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Report from a workshop held in Phnom Penh, Cambodia, February 9–10, 2012

Prepared in cooperation with FISHBIO

The Mekong Fish Network: Expanding the Capacity of the People and Institutions of the Mekong River Basin To Share Information and Conduct Standardized Fisheries Monitoring

Open-File Report 2012–1246

U.S. Department of the Interior
U.S. Geological Survey

Cover:

Background, Fishers haul in a dai net on the Tonle Sap River in Cambodia on February 11, 2012. Photograph by U.S. Geological Survey.

Left, Fisher attends to lii traps near Khone Falls, Lao People's Democratic Republic, in June 2012. Photograph by FISHBIO.

Right, Fishers attend to lii traps near Khone Falls, Lao People's Democratic Republic, in June 2012. Photograph by FISHBIO.

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U.S. Department of the Interior
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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
	Mass	
pound (lb)	0.4536	kilogram (kg)
ton, short (2,000 lb)	0.9072	metric ton

SI to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)

The Mekong Fish Network: Expanding the Capacity of the People and Institutions of the Mekong River Basin To Share Information and Conduct Standardized Fisheries Monitoring

Report from a workshop held in Phnom Penh, Cambodia, February 9–10, 2012

By Harmony C. Patricio,[1,2] Shaara M. Ainsley,[1] Matthew E. Andersen,[3] John W. Beeman,[3] and David A. Hewitt[3]

Abstract

The Mekong River is one of the most biologically diverse rivers in the world, and it supports the most productive freshwater fisheries in the world. Millions of people in the Lower Mekong River Basin (LMB) countries of the Union of Myanmar (Burma), Lao People's Democratic Republic, the Kingdom of Thailand, the Kingdom of Cambodia, and the Socialist Republic of Vietnam rely on the fisheries of the basin to provide a source of protein. The Mekong Fish Network Workshop was convened in Phnom Penh, Cambodia, in February 2012 to discuss the potential for coordinating fisheries monitoring among nations and the utility of establishing standard methods for short- and long-term monitoring and data sharing throughout the LMB. The concept for this network developed out of a frequently cited need for fisheries researchers in the LMB to share their knowledge with other scientists and decisionmakers. A fish monitoring network could be a valuable forum for researchers to exchange ideas, store data, or access general information regarding fisheries studies in the LMB region. At the workshop, representatives from governments, nongovernmental organizations, and universities, as well as participating foreign technical experts, cited a great need for more international cooperation and technical support among them. Given the limited staff and resources of many institutions in the LMB, the success of the proposed network would depend on whether it could offer tools that would provide benefits to network participants. A potential tool discussed at the workshop was a user-friendly, Web-accessible portal and database that could help streamline data entry and storage at the institutional level, as well as facilitate communication and data sharing among institutions. The workshop provided a consensus to establish pilot standardized data collection and database efforts that will be further reviewed by the workshop participants. Overall, workshop participants agreed that this is the type of support that is greatly needed to answer their most pressing questions and to enable local researchers and resource managers to monitor and sustain the valuable and diverse aquatic life of the Mekong River.

Introduction and Background

Great biological diversity is present in the Mekong River Basin. This great diversity supports the natural production of protein for tens of millions of people. Study of this complex, rich system has accelerated over the last 20 years. The environmental context is summarized below.

Regional Environmental Setting

The Lower Mekong River runs through the Union of Myanmar (Burma), Lao People's Democratic Republic (Lao PDR), the Kingdom of Thailand, the Kingdom of Cambodia, and the Socialist Republic of Vietnam and supports the most productive freshwater fisheries in the world, boasting annual catches of more than 2.6 million metric tons with an economic value between 2.2 and 7.8 billion U.S. dollars (USD) (Hortle, 2009). More than 60 million people from nearly 100 distinct ethnic groups in the Lower Mekong River Basin (LMB) depend on the fisheries for subsistence and livelihoods (Asian Development Bank, 2007; Hortle, 2009). One of the most

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biologically rich river basins in the world (Campbell, 2009; Woodruff, 2010), the LMB is home to between 850 and 1,200 fish species (Rainboth, 1996; Hortle, 2009; Dudgeon, 2011). Rare aquatic life includes the endangered giant freshwater stingray *Himantura chaophraya* that reaches about 2.5 meters in diameter, the Mekong giant catfish *Pangasianodon gigas* that grows to weigh more than 340 kilograms, and the freshwater Irrawaddy dolphin *Orcaella brevirostris*, the dolphin without a snout whose population numbers in the Mekong River may have dropped below 10 individuals. The Mekong River is one of the most hydrologically dynamic rivers in the world, exhibiting large annual discharge variation (Adamson, P.T., and others, 2009).

Many people in the LMB obtain the bulk of their protein from its wild fish and other aquatic animals and depend on its waters for farming, drinking, bathing, transportation, and sanitation. The fishing methods used in the LMB are as diverse as the ecosystems and the people. A wide range of capture techniques are used, ranging from subsistence to commercial scales, including various traps, hand-held dip nets, gill nets, and large dai bag nets (Sverdrup-Jensen, 2002).

In the LMB the impacts of population growth, pollution, climate change, overfishing, groundwater withdrawal, and irrigation and hydropower development have become increasingly apparent (Kirby and others, 2010; Dudgeon, 2011; Dapice and Vo, 2012). These stressors may act separately or synergistically to affect water use, food security, and the ecosystem of the basin. How human engineered and naturally occurring stressors will influence this dynamic system can be predicted to some degree, but the ability to accurately assess the impacts on the fisheries and food security of the region is hampered by the lack of critically important information on the distribution, abundance, migrations, and ecology of the fishes in this species-rich system (Barlow and others, 2008; Baran and Myschowoda, 2009; International Centre for Environmental Management, 2010).

Countries in the LMB have approved investigations by local and international companies to prepare for investigation or construction of 12 main-stream hydropower dams (Stone, 2011), and many dams are also under construction on or are proposed for the major tributaries of the Mekong River (Baran and Myschowoda, 2009). Hydropower generated by large dams could provide much-needed income and electricity for developing nations in the LMB, where many people live on less than 1 USD per day and the annual average per capita income is between 830 and 1,168 USD in Cambodia, Lao PDR, and Vietnam (U.S. Department of State, 2011, 2012a, 2012b). Large dams could also, however, alter the hydrology and ecology of the system by blocking movements of aquatic species (Baird and Beasley, 2005; Dugan and others, 2010; Baird, 2011; Dudgeon, 2011; Ziv and others, 2012), changing flow regimes (Asian Development Bank, 1999), and altering sediment transport (Asian Development Bank, 1999; Hirsch and Wyatt, 2004). Because the magnitude of annual variation in flow between the wet (May to October) and dry (November to April) seasons is the highest in the world (Adamson, P.T., and others, 2009), constraints on this flow variation may impact the productivity of the region. Proposed hydropower developments are likely to influence some fish and other aquatic species, particularly those that make long-distance migrations. Impacts may vary considerably depending on various construction scenarios (Sodhi and others, 2004; Ferguson and others, 2011; Ziv and others, 2012).

Climate change may have considerable effects on the hydrology of the Mekong River. Climate change projections for the LMB are uncertain because of the complexity of the predictions of intrabasin changes in the timing and volume of precipitation, evaporation, snow storage, and snow melt and, thus, are greatly dependent on the general circulation model (GCM) selected (Kingston and others, 2011). The Japan Meteorological Agency GCM indicates that there will likely be an increase in the frequency of what is currently considered an extremely high discharge event, but at a lower maximum flood magnitude (that is, more frequent but less extreme flooding), and a decrease in the likelihood of extremely low discharge events (for example, drought periods) (Kiem and others, 2008). Notably, most GCMs indicate that the predicted warmer temperatures would result in projections of earlier snowmelt in the Upper Mekong River Basin in China (Kingston and others, 2011), indicating a potential shift in the timing of runoff in the upper basin. Temperatures throughout both the Upper and Lower Mekong River Basins are generally predicted to increase (Kiem and others, 2008; Kingston and others, 2011). Changes in the water temperature could lead to shifts in the geographic distributions of fish with narrow thermal tolerances (Dudgeon, 2011). Changes in precipitation and river discharge, however, show a nonlinear response to increasing temperatures and are complicated by seasonal and spatial variability (Kingston and others, 2011). The dynamism of the entire Mekong River likely influences the uniquely high productivity of this system (Welcomme and Halls, 2003; Baird, 2006; Hai Yen and others, 2008; Baran and Myschowoda, 2009). Given the complexity of GCM projections for the entire Mekong Basin and potential effects relative to both magnitude and direction of change (Kirby and others, 2010; Kingston and others, 2011), a better understanding of fish populations is necessary to make projections of climate change impacts on fisheries of the LMB.

Historical Fish Studies

A large number of Mekong fishes (>100 species; Poulsen and Valbo-Jørgensen, 2000; Poulsen and others, 2002; Ziv and others, 2012) undertake long-distance migrations upstream from the Mekong River Delta in Vietnam and the Tonle Sap Great Lake of Cambodia, with some species reportedly reaching as far north as the Yunnan Province of China (Poulsen and others, 2004; Barlow and others, 2008; Dugan, 2008; Mollot, 2008; Halls and Kshatriya, 2009; Dudgeon, 2011). Because of the complexities involved in studying such a species-rich system, fish species are often separated

into general categories defined by movement: "white fish" are highly migratory species, "black fish" are resident species that make little or no migrations, and "grey fish" are lateral migrants that make short migrations between habitat types (Hortle, 2009). The colorful adjectives describing the migratory habits of Mekong fish originally came from a rough approximation of the colors of the fishes, associated with their assumed migratory strategies, but as more information is gathered the exceptions to the generalizations are mounting, reducing the accuracy and value of these descriptions, though they are still commonly used in the area. White fish may constitute 40–70 percent of the catch (Barlow and others, 2008), and because of their diverse habitat requirements, they may be exposed to a greater variety of stressors than are other fish species.

Despite the transboundary migrations of some white fish, for species such as the Siamese mud carp *Henicorhynchus siamensis* (synonym, *Cirrhinus siamensis*), genetic data show that some populations may retain spatial structuring; that is, some species may exhibit genetically distinguishable subpopulations that can be segregated on the basis of distribution. To preserve this genetic diversity, management strategies will need to preserve the habitats and conditions that support the population structuring (Adamson and others, 2009). Because of the importance of aquatic resources to the people of the LMB for food security and maintenance of biodiversity, and because of the increasing stresses on the ecosystem, fish population monitoring is imperative to understanding the potential impacts of various stressors (Kirby and others, 2010).

One example of current fisheries monitoring in the LMB is the commercial dai fishery in Cambodia. This is a large, highly specialized fishery that takes advantage of the substantial migrations of fish in the Tonle Sap and Mekong Rivers. A dai is a bag net with a small mesh size (less than 25 millimeters [mm]) (Sverdrup-Jensen, 2002). Several dai nets are arranged in a series across the width of the river; the fish are retrieved from the cod end by boat and then are deposited onto an associated barge (fig. 1). During the peak season, a single net can haul up to 0.5 metric tons of fish every

Figure 1. Fishers haul in a dai net on the Tonle Sap River in Cambodia on February 11, 2012. Photograph by U.S. Geological Survey.

15 minutes (Sverdrup-Jensen, 2002). The Inland Fisheries Research and Development Institute (IFReDI; www.ifredi.org) of Cambodia, established in 2002, has assembled dai fishery data from the Tonle Sap River from the past 17 years (1995–present), including sampling data they currently collect during routine monitoring. IFReDI samples a total of 64 dai in two provinces between October and March and records data such as fish species, catch composition, length and weight, and water depth.

