STANDARD OPERATION MANUAL FOR FISH ABUNDANCE AND DIVERSITY MONITORING IN THE LOWER MEKONG BASIN

November 2024

The Environmental Management Division

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CONTENTS

EXECUTIVE SUMMARY ..... **vii**

1 INTRODUCTION **7**

2 RATIONALE **9**

3 OBJECTIVES **10**

4 MONITORING PARAMETERS **10**

5 EXPLANATORY PARAMETERS **11**

6 METHODS **11**

6.1 Sampling locations 11

6.2 Selection of fishers 13

6.3 Monitoring habitats 14

6.4 Gear types for monitoring 14

6.5 Monitoring strategies 15

6.5.1 Methods for sampling artisanal fish catch 15

6.5.2 Standardised gill net surveys 15

6.6 Confounding factors 23

6.6.1 Season and Moon Phase 23

6.6.2 Time and duration 23

6.6.3 River levels and discharge 23

6.6.4 Water quality 24

6.6.5 Weather 24

6.6.6 Habitat 24

6.6.7 Fish migration 24

7 FIELD SAMPLING PROCEDURES **24**

7.1 General 24

7.1.1 Checklist 24

7.1.2 Calibration 24

7.1.3 Field staff 24

7.1.4 Boat safety 25

7.2 Procedures for completing FADM logbook/form 25

7.2.1 Recording fishing effort 25

7.2.2 Recording the whole catch 25

7.2.3 Recording a sub-sample of the catch 26

7.2.4 Recording catch and effort for two or more gears 27
7.2.5 Recording catch for two or more different habitats in a single day 27
7.2.6 Procedures for identifying fish and processing fish metrics 28
7.3 Measuring fish 31
7.3.1 Length measurement 31
7.3.2 Weighing fish 33
7.4 Photographing fish 34
7.5 Ancillary measurements 34
7.6 Data storage 35
8 DATA ANALYSES 35
8.1 Introduction 35
8.2 Species composition and relative abundance (contribute to Objectives i, ii, iii) 36
8.3 Catch rates (contribute to Objectives i, ii, iii, iv) 41
8.4 Population structure (contribute to Objectives i, ii, iv) 42
8.5 Quality control procedures 44
8.5.1 Fish Identification 44
8.5.2 Data Check 44
8.5.3 Calibration and validation 44
8.5.4 Data quality monitoring 44
8.6 Regular fisher feedback 45
8.7 Data sharing 45
8.8 Technical annual reports 45
REFERENCES 46
ANNEXES 48
Annex 1: List of threatened species in the Mekong Region according to IUCN Redlist (https://www.iucnredlist.org/) 48
Annex 2: Major Guild Types in the Lower Mekong Basin and their vulnerability to dam development (based on Welcomme et al. 2005 and MRC Council Study BioRA report 1) Grey shading highlights most vulnerable guilds. 51
Annex 3: Names of locations selected for fish abundance and diversity monitoring by country and habitat 54
Annex 4: Field trip check List 56
Annex 5: Forms or logbook for recording the data 57
Annex 6: Reporting guidelines and contents for annual reporting on Fish Abundance and Diversity Monitoring 60

FIGURES

Figure 6-1. Existing sampling locations in the LMB 12

Figure 6-2. Design of gill nets: Note multi-mesh gillnets are combinations of panels of various mesh-sizes, as shown in lower figure, joined randomly to create and elongated net one panel deep 16

Figure 6-3. Example of using Google Earth maps of each long-term sampling location to identify sampling site locations indicated. Example from Mekong at Nakhon Phanom Location, fish are sampled about 10-20 km downstream of Nakhon Phanom. Four sites contain suitable habitat for gill netting as indicated. Dry-season (December 2006 Image). 21

Figure 6-4. Illustration of fork length measurement of individual fish 22

Figure 6-5. Relation between fish size and catch process. For the smaller fish (top) the girth at the gills (indicated by the bar) matches the mesh-size and this fish is likely to be gilled. For the larger individual (bottom) the girth at the head region matches the mesh -size and this fish is therefore potentially snagged 23

Figure 7-1 Illustration of the process for recording catch weight and number by species (FEVM, 2007) 26

Figure 7-2. Illustration of the process for recording catch weight and number by species when sub-sampling the catch (FEVM, 2007) 27

Figure 7-3. Fish measuring board with *Macrognathus siamensis* 32

Figure 7-4. Crabs – measure carapace width (CW) at the widest point 32

Figure 7-5. Shrimps – measure carapace length (CL) – behind the eye stalk to the mid-posterior edge 32

Figure 7-6. Digital balances used to weigh fishes 33

Figure 7-7. Calibration weights (1 kg set) are used to check all balances 33

Figure 8-1. Abundance or biomass of individual fish species in catches at different locations. Individual graphs should be created for the main species and for all fish combined. 36

Figure 8-2. Species composition by number (left) and weight (right) of fish catches. Catches should be presented for each season separately and all country data combined as a separate column if needed. 37

Figure 8-3. Species composition by habitat or gear 37

Figure 8-4. Example of dendrogram created from cluster analysis in PRIMER to show similarities between sites of seasons or habitats or gears 38

Figure 8-5. Example of Multidimensional Scaling plot of species change in gill net catches from major dams in Botswana. 39

Figure 8-6. Diversity (*H'*, ■) and evenness (*J*, □) of fish catches at ten sites on the lower River Thames 40

Figure 8-7. CANOCO biplot illustrating the relationship between species composition and environmental drivers for Mekong fish distribution patterns 40

Figure 8-8. Monthly changes in relative abundance of three species of fish between January 2008 and October 2013. 42

Figure 8-9. PCA plot of contribution of species (numbers based on MRC species codes) to catch composition in different years 42

Figure 8-10. Example of length frequency distributions to show variation in size of fish of the same species between locations, habitats, seasons or years. 43

Figure 8-11. Mean size (or weight) of fish caught by year (or by gear, season or habitat)..... 43

TABLES

Table 6- 1. List of (common) fishing gear reported in Fish Abundance and Diversity Monitoring in LMB 14

Table 6- 2. Agreed design of multi-panel mesh size gillnet by Member Countries 19

Table 8- 1. Typical problems encountered with biological and environmental data. 36

ABBREVIATIONS AND ACRONYMS

CAS	Catch Assessment Survey
CCA	Canonical Correspondence Analysis
CPUE	Catch per unit effort
EIA	Environmental Impact Assessment
EMMP	Environmental Management and Monitoring Plan
FADM	Fish Abundance and Diversity Monitoring Program
FAO	Food and Agriculture Organization of the United Nations
FEVM	Fisheries Ecological and Valuation Monitoring
GPS	Global Positioning System
JEM	Joint Environment Monitoring
LMB	Lower Mekong Basin
MC	Member Countries
MDS	Multi-dimensional scaling
MRC	Mekong River Commission
MRCS	Mekong River Commission Secretariat
NMCS	National Mekong Committee Secretariat
OAAs	Other Aquatic Animals
PCA	Principal Component Analysis
SIMPROF	Similarity profile test
TbEIA	Transboundary Environmental Impact Assessment

EXECUTIVE SUMMARY

The Lower Mekong Basin is endowed with a rich biodiversity of fish species that support valuable fisheries, livelihoods and food security of millions of people. The fisheries are under pressure due to significant challenges on intense fishing, climate change, hydropower development and sediment mining from the river. As a consequence, there is a need to better understand the status and trends in the fish populations, fish communities and fisheries to manage the resources in a sustainable manner.

To support this need, monitoring procedures on what and how to collect the appropriate information on fish and fisheries in a standardized manner to make robust decisions about the status of the resources is described. This document provides the procedures for collecting and analysing fisheries abundance and diversity data to support management of the resources.

The overall objective of the fisheries monitoring programmes in the LMB is to measure and interpret parameters contributing to the interpretation of the status and trends of basin-wide capture fisheries as well as providing an effective means of monitoring and assessing the effects of water management and basin development activities. A range of parameters that may be derived based on catches or samples collected under FADM are proposed to reflect potential changes in capture fisheries and species diversity, and include total catch rates, catch-per-unit-effort and species diversity indices.

In the first instance, procedures to describe the selection of sampling locations, habitat types to be monitored and selection fishers and gear types are described. These are supported by descriptions of catch assessment survey (CAS) procedures, independent standardised gillnetting sampling procedures and fisher household surveys. These are backed up by detailed descriptions of field sampling methods, procedures for completing FADM fisher logbooks to support CAS monitoring, and procedures for identifying fish and processing fish metrics (length and weight) from samples.

Details are also provided on the methods for collating the data and subsequent analysis of the fisheries data both in relation to catch composition and population dynamics. Methodologies to understand the basic fish community structure, diversity and relative abundance in each sampling according to habitat and gear are provided. These data are then further analysed to understand catch rates for each species or group of species, comparison of catch rates from different locations, seasons, habitats and depths, and catch rates between different mesh sizes of gill nets or between gears. Understanding differences in population structure for a given species from location to location and from time to time using length distributions is described. Examples are provided for all analytical procedures.

To ensure robustness of the data, quality control procedures in relation to fish identification, data checking, and method calibration and validation are described.

Finally, important issues relating to health and safe of staff working near water and on boats is provided.

1 INTRODUCTION

The inland fisheries of the Mekong basin, the largest fisheries in the world, are of immense importance to over 70 million people living in the Lower Mekong basin (LMB) (SOBR, 2018, and So et al., 2015). The majority of the LMB population resides in rural areas, where rice farming and fishing are the primary occupations, with fish and other aquatic animals serving as the main source of animal protein (Hortle, 2007). Approximately 1,200 fish species have been recorded in the Mekong River basin (Baran et al., 2013; Hortle, 2009; Mekong River Commission (MRC), 2018), and more than 200 species are frequently caught in large lowland river locations. In this context, the Standard Operation Manual on Fish Abundance and Diversity is crucial as it provides a reference framework for implementing the fish monitoring activities as part of Core River Monitoring Network (CRMN).

Pressures on fisheries are increasing and fishers commonly report that catch (per fisher) and average sizes are declining, and some species have become rare at some locations (Mekong River Commission, 2010, 2021). At the same time, the basin's human population is increasing and there is a wider diversity of developments that impact on fisheries. Prominent among these are large dams, including many new or planned dams for hydropower generation, as well as agriculture, especially rice production, and development of urban centres. Dams block fish migrations and modify the aquatic environment in their vicinity in various ways, which lead to changes in species diversity, composition and production (Dugan et al., 2010), whilst agriculture detaches major floodplains and isolates fish from their nursery areas. Information on status and trends is required to understand the impacts of such developments, to provide feedback for planning, management and impact mitigation. Monitoring of fish and fisheries aims to provide such information in a practical, timely and cost-effective way.

2 RATIONALE

Fisheries monitoring is a core activity of the MRC Secretariat (MRCS), the operational arm of the MRC, now under the jurisdiction of ED. The former Fisheries Programme of MRCS provided both technical and financial support for the Fish Abundance and Diversity Monitoring (FADM) programme in the LMB to the four Member Countries from the mid-1990s. The FADM methodology employed thus far is based on an earlier fisher-based Catch Assessment Survey (CAS) developed under the Assessment of Mekong Capture Fisheries (AMCF) and Regional FADM Programme of the Fisheries Ecology, Valuation and Mitigation (FEVM) Component. CAS was also implemented for one year with FEVM funding in 2006 in Cambodia, Laos and Thailand, while FADM was implemented between 2007 and 2014 in the four MRC Member Countries and then reinstated in 2017.

The original methodology "Standard Operation Manual for Fish Abundance and Diversity Monitoring in the Lower Mekong Basin (Ngor et al., 2016)" was developed by the former Fisheries Programme, based on more than 10 years' experience and lessons learnt by the national fisheries line agency teams involved in the implementation of this monitoring in the LMB. National and regional datasets have also been developed, managed, analysed and interpreted in many MRC Technical Papers, Catch and Culture, and State of the Basin Reports. However, concerns were raised about whether this methodology was still applicable for monitoring fish abundance and diversity in the LMB as the participating fishers use multi-gears to capture fish. To address this issue, a review was carried out (Cowx, 2017) to evaluate and improve the FADM methodology to achieve the defined objectives of FADM in the LMB.

The present "Standard Operation Manual for Fish Abundance and Diversity in the Lower Mekong Basin" were developed based on the review of the existing methodology (Ngor et al., 2016) and consultation with MRCS and MCs. The aims of this manual are to (i) improve the robustness of data collection by fishers and the national fisheries agency teams who are involved in the implementation of this monitoring programme in the LMB, (ii) provide step by step guide for data collection, and (iii) allow the national fisheries agency teams to interpret the information in an appropriate and succinct manner.

3 OBJECTIVES

The overall objective of fisheries monitoring in the LMB is to measures yield indicators contributing to the interpretation of the status and trends of basin-wide capture fisheries as well as providing an effective means of monitoring and assessing the effects of water management and basin development activities. Particularly, it also aims to answer some basic questions regarding the health of fisheries, conditions of overfishing, the impacts of water management, and the status of endangered conservation species (Annex 1).

Specific objectives of the FADM are to:

i. evaluate the status and trends in fish stocks in the LMB for management purposes;

ii. monitor spatial and temporal changes in fish catch composition and abundance;

iii. evaluate the contribution of fish species, guilds and fishing habitats to the fisheries of the LMB and improve understanding of the environmental factors driving fish species composition and abundance;

iv. provide information on capture fisheries values for fisheries planning and management.

Each of these provides outputs that can be related to development impacts, after taking into account other information on potential stressors and environmental data.

4 MONITORING PARAMETERS

Fisheries monitoring typically reports abundance (numbers and biomass) of each species in catches or in samples, expressed as CPUE (catch per unit effort). CPUE is assumed to reflect underlying changes in fish stocks, after taking into account other covariates. Reporting of diversity usually includes estimates of the number of species present (richness) and their contribution to catch (some measure of evenness or dominance), i.e., the extent to which the fish species assemblage is dominated by one or a few species. Basic data are often further analysed to provide derived parameters related to population and community trends. The aim of FADM is to determine the status and trends of basin-wide capture fisheries as well as providing an effective means of monitoring and assessing the effects of water management and basin development activities. To assess these changes, a range of parameters that reflect potential changes are required. Commonly reported summary parameters that may be prepared based on catches or samples collected under FADM can include the followings:

For total catches

- Composition by fish species (numbers and biomass)
- Composition by family (numbers and biomass)
- Species richness estimate (species number, species rarefaction curve)
- Species diversity indices (based on proportion by numbers and biomass)
- Species evenness (numbers and biomass)
- Presence and proportions of indigenous and non-native species
- Frequency distributions of daily catches per fisher (and by gear or habitat type)
- Average and maximum size of fish species caught by gear or habitat type
- Proportions of fish in different ecological guilds (see Annex 2)

For common species

- Relative abundance (number and biomass) as CPUE (by gear and habitat type)
- Length frequency distribution

Each of these statistics can be used as an parameter of changes to fish populations, which may be caused by the environmental effects of hydropower or other water developments. These parameters are in line with the Mekong River Basin Indicator Framework.

5 EXPLANATORY PARAMETERS

The FADM activities are conducted in a range of habitat types at different locations and using a diversity of gears (see below). To help explain the status and trends in the fisheries yields there is a need to correlate against factors that may explain the trends. Important parameters to explain changes or trends in the above indicators are identified as:

- Gear type (see **Table 6- 1.**)
- Habitat type (Mekong mainstream, Tributaries, irrigation canal, floodplain/ swamps, estuarine)
- Hydrology (flood cycle [amplitude, duration and timing of flooding], flow, water level, flooded area and depth)
- Water quality parameters: (pH, DO, TSS, Temp., total Nitrogen)

Information on habitat type should be recorded as routine for each survey.

Information on hydrology and water quality parameters is available from MRC Technical Support Division and the Environmental Management Division, respectively.

Measures of fishing effort (e.g., estimates of the number of full and part-time fishers) can be sought from national household censuses or surveys.

In addition, fishers should be regularly interviewed to understand location-specific fishing conditions; gear used, number of fishers and to obtain their perceptions of important factors that they believe are affecting their catch rates and species diversity.

6 METHODS

6.1 SAMPLING LOCATIONS

Thirty-seven for FADM regional sites located from Bokeo in Lao PDR to the Delta in Viet Nam (**Figure 6-1**) were sampled under the existing monitoring programme. Locations are broadly defined as a section or reach of the river of several kilometres[1] in length. Locations of monitoring sites are within each of the main river reaches as defined by the MRC, as follows.

- Twenty-three (23) Mekong mainstream locations are monitored upstream and downstream of mainstream hydropower dam locations, and/or upstream and downstream of major tributaries.
- Five (5) locations on larger tributaries with significant hydropower development or plans.
- Seven (7) locations in floodplain habitats
- One (1) location in the estuarine habitat
- One (1) location in canal habitat

[1] This depends on where the fishers are fishing – it should be set at a certain distance from their village.

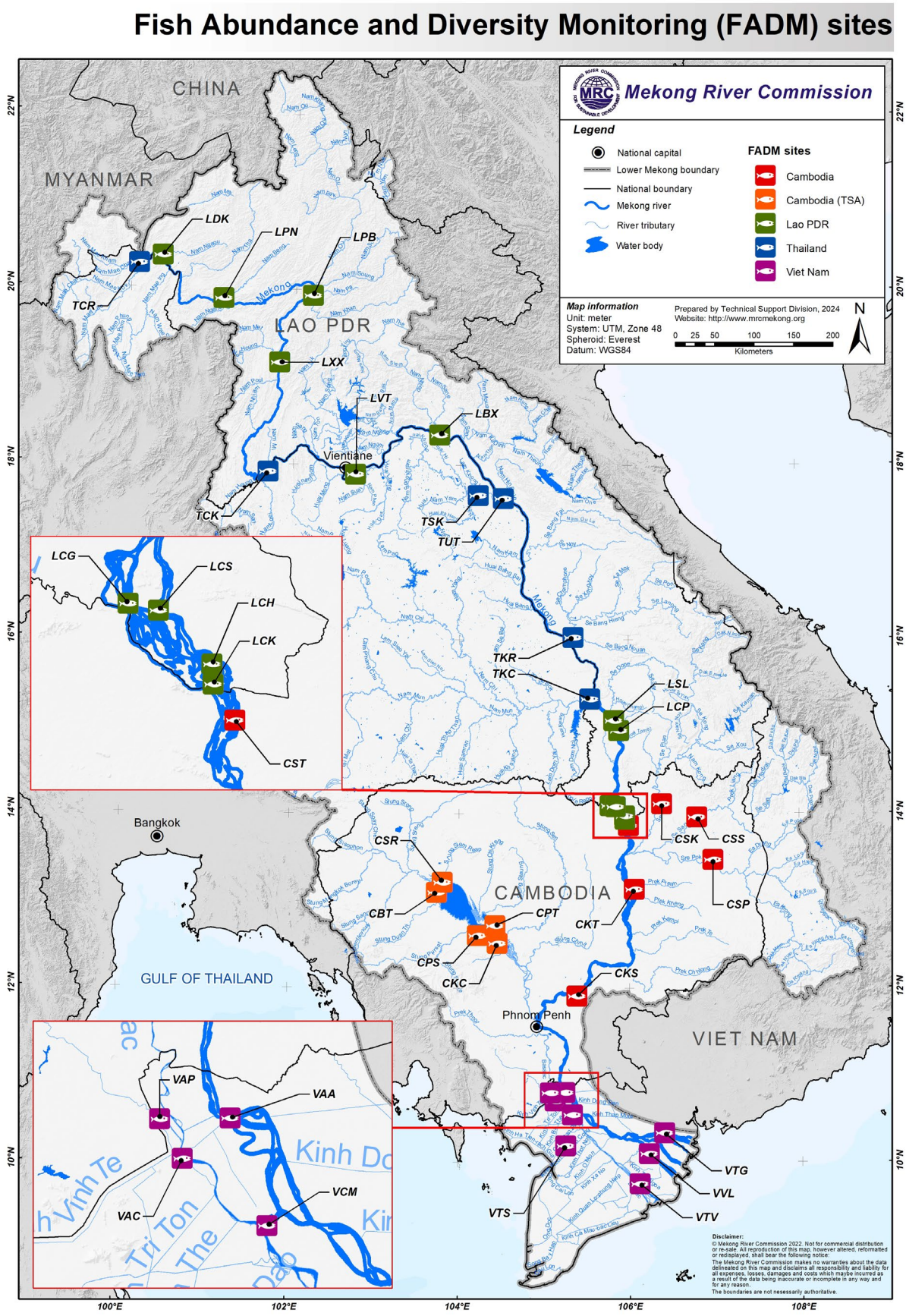

Figure 6-1. Existing FADM sampling habitats in the LMB per the redesigned CRMN

Details of each location are given in Annex 3, and are considered representative for undertaking basin-wide assessments. If funding is made available, more monitoring locations may be added to have a better coverage of sampling locations in the Lower Mekong River Mainstream and Bassac River, especially to account for estuarine habitats. Fisheries monitoring locations should be in line with other monitoring locations of the MRC. In addition, monitoring under other activities should be incorporated into this programme where possible.

