Fisheries and Environment Research and Development in the Mekong Region
Volume 25, No 3  ISSN 0859-290X  December 2019

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New State of the Basin Report

The flagship publication of the Mekong River Commission has just been published with a focus on five areas for future cooperation between Cambodia, Lao PDR, Thailand and Viet Nam and a new section on the Upper Mekong Basin in China and Myanmar. The latest report highlights an urgent need for a ‘more proactive regional approach’ to planning and management in the Lower Mekong Basin.

The Mekong River Commission launched its third State of the Basin Report at the MRC Secretariat in Vientiane on 22 October. The report aims to provide an overall picture of the Mekong River Basin in terms of its ecological health and the social and economic circumstances of its people — and the degree to which cooperation between riparian countries envisaged under the 1995 Mekong Agreement is enhancing these conditions.

Unlike previous reports in 2003 and 2010, the new report for 2018 is structured around environment, social, economic, climate change and cooperation dimensions with 15 strategic indicators for the Lower Mekong Basin that have been agreed to by MRC member countries — Cambodia, Lao PDR, Thailand and Viet Nam (see page 7). The latest report also includes a new section on the Upper Mekong Basin in China and Myanmar, both dialogue partners of the MRC (see page 10).

'We need to address these issues now'

In a statement accompanying the launch, the MRC Secretariat said major challenges highlighted in the report included the apparent permanent modification of the Mekong’s mainstream flow regime and a “substantial” reduction in sediment flows due to sediment trapping. Other challenges included continuing loss of wetlands, deterioration of riverine habitats, growing pressures on capture fisheries and limited information-sharing on water development facilities and water use.

A more proactive regional approach to basin planning and management, with an enhanced and systematic information sharing mechanism and robust monitoring of river flow “must be put in place urgently to address these basin-wide challenges,” the statement said.

“We need to address these issues now,” said Dr An Pich Hatda, chief executive officer at the MRC Secretariat. He highlighted the need to “minimize further environmental harm and protect remaining wetlands and riverine habitats before they are gone, while leveraging the benefits of more secure and increased dry-season flows and achieving a more optimal and sustainable development of the Mekong basin.”

The statement noted “increased cooperation among riparian countries to tackle these challenges, especially under the MRC framework where financial contributions from members to fund MRC critical work, notifications and information sharing, and the number of joint projects have all increased. While challenges are increasing for the Mekong River, the overall economic conditions in the basin are positive with solid economic growth, poverty reduction and productivity improvement.”

Recommendations

Below is a summary of six recommendations con-
The Mekong Basin

MAP: MRC (2019)
The Lower Mekong Basin wetlands are biodiversity hotspots that play an important role in the economy, society and culture of the region due to the resources and ecosystem services they provide. They offer various non-marketed and marketed benefits including fisheries, other aquatic animals and plants, vegetation, and non-timber forest products. Local people and communities obtain a substantial proportion of their incomes, daily foods and livelihoods from these resources.

Wetlands protect people and cities from floods and natural disasters; clean wastewater flowing out of urban, agriculture and industrial areas; and store water for irrigated agriculture. Ecosystem services include water provision, regulation, purification, and groundwater replenishment.

Despite the substantial benefits they provide, the wetlands are threatened and being gradually degraded. With population growth, there have been impacts on wetlands with reclamation and conversion to rice fields, increased urban runoff, increased riverine navigation, intensification of agriculture and aquaculture with increased use of fertilizer and pesticide and increased discharge of urban waste water. Developments such as expanding agricultural and urban/industrial areas with year-round flood protection puts pressure on the remaining wetlands. The MRC has estimated that less than two percent of the original wetland area in the Mekong Delta remains.

Eleven types of wetland have been identified with an area of 102,386 km². The largest type is freshwater wetlands which include flooded forests and inundated grasslands, and areas around the Tonle Sap and elsewhere used for recession rice agriculture. A comparison of wetland environments identifies substantial overlap between freshwater wetlands and areas of paddy rice, particularly around the Tonle Sap and in the Mekong Delta. The land cover analysis shows that the largest loss of wetland related area between 2003 and 2010 was for mangroves and grassland areas with a substantial increase in the area of aquaculture. Marshes and swamp areas increased significantly over the same period, more than doubling in area.

The condition of river habitats can be considered by examining the status and trends of some key habitat types important for fish and other biodiversity within the river channel and in the riparian zone. The extent of riverbank erosion is also an indicator of the balance of sediment supply and transport relevant to healthy geomorphological function.

Within the river channel, exposed sandy habitats are important for vegetation, herpetofauna and birds in the dry season. The availability of such habitats depends on the creation and maintenance of sandbars, banks and islands through alluvial deposition, and the exposure of the deposits in the dry season. Inundated sandy habitats are an important indicator for riverine health as many insects require a sandy substrate for life-cycle processes.

Deep pools are important geomorphic features, providing refuge and spawning habitats for a variety of fish species. It has been found that sediment pulses move through bedrock pools in northern Lao PDR on an annual basis, highlighting the link between the sediment and flow regimes for maintenance of the features. Given the dependency of these features on the balance between the timing and magnitude of flow and sediment delivery in the LMB, deep pools can also be considered as good geomorphic indicators of channel function.

Estimates from 2017 show a decline in the availability of exposed sand bars and rocky habitats and an increase in the depth of deep pools in the dry season since 1985. This is attributed to higher dry-season water levels and the greater erosive power of the flow due to the more sediment-depleted water originating from upstream. In all mainstream zones, the extent of both upper and lower riparian vegetation is estimated to have declined. In most areas, much of this decline occurred before the 1970s. However, river bank vegetation along the Tonle Sap River is estimated to have declined more recently and more substantially than in other zones. Riverbank erosion is estimated to have increased from the 1950s in most zones of the mainstream including the Mekong Delta and more recently found the Tonle Sap Lake and the Tonle Sap River.
tained in the latest State of the Basin report:

(A) Continue and enhance monitoring of flow conditions and water quality
With increasing development in the basin and the onset of climate change impacts, the need for hydro-meteorological, flow, water quality and sediment monitoring is of ever more importance. Changes in flow regime may lead to undesirable impacts on both environmental assets and riverine communities as well as to opening the potential for increased irrigation abstractions, and need to be observed carefully. These monitoring programmes are designated as core functions of the MRC and it is recommended that they should remain so with sufficient budgets and resources allocated as needed.

(B) Develop and implement a MRC Data Acquisition and Generation Action Plan
Preparation of the State of the Basin Report and the recent Council Study as well as other MRC projects and studies and the implementation of MRC Procedures and Guidelines have all been constrained by the availability of data. Comprehensive programmes to monitor environmental assets, (including fisheries), water use, agriculture, land use, socio-economic and macro-economic aspects and some aspects of development infrastructure, including hydropower and flood control projects are needed to fill these gaps.

Given that the costs of implementing the required monitoring programmes need to be kept to a reasonable minimum as the MRC moves towards self-finance, smart ways of basin monitoring need to be considered for which some studies and surveys may be needed to accredit new methodologies. The MRC data acquisition and generation action plan and data storage and management must be seen as a priority core river basin management function across all MRCS Divisions, with responsibilities at regional and national levels set out and appropriate investment included in MRC annual budget plans.

(C) Address the problem of reduced sediment concentrations
Sediment concentrations in the mainstream are observed to be much reduced largely as a consequence of reservoir sediment trapping. The consequences in the short, medium and long term of diminished sediment concentrations on the river’s morphology, bank stability, flood plain productivity, delta building processes and the productivity of coastal waters need to be fully understood in order that agreement can be reached on a sediment management plan on how best to manage sediments within the system and to mitigate the transboundary impacts of reduced concentrations (see page 12).

(D) Address the need to take urgent action to preserve and protect remaining environmental assets

Five dimensions and 15 indicators

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Strategic indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>• Water flow conditions in mainstream</td>
</tr>
<tr>
<td></td>
<td>• Water quality and sediment conditions</td>
</tr>
<tr>
<td></td>
<td>• Status of environmental assets</td>
</tr>
<tr>
<td></td>
<td>• Overall environmental condition</td>
</tr>
<tr>
<td>Social</td>
<td>• Living conditions and well-being</td>
</tr>
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<td></td>
<td>• Employment in MRC water-related sectors</td>
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<tr>
<td></td>
<td>• Overall social condition</td>
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<tr>
<td>Economic</td>
<td>• Aggregate economic value of MRC water-related sectors</td>
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<tr>
<td></td>
<td>• Contribution to basin economy</td>
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<tr>
<td>Climate</td>
<td>• Greenhouse gas emissions</td>
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<td></td>
<td>• Climate change trends and extremes</td>
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<td></td>
<td>• Adaptation to climate change</td>
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<tr>
<td>Cooperation</td>
<td>• Equity of benefits from the Mekong River system</td>
</tr>
<tr>
<td></td>
<td>• Benefits derived from cooperation</td>
</tr>
<tr>
<td></td>
<td>• Self-finance of the MRC</td>
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</table>

Source: MRC (2019)

Wetlands and key river habitats

The State of the Basin report highlights the enormous historic loss of wetlands in the Mekong Basin, which is continuing unabated today, jeopardizing...
Capture fisheries production in the Lower Mekong Basin is higher than anywhere else in the world. In 1996, the MRC estimated annual production at one million tonnes including a small contribution from aquaculture, up from an earlier estimate of only 357,000 tonnes. The estimate was later raised to 1.5 million tonnes and then 1.9 million tonnes. Based on a recent study classifying aquatic habitats into broad zones — major flood zones, rain-fed zones and permanent water bodies — the “most likely” capture fisheries yield from the basin has been estimated at 2.3 million tonnes. The higher figure does not necessarily reflect increased production but tends to reflect better estimation methods.

