between laboratories and the Mekong River Commission Secretariat. These parameters are used by the MRC to calculate three water quality indexes (for protection of aquatic life, protection of human health and agricultural use).

Analytical parameter	Recommended Analytical Methods
Temperature	2550-Temp/SM
pH	4500-H+/SM
Conductivity (Salinity)	2510-Ec/SM
Alkalinity/Acidity	2320-A/SM
Dissolved Oxygen (DO)	4500-O/SM
Chemical Oxygen Demand (COD)	Permanganate Oxidation
Total Phosphorous (T-P)	4500-P/SM
Total Nitrogen (T-N)	4500-N/SM
Ammonium (NH ₄ -N)	4500-NH ₄ /SM
Total Nitrite and Nitrate (NO ₂₋₃ -N)	4500-NO ₂₋₃ /SM
Faecal Coliform	9221-Faecal Coliform group/SM
Total Suspended Solids	2540-D-TSS-SM
Calcium (Ca)	3500-Ca-B/SM
Magnesium (Mg)	3500-Mg-B/SM
Sodium (Na)	3500-Na-B/SM
Potassium (K)	3500-K-B/SM
Sulphate (SO ₄)	4500-SO ₄ -E/SM)
Chloride (Cl)	4500-Cl/SM

SOURCE: MRC TECHNICAL PAPER No 60

ASEAN agrees to conserve biodiversity areas and address alien species threat

Biodiversity statement is among main outcomes of ASEAN summit in Vientiane in September. Leaders of the Association of Southeast Asian Nations also commit to a 'landscape-based approach' to climate resilience three days after the United States and China sign the Paris Agreement on climate change.

Southeast Asian leaders have agreed to strengthen efforts to conserve areas important for biodiversity and ecosystem services such as ASEAN Heritage Parks, which include five areas in the Lower Mekong Basin (see map on page 11). In a joint statement adopted at a summit on September 6, the 10 leaders also agreed to "improve actions to address the threat of invasive alien species, including identifying pathways of introduction through among others, sharing of experiences and lessons learned, capacity development and partnerships."

The joint statement by ASEAN leaders is expected to be submitted to the Thirteenth Conference of the Parties to the Convention on Biodiversity in Cancun in December. The international convention was adopted in Nairobi in 1992 and came into force in 1993. At the Tenth Conference of the Parties in Nagoya in 2010, the parties to the convention adopted the Strategic Plan for Biodiversity 2011-2020. The plan includes 20 targets for 2015 to 2020 organised under five strategic goals. The goals and targets, known as the "Aichi Biodiversity Targets", comprise both aspirations for global achievements and a flexible framework for achieving national or regional targets.

In their statement adopted in Vientiane, the ASEAN leaders agreed to "accelerate efforts to effectively implement the Strategic Plan" and contribute to achieving the targets by 2020 while increasing the efficiency and effectiveness of support from the Global Environmental Facility and



ASEAN leaders meeting in Vientiane on September 6

PHOTO: ASEAN SECRETARIAT

other sources to implement National Biodiversity Strategies and Action Plans. At the same time, the leaders agreed to "strengthen efforts to achieve Aichi Biodiversity Target 11 on conserving areas of particular importance for biodiversity and ecosystem services to ensure that the region's natural capital is sustained to deliver the ecosystem benefits essential for its well-being through for example, enhancing the ASEAN Heritage Parks Programme and cooperation with other regional transboundary initiatives."

Biodiversity and ecosystem services

The third goal of the Strategic Plan for 2011 to 2020 is to "improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity." As part of this goal, Aichi Biodiversity Target 11 states:

"By 2020, at least 17 per cent of terrestrial and inland water areas, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes."



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Target 11 provides for the conservation of terrestrial and inland water areas as well as coastal and marine areas by 2020 (see box above). As for heritage parks, ASEAN now has 38 such areas following the endorsement of the Bai Tu Long National Park in Viet Nam at a meeting of senior environment officials in Nay Pyi Taw in August. According to the ASEAN Secretariat, the heritage park programme "shows how people could live harmoniously with the environment" by bringing together experts to work with communities around the parks. "This shows how all sectors must work together to conserve environment," the secretariat says.

Awareness of the values of biodiversity

The third goal of the Strategic Plan for 2011 to 2020 also aims to "address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society." Under this

goal, Aichi Biodiversity Target 1 states: "By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably."

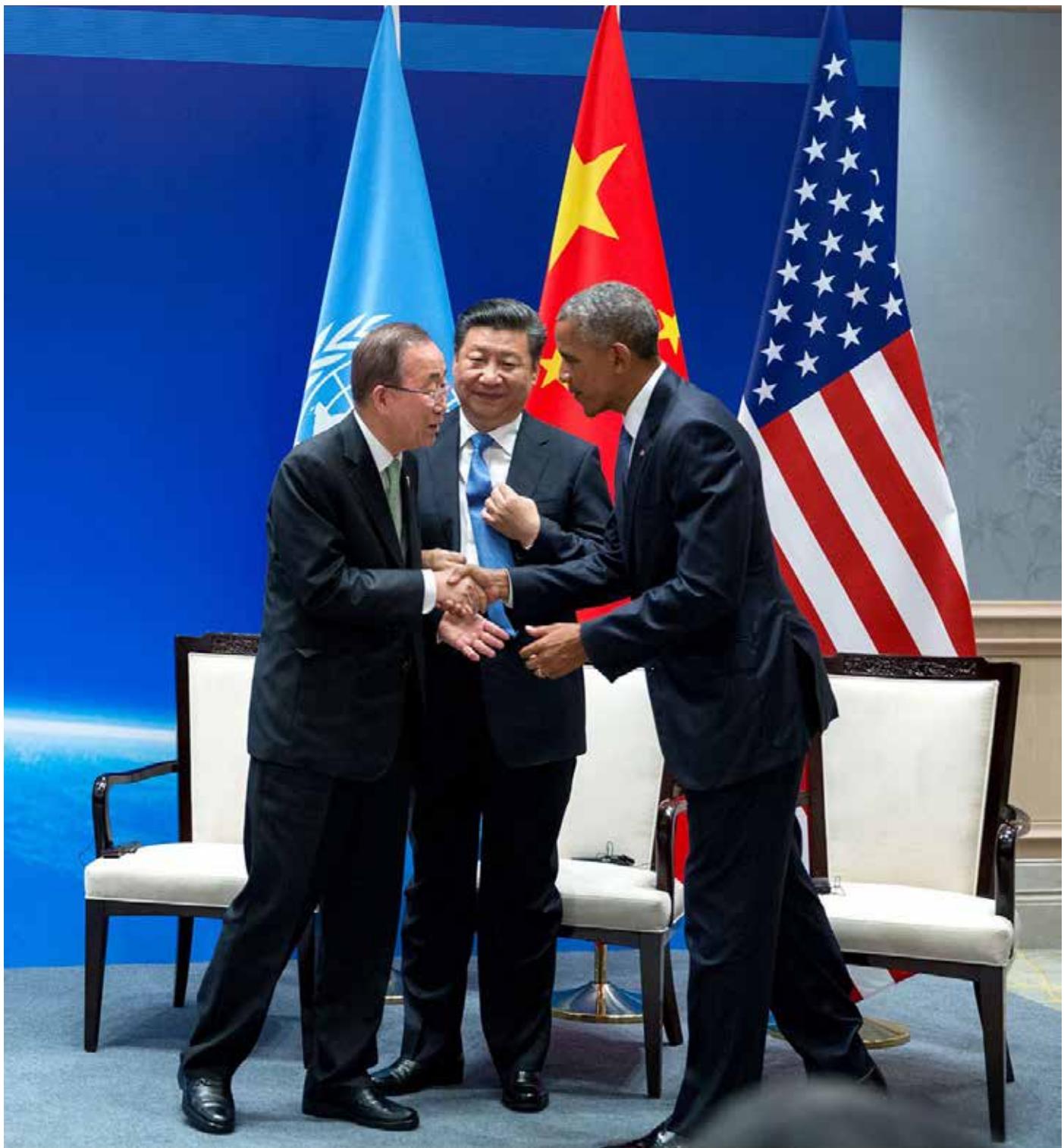


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To increase awareness of biodiversity under Target 1 (see box above), ASEAN leaders agreed to "enhance actions to implement national and regional communication, education and public awareness (CEPA) strategies, including engagement with the public and private sectors, local communities, youth and women." They also recognised the importance of mainstreaming biodiversity into national, sectoral and cross-sectoral plans, programmes and policies. At the same time, the leaders urged parties to the convention, other governments and relevant organisations to "share their experiences and practices to mainstream biodiversity" and "provide adequate financial and technical resources" to national strategies and action plans "especially to support capacity building and technical and scientific cooperation." They also agreed to "promote the effective implementation of legislative, administrative or policy measures on access and benefit sharing to support the third objective of the Convention."

The joint statement by ASEAN leaders also agreed to:

- enhance regional cooperation and partnerships to support national efforts to implement the 2030 Agenda for Sustainable Development, its SDGs and targets in particular, Goals 14 and 15 (on the conservation and sustainable use of coastal and marine resources as well as terrestrial ecosystems) for sustainable



The joint statement by ASEAN leaders on climate change on September 6 came three days after US President Barack Obama (right) and Chinese President Xi Jinping (centre) signed the Paris Agreement under the United Nations Framework Convention on Climate Change adopted in December last year. The signed copies were presented to UN Secretary General Ban Ki-moon (left) at an event on the sidelines of the G20 Summit in the Chinese city of Hangzhou on September 3. "We have a saying in America—that you need to put your money where your mouth is," said President Obama, who later travelled to Vientiane for an East Asia Summit with leaders from ASEAN as well as Australia, China, India, Japan, South Korea, New Zealand and Russia. "And when it comes to combatting climate change, that's what we're doing, both the United States and China. We're leading by example. As the world's two largest economies and two largest emitters, our entrance into this agreement continues the momentum of Paris, and should give the rest of the world confidence — whether developed or developing countries — that a low-carbon future is where the world is heading."

PHOTO: PETE SOUZA/WHITE HOUSE

development in the region; as well as to support other biodiversity-related multi-lateral agreements and frameworks;

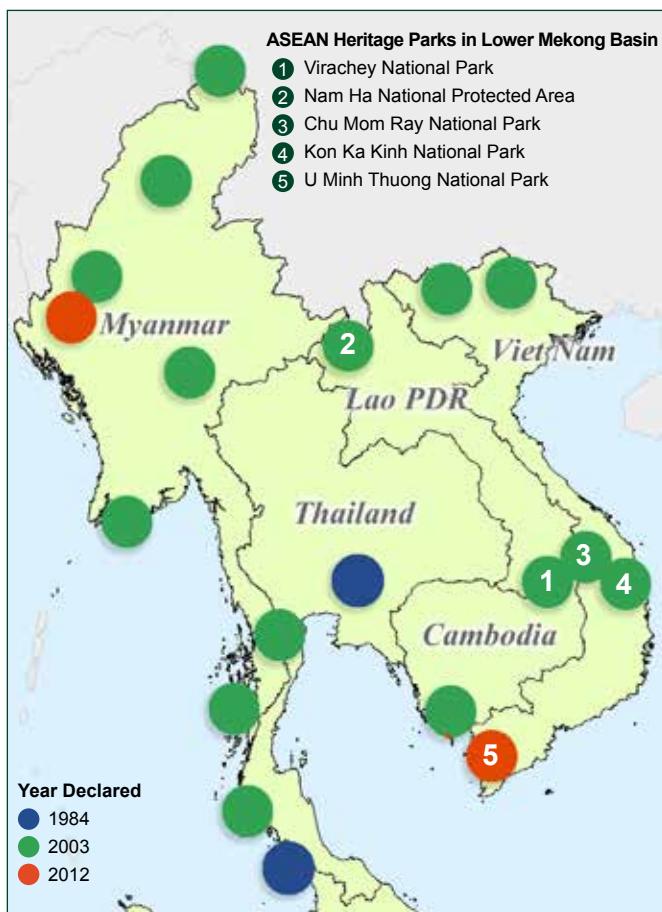
- enhance actions to address climate change impacts by implementing ecosystem-based approaches to climate change adaption and mitigation; and minimise activities that may increase the vulnerability and reduce the resilience of biodiversity and ecosystems;
- promote cooperation on species conservation and wildlife management, ecosystem restoration and where relevant, agricultural biodiversity, health and biodiversity and urban biodiversity to further support mainstreaming of biodiversity activities in the region; and
- support collaborative efforts to address transboundary conservation challenges including trafficking of wildlife and timber through, for example, the ASEAN Working Group on Convention on International Trade in Endangered Species of Wild Fauna and Flora and the ASEAN Wildlife Enforcement Network.

ASEAN joint statement on climate change

In their second statement, the ASEAN leaders expressed their commitment to "strengthen the management of ASEAN's diverse ecosystems and landscapes including its vulnerable terrestrial, coastal and marine ecosystems through a landscape-based approach to build climate resilience." According to the United Nations Environment Programme (UNEP), this approach, also known as "integrated landscape management", focuses on place-based natural resource planning rather than development based on sectors such as water, health and agriculture that has failed to deliver in past decades.

'As a matter of urgency, "adequate, predictable, and needs-based technology development and transfer, capacity building and financial support are needed"

Leaders said they were "gravely concerned about the impacts of climate change throughout the ASEAN region" in areas such as extreme climate events, food, water and energy security,



ASEAN Heritage Parks in mainland Southeast Asia in 2015

MAP: BIODIVERSITY INFORMATION SHARING SERVICE/CHHUT CHEANNA

livelihoods, health, land use and biodiversity including disproportionate impacts on women and children. As a matter of urgency, "adequate, predictable, and needs-based technology development and transfer, capacity building and financial support are needed to further scale up adaptation and mitigation efforts, and enhance awareness in the ASEAN region," the statement said. The leaders urged all parties to the Paris Agreement under the United Nations Framework Convention on Climate Change adopted in December last year to recognise the "extreme vulnerability of ASEAN Member States to climate change." In addition, they called on developed countries to fulfil mitigation and financial support commitments of \$100 billion a year under the convention in the pre-2020 period. Developed countries were also urged to provide capacity building, technical assistance, technology development and transfer as well as financing, both before and after 2020, to address mitigation, adaptation, loss and damage associated with the adverse affects of climate change.

Assessing the impact of climate change on Lower Mekong fisheries

By MAURICIOS ARIAS, SO NAM, NGOR PENG BUN, NGUYEN HUONG THUY PHAN AND NUON VANNA *

In 2015, the Fisheries Programme and the Climate Change and Adaptation Initiative of the Mekong River Commission worked together to assess the impact of climate change on fisheries resources under different climate change and development scenarios for the Lower Mekong Basin. The assessment mainly examined the impacts from two drivers of hydrological and salinity intrusion changes in important habitats in the Lower Mekong. Draft conclusions of the preliminary findings are summarised below.

Climate change is expected to bring significant impacts to the water resources of the Mekong River Basin as well as those sectors that depend on them. With regards to freshwater fisheries, it is commonly agreed that climate change could alter this sector via (1) changes in water temperature (2) hydrological alterations and (3) salt intrusion. The assessment of the impact of climate change on fisheries resources under different development scenarios in the Lower Mekong Basin primarily focused on the latter two drivers of change, for which simulation results from the ongoing hydrological assessment of climate change by MRC's Climate Change Adaptation Initiative were used. It also looked at wild fisheries in the floodplains and rice paddies as well as aquaculture in the Mekong Delta, which together account for a vast majority of the basin's total fish yields.

With regards to wild fish yields, the assessment found that the magnitude of changes is expected to be greater for the floodplains than in the rice paddies. In terms of the cumulative yields from both habitats, small changes are expected in the short term (2030) when development is absent from the scenarios; however, reductions in production become much more significant in the short term when development is considered.

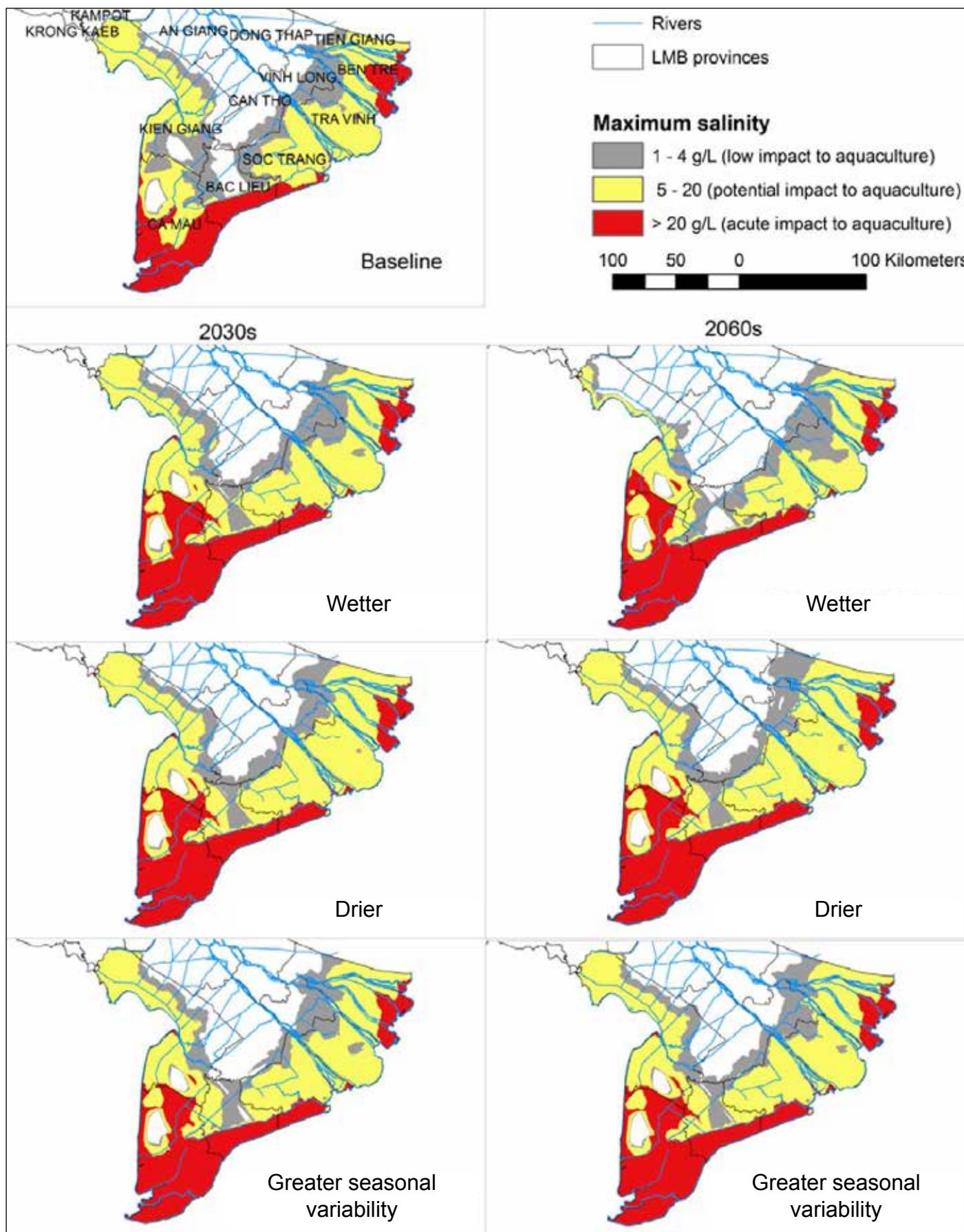
Conversely, this tendency is not as strong when comparing scenarios in the medium term (2060).

With regards to aquaculture, the assessment found that minor changes to current production could be expected despite severe salinity intrusion into the Delta. More than 60% of the current production takes place in four provinces (Dong Thap, An Giang, Can Tho and Vinh Long) that do not experience acute salinity intrusion and, according to the assessment, are not likely to experience acute salt intrusion in the short to medium term. On the contrary, great reductions in production are expected for freshwater aquaculture in Ca Mau Province, most of which will become virtually unfeasible for freshwater aquaculture.

Future adaptation strategies should focus on those areas that were shown to be resilient (and even benefited) by future conditions dictated by climate change and development. In terms of wild fish, rice paddies production appeared to be marginally unaffected by climate driven flooding shifts.

In terms of aquaculture, some of the provinces further up the terrain elevation were shown to be largely unaffected by acute salt intrusion in the future. Thus aquaculture in these (most productive) provinces is likely to remain uncompromised by salinity. Therefore, it is recommended that plans to maintain productivity and enhance the quality of aquaculture in these provinces continue. There are, however, other climate driven factors that could detrimentally affect aquaculture in these provinces, including storm damages, extreme drought and pollution, among others, and future assessments could evaluate their role in the future of aquaculture in the Delta.

* Dr Arias is a post-doctoral research fellow at Harvard University in the United States, Dr So Nam is the MRC Fisheries Team Leader, Mr Ngor Peng Bun is the MRC Capture Fisheries Specialist, Dr Phan is the MRC Climate Change and Adaptation Initiative (CCAI) Team Leader and Mr Vanna is CCAI Technical Officer



Shifts in salt-intrusion zones for medium climate-change sensitivity scenarios with no development

Aquaculture and climate change: from vulnerability to adaptation

In terms of aquaculture, three countries of the Lower Mekong Basin – Cambodia, Thailand and Viet Nam – have been considered to be among the most vulnerable countries in the world to climate change. In this extract from the FAO's annual *State of World Fisheries and Aquaculture* report published in July, we look at possible solutions and the outlook for the sector following the United Nations Conference on Climate Change in Paris at the end of last year.

Climate change will affect food security in Asia by the middle of the 21st century, with South Asia most severely affected. Almost 90 percent of aquaculture production takes place in Asia, most of it in the tropical and subtropical belts. Using a series of indicators of exposure, sensitivity and adaptive capacity in a GIS model, one study identified Bangladesh, Cambodia, China, India, the Philippines and Viet Nam as the most vulnerable countries worldwide. Recently, another study has repeated the exercise with better modelling and data, and concluded that most aquaculture countries in Asia are very vulnerable with Bangladesh, China, Thailand and Viet Nam among the most vulnerable considering all environments (freshwater, brackish-water and marine).