Supporting and complementary data should be collected at or near each location (water quality, sediments, aquatic ecology, and socio-economics).

Over the scale of interest (the Mekong mainstream), a sampling location is not a point, but a river reach which is defined based on the usual practices of fishers of making use of seasonal fishing grounds at that location. At each location, the exact places that fishers go fishing should be recorded in terms of habitat characteristics and water conditions; it is expected therefore that a location will cover several linear kilometres of a river reach or a range of wetland habitat types.

6.2 SELECTION OF FISHERS

Fisher selection is the task of agency staff. As is current practice, it is proposed that a minimum of three experienced fishers are selected at each sampling location. This decision represents a compromise between the need for precision and affordable survey costs (FEVM, 2007). If possible, it is recommended the number of fishers per location is increased or the frequency of sampling catches is reduced to 2-3 days per week (randomly selected), and the number of fishers is doubled.

The selected fishers must meet the following g criteria.

They are 'typical' medium-scale, full-time fishers at that location. They fish most days of most weeks (<200 days per year) and fishing is their primary occupation for income generation.

1. They fish from motorised boats, depending on the season, and use medium-scale gears, such as gill net, trammel net or trawl. It is recommended all fishers use gillnets as a standardised gear as it enables enhanced comparisons between locations. The mesh size of gill nets used should be recorded on each occasion to account for selectivity.
2. They are able to read and write.
3. They are willing to participate and be honest in recording fish catches.
4. Priority is given to fishers associated with organized fisher groups such as community fisheries or fish refuge pond community, if these type organisations exist in that location.
5. Their experience and capacity, including eyesight, is adequate for identifying fish and recording data.

The fishers must be trained and tested to ensure that they are able to:

1. set up a clean and tidy work area properly;
2. identify fish accurately;
3. check and calibrate balances;
4. measure fish accurately and record the data; and
5. take clear photos of fish laid out in the correct way to facilitate data checking.

Where possible, fishers participating in existing data collection activities should be retained as long as possible and continuously trained and tested in measurement and information recording.

Fishers use a variety of fishing gears, varying in accordance with seasonality of fish occurrence. Therefore, all fishers have to record their daily catches from each gear type they use on a given day and all habitat types in which they use those gears. Fishers must record fishing effort accurately, including dimensions of the fishing gear (especially mesh size) and soak hours as provided in the logbook.

6.3 MONITORING HABITATS

The following four main habitat types were identified and agreed during a regional training-workshop on FADM in Luang Prabang on 14 December 2012 as important fish habitats:

(1) Mekong mainstream

(2) Tributaries

(3) Floodplain/swamp,

(4) Lake or reservoir or canal (latter applied in Viet Nam only).

'Deep pools' and 'rapid areas' are sub-habitat types under 'Mekong mainstream' and 'Tributaries', and that 'rice field' is a sub-habitat type under 'Floodplain/swamp'. Where applicable, at least one location within each main habitat type should be selected for monitoring in a way so that the populations of the main fish guilds (rhithron, long distance and short distance migrating whitefishes, greyfishes, eurytopic generalist species and blackfishes: Annex 2) can be monitored. Ideally, all sub-habitats should also be included if adequate resources are available. The precise categorization of habitat is important when populating the database, as it can help to reduce typing errors, which usually result in too many habitat types in the database, and makes data analysis less complicated.

If possible, an additional site in the Mekong delta is recommended to account for estuarine habitats and estuarine and marine species.

6.4 GEAR TYPES FOR MONITORING

As catch efficiency varies by gear, a single gear type commonly employed in all habitats and countries should be the focus of monitoring trends. Gillnets are the gear most commonly employed by fishers within all the major habitat types and during most months in all four countries, as seen during previous monitoring activities under AMCF, FEVM and Fisheries Programme 2011-2015. For example, in 2012-13, drifting gill net and stationary gill net contributed almost 50% and 35% respectively to the reported total fisher catch in Cambodia. The fishing gears reported in Fish Abundance and Diversity Monitoring in LMB between 2007 and 2013 are shown in **Table 6- 1.** .

Table 6- 1. List of (common) fishing gear reported in FADM in LMB

No	Gear names	No	Gear names
1	Bag net	14	Hook long line
2	Barrage	15	Lift net
3	Brush bundle basket	16	Motorized pushnet
4	Cast net	17	Pumping
5	Drift gillnet	18	Scoop basket
6	Drift hook	19	Seine net
7	Eel trap	20	Single hook
8	Giant Cast net	21	Spears
9	Hand dragged gillnet	22	Stationary gillnet
10	Hands	23	Trammel net
11	Harpoon	24	Trap
12	Hit gillnet	25	Trap pond
13	Hook and line	26	Trawl

In order to account for the wide variety of gears used and also standardise the sampling effort, it is recommended two strategies are operated.

I. Continue to collect catch and effort data following the existing catch assessment monitoring programme where catches by all gears in all habitats is recorded and analysed according. This data collection will allow calibration against any subsequent modifications to the monitoring

programme. To improve the robustness of the monitoring, data from more than three fishers should be collected where possible and diversity of habitats or sampling locations should be increased. In addition, efforts should concentrate on collecting catch and effort data from the gear most commonly used by fishers, i.e. gillnetting.

II. Adopt a fisheries independent, standardised, monitoring programme to complement the fishery dependent catch assessment programme. It is recommended gillnetting is adopted as the standardised method as it is the most commonly used gear. This will have the value of standardising to account for all habitat and seasonal variability in the monitoring.

The procedures for collecting the information under the two strategies are provided in Section 6.5. Overall recording of sample or sub-sample data and storage of data are standardised and following existing procedures as described in Section 7.2.

6.5 MONITORING STRATEGIES

6.5.1 Methods for sampling artisanal fish catch

The existing operating procedures using three fishers at each location should be the minimum standard adopted. The data should be collected in several ways as described in detail in Section 7, but outlined below.

- Fishers are required to complete a log of catch and these data should be collated and interrogated regularly by the agency undertaking the monitoring.
- To maintain accuracy, the fishers should be checked periodically and their catches monitored, These data can be used to audit the reported data and improve reporting, Biological data on the fishes can also be collected from samples caught by artisanal fisheries during this assessment.
- Where possible, undertake interviews with the fishers on during the quarterly visit when collecting logbooks, and explore their perception and experiences on fish catches, trends, condition of habitats, water level and threats to their catch.
- In cases where fishers use gillnets, catches must be recorded for each gillnet type and location of sampling. Where possible the length of gillnet and mesh size should be recorded. If two or more gillnets comprising different size panels or mesh sizes are each used then treat these as separate gears and record the catch and effort for each gillnet on separate logbook pages (see below).

Catch assessment surveys should, where possible, be linked to frame surveys conducted every 3-5 years, of the total number of fishers operating in the village of sampled area. This would have to be conducted as an independent activity from the routine catch assessment and have a separate budget. The advantage of conducting frame surveys on artisanal catches is involvement of the local fisher communities and the opportunity to better understand fisher concerns over the status of the stocks, and interaction with other stakeholders, to support rational management decisions. Such involvement of fishers in the data collection may be seen as a first step in preparing the communities to take up their role in a community-based approach to the management of the fisheries resources.

6.5.2 Standardised gill net surveys

Gillnets (Figure 6-2) are one of the most widely used gears for sampling fish, with a large literature detailing its theory and practice (Backiel & Welcomme, 1980; Bonar et al., 2009; CEM, 2005; Hamley, 1975), comparisons with other methods, and the results of many studies in which gill-netting was employed. Some key references are listed in the bibliography. Gillnets tend to catch larger actively swimming fishes that move in mid-water or near the surface, and they tend to catch fewer benthic fishes and smaller less-active species. They are particularly useful for sampling in relatively shallow waters where other sampling gears are limited. They are the most commonly used fishing gears in the

region. The low cost of purchase, ready availability, and ease of use means that even the poorest can enter the fisheries.

Gillnets, like most fishing gears are selective towards specific species (as indicated above) and sizes of fish. Gillnet selectivity is widely used as a management and monitoring tool to limit the sizes of the fish that can be caught. Because of this, it is important to understand the performance of the gear so that appropriate advice can be provided for fisheries management.

It is a passive gear, relying on the movements of the fish to enmesh themselves and for this reason fish are often driven into the net by beating the water as a commercial practice. Gillnetting is a very flexible technique consisting of either setting static nets in a variety of ways that are often difficult to access for other types of gear, or as drifting nets in the open waters. Gillnets can be difficult to use in certain circumstances, for example, where there is a large amount of submerged snags, under floating and submerged vegetation, or in areas of high current. They are, however, liable to disturbance and to poaching or theft.

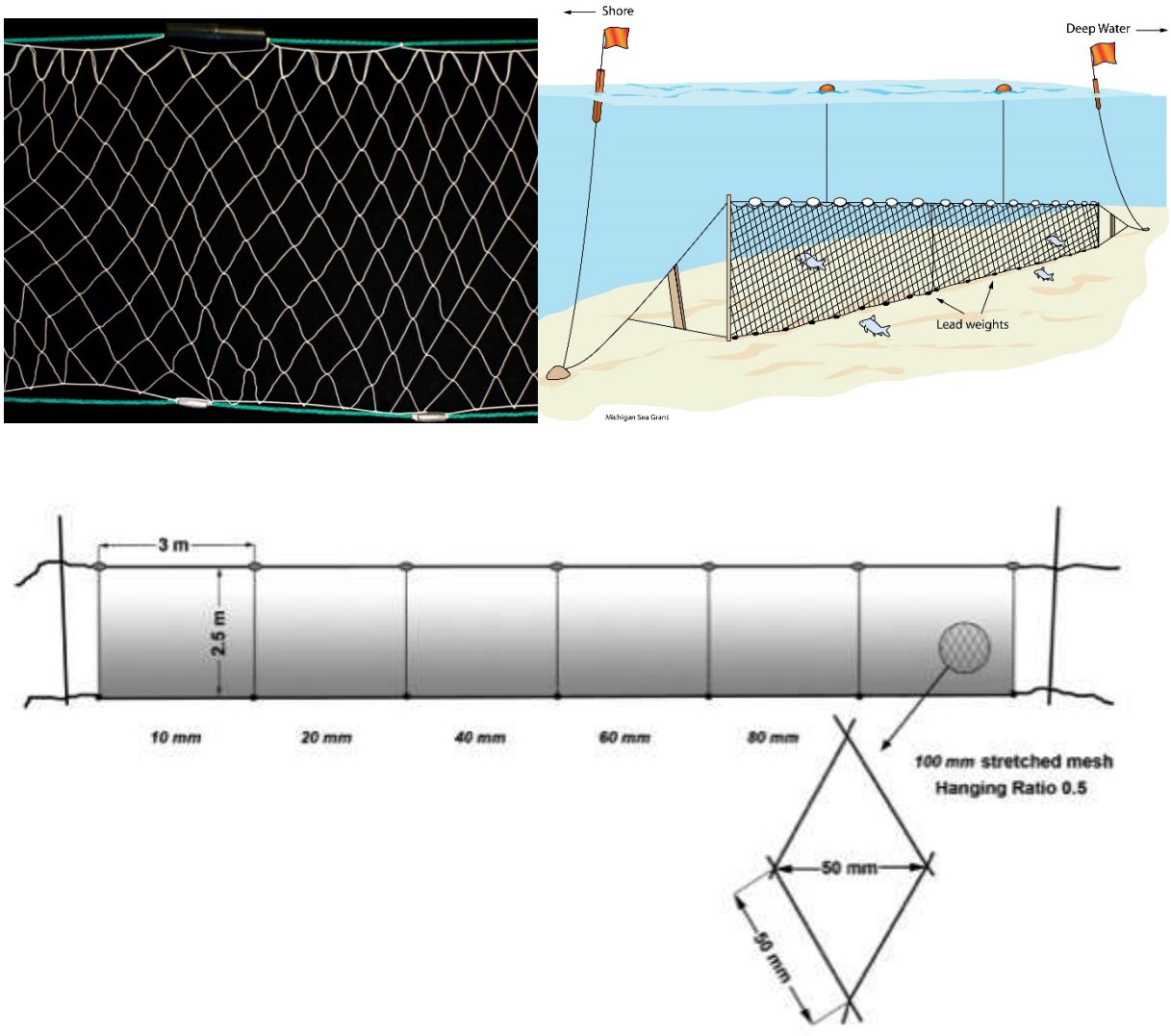

Figure 6-2. Design of gill nets: Note multi-mesh gillnets are combinations of panels of various mesh-sizes, as shown in lower figure, joined randomly to create and elongated net one panel deep

Objectives and outputs of standardised gillnet surveys

Standard sampling methods are employed to ensure the comparability of collected data between sites and occasions (spatio-temporal differences); i.e, differences in results will reflect underlying differences or changes in fish stocks. The general objective of multi-panel gillnet surveys is to provide

information for the status and trends in the fishery resources that is comparable between habitats, seasons and surveys locations. Specifically, gillnetting can be used to gather a range of information about the fishery and the fish, principally:

- The composition, relative abundance, population structure and distribution of the fishes;
- Information on biodiversity status and trends, catch rate, catchability coefficient and selectivity by mesh size of gill nets; information that can be used for setting regulations on mesh sizes;
- Biological, ecological and population parameters (food and feeding habits, reproductive biology, growth parameters) of the fishes;
- Breeding seasons and recruitment patterns especially of the major commercial fish species; information that can be used to determine closed seasons;
- Mapping of critical habitats for fish survival and for biodiversity conservation including breeding and nursery grounds of the fishes; information that can be used to identify protected areas.

The ultimate aim of an assessment survey is to estimate the absolute abundance of fish in the area surveyed. This requires information on the affected area and the catching efficiency of the gear. For highly mobile species like finfish, being caught by a static, passive gear like gillnets, it is extremely difficult to estimate the size of the affected area in practice. In most cases, no attempt is made to raise gillnet survey results to absolute abundance, and this will be the case of the FADM programme.

Catch per Unit Effort (CPUE) of gillnets set under controlled and standardized (to the extent possible) conditions[2] as described in the survey design below, will, however, provide a valuable relative index of abundance that can be related to the stock abundance (N) by the proportionality: CPUE = q N, where q is the survey catchability. In fish stock assessments, fish size or age are often accounted for by expressing CPUE by age: $CPUE_{age} = q_{age} N_{age.}$ and can be used an index of recruitment or adult population size by highlighting the proportion of each size group to the fishery in terms of harvest.

Standardized catch rates can also be derived from the analysis of commercial catch data collected through the catch assessment (logbook) surveys, although this approach can be problematic, depending on the extent and reliability of the data. The results obtained from fishery-independent gillnet surveys will provide a valuable comparison with the results of the analysis of the data from gillnets fished commercially.

Survey design

Gillnets employing standard protocols over a long period of time are particularly useful for regular monitoring of fish populations because of their relative ease of use and relatively low cost. Gillnets can be used across a range of depths and can be used in shallow water where most other sampling gears cannot be used.

Because of the selectivity of gillnets, several meshes of nets are required to monitor and collect data on different elements of the fish populations (e.g. biodiversity for small fish species, ecological guilds). Thus, standard, multi-panel, multi-mesh size gillnets will be used on all occasions. Each of these will follow a basic design consisting of a graded fleet of panels of mesh sizes ranging from 20 mm - 150 mm (20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150 mm) connected at random. Nets larger than 150 mm mesh are not used in order to comply with a fisheries law of certain MRC Member Country and also to avoid the capture of large individuals of rare species, such as the larger catfishes, which are important for maintaining stocks. Each gillnet is 2.5 m deep and mounted at a hanging ratio of 50% and repeated at least once for each mesh size. Filament diameter should be 0.28 – 0.4 mm diameter from larger to small meshes although this may be revised based on detailed design and manufacturers'

[2] Refers to setting the nets in the same position relative to the shore or in specific habitat, for the same length of time, and using the same gear on all occasions.

data. This design was piloted in the routine FADM and the pilot of a joint environment monitoring programme. The 14 randomised panels of mesh sizes with three distinct lengths (112m: 8m per panel; 70m: 5m per panel; and 42m: 3m per panel) were tested. After testing, some national teams stated that the long net (70m) was difficult to find the suitable places to set, but other teams (e.g., Tonle Sap Authority and Research Institute of Aquaculture No. 2) needed longer net since their monitoring sites (Tonle Sap Lake and Vietnam Mekong Delta) are quite wide. Additionally, the net could not capture the large fish since most of the net could be set near the riverbanks with a slow flow of the water. Particularly, the net with the small mesh sizes could not be set in the middle of the river since it trapped a lot of trash, which caused the net broken. Recognising this situation and different needs among member countries, the 14 mesh sizes are split into three sets of mesh sizes—gillnet 1 (small mesh sizes), gillnet 2 (medium mesh sizes) and gillnet 3 (large mesh sizes)—which were agreed by all the national teams to use in the FADM. Note that the length of panel and depth are varied according to conditions of the monitoring sites as well as dry and wet seasons. The agreed designs of the gillnet for each national team are showed in Table 6-2. The different mesh panels should be connected prior to deployment from the boat and where possible should be joined so there is no gap between panels[3, 4]. The range of panels with different mesh sizes should be suitable to catch the range of fishes found through the LMB but will not catch small-sized species, especially benthic species. An alternative method, such as micro-mesh seine netting should be used to capture these individuals/species if the budget is available.

Multi-panel gillnets as described for use in this manual, are widely used in many countries. Multi-panel gillnets have been successfully used in the Mekong basin in studies of intervention effects (e.g. Arthur et al., 2010, Lorenzen et al., 1998), based on the assumption that such gears catch a wide range of species and that their CPUE correlates with actual biomass of fish in a water-body.