A second example of current fisheries monitoring is the lii trap fishery at Khone Falls in the south of Lao PDR (fig. 2). Lii (wing) traps are large immovable traps with long lateral extensions, or wings (from 6 to 10 m, depending on the width of the channel), that are set in the river rapids (Roberts and Baird, 1995). The Living Aquatic Resources Research Center (LARReC) of Lao PDR has been monitoring as many as 21 lii traps annually for more than 10 years. Sampling is conducted May through September at Hoo Som Yai Channel. Fishers come to the landing site, and LARReC records the weight of the catch, fish species, and associated aquatic environment data, such as water level and velocity.

In both examples described above, the monitoring has been conducted for more than a decade. These time series are valuable data for Cambodia and Lao PDR. Not all fisheries, however, are subject to such intensive monitoring. While a substantial volume of LMB fisheries research has been completed by various institutions, the diversity of the system and limited coordination among nations have made it difficult to capture the information that is needed to make accurate analyses of development and climate change impacts or to assess long-term trends in fish populations (Food and Agriculture Organization of the United Nations and others, 2003). As the governments of the LMB nations continue to develop economically and endeavor to reduce poverty, they will face many challenging decisions. The region is developing quickly; the limited amount of comprehensive data on the value of fisheries impairs the ability of decisionmakers to account for this resource in long-term plans being prepared now.

Mekong Fish Network Workshop

The Mekong Fish Network (Network) Workshop was held in Phnom Penh, Cambodia, on February 9–10, 2012, with the objectives of determining if the proposed network was of interest and value to LMB nations, determining if future fisheries monitoring could be used to collect comparable data within each nation, and establishing methods for working together on future monitoring and research. The concept for this network developed out of a frequently cited need for researchers in the LMB to share their knowledge of Mekong River fish with other scientists and decisionmakers. A more accessible collection of fish data would also support analyses at a broader scale. A network of researchers collecting comparable data would provide a better understanding of how LMB fish populations may respond to future environmental changes and increase the scientific capacity of local researchers and institutions to assess resources for themselves. This network could be a valuable forum for researchers to exchange ideas, store data, or access general information regarding fisheries studies in the LMB.

The transboundary migrations of important LMB fish species create many complex challenges that require coordination among researchers, institutions, and development sectors from different regions of the basin (Grumbine and others, 2012). Even within national boundaries it is difficult to estimate the catch of subsistence fishers who are spread throughout urban and rural areas. Furthermore, biological and physical data are collected specifically for various projects, thereby making regional and comprehensive assessments difficult or impossible (Baran and Myschowoda, 2009). For example, researchers examining the potential hydrological changes due to climate change have been limited by the inconsistent meteorological station data for the Mekong River Basin; most stations are located in the upper basin or Thailand (Kite, 2001; Kingston and others, 2011). Ferguson and others (2011) attempted comparisons among the Fraser and Columbia Rivers in North America and the Mekong River, especially regarding impacts to fish by dams and fish passage structures, but the lack of data (fish, hydrology, water quality, sediment, land cover) and ecological knowledge limited their ability to draw definitive conclusions. To assess the sustainability of fish populations, researchers will need to overcome these data-related challenges to provide managers with a better understanding of important metrics such as species composition of catch, age structure of populations, extent of spawning migrations, segregation of subpopulations, and relative abundance of species in different regions. Researchers must also be able to collate these data across the LMB and through time.

Limited local technical capacity and funding have presented challenges to the establishment of standardized, long-term fish monitoring in the LMB. Many national governments currently depend on international aid or nongovernmental organization (NGO) support for research or fisheries agency funding. Funding is often provided on a project-by-project basis, resulting in a great deal of institutional knowledge, data, and expertise being lost in the turnover between projects. The Mekong River Commission (MRC) has provided substantial support to manage at a basin level and has plans to increase standardization in data collection among nations (Mekong River Commission, 2011). By building on past efforts and coordinating the work of the many institutions collecting data on fisheries of the LMB, it may be possible to develop standard monitoring methods that can be applied to support informed decisionmaking.

Figure 2. Fishers attend to lii traps near Khone Falls, Lao People's Democratic Republic (Lao PDR), in June 2012. Photographs by FISHBIO.

Representatives from governments, universities, NGOs, and the MRC were convened to discuss the proposed Network, which could address the need to collect, store, and analyze fisheries data with a consistent approach. The initial goals of the Network were as follows:

1. Increase knowledge of the Mekong River fish assemblage to support understanding of how fish will respond to environmental changes.
2. Increase the capacity of local people and institutions to study the Mekong River fishes.
3. Provide opportunities to people collecting Mekong River fish data to share their knowledge with scientists and decisionmakers.
4. Identify harmonious management options that will help protect Mekong River fish and their habitats for the benefit of current and future generations.
5. Provide a forum for developing scientific peer-reviewed publishing opportunities regarding Mekong River fishes.
6. Establish standardized monitoring methods that can be applied throughout the LMB.

The formation of the Network could provide a framework to achieve such goals. Implementation and standardization of fish monitoring methods and coordination of the resulting data in a manner that allows for analysis of data from larger geographic areas will aid in answering the questions most relevant to national governments and to sustained food security.

Workshop Format

The workshop began with an introduction followed by presentations that demonstrated examples of Web-accessible shared databases, methods, strategies for data collection and analysis, and data visualizations that could be selected to support the proposed monitoring network (see app. 1 for workshop agenda). Representatives from government fisheries agencies, universities, the MRC, and NGOs from each country were next on the program (app. 1); they described current and future monitoring and research activities. For the remainder of the 2-day workshop, the group was divided into smaller groups to discuss specific questions germane to fisheries monitoring. Following each small group session, the participants were reconvened to share their responses and conclusions with the larger group. The initial group session topics were broad but became progressively more specific, with the final discussion addressing the logistical aspects of operating the network. These presentations and subsequent group discussions will help to shape and inform the design of the Network.

Goals and Summaries of Introductory Presentations

The goals of the workshop were generally to determine if the proposed network, the initial network goals (listed previously), and the associated databases were of interest and value to stakeholder LMB nations; to determine if future fisheries monitoring could be used to collect comparable data within each nation; and to establish methods and an organizational structure for working together on future monitoring and research.

More specifically, the overall workshop goals were to accomplish the following:

1. Determine if the fish monitoring network and associated databases proposed at this meeting were of interest and value to LMB nations.
2. Determine types of future Mekong River fish monitoring that could be used to collect data to populate the databases.
3. Establish methods and organizational structure for working together in the future on Mekong River fish monitoring and research.

Furthermore, the workshop specific objectives were to accomplish the following:

1. Discuss current monitoring and research activities and plans for future monitoring and research.
2. Discuss data sources currently available in LMB institutions. What LMB fish data exist?
    a. Determine if institutions would be interested in sharing data via an Internet database in the future.
    b. Demonstrate Internet databases and visualizations for consideration.
3. Identify key indicators for monitoring long-term trends in fish populations and measuring impacts of changes in the system.
    a. Demonstrate how data could be analyzed once sufficient data were collected.
    b. Demonstrate how data could be presented via the Internet.
    c. Discuss what data will be needed for analyses.
4. Determine if consistent fish data collection standards can be agreed upon among LMB nations.
    a. Select shared methods and parameters for sampling fishes throughout the LMB.
5. If parties agree to work together, nominate Network representatives for each nation.

To facilitate these goals and objectives, the U.S. Geological Survey (USGS) scientists presented brief examples of tools that could be used with data collected collaboratively. They described the advantages of shared collection methods, such as relational databases in which the data are linked but sharing is not required. A few examples of geographically displayed data, such as a map of nuisance aquatic species based on data from an invasive species database, were shown. In some cases these maps can be interactive, and if a user clicks on the data point, a pop-up window can be programmed to display associated data or metadata. An example of a habitat suitability index database was used to demonstrate how users can establish certain decision rules that describe the habitat of a species (for example, vegetation, water temperature, salinity) and the associated map data layers are modified to display habitat suitability changes over time.

Three examples were presented that may be useful models for the proposed network. The first was the Fish Barcode of Life Initiative (FISH-BOL; http://www.fishbol.org/), a database that has user-selected sharing criteria that allows the users to either share or not share their data (that is, choose to share data or to use the database only to store data for personal access). Even if a user employs the database for only personal use, FISH-BOL provides a standard format for data entry, freeing the user from database development. Also, if a member of FISH-BOL has a question or concern regarding data posted by another member, there is a standard procedure for communication between the members. In contrast, the second example, the Pacific Northwest Aquatic Monitoring Partnership (PNAMP; http://www.pnamp.org/), has no common database; rather, the network was established as a forum to foster discussions about methods currently being used and the development of standardized methods. The third example was a passive integrated transponder (PIT) Tag Information System (PTAGIS; http://www.ptagis.org/), which supports a centralized database with Web-based data entry and storage. Unlike PNAMP, PTAGIS offers limited support for methods but provides users with metadata on tagging methods, site locations, and tag codes for various regional studies using passive integrated transponder (PIT) tags. In general, there are many options for sharing data (databases may be programmed to not share, limit sharing, or fully share all data with the public, depending on the alternatives selected) and for providing a Web-based database or just a forum for discussion and sharing of methods. One of the main goals of the workshop was to determine whether a network with any of the resources above would be a useful and desirable tool for researchers in the LMB. Participants expressed strong agreement that some mode of information sharing is urgently needed.

Some potential goals for the network were discussed; these potential goals related to archiving and analyzing data, with particular emphasis on the role of standardized collection and reporting. Ideally, the network would provide value-added support for data derived from both past projects and future monitoring efforts. With regard to future monitoring, the primary benefit of standardized data collection would be the ability to conduct joint analyses and make broader comparisons and inferences across the entire LMB. Common fisheries metrics to include in monitoring efforts were suggested, including catch in numbers or biomass, effort, size composition (length or weight), and maturity stage. Particular challenges to standardization on a large scale were also discussed, including species identification/taxonomic resolution and comparing or standardizing effort among gear types (for example, changing gear selectivity as a function of depth and habitat type). With support to overcome such challenges, data collected in a standard way by a network of researchers could be used to evaluate distribution and habitat selection for particular species (even with simple presence-absence data) and to assess spatial and temporal trends in relative abundance. Once a network was established, there would also be potential for more sophisticated projects such as age composition based on samples of hard parts (for example, otoliths) or tagging/telemetry studies for movement or growth.

Participants

Workshop participants included representatives from governments and universities of member nations of the MRC (Cambodia, Lao PDR, Thailand, and Vietnam), NGOs from multiple nations, and MRC staff. The workshop was jointly facilitated by the USGS and FISHBIO. The institutions represented are listed alphabetically in table 1, and the names of the participants are listed in appendix 2.

Recent and Current Mekong River Fish Studies

Before addressing the goals of the workshop, some participants from government agencies, universities, and the MRC were invited to briefly present their institution's current and planned monitoring and research activities. These presentations were intended to assess the scope of existing fisheries research in the LMB and to provide the participants from various institutions a context for the workshop discussions. The presenters were presented with a list of questions in advance for consideration (see app. 1) and were requested to address as many of the questions as they were able or wished to address.

Table 1. Institutions represented at the Mekong Fish Network Workshop, Phnom Penh, Cambodia, February 9–10, 2012.

