INSIDE

- Climate change in the Mekong and other transboundary basins
- Commercial production of hatchery-bred 'Mekong salmon'
- New species of stream loach found in northern Thailand
- Fish abundance and diversity around the Tonle Sap Lake
- South American lessons for Lower Sesan 2 Dam
- Catch and Culture comes of age
- World Bank assesses global fish supply and demand in 2030
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Cover photo by Tran Minh Tri of Second Mekong River Commission Summit in Ho Chi Minh City on April 5 showing (from left) Thai Foreign Ministry Permanent Secretary Sihask Phuangketkeow (special envoy of Thai Prime Minisiter Yingluck Shinawatra), Lao Prime Minister Thongsing Thammavong, Vietnamese Prime Minister Nguyen Tan Dung and Cambodian Prime Minister Hun Sen
Contents

4. Climate change (1)
Climate change: water, energy and food security in the Mekong Basin

10. Climate change (2)
Climate change: water, energy and food security in transboundary river basins

12. Aquaculture
Commercial production of hatchery-bred 'Mekong salmon' underway in delta

16. Taxonomy
New species of stream loach found in northern Thai province of Chiang Mai

18. Capture fisheries (1)
Dai catch almost doubles in latest season

20. Capture fisheries (2)
Monitoring fish abundance and diversity around the Tonle Sap Lake

28. Hydropower
South American lessons for fish pass opportunities at Lower Sesan 2 Dam

34. Publishing
Catch and Culture comes of age

40. Economics
World Bank assesses prospects for global fish supply and demand in 2030

46. FAO
Thirty-First Session of the FAO Committee on Fisheries

47. Management
Fish population geneticist appointed as director of MRC Operations Division
Climate change: water, energy and food security in the Mekong Basin

Government leaders from the Lower Mekong Basin countries adopted the Ho Chi Minh City Declaration at the Second Summit of the Mekong River Commission on April 5. Acknowledging opportunities and challenges over the next decade, the declaration outlines six priorities for the MRC. These include expediting a Study on Sustainable Management and Development of the Mekong River including the Impacts of Mainstream Hydropower Projects, and addressing risks posed by intensive agriculture, aquaculture and irrigation as well as hydropower, navigation and other development activities. Full text follows:

We, the Heads of the Governments of the Kingdom of Cambodia, the Lao People’s Democratic Republic, the Kingdom of Thailand, and the Socialist Republic of Viet Nam, meet in Ho Chi Minh City, Viet Nam, for the Second Summit of the Mekong River Commission (MRC).

We reaffirm the vital importance of sustainable use and management of water and related resources of the Mekong River Basin and the continuing political commitment to implement the 1995 Mekong Agreement, and consolidate the spirit of Mekong cooperation;

We note that the development of water resources of the Mekong River Basin has contributed largely to the socio-economic development of the region, such as for navigation, energy and food production, but also has negative environmental and social impacts in the Basin that need to be fully and effectively addressed;

We recognise that climate change is a global issue, which has impacted the livelihoods and economy in all parts of the Mekong River Basin.
Mitigation of and adaptation to climate change is crucial and needs to be urgently addressed;

We recall the First MRC Summit’s priority actions and commitments, including adopting and implementing the MRC IWRM-based Basin Development Strategy, the MRC Strategic Plan 2011 – 2015, and identifying opportunities and risks of hydropower, irrigation, fisheries, navigation, flood and drought management, watershed management, tourism and environment including ecosystem management in the Basin to food security and livelihoods;

'We reaffirm our strong and continued commitment to cooperating and promoting the sustainable development of the Mekong River Basin'

We reaffirm our strong and continued commitment to cooperating and promoting the sustainable development of the Mekong River Basin, and in the utilisation, conservation and management of its water and related resources, and agree to the following statements:

Achievements since the First MRC Summit
We, the Heads of Governments, recognise the progress and achievements over the last four years since the First MRC Summit.

Since the adoption of the MRC IWRM-based Basin Development Strategy in 2011, we note with appreciation that the MRC Member Countries and Secretariat have made significant efforts to develop Regional and National Action Plans for implementing the Strategy, which is supplementing Member Countries’ social and economic development plans.

We acknowledge the expanded implementation of the Procedures for Notification, Prior Consultation and Agreement (PNPCA) to support sound decision-making on proposed water resources development projects in the Mekong River Basin.

We are pleased to note that approval of the Procedures for Water Quality in early 2011 completes the full set of MRC Water Utilization Procedures, which provide a procedural and technical framework to assist MRC Member Countries in the sustainable use of water and related resources of the Mekong River Basin.

We note the importance and usefulness of continuing exchange of data and information amongst Member Countries under the Procedures of Data and Information Exchange and Sharing (PDIES), and we highly appreciate enhanced cooperation with the MRC Dialogue Partners, namely People’s Republic of China and Republic of the Union of Myanmar.

We recognise the progress achieved in the riparianisation of the MRCS with the successful launch of the MRC Junior Riparian Professional Programme and increased numbers of riparian staff and national experts working for the MRCS.

With a vision for the MRC to be financially sustained by Member Countries by 2030, we acknowledge with appreciation the preparations undertaken by the MRC for decentralised implementation of its core river basin management functions outlined in one regional and four national roadmaps, including priorities and milestones.

We are grateful for the increased financial and technical support from Development Partners that will sustain MRC programmes beyond 2015, and prepare for self-financing by 2030.

We also note that the MRC has established a working relationship with the ASEAN and the Mississippi River Commission and explored synergies with other regional and international cooperation to further promote the sustainable development and management of the Mekong Basin’s water resources.

We acknowledge with appreciation the outcomes of Mekong Rio: International Conference on Trans-boundary River Basin Management held on the 1-3 May 2012 in Phuket, Thailand, and the International Conference on Cooperation for Water, Energy and Food Security in Trans-boundary Basin under Changing Climate held on the 2-3 April 2014 in Ho Chi Minh City, Viet Nam, which provided an excellent opportunity to share and learn from global experiences in trans-boundary water development and management (see page 10).

Regional opportunities and challenges
We, the Heads of Governments, acknowledge that
New study among top priorities outlined in summit declaration

The MRC Council Study mentioned in the declaration adopted by Heads of Government in Ho Chi Minh City on April 5 dates back to the Third Mekong-Japan Summit in Bali in November, 2011. During the summit, the prime ministers of the Lower Mekong counties discussed approaching Japan to support a study on sustainable management and development of the Mekong River including impacts of mainstream hydropower projects.

At the MRC Council meeting the following month, ministers responsible for water resources agreed in principle to go ahead with the study but recognised that some Member Countries required an additional national approval process. At the same time, the meeting acknowledged that other development partners might consider supporting the study.

According to the terms or reference that have since been developed by the MRC Secretariat, the study will essentially "address the current uncertainties of the different development opportunities in the Mekong River basin." Objectives are threefold — to close knowledge gaps in the context of the impact of major water use sectors on key areas of the basin’s social, environmental and economic systems, to feed directly into the knowledgebase used for updates and developments of the MRC Basin Development Strategy and to address the need for capacity development in Member Countries with respect to scientific studies.

Outputs of the study are expected to include a technical series with six thematic reports and one main synthesis report summarising the main conclusions and elaborating on a set of recommendations. "In addition, much of the study’s data and information will be integrated into the MRC’s knowledgebase and provide a basis for future scenario analysis and other tools for the Basin Development Strategy 2016-2020," the Secretariat says.

In his remarks to the plenary session of the summit on April 5, Vietnamese Prime Minister Nguyen Tan Dung urged the MRC to "step up" its research and forecast activities "with focus on and highest priority given to the completion of the MRC Council Study."

The MRC’s development partners welcomed the priority attached to the study. "Development Partners continue support the Study’s focus on hydropower and other infrastructure impacts and look forward to its finalisation," said a statement endorsed by the Asian Development Bank, Australia, Belgium, Denmark, the European Union, Finland, Germany, the International Union for the Conservation of Nature, Japan, Luxembourg, Sweden, Switzerland, the United States, the World Bank and the Worldwide Fund for Nature.

In a separate statement issued on the eve of the summit, US State Department Deputy Spokesperson Marie Harf said challenges faced by the MRC were "greater than ever" with increasing demands, rapid development, and climate change. Greater pressure on the river is "threatening the Mekong’s unique environment and the livelihoods of the people that depend on it," she said. "There will continue to be growing competition among uses of the river: for food, for energy, for navigation, and for the ecosystem that sustains one of Asia’s great rice baskets and some of the most diverse and productive fisheries in the world. Responding to these challenges will require greater scientific and technical capacity, increased investment, and unprecedented cooperation at all levels and across all stakeholders."

Harf said the United States remained "committed to supporting the efforts of the Mekong’s riparian countries to improve regional cooperation and management of the river’s resources. We are further committed to providing scientific and technical capacity through our development assistance and increased exchanges with our technical agencies."
the MRC faces both opportunities and challenges over the next decade.

'Assuring water security, and thereby removing imminent and increasing risks to food and energy security, economic growth and stability, is a daunting challenge'

Increasing development pressures such as population growth and economic expansion create huge demand for water, food and energy, placing a burden on the Mekong River Basin resources. At the same time the global economic crises have reduced the availability of investment and funding for MRC programmes. Assuring water security, and thereby removing imminent and increasing risks to food and energy security, economic growth and stability, is a daunting challenge the region now faces.

In continuing efforts to mitigate natural disasters, recognising climate change will continue to alter the hydrological regime of the Basin impacting livelihoods and economies in all parts of the Basin.

The importance of strengthened cooperation for the sustainable development of the Mekong River Basin is acknowledged. New cooperation opportunities with other regional and international initiatives will be explored; funding and technical support from new development partners will be sought, to help sustain and ensure MRC can continue its important work.

Priority areas of action
We, the Heads of Governments, expect the MRC to focus on and prioritise:

i. Expediting the implementation of the MRC Council’s Study on Sustainable Management and Development of the Mekong River, including the impacts of mainstream hydropower projects (see box on opposite page), in coordination with the Mekong Delta
Study initiated by Viet Nam to provide sound advice and recommendations on sustainable development in the Basin (see box at left);


iii. Avoiding, reducing and mitigating risks to river ecology, food security, livelihoods and water quality posed by intensive agriculture, aquaculture, and irrigation, as well as hydropower, navigation and other development activities in the Basin, recognising that the impacts of climate change could compound these risks;

iv. Continuing to improve the implementation of the MRC Procedures to support the implementation of the 1995 Mekong Agreement; committing to the effective implementation of the MRC Procedures to realise its goals;

v. Exploring and identifying opportunities to expand cooperation between the MRC Dialogue Partners, current and new Development Partners and other regional and international initiatives;

vi. Furthering the efforts in basin wide disaster risk reduction for floods, droughts and impact of sea level rise; monitoring and taking measures to maintain good water quality in the Mekong River Basin;

**Way ahead**

We, the Heads of Governments, reaffirm our solidarity and the highest level of political commitment to the implementation of the 1995 Mekong Agreement;

We commit to working together to strengthen the role of the MRC in ensuring the application of an integrated water resources management approach to ensure the sustainable use and conservation of water, food, and energy resources in the Region;

We reiterate our support for enhancing and strengthening the MRC’s working relationships and cooperation with Dialogue Partners,
Development Partners, international and regional initiatives, civil society, the private sector and others; and call upon their support and assistance to the MRC and its individual Member Countries in implementing projects and studies on sustainable development in the Mekong River Basin;

We also express our support to the MRC to continue making preparations to decentralise MRC core river basin management functions, paving the road for the organisation to be fully self-financed by 2030;

We emphasise the needs to prioritise capacity building for the Member Countries;

We agree to task the MRC Council to ensure the effective implementation of this Declaration through practical programmes and projects.

We express our sincere appreciation to Viet Nam for hosting the Second MRC Summit, and we look forward to the third MRC Summit to be held in April 2018 in Cambodia.