Vulnerability of species and systems

Several different approaches to assessing the vulnerability of species and systems are possible for devising farmer and local-level institutional and structural adaptation strategies. However, the most practical approach is probably to categorize aquaculture units by geography, such as inland, coastal, arid-tropical, and then by farm density and intensity of production. Within the same location and with the same farmed species, it is the combination of technology, farm management practice, and area management that influence a system's vulnerability.

Poor and small-scale stakeholders are less well

Oceans, coastal areas and inland waters

The FAO report says the main drivers of climate change that could have direct or indirect impacts on aquaculture include warming of water bodies, sea-level rise, ocean acidification, weather pattern changes and extreme weather events. The report notes that the Fifth Assessment Report from the Intergovernmental Panel on Climate Change offers evidence of the "certainty" of global warming and of the effects on oceans, coastal areas and inland water bodies. "There is high confidence that coastal systems and low-lying areas will be increasingly exposed to submergence, coastal flooding, coastal erosion, and saltwater intrusion. Most at risk will be the coastal systems," it says.

The report says indirect effects of climate change occur through impacts on feeds, seed, freshwater and other inputs. These include fishmeal fisheries, sources of wild seed and terrestrial feed sources such as soybean, maize, rice, wheat and other crops. Disease can be another indirect impact. The Fifth Assessment Report "recognizes the increased threat of disease to aquaculture under climate change, and many authors have examined the indirect effect of climate change on the spread and occurrence of disease in farmed aquatic organisms and shifts in the distribution of parasites and pathogens."

placed than larger-scale commercial actors to seize opportunities and adapt to threats. Thus, a strong focus should be on building general adaptive capacity that supports poor and small-scale aquaculture producers and value chain actors to make the most of new opportunities and cope with the challenges related to climate change.

Possible solutions

There are practical adaptation measures that can

effectively address climate variability and trends at the farm, local and national levels and even at a global scale. With these measures, fish farmers and other local stakeholders can play a proactive role in addressing both long-term changes/trends and sudden changes (e.g. extreme weather events):

- aquaculture zoning to minimize risks (for new aquaculture), and relocation to less-exposed areas (existing farms);
- appropriate fish health management;
- increasing efficiency of water use, water recycling, aquaponics, etc.;
- increasing feeding efficiency to reduce pressure and reliance on feed resources;
- developing better-adapted seed stock (e.g. tolerance to lower pH, broader salinity resistance, faster-growing strains and species, and other attributes);
- ensuring high-quality, reliable hatchery production to facilitate outgrow in more stressful conditions, and to facilitate rehabilitation of production after disasters;
- improvement of monitoring and early warning systems;
- strengthening farming systems, including better holding structures (e.g. sturdier cages, depth-adjustable cages [for fluctuating water levels], deeper ponds) and management practices;
- improving harvesting methods and value addition.

Some countries are already taking action. For example, in Viet Nam, there are efforts to select for salinity-resistant catfish strains, and in Bangladesh the government and its partners are exploring options such as using salinity-resistant species, deepening aquaculture ponds, using depth-adjustable cages, and integrating fish farming with agriculture.

Outlook

While progress has been made in understanding the vulnerability of aquaculture to climate change,

much more research is needed to identify the driving processes and develop alternative aquaculture approaches and practices accordingly. However, policy-making and planning cannot wait for the improved knowledge. They must proactively address the major challenges based on what is known by developing adaptation strategies to minimize vulnerability to climate change.

Many of the measures required are part of existing best practices for aquaculture. Thus, they entail no major change in direction for stakeholders, but rather a renewed focus on priorities. For example, increased focus is required on climate-resilient aquaculture zoning, ensuring that the farms are located in areas that less exposed or that the farms in more-exposed zones adopt resilience measures (deeper ponds, more resilient strains, etc.).

A practical measure for local-level adaptation is local environmental monitoring. Aquaculture is very sensitive to sudden climate changes as well as to long-term trends. However, beyond some forms of industrial aquaculture, there are very few cases of integrated monitoring systems providing information for fish farmers to use in their decision-making. Simple data collected on a permanent basis (e.g. fish behaviour, salinity and water temperature, transparency and level) can provide a very useful basis for decision-making, especially when changes can have dramatic consequences.

Locally collected and shared information can help farmers to better understand biophysical processes and become part of the solution, e.g. through rapid adaptation measures, early warning, and long-term behavioural and investment changes. To implement such monitoring systems, key activities include training local stakeholders on the value of the monitoring and how to use the feedback for decision-making. It is also necessary to implement a simple network/platform to: receive, share and analyse the information; coordinate and connect with broader forecasts; and provide timely feedback to local stakeholders.

The original article, which appears in the Selected Issues section of the annual report, has been edited for length.

Further reading:

FAO (2016) The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome. 200 pp.

Why the Lao government is interested in fish passage research

In our previous issue, we covered the launch of a new five-year project funded by the Australian Centre for International Agricultural Research (ACIAR) to quantify the biophysical and community impacts of improved fish passage in Lao PDR (see *Catch and Culture*, Vol 22, No 1). This article looks at why the Lao government is interested in such research.

The Mekong River flows through 1,835 km of Lao territory where it has 14 tributaries. Another five rivers in the northeast flow into Viet Nam. These rivers together have a water surface area of 304,704 hectares, about a quarter of the country's water resources for capture fisheries, which are estimated at more than 1.2 million hectares. Other water bodies for wild fisheries are wet-season rice fields, small streams and floodplains (632,850 hectares), shallow lakes, small natural pools, peat swamps and wetlands (114,800 hectares), large hydropower reservoirs (96,030 hectares), irrigation reservoirs and weirs (60,000 hectares) and flooded areas (30,000 hectares). These water bodies include 1,097 hectares of fish conservation zones, established in 149 villages in seven provinces between 2005 and 2011.

According to the Lao Department of Livestock and Fisheries, the highest yields from capture fisheries are from lakes, pools, swamps, wetlands, irrigation reservoirs and weirs along with some hydropower reservoirs (Houy Ho, Nam Leuk and Nam Mang). In these water bodies, each hectare yields about 150 kg of fish a year. That compares with about 133 kg in the Nam Ngum Reservoir, 70 kg in the rivers, 50 kg in rice fields, streams and flood plains and 33 kg in the Nam Theun 2 Reservoir. In aquaculture, annual yields per hectare are about 1,500 kg in ponds, 600 kg in oxbow lakes and irrigation weirs used for aquaculture and 250 kg in rice-fish systems.

Annual consumption of inland fish is estimated at 167,992 tonnes. Lao people consume a further 40,581 of other aquatic animals such as mussels,

snails, turtles, frogs, shrimps and crabs, which are very important but often overlooked in fisheries assessments. The total estimated value is almost \$150 million each year. People still depend on fish and other aquatic animals as their most reliable source of animal protein, especially in rural areas, which account for more than 75 percent of the population. Some 481 fish species have been identified in the country, including 22 exotic species, and more are being discovered regularly. Among other aquatic animals, 37 amphibians, seven crabs and 10 shrimps have been recorded, although these represent only about 15 percent of the estimated total.

A third of the Mekong's discharge

Almost 88 percent of the Lao People's Democratic Republic drains into the Mekong River. The country accounts for about 26 percent of the Mekong Basin and about 35 percent of the river's discharge. Capture fisheries and aquaculture are mainly based on rivers and streams, hydropower and irrigation reservoirs, diversion weirs, small water bodies, flood plains and wet-season rice fields. The total area of water resources for capture fisheries alone is believed to be more than 1.2 million hectares.

Under the National Strategy for Fisheries Management and Development to 2020, the Lao government has put priority on food self-sufficiency to overcome poverty in rural areas and improve nutrition as well as people's economic status. Annual average fish protein intake is projected to rise from the current 24 kg to about 30 kg by 2020. The national strategy aims to ensure the provision of fish products as commodities for local and future export markets, supporting rural development in terms of alleviating poverty, generating incomes and providing complementary sources of cash. The strategy also aims to help reduce slash-and-burn shifting cultivation



Lao government officials meet with local villagers and district officers to discuss the design of an Australian-funded pilot fishway in Pak San District in Bolikhamsay Province in 2012

by integrating fish culture into upland farming systems and contribute to the sustainable use, appropriate management and protection of aquatic resources. In addition, the strategy provides for basic infrastructure for research, management and development of aquatic resources as well as technical support services in research, extension, management and development.

Since it is believed that substantial increases in production from capture fisheries may not be possible, any planned increase in fish production has to come from aquaculture or enhanced fisheries. While ponds and rice fields hold potential for aquaculture, the large number of small and large reservoirs developed in the country hold potential for cage culture and also enhanced fisheries.

This highlights the need for an inventory of Lao water bodies with fisheries management and

development potential such as hydropower and irrigation reservoirs, natural ponds and wetlands. Other needs include assessing indigenous fish species and other aquatic animals, studying the biology and ecology of migratory and endangered species, and also studying river morphology and hydrology such as the relationship between hydrology and fisheries. Other studies may be needed in areas such as socio-economics, management and regulation. Better fisheries information and data are also needed for fish passage design at both high-level and low-level barriers to ensure that designs are fit-for-purpose and meet the needs of all Mekong species.

* The article above is based on a presentation by Sommano Phoumsavath, Director of the Fisheries Division of the Department of Livestock and Fisheries of the Lao Ministry of Agriculture and Forestry, at an inception workshop for the new ACIAR-funded project in Pak San District, Bolikhamsay Province, on April 1. The project is being carried out by the Institute for Land, Water and Society at Charles Sturt University in Australia in collaboration with the University of Laos, the Living Aquatic Resources Research Centre in Vientiane and the University of South Australia.

Does the economic **benefit** of building a **fishway** justify the **cost**?

A benefit-cost analysis will soon let Lao decision-makers choose from at least four options to minimise the impacts of barriers to fish migration: doing nothing, removing barriers to fish migration, building fishways or developing hatcheries to stock fish. The analysis, to be completed in 2018, will be used to determine whether fishways are the best option or whether other more viable options exist.

Floodplains in the Lower Mekong Basin are being developed at an unprecedented rate with flood-control and irrigation systems such as regulators and low-head barriers. Such systems improve rice production and protect crops during seasonal floods. But they also block fish migrating to nursery and feeding habitats. Fishways help mitigate the impacts of barriers to fish migration. But there is no single design that can minimise all impacts or suit all fish species. For example, a fishway may be designed to pass large commercially important fish but not small species or juveniles. Alternatively, it may provide for all species migrating in the first three months of the wet season but not the rest of the year.

'Doing nothing can be even more costly in the longer term'

Many developers argue that the costs of building fishways exceed the benefits. Such arguments are often an excuse to do nothing. But doing nothing can be even more costly in the longer term, as seen on the Columbia River in the United States in the 1950s where no mitigation was considered for any new large dam. The salmon fishery soon collapsed and mitigation options were needed urgently. The resulting investment has cost well over \$7 billion and fishery recovery has been slow.

A new project funded by the Australian Centre for International Agricultural Research (ACIAR) is now planning to perform a benefit-cost analysis for

Not seeing the wood for the trees

Much of the public discussion about fishways in the Lower Mekong Basin in recent years has focused on large hydropower projects with little attention given to barriers to fish migration created by flood-control and irrigation systems. But an ACIAR project between 2010 and 2015 identified over 8,000 barriers to fish migration in just three tributary catchments of the Mekong (Xe Bang Hieng, Xe Champone and Nam Ngum in Lao PDR). Similar developments are progressing in other catchments and have led to sharp declines in capture fisheries in some areas. Flood-control and irrigation systems help river communities earn more stable income from improved rice yields. But they can also take away fishing income and an important source of protein, potentially leading to loss of livelihoods, poorer nutrition and social disruption.

a full range of options to mitigate the impacts of fish migration barriers in Lao PDR. The five-year project was launched in April and is building on earlier ACIAR-funded fishway research (see *Catch and Culture*, Vol 22, No 1). The project will base the analysis on the impact of a pilot fishway on the Pak Peung floodplain in the central Lao province of Bolikhamxay (see *Catch and Culture*, Vol 21, No 2). Decision-makers will then be able to choose from at least four options – doing nothing (with fisheries continuing to decline), removing barriers (with a negative impact on rice production), building fishways (with the Pak Peung fishway as the benchmark for success) or stocking fish (with the cost of building and maintaining a fish hatchery as a proxy for fishway construction).

Benefit-cost analysis (sometimes called cost-benefit analysis) emerged in the 1950s as a formal mechanism for improving choices between public

projects. It is a tool to help decision making, not an immutable truth. Such an analysis comprises four basic steps:

Establishing scope

In terms of flow-on effects, who are the winners and losers at the village, district, provincial and national levels? What will the effects be in 5 years compared with 20 years? The scope for valuing the costs and benefits of a fishway or an alternative needs to be established. Isolating benefits and costs directly and indirectly related to a specific task, while ignoring the impact of transfers, is also necessary to identify resource implications.

Quantifying costs and benefits

There are a number of possible ways to measure

fishway benefits e.g. income from labour (market prices); change in fish (shadow prices valued at market prices); and non-market benefits (environment or social benefits). Fishway costs that need to be considered include construction (materials and labour), depreciation (wear and tear) and cost of capital (irrigation traditionally does not pay for the cost of capital whereas urban water infrastructure sometimes does). Other costs include operations and maintenance, which are likely to vary depending on contractual arrangements with beneficiaries (who may be cheaper than using markets). Each benefit and cost must be assigned a monetary value that includes the opportunity cost (the foregone opportunity of investing in other infrastructure). Where market prices are available, they may be used as proxies for society's valuation.

Return on fishway investment

The annual fish yield from Lao floodplain wetlands is estimated to range from 67 kg to 137 kg per hectare with first-sale values of \$1.00 to \$1.75 per kg. The ACIAR-funded project launched in April aims to validate these figures and show that productivity in rehabilitated wetlands is restored to an annual yield of at least 100 kg per hectare. Fish passage rates will be combined with market rates to quantify actual economic outcomes. Increasing yields to 100-137 kg per hectare is expected to provide recurring annual economic benefits of \$33 to \$123 for each hectare of rehabilitated wetland.

Returns based on Pak Peung wetland of 500 hectares and construction cost of \$150,000

Scenario	Yield increase (per hectare)	First-sale price (per kg)	Annual benefit of fishway (per hectare)	Annual benefit of fishway (500 hectares)	Return on \$150,000 investment*
Wetland rehabilitated to target minimum yield (100 kg/ha/year)	33 kg	\$1.00	\$33	\$16,500	9.1 years
	33 kg	\$1.75	\$58	\$29,000	5.2 years
Wetland rehabilitated to upper estimate yield (137 kg/ha/year)	70 kg	\$1.00	\$70	\$35,000	4.3 years
	70 kg	\$1.75	\$123	\$61,500	2.4 years

* Approximate years to return on initial investment of \$150,000 (without considering discounting)

These increases can be applied over a large area if more fishways are built as planned. For example, the Lao Irrigation Department and World Bank plan to build fishways at more than 10 new sites, which could improve fish passage to about 1,500 hectares of wetlands. Based on the results of the Pak Peung fishway and the most conservative estimates of restoring annual yield to 100 kg per hectare and first-sale fish prices of \$1.00 per kg, fisheries productivity would return a value greater than the cost of a fishway project within nine years. Such a target is realistic but needs to be validated based on catch rates and fluctuating market values. This relates to productive benefits alone and ignores changes to labour availability and non-market benefits related to environmental and cultural values.



Lao government officials, local villagers and district officers inspect the construction site for the fish ladder in the Pak Peung wetland in Pak San District in Bolikhamsay Province. The pilot fishway, completed in 2012 with Australian funding, is now considered a benchmark for success. More than 170 fish species can pass through the structure — well in excess of the 100 species initially expected.

PHOTO: KHAMPHEUNG HOMSOMBATH

Discounting value

Benefits occur over time, along with operating and maintenance costs. Discounting the value assigned to future benefits and costs to compare with present values is required. This allows for incorporating the time value of money. The risk of debate over the best rate and method of discounting can be reduced by using quantitative data from previous work with village and district officers as the main source to estimate various parameters.

Applying decision rule

Only projects where benefits outweigh the costs should be chosen. These should ideally be based on economic merit, with priority on the highest and most positive net benefits. But priorities may change (to benefit the poor or deliver cultural and gender benefits, for example). Applying data to a specific decision rule is the final step of a benefit-cost analysis. Three commonly used decision rules are the maximum net present value criterion, the benefit-cost ratio criterion and the positive net present value criterion.

Benefit-cost analysis for fishways raises specific challenges. Are multiple fishways more effective than single fishways? If so, what does this do to

the benefit-cost ratio? Moreover, the ecological response is critical to capturing benefits in the analysis. At the same time, wider benefits such as cultural and environmental gains or improvements in equity broaden the scope of using innovative non-market valuation techniques.

'The analysis will be used to determine whether fishway construction is clearly the best option or whether other more viable options exist'

The analysis can also be used to compare scenarios where smallholders take varying degrees of responsibility for construction and maintenance. The outcomes of the analysis will be used to determine whether fishway construction is clearly the best option or whether other more viable options exist.

* The article above is mostly based on a presentation by Australian economist Bethany Cooper (Bethany.Cooper@unisa.edu.au) at an inception workshop for the new ACIAR-funded project in Vientiane in March and her other work in preparing the project document. The project is being carried out by the Institute for Land, Water and Society at Charles Sturt University in Australia in collaboration with the National University of Laos, the Living Aquatic Resources Research Centre in Vientiane and the School of Commerce at the University of South Australia Business School where Dr Cooper works as a senior research fellow.



The completed Pak Peung fish ladder downstream from the wetland's regulator in June this year

PHOTO: GARRY THORNCRAFT

Dead fish near Lao dam construction site linked to destructive fishing

By KENT G. HORTLE, SOMPHONE PHOMMANIVONG, YUPAPON SINGSUA AND NAKHONE HOUMPHENG *

In October last year, Don Sahong Power Company awarded a contract to China's Sinohydro Corp to develop, build and commission a hydropower project on a Lao channel of the Mekong River on the border with Cambodia. Three months after construction began in January, the Malaysian-Lao venture received a report from International Rivers, a lobby group based in Berkeley, California. On the Cambodian side of the border, "people are noticing dead fish in the waters that run past their home — lots of them," the report said. "And their numbers are increasing." The company, which is 80 percent owned by Mega First group of Malaysia and 20 percent owned by Electricité du Laos, began an investigation. We reproduce below a summary of a subsequent report released by the company in August.

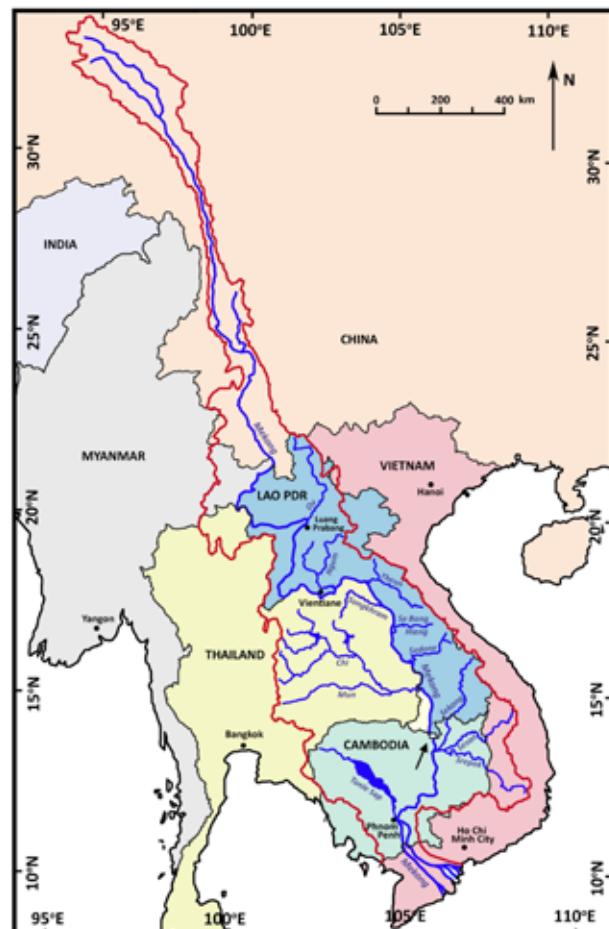
An investigation by staff of Don Sahong Power Company (DSPC) during May and June of 2016 was prompted by reports of dead fish downstream of Khone Falls near the border with Cambodia, and suggestions that the fish deaths were caused by the Don Sahong Hydropower Project (DSHP). The investigation aimed to determine the extent of the problem and its likely cause(s) and to recommend follow-up actions, and included interviews of fishermen, village chiefs and government staff, and some follow-up inspection in the field.

