



INSIDE

- Outlook for international scientific collaboration in the region
- Fish connectivity between freshwater and marine habitats
- Study of small-scale fisheries, map of threats to inland fisheries
- What caused the Mekong drought in 2019?
- Environmental, social and governance investment
- Climate change and Covid-19
- Yasuhiko Taki



Catch and Culture - Environment is published three times a year by the office of the Mekong River Commission Secretariat in Vientiane, Lao PDR, and distributed to over 650 subscribers around the world. The preparation of the newsletter is facilitated by the Environmental Management Division of the MRC Secretariat. Free email subscriptions are available through the MRC website, www.mrcmekong.org. For information on the cost of hard-copy subscriptions, contact the MRC's Documentation Centre at doccentre@mrcmekong.org. Contributions to *Catch and Culture - Environment* should be sent to peterstarr@mac.com and copied to mrcs@mrcmekong.org.

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The MRC is funded by contributions from its Member Countries and development partners of Australia, Belgium, the European Union, Finland, France, Germany, Japan, Luxembourg, the Netherlands, Sweden, Switzerland, the United States and the World Bank.

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Catch and Culture - Environment

Mekong River Commission Secretariat

Keywords: fisheries, environment

For bibliographic purposes, this volume may be cited as:

MRC (2020) *Catch and Culture - Environment*. Vol 26, No 2. ISSN 0859-290. 48 pp. Mekong River Commission Secretariat, Vientiane, Lao PDR.

Information on MRC publications and digital products can be found at <http://www.mrcmekong.org/publications/>.

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Cover photo Dr Martin Mallen-Cooper, an internationally recognised expert in fish passage (centre), at an advanced training course for dozens of fisheries scientists and engineers from the Mekong region in Bangkok in 2018. The Southeast Asian Fisheries Development Center (SEAFDEC) provided the venue for the week-long "master class" on fish passage which was supported by the MRC, the Department of the Interior of the United States, the Institute for Land, Water and Society at Charles Sturt University and the Australian Centre for International Agricultural Research (ACIAR). PHOTO: LEE BAUMGARTNER

Contents

- 4 Scientific collaboration**
Outlook for international scientific collaboration in the Mekong region
- 10 Diadromous fishes**
Connectivity of Mekong fishes between freshwater and marine habitats
- 14 Capture fisheries**
Study of small-scale fisheries and threat map for inland fisheries take shape
- 18 Hydropower**
WWF welcomes 10-year moratorium on mainstream dams in Cambodia
- 20 Meteorology and hydrology**
What caused the drought in 2019?
- 23 Folk tales**
Why older Cambodians avoid eating fish associated with a dead mother
- 24 Remote water bodies**
Water bodies in Cambodia's remote northern province of Oddar Meanchey
- 26 Environmental, social and governance investment**
Systemic power imbalances in responsible investment
- 32 Environment and health**
Climate change and Covid-19: reflections on efficiency vs resilience
- 36 New publications**
Inland fisheries in Myanmar
- 40 Obituary**
Yasuhiko Taki



Outlook for international scientific collaboration in the Mekong region

The Covid-19 pandemic has changed the way international scientists work across the world. The Lower Mekong Basin is no exception. What are the prospects for future research in the region?

As part of a series on science after the Covid-19 outbreak, the daily London-based newsletter *Nature Briefing* published an article on 4 June stating that the pandemic would force the worlds of scientists to shrink. “The pandemic has forced researchers to grapple with how restrictions on their movement will affect the way science is conducted,” it said. “Some fear that these limitations could lead to a world that favours elite scientists and established teams with less need to network, while others lose collaborators and become marginalised, and fieldwork becomes a luxury. Or, the opposite could turn out to be true: travel restrictions could help to democratize science, if virtual working allows access to more connections for people who cannot easily travel.”

Caroline Wagner, a science and policy researcher at the Ohio State University in Columbus, reportedly warned of a decline in international collaboration with scientists in developing countries apart from China “If people can’t work side by side for short periods of time, it’s going to dramatically cut international collaboration,” she was quoted as saying. She reportedly also told the newsletter that co-authorship links between China and other scientifically dominant countries for scientific papers had strengthened after the outbreak whereas participation from other developing countries had dropped off. So where does that leave international scientists working in the Lower Mekong Basin (LMB) and their colleagues in the region?

Remote working

For Dr Lee Baumgartner, Professor of Fisheries and River Science at Charles Sturt University in Albury, Australia, the headline in the article was wrong — scientists’ worlds had already shrunk. “The contrac-



Cambodian, Lao, Thai and Vietnamese trainees practice how to collect fish larvae during fisheries monitoring training in the northern Lao province of Luang Prabang in February. The training was part of a pilot project for the MRC’s Joint Environmental Monitoring (JEM) Programme. The pilot projects have been supported by German Development Cooperation and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, a federal German enterprise that supports the German Government in the field of international cooperation for sustainable development.

PHOTO: ERINDA PUBILL PANEN

tion was sudden, unexpected and unprecedented. As soon as the borders closed, research virtually stopped," he said. "The travel bans have forced us to significantly revise our delivery models and find alternative strategies to complete fieldwork and knowledge exchange. Desktop work could carry on. But for projects which are field based, or involve knowledge exchange, we are in uncharted waters."

'You need to be in the region, boots on the ground, face-to-face'

According to the Australian freshwater fisheries ecologist, "knowledge exchange cannot effectively be done remotely. You need to be in the region, boots on the ground, face-to-face. The contraction is also further hampered because most donors and funding agencies have completely shifted their research focus to Covid-19. Some have even asked researchers to redesign their entire research programs to focus on Covid-19. Whilst this is understandable — especially given some countries have seen massive mortality rates — the issues regarding water and food security will not go away. It is critical that these keep being progressed because, when the pandemic passes, the growing global population will still need water and food. For the majority of people in the Mekong, food is rice and fish."

Dr Baumgartner expects that international researchers will struggle. "Those based in the region will be better placed. But one of the advantages of the fly-in fly-out model is that much of the technology needed to drive innovation in fisheries cannot be bought off the shelf in the LMB. In fact, it is really hard to get basic research equipment. So in-country researchers will struggle with access to equipment and resources. There is a risk that LMB scientists will find themselves increasingly isolated at a time where the current river development agenda makes international collaboration and knowledge exchange critical for food security."

According to a Vietnamese fish geneticist now working abroad for an international organization, "laboratory and on-station work will be less affected by the Covid-19 pandemic than field visits and other work by social scientists. Early stages of research will be more affected than late stages."

The Vietnamese scientist, who asked not to be named, said "facilities with good conditions and capable staff should be able to continue their research work — although at a much slower speed because the teams might need to be divided and rotated with social distancing practiced. But on-site visits will obviously be cancelled or delayed so corresponding work planned will be delayed. It's a good time to analyse data and write reports or articles."

Opportunities

Dr Tuantong Jutagate, Professor at the Department of Fisheries of Ubon Ratchathani University in northeast Thailand, expects several opportunities on the horizon for both regional and international scientific research. "The pandemic of Covid-19 obviously impacts the logistics and supply chains of fishery and aquaculture products as well as market demand, both domestically and globally," he said. "To focus on and understand the scale of these impacts in Mekong countries, collaboration among Mekong scientists is now very important, especially in the fields of small-scale aquaculture and artisanal fisheries. It is also a chance for scientific collaboration to apply technologies and the Internet of Things to aquaculture and fisheries in the basin to become 'labour extensive' businesses."

"This is a great opportunity for international scientific collaboration — not only in the Mekong but in oth-



Researcher Nirun Warin (right) interviews a fish farmer in Ubon Ratchathani Province in northeast Thailand about how the pandemic has affected his business. Mr Nirun works for Aquadapt-Mekong, a project run by the Unit for Social and Environmental Research at Chiang Mai University. Partners are the Inland Fisheries Research and Development Institute in Cambodia, the National University of Laos, WorldFish in Myanmar, Ubon Ratchathani University in Thailand and Can Tho University in Viet Nam.

PHOTO: AQUADAPT-MEKONG

er large rivers worldwide — on understanding the healing potential of river ecosystems once they are less polluted by effluent and less disturbed,” Dr Tuantong said. “It is also an opportunity to develop scientific proof on resilience of Mekong fishes when ecosystems become healthier, in particular the small and medium sized species which support Mekong fisheries.”

Fieldwork

For Dr Zeb Hogan, Research Assistant Professor at University of Nevada, Reno, the impacts of the pandemic have been “pretty dramatic” in the short term. “We haven’t been able to travel, conduct field work, or field-based outreach activities,” says the American conservation biologist who is lead coordinator for the USAID-funded Wonders of the Mekong project with the Cambodian Fisheries Administration. “We’ve been putting our energy into planning, communicating using Skype/Zoom/Whatsapp, social media, data analysis and writing. We are more organised and in better communication than before Covid-19, but less able to actually get out and do stuff.

“If a vaccine was discovered tomorrow I think — from my personal perspective and a project perspective — things would go back to normal (very similar to pre-Covid-19). Given that we are unlikely to see a vaccine soon, resumption of travel, field work, and outreach activities will likely happen gradually. Already I’ve heard that in-country outreach and field work is possible in Cambodia, so that’s a good sign. Our Cambodia team members will likely take advantage and go to the field. We also sponsor students from the Royal University of Phnom Penh who are waiting for the university to re-open. Visitors from the USA are also allowed to travel to Cambodia but with restrictions that — as I understand them — make short trips impractical.

“I’m hopeful that I will be able to get back over to Cambodia by August and, if so, Wonders of the Mekong can continue more-or-less as planned. We



Dr Sudeep Chandra, Associate Professor of Limnology and Conservation Ecology at University of Nevada, Reno (left) checking Mekong water quality with Chann Kimsan, a student at the Faculty of Hydrology and Water Resources Engineering at the Phnom Penh Institute of Technology. The water was collected from the reservoir of the recently completed Sesan II hydropower project on the Sesan River, a major tributary of the Mekong that originates in central Viet Nam before flowing through southern Lao PDR and northeast Cambodia. Monitoring the water quality upstream and downstream from the dam is part of the USAID-funded Wonders of the Mekong project with Cambodia’s Fisheries Administration. Dr Chandra is co-principal investigator of the five-year project launched in 2017.

PHOTO: CHHUT CHHEANA

are planning for a lot of field activities in the last part of 2020 and first part of 2021. We are also sponsoring a Fulbright student from the USA but her program from September 2020 to January 2021 has been postponed.

“Covid-19 certainly has made collaborating in person more difficult. I don’t think overall collaboration has suffered yet — people are still very much in

touch with each other and working together — but eventually we have to be able to meet in person, and get out into the field for research, outreach, and reporting. I hope that happens soon,” the American scientist says.

Meetings

For a veteran fisheries scientist who has worked in the Mekong region for many years, “the biggest issue is going to be collaborations and international research initiatives. There is going to be a change in working practices with much more done locally for the next couple of years. Travel will remain restricted for some time yet and field-based research that requires close contact will need rethinking. Personally, I see a stagnation of environment-related research despite this being a pivotal period with calls to build on the benefits from the closedown.”

The scientist, who also asked not to be named, ex-

pects fewer meetings in Lower Mekong countries and a change in working practices. “The Covid pandemic has shown that meetings to scrutinise drafts of reports can be mostly done remotely, with only the occasional meeting to discuss the main outputs and approve the reports.” This should “reduce the heavy burden on meetings in favour of a rationalised program of evaluation freeing up time for staff to invest in further understanding the science and information collected, and translating it into actions,” he said.

Aid and students

Dr Ian Campbell, an independent consultant working on rivers including the Mekong, said the pandemic might affect foreign aid agencies funding research in developing regions including the Mekong. “That is likely to be impacted in two ways. Firstly a general economic decline will mean reduced budgets for aid agencies in general,” the Austral-



From left, Australian ecologist Dr Bruce Chessman collecting insects on the Sre Pok River near Banlung in northeast Cambodia in March, 2005 with Lao colleague Mr Chanda Vongsambath, Mr Meng Monyrak from Cambodia and another Lao colleague Dr Bounnam Pathoumthong. The team collected invertebrates by net from along the edge of the river. The bugs, bits of dead plant, gravel and sand were tipped into trays with water. The individual bugs were then picked out and preserved in alcohol to be returned to the lab and identified. Such littoral invertebrates were one of the indicators used in a biological assessment the MRC was running at the time. Mr Vongsambath and Mr Monyrak were among the principal contributing authors of *Biomonitoring of the lower Mekong and selected tributaries 2004—2007*, an MRC Technical Paper published in 2008 with Dr Chessman as the lead editor. Dr Bounnam died in a road accident a few years after this photo was taken.

PHOTO: IAN CAMPBELL



In 2019, Vietnamese fish biologist Vu Vi An spent several days in front of a billion dollar machine he had never heard about until he was driven through the front gate. The machine was the Australian Synchrotron on the outskirts of Melbourne, where powerful beams of light are used in experiments to examine molecular and atomic details of a wide range of materials. The techniques are applied to research in many areas including medicine, food, the environment, biotechnology, nanotechnology, energy, mining, agriculture, advanced materials and cultural heritage. In this photo, An is preparing to analyse fish otoliths — small calcareous bodies in the inner ears of vertebrates that sense gravity and movement (for details of his research findings, see page 10). An works for the Research Institute for Aquaculture No 2 (RIA2) in Ho Chi Minh City and has been seconded to Charles Sturt University in Albury where he is studying for his PhD. Now stuck in Australia because of the Covid-19 pandemic, his fieldwork back in Viet Nam and neighbouring Mekong countries has been delayed. “Some conferences that I was planning to attend have also been delayed,” he said. An also said that international scientific collaboration was essential for the Mekong Basin. “We need international experts to take the lead — in planning stages, for example. They have the capacity and neutral views, especially in the area of dam impact assessment, a hot issue in the basin.”

PHOTO: LEE BAUMGARTNER

ian scientist said. “Secondly, countries may well use this as a time to refocus where their aid budget is directed. For example, Australia has already signalled an intention to focus more aid on the Pacific island nations, and that change is likely to come at the expense of aid programs to other geographic regions.”

'Many researchers are existing in states of suspended animation'

The Melbourne-based consultant said travel restrictions in Australia “make it impossible to conduct field-based programs at present, and with the uncertainty about when and how those restrictions may be lifted many researchers are existing in states of suspended animation at present. It is particularly difficult for multi-regional teams. Teams based just within the Mekong countries are likely to be able to recommence field work sooner than those which include members from further afield. It may be that researchers from countries with severe outbreaks of the virus, such as the USA, the UK and Brazil may be trapped on the sidelines for longer than others.”

Dr Campbell, who worked as environment specialist at the MRC Environment Programme between 2000 and 2005, said he believed that Australian science would be “particularly severely affected by Covid. All of our universities have been earning income from foreign students, and some have been earning quite a high proportion of their total. The Australian government and state governments have declined to offer financial support to universities, seeing the education industry as less deserving of support than industries such as horse racing.

“Fees from foreign students have not only supported university teaching in Australia, but have also been used to support research,” he said. “So in Australian universities, which is where most research is conducted in Australia, there will be substantial reductions in staff, and consequently higher teaching loads — and less research time — for remaining staff as well as fewer graduate students who do much of the research and less funding to support research. In many universities, quite a number of the graduate students are foreign as well and with travel issues there will be fewer of them.”

Dr Chris Barlow, an independent consultant based

in Canberra who recently retired from the Australian Centre for International Agricultural Research (ACIAR), expects potential “troubles” for scientific collaboration without face-to-face meetings. “All good, effective international collaboration is built on trust. The most important element of that is friendship, or acceptance of each other as equals in the game,” said Dr Barlow, who ran the MRC Fisheries Programme from Phnom Penh and Vientiane between 2002 and 2009.

'A good research team will rescue a poorly designed project but a substandard team is unlikely to deliver on even the best of project designs'

“Of course that has to be backed by confidence in technical abilities of international collaborators. But still the trust and relationship aspect is the most important element. We had a saying in ACIAR that a good research team will rescue a poorly designed project but a substandard team is unlikely to deliver on even the best of project designs. All of this is self-evident to anyone who has worked for some time in international development, but still it is sometimes overlooked or not appreciated by development agencies.

“It also follows that the team needs to develop organically — meaning they need to get to know each other face-to-face, have mutual respect and a joint desire to work together. So post Covid, I see troubles, sometimes, for collaborations that have arisen over a few email exchanges with probably no face-to-face meetings, and definitely no background, small-scale testing of work arrangements and relationships — what we usually call preliminary investigations, or testing of concepts.

“And unfortunately, I think international travel will be restricted for another 12 months or more — quite possibly until an effective vaccine is available. Couple that with likely changes in developmental aid money as there will be redistribution, and natural resources is likely to be a loser. All of which means, in my estimation, that international collaborations in our broad field will be less frequent in the near future compared with the recent past.”

Further reading

Mallapaty, S. (2020) Scientists' worlds will shrink in the wake of the pandemic. *Nature Briefing*, London.

Connectivity of Mekong fishes between freshwater and marine habitats

BY AN V. VU, LEE J. BAUMGARTNER, JULIA A. HOWITT, KARIN E. LIMBURG, JULIANE REINHARDT, MARTIN MALLEN-COOPER AND IAN G. COWX *

Many Mekong fishes are associated with saline water and require movement between freshwater sections of the river, the delta and the sea. Our work has found that around 11 percent of Mekong fish species distribute in a wide range of environments (freshwater, brackish, marine). Dozens of fish species exhibit diadromous traits. A microchemistry study of 15 Mekong species has revealed that some live in the sea but migrate long distances up the Mekong River for breeding. Many others spend their lives in the river but spawn at sea. Interestingly, several species show variation in migration strategies. For example, some individuals within a given species connect with the Mekong estuary. Others simply stay, and complete their entire lives, in freshwater only. Our work is demonstrating that the life cycles of Mekong species are far more complex than previously thought. Mekong fishes need free access from freshwater and saline water to complete their life cycles.

Diadromy is a term to describe fish species that migrate regularly between freshwater and marine waters (Myers 1949). Fifty-seven percent of Mekong fishes are distributed in freshwater only (including rithron species, long/short-distance migrants, floodplain spawners, generalists, and floodplain residents). The remaining species are associated with brackish and marine habitats to a certain extent. Of this last group, many fish species exhibit diadromous traits based on available information in the MRC's Mekong Fish Database and FishBase (www.fishbase.org). Some marine species (e.g. *Scomberomorus sinensis*) travel occasionally hundreds of kilometers up the Mekong River for feeding (Rainboth 1996). In addition, some Mekong species are classified as critically endangered (1.50 percent), endangered (2.56 percent), near threatened (3.35 percent), vulnerable (3.52 percent), of least concern (36.39 percent) and data deficient (17.53 percent). But many are yet to be evaluated (35.15 percent).