[Institution names are listed in alphabetical order. Lao PDR, Lao People's Democratic Republic]

Institutions represented at the Mekong Fish Network Workshop
Cambodian Molecular Genetics Group
Cantho University – Vietnam
Conservation International
Department of Fisheries – Thailand
Department of Livestock and Fisheries – Lao PDR
FISHBIO
Fisheries Action Coalition Team – Cambodia
Fisheries Administration – Cambodia
Inland Fisheries Research and Development Institute – Cambodia
International Union for Conservation of Nature – Cambodia
Living Aquatic Resources Research Center – Lao PDR
Mekong River Commission
National University of Laos
Royal University of Agriculture – Cambodia
Scientific Capacity Development Initiative – Cambodia
Ubon Ratchathani University – Thailand
U.S. Geological Survey
Vietnam Institute of Fisheries Economics and Planning
Wildlife Conservation Society
World Wildlife Fund

Summary of Presentations on Current Fisheries Monitoring Activities in the Lower Mekong River Basin

A wide range of monitoring programs and data collection efforts occur or have occurred throughout the LMB, varying from small, short-term studies to larger, long-term monitoring efforts. Workshop participants described some of these efforts in their presentations on Day 1 and more detailed discussions of these efforts were held during Small Group Session 2. There were common elements that the existing monitoring programs in all four LMB countries shared. Rather than list in this report each project by institution as they were presented at the meeting, the projects have been grouped by similarity of type of data to enable a more holistic perspective of the current research in the LMB. The monitoring projects described by the participants are also summarized in tables in appendixes 3 and 4. The projects listed below are not intended to be an exhaustive list of current fisheries monitoring in the LMB; rather, they provide examples presented by workshop participants of projects conducted throughout the LMB that share similar objectives or methodologies. These examples could be used to identify strategies that may be of basinwide interest and therefore can provide examples to inform standardization of efforts.

General Fisheries Landing Data

General fisheries landing data are collected by various national government agencies at the provincial and national levels.

- ***Cambodia – Inland Fisheries Research and Development Institute (IFReDI)***: Monitors the dai bag net fishery in the Tonle Sap River October through March (fig. 1) by collecting data on fish species, catch composition, fish length, fish weight, and water depth.
- ***Lao PDR – Living Aquatic Resources Research Centre (LARReC)***: Monitors the lii traps (fig. 2) at Hoo Som Yai channel near Khone Falls from May to September (wet season).
- ***Lao PDR – Department of Livestock and Fisheries (DoLF)***: Collects data on commercial landings at regular intervals. Data are collected at the district and provincial levels and are sent to DoLF (national level), where the data from all provinces are aggregated.

- ***Vietnam Institute of Fisheries Economics and Planning***: Collects data on landings at regular intervals. Similar to efforts in Lao PDR, data are collected at the provincial level and reported to the national level.

- ***Thailand – Department of Fisheries (DoF)***: Conducts stock and catch assessments. Catch from landing sites is recorded by the provincial fisheries offices and aggregated by the Fisheries Information Center of DoF. Since 2002, they have also been monitoring the catch-per-unit-effort (CPUE) in reservoirs that are stocked with various aquatic organisms for put-grow-and-take fishing. Six different mesh sizes of gill nets were used to assess CPUE in two water bodies per province between 5 and 500 hectares before stocking, 2 months after stocking, and 4 months after stocking. Data collected include catch by species and by mesh size, water depth, and other water quality parameters.

Taxonomic Biodiversity Assessments and Specimen Collection

The Mekong River Basin is known for its high diversity of fish species which is supported by diverse habitats. The fisheries researchers in the basin are working to record the distribution and diversity of the fishes through surveys specifically aimed at documenting the biodiversity of the region.

- ***Cambodia – IFReDI***: Currently sampling fish at about 200 stations in inland water habitats throughout Cambodia at all times of the year. They house more than 25,000 specimens from more than 300 species, including previously undocumented species. Data collection includes species name, local name, and fish length and weight. Additionally, IFReDI conducts annual fish abundance and diversity surveys in five major rivers in Cambodia between January and February.

- ***Lao PDR – LARReC***: Collaborated on a fish taxonomy survey with W.J. Rainboth (University of Wisconsin, Oshkosh) in 1998 that has not yet been published. Additionally, they are conducting fish biodiversity monitoring in the upper LMB (from the Chinese border to Vientiane, Lao PDR), in which they collect data on fish species, catch, and habitat during periods of the wet season (September) and the dry season (February).

- ***Lao PDR – National University of Laos***: Conducted a species diversity and distribution survey in several regions throughout Lao PDR (that is, the provinces of Luang Prabang, Vientiane, Savannakket, and Bolikhamxay). Fish were collected every 2 months from different habitats by using different gear types, with each survey lasting 2 weeks. Data collected include fish size, local name, locality, habitat type, latitude and longitude, water depth, and collection method.

- ***Vietnam – Cantho University***: Currently conducting surveys of the fish diversity in Hau River, a distributary of the Mekong River in the delta, 1 day per month throughout the year. Data collected include species composition, length, and weight of individuals.

- ***Thailand – DoF***: Currently conducting fish abundance and species diversity monitoring projects that survey large reservoirs throughout Thailand. There are seasonal changes in the gear type used, associated with the hydrological regime, but the most commonly used fishing gear is the gill net.

Larval Fish Sampling

Sampling of abundance and species composition of larval fish is conducted in all four LMB countries.

- ***Cambodia – IFReDI***: Monitors fish larvae biannually in Tonle Sap and Mekong Rivers around April and September (transitional months in the wet and dry seasons) from 2003 to present. Bongo nets are used to sample drifting fish larvae, and data recorded include species, fish length, and water depth of capture. In the 8 years of study, they have found more than 200 species.

- ***Lao PDR – LARReC***: Conducted larval sampling at three sites in two provinces (Luang Prabang and Champasack) in 2009. Additionally, in 2010 four sites were sampled in Xayabouri Province.

- ***Vietnam – Cantho University***: Conducts seasonal larval fish sampling in the Hau River.

- ***Thailand – Ubon Ratchathani University***: Records the species composition of larval fishes and the water quality parameters associated with the site of capture.

- ***Mekong River Commission (MRC)***: Conducts larval sampling and records information such as site, date, and flow velocity.

Community-Based Fish Catch Monitoring

Several institutions in the LMB are working with local villagers to record valuable fisheries catch data. This can be a cost-effective method because it requires less time from professional staff while concurrently building interest and capacity within local communities. Community-based monitoring surveys can be conducted in at least two forms: (1) the local fishermen are asked to keep a record of their catch in a log book, or (2) local villagers are trained in specific data collection techniques and work with fishers to collect data according to set schedules and protocols. The current monitoring efforts using these methods, including the available gear specificity, are summarized below.

- ***Cambodia – Conservation International***: Works with local villages to monitor fish and wildlife as part of a biodiversity conservation project in the Tonle Sap Great Lake.
- ***Cambodia – International Union for Conservation of Nature (IUCN)***: Has been conducting a local knowledge study as part of their Sala Phoum research project since 2005. It is a study site in the international Ramsar wetlands study program. The objective is to monitor changes in natural resources while empowering villagers to conduct their own research. Villagers are trained in research teams to compile and document local knowledge by using five research assistants to help coordinate and document the process.
- ***Lao PDR – LARReC***: Participates in the MRC fish abundance and diversity monitoring program, which is also conducted throughout Cambodia and Vietnam. Fishers at six different sites use log books to record fish catch data. Data recorded include date, effort, gear type and dimension, habitat, start and end time, total time fishing, and species caught.
- ***Lao PDR – FISHBIO***: Local villagers who reside in the Nam Kading River Basin were trained to collect catch information to establish baseline data for wild fisheries and other aquatic animals. Data collected include species composition, individual lengths and weights, total biomass of harvests, and CPUE.
- ***Cambodia – Fisheries Administration/World Wildlife Fund (WWF)***: Has been significantly expanding their network of community-based fish catch monitoring sites in the Kratie/Stung Treng region.
- ***Thailand – Ubon Ratchathani University***: Has two projects collecting fisheries data through the participation of local fishers.

Fish Market Surveys

Some workshop participants conduct surveys of fish markets to either (1) assess the market value of fisheries resources or (2) record the distribution and presence or absence of species.

- ***Cambodia, Thailand, Lao PDR, and Vietnam – WorldFish Center***: Has begun a new project to assess the market value of fish, as well as to assess the value of the fisheries to the welfare of different social groups. The research will be conducted by a network of students at four universities in the region: Royal University of Agriculture in Cambodia, Ubon Ratchathani University in Thailand, National University of Laos, and Cantho University in Vietnam.
- ***Lao PDR – FISHBIO***: Collected aquatic resources market value data from two village surveys. Each survey determined the average monthly income for villagers and the proportion of fisher income that was derived from fish sales. Data collected included sale price, fish mass, species, and sources of fish sold at markets.
- ***Lao PDR – LARReC***: Conducts fish market surveys in three provinces (Oudomxay, Luang Prabang, and Champasack) and collects data on the quantity of fish, price, and species to evaluate trends in the markets.

Household Interview Socioeconomic Surveys

Household interview surveys were directly mentioned in only two workshop presentations; however, these interviews have often been used in LMB countries to assess the value of fisheries (Sverdrup-Jensen, 2002; Food and Agriculture Organization of the United Nations and others, 2003). Villagers are interviewed regarding their fish consumption (that is, “How much fish do you eat?” “What types of fish do you eat?” “When do you eat the most fish?”) and the value of the fish consumed. In some cases, technicians also directly measure food consumption.

- ***Lao PDR – LARReC***: Conducted a socioeconomic survey of 500 households in 27 villages of the Luang Prabang Province in 1999. A similar survey was conducted of 200 households in 20 villages of the Champasack Province in 2002.
- ***Lao PDR – FISHBIO***: Has quantified the contribution of wild fisheries to the diets of village households by training local villagers to visit randomly selected households and directly collect data on consumption of fish per household (by weight) and the proportion of the diet consisting of fish.

Some fishing methods utilized in specific, localized regions of the LMB are important components of the commercial or subsistence fisheries. These specialized fisheries may already be associated with long-term monitoring programs and are examples of data that would differ among countries or institutions. Two examples of specialized fisheries discussed by experts at the workshop were (1) the dai bag net fishery of Cambodia and (2) the lii trap fishery of Lao PDR, both of which were described previously.

Planned and Desired Fisheries Studies in the Basin

In addition to presenting the current monitoring activities, several participants offered information on planned fisheries studies, some of which will require building capacity in specific scientific fields, such as genetics, geographic information systems (GIS), and population modeling. Although these types of activities are beyond the initial scope of the Network, they indicate the kinds of information that are of interest, and they suggest some of the capacity needed. Planned fisheries studies include the following:

- ***Cambodia – IFReDI***:
  - Modeling population dynamics of commercially important fish species
  - Genetic barcoding (that is, identifying unique genetic sequences, called "DNA barcodes," that can be used to identify an individual to species) of commercially important species to facilitate the future use of fin clips for identification
  - Building a systematic monitoring strategy for the Mekong River in Cambodia through collaboration and consultations
  - Monitoring fish diversity, catch, and stocks in Tonle Sap Great Lake, including eight fish sanctuaries (in collaboration with Conservation International)
  - Developing standardized methods for gill net and seine net fish monitoring. These two types of nets target different ecological groups; seine nets target black fish or grey fish (resident species or lateral migrants), while gill nets target highly migratory white fish
  - Database management: priorities related to quality assurance checks of existing databases before sharing with others
- ***Cambodia – Conservation International***:
  - Developing methods to monitor fish stocks and species composition in the Tonle Sap Great Lake (in collaboration with IFReDI)
- ***Vietnam – Cantho University*** :
  - Investigating species composition of fishes in different habitats, especially the habitats impacted by human activities, such as agriculture and industrial pollution
  - Identifying breeding seasons and breeding grounds for important fish species to inform management strategies
  - Identifying genetic diversity within and among species. Some fish species are very difficult to identify on the basis of morphology alone, and genetic identification would be a useful tool
  - Applying GIS to fisheries monitoring and management
  - Identifying the relations between fish and human health in terms of nutrition and also the impact of pollution accumulation in fish on human health
- ***Thailand – Department of Fisheries*** :
  - Utilizing participatory research based on scientific measurement and local knowledge to monitor change in physical, ecological, biological, and socioeconomic aspects
  - Conducting a more thorough assessment of the value of fisheries resources and the impacts of development on those resources to inform the decisionmaking process
  - Conducting research on impacts of change on livelihoods and how livelihoods shift with development
- ***Basinwide – MRC***:
  - Has a basinwide strategic plan for fiscal years 2011–15 that includes 4 outcomes, 11 outputs, 25 activities, and more than 100 tasks. These outcomes include gaining a wider audience for publications and improving basinwide monitoring. Some of the key, relevant goals for the MRC's Fisheries Programme are to establish standard sampling methods that can be applied throughout the basin and to develop data to support development assessments (Mekong River Commission, 2011).