The investigation confirmed that many dead fish were seen in the river at several places at Khone Falls during the 2016 dry season (January to June) in much larger numbers than in 2015 or previous years. All people who were interviewed believe the fish to have been killed by destructive fishing, including use of explosives, poisons and electrofishers. These methods are used in the dry season when the water is clear enough to see



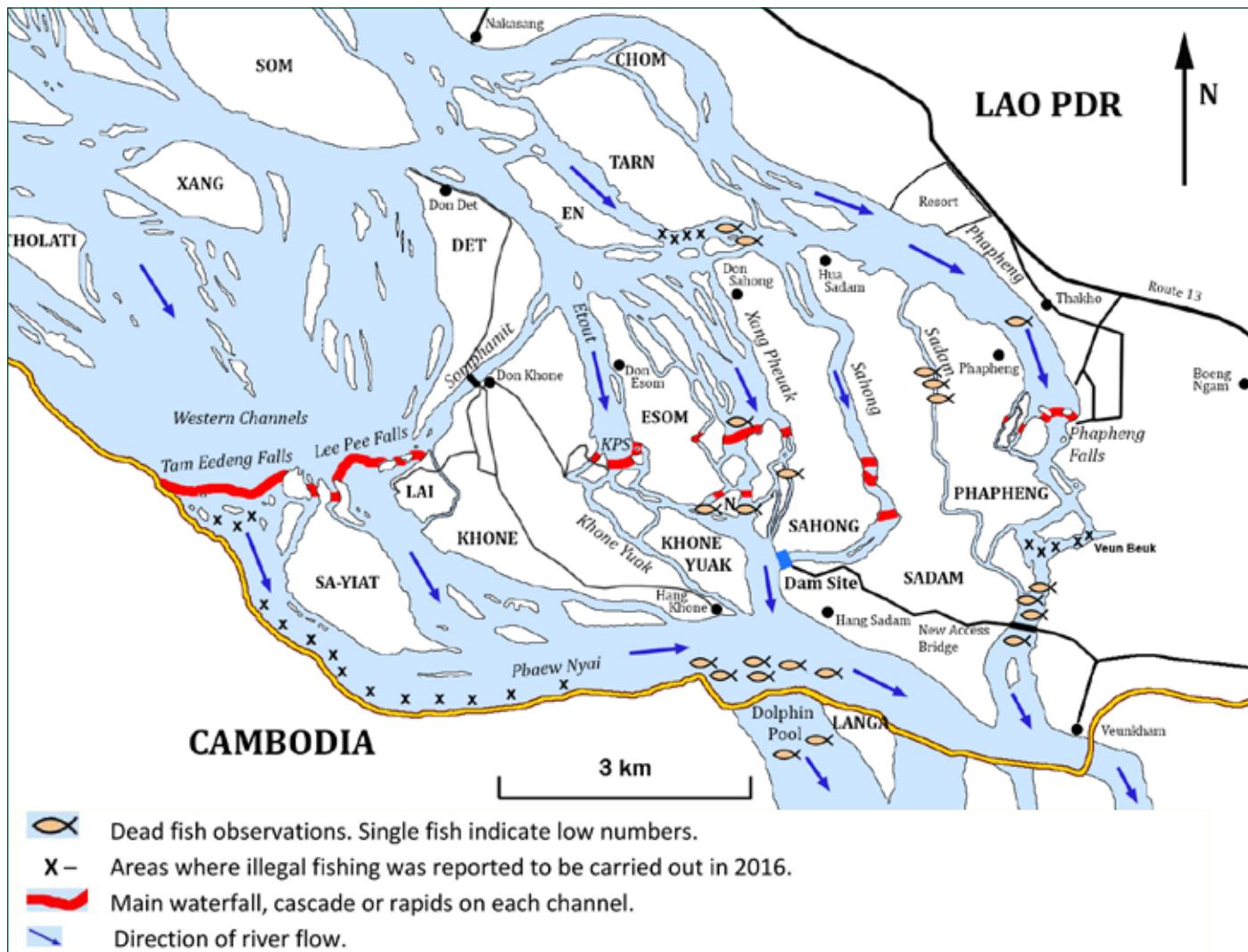
Two dead fish at Phapeng Bridge on May 19

PHOTO: SOMPHONE PHOMMANIVONG



Location of Don Sahong Hydropower Project, indicated by arrow

MAP: KENT G. HORTLE



Location of dead fish and main areas for destructive fishing at Khone Falls in 2016

MAP: LINDEN HORTLE

fish. The three main destructive fishing areas are (1) along the border with Cambodia in the main Mekong channel opposite the DSHP from the dolphin pool up to Tam Eedeng Falls; (2) Phapheng Channel between the new access bridge and the falls; (3) near Don Tarn, an island upstream of Khone Falls. There are no DSPC project activities that could directly result in dead fish at these locations, and no likely natural causes for such fish kills, whereas destructive fishing is an entirely plausible explanation for the fish kills.

Although illegal, destructive fishing is increasing mainly because of strong demand in the dry season from fish traders, who finance and provide people with the equipment to kill fish. Most of the large high-value fish are trucked to Pakse and many are sold in Vientiane and in Thailand. Destructive fishing is relatively quick and efficient compared

to legal methods, so once some people start to do it others tend to join in as they feel disadvantaged. According to interviewed fishers, the apparent increase in destructive fishing in the 2016 dry season is not directly related to the dam construction, but increased road access for outsiders may have exacerbated the increasing trend.

Destructive fishing kills or injures many fish which are not collected and which may then float downstream. Most of the dead fish seen in 2016 appeared to originate from use of rice laced with insecticide, which is fed to fish where they can be seen feeding, primarily targeting medium-sized cyprinids (carps). This is a relatively new method that is dangerous to the users and anybody eating the fish. Some people have reportedly become sick or died in Cambodia after eating poisoned fish. The main poisons are highly toxic carbamate



Seven poisoned fish from Hang Sadam village which were dissected at the company's camp on May 26, 2016 (above) and grains of rice in the mouth of one the fish, a *Hypsibarbus pierrei* (below)

PHOTOS: KENT G. HORTLE



Grains of rice in the gills of a *Hypsibarbus pierrei* from Hang Sadam village (above) and stomach contents (aquatic insect pupae) in the mouth of a *Poropuntius normani*, also from Hang Sadam (below)

PHOTOS: KENT G. HORTLE

Destructive fishing



Site of the Don Sahong Hydropower Plant on the Hou Sahong channel on May 26 (above). The dam site is confined by temporary coffer dams in the dry bed of the channel, so that blasting and excavation cannot affect fish in the river. The illustration below is an artist's impression of the plant overlooking the Cambodian border after completion in 2019.

PHOTO: KENT G. HORTLE ILLUSTRATION: DON SAHONG POWER COMPANY

insecticides, such as carbofuran and methomyl, which are openly and illegally sold in local villages. Fishing with explosives is indiscriminate, but mainly targets large valuable fish in deep water and is believed by Lao fishermen at Khone Falls to be only or mainly carried out by Cambodians who have particular expertise. One expert Lao fisherman believed that most of the fish sold at Khone Falls in 2016 were illegally caught, and 70% of those were from explosive fishing. It was rumoured that some of the explosives used in 2016 may have been stolen from the DSHP, but investigation has found no evidence. It should be noted that storage, handling and control of explosives at the project are subject to stringent controls. It is possible that the perpetrators may have created false stories to hide the actual sources, as there are other sources of explosives in Laos and many people know how to make them. For example, some Laotians were reportedly killed or injured recently while using explosives for fishing near Pakse, about 150 km upstream of Khone Falls. Electrofishers are made and sold locally in Nakasang, and many fishermen have used them, although in 2016 there was little specific information obtained on their use.

'Destructive fishing is carried out by Lao and Cambodian fishermen on both sides of the border'

Destructive fishing is carried out by Lao and Cambodian fishermen on both sides of the border and sometimes acting collaboratively in Laos. Fishermen from each country have been arrested and fined and their gear confiscated on both sides of the border for using these methods, but in Laos most of the perpetrators caught recently have been upstream of the falls, where they are more likely to be seen and reported.

To reduce the use of destructive methods, we recommend improved education, inspection and enforcement by the Don Sahong Fisheries Management Committee (DSFMC) to begin well before the 2017 dry season, when these activities are likely to recur. The committee during 2016 demonstrated its ability to act effectively by destroying large illegal gears, so with ongoing support it should also be able to reduce the incidence of destructive fishing. Inspection and enforcement should focus on the three main

Editor's note

According to the authors, the apparent increase in numbers of dead fish at Khone Falls is unlikely to be a direct result of building the Don Sahong Dam. Readers should note, however, that it's likely that some fish would have accumulated downstream of the site as the main alternative route for fish migrating upstream — Xang Pheuak Channel — was itself blocked by coffer dams for fish-passage works until May 2016 (see map on page 23). So fish trying to migrate upstream may have accumulated in Pbaew Nyai Channel and become a target for fishers using destructive methods. Have dam works contributed to at least some fish deaths? We can't dismiss the possibility. The lesson here is that fish-passage mitigation measures should be up and running before dam construction begins.

fishing areas identified, especially the two areas downstream of the falls. The committee also needs to work with the agencies responsible for controlling the sale of explosives, electrical equipment and poisons, and should inform the Ministry of Health to educate people on health risks, and should provide materials to schools and temples so they can educate people not to use these methods and not to buy fish caught using these methods.

Aside from its ongoing support to the DSFMC, the company also needs to communicate clearly with its staff and contractors on their obligations to restrict access to explosives and to not engage in or abet other illegal activities including destructive fishing, and to report any offenders to the police. The company also needs to improve its communications with local people and internal reporting of significant issues as they arise so they can be addressed effectively.

Further reading

Hortle, K.G., S. Phommanivong, Y. Singsua and N. Houmepheng (2016) Fish kills at Khone Falls in the dry season of 2016. Don Sahong Power Company (dshpp.com), Vientiane.

* Mr Hortle is an independent advisor to Don Sahong Power Company and Mr Somphone is leader of the company's fisheries team. Ms Yupapon and Mr Nakhone are members of the team's technical staff.

Global plan aims to confront 'silent crisis' of antimicrobial resistance

With intensified FAO engagement on drug resistance in several countries including Cambodia, Thailand and Viet Nam, the UN agency aims to develop national action plans by mid-2017

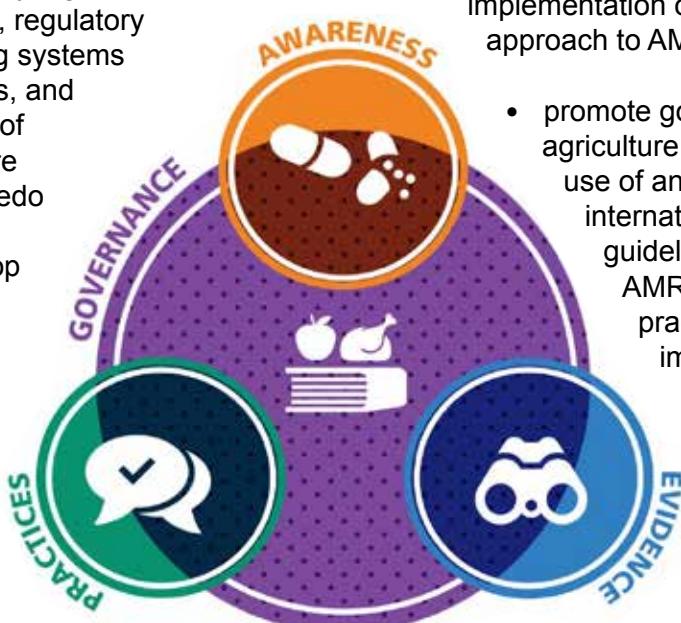
Maria Helena Semedo, deputy director-general of the Food and Agriculture Organisation of the United Nations (FAO), warned in February that antimicrobial resistance (AMR) was becoming a "global threat" requiring an international effort to counter the risks to food security (see *Catch and Culture*, Vol 22, No 1). In September, the FAO published an AMR action plan for 2016 to 2020 focussing on awareness, surveillance and monitoring, governance and good practices. In a foreword to the publication, Semedo wrote that antimicrobial drugs played a "critical role" in treating diseases of aquatic and terrestrial farm animals and plants. "Their use is essential to food security, to our well-being, and to animal welfare," the former Portuguese fisheries minister said. "However, the misuse of these drugs, associated with the emergence and spread of antimicrobial resistant micro-organisms, places everyone at great risk."

"The risk appears particularly high in countries where legislation, regulatory surveillance and monitoring systems on the use of antimicrobials, and the prevention and control of antimicrobial resistance, are weak or inadequate." Semedo said the objective was to help member states develop national action plans to combat AMR by May next year, noting that the FAO was working closely with the World Health Organization and the World Organization for Animal Health. "We must confront the silent crisis of antimicrobial

resistance together," she said.

The four focus areas of the action plan are to:

- improve awareness on antimicrobial resistance and related threats (improving awareness on AMR among food and agriculture stakeholders and integrating consideration of AMR into policy-level discussions on food and agriculture);
- develop capacity for surveillance and monitoring of antimicrobial resistance and antimicrobial use in food and agriculture (improving knowledge on AMR and antimicrobial use in the food and agriculture sectors, improving laboratory capacity on AMR and antimicrobial residue monitoring and developing country-specific integrated surveillance and monitoring systems for antimicrobial use);
- strengthen governance related to antimicrobial use and antimicrobial resistance in food and agriculture (providing information in support of improved policy and decision-making, developing and revising regulatory frameworks supported in line with internationally agreed principles and standards, and enhancing implementation of an integrated "one health" approach to AMR);
- promote good practices in food and agriculture systems and the prudent use of antimicrobials (adopting international standards and guidelines relevant to addressing AMR and applying good practices at country level, improving awareness and knowledge on approaches to prudent and responsible use of antimicrobials in the food and agriculture sectors and improving biosecurity, good



FAO ACTION PLAN FOCUS AREAS		GLOBAL ACTION PLAN OBJECTIVES
	AWARENESS	 GOVERNANCE
	EVIDENCE	 GOVERNANCE
	PRACTICES	 GOVERNANCE
	PRACTICES	 GOVERNANCE
	PRACTICES	 GOVERNANCE

practices and other measures to support prudent use of antimicrobials throughout the food chain at country level).

In a statement accompanying the publication, the FAO said it had been intensifying its engagement with farming communities, public health and veterinary specialists, regulators and food safety inspectors on AMR with workshops in several countries including Cambodia, Thailand and Viet Nam. "FAO is stressing that the fundamental way to address AMR in food and agriculture is to ensure that farm and food systems adhere to best practices for hygiene, biosecurity, and animal care and handling," the statement said. "This reduces the need for antimicrobial medicines in the first place - as does vaccinating farm animals to build their natural ability to withstand disease."

The statement noted that the use of drugs to treat sick animals and prevent diseases from spreading had increased with the intensification of food production systems over the past 50 years and had expanded from the livestock sector to aquaculture. "In some cases – albeit to a lesser degree – antimicrobial substances are spread on plant crops," it said. "Additionally, antimicrobials are added in low concentrations to animal feed

as a way to stimulate growth – a practice that is increasingly discouraged but still relatively common."

Microbes are microorganisms that include bacteria, fungi, viruses, and parasites. While resistance can occur naturally, it has been exacerbated by inappropriate and excessive use of antimicrobials. Factors include lack of regulation and oversight of use, poor therapy adherence, non-therapeutic use, over-the-counter or internet sales and the availability of counterfeit or poor-quality antimicrobials. Consequences include the failure to successfully treat infections, leading to increased mortality, more severe or prolonged illness, production losses and reduced livelihoods and food security. The FAO action plan estimates the health consequences of AMR at 10 million human fatalities a year and economic costs at 2 to 3.5 percent decrease in global gross domestic product (GDP), or \$100 trillion by 2050. "But the true cost of AMR is hard to predict," it says.

Further reading:

Food and Agriculture Organization of the United Nations (2016) The FAO Action Plan on Antimicrobial Resistance 2016-2020. FAO, Rome.

Dolphin calf spotted in Mekong

But 'massive threats' are seen putting critically-endangered juvenile at risk

The Cambodian branch of the World Wide Fund for Nature announced in July that it had spotted a mother Irrawaddy dolphin (*Orcaella brevirostris*) with a newborn calf in Kampi Pool on the banks of the Mekong River in northeast Cambodia. The pool, located around 15 km north of Kratie, is home to around 20 of the last remaining 80 Irrawaddy dolphins in Cambodia. Freshwater populations of this species are classified as critically endangered and are limited to only three rivers — the Mekong (Cambodia and Lao PDR), the Ayeyarwady River (Myanmar) and the Mahakam River (Indonesia). The dolphin, which can grow to up to 2.75 metres and 150 kg, is also found in coastal seas from Borneo to India where it is classified as vulnerable. In Cambodia, the dolphins are now concentrated in nine deep pools over a 190 km stretch of the Mekong north of Kratie to the Lao border.

Gestation period estimated at 14 months

According to WWF, Irrawaddy dolphins reach adult size at 4-6 years of age, and sexual maturity at 7-9 years. Females give birth to one calf every 2-3 years after a gestation period estimated to be 14 months. A newborn calf is around one metre long and weighs around 12 kg. It starts suckling 12 hours after birth and begins eating dead fish at six months. By two years, the calf is fully weaned and begins catching food for itself. In their first seven months, captive calves increase in length by over half a metre and 33 kg in weight.

In its announcement in July, WWF said the last remaining Cambodian dolphins face "massive threats" including illegal fishing with electroshock devices, poisons, explosives and nylon gill nets. Such practices have increased over the last 40 years, hurting both fish populations and dolphins accidentally caught and killed as by-catch. "Legal fishing with small-meshed nylon nets can also create problems for both dolphins and people, as unchecked overfishing is depleting fish stocks both depend on for food. Dams and irrigation systems destroy fish habitat and block migration to spawning grounds, further hurting

fish populations," WWF said. "Pesticides, heavy metals, plastic particles and other contaminants from industry, agriculture, and towns can also endanger the dolphins' lives."

"All these threats put the new baby at risk," WWF said, noting that the dolphins were dying at a rate that put the population's long-term survival in danger. In 2015, WWF researchers observed a 2.4% annual mortality rate among adult dolphins. For the long-term survival of small populations, the mortality rate should not be higher than 1 – 2% (see *Catch and Culture*, Vol 21, No 3).

River guards

In Kratie Province, WWF has established community fish conservation zones in 10 villages across 4 communes in Sambor District. Fishing in these areas, usually key spawning grounds, is forbidden to minimise overfishing and give fish stocks a chance to recover – benefitting both dolphins and fishermen. WWF says it has also supported the creation of many new sign posts on swimming rafts around the dolphin pools, making it clear that fishing in and around the pools is strictly prohibited by law.

To enforce these laws, WWF and the Cambodian Fisheries Administration support 68 river guards based in 16 outposts in Kratie and Stung Treng provinces. The river guards, mostly local villagers, patrol the core dolphin habitat and buffer zones to stop illegal fishing. WWF provides equipment and training to help them conserve the dolphins. The river guards date back to 2006 when they received initial training from a Korean Navy Seal and a Cambodian Navy trainer supported by the Council of Ministers (see *Catch and Culture*, Vol 12, No 3).

Today, WWF also conducts conservation programs in schools and villages, holds community meetings and workshops, and helps promote sustainable tourism in the region. "Tourists can help give the new dolphin baby a chance by visiting the eco-tourism project in Kratie – dolphin sighting is almost guaranteed for tourists visiting the province and it's not far away from Cambodia's capital," WWF said.

Fig. 1

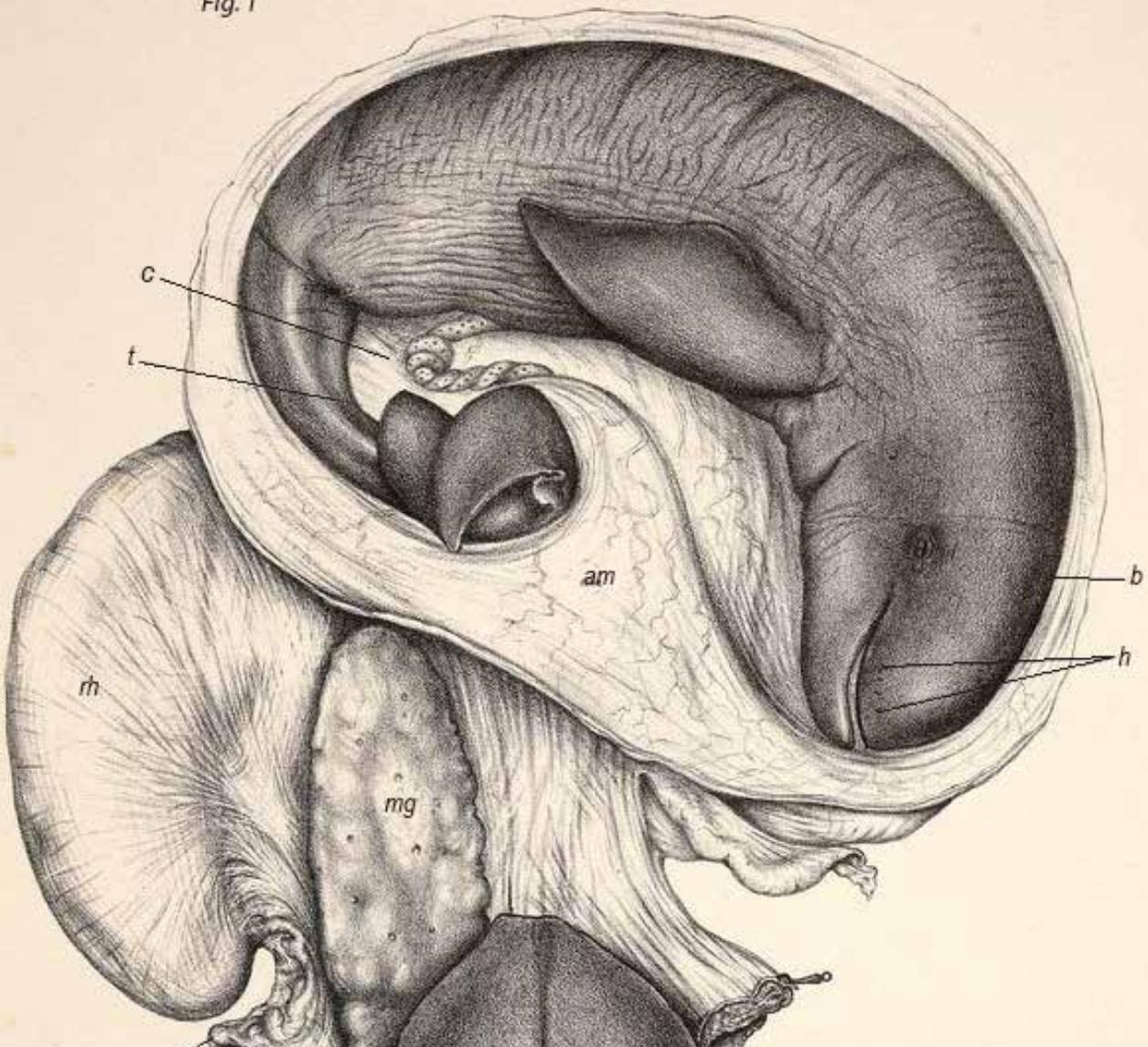


Fig. 2

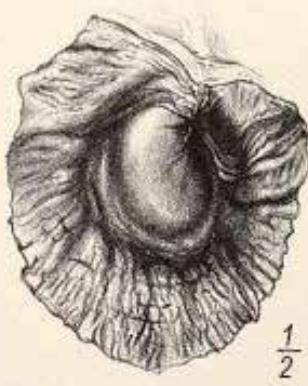
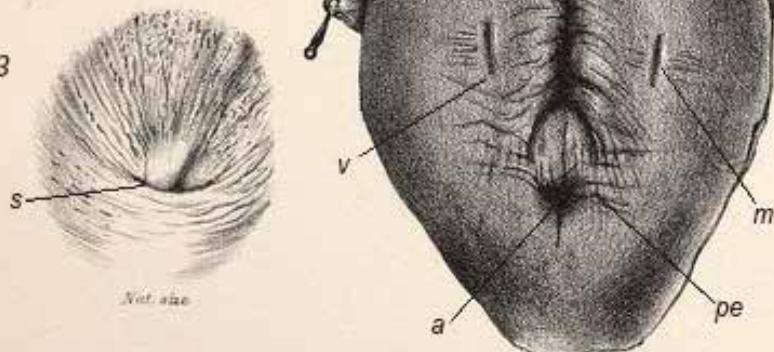


Fig. 3



Genitalia and foetus in utero of an Irrawaddy dolphin, as described by John Anderson, superintendent of the Indian Museum in Calcutta, in 1878 (see page 35). Fig. 1: **rh**: the empty right horn of the uterus, the left is opened, exposing the young animal in situ and bent upon itself; **am**: amniotic sac; **c**: umbilical cord; **t**: tail twisted in a corner of the folds of the cavity; **c**: umbilical cord; **b**: position of blow-hole; **h**: hairs or bristles of snout; **mg**: mammary gland uncovered; **m**: external mammary slit, the nipple being hidden in the slit; **v**: vulval cleft; **pe**: perineum; **a**: anus; **f**: fallopian tube and **fm**: its fimbriated extremity. Fig. 2: Sketch of the os uteri internum (internal opening of the cervical canal into the uterus) of gravid *O. brevirostris*. Fig. 3: The intrauterine surface and opening of the fallopian tube of the same cetacean.