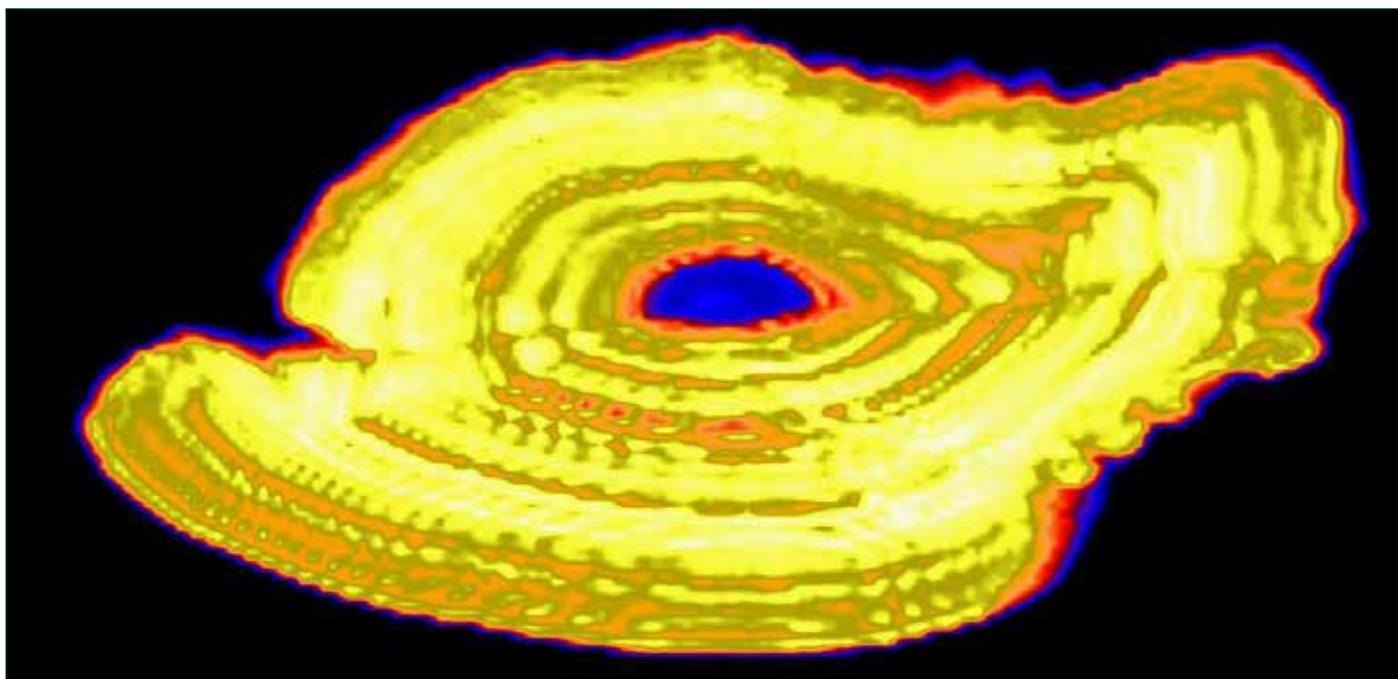
There are several migration patterns of Mekong fishes between freshwater and marine environments (potamodromy, anadromy, catadromy, amphidromy, oceanodromy — see box below). It is noteworthy that a few fish individuals within a given species move occasionally from one environment. For example, low numbers of potamodromous fishes migrate occasionally to estuarine waters — known as “freshwater wanderers” — while a few estuarine/marine residents occasionally enter freshwater, known as “estuarine/marine visitors.” Other terms exist to describe the many life history repertoires observed. For example, species that spawn in estuaries, being flushed to sea as larvae, then returning to estuaries are “estuarine migrants.” Conversely “marine immigrants” are species that breed at sea but enter estuaries as larvae, using estuaries extensively as nursery areas.

Life cycle categories of Mekong fishes

Potamodromy (migrating exclusively in freshwater); anadromy (growing at sea, then migrating to freshwater for breeding); catadromy (growing in freshwater then migrating to the sea for breeding); amphidromy (adult growth and spawning in freshwater, with juvenile growth in the estuary/sea or vice-versa); estuarine resident (migrating exclusively in brackish water); and marine resident or oceanodromy (migrating exclusively in the ocean).

Adapted from Myers (1949) and McDowall (1992)

Otoliths (“ear-stones”) are calcified structures that form part of the fish inner ear and are involved in hearing and balance. Their growth is incremental and similar to rings on a tree. Like tree rings, otoliths can be used to determine a fish’s age and thus provide critical data for fisheries management. Fascinatingly, within the growth increments, trace elements are taken up from ambient water and food



Anadromous species: fish otolith strontium map of Krempf's catfish (*Pangasius krempfi*) analysed by Scanning X-ray Fluorescence Microscopy (55 cm fork length, captured at sea). The blue interior section formed where the fish was born represents low strontium corresponding to the freshwater part of its life, the red and yellow growth increments were laid down in estuary and marine habitats respectively.

IMAGE: AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION

throughout a fish's life cycle. Hence, microchemical composition in each incremental layer acts as a natural tag that reflects different environments or habitats that a fish experienced at that time in its life. Microchemistry retrieved from otoliths can therefore be used as a proxy to explore fish life history because chemical composition is often different between environments (freshwater, brackish, and marine) or habitats (main stem, tributary, floodplain). One of the most useful trace elements to study diadromy is strontium (Sr), which substitutes readily for calcium in the otolith matrix, but is often more abundant in seawater than in inland waters. This is the case for the Mekong River.

We quantified key trace elements in Mekong fish otoliths by both Laser Ablation – Inductively Coupled Plasma Mass Spectrometry (LA ICPMS) and synchrotron-based Scanning X-ray Fluorescence Microscopy (SXF) to examine migrations between freshwater and marine waters for An's Ph.D. He collected hundreds of otoliths from over ten migratory key species in the Lower Mekong Basin. This study fills a key knowledge gap on diadromy in the region. Below are some preliminary findings from his study that display some of the striking results from work in July last year at the Australian Synchrotron in

Melbourne, where he developed two-dimensional maps showing the chemistry of sectioned otoliths. An's thesis will be completed and available soon.

Australian Synchrotron

Access to the synchrotron in Melbourne was covered by an in-kind contribution by the Australian government. The Australian Synchrotron also has a program which can help international researchers gain beam time (commercial access can be AUD 800 an hour). The only ASEAN countries with synchrotron research facilities are Singapore and Thailand. Elsewhere in East Asia, Japan has a dozen such facilities, China has five, Taiwan has two and South Korea has one.

Previously, some studies confirmed Krempf's catfish (*Pangasius krempfi*) as an anadromous species by sampling fish in fresh and brackish waters. In our present study, An collected this species at sea to examine any variation in life history. Even in *P. krempfi* sampled at sea, strontium concentration was low at the core (see image above), confirming

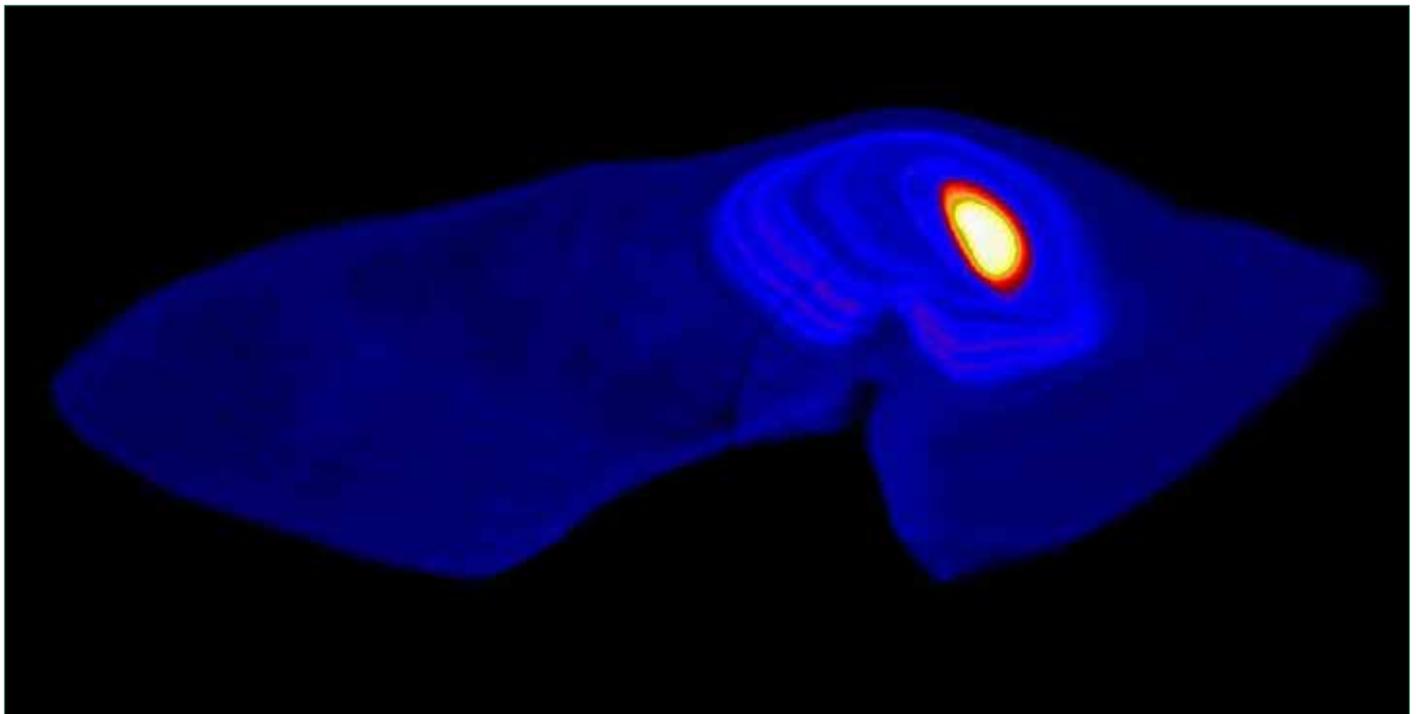
that they spawned in the freshwater Khone Falls area in Lao PDR, 700 km from the sea, where mature fish (full of eggs) have been observed. Variation in strontium from the core to the edge of otolith suggests that larvae drifted downstream to the Mekong estuarine nursery habitat to feed and grow. They then moved offshore and returned nearshore (about 35 km from the coast) where they were captured. This is a dramatic demonstration of sea-inland connectivity. All *P. krempfi* sampled, although varied, showed this necessary connectivity.

Another long-distance migratory fish species, the giant mottled eel (*Anguilla marmorata*), was confirmed as having a catadromous life cycle (born at sea, moves into fresh water to grow). Here it was found that the strontium concentration was very high at the core, from being spawned in the sea (see image below). The eels analysed then moved at least 700 km upstream for feeding. Giant mottled eel is considered as having one of the highest prices among Mekong fish in the region (about USD 30 per kg) and again depends on access to both marine and freshwater habitats to complete its life cycle.

Migration of the soldier catfish (*Osteogeneiosus militaris*) was also examined by otolith microchemistry. Variation in strontium on the otolith suggests that the soldier catfish was an estuarine species, since there is no clear signature of freshwater (see image on opposite page). Concentration of strontium at the core (when born) is relatively the same at the edge of otolith (when captured). It is likely that spawning and capture locations were at the same place. In addition, this individual was incubating eggs in the month of sampling.

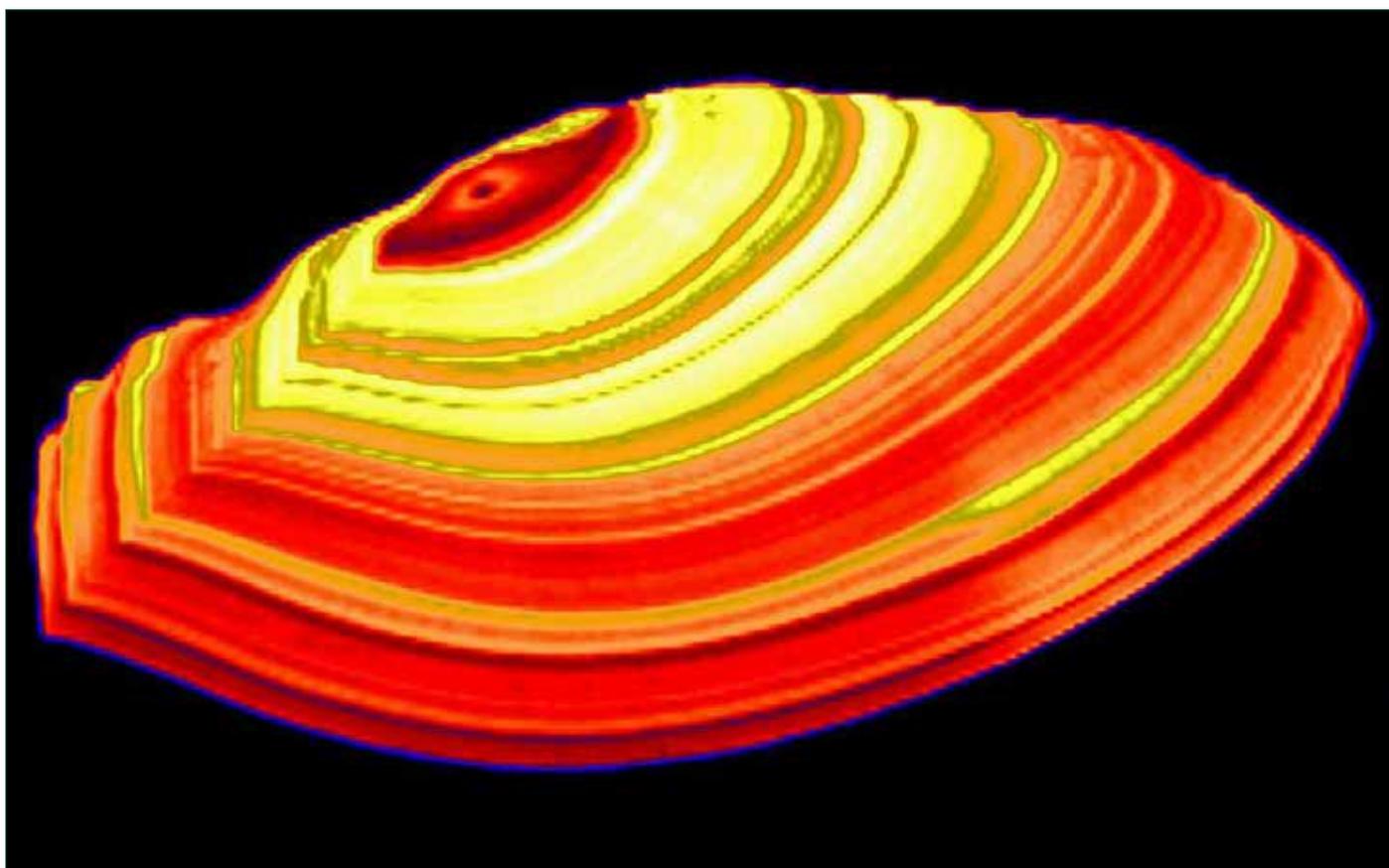
'Connectivity of Mekong fishes between freshwater and marine habitats is far more common than previously thought'

Our ongoing study reveals that connectivity of Mekong fishes between freshwater and marine habitats is far more common than previously thought. Otolith strontium has proven to be a useful tool in the Mekong River watershed to distinguish the many forms of habitat use and movements. Many more species exhibit diadromous traits that could be confirmed with this technique.



Catadromous species: fish otolith strontium map of giant mottled eel (*Anguilla marmorata*) analysed by Scanning X-ray Fluorescence Microscopy (55 cm total length, captured in the Mekong River at Khone Falls in Lao PDR). The fish has a very strong marine signal in early life, but quickly moves to freshwater.

IMAGE: AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION



Estuarine species: fish otolith strontium map of soldier catfish (*Osteogeneiosus militaris*) analysed by Scanning X-ray Fluorescence Microscopy (27 cm total length, captured in the Mekong estuary).

IMAGE: AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION

Diadromous fishes migrate between habitats at some stages of their lives to optimise feeding, breeding and refuge. They require free-flowing routes to access their critical habitats (spawning, feeding, refuge) to complete their life cycles. Disconnection between critical habitats by river development — such as hydropower or irrigation — poses a major threat to Mekong fish migrations, probably leading to extinction. Otolith microchemistry is a cost-effective and powerful tool to elucidate fish life-history. The advantage of a natural tag such as strontium over an artificial tag is that each individual fish is marked throughout its entire life, thus creating a “geochemical logbook” recording its movements. Otolith microchemistry can thus be a powerful tool to understand the “secret lives” of Mekong fishes, for better conservation and management.

** Mr An is a fish biologist at the Research Institute for Aquaculture No 2 (RIA 2) in Ho Chi Minh City who is currently engaged in doctoral studies at Charles Sturt University in Albury, Dr Baumgartner is the university's professor of fisheries and river science, the late Dr Howitt was an environmental chemist with Charles Sturt University, Dr Limburg is professor at the College of Environmental Science and Forestry at the*

State University of New York, Dr Reinhardt was an x-ray fluorescence microscopy beamline officer at the Australian Synchrotron, Dr Mallen-Cooper is a Sydney-based international expert in fish passage and Dr Cowx is director of the Hull International Fisheries Institute at the University of Hull. Mr An's study was supported by the Australia Awards Scholarships and the views expressed in this article do not represent those of the Australian Government. Analysing trace elements in otoliths was undertaken on the Scanning X-ray Fluorescence Microscopy beamline at the Australian Synchrotron and with Adelaide Microscopy at the University of Adelaide.

Further reading

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Study of small-scale fisheries and threat map for inland fisheries take shape

Building on a World Bank study published eight years ago, the FAO has joined forces with an American university and WorldFish to conduct a new global study of small-scale fisheries. Under a separate initiative, the UN agency is working with the United States Geological Survey (USGS) to map threats to the world's inland fisheries.

Small-scale fisheries are often marginalized. But with growing pressures — such as competition for aquatic resources, climate change, more people fishing, limited investment in management and conservation measures — “the costs of marginalization are increasingly apparent,” says the Food and Agriculture Organization of the United Nations (FAO). Against this background, the FAO is working with Duke University in North Carolina and WorldFish on a new global study on small-scale fisheries. Funded by the Norwegian Agency for Development Cooperation, the Swedish International Development Cooperation Agency, the Geneva-based Oak Foundation and the CGIAR Trust Fund, the research — including about 50 country case studies — is scheduled to be completed by the end of this year. The “Illuminating Hidden Harvests” study builds on similar research published by the World Bank in 2012 and follows the FAO’s development of Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication in 2015.

According to the FAO’s latest State of World Fisheries and Aquaculture report released on 8 June, the study represents “one of the most extensive efforts to compile available data and information on small-scale fisheries around the world.” The Rome-based agency said the study would address the social, environmental, economic and governance contributions and impacts of small-scale fisheries at global and local levels as well as the key drivers of change in these sectors — including threats and opportunities. The study aims to “contribute evidence to inform global dialogues and policy-making processes to enable fishers, civil society organizations and NGOs to advocate for productive, sustainable and equitable small-scale fisheries,” the FAO said.

The UN agency said the World Bank study was “a first attempt to synthesize information on the diverse and misreported contributions of capture fisheries globally” including estimates of the relative importance of large and small-scale fisheries. The study found that millions of tonnes of fish from the small-scale fisheries were unreported. The inland fisheries catch alone were estimated to be under-reported by about 70 percent. Other findings were that small-scale fisheries accounted for more than half the catch in developing countries — with 90-95 percent consumed locally in rural areas with high poverty rates. “A series of thematic studies will highlight available information on important themes, for example: gender, indigenous peoples and cultural identity,” the FAO said.

'The study is expected to contain about 50 country case studies including from 18 countries in the Asia-Pacific region'

By expanding the scope of the World Bank study, the new research “seeks to reflect the need for more comprehensive approaches to sustainable development” with new syntheses of social and nutritional benefits, governance characteristics and social aspects of benefits from different fisheries sectors. Thematic studies cover areas such as gender, indigenous peoples and cultural identity.

The study is expected to contain about 50 country case studies including from 18 countries in the Asia-Pacific region. The case-study countries rep-

Small-scale fisheries elude definition

In 2015, the FAO noted “great diversity” in small-scale fisheries. “There is no single, agreed definition of the subsector,” it said. Accordingly, its guidelines for sustainable small-scale fisheries did not prescribe a standard definition of small-scale fisheries — nor did they specify how countries should apply its guidelines.