ADOPTED at Ho Chi Minh City, Viet Nam on 5 April 2014 in the English Language.

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Development partners seek inclusion of some tributary dams in prior consultations

In a statement delivered to the April 5 summit, MRC development partners noted that impressive economic growth in the Lower Mekong Basin was largely based on the use of natural resources. "Resources in the Mekong Basin should be used in an ecologically sustainable, economically viable and socially equitable manner for the benefits of current and future generations, conserving the natural capital base and the environmental services they provide," the statement said.

"This is of crucial importance to the livelihoods and food, energy and water security of the fast-growing riparian population of the Mekong Basin, and for the protection of one (of) the world’s richest ecosystems, facing significant pressure by climate change. The sustainable use of the Mekong River and its vast resources can only be ensured through regional cooperation. This is why development partners firmly believe that the MRC is more relevant than ever as a proactive facilitator of sustainable development achieved through a platform of sound knowledge, cooperation and trust.

"With the accelerated hydropower development in the Mekong basin, it is becoming increasingly important that decision-making on hydropower and other development projects is based on sound scientific knowledge regarding their transboundary and cumulative impacts on resources and ecosystems. The MRC platforms and processes need to be further strengthened and applied as means of supporting such decisions.

"Recent hydropower developments on the mainstream and tributaries have illustrated the importance of a common understanding and application of the Procedures for Notification, Prior Consultation and Agreement (PNPCA). Development Partners encourage the MRC to consider the inclusion of tributary dams with likely transboundary impacts in the Prior Consultation process. We reiterate that information sharing fulfils a central role of the MRC and ensures that the legitimate concerns of Member Countries are taken into account."

The statement was endorsed by the Asian Development Bank, Australia, Belgium, Denmark, the European Union, Finland, Germany, the International Union for the Conservation of Nature, Japan, Luxembourg, Sweden, Switzerland, the United States, the World Bank and the Worldwide Fund for Nature.

Under the PNCPA, water use is any use of water which may have a significant impact on the quality or flow of water on the Mekong mainstream. Prior Consultation currently applies to proposed water use projects on the mainstream in the dry season, diversion of water from the mainstream to other basins in the wet season and diversion of surplus water to other basins in the dry season.
Climate change: water, energy and food security in transboundary basins

The Mekong River Commission organised the International Conference on Cooperation for Water, Energy and Food Security in Transboundary Basins under Changing Climate in Ho Chi Minh City in April. Held ahead of the Second MRC Summit on April 5 (see preceding pages), the two-day conference was attended by some 300 representatives of transboundary river basin organisations as well as international and regional agencies along with other stakeholders. Below is an edited version of a summary of the conference, delivered by Fritz Holzwarth, former deputy director general for water management at the German Ministry for the Environment, Nature Conservation, Building and Nuclear Safety.

Some 40 percent of the world’s population live in river basins shared by several countries, and these are even more when also counting shared aquifers and water shared between sovereign entities (states, provinces) within countries. Transboundary basin organisations play an important role in developing and managing shared water resources and the benefits to be derived from cooperation between upstream and downstream riparian countries.

Wise water management is critical to climate change adaptation, not least in building resilience to sea level rise and increased variability and extreme events, and is key to food and energy production. This underscores the importance of an integrated view on water, energy and food security. This becomes even more important when water is shared in order to realise the full benefits of cooperation. In addressing the overall topic, the international conference focused on three key issues:

Climate change adaptation
Progress should be acknowledged. The trend is upwards, not downwards, in openness, sharing of information, technical capacity and actions on the ground. Action should continue focusing on no/low regret options, while at the same time deepening the technical capacity and cooperation addressing trade-offs; otherwise asking for perfection may lead to inaction.

There is sense of realism and long-term commitment in climate change adaptation approaches. There is no such thing as a quick fix. Scientific advances in support of adaptation show clear policy orientation on e.g. flood management, crop development and delta management. Interaction with policymakers should be intensified to have an effective science policy.

Shared river basins and aquifers represented

Aral Sea
Columbia River
Congo River
Danube River
Ganges River
Guarani River
Geneva Aquifer
Indus River
Itaipu Binacional
Jordan River
La Plata River
Mekong River
Niger River
Nile River
North Western Sahara Aquifer
Orange Senque River
Sao Francisco River
Sava River
Senegal River
Severn River
Vuoksi River
dialogue with real impact.

'There are still gaps in important areas such as water quality, sediment transportation, fish population and ecosystem impacts'

The focus of the discussions and the actions is sharpened when concentrating on climate variability, but there are still gaps in important areas such as water quality, sediment transportation, fish population and ecosystem impacts.

Sustainable development
The nexus approach provides a very useful policy framework to understand development opportunities and challenges, and to involve multiple sector stakeholders. However, the implementation of actions to address the issues will and should still take place through existing mechanisms and institutions, bearing the nexus approach in mind.

'There is a risk that assuming that "water is everywhere" leads to "water being nowhere"'

While the nexus approach is important for the development of targets and goals in the post 2015 agenda, these targets are more likely to be reached through a dedicated goal on water. There is a risk that assuming that "water is everywhere" leads to "water being nowhere." This goal must clearly reflect transboundary surface and groundwater challenges.

Guidance is needed for the private sector to assess cumulative impacts of multiple developments to mitigate impacts on e.g. sediment transport, fisheries and livelihoods.

Benefits of cooperation
Appropriate use of a nexus perspective in transboundary basins helps transform challenges in water management into opportunities and create the will to connect.

In order to collectively benefit from the opportunities, transboundary agreements and institutions develop and need to adapt to changing environments. For these to work effectively, a combination of political will, technical cooperation and an inclusive process is required. Stakeholder’s interests, both individuals and sovereign states, need to be balanced.

The multi-stakeholder processes and institutions are key to turning social and environmental challenges into benefits to be shared between riparian communities and countries.

Conclusion
This outcome will inform the MRC Summit leaders in their deliberations on the future of the Mekong region and the MRC. It is also intended that the outcome will be useful for the transboundary basin management agenda to receive attention among the participants and negotiators addressing Sustainable Development Goals and the climate agreement at COP 21 in 2015.

In order to further disseminate and promote the outcome of this conference, a publication will be launched at the World Water Week in Stockholm in September 2014. The international sponsoring partner organisations will convey the outcome of the conference to relevant stakeholders worldwide.

Sponsoring partners
African Network of Basin Organisations (ANBO)
Asian Development Bank (ADB)
Australian National University (ANU)
Conservation International (CI)
Danish International Development Agency (Danida)
German Agency for International Cooperation (GIZ)
Global Water Partnership (GWP)
International Union for the Conservation of Nature (IUCN)
International Water Management Institute (IWMI)
International Finance Corporation (IFC)
International Water Association (IWA)
World Wide Fund for Nature (WWF)
Stockholm International Water Institute (SIWI)
Stockholm Environment Institute (SEI)
International Center for Integrated Mountain Development (ICIMOD)
United Nations Economic Commission for Europe (UNECE)
United Nations Environment Programme (UNEP)
UNESCO Institute for Water Education (UNESCO-IHE)
University of Arizona
University of West England
US Army Corps of Engineers (USACE)
World Bank
World Water Council (WWC)
Commercial production of hatchery-bred 'Mekong salmon' underway in delta

BY HUYNH HUU NGAI, TRINH QUOC TRONG AND PETER STARR *

Viet Nam is expecting its first commercial harvest of hatchery-bred Krempf’s catfish this year following a recent expansion of fingerling production at a government nursery in the Mekong Delta.

In 2002, the MRC Fisheries Programme targeted several indigenous species for aquaculture in the Lower Mekong Basin. These included Krempf’s catfish (Pangasius krempfi), an anadromous species that migrates up the Mekong River from the South China Sea to spawn. Known as ca bong lau in Vietnamese and sometimes referred to as "Mekong salmon", the species is one of the most economically valuable in the Mekong Delta. By 2005, research by the Aquaculture of Indigenous Mekong Fish Species (AIMS) component of the Fisheries Programme had found that fish caught in the wild were more likely to survive in cages than ponds (see Catch and Culture, Vol 12, No 1).

The first breakthrough came the following year at the National Breeding Centre for Southern Freshwater Aquaculture in Cai Be in Tien Giang province, part of the Research Institute for

Pangasius krempfi a few hours after hatching at the National Breeding Centre for Southern Freshwater Aquaculture in Cai Be. Following a sharp increase in fry production at the centre, hatching rates ranged from 21.2 % to 93.0 % in 2012 and 2013.

PHOTO: TRINH QUOC TRONG
Aquaculture No 2 (RIA2) in Ho Chi Minh City. AIMS staff finally managed to induce spawning in females raised in captivity. But in the absence of any sexually mature males, they used sperm from male tra catfish (*Pangasianodon hypophthalmus*), which is widely farmed and exported from the Mekong Delta (see *Catch and Culture*, Vol 12, No 3.) The big breakthrough came in 2008 with artificial propagation involving females and males from the same species. Production of fingerlings continued beyond the end of the AIMS component in 2010.

Since the Government of Viet Nam agreed to finance additional research on induced spawning of the species in 2011, production of fry at the National Breeding Centre in Cai Be has increased dramatically from less than 20,000 a year between 2008 and 2011 to around 200,000 a year in 2012 and 2013 (see table below). Over the same period,

### Results of spawning and incubation (2008 to 2013)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of injected females</th>
<th>Number of ovulated females (%)</th>
<th>Number of eggs/kg female</th>
<th>Fertilisation rate (%)</th>
<th>Hatching rate (%)</th>
<th>Number of fry</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>9</td>
<td>2</td>
<td>9,491</td>
<td>26.0 – 45.9</td>
<td>57.1</td>
<td>3,749</td>
</tr>
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<td>4</td>
<td>2</td>
<td>17,320 – 24,687</td>
<td>47.0</td>
<td>61.0</td>
<td>7,400</td>
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<tr>
<td>2010</td>
<td>3</td>
<td>2</td>
<td>10,888 – 20,296</td>
<td>71.0</td>
<td>91.5</td>
<td>5,480</td>
</tr>
<tr>
<td>2011</td>
<td>9</td>
<td>1</td>
<td>33,140</td>
<td>73.4</td>
<td>56.4</td>
<td>17,778</td>
</tr>
<tr>
<td>2012</td>
<td>11</td>
<td>8</td>
<td>8,590 – 28,331</td>
<td>53.9 – 93.0</td>
<td>222,220</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>29</td>
<td>22</td>
<td>783 – 40,420</td>
<td>11.5 – 92.0</td>
<td>195,300</td>
<td></td>
</tr>
</tbody>
</table>
Induced spawning of *Pangasius krempfi* in captivity

*Pangasius krempfi* does not reproduce naturally in captivity and therefore requires the use of hypophysation or Human Chorionic Gonadotropin (HCG). For females, many injections are used after they have been sampled for eggs to check for maturation (see left). The first four injections are 500 international units (IU) of HCG per kg or pituitary gland extract of common carp (3 kg donor fish used for 8 kg receiver), followed by a final injection of 6,000 IU of HCG per kg. For males, only one injection 2,000 IU of HCG per kg is applied.

**Photo: Trinh Quoc Trong**

Researchers from the National Breeding Centre in Cai Be checking for ovulation of female Krempf’s catfish which are kept in cages on the Mekong River (Song Tien) in Hong Ngu district in Dong Thap province

**Photo: Trinh Quoc Trong**

The females are stripped for eggs from 9.5 to 14.5 hours after the final injection (see left). Fertilisation rates varied from 7.15 – 73.4% (average 39.9 ± 24.9%). Hatching took approximately 24 to 36 hours at water temperatures of 27 – 29C. The hatching rate was found to be at 57.0 – 91.5% (average 66.4 ± 14.5%).