LITHOGRAPH: C. BERJEAU (1878)



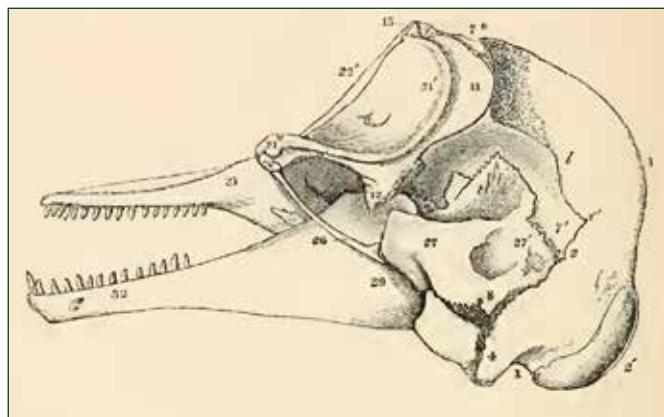
Dolphin calf with its mother in Kampi Pool on the banks of the Mekong River in Kratie Province in northeast Cambodia in June
PHOTO: © LOR KIMSAN/WWF-CAMBODIA



A brief **history** of recorded **descriptions** of the Irrawaddy **dolphin**

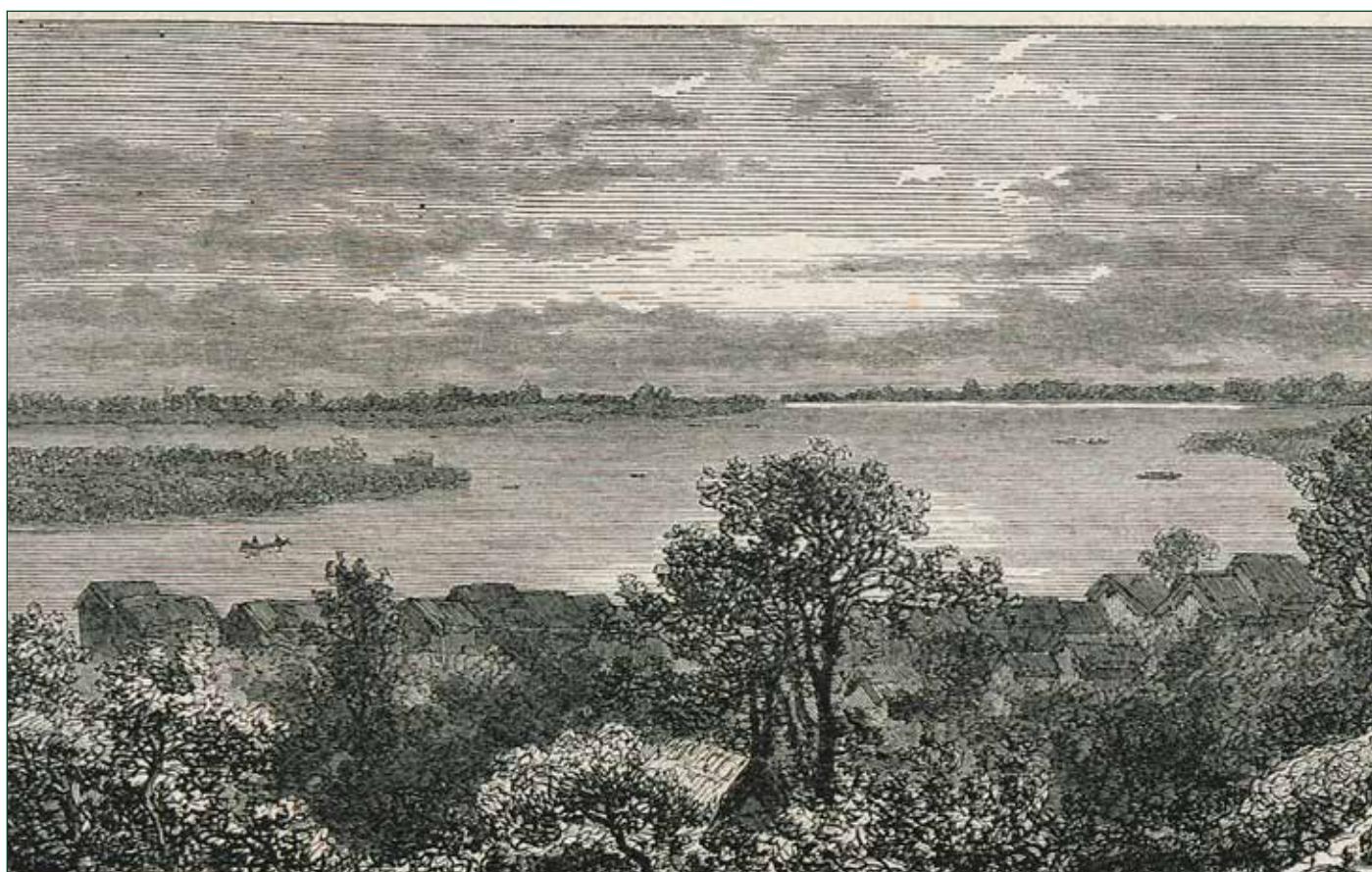
**Although first described 150 years ago,
the behaviour of the Irrawaddy dolphin
is still not well understood**

The Irrawaddy dolphin takes its name from the British colonial spelling of the Ayeyarwady River, the largest river in Myanmar. The earliest reference to dolphins in the river is believed to be in a Chinese text from about 800 which mentions trade in "river pigs" among the Pyu people (Smith, 2004). More than one thousand years later, English biologist Richard Owen, the first supervisor of the British Museum's natural history departments, described the species in a catalogue published in 1866. The description was



Skull illustration that accompanied the first description of the species published in 1866

SOURCE: BRITISH MUSEUM



Confluence of the Tonle Sap River (foreground) and the Mekong River in Phnom Penh as depicted by French explorer Henri Mouhot in the mid-19th century

SOURCE: BIBLIOTHEQUE NATIONALE DE FRANCE



Chinese writer Ouyang Xiu, who oversaw the production of the New Book of Tang which referred to trade in "water pigs" among the Pyu people who inhabited present-day Upper Myanmar. The book is a biographical history of the Tang Dynasty from 618 to 906.

based on the skull of an animal "cast ashore in a decomposed state" from a harbour on the east coast of India. According John Edward Gray, the author of the catalogue, the animal resembled a blunt-headed dolphin. But the British zoologist found that the soft muzzle and some bone characteristics indicated a new species (Gray, 1866).

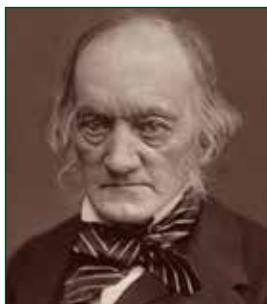
The first published record of the dolphin in the Mekong is believed to be in the memoirs of French explorer Henri Mouhot published two years later. He described "troops of porpoises jumping out of the water and running with their noses in the air" during a voyage along the Mekong from Phnom Penh to Kampong Cham in 1859 (Mouhot, 1868).

'Two dolphins from the Calcutta area described by English zoologist Edward Blyth in 1852 and 1859 were adolescents of the same new species described by Owen in 1866 and not newly born whales as Blyth had mistakenly supposed'

But it was not until 1878 that John Anderson, superintendent of the Indian Museum in Calcutta and professor of comparative anatomy at Calcutta Medical College, published the first detailed

anatomical description of the species, running to almost 50 pages. The Scottish doctor served as medical officer on two British expeditions to Upper Myanmar (then known as Burma) and Western Yunnan in China in 1868 and 1875. Based on three specimens collected on the expeditions, Anderson found that the anatomy of the small round-headed dolphin corresponded to that of *Orcella fluminalis* described in 1871 but concluded that they were "two distinct species" of freshwater and marine dolphins under the same genus. He also asserted that two dolphins from the Calcutta area described by English zoologist Edward Blyth in 1852 and 1859 were adolescents of the same new species described by Owen in 1866 and not newly born whales as Blyth had mistakenly supposed (Anderson, 1878).

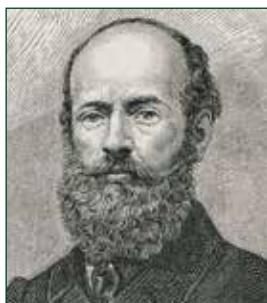
Anderson also described dolphin behaviour along the Irrawaddy River. "The Irawady (sic) dolphin has much the characters of its marine fellows, being generally seen in small schools which frequently accompany the river steamers, careering in front and alongside of them, as is the custom of dolphins of the sea," he wrote. "Occasionally, however, a solitary individual may be observed, but this is the



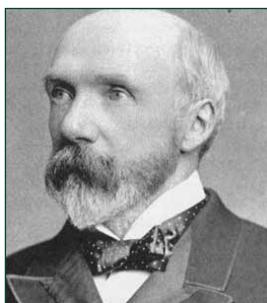
Sir Richard Owen



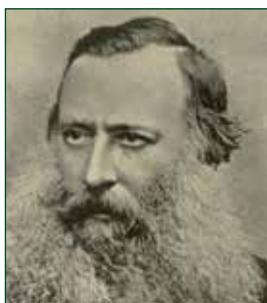
John Edward Gray



Henri Mouhot



John Anderson



Edward Blyth

Dolphin sightings on the Irrawaddy River in the 19th century

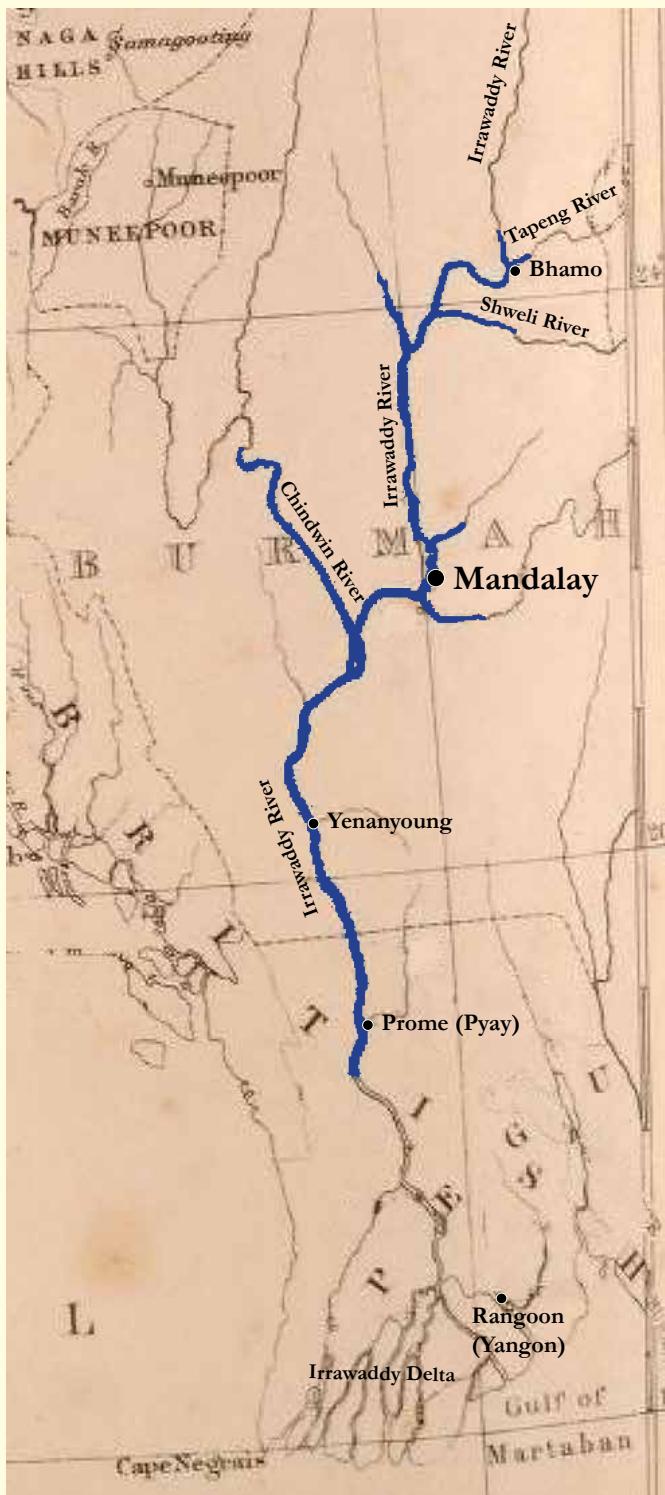
John Anderson, the Scottish medical doctor based in Calcutta, twice sailed up the Irrawaddy River from Rangoon, with the upward voyages in December and January. He returned in September, October and March so his observations of the Irrawaddy dolphin were when the river was at its highest and lowest levels. "In no instance have I seen a single example of this dolphin in the delta of the river," he wrote. "The lowest point at which I saw it on my first visit was in the deep water immediately below Prome (Pyay), where the course of the river is well defined by high banks.

"On my second voyage, although a constant outlook was kept, dolphins were not met with until the steamer had reached Yenanyoung, about one hundred miles above Prome. After the first dolphins had been encountered, they were seen almost daily in the deep reaches of the river as far as our destination, Bhamo, which is about 550 miles in a straight line from the sea, and about 800 miles by the windings of the river.

"The Tapeng, which flows down from the high Chinese valleys to the east of Bhamo, joins the Irrawaddy about a mile above the town, and at the mouth of the Tapeng many dolphins of all ages are generally to be seen disporting themselves in the long deep reach of the Irrawaddy that occurs there.

"But during the rains, when the Tapeng (Taping) and the other affluents of the great Burmese river, such as the Khyendwen (Chindwin) and Shuaylee (Shweli), are in flood, they are ascended by these dolphins. They are also numerous in the deep channels of the lower and middle defiles, and indeed may be generally observed in the majority of the deep reaches.

"The Shans of Upper Burma assert that the dolphins are not to be found beyond a point thirty miles above Bhamo, where the course of the river is interrupted by rocks, and which they style Lahine, or Dolphin Point, from the circumstance that, according to them, it is the residence of certain Nats, who there impose so heavy a toll on dolphins as to deter them from proceeding upwards."



Distribution of Irrawaddy dolphin in blue based on Anderson's two voyages along the river in 1868 and 1875. The superintendent of the Indian Museum of Calcutta and his "zoological collectors" observed the species from below Pyay to the mouth of the Tapeng River above Bhamo. Surveys by the Wildlife Conservation Society between Mandalay and Bhamo in 2003 and 2004 indicated a population of 59-72 individuals.

MAP: LITHOGRAPHIC BRANCH, SURVEYOR GENERAL'S OFFICE, CALCUTTA. REDRAWN BY CHHUT CHHEANA.

exception, as two or three are usually associated together, hence this may be considered as a gregarious form."

'It requires a very expert marksman to take aim and fire before the animal disappears'

Near Bahmo in the northernmost part of Burma, "numerous troops of dolphins may be observed passing up and down, rising every minute or two to the surface to emit the short blowing sound, which ends in the more feeble one of inspiration, and all night through this sound may be heard. They never leave the deep water, and when they rise to breathe (which they do in periods varying from 70 to 150 seconds, although occasionally exceeded) the blow-hole is first seen, then at the end of inspiration the head disappears and the back comes into view, and is gradually exposed as far as the dorsal fin, but the tail flippers are rarely visible. The act of breathing is rapid, so much so indeed that it requires a very expert marksman to take aim and fire before the animal disappears.

"I have observed some of them disporting themselves in a way that has never yet been recorded of Cetacea, as far as I am aware. They swam with a rolling motion near the surface, with their heads half out of the water, and every now and then nearly fully exposed, when they ejected great volumes of water out of their mouths, generally straight before them, but sometimes nearly vertically.

'Fishermen believe that the dolphin purposely draws fish to their nets, and each fishing village has its particular guardian dolphin which receives a name common to all the fellows of his school'

"The sight of this curious habit at once recalled to me an incident in my voyage up the river when I had been quite baffled to explain an exactly similar appearance seen at a distance, so that this remarkable habit would appear to be not uncommonly manifested. On one occasion I noticed an individual standing upright in the water, so much so that one-half of its pectoral fins was

exposed, producing the appearance against the background as if the animal was supported on its flippers. It suddenly disappeared, and again, a little in advance of its former position, it bobbed up in the same attitude, and this it frequently repeated. The Shan boatmen who were with me seemed to connect these curious movements with the season — spring — in which the dolphins breed."

Anderson found that the dolphins seemed to feed exclusively on fish. "The fishermen believe that the dolphin purposely draws fish to their nets, and each fishing village has its particular guardian dolphin which receives a name common to all the fellows of his school," he wrote. "It is this superstition which makes it so difficult to obtain specimens of this Cetacean." Indeed, Anderson got the impression from Edward Sladen, the British Political Resident in Mandalay who led the first expedition to Western Yunnan in 1868, that the dolphins were so revered by fishermen that they were sometimes the subject of lawsuits. "Colonel Sladen has told me that suits are not unfrequently brought into the Native Courts to recover a share in the capture of fish, in which a plaintiff's dolphin has been held to have filled the nets of a rival fisherman," he wrote.

According to a guide since published by the Food and Agricultural Organization of the United Nations, the dolphin is sometimes confused with finless porpoises and dugongs. Unlike these species, however the Irrawaddy dolphin has a fin on its back (see page 40). The fin is small and triangular, with a bluntly rounded tip, and is set just behind middle of the back. And unlike most dolphins, the blowhole is open toward the front (Jefferson *et al.*, 1993).

The reproductive behaviour of the species is not well understood. Seven years ago, however, a group of scientists led by Louisa Ponnampalam, a research fellow at the Institute of Ocean and Earth Sciences at the University of Malaya, observed the mating behaviour of coastal Irrawaddy dolphins during an aerial survey over the Gulf of Thailand (see pages 38-39). Two were seen pursuing each other for about two minutes near the Thai town of Khlong Yai near the Cambodian border. One was swimming belly-up while the other was swimming towards it before both aligned their bodies belly-

continued on page 41 ...



1



2



3



4

Scientists observed this pair of Irrawaddy dolphins mating during an aerial survey of coastal waters near the Thai town of Khlong Yai in Trat Province near the Cambodian border in March 2009. The two dolphins pursued each other for about two minutes. One individual was swimming belly-up while the other was swimming towards it before both individuals aligned their bodies belly-to-belly to copulate.