Under the 2015 habitat-based approach, equal proportions of fish production (45 percent) derive from river-floodplain habitats in the major flood zone (moderate-high yield over a moderate area) and from rice fields and associated habitats in the rain-fed zone (low-moderate yield over a very large area). About 10 percent derive from reservoirs and other large permanent waterbodies outside the major flood and rain-fed zones. This does not include separate yields from the estuarine zone and so is probably conservative for some habitats.

Rain-fed habitats
The latest estimate of basin-wide yield of 2.3 million includes more than 1 million tonnes from “rain-fed zones” — mainly rice fields and other wetland crops and associated habitats outside the “major flood zone” (permanent water bodies including most major rivers, the Tonle Sap system and seasonally flooded land including recession rice fields).

These rain-fed habitats, mostly former forest areas, were found to generate low to moderate yields over large areas, especially in Thailand, where fisheries yields from such habitats were estimated to be as high as almost 700,000 tonnes and, to a lesser extent, Cambodia where such yields were estimated at 180,000 tonnes. The fisheries yield from unstocked rain-fed habitats has been estimated at 50-100 kg/ha/year. In Battambang Province in northwest Cambodia, a study of all wet-season catches at 10 river flooded rice fields of 25 ha each found average yields of 119 kg/ha/year with fish comprising 77 percent of the catch, and other aquatic animals 23 percent. Yields of more than 200 kg/ha/year have been reported from the Mekong system in northeast Thailand.

Agriculture is the main threat to fisheries yields in such rain-fed habitats (high-yielding rice varieties resulting in shallower water and increased use of pesticides). But it may be possible to maintain or even increase fisheries yields by maintaining water depths, improving connectivity, developing refuge ponds and promoting integrated pest management.

Reservoir fisheries
Reservoir fisheries outside the flood zone are estimated to contribute about 10 percent of the annual fisheries yield, or about 230,000 tonnes. Almost half of the yield from these water bodies comes from Thailand and a quarter from Lao PDR. Reservoir fisheries are often stocked with various species of fish and other aquatic animals.

In Thailand, stocking giant freshwater prawns has been particularly successful, especially at Pak Mun Reservoir in Ubon Ratchathani Province. To improve fisheries management and help reverse a long-term decline in fish catches, stocking has also been undertaken at Ubol Ratana Reservoir in Khon Kaen Province.

In Viet Nam, stocking has been considered a major part of reservoir fisheries for more than 50 years. Most of the species stocked are exotic. In the Central Highlands, stocking activities have been important to a fisheries co-management model pioneered by the MRC at Easoup Ha Reservoir in Dak Lak Province in 1999.

In Cambodia and Lao PDR, governments organize annual events in which stocking takes place. Cambodia stocked more than 33 million fingerlings at National Fish Day events between 2003 and 2013. These events focus on indigenous species. Cambodia has also stocked 130 tonnes of brood fishes in community areas and sanctuaries as well as 6 million prawns. In Lao PDR, stocking is widely practiced in both hydropower and irrigation reservoirs with a focus on seven native and seven exotic fish species.
The results of this new approach would enable development opportunities to proactively provide strategic guidance to national planning for the basin across all water-related sectors in line with the aims of the 1995 Mekong Agreement. Therefore, it is recommended that the adoption of a more proactive approach to basin planning and management of trade-offs by creating various platforms for enhancing the discussion and negotiation about the better basin planning including enhancing the benefit sharing among Member Countries and sectors and management of trade-off between sectors and countries are required.

(F) Maintain and strengthen cooperation with Dialogue Partners and other stakeholders

The MRC has long recognized the importance of maintaining active dialogue with its upstream riparian neighbors. As with managing interplay of competing demands and development impacts within the Lower Mekong Basin, so too must the MRC appreciate the development aspirations and challenges of its upstream neighbors in order to arrive at good outcomes that satisfy both upstream and downstream needs.

Given the range of short- and long-term issues identified in this report, it is recommended that cooperation with the Dialogue Partners is not only maintained but also further strengthened through the exchange of data and technical ideas and resources.

Further reading

State of the Upper Mekong Basin

Development of storage capacity in the Upper Mekong Basin in China has not only significantly altered river dynamics but also provides an unprecedented opportunity to manage almost one fifth of the overall Mekong flow volume.

The Upper Mekong Basin covers a surface area of 186,356 km² which corresponds to 23.2 percent of the entire basin. Over 88 percent lies within China and 11.6 percent in Myanmar. On average, China contributes about 18 percent of annual Mekong discharge with 1-4 percent coming from Myanmar.

In China, the Upper Mekong Basin has rapidly developed in recent years with land-use changes, industrial activities and hydropower construction and operation affecting the river in various ways. In particular, dam development has led to major changes in seasonal flows and sediment loads. Both are noticeable in the Lower Mekong Basin, with the impact on flow regime becoming progressively less visible further downstream. At Chiang Saen in Thailand — the most northerly mainstream monitoring station in the lower basin — average dry-season flow increased by 35 percent in 2010-2017 compared with a reduction of 31 percent in 2000-2009.

The commissioning of the Chinese reservoir cascade has also had a substantial impact on the sediment budget of the river, with clear reductions of 60-70 percent in sediment concentrations observed directly downstream of the main dams. This, along with sand mining in both the Upper and Lower Mekong mainstream, has implications across the ba-
The Big Picture (2)

Overall Mekong flow volume. This illustrates the importance of continuing efforts to strengthen cooperation between China and the lower riparian countries to ensure effective Upper and Lower Mekong basin-wide river basin management to allow for sustainability of all benefits provided by the river.

Further alterations of the flow regime are expected over the next decades, as rising temperatures due to climate change are projected to shift the snowmelt contribution to streamflow to earlier months. An additional dam cascade is planned in Xizang (northern part of the Upper Mekong), which will further expand storage capacity, although these reservoirs will only impact on a minor part of flow volumes from a basin-wide perspective. Dam development in the lower part of the basin in Yunnan Province can be considered largely complete, with about 10 dams, including two large storage reservoirs. Recent cancellation of the Mengsong Dam is regarded as positive for maintaining transboundary fish migration.

The development of storage capacity in the Upper Mekong Basin in China has not only significantly altered river dynamics but also provides an unprecedented opportunity to manage 18 percent of the overall Mekong flow volume. The Upper Mekong Basin in Myanmar is largely undeveloped as a consequence of its remoteness and social and political issues. However, in recent years, rapid land-use changes have seen a considerable part of previously natural forests converted to cropland, plantations and mining areas. Hydropower development has also started to take off. Data availability on environmental indicators is limited, although with four percent of Mekong streamflow contributed from Myanmar, the impact of developments on basin-wide hydrology is small.

The completed and planned development of storage capacity in the Upper Mekong Basin has significantly altered river dynamics, but also provides an unprecedented opportunity to manage a substantial part of the overall Mekong flow volume and thereby affect all water-related sectors, particularly in the upper reaches of the Lower Mekong Basin.
The Big Picture (3)

Alarming decline in sediment raises important questions

Addressing the problem of reduced sediment is one of six recommendations contained in the MRC’s State of the Basin Report released in October, 2019

Sediments provide nutrients and building materials that are beneficial for the ecology and development of the Mekong Basin, although they can have negative impacts on navigation and water use. Sediment concentrations are difficult to measure and vary substantially in time and place. The MRC’s Discharge Sediment Monitoring Project has found that the concentration and variability of suspended sediments in the Mekong have decreased considerably since 2001. At Chiang Saen in northern Thailand, sediment flows have decreased from about 85 tonnes to 11 tonnes a year meaning that sediment contribution from China has fallen to about 16 percent of all sediments in the Lower Mekong Basin, down from about 55 percent historically. A similar trend is seen downstream at Pakse in southern Lao PDR where average loads decreased from 147 tonnes a year in 1994 to 66 tonnes a year in 2013.

Changes in sediment concentrations — brought about by the construction of storage reservoirs, mainly in China — signal a substantial and seemingly permanent change in the river’s morphology. Impacts of these changes can be expected all along the river as it seeks to readjust to its new regime. Furthermore, few nutrients will reach the remaining wetlands and the delta and coastal building processes will be modified. At the same time, the trapping of sediments is expected to increase river erosion and significant bank protection work will be needed. Understanding how these changes will impact the river, the environment and the socio-economic development of the basin needs to be strengthened so that coping strategies can be determined.

Reduced sediment flows are proportionally greater in the upper parts of the Lower Mekong Basin but also substantial along the length of the mainstream — which is likely to be having deleterious effects in both Cambodia and Viet Nam. Sediments carried from upstream are critical to floodplain rejuvenation, carrying nutrients that support fisheries and agriculture. These sediments also help maintain the integrity of the Mekong Delta and buffer coastal erosion processes. No trend in salinity intrusion has been identified in the delta to date.

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'The decline in sediment loads is alarming and raises important questions about how to mitigate the impacts of current and future development projects on the mainstream and tributaries'

Given the importance of sediments to nutrient transport, erosion and deposition processes, maintenance of the delta, fisheries and agricultural production, the decline in sediment loads is alarming and raises important questions about how to mitigate the impacts of current and future development projects on the mainstream and tributaries.

Suspended sediment concentrations at Chiang Saen 1994-2013

Source: MRC Discharge Sediment Monitoring Project
Freshly-mined sand from the Mekong being used for a new housing development in Kandal Province in Cambodia

Photo: Lem Samean
Sediment loads and concentrations at four sites 2009-2013

**Source:** MRC Discharge Sediment Monitoring Project
projects on the mainstream and tributaries.

"Bed materials generally showed a reduction in grain size in a downstream direction, with the percentage of gravels decreasing and percentage of silts increasing"

An extensive bed material survey was conducted in 2011. The grain-size distribution of bed material reflected the flow regime at the time of collection, with fine material present at sites during low flow, and coarser material present during the wet season. In terms of spatial distribution, the bed materials generally showed a reduction in grain size in a downstream direction, with the percentage of gravels decreasing and percentage of silts increasing. Bedload composition was dominated by gravel, pebbles and coarse sand at Chiang Saen, fine and medium sand at Nong Khai and coarse to fine sand at Kratie in Cambodia.