Mekong leads world in contribution to inland fish catch

The latest State of World Fisheries and Aquaculture report (FAO 2020) ranks the Mekong as the world’s most important hydrologic region or river basin for freshwater fish catches. The report found the Mekong Basin accounted for more than 15 percent of the global inland fisheries catch and that 50 percent of the global catch could be attributed to the top seven basins (see table at right) “Some of the world’s largest inland fisheries come from basins or river systems that are facing severe threats from anthropogenic and natural environmental pressures,” the FAO said. “However, there is limited or no routine monitoring of the status of capture fisheries in most of these basins.”

According to the report, fishing pressure on inland fisheries reflects human population density, primary productivity and secondary production of a waterbody as well as access to fishing, socio-economic dependence on fish and the availability of alternative foods and livelihoods. “Inland fisheries are strongly influenced by fluctuations in environmental and climate conditions,” it said, “and they experience high inter- and intra-annual variation as a result.” Both natural and anthropogenic environmental drivers affect aquatic habitats, water flows, connectivity and water quality. Climate variability and seasonal effects also influence both short-term annual cycles and longer-term trends. Human activities in agriculture including irrigation,

urbanization, industry and damming “all have strong impacts on water and aquatic ecosystems,” the report said.

The FAO report said 37 countries indicated rising production between 2007 and 2016, representing almost 60

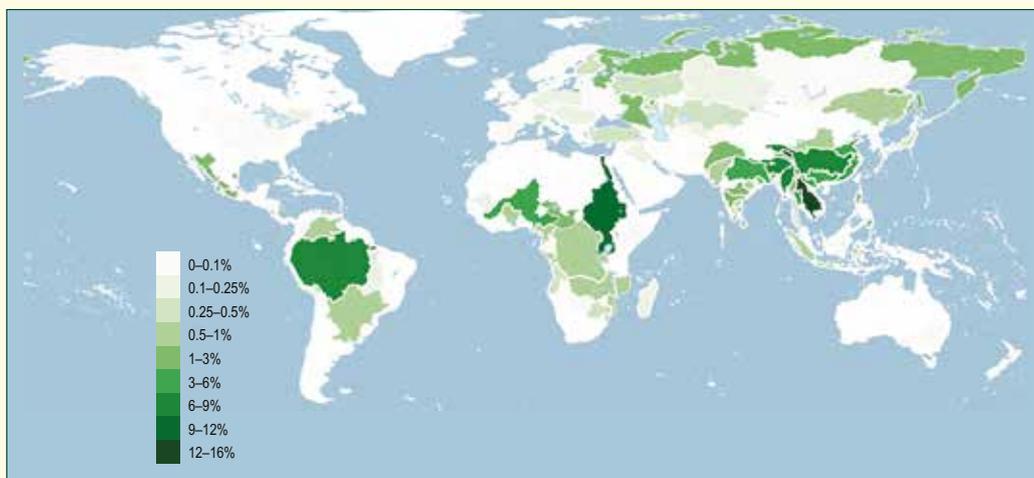
percent of the global inland fish catch. “The major drivers of this trend were China, India, Cambodia, Indonesia, Nigeria, the Russian Federation and Mexico,” it said. Twenty-eight countries indicated falling production, representing 5.9 percent of global inland fish catch, with the trend driven by Brazil, Thailand, Viet Nam and Turkey. The FAO noted that all four countries had “significant” aquaculture production. At the same time, however, “inland fisheries remain extremely important at the subnational level in these countries” — notably those in the Mekong and the Amazon basins. “Hence, this decline should not be a cause for complacency,” the report said. Neither Lao PDR nor Myanmar were included in the analysis.

Global catch from basin

Top Ten Basins	Catch
Mekong	15.18%
Nile	9.70%
Ayeyarwady	7.82%
Yangtze	6.83%
Brahmaputra	5.52%
Amazon	4.26%
Ganges	3.51%
Pearl	3.27%
China Coast*	2.75%
Red River	2.46%

* non-major Chinese rivers running into the coast

Hydrologic regions and river basins most important for the world's freshwater capture fisheries



White represents no significant catch. Lightest green indicates less than 0.1 percent and darkest green 14 to 18 percent of the global total inland fishery catch. Retained recreational catches are not included.

SOURCE: FAO/HULL INTERNATIONAL FISHERIES INSTITUTE

resent 83 percent of the global small-scale fisheries catch, 89 percent of the global inland catch and 96 percent of inland fishers and post-harvest workers. Following the launch of a synthesis report in late 2020, “thematic studies, and possibly a number of country case studies, will appear as separate reports and scientific journal articles where appropriate,” the FAO said.

In the separate FAO work with USGS, the State of World Fisheries and Aquaculture report said 20 variables were being used to assess five major threats to inland fisheries — population-related pressures, loss of connectivity, climate variability, water use and pollution (see table on opposite page). Preliminary analysis covered 87 basins, which produce 95 percent of the global inland fish catch. Almost half of these basins — accounting for 47 percent of the catch and representing some of the world’s most productive inland fisheries — face moderate to high threats.

At the basin scale, the biggest threats are from a combination of loss of hydrologic connectivity, water abstraction, low gross domestic product and high population density along with land-use change and associated runoff. The report said the threat maps might be more representative of fisheries in large, shallow lakes such as the



This map shows the biggest threat to Mekong Basin fisheries as being mainly in northeast Thailand where the Mun-Chi Sub-Basin is located. Other threats can be seen in China and northern Lao PDR as well as the floodplain in southern Cambodia and the Mekong Delta in Viet Nam.

SOURCE: FAO (2020)

Five threats, twenty variables

Major threats	Sub-indicators
Population-related	Population density; gross domestic product; road accessibility
Loss of connectivity	Dams; barrages, weirs, dykes and other barriers; channelization; dredging
Land use	Deforestation, land degradation; mining; sedimentation; nitrogen runoff; phosphorous runoff, agricultural land use
Climate variability	Temperature increase/decrease/variability; precipitation increase/decrease/variability; predicted extreme climate events
Water use	For irrigation, agriculture; industry; urban and human consumption
Pollution	Pesticides, other chemical runoff; plastics, pharmaceuticals, other pollution; aquaculture effluents; urban sewage

SOURCE FAO (2020)

Tonle Sap, riverine floodplains, wetlands, deltas and reservoirs. “This may be due to the high residence time and slow water exchange of large lake systems, allowing them to absorb or accumulate impacts, through processes that occur over a period of many years, before reaching a tipping point,” it said.

The output from the FAO and USGS work will be a composite map showing threats to the potential of waterbodies to support inland fisheries or aquatic biodiversity. “The threat map can also be considered a proxy for the relative combined anthropogenic pressure on a specific basin or sub-basin supporting fisheries,” the FAO report said. “Upon completion, the threat-mapping GIS layer will be freely available through ScienceBase and other open-source information systems. ScienceBase will serve as the data repository, a catalogue of code and data-processing documentation, and a link to acquired datasets and relevant collaborations.”

Ecosystem approach to management

The FAO said the maps would range from global to basin and sub-basin scales — and even lower resolutions where the data exist. “This allows fisheries and environmental managers to examine threats and drivers at the level appropriate to their management plans,” it said, adding that it also supported an ecosystem approach to fisheries management. “The advantage of this mapping method is that it uses global, publicly available data, allowing coverage of countries that may have very limited capacity to collect and report data to FAO.”

The report said interpretation the maps could be en-

hanced by field observations based on local knowledge and data collection. Linking the threat maps to fisheries data at a subnational level “will enable more detailed national analysis and planning, especially pointing to areas where there is a need for greater understanding of primary threats and their relationship to fisheries production and fish biodiversity,” it said. “This would enable national fishery agencies to identify important inland fisheries (or aquatic biodiversity) that are at risk and prioritize appropriate fishery monitoring and management interventions.”

It is expected that the global maps will change significantly only over a five-to-ten-year period. “This would be the typical time frame for periodic updates on a global state of threats to the inland fisheries,” the FAO said. “Ultimately, this work will require commitment and additional resources to undertake assessments of the indicator fisheries on a routine basis, and agreement to report into a common framework in order to enable FAO to collate a global assessment in a similar manner to that of the FAO marine stock status assessment.”

Further reading

FAO (2015) Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication. Food and Agriculture Organization of the United Nations, Rome.

FAO (2020) The State of World Fisheries and Aquaculture 2020. Sustainability in action. Food and Agriculture Organization of the United Nations, Rome.

World Bank (2012) Hidden harvest: the global contribution of capture fisheries. World Bank, Washington.

WWF welcomes 10-year moratorium on mainstream dams in Cambodia

Decision reportedly follows Japanese recommendation

The World Wide Fund for Nature (WWF) has welcomed a reported decision by the Cambodian government to put a 10-year moratorium on mainstream dam development on the Mekong. “Maintaining the Lower Mekong in Cambodia free-flowing is the best decision for both people and nature,” WWF Country Director Teak Seng said in a statement released on 19 March. “WWF commends the Cambodian government for ruling out the hydropower dam development and instead pursuing other energy sources such as solar to meet the Kingdom’s power demand. WWF stands ready to work with the government to support development of a system-wide sustainable energy plan that promotes clean and renewable energy alternatives, contributing to the country’s energy goals without damming Cambodia’s remaining free-flowing rivers.”

Victor Jona, director general of energy at Cambodia’s Ministry of Mines and Energy, reportedly told Reuters earlier that the government was following a study done by a Japanese consultant that recommended Cambodia seeks energy elsewhere. “According to the study, we need to develop coal, LNG, imports from neighboring countries and solar energy,” he was quoted as saying. Under government master plan for 2020 to 2030, “we have no plans

to develop a mainstream dam,” he said.

Marc Goichot, the WWF’s lead freshwater scientist for the Asia-Pacific region, said the 10-year moratorium on mainstream dams on the Mekong was “the best possible news for the sustainable future of the tens of millions of people living alongside it and for the amazing biodiversity that depends on it, especially the world’s largest population of Irrawaddy river dolphins. The science clearly shows that those dams would significantly reduce wild fisheries and



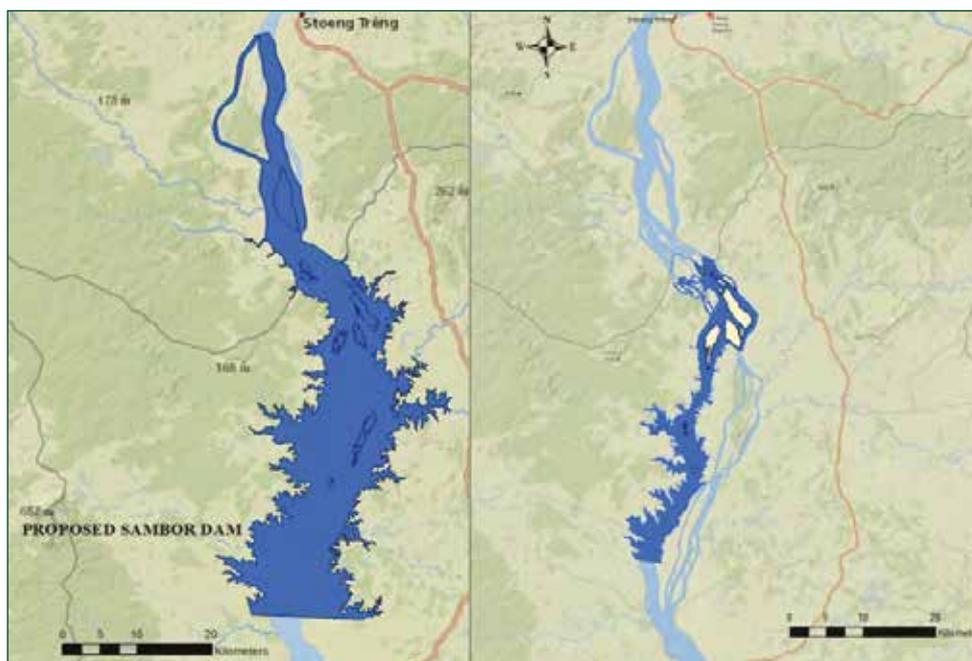
The proposed Sambor dam would be among 11 hydropower projects proposed for the Mekong mainstream — nine in Lao PDR and two in Cambodia. It would also be the lowest dam downstream from a cascade of six dams on northern Lao stretches of the river.

MAP: MRC (2018)

block sediment flows, speeding up the sinking and shrinking of the delta and threatening the future of Vietnam's major rice basket, countless fishing communities and long-term economic sustainability. Cambodia's correct decision is an example for other countries, recognizing free-flowing rivers provide invaluable benefits for people and countless wild species that depend on."

Under a Cambodia Basic Energy Plan published last year, the Ministry of Mines and Energy was considering a proposed mainstream hydropower project on the Mekong at Sambor in Kratie Province. Under the plan, prepared by the ministry's General Department of Energy with input from the General Department of Petroleum, the project would be carried out in three stages between 2025 and 2027, generating 1,800 MW upon completion. Overall power generation capacity was projected to grow from 2,536 MW in 2020 to 4,716 MW in 2030. Coal and gas are forecast to account for half the capacity (2,373 MW) followed by hydropower (1,602 MW), solar and wind (305 MW), oil (251 MW) and biomass (185 MW).

Cambodia has long been considering plans for the proposed hydropower project at Sambor and a second smaller project across the Mekong further upstream in Stung Treng. In 2018, a report by the MRC noted two options for the Sambor dam. In the first option, the dam would span 18 km across the entire Mekong. With a dam height of 54 m, the reservoir impoundment would be about 80 km in length and almost reach Stung Treng. "As fish pass solutions for large tropical rivers as the Mekong are not yet state of the art, solutions for such wide and high dams are most likely ineffective and could cause a total blockage of fish migration in upstream direction," the report said. Losses related to turbine and spillway passage or reduced flow velocity in the impoundment would also apply. The second option would cover only one of the Mekong channels, leaving an alternative route for sediment and



Two options for the proposed Sambor dam, showing the original project at left and the smaller project with mitigation at right.

MAP: MRC (2018)

fish. The related dam would only cover a width of 2.9 km. "Furthermore, with a height of 20 m the related impoundment would only affect 35 km of river length," it said. The report added that it was "very likely" the second option would require two dams – one for diverting the flow towards the main channel and the hydropower dam itself. But "not building this lowermost dam would clearly be the best option from an ecological point of view."

Further reading

ERIA (2019) Cambodia Basic Energy Plan. Economic Research Institute for ASEAN and East Asia, Jakarta

MRC (2018) Development of Guidelines for Hydropower Environmental Impact Mitigation and Risk Management in the Lower Mekong Mainstream and Tributaries. Final Case Study Report – Mainstream Dams Assessment Including Alternative Scheme Layouts. Mekong River Commission, Vientiane.

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Thaing, V. (2020) Ministry: No new dams in the next 10 years. 20 March, 2020. Khmer Times, Phnom Penh.

WWF (2020) WWF statement on Cambodian government's decision to suspend hydropower dam development on the Mekong River. 20 March, 2020. World Wide Fund for Nature, Phnom Penh.

What caused the drought in 2019?

MRC clarifies a misperception

On 21 April, the MRC published a commentary note on a satellite study that concluded that the severe lack of water in the Lower Mekong during the wet season of 2019 was largely influenced by the restriction of water from the Upper Mekong in China. According to the MRC note, the study provides a “useful perspective” on the use of satellite data to determine stream flow. “It also supports some of the findings of various earlier studies of the MRC,” it said. “However, the approach does not provide robust scientific evidence that the storing of water in Chinese reservoirs caused the exceptionally low flows.” So what did?

'The basin lost about five weeks of rain'

According to the note, preliminary analysis showed that the drought in the basin was due largely to two meteorological events. The first was insufficient rainfall during the wet season — with a delayed arrival and earlier departure of monsoon rains. The second was an El Niño event that created abnormally higher temperatures and higher evapotranspiration (the process by which water is transferred from land to the atmosphere by evaporation from soil and other surfaces and by transpiration from plants). The analysis was based on historical rainfall data between 2008 and 2019 as well as observed water flows (see chart at right).

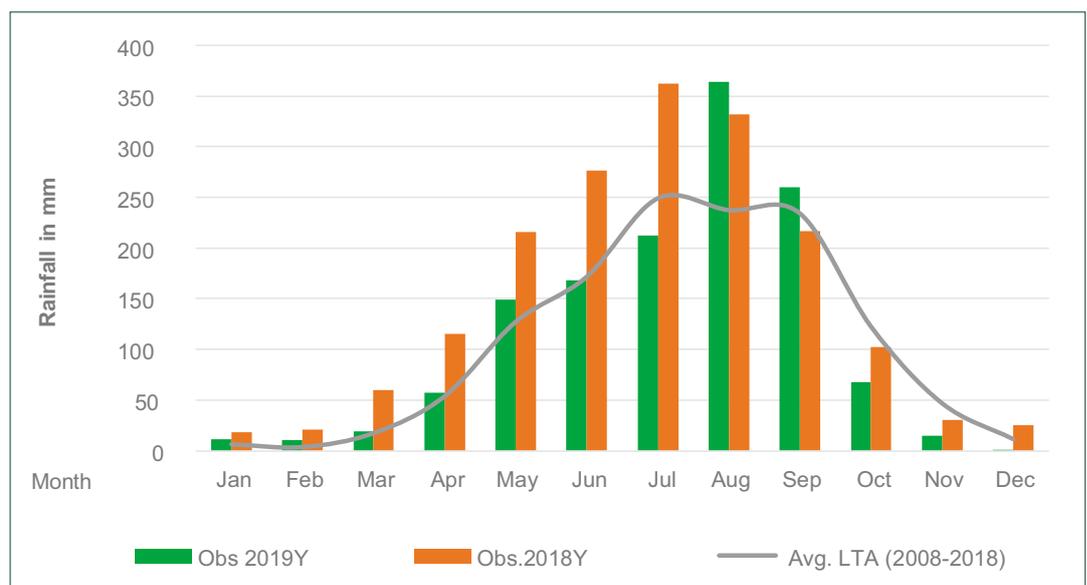
During a normal year, monsoon rains usually start in late May and end in October. In 2019, however, they began almost two

weeks late and stopped about three weeks earlier than usual. “The basin lost about five weeks of rain and only received about 75 percent of rainfall as compared to previous years,” the note said.