PHOTO: SOMCHAI MONANUNSAW



The copulation of the two dolphins lasted 40 seconds before the pair separated and swam away in opposite directions

PHOTO: SOMCHAI MONANUNSA

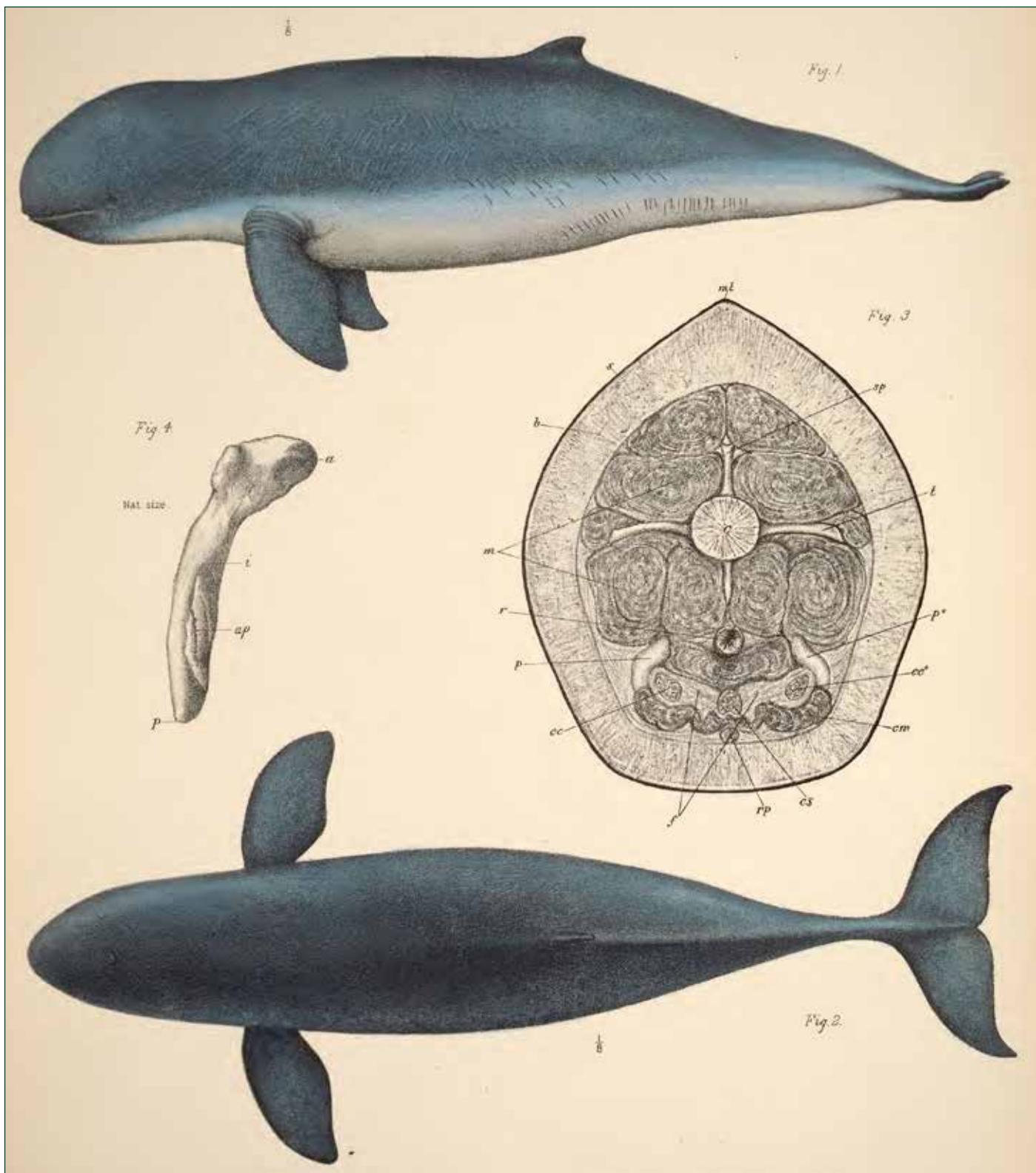


Fig. 1: Male Irrawaddy dolphin caught near Bhamo in northern Burma in June, 1876. **Fig. 2:** A bird's eye or dorsal view of the same animal. **Fig. 3:** A transverse section through the trunk of the male cut in a vertical line with the pelvic bones – **ml**: mesial line of back; **s**: skin; **b**: blubber; **sp**: spinous process of vertebra; **c**: centrum; **t**: transverse process; **m**: muscles of upper and lower parts of body; **pp***: right and left pelvic bones; **r**: rectum cut through; **cc**, **cc***: commencement of the right and left corpora cavernosa; **cs**: corpus spongiosum near commencement; **rp**: the retractor penis muscle cut across; **f**: fibrous connections of the corpora cavernosa and attached to the pelvic bones. **Fig. 4:** The right pelvic bone viewed on its under aspect – **a**: anterior end of bone; **p**: posterior extremity; **i**: inferior aspect; **ap**: place of attachment of penis.

LITHOGRAPH: C. BERJEAU (1878)

from page 37 ...

to-belly to copulate. This lasted 40 seconds before the pair separated and swam away in opposite directions (Ponnampalam *et al.*, 2013).

The scientists also observed large groups of up to 30 Irrawaddy dolphins off the coast of Trat Province engaging in intense social behaviour that appeared to be herding with probable mating during an aerial survey in 2004 and boat surveys in 2008 and 2009 as well as 2012 and 2013. Throughout these activities, which lasted about 20 to 60 minutes, a dolphin apparently in the centre of a group seemed to be trying to swim away only to be blocked by individuals surrounding it. These animals were seen swimming belly-to-belly and intertwining with each other, indicating copulation attempts. Once these activities subsided, the dolphins dispersed into smaller groups which submerged for as long as 5 minutes and surfaced unpredictably. Such behaviour has also been observed among 13 Irrawaddy dolphins in Kalimantan in Indonesia, large aggregations of up to 20 individuals in Kuching in Malaysia and even larger group sizes in Chilika Lagoon in India (Ponnampalam *et al.*, 2013)

According the Cambodian branch of WWF, Irrawaddy dolphins in the Mekong are slow, leisurely swimmers and are shy by nature, which makes them avoid boats. They are not particularly active or acrobatic but do make low leaps on occasion. They are usually seen while surfacing, with the head appearing and disappearing first followed by the back. The tail is rarely seen.

They typically dive for less than two minutes, but dive times are longer when the animal is frightened. The maximum dive time recorded is 12 minutes, and the maximum swimming speed recorded is 25 km/hr. The dolphins are usually seen in small groups, which usually consist of fewer than six individuals but which may contain as many as 10-15 animals. WWF has found that the general behaviour of Irrawaddy dolphins suggests they spend most of their time feeding.

In 2005, scientists proposed the Australian population of Irrawaddy dolphins be recognised as a new species *Orcaella heinsohni*, with Australian snubfin dolphin as the suggested common name. The proposal to split the species into two was

based on range and differences such as the height of the dorsal fin, the presence or absence of a groove in front of the fin and coloration. Analysis of genetic data indicated two clades within Asian samples — those from the Mekong River and those from all other marine and freshwater sites in Thailand, Indonesia and the Philippines. The major separation was, however between sites in Asia and those from Australia (Beasley *et al.*, 2005).

Today, the IUCN Red List of Threatened species considers the Australian snubfin dolphin as "near threatened" whereas the Irrawaddy dolphin is considered "vulnerable" except for five subpopulations including the freshwater dolphins in the Mekong, Ayeyarwady and Mahakam rivers. These are listed as "critically endangered" as are the two other subpopulations in Malampaya Sound in the Philippines and Songkhla Lake in Thailand.

Further reading

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Smith, B.D. (2004) *Orcaella brevirostris* (Ayeyarwady River subpopulation). The IUCN Red List of Threatened Species 2004: e.T44556A10919593. <http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T44556A10919593.en>. Downloaded on 18 August 2016.

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Hydropower developer tests audio system to deter fish from turbines

BY KENT G. HORTLE, SOMPHONE PHOMMANIVONG, YUPAPON SINGSUA AND NAKHONE HOUMPHENG *

The turbines of the Don Sahong Hydropower Plant may be a threat to some of the fish migrating downstream from Lao waters into Cambodia when the plant starts operating in 2019. With the prospect of fish deaths and injuries from blade strikes, the Don Sahong Power Company has been testing a 160-decibel siren to deter various species from swimming near the turbines. Below are extracts from the company's report on a preliminary trial, indicating promising results for selected catfishes and carps.

The Don Sahong Hydropower Plant is being constructed from 2016 to 2019 on one channel of the Mekong River at Khone Falls in southern Lao PDR. Once the project is completed, fish that are migrating downstream may pass through the turbines of the DSHP where they are at risk of being injured or killed. Mitigation of this impact entails either excluding fish by screens, deterring them by behavioural barriers, or by some combination of screening and deterrence. Acoustic fish deterrence (AFD) systems are behavioural barriers which have been applied at several projects elsewhere. In the Mekong fishers use various devices to scare fish into their gears (see box opposite), so acoustic deterrence of fish into alternative channels has potential at this site.

This brief study tested the response of fish to underwater sound during March 2015 in a disused pool at Phapheng Resort, near Khone Falls in Lao PDR. A 'fish house' was placed in the deepest point of the pool to provide shelter and attract fish so they could be exposed to sounds and their responses observed and filmed. Underwater speakers were powered via a control box to produce a rising and falling output (siren) up to 160 decibels, within pre-set frequency ranges. Three common species of Mekong catfishes and four species of cyprinids (carps) were tested as well as

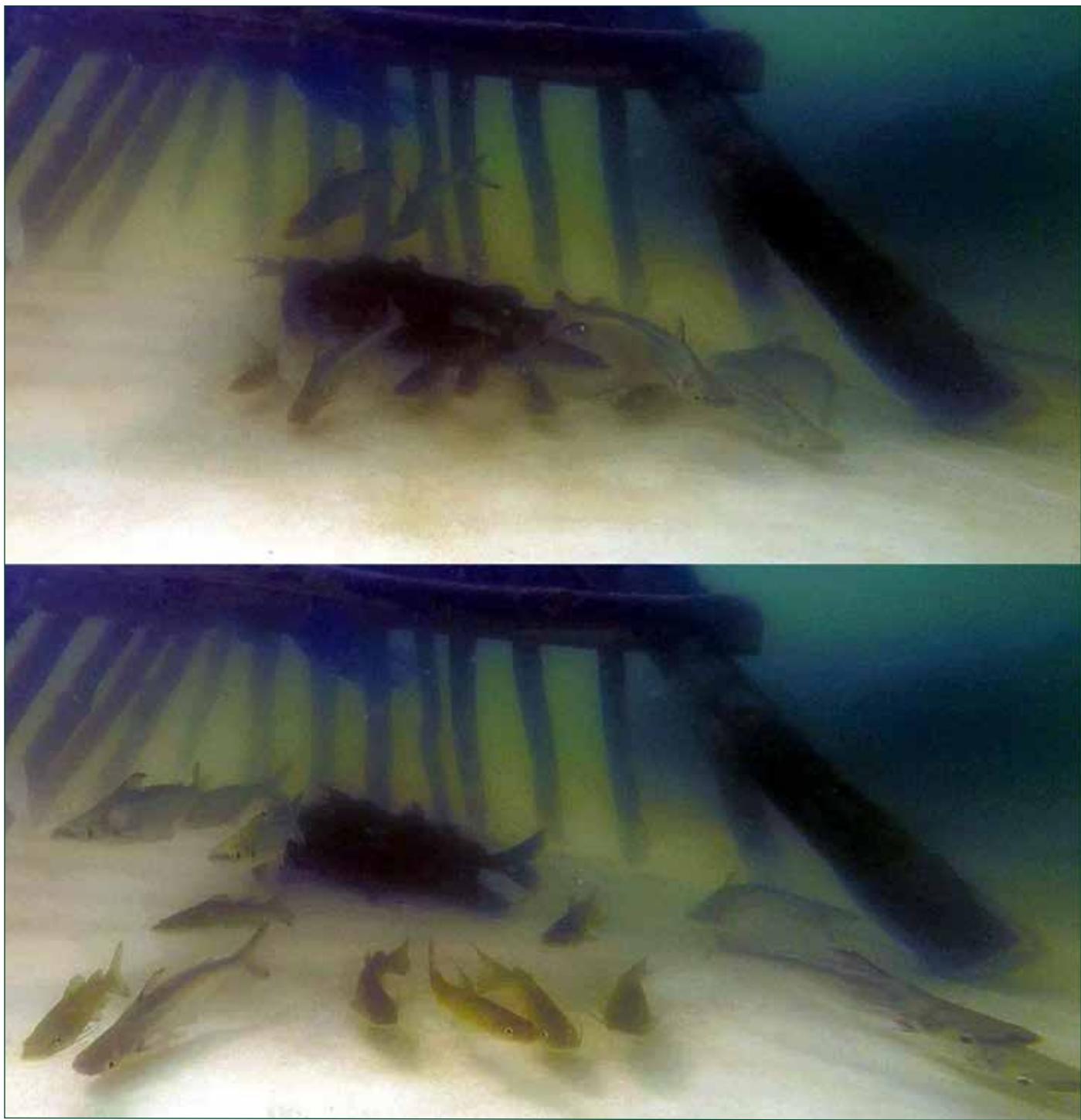
How Mekong fishers use noise to catch fish

In northeast Thailand, metal rings rattled underwater are used to scare fish into nets in reservoirs. Elsewhere in the Lower Mekong Basin, fishers in Cambodia rattle marble-filled cans underwater to divert fish into traps. In the Khone Falls area where the Don Sahong Hydropower Plant is being built, similar rattling devices are used to scare fish into nets, and these are generally banned under community fishery regulations. In shallow streams in northern Lao PDR, fishers drag cans over rocks to scare fish into traps.

The sound level of 160 decibels in water is equivalent to about 100 decibels in air – quite noisy, but well below the pain threshold for humans and not likely to cause any permanent effects on fish in its vicinity. People swam near the speakers at full volume with little or no discomfort.

Nile tilapia.

The catfishes appeared to vary from very responsive to relatively non-responsive to sounds over the ranges tested. Striped catfish (*Pangasianodon hypophthalmus*) showed the most pronounced response — within the expected range of 100-1,000 Hz, they left the fish house immediately and stayed well away for several minutes after the first two tests finished. They also reacted strongly to low-frequency sound (20-100 Hz), moving and staying well away from the speakers. They responded to higher frequency sound (4,000-10,000 Hz), but swam about rapidly rather than moving unidirectionally away from the speakers. Yellow catfish (*Hemibagrus spilopterus*) showed a relatively moderate or weak response, with some fish moving away in response to



Prior to turning on sound, striped catfish (silver) cruise at the outside of the fish group (above). The yellow catfish and red catfish (dark) are in a tight group. Speakers are centre-right in the background. When sound is turned on, all striped catfish (silver) and seven of the ten yellow catfish exit rapidly (below).

PHOTOS: KENT G. HORTLE

sound and swimming in a school with the striped catfish while others stayed in the house. Red-tailed catfish (*H. wyckioides*) showed little or no response to sound with none of the 10 individuals moving out of the fish house at any time.

After the first day of testing, the ten striped catfish were removed from the pool, leaving the two other species. The next day, these two species were re-tested. While they showed some level of response at several sound ranges, these catfishes generally stayed within the house (about 0.5 m

from the speakers) in most trials. Yellow catfish generally showed a stronger response to sound than red-tailed catfish. Interestingly, there was a very definite response by yellow catfish to very high frequency sound (2,000-20,000 Hz).

In contrast to the catfishes, each of the cyprinid species appeared to respond to sounds similarly, with the school of four species staying together throughout most of the tests. With the setup used, however, it was not possible to discriminate between individual fish behaviours within the school. The cyprinids responded most strongly to sounds between 20 and 120 Hz and also responded well to 100-500 Hz, with little or no response to higher frequencies. The general pattern was that fish were cruising before the sound started. When the sound was turned on, the fish were startled, rapidly increasing speed and changing direction before swimming away from the speakers. In one test, the five silver barbs (*Barbomyrus gonionotus*) separated for some time from the other three species which were Siamese mud carp (*Henicorhynchus siamensis*), snub-nosed barb (*Amblyrhynchichthys micracanthus*) and mrigal (*Cirrhinus cirrhosus*). This suggested

Clicks, rasps and grunts

Freshwater fishes in the major group known as Otophysi (which includes catfishes and carps) are characterised by possession of a Weberian apparatus, which links their swim bladder to their auditory apparatus, enhancing the hearing abilities of many species. Nile tilapia are non-Otophysan fish, lacking a Weberian apparatus, and apparently having limited hearing ability. Variations in the size and shape of fish bladders are likely to reflect differences in hearing ability and vocalisation patterns. Catfishes are well known for using their swim bladders or pectoral fins to produce sounds. Many Mekong catfishes and carps vocalise loudly and distinctively so it would be expected that such fishes would also be able to hear and discriminate between sounds. In the trials, striped catfish were quite vocal, frequently emitting sounds like clicks or rasps which could be heard clearly on videos. The yellow catfish and the red-tailed catfish appeared to be relatively quiet, with only occasional clicks and deeper grunts audible when they were in the fish house.

Fish species used in the trials

Family	Species	English name	Lao name	Origin	Feeding habit	Length of recorded test fish (cm)	Maximum Length (cm)
CATFISH							
Pangasiidae	<i>Pangasianodon hypophthalmus</i>	Striped catfish	Pa suai kiao	Mekong	Omnivorous	150	18
Bagridae	<i>Hemibagrus wyckioides</i>	Red-tailed catfish	Pa keung hang deng	Mekong	Omnivorous	130	21
Bagridae	<i>Hemibagrus spilopterus</i>	Yellow catfish	Pa kot leuang	Mekong	Omnivorous	36	14
CARPS							
Cyprinidae	<i>Henicorhynchus siamensis</i>	Siamese mud carp	Pa soi hua po	Mekong	Herbivorous	23	14
Cyprinidae	<i>Amblyrhynchichthys micracanthus</i>	Snub-nosed barb	Pa ta po	Mekong	Omnivorous	46	21
Cyprinidae	<i>Barbomyrus gonionotus</i>	Silver barb	Pa pak	Mekong	Omnivorous	33	12
Cyprinidae	<i>Cirrhinus cirrhosus</i>	Mrigal	Pa mrigal	India	Omnivorous	115	16
PERCH-LIKE FISHES							
Cichlidae	<i>Oreochromis niloticus</i>	Nile tilapia	Pa nin	Africa	Herbivorous	46	24

Note: lengths of test fish are ± 1 cm

some minor species-specific difference in responses, as would be expected.

'Catfishes and carps generally have good hearing abilities'

These results were much as expected, as catfishes and carps generally have good hearing abilities and many species are likely to be sensitive to and avoid loud sounds within the ranges observed. In the Mekong River, a good sense of hearing would generally be an advantage for survival of fish. By contrast, Nile tilapia (*Oreochromis niloticus*) were unresponsive to virtually all sounds, probably because they originate from relatively clear waters in Africa where they may utilise other senses (sight and smell) to a greater degree than hearing. While the Nile tilapia's hearing may be relatively poor, the strain of fish which was used is the result of an intensive breeding program which may have altered its natural hearing abilities.

Based on these results, development of an AFD system should be further investigated by pool-based testing of captive fish and by field testing as follows:

(1) Pool-based testing is recommended for large, long-lived and high-profile species such as the giant catfish (*Pangasianodon gigas*), giant barb (*Catlocarpio siamensis*) and Jullien's barb (*Probarbus jullieni*), as well as other wild-caught fish. A video should be prepared to demonstrate the potential of acoustic deterrence to mitigate impacts on downstream-migrating fish.

(2) Field testing of the sound projector with wild fish moving towards a stationary sound source will provide more realistic results to supplement the pool-based experimentation with captive fish. Field trials should be carried out in October–November when many fish are migrating downstream. It is suggested that Don Sahong Power Company also investigate the feasibility of a mechanical device such as a rotating drum or wheel with attached paddles and internal steel balls positioned underwater, and which could be driven hydraulically to create random clanging or banging noises to deter fish. Such a system would likely be much cheaper, more robust and require less maintenance than high-tech speaker-based systems. A prototype could be field-tested at the

Key Project Features

- **Location:** Hou Sahong channel, Khone Falls, Champassak Province, Lao PDR, 160 km south of Pakse, 719 km from Mekong Delta
- **Owner:** Don Sahong Power Company Ltd
- **Cost:** \$500 million (estimate)
- **Maximum Capacity:** 260 MW
- **Turbines:** 4 x 65 MW bulb type
- **Rated Head:** 17.8 m
- **Rated Discharge:** 1,600m³/s
- **Dam Height (max):** 25 m
- **Embankment Length:** 6,800 m
- **Headpond Volume:** 12 million – 25 million m³ (seasonal)
- **Headpond Level:** 70 – 73 masl (seasonal)
- **Estimated Completion:** 2019

SOURCE: DON SAHONG POWER COMPANY

same time as the sound projector.

During this brief trial, company staff developed capacity in pool management as well as fish-handling and testing procedures, with various improvements made over the course of the testing. Some minor improvements to programming of the sound projector are needed to improve its flexibility and usefulness, especially for field work. Company staff need to prepare well in advance for any future work, taking account of the lessons from this trial exercise; for example, that fish of good quality need to be purchased and set up on site in floating cages before any testing is planned.

Further reading:

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* Mr Hortle is an independent advisor to Don Sahong Power Company and Mr Somphone is leader of the company's fisheries team. Ms Yupapon and Mr Nakhone are members of the team's technical staff.

Assessing hydrologic drivers of fisheries and forecasting future catches

BY JOHN L. SABO, ALBERT RUHI, GORDON W. HOLTGRIEVE, VITTORIA ELLIOTT, MAURICIO ARIAS, NGOR PENG BUN AND SO NAM *

A study commissioned by the MRC has developed a data-driven hydro-fisheries model for the Lower Mekong Basin. The model connects hydrologic variation on the Mekong mainstream in Stung Treng in northeast Cambodia to the catch of the *dai* fishery on the Tonle Sap River near Phnom Penh, the basin's largest commercial fishery, which the MRC began monitoring in 1995. Below is a summary of the key results of the study.

The Mekong River Commission has traditionally relied on systems models to connect climate, land use, hydrology, reservoir operations and fish production and harvest in the Lower Mekong Basin (LMB). Systems models are useful because they allow for specification of mechanistic biological detail and provide a framework for hypothesis testing. However, much of the detail that connects physical processes to the fishery in LMB systems models is based on sparse biological data. By contrast, the MRC has collected long-standing records on hydrology (>100 years of daily data at some flow gages) and more recent detailed data on harvest in a number of fisheries. The most detailed of these fisheries datasets is a compilation of 17 years of standardized catch data from 14 *dais* on the Tonle Sap River.

To assess hydrologic drivers of Lower Mekong fisheries and forecast future catches, the MRC Fisheries Programme commissioned a study that developed a data-driven hydro-fisheries model for the Lower Mekong River that connects hydrologic variation in the mainstem Mekong River (Stung Treng) to catch at the *dais* (Figure 1). To do this, we combined spectral methods for quantifying discharge variation (Discrete Fast Fourier Transformation, or DFFT: Sabo and Post 2008) with a multivariate autoregressive state space (MARSS: Holmes *et al.*, 2014; Ruhi *et al.*, 2015) to measure the effect size of hydrologic drivers on

the fishery catch. This set of analyses allowed us to simultaneously measure the impact of existing dams on key attributes of discharge variation and connect this variation to the fishery. These empirical relationships also allow for near-term (<20 year) forecasting of future fishery catches based on modeled or hypothetical hydrologic scenarios.