**Photo: Trinh Quoc Trong**
nursery production of fingerlings has increased from around 1,000 a year to around 30,000 a year, of which about 20,000 have been sold to two Mekong Delta farmers for grow out over the past two years. For fingerlings of between 6 and 10 centimetres, prices have ranged from about VND 6,000 (USD 0.30) to VND 10,000 (USD 0.50).

One of the two farmers who has been buying the hatchery-produced fingerlings is Le Minh Nghiem, who owns a cage farm on the Mekong River in Long Ho district in Vinh Long province. Mr Nghiem has been farming fish since 2002 when he decided to go into aquaculture himself after working for the Vietnamese subsidiary of Cargill, the Minneapolis-based animal feed giant which operates eight feed mills in Viet Nam. He also raises Krempf’s catfish from fingerlings caught in the wild, notably from the Bassac estuary in Soc Trang province.

Mr Nghiem said the hatchery-bred fingerlings were "very expensive" but hoped they would provide a more stable source of income than red tilapia (Oreochromis sp.), which he recently abandoned due to severe fluctuations in market prices. Since stocking 9,000 fingerlings at the beginning of 2013, however, his crop was affected by another challenge — fish mortalities caused by exceptionally cold weather at the end of last year.

‘The dilemma facing the farmer is that a market for hatchery-produced Krempf’s catfish does not yet exist’

By May this year, his fish had grown to about 700 grams and Mr Nghiem was preparing for harvest in July or August by which time they were expected to have reached a more marketable size of about 1 kilogram. The dilemma facing the farmer is that a market for hatchery-produced Krempf’s catfish does not yet exist. Buyers were expected to be dealers supplying upmarket restaurants in Ho Chi Minh City and other parts of Viet Nam including Hanoi, where the fish can also command premium prices.

Wild Krempf’s catfish from the Mekong Delta were fetching between VND 100,000 ($5) and VND 120,000 ($6) a kilogram in May, about three times the price of hatchery-produced catfish from the Pangasianodon hypophthalmus species on which the Mekong Delta’s export industry heavily relies. Since *Pangasius krempfi* is well known as a premium fish among diners in Viet Nam, Mr Nghiem said he hoped his hatchery-produced fish would be fetching almost as much as those raised from the wild.

Further reading:

Huynh, HN *et al.* (2011) Artificial propagation of *Pangasius krempfi* from the Mekong Delta, Viet Nam. Oral presentation to Ninth Asian Fisheries and Aquaculture Forum, Shanghai


* * Mr Ngai, who is completing his PhD thesis on artificial propagation of Pangasius krempfi at Can Tho University, is a researcher at the National Breeding Centre for Southern Freshwater Aquaculture in Cai Be district in Tien Giang province. Dr Trong is the director of the centre and Mr Starr is the editor of Catch and Culture.
New species of stream loach found in northern Thai province of Chiang Mai

Two years ago, Apinun Suvarnaraksha of the Faculty of Fisheries Technology and Aquatic Resources at Maejo University in Chiang Mai, described a new species of stream loach (Nemacheilidae) from northern Thailand. Dr Apinun has since found another new species of stream loach from the same catchment.

The stream loach family (Nemacheilidae) comprises small benthic fishes that inhabit running water and well-oxygenated hill streams. According to Swiss ichthyologist Maurice Kottelat, many species inhabit mountainous areas, especially in northern Thailand as well as Lao PDR, Myanmar, Viet Nam, Cambodia, Malaysia and China. In 2012, the Catalog of Fishes divided stream loaches in Southeast Asia into nine genera including 184 species of Schistura and seven species of Physoschistura.

In a paper published in Zootaxa in 2012, Dr Apinun described a new species of Schistura from the Maechaem River, a tributary of the Ping River in the Upper Chao Phraya Basin in Chiang Mai province in northern Thailand. With a total length of almost 70 mm, Schistura maejotigrina is medium-sized compared with other species in the genus. It was found living in fast-running, clear water over a substrate of mixed gravel, small stones and sand.

The new species was distinguished from all other species of Schistura by its unique colour pattern consisting of 21–25 dark brown tiger-stripe bars on the side of the body and 6½ –7½ branched dorsal soft rays. At the time the paper was published, the fish — named after Maejo University where Dr Apinun works as well as the presence of the tiger-stripe bars — was known only from the Maechaem River system.

The Thai researcher has now published a paper on a new species of Physoschistura from a small tributary of the Maechaem River. Appearing in Zootaxa in late 2013, the paper describes Physoschistura chulabhornae as being small to medium-sized with a total length of almost 48 mm. It was also found in a habitat of clear running water (see box on opposite page).

According to Dr Apinun, the new species from this genus of stream loach is distinguished from all other known species of Physoschistura by having an incomplete lateral line reaching at least to the origin of the anal fin with 62–83 lateral-line canal
pores, the dorsal-fin origin slightly in front of the pelvic-fin origin, no axillary pelvic lobe, and a suborbital flap in the shape of a hammer head in the male. The new species has been named after Her Royal Highness Princess Chulaborn Walailak, the youngest daughter of the King of Thailand, in recognition of her valuable scientific work.

In his paper, Dr Apinun said he collected his specimens of the new species *Physoschistura chulabhornae* from Huay Maetalanoi, Ban Maetala, Tambon Maedaed, Maechaem District in Chiang Mai province. The stream had a mixed sand, gravel, pebble, silt, mud and rock bottom, with clear running water (see below).

Elevation is 764 m above mean sea level, and annual rainfall is more than 1,450 mm. Dr Apinun said the surrounding landscape had semi-evergreen forest, plantations, and agricultural crops, mainly corn, cabbage and tomato. Water temperature was 17°C, air temperature 20.5°C, pH 7.7, DO 6.5 mg/l, and conductivity 20 μS. Stream width averaged 4 meters, and water depth 40–60 cm. All specimens were collected during the daylight.

Other stream loaches collected from the site were *Schistura breviceps* and *Schistura maejotigrina*, the new species described in 2012. Also collected were a Sisorid catfish (*Oreoglanis siamensis*), several cyprinids (*Devario* sp., *Scaphiodonichthys burmanicus*, *Opsarius pulchellus*, *Garra cambodgiensis*, *Puntius brevis* and *Puntius stoliczkanus*), a swamp eel (*Monopterus albus*) and a snakehead (*Channa gachua*).

### Habitat of new stream loach

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### Further reading


Dai catch almost doubles

BY CHHENG PHEN, NGOR PENG BUN, SO NAM, AND NAO THUOK *

Increase partly attributed to higher flood level

The stationary trawl or bag net fishery (locally known as dai) operates along a 50-kilometre stretch of the Tonle Sap River from October through March. The river connects the Mekong River with the Tonle Sap Lake, the largest lake in Southeast Asia and home to the most productive inland fishery in the world. The 64 dai units comprise 22 units in Phnom Penh (Rows 2 to 6) 42 units in Kandal province (Rows 7 to 15) which target fishes that migrate from the lake to the Mekong River (see map on opposite page). Between 120 and 130 species are reported seasonally, mainly opportunistic small mud carps including Henicorhynchus spp., Paralaubuca typus, Osteochilus hasseltii and Labiobarbus spp.

In the latest season, the dai caught 125 species with landings rebounding 84 percent from a year earlier to 24,254 tonnes, the third highest catch over the past two decades. The increase from 13,186 tonnes in the previous season was partly attributed to higher flood levels inundating a greater area, making more nursing and feeding grounds available for fish. In 2013, the flood level peaked at 9 metres at Kampong Loung Hydrological Station in Prek Kdam, around 30 km north of Phnom Penh. That was half a metre higher than the previous season. The rebound in landings in 2013-14 followed a sharp downturn from the record landings of 46,007 tonnes in 2011-12, when Cambodia experienced exceptional floods which peaked at 10.9 metres.

Among the top ten species caught in the latest season was the small-scale mud carp (Cirrhinus microlepis), known as trey pruol in Cambodia where it is highly preferred for consumption. Dai fishery monitoring has been carried out by the Cambodian Fisheries Administration with support from the MRC Fisheries Programme since the 1995-96 season.

*Mr Chheng Phen is the acting director of Cambodia’s Inland Fisheries Research and Development Centre (IFReDI), Mr Ngor Peng Bun is the capture fisheries specialist at the MRC Fisheries Programme, Dr So Nam is the coordinator of the programme and Dr Nao Thuok is director general of the Cambodian Fisheries Administration.
Location of the rows of dai nets anchored in the Tonle Sap River between October and March. Following the decommissioning of Dai Row No 1 in Phnom Penh as part of fisheries reforms in 2000, the Lower Mekong Basin's largest industrial fishery currently comprises 14 rows.

Map: MRC Technical Paper No 32
Monitoring fish abundance and diversity around the Tonle Sap Lake

By Ngor Peng Bun, Theng Lipine, Phem Sea and So Nam *

A new three-year project monitoring fish abundance and diversity in five provinces around the Tonle Sap Lake has completed its first year. The initial results are compared with other monitoring of catches in the Tonle Sap system and eastern Cambodia with a specific focus on species diversity.

The MRC Fisheries Programme has been supporting fishery monitoring in provinces around the Tonle Sap Lake since the end of 2011. The project is in addition to other monitoring supported by the programme since the mid-1990s (see MRC Technical Paper No 33). The new programme forms an important part of regional monitoring related to the study of fish abundance and diversity in the Lower Mekong Basin. It intends to determine fisheries yield indicators related to fish catch, abundance and diversity as well as trends in fisheries resources in the provinces around the lake. The monitoring contributes to interpreting the status and trend of basin-wide capture.
fisheries as well as providing a more effective means of monitoring and assessing the impacts of management activities and basin development.

The three-year project covers five locations in five provinces, namely Kampong Chhnang, Pursat, Battambang, Siem Reap and Kampong Thom (see map on opposite page). In each location, three fishers voluntarily record daily catches all year round.

**Methods**

The project applies the same methods used for regional fish abundance and diversity monitoring (FEVM, 2007). Logbooks are used to record daily catches, species composition, maximum length of each species in every sample, type and dimensions of fishing gear used as well as fishing hours per fishing trip. To help with identification, the project has provided the fishers with photo flipcharts of more than 170 common fish species. It has also provided them with calibrated scales accurate to 1 gram and measuring boards accurate to 1 mm, and has trained all fishers how to use the logbook, identify species and measure weight and length. In addition, the project has provided training in sampling and sub-sampling techniques applied to large fish catches in the peak season. A regional database on fish abundance and diversity stores all data, which are checked for errors and cleaned quarterly before final analysis.

**Fishing gear used**

In the first year, the project targeted gillnets, the most popular fishing gear used in the Tonle Sap Lake. The 15 fishers reported that 98 percent of their catches were from gillnets of different mesh sizes with the remaining 2 percent from horizontal cylinder traps. The mesh sizes of gill nets ranged from 2 to 6.5 cm. On average, fishers used nets with lengths of between 521 and 886 metres with depths of between 1.1 and 2.1 metres. In some cases, fishers used nets that were more than two kilometres long (see table above). Fishers used monofilament nets with a filament diameter of 0.12-1.5 mm; most were 0.14 mm.

Fishers use fishing grounds outside the open area of the Tonle Sap Lake all year round but fish in the open area only between January and early June (see chart below). In the flood season, they all move to fish in areas outside the open lake including floodplains, flooded forests, canals, rivers and small lakes inside the flooded forests.