Additional Questions of Interest

Some participants offered examples of topics of interest to their institutions. Examples of specific topics mentioned during the presentations included the following:

- ***Cambodia – WWF and Fisheries Administration***: Interested in monitoring threatened species for conservation purposes and in the migration of fish species in and out of various conservation zones
- ***Lao PDR – LARReC***: Interested in assessing the nationwide fish catch for Lao PDR in both the Mekong River main stream and tributaries, gathering more detailed fish and aquatic animal consumption surveys, and learning more about the general biology and ecology of the most nutritionally and economically important fish species, aquatic plants, and other aquatic organisms such as frogs, crabs, and shrimp.
- ***Thailand – Department of Fisheries***: Interested in better assessing the overall size of the fishery in terms of basinwide consumption surveys, yield per unit area, habitat area, and locations of yield (catch or production) and modeling flood dynamics using GIS.

At the conclusion of the presentation section of the workshop, participants were asked to provide feedback on whether they felt that a fisheries network would be was useful and what the network could provide. The most common comment among the participants was that a networking program for the four countries of the LMB would be very useful but that it would be important to discuss the mechanism for operating such a network and for maintaining the network. Some suggested that a network of fish data could be established by building upon existing networks, such as the MRC or a fisheries network created by the Nagao Natural Environment Foundation. The sustainability of a network was of primary concern, and participants opined that the long-term maintenance of a network would likely depend on its ability to build capacity within the member institutions.

Technical Challenges: Results of Small and Large Group Discussions

The second part of the workshop was designed to facilitate discussions among participants from various countries and institutions on topics related to fisheries monitoring. The overall objectives of these small group discussions were to determine whether the proposed Network would be a useful tool for fisheries researchers in the LMB and to determine more specifically what kinds of monitoring activities and support would be most valuable. Four small group sessions were held, and the composition of the groups changed for each session to encourage the sharing of ideas and diverse perspectives. The participants were provided a few questions to stimulate discussion in each session (app. 5). At the end of each small group session, a representative from each group presented the results, and a large group session discussion was held. Each of these group sessions are described in sequence below.

Session 1

The objective of the first question in Small Group Session 1 was to determine which of the hundreds of fish species in the Mekong River were of specific interest for fisheries monitoring. Participants were provided with a basic list, based on expert consultation, as an example of some species for consideration. The participants were divided into two smaller groups, where both questions were considered. This session also focused on taxonomic clarity with the aim of discussing the challenges of taxonomic identification in the region:

Question 1: What fish species are most important to monitor or study?

Question 2: Do you use local names, and do you feel that those names need to be validated as unique species?

Initially, participants agreed that the answer to the question of what species were important to monitor was dependent on the objective of the monitoring itself. Therefore, each of the two small groups independently formed categories that they thought represented various objectives for monitoring, including food security, conservation, economic importance, invasive species, and basinwide distribution (table 2). These categories were then further refined because participants agreed that categories such as "ecologically important" were too broad. Group 1 defined economically important fish as those species that have a "high market value." Both groups agreed that it was important to monitor introduced species such as tilapia *Oreochromis* spp. The "basinwide" category was added to describe fish that occur in all four countries, for example Silver barb *Barbonymus gonionotus* (fig. 3), tilapia, snakeheads *Channa* spp. (fig. 3), catfishes *Pangasius* spp. (fig. 3), and *H. siamensis*. Because of their broad distribution, such species may be useful as focal species. Fish species that could fall under multiple categories were sometimes placed in one or the other on the basis of the opinion of the fishery experts participating. Group 1 further separated their categories into white fish, black fish and grey fish. Additionally, participants suggested that monitoring should not be specifically confined to fish species because all aquatic organisms (for example, crustaceans, mollusks, frogs, and insects) are considered part of the capture fisheries in the LMB. It was clear from discussions that participants could agree on some key species that are important throughout the LMB but that the list of important focal species for monitoring may also depend on the objectives of the monitoring.

Table 2. Lists of important Mekong River fish species developed during Small Group Session 1 of the Mekong Fish Network Workshop, Phnom Penh, Cambodia, February 9–10, 2012.

[The two groups in Small Group Session 1 created different categories to define important fish species. Lao PDR, Lao People's Democratic Republic; spp., species]

Group 1[1]	Group 2
Food security	**Food**
Henicorhynchus siamensis[2] White fish	*Anabas* spp.,[2] *Barbonymus gonionotus*[2]
Trey Riel (common name for a group that includes *Henicorhynchus siamensis*, *Henicorhynchus lobatus*, and *Lobocheilos cryptopogon*[2])	*Henicorhynchus siamensis* and *Henicorhynchus lobatus*[2]
	Channa striata and *Channa micropeltes*[2]
	Paralaubuca typus
	Mastacembelus
	Macrognathus spp. (Lao PDR)
Ecological	**Conservation/rare**
Henicorhynchus siamensis and *Henicorhynchus lobatus*[2]	Arowanas *Osteoglossidae* spp.
White fish	*Mekongina* spp.
Trey Riel (common name for a group that includes *Henicorhynchus siamensis*, *Henicorhynchus lobatus*, and *Lobocheilos cryptopogon*[2])	
Economic	**Economic**
Labeo chrysophekadion	All *Pangasius* spp.[2]
Cyclocheilichthys enoplos[2] White fish	*Pangasianodon hypophthalmus*
	All *Wallago* spp.
	All *Channa* spp.[2]
	Cyclocheilichthys enoplos[2]
Invasive species	**Basinwide importance**
Tilapia (*Oreochromis* spp.)[2]	Tilapia (*Oreochromis* spp.)[2]
Carp spp.	*Anabas* spp.,[2] *Barbonymus gonionotus*[2]
	All *Channa* spp.[2]
	Henicorhynchus siamensis[2]
Additional aquatic organisms	
Freshwater prawns, mollusks	

[1]*Pangasius larnaudii* was also mentioned by Group 1, but the relevant category of importance was not clear from participant discussion.

[2]Species that were most frequently mentioned during the small group discussion.

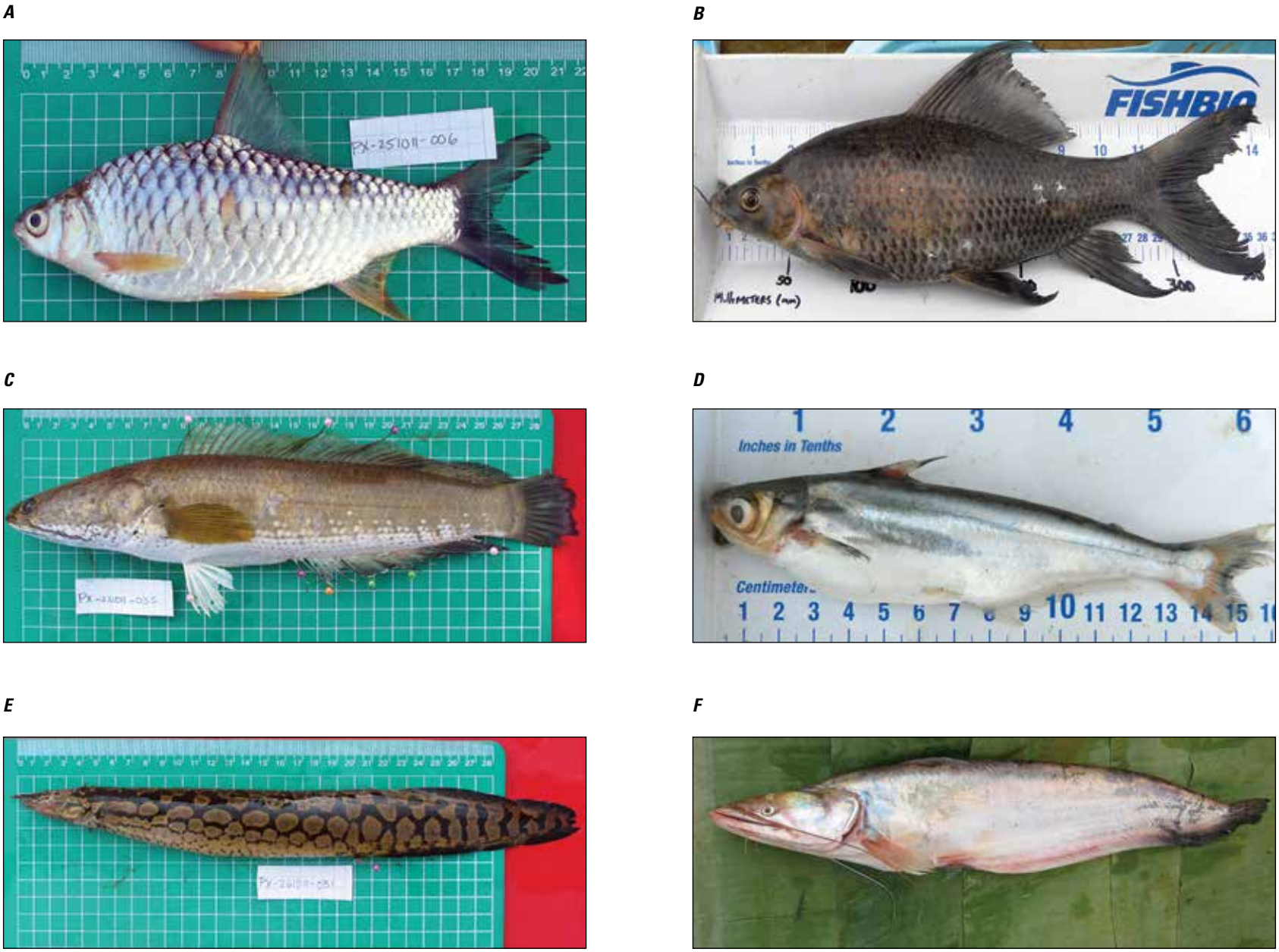

Figure 3. Some of the fish listed as important Mekong River species during Small Group Session 1. *A*, *Barbonymus gonionotus*. *B*, *Labeo chrysophekadion*. *C*, *Channa striata*. *D*, *Pangasius macronema*. *E*, *Mastacembelus armatus*. *F*, *Wallago attu*. Photographs by FISHBIO.

In general, participants agreed that confusion regarding local names and species taxonomy is an issue within the region since some local names can refer to more than one species within a genus and since the systematics of some species is not well defined. To address this in Cambodia, IFReDI recently created a list of official local common names for all known fish species in Cambodia. Concern over the topic of taxonomic clarity was expressed earlier in the workshop, which prompted some of the institutions to list genetic barcoding and taxonomy as future planned projects. The MRC's Mekong Fish Database (MFD; Mekong River Commission, 2003) provides a large volume of descriptive, taxonomic, life history, habitat use, and distribution information for fish of the LMB. It provides information for many species and subspecies. Because of the current level of taxonomic work being conducted in the region, the systematics of LMB fishes continues to evolve, and so some information in the MFD is outdated and needs to be updated.

