Guidelines for Assessing Fish Conservation Zones in Lao PDR

CRITICAL ECOSYSTEM PARTNERSHIP FUND

WWF

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Foreword

We are very proud to present this successful effort to develop a guidebook and accompanying handbook for assessing Fish Conservation Zones (FCZs) in Lao PDR. The contents of the guidebook and handbook have been developed and summarized with our scrutiny, and reflect comments from various departments, divisions, technical teams, and international experts from the central level to the local sector.

The key challenge and an important goal of the guidebook is to help local people or organizations know and understand about the importance of aquatic conservation or fish conservation zones, which are related to the country's natural resources and natural riches, such as fish abundance, species richness, and biodiversity. These resources support local food security and household consumption, and also provide income that supports national society, economy, and food security. This is relevant to population growth, domestic and foreign investment, tourism, and achieving the goal of poverty reduction in Lao PDR from now until 2020 and 2025.

The FCZ assessment guidebook is a tool for technical staff, village fisheries committees, and resource development planners from different levels in the country to use and adapt based on real situations, geographic conditions, and local needs to learn about the effectiveness of aquatic conservation and management plans, and to improve their work in the future. We would like to acknowledge and thank the Provincial Agriculture and Forestry offices, technical staff, relevant sectors and international experts for their input, comments, feedback, and contributions to complete the final version of the guidebook and handbook.

I also thank FISHBIO Lao Sole Company and FISHBIO's U.S headquarters and team for finding and supporting the grant to develop these technical guidelines for Freshwater FCZ Assessments in Lao PDR.

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The FCZ guidebook and its accompanying field handbook were inspired by “How is Your MPA Doing? A Guidebook of Natural and Social Indicators for Evaluating Marine Protected Area Management Effectiveness” (Pomeroy et al. 2004) published by IUCN. The authors would like to acknowledge participation in the pilot testing of the FCZ guidebook as well as feedback for revision and refinement provided by the Fisheries Division of the Department of Livestock and Fisheries, particularly Mr. Bounthanom Chamsinh; the World Wide Fund for Nature, including Mr. Francois Guegan, Mr. Soutchai Khamphouxay, and their team; and the Japanese International Volunteer Center, including Mr. Sisavanh Inthakhonh, Mr. Somesone Dodsaney, and their team. The guidebook has also been improved by the valuable comments of several external reviewers, including Dr. Ian Baird, Dr. Victor Cowling, Dr. Vittoria Elliott, Dr. Joanne Millar, Dr. Robert Pomeroy, Mr. Terry Warren, and Dr. Tara Whitty. Participants at a stakeholder workshop held in Vientiane Capital, Lao PDR, in November 2016 were instrumental in developing the list of indicators in the guidebook. We would like to thank The Asia Foundation in Lao PDR for permission to include their aquatic macroinvertebrate biomonitoring and habitat assessment protocols in the guidebook, and would also like to thank Dr. Vittoria Elliott and Mr. Scott Johnson of SciCap in Cambodia for their permission and assistance in including their fish catch monitoring protocols.

The authors would like to express our thanks to the communities of Ban Houaykhoualouang and Ban Korkfak in Xayabouri Province, Ban Pakpee in Luang Prabang Province, Ban Kengmeaw in Savannakhet Province, and Ban Konglor in Khammouane Province, as well as government partners from Agriculture and Forestry offices at district and provincial levels, who participated in the pilot testing of the guidebook. Funding for the guidebook was provided in part by a grant from the Critical Ecosystem Partnership Fund, a joint initiative of l’Agence Française de Développement, Conservation International, the European Union, the Global Environment Facility, the Government of Japan, the MacArthur Foundation, and the World Bank. A fundamental goal is to ensure civil society is engaged in biodiversity conservation. We also wish to acknowledge assistance from IUCN as part of the Critical Ecosystem Partnership Fund Regional Implementation Team in the Indo-Burma Region. Finally, we would like to thank Mr. Doug Demko and Ms. Andrea Fuller for FISHBIO’s in-kind support of the development of the guidebook.

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Guidelines for Assessing Fish Conservation Zones in Lao PDR

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Introduction to Fisheries Co-Management and Fish Conservation Zones

Community participation is central to fisheries management in the Lao People's Democratic Republic (Lao PDR). The Lao Fisheries Law of 2009 provides an explicit legal framework for communities to participate in the establishment and co-management of their fisheries with government support. Tools that communities may use to manage fisheries include protecting certain species of fish from harvest, restricting certain fishing gear types, restricting fishing during certain seasons or times of the year, or restricting fishing in a certain location, known as a Fish Conservation Zone (FCZ).

FCZs have become a common part of community fisheries co-management in Lao PDR. The Lao Fisheries Law defines FCZs as "deep water areas either in bodies of water or along rivers as regulated by Fisheries Management Committees or village fisheries regulations" (Department of Livestock and Fisheries 2009). These areas are "designated as a year-round prohibited zone in order to serve as habitats and safe breeding areas for aquatic fauna." Although the Fisheries Law specifically describes deep pool habitats and breeding areas, in practice FCZs have been used more broadly in other types of habitats. Additionally, some FCZs may not have "year-round" closure, but may be seasonal closures, limited access zones where some types of fishing are permitted, or may be opened for fishing on special occasions.

FCZs are established to meet a variety of objectives, based on the community's needs and the goals of facilitating organizations and government agencies. The emphasis on fisheries and the involvement of local communities are two features that distinguish FCZs in Lao PDR from other types of protected areas, such as Ramsar sites for wetlands or National Protected Areas, which are usually established in a top-down manner, and may have a variety of goals other than the protection of fishes. In this guidebook, we refer to "fishes" and "fishing" for simplicity, but recognize that FCZs may be established to benefit other aquatic animals, such as shrimps or crabs, and that the term "fishing" can also refer to harvesting other aquatic animals.

The Lao Community Fisheries and Dolphin Protection Project helped establish the first officially recognized FCZ in Khong District of Champasak Province in southern Lao PDR in 1993 (Baird 2006). This NGO-supported project helped the local government establish a process for communities to voluntarily engage in aquatic resource management. There are now more than 1,300 officially recognized FCZs throughout Lao PDR (Ounboundisane et al. 2019).

To facilitate the FCZ establishment process, the World Wide Fund for Nature (formerly the World Wildlife Fund, WWF) and the Lao Department of Livestock and Fisheries produced "Guidelines for Fisheries Co-management," a step-by-step

handbook that outlines how to establish an FCZ through a participatory approach (DLF and WWF 2009). Establishing FCZs is an important process but does not guarantee their long-term success. The handbook ends with the recommendation that community members periodically monitor and evaluate whether the FCZ regulations are helping to meet the goals of the FCZ. However, few guidelines or resources exist for communities or organizations wishing to undertake such an assessment. Therefore, this FCZ guidebook was developed as a resource for conducting FCZ assessments.

Fisheries management can be viewed as a cycle that repeats, with seven key phases (Figure 1). These phases are ideally completed with active participation from the local community, with advice from outside experts as needed. Some phases may be combined during the same meeting with communities. The first phase is to evaluate the fisheries problems in a location and come up with ideas to address these problems. The second phase is to design a management plan to address the problems, which should include clear goals, desired outcomes, management strategies, and specific indicators of management effectiveness. In the case of FCZs, this management plan must be approved by the District Governor in order for the FCZ to be formally recognized by the Lao government. The third phase is to implement the strategies in the management plan, such as establishing and enforcing an FCZ. If FCZs are used as a management tool, these first three phases are described in the "Guidelines for Fisheries Co-Management" (DLF and WWF 2009).

The fourth, fifth, and sixth phases are the focus of this guidebook. They include collecting data for an effectiveness assessment, evaluating the assessment results, and presenting the assessment findings. The seventh phase is to use the information from the effectiveness assessment to adjust fisheries management strategies, if needed. This important step is what makes the process a management “cycle” that can repeat.

The fisheries management cycle can incorporate other strategies, such as putting restrictions on fishing gear types, species caught, or fishing seasons, and multiple strategies can be used in combination to sustainably manage fisheries. For example, a committee may choose to establish an FCZ in one area, and also to ban small-mesh gill nets in all areas. While FCZs are the focus of this guidebook, they are just one of many tools available to fisheries management committees in Lao PDR, and they may not always be the best tool for a given situation. Therefore, it is important to consider all types of management tools when developing a strategy during the management cycle, and to assess the effectiveness of each tool that is used.

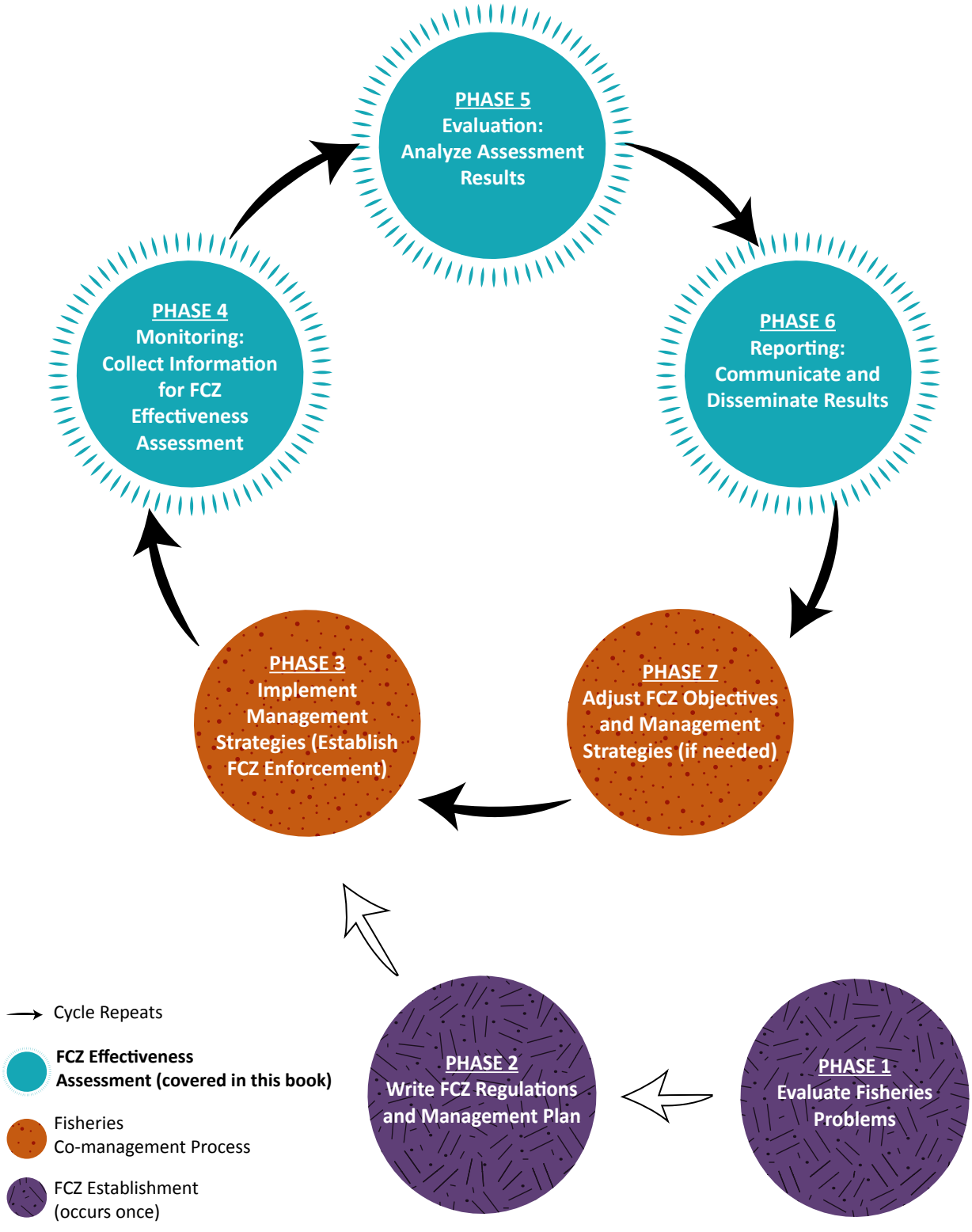

Figure 1. *Fisheries management cycle diagram with examples provided for an FCZ. This guidebook focusses on the Effectiveness Assessment portion of this cycle, and specifically covers Phases 4, 5, and 6, as well as a discussion of Phase 2.*

What is an assessment?

After a management tool, such as an FCZ, is implemented, an important part of the fisheries management cycle is to conduct regular assessments of the tool's performance (Phases 4, 5, and 6 in Figure 1). An ***assessment*** is the process of collecting, analyzing, and interpreting information on how well an FCZ is performing to determine whether the FCZ is successfully achieving its goals and desired benefits.

The purpose of conducting the effectiveness assessment is to learn from the strengths and weaknesses of current management strategies, and then to adjust fisheries management accordingly. An assessment is based on ***indicators*** of effectiveness, which are features that can be measured or recorded to determine the performance of an FCZ.

Why assess FCZs?

Assessments are necessary to understand if FCZs are functioning as desired. The conditions that existed when an FCZ was established may change over time, and management challenges may arise. Assessments can help resource managers learn from their experiences and make changes to improve the management of the FCZ.

Assessments can provide many benefits for communities, non-governmental organizations, government agencies, or other groups involved with managing an FCZ. Actively managing FCZs requires effort and resources, and assessments can determine whether these resources are being used most effectively and efficiently. Assessments also produce information or data about an FCZ that can be shared with community members, funders, or other interested parties to build or maintain support for the FCZ.

Assessments can identify FCZ strengths to build on and weaknesses to improve upon, and can contribute to successful fisheries co-management. Many multinational agreements (such as the United Nations Sustainable Development Goals and the Convention on Biological Diversity) have targets for protected areas and sustainable fisheries, and FCZ assessments can inform progress towards those targets.

What is the goal of this guidebook?

This guidebook is an assessment tool to help a community or organization answer the question, "Is this FCZ successful?" It contains a list of indicators related to common FCZ goals and desired benefits, and provides general guidance on methods for measuring the indicators in an assessment. This guidebook is not comprehensive, but rather is intended to be a starting point to begin the process of FCZ assessment. This guidebook was developed primarily for technical advisors from non-profit organizations or private groups (i.e., "facilitating organizations") that are working with communities to support FCZs. A more simplified version of this guidebook, called the **"Field Handbook for Assessing Fish Conservation Zones in Lao PDR"** was developed for FCZ assessment teams to use in the field when planning their assessment with communities (Loury et al. 2019).

Case Studies from Guidebook Pilot Testing

From October 2017 to June 2018, a draft version of the guidebook was pilot tested at three FCZs or FCZ networks located in different provinces of Lao PDR. These FCZs had all been established for at least one year, and were selected to represent a variety of provinces and organizations involved.

The field testing sites included:

1. Network of three **Northern Laos FCZs** managed by Houaykhoualoung and Korkfak villages in Xayabouri District, Xayabouri Province, and Pakpee Village in Nan District, Luang Prabang Province. These three FCZs are located on the Mekong River mainstem and were established with coordination from FISHBIO in 2014.
2. **Konglor FCZ** managed by Konglor Village in Khounkham District, Khammouane Province. This FCZ is located on the Hinboun River and was established with coordination from the World Wide Fund for Nature (WWF) in 2012.
3. **Kengmeaw FCZ** managed by Kengmeaw Village in Atsaphone District, Savannakhet Province. This FCZ is located on Xenamnoy Stream and was established with coordination from the Japanese International Volunteer Center (JVC) in 2008.

FISHBIO coordinated with WWF, JVC, and each of these communities to select and measure indicators from the guidebook that were relevant to each FCZ. Results of these case studies are presented as examples throughout the guidebook. At the end of the pilot testing, feedback from the participating organizations was solicited and incorporated into a revised version of the guidebook.

Description of Guidebook Pilot Testing Sites

Houaykoualouang Community Description

A consultation meeting was held in Houaykoualouang Village, which is the largest of the three villages involved in the Northern Laos FCZ network, in March of 2017. At that time, the village population was 488 people in 92 households. The dominant village ethnic group is Lao Loum. No full-time fishers (those fishing at least three days per week) were identified in the village, and 20 households were indicated to participate in part-time fishing (fishing one or two days per week). This included fishing in the river and small streams, both in deep pools and along the riverbank. Fishing gear types included cast nets, gill nets, spears and harpoons, and hook and line. About 40% of the catch is kept for household consumption and about 60% is sold in local markets.

About the Northern Laos FCZs

Location: Mekong River, Xayabouri and Luang Prabang provinces.

Size and description: A series of three FCZs along a 14-km stretch of the Mekong River. The northernmost FCZ is 135 m wide by 2.2 km long (29.7 ha), with an average depth of 25.72 m (measured in July 2013). About 4 km downstream is the second FCZ, which is 249 m wide by 569 m long (14.1 ha), with an average depth of 14.40 m (measured in July 2013). Another 5.6 km downstream is the third FCZ, which is 345 m wide by 680 m long (23.5 ha), with an average depth of 14.16 m (measured in July 2013).

Year Established: 2014 with facilitation from FISHBIO.

Goals: To protect all fish species, particularly *Probarbus* spp.

Notes: Management for the three FCZs is shared by three communities: Houaykoualouang and Korkfak villages in Xayabouri Province, and Pakpee Village in Luang Prabang Province.

Who is this guidebook for?

This guidebook was developed primarily for civil society organizations (CSOs) – namely, non-profit or private groups that have worked to support FCZs, as well as FCZ village committees. Government counterparts involved in FCZ management may also find this guidebook useful.