**Catch rate of gill net by mesh size**

The hourly catch rate per 100 m² of gill net was calculated based on total catch reported per

<table>
<thead>
<tr>
<th>Mesh size (cm)</th>
<th>Average length (m)</th>
<th>Minimum length (m)</th>
<th>Maximum length (m)</th>
<th>Average depth (m)</th>
<th>Minimum depth (m)</th>
<th>Maximum depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>590</td>
<td>380</td>
<td>700</td>
<td>1.1</td>
<td>0.7</td>
<td>1.5</td>
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<tr>
<td>2.5</td>
<td>604</td>
<td>100</td>
<td>1500</td>
<td>1.6</td>
<td>0.7</td>
<td>2.5</td>
</tr>
<tr>
<td>3.0</td>
<td>604</td>
<td>80</td>
<td>1600</td>
<td>1.4</td>
<td>1.2</td>
<td>2.5</td>
</tr>
<tr>
<td>3.5</td>
<td>608</td>
<td>72</td>
<td>2180</td>
<td>1.4</td>
<td>1.0</td>
<td>1.8</td>
</tr>
<tr>
<td>4.0</td>
<td>729</td>
<td>180</td>
<td>1100</td>
<td>1.9</td>
<td>1.3</td>
<td>2.5</td>
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<tr>
<td>4.5</td>
<td>886</td>
<td>40</td>
<td>1500</td>
<td>1.5</td>
<td>1.2</td>
<td>1.6</td>
</tr>
<tr>
<td>5.0</td>
<td>636</td>
<td>400</td>
<td>1500</td>
<td>1.8</td>
<td>1.2</td>
<td>2.4</td>
</tr>
<tr>
<td>5.5</td>
<td>521</td>
<td>300</td>
<td>900</td>
<td>1.4</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>6.0</td>
<td>839</td>
<td>400</td>
<td>1300</td>
<td>1.7</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>6.5</td>
<td>872</td>
<td>100</td>
<td>1800</td>
<td>2.1</td>
<td>1.2</td>
<td>4.3</td>
</tr>
</tbody>
</table>
Catch rate of gill net (gram per fisher per hour per 100 m²) by mesh sizes Jan-Dec 2012

<table>
<thead>
<tr>
<th>Mesh size (cm)</th>
<th>2.00</th>
<th>2.50</th>
<th>3.00</th>
<th>3.50</th>
<th>4.00</th>
<th>4.50</th>
<th>5.00</th>
<th>5.50</th>
<th>6.00</th>
<th>6.50</th>
<th>All sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>259.44</td>
<td>189.24</td>
<td>184.55</td>
<td>254.84</td>
<td>56.53</td>
<td>54.68</td>
<td>83.18</td>
<td>91.26</td>
<td>90.79</td>
<td>78.01</td>
<td>137.49</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>186.79</td>
<td>372.48</td>
<td>144.27</td>
<td>308.19</td>
<td>40.23</td>
<td>54.43</td>
<td>64.91</td>
<td>74.95</td>
<td>42.57</td>
<td>62.27</td>
<td>209.09</td>
</tr>
<tr>
<td>Minimum</td>
<td>30.30</td>
<td>11.43</td>
<td>7.41</td>
<td>25.75</td>
<td>4.20</td>
<td>4.48</td>
<td>4.80</td>
<td>6.72</td>
<td>5.44</td>
<td>0.92</td>
<td>0.92</td>
</tr>
<tr>
<td>Maximum</td>
<td>1462.59</td>
<td>5555.56</td>
<td>1136.36</td>
<td>392.86</td>
<td>312.50</td>
<td>712.04</td>
<td>312.50</td>
<td>438.91</td>
<td>312.50</td>
<td>666.67</td>
<td>5555.56</td>
</tr>
<tr>
<td>Observation</td>
<td>194.00</td>
<td>500.00</td>
<td>387.00</td>
<td>863.00</td>
<td>276.00</td>
<td>764.00</td>
<td>199.00</td>
<td>311.00</td>
<td>216.00</td>
<td>956.00</td>
<td>4666.00</td>
</tr>
<tr>
<td>Confidence Level (95.0%)</td>
<td>26.73</td>
<td>32.73</td>
<td>14.42</td>
<td>20.59</td>
<td>4.77</td>
<td>3.87</td>
<td>9.07</td>
<td>8.36</td>
<td>5.71</td>
<td>3.95</td>
<td>6.00</td>
</tr>
</tbody>
</table>

Fishers who used smaller mesh sizes net (2.0–3.5 cm) tended to catch more fish with average catch rates ranging between 185 and 259g/hour/100 m² (see table above) The smallest meshes caught about three times more fish (by weight) than the largest meshes, as would be expected where smaller fish are more abundant than larger fish. Fishers who used gill nets with larger mesh sizes (4.0–4.5 cm) had the lowest average catch rates of around 55 g/hour/100 m².

Catch and Culture (2)

The 15 fishers reported 98 fish species from 30 families in their catches for the Tonle Sap Lake between January and December 2012 (see table at right). The top ten families contained 75 percent of the species. Cyprinidae ranked first (40 percent) followed by Siluridae (7 percent) , Bagridae (6 percent) and Pangasiidae (5 percent).

Cyprinidae also contributed a large proportion to the total catch (58 percent) and total number of fish in the catch (59 percent). More details on catch composition by families and by number of individual fishes are given in the charts on the opposite page. Relative abundance or number of fish by family. Key species reported under Cyprinidae are mainly migratory species or white fish including Puntioplites proctozysron (16 percent), Henicorhynchus siamensis (16 percent), Henicorhynchus lobatus (11 percent) and Osteochilus hasselti (11 percent). The rest contributed between 3 and 8 percent to the catch of Cyprinidae.

Osphronemidae made up of the second largest proportion of catch (8 percent) and of the total number of individual fish (15 percent) in the catch. Three floodplain species or black fish reported under this family were gouramies, namely Trichogaster pectoralis, Trichogaster microlepis and Trichogaster trichopterus.

Bagridae ranked third, representing 7 percent of relative biomass (catch) and 8 percent of abundance (number of fish). Species reported under this family were the Bagrid catfishes Hemibagrus nemurus, Mystus albolineatus, Mystus bocourti, Mystus singaringan, Mystus atrifasciatus and Hemibagrus filamentus.

Campbell et al. (2006) indicated that 149 fish species belonging to 35 families had been recorded from the Tonle Sap Lake. However,
the one-year study of 15 gill net fishers in 2012 recorded only 98 fish species from 30 families. The difference could result from fishing gear selectivity. For example, it is highly unlikely that gill net fishers could capture species listed in 2006 such as requiem sharks, stingrays, sawfish, true eels, eel-like catfishes, needlefishes, spiny eels and sleepers. In addition, the new MRC project reports results of only one year monitoring. There tends to be more species recorded if monitoring (sampling effort) continues for a longer period. Further, Campbell et al. (2006) also stated that most of fish species recorded in the Tonle Sap Lake belonged to Cyprinidae (39 percent), Bagridae (8 percent), Siluridae (7 percent) and Pangasiidae (7 percent). The one-year study in 2012 shows similar results where 39 species (40 percent) belonged to Cyprinidae, 7 species (7 percent) to Siluridae, 6 species (6 percent) to Bagridae and 5 species (5 percent) to Pangasiidae.

Using catch data from fishing lot owners in provinces around the Tonle Sap Lake and River between 1995 and 1997, Lim et al. (1999) reported 120 fish species from 26 families. The greater number could result from the longer period (three years) of catch data used in their analysis. However, the one-year monitoring in 2012 recorded more families. Apart from this, Lim et al. (1999) reported that Cyprinidae represented 40 species, which is similar to the latest study where 39 species were reported under this family.

"Fishers in the Tonle Sap River reported 163 fish species from 38 families in the five years to 2012"

The MRC Fisheries Programme has also been supporting fisher catch monitoring in the Tonle Sap River since mid-2007. Species recorded in the river seem similar to those found in the lake, especially river or white fishes. The river monitoring involved three fishers recording daily catches and species composition. Fishers commonly used Gill nets but also other fishing gear including cast nets and big bamboo vertical cylinder traps. The number of fish species recorded in the river varied with 117 species from 33 families in 2008, 116 from 29 families in 2009, 111 from 30 families in 2010 and 96 from 29 families in 2011. In 2012, the fishers reported only 76 fish species from 21 families. Overall, the
Fishers in the Tonle Sap River reported 163 fish species from 38 families in the five years to 2012. This was higher than those reported by Lim et al. (1999) and Campbell et al. (2006) as well as in 2012. The recording of fewer species and families in 2012 may be because fishers in the river target mainly migratory or white fishes whereas fishers in the lake target both black and white fish species. Hydrology and other factors influencing the productivity of fisheries in the Tonle Sap Lake could also affect catches and species diversity in the catches.

'Over the past ten years, 141 fish species have been recorded in catches from the dai fishery'

In addition to the new project monitoring abundance and diversity around the Tonle Sap Lake, the Fisheries Programme has supported catch monitoring by a commercial fishery known as the dai fishery along the Tonle Sap River since 1994. The stationary fishery targets "white" fishes migrating from the Tonle Sap Lake and its surrounding floodplains to the Mekong River between October and March. The number of fish species reported in seasonal catches has varied between 120 and 129 since 2002-2003. For instance, there were 126 fish species in 2011-12 and 124 in 2012-13. Over the past ten years, 141 fish species have been recorded in catches from the dai fishery.

Ngör et al. (2005) monitored dai trey linh, a stationary trawl fishery in the Tonle Touch which targets small cyprinids (*Thynnichthys thynnoides*) migrating out of surrounding floodplains in Prey Veng province in the Mekong Delta in southeastern Cambodia. Between July and December 2003, up to 161 species were recorded. A similar study by Ngör et al. (2006) monitored the giant river prawn (*Macrobrachium rosenbergii*) fishery in the same province, recording up to 153 fish species.

Since mid-2007, the Fisheries Programme has also been involved in collecting daily catch data from the Sesan River, the Sekong River and the Srepok River, three major tributaries of the Mekong which flow through northeast Cambodia. Over a five-year period, a total of 267 fish species...
from 46 families were reported (189 species from 35 families in 2008, 186 from 36 families in 2009, 178 from 33 families in 2010, 163 from 37 families in 2011 and 165 from 35 families in 2012). Fish species seem to be more diverse in eastern Cambodia than the Tonle Sap Lake, even though the lake is known as the most productive fishing ground contributing around 60 percent to Cambodia’s inland fisheries yield (Lieng and van Zalinge, 2001).

**Diversity indices**

To provide baseline information for management evaluation, species richness and diversity indices have been calculated for each monitoring site. Margalef and Shannon-Wiener indices were computed using Primer v6 (Clark and Gorley 2006).

The Margalef index measures the number of species present for a given number of individuals; it is weighted toward species richness (Khan undated). Clark and Warwick (2001) indicated that the Shannon diversity index was generally used to compare diversity between different habitats.

Fishers in Kampong Thom province recorded 85 fish species – the highest number of all sites monitored in 2012 (see chart below). Fishers in Kampong Chhnang province recorded the lowest (43 species). Over the same one-year period, fishers in Pursat province reported up to 75 fish species, ranking second after Kampong Thom. In other provinces around the lake, the number of species was 60 in Siem Reap and 49 in Battambang. The Margalef index indicates that Kampong Thom province is richest in species diversity followed by Pursat, Siem Reap, Battambang and Kampong Chhnang.

By contrast, the Shannon-Wiener diversity index suggests that Pursat has the greatest fish species diversity with Siem Reap ranking second and Kampong Thom third followed by Kampong Chhnang and Battambang. The different rankings by the two indices may need further investigation.

Many researchers state that the number of species recorded can be influenced by sampling effort. More species tend to be counted when more samples are taken from a sampling site. This affects species richness calculation. Heip et al. (1998) mentioned that the measure of species richness is highly correlated with sample size. Gotelli and Colwell (2001) pointed out that differences in species abundance may mirror the differences in sampling effort. For this study, sample sizes were different among the five monitoring sites. The table below gives detailed information about sample sizes and corresponding number of fish species recorded in each site. Gotelli and Colwell (2001) indicate that comparing two taxon counts for two or more assemblages can generate misleading results and that “sample size to which one rarefies can potentially change the rank order of estimated richness amongst communities” (p 383).

