

KINGDOM OF CAMBODIA

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MINISTRY OF AGRICULTURE, FORESTRY AND FISHERIES
FISHERIES ADMINISTRATION



MANUAL FOR FISH CATCH MONITORING ASSESSMENT FOR MARINE FISHERIES IN CAMBODIA

Cambodia Programme for Sustainable and Inclusive Growth in the Fisheries Sector:
Capture Component (CAPFISH-Capture)

January 2021

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ACKNOWLEDGEMENTS

This manual was prepared with financial assistance from the European Union by the FAO CAPFISH project, with the assistance of staff at MaFReDI. Sincere thanks to H.E. Eng Cheasan, Delegate of the Royal Government of Cambodia, Director General of the Fisheries Administration (FiA) for his continued guidance, providing good perspectives and encouragement for preparing and finalising this manual. Special thanks to the director of MaFReDI, Mr. Suy Serywath, who provided general guidance and overview of coastal fisheries and Dr. Chea Tharith, who provided many useful inputs and corrections on the species list, survey methodology and the use of information from the 2018 vessel census to ensure that the proposed approach was practical and relevant to the specific circumstances in Cambodian marine fisheries. This manual was also reviewed and commented by the sub-group of research of Technical Working Group on Fisheries (TWGFi), which assisted in finalising this manual. Also, many thanks to Mr. Kim Sour from Fauna and Flora International, who was instrumental in providing inputs on both the general methodology and the landing site assessment.

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ISBN-13: 978-9924-550-04-4

Citation:

Fisheries Administration (FiA). 2021. Manual for Fish Catch Monitoring Assessment for Marine Fisheries in Cambodia. Marine Fisheries Research and Development Institute of the Fisheries Administration, Phnom Penh, Cambodia. 38 pages.

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PREFACE

The coastal area in Cambodia includes several large bays and extends across the four provinces of Koh Kong Preah Sihanouk Kampot and Kep province. The offshore marine area contains numerous islands. The Exclusive Economic Zone (EEZ) covers approximately 55,600 km² and is relatively shallow with an average depth of about 50 metres.

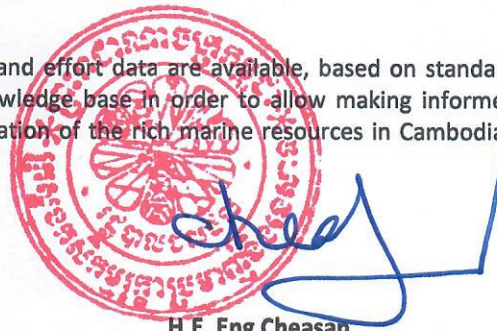
Although marine capture fisheries, are smaller than the inland fisheries by total catch weight, they play an essential role in the coastal provinces, by providing, job opportunities, income and ensuring food security. According to data available with the FiA, marine fisheries of Cambodia are a significant source of employment, contribute to the livelihoods of the poor and Cambodia's food security, the GDP, and foreign exchange balance for many years. The marine fisheries sector provides full-time, part-time, and seasonal employment for more than 140,000 people in the coastal provinces of Cambodia, while fish provides over 81.5% of animal protein intake in the national diet and is a critical source of vitamins and micronutrients. The production from marine fisheries contributed about 20% to the total fisheries production in 2019 (FiA, 2020).

The recent vessel census identified a total of over 7000 small-scale and middle-scale marine fishing vessels, using a large variety of fishing gears and employing an estimated 20,000 workers. Marine fisheries is of enormous economic importance for local communities as well as for export, mainly of shrimps, crabs, squids, and also for finfish.

FiA reported that marine catch production has dramatically increased over the past two decades, with statistics suggesting that marine fish landings have tripled from 36,000 tonnes in 2000 to 122,250 tonnes in 2019. The actual volume of marine catch production might be even higher than what the national statistics record shows, due to unreported catch from small landing sites in remote villages. The rapid increase in catch since 2000 indicates that the amount of effort expended on fishing has also increased, and there has been an equal increase in the number and size of vessels, the amount of size of fishing equipment used, and the amount of time fishers spend fishing.

Although current catch statistics indicate that marine fisheries output is stable, the data is collated from provincial reports that use non-standard and non-scientific approaches based on information provided by key informants. It doesn't include sufficient species and effort detail for assessing the status and trends of marine capture fisheries for policy and planning, nor for evaluating current and future management interventions.

This manual is a first step in ensuring that catch and effort data are available, based on standard scientific methodologies, and to improve the knowledge base in order to allow making informed decisions on management and sustainable exploitation of the rich marine resources in Cambodian waters.



H.E. Eng Cheasan

Delegate of the Royal Government of Cambodia
Director General of the Fisheries Administration

LIST OF ABBREVIATIONS

| | |
|---------|---|
| ASFIS | Aquatic Sciences and Fisheries Information System |
| CAPFISH | Cambodia Programme for Sustainable and Inclusive Growth in the Fisheries Sector |
| CAS | Catch Assessment Survey |
| CFi | Community Fisheries |
| CFR | Community Fish Refuge |
| CL | Confidence Limits |
| CPUE | Catch per Unit of Effort |
| CWP | Co-ordinating Working Party |
| DPFIC | Department of Planning, Finance and International Cooperation |
| EEZ | Exclusive Economic Zone |
| EU | European Union |
| FAC | Fishery Activity Coefficient |
| FAO | Food and Agriculture Organisation |
| FAS | Fishing Activity Survey |
| FiA | Fisheries Administration |
| FiAC | Fisheries Administration Cantonment |
| FSP | First Sale Price |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| HCI | Household Catch Interview |
| MaFrEDI | Marine Fisheries Research and Development Institute |
| MCS | Monitoring Control and Surveillance |
| MF | Marine Fish (for species codes) |
| MT | Metric Ton |
| NIS | National Institute for Statistics |
| NPCI | National Plan of Control and Inspection |
| OAA | Other Aquatic Animals |
| PAP | Pre-Analysis Plan |
| PDAFF | Provincial Department of Agriculture, Forestry and Fisheries |
| QA/QC | Quality Assurance Quality Control |
| QAP | Quality Assurance Plan |
| SEAFDEC | South-East Asian Fisheries Development Centre |
| SP | Species proportion |
| USD | United States Dollar |

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1. SUMMARY OVERVIEW

- *The small-scale and middle-scale marine fisheries will be monitored using a sample-based landing site survey for catch and effort or Catch Assessment Survey (CAS), including a recall question for vessel activity or Fishing Activity Survey (FAS) for the previous week;*
- *The survey will initially focus on fishing vessels smaller than 18 meters*
- *The main requirements for indicators to be included are catch by species, individual size and catch location, additional data collected are indicators for effort (which allows to calculate catch per unit of effort), which may ultimately be collected for individual gear and/or vessel-gear combinations;*
- *Data collection is conducted by FiA/MaFReDI staff supported by FiAC staff, while Quality Assurance and Quality Control (QA/QC) and field supervision is done by a separate MaFReDI team;*
- *The survey will target 2 representative landing sites (or groups of smaller landing sites) in each province, based on information provided by FiAC in a pre-assessment questionnaire on the main landing sites present for small- and middle-scale vessels in each province;*
- *Each landing site will be visited on 4 consecutive, days each month during which at least 7 landings will be randomly selected, each day for recording of catch and effort (CAS and FAS) by each FiA/MaFReDI survey team;*
- *The survey will target to record the catch and effort for at least 224 landings/month for all four provinces combined, with around 56 vessels covered in each province/month;*
- *Data is collected each month according to a sampling schedule decided by FIA/MaFReDI;*
- *Monthly reports with estimates of the main indicators included are produced for publication on the FIA web-site, status reports, with information on survey implementation are produced at 3-monthly intervals, with the frequency reviewed after a full year of data collection;*
- *Small- and middle-scale vessels will initially not be sampled separately from middle-scale vessels, nor will sampling target specific gears operated, until activity and landing patterns, as well as catch characteristics and variation in landed weight have been established for vessel-gear categories during the first 12 months of the survey. Based on this data the sampling design will be adjusted;*
- *Vessel size, details of gears operated and effort, will be recorded for each random selected landing, alongside catch data by species based on direct measurement of landed weight (whenever possible), without interfering with normal trade practices;*
- *Estimates for total species catch (at national and provincial levels) will be based on the average recorded species catch, extrapolated for the total number of registered vessels and the vessel activity data. Estimates for variation and relative error will be calculated to indicate the precision and statistical precision¹ of the catch estimates; and,*
- *Based on the collected data and observations in the field, the sample size, field protocol and survey implementation will be evaluated within 3 months of the start of the survey and adjusted by MaFReDI in close consultation with FAO.*

¹ The chance that the estimate is within a certain range from the true value, assuming an unbiased random sample

2. INTRODUCTION

This manual was developed based on discussions between MaFReDI and FAO CAPFISH-Capture, following the preparation of the Cambodia Marine Fisheries Catch Assessment Guidelines (Visser, 2020). It covers the agreed method for the Catch Assessment Survey (CAS) for the marine fisheries in Cambodia.

Cambodia's Fisheries have a large pelagic component. According to a review by Gillet (2004) based on Try (2003), of the 33 species of commonly exploited finfish, the five most abundant species in landings are *Megalaspis cordyla* (Torpedo scad), *Scomberomorus commerson* (Narrowbarred Spanish mackerel), *Rastrelliger brachysoma* (Short mackerel), *Rastrelliger kanagurta* (Indian mackerel) and *Atule mate* (Yellowtail scad). Shrimp fishing is significant in Cambodia not only for domestic consumption, but also as a valuable export product. While blue swimming crab, squid and octopus also are an important component of the commercial landings.

The FiA classifies the scale of the fisheries mainly by the length of the vessel (Table 1), while the results of the vessel census also added consideration for the gear employed, all trawlers, regardless of size are regarded as middle-scale and are required to be licensed with submission of mandatory catch logbooks. According to the preliminary results of the 2018 vessel census, there are around 1100 vessels smaller than 12 meters in length operating trawls.

The small number of large-scale commercial vessels mainly using anchovies seine nets will be covered by mandatory logbooks and vessel and port-side inspections of landings and will not be covered by the catch monitoring survey. Current planning for implementing mandatory logbooks for middle-scale vessels > 18 meters, expects full coverage before the end of 2020. The NPCI, sets a target for a 40% coverage for middle-scale vessels 12-18 meters for 2021, with a 100% coverage expected for 2023.

Table 1. Number of small- and middle-scale marine fishing vessels by province, in absolute numbers and proportion of total

| | Classification | Koh Kong | Preah Sihanouk | Kampot | Kep | Total |
|---------------------|----------------|----------|----------------|--------|-------|-------------|
| Small-scale | < 12 m | 2613 | 1593 | 722 | 290 | 5218 |
| | | 50.1% | 30.1% | 13.4% | 5.6% | |
| Middle-scale | 12-24 m | 773 | 930 | 317 | 304 | 2324 |
| | | 33.3% | 40.0% | 13.6% | 13.1% | |

Based on summary produced by FiA, 17 December 2019

There is some uncertainty about the schedule and progress with licensing and enforcing mandatory catch logbooks, therefore this was not taken into account in the decision on coverage for various length classes in the CAS. Marine fisheries will be covered by direct measurement of catch and effort at landing sites for small- and middle-scale fisheries.

For clarity a glossary has been included in Annex 7 for some of the main fishery related terms of interest for catch monitoring. This is based on both FAO and SEAFDEC definitions, as well as other sources.

Regardless of the availability of mandatory catch logbooks, it is expected that both small-scale and middle-scale marine fisheries need to be monitored long-term, as it is not known when mandatory logbooks will be fully implemented (nor how reliable they will be). In case only partial coverage of

middle-scale vessels >18 meter is reached, catches from these vessels², can be estimated based on random samples of logbooks that are submitted³. After the initial 3 months of data collection, expansion of the survey to also include larger vessels, will be considered.

The main target for the catch monitoring is to produce accurate estimates of the total catch by species, at least at national level, an indicator of the average fish size and whenever practical, the catch location. A measure for the effort and catch per unit of effort (CPUE) will also be produced, as detailed as the data collection allows, but this is not required under the targets set by EU.