Session 2

The objective of the questions for Small Group Session 2 was to discuss the current approaches to monitoring in the LMB. Much of the relevant information for each institution was provided during the presentations on Day 1 and therefore will not be presented in this section. Furthermore, discussions in Session 2 turned to what approaches may be ideal or desirable in terms of fisheries monitoring in the LMB, which was the topic of Session 3; therefore, many of those comments are addressed in the section on Session 3. Participants were provided three questions regarding their current monitoring programs:

Question 1: What data parameters are currently recorded?

Question 2: What sampling methods are currently used?

Question 3: Is there a standardized way in which you currently manage data?

The small discussion groups agreed that generally all of the data on the example list for Question 1 (app. 5) are collected, with the exception of catch age composition data. Additional parameters collected by the participants that were not on the example list included landing site, time of day, lunar and tidal cycles, weather conditions, local names, distance traveled to fishing area, and catch per fisher. Some studies collect data on reproductive parameters, examine the gonadal development, and process tissues for histology, though these types of sampling seemed limited to universities. Additionally, water quality data (for example, nitrogen, phosphorus, and conductivity) were mentioned as types of information that were not usually collected but that would be valuable to collect along with the biological sampling.

Dialogues regarding Question 2 indicated that the most common fisheries monitoring techniques include community interview surveys, direct sampling of fish catch by researchers or trained fishers, commercial harvest sampling, and market surveys. Additionally, various fisheries-independent sampling is conducted by researchers using fishing gear (for example, seine, gill net, traps) or specialized research sampling techniques usually requiring permits (for example, electrofishing, poisoning). There was discussion over the utility of household interview surveys, which are a common method of gathering basic fisheries data in the region (Sverdrup-Jensen, 2002; Food and Agriculture Organization of the United Nations and others, 2003). Participants concluded that the surveys are useful but need to be validated because the interviewees may have difficulty answering the questions accurately and because responses vary depending on which household member is interviewed. Responses may change whether the most senior male, most senior female, or the children of the household are interviewed (Food and Agriculture Organization of the United Nations and others, 2003).

When discussing community-based monitoring surveys, the participants of the workshop generally agreed that the first method (that is, local fishers are asked to keep records of their catches in log books) lacks scientific rigor and that the second method (that is, local villagers are trained in specific data collection techniques and collect data according to set schedules and protocols) can be a cost-effective approach to fisheries monitoring when funding and staff are limited. Participants suggested that researchers could conduct standardized sampling to validate the data collected by nonscientists.

Data management in the region appears largely to be on a project-by-project basis, with the exception of the MRC, which has been gathering and merging regional datasets. The workshop participants agreed during the small group discussions that most LMB fisheries data are stored and managed by using the software program Excel (Microsoft®, Redmond, Wash., USA) since it is widely accessible and relatively easy to use. Additionally, some organizations, including IFReDI (Cambodia), the Royal University of Agriculture (Cambodia), FISHBIO (Lao PDR), National University of Lao, and the MRC are currently using Access (Microsoft®, Redmond, Wash., USA) to manage some or all of their data.

A large fraction of the full group discussion was devoted to the topic of data storage and management. Although Excel is an easy software for LMB researchers to use, MRC representatives expressed concerns regarding the high error rate of data entered into Excel in comparison to other programs such as Access, which can be structured to reduce errors that occur during data entry. The MRC uses relational databases and has strict data management protocols. Because of their experience in reviewing datasets from around the region, the MRC representatives are concerned about the level of quality assurance and quality control (QA/QC) in the LMB. Over the past two or three decades there has been an increasing effort to collect raw

data in the field; however, they felt that these data need to be managed with more stringent QA/QC methods in order to reduce errors. At this point, the MRC does not use a standardized software system; this approach allows receipt of data in various formats (for example, Excel, Access).

Participants agreed that some fisheries institutions in the LMB are currently limited by their capacity to enter, manage, and analyze data. In some cases institutions have a database, but they may not have the resources, staff, or capacity to continue to maintain the database. The type of information technology (IT) skills required to create and maintain a database are in demand, and trained IT staff may be lost to higher paying jobs in the private sector. Therefore, the institutions are frequently training new IT personnel in order to maintain capacity, while at the same time also desiring to increase this capacity to meet additional challenges. The physical capacity to manage data (that is, software, computers, and servers) and to afford the latest version of software may be limited at LMB institutions. If the institution does not have robust, up-to-date antivirus software, then databases and host computers may be compromised.

Regardless of the software used and the development of capacity to manage the data, the importance of QA/QC should not be overlooked. Participants emphasized that before sharing or combining data, strict QA/QC protocols will need to be established that include entering metadata to document how the raw data were collected and what level of QA/QC was performed. The MRC has long-term plans to help develop national data QA/QC systems and to transfer the data QA/QC and management systems to each representative country. Some participants felt that the MRC QA/QC program is too complex and time consuming and consequently would be difficult to implement at the national level. Therefore, there was interest in both developing a protocol that was more simplified and approachable and developing the capacity within each country to implement these protocols.

Session 3

Before designing an LMB fish monitoring network, it is important to understand the basic fisheries questions that are of interest to the LMB nations. The participants were asked to discuss this topic in Small Group Session 3, which involved a more detailed conversation about the important fisheries questions. Four questions were posed to the participants divided into three groups:

Question 1: What are the important fisheries questions that you are trying to answer or hoping to answer?

Question 2: What fish data parameters are most important for indicating change?

Question 3: How would you prioritize data parameters given limited resources? (Take the list you created above and number them by priority.)

Question 4: Which sampling methodologies would be the most useful to obtain fish data parameters given the priorities above and your resources?

In general, it seemed that the research topics suggested by participants in response to Question 1 arose from the general issue of sustaining fisheries in the LMB. These questions included the following:

- What are the status and trends of the fisheries?
- What is the species composition of the catch? Is the species diversity changing over time?
- What is the size composition for a given species?
- What are the long-term maximum sustainable yields for stocks?
- What is the intensity (for example, length of time the gear is set) of fisheries at specific locations?
- What is the yield by habitat type (for example, flooded forest, main stream, flood plain)?
- What is the ecosystem productivity (for example, zooplankton, phytoplankton, fish)?

An additional subset of important monitoring questions, which were economic and societal in nature, was suggested independently in each group. Participants were interested in the economic (for example, food security) and societal (for example, nutrition, health, user fishing rights) values of the fisheries in the LMB and pointed out that there are different metrics with which to measure the value of a fishery. The potential effects of various hydrological changes were highlighted as important factors within the LMB nations because the fisheries are highly dependent on the hydrologic regime. Questions were posed regarding the ecology of important fish species (including white fish, black fish, and grey fish) with a specific interest in the timing and location of spawning migrations and recruitment. Many participants were interested in determining the length and duration of spawning runs and identifying critical spawning and dry season habitats.

Questions 2 and 3 asked participants to consider what fish data parameters are most important for indicating change in the system and how they would prioritize collection of these parameters considering limited resources. Participants were provided with a list of example parameters to initiate the discussion (app. 5).

The length and weight of individual fish were key parameters included in all three small group responses. Although length-weight curves are available in the literature and on FishBase (http://www.fishbase.org/) for some of the important species, they may not be available for all species, or the relations may vary by region. The participants generally agreed that both length and weight for individual fish were important parameters to collect in order to support continued development and refinement of length-weight curves.

Measuring relative abundance, as with CPUE, is considered essential, as it was discussed in detail by all three small groups. Participants established that CPUE is problematic to measure because of the diversity of fish species and gear types used in the region. This parameter would ideally be measured for each important species by gear type and by habitat type. The challenge posed by CPUE was apparent in the rankings; because of the importance of the parameter, Group 1 prioritized it first, but in contrast, because of the difficulty of measuring it, Group 3 prioritized it last.

Although not discussed in detail during the large group discussions, Group 3 considered the overall total biomass of fish catch to be the most important parameter to measure because it is the single parameter that contributes the most to scientific understanding, as well as being relatively easy to measure. If possible, biomass of catch by species or for focal species would also be an important parameter to measure. These biomass data may be used to assess CPUE if a standard measure of effort is developed.

Physical, chemical, and hydrological parameters, such as water depth, water velocity, water temperature, turbidity, and nutrient concentrations, were brought up and discussed independently within each small group. The parameters were not prioritized because the question specifically asked about fish parameters; however, participants agreed that water quality and sedimentation can play a vital role in ecosystem productivity, and therefore it would be useful to monitor these parameters within a fish monitoring network. A representative for the MRC pointed out that many water quality measures are monitored in various locations around the LMB for human health and welfare studies, but these data have not been collected in conjunction with fisheries data. The MRC has recently begun trying to synchronize sediment, water quality, and biological data collected around the basin during various projects.

To identify what types of sampling may be most beneficial to standardize in a fish monitoring network, participants were asked in Question 4 to identify which sampling methods would be most useful to obtain fish data parameters considering their previously listed priorities and their available resources. A list of example methodologies was provided to stimulate discussion, but participants initially expressed confusion over the terms used to define the example methodologies (app. 5). To clarify, participants decided that "community fisher surveys" refers to surveys that are conducted by fishers or villagers who have been trained by technical experts to collect specific data, whereas "creel or commercial harvest surveys" refers surveys in which technical experts directly collect data on a fisher's catch. The term "community interview surveys" refers to surveys similar to household surveys, where technical experts ask fishers questions about their catch, but the experts do not directly measure the catch. Additionally, there are fishery-independent surveys conducted by research groups on various topics such as studies of gonad development, fish movement, or fish behavior, which were called "independent biodiversity surveys."

The participants generally rated fishery-independent surveys, where limited resources are expended to collect the most accurate data, as the primary sampling methodology that would be most useful to obtain the desired fish data parameters. Because these surveys are designed and conducted exclusively by technical experts, this indicates a high priority placed on utilizing limited resources to collect the most accurate data. Secondarily, participants preferred creel or commercial harvest surveys conducted by technical experts, a preference that emphasizes the importance of data collected with greater accuracy. Community fisher surveys were considered the third most useful survey type, and community interview surveys and market surveys were generally placed last.

The conversations in the small groups regarding relative value of data resulted in higher value being assigned to methodologies leading to accurate data collected in the most efficient manner possible, which thereby recognized that the most accurate data are likely collected by professionals. Surveys conducted directly by trained experts would utilize more resources and would be limited spatially and temporally; however, the data gathered could be expected to be the most accurate. In contrast, local villagers could be trained by technical experts to be citizen scientists and could collect greater quantities of data because of the greater number of surveyors. These data may be less accurate, but the coverage of the study (spatially and temporally) could be broader. Many participants were supportive of the concept of training local villagers to collect the data, recognizing that because of limited staff capacity they would not be able to accomplish as much on their own. Also, it was noted during a discussion earlier in the workshop that technical experts could be used to test and calibrate the accuracy of these data collected by villagers.

During the discussion regarding monitoring methodologies in Small Group Sessions 2 and 3, participants consistently brought up the topic of directing certain monitoring activities towards different habitat types. They recommended that sampling methods should take into consideration the locations, habitat types, and gear types (especially with reference to seines for shallow water and gill nets for deeper water). One group recommended that the monitoring network use standard gear for specific habitat types and locations. For example, IFReDI in Cambodia uses two standard gear types depending on the sampling: seine nets are used to target black fish, whereas gill nets are used to target white fish.

Session 4

During the workshop the participants were asked to identify what would be important to take into account when planning a fish monitoring network that would allow their agencies or organizations to participate. The specific questions were as follows:

Question 1: What would be the most important considerations to take into account that would allow your agency or organization to participate in a fish monitoring network?