**Samples taken and species recorded**

<table>
<thead>
<tr>
<th>Province</th>
<th>Number of samples</th>
<th>Number of species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battambang</td>
<td>937</td>
<td>49</td>
</tr>
<tr>
<td>Kampong Chhnang</td>
<td>770</td>
<td>43</td>
</tr>
<tr>
<td>Kampong Thom</td>
<td>992</td>
<td>85</td>
</tr>
<tr>
<td>Pursat</td>
<td>1014</td>
<td>75</td>
</tr>
<tr>
<td>Siem Reap</td>
<td>954</td>
<td>60</td>
</tr>
</tbody>
</table>

The largest number of samples (1,014) was taken in Pursat where 75 fish species were recorded. Fishers from Kampong Chhnang reported the least number of samples (770) with only 43 fish species recorded. Standardising sampling effort (sample sizes) across monitoring sites, Gotelli and Colwell (2001) suggested that repeated averaged sample-based rarefaction produces smooth curves for comparison. According to
Colwell (undated, p. 257), “rarefaction curve is the statistical expectation of the number of species in a survey or collection as a function of the accumulated number of individuals or samples, based on re-sampling from an observed sample set.” Sample-based rarefaction curve was computed by repeating re-sampling using a software programme called EstimateS version 9.1.0 (Colwell, 2013). EstimateS allows for an extrapolation of number of samples from a reference sample to the expected richness in order to standardise sample sizes when estimating species richness across monitoring sites. EstimateS also allows rarefaction curves to be computed directly along with 95 percent confidence interval (CI).

Species abundance data were therefore prepared in a format that can be accepted by EstimateS. One hundred randomly repeated re-samplings with an extrapolation from an actual number of samples reported in each site to a total of 1,014 samples were carried out using this software for all the five monitoring sites in order to generate rarefaction curves, to estimate species richness and corresponding 95 percent confidence intervals for each site. The sample-based rarefaction curve is shown below. As with the Margalef diversity index, this shows that Kampong Thom is the most diverse site followed by Pursat, Siem Reap, Battambang and Kampong Chhnang (see below).

To indicate the reliability of an estimate on species richness (whether species richness of two sites being compared are statistically significantly different), Colwell (2013a) indicates that non-overlap of 95 percent confidence intervals can be used as a simple but conservative criterion of statistical difference. Therefore, to see if an estimate of species richness for a monitoring site is higher than the other, 95 percent of confidence intervals generated by EstimateS with an extrapolation of sample sizes to a total of 1,014 for all sites were compared (see below).

### Estimated species richness

<table>
<thead>
<tr>
<th>Site</th>
<th>Upper limit</th>
<th>Mean species richness</th>
<th>Lower limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battambang</td>
<td>55.65</td>
<td>49</td>
<td>43.16</td>
</tr>
<tr>
<td>Kampong Chhnang</td>
<td>44.3</td>
<td>43</td>
<td>42.06</td>
</tr>
<tr>
<td>Kampong Thom</td>
<td>91.1</td>
<td>85</td>
<td>79.34</td>
</tr>
<tr>
<td>Pursat</td>
<td>83.15</td>
<td>75</td>
<td>66.85</td>
</tr>
<tr>
<td>Siem Reap</td>
<td>67.77</td>
<td>60</td>
<td>53.46</td>
</tr>
</tbody>
</table>

"Kampong Thom initially seems to be most diverse of all sites followed by Pursat, Siem Reap, Battambang and Kampong Chhnang"
Conclusion

Fishers in the Tonle Sap Lake used different mesh sizes of gill net ranging from 2.0 to 6.5 cm. A net filament of 0.14 mm in diameter was most common. Gill net fishers used floodplains, flooded forests, canals and lakes inside flooded forests as common fishing grounds all year round. The open area of the Tonle Sap Lake is partly used only between January and early June.

‘There could be more fish species reported in catches if monitoring effort/period is expanded as with other monitoring supported by the Fisheries Programme’

Catch rates appeared to be highest for fishers who used smaller mesh size gill nets between 2 and 3.5 cm. Over the one-year monitoring period from January to December 2012, gillnet fishers recorded 98 fish species from 30 families in the five monitoring sites in five provinces around the lake. There could be more fish species reported in catches if monitoring effort/period is expanded as with other monitoring supported by the Fisheries Programme. These species could represent common fish species reported in fisher catches.

From the one-year catch data, fish species in Kampong Thom province seemed to be more diverse than in the three other provinces of Battambang, Kampong Chhnang and Siem Reap. Fish species in Kampong Chhnang tended to be less diverse than in Kampong Thom, Pursat and Siem Reap. Variations in fish species richness probably reflect habitat diversity and proximity to the Mekong, and from where fish migrate into the Tonle Sap system.

Acknowledgments

Thanks to Mr Kent Hortle for his comments on the report and to Mr Sou Virak for his assistance in map preparation.

* Mr Ngor Peng Bun is the capture fisheries specialist at the MRC Fisheries Programme, Mr Theng Lipine is a junior riparian expert at the programme, Mr Phem Sea is deputy director of the Exploitation, Control and Conservation Department of the Tonle Sap Authority and Dr So Nam is coordinator of the MRC Fisheries Programme.

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South American **lessons for** fish pass opportunities at Lower Sesan 2 Dam

The WorldFish Center reviews fish passes in South America to propose a possible system for a hydropower project on the lower reach of a major Mekong tributary without modifying the design of the dam.

Blocking the lower part of the Sesan and Srepok rivers in Steung Treng province in northeast Cambodia will clearly have a negative impact on biodiversity, fish migrations, fish catch and food security in the area and far beyond. This calls for the construction of a fish pass at the Lower Sesan 2 site, while bearing in mind that the project is already approved and that its main design cannot be modified. Three fish-passage systems in South America offer important insights into the opportunities and challenges of establishing a successful fish passage at the Lower Sesan 2 site.

Studies of fish passage systems on high dams in South America showed that in a species-rich tropical environment, up to 116 species were found, with a few species (mostly excellent swimmers) predominating among those reaching the top. This underlines the fact that the fish pass might be considered more or less successful depending on the objectives stated; either limited success for overall biodiversity conservation or, on the contrary, a good success rate for protection of a few target species (e.g. good swimmers such as Pangasiid catfishes) contributing to commercial fish catches.

The success of three fish passages on dams in South America seems closely linked to the water velocity in certain stretches. A review suggests that a velocity of 2.3 m/s$^{-1}$ is acceptable to many neotropical species (with 0.8 m minimum depth)

![Aerial view of the confluence of the Sesan and Srepok rivers in northeast Cambodia showing the location of the future Lower Sesan 2 Dam](Photo: Eric Baran)
The Sesan River Basin and the Srepok River Basin cover both northeast Cambodia and the Central Highlands of Viet Nam while the Sekong River Basin extends from Cambodia and Lao PDR into the north-central Vietnamese province of Thua Thien Hue.

MAP: INFORMATION AND KNOWLEDGE MANAGEMENT PROGRAMME, MRC
Fish and fisheries in the Sekong, Sesan and Srepok basins

The Srepok, Sesan and Sekong Rivers are characterised by a high level of fish biodiversity with 329 species. This corresponds to 42 percent of all Mekong fish species, for an area representing only 10 percent of the Mekong Basin. The Sesan River features 133 fish species, i.e. approximately 40 to 50 percent fewer species than the Sekong and Srepok Rivers.

The three rivers are home to 14 endangered fish species, including the critically endangered giant salmon carp (*Aaptosyax grypus*), the giant carp (*Catlocarpio siamensis*) and the Mekong giant catfish (*Pangasianodon gigas*). Fifteen species are found exclusively in the Sekong River and two in the Srepok River; they are found in no other Mekong tributary and nowhere else in the world. No species is exclusively found in the Sesan River.

The system is characterised by at least 89 migratory fish species belonging to 15 families. More specifically, the Sekong, Sesan and Srepok Rivers are characterised by 64, 54 and 81 migratory fish species respectively. At least 41 migratory fish species are commonly caught by fishermen in the Sesan River, and these migratory species represent 60 percent of the fishermen’s total catch.

'There has been a drastic decline in the abundance of most fish species'

There is unanimous agreement that there has been a drastic decline in the abundance of most fish species, or more specifically in the catch per fisherman, along the three rivers. This decline applies to species in all families and to all three of the rivers. In the Sesan River, for instance, the Siamese mud carp (*Henicorhynchus siamensis*) and the Mekong mud carp (*H. lobatus*) had not been seen upstream for about ten years (though they reappeared in 2010 for an unknown reason). The Srepok seems to be the river where the decline is smallest.

The total catch in the Sesan River Basin is not precisely known and estimates range between 370 and 6,700 tonnes of fish per year. This wide range of estimates underlines the urgent need for a proper assessment of fish catches along the Sesan River. The contribution of the Sesan River to the fish production of floodplains in Cambodia and Viet Nam should also be assessed. The total value of the fish production along the Sesan River ranges from USD 1 to 25 million, the central estimate being between USD 2-16 million, depending on estimates of total yield and of price per kilogram.

With only 20 to 40 tonnes of fish produced in 2010 there is no substantial aquaculture sector in the Cambodian part of the system. In Viet Nam no detailed or recent aquaculture statistics could be found; in 2003 about 5,000 tonnes (i.e. less than 1 percent of the national production) were produced. Actually, 2010 reviews indicate that 70-80 percent of the catch in the aquaculture sector originates from reservoir fisheries.

The population living along the Sesan River Basin in Cambodia and Viet Nam reaches 840,000 people. The number of people dependent on riverine resources along the Sesan River is subject to multiple contradictory estimates; in Cambodia, this number ranges from 30,000 to 50,000 people. Dependency might be less in Viet Nam. Overall, it is difficult to assess the degree of dependency of local populations since it depends on distance to a river, household wealth, and level of local development. Fish is still regarded as the main source of protein in the diet of the Sesan people. Estimates of fish consumption vary between 15 and more than 100 kg/person/year (17-53 kg/person/year along the Sekong and around 25 kg/person/year along the Srepok River).

Source

Baran, E (2013) *Fish and Fisheries in the Sekong, Sesan and Srepok Basins (3S Rivers, Mekong Watershed) with specific reference to the Sesan River*. WorldFish Center
and low turbulence), but that studies aimed at achieving a lower water velocity should be undertaken since that might cater to more species.

'"The behaviour and swimming capabilities of the target fish species should be considered a research priority'"

In order to improve the chances of a greater variety of species and a larger numbers of individuals passing successfully, the behaviour and swimming capabilities of the target fish species should be considered a research priority. In addition to applying this knowledge in the planning and location of the fish passage, it would be important to establish continuous monitoring and evaluation so that the design of critical sections of the fish passage can be improved.

Experience from South America shows that the sustainability of fish stocks also depends on the size of the dam reservoir: large reservoirs hinder the survival of eggs and fry during their downstream migration, regardless of the performance of the fish pass vis-à-vis the upstream migration of adults. In terms of downstream migration of adults, a fish pass may be more successful if it is directly connected to a part of a reservoir that is flowing and well oxygenated (lotic or river-like conditions). More generally, the distribution of favourable habitats for reproduction upstream should be taken into account (Fernandez et al., 2007a; Pompeu et al., 2012). Downstream dispersal of eggs and fry is an issue that should be further studied. The focus on upstream migration has overshadowed the need for a solid understanding of downstream migrations and the completion of life cycles. In that regard, fish ladders "should be viewed as an operational management tool based on a complete spatio-temporal understanding of fish populations (Fernandez et al., 2007b).