Multi-panel gillnet surveys should be conducted at minimum once every week with the day chosen randomly in period to cover the main seasons of the year and phases of the moon. Different habitat types including river, tributaries, streams, pools, floodplain areas, estuarine areas and ponds/reservoirs should be sampled, and areas with marginal macrophytes or submerged wood, and different depths should be surveyed. To achieve this, it may be necessary to set the three nets with three different locations per monitoring site. Whatever the sampling schedule, the nets should be set at the same location on each sampling occasion. Where possible, nets should be set at the surface and on the bottom to target different species. The weights and floats should be adjusted depending on the depth of setting.

[3] Preferably all nets used by the different countries are made by the same manufacturer using the same materials and design to ensure standardisation across the LMB.

[4] It is recommended to use quick release cable ties to link the panels if the multi-panel net is not pre-constructed.

Table 6- 2. Agreed design of multi-panel mesh size gillnet by Member Countries

Country	Gillnet set	Mesh sizes (mm)	Length per panel (m)	Depth (m)	Total length (m)
Cambodia		**Wet season: Fisheries administration**			
	1	20-50-40-30-60	10	2.5	50
	2	70-90-100-80-110	10	4	50
	3	120-150-140-130	10	6	40
		Dry season: Fisheries administration			
	1	20-50-40-30-60	10	2.5	50
	2	70-90-100-80-110	10	2.5	50
	3	120-150-140-130	10	2.5	40
		Wet season: Tonle Sap Authority			
	1	20-50-40-30-60	20	2.5	100
	2	70-90-100-80-110	20	3.5	100
	3	120-150-140-130	20	3.5	80
		Dry season: Tonle Sap Authority			
	1	20-50-40-30-60	20	1	100
	2	70-90-100-80-110	20	1	100
	3	120-150-140-130	20	1	80
Lao PDR		**Wet season**			
	1	20-50-40-30-60	10	2.5	50
	2	70-90-100-80-110	10	2.5	50
	3	120-150-140-130	10	2.5	40
		Dry season			
	1	20-50-40-30-60	10	1.5	50
	2	70-90-100-80-110	10	2	50
	3	120-150-140-130	10	2	40
Thailand		**Wet and dry season**			
	1	20-50-40-30-60	10	2	50
	2	70-90-100-80-110	10	2	50
	3	120-150-140-130	10	4	40
Vietnam		**Wet and dry season**			
	1	20-50-40-30-60	20	2.5	100
	2	70-90-100-80-110	20	2.5	100
	3	120-150-140-130	20	2.5	80

Setting position and spacing of multi-panel gillnets

Setting nets close together can reduce the catch per net because of interaction between the nets acting on pool of fish available. It is therefore important to space the nets at least 100 m apart so that they fish independently. The general principles for positioning where to set nets at each shown in Figure 6-3. The positioning of the nets should ensure that as many habitat types are sampled on each occasion, especially to account for flooded habitats. It is therefore recognised that the position of the nets may have to be changed between sampling in relation to the flooding cycle.

Three sets of multi-panel gillnets are set at each site. This is a reasonable balance for the time and cost involved in setting and clearing nets.

Gillnets are set between 16:00 and 18:00 hr in a sequence starting from downstream to upstream and are retrieved the following morning between 06:00 and 08:00 in the same sequence to provide a standard night-set. Note that in the Viet Nam Mekong Delta the time for setting sets might be different from the abovementioned time since the sites are influenced by the tide, so the net will be set based mainly on the fisher knowledge about the tide in that area.

Nets must be set so they hang away from the bank. Usually each net is hung at the edge of an eddy or backwater where a slow flow of water tends to hold the net away from the edge, or they may be hung on the upstream side of small inflows. Nets should not be hung in areas of fast or unidirectional water current where their bottom leads would be lifted from the bottom or where they would be pushed into the bank.

Each net is set starting at the bank. The upper rope of each net is tied to a stake (or suitable natural feature) near the bank and the boat is reversed. One person plays-out the upper float rope and the other plays out the lead line. A buoy is attached to the outer edge of the upper line. After setting, each net is checked for a few minutes to make sure it is hanging correctly in the current. If necessary, the outer end is weighted and may be also staked if required. Generally the entire set of nets may be quickly checked while driving past them on return to shore.

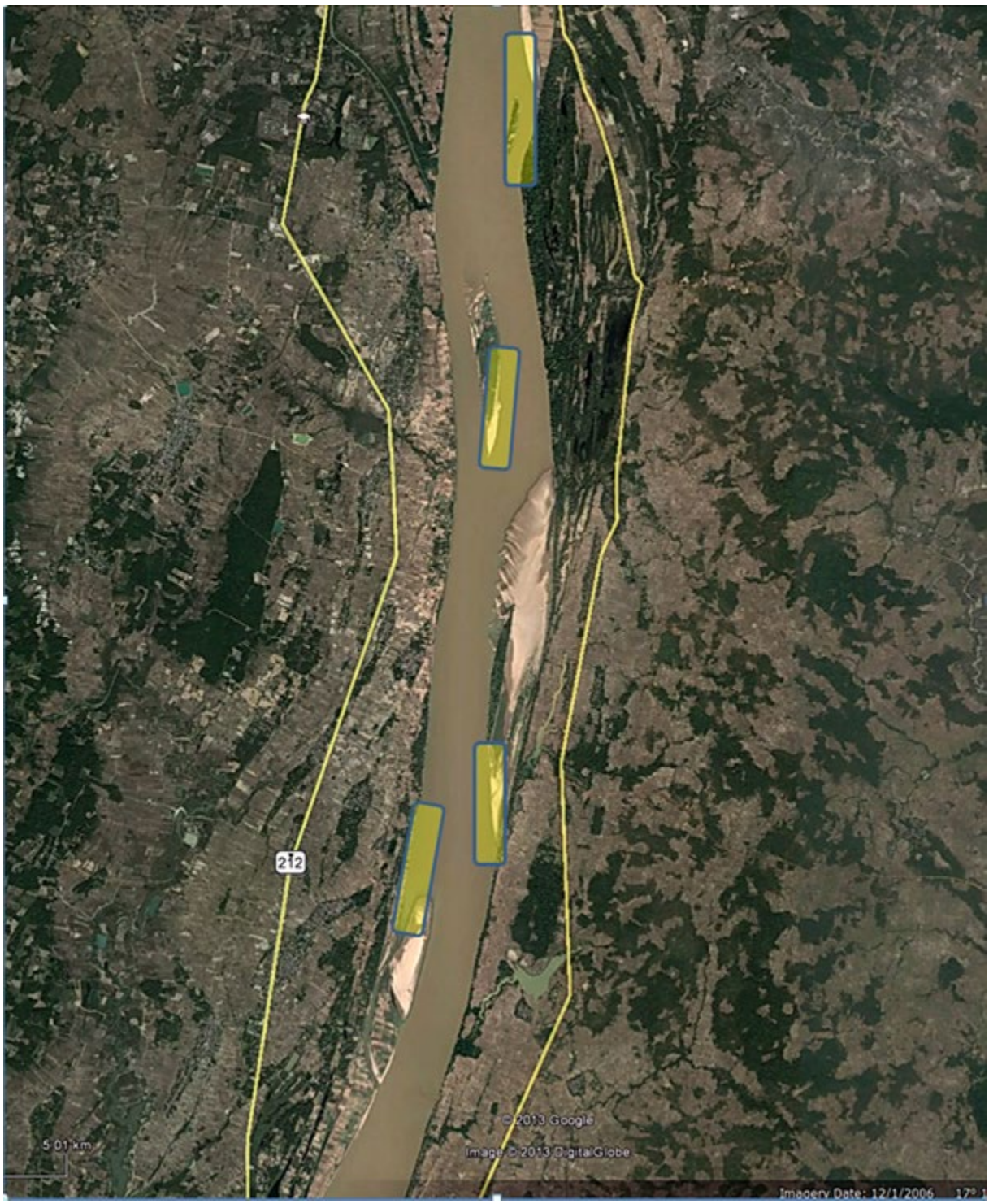

Figure 6-3. Example of using Google Earth maps of each long-term sampling location to identify sampling site locations indicated. Example from Mekong at Nakhon Phanom Location, fish are sampled about 10-20 km downstream of Nakhon Phanom. Four sites contain suitable habitat for gill netting as indicated. Dry-season (December 2006 Image)

Net removal and clearing

Nets are removed from the water in the same sequence as setting and brought back to the bank with fish in each net (do not remove fish in the boat). On the bank, fish are removed from each panel of the net using screwdrivers and cutters where necessary to avoid damaging the mesh. They should be placed in separate buckets that have had a marker indicating the mesh size placed in the bottom before removing the fish.

Catch handling and recording from gill net surveys

The following data should be recorded for each mesh size and each set using Forms 1 and 2 in Annex 5:

- Date and time of capture (season, diurnal light cycle)
- Species composition
- Total weight of catch
- Numbers of specimens per species
- Fish Length data (minimum and maximum length) (Annex 5 – Form 2)
- Physical and biological parameters (see procedure on biological sampling).

Length data (preferably measured in fork length mm [**Figure 6-4**] although total length if species has no obvious fork in tail) should be collected, where possible, for a minimum and maximum length of each species from each mesh panel to undertake length frequency analysis. However, it is recognised this could compromise the quality of the catch for sale in the market for fish taken from normal fishing operations and is only recommended to measure the maximum length for fisher catch assessment monitoring.

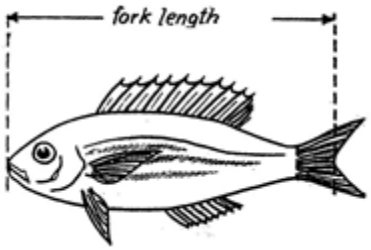

Figure 6-4. Illustration of fork length measurement of individual fish

Data from gill net surveys should be combined with the results of other surveys for biological studies and formulation of fisheries policies.

It should be noted that various selectivity experiments will have to be carried out using length frequency distributions and catches (numbers and weight) from different mesh sizes if a full assessment of the stock abundance is to be possible. This will require considerable data of high quality for each species and the full size range of fish to be caught in the different nets and information on how the fish were caught in the net. To achieve this, the position of fish in the net (top, bottom or mid), distribution of fish in the net (e.g. clumped, random), the direction of fish (off-shore or onshore for parallel sets; left or right for perpendicular sets), and whether entangled or gilled, should be noted, where possible by species, during net retrieval and prior to removing the fish. This information is particularly important for selectivity experiments (see also **Figure 6-5**) and fully assessing the length distribution of the main species caught.

- **Gilled**: The fish is meshed immediately behind the gill cover.
- **Wedged**: The fish is meshed around the body somewhere behind the gill cover. Wedging is hardly distinguishable from gilling when the maximal girth is found at a position close to the gill cover.
- **Snagged**: The fish is attached to the netting at the head region. This catch process is most common for species with protruding maxilla or pre-opercula.
- **Entangled**: The fish is wrapped into the netting, held by pockets of netting or attached to the net by teeth, fins, spines or other projections. Fish that are already caught by other catch processes may subsequently be wrapped into the netting while struggling to free themselves.

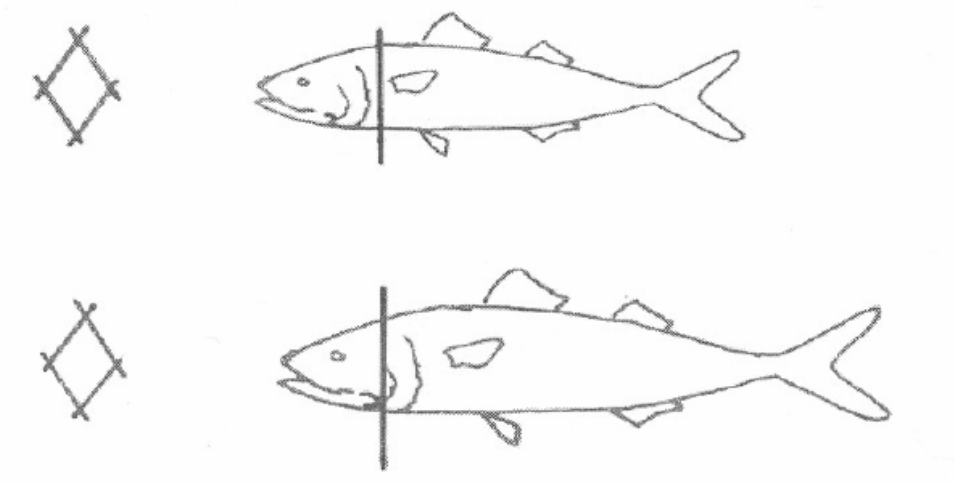

Figure 6-5. Relation between fish size and catch process. For the smaller fish (top) the girth at the gills (indicated by the bar) matches the mesh-size and this fish is likely to be gilled. For the larger individual (bottom) the girth at the head region matches the mesh -size and this fish is therefore potentially snagged

This type of study is not considered practical as part of the fisher monitoring programme, especially with the small sizes of nets required for selectivity experiments. As a consequence, dedicated standardised gillnet studies have to be carried out by the MC agencies.

6.6 CONFOUNDING FACTORS

Gear efficiency is influenced by various factors that can be measured at the same time during sampling or can be obtained from other databases. By recording catches every day, the effect of some factors that vary over time can be taken into account in subsequent multivariate analyses.

Fishers should also be interviewed at each location to access Local Ecological Knowledge (LEK) on the factors they consider significant in affecting catches.

Some important factors that should be considered in sampling and analyses are discussed below.

6.6.1 Season and Moon Phase

Fish catches are highly affected by large-scale migrations and by moon phase. Fish are most catchable on the new moon and for the following 4 days *(but this must be checked by interviews at each site during the quarterly site visit of responsible agency staff).* Migrations are seasonal; many fish move upstream early in the wet season and return to their refuge areas late in the wet season, although fish from Tonle Sap Lake migrate upstream at the end of the wet season or early dry season. Recording catches every day allows for later analyses to determine the effect of these factors.

6.6.2 Time and duration

Many river fish are more active and catchable at certain times year round; for example crepuscular[5] behaviour is common. Recording the day time or night time, i.e. the light conditions that gears are used allows for later analysis of any effect of differences in the time that gears are set.

6.6.3 River levels and discharge

Fish often migrate upstream at times of rising discharge and downstream during falling discharge after the flood. These factors are generally controlled by sampling at the same time each year, as the

[5] "Crepuscular" means active during twilight, i.e. at the beginning and end of each day; during this day time many fish species search for food.

Mekong's discharge pattern is very regular by world standards, so fish migration timing is relatively predictable. Discharge data for analyses are obtained from the Technical Support Division of MRCS.

6.6.4 Water quality

High turbidity usually increases fish catch efficiency, as fish cannot see the net. Turbidity is measured at each location at the time of sampling – see 'Ancillary Measurements'. Other water quality parameters: smell and taste of water, O_2, pH, conductivity etc. may be significant. General observations should be recorded at the time of sampling. Water quality data (excluding water turbidity) for analyses are obtained from the ED of MRCS.

6.6.5 Weather

Wind and rain, as well as sun shine and cloud cover may affect fish behaviour and thereby catches. Details are entered on the field sheet at the time of sampling.

6.6.6 Habitat

Fish tend to be within certain ranges of depth, current speed, snags and brush, depending upon species and size. Information on these topics should be included in logbooks from fishers and noted on maps of sampling locations. These parameters must also be noted for the multi-panel gillnetting surveys and collected on each occasion.

6.6.7 Fish migration

As well as responding to external cues such as discharge and water quality changes, migration is driven partly by each fish's internal chemistry and physiology. Migrating fish become more catchable at certain times and places, so a good understanding of migration patterns and timing is generated for each location. Information on this topic should be included in logbooks from fishers.

7 FIELD SAMPLING PROCEDURES

7.1 GENERAL

7.1.1 Checklist

Checklist is to be performed by the responsible national agency staff. Standardization of equipment, tools and procedures is essential for producing comparable data. At least one week prior to each field trip, the sampling agency staff should complete a field-trip checklist, check all items and their condition, contact relevant field staff responsible for fisheries sampling oversight, contact relevant fishers, and organise transport, accommodation and cash for any field payments. Refer to field checklist for full details (Annex 4).

Plan the departure time to allow arrival at a time suitable for meeting fishers and observing their fish processing activities.

7.1.2 Calibration

Responsible staff agency (with participation of fishers) must set up field balances and calibrate them following a separate procedure. Check and synchronise time and date of cameras and watches.

7.1.3 Field staff

The same staff members are used each time at each location as far as possible. Any new staff members and fishers should be trained prior to participation in actual sampling.

7.1.4 Boat safety

Field teams should exercise a reasonable level of caution when accompanying fishers on their boats to check their sampling operations. In particular, agency staff should wear lifejackets and carry any needed equipment to deal with emergencies or delays – including mobile phones, torches and first aid kits. Check the condition of a boat before accompanying fishers. Do not overload boats. Check that fishers have enough fuel and some excess. Have a contingency plan in case of accident or if the boat's engine malfunctions.

7.2 PROCEDURES FOR COMPLETING FADM LOGBOOK/FORM

This section provides guidelines for recording 1) fisher catch and effort and 2) standardised gillnet survey data in logbooks and describes how catch sample and sub-samples are taken when weight and number of individual fish by species are recorded. The first page should form the cover of the logbook and include the following information: Fisher's Name; Village; District; Province; and Country. The second page contains the fields required to record catch by species and effort by gear type, including different mesh sizes of gillnets, on each day. At least 40 of these pages should be included and bound as a logbook to allow for the recording of catch and effort for different gear types on separate pages on any one day. In addition, fish prices (by species) at landing locations are also included in this form or logbook. The third page should report individual length data recorded from catches, but also from different gillnet mesh panels from the standardized gillnet sampling. Again 40 pages should be included in the logbook. Forms for recording the data to be held in the logbook are given in Annex 4.

7.2.1 Recording fishing effort

In cases where fishers use a number of attached gillnet panels of different depths (heights), fishers should estimate and record the average depth (height) of each gillnet panel in the box entitled 'HEIGHT' and the total length of the gillnet (based upon the combined lengths of all panels) in the box entitled 'LENGTH OR WIDTH' (Annex 4).

If two or more gillnets comprising different sizes of panels or mesh sizes are used then treat these as separate gears and record the catch and effort for each gillnet on separate logbook pages.

'**Gear units'** - These should be recorded only for traps and hooks.

'**Hours fishing'** should not include travel time to the fishing location or time spent setting or hauling gear. For gillnets and traps this information should relate to the time (hours) the gear is 'soaked' in the water between setting the gear (START DATE AND TIME) and hauling the gear (END DATE AND TIME). **If travel time between fishing locations exceeds 1 hour, use a separate form for each fishing location.**

7.2.2 Recording the whole catch

It is anticipated that in most cases, individual fishers will land small quantities (<10 kg) of fish. The total catch (landed) weight of all species combined for each gear type should be recorded in the box entitled 'TOTAL CATCH (kg) (Steps 1 & 2, **Figure 7-1**). In these cases fishers should sort and weigh their entire catch, recording details of the numbers, weights and prices by species and gear (Steps 3 & 4, **Figure 7-1**). When the entire catch is counted and weighed, enter a tick for each row in the column entitled 'Sample? NO'. Check that the sum of the species weights equals the total catch weight. If the fisher cannot accurately recall this data, no record of the day's catch should be made. In some cases, the fisher may sell part of the catch before recording information relating to the remaining catch. This will *bias* the catch and CPUE estimate. In this situation, the fisher should add the total weight of fish sold to the TOTAL CATCH weight AND include details of the total weights, numbers and prices of fish sold in separate rows for each species including a tick in the column 'SAMPLE NO'. Fishers should therefore be encouraged to complete the form before selling any part of the catch or allocating any part of it for personal consumption.