Question 2: What resource needs do you recognize in terms of equipment, personnel, and training?

The discussion tended to address both Questions 1 and 2 simultaneously since identifying considerations corresponded with recognizing the technical capacity and resource needs of the institutions. Therefore, the two discussions are presented here together.

Above all other concerns, participants voiced a great need for technical and financial support, such as training in the use of various software and dedicated IT staff to help manage databases. There were discussions regarding training needs at all levels. Some discussed the importance of building technical capacity at the district or provincial level because most fisheries landing data are collected at that level and passed up to the central government. Building district- or provincial-level capacity would improve the skills of the people already in positions to be involved in the network and also relay to local officials the importance of collecting thorough and accurate data. On the other hand, participants also discussed the importance of training students in standard sampling, taxonomic, and statistical procedures and providing additional financial support to students in biology and fisheries departments of regional universities. This emphasis on student support provides for the training of the next generation of local fishery experts, thereby building local capacity. Some participants suggested that the Network itself could arrange regular trainings for university students and government staff within the Network (that is, involving all levels of expertise), which would also provide an opportunity to exchange and share knowledge with students in other countries.

A consideration discussed in the larger group and in the smaller groups was the significance of the language barrier in the development of the databases and in network communications. One approach mentioned to address the language issue would be to develop separate databases, which would be bilingual (using both the national language and English), for each nation. The national databases would be relational and could be joined when researchers from different countries were interested in collaborating. To facilitate communication among network participants, it may be necessary to translate all network-related materials into all languages, which could be a costly and time-consuming task. Participants also suggested that the network could help to translate some of the important literature resources from the various member countries, which are currently only in the local language and therefore possibly inaccessible to researchers in other countries. Additionally, many institutions do not currently have the time and funding to upload unpublished reports and publications. In general, researchers agreed that a repository of unpublished reports that are not currently available on the Internet would be a very useful tool for the network.

Participants also raised concerns regarding specific resource needs relevant to a fish monitoring network, including a need for additional computers, improved servers, additional facilities, and additional monitoring equipment, especially water quality measuring equipment. Participants suggested that having standardized sampling equipment, such as seines and gill nets, would improve efforts to standardize data collection and would also provide much needed resources.

In addition to the need for more technical capacity and resources, the participants discussed what type of coordination would be necessary to allow their agencies or organizations to participate in a fish monitoring network. Participants from government agencies requested more information regarding their roles in the network, the potential benefits to their agencies, and how they can contribute their time and efforts. There was considerable agreement on the need for national coordinators, or "point persons," who could provide assistance and stimulate collaboration. Furthermore, participants agreed that there should be one person or institution that is responsible for coordination of the network at the level of the entire LMB. The national coordinators could then report to this central person. Participants suggested regular meetings during which members of the network could develop and discuss an annual action plan.

Although the participants recognized the importance of coordination, they were also concerned with the potential time commitment this coordination may require. There was considerable discussion about whether the network would be too much of a time commitment for its members. Several participants gave examples of networking efforts in the region that had not succeeded because researchers lacked time and an incentive to participate. If they were expected to contribute extra time and effort, then how they (or their agencies or organizations) would be compensated was unknown. Because of funding shortages, many government employees may not be allowed to participate if it takes them away from their other tasks. Some participants expressed the concern that they would need both technical reasons and financial support to warrant participation in the Network.

Representatives of the different nations discussed the importance of data sharing agreements and the option of providing general information on research activities rather than making raw data accessible to any member of the network. The MRC and IFReDI representatives mentioned that the MRC has a system of permissions for sharing data, which could be used as a model for data sharing within the

network. Different institutions face different barriers regarding the sharing of data. While data sharing will vary by institution, university participants generally agreed that they are more able to share data, whereas government officials may need to obtain official permission and agreements from the appropriate ministries.

Conclusions

During the workshop, there was consensus among participants that some form of a fish monitoring network and the collection of comparable data throughout the LMB region would be highly valuable. It was also clear that there are numerous interests and priorities that could potentially be addressed within the context of a network. The workshop provided an opportunity to discuss some of these interests and priorities, and some conclusions can be drawn from those dialogues. The diversity of interests and topics discussed, however, necessitates the development of more detailed network goals and objectives before specific sampling designs and support tools can be developed.

While the potential metrics and collection methods discussed in the small group sessions were similar among the three small groups, the resulting prioritizations of metrics differed considerably, indicating that further conversations regarding the importance of various metrics and methodologies may be necessary during the development of the network. There currently appears to be a preference for studies conducted directly by technical experts, although interest was also expressed in training local villagers to collect some data. The groups emphasized that, at least initially, greater accuracy in data collection should be emphasized over greater quantities of data. The participants were asked to prioritize the collection methods, however, and were not asked to consider a combination of various methods. During the small group discussions, participants perceived different methods as having different values. Some assigned different values to different methods; therefore, some combination of studies by technical experts and by trained local people may be of interest to maximize both coverage and accuracy.

If the network conducted standardized monitoring using technical experts in the field, then starting with a small number of common gear types, such as gill nets and seines, might be convenient for the majority of participants. These gear types could be used to target different habitat types, as suggested by participants. A standardized study design conducted in different regions of the LMB by using nets with the same specifications and effort could be one aspect of monitoring conducted by technical researchers in the network.

The importance of and level of interest in taxonomic clarity to a monitoring network is likely to depend on the objective of the monitoring. If the objective of a monitoring program is conservation, then taxonomy may be more important than if the objective is food security. In some cases, it may be sufficient to pool species into general categories. Overall, it became apparent that there are a few species/genera that are considered important for multiple objectives and were mentioned independently by both groups, such as *H. siamensis*, *H. lobatus*, *Channa* spp., all *Pangasius* spp., tilapia *Oreochromis* spp., *C. enoplos*, *Lobocheilos cryptopogon*, and *B. gonionotus*. Depending on the sampling design and the objectives of the monitoring, these species could be targeted for more specific data collection.

Early in the workshop, participants expressed strong agreement that some mode of information sharing is urgently needed. After the small group discussions, however, the general consensus was that most fisheries institutions in the LMB are currently limited by their capacity to enter, manage, and analyze data. A well-developed, centralized, relational database for each country, introduced with the proper level of hands-on training, could address this limitation. For example, relational databases could be developed separately for the dai fishery in Cambodia and for the lii trap fishery in Lao PDR and could be linked by taxonomy. Consequently, the monitoring methodology itself would not be comparable, but the species composition data (presence/absence of species) or the timing of occurrence in the catch for various species could be compared. The USGS and FISHBIO described some of their relevant experience developing and managing databases in their opening presentations and offered their expertise. The MRC representatives confirmed that database development could be coordinated with the MRC and their IT staff.

The network could build on efforts similar to the MRC's MFD (2003) by developing an interface that is easily accessible via the Internet. Participants generally agreed that, while the MFD is a valuable resource, it is in need of updating because the entries are beginning to no longer reflect current fish taxonomy of the region. Limited access to the MFD was also cited as a concern. Building a database that is accessible through the Internet would allow network members to suggest corrections and updates to the taxonomy used in the database, as well as increase communication among researchers active in different portions of the LMB. The FISH-BOL initiative was used as an example of a database that facilitated communication among members regarding various data, including species identifications. It was also suggested that the network databases could be linked with FishBase, which could provide updates on taxonomy and species-specific information for species collected during monitoring efforts. Formal Terms of Reference or Memoranda of Understanding are means by which some data sharing agreements have been developed, and the Network could build from such approaches to facilitate variable levels of data sharing.

Future Actions

The workshop brought together diverse scientists and managers, who provided consensus about the following activities to pursue.

Pilot Monitoring Project for Standardized Fish Sampling

The USGS and FISHBIO are coordinating a pilot study to test standardized methods that may be applied throughout the LMB. Initially data would be collected in Lao PDR and Vietnam, with plans for future expansion into Cambodia and Thailand. Support for providing training in these methods is being sought. The sampling would include a combination of more frequent supervised surveys by trained villagers (that is, community-based surveys) and less frequent fishery-independent surveys by technical experts. Standard gear would be utilized in all locations, and timing of sampling would be coordinated so that data could be comparable across sampling sites. Experience gained from the pilot study could be used to establish a sampling design with the objective of collecting discharge, water quality, and biological data simultaneously. This is the type of experience that could be used to gain government support and funding for the proposed Network.

Database Design and Development

A preliminary online network portal will be designed by the USGS to provide a forum for the network and to host the database and other network content. The portal would contain a database with a design based on data collected during the pilot study and in coordination with FISHBIO and the MRC. The portal Web site could have a simple template datasheet to provide information on the preferred format for data. Data could be submitted to the database in various ways. The user could send a data file as an email attachment, upload the file in a standard format, or enter the data directly into the template online. There could be information provided on the preferred methods or protocols for data collection and a short list of gear types and key data to collect for each gear. Depending on the sharing settings, available outputs could be password protected. Outputs could include locations of projects in the database (shown on a map, for example, Google Maps©), as well as the status of the work and data (for example, project descriptions and metadata, data uploaded, data QA/QC complete, data shared/not shared). Additionally, the portal could provide a library of relevant documents (or a link to a similar, established archive such as the Aquatic Commons, http://aquaticcommons.org/) and a page of links to pertinent information. Cooperators in the monitoring network will continue to discuss possible database approaches and content.

Seeking Additional Support To Expand Work and Address Scientific Questions

Because of the concerns expressed at the workshop regarding the capacity and funding that would be required to implement the network, the success of the network will likely depend on whether it can offer one or more tools that provide clear benefits to researchers in the LMB. As an initial step, participants recommended the development of a proposal for the network with well-defined goals and objectives that they could submit to funding sources and to relevant national agencies. In general, governments will require a document for review in order for national scientists to obtain approval and support. Some participants indicated that including funds in the proposal to hire dedicated staff to facilitate active coordination within the network, and to assist with data uploads or document translations, would improve the likelihood that network members could be involved with minimal additional time commitments.

Eventually, with the development of a strong network of researchers and dedicated funding, the Network could facilitate the coordination of more advanced research to provide quantitative data on fish migrations (for example, telemetry), status of populations, species composition and landings at specific habitat types, effects of environmental change on fisheries, estimates of sustainable harvest levels, or genetic studies. Overall, workshop participants agreed that the establishment of a structure such as the Network is the type of support that is greatly needed to answer their most pressing questions and to enable local researchers and resource managers to monitor and sustain the valuable and diverse aquatic life of the Mekong River.

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Appendixes

Appendix 1. Agenda and Presenter Guidelines for the Mekong Fish Network Workshop, Phnom Penh, Cambodia, February 9–10, 2012

Proposed Mekong Fish Network Goals

1. Increase our knowledge of the Mekong River fish community to support understanding of how fish will respond to environmental changes.
2. Increase the capacity of local people and institutions to study the Mekong River fishes.
3. Provide opportunities to people collecting Mekong River fish data to share their knowledge with scientists and decisionmakers.
4. Identify harmonious management options that will help protect Mekong River fish and their habitats for the benefit of future generations of people.
5. Provide a forum and exchange opportunity for developing scientific peer-reviewed publishing opportunities regarding Mekong River fishes.

Workshop Goals

1. Determine if the fish monitoring network and associated databases proposed at this meeting are of interest and value to Lower Mekong River Basin (LMB) nations.
2. Determine types of future Mekong River fish monitoring that could be used to collect data to populate the databases.
3. Establish methods and organizational structure for working together in the future on Mekong River fish monitoring and research.