'"Nature-like fish passes that attempt to simulate a natural flow have several advantages compared to traditional ones'"

Last, efficient fish passage systems for high dams must mimic the natural systems in order to facilitate the maintenance of natural fish populations (Pompeu et al., 2012). A variety of biotopes along an extended fish passage system creates beneficial conditions for more species to pass the obstacle. Thus, Makrakis et al., argue that nature-like fish passes that attempt to simulate a natural flow have several advantages compared to traditional ones, in that they usually encompass heterogeneous structures that offer varied velocities and depths and thereby cater to a great variety of species and fish sizes.

A review of local conditions at the Lower Sesan 2 site shows that the stream located 9.8 km downstream of the dam on the right bank (see Path B above) would potentially be a good path to consider for the development of a fish passage.
The Canal da Piracema fish passage was completed in 2002 in order to mitigate the habitat fragmentation caused by the Itaipu Dam built 20 years earlier. It links the Paraná River, forming the border between Brazil and Paraguay, with the dam reservoir. This fish passage system consists of a natural channel followed by four fish ladders and four artificial lakes aimed at allowing fish to rest. All together, this fish passage system is 10 km long and 120 meters high, which makes it the longest and the highest in the world.

Segment 1, i.e. the lower part of the passage system, consists of a 6.8 km long nature-like river created using the original bed of the Bela Vista River and of the Brasilia Creek (4 to 6 m wide and 0.5 to 2.0 m depth; 1.3 percent mean slope reaching 4 percent in some sections, 1.4 m/s mean water velocity with a maximum of 3.5 m/s) and whose entrance is located 4.0 km below the dam. In terms of fish attraction, the system might still be sub-optimal for two reasons: i) the insertion of the Bela Vista River into the Paraná River features an unfavourable 60º angle, and ii) water velocity at the entrance of the pass is lower than in the Paraná River, where it reaches about 2 m/s at the surface.

Segment 2 features a 200 m long fish ladder (5 m wide x 2.5 m high, 6.25 percent slope, 1.4 m/s mean velocity with a maximum of 2.5 m/s) with concrete deflectors every 4 m to reduce the water velocity, the opening between 2 deflectors being 1 m wide); it links segment 1 to an artificial Lower Lake (1.2 ha area, 4 m maximum depth).

Segment 3 connects the Lower Lake to the artificial Principal Lake (14 ha; 5 m maximum depth) via a 521 m long fish ladder (1.4 percent slope, 1.6 m/s mean water velocity with a maximum of 2.7 m/s, concrete deflectors as above).

Segment 4 includes a 1.6 km long fish ladder (12 m wide, slope varying between 0.8 and 3.0 percent, mean water velocity of 0.9 m/s maximum of 2.1 m) opening into the artificial Grevilhas Lake (0.5 ha, 3.0 m depth).

Segment 5 includes another fish ladder extending over 730 m (8 m wide, slope varying between 0.7 and 5.0 percent, mean water velocity of 0.9 m/s maximum of 2.4 m/s, with concrete deflectors, the opening between 2 deflectors being 1 m wide).

Above this uppermost ladder is the upstream entrance of the Canal de Piracema in the Itaipu reservoir. This entrance is 3.3 m deep (when the operating level of the reservoir is maximal, i.e. 220.3 m) and is located 5.8 km from the closest turbine. A concrete structure captures water from the reservoir to hold it in a stabilisation lagoon (area: 0.4 ha) before discharging it into the ladder.
The stream shown in Path B is potentially considered a good path for the development of a fish passage system similar to that of the Canal da Piracema at the Itaiup Dam in South America (see opposite page). That fish pass would consume at most 1.2 percent of the reservoir water and result in a loss of hydropower not superior to 1.1 percent of the planned production.

**Source**
Gätke P, et al. (2013) *Fish Passage Opportunities For The Lower Sesan 2 Dam In Cambodia: Lessons From South America*. WorldFish Center

**References**


Catch and Culture enters its 20th year this August as the only newsletter dedicated to fisheries research and development in the Mekong region. For the past two decades, the newsletter has been produced in Bangkok, Phnom Penh and Vientiane, depending on the location of the MRC Fisheries Programme. Production returned to Phnom Penh in 2010 when the programme moved back from Vientiane as part of a restructuring of the MRC Secretariat into two offices in the Cambodian and Lao capitals. We look back on the early years of the newsletter in Bangkok and Phnom Penh as well as some of the key people involved in its development.

The first issue of Catch and Culture was published in Bangkok in August of 1995, a few months after the Mekong Agreement between Cambodia, Lao PDR, Thailand and Viet Nam came into force. The original editorial panel comprised Jorgen Jensen, Kathleen Matics and Sam Nuov. These founding members steered the "Mekong fisheries network newsletter" over its first six years.

Mr Jensen was chief project officer for fisheries and also head of the Agriculture, Irrigation, Forestry and Fisheries (AIFF) Unit at the MRC Secretariat in Bangkok. Before that, he was affiliated with the Technical Advisory Service of Danish International Development Assistance (Danida) for eight years. Dr Matics had been editor of the quarterly newsletter of the Southeast Asian Fisheries Development Center (SEAFDEC) in Bangkok between 1978 and 1986, when she joined the secretariat of what was then known as the Interim Mekong Committee. Mr Sam Nuov had been working as a fisheries officer at the secretariat in Bangkok since 1994, a year after his graduation with a master's degree from the Asian Institute of Technology. Before that, he was director of Chrain Chamres Fisheries Research Station on the Tonle Sap River north of Phnom Penh. The three founding members of the editorial panel were assisted by Ruamporn Visuthipichaipun. Ms Ruamporn was the fisheries project secretary at the AIFF Unit in Bangkok.

"When the MRC Fisheries Programme started, the inland fish resources of the Mekong Basin were considered a lost case," Mr Jensen recalled earlier this year. "An annual production of only 357,000 tonnes, when all the official statistics were counted, tended to decline year by year. But how come, when everybody was eating fish? And who did the counting? And where?"

Mr Jensen, who now works as a coordinator for the Danish Arab Partnership Programme at Denmark's Ministry of Foreign Affairs, said the Fisheries Programme subsequently undertook a catch survey in Cambodia and included the first consumption survey by the Department of...
Fisheries in northeast Thailand.

"After a lot of thinking and counting, a revised estimate — considered partly crazy by many — was published in Catch and Culture, in August, 1996, under the headline ‘1,000,000 TONNES OF FISH FROM THE MEKONG?’ Such a resource would have been worth at least $800 million. It was a guess, but a qualified one. And it got us on the map,” Mr Jensen said. “Within a short time, the figure was cited by the World Bank. It underscored the importance of the wild fish resources in the regional economy both at present and in the future. And Catch and Culture became known outside the basin.”

Mr Jensen said the figures were confirmed and updated by Catch and Culture to "probably more than 1.2 million tonnes" in 2000. "Now it has grown and been verified as almost three times as much and ten times the old official figure. It was a turning point in the history of Mekong fisheries, and Catch and Culture broke the news," he said.

Targeting a wide audience

Catch and Culture traces its roots back to 1992 when a fisheries sector review was conducted by the then Interim Mekong Committee. Among the recommendations were the establishment of a fisheries network for the basin and a regional fisheries newsletter. As a result of the review, a technical assistance project for fisheries development began in 1993 with support from Danida.

At a regional fisheries seminar in Bangkok in 1994, all four riparian countries recommended establishing the newsletter. It was first published in August of 1995, four months after the signing of the Mekong Agreement in Chiang Rai and the same month as the launch of a reservoir fisheries management project, the first involving fisheries activities in all four countries of the Lower Mekong Basin.

The maiden issue stated that Catch and Culture would serve as the "primary medium of communication regarding capture fisheries and aquaculture in the Mekong Basin." Readers were reminded, however, that the newsletter was "not a scientific publication and does not intend to compete with international journals."

The target audience was "public administrators and fisheries scientists working in ministries, departments and institutes and projects related to fisheries management, research, extension etc in the Mekong Basin."

The newsletter also targeted "individuals carrying out research in the basin using either private or public funds" as well as "regional and international institutions or agencies involved to some extent in fisheries development or related areas." In other words, readership was expected to be broad. "For example, the results of regional workshops as well as other relevant information will reach a wider audience than just the participants themselves."
When he returned to the Cambodian Fisheries Department to take up the job of deputy director general in 2000, Mr Sam Nuov was succeeded on the editorial panel by Nguyen Van Trong who had been a fisheries project officer in Viet Nam since 1997. Mr Trong, a graduate of Nha Trang University who had also studied in the former Soviet Union, had worked on various projects for the Vietnam Ministry of Fisheries at the Research Institute for Aquaculture No 2 in Cai Be in the Mekong Delta.

After the secretariat moved from Bangkok to Phnom Penh in 1998, the editorial panel of Catch and Culture was expanded in 2001 with the arrivals of Chris Barlow as senior programme officer and Chumnarn Pongsri as programme officer. Dr Barlow was previously programme leader for aquaculture at the Queensland Department of Primary Industries in Australia where he had earned a doctorate in zoology from James Cook University. Dr Chumnarn, who completed his doctoral degree at the University of Wales, had been appointed as the new Director General of the Department of Fisheries of Thailand.

Interviews were not limited to government officials. In 1996, the newsletter interviewed American taxonomist Walter Rainboth, an associate professor from the University of Wisconsin. At the time, Dr Rainboth was completing a field guide to identify Mekong fishes of Cambodia which was subsequently published by the MRC River Commission and the Food and Agriculture Organisation of the United Nations. And in 1997, Catch and Culture ran an exclusive interview with Canadian scientist Garry Bernacsek, the world-renowned reservoir fisheries specialist who later came to work for the MRC Fisheries Programme.

Early achievements

Between 1995 and 1997, Catch and Culture featured profiles of top fisheries officials in all four riparian countries. The first issue in 1995 carried an interview with Singkham Phonvisay, director of the Lao Livestock, Veterinary and Fisheries Service. The third issue the same year had an interview with Ly Kim Han, director of the Cambodian Fisheries Department.

By the time its was celebrating its first anniversary in 1996, the newsletter was featuring an interview with Ta Quang Ngoc, the vice minister at the Vietnamese Ministry of Fisheries who became minister the following year. Towards the end of 1997, Catch and Culture discussed fisheries development plans with Dhammarong Prakoboon who had just
previously worked as senior fisheries biologist at the Inland Fisheries Division of the Thai Department of Fisheries. It was around this time that Mr Jensen was succeeded on the editorial panel by Jeanineke Dahl Kristenen, the new manager of the Fisheries Programme. Ms Kristensen had previously worked for the Ministry of Foreign Affairs of Denmark where she was task manager for all fisheries activities supported by Danida.

By the time *Catch and Culture* underwent a major revamp in 2003, the editorial panel included Delia Paul, a veteran journalist from Malaysia. Ms Paul was the first communications officer at the MRC Secretariat, reporting directly to the chief executive officer. She played a key role in redesigning the newsletter with Dr Barlow, who was by now the manager of the Fisheries Programme, and Cambodian graphic designer So Sawaddh. Also in 2003, another two programme officers joined the editorial panel — Kamtanh Vatthanatham from Lao PDR and Nguyen Quoc An from Viet Nam.

"Four things come to mind when I look back on the 20 year history of C&C," recalled Dr Barlow, who is now research programme manager for fisheries at the Australian Centre for International Agricultural Research (ACIAR). "The first is the vision and drive of Jorgen Jensen in establishing C&C in the mid-1990s. Even the Mekong Secretariat did not have any form of newsletter at the time (nor did it for many subsequent years), so it was a brave move, and one that required Jorgen to write most of the articles for the first five to six years. It was his energy and enthusiasm that sustained the newsletter in the early days.

"The second is the benefit of Delia Paul’s professional knowledge of communication media and processes. She was the one who showed us how to structure the newsletter to give it consistency, relevance and overall a more professional look. She was also the wise one who encouraged me to employ a professional editor, which we did," Dr Barlow said.