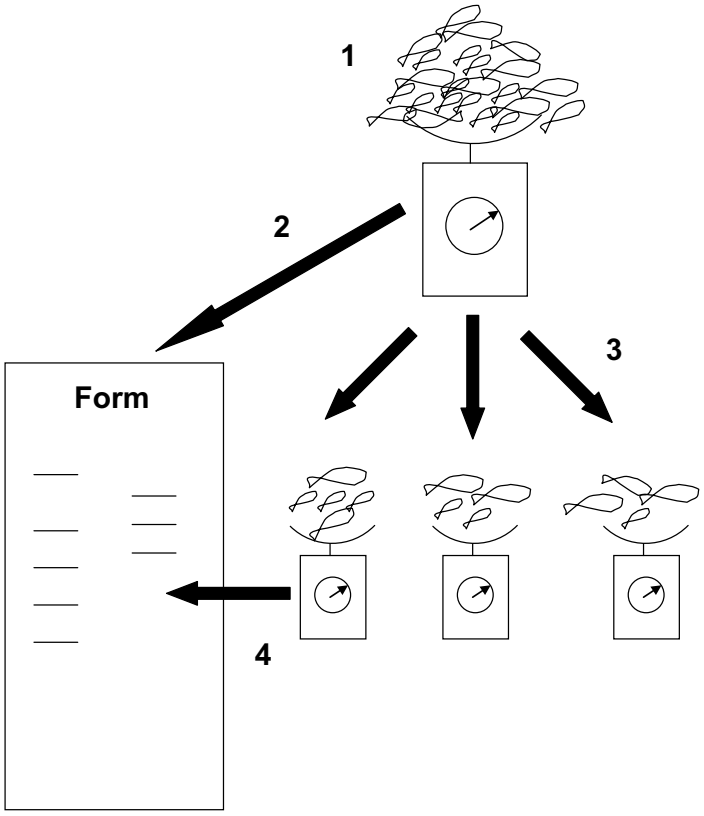

Figure 7-1. Illustration of the process for recording catch weight and number by species (FEVM, 2007)

7.2.3 Recording a sub-sample of the catch

When landings by a gear type are large (say >20kg) then it may be necessary for fishers to sub-sample their landings to record numbers, weights and prices by species for the gear after recording the total weight of the catch for all species combined in the box entitled ''TOTAL CATCH (kg)'.

In this case, after weighing the total catch of all species combined, fishers should first remove all large fish (say >200g) and any fish which are uncommon (<10 individuals) and record their total weight and number in separate rows for each species. For these records, a tick should be entered in the column entitled 'Sample? NO' for each species row.

Next, the remaining small fish should be thoroughly mixed and then the sub-sample (¼ or ½ of the remaining) should be randomly taken.

The total weight of all the mixed fish in either one half or one quarter of the pile should then be recorded in the box entitled 'CATCH SAMPLE (kg)'.

The numbers, weights and prices of fish by species in this catch sample should then be recorded – one row for each species. A tick should be entered in the column entitled 'Sample? YES' for each of the species rows.

A query will be written in the database to raise catch sample weights by species to give total catch weights by species for those species rows for which a tick is given against 'Sample? YES'.

Figure 7-2 may help to illustrate the catch data recording process when sub-sampling is necessary.

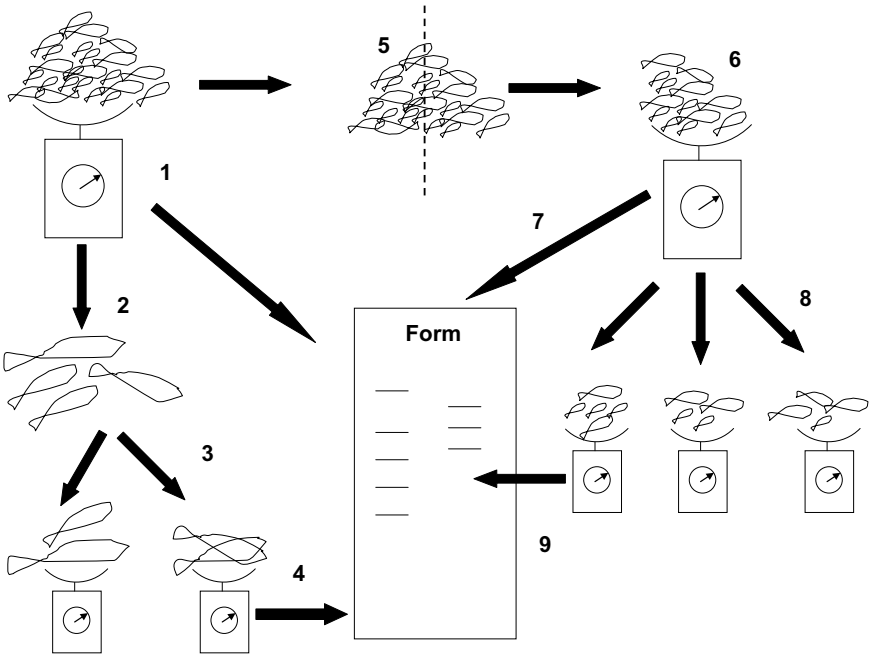

Figure 7-2. Illustration of the process for recording catch weight and number by species when sub-sampling the catch (FEVM, 2007)

Notes on steps (1-9) in Figure 7-1 and Figure 7-2 are as follows:

1. Weigh the total combined catch of all species and record weight in Box: TOTAL CATCH (kg)
2. Remove large individuals and uncommon fish species (<10 individuals) from the catch.
3. Sort these by species.
4. For each species record the weight of all individual fish combined in the 'WEIGHT' column and the number of individual fish in the column 'N' as well as the price per kilogram in the "PRICE" column. Use a separate row for each species. NB for each row, add a tick to the column SAMPLE? NO.
5. Mix the remaining fish from the catch thoroughly and then randomly take ¼ or ½ **subsamples from the remaining**.
6. Remove one of the equal parts and weigh.
7. Record the weight of this part in column 'CATCH SAMPLE' (kg).
8. Sort the sample by species and for each species weigh the total weight and count the number of the individual fish.
9. Record this information in the form in the 'WEIGHT', 'N' and 'PRICE' column, respectively. Use a separate row for each species. NB for each row, add a tick to the column SAMPLE? YES.

7.2.4 Recording catch and effort for two or more gears

A separate form (page) should be used to record the catch and effort of each gear type used. If fishing with two or more gears is found to be common practice among participating fishers, then, fishers should be provided with two or more baskets to keep their catches for each gear type separate before recording their details.

7.2.5 Recording catch for two or more different habitats in a single day

If two or more habitats are fished in a single day, then the catch and effort for the gear set in each habitat should be recorded on separate forms (pages).

7.2.6 Procedures for identifying fish and processing fish metrics

The procedures for identifying fish and processing fish metrics has the following purposes:

- To identify and measure fish from samples accurately to provide the basic data which are used in calculation of catch per unit effort (CPUE) and other indicators of fisheries status.
- To obtain accurate length and weight measurements for each species, which can be used for length-frequency analysis or analyses of condition factors to give an indication of the status of recruitment to the target fish populations as well as the wellbeing of the individuals in the population.
- To record information on reproductive condition of fish to aid the interpretation of migration patterns and the health of fish.

If the identification and measurement of individual fish forms part of the daily logbook catch assessment the measurements should be taken by the fisher and recorded in the appropriate log book (See Section 7.3). If the measurements are from the standardised gillnet surveys, this procedure should be performed by responsible agency staff with assistance by fishers. Steps for the procedure are as follows:

Preparation

In the field, fish are removed from each gear, washed and stored in plastic containers or bags labelled with unique names (gear/replicate/mesh). As well as fish, other aquatic animals (OAAs) such as shrimps, crabs and snakes should also be retained as they are part of the fishery.

Samples should be stored in an icebox in layers of crushed ice and transported to a field laboratory for processing within one hour of removal from gears. If processing is to be delayed, fish should be stored in refrigerators or if on ice, the ice must be periodically re-filled.

Do not combine any samples from different gears. Store and process each sample individually.

In the laboratory, two people are needed to process fish, one to handle and measure them and one to record data. Note: each person who is measuring or recording data should have a fish ID exam when beginning work with the project; these tests should be repeated annually.

For each sample proceed as follows:

1. Prepare a clean work area and flat work table which is free of any unnecessary items.
2. Ensure that the working bench area is well-lit by natural or artificial light and
3. Keep onlookers and domestic animals away to prevent them from distracting people from their work.
4. Use a spirit level to make sure the balance and measuring board are horizontal.
5. Shield the balance from any wind or breezes.
6. Wash all fish in clean fresh water and remove all detritus and sediment.
7. Drain off water and arrange all fish in trays, with the fish from each gear in separate groups and arranged by **location, gear, replicate, species and size (descending order),** with labels and a metric ruler. Labels include location, gear, date and time of gear retrieval, and fisher name. Fish on trays should be **covered with wet cloth towels** to ensure that they neither absorb excess moisture nor dry out.

Identifying fish at Mekong Basin sampling locations

There are about 1200 fish species known from the Mekong basin (MRC, 2018a) and more than 100 species can be recorded in a single sampling exercise. Identifying fish correctly is important and fundamental for obtaining useful monitoring data. However, correct fish identification is challenging because:

1. The scientific classification of some fish is not clear and names are changed frequently in scientific literature. Following rules as set by the International Commission on Zoological Nomenclature (ICZN), the most recent published names for any genus generally supersede older names.
2. New species are being described and new fish are being recorded regularly in the Mekong basin.
3. Local names are useful for many species, but may be misleading or confusing for several reasons:
    - A single local name may be applied to a single species where it is distinctive and there are no similar fish. Generally, larger commercially valuable fish in which the fishers have a strong direct interest tend to be given a unique name.
    - However, a different name is quite often used for large and small individuals of the same species; again this usually applies to the larger commercially valuable fish.
    - A single name is often applied to two or more species that are similar in appearance; they may be closely related or just of similar shape and colour. These tend to be smaller fishes which are of less commercial value and interest to the fishers.
    - Some more astute or experienced fishers tend to use distinctive names for fish; others use more general names and some use incorrect names.
    - Within one country, the names of fish differ between places; this can cause problems for researchers from another part of the country.

Many published and unpublished reports from other parts of the basin indicate that there is a significant on-going problem with species misidentification or 'lumping' of species under one name.

Issues to be addressed with regards to species identification are as follows:

1. The complete list of fish in the Mekong Fish Database has been progressively updated and cross-checked against FishBase.
2. Fish are identified by fishers in consultation with supervisors who check their identifications during the start-up training and on a quarterly basis.
3. The local names of each fish should be re-checked during each field trip with the project's expert fishers
4. Where a single name is being applied to multiple species, an unambiguous local name in local language should be created to accurately describe each species in consultation with the project's fishers. Typically a descriptive suffix can be added to the local name.
5. Local names should be progressively updated in the Fish Species Table in the project database.
6. Photographs of each species of fish caught in the program should be taken as they are caught so a photo chart can be compiled and progressively updated with the agreed local names for each fish.
7. After data is entered in a database, species names are checked against the photos for that day by supervisors, who also check the number of fish and sizes.

The most up-to-date reference material on fishes for the Mekong basin is available on Nagao foundation website http://www.nagaofoundation.or.jp/e/index.html and Fishes of the Indochinese Mekong (2021). Fisheries agencies in each country have posters of most Mekong fishes, and images of most Mekong and Chao Phraya fishes are available on the Nagao website (Kano et al., 2013).

The MRC Fish Photo Book of nearly 300 species (Ngor et al., 2016)[6] has been updated from a fish photo catalogue prepared in the early 2000s which formed the basis of the MRC Mekong Fish Database 2003. This updated version uses photos with higher resolution and updated scientific and common names of the Mekong fishes from the most up-to-date available sources, including Kano et al. 2013. This fish photo book is a key tool for FADM of Mekong fisheries.

The key fish identification reference literature for each country is listed below. The references can be used in each country for cross-checking details of species that are present in that country.

CAMBODIA

So et al. (2019): Fishes of the Cambodia Freshwater Bodies. Field Guide to Fishes of Freshwater Bodies in Cambodia ' is (1) mainly composed of photographs of fish specimens with an accompanying brief description; (2) names of fish body parts and the methods to count and measure the body and body parts; (3) the contents of the 'Fish search aid' help the users who are unfamiliar with fish taxonomy, enabling users to find the fish being searched or similar fish while consulting with photographs; and (4) the major part of this book, a photograph of each fish species is shown with a brief description of its body characteristics and habitat.

Rainboth (1996) is particularly useful for its clear depiction of the features which characterises a species, as well as each genus. Warning: not all fish in this book are known from the Mekong. Note that names have changed for some fishes and all need to be updated regularly from FishBase. The names should be updated manually in the book as time permits.

LAO PDR

Praxaysonbath et al. (2020): Fishes of the Mekong Basin of Laos. Field Guide to Fishes of the Mekong Basin of Laos" is mainly composed of photographs of fish specimens with brief explanations. In the Section 1, names of fish body regions and parts, and the methods of counting and measuring are explained. Section 2 is the 'Fish Search Aid' that helps users who are unfamiliar with fish taxonomy. Users find the fish or similar fish that they are searching for from photographs given, and proceeds to the pages of Section 3. Section 3 gives larger photographs of each species with brief explanations for identification.

Kottelat (2001) is the key text for Lao fish which shows how to differentiate genera and species of fish in Laos. After determining the likely species from Baird and discussions with fishers, use Kottelat (2001) to check the key features of the species and to discriminate between similar species. The keys should also be used to recheck identifications.

Some cautionary notes:

1) Many names have been revised; the names should be updated manually in the book as time permits.

2) There are some minor errata in the book; these should be noted on each copy.

3) Meristic counts are not always totally inclusive, because they may have been be based on few specimens; minor differences are likely not significant.

THAILAND

Vidthayanon (2005) includes photographs, distribution maps and basic information for 196 freshwater fishes from Thailand, including the most common Mekong species.

For accurate information on diagnostic characters this book should be supplemented by Rainboth (1996) and Kottelat (2001).

[6] Available at http://www.mrcmekong.org/assets/Publications/Photos-of-Common-Fishes-in-the-Lower-Mekong-River-20-June-2016.pdf

VIETNAM DELTA

Tran et, al. (2013) is similar to Vidthayanon (2008) in coverage of delta fish, but has more species and some better photos. This text contains useful photos and some identification points, but is limited in terms of quantitative information for identification. Names are mostly up-to-date. It can be downloaded from http://www.nagaofoundation.or.jp/e/index.html.

Vidthayanon (2008) contains useful photos and some identification points, but is relatively poor in terms of quantitative information for identification and is primarily to be used as a back-up. Names are mostly up-to-date.

Other sources include:

- Froese & Pauly (2022)
- Kano et al. (2013)
- Kottelat (2013)
- MFD (2003) or (http://mfdb.mrcmekong.org/)[7]
- Rainboth et al. (2012)
- Vidthayanon (2005)

7.3 MEASURING FISH

Fish should be measured, and data recorded in a logical order by location, gear, species and size (descending order).

7.3.1 Length measurement

Steps for measuring and recording fish length and weight are as follows:

1. Each fish is measured on a measuring board, with its snout pressed gently against the vertical piece and with its mouth closed.
2. Fish should not be stretched, bent, or manipulated in any way and should be in a natural position.
3. Measure each fish's fork length (FL) as shown in **Figure 7-3**. For fish with non-forked caudal fins (rounded, truncate or pointed), total length is measured. When a fish is in position on the measuring board, a pencil or probe is placed on the ruler at the measurement point (behind the caudal fin) and the fish is then removed so that the ruler is clearly displayed.
4. The carapace length of crabs and shrimps should be measured as shown in **Figure 7-4** and **Figure 7-5**, respectively.
5. Units are read aloud in mm (e.g. four-one-six for 416 mm). Fishers are to be tested for comprehension of the units of cm and mm and what to record.
6. The person who is measuring must check that the data recorder is correctly hearing and writing his measurements.

[7] The information (e.g. scientific name and ecological and biological information) of MFD is being updated.

Figure 7-3. Fish measuring board with *Macrognathus siamensis*

Figure 7-4. Crabs – measure carapace width (CW) at the widest point

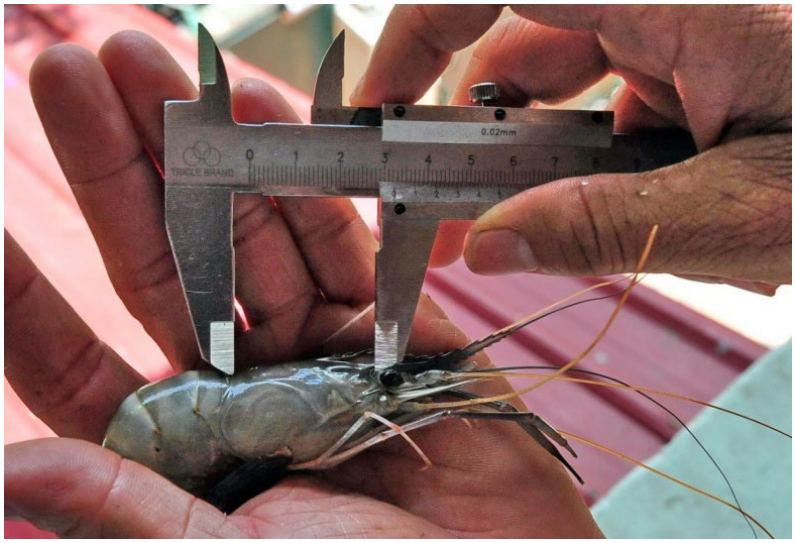

Figure 7-5. Shrimps – measure carapace length (CL) – behind the eye stalk to the mid-posterior edge

7.3.2 Weighing fish

Steps for weighing fish are as follows:

1. Use the same type of digital electronic balances (5 kg x 0.1 g) wherever possible (**Figure 7-6**). Use other balances only for very large fish or large catches or in the event of malfunction of electronic balances.
2. Calibrate each balance prior to use using a weight set. Calibration weights are to be handled using forceps and cleaned with tissue paper.
3. Fish are to be weighed in a plastic pan. Never put fish directly on the balance, because water and slime may run inside the balance and damage it.
4. Tare the balance (i.e. to 0.0) with the pan on it before weighing each fish.
5. Check that airflow is not moving the pan and use shields to prevent draughts.
6. Blot excess water from each fish using a damp cloth towel; fish are to be weighed damp but not dry.
7. Place each fish in the pan and read the units aloud (e.g. four-six-point-3) for 46.3.
8. The person who is measuring must check that this data recorder is correctly hearing and writing his measurements.
9. Clean any excess water from the weighing pan and re-tare the balance before each measurement. Digital balances are used because they are accurate and there is little chance of misreading.

Figure 7-6. Digital balances used to weigh fishes

Figure 7-7. Calibration weights (1 kg set) are used to check all balances

Any new fish species should be pinned-out and photographed individually.