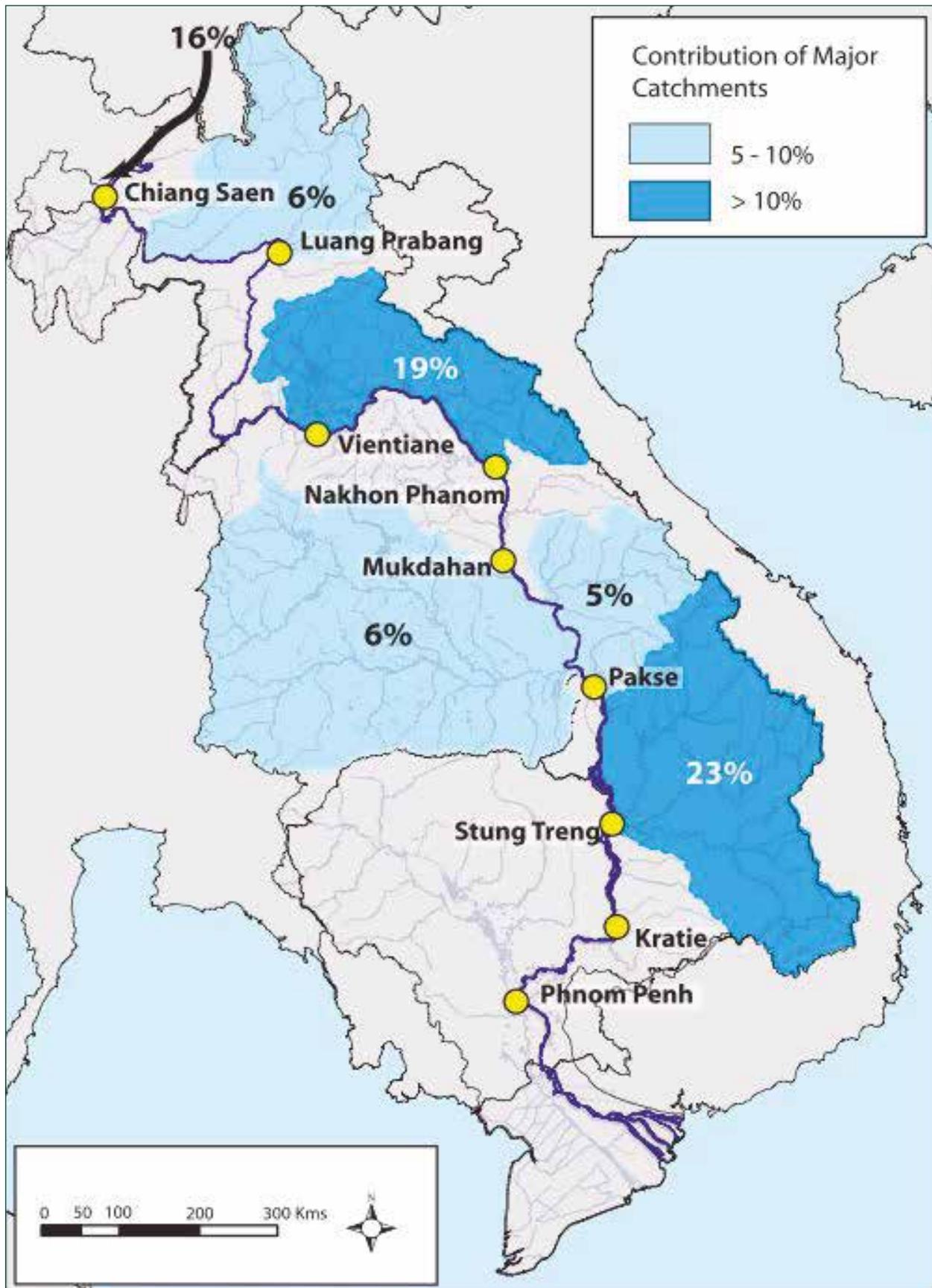
The MRC commentary highlighted the major contribution to Mekong flows of rainfall in the northern and eastern catchments of the Lower Mekong Basin — in Lao PDR, Cambodia and the Central Highlands of Viet Nam — and that this should have been noted in the satellite study (see opposite). By far, the biggest contributions are from the left-bank (eastern) tributaries, especially those that flow into the Mekong between Vientiane and Nakhon Phanom (19 percent of the Mekong’s flow) and between Pakse and Stung Treng (23 percent of the Mekong’s flow). This means that water infrastructure in the Lower Mekong tributaries, where some 73 out of 150 planned dams have been installed over the last 55 years, “could have various degrees of impact on the flow.”

As for reports of drought in the Mekong Delta in March this year, the MRC note said dry-season flows from China had been higher than normal in 2020 — as had flows downstream from Vientiane including at Kratie in Cambodia. “The higher than

Monthly distributed rainfall over the Lower Mekong Basin



SOURCE: MRC



The biggest contributions to Mekong flow are from the left-bank (eastern) tributaries, especially those that flow into the river between Vientiane and Nakhon Phanom and between Pakse and Stung Treng. The latter includes the "3S" system comprising the Sekong, Sesan and Srepok rivers which originate in Viet Nam and join the mainstream of the Mekong in Cambodia.

MAP: MRC

Echoes of 2004

The temptation to blame Chinese dams as the usual suspect for low Mekong flows goes back at least to 2004 when water levels were the lowest recorded in 44 years. Dr Ian Campbell, an environmental specialist with the MRC at the time, dismissed reports blaming Chinese dams for the lower water levels and said reduced water levels were clearly linked to lower rainfall during the wet season in 2003 (see *Catch and Culture*, Vol 10, No 1).

"We looked at it from June to September when it started to become an issue," Dr Campbell told *Catch and Culture* at the time. He said the MRC selected 16 sites based on past records and reliability. The figures showed clearly that the amount of rainfall was unusually low in June and July in 2003 as well as November. In July 2003 alone, average rainfall at the 16 sites was 231 millimetres — well below the 261 millimetres recorded during the same month in 1992, the driest year for the river since 1960. The MRC noted that rainfall between July and October accounts for most of the Mekong's average water flow every year. In Phnom Penh alone, these four crucial months ac-

count for 74 percent of the average annual flow.

Dr Campbell is now based in Melbourne where he works as an independent consultant on rivers including the Mekong. During his five years with the MRC between 2000 and 2005, he oversaw the commission's Environment Program which merged with its Fisheries Program in 2016 to form the new Environmental Management Division at the MRC Secretariat in Vientiane. As international specialist with the former Environment Program, Dr Campbell initiated the first assessments of river health for the Lower Mekong, the first ecological risk assessments, the first State of the Basin Report, the first analysis of water quality data and the first environmental flows investigations of the Lower Mekong.

Further reading

MRC (2020). Understanding the Mekong River's hydrological conditions: A brief commentary note on the "Monitoring the Quantity of Water Flowing Through the Upper Mekong Basin Under Natural (Unimpeded) Conditions" study by Alan Basist and Claude Williams (2020). MRC Secretariat, Vientiane.

typical flows downstream of Vientiane could most likely be due to tributary hydropower projects," it said. This indicated a meteorological drought in the Mekong Delta rather than a hydrological drought (meteorological droughts refer to dry weather patterns dominating a certain area for a period of time whereas hydrological droughts occur when low water supply becomes evident, usually after many months of a meteorological drought.)

While it is known that the operation of dams in China cause impacts to the Lower Mekong Basin (LMB), "it is not true that the lack of water in the LMB during 2019 and 2020 was influenced mainly by these dams," the MRC note concluded. "The water flow contributions across the whole basin must be analysed."

In a statement accompanying the release of the commentary, Dr An Pich Hatda, Chief Executive Of-

ficer at the MRC Secretariat in Vientiane, highlighted the "paramount" need for all countries along the Mekong to strike a balance between the benefits of development, social justice, and environmental sustainability. "A transparent data sharing arrangement on how water and related infrastructures are operated will help everyone manage risks and avoid misperception," he said.

The statement said the MRC Secretariat was preparing for a "comprehensive upgrade" of its Decision Support Framework that can monitor river conditions and identify causes of change. By providing accurate, up-to-date information, decision makers and the public will have the means to address emerging issues, such as low flows and reduced rainfall, rapidly and effectively. "To achieve this, cooperation from all the riparian countries and their timely and transparent sharing of data and information on water use and infrastructure is pivotal," Dr Hatda said.

Why older Cambodians avoid eating fish associated with a dead mother

BY CHHUT CHHEANA *

The marbled goby (*Oxyeleotris marmorata*) is native to the Lower Mekong Basin and neighbouring countries. Found in commercial and subsistence fisheries as well as aquaculture, it is considered a delicacy over much of East Asia. But in Cambodia, older people tend to avoid consuming the fish, which is known as trey damrey (“elephant fish”) in Khmer. A part of its activities to raise public awareness of fisheries, the USAID-funded Wonders of the Mekong Project with Cambodia’s Fisheries Administration explains why.

Komarey was the daughter of a couple whose parents lived next door to each other and fell in love. The couple eloped and settled down unknowingly in a district of thieves. Komarey’s parents later asked the district chief to be their “godfather.” The district chief, who was also the head thief, agreed and offered money and servants to his new “godchildren.” Wanting to have a family and live independently, Komarey’s mother asked her godfather if she and her husband could settle in a new village. He agreed and Komarey was born. The district chief later died and Komarey’s father became the new district chief.

When Komarey was about seven, her father was seduced by a widow who lived with her sister and two daughters. The widow’s family eventually came to live with Komarey and her parents. As the family’s fortune declined, Komarey’s stepmother started talking badly about her real mother. Before long, Komarey’s father started beating her mother every day.

Komarey’s father later took her

mother fishing and beat her to death, throwing her body into the river. Upon seeing her father return home without her mother, Komarey cried and ran to the riverbank where a thevada (“angel”) appeared. “Your mother is dead,” the thevada said. “Her body has turned into a marbled goby.” Komarey cried out for her mother. A marbled goby swam close and told her what had happened.

Living with her father and stepmother, Komarey had to take on a lot of hard work. But she never forgot to bring rice bran for her mother in the river. Since then, local residents renamed her Moranakmeada (“Dead Mother”).

* Mr Chhut Chheana is communications officer for the USAID-funded Wonders of the Mekong project with the Cambodian Ministry of Agriculture, Forestry and Fisheries. He is also responsible for the graphic design of Catch and Culture - Environment.

Further reading

Chay Sok (undated) Moranakmeada. Somroulbotomray pikomnapdoem. Songkhebdoy Lok Chay Sok.



Komarey listening to her mother explain why she’s now a marbled goby

Water bodies in Cambodia's remote northern province of Oddar Meanchey

Cambodia's Fisheries Administration ventured as far as it has ever been for National Fish Day last year — the remote northern province of Oddar Meanchey bordering Surin Province in Thailand. The Cambodian province is near the Dangrek Mountains which form a natural border between the two countries.

These photos highlight the province's two main water bodies.

Anlong Veng Lake

Anlong Veng is a window into the final days of Pol Pot's Khmer Rouge movement in 1998. Until 40 years ago, it was mostly a sleepy town of little historical significance. After 1979, when Khmer Rouge forces were defeated, and particularly after 1989, when Vietnamese forces withdrew from Cambodia, the area became a critical stronghold of the

Khmer Rouge. Its location near the Dangrek Mountains and the Thai border were key elements in the Khmer Rouge decision to establish military bases in the region. As the Khmer Rouge weakened — from defections, military withdrawals and political-economic isolation — its ability to control the terrain diminished.

Anlong Veng Lake is 417 ha in size and located near the centre of town. It was originally a natural stream with clear water, trees and fish. The Khmer Rouge depended on fish in the lake as their primary food source. During the dry season of 1990, Chhit Chhoeun — a Khmer Rouge military leader who went by the name of Ta Mok — began the first of three phases of reservoir construction. Under the first, an embankment was completed in 1991. This was raised to hold more water in 1992. Ta Mok



Aerial view of Anlong Veng Lake on 29 June last year showing the former compound of Ta Mok, the Khmer Rouge leader who died in 2006. The four houses now serve as the Anlong Veng History Museum, run by the Ministry of Tourism and the Documentation Center of Cambodia.

PHOTO: CHHUT CHHEANA / USAID WONDERS OF THE MEKONG



Aerial view of Boeung Snaur during Cambodia's National Fish Day ceremony in Samraong on 1 July last year

PHOTO: CHHUT CHHEANA / USAID WONDERS OF THE MEKONG

oversaw construction of a bridge and further enlargement of the reservoir in 1994, increasing significantly the volume of water in the lake. After the collapse of the Khmer Rouge at the end of 1998, Ta Mok was put under house arrest and transferred to a military prison in Phnom Penh awaiting trial. He died in 2006 at the age of 80.

Source: Dearing, C and Ly S.K. (2016) A History of the Anlong Community - The Final Stronghold of the Khmer Rouge Movement. Documentation Center of Cambodia and Ministry of Tourism, Phnom Penh:

Boeung Snaur Reservoir

Covering an area of 101 ha, Boeung Snaur Reservoir is at the centre of the provincial capital of Samraong, located between a small commercial district and a larger area housing provincial government departments. It was originally a natural lake. To store water for irrigation and daily use, the owner of the land built a 1-metre embankment, allowing farmers to grow rice on the surrounding land. After 1979, further work was undertaken to get water for the town. Between 1972 and 1974, the area was a major battlefield in Cambodia's civil war. Under

a royal decree promulgated in 1995, provincial authorities have worked with the Ministry of Water Resources and Meteorology to rehabilitate the water body which now holds 2.5 million cubic metres of water which is used for domestic consumption and recreation activities as well as a habitat for fish and other aquatic animals.

Source: MAFF (2019) Report to National Fish Day, Boeung Snaur Reservoir, Samraong Commune, Samraong Municipality, Oddar Meanchey Province. 1 July, 2019. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh.



Monument to Cambodian-Vietnamese friendship in Samraong

PHOTO: CHHUT CHHEANA / USAID WONDERS OF THE MEKONG

Systemic power imbalances in responsible investment

BY LEE SOO-HYUN *

If environmental factors are seen as most accessible, sustainable investment may harness investor confidence in environmental investments alone — at the expense of social and governance factors. These imbalances can be addressed by key performance indicators such as those developed for the water sector under UN Principles for Responsible Investment.

The recent surge of interest in environmental, social, and governance (ESG) investments has brought with it closer scrutiny of the way in which ESG factors are evaluated as conditions before an investment can be categorized as such. Environmental factors have been receiving a lion's share of the attention in these investments, which have been riding on the institutional clout lent unto them by green growth. Governance factors — while not as much of a predominant issue for portfolio investments given their necessary acceptance of the domestic regulatory regime in which the investment is being made — also come with substantial institutional and academic presence, particularly due to the inclusion of rule of law in democratic peace-building. International financial institutions have also debuted enormous data-driven projects on governance factors upon which they base their financing and risk decisions. Of these, social factors have by far been receiving the least and most narrow attention, largely due to the less obvious role that the private sector can assume outside of corporate social responsibility.

Private equity firms and financial institutions have been pouring considerable resources into boosting the coherence and profitability of ESG investments. However, rather than viewing E, S, and G as isolated variables, a co-beneficial approach is necessary to avoid the same problems that the progenitors of the World Bank governance indicators encountered. That is, an environmental factor viewed in isolation may have negative repercussions for the social or governance factors. Systemic power imbalances, however, make this difficult to achieve.

A single metabolic system

Power relations are a common theme in the scholarship of environmental justice and degrowth. For instance, Akbulut *et al.* (2019) features a call for a “politico-metabolic reconfiguration” that views the use of ecosystem resources, the socio-economic units that use them, and the institutions that govern both as constituting a single metabolic system. ESG, from this purview, offers enlighten-



Lee Soo-hyun

What is socioeconomic metabolism?

In 2015, the journal *Ecological Economics* published a paper that found a “wide spectrum” of quantitative approaches to assess sustainable development strategies. The two authors — from the Industrial Ecology Programme at Norwegian University of Science and Technology in Trondheim — noted that these methods described certain aspects of the biophysical basis of society. But “the methods are often developed and applied in isolation, which dampens scientific progress and complicates communication between scientists and decision makers,” they wrote. The authors argued that the concept of socioeconomic metabolism was a “powerful boundary object that can serve as paradigm for studying the biophysical basis of human society.” Such a paradigm was seen leading to “more robust and comprehensive interdisciplinary assessments of sustainable development strategies” while helping to justify alternative economic concepts.

Further reading

Pauliuk, S. and E.G. Hertwich (2015) Socioeconomic metabolism as paradigm for studying the biophysical basis of human societies. *Ecological economics*. Vol 119, November 2015, pages 83-93.

ESG investment can play ‘critical’ role in reducing income inequality caused by Covid-19

How is ESG investment performing during the Covid-19 pandemic? According to research by the Asian Development Bank Institute (ADBI) in Tokyo, Japanese companies with higher ESG ratings performed better in the March quarter. Financial economist Naoko Nemoto and research associate Lian Liu compared the stock prices of Japan’s 100 top companies based on market capitalisation. The companies were ranked to reflect employment environment society, and governance factors evaluated by Toyo Keizai, a publisher of quarterly information on Japanese companies.

The stock prices of companies with the lowest CSR ratings were found to have fallen almost 18 percent from the first quarter of 2019. That compared with less than 13 percent for those with the highest ratings. At the same time, Nemoto and Lian noted a report by the Institute of International Finance showing that the amount of money flowing into publicly traded mutual funds based on ESG ratings rose 30 percent from a year earlier between January and April this year.

Strong and rapid uptake in Asia

“Despite a slow start at first, Asia and the Pacific has also seen a strong and rapid uptake in ESG investment,” the researchers wrote in an ADBI blog published on 15 June. “ESG investment can help to support Asian countries by boosting their potential growth. If companies promote environmental protection, employee education, and women’s participation, for example, their corporate value will increase, spurring economic growth in a virtuous cycle.”

According to Nemoto and Lian, ESG investment “can play a critical role in reducing the income inequality caused by the coronavirus disease.” Amid the Covid-19 crisis, “society has started to focus more on the health and safety of its employees, such as by securing employment and responding to customers’ needs. Until now, social factors were considered to have a relatively small impact on stock prices and corporate value compared to environment and governance-related factors. This view is now gradually changing, with significant implications for the investment landscape.”

While ESG investment could be crucial for sup-



Naoko Nemoto



Lian Liu

porting sustainable growth in Asia, the researchers highlighted several challenges in the region. “First is the problem of ensuring the quality and accuracy of information. The financial data of listed firms is checked by auditing firms, but non-financial data are not endorsed by third parties in many cases. The rules of disclosure vary, and the conversion and standardization of disclosure guidelines still need to be developed.

“Second, it is not easy to analyze and evaluate the huge amount of necessary information. Investors are increasingly referring to ESG indexes, but there are criticisms that not all of the specific features of industries and companies are fully factored in when compiling these indexes. Third, many of the criteria and standards have been developed mainly in European countries. Applying uniform standards to countries with differing stages of economic development could result in the misallocation of economic resources.

“To overcome these obstacles, policy makers and companies in Asia need to be proactive in disclosing ESG information, encouraging ongoing dialogue with global investors, and actively engaging in the creation of effective investment standards.”

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Environment, social and governance investment in the Mekong region

The following is from the first chapter of a book on ESG investment opportunities and risks in Asia published by the Asian Development Bank Institute in June. The author is Upalat Korwatanasakul, an assistant professor at the School of Social Sciences at Waseda University in Tokyo.

Awareness of ESG in **Cambodia** is limited. However, in 2019, a movement of independent non-government organizations, including Oxfam, CSR Asia, among others, promoted the importance of ESG investment. Although ESG practices barely exist in the country, a few firms, including Cambodian Mango Farms and NagaCorp, started incorporating ESG factors into their business philosophy and strategies. With increasing international pressure to promote sustainable development, Cambodia needs to do more or risk being left behind. Financial institutions and the banking sector may pioneer ESG investment and raise awareness of its importance.

Lao PDR is one of the most active countries outside ASEAN-6 (Brunei, Indonesia, Malaysia, the Philippines, Singapore and Thailand) promoting responsible investment, especially in agriculture. The Ministry of Planning and Investment's Quality Investment Promotion initiative encourages environmental and social responsibility among investors. Firms such as Lao Tobacco Ltd, Stora Enso Lao PDR, and Lao Banana Company have focused on the "S" element of ESG, aiming to contribute to community development and maintain good relationships with their workers. Lao PDR has no CSR (corporate social responsibility), ESG, or sustainability policies relating to disclosure. The government will need to play a key role in implementing and encouraging such measures and increase targeted coordination.