"The articles have highlighted the importance of fisheries for livelihoods and nutrition, as well as developments that impact negatively on fisheries resources"  

"The third is the contribution of C&C to the political and scientific discourse in the Mekong region. The articles have highlighted the importance of fisheries for livelihoods and nutrition, as well as developments that impact negatively on fisheries resources. Politically sensitive issues have been discussed with objectivity and common-sense – and, admittedly, at times with a little trepidation.

"Finally, C&C remains the only programme-based newsletter within MRC, which is testament to the vision of Jorgen Jensen and the efforts of all who have been involved in its production since 1995. Without a doubt, C&C has been and continues to be a worthy vehicle for supporting fisheries and fisher people in the Mekong."

Ms Paul recalled that the Internet revolution was "still a distant glow on the horizon" in Phnom Penh in 2003. "Our revamp focused a lot on the look and feel of the newsletter, assuming readers were going to hold it in their hands," she said. "The redesign featured crisp
black text on white paper on the inside, and a textured cream stock for the cover, with a freehand drawing on the front by the MRC communication unit’s multi-talented graphic designer, So Sawaddh (see below). Detailed line drawings of fish species appeared on the inside pages, lending what I hoped was going to be an authoritative note to our publication, given its shift in tone and style.

"We aimed for a lively mix of industry news, science and pointers - in the form of a ‘Mekong Fisheries Index’ – to reports from other sources. The first issue of the revamp explained: 'Catch and Culture is not an academic journal, but aims to bring you the ideas and events that are shaping fisheries management today.'

"I think it has done that under the able guidance of so many people over the years," said Ms Paul, who is now based in Bangkok as a writer and poverty, rights and governance expert for the Winnipeg-based International Institute of Sustainable Development. "I look back with pleasure on my collection of past issues – I left MRC in 2004, and would swipe a few copies on every visit back to the secretariat. I hope that everyone who has had a role in Catch and Culture over the years feels as proud of their association with it as I do, and is as pleased to see it continue."

One of the first big coups under the new format was an article in October, 2003, on how Vietnamese catfish farmers in the Mekong Delta were being affected by punitive tariffs imposed by the United States Commerce Department. The article was soon picked up by a Vietnamese journalist visiting Phnom Penh and run by his Hanoi-based newspaper in Vietnamese. The Catch and Culture article was subsequently reprinted by Nhan Dan, the official organ of the Communist Party of Vietnam.

Since 2004, when the MRC Secretariat moved to Vientiane, editorial panel members have included Buoy Roitana, Ngor Peng Bun and Kong Sovanara from Cambodia, Kaviphone Pouthavongs and Souvanny Phommakone from Lao PDR, Suchart Ingthamitr, Theerawat Samphawamana and Malasri Khumsri from Thailand and Pham Mai Phuong and Nguyen Hai Son from Viet Nam. Also on the panel have been Xaypladeth Choulamany, the first MRC Fisheries Programme coordinator from a riparian country who oversaw..."
the conversion to full colour in 2011, along with the current coordinator So Nam. Other members of the panel have included chief technical advisors Kent Hortle and Peter Degen along with Vientiane-based communication officers Virginia Addisson, Aiden Glendenning and Damian Kean.

Current members of the Editorial Panel

Dr So Nam
Mr Buoy Roitana
Mr Theerawat Samphawamana
Mr Ngor Peng Bun
Ms Souvanny Phommakone
Mr Peter Degen
Dr Malasri Khumsri
Mr Nguyen Hai Son
Mr Kong Sovanara
World Bank assesses prospects for global fish supply and demand in 2030

A discussion paper published by the World Bank earlier this year offers a global view of fish supply and demand using a newly improved model developed by the International Food Policy Research Institute (IFPRI). Produced in collaboration with the Food and Agriculture Organisation (FAO) of the United Nations and the University of Arkansas, the paper finds that the fishes with the fastest growth prospects worldwide up until 2030 are tilapia, carp and pangasius, the latter being native to the Lower Mekong Basin. In terms of both capture fisheries and aquaculture, China, South Asia and Southeast Asia are projected to have the fastest growth in production over the same period.

With the global population expected to reach 9 billion by 2050, food producers will have to increase production and reduce waste. In an environment where resources necessary for food production such as land and water are even scarcer, the sector needs to be far more efficient. And in the face of climate change, the world is required to change the ways economic activities are conducted.

'Even in small quantities, provision of fish can be effective in addressing food and nutritional security among poor and vulnerable populations'

Fisheries and aquaculture must address many of these difficult challenges. With rapidly expanding aquaculture, there is a large potential for further and rapid increases in fish supply. During the last three decades, capture fisheries production increased from 69 million to 93 million tons. In the same period, world aquaculture production increased from 5 million to 63 million tons. Globally, fish represents about 16.6 percent of animal protein supply and 6.5 percent of all protein for human consumption. Fish is usually low in saturated fats, carbohydrates and cholesterol, and provides not only high-value protein but also a wide range of essential micronutrients, including various vitamins, mineral, and polyunsaturated omega-3 fatty acids. Thus, even in small quantities, provision of fish can be effective in addressing food and nutritional security among poor and vulnerable populations.

In some parts of the world and for certain species, aquaculture has expanded at the expense of the natural environment (for example, shrimp aquaculture and mangrove cover) or under technology with high input requirements from capture fisheries (for example, fishmeal). However, some aquaculture can produce fish efficiently with low or no direct input. For example, bivalve species such as oysters, mussels, clams and scallops are grown without artificial feeding; they feed on materials that occur naturally in their environment. Silver carp and bighead carp are grown with planktons proliferated through fertilization as well as waste and leftover feed in multispecies aquaculture systems.

While the proportion of non-fed species in global aquaculture has declined relative to higher trophic-level species of fish and crustaceans over the decades, these fish still represent a third of all farmed food fish production, or 20 million tons. Further, production efficiency of fed species has improved. For example, the use of fishmeal and fish oil per unit of farmed fish produced has declined substantially as reflected in the steadily declining inclusion levels of average dietary fishmeal and fish oil within compound aquafeeds. Overall, a 62 percent increase in global aquaculture production was achieved when the global supply of fishmeal declined by 12 percent during the 2000–08 period.

Many of the fishers and fish farmers in developing countries are smallholders. The Food and Agriculture Organization (FAO) estimates that 55 million people were engaged in capture fisheries...
Growth in aquaculture projected to be led by freshwater species

Looking across species, the fastest supply growth is expected for tilapia, carp, and pangasius catfish. Global tilapia production is expected to almost double from 4.3 million tons to 7.3 million tons between 2010 and 2030. Demand for fishmeal and fish oil will likely become stronger, given the fast expansion of global aquaculture and sluggish global capture fisheries that supply their ingredients. During the 2010–30 period, prices in real terms are expected to rise by 90 percent for fishmeal and 70 percent for fish oil. Nonetheless, with significant improvements anticipated in the efficiency of feed and management practices, the projected expansion of aquaculture will be achieved with a mere 8 percent increase in the global fishmeal supply during the 2010–30 period. In the face of higher fishmeal and fish oil prices, species substitution in production is also expected, where production of fish species that require relatively less fish-based feed is preferred.

Across regions, China will likely increasingly influence the global fish markets. According to the baseline model results, in 2030 China will account for 37 percent of total fish production (17 percent of capture production and 57 percent of aquaculture production), while accounting for 38 percent of global consumption of food fish. Given the continued growth in production projection, China is expected to remain a net exporter of food fish (net importer of fish if fishmeal is considered). Fast supply growth is also expected from aquaculture in South Asia (including India), Southeast Asia, and Latin America. Per capita fish consumption is projected to decline in Japan, Latin America, Europe, Central Asia, and Sub-Saharan Africa.
Aquaculture and small-scale fisheries employed over 90 percent of the world's capture fishers. To these small-scale producers, fish are both sources of household income and nutrients. Sustainable production and improved efficiency would contribute to improve their livelihoods and food security.

"Developing countries are well integrated in the global fish trade, and the flow of exports from developing countries to developed countries has been increasing"

One important feature of this food-producing sector is that fish is highly traded in international markets. According to the FAO, 38 percent of fish produced in the world was exported in 2010. This implies that there are inherent imbalances in regional supply and demand for fish. International trade—through price signals in markets—provides a mechanism to resolve such imbalances. Therefore, it is important to understand the global links of supply and demand of fish to discuss production and consumption in a given country or a region, while understanding that the drivers of fish supply and demand in major countries and regions is essential in making inferences about global trade outcomes. Developing countries are well integrated in the global fish trade, and the flow of exports from developing countries to developed countries has been increasing. In value, 67 percent of fishery exports by developing countries are now directed to developed countries.

Based on production and consumption trends driven by income and population growth, the newly improved International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) of the International Food Policy Research Institute simulates outcomes of interactions across countries and regions and makes projections of global fish supply and demand into 2030. The model covers 115 model regions for a range of agricultural commodities, to which fish and fish products are added. Projections are generated under different assumptions about factors considered as drivers of global fish markets.

**Baseline**

After demonstrating that the model successfully approximates the dynamics of global fish supply and demand over the 2000–08 period, the outlook...
Aquaculture likely to dominate future global fish supply

From the modeling exercise and scenario analyses, it is clear that aquaculture will continue to fill the growing supply-demand gap in the face of rapidly expanding global fish demand and relatively stable capture fisheries. While total fish supply will likely be equally split between capture and aquaculture by 2030, the model predicts that 62 percent of food fish will be produced by aquaculture by 2030.

Beyond 2030, aquaculture will likely dominate future global fish supply. Consequently, ensuring successful and sustainable development of global aquaculture is an imperative agenda for the global economy. Investments in aquaculture must be thoughtfully undertaken with consideration of the entire value chain of the seafood industry.

Policies should provide an enabling business environment that fosters efficiency and further technological innovations in aquaculture feeds, genetics and breeding, disease management, product processing, and marketing and distribution. The same is true for capture fisheries—developing enabling environment through governance reforms and other tools represents the first step toward recovery of overharvested fish stock and sustainability of global capture fisheries.

is projected under the scenario considered most plausible given currently observed trends. The model projects that the total fish supply will increase from 154 million tons in 2011 to 186 million tons in 2030 (see table above). Aquaculture’s share in global supply will likely continue to expand to the point where capture fisheries and aquaculture will be contributing equal amounts by 2030. However, aquaculture is projected to supply over 60 percent of fish destined for direct human consumption by 2030. It is projected that aquaculture will expand substantially, but its growth will continue to slow down from a peak of 11 percent per year during the 1980s. The global production from capture fisheries will likely be stable around 93 million tons during the 2010–30 period. Six additional scenarios investigate the potential impacts of changes in the drivers of global fish markets.

Scenario 1: Faster aquaculture growth
Under this scenario, aquaculture grows 50 percent faster than under the baseline between 2011 and 2030. The scenario assumes faster technological progress leading to lower costs but assumes the same feed requirements per unit weight of production. Progress may include genetic improvement, innovations in distribution, improvements in disease and other management practices, control of biological process for additional species, improvements in the condition of existing production sites and expansion of new production sites. Aquaculture production in 2030 would expand from 93.2 million tons under the baseline to 101.2 million tons under this scenario. Faster growth in all aquaculture would stress the fishmeal market, dictating which species and regions would grow faster than others. Under this scenario, tilapia production in 2030 would be 30 percent higher than the baseline. Production of mollusks, salmon and shrimp would be more than 10 percent higher. As a result, all fish prices in 2030 would be as much as 2 percent lower in real terms, except for fishes in the other pelagic category which are used for fishmeal and fish oil. Fishmeal prices in 2030 would be 13 percent higher than under the baseline. Fish oil prices would be 7 percent higher.