A bedload monitoring program is currently in place for 17 stations. Five to ten bedload samples are collected from each site up to 17 times per year, with the sampler deployed at each point for one minute. Monitoring results for 2014 and 2015 are summarised above.

In the Upper Mekong Basin in China, the commissioning of a cascade of reservoirs has had a substantial impact on the sediment budget of the river. Reductions in sediment concentrations of 60 to 70 percent have been observed directly downstream of the main dams. This — along with sand mining in both the Upper and Lower Mekong (see page 16) — has implications throughout the mainstream down to the Mekong Delta and the coast. For the Lower Mekong Basin, the full consequences are yet to be seen.

Further reading

Mekong sand mining estimated to be worth at least $175 million a year

The MRC’s new State of the Basin Report finds that sand mining in the Lower Mekong Basin is driven by the construction and industrial sectors, especially for upgrading infrastructure in the Mekong Delta, and demand from Malaysia and Singapore. Sand mining is also expanding in the Upper Mekong Basin in China. Estimates of the volume and value of sand mining remain conservative. Below is a summary of the study in the flagship report released in October, 2019.

Sand mining in the Lower Mekong Basin (LMB) is extensive and provides a critical input into the construction and industrial sectors. Extraction of sand in the region has increased sharply with stronger demand from the rapidly developing riverine economies. Much demand has been driven by infrastructure upgrading in the Mekong Delta as well as export markets in Malaysia and Singapore.

Data for sand and sediment mining activities in the basin are not systematically collected. The best available data on the extent and economic output of the sector is a study by the Worldwide Fund for Nature (WWF) in 2013. Based on declarations by miners, it estimates that about 35 million square metres or 55.2 million tonnes were extracted from the Mekong mainstream in 2011. But miners have an incentive to underreport the amount of sediment extracted to avoid royalties and taxes. Given relatively weak government monitoring capabilities in the region, the figure is likely to be higher. Moreover, the study covered only the mainstream and did not cover extraction on Mekong tributaries. As such, the figure is illustrative of the likely scale of

A Cambodian sand-mining operation on the Mekong mainstream in Kien Svay District in Kandal Province, about 15 km downstream from Phnom Penh, in October, 2019

PHOTO: LEM SAMEAN
sand mining in the Lower Mekong Basin (LMB) but falls short of a realistic estimate of extraction in the basin as a whole.

The value of mined sand essentially consists of the price of extraction and transport and therefore varies significantly. To obtain a reliable figure, estimated sand values at extraction sites were used to obtain an overall output value. Global Witness estimated the value of sand at point of extraction in Cambodia at $3 a tonne in 2010. Assuming this price is applicable across the LMB and adjusting for price increases between 2010 and 2011, the total value of sand extraction reported in the table below is almost $175 million (in 2011 prices). However, this is only an unofficial estimate of mined sand extraction in the basin as a whole.

**Extraction of sand, gravel and pebbles**

Unofficial estimates of cubic metres per year (2011)

<table>
<thead>
<tr>
<th>Country</th>
<th>Sand</th>
<th>Gravel</th>
<th>Pebbles</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cambodia</td>
<td>18,748,503</td>
<td>2,044,940</td>
<td>0</td>
<td>20,793,443</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>904,100</td>
<td>10,000</td>
<td>454,500</td>
<td>1,368,600</td>
</tr>
<tr>
<td>Thailand</td>
<td>3,677,200</td>
<td>857,740</td>
<td>0</td>
<td>4,534,940</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>7,750,000</td>
<td>0</td>
<td>0</td>
<td>7,750,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>31,079,803</strong></td>
<td><strong>2,912,680</strong></td>
<td><strong>454,500</strong></td>
<td><strong>34,446,983</strong></td>
</tr>
<tr>
<td>%</td>
<td>90</td>
<td>8</td>
<td>1</td>
<td>100</td>
</tr>
</tbody>
</table>

From the dredging operation on the Mekong (opposite), water and sand are pumped about 2 km underground to this pond in a neighboring village near National Highway No 1, where the water is separated from the sand.

*Photo: Lem Samean*
From the pond, the sand resumes its journey, travelling under the highway for another 500 metres into a third village

Photo: Lem Samean
WWF research into the volume of sand mining was in collaboration with the MRC with funding from Finland, France and Germany. The WWF study estimated that a maximum of 30 million tonnes of sand was being transported by the Mekong each year — indicating that the annual extraction of 55 million tonnes left a deficit of 25 million tonnes.

In addition, “work in the delta showed that river channels had deepened by an average of 1.4 m between 1998 and 2008, with the changes not attributable to changes in flow or hydraulics,” the study said. The delta front experienced “extensive change” between 2003 and 2010, “with most areas recording erosion the changes consistent with the reduced delivery of sediment.” The study also found that the coastal sediment plume showed falling concentrations of suspended particulate matter and nutrients over the same period — with annual decreases averaging about five percent.

Data in the region and MRC Member Countries do not accept the figures in the table as official figures.

Official data for Cambodia from the Ministry of Mines and Energy in 2017 suggests a much lower level of sand and sediment extraction of around 10.2 million cubic metres. This figure is for both the Bassac and the Mekong rivers, but is less than half the WWF estimates for 2013. This difference is unlikely to be driven by changes in demand which if anything is likely to have increased. Rather, it may reflect policy changes between 2013 and 2017, or differences in data collection methods.

In the Upper Mekong Basin in China, sand mining is a growing business, driven by the extensive regional development of housing and infrastructure.

Further reading


Playing cards aim to raise fisheries awareness among students

The USAID-funded Wonders of the Mekong Project has added playing cards to the educational materials it’s developed since the project was launched with Cambodia’s Fisheries Administration in 2017 (see Catch and Culture, Vol 23, No 1). Other materials aimed at raising fish conservation awareness include coloring books for children and wall calendars. Card playing is a popular recreational activity in Cambodia, especially Tiến lên, a Vietnamese game that usually involves four players.

The cards include these four species assessed as critically endangered by the Switzerland-based International Union for the Conservation of Nature (IUCN). There are also three endangered, six vulnerable and six near-threatened species along with four fishes for which data are insufficient and 29 species assessed by IUCN as being of least conservation concern.

- **Giant salmon carp**
  - Scientific Name: Aaptosyax grypus
  - English Name: Giant salmon carp

- **Giant barb**
  - Scientific Name: Catlocarpio siamensis
  - English Name: Giant barb

- **Giant freshwater whipray**
  - Scientific Name: Himantura polylepis
  - English Name: Giant freshwater whipray

- **Mekong giant catfish**
  - Scientific Name: Pangasianodon gigas
  - English Name: Mekong giant catfish
How do scientists count and measure the body and parts of a fish that help distinguish one species from another? What are the terms used for the different body parts? This special educational supplement explains.

In June this year, the Inland Fisheries Research and Development Institute (IFReDI) of the Cambodian Fisheries Administration published a field guide covering 411 fish species. The fishes were collected and recorded from the Mekong river system and streams in the Cardamom Mountains in southwest Cambodia during extensive field surveys by IFReDI and Japan’s Nagao Natural Environment Foundation (NEF). The joint research team also engaged in fish biodiversity monitoring surveys supported by the Japan Fund for Global Environment (JFGE) and the Keidanren Nature Conservation Fund (KNCF), a public trust set up by the Japan Business Federation.

Environmental awareness
Faced with rapid environmental exploitation and deterioration of fish habitats, the field guide aims to develop management and conservation awareness and to advance conservation activities among local people. “To alleviate the loss of fish resources, environmental awareness is now quite important,” the introduction says. The following eight pages cover the first section of the 197-page guide — from the names of body parts and terms used to measure the body to more detailed descriptions of mouths, barbels, fins, scales and gills.

Names

**Head:** Region from the tip of the snout to the posterior margin of the gill cover

**Snout:** Region from the tip of the head to the anterior margin of the eye

**Trunk:** Region from the posterior margin of the gill cover to the anus

**Tail:** Region from the anus to the posterior margin of the hypural bone

**Caudal peduncle:** Region from the end of the anal fin base to the posterior margin of the hypural bone

Photo: IFReDI/NEF
**Measurements**

**Standard length (SL):** Distance between the tip of the snout and the end of the hypural bone

**Total length (TL):** Distance between the tip of the snout and the tip of the depressed caudal fin

**Body depth (BD):** Vertical distance between the topmost and bottommost points of the body

**Head length (HL):** Distance between the tip of the snout and the posterior margin of the gill cover

**Snout length (SnL):** Distance between the tip of the snout and the anterior margin of the eye

**Disc width (DW):** Distance between the leftmost and rightmost pectoral fins of stingrays
Mouths

Terminal

Superior

Subterminal

Inferior

Photo: IFReDI/NEF

Barbels

Nasal barbel: attached to nostril

Maxillary barbel: attached to upper jaw

Rostral barbel: located between nostril and upper jaw

Mandibular barbel: attached to lower jaw

Illustration: IFReDI/NEF
Fins

- Pectoral fin
- Pelvic fin
- Dorsal fin
- Caudal fin
- Anal fin
- Adipose fin
- First dorsal fin
- Second dorsal fin

Photo: IFREDI/NEF
Fin rays

Fish fins are usually supported by fin rays. The two types—hard rays (spines) and soft rays. If they exist, hard rays are always located before soft rays which are flexible.