Thailand has emerged as a forerunner of ESG in ASEAN, and Thai companies comprise the highest share among ASEAN members in the Dow Jones Sustainability Indices. The country has among the highest levels of ESG disclosure in ASEAN and makes reporting mandatory. The SET (Stock Exchange of Thailand) requires annual reporting on ESG disclosure by its listed companies. The SET established the Corporate Social Responsibility Institute in 2007, signaling increas-

ing awareness of CSR and ESG. Regulations related to specific ESG elements include the Occupational Safety, Health and Environment Act; the Enhancement and Conservation of National Environmental Quality Act; and the Environmental Quality Standard. More listed Thai companies are being chosen for inclusion in the Dow Jones Sustainability Indices, confirming their high performance. The SET is producing a sustainability index for ESG reporting.



Upalat Korwatanasakul

Viet Nam is broadly committed to promoting ESG, and it engages in a range of ESG initiatives at the stock exchanges in Ho Chi Minh City and Ha Noi, which list a total of more than 700 companies. The Ho Chi Minh Stock Exchange, in particular, has comprehensive measures to promote ESG measures and factors, including the use of annual sustainability reports and the reporting requirement to ensure company accountability. The exchange supports companies by providing training on ESG-related issues, written guidance on reporting, and indexes to monitor progress, targets, and achievements. A 2015 circular requires listed companies to report on their impacts on society and the environment. The Environmental Protection Law relates to environmental protection, environmental impact and climate change assessments, and resource conservation. The Labour Code aims to protect workers through legislation on working hours, workers' rights, health and safety, and minimum wages. Viet Nam shows good potential and the introduction of the Sustainability Reporting Awards shows increasing awareness of and priority given to ESG issues. Further disclosure requirements can be expected in the medium term.

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ing options for reflection. Ecological and socioeconomic systems are seen as sharing a “continuous throughput of energy and materials in order to maintain their internal structure” over which “politico-institutional structure[s]” govern them in order to “reach higher levels of ecological sustainability” if seeking to achieve environmental justice. Viewing these ecological and socioeconomic systems separately means that their shared “throughput of energy and materials” shall no longer be aligned, tilting it off a sustainable balance. In understanding this balance — while a central consideration is the “power relations that shape metabolisms, i.e. the political economy” — there are other equally systemic imbalances that hinder the achievement of that sustainable balance that very much exist in responsible investment systems like ESG.

'Screening investments under a quantification of potentially competitive indices — such as socially responsible investment with lesser concern for the environment — can perpetuate the imbalance in power relations'

Bringing the social element of ESG under the lens of this discussion raises the challenges of how power relations affect the way that so-called socially responsible investments are screened or assessed across this scale of power relations. For instance, if the enactment of an environmental policy results in a more vulnerable social class shouldering a greater burden of the change, this moves only to deepen double-injustices. The imbalance present in ESG to the E and G factors also provides a forum to reflect on this power imbalance challenge raised by the politico-metabolic configuration in an innovative way. That is, the imbalance between the power lent to environmental and governance factors in a nascent yet solidifying system of finance would — if left unaddressed — continue to subdue social concerns to the relative merits (accessibility) of environmental and governance factors. Within that scenario and in the operating principle of profit maximization, the potential social consequences of an ESG investment (or, perhaps, an E and/or G investment) may be considered to be acceptable collateral in the arithmetic of net value.

If one were to step back and view this challenge more metaphysically, then the entire undertak-

ing of ESG investments and the reliance on indices can be ontologically problematic. Screening investments under a quantification of potentially competitive indices — such as socially responsible investment with lesser concern for the environment — can perpetuate the imbalance in power relations discussed in the metabolic purview. An investment that may be evaluated as partially sustainable or responsible due to its inclusion of environmental factors, as a less-contested regime, may promote unsettling social harm.

As Martinez-Alier *et al.* (2012) identify with attempts to green gross domestic product, the extent to which various factors are included or excluded in these indices “reflect the social and political strength of different interests and social values.” This challenge becomes especially reverberant when attempting to standardize those systems of indices across countries with highly disparate levels of development. If environmental factors are seen as the most accessible (in terms of quantification, for instance), then sustainable investment may harness investor confidence in environmental investments alone — even if those projects may very well exacerbate the power imbalances ingrained in social values such as gender empowerment.

Investing in water

How are these power imbalances being addressed in ESG investments? One way has been by applying key performance indicators that are different from entry condition requirements. For instance, according to recommendations by the (UN) Principles for Responsible Investment (PRI) under its thematic investment category of water, companies that qualify for impact investments need to “generate at least 70 percent of their direct revenues from water products, services technologies or products” (or 100 percent for suppliers of crucial components or services) as well as satisfy the thematic conditions.

'Indicators used for thematic investments in water include such measurements as the number of unique women, unique poor individuals'

Simultaneously, common key performance indicators used for thematic investments in water include such measurements as the number of unique

Climate change, low-carbon transition increasingly relevant to global credit markets

Environmental, social and governance (ESG) issues related to climate change and the transition to a low-carbon economy are increasingly influencing credit quality assessments and investment decisions, Moody's Investors Service says. In a report released on February 10, matters such as water scarcity, biodiversity, land use, deforestation and food insecurity would put a spotlight on resource management by borrowers.

"One major trend is that climate change and the transition to a low-carbon economy are growing in relevance for global credit markets," Moody's ESG analyst Ram Sri-Saravanapavaan said "Investors are seeking more disclosure from companies about how they are addressing these risks as the financial implications are becoming clearer."

Moody's said stricter climate policies would raise transition risk for the most exposed carbon-intensive sectors such as utilities, oil and gas, auto manufacturing, airlines, building materials and shipping. "Public interest in preserving natural assets such as land, water and living things, will increase significantly over the coming years," the rating agency said. Consumer activism and heightened focus on responsible production throughout the supply chain will exacerbate the

risks of certain products and services."

ESG concerns growing in banking sector

In the banking sector, ESG concerns are growing for regulators, investors and stakeholders. "Policymakers, consumers and investors expect banks to play a key role in funding the development of a sustainable economy. The rise of sustainable finance opens up new lending opportunities for banks but also exposes them to increased risk of stranded assets, regulatory penalties, capital constraints and reputational damage," it said.

"Environmental factors will increasingly affect banks' lending and investment decisions. We also expect a rising share of sustainability-linked and green bonds in banks' market funding as investors' decisions are increasingly linked to companies' sustainability credentials. "Social risks have become more pronounced for banks after the global financial crisis resulted in negative shift in popular attitudes toward banks. This has made customer backlash against business practices deemed to be socially unacceptable more likely.

"Governance is an established driver of bank creditworthiness but it is becoming more significant due to changes in regulation, government policy, social attitudes and market development."

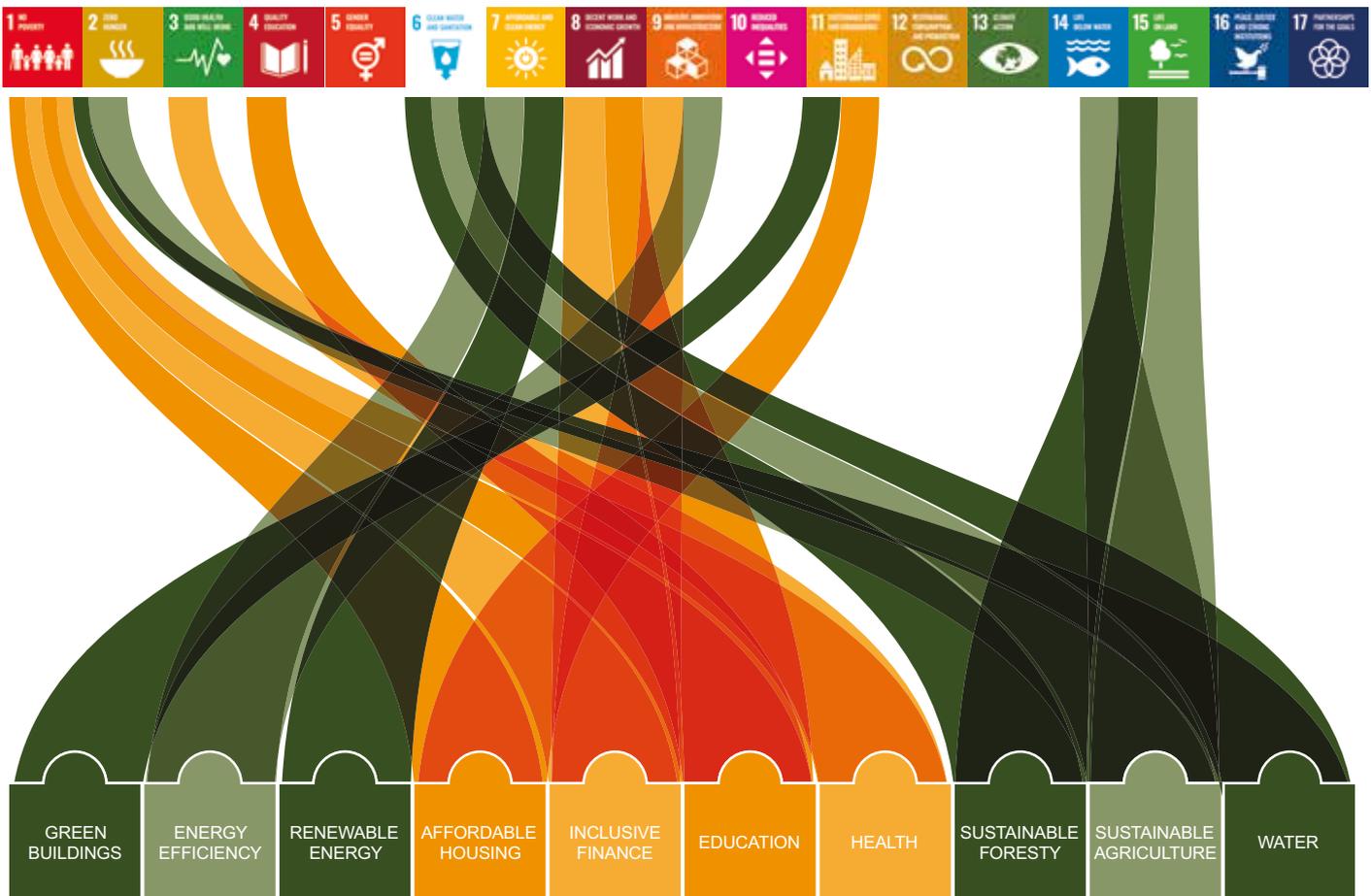
Five social issues most relevant to private-sector issuers

<p>Customer Relations</p>  <ul style="list-style-type: none"> » Data security & customer privacy » Fair disclosure & labelling » Responsible distribution & marketing 	<p>Human Capital</p>  <ul style="list-style-type: none"> » Labour relations » Human resources » Diversity & inclusion 	<p>Demographic & Societal Trends</p>  <ul style="list-style-type: none"> » Demographic change » Access and affordability » Social responsibility » Consumer activism
<p>Health & Safety</p>  <ul style="list-style-type: none"> » Accident & safety management » Employee health & well-being 	<p>Responsible Production</p>  <ul style="list-style-type: none"> » Product quality » Supply chain management » Community stakeholder engagement » Bribery & corruption » Waste Management 	

Note: Subcategories are representative and not exhaustive. The private-sector social categories used are for business-like governmental entities, such as municipal utilities and mass transit enterprises.

SOURCE: MOODY'S INVESTORS SERVICE

Matrix and themes for Sustainable Development Goals



SOURCE: UNITED NATIONS (2018)

women, unique poor individuals, and unique low income-individuals “who were clients of the organisation during the reporting period” (PRI 2018: 56–57). In reflecting on this approach, it becomes clear that embracing a metabolic approach to ESG investments depends on the rigour of the conditions imposed as well as the weight and design of the key performance indicators.

While investment in water and its impact within Sustainable Development Goal (SDG) 6 are relatively easy to compute, this exercise becomes harder when working with topics such as SDG 5 (Gender Equality) and SDG 10 (Reduced Inequalities). This is perhaps also reflected in the distribution of the representative thematic investments identified by the Principles for Responsible Investment. As responsible investment continues to grow, viewing the impact within the system of a continuous throughput shall without a doubt be a helpful exercise in addressing questions of power relations between stakeholders and stakeholding interests.

* Mr Lee is a 2030 Agenda Programme PhD Researcher (International Economic Law and Sustainable Development) at the Faculty of Law at Lund University. This article was originally published on 7 February by Asian Pathways, the blog of the Asian Development Bank Institute in Tokyo.

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Climate change and Covid-19: reflections on efficiency vs resilience

In our April issue, we published excerpts from a book on financial stability in the age of climate change (see *Catch and Culture - Environment*, Vol 26, No 1). Published by the Bank for International Settlements (BIS) in January, *The Green Swan* dealt with climate events outside the normal range of expected events but nevertheless likely to occur. It was inspired by *The Black Swan* by Lebanese-American essayist Nassim Nicholas Taleb. Published in 2007, this described unexpected “outlier” events with wide-ranging or extreme impacts that could be explained only after the fact. Here, Brazilian economist Luiz Awazu Pereira da Silva — the BIS deputy general manager who co-authored *The Green Swan* — takes a fresh look at both black and green swans in light of the Covid-19 pandemic. His reflections below, which have been edited, are based on remarks at the OECD Chief Economist Talk Series in Paris on 23 April and a Research Webinar at the BIS headquarters in Basel on 13 May.

The damage caused by black and green swans to societies and their economies have a lot in common. They are unexpected by most agents, both feature non-linear propagation, their effects cascade into multiple sectors and countries simultaneously, and they are of a very large magnitude and intensity. From a strictly economic policy viewpoint, climate-related risks and pandemics such as Covid-19 produce similarly devastating effects on both the real and financial sectors, causing recessions, unemployment and a large depreciation of value across all asset classes.

Another feature is that they both entail large negative externalities at a global level. Hence, neither the private sector nor government can adequately “price” the associated risks in the costs of our goods and services. For instance, the macro-financial risk of global pandemics has previously been at best minimised if not ignored. Most scenarios concerned diseases with high levels of contagion and relatively mild lethality, or with high lethality but only very

limited transmissibility. Neither public health nor economic systems were prepared for the risk of a Covid-19 scenario, no insurance market had developed to hedge this risk and no financial market had fully priced the possibility of its occurrence, despite the role of regulators in building multidimensional stress tests.



Mr Pereira da Silva

Photo: BIS

Yet these two major global risk categories differ in important respects. The first difference is about predictability. Green swans are events such as pandemics and climate change that are either extremely likely or quite certain to occur, as confirmed by our best science today. When, where and how are unknown. By contrast, black swans do not manifest themselves with this high likelihood or quasi-certainty. Black swans are severe and unexpected negative events that can only be rationalised and explained after their occurrence, as in the case of the Global Financial Crisis. The predictability of both black and green swans will always differ from the modelling of risks encountered in traditional risk management .

The second difference is about who provides the main explanation for these events. For black swans, the field is mostly occupied by economists and financial analysts. For green swans, the main underlying literature comes from scientists. The third difference is about impact. The effects of green swans are in most cases irreversible whereas black swans have effects that are long-lasting but can eventually be corrected. A fourth difference between black and green swans resides in the way we derive policy recommendations to prevent their occurrence. Finally, perhaps the major difference is that green swans relate to changes we make to our environment and our ecosystems that pose a massive, direct and irreversible threat to human lives.

Faced with sets of events that are complex, subject to radical uncertainty but with the likelihood of a massive future impact, green swans call less for improvements in risk modelling and more for decisive and immediate action and coordination.

More global cooperation needed

Due to the complexity of green swans, no single actor, whether national or global, will have a silver bullet for their solution. By definition, global negative externalities require coordinated global action. The responses to the Covid-19 crisis have shown a promising degree of fiscal and monetary policy coordination at both local and global levels. But an even more encompassing approach is necessary. First, more global coordination is needed to foster change in methodologies and mindsets to deal with this type of global risk. Second, when dealing with climate-related risks, there are many agents with whom coordination is needed such as governments, multilateral development banks, regulators and the financial sector. Coordination could also extend to standard setters, by considering more “ecological” accounting frameworks, with the possible obligation to disclose additional types of exposure, and new accounting approaches (e.g. natural capital) to capture interactions between the economy and the natural world. This might necessitate revisiting the many factors that we need to manage to increase the resilience of our global commons.

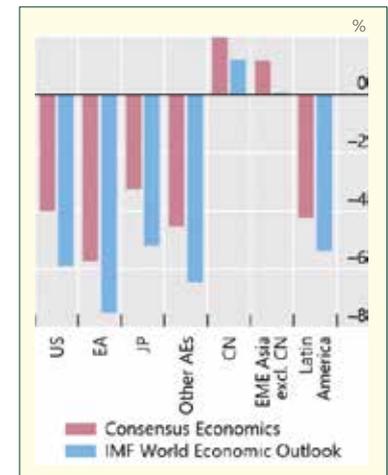
Should coordination be extended between global agencies that survey macro-financial stability and agencies that survey other public health vulnerabilities? For climate risks, this would rely on climate scientists and experts in a number of meetings and working groups etc. For pandemics, given their potential real and financial consequences, the issue could be to operationalise an adequate level of cooperation between agencies that assess global macro-financial vulnerabilities and agencies that measure public health vulnerabilities on both the local and the global level (e.g. more detailed reports on stress tests of health facilities). Should these agencies also have a more systematic relationship with local centres for disease control to constantly review their response capacities?

Such a closer and systematic relationship would obviously be beneficial if there is appetite to consider building a global safety insurance framework for pandemic risk. Such a framework is obviously not

easy to build and it would certainly be costly to keep operational. However, whatever its cost, this would pale into insignificance beside that of the current global sudden stop. The very large economic and human costs already inflicted by the current pandemic are bound to alter our myopic behaviour. Indeed, many countries developed mitigation strategies after SARS but hardly any were implemented. The current crisis may incentivise the building of buffers and the search for insurance.

GDP forecasts for 2020

Annual percentage change



EA = European Area. JP = Japan. Other AEs (Advanced Economies) = Australia, Canada, Sweden, Switzerland and United Kingdom. CN = China. EME Asia excl. CN (Emerging Market Economies in Asia excluding China) = Chinese Taipei (Taiwan), Hong Kong, India, Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand. Latin America = Argentina, Brazil, Chile, Colombia, Mexico and Peru.

SOURCE: PEREIRA DA SILVA (2020)

A lower carbon economy and better public health

What kind of carbon footprint can we afford to create during the recovery and beyond? Could we engineer a “green” recovery and might we also improve our surveillance of public health conditions globally and locally? As of today, we know that there are several scenarios for the recovery, each with different speeds and patterns. The most likely recovery may include several stop-and-go episodes as emergency measures are relaxed in different countries. But what will its carbon footprint be?

The challenges and complexity of a recovery with a lower carbon footprint are obvious. Nevertheless, there has also been an increase in awareness of the immediate reduction in greenhouse gases and other pollutants due to our global sudden stop. It is likely that, whatever the shape of the recovery, growth will be subdued for quite a while, thereby cutting greenhouse gases emissions and lowering our carbon footprint. In addition, Covid-19 might have presented a vivid image of what the future might look like if nothing is done to reduce green-

Natural habitat destruction and pandemics

In his reflections on climate change and Covid-19, Mr Pereira da Silva notes that many scientists argue that the roots of the pandemic lie in the destruction of natural habitats and loss of biodiversity. Illegal trafficking, development, industrialisation of agriculture and deforestation are blamed for declines in numbers of wild species and genetic diversity — and new diseases evolving as humans come into closer contact with vectors such as bats. Environmental and health crises potentially reinforce each other. In this sense, the Brazilian economist says, Covid-19 qualifies as a green swan.