7.4 PHOTOGRAPHING FISH

For photographing the samples, fishers should be properly trained by the responsible agency staff. Fishers should be provided with a digital camera and they should take digital photos of all fish from samples on trays. The photos are used for later checking of data.

- Check camera settings – correct date, time, and highest image quality and size.
- Check the camera lens and clean it as necessary.
- On sunny days take photos in the shade to reduce contrast, or take photos under a white sheet which acts as a diffuser.
- On shady days take photos in the open.
- Take photos about one metre from the tray to reduce distortion or blurring.
- The camera lens should be positioned directly above the centre of the tray.
- Check photos for clarity before proceeding to process the sample; if necessary, adjust the (light) conditions to take a better photo.

Take separate digital photos of any individual fish which are unusual or where their identity is uncertain.

7.5 ANCILLARY MEASUREMENTS

Recording explanatory variables

During each quarterly site visit, each fisher should be interviewed to determine factors they believe are affecting their catch rates and fish diversity. This information should be formally recorded, and reported in quarterly progress reports as well as summarized and reported alongside estimates of fish abundance and diversity each year.

Water quality

Field measurements are made of turbidity (Secchi disc transparency) and temperature.

Habitat

This section should be implemented by the national research teams who are involved in quarterly field visits to the sampling locations. National researchers should sketch the position of each gear on the base map and note any unusual features or changes since previous sampling.

- Note position of backwaters, sandbars and any small tributaries or anabranches.
- Depth - Measure the depth along each gill net ($\pm$0.1 m) and record: bank-middle-end.
- Current speed – estimate current speed at 3 points on each net: bank-middle-end. Use a float timed over 10 m of drift to estimate speed in m s^{-1}.
- Estimate the area of any snags or brush visible within 50 m of each set net and record.
- Take some photographs of the vegetation and any other significant features in the location, with objects for scale where possible.
- Note any recent habitat changes such as excavations or in-fills or new channels.
- Note illegal fishing or evidence of recent fishing.

- Note any water birds or other animals seen at the sampling location, particularly predatory birds, or migratory birds.

7.6 DATA STORAGE

As soon as possible, data from field sheets are entered into standardised databases. Ideally, data are entered in the field, or immediately upon return to the office. The staff that carried out field sampling should enter the data or supervise data entry. Field sheets should be photocopied or scanned for a backup and then stored systematically in separate files. Databases should be backed up each day to a separate external hard disc.

8 DATA ANALYSES

8.1 INTRODUCTION

Fisheries data are highly variable and provided in range of formats, quality and accuracy.

- Quantitative: e.g. species abundance or catch statistics, water depth, flow
- Semi-quantitative: Abundance scale or catch per unit effort, species composition
- Nominal/Categorical: Presence-absence

Data collected under the FADM programme are held in the MRC Fisheries database and need to be extracted to an Excel spreadsheet for further analysis. In general terms the data need to be imported into Excel spreadsheets and sorted to create tables that allow analysis to meet defined research objectives or test research hypotheses.

It is important to recognize that biological data are characterised by:

- large numbers of zero values;
- often highly skewed;
- irregular/non-linear relationships;
- redundancy.

Environmental data are often of differing scales, a mixture of nominal (numerical) and categorical (abundance classes) and missing data. All these parameters need to be accounted for when undertaking analyses. The type of analysis is dependent on the analytical techniques available but typically need to be adjusted for:

- Normality
- Equality of variance
- Monotonic/unimodal/linear relationships
- Other data issues e.g. Outliers, rare species, missing data.

The normal distribution is defined by symmetrically distributed data with no skew, resulting in a bell-shaped curve when graphed. In this distribution, the majority of data points are concentrated around a central region, with values tapering off as they move further from the center. Analyzing CPUE (Catch Per Unit Effort) data, the distribution is not normal but instead exhibits a positive skew. In positively skewed distributions, the mean is greater than the median and is particularly affected by extreme values and outliers, often leading to an overestimation of the most frequent values. Consequently, the mean is not an ideal measure of central tendency for such data.

To address, the skewed dataset should be transformed to approximate a normal distribution. This transformation is achieved by applying logarithms to CPUE observation, either using base-10 logarithms (LOG in spreadsheet software) or natural logarithms (base-e, represented as LN in spreadsheets), with base-e being more commonly used. If the dataset contains zeros, a small constant

(e.g., 0.01, 0.1, or 1) must be added to each value to avoid the issue of taking the logarithm of zero. If the log transformation successfully normalizes the distribution, the original data distribution is then considered 'log normal.'

The various solutions to these problems are highlighted in **Table 8- 1**.

Table 8- 1. Typical problems encountered with biological and environmental data.

Problem	Solution
Skewed/Non Normal data	Transformation – Log, square root, 4th root. Box-Cox, Arcsine, log ratio
Different Scales	Standardisation
Missing Data	Omit sample/variable or estimate
Outliers	Transformation or omission
Rare Species	Removal/Downweighting

8.2 SPECIES COMPOSITION AND RELATIVE ABUNDANCE (CONTRIBUTE TO OBJECTIVES I, II, III)

Data should be analysed to investigate fish community structure and relative abundance in each sampling. Catches are used to calculate the relative abundance of each fish species in each sample and presented in a simple manner for density and biomass such as in **Figure 8-1**

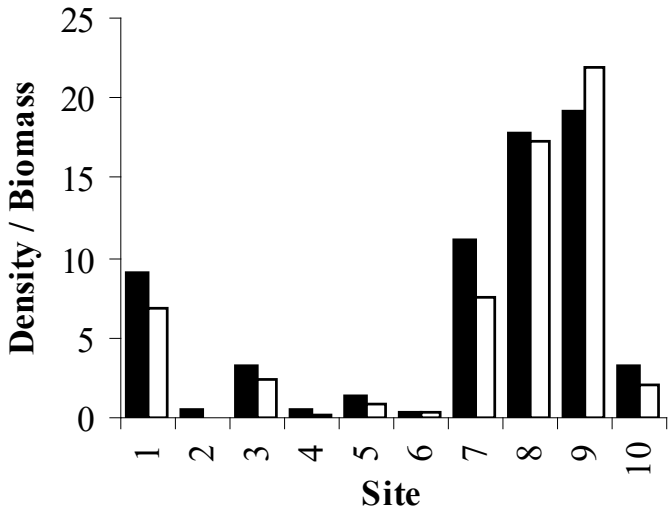

Figure 8-1. Abundance or biomass of individual fish species in catches at different locations. Individual graphs should be created for the main species and for all fish combined.

The relative abundance of a species is defined as the percentage of total catches (by numbers or weight) comprised by the given species and should be calculated for each gear and for the catch as whole according to explanatory variables. When comparing between sites the data can be presented as in **Figure 8-2**. The relative abundance ($\%A_i$) of species *i* is described as:

$$\%A_i = \frac{\sum S_i}{\sum S_t} \times 100$$

where S_i is the sample content (number) composed by species *i*, and S_t is the total content of all species (Hynes, 1950).

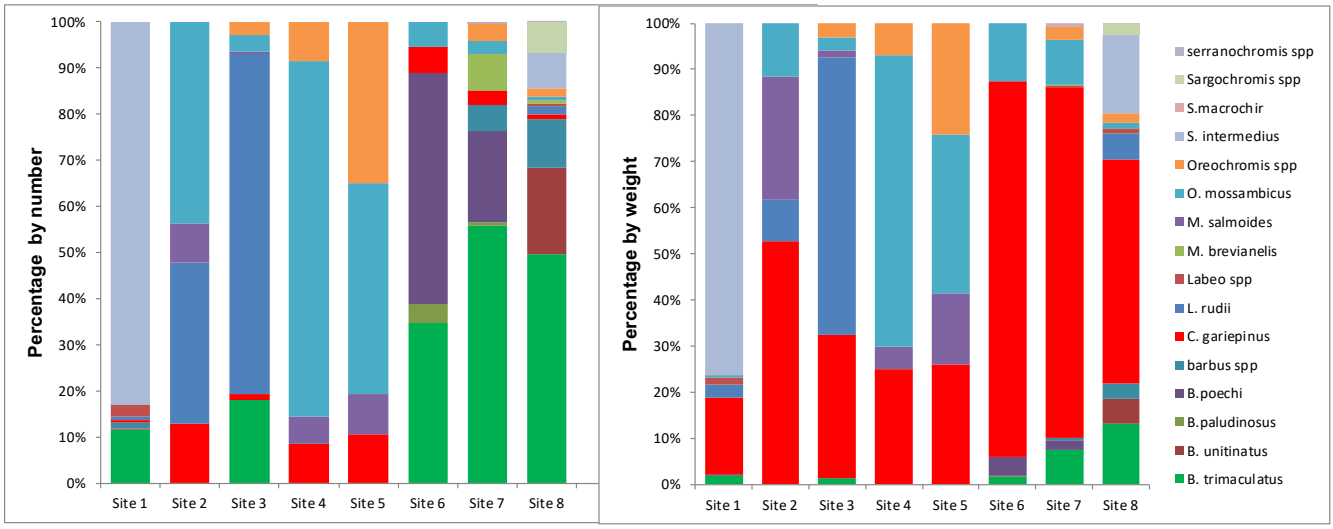

Figure 8-2. Species composition by number (left) and weight (right) of fish catches. Catches should be presented for each season separately and all country data combined as a separate column if needed

In addition the data can be presented according to habitat or gear as in **Figure 8-3**.

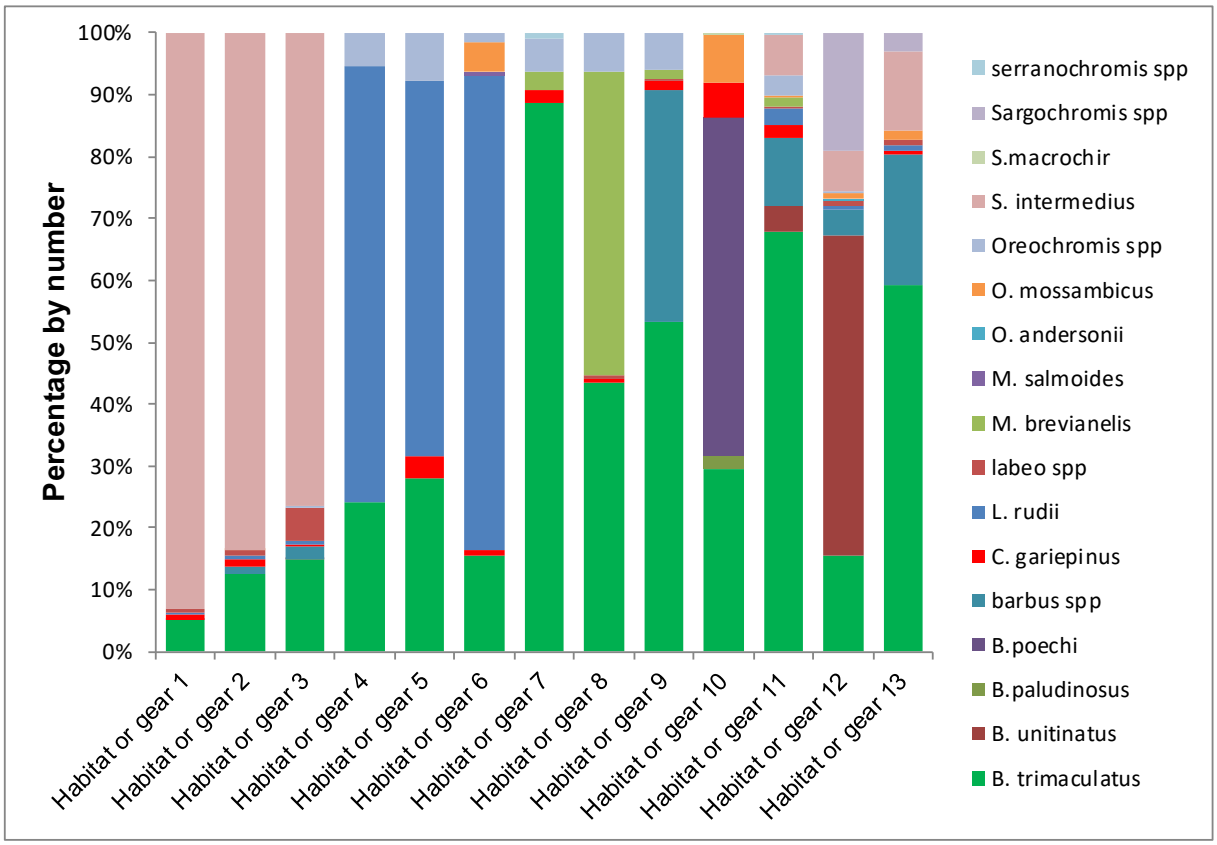

Figure 8-3. Species composition by habitat or gear

For each survey, a Bray-Curtis similarity matrix should be calculated and presented as a dendrogram using hierarchical agglomerative clustering (group average) to investigate similarities in fish community structure between sites or dams using the PRIMER software package (as shown in **Figure 8-4**). The Bray-Curtis similarity index (C_z) represents the overall similarity between each pair of samples, taking the abundance of all species into consideration, and is calculated as:

$$C_z = \frac{2W}{(a+b)}$$

where *W* is the sum of the lesser percent abundance value of each species common to two samples (including tied values), and *a* and *b* are the sums of the percent abundances of species in samples *a* and *b*, respectively. The index ranges from 0 (no species in common) to 1 (identical samples), and a similarity profile test (SIMPROF) can be used to ascertain whether clusters of sites were significantly similar with one another (Anderson *et al*. 2008). SIMPROF is a permutation test of the null hypothesis that a specified set of samples, which are not *a priori* divided into groups, do not differ from each other in multivariate structure. In this process, tests are performed at every node of the completed dendrogram to provide objective stopping rules and identify whether groups being sub-divided have significant internal structure (i.e. that samples in each group show evidence of multivariate pattern).

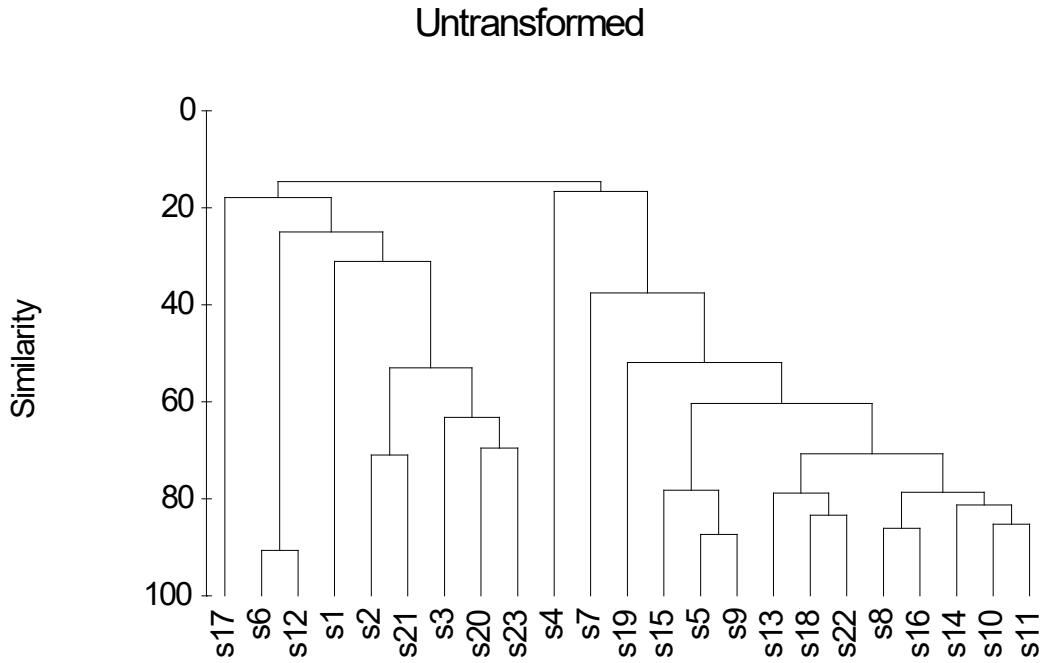

Figure 8-4. Example of dendrogram created from cluster analysis in PRIMER to show similarities between sites of seasons or habitats or gears

Multi-dimensional scaling (MDS) can be used to establish any relationships between species abundance at the different sites/habitats or between gears and identify key differences between locations or gears or sites in terms of contribution to the fish fauna. Nested groupings of similar sites are created using the cluster overlap function within the PRIMER statistical package. MDS can also be used to identify similarities between catches in the samples or changes in catch composition over different years and determine the trajectory of this trends (**Figure 8-5**). This is achieved by running the join centroids function in PRIMER for data from different years at the same locations.

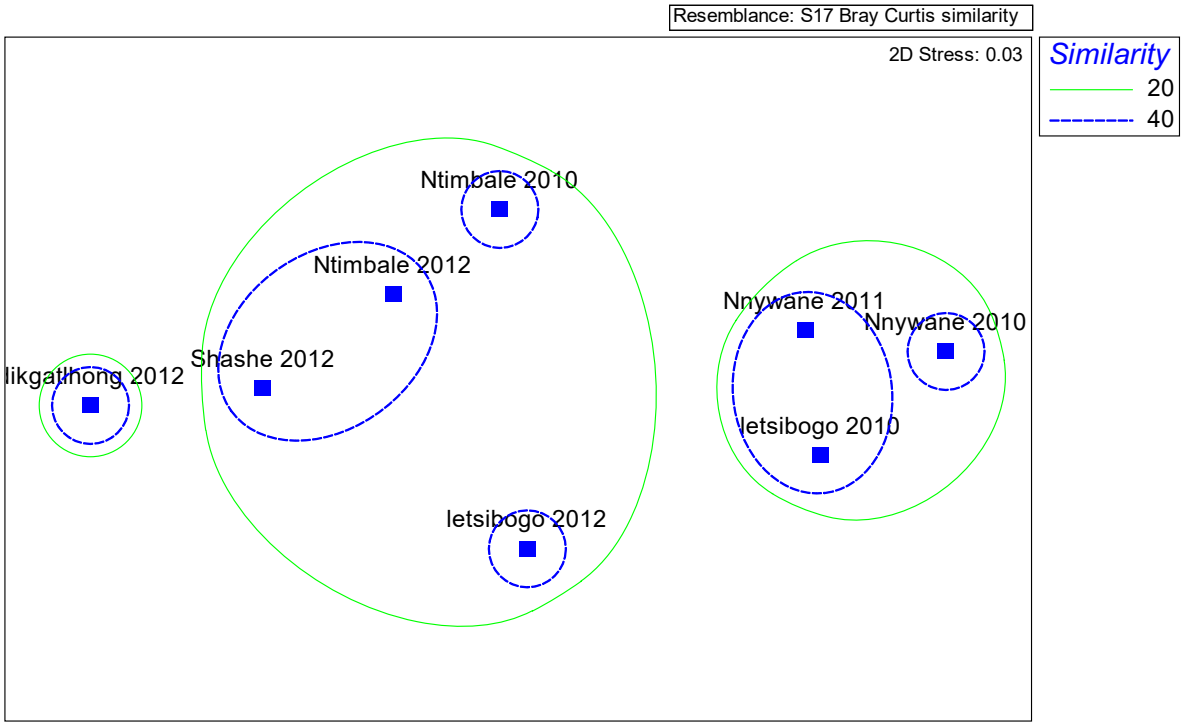

Figure 8-5. Example of Multidimensional Scaling plot of species change in gill net catches from major dams in Botswana.