- **Non-governmental organizations (NGOs, such as non-profit or private groups):** This guidebook can be used by NGOs that are working with communities to facilitate FCZ management. In some cases, these organizations will have the expertise to conduct the more technical methods included in this guidebook. If the methods relevant to the FCZ assessment are outside an NGO's field of expertise, they may want to seek additional assistance from an expert in that particular field.
- **FCZ village committees and community groups:** While community groups may be able to measure many of the indicators included in this book, it was developed with the assumption that they would receive training and support from a facilitating organization or technical expert. Some indicators are more difficult to measure than others and, where relevant, we have noted methods that are more technical or less technical to perform.
- **Government agencies:** Government staff at the district or provincial level can also play an important role in supporting the management of FCZs, and would likely benefit from using this guidebook. They may be included in an assessment team, or may be the audience for the results of an assessment.

Konglor Community Description

A consultation meeting was held in Konglor Village in April of 2017. At that time, the village population was 1,337 people in 228 households. The dominant village ethnic group is Bor. Although no full-time fishers were identified in the village, all of the households were indicated to participate in part-time fishing. This included fishing in rice fields and small streams with a variety of gear types, including cast nets, gill nets, scoop nets, lift nets, surrounding nets, fence traps, hook and line, fishing poles, and woven wedge traps. This fishing was identified as subsistence fishing, with essentially all of the catch kept for household consumption or given to family and friends.

About Konglor FCZ

Location: Hinboun River, Khammouane Province.

Size and Description: 60 m wide by 250 m long (1.5 ha), depth of 5 m in the dry season, located at the mouth of Konglor Cave.

Year Established: 2012 with facilitation from WWF.

Goals:

1. To protect all aquatic life, including fish species, to attract tourists with fish abundance and diversity.
2. To obtain income benefits from ecotourism.
3. To enhance downstream fisher catches through spillover.

Notes: This FCZ is adjacent to Konglor Cave, which is a popular tourist attraction.

Kengmeaw Community Description

A consultation meeting was held in Kengmeaw Village in April of 2017. At that time, the village population was 749 people in 163 households. The dominant village ethnic group is Phou Thai. No full-time fishers were identified in the village, and 30 households were indicated as participating in part-time fishing. This included fishing in the river and small streams, in deep pools and along the riverbanks, as well as in rice fields. Fishing gear types included cast nets, gill nets, lift nets, seine nets, hook and line, and fishing poles. This fishing was identified as subsistence fishing, with about 90% percent of the catch kept for household consumption or given to family and friends, and the rest being sold in local markets.

About Kengmeaw FCZ

Location: Xenamnoy Stream, Savannakhet Province.

Size and Description: 35 m wide by 250 m long (0.875 ha), 3.5–4 m deep in the dry season.

Year Established: 2008 with facilitation from JVC.

Goals:

1. To conserve all fish species.
2. To protect fish spawning.
3. To sustain fish populations for future generations.

How to use this guidebook to conduct an assessment:

This guidebook can be used to plan and carry out an FCZ assessment (Phases 4–6 in the management cycle shown in Figure 1). These phases consist of the following key steps that can be carried out to design and complete an effectiveness assessment:

- **Step 1:** Identify FCZ goals and desired benefits
- **Step 2:** Select indicators to assess these goals and desired benefits
- **Step 3:** Plan the assessment and select methods to measure each relevant indicator
- **Step 4:** Collect data for the assessment
- **Step 5:** Analyze and evaluate assessment results
- **Step 6:** Communicate assessment findings
- **Step 7:** Provide recommendations for how to adapt management strategies if needed

Step 1: Identify FCZ goals and desired benefits

The purpose of an FCZ assessment is to determine whether the FCZ is successfully meeting its goals, or functioning as it was intended. This requires first identifying the purpose of the FCZ, and which goals the FCZ is intended to accomplish. A ***goal*** is a broad description of what the FCZ is trying to achieve, and can be phrased as a mission statement. Within a goal, there may be several desired outcomes or benefits that are more specific. Ideally, these should be measurable and realistically achievable.

Goals and desired benefits may be different for each FCZ, and should be specific to the local context. FCZ goals and desired benefits can relate to the governance and management of the FCZ (enforcement and compliance), to benefits for people (food security, livelihoods, cultural traditions), or to the ecology of the aquatic environment (how different animals and plants interact). While ecological goals, such as protecting fish populations or fish diversity, are often a main motivation for establishing an FCZ, the community may also wish to achieve socioeconomic or governance goals, such as ensuring future generations can continue to catch fish, or improving enforcement activities against illegal fishing.

Clear FCZ goals, as agreed to by the community, are an essential starting point for selecting indicators. This is very important. If the goal of the FCZ is directly stated in the existing FCZ management plan, then the group can move to Step 2. If the goals are not clear in the management plan, then the community should first identify specific desired benefits or outcomes of the FCZ before moving forward with an assessment.

Since different community members may envision different goals for the FCZ, the goals should ideally be developed through a participatory process when the FCZ is established. It can help to start by brainstorming a vision of a successful FCZ with all stakeholders (essentially, what everyone wishes the FCZ will achieve), then use this vision to identify the particular goals that can help achieve the vision. This list of FCZ goals can then be used to develop more specific, measurable desired benefits (see Box 1). FCZ management is a cyclical process (see Figure 1), and it does not end after one cycle. It is important to regularly re-examine and revise FCZ goals and desired benefits as needed by conducting assessments.

Defining FCZ Success: Ecological Example

Vision: The aquatic biodiversity of the FCZ is healthy and being protected, and fisheries resources outside of the FCZ are abundant.

Goal: Individual species are protected inside the FCZ.

Desired Benefit: *Probarbus* spp. abundance is increased or maintained inside the FCZ.

Box 1: *An example of how FCZ goals and desired benefits relate to the vision of a successful FCZ.*

Step 2: Select relevant indicators

This guidebook categorizes FCZ goals into three themes: 1) governance, 2) socioeconomic, and 3) ecological goals. For each theme, FCZ goals and desired benefits are matched with indicators that can be used to measure progress towards those goals. Once you have identified your FCZ goals and

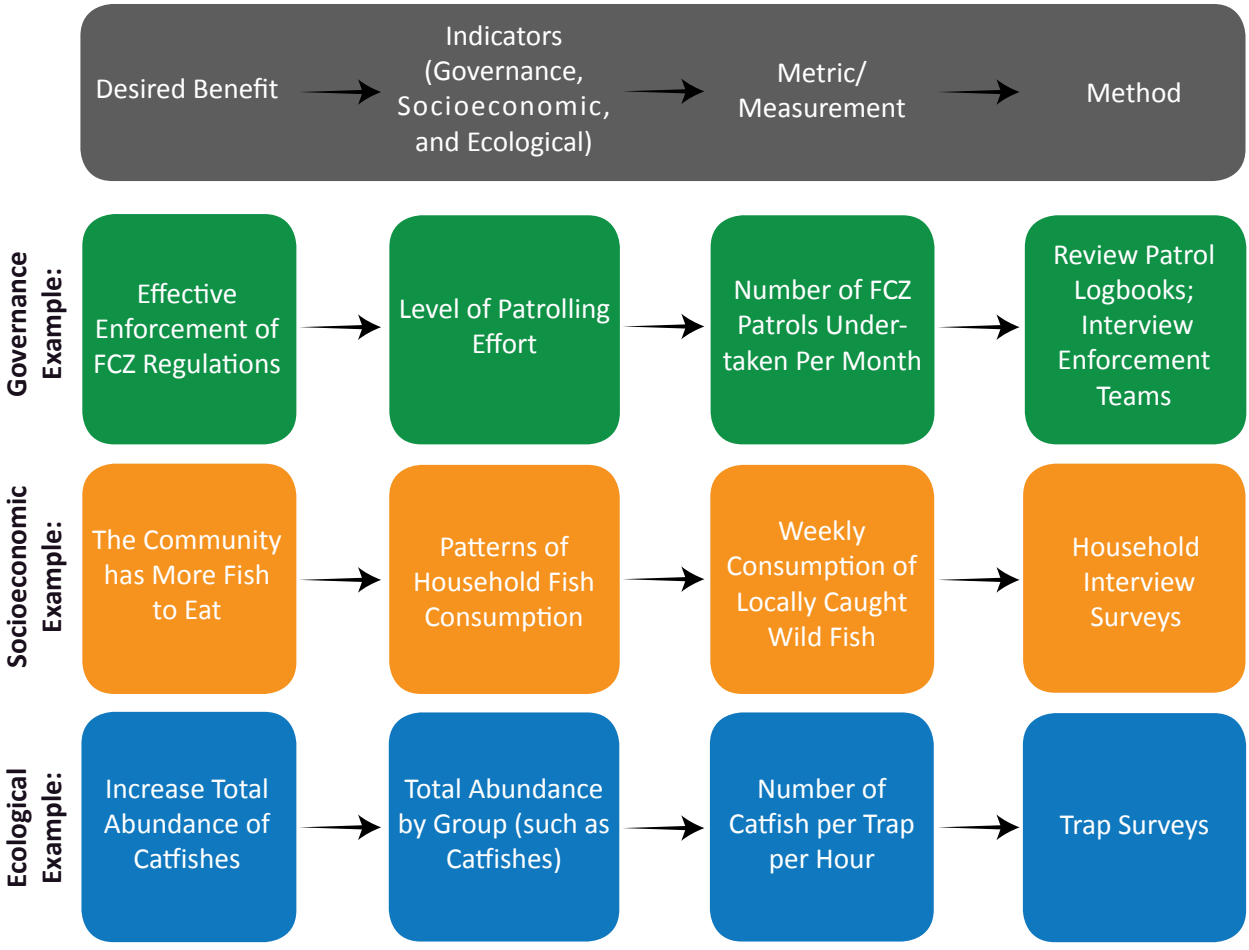

Figure 2. *Example of the process of selecting indicators and methods based on an FCZ's goals and desired benefits.*

desired benefits, please use the checklist included in the section for each theme to select the indicators that are most relevant for your assessment. The companion "Field Handbook for Assessing Fish Conservation Zones in Lao PDR" can help you walk through this process. A list of all indicators included in this guidebook can be found in Table 1. **It is not necessary to measure all of the indicators in this guidebook.** You should only measure those that are related to your FCZ goals, and that are feasible to conduct given the assessment team's capacity and resources. This guidebook does not describe all possible indicators of FCZ effectiveness, and there are many other indicators that potentially could be used for an assessment, if needed. Some examples are found in Appendix 1.

Indicators can be described by various metrics or measurements that have a unit of scale, and data for these metrics may be collected using a variety of methods. The metrics and methods you should use in your assessment will depend on the question you are trying to answer. For example, the ecological indicator "Total abundance by group" (such as "catfishes") can be measured with the metric of "number of fish per trap per hour," which can be obtained using the method of fish trap surveys (Figure 2).

Table 1. *FCZ indicators with example questions that can be answered by measuring each indicator.*

Governance Indicators	Questions to Consider
G1) Existence of an active management committee	Is there a group of people responsible for making decisions about FCZ management?
G2) Existence and adoption of a management plan	Is there a document that describes the purpose, goals, and objectives of the FCZ, and describes the FCZ rules, regulations and responsibilities?
G3) Local understanding of FCZ rules and regulations	Does the community know the FCZ exists and why? Do they understand what is allowed and not allowed in the FCZ?
G4) Availability and use of FCZ administrative resources	Is there enough funding, materials, equipment, and people to manage the FCZ? How are they used?
G5) Level of community participation and satisfaction in management	Do community members participate in FCZ management decisions and activities? Do they agree with and support FCZ management decisions and activities?
G6) Clear enforcement procedures and level of patrolling effort	Does the enforcement team have clear guidelines to follow to enforce the rules of the FCZ? How much effort is spent patrolling and enforcing the FCZ?
G7) Level of compliance with FCZ regulations	How many people are breaking the rules of the FCZ? Who is breaking the rules? How often does this happen?

Socioeconomic Indicators	Questions to Consider
S1) Local fishing patterns and practices	How, when, and where are community members harvesting fish, plants, or other aquatic animals? Are the patterns changing over time?
S2) Perceptions of local fish catch	What do local fishers think about their current fish catches and how these catches have changed over time?
S3) Patterns of household fish consumption	How much locally caught wild fish are people eating in the community? Is this changing over time?
S4) Perception of benefits derived from the FCZ	Do community members feel the FCZ has had a positive or negative impact on their lives? How?
S5) Household income/effort distribution by source	What are the primary livelihood activities of local households? How many are related to the FCZ? Is this changing over time?
S6) Local values and beliefs about aquatic resources	How do customs, traditions, or understanding about the aquatic environment affect how people use aquatic resources?
S7) Level of environmental awareness and understanding of conservation	Does the community understand how human activities affect the environment, and what kinds of practices are sustainable or not sustainable?

Ecological Indicators	Questions to Consider
E1a) Presence/absence of key species	Is a species of interest found inside the FCZ? Is this changing over time?
E1b) Abundance of key species	How many of a species of interest are found inside the FCZ by number (ex: 5 climbing perch/m^3) or weight (ex: 10 kg of climbing perch/m^3)? Is this changing over time?
E2) Population structure of key species	What are the sizes or ages of fish in the population of a particular species? How many "large" fish are present? Is this changing over time?
E3) Total abundance by group (such as "fishes")	How many total fish or invertebrates are in the FCZ by number (ex: 10 fish/m^3) or weight (ex: 15 kg of fish/m^3) for all species combined? Is this changing over time?
E4) Composition and structure of the aquatic community	What is the diversity of aquatic animals and/or plants in the FCZ? How many species are there, and how many of each species? Is the composition of the animals and/or plants changing over time?
E5) Total catch per unit of fishing effort	How much fish is caught per time spent fishing? (Ex: 3 fish/net per hour; 7 kg of fish/trap per hour) Is the catch increasing or decreasing over time?
E6) Water quality	What is the condition of the water in terms of temperature, oxygen, salinity, acidity, or clarity? Is water quality changing over time?
E7) Habitat distribution and quality	How many types of habitats are in the FCZ (such as rocks, sand bars, deep pools, or wetlands) and where are they located? Is the amount of habitat of interest in the FCZ changing over time?

Selecting Indicators During Pilot Testing

During guidebook pilot testing, each community was asked to identify goals and desired benefits of their FCZ to inform the design of an FCZ assessment. Appropriate indicators were then selected to assess whether the FCZ was achieving these goals and desired benefits. However, the indicators that were actually included in the assessments at each FCZ often went beyond those related to the FCZ's goals and desired benefits. Sometimes other indicators were chosen because they were easier to measure than those related to the official goals, given the constraints of the pilot testing timeline and budget. Additional indicators were also measured based on the interests of the community or the assessment team. Assessment teams are encouraged to focus on indicators related to an FCZ's goals so that the results of the assessment can be most informative for management. However, measuring other indicators related to desired benefits or outcomes of the FCZ can also provide interesting and valuable information about an FCZ.

Case Study Example: Kengmeaw FCZ Indicator Selection

Here we provide one example of the indicator selection process. When the community of Kengmeaw was asked what they wanted to know about the performance of their FCZ, they identified the following desired benefits and outcomes:

1. To conserve all fish species and their reproduction for future generations.
2. To follow up on all violations against the FCZ regulations.
3. To have spillover from the FCZ benefit fish catches of local fishers downstream.

The assessment team and the community selected the following indicators based on these desired outcomes:

1. To conserve all fish species and their reproduction.
    - E3, *Total abundance by group (such as "fishes")*
2. To follow up on all violations against the FCZ regulations.
    - G6, *Clear enforcement procedures and level of patrolling effort*
    - G7, *Level of compliance with FCZ regulations*
3. To have spillover from the FCZ benefit fish catches of local fishers downstream.
    - S1, *Local fishing patterns and practices*
    - S4, *Perception of benefits derived from the FCZ*

The team also decided to collect information related to these additional indicators as part of the FCZ assessment:

- G3, *Local understanding of FCZ rules and regulations*
- G5, *Level of community participation and satisfaction in management*
- S3, *Patterns of household fish consumption*
- S5, *Household income/effort distribution by source*

Step 3: Plan the assessment and select methods to measure each relevant indicator

Once you have selected your indicators, it is time to plan the assessment, including selecting the method(s) you will use to measure each indicator. A full description of methods for each indicator is beyond the scope of this guidebook, but it provides some examples for each indicator and includes references to resources with more information. Additional research or consultation with technical experts will likely be needed to best design an assessment. Conducting an assessment requires many kinds of resources, including time, people, and funding. This planning process will help you to determine whether you have enough of each of these resources before beginning your assessment.

You should also identify an assessment team, or the group of people who will be conducting the assessment. Roles of the assessment team members include planning the assessment, collecting the data, and analyzing and communicating the results. The responsibility of collecting the data can be divided among the team members depending on their capacity, and not all team members need to be involved in this step. For example, some team members can be responsible for collecting socioeconomic indicator data, while others are responsible for collecting ecological indicator data. Attempting to keep the data collectors the same will contribute to the data being more consistently recorded, an important element of data quality control.

Assessments can cover multiple fields of study, including governance, socioeconomics, and ecology, and it is helpful for members of the assessment team to have experience in these relevant fields. If a facilitating organization does not have all the relevant expertise needed to conduct an FCZ assessment, this may require partnering with other organizations, or consulting with technical experts for their advice. It is also valuable for community members, such as fishers or other stakeholders, to participate in the assessment team. Community members can provide valuable knowledge about the local setting to inform the assessment, and researchers can train the community in technical methods. This can help create a sense of community ownership or buy-in regarding the results of the assessment, rather than it being viewed as an outsider effort.

During the planning stage, the team will need to determine the methods they will use, the timing of the assessment (schedule), and the equipment or other resources they will need. Methods to assess some indicators may be possible to complete in a single day (such as interview surveys), while others may take several days and may need to be repeated throughout the year (such as fish sampling).