3. CATCH MONITORING METHODOLOGY

The proposed catch monitoring methodology is adjusted from the standard FAO survey approach (Stamatopoulos, 2002) which recommends 3 independent surveys for:

Active fishing days, this is carried out at the end of each month, after all other sampling is completed, to provide the number of fishing days, for each stratum⁴ and vessel-gear combination covered by the catch monitoring survey. This only verifies if there were any non-fishing days due to (religious) holidays, weather events for extrapolation of the sample data to totals by province.

Fishing Activity Survey (FAS), is always done at homeports and needs to be sampled separately for each vessel-gear category. This survey counts the proportion of boats that went out fishing on a number of random selected days in the month, taking a sample from all vessels registered at these homeports, to get a proportion of active fishing vessels for each vessel-gear combination covered by the catch monitoring survey.

Catch Assessment Survey (CAS), is always done at landing survey, targets direct measurement⁵ of fish catch at landing sites, by survey teams, who measure and weigh all or a sub-sample of individual landings by a random selection of vessels. It is always conducted at landing sites and thus can cover landings from vessels from multiple homeports. Landings are recorded by vessel-gear combination (which can be subject to change for individual vessels by season). Aims to estimate the catch and CPUE as the average total daily catch for each vessel-gear combination covered by the catch monitoring survey.

The main change to this standard approach is that instead of implementing an independent survey for the fishing activities (FAS), this is now incorporated into the CAS, as a question to all fishers sampled for the CAS for the number of fishing days in the previous week. This also removes the need for a survey to establish the overall active fishing days. This is referred to as a horizontal sampling for vessel activity. This is a valid approach in fisheries with limited migration of vessels between home ports and landing sites and will reduce the amount of time required for conducting the survey. The second change is that the CAS is implemented for consecutive calendar days at each landing site, instead of on random selected days each month.

Detailed planning for the CAS depends on detailed frame survey data. This is a complete description of the structure of the primary fishery sector including an inventory of ports, landing places, number and type of fishing units (boats and gear), and a description of fishing and landing activity patterns, fish distribution routes, processing and marketing patterns, and supply centres for goods and services.

² Approximately 150 vessels

³ This doesn't take into consideration any inconsistencies or under-reporting often associated with mandatory logbook schemes

⁴ A stratum refers to a subgroup within a fishery that is sampled independently, e.g. small-scale fisheries and middle-scale fisheries are separate strata, provinces can also be considered strata, if they are sampled independently.

⁵ The feasibility of direct measurement of catches depend on the skill level of the field staff, the way catches are landed and the time available for data collection, the alternative is to largely depend on sales records while ensuring sufficient species detail is collected

Without information on fishing and landing activity patterns for specific vessel-gear types some simplifications are necessary. Initially, the CAS is implemented without any stratification (grouping) of vessels by size and gear classes except excluding middle- and large scale fishing vessels (>18 meter).

Based on the preliminary vessel census data the total numbers of reported main gears are indicated in Table 2. This would normally be used as the basis to establish vessel-gear categories that are sampled separately, to reduce the variation between landings and allow to reduce the total required number of samples. However, about 50% of the small- and middle-scale vessels, or approximately 3,500 vessels, report a second gear (of which 2,400 are small-scale vessels), and 3,200 vessels report a third gear (2,200 small-scale).

Table 2. Number of vessels by size class operating primary gears, as reported in the 2018 Vessel Census

| Rank | Fishing gear type | Size boat >24m | Size boat 18-24m | Size boat 12-18m | Size boat 6-12m | Size boat <6m | Total of fishing gears |
|------|-----------------------|----------------|------------------|------------------|-----------------|---------------|------------------------|
| 1 | Trawl | | 50 | 399 | 1120 | 0 | 1569 |
| 2 | Crab trap | | 4 | 224 | 455 | 490 | 1173 |
| 3 | Crab gillnet | | 1 | 204 | 705 | 139 | 1049 |
| 4 | Fish Gillnet | | 21 | 346 | 483 | 67 | 917 |
| 5 | Collapsible fish trap | | | 310 | 308 | 6 | 624 |
| 6 | Shrimp gillnets | | 1 | 258 | 290 | 5 | 554 |
| 7 | Squid tow longline | | 1 | 54 | 332 | | 387 |
| 8 | Octopus trap longline | | 4 | 201 | 61 | 5 | 271 |
| 9 | Push net | | 2 | 26 | 170 | 9 | 207 |
| 10 | Blood cockle dragnet | | | 33 | 68 | | 101 |
| 11 | Fish trap | | 3 | 41 | 37 | 7 | 88 |
| 12 | Anchovy seine net | 10 | 24 | 14 | | | 38 |
| 13 | Capture by hand | | | | 30 | 70 | 100 |
| 14 | Fish hook | | | | 38 | 37 | 75 |

There is currently insufficient information on gear use, with some vessels using more than one gear during the same fishing trip (concurrent gear use) and some vessels that change the main gear (or gear combinations) seasonally (seasonal or sequential gear use). To allow adjusting the sampling design and introduce sampling by separate vessel-gear types, fishing and landing activity patterns for specific vessel-gear types will be recorded for all random selected landings. After a full year of data is collected, the available information, together with the upcoming landing site survey will allow MaFReDI to formulate adjustments to the sampling design.

3.1. Catch Assessment Survey Data Coverage

The main focus of the CAS is on:

- **Species catch** (quantity and species composition) of the catch (kg) landed, this includes both **fish** and **OAA** (Other Aquatic Organisms) which will be covered by main species and species group, where relevant as target species or bycatch;
- **Species size** which is assessed by recording the weight of the number of individuals in a sub-sample, allowing to calculate average species weight (no length-weight measurements are recorded)

- **Fishing location**, is considered based on rough localisation using a grid of the coastal area (EEZ), as included in Annex 4, and indicating if fishing was done inshore (< 20-meter depth) or offshore (> 20-meter depth);
- **Fishing activities** as replacement for implementation of an independent parallel FAS, fishers selected for the CAS will be asked for the number of fishing days for the previous 7 days.

Additional indicators that will be collected alongside the primary data are:

- **Gear use**, gear type, sizes and units are recorded, where these are readily available, depending on the level of trust between the survey team and the fishers;
- **Effort**, expressed, whenever possible by gear specific fishing duration. This is recorded depending on the available data, e.g. trawling duration or number of traps/nets/hooks set (including soaking time), and level of detail readily available from interviewing fishers and captains, see Annex 6 for the main considerations related to effort measurements. The combination of catch and effort allows calculating the catch per Unit of Effort (CPUE), which may be expressed by standard sized gear used for the main fishing gears utilised (or by number of vessels, fishing trips and fishing days, depending on the frequency of concurrent gear use); and,
- **Disposal of catch**, is based on sales information, self-consumption may be more relevant for small-scale fishing and will initially be included. The proportion of the catch that is discarded or used as bait, is initially only included as an optional item, this may become part of a scientific study.

A draft recording format for landing site survey is included in Annex 2. This will be tested during the field training and finalised before the start of the CAS in December 2020. The sub-sampling form for species contribution is included in Annex 1.

3.2. Sampling Design

The main challenge for on-shore catch monitoring based on a sample survey is the need to rely on commercial landings. Representative sampling of the catch is difficult with the use of a wide variety of gears, vessel sizes and fishing grounds, with a high variation of catches between vessels and locations. In addition, a proportion of the catch may be discarded. Sampling therefore has to consider the sample size that is possible under the budget and staffing limitations, but also the level of stratification (grouping of similar vessels/gears) and selection of landing sites. In addition, landing and fish trading practices will make sampling challenging, landings can be split between different markets/traders, and in some cases, landings are traded at sea (transshipment) or are offloaded directly from a fishing vessel to a truck, often mixing landings of different vessels. Data collection in the field will be a challenge.

In the following the main considerations for stratification by vessel and gear type, selection of landing sites, sample size and field protocol will be discussed in detail. This is based on the main requirement for indicators and the level at which estimates for species catch need to be available.

3.2.1. Stratification by gear use

CAS for fisheries normally aims for monitoring the fisheries for the main observed vessel-gear combinations. However, separating vessels by main gear operated may be difficult, besides sampling cost considerations, many fishing vessels use more than one type of fishing gear (alternated, based on season) or may use more than one gear concurrently. The available data suggests that most middle-scale vessels only (or mainly) use a single fishing gear, i.e. the census (registration) is for a vessel and single gear. However, multiple gears are reported for more than 30% (1100), middle-scale vessels and in view of uncertainty about concurrent and alternate gear use, **it is decided not to stratify the sampling by vessel-gear types**, until more information on gear use becomes available from the reported gear use in the CAS.

A final decision on stratification by gear and sample size will be made after a full year of data is collected, to account for seasonal differences in gear use and catches. It makes sense to evaluate adjustments to the sampling design after the first 3 months, for issues with implementation. The main gear types used for recording catches follow the gear types as included in Table 2. When sampling landings, the fishing gears used will be recorded with the number of units and relevant size details (width/depth and mesh width for gill nets, number of lines/hooks), for analysis afterwards. However, catches cannot be separated by gear if more than one gear is used concurrently, unless there is limited overlap in target species between gear combinations.

Even without sampling of landings by vessel-gear type, catch and effort estimates can be made by vessel-gear types. The validity of these estimates depends on the observed variation and the total number of landings observed. Calculating the relative error and confidence limits are an indication of the precision of the estimates and give a range with a selected confidence level. This will be used to propose adjustments to the sampling design. If the observed data indicates that stratification for some gear types makes sense, e.g. for reducing the sample size or increasing the precision/accuracy, this will be considered after a full year of data is collected.

The CAS will initially sample small- and middle-scale vessels as a single group, despite expected differences in gear use, operations and fishing grounds, to establish fishing activity and landing patterns. When fishing and landing patterns are known this will allow identifying seasonal patterns in the fisheries and provide sufficient data on variations in species catch and yield between different vessel-gear types to re-design the survey approach. In the case of predictable changes in seasonal or sequential changes in gear use, this will be incorporated in the sampling design.

3.2.2. Selection of landing sites

At this moment, almost no information is available for landing sites, not even the exact locations are known. There is no available information on the daily trade volume, number of landings/day, types of vessels landing, periodicity of landings over the month, number of traders, presence of facilities, trading practices and seasonal migration between home ports and landing sites.

Table 3. Reported number of home ports by province by number of vessels registered and total number of vessels reported by province (from 2018 vessel census)

| Vessel number | 15-49 | 50-99 | >100 | Total ports | Vessels |
|----------------|-----------|-----------|-----------|-------------|-------------|
| Kampot | 9 | 4 | 3 | 16 | 1040 |
| Koh Kong | 12 | 14 | 9 | 35 | 3387 |
| Preah Sihanouk | 11 | 7 | 3 | 21 | 2477 |
| Kep | 3 | 0 | 3 | 6 | 594 |
| Total | 35 | 25 | 18 | 78 | 7498 |

The 2018 vessel census contains the interview location, assumed to be the home port⁶. Home ports often are landing sites or landing sites often are located close to home ports. The importance of landing sites is not just based on the number of vessels that normally land at a site. Although the 2018 vessel census also includes the names of main landing sites, these cannot be linked to actual geographic locations. Based on the currently available data, over 130 home ports have been reported, with 78 home ports reporting 15 or more vessels (Table 3).

Selected landing sites need to represent all vessel types and gear types involved in the fisheries, and with limited resources, sampling should focus on sites with larger numbers of fishers/vessels, as these

⁶ This is not true for all vessels, but more likely to be true for vessels < 18 meters as these are mainly owned by their operators (fishers)

are expected to have landings with a wider range of vessel-gear types. However, large landing sites may not be representative for the fisheries in general and groupings of smaller landing sites can be selected (or changing the landing sites covered, on a monthly basis).

A landing site inventory is currently planned for 2021 (see Section 4.3), which will be used to revise the landing site coverage. Without comprehensive information on landing sites, they will be selected based on:

- The locations cited in the 2018 fishing vessel census, which were inferred from fisher interviews;
- The results of returns for a pre-assessment questionnaire, filled out by each FiAC on identifying the main landing sites; and
- On-site assessments/observations by FiA/MaFReDI staff.