Workshop Objectives

1. Discuss current monitoring and research activities and plans for future monitoring and research.
2. Discuss data sources currently available in LMB institutions. What LMB fish data exist?
    a. Determine if institutions would be interested in sharing data via an Internet database in the future.
    b. Demonstrate Internet databases and visualizations for consideration.
3. Identify key indicators for monitoring long-term trends in fish populations and measuring impacts of changes in the system.
    a. Demonstrate how data could be analyzed once sufficient data were collected.
    b. Demonstrate how data could be presented via the Internet.
    c. Discuss what data will be needed for analyses.
4. Determine if consistent fish data collection standards can be agreed upon among LMB nations.
    a. Select shared methods and parameters for sampling fishes throughout the LMB.
5. If parties agree to work together, nominate Network representatives for each nation.

Advanced Questions for Consideration by Presenters:[1]

Please address as many of these as you are able and wish to address in the short time available. We will also discuss aspects of these questions in small groups.

1. What reaches of the Mekong and large tributary rivers provide the most food fish for people?
2. What is the scope of your existing fish monitoring, and what capacity do you have to continue this work in the future? In other words, approximately how many people are studying fish, what kind of work are they doing, where are they working, are fish being collected, are the data being analyzed, and so on? What fish capture gears are you currently using?
3. Would you consider sharing Mekong River fish data with other partners in the network? Would you need assistance (for example, personnel or training) in order to participate in data sharing?
4. What fish data are most important for indicating changes in fish diversity, abundance, availability, and habitat suitability? Which of these types of indicators is your organization interested in (for example, number or biomass captured, catch per unit effort, habitat use)? What kind of data would be needed to create these indicators?
5. What types of data would you like to collect in the future, and would you need assistance? If so, what kind of assistance is most needed?

[1]Presenters will be contacted separately and informed of their roles. Attendees from other institutions will have an opportunity to contribute short comments or to provide their opinions in the small group discussions.

6. If you know of historical data on Mekong River fishes, can you briefly explain what type of data it is and whether it could be shared with other partners in the network? For example, does the historical data contain one or more of the following?

    a. Species captured

    b. Number of individuals captured

    c. Size information for captured fish, for example, length or weight

    d. Habitat information, for example, water quality (including temperature), substrate, depth, turbidity, shoreline habitat

Table 1–1. Agenda for the Mekong Fish Network Workshop, Phnom Penh, Cambodia, February 9–10, 2012, hosted by FISHBIO and the U.S. Geological Survey (USGS).

[The workshop was held at the Hotel Cambodiana, Tonle Sap Room, second floor. NGOs, nongovernmental organizations; Lao PDR, Lao People's Democratic Republic; min, minute; h, hour]

Thursday, February 9, 2012	
Time	**Agenda item**
8:00–8:30	Registration
8:30–8:45	Welcome and Introduction Proposal: Mekong Fish Network. We think such a network helps achieve the Network Goals outlined above. This meeting is organized to make some suggestions about the Network for your consideration.
8:45–8:55	Welcome and develop consensus around ground rules/code of meeting conduct
8:55–9:15	Demonstrations of data representation tools and using data/decision rules
9:15–9:30	Advantages of shared collection methods, data sharing examples
9:30–9:45	Summary statistics and analysis methods
9:45–10:05	Presentation: Cambodian Fisheries – Government activities Address advance questions (see end of this agenda)
10:05–10:25	Presentation: Cambodian Fisheries – NGOs, University, other researchers Address advance questions (see end of this agenda)
10:25–10:40	Coffee/tea break
10:40–11:00	Presentation: Lao PDR Fisheries – Government activities Address advance questions (see end of this agenda)
11:00–11:20	Presentation: Lao PDR Fisheries – NGOs, University, other researchers Address advance questions (see end of this agenda)
11:20–11:40	Presentation: Vietnam Fisheries – Government activities Address advance questions (see end of this agenda)
11:40–12:00	Presentation: Vietnam Fisheries – NGOs, University, other researchers Address advance questions (see end of this agenda)
12:00–13:30	Lunch
13:30–13:50	Presentation: Thailand Fisheries – Government activities Address advance questions (see end of this agenda)
13:50–14:10	Presentation: Thailand Fisheries – NGOs, University, other researchers Address advance questions (see end of this agenda)
14:10–14:30	Presentation: MRC Fisheries Address advance questions (see end of this agenda)
14:30–15:00	Review of fish monitoring network concept Do workshop participants wish to voice concerns? Consensus that we proceed with discussion in small and large groups?
15:00–15:15	Coffee/tea break
15:15–15:30	Introduce Small Groups. Address specific questions, develop answers to share with entire group, identify a recorder (FISHBIO/USGS) and a reporter in each group.
15:30–16:15	Small Group Session 1 (45 min): *What fish species are most important to monitor or study?* *Do you use local names, and do you feel those names need to be validated as unique species?*
16:15–16:45	Large Group Session 1 (30 min): Present outcomes of small group session Compare species lists
16:45–17:00	Wrap-up Review progress of first day and summarize goals for tomorrow Questions
18:30	Group dinner at *Romdeng* – Meet in the Hotel Cambodiana lobby at 18:30

Table 1–1. Agenda for the Mekong Fish Network Workshop, Phnom Penh, Cambodia, February 9–10, 2012, hosted by FISHBIO and the U.S. Geological Survey (USGS).—Continued

[The workshop was held at the Hotel Cambodiana, Tonle Sap Room, second floor. NGOs, nongovernmental organizations; Lao PDR, Lao People's Democratic Republic; min, minute; h, hour]

Friday, February 10, 2012	
Time	**Agenda item**
8:00–8:15	Review first day Overview of agenda Questions and concerns Review ground rules
8:15–9:00	**Small Group Session 2** (45 min): *What data parameters are currently recorded?* *What sampling methods are currently used?* *Is there a standardized way in which you currently manage data?*
9:00–10:00	**Large Group Session 2** (1 h): Present outcomes of small group session.
10:00–10:30	Coffee/tea break
10:30–11:30	**Small Group Session 3** (1 h): *What are the important fisheries questions that you are trying to answer or hoping to answer?* *What fish data parameters are most important for indicating change?* *How would you prioritize data parameters given limited resources?* *Which sampling methodologies would be the most useful to obtain fish data parameters given the priorities above and your resources?*
11:30–12:30	**Large Group Session 3** (1 h): Present outcomes of small group session
12:30–13:45	Lunch
13:45–14:45	**Small Group Session 4** (1 h): *What would be the most important considerations to take into account that would allow your agency or organization to participate in a fish monitoring network?* *What resource needs do you recognize in terms of equipment, personnel, and training?*
14:45–15:45	**Large Group Session 4** (1 h): Present outcomes of small group session
15:45–16:15	Coffee/tea break
16:15–17:00	Review the workshop conclusions and next steps, including how FISHBIO and the USGS can support a Mekong Fish Monitoring Network

Appendix 2. Workshop Participants and Attendees

Table 2–1. Participants and attendees of the Mekong Fish Network Workshop, Phnom Penh, Cambodia, February 9–10, 2012, hosted by FISHBIO and the U.S. Geological Survey.

[Names are listed in alphabetical order by surname; affiliations and home countries are also listed. Lao PDR, Lao People's Democratic Republic]

Shaara Ainsley, FISHBIO, United States

Matthew Andersen, U.S. Geological Survey, United States

Eric Baran, WorldFish Center, Cambodia

John Beeman, U.S. Geological Survey, United States

Chouk Borin, Faculty of Fisheries, Royal University of Agriculture, Cambodia

Doug Demko, FISHBIO, United States

Vittoria Elliott, Cambodian Molecular Genetics Group and Scientific Capacity Development Initiative, Cambodia

Pelle Gatke, Fisheries Action Coalition Team, Cambodia

Taber Hand, Conservation International and Wetlands Work!, Cambodia

Sokrith Heng, Conservation International, Cambodia

David Hewitt, U.S. Geological Survey, United States

Kent Hortle, Private Consultant, Australia

Erland Jensen, Mekong River Commission, Lao PDR

Tuantong Jutagate, Fisheries Program, Faculty of Agriculture, Ubon Ratchathani University, Thailand

Kaing Khim, Fisheries Administration, Cambodia

Malasri Khumsri, Department of Fisheries, Thailand

Chamnan Kim, Conservation International, Cambodia

Kong Kimsreng, International Union for Conservation of Nature, Cambodia

Simon Mahood, Wildlife Conservation Society, Cambodia

Bunnara Min, Conservation International, Cambodia

So Nam, Inland Fisheries Research and Development Institute, Cambodia

Nguyen Bach Loan, Cantho University, Vietnam

Sinsamout Ounboundisane, FISHBIO, Lao PDR

Harmony Patricio, FISHBIO, Lao PDR

Nor Pengbun, Mekong River Commission, Cambodia

Somany Phay, World Wildlife Fund Freshwater Programme, Fisheries Administration, Cambodia

Koneouma Phongsa, National University of Laos–Dong Dok Campus, Lao PDR

Cao Le Quyen, Vietnam Institute of Fisheries Economics and Planning, Vietnam

Dongdavanh Sibounthong, Ministry of Agriculture and Forestry, Department of Livestock and Fisheries, Lao PDR

Douangkham Singhanouvong, Ministry of Agriculture and Forestry, National Agriculture and Forestry Research Institute, Living Aquatic Resources Research Center, Lao PDR

Rick Switzer, U.S. Department of State, Regional Environment, Science, Technology and Health (ESTH) Hub Chief for East and Southeast Asia, U.S. Embassy, Thailand

Vu Ngoc Ut, Cantho University, Vietnam

Appendix 3. Monitoring Efforts Described by Workshop Participants in Presentations on Day 1

Table 3–1. Monitoring efforts described by workshop participants in presentations on day 1. The projects listed below are not intended to be an exhaustive list of the current fisheries monitoring in the LMB, rather they provide examples of similar projects being conducted throughout the basin.

[The projects listed below are not intended to be an exhaustive list of the current fisheries monitoring in the Lower Mekong River Basin (LMB); rather, they provide examples of similar projects being conducted throughout the basin. IFReDI, Inland Fisheries Research and Development Institute; LARReC, Living Aquatic Resources Research Centre; Lao PDR, Lao People's Democratic Republic; DoLF, Department of Livestock and Fisheries; DoF, Department of Fisheries; WWF, World Wildlife Fund ; MRC, Mekong River Commission; IUCN, International Union for Conservation of Nature; CPUE, catch-per-unit-effort]

Monitoring activity	Agency, university, or organization	Location	Season	Data collected
Assessing catch of the bag net (dai) fishery	IFReDI (Cambodia)	Tonle Sap River (Kandal and Phnom Penh)	Late wet to early dry (October through March, four lunar phases each month, 7 days/ phase)	Fish species, catch composition, length, weight, and water depth
Assessing catch of the wing (lii) traps	LARReC (Lao PDR)	Hoo Som Yai channel near Khone Falls	Wet (May to September)	Sample from up to 21 wing (lii) traps
Landings data	DoLF (Lao PDR)	In each Province	Every year: 6 month, 3 month, and few weeks	Catch from various landing sites is recorded for each province and is aggregated by the department
Landings data	Vietnam Institute of Fisheries Economics and Planning	In each Province	Every year: 6 months and 3 months	Catch from various landing sites is recorded for each province and is aggregated by the department
Stock and catch assessments	DoF (Thailand)	In each Province, in large reservoirs	Over 10 years of data	Catch from various landing sites is recorded by each provincial fisheries office and aggregated by the Fisheries Information Center (of DoF)
Fish species identification and specimen collection and preservation surveys	IFReDI (Cambodia)	Over 200 stations in inland water habitats throughout Cambodia	Wet and dry (January–December, all times of year)	Fish species, length, weight, and local names
Fish abundance and diversity surveys	IFReDI (Cambodia)	Tonle Sap River, Mekong River in Kratie and Stung Treng, Sekong River, Sesam River, and Srepok River	Dry (January–February)	Fish species, catch composition, length, weight, and water depth
Fish biodiversity monitoring	LARReC (Lao PDR)	From the Lao-Chinese border to Vientiane, Laos	Wet - September and dry - February (first phase in 2003–5; second phase in 2011–12)	Fish species, catch, and habitat
Fish taxonomy survey	LARReC (Lao PDR) with Rainboth (University of Wisconsin)		1998	Survey is complete but has not yet been published. Rainboth has specimens in USA