Some questions to consider when planning the assessment are:

1. What kinds of information need to be collected for the indicators you have chosen?
2. What methods will you use to collect this information?
3. How much information needs to be collected, and when?
4. Is it important to collect information in multiple seasons?
5. What kind of equipment is needed to collect information for each indicator?
6. Does someone on the assessment team have the skills to collect information for each indicator? If not, can the team receive training to collect the information?
7. Are additional resources (people, funding, equipment) needed to conduct the assessment? If yes, is there a plan in place for obtaining these resources?
8. Where will assessment plan and results and information be safely stored so others can find them to compare to future assessments?

The assessment plan should be documented in writing and notes should be made about any modifications to the plan so that the process may be repeated in future years, and results of subsequent assessments can be compared.

Case Study Example: Planning the Konglor FCZ Assessment

The assessment team for the Konglor FCZ assessment consisted of eight people: two staff from WWF Laos, two staff from FISHBIO Laos, and four government staff that represented district, provincial, and central level government offices. The assessment team decided to divide into three smaller groups to collect data for the assessment: three people would collect data on the governance indicators, three people would collect data on socioeconomic indicators, and two people would collect data on ecological indicators. The team then selected the methods that they would use for the assessment. To measure the governance indicators, they decided to conduct a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis with key stakeholders. To measure the socioeconomic indicators, they decided to conduct semi-structured interviews with key stakeholders. To measure the ecological indicator, they decided to conduct a visual habitat survey. The team then designed questionnaires and data sheets with questions related to each of the indicators they planned to measure. When the assessment team arrived at the village, they met with the village head to help identify community members to be interviewed for the assessment survey. The team particularly wanted to include the perspectives of fishers when assessing socioeconomic indicators, and the village head helped identify 10 fishers (people who fish at least one or two days per week) and 20 "other villagers" to interview for the assessment.

Planning for Long-Term Assessments

Assessments can help resource managers learn from their experiences, and make changes to improve the management of the FCZ, which is a key part of the fisheries management cycle. As described in Figure 1, the cycle of assessment and learning continues indefinitely over time, and FCZ assessment is a long-term effort. It is important to think of the assessment as a long-term program from the beginning. During the assessment design phase, the fisheries management committee and the assessment team should consider how to maintain the consistency of data collection over the long-term. A long-term program may have different considerations from a one-year program in terms of the difficulty of the methods, flexibility of the program, cost, and comprehensiveness of data collection. This includes considering the financial and time commitment of the assessment, and how much funding and resources are available for long-term data collection. Keep in mind the sustainability of the program – it may not be helpful to design a big assessment if the level of sampling cannot be maintained for more than one year. This could mean deciding not to collect data on certain indicators during every assessment (for example one indicator can be assessed every year, and another indicator can be assessed every five years).

Baseline data generally refers to the data that are collected at the starting point of a long-term program. Ideally, these baseline data are collected before the FCZ is established so that you can look for changes in indicators as the environment and community respond to FCZ protection. However, if the FCZ is already established, you may consider the first year or two of data collection as a type of

baseline to look at changes over time in an established FCZ.

Maintaining consistency is an important, but difficult, aspect of a long-term assessment program and it requires significant commitment. This is a challenge for all long-term programs. A long-term assessment program seeks to identify year-to-year patterns in indicators; therefore, it is essential to use the same methods, sites, and sampling schedule (and if possible, data collectors) during each assessment to maintain consistency in the program. If you change your sampling methods each year or during each assessment, then it becomes very difficult to compare one year to the next, or one assessment to the next. Sometimes it may not be possible to continue using a certain method or continue sampling at a specific location. If this occurs, then the assessment team should consider all other options for collecting data on the relevant indicator, discuss the best way to meet the assessment objectives, and make a change to the data collection process just once (such as to begin a new series of data collected with a new method or in a new location). This decision should be made carefully, possibly in consultation with technical advisors, to ensure only changing the methods one time, and to maintain as much consistency as possible.

Step 4: Collect data for the assessment

Data should be collected during an assessment to measure specific FCZ indicators. Suggestions and resources for relevant methods to collect data are listed for each indicator in this guidebook. During the data collection process, the assessment team members should communicate with each other, share updates on how the plan is proceeding, and discuss any challenges or required changes to the plan. For example, if the team planned to conduct fish surveys with gill nets but the river water level is too high and dangerous for sampling, then the team can meet and discuss whether to change to a different sampling method, or to delay the activity. Information should be carefully recorded in writing from each assessment activity, and the final results should be summarized so that they can be examined and interpreted in Step 5. Once the data collection step is complete, it may be helpful for the assessment team to have a discussion of the strengths, weaknesses, and constraints of the assessment, and lessons learned from the experience of conducting the assessment.

During this discussion, the team can ask themselves:

- Were there any methods that were planned but were too difficult to carry out?
- Was there anything that you wish you had planned for that you did not?
- What would you do differently next time?

Have a team member record this information and include it with the written plan in a safe place to help inform future assessments.

Step 5: Analyze and evaluate assessment results

Assessments involve the collection, analysis, and interpretation of data, and all these steps must be completed. Collecting data alone without analyzing it is not sufficient to complete an assessment. Suggestions and resources for analyzing and interpreting assessment results are provided for each indicator in this guidebook. Additional advice on data analysis and interpretation is included in Appendix 4. You may need assistance from a technical expert to analyze the assessment results.

The results of an FCZ may be summarized as tables, charts, graphs, diagrams or written descriptions. They should provide information on whether the FCZ is successfully achieving its goals and desired

benefits. There is no single definition of a successful FCZ because the definition of "success" depends on each individual community's or organization's vision and goals for their FCZ. The results of the assessment should be interpreted based on the local context and conditions that determine which outcomes are desirable or undesirable. It may be that the FCZ is successful in achieving some goals or desired benefits, and not successful in achieving others. The results of the assessment can be used to create a list of FCZ strengths and weaknesses. The assessment team should use this process to decide on the key message or story they want to share about the FCZ and their findings during Step 6.

Step 6: Communicate assessment findings

The assessment team should share the findings of their work broadly with the fisheries management committee and the community so that all community members can understand how the FCZ is performing. This can be done through a community meeting in smaller communities. In larger communities, it may be necessary to also share the findings through fliers, social media, or other methods to ensure that many community members have heard the information. Community members can offer input to the fisheries management committee on next steps that can be taken for FCZ management based on the assessment results.

During community meetings, the team can explain:

- Why they conducted the assessment
- What information they collected
- How they collected the information
- What the results mean

Assessment findings can also be shared with relevant government staff like District Agriculture and Forestry Office (DAFO) and Provincial Agriculture and Forestry Office (PAFO) officials, and can be communicated to project donors. If the assessment identifies strengths in FCZ management, these aspects can be supported or expanded. If the assessment identifies weaknesses in FCZ management, these aspects can be changed, or more funding and support can be requested to improve them. Results may be communicated in written reports, shared during meetings or workshops, or in other ways using media such as posters, photos, video, radio, or the Internet.

Step 7: Provide recommendations for how to adapt management strategies if needed

If the community is satisfied with the performance of the FCZ based on the assessment, no changes may be needed to adapt FCZ management. However, if the assessment identifies areas that need improvement, the assessment team can make recommendations to the village fisheries management committee, which can decide on changes that are needed to improve FCZ management. For example, if the assessment finds that many people are not complying with the FCZ regulations, the assessment team could recommend that more signs are needed, that more patrolling is needed, or that more outreach is needed to educate community members. Village leadership can choose to assign responsibility or seek resources to carry out these changes.

In Phase 7 of the fisheries management cycle (see Figure 1), if the fisheries management committee decides that changes to the FCZ regulations are required (such as changing the FCZ boundaries, rules, or penalties), then the committee should work with district officials to make changes to the FCZ regulations. Management actions should also be adjusted to match any changes in the regulations. At this stage, if the management committee has found the assessment useful, any relevant FCZ goals, desired outcomes, and indicators of management effectiveness could be added to the FCZ management plan if they are not already described. Some questions for the fisheries management committee to consider include:

1. Are the goals and desired benefits of the FCZ still relevant or realistic? Do they need to be updated in the management plan?
2. If the assessment finds that a particular management strategy is not working, how can it be changed and improved?
3. Are there strategies <u>other</u> than FCZs that can be used? (Gear restrictions? Size restrictions?)

4. If the results of the assessment are not useful for management, how could better information be collected in a future assessment?

Conclusions

This guidebook offers suggestions and recommendations for assessing FCZs, but there is no one correct way to conduct an FCZ assessment. Each FCZ assessment will be different depending on the interests and resources of a particular community, as well as the setting and conditions of a particular FCZ. After an assessment is completed, it is important for the fisheries management committee to take steps to address any weaknesses of the FCZ or explore solutions to address any challenges identified by the assessment. This will help strengthen the management of the FCZ.

It is important to note that measuring a single indicator once will not provide much valuable information about an FCZ because you do not know whether the indicator is increasing, decreasing or staying the same. The value of FCZ assessments comes from measuring several different indicators over time to provide an overall picture about how an FCZ is performing. Managing an FCZ is an ongoing process, and so is assessing an FCZ. FCZ assessments are most informative when they can be conducted regularly, not just once. How often an FCZ should be assessed will depend on the resources available, but it may be helpful to establish a goal of assessing an FCZ once every three or five years. If lessons learned are passed along to the next assessment team, this can make the process easier each time. It is important to keep the results on an FCZ assessment in a safe place so that future assessments can use these results to see how indicators may be changing over time. The benefits of a successful FCZ can take time to appear, sometimes many years, especially when it comes to ecological changes. This is why it is important to conduct assessments over the long term.

Establishing and sustaining FCZs requires a commitment from communities, government officials, and supporting organizations to invest the time, effort, and resources needed to ensure an FCZ can succeed. While it is not an easy task to conduct an FCZ assessment, these reviews are a valuable and necessary part of ensuring FCZ success. By identifying opportunities to improve FCZ management, assessments can help improve the conservation outcomes of FCZs, ensuring that communities can continue to benefit from the rich fisheries and aquatic resources of Lao PDR for generations to come.

About this guidebook

This guidebook was developed with funding from the Critical Ecosystem Partnership Fund. The indicators in this guidebook were developed from several sources, and it is modelled after a guidebook called “How is Your MPA Doing? A Guidebook of Natural and Social Indicators for Evaluating Marine Protected Area Management Effectiveness” by Pomeroy et al. (2004). This FCZ guidebook also draws on a literature review of marine and freshwater protected area assessments, as well as the Socioeconomic Manual for Coral Reef Management (Bunce et al. 2000). The lists of goals and indicators relevant to FCZs in Lao PDR were refined through a workshop of 43 stakeholders held in Vientiane, Lao PDR, in November 2016, and two rounds of review by relevant experts.

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Definitions of Key Terms

- **Absence:** When a species is not found in the FCZ or study area.
- **Absolute abundance:** Every single individual of a species in a study area. It is typically very difficult to estimate absolute abundance, so "relative abundance" is used instead.
- **Abundance:** An ecological term for the total amount of an animal by number or weight.
- **Aquatic environment:** Any freshwater environment, such as a river, stream, lake, reservoir, or wetland.
- **Aquatic community:** The collection of aquatic animals and plants that interact with each other in the same place at the same time (different from the "human community" that may live near an FCZ).
- **Aquatic community structure:** The relative abundance of the different species that make up the aquatic community, and how they are organized.
- **Assemblage:** A portion of the aquatic community that is closely related, such as the fish assemblage or the macroinvertebrate assemblage.
- **Assessment:** The process of collecting, analyzing, and interpreting information on how well an FCZ is performing to determine whether the FCZ is succeeding in meeting its goals and desired benefits.
- **Assessment team:** The team of people who are conducting the FCZ effectiveness assessment, which may include CSO staff, community members, and/or technical experts.
- **Belief:** A shared understanding of how the world works.
- **Biodiversity:** The number and type of all living things, including animals and plants, that exist in a specified area.
- **Civil Society Organization (CSO):** Any non-governmental group or organization such as a community group or committee, a non-profit organization, or a private company.
- **Control site (or reference site):** A site outside the boundaries of the FCZ that shares similar characteristics to the FCZ, such as size and habitat. The control site is compared to the FCZ to understand the effects of FCZ protection.
- **Creel surveys:** Interviews conducted by trained assessment team members with fishers that are returning from fishing.
- **Direct sampling:** Collecting data for an indicator through first-hand surveys or observations. Ex: measuring fisher catch by weighing the amount of fish caught by each fisher; measuring the amount of fishing effort from boats by observing the number of boats fishing on the water.
- **Dominance:** A measure of the degree to which a species is more numerous or more abundant than others.
- **Evenness:** A measure of how equally represented different animals are in the aquatic community.
- **Fish Conservation Zone (FCZ):** An area in a river, wetland, reservoir, or other habitat in the aquatic community that prohibits some or all fishing.
- **Fisher:** Any person who catches or harvests fish, other aquatic animals, or plants using any method.
- **Fishery-dependent sampling:** Collecting data about the activities of fishers, such as key species, gear types, fishing effort, and total weight of fishing catch.
- **Fishery-independent sampling:** Collecting data about fish populations in a consistent way (consistent gear type and effort) for the purposes of a scientific assessment.
- **Fishing:** The catch or harvest of any aquatic animal or plant using any method.
- **Fishing effort:** The time and number of people involved in fishing with a particular type of gear.
- **Goal:** A broad description of what an FCZ is trying to achieve. It can be phrased as a mission statement.
- **Governance:** Relating to all aspects of making decisions and carrying out management actions (such as those related to an FCZ).
- **Indicator:** A specific qualitative or quantitative variable directly linked to management goals that is used to measure management effectiveness.

- **Indirect sampling:** Collecting data for an indicator by asking people to report it from their memory. Example: measuring fisher catch by interviewing fishers to ask how much they typically catch; measuring the amount of boat fishing effort by asking community members how many boats are typically fishing on the water.
- **Key species:** Any species of interest. This species could be a focus of protection in an FCZ, or it could be the focus of an FCZ assessment because of its ecological, cultural, or commercial importance.
- **Local ecological knowledge:** Knowledge of a natural environment that comes from living in and interacting with that environment on a regular basis.
- **Macroinvertebrate:** Aquatic insects, insect larvae, molluscs (clams, snails), or crustaceans (shrimps).
- **Other Aquatic Animals (OAA):** This term is often used to refer to aquatic animals other than fish that may be harvested for food in Lao PDR, and may include frogs, turtles, shrimp, crabs, molluscs, insects, or other species.
- **Population structure:** How many individuals in a population fall into different size or age categories.
- **Presence:** When a species is observed or documented inside the FCZ or in the study site.
- **Relative abundance:** Comparing species abundance values that are relative to other times or locations. Multiple values of relative abundance can be compared to understand how a species abundance differs between locations or is changing over time.
- **Resource managers:** People who can make decisions about managing natural resources and Fish Conservation Zones. This can include village committees or government fishery officers.
- **Sampling effort:** The amount of time and/or gear units used to actively sample for aquatic animals (such as number of hours per trap fished, number of hours per net fished).
- **Species richness:** The total number of species in the aquatic community.
- **Spillover:** The increase of fish populations inside of an FCZ that causes fish to move outside FCZ borders, where they can be harvested by fisheries.
- **Stakeholders:** People, groups, or organizations who use and depend on aquatic resources, whose activities affect the aquatic environment or the FCZ, or who have an interest in aquatic activities. Stakeholders can be divided into three groups:
  - **Primary stakeholders:** People who directly depend on aquatic resources for a living, who directly use the aquatic environment (such as fishers, fish processors, etc.), and who may be affected by the FCZ.
  - **Secondary stakeholders**: People who do not harvest from the aquatic environment directly, but who do make use of aquatic products or services (such as fish traders), or who may affect the FCZ through their actions (such as farmers on land next to or upstream of the FCZ), and who may be affected by the FCZ.
  - **Relevant organizations:** Groups with a direct responsibility for managing the FCZ, or with an interest in the primary or secondary stakeholders (such as village committees, government agencies, or NGOs).
- **Study design phase:** The phase of an assessment that comes after identifying the goals of the FCZ, and is when the assessment indicators and methods are chosen and the sampling plan is designed.
- **Taxon:** A group of species that are closely related. The grouping may be broad (“fishes”) or more specific “catfishes”).
- **Value:** A social norm of what is important or good that has been shaped by history and culture.
- **Water quality:** Conditions of water in an aquatic environment that may affect animals and plants. Some examples include temperature, salinity, pH, dissolved oxygen, smell, and turbidity/transparency.

Governance Section

Introduction

FCZs are a management tool that influences the relationship between people and the aquatic environment. Because an FCZ functions through the management process, effective governance is an important element of FCZ success. ***Governance*** relates to all aspects of making decisions and carrying out management actions related to an FCZ. This guidebook recognizes that under the Lao Fisheries Law (2009), FCZs are governed by the framework of co-management, where responsibility for management is shared between communities and the Lao government. FCZs in Lao PDR may have one or more desired benefits or outcomes related to the governance of the system that can generally be categorized under three different goals: 1) maintaining an effective management approach, 2) ensuring effective stakeholder participation and representation, and 3) enhancing compliance with the FCZ management plan.