For each province, 2 landing sites (or a grouping of smaller landing sites) will be selected based on this information and this manual will be updated when that decision is made.

3.2.3. Sampling strategy

The catch monitoring surveys will use random sampling at landing sites to select landings on a limited number of sampling days. Sampling of landings at each landing site is limited to 4 consecutive days, each month, due to budgetary and staff limitations it is not possible to select random non-consecutive days. The sampling schedule for each month will be decided by FIA/MaFReDI in advance to indicate for which calendar days each landing site needs to be visited.

In the absence of fisheries catch and effort data for the main indicators, the optimal sample size cannot be established in advance. Therefore, the starting point for the landing site surveys are 'safe' sample sizes, from tables developed by FAO, that will be adjusted based on observed variability in data collected, by calculating the relative error⁷. The main consideration is the precision, a higher precision requires a much higher number of samples, which increases the cost (staff time and budget).

Without stratification by vessel-gear types, a higher variation is expected between individual landings. Therefore, the target is for safe sampling sizes at 95% accuracy, that need 128 landings/month. Small-scale and middle-scale fisheries are initially not sampled separately, this will add more variation and will reduce the accuracy of estimates.

Instead of considering statistical accuracy, often the sampling effort is based on the existing staff of FiA/MaFReDI and budget limitations, supported by FiAC staff for a maximum of 4 sampling days in each province⁸. Since no catch monitoring using the proposed method has ever been done in Cambodia, it is very difficult to know how many landings can be covered by each field team under actual field conditions. The initial target is to record the catch and effort for (at least) 14 random selected landings (vessels)/day for a total of 56 landings/month/province and 224 landings/month for all four coastal provinces combined.

The initial target assumes that landings are only recorded during 4-hour periods (early morning, 5:00-9:00 AM) and that the sample size is equal between provinces⁹. Changes to this target will be made based on field observations and the combined workload once the recall survey for small-scale traditional marine fisheries (the Household Catch Interview, or HCI survey) starts early 2021. It is expected that there is enough flexibility, once field staff get more familiar with the CAS, to increase the sampling effort in case independent sampling for vessel-gear categories would be implemented¹⁰.

⁷ The precision of any estimate is calculated with the relative error (ϵ)

⁸ staff availability has not yet been discussed and agreed with FiAC and covering 4 landing days will take 8 working days

⁹ This may need to be adjusted based on observed landing patterns, as some small-scale fisheries may land later in the day, depending on the season and the gear used

¹⁰ Vessel-gear categories would initially be sampled with a 90% accuracy with 32 landings/month each

Since each province will collect data from 2 landing sites and to limit the total number days in the field, the FiA/MaFReDI field teams will, after an initial pilot period, target two landing sites on the same day. Each landing site will be visited and sampled with logistical support of FiAC staff. In order to avoid a difference in the proportion of landings recorded by landing site, it is recommended to select one large landing site (>100 average landings/day) and combine two smaller sampling sites that are located close together, with a combined number of a similar number of average landings/day.

Further re-distribution of sampling may be considered depending on fishing patterns over the month. For example, if a peak fishing period is present, based on the lunar cycle, this would lead to a further stratification of the sampling effort, with peak and low catch periods sampled separately to ensure the highest accuracy. In addition, sampling effort may later be (re)distributed selectively towards vessel-gear categories with higher variation in the catches.

Sampling 224 landings/month, is expected to be sufficient to produce accurate estimates at national level and possibly also for provincial level estimates. However, the precision of all estimates will be assessed based on the data collected. The sample size that FiA can afford, needs to be sufficient to meet the survey objectives. Of special importance is the level of change that can be detected. This can be indicated by calculating the sample error or by evaluating the confidence levels (see section 4 on estimating indicators). Appropriate statistical approaches will be agreed between FAO and MaFReDI for evaluating the starting sample sizes, with relevant modules in R¹¹ or other statistical software. This will be done at monthly intervals, with status reports produced at 3-monthly intervals, until after a full year of data collection a new sampling design is developed.

3.3. Survey Implementation

Data collection will be done by primarily by FiA/MaFReDI staff, with support from FiAC staff, with training and field supervision conducted by FiA/MaFReDI, based on the methodology included in the current manual.

3.3.1. Landing site protocol

Practical methods for random selection of landings and detailed technique for recording catch and effort depend on how catches are landed and the time available for each landing. Approaches for mobilisation of field staff, characteristics of landings and landing sites, as well as field protocols will be discussed and developed together with provincial authorities during consultations involving central level staff from FiA/MaFReDI and representatives for PD AFF and FiAC.

Each field team should have the following equipment and materials:

- ID card identifying the field staff as working for MaFReDI
- Photo flipchart with laminated pages
- Survey forms for main form and sub-sampling form
- Laminated gear, species and product lists
- Laminated map with the Marine Fishing Areas of Cambodia (Annex 4)
- Sampling baskets
- Scales (preferably electronic)
- Plastic sheet for sorting fish
- Blank paper and markers
- Waterproof ballpoints with blue ink
- Digital camera with GPS (or smart phone)

¹¹ R is a programming language and free software environment for statistical computing and graphics supported by the R Foundation for Statistical Computing, see: <https://www.r-project.org/>

- Plastic gloves
- Cleaning spray and paper towels/tissue
- Pre-printed (laminated) labels for landing site name, survey date and rank numbers for species entries on the sub-sampling form (for taking photo of sorted species)

Selection of landings (vessels/fishers) for the CAS needs to be done random. Without first-hand experience with how landings are processed and trade is conducted, it is very difficult to develop a method that fits all possible ways that fish is transported from vessels to traders. Therefore, this section will outline the general approach, with the actual field implementation gradually adjusted to the realities at landing sites.

Before conducting the CAS, the average number of landings/day is needed and how landings are spread over the day. It is likely that vessels arrive at the landing site within a short period, starting from early morning from approximately 5:00-9:00 AM, depending on the location and will show a clear peak with most of the vessels arriving close together. The method for implementing the CAS also depends on where the landing site is located, at a beach, a pier or in a port and how fishers sell their catch to traders.

Random sampling in practice means that vessels arriving at a landing site are selected based on when they arrive at the landing site, because of the uncertainty on how landings are distributed over the sampling period, there are a number of options for selecting the first and subsequent landings to be sampled based on:

Option 1. a table with random numbers

Option 2. a random number generated with a phone app; or

Option 3. the sum of one or two dice throws.

If the random selected fisher refuses to co-operate, then the next vessel after that is selected, without need for another random selection.

The range for the random numbers depends on the total expected number of landings at a landing site. That information is available from FiAC or will be based on observations by the FIA/MaFRoDI team during data collection, or interviews with fishers. For example, if on average 60 landings are expected on a day, then the interval for random numbers should be selected between 1 and 6, if at a site 300 landings are expected, then the interval needs to be between 20 and 25. If the distribution of vessels landing at a landing site is known this can be used to adjust the sampling schedule, with a shorter interval during quiet periods and a longer interval during the peak period.

This will not always be practical, depending on how vessels arriving at a landing site are clustered together and how trade is conducted. The sampling protocol needs to be developed based on field experience. It is possible that at a landing site with 60 landings per day, most landings will arrive within a short period, making it impossible to collect data for (at least) 7 vessels (especially when only a single field team is assigned to a landing site). Therefore, there needs to be some flexibility in the random sequence (the interval with which the next landing is selected), by generating the sequence on-site, after a landing is recorded.

With this method of relying on random numbers to select the vessel to be covered by the CAS, field level decisions on which landing to record are not left to field staff. This will avoid the tendency with field staff, to sample the boats with the easy landings, e.g. lower catches or only those with pre-sorted catch or depend exclusively on fish traders' records. The randomness of selection of subsequent landings is needed to avoid sample bias. Field supervision is very important to make sure that sampling bias is avoided as much as possible, by making sure that sampling is done random and accepting the

outcome of the random selection, without field staff selecting only 'easy' landings or vessels during quiet periods.

Flexibility also means that if not all required daily target landings can be obtained, this needs to be compensated during the next sampling day.

Recording landings needs to disturb trade as little as possible and should be done as fast as possible. Unless there is a legal obligation for allowing inspections of landings, data collection is based on voluntary collaboration. Either way, FiAC staff need to:

- 1) identify themselves as fisheries officials (ID card), preferably as coming from MaFReDI, to emphasise the scientific (research) nature of the survey;
- 2) introduce the reason for their presence (catch monitoring for research purposes); and
- 3) explain what data will be collected and the data collection method.

Even with a legal obligation to co-operate, fishers and captains are probably unfamiliar with catch monitoring. After selecting the landing sites to be covered, an announcement should be posted to explain the objectives of catch monitoring and discussed with local authorities, landing site management and representatives of fishers. This will increase understanding and co-operation with data collection.

It is essential that FiA/MaFReDI and FiAC staff involved in catch monitoring are not involved in inspections or patrol teams, to avoid any misunderstanding that recording of catches and gears used somehow may lead to taxation or fines. Catch monitoring should not be confused with inspections and the scientific purpose of the survey needs to be made clear before recording the catches and interviewing the fisher on effort. However, if a fisher is unwilling to allow data collection, this needs to be respected and the survey will move to the next replacement landing.

Catches come sorted in baskets (or other standard containers) for the main commercial categories with similar volume between baskets. It is likely that lower value fish (juveniles, by-catch and small species) are not separated, or that none of the catch, except for high value species, is separated at the level that is required for the catch monitoring survey. This means that species will normally be landed mixed. It will be impossible to weigh all catch by species. Assuming that fish is landed in standard containers, these then need to be sub-sampled for species composition and weight, to estimate the total weight and contribution for each species:

- weight by basket (for extrapolation of the sub-sample to the whole catch)
- weight by species (or species group) to estimating the total catch by species; and
- number of fish by species (for the average weight by individual)
- Total number of baskets/containers by category that is sub-sampled

If the catch is landed sorted in multiple categories, e.g. shrimp, bycatch large fish and mixed small species, all three categories need to be sub-sampled separately.

The total landed weight will be copied from sales records as a check for the total extrapolated weight from the sub-sample. If parts of the landing are sold to different traders, this needs to be recorded, with the catch amount and value recorded from each trader. This can be added to the same form, if the traders are present at the landing, otherwise the total catch sold to other traders elsewhere is recorded in section 7_3 of the survey form in Annex 2.

If less than 10 containers for the same commercial category or mixed species is landed, then record the weight for individual containers (copy scale readings or notes from trader), fill in the total weight and value on the form and separate the content of 1 random selected container by species (based on

appearance) and weigh each pile of fish separately. This is recorded on a separate species sub-sampling form, which is similar to the data collection form for landings (Annex 1). If more than 10 containers with mixed species is landed, then separate the content of 2 random selected containers by species for the sub-sample.

The contribution of each species in the sub-sample is applied as a proportion to the total weight of the landed weight for each economical category that is sub-sampled separately.

The species are quickly sorted by appearance, and if the Khmer name is known (from observation or from fisher), this is written down on the species sub-sampling form. Each species pile is weighed and the number of fish in each pile recorded.

For processed catch, that can still be assigned to species, the type of process used is indicated in the product column (Table 4), if it is mixed species that cannot be separated, record by processed product, so that the CPUE can be calculated. The processed product category is important for calculating the fresh weight, using conversion factors, these can differ by species and even season (because of fat content).