Table 3–1. Monitoring efforts described by workshop participants in presentations on day 1. The projects listed below are not intended to be an exhaustive list of the current fisheries monitoring in the LMB, rather they provide examples of similar projects being conducted throughout the basin.—Continued

[The projects listed below are not intended to be an exhaustive list of the current fisheries monitoring in the Lower Mekong River Basin (LMB); rather, they provide examples of similar projects being conducted throughout the basin. IFReDI, Inland Fisheries Research and Development Institute; LARReC, Living Aquatic Resources Research Centre; Lao PDR, Lao People's Democratic Republic; DoLF, Department of Livestock and Fisheries; DoF, Department of Fisheries; WWF, World Wildlife Fund ; MRC, Mekong River Commission; IUCN, International Union for Conservation of Nature; CPUE, catch-per-unit-effort]

Monitoring activity	Agency, university, or organization	Location	Season	Data collected
Fish species diversity and distribution survey	National University of Lao	Several reaches of the Mekong River, including Luang Prabang Province, Vientiane, Savannakket, Bolikhamxay	Terminal project, sampled every 2 months using different gear types in different habitats	Size, Lao name, species name, locality, habitat, latitude and longitude, depth, date, hour, economic value, and collection method
Fish diversity surveys	Cantho University (Vietnam)	Throughout the Hau River	Year-round, 1 day per month (always on the same date)	Species composition, number of individuals, length and weight of individuals, species caught by gear type, water quality (temperature, flow, and turbidity)
Fish diversity surveys	Ubon Ratchathani University (Thailand)	Mountainous area, north of Thailand		Species composition, count and weights of fishes, as well as the associated water quality parameters.
Fish abundance and fish diversity surveys	DoF (Thailand)	Large reservoirs throughout Thailand		The project examines seasonal changes in hydrological regime and associated catch
Biodiversity surveys of the Mekong River	WWF, Fisheries Administration and Forestry Administration (Cambodia)	Between Kratie and Stung Treng towns, northeast Cambodia	Three seasonal periods: the early dry season (receding water levels, November 2006), the mid-dry season (low water levels, March–April 2007) and the wet season (high water levels, July-August 2007)	Data were collected on all wildlife and plants, not just fishes. Surveys inventoried all fish taxa encountered in the study area, with opportunistic collection of shellfish and aquatic crustaceans. Surveys comprised sampling within the Mekong River channel and visits to large urban markets, villages and fish traders
Fish larvae drift	IFReDI (Cambodia)	Tonle Sap and Mekong Rivers in Phnom Penh	Late dry to wet (April–September)	Fish species, catch composition, length, and water depth
Larval fish sampling	LARReC (Lao PDR)	Three sites in two provinces: Luang Prabang, Champasack Province in 2009; four sites were sampled in Xayabouri Province in 2010		
Larval fish sampling	Cantho University (Vietnam)	Hau River	Seasonal	
Larval fish sampling	Ubon Ratchathani University (Thailand)	Opportunistic project-based sampling during other studies		Species composition of larval fishes, as well as the associated water quality parameters

Table 3–1. Monitoring efforts described by workshop participants in presentations on day 1. The projects listed below are not intended to be an exhaustive list of the current fisheries monitoring in the LMB, rather they provide examples of similar projects being conducted throughout the basin.—Continued

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Monitoring activity	Agency, university, or organization	Location	Season	Data collected
Conducts larval sampling	MRC			Data collected in addition to larval samples includes site, date, volumetric flux, velocity
Community-based fish catch monitoring	Conservation International (Cambodia)	Tonle Sap Lake		Works with local villages to monitor fish and wildlife
Community-based fish catch monitoring	IUCN (Cambodia)	Sala Phoum Ramsar Site		The objective is empowering villagers through conducting their own research. Villagers are trained in research teams to monitor changes in natural resources and document local knowledge
Community-based fish abundance and diversity monitoring	LARReC (Lao PDR) participates in this MRC program. This is also conducted throughout Cambodia and Vietnam	Fishers at 6 different sites (18 fishers total) use log books to record fish catch data Luang Prabang Province; Vientiane Capital; Bolikhamxay Province; Champasack Province		Date, effort, gear, habitat, dimensions of gear, start and end time, total time fishing, and species caught
Community-based fish abundance and diversity monitoring Additionally, the study quantified the contribution of wild fisheries to the diet of households through surveys	FISHBIO (Lao PDR)	Nam Kading River, and confluence with Mekong, Bolikhamxay Province, Lao PDR	Wet and dry (June 2010 to January 2012)	Species composition and total biomass of harvests, relative abundance by species and CPUE, daily consumption of fish per family (in kilograms), and the proportion of diet consisting of fish
Community-based fish catch monitoring	Fisheries Administration and WWF (Cambodia)	Four selected villages along the Srepok River (Koh Myeul Leu, Koh Myeul Krom, Chi Met and Nong Bor); the 10 trained community representatives Will be trained by WWF staff in order to analyze, utilize, and manage data, records, and information collected in the four villages		

Table 3–1. Monitoring efforts described by workshop participants in presentations on day 1. The projects listed below are not intended to be an exhaustive list of the current fisheries monitoring in the LMB, rather they provide examples of similar projects being conducted throughout the basin.—Continued

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Monitoring activity	Agency, university, or organization	Location	Season	Data collected
Community-based fish catch monitoring	Ubon Ratchathani University (Thailand)			Two projects collecting fisheries data through the participation of local fishers: (1) Study on the aquatic fauna and flora and conservation activities participated in by local residents and (2) community participatory and geographic information system for deep pool fisheries management (with National University of Singapore)
Market value of fisheries resources	WorldFish Center	Projects will occur in all four LMB countries (Thailand, Laos, Cambodia and Vietnam)		Assessing economic and welfare values of fish in the LMB
Market value of fisheries resources	FISHBIO (Lao PDR)	Nam Kading and confluence with Mekong, Bolikhamxay Province, Lao PDR	Wet and Dry (June 2010 to January 2012)	Surveys in village markets for species, total biomass, origin of fish, price per kilogram, total sales per vendor (kilograms sold and money earned per species per day)
Assessments of the household interview socioeconomic surveys	LARReC (Lao PDR)	Luang Prabang Province (1999), 27 villages, 500 households Champasack Province (2002), 20 villages, 200 households		
Market surveys	LARReC (Lao PDR)	Oudomxay Province; Luang Prabang Province; Champasack Province		
Market surveys	Cantho University (Vietnam)			
Deep Pool Fish Monitoring	LARReC (Lao PDR)	Six deep pools in four provinces: Bokeo Province; Luang Prabang Province; Xayabouli Province; Champasack Province	Dry (March 2008–9)	Six deep pools surveyed
Fishway Sampling Project	LARReC (Lao PDR)			Fish species, catch, and fish passage scope

Appendix 4. Example Mekong River Basin Fish-Sampling Methods

Table 4–1. Some examples of common fish-sampling methods used by participants of the Mekong Fish Network Workshop, Phnom Penh, Cambodia, February 9–10, 2012, hosted by FISHBIO and the U.S. Geological Survey.

[If methods are used by fishers throughout the Lower Mekong River Basin (LMB), they are listed as "regional." DoF, Department of Fisheries; Lao PDR, Lao People's Democratic Republic; cm, centimeter]

Gear type	Country	Habitat type	Season
Bag net	Cambodia (Dai)	Mekong River	October to March
	Thailand–DoF	Large-scale fishers, reservoirs	
Bamboo trap	Regional	Stream	Year-round
		River	
		Flooded areas	
Cast net	Lao PDR–National University, fishers	Stream	Full year, every 2 months (University)
		River	
	Thailand–DoF	Small-scale fishers, reservoirs	
Electrofishing	Thailand–Ubon Ratchathani University		
Gill net	Cambodia	Mekong River	
	Thailand–DoF (size: 3–9 cm)	Small-scale fishers, reservoirs	
	Regional	Stream	Year-round except in high flows
		River	
Hook and line (with and without rod)	Regional	Stream	Year-round
		River	
		Flooded areas	
Lift net	Regional	Stream	Year-round
		River	
		Flooded areas	
Lii (wing) trap	Lao PDR	Mekong River, Si Phan Don	Wet season (May to October)
Long line	Thailand–DoF	Small-scale fishers, reservoirs	
Poison	Thailand–Ubon Ratchathani University		
Push net	Thailand–DoF	Large-scale fishers, reservoirs	
Scoop net	Lao PDR–National University, fishers	Shallow water	Full year, every 2 months (University)
		Channel	
		Swamp	
		Rocky	
Seine net	Cambodia	Mekong River	
		Shallow water	
	Lao PDR–National University, fishers	Stream	Full year, every 2 months (University)
		River	
	Thailand–DoF	Large-scale fishers, reservoirs	
	Vietnam–Cantho University	Stream	Year-round
		River	
		Shallow water	
Spear	Lao PDR–National University, fishers	Deep water	Full year, every 2 months (University)
Trawl	Cambodia	Mekong River	
	Vietnam–Cantho University	Deep river	Year-round

Appendix 5. Questions Posed During the Small Group Sessions at the Mekong Fish Network Workshop, Phnom Penh, Cambodia, February 9–10, 2012

Small Group Session 1

Q1: What fish species are most important to monitor or study?

Q2: Do you use local names, and do you feel those names need to be validated as unique species?

Small Group Session 2

Q1: What data parameters are recorded?

For example:

- Individual lengths (total, standard, fork)
- Individual weights
- Length-weight relations
- Biomass of each haul/catch
- Biomass of each haul/catch by species
- Gear type for each haul/catch
- Gear size for each haul/catch
- Effort for each haul/catch
- Catch-per-unit-effort for each fishery and gear type
- Species presence/absence
- Species composition/richness
- Species abundance
- Age composition
- Size composition

Q2: What sampling methods are currently used?

For example:

- Community fisher surveys
- Creel surveys
- Community interview surveys
- Commercial harvest surveys
- Total catch biomass surveys
- Independent biodiversity survey

Q3: Is there a standardized way in which you currently manage data?

For example:

- Hardcopies
- Excel® spreadsheet
- Access® database

Small Group Session 3

Q1: What are the important fisheries questions that you are trying to answer or hoping to answer?

Q2: What fish data parameters are most important for indicating change?

For example:

- Individual lengths (total, standard, fork)
- Individual weights
- Length-weight relations
- Biomass of each haul/catch
- Biomass of each haul/catch by species
- Gear type for each haul/catch
- Effort for each haul/catch
- Catch-per-unit-effort for each fishery and gear type
- Species presence/absence
- Species composition/richness
- Species abundance
- Age composition
- Size composition

Q3: How would you prioritize data parameters given limited resources?
(Take the list you created above and number them by priority.)

Q4: Which sampling methodologies would be the most useful to obtain fish data parameters given the priorities above and your resources?

For example:

- Community fisher surveys
- Creel surveys
- Community interview surveys
- Commercial harvest surveys
- Total catch biomass surveys
- Independent biodiversity surveys

Small Group Session 4

Q1: What would be the most important considerations to take into account that would allow your agency or organization to participate in a fish monitoring network?

Q2: What resources needs do you recognize in terms of equipment, personnel, and training?

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