Branched rays

Branched rays are a kind of soft ray that diverges into two or more parts. The base of rays (▼) should be used when counting. Eight branched rays are counted in the photo on the left.

Unbranched rays (simple rays)

Unbranched rays are a kind of soft ray that is simple (not branched). The last unbranched ray is usually the longest. It is sometimes stiffened and enlarged. In such cases, it is regarded as a spine.

Photos: IFReD/NEF
Caudal fin shape

Hypural bones are plate-like bones supporting the caudal fin. They are not visible externally but their ending points are approximate to the position the skin fold appears when the fin is bent.

Photo: IFReDI/NEF
**Scales**

**Lateral line (LL):** series of sensory pores on the side of the body

**Lateral line scales (LLs):** perforated scales running along the lateral line

**Longitudinal scale row:** scale rows along the mid-lateral line (*counted when LL incomplete or absent)*

**Predorsal scales:** scale rows along the mid-dorsal line before the dorsal fin

**Circumpeduncular scales:** scale rows around the caudal peduncle

**Scutes:** hardened and thorned scale rows along the mid-ventral line
Gill rakers are usually arranged regularly along the inner edges of gill arches. They vary both in shape and number according to species. In some, they are very long and close-set. In others, they are well-spaced and knob-like or absent. The status of gill rakers is stable in a species so they are often used for species identification. A gill arch is composed of two parts — an upper limb with fewer gill rakers and a lower limb with more. The number of gill rakers is usually counted on both limbs unless specified.
# Understanding the Terminology Used by Fish Taxonomists

Knowledge of Latin helps Native speakers of Romance languages like French or Spanish generally have few problems understanding terms used in taxonomic descriptions which are mostly derived from Latin, the language from which this group of languages evolved. Comprehension can be challenging for native speakers of other languages without knowledge of Romance languages or Latin as many of the terms appear to be obscure or somewhat archaic — notwithstanding their precision. Below is some of the jargon used in English accompanied by relevant definitions and the origins of the words.

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adipose</td>
<td>(especially of body tissue) used for the storage of fat</td>
<td>mid-18th century: from modern Latin <em>adiposus</em>, from <em>adeps</em>, <em>adip-</em> ‘fat’</td>
</tr>
<tr>
<td>Anterior</td>
<td>nearer the front, especially situated in the front of the body or nearer to the head</td>
<td>mid-16th century: from French <em>antérieur</em> or Latin <em>anterior</em>, comparative of <em>ante</em> ‘before’</td>
</tr>
<tr>
<td>Caudal</td>
<td>at or near the tail or the posterior part of the body</td>
<td>mid-17th century: from modern Latin <em>caudalis</em>, from Latin <em>cauda</em> ‘tail’</td>
</tr>
<tr>
<td>Dorsal</td>
<td>of, on or relating to the upper side or back of an animal, plant or organ</td>
<td>late Middle English: from late Latin <em>dorsalis</em>, from Latin <em>dorsum</em> ‘back’</td>
</tr>
<tr>
<td>Lunate</td>
<td>crescent-shaped</td>
<td>late-18th century: from Latin <em>lunatus</em>, from <em>luna</em> ‘moon’</td>
</tr>
<tr>
<td>Mandibular</td>
<td>the jaw or a jawbone, especially the lower jawbone in mammals and fishes</td>
<td>late Middle English: from Old French, or from late Latin <em>mandibula</em>, from <em>mandere</em> ‘to chew’</td>
</tr>
<tr>
<td>Maxillary</td>
<td>of or attached to a jaw or jawbone, especially the upper jaw</td>
<td>early-17th century: from maxilla, probably suggested by Latin <em>maxillaris</em></td>
</tr>
<tr>
<td>Pectoral</td>
<td>relating to the breast or chest</td>
<td>late Middle English (in the sense ‘breastplate’): from Latin <em>pectorale</em> ‘breastplate’, <em>pectoralis</em> ‘of the breast’, from <em>pectus, pector-</em> ‘breast, chest’</td>
</tr>
<tr>
<td>Peduncle</td>
<td>a stalklike part by which an organ is attached to an animal's body, or by which a barnacle or other sedentary animal is attached to a substrate</td>
<td>mid-18th century: from modern Latin <em>pedunculus</em>, from Latin <em>pes, ped-</em> ‘foot’</td>
</tr>
<tr>
<td>Posterior</td>
<td>further back in position; of or nearer the rear or hind end, especially of the body or a part of it</td>
<td>early-16th century (as a plural noun denoting descendants): from Latin, comparative of <em>posterus</em> ‘following’, from <em>post</em> ‘after’</td>
</tr>
<tr>
<td>Rostral</td>
<td>situated or occurring near the front end of the body, especially in the region of the nose and mouth or</td>
<td>early-19th century: from rostrum + al mid-16th century: from Latin, literally ‘beak’ (from <em>rodere</em> ‘gnaw’). The word was originally used (at first in the plural rostra) to denote part of the Forum in Rome, which was decorated with the beaks of captured galleys, and was used as a platform for public speakers.</td>
</tr>
<tr>
<td>Truncate</td>
<td>(of a leaf, feather or other part) ending abruptly as if cut off across the base or tip</td>
<td>late-15th century (earlier (Middle English) as truncation): from Latin <em>truncat-</em> ‘maimed’, from the verb <em>truncare</em></td>
</tr>
<tr>
<td>Ventral</td>
<td>of, on or relating to the underside of an animal or plant</td>
<td>late Middle English: from Latin <em>venter, ventr-</em> ‘belly’ + al</td>
</tr>
</tbody>
</table>

*Source: Dictionary Version 2.2.2 (203), Apple Inc*
Thai company gets THB 3 bln from ADB for country’s largest wind farm

Bank says Hanuman wind farm in Chaiyaphum Province in northeast Thailand is expected to reduce country’s annual carbon emissions by 200,000 tonnes by 2020

The Asian Development Bank (ADB) has announced plans to invest THB 3 billion ($100 million) in a THB 10 billion green bond issue by Thailand’s Energy Absolute Public Co Ltd to help support the long-term financing of the company’s 260-MW Hanuman wind farm in northeast Thailand. “The investment will contribute to Thailand’s renewable energy objectives and its ongoing efforts to reduce carbon emissions,” the ADB said. The bank said the agreement was signed in Bangkok on 17 October by Christopher Thieme, deputy director general of the ADB’s Private Sector Operations Department, and Amorn Sapthaweekul, deputy chief executive officer at Energy Absolute.

“It will only be the second Climate Bonds Standard-certified bond issued by a Thai energy company and the first green bond for a wind power project in Thailand,” the ADB said. “The Climate Bonds Standard is a science-based international labeling scheme for debt investments used by bond issuers, governments, and investors to assess investments which genuinely help to address climate change.”

Mr Thieme said Thailand had “ample” renewable energy resources. “Its green and climate bond market has tremendous potential,” he said. “This maiden green bond issuance by Energy Absolute will contribute to the evolution of that market, while supporting the clean energy ambitions of Thailand’s Power Development Plan by underpinning the growth of wind power generation.”

‘Lower cost of financing’
Mr Sapthaweekul said the green bond issue “benefits our company through lower cost of financing and demonstrates our strong commitment to sustainable development including environmental and social dimensions.” After the success of the Hanuman project, “we took another significant step to become a more value-added business by focusing more on patent development and innovation in clean energy and related industries including energy storage systems, electric vehicles (EV) and EV charging stations, and electric ferries,” he said. “We are also preparing to launch an energy trading platform, which we have studied and developed through our own technology and innovation. This platform will play a major role in demand-side management for energy efficiency.”

The ADB said renewable energy sources were expected to contribute 15 to 20 percent of Thailand’s energy production by 2036, up from the current 10 percent. The Hanuman wind farm in northeastern Chaiyaphum Province is the largest wind farm in Thailand and is expected to reduce the country’s annual carbon emissions by 200,000 tonnes by 2020.
Green bonds

Hanuman Wind Farm in Chaiyaphum Province in northeast Thailand

PHOTO: ADB/ENERGY ABSOLUTE

‘Feeding more than 200,000 households’
Established in 2006, Energy Absolute is one of the largest renewable energy companies in Thailand with an installed capacity of 664 MW at four solar and two wind power plants. The bank said its strategy was aligned both with Thailand’s industrial development and climate targets and with ADB’s Strategy 2030 — under which at least 75 percent of the bank’s committed operations will support climate change mitigation and adaptation by 2030. ADB’s climate financing is expected to reach $80 billion over 2019-2030.

Energy Absolute said the THB 20 billion Hanuman project was “approximately” complete in early 2019 and that it would be feeding more than 200,000 households.

In December 2018, the ADB announced plans to invest THB 5 billion in green bonds issued by Thailand’s B. Grimm Power Public Co Ltd, the first certified climate bonds issued in Thailand. Proceeds were earmarked for nine operational solar power plants with a capacity of 67.7 MW and seven solar plants under construction with a capacity of 30.8 MW. This was the ADB’s second green bond project — the first being a guarantee to support a green bond issue for a geothermal power project in the Philippines in 2016.

Further reading


Study finds ‘great potential’ for using drone technology in fisheries science

Scientists in the American state of Louisiana have found that fisheries research would benefit significantly from broader use of emerging drone technology. Recalling that satellite and aircraft-based remote-sensing technology in past decades has improved understanding of large-scale spatial patterns and processes, the scientists conclude that drone technology could put those tools in the hands of individuals for similar research at a fraction of the cost. Published in Transactions of the American Fisheries Society in July, their study includes guidelines for drone projects — from choosing the platform and sensors to data acquisition and analysis. The summary of the study below focusses on how drones are being used in fisheries research and potential future research directions.