Table 4. Tentative codes and categories for processed marine organisms

| Product Code | Description English | Notes |
|--------------|------------------------------------|--------------------------|
| 01 | Fresh whole | |
| 02 | Fresh gutted head on | |
| 03 | Fresh gutted w/o head | |
| 04 | Fresh gutted skin off | Squid |
| 05 | Fresh gutted w/o tentacles | Squid |
| 06 | Fresh peeled | Shrimps and prawns |
| 11 | Fillets fish raw | |
| 12 | Fillets fish skin off | |
| 21 | Dried fish fillets | |
| 22 | Dried whole | |
| 23 | Dried gutted | |
| 24 | Dried meat | Crustaceans and molluscs |
| 31 | Salted fish whole | |
| 32 | Salted fish gutted | |
| 41 | Smoked fish whole | |
| 51 | Chilled or frozen whole | |
| 52 | Chilled or frozen gutted | |
| 53 | Chilled or frozen meat | Crustaceans and molluscs |
| 54 | Chilled or frozen tails (shell on) | Shrimps and prawns |
| 55 | Chilled or frozen tails (peeled) | Shrimps and prawns |

If possible, to verify identification and checking of species (group or family) names, the sorted sub-sample is photographed against a neutral background, with labels for species names (where available) or the rank number (1, 2, etc...), as they have been recorded on the species sub-sampling form. Include a pre-written note with date, time, landing site and add the vessel number (registration or census number). Add a standard 30 cm ruler for scale. Take multiple photos, numbered sequentially if necessary. Make sure to enable GPS co-ordinates in camera (app).

This means that some pre-printed labels for landing site name, date and rank order from the sub-sample species list (preferably re-usable, e.g. plastic written with permanent markers) should be prepared.

It is likely that there will not be a lot of time to process each landing and if necessary, with permission from the fish trader, the sub sampling sometimes can be done immediately afterwards the fish trade is concluded. Make sure to ask for permission and explain the sub-sampling process to the trader, so he/she can set aside the sub-sample for processing by the data collector, before mixing it with the catch from other landings. Another option is to sub-sample the sub-sample, i.e. instead of sorting the entire catch, only every third fish is sorted by species or species group. This still will provide a reliable estimate for the species proportion and the average weight by species.

Traders can be mobile, moving between vessels or stationery or employ porters that rapidly move fish from vessels to a weighing station or landing processing location. Data collection should be flexible and adjust to what is possible at any given landing site.

Species identification is important, but there may not be sufficient time for this with large landings, which then need to depend on information by fishers, vessel owners or traders. In addition, FiA/MaFReDI and FiAC staff may not be familiar with all species, if inexperienced, leading to potential mis-identification. Depending solely on local Khmer names provided by the fisher/trader and bystanders is a good starting point, as it is likely fishers and bystanders will initially be better at recognising species than most of the field staff. If experience shows that the Khmer names are non-standard or refer to different species with the same name, the photos of the sorted fish from the sub-sample may be used to assign the correct species names.

Another approach, especially for bycatch of shrimp fisheries (if bycatch is landed at all) which consists of mixed species, is to record this simply as shrimp bycatch (small mixed fish). This is assumed to be similar in species composition, although there is likely some seasonal variation. Then for a few random landings each month a sub-sample is done to get an estimate for the species proportion and average size (number of fish/total weight). The need for species sub-sampling and the exact methodology, will be decided based on the field experience during data collection. For some groups consisting of straddling fish stocks the species proportion may vary seasonally, which means this needs to be implemented on a regular basis, by highly trained FiA/MaFReDI staff, independent from the catch monitoring survey.

Initially data collection will be done using paper forms, but electronic data collection will be implemented as soon as possible, to reduce delay from additional data entry and error checking steps. The draft forms for the species sub-sample form and CAS, are included as Annex 1 and Annex 2 respectively.

The sampling days for landing sites are decided centrally by FiA/MaFReDI and sent to FiAC at least a week before the start of the month. This allows FiA/MaFReDI to plan their field inspections.

Periodicity of landings, the distribution of landings over a 24-hour period needs to be known before finalising the field sampling protocol. Since this information is currently not available, this was included in a rapid appraisal using a questionnaire sent out to FiAC (Annex 5), the results of which will be used for the planning discussion during the training. Besides conducting the CAS, field staff will observe landing patterns at the target landing sites, which will be used to optimise the selection procedures after the first month of data collection.

If landings are expected 24 hours a day, then landings should also be sampled 24 hours a day, to avoid sampling bias. This is best done by dividing a 24-hour period in 3 periods:

| | |
|----------|---|
| Period 1 | 10:00-16:00 on day 1 direct measurement |
| Period 2 | 04:00-10:00 on day 2 direct measurement |
| Period 3 | 16:00-04:00 on day 2 recall survey |

To reduce staff travel, FiAC staff need to be present for period 1 and period 2 on subsequent days: period 1 on sample day 1 and period 2 on the following day, with an overnight stay to ensure staff can be at the landing site on time for period 2. The data obtained for period 1 and period 2, is expected to cover almost all landings. In case information from the landing sites, indicate night time landings occur for certain gears that are not represented in data for period 1 and period 2, period 3 needs to be covered by enquiry (interviews of fishers, traders and/or harbour master on both number of landings, species catch and value) on following day morning.

It is likely that night time landings only occur for large-scale vessels. Therefore, it is expected that most landings will fall in period 2, unless information from local authorities and fishers indicate otherwise.

3.3.2. Training and supervision

A training event/workshop will be organised for FiA/MaFReDI staff shortly before the start of data collection, this will also include FiAC staff. This will consist of a day introduction to the survey form, photo flip chart (species field guide) and sub-sampling techniques (weighing and identifying fish), which is followed by a discussion on random sampling approaches. A field test of the data collection is conducted in one landing site. The training will be used to rationalise the field protocol to adjust to local practices at landing sites.

Training material is already prepared based on the current manual by MaFReDI with support from FAO CAPFISH.

Data collection at landing sites is expected to be done by individual FiA/MaFReDI staff, due to staff number restrictions, which makes it important that field supervision and regular feedback to field staff is implemented, by a separate team of FiA/MaFReDI staff. Based on the agreed sampling schedule, a field inspection schedule is developed for surprise field visits to observe field activities to ensure that the data is recorded on the assigned sample days, that the methodology for assessing species catch is implemented correctly (including correct use of sub-sampling), that there are no mistakes made in recording the data and identify and limit any selection bias.

Monthly meetings will be conducted after all data is collected to discuss solutions to various issues, necessary adjustments to the methodology, adjust the field manual and assess performance of all field staff. A designated FiA/MaFReDI resource person will be assigned to be on-call at all times to answer queries and resolve issues with data collection.

4. ESTIMATING INDICATORS

This section includes the methods for estimating the various indicators and total catch and effort that need to be included in the automatically generated monthly reports in the database.

Besides a national estimate, the species catch is needed for each coastal province separately. The proposed sampling design allows estimating the species catch (and total catch):

- 1) At national level, combining all data collected and distributing the estimated total species catch, based on proportion of vessel registered in each province.
- 2) At province level, directly based on the data collected in each province

The precision will be calculated for both methods, allowing evaluation of the estimates.

The main fishery indicators that need to be estimated are total monthly catch (and total monthly species catch), fishing effort (gear effort) and CPUE. Due to the relative complex nature of the sampling design, this requires explaining in some detail.

Averages are expressed as the mean, but for skewed distributions (as is the case for most fisheries related data), may be better represented by the median. It is best if both are calculated, adding the standard deviation for the mean (and 25% and 75% quantiles for medians) and indicating the confidence interval.

With fisheries data collection, we often deal with small sample sizes that are not completely normally distributed, under those circumstances, confidence limits are calculated by making use of the t-distribution.

$$\text{Confidence limits} = \pm t(\alpha, n-1) * \frac{s}{\sqrt{n}}$$

Where:

s = standard deviation of the sample;

t_{n-1} = is the upper critical value of the t-distribution with n – 1 degrees of freedom (1.96 at 95% accuracy for sample size larger than 100);

α = 1-confidence level, at 95% confidence $\alpha = 0.05$

n = number of samples taken;

$\frac{s}{\sqrt{n}}$ is also called the standard error of the mean (sem) and we could write:

$$\text{Confidence limits} = \pm t(\alpha, n-1) * sem$$

The 95 percent upper and lower confidence limits mean that we are 95 percent sure that the true target population mean lies somewhere between the upper and lower limits, within the confidence interval¹².

Confidence limits are expressed in absolute values. Dividing the confidence limit by the sample mean gives the maximum relative error, which is expressed as a percentage of the mean.

The maximum relative error¹³ (percentage) is used to establish correct sample sizes.

$$\varepsilon = \frac{CL}{\mu} \text{ or } \frac{t(\alpha, n-1) * s}{\sqrt{n} * \mu}$$

Where:

CL = confidence limits

μ = mean

In principle, the aim is a relative error of is less than 10 percent. The value of the relative error is determined by:

- The variance in the target population; and
- The sample size.

Accuracy and precision are not the same. Accuracy is a measurement of how far the true value diverges from the estimated mean. In other words, if you have biased samples, your estimated value

¹² Actually, the confidence coefficient is the proportion of samples of a given size that may be expected to contain the true mean. That is, for a 95 percent confidence interval, if many samples are collected and the confidence interval computed, in the long run about 95 percent of these intervals would contain the true mean.

¹³ For infinite or large populations

can be very precise if you have taken enough samples. However, the estimated value can be highly inaccurate as, owing to the bias, it is far from the true population mean. The accuracy can only be assessed by comparing the estimate for an indicator with the true value, either from other existing sources or from the results of a validation survey.

4.1. Total catch

Since the data collection will not independently sample sufficient numbers for the main vessel-gear types, estimation of total catch is based on fishing days. The estimate for total catch is made both at national level for all data combined for all four provinces and for each province separately.

Total Catch = CPUE x Effort

CPUE average recorded daily catch (all species combined) from CAS

Effort total estimated fishing days = **FAC** × **F**

FAC is the Fishery Activity Coefficient indicating the proportion of vessels (or gears), active in a month or how many times a fishing unit goes fishing, it is estimated by the average number of fishing days for the previous 7 days from the CAS.

FAC average proportion for reported number of (fishing) days in a week/7 days.

F total number of vessels (from vessel census);

Species Catch = SP x Total Catch

SP observed proportion for a species (group) in total recorded catch

Total estimated value is the sum of all individual reported values extrapolated to the estimated total catch

Total Species Value = Total reported value x (total estimated weight/total reported weight)

4.2. Fish size

Mean individual size will be calculated by species for each landing sampled separately (linked to the vessel-gear size if sufficient observations are available). This is based on the (estimated) total species catch and the number of individuals in each landing by species.

$$W_i = W_t/N_t$$

W_i = individual weight

W_t = total weight

N_t = total count

This will be calculated for the main species by weight, including non-fish catch, when sufficient data is available. The variation and confidence levels will be calculated and presented in monthly scatter-box plots to show how average species size varies over time. Depending on the available data, this will be analysed by vessel-gear type and possibly for the general inshore-offshore catch location.

4.3. Catch location

Based on the reported grid location a number of analysis is done:

- Distribution of fishing days (or selected vessel-gear effort);

- Contribution of each grid quadrant to total reported catch; and
- CPUE (as weight/fishing day) by grid quadrant (for selected vessel-gear type).

In view of the likely inaccuracies and gaps in the grid location data, a parallel comparison will also be made between inshore and offshore fishing, which is expected to be less problematic to obtain from fishers.

4.4. Total effort

Even though effort and the associated CPUE are not the main focus for the CAS, data to assess the effort will be collected as it is an important tool for fisheries management. There are two options for the unit of effort:

1. **Fisher or fishing day.** This is the most appropriate measure for **small-scale fisheries**, as these often combine different gears, or gear sizes, making it impossible to assign total catch or species catch to a single gear type.
2. **Vessel-gear type.** This is used as the unit of choice for **marine fisheries**, especially in the standard catch monitoring conducted at landing sites this is the most common approach:
 - a) Frame surveys (vessel census) usually are designed to give the numbers of vessels by vessel-gear category that is subsequently used for estimating total potential fishing effort (or fishing capacity);
 - b) The level of fishing activity is frequently measured by the Fishery Activity Coefficient (FAC), this expresses the probability that a vessel type is active on a given day.
 - c) Catch Per Unit of Effort (CPUE) is often expressed as the average catch per day of a vessel of a certain vessel-gear type
 - d) Fishing without using a vessel can still be accommodated, by adding a separate category.

Total effort is estimated based on the observed average effort (by fisher or vessel-gear combination) multiplied by the total number of units (fishers or fishing vessels) in the frame (obtained from the vessel census).