“The importance of genetic diversity as a barrier to the propagation of new viruses is particularly relevant to the discussion on resilience versus ef-

iciency,” Mr Pereira da Silva says, “Redundancy is fundamental to an ecosystem’s resilience, although it comes at the expense of greater efficiency. The Covid-19 crisis could act as a wake-up call to the fact that some level of redundancy is also necessary to the resilience of our socio-economic systems.

There are more speculative debates about how pandemics may be linked to climate change. Beyond 2°C of global warming, the chances increase of reaching tipping-points such as the melting of the Arctic permafrost. “This raises the question whether rising temperatures could revive ancient viruses, now frozen, to which we could be as vulnerable as to Covid-19,” Mr Pereira da Silva says.

house gases, inflicting similar stoppages worldwide after some tipping-point is reached. It may also have raised awareness of the fragility of some of our systems and therefore of the need for improved efficiency and greater resilience.

Therefore, the Covid-19 crisis might result in a possible shift in the mindset of our societies that could lead to greater acceptance of green policies. This is related to “behavioural contagion theory” — behaviours may change only if a belief can be backed by a significant amount of evidence. The extreme weather events seen with increasing frequency in the last few years were beginning to persuade people of the dangers posed by climate change. Covid-19 is so overwhelming that it might just have produced this tipping-point where societies begin to fully internalise and understand the danger of complex global risks. If so, it may perhaps bring the political opportunity to further incentivise and then trigger a change in behaviour with a higher probability of success.

It is because of this opportunity that, increasingly, some policymakers are calling for “a green light to lead us on the path of economic recovery. Indeed, there are some useful policy and institutional lessons to consider if we want to grow again, reduce climate-related risks and improve our resistance to epidemics. If we are not to waste this crisis, reforms will need to result in enduring welfare improve-

ments. In particular, there are calls to take advantage of the existing regional institutional set-ups to “share prosperity” during the recovery.

Some further elements could help to green the recovery. For example, after the Global Financial Crisis, the bailouts for the automotive industry incentivised it towards producing more electric cars. We have begun to see that teleworking can be effective, so we can cut out unnecessary trips, thus lowering the carbon footprint of many economic activities. New technologies and changes in the locus of production and work sites could also reduce greenhouse gas emissions. The recovery may need some heavy lifting to overcome the resistance to change of households and corporates. Massive public investment programs using, inter alia, multilateral development banks to boost activity could be geared to a global transition to new energies that are less carbon-intensive and to stepping up research in carbon reduction and absorption.

Recent studies rank five policies according to both their economic multiplier and their climate impact — clean physical infrastructure, efficiency retrofits for buildings, investment in education and training, natural capital investment, and clean R&D. Last but not least, some major regions could take the lead in promoting both climate-related and public health measures. Regional norms in large markets might differ, but if they point in the same direction, they

'Buffers' as shock absorbers

Mr Pereira da Silva argues that green swans require rethinking the trade-offs between the efficiency and resilience of socio-economic systems. In addition to adding global insurance frameworks, he proposes considering buffers or some necessary degree of redundancy for absorbing such large shocks. The former deputy governor of the Brazilian central bank notes that countries build foreign exchange reserves and banks maintain capital buffers as required by regulators. "Perhaps similar 'buffers' could be used in other areas of our societies," he says. "For example, could it be time to re-assess our production systems, which are meant to be lean and less costly for maximum efficiency?"

The Global Financial Crisis led to the building of a banking sector with fewer vulnerabilities, more capital and stronger buffers. Could the notion of buffers be extended to climate change and pandemics? "The answer to this question will require some thorough assessment," Mr Pereira da Silva says. "This new approach has already begun to be undertaken by the private sector in re-assessing its own risks and learning lessons from current events, as Covid-19 is affecting global value

chains, with a significant local and global impact on services and manufacturing output. Stress tests on their resilience need to be conducted."

The private sector has made some progress in integrating climate risk into its cost-benefit calculations for locating its facilities and assessing the carbon footprint of its activities. "It is likely that it will do the same for pandemics," the BIS deputy general manager says. "Progress in logistics and lower transportation costs have made possible just-in-time production models with zero stocks. This has greatly increased productivity and allowed production lines to be distributed across the whole planet. But it has also made our economies much less resilient to shocks." Mr Pereira da Silva many companies are expected to learn from the Covid-19 pandemic to become more resilient against future shocks — including climate-related ones. "They will start planning alternative locations for their production plants, cut down on business travel, and add more redundancy (in terms of insurance and buffers) that will perhaps increase costs but address these new sources of fragility," he says. "Many risks once seen as acceptable will now perhaps be perceived as excessive, based on the impact of Covid-19."

could create market incentives for firms worldwide to enhance or maintain trade relations, and to accelerate the adaptation to a lower carbon economy and improved public health measures at home. Of course these issues are not simple. Trade wars could resume, unemployment may increase and other problems may arise. Nevertheless, without at least thinking about these potential new directions, we will miss the opportunity to draw some of the lessons instilled by this very severe crisis.

To realise a win-win scenario as a basis for the recovery, we will need to rethink the adequate measurement of global risks; their proper pricing as negative externalities; and the resilience of our systems, institutions and *modus operandi* in avoiding green swans. This will require us to look at repricing risk and building buffers as forms of insurance and evaluating the possibility of supplying more global public goods in the area of public health. These measures might appear costly, but the tremendous

burden imposed by the current pandemic should be capable of changing our myopic attitudes vis-à-vis green swans by incentivising buffers and insurance. Success here will depend on a revival of global multilateral cooperation in managing both climate change and pandemics. It will also entail a redesign of our safety nets and frameworks for aid and global surveillance. For the moment, it seems, one approach to initiating a new way of thinking along these lines would be to build on or expand an existing "coalition of the willing" of both public and private actors. And we should start this work immediately. As the great poet Antonio Machado said: "Caminante no hay camino, se hace camino al andar" or "Walker, there is no road. The road is made as you walk."

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Inland fisheries in Myanmar

Study sheds new light on one of the world's biggest fish producers

The Australian Centre for International Agricultural Research (ACIAR) has published a book on the inland fisheries of Myanmar based on a decade of collaboration between scientists from WorldFish and the country's Department of Fisheries. Funded by ACIAR, the research highlights similarities and differences in fish diversity and consumption between Myanmar and the Lower Mekong.

Released on March 31 this year, the 10-year review notes that while Myanmar is the second-largest country in Southeast Asia in terms of land area, its freshwater fish fauna is among the "least known" in the region. According to the book, the international fisheries research database FishBase indicated

that scientists had documented 511 freshwater fish species in Myanmar as of 2018. Of these, 439 were native, 58 endemic and 14 introduced. On the other hand, an assessment published by Myanmar's Hydro-Informatics Centre and National Water Resources Committee in 2017 suggested that the Ayeyarwady Basin alone was home to 388 fish species (the Ayeyarwady is the country's longest river with a discharge estimated to be close to that of the Mekong). Of these, 193 species were endemic to the basin and 100 were known to exist only in Myanmar.

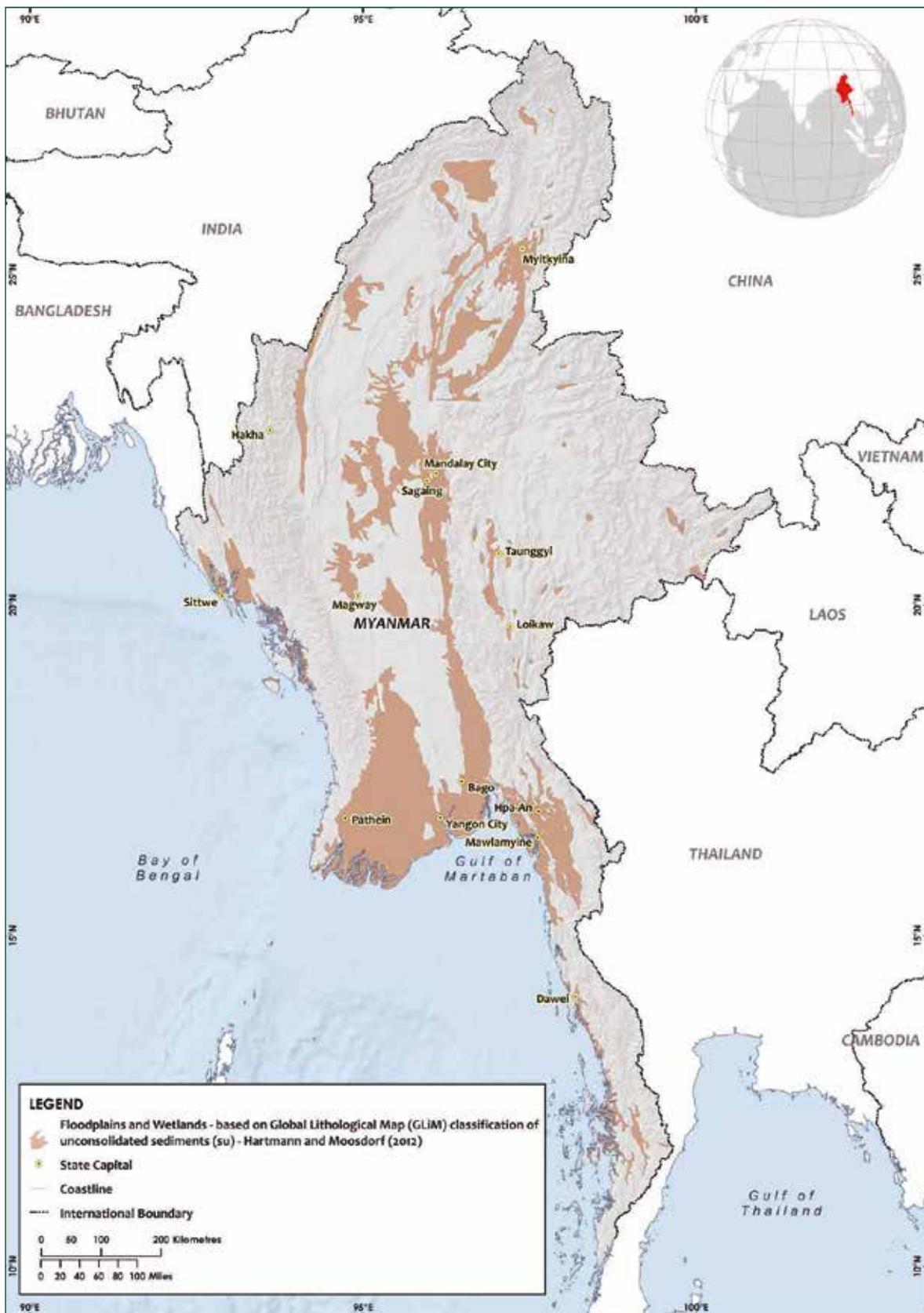
High endemism

"These records suggest that endemism in Myanmar is higher than in neighbouring countries," the book says, noting reports of 22 endemic species in Thailand, two in Lao PDR, one in Bangladesh and none



The spotted barb (*Barbodes binotatus*) is a small indigenous species that the Myanmar Sustainable Aquaculture Programme (Mysap Inland) and WorldFish are promoting for small-scale farming. Households with ponds of less than 0.2 ha are encouraged to stock the species and other small self-replicating fishes such as flying barb (*Esomus* sp) and the mola carplet (*Amblypharyngodon mola*) with larger market-sized species. Partial harvesting of the small species with shallow floating gill nets is promoted six weeks after stocking and every two weeks after that. The EU and Germany are funding the aquaculture program which is being implemented by WorldFish. The spotted and flying barbs are also native to the Mekong Basin whereas the mola carplet is indigenous to Pakistan, India, Bangladesh and Myanmar.

PHOTO: MYSAP



Flood plains and wetlands in Myanmar, derived from a geological map of unconsolidated sediments. The book focuses on the Ayeyarwady Delta in the south and the Central Dry Zone, the two most densely populated regions of Myanmar where much of the research on natural resources and livelihoods has been carried out including that related to fisheries. The Ayeyarwady Delta southwest of Yangon covers about 3.2 percent of Myanmar and boasts the country's highest land productivity with abundant water resources supporting productive fisheries. The Central Dry Zone encompasses 13 percent the country, covering large parts of the Magway, Mandalay and lower Sagaing divisions in the central plains.

MAP: ACIAR (2020)

in Cambodia or Viet Nam. Fish endemism in Myanmar is believed to be particularly high in forested streams and rivers in the upper catchments of the country as well as inland natural lakes. Large and migratory species of commercial significance — such as *Wallago* and *Pangasius* catfishes — were found to be still considered common in Myanmar, whereas they have become rare in most tropical rivers including the Mekong.

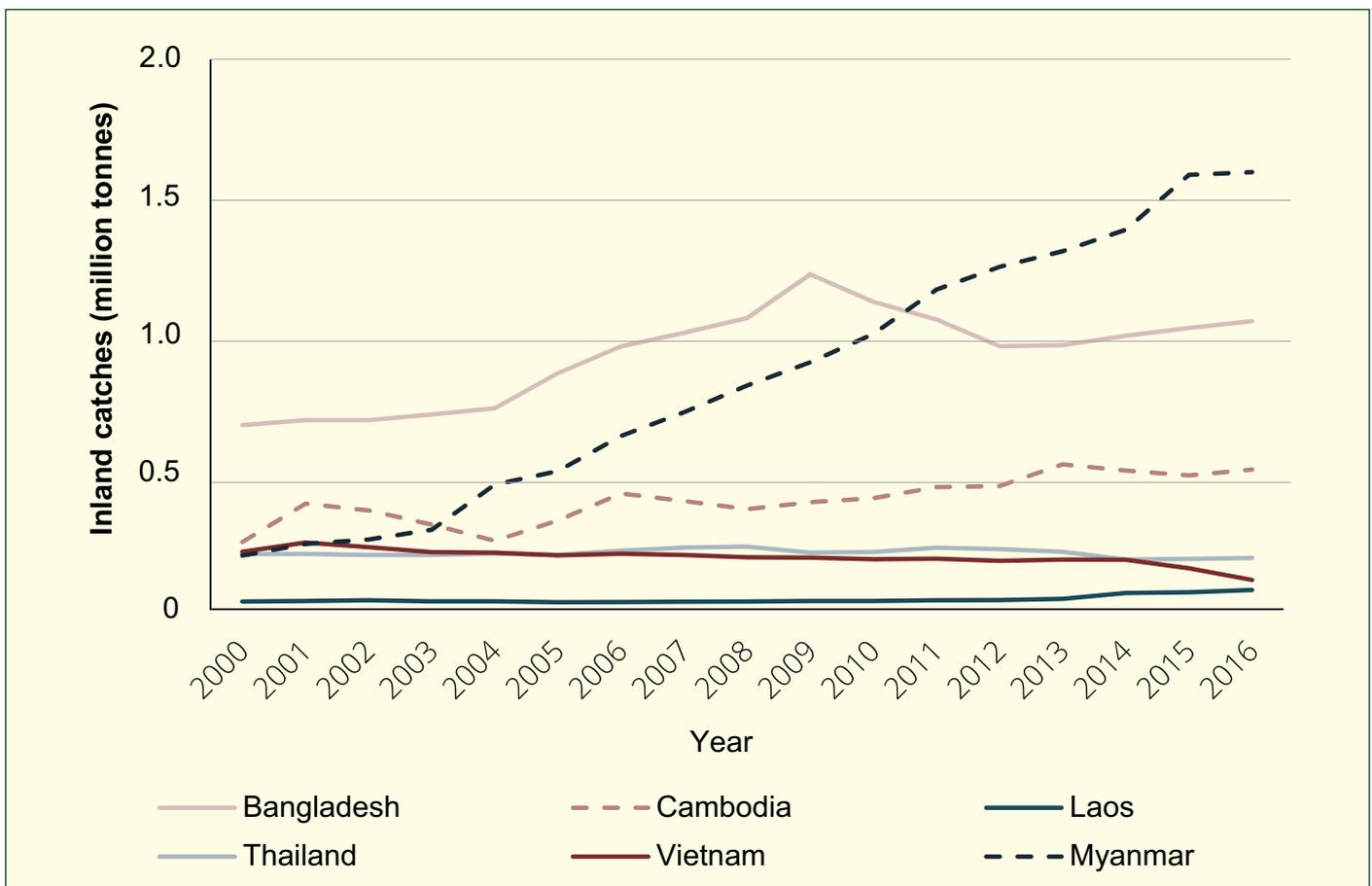
The book refers to more than 30 specific freshwater fish species in Myanmar, both native and introduced. Seven of these are native to the Lower Mekong — the bronze featherback (*Notopterus notopterus*), the climbing perch (*Anabas testudineus*), the giant pangasius (*Pangasius sanitwongsei*), another shark catfish species (*Pangasius conchophilus*), the snakeskin gourami (*Trichopodus pectoralis*), the striped snakehead (*Channa striata*), the walking catfish (*Clarias batrachus*) and the Wallago catfish (*Wallago attu*).

Among small and medium-sized inland fishes, the ten most widely consumed species in Myanmar were found to include bronze featherback, climbing perch, striped snakehead and walking catfish which are also popular food species in the Lower Mekong. While fish account for 60 percent of the animal protein consumed in Myanmar, the book notes that “Myanmar people prefer to consume freshwater species, even in coastal areas.”

Production

The book goes into considerable detail about efforts to improve estimates of fisheries production in Myanmar, especially over the past five years. In terms of inland capture fisheries, national statistics indicate that production overtook that of Cambodia around 2004 and Bangladesh around 2011 (see below). Until then, it had been estimated that Bangladesh was the world’s largest producer of freshwater fish behind China and India. But a review of these statistics by the Food and Agriculture Organization

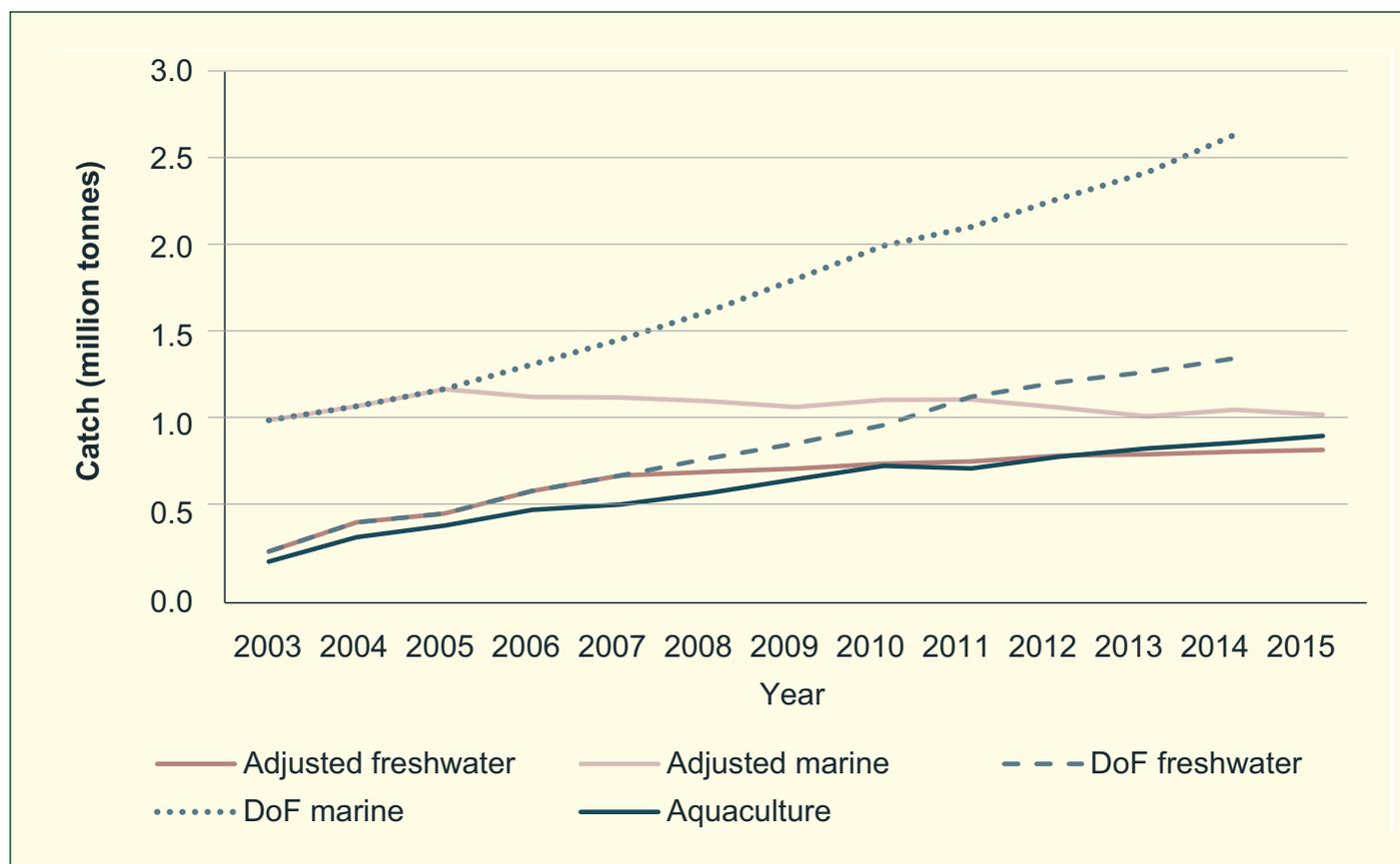
Myanmar's reported inland catches compared with those of neighbouring countries



Reported inland fish catches for Myanmar compared with countries of the Lower Mekong Basin and Bangladesh, 2000-16

SOURCE: ACIAR (2020)

Myanmar's revised catches from capture fisheries



Comparison of Department of Fisheries statistics and the adjusted figures calculated by FAO (2016) for marine and inland capture fisheries production. The FAO did not adjust aquaculture statistics (presumably because they are usually more accurate).