Drone use has recently increased across many scientific disciplines. From highly applied research in agriculture and inspections to basic research in ecology and geology, drones offer a unique opportunity to collect data that was either very costly or impossible before. The prospect of high-frequency, high-quality, low-cost data is appealing. But determining the right drone platform, sensors, and data-processing pipeline can create a high barrier to entry for many researchers.

One of the most significant advances in drone technology in recent years is the automation of flight controls and flight planning in nearly every mid to high-end platform available today. The levels of automation and flight stability now available let researchers deploy remote-sensing equipment — traditionally limited to satellites and larger aircraft.

Multispectral photography, thermal imagery, light detection and ranging (LIDAR), and other sensors can now be deployed using drones with higher resolution and lower costs than ever before. As the platforms and sensors become less expensive and easier to use, processing and analyzing drone data have emerged as the primary bottleneck. Data processing is often the costliest and most time-consuming aspect of any drone project. It is therefore critical to thoroughly plan projects so final deliverables meet objectives of research questions and drive platform choice and analytical process to ensure project success.

Two primary uses
In fisheries research, drones are used for two primary purposes — to delineate habitats and provide high-quality evaluations, and to catalog the occurrence of species or individuals. Both coastal and rapidly moving freshwater environments have seen increased use of drone technology to identify and map critical habitats including tidal wetlands, fish nursery grounds, inlet topography, coastline mapping, channel morphology, river bathymetry, restoration monitoring and physical habitat assessments. These data streams can then be used for management tasks from identifying critical nursery habitats to determining sites for remediation and removing invasive species. Using drones to identify individuals and species for abundance and telemetry information is mostly done for megafauna like whales and sharks. The primary advantage of drones is the area covered and the field of view. Outside of megafauna studies, the literature for fisheries population assessments is limited, although such surveys would be possible, particularly in clear coastal waters or stream ecosystems.

Animal response
Unmanned aircraft systems present a minimally invasive means to study animals. But researchers should exercise caution to ensure that they do not become a new source of disturbance for wildlife. Noise and visual cues such as shadows are the two primary types of disturbance. Response level depends on many factors, including aircraft type and size, flight altitude, and the organism’s life stage and state — migrating, breeding, feeding or resting, for example. Negative reactions to drones have been documented for birds, reptiles and mammals. Marine mammals show a broad range of responses to different platforms, approaches and proximities. Individual and species-specific responsiveness requires caution and quality documentation of how
animals are affected by drones. Due to the limited understanding of undesirable impacts caused by low-altitude flights, we must strive to reduce the risk of disruption, report positive and negative observational responses and continue to develop criteria for best possible practices in field research.

Limitations
New technology comes with new obstacles and challenges. Although now easier to use, drones are still constrained by many practical limitations. Like other air-borne platforms, drone operations can be significantly impacted by environmental conditions. Flights require fair weather, and many surveys need good sunlight. Moderate cloud cover and humidity degrade image quality and can limit the detection of individuals. Wind strength varies with altitude, and sustained speeds greater than 24.14 km/h quickly deplete batteries. Short battery life and flight duration remain issues with many drone platforms. Additional batteries are usually necessary — especially with multi-rotor drones — and some projects require a field-charging system. Regulations requiring visual line of sight (VLOS) significantly restrict survey range. An aircraft's visible distance is unique to daily environmental conditions, the type and size of the vehicle and an individual pilot's ability to maintain visual contact. A small multi-rotor drone flies out of eyesight typically between 500 and 900 m and a mid-sized model does so at around 1-2 km. But unfavorable weather greatly reduces these distances. Strobe lights can be added as visual aids, but flights

Drone view of a Lao stretch of the Mekong that includes the Kengmai Rapids, located upstream from the capital in Vientiane. Fishbio established a fish conservation zone covering nearly 5 km of the river in four villages — Ban Donmen and Ban Houayla in Xayabouri Province and Ban Donsok and Ban Phalat in Vientiane Province.

PHOTO: DEE THAO/FISHBIO
are still restricted to daylight or twilight, prohibiting any nocturnal analysis. Airspace regulation is another limiting factor.

**Challenges**

Advances in new technology beckon resource managers and scientists to ask and answer new questions about ecological processes. Unmanned aircraft systems have revolutionized spatial ecology with the arrival of high-resolution data, low operating costs, and repeatability with user-determined survey times. Platforms, data processing and analytical tools are easily available to practitioners of any experience level. Data previously unattainable can now be readily produced with this technology. Although barriers to entry are lower than ever before, the technology does not come without challenges. Burden of regulation, short flight durations, limited payload capacity and difficulties in processing large data sets all hinder expansion. Improvements in hardware and software are addressing many of these concerns. A key part of the process is to identify fundamental questions before flights and to think of a drone as a true remote-sensing tool with the same capabilities as aircraft and commercial satellites but on a local scale and within reach of almost any researcher.

**Surveying underwater with drones**

Fluid lensing is an experimental algorithm that uses water-transmitting wavelengths to survey underwater objects with drones and multispectral sensors to create habitat maps and 3D bathymetry models at centimetre-scale accuracy. The fluid-lensing algorithm helps to remove refractive distortions in imagery caused by surface waves and produces a depth estimate for use in combination with the structure-from-motion photogrammetry approach, allowing the creation of 2D and 3D underwater scenes.

The technique has been applied to coral reef ecosystems and is limited by water clarity, irradiance and depth (about 10 m). Reconstructions have allowed for delineation of bleached coral from living coral, fish identification and fish size estimation (about 20 cm), and documentation of morphologically distinct stromatolites (calcareous mounds built up of layers of lime-secreting cyanobacteria and trapped sediment, found in the earliest known fossils and still being formed in lagoons in Australasia). This method has the potential to revolutionize monitoring and management of shallow-water environments through rapid, low-cost habitat and species surveys. Fluid lensing has counterparts in imagery processing for other remote-sensing configurations. But many novel processing techniques for drone data are still in their infancy.

**Further reading**


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**Photo: Sor Sovann**

Flying drones is prohibited around the Cambodian National Assembly
surface habitats are examples of novel post-processing techniques that can provide greater insight into critical questions in fisheries research.

Drones provide tremendous opportunities for fisheries managers to improve resource monitoring through real-time survey information — such as information on fishing gear, boat/fisher counts and socioeconomic data — and to combat illegal, unreported and unregulated fishing. Protected areas would benefit from more observation to preserve biodiversity and uphold conservation goals. Many nations have incorporated drones into law-enforcement frameworks. Although passive surveillance helps document unlawful behavior, it can come at the cost of privacy for others. Drones can also improve monitoring and documentation of cultural fishing practices, thus better preserving artisanal or subsistence tradition and heritage. These methods can also be used globally for determining effort of remote or recreational fisheries.

'The primary use of drones and the most beneficial products will be determined by where the technology goes in the next few years'

There is great potential for the use of drone technology in fisheries science. The primary use of drones and the most beneficial products will be determined by where the technology goes in the next few years and by the efforts of scientists in taking the next steps with the data. Post-processing analysis is pivotal to further this technology’s contribution to the field. Drones offer safe and affordable methods to study ecological phenomena at higher resolutions and on spatial and temporal scales that are unattainable with satellites or manned aircraft. Technological improvements with platforms and automated flight planning combined with modern processing and analytical software present researchers across all disciplines with powerful tools at a low barrier to entry.

'A viable option for anyone'

Drones can help to fill a niche in scientific remote-sensing and supply spatial information for wildlife surveys, aquatic habitat maps, water resource and disturbance event monitoring and socioeconomic analysis. Future developments in sensors, post-processing software and algorithms as well as automation in animal detection will continue to refine procedures and strengthen results. Increased freedom in flight restrictions with regard to VLOS rules would provide greater opportunity for pilots. In the United States, the Federal Aviation Administration maintains that the aircraft must stay close enough to be seen by the operator without the use of visual aids other than corrective lenses. Although challenges remain, modern technology and the current regulatory environment have made using drones a viable option for anyone.

Drone use in the Mekong region

Fishbio Inc, a fisheries and environment consultancy based in California, says it’s experimented with drones for salmonid surveys in hard-to-access locations, mapping floodplain habitats and collecting topography data for potential river restoration sites.

“Online services like Drone Deploy make it possible to upload hundreds of images that can be merged and overlaid on known points to create very accurate maps,” the company wrote in a blog on 2 September.

Fishbio operates from three locations in California and also has an office in Vientiane. In addition, the company has partnered with the USAID-funded Wonders of the Mekong project launched with the Cambodian Fisheries Administration in 2017 (see Catch and Culture, Vol 23, No 1).

The project started using a drone in early 2018—a Mavic model made by DJI, a private Chinese company based in Shenzhen. “We aren’t actively using drones for research,” said Zeb Hogan, lead coordinator an investigator for the project. But Dr Hogan, a research professor at the Global Water Center at University of Nevada, Reno, said the project had been getting “great photos and video” for outreach activities in Cambodia, which have been focussing on local schools, fishing communities and the media.

Further reading

Translating the needs of inland fisheries into irrigation decisions to end hunger

A study published in the journal Marine and Freshwater Research in August looks at whether the UN’s Sustainable Development Goals (SDGs) for 2030 can translate the needs of inland fisheries into irrigation decisions. The study notes that inland fisheries play an important role in supporting many SDG objectives — but that these contributions can sometimes be at odds with irrigated agriculture. Using case studies of the Lower Mekong Basin and the Murray–Darling Basin in Australia, the authors highlight conflicts and opportunities for better outcomes between irrigated agriculture and inland fisheries. Below is a summary of the case study on the Lower Mekong and a discussion of how SDG 2 (Zero Hunger) can help advance irrigation to benefit both agriculture and inland fisheries, preserving biodiversity and enhancing the economic, environmental and social benefits they both provide to people.