4.5. Monthly reports

The database will support automatically generating reports estimating the most common fishery indicators that can be obtained from the data collected. This will include the following estimates at national level and by province for:

- Estimated **species catch** (with proportion of total catch) by species group and/or vessel-gear type and cumulative contribution to the total catch
- Estimated total value (with proportion of total catch) and cumulative contribution to the total value
- **Total estimated catch** separated by fish and OAA as pie-graph
- Reported catch by vessel-gear type:
 - Contribution of reported **catch amount** and **value** by small-scale and middle-scale (proportion) as pie graph
 - Contribution of main gear types (by small-scale and middle-scale) for **catch amount** for single gear use and for use of concurrent gear types as table and pie graph
- Monthly scatter-box plot for average individual weight, for selected species
- Catch location, fishing days by main vessel-gear types and if possible CPUE will be presented as a colour-scaled quadrant map for the fishing grid. With comparison of the distribution of the catch and effort between inshore and offshore areas included as a table.
- Estimated **total effort** by vessel-gear type separated by small-scale and middle-scale fisheries as:
 - Vessel fishing days

- Vessel-gear type in duration for standardised effort units (hours fished, 1000 hooks, number of hauls, drags or sets and/or days at fishing ground)
- Estimated **average CPUE** separated for small-scale and middle-scale fisheries by:
 - Catch per fishing day
 - Standardised effort units

All weight estimates will be made in Metric Tons (MT), while value will be reported in Riel and converted to USD. All estimates will come with standard deviation, number of observations, confidence intervals and maximum relative effort.

5. DATA ENTRY AND STANDARDISED CLASSIFICATIONS

As preparation for training, implementation and data processing, several components are needed.

5.1. Development of database and monthly reporting

Based on the CAS methodology and formats included in Annex 1 and Annex 2 and agreement on how the required indicators will be calculated in a pre-analysis plan (PAP) as included in the current manual, a database will be developed that will include:

- User-interface in Khmer and English for data entry, data management and analysis;
- Text entries available in Khmer and English;
- Lookup tables for locations (administrative units, landing sites), species, gears, fishing zones using common codes and names shared with other FiA databases;
- Population census data and links to vessel census data to support extrapolation calculations;
- Reporting tools for selecting and automatically calculating key fishery indicators (species catch, effort and CPUE) with estimates for the precision, including standard deviation, maximum relative error and confidence limits) at national and provincial levels, both in table formats and time series;
- Various access levels for general public, government level and within FiA/FiAC access levels for: read-only access, data entry and database management;
- Local, network and browser-based access, including if necessary dedicated app, integrated with other FiA databases (e.g. vessel/licensing database, mandatory logbook, CFI/CFR database, Landing site inventory); and
- Integrated user manual and help file, including bi-lingual tooltips.

The PAP with the species/gear field materials will form the basis of the training for FiAC and MaFRReDI staff.

5.2. Classifications for species and gears

An important aspect of catch monitoring is to reduce catch assigned to 'other species' to less than 30% of the total catch. Complete separation by species may not be possible, instead of relying on the expertise of the enumerators (FiA/MaFRReDI field staff), species will be recorded by Khmer name as provided by the captain/owner. Independent assessments of species occurrence and abundance may be implemented as part of the validation of the CAS data. The level of species detail possible, also depends on how vessel land their catch (sorted or not) and the daily volume, i.e. the time enumerators have to sub-sample and weigh the catch.

FishBase lists 486 confirmed marine fish species in Cambodian waters, of which 33 are listed as of commercial interest. A field guide for marine living resources of Cambodia (Ing *et al.*, 2006), includes a total of 288 species. Some species and species groups that are important for trawl fisheries or are known to be abundant in catches reported by Thailand (Sampantamit *et al.*, 2019), were considered for addition (Annex 3), including many family level species groups. In general, it is known that

mackerel, scad, anchovy, sardine, tuna and pomfret are the most economically important pelagic fish species and threadfin bream, croaker, big-eyes, lizard hair-tail fish, flat fish, snapper, barracuda, grouper, shark and conger eel being the most important demersal fish species.

Standardised classifications and codes were developed for species (and species groups). This is based on the established standard included in the currently reported fish catch statistics by DPFIC (including 45 species and species groups) and expanded by MaFRaDI, based on the current knowledge on the fishery and is included in Annex 3. This list includes 96 species and species groups and was used as the basis for a field species guide or photo flipchart that will be provided to all field staff. This includes standardised Khmer and scientific species names, as well as International codes to facilitate linking catches directly to codes used by SEAFDEC and FAO (as included in the FAO ASFIS¹⁴ database). The photo flipchart is expected to be further developed into a species field guide as an update to the existing field guide (Ing *et al.*, 2006) for field staff including easy to use identification tools.

The gear classifications (including gear codes), may need development of a gear catalogue, using available resources within Cambodia and regionally (Ruangsivakul *et al.*, 2007). The current list is mainly based on the gears that are included in the 2018 Vessel Census (FiA, 2019), this is included in Annex 8. These codes and gear types may need to be harmonised with the gears included in the DPFIC questionnaire sent to FiAC as well as with reporting commitments related to FAO and SEAFDEC. The level of gear detail that is reported needs to be harmonised between the sample-based CAS and the mandatory logbooks used for reporting of catches by middle and large-scale economical marine fisheries. This can be based on SEAFDEC or FAO gear catalogues and codes, as developed by the Coordinating Working Party on Fishery Statistics (CWP).

Species and gear lists (and field guides) need to be available as hard copy and electronic files for use inside the database and apps.

5.3. Landing site and home port census

As indicated in the NPCI, all landing sites (and home ports) need to be registered. The main reason seems to be to initiate licensing of landing sites. However, it is important that this landing site inventory also provides information that can be used for adjustment of the landing site selection for the catch monitoring. This should build on existing information collected for the 2018 vessel census, since many home ports are also landing sites. In the preparation of the current manual a questionnaire was designed and sent to FiAC (Annex 5) to assist with selecting landing sites to be covered by CAS in each province.

The full landing site inventory is currently planned for the first half of 2021.

6. TENTATIVE IMPLEMENTATION SCHEDULE

With the finalisation of the current manual, the activities needed in preparation of data-collection are listed below. The schedule for preparing the routine catch monitoring is the same for all intended surveys for traditional family fishing and for small- and middle-scale fishing.

The main issue relates to availability of staff to conduct the various catch monitoring surveys. As well as the many ongoing activities, including assisting with inspections, licensing etc... The number of FiAC field staff is extremely limited and in that light, staff availability for additional data collection activities is going to be challenging.

¹⁴ Aquatic Sciences and Fisheries Information System

October 2020:

- Preparation of detailed field manual
- Consultations with FiAC on selection of landing sites
- Workshop(s) with MaFReDI staff to discuss preparation of training

November 2020:

- Developing database and data entry interface
- Translation of manual to Khmer
- Preparation of species photo flipchart
- Training of FiA/MaFReDI staff and field pilot
- QA/QC planning
- Final sampling design (with FiAC consultation)

December 2020 onwards:

- Implementation of routine collection under supervision of MaFReDI staff
- Monthly data reports, evaluation and adjusting surveys

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Annex 1. Sub-sampling for species composition of landing

1 Landing ID

| | | | |
|--------------------------------------|--|--------------------------|---------------------|
| 1 Landing site | | 2 Village code | |
| 3 Date | | 4 Time | 5 Landing No |
| 6 Vessel Name | | 7 Registration No | |
| 8 Economical species Category | | 9 Total Weight | |

2 Species Catch

| | | | |
|------------------------|-----------------------------|--------------------------|--|
| 0 Total landing | 0 Species sub-sample | Sub-sample Weight | |
|------------------------|-----------------------------|--------------------------|--|

| Khmer species (group/family) name | Sp. Code | Weight | # of fish | Species % |
|--|-----------------|---------------|------------------|------------------|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | | | | |
| 12 | | | | |
| 13 | | | | |
| 14 | | | | |
| 15 | | | | |
| 16 | | | | |
| 17 | | | | |
| 18 | | | | |
| 19 | | | | |
| 20 | | | | |
| 21 | | | | |
| 22 | | | | |
| 23 | | | | |
| 24 | | | | |
| 25 | | | | |
| 26 | | | | |
| 27 | | | | |
| 28 | | | | |
| 29 | | | | |
| 30 | | | | |
| 31 | | | | |
| 32 | | | | |
| 33 | | | | |
| Total | | | | |

Annex 2. Marine fisheries catch assessment survey form

1 Landing Site ID

| | | | |
|----------------|--|----------------|--------------|
| 1 Landing site | | 2 Village code | |
| 3 Date | | 4 Time | 5 Landing No |

2 Vessel Fisher ID

| | | | |
|----------------|--|-------------------|--|
| 1 Vessel Name | | 2 Registration No | |
| 3 Vessel Owner | | 4 Vessel length | |
| 5 Respondent | | 6 Home port | |

3. Gear and effort (see gear code list)

| | | | |
|---------------------------------------|--|---|--|
| 1 | | 2 | |
| 3 | | 4 | |
| 5 Number of hours fished | | 6 Number of 1000 hooks used | |
| 7 Number of hauls, drags or sets made | | 8 Number of days at ground | |
| 9 Fishing location (grid position) | | 10 <input type="radio"/> Inshore <input type="radio"/> Offshore | |
| 11 Fishing trips past 7 days (FAS) | | 12 Total landed weight (kg) | |

4. Species Catch

| O Total landing | | O Species sub-sample | | Sub-sample Weight (kg) | |
|-----------------------------------|------|----------------------|-----------|------------------------|--|
| Khmer species (group/family) name | Code | Weight (Kg) | # of fish | Species % | |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |
| 15 | | | | | |
| 16 | | | | | |
| 17 | | | | | |
| 18 | | | | | |
| 19 | | | | | |
| 20 | | | | | |
| 21 | | | | | |
| Total | | | | | |

5. Economical species category weight and value

| Economical species category name | Weight | Value |
|----------------------------------|--------|-------|
| | | |
| | | |
| | | |
| | | |
| | | |
| Total Catch and Value | | |

6. Gear size and numbers

| Name | Code | Length (m) | Width (m) | Height (m) | Size | Number |
|------|------|------------|-----------|------------|------|--------|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |

7. Catch weight used for other purpose (kg)

| | | | |
|---------------------------|--|-------------------|--|
| 1 Consumption | | 2 Bait | |
| 3 Traded elsewhere | | 4 Discards | |

| | | | |
|--|------------------|--|-------------------------------------|
| Comments | | | |
| Form checked without mistakes Date / / | <i>Name</i> | | Enumerator / / |
| | <i>Signature</i> | | |