Table 2 describes a checklist of FCZ governance goals and desired benefits with a list of related indicators. The first step in deciding which indicators are best to use for your assessment is to mark the goals and desired benefits that are related to your FCZ (please see the section in the guidebook Introduction on page 8 about the importance of defining clear goals before the assessment). The checklist will help you narrow down and focus on the indicators that are most useful for your specific FCZ goals. There are seven governance indicators included in the guidebook. Some indicators are relevant for more than one set of goals and desired benefits (Table 2). Other relevant governance goals and indicators do exist, but were beyond the scope of this guidebook. For a list of additional indicators, see Appendix 1. In particular, one important governance goal of an FCZ may be to reduce the level of resource conflict occurring among resource users in a single village, among resource users in neighboring villages, or as a result of illegal fishing by powerful people. The indicator "*level of resource conflict*" can be measured to assess an FCZ's success in meeting this goal; however, measuring this indicator was deemed too complex to include in this guidebook. If this is an important goal of your FCZ, we recommend you seek technical expertise in resource conflict to help your assessment team develop an appropriate method for measuring this indicator. The description of each governance indicator in this section includes a list of example methods and suggested questions that may be included in surveys to measure that indicator. Please keep in mind that these are just examples, and other or additional methods may be appropriate for your assessment.

General Considerations for Governance and Socioeconomic Data Collection

Many of the same methods can be used for collecting information on governance indicators as well as the socioeconomic indicators discussed in the next section. Data for some governance and socioeconomic indicators may also be collected during the same set of community interviews. Therefore, this section applies to both the governance and socioeconomic indicators.

Before conducting a governance or socioeconomic assessment, a consultation meeting should be held with the community to discuss the purpose and plans for the assessment, allow community members to provide input and express insights or concerns regarding the assessment, and discuss the logistics of the assessment to try to reduce disruption to the community. The consultation is a chance to identify which people and how many are part of different stakeholder groups related to the FCZ. An assessment team may include members of the community, as well as people who are from outside the community (such as NGO staff, government staff, and technical experts). Because many of the

Table 2. *List of desired FCZ governance benefits, related indicators, and example questions that can be answered by measuring each indicator.*

Desired Governance Benefits and Outcomes		Indicators	Questions to Consider
Effective Management Approach	□ Make effective management decisions about the FCZ	□ Existence of an active management committee (G1)	• Which people are responsible for making decisions about FCZ management? • Is this group actively engaging in FCZ management?
	□ Have clear guidelines for FCZ regulations, penalties, and management actions	□ Existence and adoption of a management plan (G2)	• Have the goals of the FCZ been agreed upon and legally approved? • Does the plan provide clear guidelines for FCZ management? • Are the regulations and penalties clearly described in the plan?
	□ The community clearly understands the rules of the FCZ	□ Local understanding of FCZ rules and regulations (G3)	• Do community members understand which activities are allowed and not allowed in the FCZ? • Do community members understand why the FCZ exists? • Do community members understand the penalties for breaking the rules?
	□ There is enough funding and resources to support management and enforcement	□ Availability and use of FCZ administrative resources (G4)	• What funding, equipment, and personnel are available to support FCZ management? How are they used? • Are more resources needed?
Community Participation and Satisfaction	□ Community members participate in FCZ management decisions	□ Level of community participation and satisfaction in management (G5)	• Do community members play a role in making decisions about the FCZ? • Are community members satisfied with decisions that are made about the FCZ?
	□ Community members accept and support the FCZ regulations and management	□ Local understanding of FCZ rules and regulations (G3)	• Do community members understand the FCZ regulations and think they are acceptable?
		□ Level of community participation and satisfaction in management (G5)	• Are community members satisfied with decisions that are made about the FCZ?

	Desired Governance Benefits and Outcomes	Indicators	Questions to Consider
Effective Enforcement and Compliance	□ Community members actively participate in and support FCZ enforcement	□ Level of community participation and satisfaction in management (G5)	• Do community members play an active role in monitoring and enforcing the FCZ? • Are community members satisfied with the enforcement of the FCZ?
	□ Good compliance with FCZ regulations	□ Level of compliance with FCZ regulations (G7)	• Do many people break the rules of the FCZ? How often does this happen?
	□ Effective patrolling and monitoring of FCZs	□ Availability and use of FCZ administrative resources (G4)	• Who is responsible for enforcing the FCZ? Do they have enough resources to function effectively?
		□ Clear enforcement procedures and level of patrolling effort (G6)	• Does the enforcement team follow clear guidelines? Do they patrol regularly?
		□ Level of compliance with FCZ regulations (G7)	• Are patrolling activities helping to reduce violations in the FCZ?
	□ Effective enforcement when FCZ regulations are violated	□ Clear enforcement procedures and level of patrolling effort (G6)	• When someone breaks the rules of the FCZ, are they apprehended? Do they receive a fine?
		□ Level of compliance with FCZ regulations (G7)	• Are enforcement actions helping to reduce violations in the FCZ?

governance and socioeconomic indicators depend on interviews or other interactions with community members, the assessment is influenced by the interviewing skills of the assessment team, and the relationship they build with the community. There are several guiding principles that an assessment team should follow while conducting governance and socioeconomic assessments with communities (Bunce et al. 2000, Hoon et al. 2008):

- **Respect all community members,** including their knowledge, opinions, customs, and time/schedules.
- **Keep survey responses confidential, and to the extent possible, anonymous.** This includes not putting respondent names directly on the questionnaires, but rather assigning each respondent a code. You can then create a separate list that matches codes to names and demographic data.
- **Clearly state the purpose of the assessment** so stakeholders understand why their involvement is requested and how their responses will be used.
- **Recognize and reduce biases of the assessment team.** Recognize that some people may be unintentionally excluded from the assessment based on the perceptions and experiences of the team members, and extra effort may need to be taken to include these groups. Such groups may include women, community members living in remote areas, poor or uneducated community members, or ethnic groups that might speak different languages.
- **Address gender issues** by talking specifically with women as a separate stakeholder group, and by including women on the assessment team. When recording any interviewee's name and demographic information, be sure to record gender (regardless of stakeholder category) so that later you can see how many women were in each stakeholder group.
- **Address language differences** by conducting interviews using an interpreter if the interviewer does not speak the same language as the person being interviewed. It is important for the interpreter to clearly understand the objective of the survey and not unintentionally bias the responses during interpretation.
- **Take detailed notes,** which include not just *what* people say but *how* they say it, and may include notes on the interview participant's attitudes, behavior, or interactions with others. It may help to have one assessment team member ask the questions to the interview participant, and have a second assessment team member take notes during the interview.
- **Cross-check the data,** which means to compare data collected in different ways for the same indicator. Ideally, data should be compared from three different sources collected with different methods by different assessment team members. This is known as triangulation.
    - For example, data on Indicator G6, *Clear enforcement procedures and level of patrolling effort* could be collected by 1) interviewing the enforcement team about their enforcement procedures, 2) observing enforcement team procedures in the field, and 3) reviewing the FCZ management plan or other written document explaining the enforcement procedures.
    - Data on Indicator S1, *Local fishing patterns and practices* could be collected by 1) interviewing fishers about their fishing methods and catch, 2) observing fishers' methods and catch in the field, and 3) reviewing logbooks or government reports about local fish catch and methods.

Methods for Governance and Socioeconomic Data Collection

Measuring governance and socioeconomic indicators requires identifying relevant stakeholder groups for the assessment. FCZ ***stakeholders*** are people, groups, or organizations who use and depend on aquatic resources, whose activities affect the aquatic environment or the FCZ, or who have an interest in aquatic activities. Stakeholders can be divided into three groups:

1. **Primary stakeholders:** People who directly depend on aquatic resources for a living or source of food, who directly use the

aquatic environment (such as fishers or fish processors) and who may be affected by the FCZ.

2. **Secondary stakeholders:** People who do not harvest from the aquatic environment directly, but who do make use of aquatic species or services (such as fish traders), or who may affect the FCZ through their actions (such as farmers on land next to or upstream of the FCZ), and who may be affected by the FCZ.
3. **Relevant organizations:** Groups with a direct responsibility for managing the FCZ, or with an interest in the primary or secondary stakeholders (such as village committees, government agencies, or NGOs).

The stakeholder groups of interest may differ depending on the indicator measured, and the goals of the assessment.

Often, all of the relevant stakeholders cannot be interviewed for an assessment, in which case the assessment team must select a sample of stakeholders. This can be done in a number of ways:

1. **Simple random selection:** Each household or individual stakeholder is given a number, and a sample of numbers to be interviewed is chosen at random. Although this is an ideal method, it is often challenging and may not be possible.
2. **Purposive selection:** The assessment team deliberately chooses stakeholders to be interviewed based on their relationship to the FCZ and their willingness to be interviewed.
3. **Referral sampling:** Interviewees are chosen starting with an initial contact, such as recommendations from the village head, and each person interviewed recommends the next person to be interviewed.
4. **Stratified sampling:** This process ensures that diverse groups are represented, and it can be applied to purposive or referral sampling. The assessment team documents the different types of groups they wish to include in surveys, which may be based on fishing gear types used, gender, age groups, or other characteristics. Roughly estimate the number of people in each group, then aim to survey a representative sample from each group, potentially by using random selection.

The type of sampling and the number of stakeholders to interview (called the sample size) depends on the goal of assessment. If the sample of stakeholders is intended to accurately represent the larger community based on statistical calculations (known as a "statistically representative sample"), then the assessment should use random sampling. Several resources describe how to calculate the sample size for statistically representative samples (such as Rea and Parker 2004), and are too detailed to include in this guidebook. Statistically representative samples can be very expensive and time consuming to collect, and sometimes the assessment team can still gain useful information about a population by interviewing a smaller number of people that is not statistically representative. In these cases, Hoon et al. (2008) provide recommended survey sample sizes for populations of different sizes (see Table 3).

Table 3. *Suggested sample sizes of people to interview for non-statistically representative sampling from Hoon et al. (2008).*

Population	Sample Size
100	25
200	40
300	60
400	70
500	80
1,000	100

The following methods can be used to measure the governance and socioeconomic indicators in this guidebook. More details about these methods can be found in Bunce et al. (2000) and Hoon et al. (2008).

<u>Who to interview:</u>

- **Key informant interviews:** Key informants are people with a unique perspective or knowledge of an issue because of their experience or status. These interviews are useful when the assessment

team wishes to collect information on basic facts, such as the existence of an FCZ management plan, or the number of fishing boats in a village. A key informant might be the village head, members of the fisheries management committee, or an experienced fisher, depending on the question being asked. It is useful to interview informants individually (one-on-one confidentially) so their perspective is not influenced by others in a group. Individual interviews should be conducted with multiple key informants to gain a broader perspective on a topic.

- **Focus group interviews:** These are interviews with small groups of key informants (4 to 10 people) at the same time, and can be useful to encourage discussion among the people being interviewed. A focal group might be the fisheries management committee, fisher committee, or enforcement team. However, group interviews can be challenging to facilitate, and more outspoken or opinionated people may dominate the discussion.
- **Household or individual interviews:** These interviews are conducted to collect information on general perspectives, activities, or knowledge in the community. They can be conducted at the household level (What are the main livelihood activities of your household?), or at the individual level (What are the main livelihood activities of you personally?). These interviews should be conducted with one individual or household at a time, so the answers of the person/people being interviewed are not influenced by a larger group.

How to interview:

- **Semi-structured interviews:** These interviews are based on a mix of closed questions and open-ended questions that allow the interviewer to ask follow-up questions. A benefit of semi-structured interviews is they allow the person being interviewed to give in-depth explanations and have some discussion with the interviewer. A drawback is that it requires training and practice to conduct interviews consistently, and the data can be challenging or time-consuming to analyze.
- **Closed-question surveys:** These surveys have a limited set of answers, such as multiple choice or true/false questions. A benefit of closed-question surveys is that it can be quicker and easier to summarize and analyze the results than for semi-structured interviews. A drawback is that these surveys may not allow the person being interviewed to share valuable perspectives or information that are not included in the set of answers to the survey questions.
- An interview with a key informant or household might combine some elements of a semi-structured interview and a closed-question survey.

Direct observations: Another way to collect data on governance and socioeconomic indicators is for members of the assessment team to make direct observations in the field and record information about what they see. These direct observations can be used to verify the information collected during interviews. Direct observations could include watching fishers catch fish, observing other livelihood activities in the community, attending an FCZ management committee meeting, or following an FCZ enforcement team on a patrol. The observer should take care not to disrupt the activity being observed, or alter the outcome of an activity by their presence.

References

The following references are cited above or provide more information that is relevant to all the governance indicators included in this guidebook:

Bunce, L., P. Townsley, R. Pomeroy, and R. Pollnac. 2000. Socioeconomic Manual for Coral Reef Management. Australian Institute of Marine Science, Townsville, Australia. Available at www.reefbase.org.

Clark, J. R., R. V. Salm, and E. Siirila. 2000. Marine and Coastal Protected Areas: A Guide for Planners and Managers. 3rd edition. IUCN, Gland, Switzerland.

Department of Livestock and Fisheries. 2009. Fisheries Law. Vientiane Capital, Lao PDR.

Hoon, V., G. Sriskanthan, P. Townsley, B. Cattermoul, L. Bunce, and B. Pomeroy. 2008. Socioeconomic Monitoring Guidelines for Coastal Managers of South Asia. SocMon South Asia. IUCN/CORDIO.

Pomeroy, R. S., J. E. Parks, and L. M. Watson. 2004. How is Your MPA Doing? A Guidebook of Natural and Social Indicators for Evaluating Marine Protected Area Management Effectiveness. IUCN, Gland, Switzerland and Cambridge, UK.

Rea, L. M., and K. R. Parker. 2014. Designing and Conducting Survey Research: A Comprehensive Guide. 4th edition. Jossey-Bass, San Francisco, California.

Governance Indicators

G1. Existence of an active management committee

Description (What is this?)

A management committee is a group of people with the authority to make decisions about the management of an FCZ, and to turn those decisions into actions. There may be one group responsible for both decision making and management, or these roles may be split between different groups.

Why measure this?

FCZs are not static, but should be actively monitored and enforced, and should be changed and adapted as needed to make them more effective. It is important to identify who is responsible for making and carrying out decisions about the FCZ to ensure effective management. Having a recognized management body with clear authority can help make an FCZ more successful.

General considerations for data collection

- Methods for assessing the existence of an active management committee can include conducting interviews, examining documents, and making direct observations.
- Semi-structured interviews may be conducted with key informants related to FCZ management, such as the village head, village committee, fisher committee and/or FCZ committee, and local government officers.
- Supporting documents related to the management committee should be thoroughly reviewed as part of the assessment, such as FCZ approval documents, a management committee roster, or records of management group meetings.
- The assessment team can also collect information by direct observation of the management committee. This can be accomplished by attending management committee meetings, where the assessor can observe and record the process of decision making, as well as the roles of different members (more technical method).
- Ideally, the existence of an active management committee should be assessed at least once every three years.

Example methods

Examples of questions that may be asked during semi-structured interviews or answered by direct observation include:

1. Is there a management group that specifically has the responsibility to manage the FCZ? What other responsibilities do they have?
2. What is the relationship between this management group and other management groups, such as the village committee or fisher committee?
3. Who are the members of the management committee and what are their roles?
4. How are the roles on the management committee determined?
5. When do new members join the committee?
6. Which stakeholder groups are represented by the management committee? What is the representation of genders, ages, livelihoods, or other groups?
7. Are there documents that legally recognize the authority of the management body?
8. How often does the management committee meet?
9. What is the decision-making process of the management committee?
10. Are written records kept of management committee meetings?

Examples of how to interpret the results

An organization chart (Figure 3) can be created that shows the relationship between all groups with decision-making and management authority, the stakeholder groups represented, and the flow of decision making.

Questions to consider:

1. Does the assessment suggest the management body is functioning effectively?
2. If this indicator has been used previously, has the management group changed over time?
3. Are there recommendations for improving the organization and function of the management body?

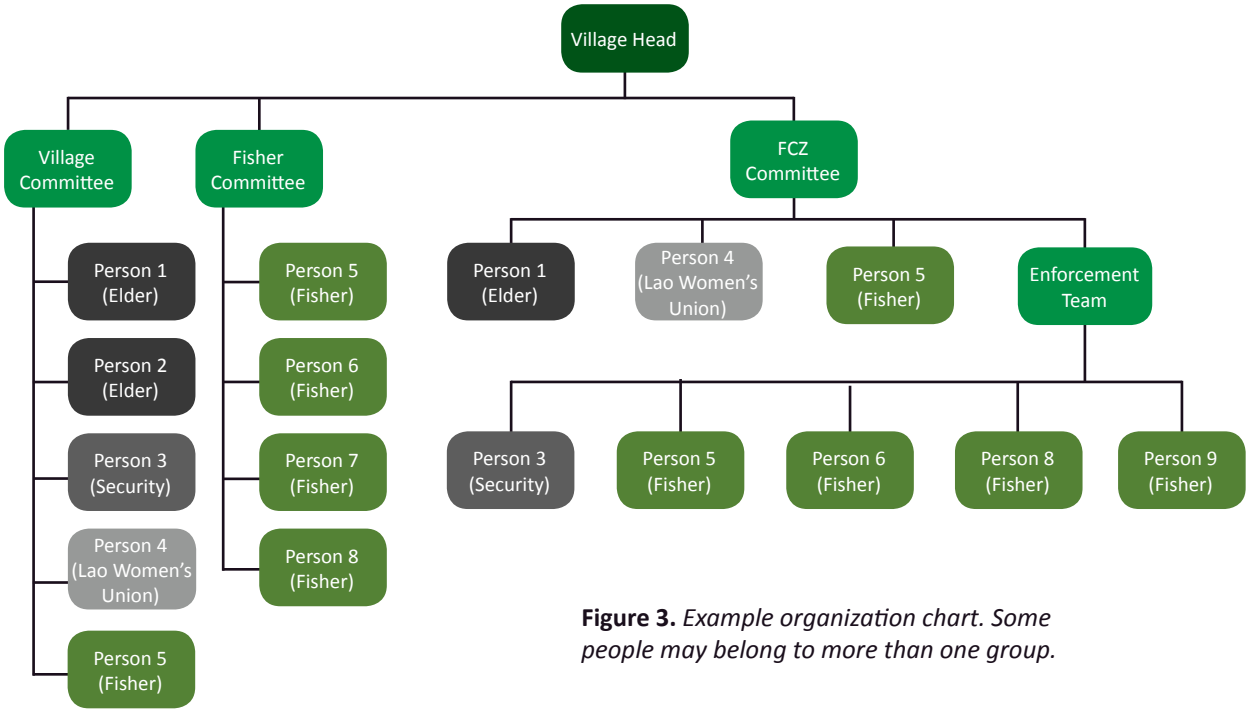


Figure 3. *Example organization chart. Some people may belong to more than one group.*

G2. Existence and adoption of a management plan

Description (What is this?)