SOURCE: ACIAR (2020)

of the United Nations (FAO) suggested much more modest growth in Myanmar's inland fisheries, slowing to a very gradual increase between 2010 and 2015 (see above).

'Inland fisheries and aquaculture make a more important contribution than was previously believed'

The downward revisions by the FAO still leave Myanmar as one of the world's largest fish producers. When combined with marine capture fisheries, the FAO estimated in 2016 that Myanmar's total fish production accounted for more than seven percent of global output. Inland capture fisheries and aquaculture — mostly in freshwater systems — are estimated to account for about two-thirds of production.

'Dearth of knowledge'

The book's final chapter concludes that Myanmar's capture fisheries and aquaculture sectors are still "characterised by a dearth of knowledge." But the

FAO adjustments to national statistics suggest that "inland fisheries and aquaculture make a more important contribution than was previously believed," it says.

In his foreword to the book, ACIAR chief executive officer Andrew Campbell describes Myanmar's inland fisheries sector as "very critical" for the food security and livelihoods of millions of people. But fish diversity and the availability of small native nutrient-dense fish consumed whole "can only be sustained by improving the management of inland capture fisheries."

Further reading:

So, N., K. Utsugi, K. Shibukawa, P. Thach, S. Chhuoy, S. Kim, D. Chin, P. Nen and P. So (2018) *Fishes of Cambodian Freshwater Bodies*. Inland Fisheries Research and Development Institute, Fisheries Administration, Phnom Penh. 197 pp.

Soe, K.M., Baran, E., Grantham, R., Tezzo, X. & Johnstone, G. (2020) *Myanmar inland fisheries and aquaculture: a decade in review*, Monograph No. 209, Australian Centre for International Agricultural Research, Canberra, & WorldFish, Yangon, 93 pp.

Yasuhiko Taki

A Japanese scientist leaves a nomenclatural legacy in the Mekong region

In 1864, Dutch ichthyologist Pieter Bleeker described a new fish species, classifying it in the *Botia* genus of what was then mainly “Indian loaches” from Asia (there were also a couple of other fishes from Indonesia and one from Japan among 10 species listed in the genus in 1863). According to Bleeker’s description, published in the Dutch Journal of Zoology the following year, individuals from the new species belonged to the Museum of the Jardin des Plantes in Paris and had come from French zoologist Marie Formin Bocourt who had brought them back from Thailand.

But the Dutchman was a bit puzzled. “I cannot relate this species to any of the known *Botia* species.

Although individuals are not in an impeccable state of preservation, I cannot assume that the complete absence of bands or spots on the body and fins can be attributed to preservation in alcohol,” he wrote. “It would therefore be the only species where neither spots nor bands appear.” Bleeker said the new species, which he named *Botia modesta*, resembled a fish half way between *Botia dario*, the “Bengal loach” native to the India (Assam and Bengal), and what was thought to be another *Botia* species found in the same area (since reclassified as the same Bengal loach).

In the newly acquired French colonies of Cambodia and Viet Nam, colonial administrator Gilbert Tirant described a similar new species *Botia morleti* in 1885, naming the fish after malacologist L.J. Morlet. Commonly known in English these days as

Ten loach species in *Botia* genus from India, Indonesia and Japan

Listed in the Dutch Journal of Zoology in 1863

A year before Bleeker described *Botia modesta* as a new species of loach from Thailand, the Dutch Journal of Zoology listed the ten fishes on the right as the only species known from the genus at the time. The specimens were collected from a broad area spanning present-day India, Bangladesh and Myanmar (including Almora, Assam, Bengal, Darjeeling and Tenasserim), Indonesia (Borneo, Java and Sumatra) and Japan. Of the descriptions highlighted here, five were from Bleeker. The others are from British zoologists Edward Blyth (four species) and John Edward Gray (one). Today, only five are still classified as belonging in the *Botia* genus. The first species listed here has been renamed *B. Almorae* (Almorha loach). The second species retains its name of *B. Dario* (Bengal loach). The next two fishes were confused with the first two (the third turn out to be *B. Almorae* and the fourth is *B. Dario*) and the seventh is still called *B. histri-*

Les espèces de la famille jusqu'ici connues, sont les suivantes.

Species Cobitioideorum hucusque cognitae.

<i>Botia grandis</i> Gr. = <i>Cobitis grandis</i> Val. = <i>Hymenophysa grandis</i> Blkr.	Almoreh.
” <i>dario</i> Blyth = <i>Cobitis dario</i> Ham. Buch. = <i>Schistura dario</i> McCl. =	
” <i>Diacantha flavicauda</i> Swns.	Beng., Assam.
” <i>geto</i> Blyth = <i>Cobitis geto</i> Buch. = <i>Schistura geta</i> McCl. = <i>Diacantha zebra</i> Swns.	Beng., Assam.
” <i>Blythi</i> Blkr = <i>Schistura grandis</i> McCl. = <i>Syncrossus grandis</i> Blyth.	Khasya mont.
” <i>Berdmorei</i> Blkr = <i>Syncrossus Berdmorei</i> Blyth (an fors. ead. spec. ac <i>Schistura grandis</i> McCl???)	Tenasserim.
” <i>nebulosa</i> Blyth	Darjeling.
” <i>histrionica</i> Blyth.	Tenasserim.
” <i>curta</i> Blkr = <i>Cobitis curta</i> Schl. = <i>Hymenophysa curta</i> Blkr.	Japonia.
” <i>hymenophysa</i> Blkr = <i>Cobitis hymenophysa</i> Blkr = <i>Hymenophysa MacClellandi</i> Blkr.	Java, Sumatra.
” <i>macracanthus</i> Blkr = <i>Cobitis macracanthus</i> Blkr = <i>Hymenophysa macracanthus</i> Blkr.	Sumatra, Borneo.

onica (sometimes known as the Burmese loach). As Bleeker indicates, the valid name for the fifth species is *Syncrossus berdmorei* (Blyth’s loach). The rest have also been transferred to other genera with the sixth fish listed now known as *Acanthocotus botia* (mottled loach), the eighth as *Parabotia curtus* (kissing loach), the ninth as *Syncrossus hymenophysa* (tiger loach) and the tenth as *Chromobotia macrocanthus* (clown loach).

SOURCE: SCHLEGEL, BLEEKER AND WESTERMAN (1863) AND FISHBASE

the “skunk botia”, this new species was found in Thu Dau Mot, about 20 km north of Saigon. Half a century later, the American zoologist Henry Weed Fowler described another new *Botia* species from Khemmarat, a district on the right bank of the Mekong River in Ubon Ratchathani Province in north-east Thailand. Fowler named the new species *Botia lecontei*, which became known as “silver loach” in English.

Three species described from Lao water bodies

In the latter part of the 20th century, descriptions of new loach species in the Mekong region accelerated. Yasuhiko Taki, a relatively young Japanese ichthyologist in his early forties, described a new species from the genus in 1972, naming it *Botia eos* after the Greek goddess for dawn. The new species was a spiny loach from about 20 km north of the Lao capital of Vientiane and became known as the “sun loach” in English. In 1974, the Lao mission of the United States Agency for International Development published a study by Dr Taki on fishes of the Lao part of the Mekong Basin. In 1995, Dr Taki and a Japanese colleague were describing two more loaches from the southern Lao provinces of Attapeu and Champasak. They named these new species *Botia caudipunctata* and *Botia longidorsalis*. A few months later, American taxonomist Tyson Roberts was describing yet another new loach species from Attapeu, which he named *Botia splendida*.

Other research and development work

Dr Taki was a professor of ichthyology at the Tokyo University of Fisheries until 1994. He described *Lates japonicus* as well in 1984. He authored several papers on iron and fluoride concentrations in fish teeth. He also worked for the Japan International Cooperation Agency (JICA) in the assignment to Deputy Chief of SEAFDEC AQD Philippines (1984–85), on a five-year project to develop turbot farming on the Black Sea in Trabzon Turkey (1997–2002), indigenous fish farming project in Malawi (1999–2006). In addition, he served as board chairman of the Japan Wildlife Research Center and the Nagao Natural Environment Foundation (NEF) concurrently. Then his work was extended to the Mekong Basin in a survey of wild aquatic insects and other animals and plants consumed as food from 2006.

Conservation research in the Mekong

Dr Taki’s association with the Mekong Basin continued after he joined the Nagao Natural Environment Foundation in Tokyo which began conservation re-

search and activities in Cambodia, Lao PDR, Thailand and Viet Nam in 2006. As NEF board chairman, he launched and supervised the program focusing on the fauna and flora of the Mekong and Chao Phraya basins, extended into a second phase in 2011. Participants included the Inland Fisheries Research and Development Institute in Cambodia, the National University of Laos and the Namxouang Aquaculture Development Center in Lao PDR, Kasetsart University, Maejo University, Srinakharinwirot University and Ubon Ratchathani University in Thailand, and Can Tho University in Viet Nam.

The work of Dr Taki in the Mekong region was internationally recognized as early as 2002, when Romanian ichthyologist Teodor Nalbant reclassified several species from the *Botia* genus as belonging to a new genus — *Yasuhikotakia*, named in honor of Dr Taki. Swiss taxonomist Maurice Kottelat took issue with two of these species which have since been reclassified to another genus.

In his magnum opus on loaches published by the *Raffles Bulletin of Zoology* in Singapore in 2012 after more than three decades of research, Kottelat identified seven species from the new genus named after Dr Taki (see table on following page). These were all “Mekong loaches” and included not only the three new fishes the Japanese scientist discovered in Lao PDR but also the strange new fish from Thailand described by Bleeker in 1864. Now widely known as the red-tail botia or blue botia in English, *Yasuhikotakia botia* is today highly prized in the global ornamental fish trade along with other Mekong species from the genus, notably *Yasuhikotakia eos*, the sun loach described by Dr Taki in 1972.

Japanese imperial family

According to a book on the Japanese imperial family’s contribution to biological research, Dr Taki encouraged an early interest in fish expressed by Prince Akishinomiya, the younger brother of Emperor Naruhito. Dr Taki is quoted as saying that he became “definitely interested in catfish” while feeding fish in a royal moat during a visit to Thailand as an undergraduate student. The book, published last year, says the Japanese scientist “provided guidance about ichthyological research” to the prince for a paper he authored comparing the Mekong giant catfish (*Pangasianodon gigas*) with other pangasiids. The paper was completed in 1987 before Prince Akishinomiya left Tokyo for

Seven loach species in *Yasuhikotakia* genus from Mekong region

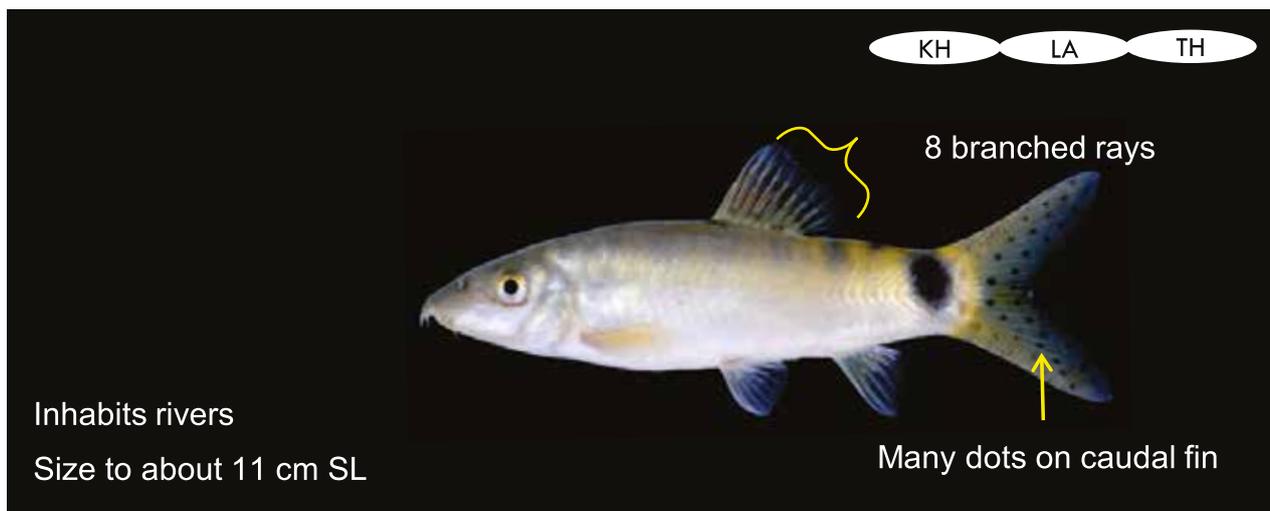
Listed in the Raffles Bulletin of Zoology in 2012

Species	Author (s)	Year	Locality Collected
<i>Yasuhikotakia caudipunctata</i> Synonym: <i>Botia caudipunctata</i> Common names: (En) Speckle-tailed loach (La) Pa mou man	Taki & Doi	1995	Lao PDR: Mekong River at Hatsalao, near Pakse
<i>Yasuhikotakia eos</i> Synonym: <i>Botia eos</i> Common names: (En) Sun loach (Kh) Trey kranchrouk krawhorm (La) Pa mou man	Taki	1972	Lao PDR: Nam Ngum at mouth of Nam Khon at Tha Ngon, about 22 km north of Vientiane
<i>Yasuhikotakia lecontei</i> Synonym: <i>Botia lecontei</i> Common names: (En) Silver loach	Fowler	1937	Thailand: Kemarat
<i>Yasuhikotakia longidorsalis</i> Synonym: <i>Botia longidorsalis</i> Common names: (En) Silver loach, silver botia (Kh) Trey kranchrouk loeung (La) Pa mou man (Th) Pla moo (Vn) Ca heo	Taki & Doi	1995	Lao PDR: Mekong River at Hatsalao, near Pakse
<i>Yasuhikotakia modesta</i> Synonym: <i>Botia modesta</i> Common names: (En) Red-tail botia, blue botia (La) Pa mou man (Th) Pla moo khao, pla moo lueng (Vn) Ca heo rung, ca heo xanh	Bleeker	1864	Thailand: Ayuthaya
<i>Yasuhikotakia morleti</i> Synonym: <i>Botia morleti</i> Common names: (En) Skunk botia, skunk loach	Tirant	1885	Viet Nam: Thu Dau Mot
<i>Yasuhikotakia splendida</i> Synonym: <i>Botia splendida</i> Common names: (En) Yellow-tail polka-dot loach	Roberts	1995	Lao PDR: Attapeu Province: Xe Pian 5–6 km upstream from Ban Hin Lat and 1 km downstream from Se Pa waterfall

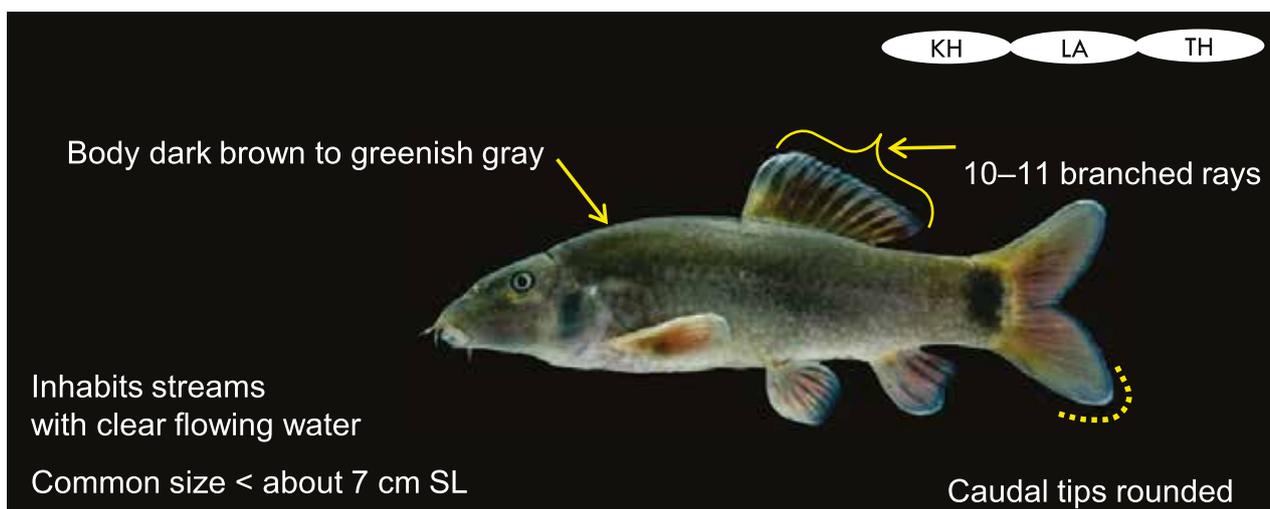
En = English, Kh = Khmer, La = Lao, Th = Thai, Vn = Vietnamese

SOURCE KOTTELAT (2012), FISHBASE, WWW.LOACHES.COM AND WWW.PRACTICALFISHKEEPING.CO.UK

Yasuhikotakia caudipunctata (Taki & Doi, 1995)



Yasuhikotakia eos (Taki, 1972)



Two of the three new Mekong loach species described by Dr Taki in 1972 and 1995

IMAGE: SO ET AL (2018)

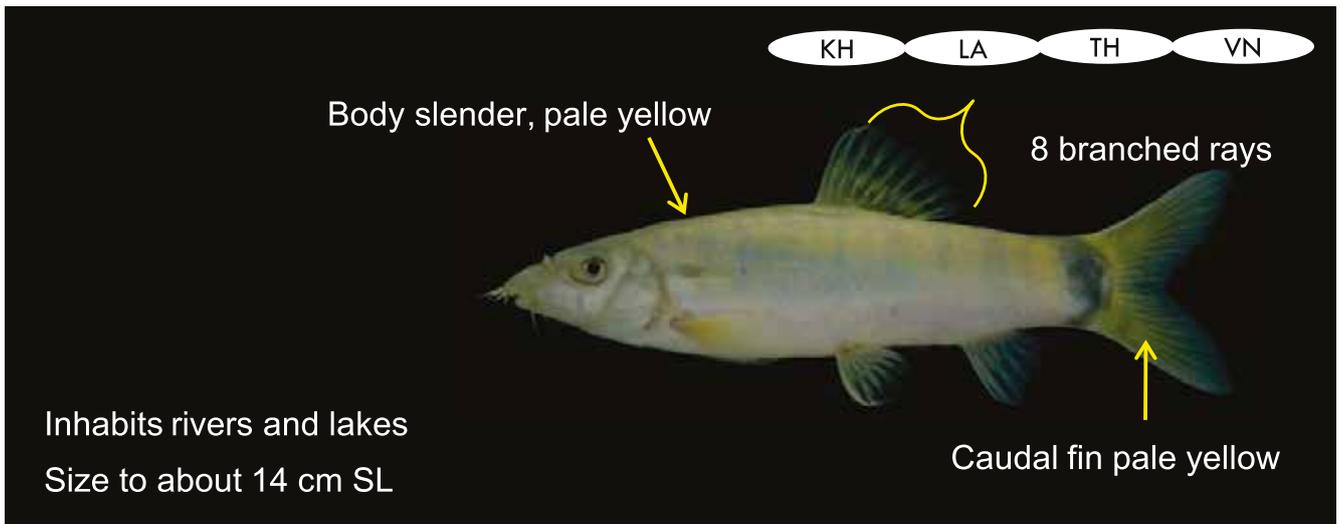
the Graduate School of Zoology at the University of Oxford.