Annex 3. MaFReDI CAS species list

| No | FiA code | Khmer | English Common | Family | Scientific name | Eco zone |
|----|----------|----------------------------|-------------------------------|----------------|--------------------------------|----------|
| 1 | FM001 | ត្រីតុកកែ | Sea basses and groupers | Serranidae | | |
| 2 | FM002 | ត្រីបេកា | Spanish mackerel species nei | | <i>Scomberomorus sp.</i> | Pelagic |
| 3 | FM003 | ត្រីស្កង់ | Barramundis, sea perches | Centropomidae | | Demersal |
| 4 | FM004 | ត្រីកាវ៉ាវ | Threadfins | Polynemidae | | Pelagic |
| 5 | FM005 | ត្រីបេកាខ្មៅឬត្រីបេកាឆ្នុត | Narrowbarred Spanish mackerel | Scombridae | <i>Scomberomorus commerson</i> | Pelagic |
| 6 | FM006 | ត្រីចាប | Pomfrets | Bramidae | | Pelagic |
| 7 | FM007 | ត្រីកម្ពុជខ្លួនវែង | Indian mackerel | Scombridae | <i>Rastrelliger kanagurta</i> | Pelagic |
| 8 | FM008 | ត្រីឆ្លាម | Sharks | | | |
| 9 | FM009 | ត្រីអណ្តាតផ្លែ | Flounders and soles nei | | | Demersal |
| 10 | FM010 | ត្រីប្រម៉ា | Longtail Tuna | Scombridae | <i>Thunnus tonggol</i> | Pelagic |
| 11 | FM011 | ត្រីត្រសក់ | Terapons | Terapontidae | | |
| 12 | FM012 | ត្រីគ្រាប់ខ្នុរ | Emperors, scavengers | Lethrinidae | | |
| 13 | FM013 | ត្រីសេក | Parrot fish | Scaridae | | |
| 14 | FM014 | ត្រីដងដាវ (ស្រោមដាវ?) | Wolf herring | Chirocentridae | | |
| 15 | FM015 | ត្រីក្រហម | squirrelfish | Holocentridae | | |
| 16 | FM016 | ត្រីអង្រែ | Barracuda | Sphyraenidae | | |
| 17 | FM017 | ត្រីកាតាំង | Surgeonfish | | <i>Acanthurus sp.</i> | |

| | | | | | | |
|----|-------|---------------|------------------------|------------|----------------------------|---------|
| 18 | FM018 | ត្រីជី | trash fish | | | |
| 19 | FM019 | បង្កាខ្លីង | Giant tiger prawn | Penaeidae | <i>Penaeus monodon</i> | |
| 20 | FM020 | បបែល | Rays nei | Dasyatidae | | |
| 21 | FM021 | មីក | Squids nei | | | |
| 22 | FM022 | បង្កងកណ្តុប | Mantis shrimp | | | |
| 23 | FM023 | ក្តាមសេះ | Crenate swimming crab | Portunidae | <i>Thalamita crenata</i> | |
| 24 | FM024 | ក្តាមសេះ | Swimming crab | Portunidae | <i>Portunus pelagicus</i> | |
| 25 | FM025 | ក្តាមជ័រ | Vinegar crab | Sesarmidae | <i>Episesarma sp.</i> | |
| 26 | FM026 | ក្តាមផ្សេងៗ | Crabs nei | | | |
| 27 | FM027 | ត្រែងឈាម | Blood cockle | Arcidae | <i>Anadara granosa</i> | |
| 28 | FM028 | ងាវចំរុះ | Shellfish nei | | | |
| 29 | FM029 | តី | Small mixed shrimp nei | | | |
| 30 | FM030 | ត្រីឈាម | Tuna | Scombridae | | |
| 31 | FM031 | ត្រីអាំងកឹយ | Snappers, jobfishes | Lutjanidae | | |
| 32 | FM032 | ត្រីធ្មោង | Needlefish | Belonidae | | |
| 33 | FM033 | ត្រីកាំកូច | Trevallies | | | |
| 33 | FM034 | ត្រីក្បក | Herrings | Clupeidae | | |
| 35 | FM035 | ត្រីកន្ទុយរឹង | Torpedo scad | Carangidae | <i>Megalaspis cordyla</i> | Pelagic |
| 36 | FM036 | ត្រីកូនគុំ | Round scad | Carangidae | <i>Decapterus maruadsi</i> | |

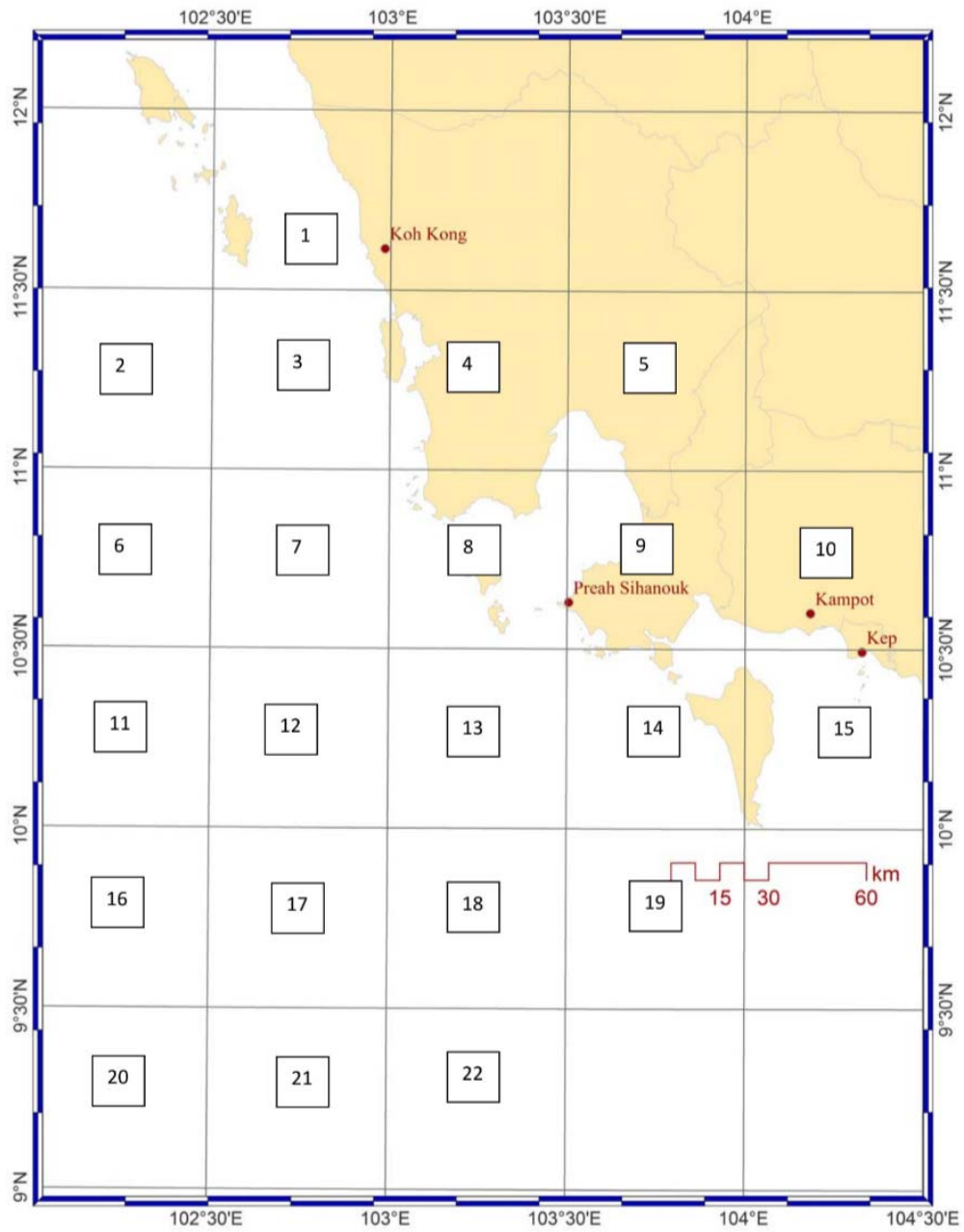
| | | | | | | |
|----|-------|---------------------------------|--------------------|---------------|--------------------------------|-----------|
| 37 | FM037 | ត្រីបោះត្រា | Russell's snapper | Lutjanidae | <i>Lutjanus russelli</i> | |
| 38 | FM038 | ត្រីក្រចកក្របី | Indian anchovy | Carangidae | <i>Stolephorus indicus</i> | Anchovies |
| 39 | FM039 | ត្រីក្តុចិន | Lizardfish | Synodontidae | | |
| 40 | FM040 | ត្រីកាដី | Grunts | Haemulidae | | |
| 41 | FM041 | ត្រីផ្ទុក់សមុទ្រ | Cobia | | <i>Rachycentron canadum</i> | |
| 42 | FM042 | អន្ទង់សមុទ្រ | Morray eel | Muraenidae | | |
| 43 | FM043 | ត្រីកូនគុំ | Yellowtail scad | Carangidae | <i>Atule mate</i> | Pelagic |
| 44 | FM044 | ត្រីប្លាធូ ឬត្រីកាម៉ុងខ្លួនខ្លី | Short mackerel | Scombridae | <i>Rastrelliger brachysoma</i> | Pelagic |
| 45 | FM045 | ត្រីកន្ទុយរឹងភ្នែកធំ | Bigeye scad | Carangidae | <i>Selar crumennophthalmus</i> | Pelagic |
| 46 | FM046 | បង្កា | Prawns nei | Penaeidae | <i>Penaeus sp.</i> | |
| 47 | FM047 | ក្តាមថ្មី | Mud crab | Portunidae | <i>Scylla serrata</i> | |
| 48 | FM048 | | Mullets | Mugilidae | | |
| 49 | FM049 | | Pony fishes | Leiognathidae | | |
| 50 | FM050 | ត្រីក្រហម ឬត្រីឆ្កួតពីរ | Breams | Memipteridae | | |
| 51 | FM051 | | Drums and croakers | Sciaenidae | | |
| 52 | FM052 | | Sicklefish | Drepaneidae | | |
| 53 | FM053 | | Cutlassfish | Trichiuridae | | |
| 54 | FM054 | | Rabbitfish | Sigandae | | |
| 55 | FM055 | | Butterfish | Stromateidae | | |

| | | | | | | |
|----|-------|-----------------|---------------------------|----------------|---------------------------------|---------|
| 56 | FM056 | | mixed coral reef fish nei | | | |
| 57 | FM057 | ត្រីកន្ទុយរឹង | Slender scad | Carangidae | <i>Decapterus russelli</i> | Pelagic |
| 58 | FM058 | | Mackerel tuna | Scombridae | <i>Euthynnus affinis</i> | |
| 59 | FM059 | | Largehead hairtail | Trichiuridae | <i>Trichiurus lepturus</i> | |
| 60 | FM060 | | Daggettooth pike conger | Muraenesocidae | <i>Muraenesox cinereus</i> | |
| 61 | FM061 | | Dorab wolf-herring | Chirocentridae | <i>Chirocentrus dorab</i> | |
| 62 | FM062 | | Indian halibut | Psettodidae | <i>Psettodes erumei</i> | |
| 63 | FM063 | | Congers | Muraenesocidae | | |
| 64 | FM064 | | Tilapia | Cichlidae | <i>Tilapia sp.</i> | |
| 65 | FM065 | ត្រីកាហាវ | Herring scad | Carangidae | <i>Alepes vari</i> | Pelagic |
| 66 | FM066 | ត្រីនៃកាម | Orangespotted trevally | Carangidae | <i>Carangoides bajad</i> | Pelagic |
| 67 | FM067 | ត្រីកាំកូច | Barcheek trevally | Carangidae | <i>Carangoides plagiotaenia</i> | Pelagic |
| 68 | FM068 | ត្រីប្លាធុ | Shortfine scad | Canrangidae | <i>Decapterus macrosoma</i> | Pelagic |
| 69 | FM069 | ត្រីឆ្មុតលឿង | Yellow stripe trevally | Canrangidae | <i>Selaroides leptolepis</i> | Pelagic |
| 70 | FM070 | ត្រីគួន | goldstripe sardine | Clupeidae | <i>Sardinella gibbosa</i> | Pelagic |
| 71 | FM071 | ត្រីរាំងកឹយ | two-spot red snapper | Lutjanidae | <i>Lutjanus bohar</i> | Pelagic |
| 72 | FM072 | ត្រីឆ្មុតក្រហម | humpback red snapper | Lutjanidae | <i>Lutjanus gibbus</i> | Pelagic |
| 73 | FM073 | ត្រីចោរខ្លួនមូល | Bludger trevally | Carangidae | <i>Carangoides gymnostethus</i> | Pelagic |