With economic growth in Thailand and the renovation periods starting in Viet Nam and Cambodia in the 1980s, agricultural production and productivity in the Mekong Delta increased rapidly. However, this traditional rice-growing system produced low yields. Higher-yield varieties of rice with shorter growing periods of three months were introduced into the Lower Mekong Basin (LMB) to supply growing needs for local consumption and export. These high-yield rice varieties can grow up to three crops per year.

But to support the farming practices, there has been an unprecedented boom in irrigation expansion across the LMB (Hoanh et al. 2009). Extensive canals and sluice gates have been built to transport water from the Mekong River to rice fields. Dyke systems have been constructed to protect both seasonal and permanent crop systems from flooding. For example, over 13,000 km of dykes were built to protect rice investment in redundant research or, worse still, the application of less-than-optimal technologies well behind current best practices. Irrigation across the Mekong is already significantly affecting fish migration routes and modifying natural hydrology (Amornsakchai et al. 2000). Disrupting these movements further will add to the existing adverse effects on the productivity of fisheries that rely on more natural conditions. A significant, often unacknowledged, issue is the substantial diversion and abstraction of water resources. There are potentially millions of fish moved from main river channels into unproductive irrigation systems annually (Baumgartner et al. 2009). But the scale and extent of this problem is not being investigated. Protocols to manage water gates to benefit fisheries and biodiversity while maintaining rice production need to be developed (Hoggarth et al. 1999).

In addition, properly designed fish-passage facilities should be promoted to improve access for migratory fishes to irrigated systems. For example, some fishways have been engineered in the LMB to allow fish to migrate around obstructing irrigation barriers, either upstream or into flood plains for spawning and feeding. Linked to this need, the effectiveness of fishways needs to be assessed to improve design and operation (Baumgartner et al. 2014). In addition, local governments, fisheries experts and donors should make a greater effort to share lessons learnt from other river basins and solve existing challenges in the LMB.

The role inland fish and fisheries play across the LMB is considerable, because it contains the most productive inland fishery in the world. That said, irrigation, hydropower, industrial and agricultural pollution and aquaculture are all proliferating (Baumgartner et al. 2014). They have the potential to support or damage progress towards SDGs depending on whether or not those activities progress...
Fish and irrigation

Existing irrigation headworks and reservoirs in the Lower Mekong Basin

SOURCE: MRC IRRIGATION DATABASE IMPROVEMENT FOR THE LOWER MEKONG BASIN (2018)
at the expense of the health of the river and wild capture fisheries. The goal should be for sustainable development of the region so that new farming and aquaculture activities add to an already productive system.

**Ending hunger**

Fish and irrigation both provide a strong contribution to achieving the eight targets of Sustainable Development Goal 2 (Zero Hunger) and underpin food security (Hussain and Hanjra 2004; Lynch et al. 2017). To end hunger, improvements are needed in agriculture and aquaculture systems. Likewise, aquatic ecosystems need to be restored and maintained to sustain wild-capture fisheries and other services. If there is a strong focus on irrigation, the negative effects on capture fisheries may negate the benefits from investments in improving irrigation practices. However, optimising irrigation interventions can help reduce impacts on fisheries while increasing agricultural production.

Desirable irrigation practices can include ecologically minded modernisations to water capture, diversion, delivery and storage as well as managing drainage and return flows, facilitating multiple-use systems and ecologically sensitive application of fertiliser and pesticides. In some cases, decision makers may even decide that no irrigation is the most appropriate course of action — more value in keeping the water in the main river channel for other ecosystem services, for example. These approaches can facilitate a true ‘win–win’ outcome in that by optimising the system holistically, human nutrition, livelihood and well-being benefits can exceed what they would have if each sector operated in a silo. The SDGs provide the framework for local and national governments, as well as development
Need for greater collaboration
The current era of extensive irrigation expansion compromises many fisheries priorities. This should be compelling decision makers to devise progressive policies that address environmental sustainability, food security, economic and social wellbeing. Growing local, national and international commitment to the SDG agenda presents an opportunity to accelerate the changes that are needed. Inland fisheries is a sector that urgently needs to be incorporated into environmental governance strategies to protect and restore broader ecosystem services — such as water and environmental integrity, land and watershed rehabilitation, reforestation, wetland management, water and nutrient cycling, water storage and carbon sequestration (Gregory et al. 2018). If properly planned and implemented, these integrated policies will positively affect freshwater environments and directly or indirectly benefit inland fish and fisheries and the communities that depend on them for their livelihoods, food security, health and well-being.

It can be difficult to initiate policy reforms that seek to rebalance the social, economic and ecological needs across large and complex river basins. Irrigation has and will continue to support economic development and reduce hunger and poverty globally; the opportunity through the SDG framework is to ensure this is done without detriment to fisheries productivity and the wider environment. Greater collaborative links between irrigation, fisheries and other natural resource agencies will be required to ensure that increased food production from irrigation can occur without further compromising fisheries production and the aquatic environment that is already under immense pressure (Ramsar 2017). Establishing these links is essential if a holistic approach is to be developed as a major contribution to meeting the demands of growing populations by achieving SDG 1 (No Poverty) and SDG 2 and other development and biodiversity goals.

Further reading

References


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Student awarded for developing bioplastic bags from fish waste

Inventor says material from fish skins and scales bound with red algae biodegrades faster and more easily than polylactic acid bioplastic that needs special industrial facilities to decompose

Britain’s James Dyson Foundation announced in September that a University of Sussex student had won its national design award for inventing a home-compostable material from fish waste and algae as an alternative to single-use plastic films found in packaging. In a statement, the foundation said the translucent and flexible sheet material did not require special infrastructure for disposal and could biodegrade in four to six weeks. The material is “stronger, safer and much more sustainable” than plastic and relatively low tech with production requiring comparatively low temperatures of less than 100 °C.

Fully biodegradable at home
The foundation said the material, known as MarinaTex, was stronger than low-density polyethylene or LDPE (see box on page 41). It could also compete with polylactic acid (PLA) bioplastics (see page 44). PLA bioplastics “can only be composted in specialised industrial facilities and have been contaminating mainstream facilities resulting in compostable waste being sent to landfill.” MarinaTex, on the other hand, “can fully biodegrade in home food recycling bins or home composts without leaching toxic chemicals into the environment.” Due to its different chemical structure, the material will not contaminate mainstream facilities and will divert waste from landfill.

Lucy Hughes, the fourth-year product design student who developed the material, said she was motivated to address the problem of badly used plastic and single-use plastics after hearing reports that there would be more plastic in oceans than fish by weight by 2050. “Plastic is an amazing material,” she said. “However, we have become too plastic happy and design only for the use of the product, which can sometimes be a fraction of the product’s overall lifespan.” Another motivation was the global fishing industry’s annual production of an estimated 50 million tonnes of waste, she said.

Skins, scales and red algae
The 23-year-old student from Twickenham said she began her research by visiting a fish processing plant and wholesaler. “I went there with the intention of identifying their waste streams to see if I could add value to the waste and keep it from landfill,” she said. “The waste identified varied from offal, blood,
Polyethylene was discovered by accident in the 1930s by Britain’s Imperial Chemical Industries (ICI), now part of Dutch paint and coatings company AkzoNobel. The discovery followed research into a waxy solid formed by high-pressure experiments by ICI scientists who heated ethylene and benzaldehyde to 170°C in 1933. The reactions were so explosive that ICI halted the research. But ICI scientists reinvestigated the experience using ethylene alone in 1935.

"I’ll never forget the day we realised we’d got something pretty important," ICI researcher Edmund Williams reportedly told a British magazine in 1961. "We’d been heating a certain substance to well over boiling point. For once it didn’t explode — usually it did — and we thought something must be wrong. So we left it to cool overnight. And when I looked inside the metal container the next day, I found what looked like a lump of sugar. In fact, that ‘sugar’ was polyethylene." The material developed by ICI later became known as low-density polyethylene (LDPE).

Today, one of the largest markets for LDPE is film for packaging, according to the British Plastics Federation. “Low cost, ease of sealing and good product protection have helped to make film the largest polyethylene market,” the federation says.

German market research company Ceresana estimates that global LDPE revenues were almost $33 billion in 2013 and forecasts annual sales to increase by 1.5 percent until 2021. The Konstanz-based company — which researches chemicals, plastics, packaging and industrial goods — estimates that LDPE film production accounts for more than 60 percent of demand with packaging films occupying the the largest market share in this sector. “Bags and sacks as well as other films rank second and third,” it says.

'Countries are increasingly adapting to Western standards for packaged food'

Ceresana says the biggest growth markets are in Asia, especially China and India, along with the Middle East. “The markets for LDPE in Western Europe and North America, on the other hand, are largely saturated and will thus grow only slowly in the future,” it says. The Asia-Pacific region alone processed about 7.1 million tonnes of LDPE in 2013 of which about 58 percent was consumed in China. Asia is seen as having the largest growth potential for LDPE. “Asian countries are increasingly adapting to Western standards for packaged food,” the company says.

Further reading


https://www.bpf.co.uk/plastipedia/polymers/LDPE.aspx

Hughes said she then started experimenting with different organic binders including chitosan from crustacean & shellfish exoskeletons and fish skins & scales. From these different wastes I needed to first understand the composition and potential of each waste. After researching the waste streams, I found that the fish skins and scales had the most potential locked up in them due to their flexibility and strength-enabling proteins.