But Dr Taki's ties to the imperial family went back to the previous decade when Prince Akishinomiya's father — the then Crown Prince Akihito, who abdicated as Emperor last year — was researching a new goby from Viet Nam. According to the book, one of the specimens had been collected by Dr Taki and Prince Akihito asked his chamberlain Katsusuke Meguro find a suitable Vietnamese museum where it could be stored. By 1976, when a paper on the new species by Prince Akihito and Mr Meguro had been published by the Japanese Journal of Ichthyology, paratype-specimens were with the Zo-

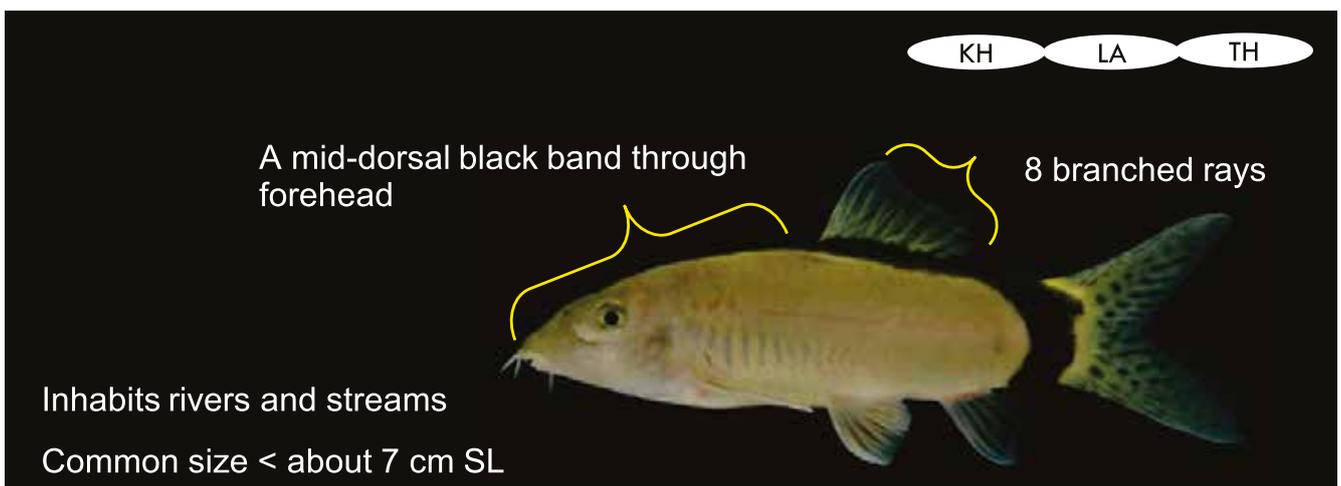
ology Museum at the University of Hanoi. According to the paper, the paratypes were collected in the Bassac River from about 1 km downstream from Can Tho in Mekong Delta in March 1974, a year before the end of the American war in Viet Nam.

When Dr Taki asked Mr Meguro why the crown prince wanted the paratypes sent to a Vietnamese museum in Viet Nam, the future Emperor of Japan is said to have stated: "Most of the plants and animals of Japan were described as new species by western scientists in the past and their type specimens are displayed in Western museums. At present, Japanese researchers have to expend considerable time and labor in order to get an op-

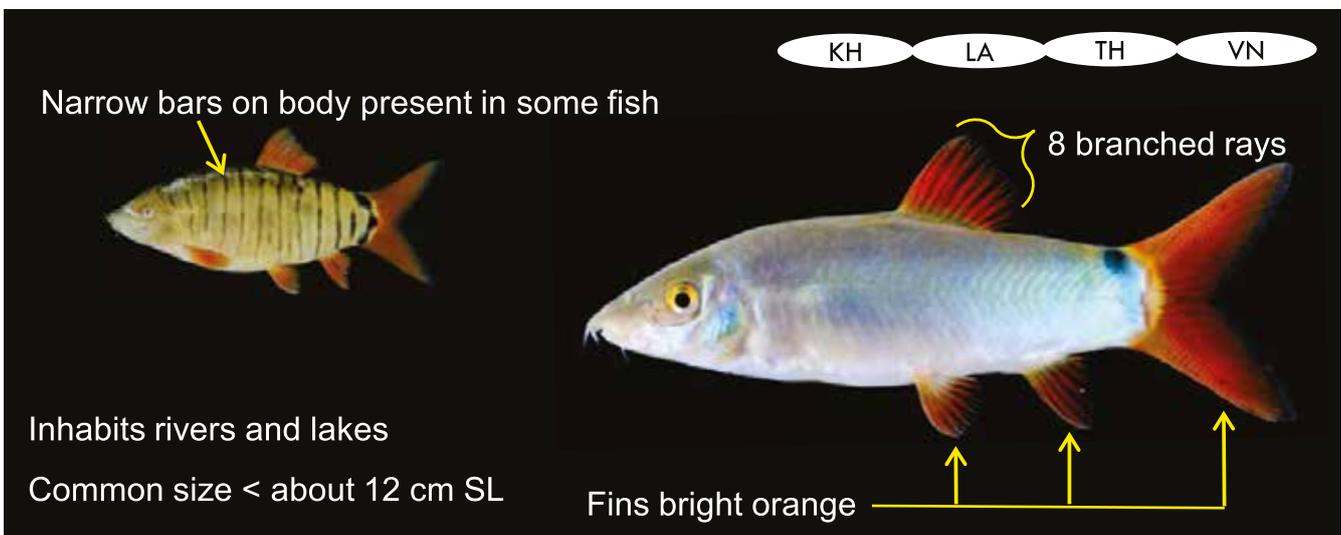
Yasuhikotakia lecontei (Fowler, 1937)



Yasuhikotakia morleti (Tirant, 1885)



Yasuhikotakia modesta (Bleeker, 1864)



Three loach species described by western scientists before the genus was renamed in honor of Dr Taki

IMAGE: SO ET AL (2018)



Dr Taki speaking at Can Tho University in 2011

PHOTO: NAGAO NATURAL ENVIRONMENT FOUNDATION

portunity to closely observe the specimens. I would prefer that the Vietnamese researchers not experience the same difficulty as we did.”

On 24 March this year, Dr Taki died at the age of 88. At the time of his death, he held the position of Professor Emeritus at Tokyo University of Marine Science and Technology and was also serving as an advisor to NEF.

Further reading

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FAO Fish Price Index
(2002-2004 = 100)



Source of the raw data for the FAO Fish Price Index: EUMOFA, INFOFISH, INFOPECSA, INFOYU, Statistics Norway

Production, trade, utilisation and consumption FAO Food Outlook, May, 2020	2018	2019 Estimate	2020 Forecast	Change 2020/2019
	Million tonnes			%
Production	178.5	175.9	172.9	-1.7
Capture fisheries	96.4	91.8	89.9	-2.0
Aquaculture	82.1	84.1	82.1	-1.4
Trade value (exports USD billion)	164.1	159.6	150.4	-5.8
Trade volume (live weight)	67.1	65.3	63.2	-3.2
Total utilisation	178.5	175.9	172.9	-1.7
Food	156.4	156.4	154.2	-1.4
Feed	18.2	15.5	15.0	-3.5
Other uses	4.0	4.0	3.7	-7.5
Consumption per person				
Food fish (kg/yr)	20.5	20.3	19.8	-2.4
From capture fisheries (kg/year)	9.7	9.4	9.1	-2.4
From aquaculture (kg/year)	10.8	10.9	10.6	-2.4
FAO Fish Price Index (2002-2004 = 100)	2018	2019	2020	Change
	158	154	Jan-May 147	Jan-May 2020/Jan-May 2019 -8.3

Thailand Talaad Thai Wholesale Market, Pathum Thani Province			THB per kg	
			March, 2020	July, 2020
Item			Price	
Chinese edible frog (<i>Haplobatrachus rugulosus</i>) (small)	กบนา (เล็ก)		80 - 90	80 - 90
Asian redtail catfish (<i>Hemibagrus wyckioides</i>)	ปลากดคัง		120 - 185	120 - 185
Yellow mystus (<i>Hemibagrus filamentus</i>)	ปลากดเหลือง		100 - 120	100 - 125
Tire track eel (<i>Mastacembelus favus</i>)	ปลากระทิง		150 - 250	150 - 250
Clown featherback (<i>Chitala ornata</i>)	ปลากทราย		160 - 190	160 - 190
Iridescent mystus (<i>Mystus multiradiatus</i>) (large)	ปลาเขยง (ใหญ่)		80 - 100	80 - 100
Iridescent mystus (<i>Mystus multiradiatus</i>) (small)	ปลาเขยง (เล็ก)		50 - 60	50 - 60
Wallago (<i>Wallago attu</i>) (large)	ปลาเคียวขาว (ใหญ่)		180	180
Wallago (<i>Wallago attu</i>) (small)	ปลาเคียวขาว (เล็ก)		120	120
Bronze featherback (<i>Notopterus notopterus</i>)	ปลาสร้อย หรือ ปลาฉลาม		90 - 100	90 - 100
Wild striped snakehead (<i>Channa striata</i>) (large)	ปลาช่อน (ใหญ่)		—	—
Wild striped snakehead (<i>Channa striata</i>) (small)	ปลาช่อน (เล็ก)		—	—
Farmed giant snakehead (<i>Channa micropeltes</i>) (large)	ปลาชะโด เลียง (ใหญ่)		100	100
Farmed giant snakehead (<i>Channa micropeltes</i>) (small)	ปลาชะโด เลียง (เล็ก)		95	90
Bighead walking catfish (<i>Clarias macrocephalus</i>) (large)	ปลาดุกอูย หรือ ปลาดุกนา (ใหญ่)		—	—
Bighead walking catfish (<i>Clarias macrocephalus</i>) (small)	ปลาดุกอูย หรือ ปลาดุกนา (เล็ก)		—	—
Farmed North African walking catfish hybrid (<i>Clarias</i> spp.) (large)	ปลาดุก เลียง (ใหญ่)		50 - 65	53 - 55
Farmed North African walking catfish hybrid (<i>Clarias</i> spp.) (small)	ปลาดุก เลียง (เล็ก)		48 - 50	48 - 52
Siamese red catfish (<i>Phalacronotus bleekeri</i>) (large)	ปลาแดง (ใหญ่)		280 - 380	280
Siamese red catfish (<i>Phalacronotus bleekeri</i>) (small)	ปลาแดง (เล็ก)		100 - 170	100 - 170
Silver barb (<i>Barbonymus gonionotus</i>) (large)	ปลาตะเพียนขาว หรือ ปลาตะเพียนเงิน (ใหญ่)		50	50
Silver barb (<i>Barbonymus gonionotus</i>) (small)	ปลาตะเพียนขาว หรือ ปลาตะเพียนเงิน (เล็ก)		30 - 35	35
Red tilapia hybrid (<i>Oreochromis</i> spp.) (large)	ปลานิลแดง (ใหญ่)		85 - 90	85 - 90
Red tilapia hybrid (<i>Oreochromis</i> spp.) (small)	ปลานิลแดง (เล็ก)		70	70
Nile tilapia (<i>Oreochromis niloticus</i>) (large)	ปลานิล (ใหญ่)		55 - 65	50
Nile tilapia (<i>Oreochromis niloticus</i>) (small)	ปลานิล (เล็ก)		20 - 25	20
Whisker sheatfish (<i>Kryptopterus</i> spp.) (large)	ปลาชาก (ใหญ่)		380	380
Whisker sheatfish (<i>Kryptopterus</i> spp.) (small)	ปลาชาก (เล็ก)		140 - 200	140 - 190
Common carp (<i>Cyprinus carpio</i>) (large)	ปลานิล (ใหญ่)		38 - 40	—
Mekong giant catfish (<i>Pangasianodon gigas</i>)	ปลาบึก		55 - 65	50 - 65
Boeseman croaker (<i>Boesemania microlepis</i>)	ปลาหมอ		240 - 300	240 - 360
Horse-face loach (<i>Acantopsis choirorhynchus</i>)	ปลารากกล้วย		140 - 170	140
Giant gourami (<i>Osphronemus goramy</i>)	ปลาแรด		80 - 90	85 - 90
Siamese mud carp (<i>Henicorhynchus siamensis</i>)	ปลาสร้อยขาว		50 - 55	55
Snakeskin gourami (<i>Trichopodus pectoralis</i>)	ปลาสร้อย		138 - 200	130 - 185
Striped catfish (<i>Pangasianodon hypophthalmus</i>)	ปลาสร้อย		28 - 32	30 - 35
Climbing perch (<i>Anabas testudineus</i>) from rice paddy (large)	ปลาหมอ นาข้าว (ใหญ่)		90	90
Climbing perch (<i>Anabas testudineus</i>) from rice paddy (small)	ปลาหมอ นาข้าว (เล็ก)		80 - 85	85
Farmed climbing perch (<i>Anabas testudineus</i>) (large)	ปลาหมอ เลียง (ใหญ่)		90 - 95	90
Farmed climbing perch (<i>Anabas testudineus</i>) (small)	ปลาหมอ เลียง (เล็ก)		80 - 85	85
Spot-fin spiny eel (<i>Macrognathus siamensis</i>) (large)	ปลาหลดจุด (ใหญ่)		170	170
Spot-fin spiny eel (<i>Macrognathus siamensis</i>) (small)	ปลาหลดจุด (เล็ก)		100 - 150	130 - 150
Rice-field eel (<i>Monopterus javanensis</i>) (large)	ปลาไหลนา หรือ ปลาไหลบึง นาข้าว (ใหญ่)		250	250 - 280
Rice-field eel (<i>Monopterus javanensis</i>) (small)	ปลาไหลนา หรือ ปลาไหลบึง นาข้าว (เล็ก)		320	300
Pond snail (<i>Filopaludina martsensi</i>)	หอยขม		100	100

Viet Nam Vietnam Association of Seafood Exporters and Producers (VASEP) Dong Thap Province in the Mekong Delta except black tiger shrimp (Da Nang)			VND per kg unless otherwise stated	
			February, 2020	July, 2020
Item		Size	Price	
Pangasius (<i>Pangasianodon hypophthalmus</i>) (white flesh)	Cá tra thịt trắng	0.7 – 0.8 kg	18,000 – 19,000	18,000 – 18,500
Pangasius fry (<i>Pangasianodon hypophthalmus</i>)	Cá tra bột	Bột	1.0 – 3.0 đ/con	0.8 – 1.5 đ/con
Pangasius sub-fingerlings (<i>Pangasianodon hypophthalmus</i>)	Cá tra hương	Hương (3,000 con/kg)	—	—
Pangasius fingerlings (<i>Pangasianodon hypophthalmus</i>)	Cá tra giống	Giống (28 – 32 con/kg)	600 – 900 đ/con	21,000 – 22,000
Red tilapia (<i>Oreochromis</i> spp.)	Cá diêu hồng	> 300 g – 1,000 g	31,000 – 32,000	31,000 – 33,000
Red tilapia fingerlings (<i>Oreochromis</i> spp.)	Cá diêu hồng	Giống (30 – 35 con/kg)	650 – 720 đ/con	22,000 – 23,000
Snakehead (<i>Channa</i> spp.)	Cá lóc nuôi	≥ 500 g	110 – 140 đ/con	110 – 140 đ/con
Snakeskin gourami (<i>Trichopodus pectoralis</i>)	Cá sặc rằn	6 con/kg	37,000 – 39,000	40,000 – 45,000
Climbing perch (<i>Anabas testudineus</i>)	Cá rô đầu vuông	3 – 5 con/kg	27,000 – 29,000	26,000 – 28,000
Japanese wrinkled frog fry (Thai strain) (<i>Glandirana rugosa</i>)	Ếch Thái	3 – 5 con/kg	27,000 – 29,000	28,000 – 29,000
Japanese wrinkled frog (Thai strain) (<i>Glandirana rugosa</i>)	Ếch Thái giống	Giống (120 – 140 con/kg)	400 – 450 đ/con	400 – 450 đ/con
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>)	Tôm càng xanh	>100 g	180,000 – 220,000	250,000 – 270,000
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>)	Tôm càng xanh	75 g – 99 g	140,000 – 160,000	190,000 – 210,000
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>)	Tôm càng xanh	50 g – 74 g	120,000 – 130,000	140,000 – 160,000
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) *	Tôm càng xanh	Tôm trứng, càng xào	90,000 – 100,000	90,000 – 100,000
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) P/L	Tôm càng xanh post	80,000 – 90,000 con/kg	150 – 250 đ/con	100 – 120 đ/con
Black tiger shrimp (<i>Penaeus monodon</i>)	Tôm sú	15 con/kg	440,000	480,000
Black tiger shrimp (<i>Penaeus monodon</i>)	Tôm sú	25 – 30 con/kg	250,000	240,000
Black tiger shrimp (<i>Penaeus monodon</i>)	Tôm sú	40 con/kg	220,000	175,000
Black tiger shrimp (<i>Penaeus monodon</i>)	Tôm sú	40/kg	220,000	175,000

* Berried females, inferior old blue-claw males



PHOTO: NAGAO NATURAL ENVIRONMENT FOUNDATION

Veteran Japanese ichthyologist Yasuhiko Taki died on March 24. Dr Taki was 88 and had worked in the Mekong region over a period spanning five decades. In honour of his extensive work, including with the Japanese imperial family, a genus of loaches now bears his name — *Yasuhikotokia*. The genus includes three species Dr Taki discovered in Lao PDR — one described in 1972 and two others which he described in 1995. As chairman of the Nagao Natural Environment Foundation in Tokyo, Dr Taki later supervised a program on the fauna and flora of the Mekong and Chao Phraya basins in partnership with Cambodian, Lao, Thai and Vietnamese scientists. (see page 40).



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