A management plan is a document that recognizes the authority of the FCZ; describes the purpose, goals, and desired benefits of the FCZ; describes the rules and regulations of the FCZ; and describes the roles and responsibilities of the management committee.

Why measure this?

There are many ways to manage an FCZ, so it is important to have an agreed upon written document that can guide the management of the FCZ. The management plan sets the goals and desired benefits of the FCZ, which influences the actions used to manage the FCZ in a strategic way. There also needs to be a legal basis for the plan in order to enforce it.

General considerations for data collection

- The primary method for measuring this indicator is to review the written management plan for the FCZ. Key informant interviews can also be conducted to understand how the management plan is carried out.
- Ideally, the existence and adoption of management plan should be assessed once every three years.

Example methods

One method for collecting data on this indicator is to use a checklist of management plan attributes when reviewing the written management plan or conducting an interview. The following checklist (Figure 4) is adapted from Pomeroy et al. (2004).

Examples of how to interpret the results

Use the checklist to create a written summary or description of the management plan.

<u>Questions to consider:</u>

1. Does the assessment suggest the management plan is complete?
2. Are there recommendations to improve any missing sections of the management plan, or to make the existing sections more complete or effective?

References

General references are listed in the Introduction to the Governance Indicators section.

Pomeroy, R. S., J. E. Parks, and L. M. Watson. 2004. How is Your MPA Doing? A Guidebook of Natural and Social Indicators for Evaluating Marine Protected Area Management Effectiveness. IUCN, Gland, Switzerland and Cambridge, UK.

Management Plan Adoption

- Does the management plan exists as a paper document? _____
- Where is the management plan stored? _____
- How many copies of the management plan exist? _____
- Date of the plan _____
- Date of any updates _____
- Has the plan been approved/adopted? _____
- Date of approval/adoption: _____
- Has the plan been signed? _____
- Level of approval (village, district, DAFO, PAFO?): _____

Does the Management Plan Contain: (Check all attributes that are included)

☐ FCZ goals/purpose
☐ Roles and responsibilities of the management committee with adequate descriptions
☐ FCZ boundaries in wet season and dry season (GPS coordinates or landmarks?)
☐ FCZ regulations
☐ FCZ penalties
☐ Plan and protocols for patrolling and enforcement
☐ Training requirements for enforcement
☐ Budget and financial plan or funding sources
☐ Equipment inventory and protocols
☐ Community outreach and education plan
☐ Guidelines for reviewing and evaluating management plan effectiveness
☐ Procedures and guidelines for amending the management plan
☐ Documentation of any amendments that have been made since the original document was created
☐ Indicators to measure management effectiveness

Figure 4. *Example FCZ management plan checklist.*

G3. Local understanding of FCZ rules and regulations

Description (What is this?)

This indicator assesses whether community members know the FCZ exists, and how familiar they are with the FCZ purpose and regulations. This could be assessed in the community responsible for managing the FCZ as well as in other nearby communities that may be fishing near the FCZ.

Why measure this?

The rules of an FCZ typically place limits on the actions of community members. Community members are more likely to support the FCZ if they understand why it exists. People must also be aware of and understand the FCZ regulations to comply with them. Measuring this indicator helps identify any confusion in the community related to the FCZ regulations. While meetings may have been held with community members about the FCZ's purpose and regulations when it was first established, not all of the community members may have been present during these meetings. Measuring this indicator can also help determine whether community members have forgotten about the FCZ's purpose or regulations since it was established.

General considerations for data collection

- This indicator can be measured by conducting semi-structured interviews with households or individuals. The interviews may include some Yes/No or multiple choice questions.
- The interviews should include a broad spectrum of community members, including men, women, children, fishers and non-fishers.
- The interviewer should have a copy of the FCZ regulations to refer to when conducting the interviews.
- The interviewer should explain that the value of the interview depends on the interviewee being as open and honest as possible. Effort should be made to help the interviewee feel comfortable and at ease with being interviewed, and to keep responses confidential.
- Ideally, local understanding of FCZ rules and regulations should be assessed at least once every three years.

Example methods

Examples of questions that may be asked during semi-structured interviews with community members include:

1. Are you aware of the FCZ in your village? (Yes/No)
2. Where are the boundaries of the FCZ located?
3. What is the goal/purpose of the FCZ?
4. What are the rules and regulations of the FCZ? Please list as many as you can.
5. Who is responsible for enforcing the FCZ regulations?
6. What penalties will people face if they break the rules?
7. On a scale of 1 to 5, how difficult are the regulations to understand? (1 = very easy to understand, 5 = very difficult to understand)

8. Do you think the regulations were developed in a participatory way that included community input? (Yes/No)
9. Do you think the regulations are socially acceptable to the community? (Yes/No) If you answered "No," would you be willing to explain why?
10. Which rules do you think are acceptable? Which rules do you think are unacceptable?
11. Do you have any feedback or concerns about the regulations?

Examples of how to interpret the results

The responses from the community to interviews can be summarized in tables or charts by graphing the percentage of people who gave a particular answer. These percentages can be graphed as stacked bar graphs and compared between different user groups (such as men and women, adults and children, or fishers and non-fishers). If this indicator has been used in a previous assessment of the FCZ, you can also compare the changes in percentages over time if similar types of people were interviewed during each assessment. Narratives can be written to summarize open-answer questions.

Questions to consider:

1. Do most people understand and accept the FCZ regulations?
2. Are there key groups of people whose understanding of the regulations could be improved?
3. Are there particular regulations that are difficult for the community to understand or accept?
4. Are there recommendations to be made or actions that can be taken to improve community understanding of the regulations?
5. Are there recommendations to be made or actions that can be taken to improve community approval and support of the regulations?

References

General references are listed in the Introduction to the Governance Indicators section.

Chomchanta, P., P. Vongphasouk, S. Chanrya, C. Soulignavong, B. Saadsy, and T. J. Warren. 2000. A preliminary assessment of Mekong Fishery Conservation Zones in the Siphandone area of Southern Lao PDR, and recommendations for further evaluation and monitoring. Data & Information Unit, Living Aquatic Resources Research Center, Vientiane, Lao PDR.

Case Study Example: Kengmeaw FCZ

The FCZ assessment team interviewed 39 people in Kengmeaw Village about their understanding of the FCZ regulations (about 5% of the village population). These people were identified with help from the village head to represent four groups: elders (10 people), women (10 people), fishers (10 people), and other villagers (9 people). The fishers were those who typically fished in the river from boats.

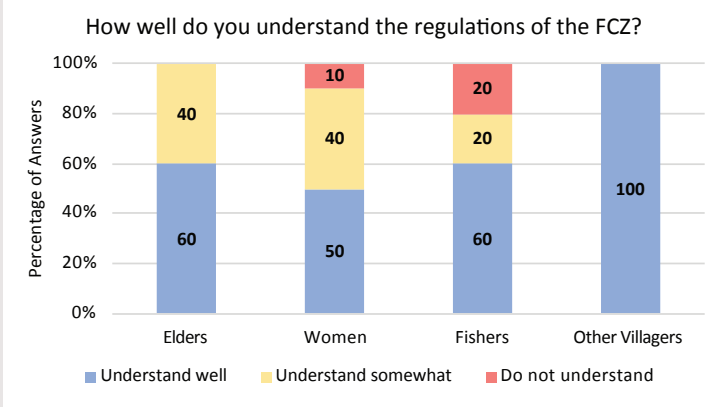
While ensuring representation is valuable, collecting data in this way presents some challenges for interpretation, since the categories are a mix of age, gender, and livelihood. For example, while the great majority of the elders and fishers were men, some women were also included in these groups, and were not counted as part of the "women" group. Therefore, the results of the survey should be interpreted with caution when trying to extrapolate the results of the surveys to the entire community. This demonstrates the importance of gathering demographic data (age, gender, livelihood) about *each* stakeholder interviewed to allow responses to be categorized in different groups during analysis.

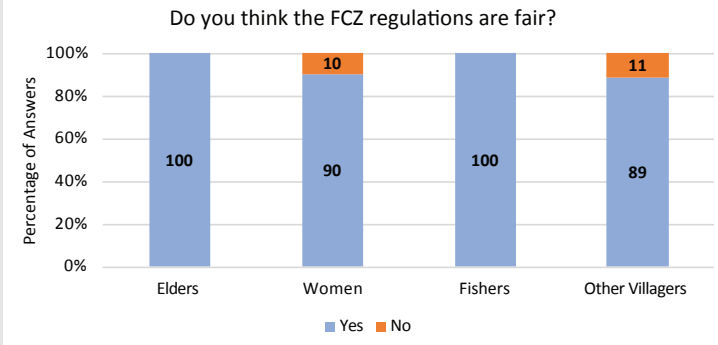
G3. Local understanding of FCZ rules and regulations

Although it would have been preferable to interview 10 people in the "other villager" category to have an equal sample size among groups, only nine people were available.

All of the interviewees said they had heard of the FCZ in the village. The assessment teams asked the interviewees to rate their understanding of the FCZ regulations (Do not understand, Understand somewhat, or Understand well), and whether or not they thought the FCZ regulations were fair.

The number of people who gave each answer in each category was calculated as a percentage, and the percentages were graphed as stacked bar graphs to compare answers between groups.





For example, when asked how well they understand the regulations, 6 elders answered they "Understand well" and 4 elders answered they "Understand somewhat."

The percentage of "Understand well" answers for elders = (6/10)*100 = 60%.
The percentage of "Understand somewhat" answers for elders = (4/10)*100 = 40%

When asked if they thought the FCZ regulations were fair, 8 people in the "other villagers" category said "Yes" and 1 person said "No."

The percentage of "Yes" answers for other villagers = (8/9)*100 = 89%
The percentage of "No" answers for other villagers = (1/9)*100 = 11%

When asked why they thought the regulations were not fair, some of the interviewees said they wanted to increase the fines in the FCZ, which they thought were too low to discourage people from breaking the rules. The team also asked interviewees which groups are allowed to fish inside the FCZ: The village committee; Special groups of visitors; Outsiders; or Nobody. All respondents correctly identified that nobody is allowed to fish inside the FCZ.

Based on these results, the assessment team noted that the villagers seemed to have a good basic understanding that fishing by anyone is prohibited inside the FCZ. The team also recommended conducting additional outreach and explanation of the FCZ regulations with key groups, such as fishers, women, and elders, which could help clarify and increase confidence in their understanding of the FCZ regulations.

G4. Availability and use of FCZ administrative resources

Description (What is this?)

FCZ administrative resources are the funding, materials, equipment, and personnel used to manage the FCZ. This indicator looks at whether there are adequate resources available to manage the FCZ, and how they are used or distributed.

Why measure this?

FCZ management is an active and ongoing process, and resources are needed to sustain management activities over time. In particular, sufficient personnel, equipment, and funding are needed to enforce the regulations of the FCZ and ensure compliance. This indicator helps identify whether additional resources are needed, or how existing resources can be redistributed to improve the effectiveness of FCZ management.

General considerations for data collection

- This indicator can be measured by using interviews or observations to create an inventory of FCZ resources, and by conducting semi-structured interviews with key informants or focus groups, such as the fisheries management committee and enforcement team.
- Key documents should also be reviewed, such as the FCZ management plan and any financial accounting documents.
- When possible, the assessment team should document physical evidence of the resources (such as taking photos of signs and equipment). An example equipment inventory is provided in Figure 5.
- Ideally, the availability and use of FCZ administrative resources should be assessed at least once every three years by an assessment team, but the management committee should be examining the availability and sufficiency of their resources more frequently.

Example methods

<u>Funding</u>

1. What is the annual budget for managing the FCZ? How is that budget divided by category? (Patrolling, per diem, signs, education, etc.)
2. How much funding is available to manage the FCZ each year? Is the funding sufficient to cover the costs of managing the FCZ?
3. How much of the funding comes from donors? From the community? From the government or other sources?
4. Is there a transparent accounting system to document expenses and how funding is used?
5. Is there someone responsible for ensuring that there is adequate funding for the FCZ, and seeking new sources of funding?

Materials (Signs)

1. How many sign boards are there for the FCZ regulations?
   a. Where are they?
   b. Are they visible and legible?
   c. Do they list the regulations and penalties of the FCZ?
2. Are there signs or markers to mark the boundaries of the FCZ?
   a. How many are there?
   b. Are they visible and legible?

Equipment

1. What is the age and condition of the equipment used?
2. Where is the equipment stored?
3. Is the equipment used for other activities unrelated to the FCZ?
4. How well is the equipment maintained?
5. Are there procedures for keeping records on when and where the equipment is used (like a sign-out form)?

Equipment Inventory
(Also note how many of each item):

- ☐ Boat and motor
- ☐ Guard station
- ☐ Radio
- ☐ GPS
- ☐ Binoculars
- ☐ Lights
- ☐ Uniforms
- ☐ Camera
- ☐ Logbook

Figure 5. *Example equipment inventory checklist.*

Personnel

1. How many people are involved with enforcing the FCZ?
2. How many years of experience does each person have?
3. What kind and level of training is provided to enforcement personnel?
4. How many people involved with enforcing the FCZ are volunteers? How many of them receive some compensation?

Examples of how to interpret the results

A report can be produced that summarizes the results of the assessment for this indicator in narrative form. A pie chart can be made showing the different sources of funding.

Questions to consider:

1. If this indicator has been used in a previous assessment of this FCZ, has there been a change in the amount and sources of funding? If there has been a decline in funding, is the available funding still sufficient?
2. Are additional resources required to manage the FCZ?
3. Are there opportunities for obtaining additional funding or equipment? Do those responsible for seeking additional funding have enough capacity to do so?
4. Do any of the existing equipment or materials need to be replaced or updated?
5. Do additional people need to be trained to assist with the management of the FCZ?
6. Are there recommendations for how the current resources could be used differently to improve management of the FCZ?

Case Study Example: Northern Laos FCZs

During the assessment of the Northern Laos FCZs, assessment team members asked the community enforcement teams whether or not they had enough resources to patrol the FCZ. The enforcement teams described how they did not have a boat and motor for patrolling. While members of enforcement teams initially used their own boats to patrol the FCZs, they had stopped doing this after the boats of two enforcement team members were destroyed, presumably by disgruntled fishers who had recently received fines from fishing in the FCZ.

The enforcement teams also noted they did not have lights for patrolling at night, and did not have communication devices, as a mobile phone that had been provided during the establishment of the FCZ had fallen into the river. As a result of this assessment, the facilitating organization (FISHBIO) learned about the need to provide additional equipment to the enforcement teams, and also about the need to address conflict in the community between fishers and the enforcement teams.

G5. Level of community participation and satisfaction in management

Description (What is this?)

This indicator measures the level of community engagement in FCZ management activities, and whether community members agree with and support management activities. It considers whether community members feel the FCZ managers take their views and concerns into account.

Why measure this?

Community members are more likely to support the FCZ and comply with its regulations if they play a role in the management of the FCZ and are satisfied with management activities. Participation can help people feel a sense of ownership for the FCZ. This is particularly important in Lao PDR, where communities have a large responsibility for managing their FCZs under a co-management framework. Studies of community-managed protected areas have shown that community participation plays an important role in the success and sustainability of the protected area (Beger et al 2005; Maliao et al. 2009; Velez et al. 2014).

General considerations for data collection

- Semi-structured interviews or surveys can be conducted with individuals or focus groups representing various groups of stakeholders in the community, such as fishers, elders, women, youth, etc.
- Semi-structured interviews may also be conducted with members of the management committee to ask about their perceptions of stakeholder satisfaction. This perceived satisfaction can be compared to the level of satisfaction reported by stakeholders to see if there is a disconnect. For example, does the management committee believe that stakeholders are satisfied with FCZ management, when in reality they are not?
- Interviews that ask stakeholders about their level of participation and satisfaction in FCZ management can include both open-ended and closed questions.
- The interviewer should explain that there is no "correct" answer, and the value of the interview depends on the interviewee being as open and honest as possible. Because of this, it would be best if the interviews were conducted by a person who is viewed as independent of the FCZ management process. Effort should be made to help the interviewee feel comfortable and at ease with being interviewed, and to keep responses confidential.
- The assessment team can also directly observe and record stakeholder participation by attending FCZ management meetings or enforcement activities (a more technical approach).
- Ideally, stakeholder participation and satisfaction should be assessed at least once every three years.

Example methods

Example questions to ask about stakeholder participation:

1. Who are the stakeholder groups?
2. How many members of each stakeholder group are involved in making FCZ management decisions?

3. How many members of each stakeholder group are involved with enforcement activities?
4. What are the key interests of each stakeholder group?
5. How are these interests affected by the FCZ? (not affected, positively affected, negatively affected, or both positively and negatively affected?)

Example questions to ask stakeholders about their satisfaction:

1. How satisfied are you with the current management of the FCZ?
   1 – Very dissatisfied
   2 – Somewhat dissatisfied
   3 – Neutral
   4 – Somewhat satisfied
   5 – Very satisfied
2. How satisfied are you with your ability to participate in FCZ management?
   1 – Very dissatisfied
   2 – Somewhat dissatisfied
   3 – Neutral
   4 – Somewhat satisfied
   5 – Very satisfied
3. What changes would you like to see to improve your satisfaction with FCZ management?
4. What changes would you like to see to improve your satisfaction with community participation in FCZ management?