Hughes said she then started experimenting with different organic binders including chitosan from crustaceans and agar from red algae. “I wanted the binder to be from the sea to keep the solution localised thus reducing transportation,” she said. "It took over 100 different experiments to refine the material and process. Once this produced a constant and plastic-like outcome, I then looked into best applications. As the material is biodegradable and translucent, the most impactful alternative applications were single-use plastics." According to Hughes, the 6.8 kg of waste produced by a 12-kg Atlantic cod (Gadus morhua) is enough to produce 477 shopping bags. It was not clear if Hughes ex-
Plastic bags dominate household garbage tossed into a backwater of the Mekong in Kok Prak, about 15 km downstream from Phnom Penh

Photo: Chhut Chheana / Wonders of the Mekong

Plastic debris in Mogan Village in Ranong Province in Thailand

Photo: Siriporn Sriaram/IUCN

Plastic garbage on a Lao branch of the Mekong at Ban Hat, 22 km upstream from the Lao-Cambodia border

Photo: Kent Hortle

Plastic garbage on a branch of the Mekong in Tân Hoà District in Vĩnh Long Province in Viet Nam

Photo: Nguyễn Huỳnh Duy
experimented with the fins or scales of fish species other than cod. Nor was it clear which species of red algae she used as the binding agent.

**Invention also wins international award**

As *Catch and Culture - Environment* was going to press, the James Dyson Foundation announced on 14 November that Hughes had won its international prize in addition to the national award for Britain and that the student would receive £30,000 for further research. “I’m so delighted,” Hughes said. “The invention is still in its infancy and I never thought it would make it to this stage, so it’s really encouraging to have the potential of the material acknowledged by such a prestigious award.

The student said her future plans included getting funding for more research into mass manufacturing. She also wants to develop a business plan with full legal protection of the material and process while doing more research into the material’s performance under different conditions. Other priorities are acquiring more precise equipment for tweaking her formula, developing a website and getting certifications in areas such as food safety, allergies, biodegradability and nutritional value since the material is edible. “I hope that this material could be a viable alternative to plastic in various applications,” she said. “This means that the production costs would be low and the production could be applied globally whilst remaining sustainable.”

The University of Sussex announced the invention in June, identifying the fish processor Hughes visited as MCB Seafoods Ltd, a sustainable fishing company in Newhaven that markets both marine and freshwater species including striped catfish (*Pangasianodon hypophthalmus*) native to the Mekong. “The issue I faced during development was that the sheets I made without the fish waste seemed to revert back into a crinkled seaweed shape,” she told the university’s online newspaper. “I needed to find a material that would make the formula more consistent. I challenged myself to find a material that was from a local waste stream.” After experimenting with mussel and crustacean shell, she eventually settled on waste from fish. The newspaper said Hughes was optimistic that — with the right support — the product could be ready for market in little over a year.

The James Dyson Foundation is a British charity that works in 27 countries and regions. Its major focus is Britain, the United States, Japan, Malaysia and Singapore. The foundation was established in 2002 by engineer Sir James Dyson, the founder of Dyson Ltd, a privately owned Wiltshire-based company that designs household appliances. Sir James is reportedly moving the company headquarters from the English town of Malmesbury to Singapore.

**Further reading**


New bioplastics plant in Thailand certified for using sustainable sugar

Dutch-French venture in Rayong uses sugar cane to produce biodegradable polylactic acid materials

Polylactic acid (PLA) is a thermo-plastic polymer based on renewable resources, usually cornstarch broken down to glucose. The sugar is fermented to lactic acid which is chemically converted to lactide. PLA has properties similar to polystyrene. Stiff and transparent, it is suitable for bottle, cups, packages and films. PLA is also non-toxic.

But PLA plastic suffers from several drawbacks including low impact strength, poor barrier properties and low heat resistance in its amorphous state. The material is biodegradable through hydrolysis in high humidity at elevated temperatures but will not quickly degrade in homes where temperatures are typically much lower.

Despite the drawbacks, a 50-50 joint venture between Dutch biochemicals company Corbion and French energy giant Total opened what was described as the world’s second-largest PLA bioplastics plant in Thailand in late 2018. Located in Rayong, the plant uses sugarcane as the source material and has a production capacity of 75,000 tonnes of PLA a year. To supply the new plant, Corbion — the world’s biggest producer of lactic acid, lactic acid derivatives and lactides — expanded a neighboring lactide plant to increase capacity from 75,000 tonnes to 100,000 tonnes.

“People are increasingly concerned about the impact of conventional plastics on our natural resources, and believe the work they are part of will help make a critical difference in the way the world shapes a more sustainable future,” the Dutch company says. “Efficient, renewable solutions such as PLA bioplastics inspire confidence in the idea of a truly achievable circular economy.”

'Production standard for smallholder farmers'

Corbion announced this year that it started buying sugar from Saraburi Sugar Co Ltd which adheres to the Bonsuco Production Standard for Smallholder Farmers, developed by a London-based group with more than 500 members in over 40 countries Saraburi — part of the Thai Roong Ruang Sugar

Lactide monomers (left) used to make PLA resins (right). Total Corbion has four categories including high-heat PLA for demanding applications, standard PLA for general applications and low-heat PLA typical used a seals. The fourth category has industrial applications.

PHOTOS: TOTAL CORBIION PLA
Group which owns nine sugarcane mills — estimates that 83 percent of Thailand’s sugarcane growers are smallholders. The company says the Corbion-Total PLA venture was one of the first buyers of Bonsucro-certified sugar from its mill in central Thailand.

For its part, Total says its PLA venture with Corbion in Thailand is part of the French company’s refining and chemicals strategy which includes “innovating in low carbon activities by developing biofuels, biopolymers and plastics recycling solutions as well as materials contributing to the energy efficiency of the group’s customers.”

Further reading


https://www.bonsucro.com/

https://spark.adobe.com/page/ds39uAZUwVIvB/
**Prices**

**FAO Fish Price Index**

Norwegian Seafood Council (2002-2004 = 100)

<table>
<thead>
<tr>
<th>Year</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>Change 2019/2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan-Sep</td>
<td>156</td>
<td>158</td>
<td>156</td>
<td>-2.1</td>
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</table>

**Production, trade, utilisation and consumption**

FAO Food Outlook, November, 2019

<table>
<thead>
<tr>
<th>Category</th>
<th>2017</th>
<th>2018 Estimate</th>
<th>2019 Forecast</th>
<th>Change 2019/2018</th>
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<tbody>
<tr>
<td>Million tonnes</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>172.6</td>
<td>177.7</td>
<td>177.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Capture fisheries</td>
<td>92.5</td>
<td>94.5</td>
<td>91.3</td>
<td>-3.4</td>
</tr>
<tr>
<td>Aquaculture</td>
<td>80.1</td>
<td>83.2</td>
<td>86.5</td>
<td>3.9</td>
</tr>
<tr>
<td>Trade value (exports USD billion)</td>
<td>155.7</td>
<td>163.1</td>
<td>160.5</td>
<td>-1.4</td>
</tr>
<tr>
<td>Trade volume (live weight)</td>
<td>64.9</td>
<td>65.1</td>
<td>64.5</td>
<td>-1.2</td>
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<tr>
<td>Total utilisation</td>
<td>172.6</td>
<td>177.7</td>
<td>177.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Food</td>
<td>153.4</td>
<td>155.7</td>
<td>158.2</td>
<td>1.6</td>
</tr>
<tr>
<td>Feed</td>
<td>14.6</td>
<td>17.5</td>
<td>15.0</td>
<td>-14.2</td>
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<tr>
<td>Other uses</td>
<td>4.7</td>
<td>4.6</td>
<td>4.6</td>
<td>0.0</td>
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<tr>
<td>Consumption per person</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Food fish (kg/yr)</td>
<td>20.3</td>
<td>20.4</td>
<td>20.5</td>
<td>0.6</td>
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<tr>
<td>From capture fisheries (kg/year)</td>
<td>9.7</td>
<td>9.5</td>
<td>9.3</td>
<td>-2.0</td>
</tr>
<tr>
<td>From aquaculture (kg/year)</td>
<td>10.6</td>
<td>10.9</td>
<td>11.2</td>
<td>2.8</td>
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### Prices