Key Result #1: Several key hydrologic indicators of the fishery have changed since the construction of the first dam on the Mekong system (Ubol Ratana in Thailand in 1964-1965), and the trend of the change is consistent with a declining fishery. We analyzed changes in a two high level discharge metrics over the >100 year record



Figure 1: Location of Stung Treng and the stationary trawl *dai* fishery on the Tonle Sap River near Phnom Penh. The fishery targets small cyprinids and operates between October and March as floodwaters recede from the Tonle Sap Lake. The MRC started monitoring the fishery, the largest in the Lower Mekong Basin, in 1995. Map by Chhut Chheana (redrawn from MRC Technical Paper No 33).

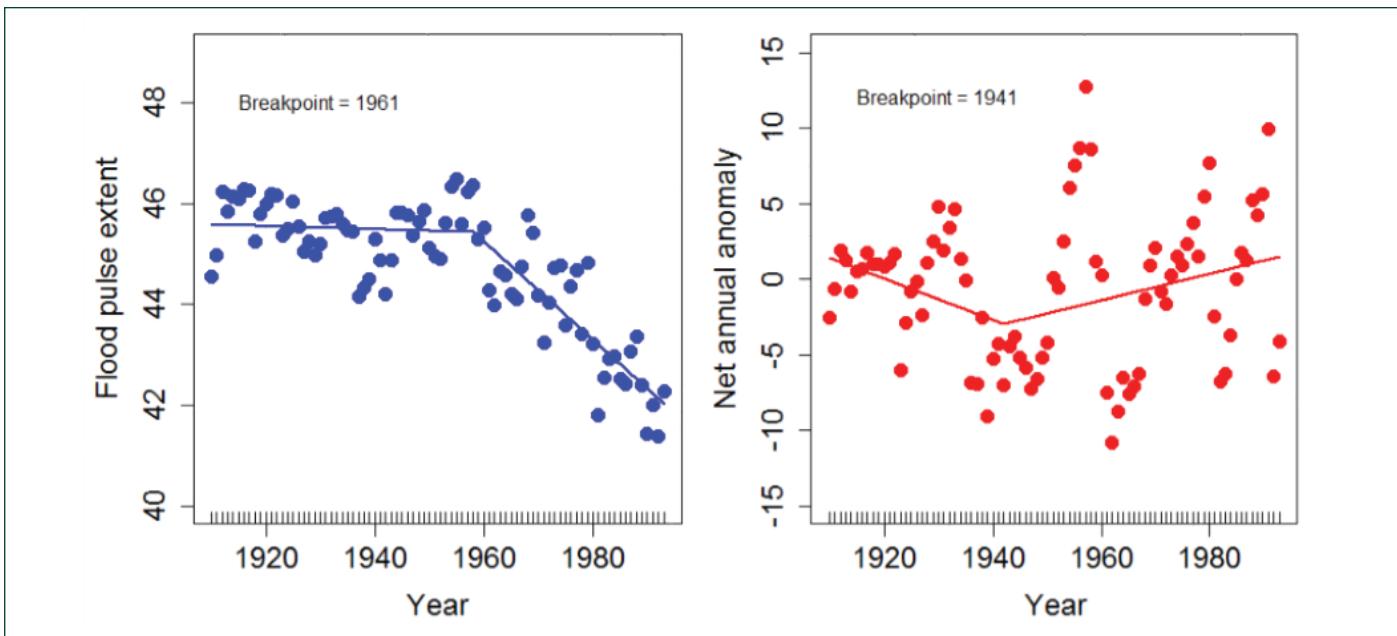


Figure 2: Segmented regression analysis to identify year (“breakpoint”) in which trends for Flood Pulse Extent and Net Annual Anomaly change direction. Linear relationships are significant if trend line is present and breakpoint is significant if year is indicated.

at Stung Treng, Cambodia—flood pulse extent and the net annual anomaly. Flood pulse extent (FPeX) is defined as the product of the number of days stage exceeds the long term average and the deviation from this average discharge level (duration x magnitude). The Net Annual Anomaly is a composite measure of variation in stage (or discharge) that quantifies the timing, magnitude and frequency of unexpected events—early floods or long droughts. Both measures are quantified in sequential 20-year windows. Given this windowed approach, we expect that if dams have some influence on flood pulse extent or NAA that these effects should manifest as early as the 1945–1964 (breakpoint 1945) window and as late as the 1964–1983 window (breakpoint 1964). Breakpoints of FPeX and NAA are 1961 and 1941, respectively (Figure 2). FPeX has declined significantly and NAA increased and become more positive since construction began on the first dam in the Mekong River system. As we show below, FPeX and NAA are positively and negatively (respectively) related to catch; hence, the trend of hydrologic impact on the fishery is negative.

Key Result #2: Flood pulse extent and the net annual anomaly both have significant effect sizes on total catch in the Tonle Sap *dai* fishery. We used a multivariate autoregressive state-space approach to quantify trends in catch in the *dai* fishery. Importantly, we included FPeX and NAA as

drivers (covariates) of catch. Multi-model inference suggests that a density independent model with both covariates has the most support. Effect size was positive for FPeX and negative for NAA. Not surprisingly, the flood pulse (magnitude x duration) is positively related to catch (Figure 3). However, NAA is negatively related to catch suggesting that some aspects of dry season (low-flow variation) are also important to the fishery.

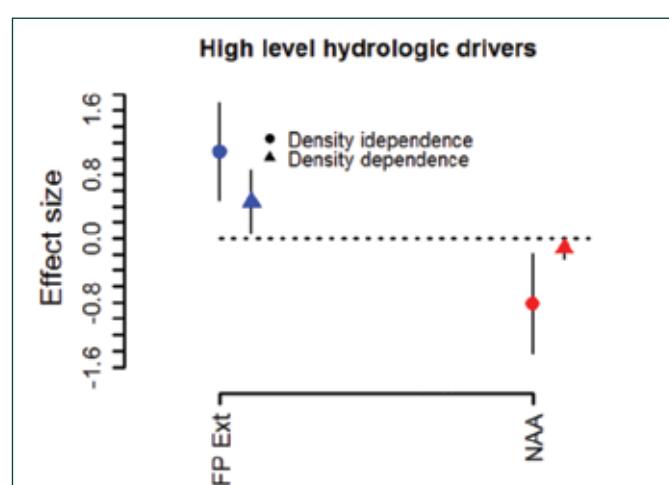


Figure 3: Weighted coefficients (effect sizes) from MARSS-DFFT using historical hydrology and catch data, under assumptions of density independence (a) and density dependence (b). There was higher support for MARSS that included density dependence; however variance estimates were suspect in this model leading to greater confidence in a density independent model.

Key Result #3: The net annual anomaly is a composite measure of hydrologic variability. We further quantified several NAA component metrics that reflect unexpected shape of the annual hydrograph. NAA component metrics describe both high- and low-flow properties including the magnitude, frequency and timing of high- and low-flow anomalies, Inter-flood interval (IFI), and transition time between the low and high annual anomaly. Inter-flood interval measures the duration of low flows between consecutive annual flood peaks—long IFI is akin to hydrologic drought in this flood pulse context. IFI was the single best predictor (highest effect size) of total catch in the *dai* fishery regardless of whether density dependence was considered or not. Importantly, IFI is positively related to catch in the *dai* fishery. Drought in this flood pulse system is good for the fishery within reason. A possible mechanism linking IFI to fishery catch is a longer accumulation time for atmospheric and agricultural deposition of limiting nutrients and optimization of redox conditions that mobilize these nutrients during the rising limb of the hydrograph, and that these nutrients increase fish production and ultimately catch. This potential mechanism needs further examination through directed field studies and long-term data collection. As in models with high level drivers (FPeX and NAA), a model without density dependence had the most support. In this model, the magnitude and frequency of high-flow anomalies also had significant positive effects

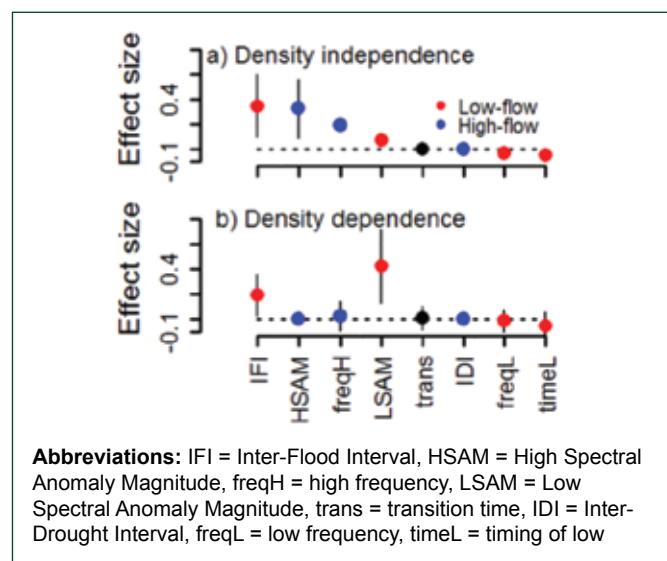


Figure 4: Weighted coefficients (effect sizes) from MARSS-DFFT using historical hydrology and catch data, under assumptions of density independence (a) and density dependence (b). There was higher support for MARSS that included density dependence; however variance estimates were suspect in this model leading to greater confidence in a density independent model.

on catch in the *dai* fishery. These results suggest that there is a particular shape of hydrograph that promotes production of the fishery and hence catch. This hydrograph has a long low-flow period punctuated by a high magnitude flood pulse characterized by multiple flood impulses from serial monsoon storms.

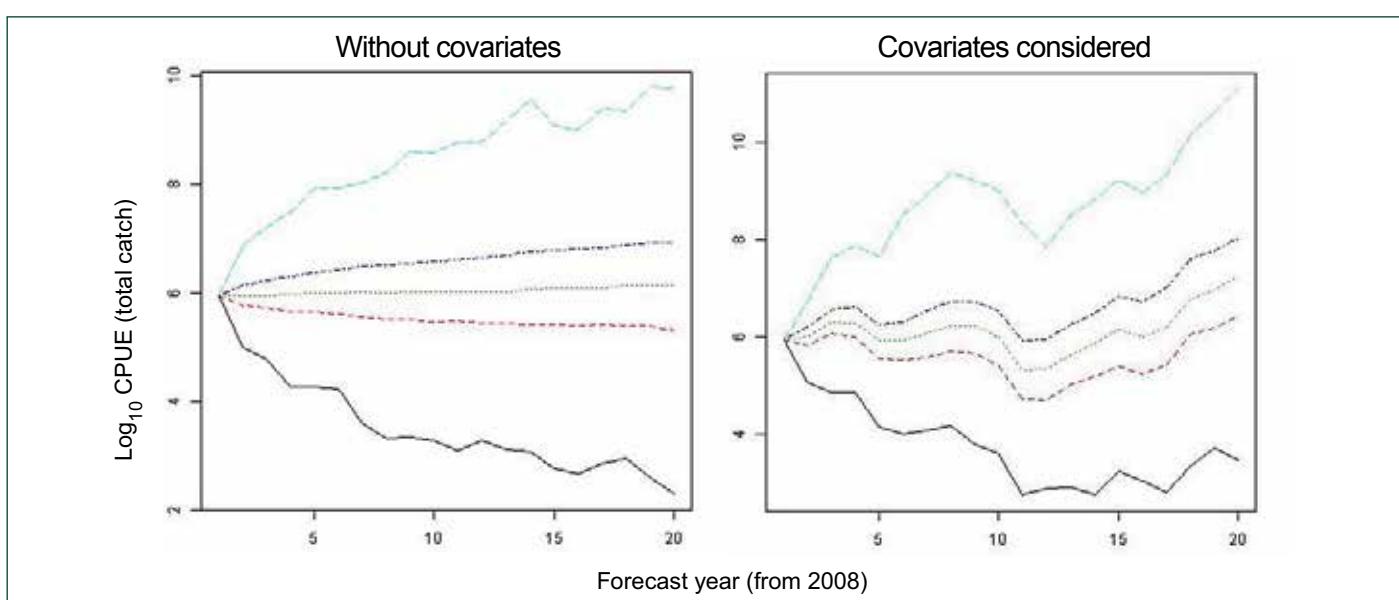


Figure 5: Forecasted total catch (bootstrapped median bracketed by 5th, 25th, 75th and 95th percentiles) using future high-level hydrologic drivers—flood pulse extent and net annual anomaly—from the Goddard Institute for Space (GISS) Studies model under representative carbon pathway, RCP 8.5.

Key Result #4: Finally, we developed an approach for forecasting the near-term (<20 year) catch in the *dai* fishery. Briefly, this method leverages measured covariate effect sizes (Figures 3 and 4) from the historical record and SWAT modelled discharge (also at Stung Treng) under MRC generated future climate scenarios. In 2008, the MRC carried out a detailed analysis of projected climate and hydrology in the basin. In projecting the fishery, we therefore begin with 2008 projected hydrology and the observed catch, generating estimates of near-term catch from 2008-2027. The model is developed such that it can be applied again to compare short-term projections of total catch from the *dai* fishery with and without hydrologic drivers (covariates), assuming no density dependence (consistent with our multimodel inference). The most notable difference is that the projected fishery oscillates when projected with hydrologic drivers (covariates), and these oscillations do not dissipate at low percentile abundance levels (outside lines). This is an important result because it suggests that, unlike a simple stochastic projection in which random variation determines year-to- year variation in catch, here hydrology underlies the variation and that relationship—hydrology—catch—is predictable. Hence, given these results one can assess the periodicity and return intervals of low-harvest years and reduce vulnerability to this eventuality. From our short projection (20 years), it appears that the fishery has a 5-8 year return interval for low-harvest years (5, 11 and 17 years from the start of the projection).

Projection of the fishery should be improved with a better climate product (e.g., Regional Climate Model) and by resampling hydrographs from RCM-driven SWAT realizations in a way that more accurately captures the distribution of future temporal variability. Moreover, we conclude that the real power of DFFT-MARSS fishery projections such as these lies in scenario planning rather than forecasting. Specifically, the fishery could be projected under hypothetical hydrographs that represent a variety of operations and climate scenarios. The goal of such hydrograph design would be to prescribe hydrograph shapes that co-optimize hydropower production and food security.



Figure 6: Harvesting fish from the *dai* fishery on the Tonle Sap River near Phnom Penh, the largest commercial fishery in the Lower Mekong Basin

PHOTO: CHHUT CHHEANA

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Variability in the contribution of fisheries to the welfare of rural Cambodians

BY ERIC MOUSSET AND ERIC BARAN *

As part of a four-year project funded by the Australian Centre for International Agricultural Research, WorldFish and the Cambodian Agricultural Research and Development Institute surveyed 747 households in 37 villages around the Tonle Sap Lake as well as in the Upper Mekong region and lowland areas further downstream. The results of the surveys in 2012, 2013 and 2014 indicate how fisheries contribute to the welfare of almost four million Cambodians in terms of wealth, labor, nutrition, health and resilience. Below are the conclusions of a welfare data analysis based on the survey findings. The results of the overall project are expected to guide future agricultural and rural development programs aimed at improving welfare in the Lower Mekong Basin.

A survey of comprehensive and unprecedented scope has been conducted in Cambodia in fishing-dependent areas of the Tonle Sap, Upper Mekong and Lowland agro-ecological zones. Important data have been collected on household welfare from the point of view of wealth, labor, nutrition, health and resilience. A quantitative analysis ensued, based on descriptive statistics — possibly generalizing to 3.7 million inhabitants of Cambodia living in rural and fishing-dependent areas. Results and findings have drawn a general depiction of households across the entire population under study and have also uncovered statistically significant differences between household groups based on gender, wealth, fishing dependency and location.

A first and important implication for policy efforts is the necessity for analysts to take the aforementioned parameters into consideration while formulating policy directions. Relevant

findings and suggestions are summarized below, with particular attention to post-harvest capabilities for capture fishery and aquaculture value chains.

'Both capture fisheries and aquaculture feature particularly high labor efficiency compared with non-fishing related activities. In addition, capture fisheries feature favorable returns on assets'

The study concludes that fish plays an important, yet variable, role within the population of households in focus. From a nutrition point of view, fish represents the first source of protein, in terms of both quantity and frequency of food intake. Fishing is a mitigation strategy against food insecurity (a risk feared by a majority of households across all zones) — and is chosen regularly by 37% of Tonle Sap households and 36% of Lowland households. Net income from capture fisheries or aquaculture — similar to net income from other farming or natural environment-dependent activities — represents a secondary source of overall income with the primary source originating from salaries, wages or businesses.

Among secondary sources, both capture fisheries and aquaculture feature particularly high labor efficiency compared with non-fishing related activities. In addition, capture fisheries feature favorable returns on assets (requiring equipment of more modest value than non-fishing related activities for the same level of net income). The latter aligns with another finding that capture fishery profit margins are significantly higher in asset-insufficient households. However, 75% of fish processed by households is for their own consumption. Higher leverage may be gained for capture fisheries by building capacity at post-harvest levels of the value chain, namely (a) fish-processing capabilities to better align production

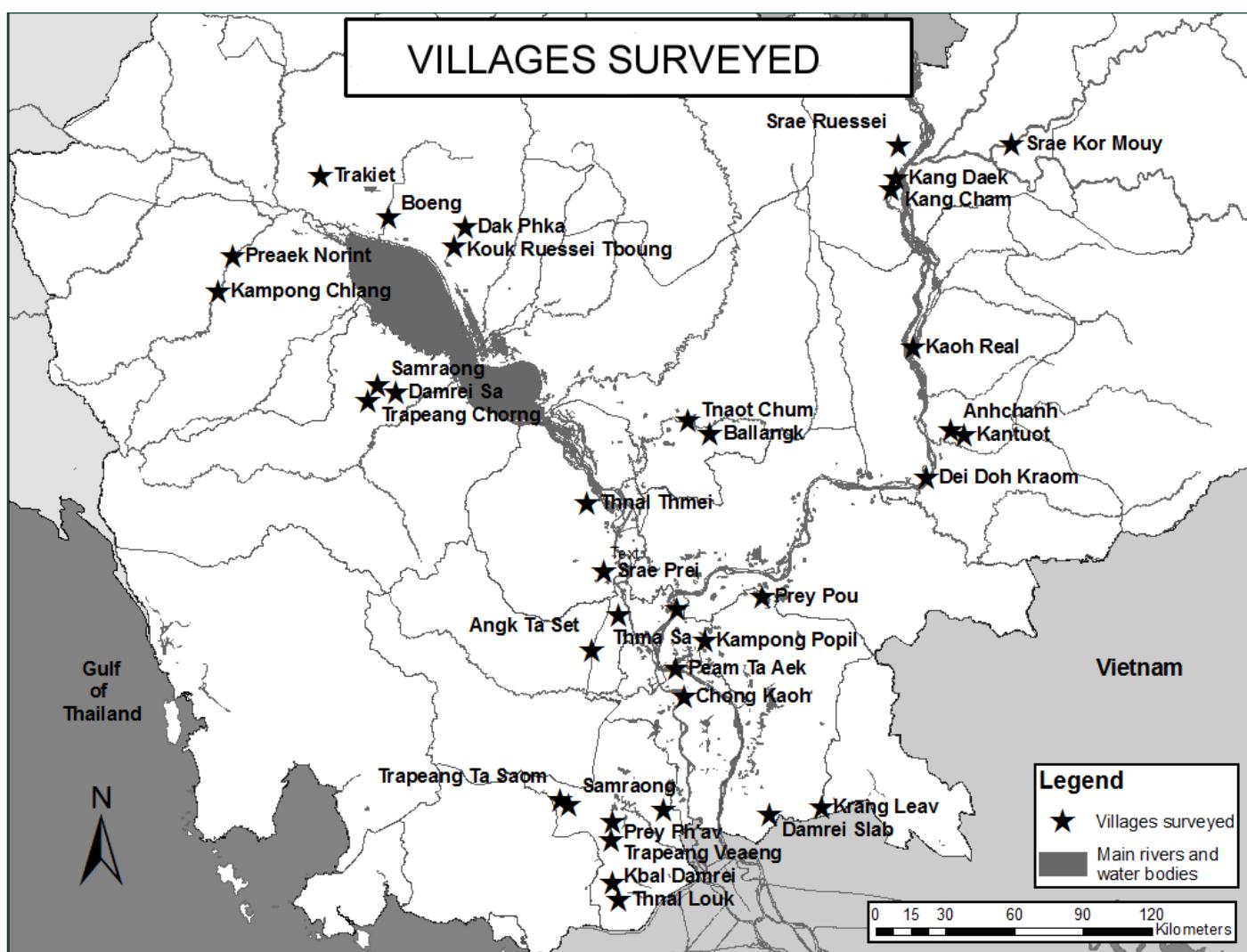
with demand and increase profit margins and (b) marketing capacity to enhance market access, possibly concentrating on segments of the population already found to be showing a fair performance (households located in high and very high fish-dependency areas of the Tonle Sap zone).

'The behavior of Upper Mekong households tends to differ significantly from that of Tonle Sap and Lowland households'

The behavior of Upper Mekong households tends to differ significantly from that of Tonle Sap and Lowland households. For instance, Upper Mekong households allocate labor inputs

that are significantly higher than Tonle Sap and Lowland households for poultry farming, collecting terrestrial resources for household use, cattle raising, rice farming, catching fish, processing floodplain resources and collecting terrestrial resources for selling — activities that all depend on the natural environment. Upper Mekong households derive income from livestock that is significantly higher compared with Tonle Sap and Lowland households.

Even though they allocate higher labor inputs into capture fisheries, the inputs do not translate into stronger economic performance. On the contrary, the gross margin ratio for capture fisheries in Upper Mekong households tends to be weaker than for Tonle Sap and Lowland households. At the same time, Upper Mekong household debt appears to be significantly lower than in the other



The 37 villages surveyed around the Tonle Sap Lake, the Upper Mekong region and lowland areas further downstream

two zones, which suggests more conservative behavior and weaker investment in productive assets.