Examples of how to interpret the results

An average satisfaction score can be calculated for each stakeholder group and for the community as a whole. Average stakeholder satisfaction scores can be compared between stakeholder groups to see if some stakeholders are more satisfied than others. The satisfaction score can also be compared to the management committee's perceived satisfaction score to see if there is a discrepancy. Changes in this score can be monitored over time in later assessments. A report can be produced that summarizes stakeholder participation and satisfaction.

Questions to consider:

1. Are key stakeholder groups well represented in FCZ management activities through active participation?
2. Are there certain stakeholder groups that could increase their participation in FCZ management activities?
3. Are community members generally satisfied or dissatisfied with FCZ management?
4. If this indicator has been used in a previous assessment, has the level of satisfaction increased, decreased, or stayed the same?
5. Are some stakeholder groups less satisfied than others? You can show this visually using stacked bar graphs of the proportion of people expressing different levels of satisfaction in each stakeholder group.
6. Are there recommendations to improve stakeholder participation or satisfaction in FCZ management?

References

General references are listed in the Introduction to the Governance Indicators section.

Beger, M., A. R. Harborne, T. P. Dacles, J. L. Solandt, and G. L. Ledesma. 2005. A framework of lessons learned from community-based marine reserves and its effectiveness in guiding a new coastal management initiative in the Philippines. Environmental Management 34:786-801.

Chomchanta, P., P. Vongphasouk, S. Chanrya, C. Soulignavong, B. Saadsy, and T. J. Warren. 2000. A preliminary assessment of Mekong Fishery Conservation Zones in the Siphandone area of Southern Lao PDR, and recommendations for further evaluation and monitoring. Data & Information Unit, Living Aquatic Resources Research Center, Vientiane, Lao PDR.

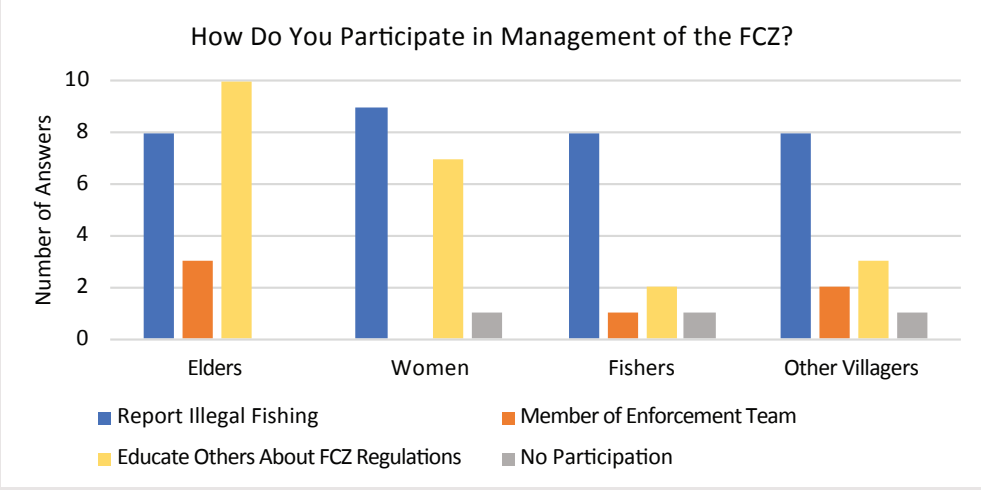
Maliao, R. J., R. S. Pomeroy, and R. G. Turingan. 2009. Performance of community-based coastal resource management (CBCRM) programs in the Philippines: A meta-analysis. Marine Policy 33:818-825.

Velez, M., S. Adlerstein, and J. Wondolleck. 2014. Fishers' perceptions, facilitating factors and challenges of community-based no-take zones in the Sian Ka'an Biosphere Reserve, Quintana Roo, Mexico. Marine Policy 45:171-181.

Case Study Example: Kengmeaw FCZ

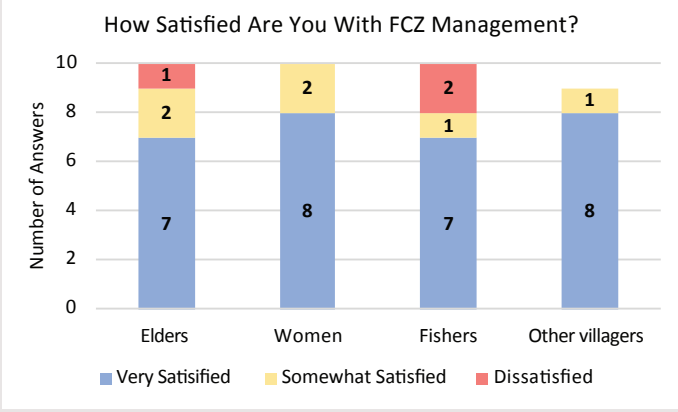
The FCZ assessment team interviewed 39 people in Kengmeaw Village about their participation in FCZ management activities. These people were chosen to represent four groups: elders (10 people), women (10 people), fishers (10 people), and other villagers (9 people). Although it would have been preferable to interview 10 people in the "other villager" category to have an equal sample size among groups, only nine people were available. Almost all of the elders and fishers were male, and the fishers were those who typically fished in the river from boats. Please see the Case Study Example on page 32 regarding the challenges of grouping stakeholders this way.

Participation was categorized in four categories: Report illegal fishing to the village committee; Serve as a member of the enforcement team; Educate others about FCZ regulations, and No participation. Interviewees were allowed to give multiple answers if they participated in multiple ways. The results of this question are graphed below.



Based on these results, it appears that community participation in FCZ management is generally high, with most people participating in reporting illegal fishing when they see it. Elders and women appear to be particularly involved in helping educate others about the FCZ, which can be useful for the fisheries management committee to know if they ever decide to make changes to the FCZ regulations.

Interviewees were also asked to rate their level of satisfaction with the FCZ regulations as either: Dissatisfied; Somewhat satisfied; or Very satisfied. The results of this question are graphed to the right.



An average satisfaction score can be calculated for each stakeholder group and for the community as whole by assigning a value to each answer. For example:

Very satisfied = 3

Somewhat satisfied = 2

Dissatisfied = 1

For the total of 39 people interviewed:

Very satisfied = (Score of 3)*(30 people) = 90

Somewhat satisfied = (Score of 2)*(6 people) = 12

Dissatisfied = (Score of 1)*(3 people) = 3

Average satisfaction score = (90+12+3)/39 people = 105/39 = 2.7

The same formula can be used to calculate a satisfaction score for each group of people interviewed:

Elders = [(3*7 people)+(2*2 people)+(1*1 person)]/10 people = 26/10 = 2.6

Women = [(3*8 people)+(2*2 people)]/10 people = 28/10 = 2.8

Fishers = [(3*7 people)+(2*1 person)+(1*2 people)]/10 people = 25/10 = 2.5

Other villagers = [(3*8 people)+(2*1 person)]/9 people = 26/9 = 2.9

Based on these results, most community members appear to be satisfied with FCZ management. It is interesting to note that fishers are the group with the lowest satisfaction score, which is understandable because their activities are most directly affected by the FCZ. It would have been valuable for the assessment team to ask follow-up questions during the interview to ask why these people said they were dissatisfied with FCZ management. Understanding why people are dissatisfied can help the fisheries management committee think about how they might adjust their management strategy or outreach efforts with the community, particularly with fishers.

G6. Clear enforcement procedures and level of patrolling effort

Description (What is this?)

This indicator assesses the guidelines and procedures used by the people who enforce the regulations of the FCZ. Such guidelines should describe how the enforcement personnel should act depending on the types of violations they encounter. It can also assess the amount of effort spent patrolling to monitor the FCZ, such as the amount of area patrolled, the amount of time spent patrolling, and the frequency of patrolling.

Why measure this?

Enforcement is a key element of a successful FCZ because without it, people might still catch fish in the protected area and affect aquatic animal or plant populations. Having clear procedures can help make enforcement teams more effective, and help community members understand the consequences of violating the FCZ regulations. Therefore, it is helpful to also measure Indicator G3, *Local understanding of FCZ rules and regulations* in addition to Indicator G6, so that you can also determine the level of community understanding. Enforcement effort is a measure of the thoroughness and consistency of enforcement team activities. A higher amount of enforcement effort may increase the likelihood of encountering and apprehending people who violate the FCZ regulations. Understanding enforcement effort can help identify trends in violations.

General considerations for data collection

- This indicator can be assessed by interviewing key informants, such as the enforcement team and fisheries management committee.
- The assessment should examine supporting documents, such as the FCZ management plan, and any logbooks of patrol records and recorded violations.
- A less technical method would be to interview the enforcement teams about their procedures and enforcement effort. However, it would be important to validate the information gathered in this interview with information from another source, such as by interviewing resources users as discussed below.
- A more technical method would be to both conduct interviews and directly observe and record the enforcement procedures during patrolling. Observations should be made of multiple patrols to assess enforcement consistency.
- Interviews can also be conducted with resource users (fishers) to ask how enforcement team members act during a patrol, and any problems that might arise. This question could be asked when conducting interviews for Indicator G5, *Level of community participation and satisfaction in management.*
- The amount of effort required for effective enforcement may be related to the distance of the FCZ from the village.
- Ideally, data on enforcement procedures and effort should be collected at least once every three years.

Example methods

Examples of questions that may be asked during semi-structured interviews or answered by direct observation include:

1. Does the community have informal enforcement, where all community members are involved in reporting violations?
2. Is there a system for community members to report violations to the enforcement team or authorities?
    a. Are community members aware of this system?
3. Does the community have formal enforcement by members of an official patrol team?
    a. What is the membership of the enforcement team and what are their roles?
    b. How is the membership determined and how are vacancies filled? Are these procedures documented?
4. Is there a logbook system to record patrols and violations?
5. Are enforcement records kept regularly?
6. Are there formal or informal guidelines for when, where, and how often to patrol the FCZ?
    a. Are these guidelines documented in writing?
    b. Is a copy of the guidelines available and accessible to enforcement team members?
7. When does patrolling occur and for how long? How is this decided?
8. Where and how is patrolling completed? (In the FCZ by boat? From a guard post on land?)
9. How frequently are patrols conducted?
10. What time of day or night do patrols occur, and how long is each patrol?
11. How many hours are spent patrolling per day/week/month?
12. How much of the FCZ area is covered during a patrol?
13. Does the patrolling effort change throughout the year (seasonally)?
14. Is there a procedure for confronting and apprehending violators?
15. Is there a procedure for reporting violations to local authorities, such as the District Agriculture and Forestry Office (DAFO)?
    a. Do these authorities follow-up on reports from the community?
16. Are enforcement staff trained in the enforcement guidelines and procedures?
17. Are enforcement procedures periodically reviewed and updated?
18. Is there a procedure for holding or disposing of confiscated gears?
19. What is the number of successful apprehensions of illegal fishers that have been made following the enforcement procedures in the past year?
20. Have any apprehensions or penalties failed? Was this due to weaknesses in the procedures?
21. Have these procedures been modified since the establishment of the FCZ? If so, then please describe.

Examples of how to interpret the results

A report can be produced that summarizes the enforcement procedures and identifies any gaps or areas for improvement.

If this indicator is measured over time, the open question responses and yes/no responses (such as, "Are enforcement records kept regularly?") can be compared in a table to responses from previous years to see if the enforcement procedures are becoming better documented over time.

For questions with numeric responses (such as, "How many hours are spent patrolling per day/ week/month? What is the proportion of illegal fishers that have been successfully apprehended during the past year?"), graphs can be made to compare changes over time.

A map can be drawn that shows the area patrolled, and any variations in patrolling patterns (Figure 6).

Questions to consider:

1. What are the strengths of the current enforcement procedures? What are the weaknesses of the procedures?
2. How well documented are the procedures?
3. Is the enforcement coverage enough to discourage or catch violators?
4. Is it possible that illegal fishers could be avoiding patrols?
5. If this indicator has been used in a previous assessment, has there been any change in the frequency or duration of patrols?
6. Are there recommendations to improve enforcement procedures or effort?

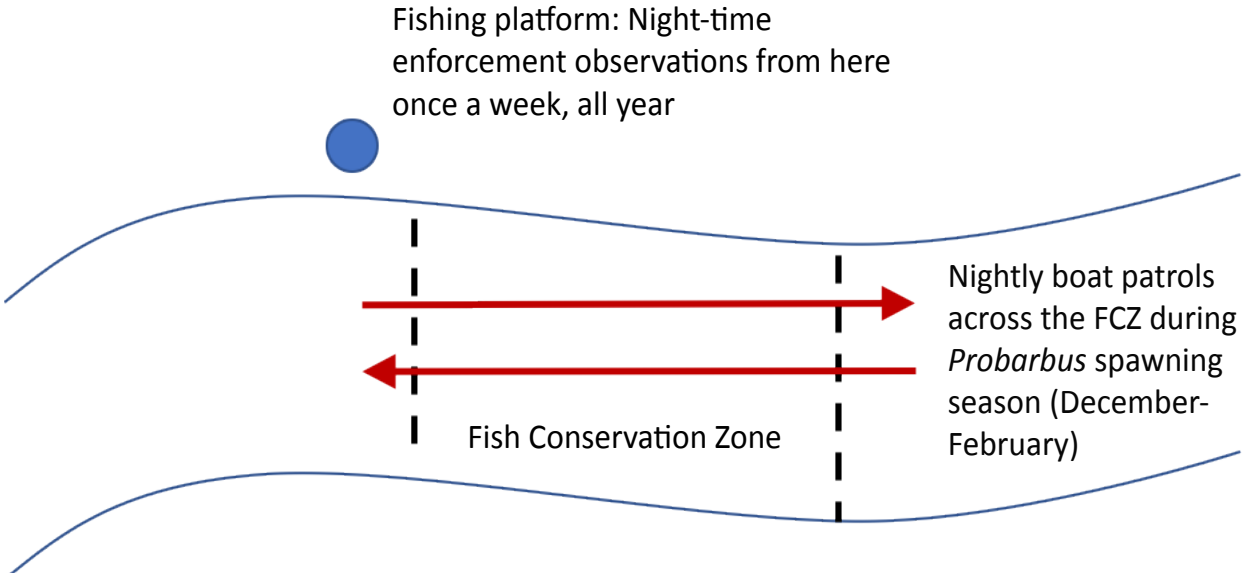


Figure 6. *Example patrolling effort map.*

Case Study Example: Kengmeaw FCZ

The FCZ assessment team interviewed the Kengmeaw community enforcement team to learn about their enforcement procedures.

This is the information they recorded:

> *The whole community is involved with reporting illegal fishing in the FCZ. During the day time, the enforcement team follows up on reports of illegal fishing that they receive from members of the community. During the night time, the enforcement team conducts regular patrolling. There are four patrol teams in the village. One patrol team works every night, and a new team works the following night. Each team consists of five people: three village soldiers and two village police.*
>
> *Nighttime patrols last from 6 PM until 6 AM the next day. During each patrol, the team conducts four rounds of inspection, and each round lasts about 30 minutes. Due to the small size of the FCZ, the team does their patrolling on foot rather than by boat. The patrol team walks to the FCZ during each inspection, which is a distance of about 125 m from the village. There are two critical points where violators tend to fish in the FCZ: one in the upstream section and one in the downstream section. The patrol team uses flashlights during their inspection and cell phones to facilitate communication.*

From this report, it appears that the enforcement team has clear procedures and regular enforcement effort, but these procedures do not appear to be documented in writing. The assessment team recommended that the enforcement team formalize their patrolling procedures in writing and keep a logbook of their patrols so they can document their enforcement effort and make notes about what they encounter during their patrols. This can help calculate a violation ratio for Indicator G7, *Level of compliance with FCZ regulations.*

G7. Level of compliance with FCZ regulations

Description (What is this?)

This indicator measures the extent to which people are complying with or violating the regulations of the FCZ. This includes both violations that are formally reported by the enforcement team and that may or may not have resulted in an apprehension or a fine, as well as violations that are observed and informally reported by the community.

Why measure this?

FCZs are only meaningful and effective as conservation tools if people follow the regulations. Therefore, the level of compliance with FCZ regulations may be one of the most important governance indicators to measure. If compliance with regulations is very low, then it is unlikely that the FCZ will be able to achieve many of its desired benefits.

General considerations for data collection

- Compliance can be difficult to measure because people may not feel comfortable talking about how they, or others in the community, break regulations. If interviews are conducted, it is important to ensure that they are conducted in a comfortable setting, once trust has been established between the interviewer and the respondent. This could mean collecting this indicator towards the end of an assessment, rather than at the beginning.
- In order to collect the most accurate data for this indicator, it may be important to conduct interviews one-on-one with people (not in a group) so they feel more comfortable about speaking freely, and to record the interview responses on anonymous data sheets.
- Interviews may be conducted both with the community to ask about general compliance and informally observed violations, as well as with members of the enforcement team and local government officials to ask about officially documented violations and those that resulted in fines.
- Supporting documents can also be reviewed, such as logbooks of patrol records and reports of violations.
- Ideally, compliance with FCZ regulations should be measured every year.

Example methods

Examples of questions that may be asked to both members of the community and the enforcement team during semi-structured interviews include:

1. In general, how many people follow the regulations of the FCZ, on a scale of 1 to 5? (1= almost no one, 5 = almost everyone)
2. If no one is breaking the rules of the FCZ, why do you think this is?
3. If people are breaking the rules of the FCZ:
    - Why do you think this is?
    - What kinds of people typically break the rules of the FCZ? (Are they members of the community or from outside the community? Are they people in positions of power?)
    - What types of fishing gear do violators typically use inside the FCZ? (Gill nets? Electrofishing? Dynamite?)