Various types of measures of diversity are available. The simplest measure of species diversity is species richness – i.e. the total number of species per unit area or volume (i.e. in a sample). Simpsons Index [$D = 1-\sum(n/N)^2$ where n is the number of individuals of a particular species and N is the total number of individuals] incorporates additional information on the number of individuals of each species. The number of animals representing each species is divided by the total number of animals in the sample and this value is then squared. D is 1 minus the total sum of these values for each species.

The Shannon-Wiener (*H'*) diversity index, Pielou's measure of evenness (*J*) and Margalef's index (*d*), can be applied to investigate spatial or temporal variations in diversity and evenness of fish catches. *H'* and *J* are calculated as:

$$H' = -\sum p_i \ln p_i$$

$$J = H' / H'_{max}$$

$$d = (S - 1) / \log N$$

where *S* is the species number, *N* the total number of individuals and p_i is the proportion of the total count arising from the *i*th species, and $H'_{max} = \ln(k)$, the maximum possible diversity for a set of data of *k* categories. These indices are different in that the Shannon Weiner index is a measure of the proportional representation of each species and the Margalef index a measure of the number of species present for a given number of individuals. Data can be presented simply as in **Figure 8-6**.

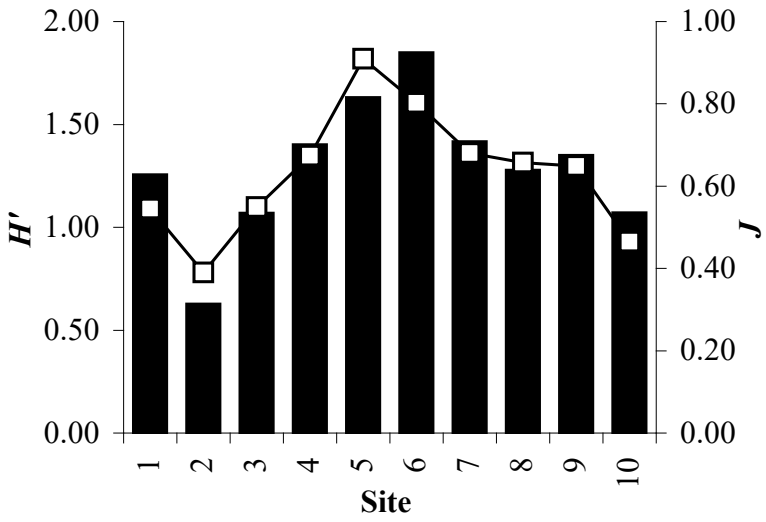

Figure 8-6. Diversity (H', ■) and evenness (J, □) of fish catches at ten sites on the lower River Thames

If appropriate data are available to relate fish catches to environmental variables, Canonical Correspondence Analysis (CCA) (sometimes inaccurately referred to as Canonical Correlation Analysis) can be used to investigate the influence of environmental variables on the relative abundance and community composition of fish species in each dam (Clarke & Warwick, 2001; Zuur *et al*., 2007). This tool is powerful to show the environmental drivers of fish catch composition and how catch composition changes over time and space as a result of habitat degradation and fishing pressure. Analysis can be carried out using the CANOCO proprietary software or other open-source programmes (e.g. R programme). A typical out is shown in **Figure 8-7** where the factors driving particular species are grouped along the vectors (red arrows). The longer the vector the more influential it is in explaining the presence of the species. Species in the opposite direction of the vector show an inverse relationship to the vector.

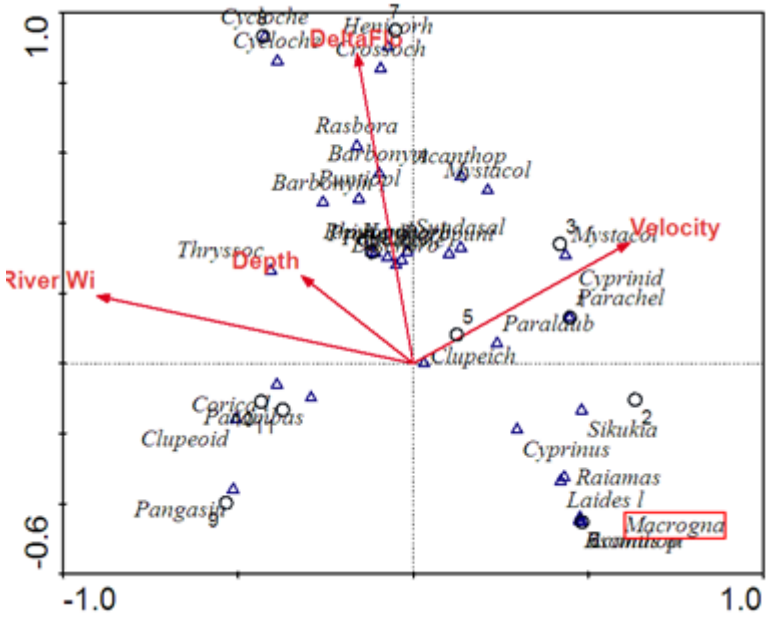

Figure 8-7. CANOCO biplot illustrating the relationship between species composition and environmental drivers for Mekong fish distribution patterns

8.3 CATCH RATES (CONTRIBUTE TO OBJECTIVES I, II, III, IV)

Data can be analysed in Excel to determine catch rates according to

- mean catch rates for each species or group of species;
- compare the mean catch rates for the different locations, seasons, habitats and depths
- compare mean catch rates between different mesh sizes of gill nets or between gears.

Relative (multi) species fish abundance is indicated by estimates of mean catch per unit effort (CPUE). The estimates of catch per unit effort (CPUE) at location *j* in year *y* and month *m* for gear *g* is given by:

$$\overline{CPUE}j, y, m, g = \left[\sum_{i}^{n} \frac{C_{j,y,m,g,i}}{E_{j,y,m,g,i}}\right].\frac{1}{n}$$

Where $C_{j,y,m,g,i}$ is the combined catch weight for all species in catch sample *i* at location *j* in year *y*, month *m* with gear *g*, and *E* denotes the corresponding fishing effort.

The equivalent expression for a given species *s* is:

$$\overline{CPUE}j, y, m, g, s = \left[\sum_{i}^{n} \frac{C_{j,y,m,g,s,i}}{E_{j,y,m,g,i}}\right].\frac{1}{n}$$

Where *n* is the total number of catch samples in month *m*, recorded by participating fishers and where:

$$E_{j,y,m,g,i} = H_{j,y,m,g,i}.P_{j,y,m,g,i}$$

and *H* is the number of effective fishing gear hours (e.g. soak hours) and *P* is the effective power of the gear. For (gill)nets *P* is the total net area (m^2), and for traps and hooks *P* is the number of units.

All data should be reported as kg/fisher/hour for each gear or sample date, or g/100 m^2/hour for habitat type and can be presented in line graphs (e.g. Figure 8-8). To achieve this, all catch data should be standardised for number or size of gears used, for example for gillnets catch should be standardised as catch/100 m^2/hr of net area as ((*100/total area of net used by fisher*)/*number of hours fished*). Note it is recommended that data for no more than three species are represented on any one graph.

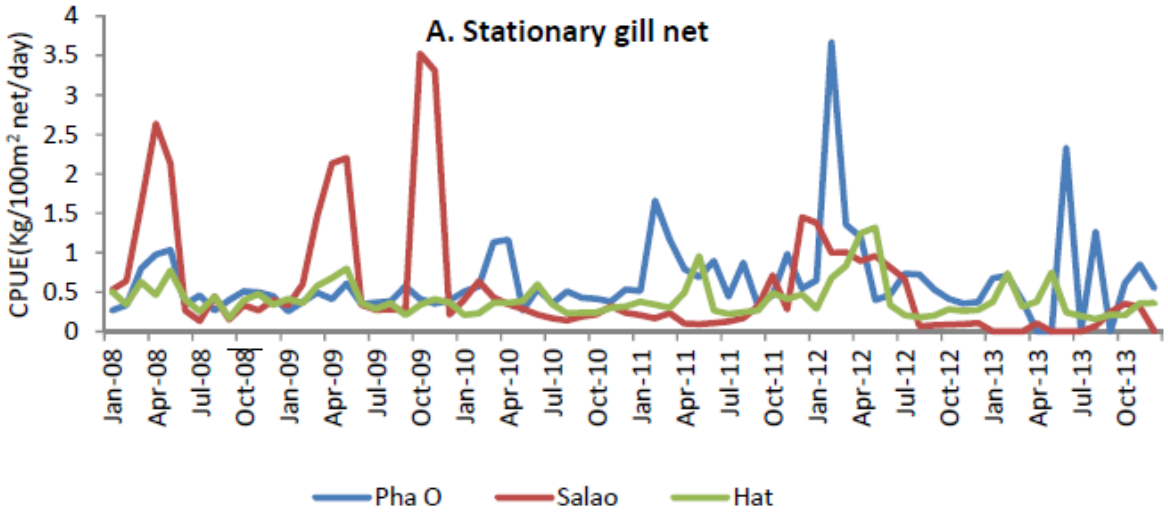

Figure 8-8. Monthly changes in relative abundance of three species of fish between January 2008 and October 2013.

Appropriate statistical methods (Principal Component Analysis – within the PRIMER software or R progamme) can be used to investigate trends in species composition (**Figure 8-9**) or relate catch rates to changes in environmental conditions. All data should be presented in simple line graphs but should be repeated for different sites, habitats or gears to avoid crowded graphs – on the most important species should be presented.

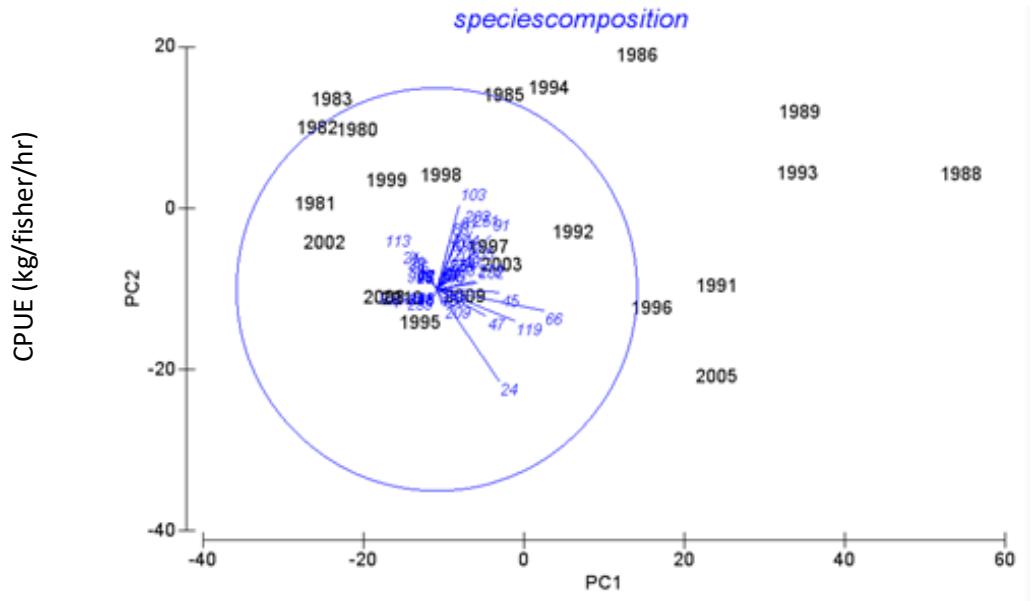

Figure 8-9: PCA plot of contribution of species (numbers based on MRC species codes) to catch composition in different years

8.4 POPULATION STRUCTURE (CONTRIBUTE TO OBJECTIVES I, II, IV)

To compare length distributions for a given species from location to location and from time to time, it is necessary to calculate the combined distributions for each species on each occasion in each location (see **Figure 8-10** for example). These distributions should be plotted on the same scales, and simply laid next to each other in chronological order and look for differences in characteristics such as modal lengths and minimum and maximum lengths. The analysis can be performed in Excel based on simple individual length data (aligned in one column) using the histogram function and plotting the length frequency data as a standard bar chart.

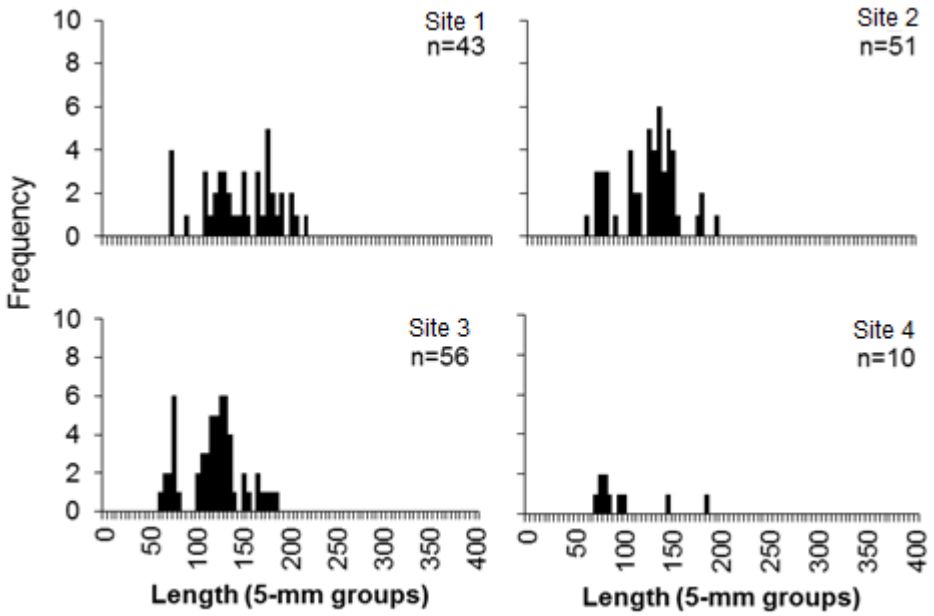

Figure 8-10. Example of length frequency distributions to show variation in size of fish of the same species between locations, habitats, seasons or years.

Such an examination can reveal much about the way fish are growing over time (shown by shifts in modal lengths over time), or any progressive loss of larger fish or lack of recruitment. This type of visual examination will also show the potential for analysing the modes in the length distributions to estimate growth parameters. If the length distributions do not show reasonably obvious and consistent modes, then an analysis of length frequency distributions will be highly subjective and is unlikely to be successful. Differences between length distributions can be examined using the Kolmogorov-Smirnov Goodness-of-Fit Test, but for samples with large numbers of fish this tends to be overly sensitive, indicating differences between distributions that are not really indicative of genuine differences in biological processes. It is also useful to compare mean lengths of different samples using a standard test such as Student's t test. This can be achieved by presenting the mean size of fish of each species per locations, habitats, seasons or years (**Figure 8-11**).

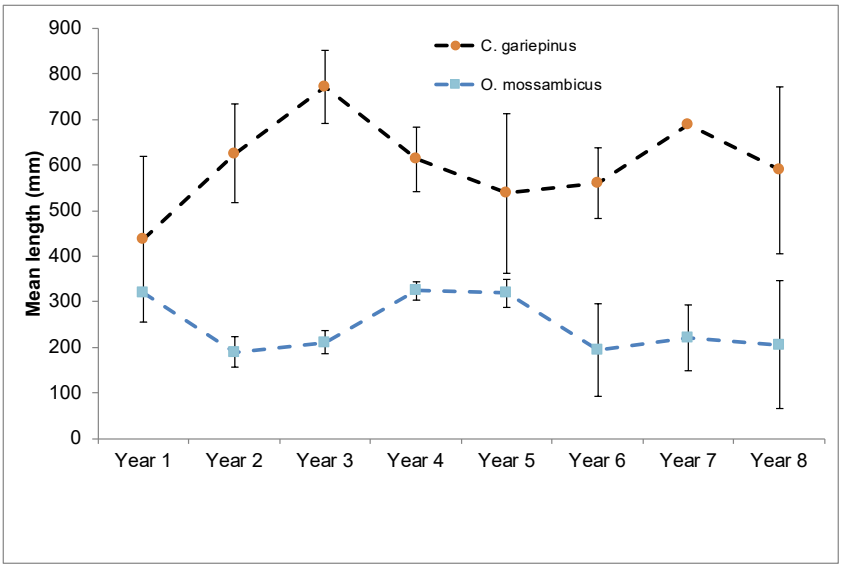

Figure 8-11. Mean size (or weight) of fish caught by year (or by gear, season or habitat)

Note that before such an analysis of growth and population characteristics can be fully assessed from the length frequency data (**Figure 8-10**), due account must be taken of selective of the gear, especially the selectivity of different mesh panels of gill nets. The data collected from the gillnets should be input into software such as SELECT or PASGEAR to adjust for selectivity before establish growth parameters

using length-based methods. If sufficient length data (at least 30 individual length measurements per species monthly over 12 months) are available it may be possible to undertake length-based growth assessments that can be converted in the catch curves and ultimately determine mortality rates. This can be carried out in appropriate software such as the FAO FiSAT (http://www.fao.org/fishery/topic/16072/en) and readers should refer to the manual to undertake the analysis.

8.5 QUALITY CONTROL PROCEDURES

Changing the sample procedure or sampling under varying conditions or with different staff or field crews may cause large variations in results, so it is important to follow the Standard Operating Procedures and fill field data sheets accurately. On any occasion, if it is necessary to modify the procedure at a location, full details should be recorded for future reference and for possible adjustment at other locations.

After all sample processing is completed several quality checks should be carried out.

8.5.1 Fish Identification

An expert taxonomist checks a summary of species at each location (from databases) against the photo set from the field sampling. The taxonomist signs-off on the field data sheet and in the database.

8.5.2 Data Check

The final computerised data are cross-checked against the contents of the field sheet, and against the photographs of each sample, in terms of:

- Species recorded
- Total counts or approximate counts
- Approximate size and weight ranges

The data are also checked against the historical data for the location and if any major changes are evident (i.e. absence of previously abundant taxa or dominance of previously rare taxa), the laboratory book data and photographs are re-checked.

8.5.3 Calibration and validation

Periodically, responsible agency staff may replicate nets to calibrate and validate with the fisher fishing methods. Calibration of the method requires that it produces consistent results under given conditions, note that it provides absolute estimates of abundance. Spatial variation in fish abundance is a large source of variation (related largely to habitat variation), but we assume that the use of replicate nets set over a distance of 5-10 km reduces (smooths) such variation. Method validation involves comparing catches to another method which provides an estimate of all fish in the targeted habitat at the time of sampling.

8.5.4 Data quality monitoring

Institutions/researchers responsible for implementing the monitoring programme should take measures to ensure that the data recorded by fishers is unbiased and as accurate as possible by regularly overseeing and checking data recording activities. Institutions should encourage fishers to report any problems they experience and provide further training or additional equipment as necessary. Fishers should be provided with appropriate equipment and materials e.g. electronic weighing scales, to complete their enumeration activities. Regular feedback is also very important (see below).

Each quarter the database should also be examined for evidence that the data have not been fabricated (e.g. systematic patterns and anomalies). The likely accuracy and reliability of the data collected should be reported each quarter and year along with recommendations to resolve any shortcomings.