From the point of view of nutrition, Upper Mekong households consume rice in significantly higher quantities, and their yearlong patterns of fish consumption are less prone to seasonal variations (which may be due to their upstream position in Cambodia's water system). Nonetheless, cases of children with malnutrition symptoms are reported in significantly higher numbers in Upper Mekong households, with 25% reporting cases of children with permanently swollen bellies and 21% reporting children who have developed blond hair. Further research focusing on the Upper Mekong zone is warranted to understand the root causes of nutrition, subsistence and resilience issues.

'Further leverage may be gained around capture fishery and aquaculture value chains in the Tonle Sap zone'

In contrast, the role of fish in the Tonle Sap zone is more commercially oriented — households catch a lower quantity of fish compared with the Upper Mekong each year but retain a smaller share of the catch for their own consumption, leaving a larger share for commercialization. Tonle Sap capture fisheries also feature high profitability with a 92% gross margin ratio that is significantly higher compared with Lowland households.

Fish as a consumption product appears more "elastic" in Tonle Sap households than in Upper Mekong households, as reflected by stronger seasonality of consumption. Further leverage may be gained around capture fishery and aquaculture value chains in the Tonle Sap zone by harnessing opportunities linked to the proximity of the three largest cities of Cambodia by exploring options for enhancing infrastructure and market access.

Engaging in farming and other natural environment-dependent activities is an option generally favored by income-insufficient households, which allocate a significantly higher input of labor than asset-insufficient households towards capture fisheries, rice farming, poultry, cattle, collecting floodplain natural resources

and collecting terrestrial resources. However, financially sound households mobilize a significantly higher input of labor into aquaculture in comparison with financially vulnerable households — probably due to a higher value of aquaculture assets and cash-flow requirements linked to higher operation costs. Skills development may be considered as a worthwhile option while addressing issues specific to income-insufficient households, while technology transfer may prove beneficial to aquaculture entrepreneurs.

Finally, survey results confirm the influence of gender on a range of indicators. Interestingly, they also suggest that gender in terms of leadership (whether a household is headed by a male or a female) has a stronger influence on household choices than household gender ratios (whether a household is male-prevalent, female-prevalent or balanced).

For example, male-prevalent households headed by males own a significantly higher number of fishing assets (representing a significantly higher value) compared with male-prevalent households headed by females. As expected, labor input in capture fisheries is significantly higher in male-prevalent households headed by males compared with male-prevalent households headed by females. Also, quantity of fish catches is significantly higher in gender-balanced households headed by males compared with male-prevalent households headed by females.

Quantity of fish consumed by gender-balanced male-headed households and also male-prevalent male-headed households is significantly higher than fish consumed by gender-balanced female-headed households. In general, within income-insufficient and financially vulnerable wealth groups, male-headed households earn net income that is significantly higher than female-headed households. Such findings suggest prioritizing skills development primarily to household heads and tailoring related training programs according to the gender of household heads.

* Dr Mousset is an independent consultant based in Phnom Penh where he lectures at the Royal University of Law and Economics and Dr Baran is a senior scientist. The welfare data analysis included inputs from Victoria Rogers, Samadee Saray, Kithya Ouch, Sinath Srey and Mith Samonn.

Aquaculture offsets lower freshwater fisheries production in Cambodia

Although the country's overall fisheries production was almost unchanged in 2015, output from aquaculture continued to expand, more than compensating for a decline in freshwater capture fisheries production.

After promoting the farming of fish and other aquatic animals such as freshwater prawns for three decades, the Cambodian government is finally starting to see the fruits of its labour during exceptionally dry years when the inland fisheries

catch declines. "Aquaculture is nothing new for the Cambodian People's Party," Prime Minister Hun Sen told this year's National Fish Day ceremony at Anlong Chrey Reservoir in Kampong Speu Province about 80 km north of Phnom Penh on July 1. He recalled that the ruling party started promoting aquaculture in 1985 during the Fifth Congress of what was then known as the Khmer People's Revolutionary Party. "Because war was yet to end, we could not make more efforts to organise it," Samdech Hun Sen said. "However, in a gradual manner, we have widened the scope of the program."



Prime Minister Hun Sen helps to release fish and other aquatic animals into the Anlong Chrey Reservoir at the end of a ceremony marking Cambodian's National Fish Day on July 1. The fish release involved one million fingerlings and broodstock of various carp and other fish species as well as frogs and turtles. Also released were 100,000 post-larval giant freshwater prawns (*Macrobrachium rosenbergii*). Samdech Hun Sen said aquaculture was becoming "more sophisticated and effective" after three decades of promoting the farming of fish and other aquatic animals among Cambodian people.

PHOTO: LEM CHAMNAP



Prime Minister Hun Sen speaking at Anlong Chrey Reservoir in Kampong Speu Province on July 1

PHOTO: LEM CHAMNAP

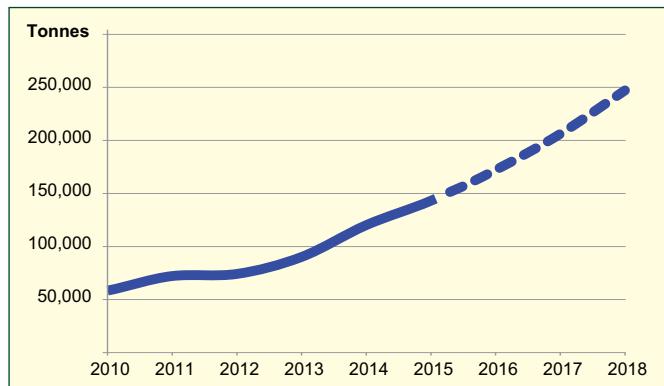
Aquaculture is now "more sophisticated and effective," the prime minister said, noting the increasing number of farmers using their newly-acquired expertise to breed aquatic animals. "Many farmers know how to breed fingerlings and widely distribute them to other farmers who need them," he said. "Some of them have learned to breed not only fish but also giant freshwater prawns, thanks to the assistance provided by JICA of Japan, and sell them to other fish farmers or raise them by themselves."

Wild fish resources declining

The upshot is that Cambodia's aquaculture production grew 20 percent from a year earlier to

Cambodia's aquaculture production

Production more than doubled from 60,000 tonnes in 2010 to 143,000 tonnes in 2015. In the latest year, output was up by around 20 percent. If production continues to grow at the same pace, the government will reach its target of 250,000 tonnes by 2018, a year ahead of schedule.



SOURCE: MINISTRY OF AGRICULTURE, FORESTRY AND FISHERIES



Agriculture, Forestry and Fisheries Minister Veng Sakhon

PHOTO: LEM CHAMNAP

143,000 tonnes last year, according to Agriculture, Forestry and Fisheries Minister Veng Sakhon (see chart below). Speaking ahead of the prime minister at the Anlong Chrey Reservoir event, he said aquaculture – which mostly involves freshwater species – was playing an "important role" in supporting consumer demand for fish products. "Wild fisheries resources have been gradually declining due to population growth, climate change and hydropower dam development in the upper part of the Mekong River," he said.

'Water levels in the Tonle Sap dropped to as low as 10 cm in some places, causing fish to die in the Boeung Chmar fish sanctuary in Kampong Thom Province as well as flooded-forest areas where important fish habitats were ravaged by fire'

The minister said Cambodia's total fisheries production came to some 751,000 tonnes in 2015, up from 745,000 tonnes a year earlier. Freshwater fish accounted for about 487,000 tonnes, down from 505,000 tonnes in 2014, and marine fish production was unchanged at about 120,000 tonnes. The country had more than 77,000 households farming fish and other aquatic animals in 2015, up from some 65,000 a year earlier and about 61,000 in 2013. The minister said Cambodia also had 307 hatcheries with an annual production

capacity of 180 million fingerlings. That compares with 305 hatcheries with a capacity of 120 million fingerlings a year in 2014.

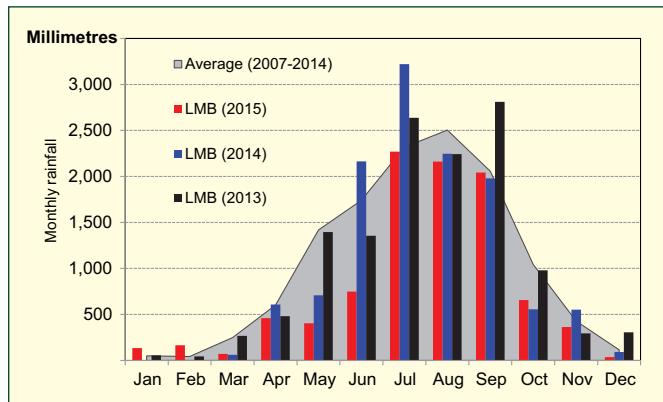
El Niño takes its toll

Veng Sakhon noted that last year's freshwater fish catches were adversely affected by the El Niño weather phenomenon, which resulted in severe drought in much of Southeast Asia (see *Catch and Culture*, Vol 22, No 1). He said water levels in the Tonle Sap dropped to as low as 10 cm in some places, causing fish to die in the Boeung Chmar fish sanctuary in Kampong Thom Province as well as flooded-forest areas where important fish habitats were ravaged by fire. Moreover, the minister said, the water quality in the Tonle Sap was "bad" last year with increased nitrogen linked to inflows of chemical agricultural fertilisers and waste, especially in the provinces of Kampong Chhnang, Pursat and Siem Reap.

To counter the long-term silting up of water bodies over the past few decades, the prime minister urged Cambodians to dig more ponds and reservoirs. "We know that the areas for fish species to reproduce are getting shallow," he said. "We must take measures to deepen

Monthly rainfall over the Lower Mekong Basin

Average monthly rainfall between 2007 and 2014 (grey) compared with monthly rainfall in 2015 (red), 2014 (blue) and 2013 (black)

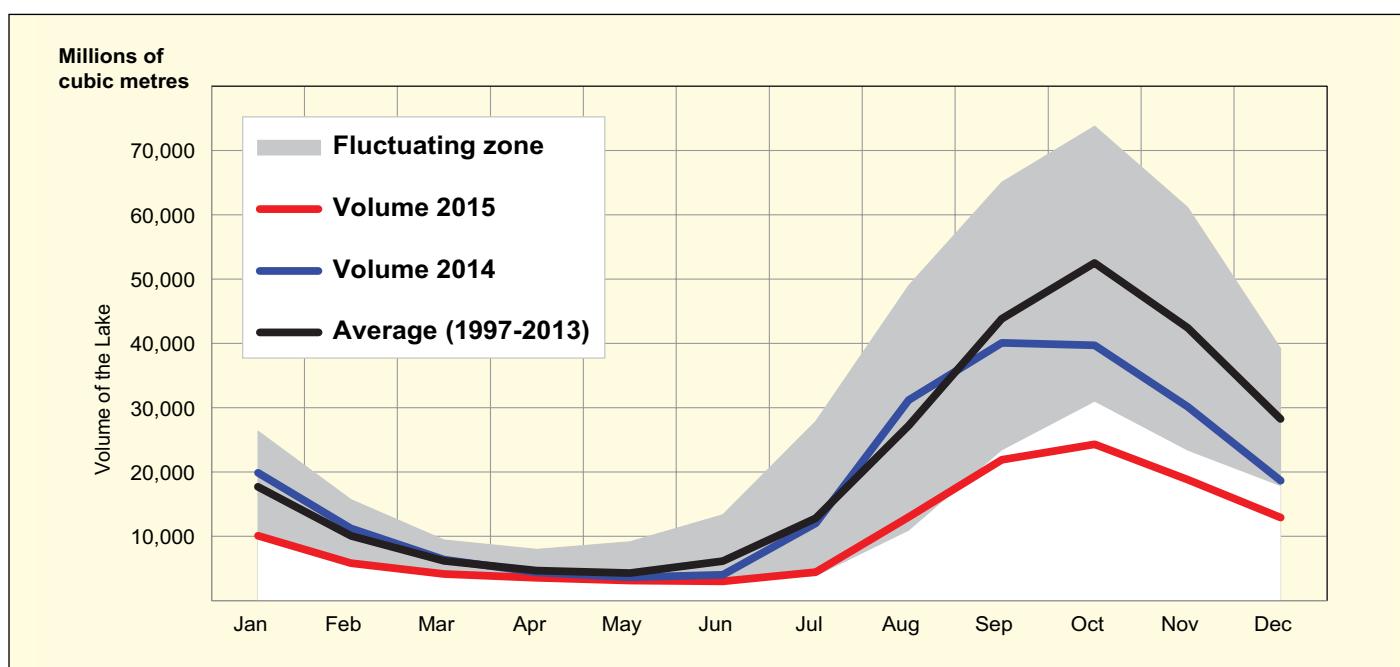


SOURCE: FLOOD MANAGEMENT AND MITIGATION TEAM, MEKONG RIVER COMMISSION

them." Samdech Hun Sen noted that Cambodia previously had deeper water, more fish and fed fewer people. "Now we have a shallow water system, less fish and feed more people. This is ... why I said we could not depend on fish from the natural system anymore." As a result, people "must" farm fish in their ponds. "People can also farm fish in their rice fields, where they harvest both," he said.

Monthly changes in the volume of water in the Tonle Sap Lake

As a result of the severe drought in 2015, the volume of water flowing into the Tonle Sap Lake from the Mekong River in 2015 was 33% of the average inflow. The volume was also significantly below the minimum flow recorded between 1996 and 2006, which was 60% of the average inflow. The sharply reduced inflow combined with low rainfall over the upper catchment area of the Tonle Sap Lake resulted in the lake's water levels dropping to historic lows.



SOURCE: FLOOD MANAGEMENT AND MITIGATION TEAM, MEKONG RIVER COMMISSION

MRC publishes fish photo book and monitoring manual for Lower Mekong

New publications designed to help fish abundance and diversity monitoring, a core activity of the Mekong River Commission

The Mekong River Commission has published a photo book on common fishes of the Lower Mekong Basin along with a manual on standard sampling procedures for monitoring fish abundance and diversity in the region. The MRC developed the photo book and monitoring manual in collaboration the Inland Fisheries Research and Development Institute in Cambodia, the Living Aquatic Resources Research Centre in Lao PDR, the Department of Fisheries in Thailand and the Research Institute for Aquaculture No. 2 in Viet Nam.

The first publication, *Photos of Common Fishes in the Lower Mekong Basin*, updates a catalogue from the early 2000s that formed the basis of the *Mekong Fish Database* published by the MRC in 2003. It uses photos with higher resolution and updated scientific and common names of the Mekong fishes from sources including a 2015 version of the global online database of the FishBase consortium (<http://www.fishbase.org>), a separate database on the fishes of mainland Southeast Asia developed by the Nagao Natural Environment Foundation of Japan in 2013 (<http://ffish.asia>) and a catalogue of fishes from the inland waters of Southeast Asia by Swiss ichthyologist Maurice Kottelat published in 2013 (<http://zoobank.org/References/0B66AE04-C644-43CD-9B76-043848FAA9FE>).

Covering 272 common fish species in the lower basin, the photo book includes species codes, local names, scientific names, common English names, maximum lengths and the families to which species belong. The book is aimed at researchers to address a basic problem in identifying species, especially those supervising monitoring in the field who train fishers in recording catch composition. The goal is for standardised records across the Lower Mekong Basin, contributing to harmonised national and

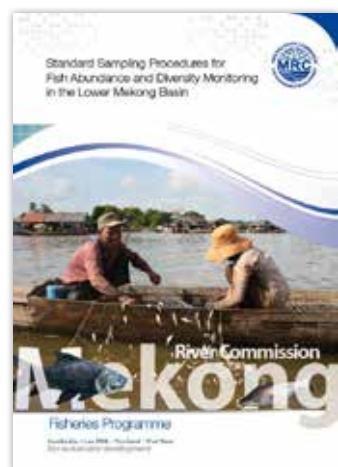
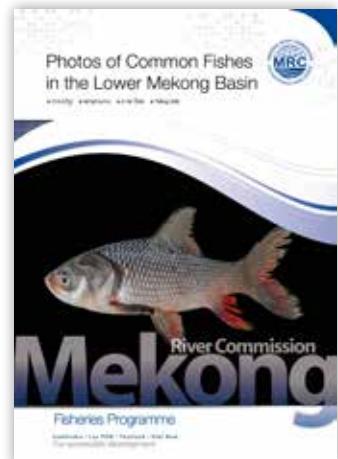
regional datasets. Researchers and fishers alike are encouraged to provide feedback from field observations to correct and update the document. Any feedback will be acknowledged.

The second publication, builds on two decades of fish abundance and diversity monitoring supported by the MRC. The monitoring has included catch assessment surveys in Cambodia, Lao PDR and Thailand in 2006 and all four countries of the Lower Mekong Basin including Viet Nam between 2007 and 2013. Over the past decade, many lessons have been learnt by analysing the MRC Database on Fish Abundance and Diversity Monitoring. Other feedback has come from regional meetings, training workshops and field trips by the MRC Fisheries Programme in cooperation with national fisheries staff. The new manual, *Standard Sampling Procedures for Fish Abundance and Diversity Monitoring in the Lower Mekong Basin*, is therefore designed to improve the accuracy of data collection by fishers and national fisheries agency teams in all four countries.

Further reading

Ngor, P.B., Chhut, C., Theng, L., Ly, V., Phommakone, S., Samphawamana, T., Nguyen, H.S., Degen, P. and So, N. (2016) Photos of Common Fishes in the Lower Mekong Basin. MRC Fisheries Programme, Phnom Penh.

Ngor, P.B., Hortle, G.K. and So, N. (2016) Standard Sampling Procedures for Fish Abundance and Diversity Monitoring in the Lower Mekong Basin. MRC Fisheries Programme, Phnom Penh.



Code for trans-boundary movement of live aquatic organisms

The Mekong River Commission and the Network of Aquaculture Centres in Asia Pacific have finalised a Code of Practice for Trans-Boundary Movement of Live Aquatic Organisms in the Lower Mekong Basin. The code is based on national reviews of the impacts of exotic species on the natural environment and aquaculture-related issues of MRC Member Countries as well as regional and international codes of practice and their requirements. We reproduce below the preface to the code, developed under a memorandum of understanding between the MRC Fisheries Programme and NACA with funding from DANIDA, SIDA and USAID.

The demand for fisheries and aquaculture products is continuously increasing while natural aquatic resources continue to decline due to over-exploitation, environmental degradation and other problems (e.g. diseases). As such, the aquaculture sector will further intensify and develop, and this will be heavily based on the movement of live aquatic animals and their products from one country to another.

Trade is important and will continue because it is a necessity for aquaculture development at both the subsistence and commercial scales. This is especially true along the Mekong River system where fisheries and aquaculture activities are highly active and often unregulated. Trading and movements (both legal and unregulated) of live aquatic organisms within the Mekong River system may also pose significant problems in terms of spread of trans-boundary aquatic animal diseases, introduction of unwanted species, and loss of genetic diversity. Unregulated industry operations may also bring about pollution and contamination along the Mekong River, which may have negative implications on food safety and quality of aquaculture and fishery products.

Although related regional and international

guidelines and other documents on responsible movement of live aquatic animals are already available, a Code of Practice specific to the nature and condition of the Mekong River system/environment is currently lacking. Thus, it is high time that this Code is developed for implementation in the basin.

This Code of Practice is prepared to promote or ensure compliance to World Trade Organisation-Sanitary and Phytosanitary (WTO-SPS) measures for the movement of live aquatic organisms in the Lower Mekong Basin (LMB). The long-term goals of the Code are to achieve environmental protection and management, biodiversity conservation as well as prevention of spread of disease epizootics. Most of the important points listed in this Code are based on the inputs of MRC Member Countries through national reviews on the Impacts of Exotic Species on Natural Environment and Aquaculture.

This Code requires MRC Member Countries to take responsibility in determining what aspects of the different activities related to trans-boundary movement of aquatic animals in the basin that may bring significant risks to the environment, biodiversity as well as to the aquaculture and fishery industries in the region. The Code further requires members to formulate, develop and implement necessary actions to mitigate the negative impacts of aquatic animal species introductions, especially exotics, into the basin.

The Code is approved by the Technical Advisory Body on Fisheries Management in the LMB (TAB). The approved Code will be guidance for Member Countries to consider developing and formulating their national codes accordingly to mitigate the negative impacts from unregulated movement within and across national boundaries and for economic, social and development purposes in the basin.

Further reading

<http://www.enaca.org/publications/genetics-and-biodiversity/code-of-practice-movement-live-aquatic-animals-lower-mekong.pdf>

FAO and Michigan State University promote responsible inland fisheries

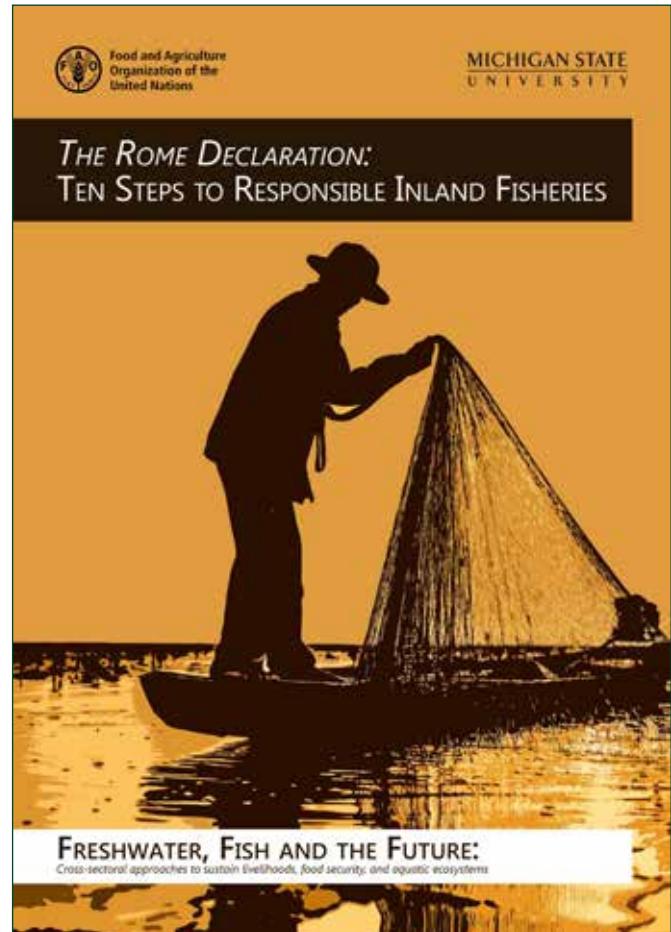
The Food and Agricultural Organization of the United Nations (FAO) and Michigan State University have recently published recommendations derived from the Global Conference on Inland Fisheries held in Rome in January 2015. According to the authors, the Ten Steps to Responsible Inland Fisheries are general and not targeted at specific groups. They are partly based on principles contained in the Convention on Biological Diversity adopted in Nairobi in 1992, Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication published by the FAO in 2015 and Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security published by the FAO in 2012.