4. How frequently are people violating the rules of the FCZ?
    - Never
    - A few times a year
    - Monthly
    - Weekly
    - Daily

Examples of questions that may be asked to members of the enforcement team and government officials include:

1. How frequently is fishing gear found in the FCZ?
    - Never
    - A few times a year
    - Monthly
    - Weekly
    - Daily
2. What is the number of violations reported by community members per year?
3. What is the number of violations observed by the enforcement team per year?
4. Is there a time of year (season) when there are more violations?
5. How many violators have been confronted or successfully apprehended during patrols over the past year?
6. How many violators were given warnings during the past year? Were these warnings officially documented?
7. How many apprehended violators have been made to pay fines during the past year?
8. How many violators have been observed but not confronted, apprehended or fined during the past year? Why not?

Examples of how to interpret the results

A narrative report can be produced that describes the frequency and type of FCZ violations, and how this compares with the number of people who are actually apprehended and fined.

A violation ratio can be calculated by dividing the number of violations encountered by the number of hours spent patrolling (which can be obtained from measuring Indicator G6, *Clear enforcement procedures and level of patrolling effor*t). This ratio can be tracked over time to observe changes.

- Ex: 5 violations/80 hours of patrolling = 0.0625 violations/hour of patrolling

If almost no one is violating the rules according to both the community members and the enforcement team, and the proportion of successful apprehensions of illegal fishers is high, then this is an indication of a well-functioning enforcement process.

If this indicator is measured over time, the open question responses and yes/no responses (e.g., If no one is breaking the rules of the FCZ, why do you think this is?) can be compared in a table to responses from previous years to see if there has been a shift in perception regarding the motivations for compliance.

For questions with numeric responses (such as, What is the number of violations reported by community members per year?), graphs can be made to compare changes over time in this response.

A report can be prepared that summarizes the extent and patterns of compliance or noncompliance with FCZ regulations. If people are violating the regulations of the FCZ on a regular basis, then this situation might be addressed with more regular enforcement patrols. However, if violations occur rarely and sporadically, this might be harder to address. If this indicator shows consistent violations of the regulations, then results of other indicators, such as G5, *Level of community participation and satisfaction in management*, or S4, *Perception of benefits derived from the FCZ*, may offer insight into why there is so little compliance. Understanding the reason for the lack of compliance would be key to improving FCZ management.

Case Study Example: Kengmeaw FCZ

The assessment team asked a sample of 39 community members (about 5% of the village population) whether they thought people in the community were following the rules of the FCZ, and all of the interviewees responded "Yes." The assessment team also asked the enforcement team about the number of officially reported violations that resulted in fines. The answers were:

1. In 2010, 1 person from the village using a gill net was fined 500,000 LAK.
2. In 2011, 1 person from the village using a gill net was fined 500,000 LAK.
3. In 2014, 1 person from the village using a cast net was fined 500,000 LAK.
4. In 2017, 1 person from outside the village using hook and line was fined 500,000 LAK. He said he did not see the FCZ signboard.

Based on these results, it appears that compliance with the regulations is generally high, and that the enforcement team has experience with apprehending and fining people who break the rules. To get a more complete understanding of compliance at the FCZ, it would have been valuable to ask about how many people break the rules but were not apprehended, or who were apprehended but not fined. It would also be informative to have information on the enforcement effort (which can be obtained from measuring Indicator G6, *Clear enforcement procedures and level of patrolling effort*) to calculate a violation ratio. If the ratio was relatively low for each year, then this would be another indication that compliance is high. Based on the most recent fine, one recommendation to the fisheries management committee would be to make sure the signs demarcating the FCZ are clearly visible and legible, and to conduct outreach about the FCZ with neighboring villages. Over time, FCZ signs can become faded, damaged, or overgrown with vegetation.

Questions to consider:

1. Are there recommendations to improve compliance with the FCZ regulations? (More or improved signs? More or improved education and outreach with the community and neighboring villages?) Is the enforcement coverage enough to discourage or catch violators?
2. If there is a difference between the community's perception of how many people are following the regulations and the number of violations observed by the enforcement team, is it possible that illegal fishers could be avoiding patrols?
3. If this indicator has been used in a previous assessment at this FCZ, has there been any change in the violation ratio? If there has been a change, is there any evidence as to why this change has occurred?
4. If the proportion of successful apprehensions of illegal fishers has been low, why are violators getting away? Does the enforcement team have the resources and training they need to pursue violators (based on Indicator G4, *Availability and use of FCZ administrative resources*)?

Socioeconomic Section

Introduction

Fish and other aquatic animals provide food and a source of income to many people in Lao PDR. Therefore, if FCZs successfully increase or benefit fish populations, they are expected to also provide increased food and income benefits to local communities. Many FCZs in Lao PDR are established with the expectation that they will provide socioeconomic benefits to the community that will outweigh any socioeconomic costs related to fishing restrictions included in the FCZ regulations. Therefore, assessing socioeconomic indicators related to food and livelihoods is important for determining the success of these FCZs.

This guidebook considers socioeconomic benefits for FCZs that can generally be categorized under four different goals: 1) enhancing or maintaining food security, 2) enhancing or maintaining livelihoods, 3) respecting cultural values and practices, and 4) enhancing environmental awareness and knowledge.

Table 4 describes a checklist of FCZ socioeconomic goals and desired benefits with a list of related indicators. The first step in deciding which indicators are best to use for your assessment is to mark the goals and desired outcomes that are related to your FCZ (please see the section in the Introduction on page 8 about the importance of defining clear goals before the assessment). The checklist will help you narrow down and focus on the indicators that are most useful for your specific FCZ goals. Of the seven socioeconomic indicators included in the guidebook, some are relevant for more than one set of goals and desired benefits (Table 4). This list of indicators is not exhaustive, and there may be other indicators that are relevant to your FCZ. For a list of additional indicators, see Appendix 1.

The description of each socioeconomic indicator in this section includes a list of example methods and suggested questions that may be included in surveys to measure that indicator. Please keep in mind that these are just examples, and other or additional methods may be appropriate for your assessment. There is sometimes a clear link between socioeconomic indicators and ecological indicators (such as fishing effort or changes in fish populations, whether perceived or documented), and we have noted where information for these indicators may be collected at the same time.

General Considerations for Socioeconomic Data Collection

Important considerations and methods that can be used to collect data on the socioeconomic indicators are described in the Introduction to the Governance Section on page 21. The section includes guiding principles, identifying stakeholders, methods for data collection, suggested sample sizes, and advice for conducting interviews. Please refer to this section for advice on planning a socioeconomic assessment, as well as the references listed below.

References

The following reference are cited above or provide more information that is relevant to all the socioeconomic indicators included in this guidebook:

Bunce, L., P. Townsley, R. Pomeroy, and R. Pollnac. 2000. Socioeconomic Manual for Coral Reef Management. Australian Institute of Marine Science, Townsville, Australia. Available at www.reefbase.org.

Hoon, V., G. Sriskanthan, P. Townsley, B. Cattermoul, L. Bunce, and B. Pomeroy. 2008. Socioeconomic Monitoring Guidelines for Coastal Managers of South Asia. SocMon South Asia. IUCN/CORDIO.

Pomeroy, R. S., J. E. Parks, and L. M. Watson. 2004. How is Your MPA Doing? A Guidebook of Natural and Social Indicators for Evaluating Marine Protected Area Management Effectiveness. IUCN, Gland, Switzerland and Cambridge, UK.

Rea, L. M., and K. R. Parker. 2014. Designing and Conducting Survey Research: A Comprehensive Guide. 4th edition. Jossey-Bass, San Francisco, California.

Table 4. *List of desired FCZ socioeconomic benefits, related indicators, and example questions that can be answered by measuring each indicator.*

Desired Socioeconomic Benefits and Outcomes		Indicators	Questions to Consider
Improve Food Security and Livelihoods	□ The community can catch more fish	□ Local fishing patterns and practices (S1)	• How much effort are people spending to catch fish?
		□ Perceptions of local fish catch (S2)	• Are people catching more fish now than in the past?
		□ Perception of benefits derived from the FCZ (S4)	• Do people think the FCZ is providing them more fish to catch?
	□ The community has more fish to eat	□ Patterns of household fish consumption (S3)	• Are people eating more locally caught wild fish now than in the past?
		□ Perception of benefits derived from the FCZ (S4)	• Do people think the FCZ is providing them more fish to eat?
	□ The FCZ supports community livelihoods	□ Household income/effort distribution by source (S5)	• How many households are engaged in activities affected by the FCZ? How important are these activities to their income?
		□ Local fishing patterns and practices (S1)	• Are the fishing livelihood activities in the community affected by the FCZ?
		□ Perception of benefits derived from the FCZ (S4)	• Do people think the FCZ has helped provide them with more income?

Desired Socioeconomic Benefits and Outcomes		Indicators	Questions to Consider
Respect Cultural Values and Practices	□ The FCZ does not negatively affect traditional practices, relationships, or social systems	□ Local fishing patterns and practices (S1)	• Do people still engage in culturally important fishing practices and activities in or around the FCZ?
		□ Local values and beliefs about aquatic resources (S6)	• What traditional values and beliefs does the community have about the area and environment where the FCZ is located? Are FCZ management activities compatible with these values and beliefs?
	□ Maintain/increase respect for and observance of traditional beliefs and practices	□ Local fishing patterns and practices (S1)	• Does FCZ management support the practice of culturally important fishing activities in or around the FCZ?
		□ Local values and beliefs about aquatic resources (S6)	• Does FCZ management provide an opportunity to increase awareness and respect for traditional values and beliefs about the aquatic environment?
Increase Understanding and Support for Conservation	□ Increase environmental awareness and knowledge	□ Level of environmental awareness and understanding of conservation (S7)	• Do community members understand the purpose of conservation in the FCZ?
		□ Perceptions of local fish catch (S2)	• Do community members understand the relationship between overfishing and fish population declines? Do community members understand how the FCZ can help address fish declines?
	□ Promote ecotourism	□ Household income/effort distribution by source (S5)	• Which activities around the FCZ are related to ecotourism? How many households are engaged in activities related to ecotourism? How important is ecotourism to their income?

Socioeconomic Indicators

S1. Local fishing patterns and practices

Description (What is this?)

This indicator looks at patterns in the ways community members fish, harvest, and otherwise use aquatic resources. Aquatic resources may be fish, crustaceans and other aquatic animals, or aquatic plants.

Why measure this?

Looking at changes in fishing patterns and practices can help determine whether the FCZ is making it harder or easier for people to catch fish (or other aquatic animals), or whether people are harvesting these resources in different ways as a result of the FCZ. Understanding fishing patterns can also help FCZ managers adjust regulations to accommodate community needs, such as opening the FCZ during certain times of year, or allowing certain kinds of fishing gear or harvest in certain portions of the FCZ. This indicator has some overlap with Ecological Indicator E5, *Total catch per unit of fishing effort.*

General considerations for data collection

- This indicator can be measured using focus group interviews or household/individual interviews of fishers to understand their patterns of resource use.
- This indicator can also be measured by making direct observations of fishers to record fishing patterns, such as observing fishing trips, recording activities by the river, etc. (a more technical method).
- This indicator could be expanded to account for all aquatic uses around the FCZ by all groups of people, including men, women, and children. This may include uses other than fishing, such as washing motorbikes, bathing livestock, collecting drinking water, etc.
- Ideally, data on fishing patterns and practices should be collected every year and divided into seasons.

Example methods

Examples of questions that may be asked during interviews or answered by direct observation include:

1. What types of aquatic resources are being harvested using all types of methods? (fish, insects, riverweed, etc.)
2. Who is fishing? (How many people, gender, age, status, etc.)
3. Where are they fishing? (Which habitats? How close to the FCZ?)

4. When are they fishing? (Seasonal patterns? Time of day/night?)
5. What species are they catching? (Are there key species? What are the important or dominant species in the catch? How many kilograms of each important species are caught each month?)
6. How are they fishing? (What gear types are used? Are people fishing from boats or on shore?)
7. Are people using the rivers/waterbodies for other uses such as collecting drinking water, bathing, washing clothes, etc.? Where and when does this occur?
8. Have changes occurred to fishing activities or other aquatic activities since the FCZ was established? If yes, what changes? How might the FCZ have affected fishing activities or other aquatic activities?

Examples of how to interpret the results

A fishing and resource-use map (Figure 7) can be created that shows where and when different activities occur in the aquatic environment around the FCZ.

A fishing and resource-use calendar (Figure 8) can be created that shows seasonal patterns and timing of various activities throughout the year.

A community fishing profile (Table 5) can be created that includes:

- The number of fishers
- The age and gender of fishers
- The number of fishing boats
- An inventory of gear types used (Table 6)

A narrative report can be prepared that summarizes patterns in fishing and aquatic resource use.

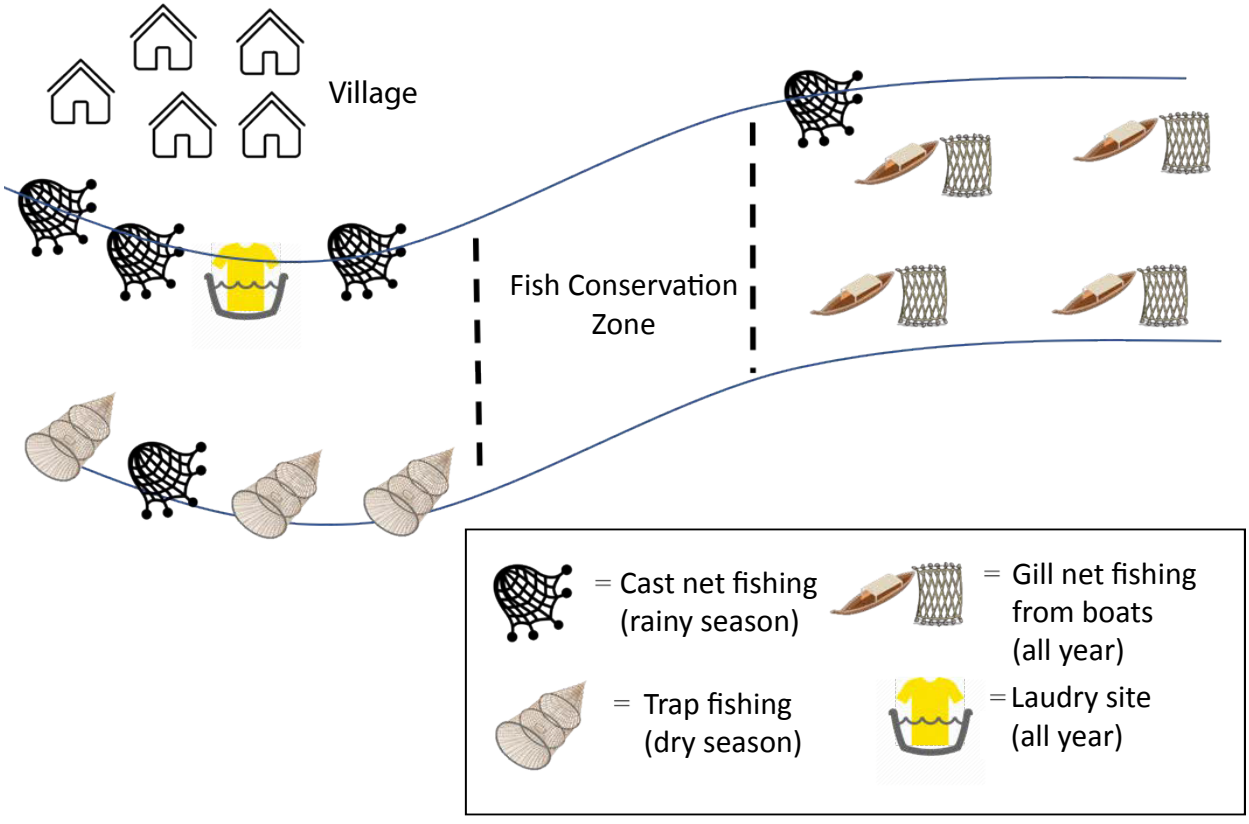


Figure 7. *Example fishing and resource-use map.*

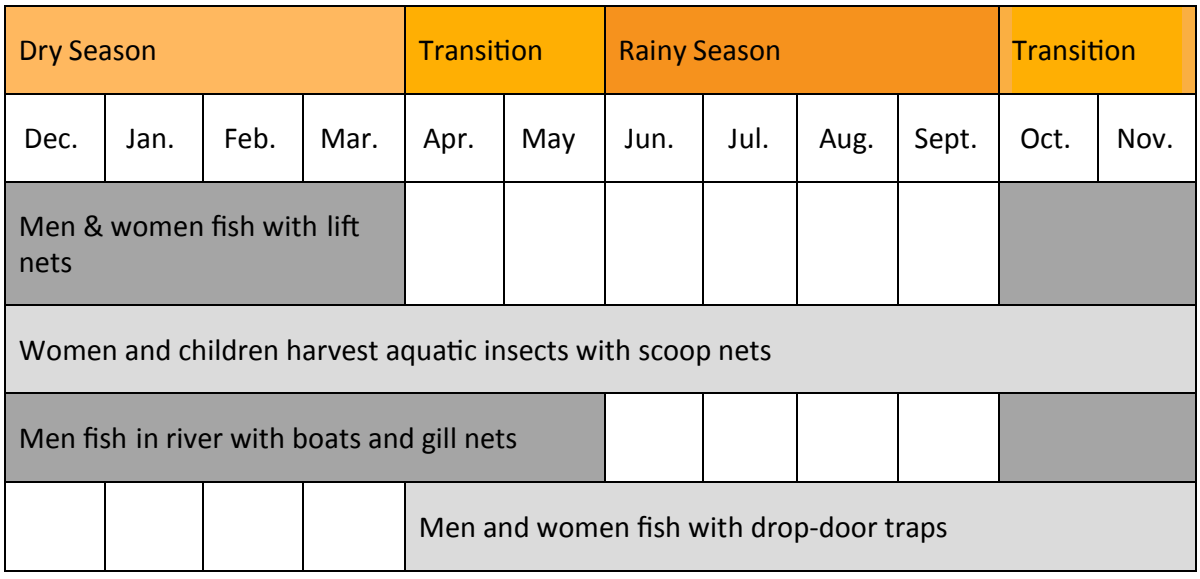


Figure 8. *Example fishing and resource-use calendar.*

Table 5. *Example community fishing profile.*

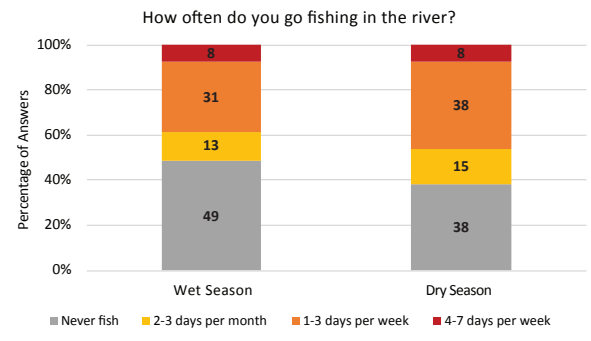
Fisher Age	#Male Fishers	Primary Gear Types	# Female Fishers	Primary Gear Types
0–9 years	3	Scoop nets	8	Scoop nets
10–19 years	5	Scoop nets, hook and line	8	Scoop nets, lift nets
20–29 years	10	Gill nets, long lines	20	Scoop nets, lift nets
30–39 years	20	Gill nets, long lines	15	Lift nets, basket traps
40–49 years	15	Gill nets, long lines	10	Scoop nets, basket traps
50–59 years	5	Gill nets	5	Scoop nets
60–69 years	3	Basket traps	0	———
70 and older	3	Basket traps	0	———
Total	**64**		**66**	