8.6 REGULAR FISHER FEEDBACK

The reliability and sustainability of the monitoring programme will largely depend upon fishers understanding and interest in their monitoring activities. NB: It is therefore very important that research institutions or researchers take the necessary time to explain to participating fishers the purpose of their data collection and to regularly feedback the results of the monitoring programme in a readily understandable format. Fishers or organised fisher groups need to see the results of their hard work and to understand how the data they collect contribute to the larger scheme of things. Providing regular feedback helps to maintain motivation and to ensure that the data continue to be collected well (see pages 79-81 of the FAO 'Guidelines on Designing Data Collection Systems').

8.7 DATA SHARING

MRCS ED has a central role to compile data submitted by national partners and synchronise them into a regional database for regional sharing. They also have a central role to synthesis all the data and provide a regional analysis of the data in a report following the structure provided in Annex 6.

8.8 TECHNICAL ANNUAL REPORTS

Annual technical reports summarizing monitoring activities and data of Fish Abundance and Diversity in Lower Mekong Basin will be prepared by national agencies involved in the monitoring. Guidelines for these reports are provided in Annex 6. The reports will be submitted to the MRCS ED, where the data will be compiled, and further regional analyses will be conducted (if required) a Regional Annual Report and MRC Technical Paper at the end of each phase.

The reports should follow the provided analysis guidelines, with annual data presented clearly and explanations included. A review of changes in fish abundance and diversity over time should be conducted, with comparisons made across sampling years. The same analysis methods, such as trends in catch composition, CPUE, diversity indices, and size composition, should be applied. Statistical analyses, including cluster analysis, MDS, and PERMANOVA (via PRIMER), should be carried out to determine the significance and causes of any changes. Detailed explanations of observed changes and recommendations for addressing negative effects should be provided by the MCs.

The national reports will be synthesized by the MRC into a regional analysis, with all data combined and a similar structure followed. A more detailed analysis of spatial and temporal changes will be included, incorporating data from other programs where possible.

Once sufficient data are available, trend analyses related to environmental drivers will be conducted, and the impact of any development activities will be assessed where possible.

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ANNEXES

ANNEX 1: LIST OF THREATENED SPECIES IN THE MEKONG REGION ACCORDING TO IUCN REDLIST

Family Name	Species		Guild	Size Category	Common English
Bagridae	*Mystus bocourti*	Vulnerable	G4	Small	
Balitoridae	*Hemimyzon confluens*	Vulnerable	G1	Small	
Botiidae	*Syncrossus beauforti*	Near Threatened	G3	Small	Chameleon loach
Botiidae	*Yasuhikotakia nigrolineata*	Vulnerable	G3	Small	
Botiidae	*Yasuhikotakia splendida*	Vulnerable	G3	Small	
Clariidae	*Clarias macrocephalus*	Near Threatened	G6	Medium	
Clupeidae	*Tenualosa thibaudeaui*	Vulnerable	G3	Medium	Laotian shad
Cyprinidae	*Aaptosyax grypus*	Critically Endangered	G3	Giant	
Cyprinidae	*Bangana elegans*	Near Threatened	G3	Medium	
Cyprinidae	*Boraras urophthalmoides*	Near Threatened	G6	Small	Exclamation-point rasbora
Cyprinidae	*Catlocarpio siamensis*	Critically Endangered	G10	Giant	Giant barb
Cyprinidae	*Cirrhinus cirrhosus*	Vulnerable	G11	Giant	Mrigal
Cyprinidae	*Cirrhinus microlepis*	Vulnerable	G3	Large	
Cyprinidae	*Cirrhinus molitorella*	Near Threatened	G3	Medium	Mud carp
Cyprinidae	*Devario apopyris*	Vulnerable	G1	Small	
Cyprinidae	*Epalzeorhynchos munense*	Vulnerable	G1	Small	
Cyprinidae	*Hypsibarbus lagleri*	Vulnerable	G3	Medium	
Cyprinidae	*Labeo pierrei*	Vulnerable	G3	Large	
Cyprinidae	*Luciocyprinus striolatus*	Endangered	G3	Giant	
Cyprinidae	*Macrochirichthys macrochirus*	Near Threatened	G4	Large	
Cyprinidae	*Mekongina erythrospila*	Near Threatened	G1	Medium	
Cyprinidae	*Mystacoleucus lepturus*	Vulnerable	G1	Small	
Cyprinidae	*Onychostoma gerlachi*	Near Threatened	G1	Medium	
Cyprinidae	*Oxygaster pointoni*	Vulnerable	G3	Small	

Cyprinidae	*Poropuntius bolovenensis*	Endangered	G1	Small	
Cyprinidae	*Poropuntius consternans*	Endangered	G1	Small	
Cyprinidae	*Poropuntius deauratus*	Endangered	G1	Small	
Cyprinidae	*Poropuntius lobocheiloides*	Endangered	G1	Small	
Cyprinidae	*Poropuntius solitus*	Endangered	G1	Small	
Cyprinidae	*Poropuntius speleops*	Vulnerable	G1	Small	
Cyprinidae	*Probarbus jullieni*	Endangered	G2	Giant	Isok barb
Cyprinidae	*Probarbus labeamajor*	Endangered	G2	Giant	Thicklip barb
Cyprinidae	*Probarbus labeaminor*	Near Threatened	G2	Large	Thinlip barb
Cyprinidae	*Pseudohemiculter dispar*	Vulnerable	G3	Medium	
Cyprinidae	*Rhodeus laoensis*	Vulnerable	G4	Small	
Cyprinidae	*Scaphognathops bandanensis*	Vulnerable	G3	Small	
Cyprinidae	*Scaphognathops theunensis*	Critically Endangered	G3	Medium	
Cyprinidae	*Tor ater*	Near Threatened	G1	Medium	
Cyprinidae	*Tor sinensis*	Vulnerable	G1	Medium	
Cyprinidae	*Troglocyclocheilus khammouanensis*	Vulnerable	?	Small	
Datnioididae	*Datnioides pulcher*	Critically Endangered	G4	Medium	
Datnioididae	*Datnioides undecimradiatus*	Vulnerable	G3	Medium	
Gastromyzontidae	*Sewellia breviventralis*	Critically Endangered	G1	Small	
Gastromyzontidae	*Sewellia elongata*	Near Threatened	G1	Small	
Gastromyzontidae	*Sewellia patella*	Endangered	G1	Small	
Gobiidae	*Rhinogobius albimaculatus*	Vulnerable	G1	Small	
Indostomidae	*Indostomus spinosus*	Near Threatened	G4	Small	Pipe fish
Nemacheilidae	*Nemacheilus banar*	Vulnerable	G1	Small	
Nemacheilidae	*Schistura atra*	Vulnerable	G1	Small	
Nemacheilidae	*Schistura bairdi*	Endangered	G1	Small	
Nemacheilidae	*Schistura bolavenensis*	Endangered	G1	Small	
Nemacheilidae	*Schistura kaysonei*	Vulnerable	G1	Small	
Nemacheilidae	*Schistura kontumensis*	Vulnerable	G1	Small	

Nemacheilidae	*Schistura leukensis*	Critically Endangered	G1	Small	
Nemacheilidae	*Schistura nudidorsum*	Endangered	G1	Small	
Nemacheilidae	*Schistura personata*	Near Threatened	G1	Small	
Nemacheilidae	*Schistura quasimodo*	Endangered	G1	Small	
Nemacheilidae	*Schistura spiloptera*	Critically Endangered	G1	Small	
Nemacheilidae	*Schistura tenura*	Critically Endangered	G1	Small	
Nemacheilidae	*Schistura tubulinaris*	Vulnerable	G1	Small	
Notopteridae	*Chitala blanci*	Near Threatened	G1	Giant	Indochina featherback
Odontobutidae	*Terateleotris aspro*	Endangered	G1	Small	
Osphronemidae	*Betta splendens*	Vulnerable	G6	Small	Siamese fighting fish
Osphronemidae	*Osphronemus exodon*	Vulnerable	G1	Large	Elephant ear gourami
Osphronemidae	*Trichopodus leerii*	Near Threatened	G6	Small	Pearl gourami
Osteoglossidae	*Scleropages formosus*	Endangered	G1	Large	Golden arowana
Pangasiidae	*Pangasianodon gigas*	Critically Endangered	G2	Giant	Giant catfish
Pangasiidae	*Pangasianodon hypophthalmus*	Endangered	G2	Giant	Sutchi catfish
Sciaenidae	*Boesemania microlepis*	Near Threatened	G4	Giant	Boeseman croaker
Serpenticobitidae	*Serpenticobitis cingulata*	Vulnerable	G1	Small	
Siluridae	*Ceratoglanis pachynema*	Critically Endangered	G3	Medium	
Siluridae	*Pterocryptis inusitata*	Endangered	G1	Small	
Siluridae	*Wallago attu*	Near Threatened	G3	Giant	Great white sheatfish
Sisoridae	*Bagarius suchus*	Near Threatened	G1	Large	Crocodile catfish
Sisoridae	*Bagarius yarrelli*	Near Threatened	G1	Giant	
Sisoridae	*Oreoglanis lepturus*	Critically Endangered	G1	Small	

ANNEX 2: MAJOR GUILD TYPES IN THE LOWER MEKONG BASIN AND THEIR VULNERABILITY TO DAM DEVELOPMENT

(Based on Welcomme et al. 2005 and MRC Council Study BioRA report 1) Grey shading highlights most vulnerable guilds.

Guild	Migratory guild name	Typical characteristics	Relative effect of mainstream dams on migration	Relative effect of change in flow regime on fish production
1	Rhithron resident guild	• Resident in rapids torrents, rocky areas and pools in the rhithron.	Little or no impact from mainstream dams (but note, potentially high in upland storage dams)	Little or no impact from mainstream dams (But note potentially high in upland storage dams dues to possible exposure of riffle areas and inundation of habitats upstream)
	Indicator groups and/or species **Notopteridae**: *Chitala blanci* (main channel with rocky only), **Cyprinidae:** *Gara* spp., *Brachydanio* spp., *Devario* spp., *Poropuntius* spp., *Tor* spp., *Neolissocheilus* spp., *Osteochilus waandersii*, *Raiamas guttatus*, *Opsarius* spp., *Lobocheiros* spp., *Onychostoma* spp.(Laos), *Scaphidonuchthys acanthopterus* (Laos), *Mekongina erythrospila* (Stuntreng-3S, Laos), *Mystacoleucus* spp., **Balitoridae:** all species (eg. *Homaloptera* spp., *Balitora* spp. etc.), **Nemacheilidae:** all species (eg. *Nemacheilus* spp., *Schistura* spp.), **Akysidae:** all species (eg. *Akysis* spp., *Pseudobagarius* spp.), **Sisoridae:** *Gryptothorax* spp., *Bagarius* spp. (main channel), **Datnioididae:** *Datnioides undecimradiatus* (main channel only), **Channidae**: *Channa gachua,* **Osphronemidae**: *Osphronemus exodon,* **Gobiidae:** *Rhinogobius mekongianus* (above Stuntreng), **Tetraodontidae**: *Pao baileyi* (main channel only), *P. turgidus*			
2	Migratory main channel (and tributaries) resident guild	• Long distance migrants spawning in the main channel (sometimes in upper zone of the Mekong (Figure 1) upstream of adult feeding habitat in the main channel. • May migrate to refuges (deep pools) in the main channel during the dry season. • Pelagophilic members have drifting pelagic egg or larval stages returning to adult habitat using backwaters and slacks as nurseries. • Adults do not enter floodplain and may be piscivorous.	Very high	High: flow variation may affect the passability at Khone falls and other natural barriers and delayed flooding disrupt migratory cues
	Indicator groups and/or species **Cyprinidae:** *Cirrhinus microlepis*, *Cyclocheilos enoplos*, *Cosmochirus harmandi*, *Probarbus jullieni* **Pangasiidae**: *Pangasianodon hypophthalmus* (all places), *Pangasius larnardii* (all places), *P. mekongensis* (DT-PP-TS only), *P. bocourti* (except TS system), *P. concophilus* (except TS system)			
3	Migratory main channel spawner guild	• Spawn in the main channel, tributaries or margins upstream of floodplain feeding and nursery habitat often with pelagic egg or larval stages. • Adults and drifting larvae return to floodplains to feed. • May migrate to refuges (deep pools) in the main channel during the dry season.	Very high	Very high: loss of connectivity and flooding of spawning and nursery habitat

Guild	Migratory guild name	Typical characteristics	Relative effect of mainstream dams on migration	Relative effect of change in flow regime on fish production
	Indicator groups and/or species **Clupeidae:** *Clupeichthys aesarnensis* (all places), *Clupeoides borneensis* (all places), *Corica laciniata* (DT-PP-TS), **Cyprinidae:** *Cirrhinus prosemion*, *C. jullieni*, *Hypsibarbus* spp., *Puntioplites falcifer* (above Kratie), *P. proctozysron* (below Kratie till DT). , *Labeo chrysophekadion, L. pierrei*, *Sikukia* spp., *Incisilabeo behri*, *Scaphognathops* spp. (above Kratie), *Barbichthys laevis*, *Leptobarbus rubripinna, Amblyrhynchichthys micracanthus,* **Botiidae:** all species (*Syncrossus* spp., *Yasuhikotakia* spp.), **Pangasiidae:** *Pangasius macronema, Pseudolais pleurotaenia, Helicophagus leptorhynchus,* **Siluridae:** *Walago attu, Phalacronotus* spp*., Kryptopterus* spp., **Bagridae:** *Hemibagrus* spp., **Cobitidae:** *Acantopsis* spp., *Acanthopsoides* spp. (prefers sandy bottom), **Gyrinocheilidae:** all species, **Tetraodontidae:** *Auriglobus nefastus*			
4	Migratory main channel refuge seeker guild	• Migrates from floodplain feeding and spawning habitat to refuges (deep pools) in the main channel during the dry season. • Spawning occurs on the floodplain and main channel used as refuge during dry season.	Medium	High: loss of connectivity and flooding of spawning and nursery habitat
	Indicator groups and/or species **Cyprinidae:** *Barbonymus altus*, *B. schwanefeldii* , *Cyclocheilichthys* spp., *Rasbora* spp., *Paralaubuca* spp., *Parachela* spp., *Thynnichthys thynnoides,* **Cobitidae:** *Pangio* spp., **Siluridae:** *Ompok siluroides;* **Bagridae:** *Mystus* spp., **Pristolepididae:** *Pristolepis fasciata*, **Ambassidae:** *Parambassis wolfii*, *P. apogonoides,* **Sciaenidae:** *Boesemania microlepis* (d/s Stuntreng common, above Khone Falls very rare now), **Tetraodontidae:** *Pao cambodgiensis*, *P. suvattii* (above Khone Falls only)			
5	Generalist guild	• Limited non-critical migrations in mainstream. • Highly adaptable, mobile and static elements in their genome make them highly adaptable to habitat modification.	Little or no impact	Medium: loss of connectivity and reduced flooding of floodplain
	Indicator groups and/or species: **Notopteridae:** *Notopterus notopterus*, *Chitala ornata*., **Cyprinidae:** *Gymnostomus* spp., *Barbonymus gonionotus*, *Systomus orphoides*, *Crossocheirus* spp. *Osteochirus vittatus*, *O. microcephalus*, *Hampala* spp., *Labiobarbus* spp., *Cyclocheilichthys* spp. **Syngnathidae:** *Doryichthys boaja* (below Kratie to DT-TS), *D. deokhatoides* (below Kratie to DT-TS), *D. contiguus* (confirmed between Vientiane-Ubonratchathani, not exists below K fall), **Mastacembelidae:** *Mastacembelus* spp. (eg. *M. favus*, *M. armatus*), **Ambassidae:** *Parambassis siamensis,* **Eleotridae:** *Oxyeleotris marmorata*			
6	Floodplain resident guild (Blackfish)	• Limited migrations between floodplains pools, river margins, swamps, and inundated floodplains. • Tolerant to low oxygen concentrations or complete anoxia.	Little or no impact	Medium: loss of connectivity and reduced flooding of floodplain
	Indicator groups and/or species: **Cyprinidae:** *Esomus* spp., **Cobitidae:** *Lepidocephalichthys hasselti,* **Clariidae:** all species (eg. *C. macrocephalus*, *C.* cf *batrachus*), **Adrianichtyidae:** *Oryzias siamensis*, *O. minutillus,* **Hemiramphidae:** *Dermogenys siamensis,* **Channidae:** *Channa striata*, *C. lucius*, **Anabantidae:** *Anabas testudineus ,* **Osphronemidae:** *Trichopodus* spp., *Trichopsis* spp. , **Synbranchidae:** *Monopterus albus ,* **Mastacembelidae:** *Macrognathus* spp., **Tetraodontidae:** *Pao cochinchinensis*			
7	Estuarine resident guild	• Limited migrations within the estuary in response to daily and seasonal variations in salinity.	Little impact (if dam is upstream of estuary and does not	Little or no impact

Guild	Migratory guild name	Typical characteristics	Relative effect of mainstream dams on migration	Relative effect of change in flow regime on fish production
			influence salinity dynamics in estuary).	
	Indicator groups and/or species **Plotocidae:** *Plotosus canius* (DT), **Ariidae:** all species (DT), **Adrianichthidae:** *Oryzias haugiangensis* (DT), **Gobiidae:** *Glossogobius* spp. (DT-TS-PP), **Polynemidae:** *Polynemus* spp. (DT-TS-PP), **Cynoglossidae:** all species (DT-PP-TS), **Soleidae:** *Brachirus* spp. except *B. harmandi* and *B. siamensis*			
8	Anadromous guild	• Enters fresh/brackish waters to breed. • Enters freshwaters as larvae/juveniles to use the area as a nursery, either obligate or opportunistic.	High (for dams located in river mouths or lower potamon).	Little or no impact
	Indicator groups and/or species **Pangasiidae:** *Pangasius krempfi*, *P. elongates* (mainstream only), Ariidae: all species (DT-PP)			
9	Catadromous guild	• Reproduction, early feeding, and growth at sea. • Juvenile or sub-adult migration to freshwater habitat, often penetrating far upstream.	Very high	Very high: loss of connectivity to feeding and nursery habitat
	Indicator groups and/or species **Angullidae:** *Anguilla marmorata, A. bicolor* (all nodes), **Ophichthidae:** *Pisodonophis boro* (DT-PP-TS)			
10	Marine visitor guild	• Enters estuaries opportunistically	Little or no impact	Little or no impact
	Indicator groups and/or species **Scombridae:** *Scomberomorus sinensis* (DT-PP), **Gerreidae:** all species (DT), **Ambassiidae:** all species except *Parambassis* spp. (DT), **Terapontidae:** *Terapon jarbua,* **Sciaenidae:** all species except *Boesemania,* **Gobiidae:** *Pseudapocryptes elongatus, Periophthalmodon schlosseri*			
11	Non-native		Little or no impact	Little or no impact
	Indicator groups and/or species , **Cyprinidae:** *Labeo rohita, Cirrhinus cirrosus*, Cyprinus *rubrifuscus*, **Serrasalmidae:** *Piaractus brachypomus*, **Clariidae:** *Clarias gariepinus*, **Loricariidae:** *Pterygoplichthys* spp., **Cichlidae:** *Oreochromis* spp.			