| | | | | | | |
|----|-------|-----------------------|-------------------------|-----------------|-------------------------------------|-----------|
| 74 | FM074 | ត្រីកាំកូចខ្ចីមបារាំង | Coastal trevally | | <i>Carangoides coeruleopinnatus</i> | Pelagic |
| 75 | FM075 | ត្រីបណ្តូលអំពៅ | Shorthead anchovy | Engraulidae | <i>Encrasicholina heteroloba</i> | Anchovies |
| 76 | FM076 | ត្រីស្លឹកឫស្សី | Hamilton's thryssa | Engraulidae | <i>Thryssa hamiltonii</i> | Anchovies |
| 77 | FM077 | ត្រីគួនបារាំង | Spotted sardine | Clupeidae | <i>Amblygaster sirm</i> | Anchovies |
| 78 | FM078 | ត្រីគួន | Goldstripe sardine | Clupeidae | <i>Sardinella gibbosa</i> | Anchovies |
| 79 | FM079 | ត្រីគួន | Smoothbelly sardine | Clupeidae | <i>Amblygaster leiogaster</i> | Anchovies |
| 80 | FM080 | ត្រីភ្នែកឡាន | Purple-spotted bigeye | Priacanthidae | <i>Priacanthus tayenus</i> | Demersal |
| 81 | FM081 | ត្រីអាងតឹមលី | Ornate treadfin bream | Nemipteridae | <i>Nemipterus hexodon</i> | Demersal |
| 82 | FM082 | ត្រីសំបោរហៀរ | Common ponyfish | Leiognathidae | <i>Leiognathus equulus</i> | Demersal |
| 83 | FM083 | ត្រីសំបោរហៀរអិល | Goldstripe ponyfish | Leiognathidae | <i>Karalla daura</i> | Demersal |
| 84 | FM084 | ត្រីសំបោរហៀរគ្មានអិល | Toothpony | Leiognathidae | <i>Gazza minuta</i> | Demersal |
| 85 | FM085 | ត្រីអណ្តាតឆ្មៃ | Gulf flounder | Paralichthyidae | <i>Paralichthys albigutta</i> | Demersal |
| 86 | FM086 | ក្តាមជ័រ | Violet vinegar crab | Sesarmidae | <i>Episesarma versicolor</i> | |
| 87 | FM087 | បំបែលអុជ | Whitesporttted whipray | Dasyatidae | <i>Maculabatis gerrardi</i> | |
| 88 | FM088 | បំបែលមាន់ | Scaly whipray | Dasyatidae | <i>Himantura imbricata</i> | |
| 89 | FM089 | ឆ្លាម | Spottail Shark | Carchahinidae | <i>Carcharhinus sorrah</i> | |
| 90 | FM090 | ឆ្លាមភ្នំត | Brownbanded bambooshark | Hemiscyllidae | <i>Chiloscyllium punctatum</i> | |
| 91 | FM091 | បង្កាប៉ារា | Banana shrimp | Penaeidae | <i>Penaeus merguensis</i> | |
| 92 | FM092 | | | Penaeidae | <i>Metapenaeus spp.</i> | |

| | | | | | | |
|----|-------|-----------------|-----------------|------------|-------------------------|--|
| 93 | FM093 | ក្ដាមសែ៖ | Swimming crabs | Portunidae | <i>Portunus spp.</i> | |
| 94 | FM094 | មីកស្នុក | Cuttlefish | | <i>Suborder Sepiina</i> | |
| 95 | FM095 | | Octopus | | | |
| 96 | FM300 | ប្រភេទត្រីចំរុះ | Other fish nei | | | |
| 97 | FM301 | ផ្សេងៗ | Other catch nei | | | |

Annex 4. Grid for marine fishing areas in Cambodia



Annex 5. Questionnaire for collecting information on landing sites separated for small-scale and middle-scale home ports

| No. | ផែនទីឃុំ (Landing site) | Village code | ចំនួនទូកនេសាទចូលចត (Vessel count) | Please fill information (fishing gear, what landing site to be selected) | | | | | | | | | | | | | | | | | | | |
|-----|------------------------------------|--------------|--------------------------------------|--|--------|------------------|-----------------------|-------|---------------------|-----------------|-----------|--------------|--------------|-----------------------|----------------------|----------------------|-----------|----------|-------------------------|------------------|--------------|-----------|--|
| | | | | verified LS | Select | Vessels (Number) | Trade volume (MT/day) | Trawl | Centipede fish trap | Shrimp gillnets | Crab trap | Crab gillnet | Fish gillnet | Octopus trap longline | Squid towed longline | Blood cockle dragged | Fish trap | Push net | Other Vessel-Gear types | Traders (Number) | Cold storage | Ice plant | Active period (start hour to end hour) |
| | ខេត្តកោះកុង (Koh Kong Province) | | 2617 | | | | | | | | | | | | | | | | | | | | |
| | Pre printed locations | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | |

Annex 6. Notes on fishing time and effort

In giving data on fishing time effort measures, the following desirable priorities are to be followed:

- First priority:** either “no. of hours fished” or “1000 hooks fished” should be provided; in addition, “no. of hauls, drags or sets made” should also be given.
- Second priority:** “no. of days on ground” and “no. of days absent from port.”
- Third priority:** “no. of trips made”.

1) **Number of hours or 1000 hooks fished**

- a) No. of hours fished for trawls is defined as “the total number of hours during which the trawl was on the bottom and fishing”; if countries are unable to report so precisely they should give the nearest approximation with the precise definition of the approximation used.
- b) No. of hours fished: for dory vessels¹⁵ this is defined as “the number of hours the dory fleet is absent from the mother vessel times the number of dories”.
- c) Thousands of hooks fished: this is defined as “the number of hooks used in each set times the number of sets”. This figure should be calculated to the nearest thousand hooks.
- d) For other fishing gear: the number of hours the nets, seines, traps, pots, dredges, harpoons etc. were used in the fishing operations; this is the product of the number of hours per unit times the number of units.

2) **Number of hauls, drags or sets made**

- a) The number of times the fishing gear has been hauled or dragged or set, whichever description is appropriate to the fishing gear or technique used.

3) **Number of days fished**

- a) The number of days (24-hour periods, reckoned from midnight to midnight) on which any fishing took place.
- b) For those fisheries in which searching is a substantial part of the fishing operation, days “on grounds” in which searching but not fishing took place, should be included in the days fished data.

Taking into account the inclusion of “searching time” the definition of “number of days fished” could be further refined at the national level if possible as follows: “The number of days (24-hour periods, reckoned from midnight to midnight) on which the fishing craft was on the fishing grounds, intent on catching fish (not counting the time spent steaming to or from port and between grounds) minus the number of fishing days lost through delays from weather, breakdown or other factors”.

4) **Number of days on grounds**

This is defined as the number of days (24-hour periods, reckoned from midnight to midnight) in which the craft was on the fishing ground, and includes in addition to the days fishing and searching also all the other days while the craft was on the ground.

5) **Number of days absent from port**

The number of days absent from port on any one trip should include the day the fishing craft sailed but not the day of landing.

Where it is known that fishing took place on each day of the trip the number of “days absent from port” should include not only the day of departure but also the day of arrival back in port.

Where on any trip a fishing craft visits more than one “fishing area” (as defined for statistical purposes) an appropriate fraction of the total number of days absent from port should be allocated to each

¹⁵ Fishing with a main vessel and a number of smaller support vessels

“fishing area” in proportion to the number of days spent in each, so that the total number of days absent on any trip will be the sum of the number of days allocated to all of the different “fishing areas” visited.

6) Number of trips made

Any voyage during which fishing took place in only one “fishing area” is to be counted as one trip.

When in a single trip a craft visits more than one “fishing area” an appropriate fraction of the trip should be apportioned to each “fishing area” in proportion to the number of days spent fishing in each, so that the total number of trips for the Statistical Area as a whole will be the same as the sum of trips to each “fishing area”.

Annex 7. Glossary of the relevant data collection terms

The terms and definitions in this glossary have been taken from a number of sources, ICLARM's Fishbase, MRC's Mekong Fish Database 2003 and various FAO sources, like the FAO Fisheries Atlas. Where necessary they have been adapted to fit the use and users of this manual in the Cambodian context. Where SEAFDEC definitions are available these have been used in favour over other definitions. A more complete glossary is included in Visser (2020).

- Accuracy of estimates** Indicator of the closeness of an estimated population parameter to the actual population value. Accuracy is generally not known unless crosschecking procedures are conducted from time to time using other survey approaches. It should not be confused with precision which measures the variability of the estimates and can always be computed from the samples.
- Active fishing days** Time extrapolating factor used in the estimation of total fishing effort. It is boat/gear specific and defined as the number of days in a reference period (e.g. a calendar month) during which fishing activities are "normal". Usually this variable is defined in reverse manner: by subtracting from the calendar days those days known for zero or negligible activity. Definition of active days is in itself a sample-based survey involving several sites and boat/gear types, but it is often specified at minor stratum level by means of empirical knowledge and/or information from the enumerators.
- Base port** Location from which fishing units operate, irrespective of where they are registered (homeport). The differentiation between base ports and homeports occurs when fishing units migrate from the locations indicated by the frame survey to other sites, usually on a seasonal basis.
- Bias** How far the average estimate/indicator value lies from the parameter it is estimating, i.e. the error which arises when estimating a quantity. Errors from chance will cancel each other out in the long run, those from bias will not.
- Bias in estimates** Estimated population parameters that are systematically smaller (negative bias) or higher (positive bias) than the actual population value. Biases are not traceable unless cross-checking parallel surveys are conducted from time to time. High precision is not an indication of unbiased estimates; in fact, extremely high precision (= very low variability in the samples) may well be associated with positively biased samples.
- Biomass** 1) The total weight of the living organisms concerned, whether in a system, a stock, or a fraction of a stock, e.g. plankton biomass in an area, biomass of spawners or of newly recruited fish.
2) Total weight of a resource, a stock, or a component of such stock. Examples: the biomass of all demersal fish in the Gulf of Thailand; the biomass of the mackerel stock in Cambodia coastal waters; the spawning biomass (i.e. the weight of mature females).
- Boat day** Measure of fishing effort; e.g. 10 vessels in a fishery, each fishing for 50 days, would have expended 500 boat-days of effort.
- Bycatch** Total catch of non-target animals, the harvest of marine life and seabirds during fishing operations when other fish were the target.
- Catch** or **gross catch**, includes all living biological material retained or captured by the fishing gear, including corals, jellyfish, tunicates, sponges and other non-commercial organisms, whether brought on board the vessel or not.
- Catch assessment** Used interchangeably with catch monitoring (see below). Sometimes considered to be equivalent to stock assessment.
- Catch monitoring** observing and understanding the fishery and its dynamics. It includes routine (continuous) observation and examination of the catches, landings of living marine resources and the associated fishing effort and gear use

- Commercial fishery** fisheries resources and the whole process of catching and marketing fish, molluscs and crustaceans. It includes the fishermen and their boats, and all activities and resources involved in harvesting, processing, and selling.
- Census** A "complete enumeration" or count of certain variables for all members of a population. Compare with Sample.
- Catch per unit effort (CPUE)** The catch for a given amount of fishing effort measured in either number of fishing hours, number of fishers or number of boats. It is commonly used to measure the health of the fisheries stocks. CPUE can be used as a measure of the economic efficiency of a type of gear, but normally it is used as an index of abundance, i.e. a proportional change in CPUE is often assumed to represent the same proportional change in abundance (of fish). Nominal CPUE is simply the measure of CPUE from the fishery. However, it is known that there are many factors (including economics, geographical distributions) which may affect CPUE but do not represent changes in abundance. Therefore, CPUEs are often "standardized" using a variety of statistical techniques to remove the effect of those factors which are known not to be related to abundance. Thus, using the standardized CPUE will be more appropriate for an index of abundance. Most assessment analyses (production models, virtual population analyses) use the index of abundance data to fit to calibrate (tune) the models.
- Data validation** Confirmation of the reliability of data through a checking process, usually involving information from an alternative source.
- Discards** that portion of the catch which is returned to the sea either dead or alive, includes fish, OAA and sea birds. It does not include plant materials and post-harvest waste such as offal.
- Estimate** Value that is obtained from a sample, e.g. the average species catch for small-scale fishing vessels as calculated for the sampled landings.
- Exclusive Economic Zone (EEZ)** 1) A zone under national jurisdiction (up to 200-nautical miles wide) declared in line with the provisions of 1982 United Nations Convention of the Law of the Sea, within which the coastal State has the right to explore and exploit, and the responsibility to conserve and manage, the living and non-living resources.
2) The area adjacent to a coastal state which encompasses all waters between
a) the seaward boundary of that state;
b) a line on which each point is 200 nautical miles (370.40 km) from the baseline from which the territorial sea of the coastal state is measured (except when other international boundaries need to be accommodated); and
c) the maritime boundaries agreed between that state and the neighbouring states.
- Frame survey** A complete description of the structure of the primary fishery sector including an inventory of ports, landing places, number and type of fishing units (boats and gears), and a description of fishing and landing activity patterns, fish distribution routes, processing and marketing patterns, supply centres for goods and services, etc.
- FiA** Fisheries Administration, of the Ministry of Agriculture, Forestry and Fisheries of Cambodia is a government agency responsible for the management, regulation and promotion of the national fisheries sector.
- Fisher** A person (male or female) participating in a fishery (in preference to the previously used term 'fisherman'). An individual who takes part in fishing conducted from a fishing vessel, platform (whether fixed or floating) or from the shore. Often the term fisher folk is preferred.
- Fisheries census** Collection of structural fisheries information using a census approach. In practice this is often done by approaching key informants (like village representatives). The primary objective of fisheries censuses is to provide a detailed classification of the fisheries structure of the country. It provides estimates for each household, and therefore, aggregate data for the smallest administrative, political or statistical subdivisions of the country and for classifications of households by size or other subgroups of interest.