#### Thailand

<table>
<thead>
<tr>
<th>Species</th>
<th>Size Description</th>
<th>August, 2019</th>
<th>November, 2019</th>
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</thead>
<tbody>
<tr>
<td>Chinese edible frog (Haploidobatrachus rugulosus)</td>
<td>(large)</td>
<td>80 - 90</td>
<td>80 - 90</td>
</tr>
<tr>
<td>Chinese edible frog (Haploidobatrachus rugulosus)</td>
<td>(small)</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Asian redtail catfish (Hemibagrus wyckoides)</td>
<td></td>
<td>110 - 190</td>
<td>125</td>
</tr>
<tr>
<td>Yellow mystus (Hemibagrus filamentosus)</td>
<td></td>
<td>90 - 190</td>
<td>90 - 120</td>
</tr>
<tr>
<td>Tire track eel (Mastacembelus favus)</td>
<td></td>
<td>120 - 150</td>
<td>150 - 190</td>
</tr>
<tr>
<td>Clown featherback (Chitala smalata)</td>
<td></td>
<td>160 - 190</td>
<td>160 - 190</td>
</tr>
<tr>
<td>Indescent mystus (Mystus multiradiatus) (large)</td>
<td></td>
<td>80 - 100</td>
<td>80 - 100</td>
</tr>
<tr>
<td>Indescent mystus (Mystus multiradiatus) (small)</td>
<td></td>
<td>50 - 60</td>
<td>50 - 60</td>
</tr>
<tr>
<td>Walleago (Wallago atu) (large)</td>
<td></td>
<td>180</td>
<td>180</td>
</tr>
<tr>
<td>Walleago (Wallago atu) (small)</td>
<td></td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Bronze featherback (Notopterus notopterus)</td>
<td></td>
<td>90 - 100</td>
<td>90 - 100</td>
</tr>
<tr>
<td>Wild striped snakehead (Channa striata) (large)</td>
<td></td>
<td>120 - 125</td>
<td></td>
</tr>
<tr>
<td>Wild striped snakehead (Channa striata) (small)</td>
<td></td>
<td>75 - 100</td>
<td></td>
</tr>
<tr>
<td>Farmed giant snakehead (Channa micropheltes) (large)</td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Farmed giant snakehead (Channa micropheltes) (small)</td>
<td></td>
<td>90 - 95</td>
<td>95</td>
</tr>
<tr>
<td>Bighhead walking catfish (Clarias macrocephalus) (large)</td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Silver barb (Barbonymus gonionotus)</td>
<td></td>
<td>50 - 55</td>
<td>50 - 55</td>
</tr>
<tr>
<td>Silver barb (Barbonymus gonionotus)</td>
<td></td>
<td>30 - 35</td>
<td>30 - 35</td>
</tr>
<tr>
<td>Red tilapia hybrid (Oreochromis spp.) (large)</td>
<td></td>
<td>85 - 90</td>
<td>85 - 90</td>
</tr>
<tr>
<td>Red tilapia hybrid (Oreochromis spp.) (small)</td>
<td></td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Nile tilapia (Oreochromis niloticus) (large)</td>
<td></td>
<td>55 - 65</td>
<td>55 - 65</td>
</tr>
<tr>
<td>Nile tilapia (Oreochromis niloticus) (small)</td>
<td></td>
<td>28 - 35</td>
<td>25 - 30</td>
</tr>
<tr>
<td>Whisker sheatfish (Kryptopterus spp.) (large)</td>
<td></td>
<td>–</td>
<td>380</td>
</tr>
<tr>
<td>Whisker sheatfish (Kryptopterus spp.) (small)</td>
<td></td>
<td>–</td>
<td>140 - 200</td>
</tr>
<tr>
<td>Common carp (Cyprinus carpio)</td>
<td>(large)</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Mekong giant catfish (Pangasianodon gigas)</td>
<td>(small)</td>
<td>55 - 60</td>
<td>50 - 65</td>
</tr>
<tr>
<td>Boeseman croaker (Boesemania microlepis)</td>
<td>(large)</td>
<td>240 - 300</td>
<td>240 - 300</td>
</tr>
<tr>
<td>Horse-face loach (Acantopsis choirorhynchos)</td>
<td>(small)</td>
<td>120 - 190</td>
<td>190</td>
</tr>
<tr>
<td>Giant gourami (Osphronemus goramy)</td>
<td>(large)</td>
<td>80 - 90</td>
<td>80 - 90</td>
</tr>
<tr>
<td>Siamese mud carp (Henchinohynchus siamensis)</td>
<td>(large)</td>
<td>50 - 60</td>
<td>50 - 60</td>
</tr>
<tr>
<td>Snakekin gourami (Trichopus pectoralis)</td>
<td>(large)</td>
<td>135 - 200</td>
<td>135 - 200</td>
</tr>
<tr>
<td>Striped catfish (Pangasianodon hypophthalmus)</td>
<td>(large)</td>
<td>25 - 30</td>
<td>25 - 30</td>
</tr>
<tr>
<td>Climbing perch (Anabas testudineus) from rice paddy (large)</td>
<td></td>
<td>–</td>
<td>90</td>
</tr>
<tr>
<td>Climbing perch (Anabas testudineus) from rice paddy (small)</td>
<td></td>
<td>–</td>
<td>80 - 85</td>
</tr>
<tr>
<td>Farmed climbing perch (Anabas testudineus) (large)</td>
<td></td>
<td>–</td>
<td>90 - 95</td>
</tr>
<tr>
<td>Farmed climbing perch (Anabas testudineus) (small)</td>
<td></td>
<td>–</td>
<td>80 - 85</td>
</tr>
<tr>
<td>Spot-fin spiny eel (Macrognathus siamensis) (large)</td>
<td></td>
<td>–</td>
<td>170</td>
</tr>
<tr>
<td>Spot-fin spiny eel (Macrognathus siamensis) (small)</td>
<td></td>
<td>–</td>
<td>100 - 150</td>
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<tr>
<td>Rice-field eel (Monopterus javanensis) (large)</td>
<td></td>
<td>220 - 250</td>
<td>220 - 250</td>
</tr>
<tr>
<td>Rice-field eel (Monopterus javanensis) (small)</td>
<td></td>
<td>320</td>
<td>320</td>
</tr>
<tr>
<td>Pond snail (Fitopaldula martensii)</td>
<td>(large)</td>
<td>90 - 100</td>
<td>90 - 100</td>
</tr>
</tbody>
</table>

#### Vietnam

<table>
<thead>
<tr>
<th>Species</th>
<th>Size Description</th>
<th>July, 2019</th>
<th>October, 2019</th>
<th>VND per kg unless otherwise stated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pangasius (Pangasianodon hypophthalmus) (white flesh)</td>
<td>(3,000/kg)</td>
<td>19,500 - 21,000</td>
<td>18,500 - 20,500</td>
<td></td>
</tr>
<tr>
<td>Pangasius fry (Pangasianodon hypophthalmus)</td>
<td>(white flesh)</td>
<td>0.6 - 1.5 each</td>
<td>0.6 - 1.5 each</td>
<td></td>
</tr>
<tr>
<td>Pangasius sub-fingerlings (Pangasianodon hypophthalmus) (3,000/kg)</td>
<td></td>
<td>200 each</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Pangasius fingerlings (Pangasianodon hypophthalmus) (28 - 32/kg)</td>
<td></td>
<td>500 - 600 each</td>
<td>500 - 600 each</td>
<td></td>
</tr>
<tr>
<td>Red tilapia (Oreochromis spp.) &gt; 300g - 1,000g</td>
<td></td>
<td>33,000 - 34,000</td>
<td>33,000 - 34,000</td>
<td></td>
</tr>
<tr>
<td>Red tilapia fingerlings (Oreochromis spp.) (30kg)</td>
<td></td>
<td>600,000 - 740,000</td>
<td>37,000 - 39,000</td>
<td></td>
</tr>
<tr>
<td>Snakehead (Channa spp.) ≥ 500g</td>
<td></td>
<td>40,000 - 42,000</td>
<td>37,000 - 39,000</td>
<td></td>
</tr>
<tr>
<td>Snakehead fry (Channa spp.) (1,200/kg)</td>
<td></td>
<td>110 - 140 each</td>
<td>110 - 140 each</td>
<td></td>
</tr>
<tr>
<td>Snakekin gourami (Trichogaster pectoralis) (6/kg)</td>
<td></td>
<td>48,000 - 50,000</td>
<td>40,000 - 50,000</td>
<td></td>
</tr>
<tr>
<td>Climbing perch (Anabas testudineus) (3 - 5/kg)</td>
<td></td>
<td>27,000 - 28,000</td>
<td>27,000 - 28,000</td>
<td></td>
</tr>
<tr>
<td>Japanese wrinkled frog (Thai strain) (Glandirana rugosa) (3 - 5/kg)</td>
<td></td>
<td>28,000 - 30,000</td>
<td>23,000 - 25,000</td>
<td></td>
</tr>
<tr>
<td>Japanese wrinkled frog (Thai strain) fry (Glandirana rugosa) (120 - 140/kg)</td>
<td></td>
<td>500 - 550</td>
<td>500 - 550</td>
<td></td>
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<tr>
<td>Giant freshwater prawn (Macrobrachium rosenbergii) (&gt;100g)</td>
<td></td>
<td>190,000 - 230,000</td>
<td>160,000 - 170,000</td>
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</tr>
<tr>
<td>Giant freshwater prawn (Macrobrachium rosenbergii) (50g - 74g)</td>
<td></td>
<td>170,000 - 200,000</td>
<td>160,000 - 170,000</td>
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</tr>
<tr>
<td>Giant freshwater prawn (Macrobrachium rosenbergii) (75g - 99g)</td>
<td></td>
<td>140,000 - 160,000</td>
<td>130,000 - 150,000</td>
<td></td>
</tr>
<tr>
<td>Giant freshwater prawn (Macrobrachium rosenbergii) (berried females, inferior old blue-claw males)</td>
<td></td>
<td>90,000 - 110,000</td>
<td>90,000 - 110,000</td>
<td></td>
</tr>
<tr>
<td>Giant freshwater prawn (Macrobrachium rosenbergii) (80,000 - 90,000/kg)</td>
<td></td>
<td>150 - 200 each</td>
<td>150 - 200 each</td>
<td></td>
</tr>
<tr>
<td>Black tiger shrimp (Penaeus monodon) (15/kg)</td>
<td></td>
<td>480,000</td>
<td>480,000</td>
<td></td>
</tr>
<tr>
<td>Black tiger shrimp (Penaeus monodon) (25 - 30/kg)</td>
<td></td>
<td>260,000</td>
<td>300,000</td>
<td></td>
</tr>
<tr>
<td>Black tiger shrimp (Penaeus monodon) (40kg)</td>
<td></td>
<td>220,000</td>
<td>250,000</td>
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<tr>
<td>Black tiger shrimp post larvae (Penaeus monodon) (15 days)</td>
<td></td>
<td>700 - 800 each</td>
<td>700 - 800 each</td>
<td></td>
</tr>
</tbody>
</table>
This illustration of the vulnerable carp species *Incisilabeo behri* is among 52 drawings of Mekong fish species featured in a set of playing cards developed by the USAID-funded Wonders of the Mekong project. The herbivorous species, known as *trey pava mok pi* in Khmer, occurs in the upper reaches of the Mekong and tributaries in Cambodia, Lao PDR and Thailand. The fish also occurs in the Chao Phraya Basin in Thailand, where it is known as *pla wa na nor* (see page 20).