ANNEX 3: NAMES OF LOCATIONS SELECTED FOR FISH ABUNDANCE AND DIVERSITY MONITORING BY COUNTRY AND HABITAT

No	Country	Province/City	District	Commune	Village	Standard habitat	Latitude (N)	Longitude (E)	Number of fishers	Agency	Remark
1	Cambodia	Stung Treng	Siem Pang	Tmar Keo	Pres Bang	Tributaries	14° 7'0.43"	106°23'23.99"	3	IFReDI	2003-2021
2	Cambodia	Ratanakkiri	Lumpat district	Chey Udom	Day Lo	Tributaries	13°28'18.08"	106°59'16.26"	3	IFReDI	2003-2021
3	Cambodia	Ratanakkiri	Veunsai	Banpong	Fang	Tributaries	13°57′43.14″	106°48′7.11″	3	IFReDI	2003-2021
4	Cambodia	Stung Treng	Talaborivat	Ou Svay	Ou Run	Mekong mainstream	13°52'0.13"	105°59'53.91"	3	IFReDI	2003-2021
5	Cambodia	Kratie	Sambo	Ou Krieng	Koh Khne	Mekong mainstream	13°08′9.15″	106°03′51.75″	3	IFReDI	2003-2021
6	Cambodia	Kandal	Ponhe Leu	Kampong Luong	Sang Var	Tributaries	11°49′9.52″	104°48′16.54″	3	IFReDI	2003-2021
7	Cambodia	Kampong Chhnang	Boribo	Chhnouk Trou	Chhnouk Trou	Floodplain/swamp/Lake/tributaries	12°30'55.10"	104°27'26.91"	3	TSA	2011-2021
8	Cambodia	Pursat	Kor Kor	Kompong Loung	Ti 2	Floodplain/swamp/Lake/tributaries	12°36'21.09"	104°13'27.44"	3	TSA	2011-2021
9	Cambodia	Battambong	Ek Phnom	Prek Torl	Prek Torl	Floodplain/swamp/Lake/tributaries	13° 6'1.48"	103°44'36.37"	3	TSA	2011-2021
10	Cambodia	Siem Reap	Siem Reap	Chong Khneas	Ti 3,4,5	Floodplain/swamp/Lake/tributaries	13°12'54.07"	103°48'45.29"	3	TSA	2011-2021
11	Cambodia	Kampong Thom	Kompong Svay	Phat Sanday	Neang Sav	Floodplain/swamp/Lake/tributaries	12°43'1.52"	104°25'45.64"	3	TSA	2011-2021
12	Lao PDR	Luangprabang	Luangprabang		Pha Oh village	Mekong mainstream	19°56'4.39"	102°12'21.97"	3	LARReC	2003-2021
13	Lao PDR	Vientiane Capital	Hatsaifong		Tha Mouang	Mekong mainstream	17°53'26.87"	102°44'45.86"	3	LARReC	2003-2021
14	Lao PDR	Bolikhamxay	Paksan		Sinxay	Mekong mainstream	18°20'51.40"	103°45'9.42"	3	LARReC	2003-2021
15	Lao PDR	Champasack	Phonthong		Hatsalao	Mekong mainstream	15° 4'28.16"	105°49'38.79"	3	LARReC	2003-2021
16	Lao PDR	Champasack	Khong		Hat	Mekong mainstream	14° 5'2.67"	105°50'42.54"	3	LARReC	2003-2021
17	Lao PDR	Bokeo	Houaysai		Houay Tab	Mekong mainstream	20°19'38.88"	100°22'51.08"	3	LARReC	New (2013-21)
18	Lao PDR	Bokeo	Houaysai		Donkhoun	Tributaries	20°22'3.73"	100°22'22.02"	3	LARReC	New (2013-21)
19	Lao PDR	Oudomxay	Pakbeng		Pak Ngeuy	Mekong mainstream	19°53'20.84"	101° 7'18.29"	3	LARReC	New (2013-21)
20	Lao PDR	Oudomxay	Pakbeng		Beng	Tributaries	19°53'29.72"	101° 8'17.65"	3	LARReC	New (2013-21)
21	Lao PDR	Luangprabang	Xieng Ngeung		Pha Nom	Tributaries	19°53'9.14"	102° 9'34.41"	3	LARReC	New (2013-14)*
21	Lao PDR	Xekong	Lamam		Gnai Nava	Tributaries	15°20'49.42"	106°44'29.17"	3	LARReC	New(2017-21)**
22	Lao PDR	Luangprabang	Pak Ou		Hat Nga	Tributaries	20° 5'6.33"	102°15'41.98"	3	LARReC	New (2013-14)
23	Lao PDR	Xayaboury	Xayaboury		Tha Dua	Mekong mainstream	19°25'52.93"	101°50'20.32"	3	LARReC	New (2013-14)
24	Lao PDR	Xayaboury	Xayaboury		Na Sam	Tributaries	19°13'47.50"	101°42'28.24"	3	LARReC	New (2013-14)
25	Lao PDR	Bolikhamxay	Paksan		Posy	Tributaries	18°25'29.64"	103°37'5.49"	3	LARReC	New (2013-14)*
25	Lao PDR	Attapeu	Samakhixay		Saphaothong	Tributaries	14°48'33.98"	106°47'18.35"	3	LARReC	New (2017-21)**
26	Lao PDR	Champasack	Pakse		Hae	Tributaries	15° 8'34.40"	105°48'7.43"	3	LARReC	New (2013-14)*
26	Lao PDR	Champasak	Khong		Hangsadam	Mekong mainstream	13°56'8.04"	105°57'31.84"	3	LARReC	New (2017-21)**
27	Thailand	Loei	Chiang Khan		Ban Noy	Mekong mainstream	17°54'38.64"	101°41'45.81"	3	DoF	2003-2021

28	Thailand	Nong Khai	Tha Bo		Thadaeng	Tributaries	17°53'10.62"	102°34'1.32"	3	DoF	2003-2021
29	Thailand	Nakhon Phanom	Tha Uthen		Woen Phrabat	Mekong mainstream	17°37'25.67"	104°31'2.71"	3	DoF	2003-2021
30	Thailand	Nakhon Phanom	Si Songkhram		Ban Tha Bho	Floodplain/swamp	17°39'21.42"	104°13'5.80"	3	DoF	2003-2021
31	Thailand	Ubon Ratchathani	Khemarat		Ladjalean	Mekong mainstream	16° 1'39.51"	105°21'0.17"	3	DoF	2003-2021*
31	Thailand	Ubon Ratchathani	Khong Chiam		Weonbuk	Mekong mainstream	15.321692	105.54645	3	DoF	New(2021)**
32	Viet Nam	Vinh Long	Vung Liem	Thanh Binh	Lang	Mekong mainstream	10°05’ 57.7	106°13’ 38.5	3	RiA2	2003-2021
33	Viet Nam	An Giang	Toai Son	Nui Sap	Tay Son	Floodplain/swamp	10°11'21.30"	105°15'27.62"	3	RiA2	2003-2021
34	Viet Nam	An Giang	Cho Moi	My Hoi Dong	My Thuan	Mekong mainstream	10°32’ 49.5	105°20’ 06.6	3	RiA2	2003-2021
35	Viet Nam	An Giang	An Phu	Phu Hoi	Ap 2	Canal	10°47'55.73"	105°04'46.79"	3	RiA2	2003-2021
36	Viet Nam	Tra Vinh	Tieu Can	Cau Quang	Khom 3	Estuarine	09°45'15.46"	106°07'09.88"	3	RiA2	2003-2021
37	Viet Nam	Can Tho	Phong Dien	My Khanh	My Thuan	Floodplain/swamp	10°00'27.82"	105°42'20.70"	3	RiA2	2003-2021
38	Viet Nam	Tra Vinh	Tra Vinh city	Long Duc	Long Trị	Estuarine	09°59’ 24.4"	106°21’ 11.7"	3	RiA2	2003-2021
39	Cambodia	Kampong Cham	Kaoh Soutin			Mekong Mainstream	11.909	105.388	3	IFReDI	CRMN from 2025
40	Lao PDR	Champasak	Champasak			Mekong Mainstream	14.95666	105.8869	3	LARReC	CRMN from 2025
41	Thailand	Chiang Rai	Chiangsaen			Mekong Mainstream	20.27412	100.0885	3	DoF	CRMN from 2025
42	Thailand	Ubon Ratchathani	Khong Chiam		Weonbuk	Mekong Mainstream	15.32169	105.5465	3	DoF	CRMN from 2025
43	Viet Nam	Tien Giang	Cho Gao			Mekong Mainstream	10.33754	106.4046	3	RiA2	CRMN from 2025
44	Viet Nam	An Giang	Tan Chau			Mekong Mainstream	10.80062	105.248	3	RiA2	CRMN from 2025
45	Viet Nam	An Giang	Chau Doc			(Bassac) Tributaries	10.7052803	105.133507	3	RiA2	CRMN from 2025

Note: * represented non-operated sites and ** represented newly selected sites in 2017

ANNEX 4: FIELD TRIP CHECK LIST

List to be further discussed

- Gill net set
- Forms/logbook
- Fish measuring boards, 1 m in mm increments.
- Calibrated electronic balance(s), 5 kg x 0.1 g; 10 kg x 10 g.
- Callipers
- Digital camera – used for recording each catch and details of net setting locations – check time and date and set up for maximum resolution.
- GPS – used for recording positions where nets were set; check settings.
- Plastic trays for fish photography.
- Fish identification books and guides suitable for the sampling location
- Calibration weights
- Small cloth towels
- Buckets for washing/holding fish
- Plastic bags
- Insect spray (knockdown spray for flying insects)
- Head torches
- Dissecting kit with scissors, scalpel and forceps
- Plastic containers suitable for temporarily holding fish
- Screwdrivers and cutters
- Waterproof labels
- Tape measure and fish-finder for depth measurements.
- Secchi Disc
- Thermometer
- Stakes, floats, weights for gill nets
- Watches and/or hand-phones for time recording – synchronised.
- First Aid Kit
- Head torches, mosquito repellent, hats, sunscreen
- Buffered formalin, (40% formaldehyde solution).
- Ice-chests and ice. Generally three ice-chests with 20 L of ice and another empty ice-chest are required as a minimum.
- Waterproof field data sheets
- Waterproof sample labels
- Waterproof markers
- Laptop computer

ANNEX 5: FORMS OR LOGBOOK FOR RECORDING THE DATA

Cover page of the logbook

Research Institution Logo

Environmental Management Division

Fishing Logbook

(Local language)

Fisher name ..... Village ..... Commune .....

District ..... Province .....Country.....

(Local language)

Address:
Implementing agency .....
.....
.....
.....

Office of the Secretariat in Phnom Penh (OSP)
576 National Road, #2, Chak Angre Krom,
P.O. Box 623, Phnom Penh, Cambodia
Tel: (855-23) 425 353
Fax: (855-23) 425 363

ANNEX 5: (CONTINUED)

Form 1: Logbook

Fisher Catch Monitoring

DATE (D D M M Y Y Y Y)

HABITAT

TOTAL CATCH (KG)

CATCH SAMPLE (KG)

WATER LEVEL: Rising / Static / Falling / Don't know

Fishing GEAR

Length or width (m)

Height (m):

Mesh (mm) or Hook Size #

Units (traps and hooks)

Engine HP

START DATE (D D M M Y Y)

START TIME (HH:MM)

END DATE (D D M M Y Y)

END TIME (HH:MM)

HOURS FISHING: HH MM

CATCH By SPECIES

CODE	FISH LOCAL NAME	N	WEIGHT (KG)	PRICE/KG	Maximum Length (CM)	Minimum Length (CM)	SAMPLE	
							YES	NO

ANNEX 5 (CONTINUED)

Form 2: Logbook

Mutipanel Gillnet Monotoring

DATE D D M M Y Y Y Y

Fishing GEAR _____

HABITAT _____

Length or width (m) ☐

Height (m): ☐

TOTAL CATCH (KG) _____

WATER LEVEL ☐ Rising ☐ Static ☐ Falling ☐ Don't know

START DATE D D M M Y Y

START TIME (HH:MM)

END DATE D D M M Y Y

END TIME (HH:MM)

HOURS FISHING: HH MM

CATCH By SPECIES

CODE	FISH LOCAL NAME	N	WEIGHT (KG)	Maximum Length (CM)

ANNEX 6: REPORTING GUIDELINES AND CONTENTS FOR ANNUAL REPORTING ON FISH ABUNDANCE AND DIVERSITY MONITORING

1. Reporting guidelines

The technical reports of Implementing Partners of Work Agreements with MRC FP should be prepared using the following template:

Format:

- A4, single-spaced
- Standardized cover page (see attached)
- Margin (top, bottom, left and right): 25.4 mm / 1 inch
- Heading font: Arial, 12-14 pt, bold, left-aligned
- Body font: Times New Roman, 12 pt, justified
- Page number: bottom-centre
- Allow one empty line before and after the section titles/headings

Items in the report should include:

- Cover page (format provided on the following page)
- Table of contents
- Table of Tables and Figures, numbered progressively and systematically captioned
- Abbreviations and Acronyms
- Acknowledgements
- Executive summary
- Report main text
- References (reference list should follow a consistent style, e.g. APA style)
- Appendices

Please check the English grammar and typos very carefully before the submission of the report to the FP. We suggest authors to run spell check on Microsoft Word also.

Copyrights should be respected and citation should be done in a professional way using the proper citation style such as APA (i.e. http://psychology.about.com/od/apastyle/ig/APA-Format-Examples/references.htm or http://employees.csbsju.edu/proske/nursing/apa.htm).

2. Table of Contents for national and regional annual reporting on Fish Abundance and Diversity Monitoring

NAME OF PARTNER INSTITUTION AND LOGO **MEKONG RIVER COMMISSION**

Fish Abundance and Diversity Monitoring

For the MRCS Environmental Management Division

Prepared by

Reporter name (FAMILY NAME, Given name)

(Name of Reporter's Organization)

[Place], Date.....

Table of Contents

Table of Figures

Table of Tables

Abbreviation and Acronyms

Acknowledgements

Executive summary

1. Introduction

1.1. Background

1.2. The purpose of the study

1.2.1. Overall objective

1.2.2. Specific objectives

1.3. Structure of the report

2. Methods

- **Sampling habitats** (including the selection of habitats)
- **Location selection**
  - Describe background of the study locations (previous work: since when have fish been monitored at location? Always using the same methods? Or not? , importance of fisheries, type of fisheries, recent trends (if something important happened in the locations), etc. Provide a map showing all study locations
  - Criteria for location selection
- **Fisher selection**
  - Criteria for fisher collection
  - Three or more fishers for each study location
  - Assigned a new 'FisherID' to each newly selected fisherman to ensure consistency with the database
- **Sampling and sub-sampling techniques**
- **Sample sizes**
  - Approximately, 20 samples taken per month for each location … (Can be calculated from the database)
- **Data collection**
  - Logbook
  - Design of photo flipchart
  - Quarterly monitoring trip
    - Monitoring process of data collection
    - Collecting data from all the selected fishers
- **Database**
  - Data entry, data cleaning, data processing and analysis
- **Reporting**
- **Survey materials**

- Measuring equipment
- Maintenance of equipment (calibration)

Information highlighted in red above should be provided in the first reporting only and reference made to FADM guidelines. Any deviation between years for these aspects should be provided and explanations for the changes given.

3. Results

3.1. Fisher profile (only provide in initial report)

Description of change in fisher profile since previous report

3.2. Fishing habitats

3.2.1. Mekong River, Mekong tributaries, flood plains, ponds/reservoirs, deep pools, canals, rice field …

3.2.2. Can be presented in a graph (monthly counting and expressing in percentage)

3.2.3. Frequencies of fishing by habitat types

3. 3. Fishing gear monitored (fishing effort)

3.3.1. Description of number of fishing gears used by locations

3.3.2. Composition of fishing gear use in terms of annual catch

3.3.3. Seasonality of fishing gears use by locations

3.3.4. Monthly variation in gillnet mesh sizes by location by season i.e. gillnet with a mesh size of 2-4 cm, 5-7 cm, 8-10 cm, 11-13 cm, 14-17 cm.

3.3.5. Monthly variation of hook sizes by fishers by locations (if applicable)

3.3.6. Variation of fishing transport (on foot, paddle boat, engine boat; if engine boat is used, please provide horse power) by months, (by gear types?) and by location.

3.3.7. Actual fishing hours (soak hours) per fishers per fishing trip by month by locations

3.4. Fish Catch (repeat for standardised gillnets and monitoring of fisher catches by logbooks)

3.4.1. Annual total catch at target monitoring locations (03 fishers)

3.4.2. Monthly total catch at target monitoring locations (03 fishers)

3.4.3. Annual fish catch by gear types (all target monitoring locations combined)

3.4.4. Total catch at target monitoring locations by gear types

3.4.5. Total catch by habitat types at locations

3.4.6. Total catch (by locations) of Mekong species versus introduced (alien) species

3.4.7. Total catch by ecological guild of fish species (white fish species, black fish species, grey fish species, estuarine species)

3.4.8. Total catch by ecological guild of fish species by habitats

3.5. Catch Rate (CPUE)

3.5.1. Monthly average daily catch rate per fishing hour per fisher by locations/(by habitats

3.5.2. Monthly average catch rate per fisher by gear types

3.5.3. Daily variation in catch rate per location/site

3.5.4. Daily catch rate by gear type

3.5.5. Catch rate per hour per fisher (by a unit of gear type)

3.5.6. Correlation between catch rate versus peak tide (for delta study)

3.5.7. Monthly catch rates by species for standardised gillnetting per mesh size per habitat per location (where appropriate)

3.5.8. Daily catch rates by species for standardised gillnetting per mesh size per habitat per location (where appropriate)

3.6. Species diversity (repeat for standardised gillnets and monitoring of fisher catches by logbooks)

3.6.1. Species composition

3.6.2. Species composition by gear type by locations

3.6.3. Species relative abundance

3.6.4. Species richness (Should describe limitation of the study and suggestion for improvement)

3.6.5. Species diversity indices (Should describe limitation of the study and suggestion for improvement)

3.6.6. Cluster analysis and MDS comparison of species catch composition per location per gear

3.7. Length frequencies (top ten species and repeat for standardised gillnets)

3.7.1. Distribution of length by species

3.7.2. Distribution of length by species by gear types

3.8. Trends in catch and species diversity (in the last xxx years since the survey begun)

3.8.1. Trends in catch rate per fisher per 100 m^2 of gillnets (with different types and mesh sizes) by habitat types

3.8.2. Trends in catch per habitat type (g/100 m^2/hour) by year

3.8.3. Trend in monthly average catch rate per actual fishing time (per hour)

3.8.4. Change in catch composition of fish species grouped according to their ecological guild

3.8.5. Change in catch proportion of the Mekong indigenous species versus alien species

3.8.6. Trends (of species richness) in number of fish species combined and by habitats

3.8.7. Trends in length frequencies of top ten important species in terms of catch

3.8.8. Cluster analysis and MDS comparison of catch per location per gear per year (to understand trajectory of fish species catch composition)

3.8.9. Drivers of change in abundance and diversity of catches with time and habitat (Canonical Correspondence Analysis using CANOCO and PCA)

4. Discussion

Highlight the key messages from the monitoring programme in specific year and discuss changes in fisheries over space and time as described in Section 8.8

5. Conclusions

6. Recommendations

7. References

- Copyrights should be respected, and citation should be done in a professional way using the proper citation style such as APA.

8. Appendices

- Include all data used for this report.

MRC consolidated report

MRC should provide regional overview based on consolidated data analysis, including comparison between MCs. The report should include a deep analysis based on consolidated data to allow a regional perspective of the status and trends and factors causing change in the fisheries.

Mekong River Commission Secretariat

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