1. IMPROVE THE ASSESSMENT OF BIOLOGICAL PRODUCTION TO ENABLE SCIENCE-BASED MANAGEMENT

Accurate and complete information about fishery production from inland waters is lacking at local, national and global levels. Governments often lack the resources or capacity to collect such information due to the diverse and dispersed nature of many inland fisheries. There is much scope for developing and refining biological assessment tools to facilitate science-based management.

2. CORRECTLY VALUE INLAND AQUATIC SYSTEMS

The true economic and social values of healthy, productive inland aquatic ecosystems are often overlooked, underestimated and not taken into account in decision-making related to land and water use. Economic and social assessment is often difficult and valuation often limited.



In most cases, especially in the developing world, inland fisheries are part of the informal or local economy, so their economic impact is not accurately measured in official government statistics.

3. PROMOTE THE NUTRITIONAL VALUE OF INLAND FISHERIES

The relative contribution of inland fisheries to food security and nutrition is higher in poor food-insecure regions of the world than in many developed countries that have alternate sources of food. Good nutrition is especially critical in early childhood development (i.e., the first 1,000 days). Loss of inland fishery production will undermine food security, especially in children, in these areas and

put further pressure on other food producing sectors.

4. DEVELOP AND IMPROVE SCIENCE-BASED APPROACHES TO FISHERY MANAGEMENT

Many inland waterbodies do not have fishery or resource management arrangements that can adequately address sustainable use of resources. Where management arrangements exist, compliance and enforcement are often minimal or non-existent. This may result in excessive fishing pressure, decreased catch per unit effort, and conflicts between fishers, as well as changes in the productivity of fishery resources. In some areas, reductions in fishing capacity will be required. To facilitate fishery management, it will be important to improve access to and promote better sharing of data and information about inland fisheries supporting the assessment–management cycle.

5. IMPROVE COMMUNICATION AMONG FRESHWATER USERS

Information on the importance of the inland fishery and aquaculture sectors is often not shared with or accessed by policy-makers, stakeholders and the general public, thereby making it difficult to generate political will to protect inland fishery resources and the people who depend on them. Moreover, many misconceptions exist on the needs and desires of fishing communities

6. IMPROVE GOVERNANCE, ESPECIALLY FOR SHARED WATER BODIES

Many national, international and transboundary inland waterbodies do not have a governance structure that holistically addresses the use and development of the water and its fishery resources. This often results in decisions made in one area adversely affecting aquatic resources, food security, and livelihoods in another.

7. DEVELOP COLLABORATIVE APPROACHES TO CROSS-SECTORAL INTEGRATION IN DEVELOPMENT AGENDAS

Water-resource development and management discussions very often marginalize or overlook

inland fisheries. Therefore, trade-offs between economically and socially important water-resource sectors and ecosystem services from inland water systems often ignore inland fisheries and fishers. Development goals based on common needs, e.g., clean water and flood control, can yield mutually beneficial outcomes across water-resource sectors.

8. RESPECT EQUITY AND RIGHTS OF STAKEHOLDERS

Lack of recognition of the cultural values, beliefs, knowledge, social organization, and diverse livelihood practices of indigenous people, inland fishers, fishworkers, and their communities has often resulted in policies that exclude these groups and increase their vulnerability to changes affecting their fisheries. This exclusion deprives these groups of important sources of food as well as cultural and economic connections to inland aquatic ecosystems.

9. MAKE AQUACULTURE AN IMPORTANT ALLY

Aquaculture is the fastest-growing food production sector and an important component in many poverty alleviation and food security programmes. It can complement capture fisheries, e.g., through stocking programmes, by providing alternative livelihoods for fishers leaving the capture fisheries sector, and by providing alternative food resources. It can also negatively affect capture fisheries, e.g., introduction of invasive species and diseases, through competition for water resources, pollution, and access restrictions to traditional fishing grounds.

10. DEVELOP AN ACTION PLAN FOR GLOBAL INLAND FISHERIES

Without immediate action, the food security, livelihoods and societal well-being currently provided by healthy inland aquatic ecosystems will be jeopardized, risking social, economic, and political conflict and injustice.

Further reading:

http://www.fao.org/3/a-i5735e.pdf?utm_source=FISHBIO+Fish+Report%3A+Responsible+Inland+Fisheries+and+the+Rome+Declaration&utm_campaign=Fish+Report%3A+Responsible+Inland+Fisheries+and+the+Rome+Declaration&utm_medium=email

Dr Nao Thuok assumes vice-ministerial role at Cambodian agriculture ministry

New Secretary of State previously worked with Mekong River Commission on projects to manage capture fisheries and value wetlands.

Dr Nao Thuok has been appointed Secretary of State at the Cambodian Ministry of Agriculture, Forestry and Fisheries with overall responsibility for the fisheries sector. He was previously Under Secretary of State at the Ministry. Before that, he served as Director General of the Fisheries Administration (formerly known as the Department of Fisheries) for 15 years, a period which saw two phases of fisheries reforms and parliamentary passage of a new fisheries law (see *Catch and Culture*, Vol 12, No 3 and Volume 18, No 1). His latest promotion was part of a cabinet reshuffle in April that saw the appointment of Veng Sakhon, former Secretary of State at the Ministry of Water Resources and Meteorology, as Minister for Agriculture, Forestry and Fisheries.

Born in Prey Krabass District in Takeo Province in 1950, Dr Nao Thuok studied fisheries management at the Preak Leap Agricultural College for four years before earning a BSc at the Royal University of Phnom Penh in 1975. He initially worked as a fisheries inspector on the Tonle Sap Lake. Following the collapse of the Pol Pot regime in 1979, he joined the Department of Fisheries in Siem Reap Province, becoming deputy provincial chief in 1980 and chief of the department in 1982. He later studied crocodile farming and management in Cuba and became deputy provincial chief of the Siem Reap Department of Agriculture, Forestry and Fisheries in 1991 and then Deputy Director-General of the then Fisheries

Department in 1997. During this period, he served as National Director for both the MRC Freshwater Capture Fisheries Management Project and the MRC Wetlands Valuation Project before becoming Director-General of the Fisheries Department in 2000.

Dr Nao Thuok earned an MSc in rural development management at Khon Kaen University in Thailand in 1993 and a PhD in rural development and social



Dr Nao Thuok (right) with Prime Minister Hun Sen at Cambodia's National Fish Day ceremony in Kep Province in 2009

PHOTO: LEM CHAMNAP

work at the Institute of Post-Graduate Studies in Phnom Penh in 2009. Between 2006 and 2013, Dr Nao Thuok was Special Advisor to Prime Minister Hun Sen. He has also served as the Cambodian Commissioner for the International Whaling Commission since 2008 and as Professor at the Fisheries College of the Royal University of Agriculture in Phnom Penh since 2012. He also taught at the Prek Leap Agricultural School since the late 1980s and began teaching fisheries law at the Fisheries College in 1998.

MRC Secretariat to consolidate into one central office in Vientiane

Agreement between Cambodian and Lao prime ministers puts end to co-hosting of Secretariat in Phnom Penh and Vientiane

The Mekong River Commission Secretariat has announced that the Cambodian and Lao governments will soon start discussing practical arrangements for the Secretariat to operate out of a single office in Vientiane. In a statement issued on 10 August, it said Cambodian Water Resources and Meteorology Minister Lim Kean Hor had informed Lao Natural Resources and Environment Minister Sommad Pholsena of an agreement between Cambodia's Prime Minister Hun Sen and his Lao counterpart Thongloun Sisoulith. "At a bilateral meeting on 6 August in Vientiane, the prime ministers agreed that the headquarters of the MRC Secretariat will be located only in Vientiane, but that the MRC Regional Flood Management and Mitigation Centre will remain in the Cambodian capital, Phnom Penh," it said.

"The practical arrangements of this decision will soon be discussed by the concerned ministries in both countries. The possibility of consolidating the two offices has been part of the discussions regarding the organisational restructuring of the MRC as it entered a new five-year strategic cycle in 2016 (2016-2020). The reform aims to create a leaner, more efficient organisation that is self-sustained by its member countries.

"From 1998 the Secretariat was based in Phnom Penh and in 2004 it moved to Vientiane. In 2009 the governments of the four member countries decided to decentralise the Secretariat into two permanent locations in the basin, and in August 2010 the Office of the Secretariat in Phnom Penh was inaugurated.

"The Regional Flood Management and Mitigation Centre opened in 2008. During the June-October flood season, it issues daily flood forecasts and warnings. This information can help member countries prepare and react to potential emergencies. The Secretariat is the



Prime Minister Hun Sen speaking in Koh Thom on 8 August

PHOTO: WWW.FACEBOOK.COM/HUNSENCAMBODIA

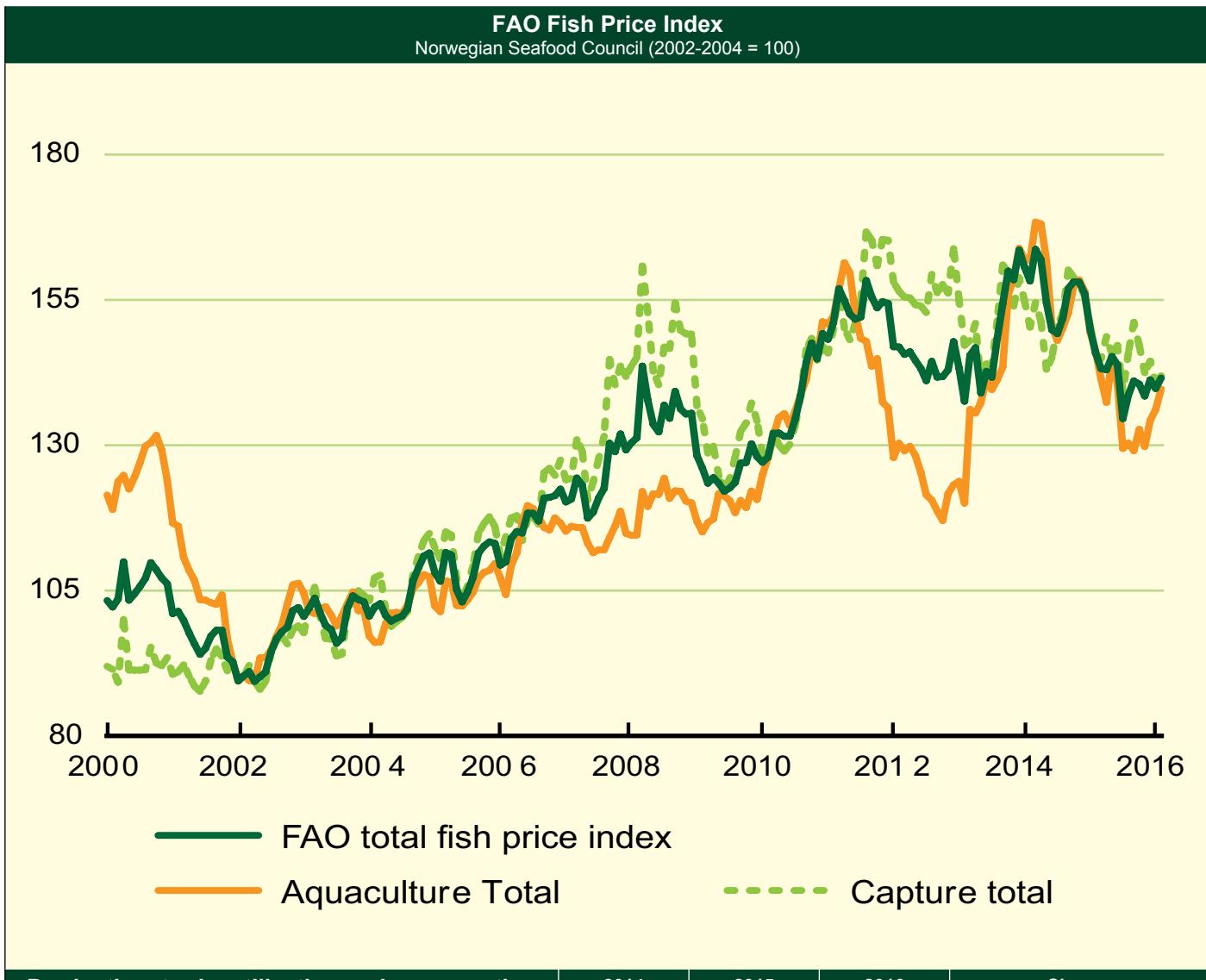
'Grabbing for a crab shell'

Cambodian Prime Minister Hun Sen announced the agreement to consolidate the Secretariat during a ceremony to mark the connection of the main span of a new Chinese-funded bridge over the Bassac River in Koh Thom District in Kandal Province on 8 August. "I joked with the Lao prime minister that we two brothers have been grabbing for a crab shell," the prime minister said. "We have decided to allow the part in Cambodia to join with the other part in Laos. We will keep in Cambodia only the Regional Management and Mitigation Centre."

Further reading

<http://cnv.org.kh/connect-main-span-bridge-koh-thom/>

operational and administrative arm of the MRC, whose structure consists of the Office of the Chief Executive Officer, and four divisions: Administration Division, Planning Division, Environmental Management Division, and Technical Support Division."



Production, trade, utilisation and consumption FAO Food Outlook, June 2016	2014	2015 Estimate	2016 Forecast	Change 2016/2015
	Million tonnes			%
Production	167.2	171.0	175.0	2.3
Capture fisheries	93.4	93.5	93.6	0.1
Aquaculture	73.8	77.5	81.4	5.0
Trade value (exports USD billion)	148.1	134.1	132.6	-1.1
Trade volume (live weight)	60.0	59.9	59.9	0.0
Total utilization	167.2	171.0	175.0	2.3
Food	146.3	149.4	153.6	2.8
Feed	15.8	16.5	16.3	-1.2
Other uses	5.1	5.1	5.1	0.0
Consumption per person				
Food fish (kg/yr)	20.1	20.3	20.6	1.7
From capture fisheries (kg/year)	10.0	9.8	9.7	-0.7
From aquaculture (kg/year)	10.1	10.5	10.9	3.9
FAO Fish Price Index (2002-2004 = 100)	2014	2015	2016 Jan-Feb	Change Jan-Feb 2016/Jan-Feb 2015
	156	142	141	-5.0

Thailand Talaad Thai Wholesale Market, Pathum Thani Province	THB per kg	
	February, 2016	September, 2016
Slender rasbora (<i>Rasbora daniconius</i>)	40 - 45	50 - 55
Chinese edible frog (<i>Haplobatrachus rugulosus</i>) (large)	85 - 90	80 - 85
Chinese edible frog (<i>Haplobatrachus rugulosus</i>) (small)	75 - 80	65 - 70
Asian redtail catfish (<i>Hemibagrus wyckioides</i>)	160 - 180	200 - 230
Yellow mystus (<i>Hemibagrus filamentus</i>)	80 - 100	120 - 130
Tire track eel (<i>Mastacembelus favus</i>)	120 - 220	120 - 220
Clown featherback (<i>Chitala ornata</i>)	230	100
Iridescent mystus (<i>Mystus radiatus</i>) (large)	60 - 90	100
Iridescent mystus (<i>Mystus radiatus</i>) (small)	50 - 60	80
Wallago (<i>Wallago attu</i>) (large)	180	220 - 230
Wallago (<i>Wallago attu</i>) (small)	120 - 140	200
Bronze featherback (<i>Notopterus notopterus</i>)	100	100
Wild striped snakehead (<i>Channa striata</i>) (large)	135 - 140	135 - 145
Wild striped snakehead (<i>Channa striata</i>) (small)	75 - 85	65 - 100
Farmed Indonesian snakehead (<i>Channa micropeltes</i>) (large)	140	120 - 125
Farmed Indonesian snakehead (<i>Channa micropeltes</i>) (small)	60 - 110	65 - 100
Bighead catfish (<i>Clarias macrocephalus</i>) (large)	110 - 120	100 - 110
Bighead catfish (<i>Clarias macrocephalus</i>) (small)	110 - 120	80 - 85
Farmed North African walking catfish hybrid (large)	53 - 56	48 - 50
Farmed North African walking catfish hybrid (small)	45 - 48	46 - 48
Siamese red catfish (<i>Phalocronotus bleekeri</i>) (large)	270 - 290	420 - 430
Siamese red catfish (<i>Phalocronotus bleekeri</i>) (small)	180 - 190	330 - 350
Silver barb (<i>Barbonymus gonionotus</i>) (large)	55 - 60	50 - 60
Silver barb (<i>Barbonymus gonionotus</i>) (small)	72 - 78	85 - 88
Red tilapia hybrid (large)	75 - 80	75 - 80
Red tilapia hybrid (small)	60 - 65	60 - 65
Nile tilapia (<i>Oreochromis niloticus</i>) (large)	58 - 65	50 - 55
Nile tilapia (<i>Oreochromis niloticus</i>) (small)	35 - 45	30 - 35
Whisker sheatfish (<i>Kryptopterus spp.</i>) (large)	140 - 150	160 - 170
Whisker sheatfish (<i>Kryptopterus spp.</i>) (small)	100 - 110	100 - 120
Common carp (<i>Cyprinus carpio</i>) (large)	40	38 - 45
Mekong giant catfish (<i>Pangasianodon gigas</i>)	50 - 60	50 - 60
Boeseman croaker (<i>Boesemania microlepis</i>)	65 - 250	100 - 120
Horseface loach (<i>Acantopsis choirorhynchos</i>)	160 - 180	200 - 230
Giant gourami (<i>Osphronemus goramy</i>)	80 - 100	80 - 85
Siamese mud carp (<i>Henicorhynchus siamensis</i>)	50 - 60	60 - 65
Snakeskin gourami (<i>Trichopodus pectoralis</i>)	120 - 195	120 - 205
Striped catfish (<i>Pangasianodon hypophthalmus</i>)	30 - 32	30 - 35
Climbing perch (<i>Anabas testudineus</i>) from rice paddy (large)	95 - 110	95 - 110
Climbing perch (<i>Anabas testudineus</i>) from rice paddy (small)	75 - 85	75 - 80
Farmed climbing perch (<i>Anabas testudineus</i>) (large)	90 - 95	90 - 100
Farmed climbing perch (<i>Anabas testudineus</i>) (small)	65 - 75	60 - 85
Peacock eel (<i>Macrognathus siamensis</i>) (large)	150 - 160	200 - 220
Peacock eel (<i>Macrognathus siamensis</i>) (small)	120 - 140	140 - 160
Swamp eel (<i>Monopterus albus</i>) (large)	200	230 - 250
Swamp eel (<i>Monopterus albus</i>) (small)	300	300 - 310
Pond snail (<i>Filopaludina martsensi</i>)	30 - 35	30 - 35
Viet Nam Vietnam Association of Seafood Exporters and Producers, Dong Thap Province and Danang		VND per kg unless otherwise stated
		June, 2015
		August, 2015
White pangasius (<i>Pangasianodon hypophthalmus</i>) (Type 1)	20,000	18,800 - 20,800
White pangasius (<i>Pangasianodon hypophthalmus</i>) (Type 2)	18,700	17,800 - 18,800
Pangasius fry (<i>Pangasianodon hypophthalmus</i>) (1 pc)	0.5 - 0.7	0.6 - 1.0
Pangasius fingerlings (<i>Pangasianodon hypophthalmus</i>) (3,000 pcs)	30 - 35	20 - 25
Pangasius seed (<i>Pangasianodon hypophthalmus</i>) (2 cm)	500 - 600	500 - 560
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) (>100 grams)	350,000 - 370,000	300,000 - 310,000
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) (75 - 99 grams)	300,000 - 340,000	268,000 - 280,000
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) (50 - 74 grams)	250,000 - 280,000	220,000 - 240,000
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) (gravid, <50pcs/kg)	150,000 - 200,000	120,000 - 130,000
Black tiger shrimp (<i>Penaeus monodon</i>) (8 pcs/kg)	500,000	-
Black tiger shrimp (<i>Penaeus monodon</i>) (15 pcs/kg)	410,000	350,000
Black tiger shrimp (<i>Penaeus monodon</i>) (25 - 30 pcs/kg)	240,000	240,000
Black tiger shrimp (<i>Penaeus monodon</i>) (40 pcs/kg)	140,000	120,000



On September 21, Vietnamese news outlets ran photos of a Mekong giant catfish (*Pangasianodon gigas*) that was reportedly purchased in Cambodia. A report in *Thanh Nien Online* said the 200 kg specimen was bought from the Tonle Sap Lake on September 20 before being taken to the house of the buyer in the Vietnamese city of Long Xuyen, capital of An Giang Province which borders Cambodia. VietnamNet Online Newspaper reported a day later that the owner of a restaurant in District 7 in Ho Chi Minh City had bought the fish for an undisclosed sum. The fish was so heavy eight people had to carry it to a vehicle before it was transported to the restaurant. "According to the owner, the fish is popular with diners," it said, adding that it fetched VND 1.5 million (\$71) a kilogram. "Many people rushed to the restaurant to see the fish." Under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) of 1973, international trade in this critically-endangered species is banned except when the purpose of import is not commercial. In Cambodia and Viet Nam, it is illegal to catch, sell or transport the species, which has been listed by the International Union for the Conservation of Nature (IUCN) as critically endangered since 2003.

PHOTO: THANH Nien Online



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