- Fishery** The sum (or range) of all fishing activities on a given resource, i.e. the collective enterprise of taking fish, usually used in conjunction with reference to the species, gear or area involved. The term is often widened to include aquatic animals other than fish and is often defined to be targeting one or more stocks of fish, that can be treated as a unit for purposes of conservation and management and that is identified on the basis of geographic, scientific, technical, recreational, social or economic characteristics, and/or method of catch.
- Fishery Activity Coefficient (FAC)** The proportion of fishing units that are expected to be fishing during any given day of the survey period. It is a sample effort parameter and usually expressed in percentage form.
- Fishery-independent** Characteristic of information (e.g. stock abundance index) or an activity (e.g. research vessels survey) obtained or undertaken independently of the activity of the fishing sector. Intended to avoid the biases inherent to fishery-related data.
- Fishing effort** 1) Amount of fishing vessels and gears of a specific type (or numbers of fishing unit or total engine capacity of fishing unit) used in the fishing ground over a given unit of time.
2) The overall amount of fishing (usually per unit of time) expressed in units such as boat days on the fishing ground, number of traps, or trawl hauls, or (gillnet length x soaking time), etc. The effort may be nominal, reflecting the simple total of effort units exerted on a stock in a given time period). It may also be standard or effective when corrected to take account of differences in fishing power and efficiency and ensure direct proportionality with fishing mortality). If more than one gear is considered, standardization in relation to one of them is necessary. For biologists, a good measure of fishing effort should be proportional to fishing mortality. For economists it should be proportional to the cost of fishing.
- Fishing mortality** A mathematical expression of the rate of deaths of fish due to fishing. See: **Natural mortality**
- Fishing vessel** Any vessel, boat, ship, or other craft that is used for, equipped to be used for, or of a type that is normally used for the exploitation of living aquatic resources or in support of such activity. This definition may include any vessel aiding or assisting one or more vessels at sea in the performance of any activity relating to fishing, including, but not limited to, preparation, supply, storage, refrigeration, transportation, or processing (e.g. mother ships).
- Fish stock** General term for group of individuals of one or multiple species
- Gear** or **Fishing gear**, equipment used in fishing operations for catching fish, such as hook and line, trawls, gill nets, traps, spear etc.
- Home port** Location from which fishing units operate, irrespective of where they are registered (sometimes referred to as base port). The difference between base ports and homeports occurs when fishing units migrate from the locations indicated by the frame survey to other sites, usually on a seasonal basis.
- Household** Basic unit for socio-cultural and economic analysis. It includes all persons, kin and non-kin, who live in the same dwelling and share income, expenses and daily subsistence tasks.
- Indicator:** A variable, pointer, or index. Its fluctuation reveals the variations in key elements of a system. The position and trend of the indicator in relation to reference points or values indicate the present state and dynamics of the system. Indicators provide a bridge between objectives and action.
- Inshore** Refers to marine waters less than 20 meters of depth.
- Large-scale fishery** Fishing activities conducted by fishing vessels larger than 24 meters length.
- Landing site** Location of first point of sale for catch by fishers/vessels.
- Landing** Amount of fish and Other Aquatic Organisms (OAA) from one fisher/vessel (fishing unit) brought to shore.

- Logbook** A record of the fishing activity registered systematically by the fisher, including catch and its species composition, the corresponding effort, and location. In many fisheries completion of logbooks is a compulsory requirement of a fishing licence.
- Major stratum** Describes various types of population groupings that are already in place and imposed on a data collection programme, e.g. provinces often are major strata. They constitute standard aggregating levels for estimates for reporting purposes. Estimates are normally produced at minor stratum and not at major stratum level.
- Maximum Sustainable Yield (MSY)** as a reference point is recommended for evaluating stock that are at or above the MYS considered to be biologically sustainable, and those are lower are considered to be overfished.
- Median** The middle number (for an odd number of values) or the arithmetic mean of the two middle values (for an even number of values) for a set of numbers sorted by size/value.
- Minor stratum** Describes grouping of the fishery into homogeneous population sub-sets defined by the survey planner with the purpose of increasing the precision of estimated population parameters. Small-scale and middle-scale fisheries, as well as vessel-gear types are examples of minor strata. Estimates are almost always produced at minor stratum level.
- Middle-scale fishery** Fishing activities conducted with fishing vessels between 12-24 meters length.
- Monitoring** The long-term (routine) collection of information for the purpose of
- Establishing trends and issues in the fisheries to be used for formulating management interventions; and
 - Assessment of the progress and success of a fishery management plan and enforcement of regulations, with the aim to revise the original plan.
- MT** Metric Tons, a unit of mass and weight equal to 1000 kilograms.
- Offshore** Refers to marine waters deeper than 20 meters.
- Natural mortality** Deaths of fish from all causes except fishing (e.g. ageing, predation and disease). It is often expressed as an annual rate that indicates the percentage of fish dying in a year; e.g. a natural mortality rate of 0.2 implies that approximately 20% of the population will die in a year from causes other than fishing. Scientists use the instantaneous natural mortality rate, M , which may also be split into one part due to predation and the other due to all other natural causes (disease, ageing). See: Fishing mortality.
- Outlier** An outlier is an observation in a data set which is far removed in value from the others in the data set. It is an unusually large or an unusually small value compared to the others. An outlier might be the result of an error in measurement, in which case it will distort the interpretation of the data, having undue influence on many summary statistics, for example, the mean. If an outlier is a genuine result, it is important because it might indicate an extreme characteristic of the process under study. For this reason, all outliers must be examined carefully before embarking on any formal analysis. Outliers should not routinely be removed without further justification.
- Population** Any entire collection of people, animals, plants or things from which data is collected.
- Recruitment** the number of fish surviving to enter a fishery
- Reference point** 1) An estimated value derived from an agreed scientific procedure and/or model, which corresponds to a specific state of the resource and of the fishery, and that can be used as a guide for fisheries management. Reference points may be general (applicable to many stocks) or stock-specific. 2) A reference point indicates a particular state of a fishery indicator corresponding to a situation considered as desirable (**Target Reference Point**) or undesirable and requiring immediate action (**Limit Reference Point**).
- Routine data collection** Gathering of data on a regular continuous basis

- Sample** A subset of a population; a value or number of values that constitute a subset of a population; it is used to describe attributes of the population through a number of indicators, like the mean and the variance
- Sample design** Refers to the techniques for selecting a sample and the methods to obtain estimates of the survey variables from the data collected in a sample survey.
- SEAFDEC** South East Asian Fisheries Development Center, an autonomous intergovernmental body established as a regional organization in 1967 to promote fisheries development in Southeast Asia.
- Skewness** Asymmetry in the distribution of the sample data values. Values on one side of the distribution tend to be further from the 'middle' than values on the other side. If there is evidence of skewness in the data, we can apply transformations, for example, taking logarithms of positive skew data.
- Small-scale fishery** Fishing activities conducted with motorised or no-motorised fishing vessels smaller than 12 meters in length, including fishing activities without the use of vessels (or fishing gears), e.g. collection by hand, or gathering molluscs
- Spawning stock** Mature part of a stock responsible for the reproduction.
- Spawning Stock Biomass (SSB)** The total weight of all sexually mature fish in the population (both males and females). This quantity depends on the abundance of year classes, the exploitation pattern, the rate of growth, both fishing and natural mortality rates, the onset of sexual maturity, and environmental conditions.
- Standard Error** The standard deviation of the values of a given function of the data (parameter), over all possible samples of the same size.
- Stratified Sampling** Taking samples from each stratum or sub-group of a population, to obtain a sample that is representative of the entire population.
- Stock assessment** The process of collecting and analysing biological and statistical information to determine the changes in the abundance of fishery stocks in response to fishing, and, to the extent possible, to predict future trends of stock abundance. Stock assessments are based on resource surveys; knowledge of the habitat requirements, life history, and behaviour of the species; the use of environmental indices to determine impacts on stocks; and catch and effort statistics. Stock assessments are used as a basis to assess and specify the present and probable future condition of a fishery.
- Survey design** The overall survey design of a probability survey refers to the definitions and the established methods and procedures concerning all phases needed for conducting the survey the sample design, the selection and training of personnel, the logistics involved in the management of the field force and the distribution and receipt of survey questionnaires and forms, and the procedures for data collection, processing and analysis.
- Target species** Those species that are primarily sought by the fishermen in a particular fishery. The subject of directed fishing effort in a fishery. There may be primary as well as secondary target species.
- Transshipment** Act of transferring the catch from one fishing vessel to either another fishing vessel or to a vessel used solely for the carriage of cargo.
- Trash fish** Those fish with little or no commercial value and not sorted by species before landing. Often part of a trawlers' by-catch. It can be used for aquaculture, fishmeal/animal meal production and in many developing countries, for human consumption.
- Variable** Anything that can change, a quantity that varies.
- Variance** The (population) variance of a random variable is a non-negative number which gives an idea of how widely spread the values of the random variable are likely to be; the larger the variance, the more scattered the observations on average.
- Yield** The weight or number of fish removed by fishing during a defined time period. Catch and yield are often used interchangeably

Annex 8. Gear types and codes, with tentative total number of vessels main gear

| No | FiA Code | Gear type Khmer | Gear type English | Total |
|----|----------|-----------------|-----------------------|-------|
| 1 | | | Trawl | 1569 |
| 2 | | | Crab trap | 1173 |
| 3 | | | Crab gillnet | 1049 |
| 4 | | | Fish gillnet | 917 |
| 5 | | | Centipede fish trap | 624 |
| 6 | | | Shrimp gillnet | 554 |
| 7 | | | Squid tow longline | 390 |
| 8 | | | Octopus trap longline | 271 |
| 9 | | | Push net | 207 |
| 10 | | | Capture by hand | 110 |
| 11 | | | Blood cockle dragged | 102 |
| 12 | | | Fish trap | 88 |
| 13 | | | Fish hook | 80 |
| 14 | | | Anchovy seine net | 55 |
| 15 | | | Squid trap | 49 |
| 16 | | | Spear | 48 |
| 17 | | | Small winged set bag | 43 |
| 18 | | | Fish bottom longline | 27 |
| 19 | | | Oyster collection | 26 |
| 20 | | | Encircling seine | 22 |
| 21 | | | Mantis shrimp gillnet | 18 |
| 22 | | | Lighted fishing | 18 |
| 23 | | | Shrimp trap | 14 |
| 24 | | | Krill push net | 14 |
| 25 | | | Crab basket | 13 |
| 26 | | | Fish longline | 13 |
| 27 | | | Fish trawl | 11 |
| 28 | | | Ray bottom longline | 9 |
| 29 | | | Beach seine net | 8 |
| 30 | | | Fish gillnet | 7 |
| 31 | | | Purse seine net | 7 |
| 32 | | | Encircling gillnet | 6 |
| 33 | | | Crab Clamp | 5 |
| 34 | | | Cast net | 3 |
| 35 | | | Snail trap | 2 |



Prepared by:
Marine Fisheries Research and Development Institute



Food and Agriculture
Organization of the
United Nations

Technical Support by:
Food and Agriculture Organization of the United Nations



This publication was produced with the financial support of the European Union. Its contents are the sole responsibility of Fisheries Administration and do not necessarily reflect the views of the European Union

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