Scenario 2: Expanded use of waste
This scenario investigates how expanded use of waste in fishmeal and fish oil production might affect the market of these fish-based products. In addition to the baseline countries, all countries that produce fishmeal or fish oil are assumed to have the option of using waste in their production starting in 2011. The model indicates that fishmeal production in 2030 would increase by 12 percent compared to the baseline and that fishmeal prices would fall by 14 percent. This would boost the production of freshwater and diadromous fish, salmon and crustaceans. Although cost is involved in selection, collection and reduction of waste, use of additional feedstock represents a great opportunity to increase fishmeal and fish oil production, especially where organised fish
Aquaculture

Summary Results for Year 2030 under Baseline and Alternative Scenarios

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
<th>Scenario 5</th>
<th>Scenario 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Faster</td>
<td>Waste</td>
<td>Disease</td>
<td>China</td>
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<td>Cc-B</td>
</tr>
<tr>
<td>Total fish supply</td>
<td>186.8</td>
<td>194.4</td>
<td>188.6</td>
<td>186.6</td>
<td>209.4</td>
<td>196.3</td>
<td>184.9</td>
</tr>
<tr>
<td>(million tonnes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capture supply</td>
<td>93.2</td>
<td>93.2</td>
<td>93.2</td>
<td>93.2</td>
<td>105.6</td>
<td>90.2</td>
<td>90.2</td>
</tr>
<tr>
<td>(million tonnes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquaculture supply</td>
<td>93.6</td>
<td>101.2</td>
<td>95.4</td>
<td>93.4</td>
<td>116.2</td>
<td>90.7</td>
<td>94.7</td>
</tr>
<tr>
<td>(million tonnes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrimp supply</td>
<td>11.5</td>
<td>12.3</td>
<td>11.5</td>
<td>11.2</td>
<td>17.6</td>
<td>11.6</td>
<td>11.5</td>
</tr>
<tr>
<td>(million tonnes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salmon supply</td>
<td>5.0</td>
<td>5.4</td>
<td>5.1</td>
<td>5.0</td>
<td>6.1</td>
<td>5.0</td>
<td>4.8</td>
</tr>
<tr>
<td>(million tonnes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tilapia supply</td>
<td>7.3</td>
<td>9.2</td>
<td>7.4</td>
<td>7.3</td>
<td>7.4</td>
<td>7.2</td>
<td>7.3</td>
</tr>
<tr>
<td>(million tonnes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishmeal price ($/tonne; % to baseline)</td>
<td>1,488.0</td>
<td>13%</td>
<td>-14%</td>
<td>-1%</td>
<td>29%</td>
<td>-7%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish oil price ($/tonne; % to baseline)</td>
<td>1,020.0</td>
<td>7%</td>
<td>-8%</td>
<td>-0%</td>
<td>18%</td>
<td>-6%</td>
<td>3%</td>
</tr>
</tbody>
</table>

Source: IMPACT model projections. Note: CC-a = climate change with mitigation, CC-b = climate change without drastic mitigation

processing is practiced. For example, 90 percent of ingredients in fishmeal produced in Japan come from fish waste. Globally, about 25 percent of fishmeal is produced with waste as an ingredient. Increased use of waste would reduce competition for small fish between fishmeal production and direct human consumption.

**Scenario 3: Major disease outbreak**

Under this scenario, a hypothetical major disease outbreak hits shrimp culture in China and South and Southeast Asia, reducing their production by 35 percent in 2015. The model suggests that countries unaffected by the disease would initially increase shrimp production by 10 percent or more in response to higher prices caused by the decline in world supply. However, since Asia accounts for 90 percent of global shrimp culture, the unaffected regions would not entirely fill the gap. Global shrimp supply would contract by 15 percent in the year of the outbreak. Under a simulated recovery, the projected impact of disease outbreak on global aquaculture is negative but negligible by 2030.

**Scenario 4: Increased Chinese demand**

In this scenario, Chinese consumer demand for certain high-value fish products expands more aggressively. Per capita consumption of high-value shrimp, crustaceans and salmon in 2030 would be three times higher than under the baseline. Demand for mollusks would be twice as high. Except for mollusks, these species require fishmeal in their production. Under this scenario, global aquaculture production could increase to more than 115 million tons by 2030. This would benefit producers and exporters such as Southeast Asia and Latin America. While overall fish consumption in China in 2030 would be 60 percent higher than the baseline, all other regions would consume less fish by 2030. Compared to the baseline, fishmeal prices would increase by 29 percent in real terms and fish oil prices would rise by 18 percent. Fishmeal production would increase by more than 300,000 tons, reducing the amount of fish destined for direct human consumption by 1 million tons.

**Scenario 5: Faster capture growth**

This simulates the impacts of a long-term increase in the productivity of capture fisheries where fish stocks recover to levels that permit maximum sustainable yield. Effectively managed fisheries are assumed to sustain harvests 10 percent above the current level by 2030. Compared to the baseline, the world would have 13 percent more wild-caught fish. Increased production of small pelagic and other fish for fishmeal and fish oil would reduce pressure on the feed market resulting from the continued rapid expansion of
aquaculture. Fishmeal prices are expected to be 7 percent lower than under the baseline. Production in all regions would benefit from this scenario. Distributional implications of the scenario would be even higher if the stock recovery process is accompanied by efforts to substantially reduce the inefficiency often prevalent in the harvest sector, estimated to cost $50 billion each year. The relative abundance of fish under this scenario would dampen prices so aquaculture production in 2030 would be reduced by 3 million tons compared to the baseline.

Scenario 6: Impacts of climate change
The final scenario considers the impacts of global climate change on the productivity of marine capture fisheries. Changes in global fish markets are simulated based on maximum catch potentials under two scenarios: one with mitigation measures so no further climate change occurs beyond the 2000 level and the other with the continuing trend of rising ocean temperature and acidification. Mitigation yields a 3 percent reduction in production in 2030 compared with the baseline. The no-mitigation scenario results in marginal additional harm with the global harvest reduced by 0.02 percent. In principle, high-latitude regions are expected to gain while tropical regions lose in capture harvest. The highest gains are expected in Europe and Central Asia (7 percent) and the largest losses in Southeast Asia (4 percent) and East Asia and Pacific (3 percent). The model predicts that market interactions will attenuate the impact of changes in harvest and distribution. Aquaculture will likely offset the small loss in the capture harvest. Imports and exports will likely smooth the supply-demand gap and fish consumption levels in 2030 are not expected to change in any region due to climate change.

The simulated loss in global catches is relatively small as it uses medium-term projections whereas climate change is a long-term phenomenon.

Source

Fisherman catching small cyprinids on the Mekong River in Talarborivat district in Stung Treng province in northeast Cambodia
PHOTO: NGO R PENG BUN
Thirty-First Session of the FAO Committee on Fisheries

Statement by Dr So Nam, coordinator of the MRC Fisheries Programme, at the FAO Committee on Fisheries meeting in Rome from June 9 to 13

The inland fisheries of the Mekong River Basin are amongst the largest fisheries in the world and contribute to the food security of millions of rural people. From around 1,100 fish species estimated in the Mekong basin at least 850 have been recorded as strictly freshwater species. In 2010 the LMB fisheries produced about 4.0 million tonnes, of which 2.3 million tonnes were from capture fisheries that is about 20% of total world inland capture fisheries production, the highest productivity in the world. The annual economic value of the fisheries is estimated up to seven billion US dollars.

‘Inland fisheries provide a major element of livelihoods, income generation and food and nutrition security for the largely rural population’

Further, the inland fisheries provide a major element of livelihoods, income generation and food and nutrition security for the largely rural population. Basin-wide consumption of fish and other aquatic animals annually averages about 51 kg/capita, which is well above the world average consumption of about 19 kg/capita. Inland fish and other aquatic animals contribute more than 50% of the total animal protein in the LMB, which is significantly higher than the world average of 16%.

The Fisheries Programme of MRC is characterized by a two-pronged approach of 1) supporting Member Country agencies in applying improved methods and tools for regional cooperation in fisheries research, development and management; and 2) moving towards implementation of long-term core functions. In addition, it will address a number of regional and national priorities, such as improving national capacity for regional fisheries cooperation, filling information and knowledge gaps, and fostering communication and participation.

The MRC FP wishes that FAO, in cooperation with other regional and international organizations, research institutes, and universities will fill information and knowledge gaps. We congratulate the signing of MOU between FAO and Michigan State University yesterday with regard to inland fisheries research and development cooperation and collaboration.

With about 20 years experiences in inland fisheries research, development and management in the Mekong region, the MRC FP is willing to share and cooperate with FAO with regards to filling information and knowledge gaps on fish yield estimate at a land scale, fisheries value and valuation, fish migration and stocks, fish consumption, income and occupation.

The MRC FP strongly supports the FAO-COFI 31’s proposal on the need for a high level policy meeting on inland capture fisheries, in conjunction with the Global Conference on Inland Fisheries in January 2015.
Fish population geneticist appointed as director of MRC Operations Division

The Mekong River Commission has appointed Naruepon Sukumasavin as director in charge of the Operations Division of the MRC Secretariat. Dr Naruepon joined the Office of the Secretariat in Phnom Penh in March from the Thai Department of Fisheries where he had been working for more than 30 years. His fields of expertise are fisheries resource management, population genetics and biodiversity conservation as well as tropical fish breeding and broodstock management. Dr Naruepon is the first director with a fisheries background to be put in charge of the Operations Division which oversees the commission’s Fisheries Programme as well as its Navigation Programme, Agriculture and Irrigation Programme and Drought Programme, all based in Phnom Penh.

Dr Naruepon had been working as the aquatic ecology expert of the Department of Fisheries after serving as director of the department’s Information Technology Centre between 2007 and 2011. Before that, he was technical group head at the Inland Fisheries Research and Development Bureau and head of the Inland Fisheries Station in Surin, a northeast province of Thailand bordering Cambodia where he had been working since 1994. Over the previous 12 years, he worked as fisheries biologist at the Inland Fisheries Station in Kalasin, a nearby province which is also located in the Lower Mekong Basin.

The Thai scientist has been closely associated with the MRC Fisheries Programme since 2002, when he co-authored MRC Technical Paper No 3, *Mekong giant fish species: on their management and biology*. Dr Naruepon has since conducted extensive consultancy work for the MRC, including the Aquaculture of Indigenous Mekong Fish Species (AIMS) project of the Fisheries Programme, as well as the Support for the Development of Freshwater Aquaculture (SUFA) project in Viet Nam. His latest work for the MRC in 2012 focussed on trans-boundary fisheries management planning and propagation techniques for indigenous aquatic species from the Mekong. In addition, Dr Naruepon has authored or co-authored dozens of scientific papers, notably on the induced spawning of the Thai carp (*Puntius gonionotus*) and the Mekong giant catfish (*Pangasiandon gigas*). He has also served on numerous technical committees at the Department of Fisheries.

Dr Naruepon completed his PhD in applied population genetics at Japan’s Tohoku University in 2005. He also has a Master of Science degree in zoology from the University of British Colombia in Canada and a Bachelor of Science degree in marine science from Thailand’s Kasetsart University. His academic positions have included a three-year stint as a lecturer on intensive aquaculture at Suranaree University of Technology in Nakhon Ratchasima in northeast Thailand. He more recently served on the Thesis Research Committee on Fish Population Genetics at Kasetsart University, also for three years.

Dr Naruepon is the second fisheries scientist to serve as an MRC director. The first was former Fisheries Programme officer Chumnarn Pongsri, who was director of the Environment Division between August 2003 and February 2005. Dr Chumnarn, also from Thailand, is now secretary-general of the Southeast Asia Fisheries Research Center (SEAFDEC) based in Bangkok.
Dr Waraporn Prompook, senior expert on international fisheries affairs at the Thai Department of Fisheries, at the Thirty-First Session of the Committee on Fisheries of the Food and Agriculture Organization in Rome in June (see page 46 for MRC statement)

Photo: FAO/Alessandra Benedetti