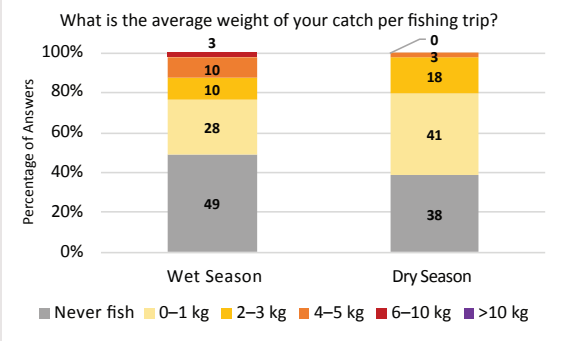
Table 6. *Example inventory of gear users.*

Fishing Gear Types	# Male Users	# Female Users	# Total Users (Male + Female)
Long lines	10	0	10
Gill nets	6	3	9
Basket traps	7	7	14
Scoop nets	0	20	20

Case Study Example: Kengmeaw FCZ

The FCZ assessment team asked a sample of 39 Kengmeaw community members (about 5% of the village population) how frequently they went fishing in the wet and dry seasons, and the average weight of their fish catch per fishing trip in each season. The community members represented a mix of elders, women, fishers, and other villagers. Almost all of the elders and fishers were male, and the fishers were those who typically fished in the river from boats. The results of these questions are shown below.





Based on these results, it appears that many people in the village do not fish at all, and of those that do, it is most common to fish a few days per week. The frequency of fishing is similar in the wet and dry seasons, with slightly more people fishing in the dry season. Fish catches are generally small, and most people who fish reported catching 1 kg of fish or less per fishing trip in both seasons. More people reported larger catches (4–5 kg or 6–10 kg) in the wet season. If the assessment team measures this indicator again in a future assessment, they will be able to see whether changes are occurring in the frequency or average weight of fishing catches over time, and investigate whether these changes might be related to the FCZ.

Questions to consider:

1. Are there locations where multiple resource uses overlap?
2. Are local fishing patterns compatible with FCZ management? Are there conflicts?
3. Have fishing patterns changed after the FCZ was established?
    a. For example, after collecting data on gear users for multiple years, you can graph the number of male and female users of various fishing gear types to see if there is a change over time.
4. Are people spending more time and effort fishing after the FCZ was established? Do they have to travel farther to fish because their original fishing grounds are now protected in the FCZ?
5. Are there recommendations that can be made to make FCZ management more compatible with local fishing patterns?
6. Are there recommendations that can be made to make fishing and other resource use patterns more sustainable?

References

General references are listed in the Introduction to the Socioeconomic Indicators section.

Chomchanta, P., P. Vongphasouk, S. Chanrya, C. Soulignavong, B. Saadsy, and T. J. Warren. 2000. A preliminary assessment of Mekong Fishery Conservation Zones in the Siphandone area of Southern Lao PDR, and recommendations for further evaluation and monitoring. Data & Information Unit, Living Aquatic Resources Research Center, Vientiane, Lao PDR.

S2. Perceptions of local fish catch

Description (What is this?)

This indicator measures what local fishers think about their current catches of fish or OAA, and how these catches may have changed over time.

Why measure this?

Natural resource users such as fishers can have a unique perspective and understanding about their local environment. This indicator assesses local ecological knowledge, and is an indirect way of assessing whether fish populations have increased or decreased. It can be measured to complement ecological indicators E1b, *Abundance of key species*, and E5, *Total catch per unit of fishing effort*. FCZs have the potential to increase fish catches outside their borders through spillover, and measuring changes in this indicator through time is one way of assessing FCZ spillover. If local perceptions of catches are positive, fishers may be more supportive of FCZ management. If local perceptions of catches are negative, then fishers may be less supportive of FCZ management, and changes in management may be needed if the FCZ is not achieving its goals, or increased outreach may be needed to explain that the benefits of FCZs may take time to occur. Perceived changes in fish catch may also be due to reasons unrelated to the FCZ. It is therefore valuable to ask community members why they think such changes are occurring. It could also be valuable to measure ecological indicators E6, *Water quality* and E7, *Habitat distribution and quality,* to understand if there are changes in the river unrelated to the FCZ that may be affecting fish abundance.

General considerations for data collection

- This indicator should be measured by conducting a survey with individual fishers.
- This indicator should take into account the perceptions of a wide range of fishers, including men and women.
- Women often process the fish that men catch, whether through cooking, drying, or fermenting. It may be useful to ask women about trends in fish processing in addition to harvesting.
- Ideally, data on perceptions of fish catches should be collected at least once every three years.

Example methods

<u>Increasing/decreasing survey:</u>

Surveys may be conducted to specifically examine whether the fisher being interviewed perceives various metrics of harvest to be increasing or decreasing, and by how much. Examples of multiple-choice questions or open-ended questions that may be asked during semi-structured interviews include:

1. Since the FCZ was established (or during the last 5 years or 10 years, etc.), have total catches in (a species of interest):
    a. increased a lot
    b. increased a little
    c. stayed the same
    d. decreased a little
    e. decreased a lot
    f. I don't know/I don't have an opinion

2. Since the FCZ was established (or during the last 5 years or 10 years, etc.), have the sizes of (a species of interest):
    a. increased a lot
    b. increased a little
    c. stayed the same
    d. decreased a little
    e. decreased a lot
    f. I don't know/I don't have an opinion
3. Since the FCZ was established (or during the last 5 years or 10 years, etc.), has the amount of time you've spent fishing (to catch a species of interest, or to catch fish using a certain gear type):
    a. increased a lot
    b. increased a little
    c. stayed the same
    d. decreased a little
    e. decreased a lot
    f. I don't know/I don't have an opinion
4. If changes have occurred in your fishing catch, sizes of key species, or your amount of fishing effort, why do you think these changes have occurred? Have there been events or activities since the FCZ was established that are unrelated to the FCZ and that may influence your fishing catch and effort?

Ladder-scale diagram

A more technical method is to use a ten-point ladder scale (Figure 9), where 1 is the worst situation and 10 is the best situation. The person being interviewed is asked to choose a position on the ladder scale to represent today, and a position on the ladder scale to represent the relative fish abundance during a time in the past (before the FCZ was established, or 5 years ago, 10 years ago, etc.).

Each step on the ladder can be represented with beans, rocks or other physical objects (used as "counters") to show differences in abundance.

Questions to ask the person being interviewed:

1. Which step on the ladder represents your total catch or catch of (a species of interest) today?
2. Which step on the ladder represents your total catch or catch of (a species of interest) before the FCZ was established?

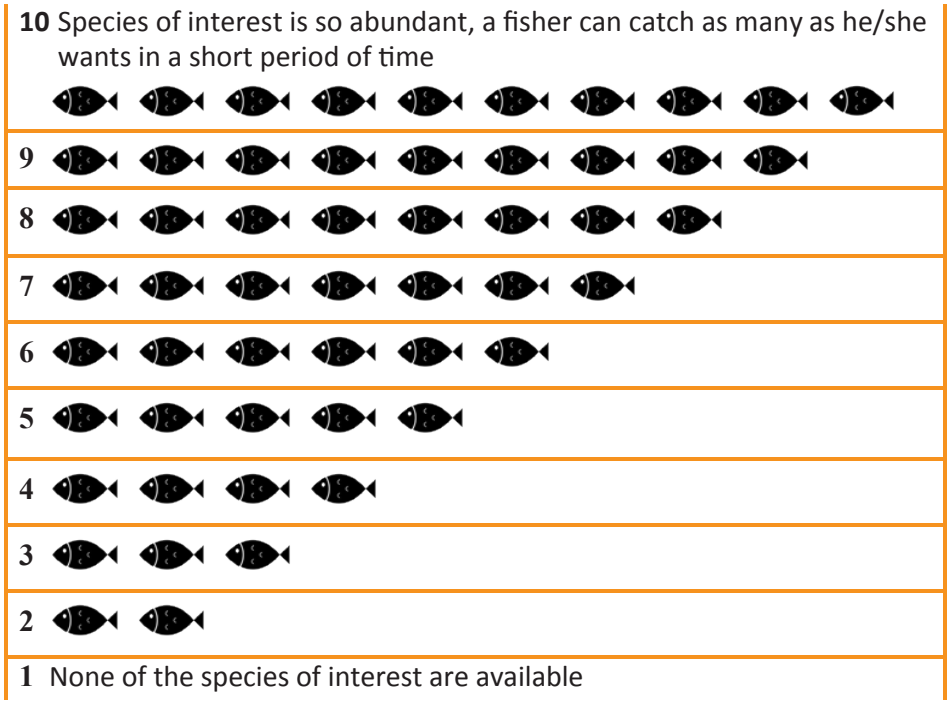


Figure 9. *Example ladder-scale diagram.*

Examples of how to interpret the results

Increasing/decreasing survey:

A table can be made that shows the percentage of respondents that chose each answer of a survey. These results can also be graphed using a bar graph. You can compare responses for each question or compare responses for a single question over time using stacked bar graphs, where each bar shows the percent of different responses to a question, and all bars add up to a total of 100%.

Ladder-scale diagram

First, calculate the average scores for "Past" (Time 1; T1) and "Today" (Time 2; T2) See Table 7.

Next, calculate the difference between today and the past (T2 – T1):

T2 – T1 = 3.4 – 7.4 = **- 4**

Finally, use statistics software such as Excel to conduct a *paired sample t-test* to test whether the average scores are significantly different between Today and Past. In this example, the *p-value* is <0.01, so the difference in perceived catches between Today and Past is statistically significant.

Because the difference between Today and Past is a negative number (-4), perceived fish catches have significantly decreased between the Past and Today. (If the difference between Today and Past is a positive number, perceived fish catches have increased between the Past and Today.)

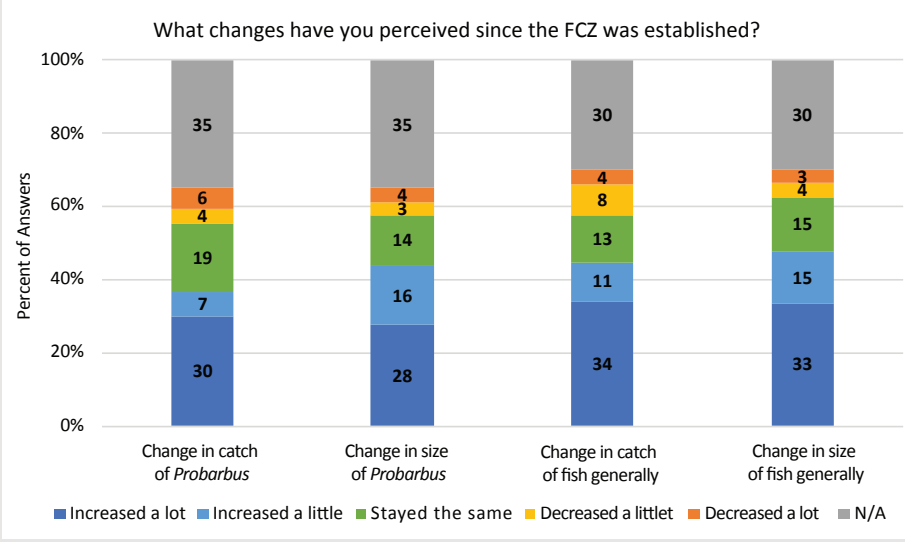
Table 7. *Example ladder-scale diagram survey results.*

	Past (T1) Score	Today (T2) Score
Fisher 1	6	4
Fisher 2	8	2
Fisher 3	8	5
Fisher 4	9	3
Fisher 5	6	3
Average:	37/5 = **7.4**	17/5 = **3.4**

Case Study Example: Northern Laos FCZs

The FCZ assessment team interviewed a total of 123 people from the three villages that manage the Northern Laos FCZs (60 people from Houaykhoualouang Village, 37 people from Korkfak Village, and 26 people from Pakpee Village), representing about 14% of the population in all villages combined. The interviewees were a mix of elders, women, fishers, and other villagers. Almost all of the elders and fishers were male, and the fishers were those who typically fished in the river from boats. The assessment team asked interviewees how they thought the total catches and sizes of all fish species had changed since the FCZ was established. They also asked interviewees how they thought the catches and sizes had changed for *Probarbus* spp., a local target species for fishers and a key species of conservation interest for the FCZ. The FCZ was established in 2014, and the interview took place in 2018.

Interviewees were asked whether they thought catches or sizes had Increased a lot; Increased a little; Stayed the same; Decreased a little; or Decreased a lot. If the interviewee did not have an opinion about the changes, their response was recorded as N/A. The results of the surveys are shown below:



The results indicate that most of the community members who answered the question perceived that fish catches and sizes have increased since the FCZ was established. While this suggests a general positive perception of the fish populations that may be attributable to the FCZ's performance, it would be valuable to compare this indicator to S4, *Perception of benefits derived from the FCZ*, to verify if community members believe these changes are the result of the FCZ, and to directly assess the fish populations using ecological indicators (E1, E2, or E3) to verify if such changes are actually occurring.

S3. Patterns of household fish consumption

Description (What is this?)

This indicator looks at how much fish people are consuming in the community and how frequently they are consuming it. It can be used to compare the amount of wild-caught fish that people eat compared to farm-raised fish, and can compare the amount of fish consumed to other forms of protein.

Why measure this?

FCZs are often established with the hope that they will improve the food security of local communities by increasing the abundance of fish populations that can then be caught and consumed. Wild-caught fish provides an important source of protein and micronutrients for many people in Lao PDR that is available to harvest from nature. Measuring this indicator can help identify whether the community is eating more or less fish since the establishment of the FCZ. This indicator is based on the assumption that if there are more wild fish available for fishers to catch (presumably from spillover from the FCZ), then there would also be an increase in wild fish consumption in the local community. Alternatively, if there are fewer wild fish available for capture due to the fishing restrictions of the FCZ, the assumption is that fewer wild fish will be consumed in local households. While the hope is that the FCZ will help provide more fish to the community over the long-term, there may be an initial decrease in fish consumption after FCZ establishment due to fishing restrictions in the FCZ.

It is important to keep in mind that many other factors could influence household fish consumption besides the availability of locally caught wild fish. For example, an increase in market access to affordable farm-raised fish or wild fish from other areas could lead to a decrease in locally caught wild fish consumption, regardless of the availability of wild fish. Therefore, this indicator is best used along with other indicators such as E5, *Total catch per unit of fishing effort*; S2, *Perceptions of local fish catch;* and S5, *Household income/effort distribution by source*, which together can describe whether fish availability alone, or other livelihood factors may be contributing to a change in household fish consumption.

General considerations for data collection

- Data for this indicator can be collected by conducting semi-structured interviews with a sample of households in the community.
- The primary food purchaser or food preparer of a household should be interviewed to measure this indicator.
- If villagers being interviewed are not familiar with reporting in percentages, you can give them objects (such as beans or rocks) that they can divide up to show proportions, such as the proportion of wild-caught fish that they obtain from different sources, or the proportion of fish that they eat compared to other forms of protein.
- If there is a substantial difference in household fish consumption by season, then you can ask interviewees to answer the questions for each season.
- Ideally, data on fish consumption should be collected at least once every three years.

Example methods

Examples of closed questions and open-ended questions that may be used during semi-structured interviews include:

1. Are there seasons or times of year when more wild fish are available for consumption? Are there seasons or times of year when fewer wild fish are available for consumption? (If the interviewees report that there are seasonal differences in fish availability or consumption, then consider asking Questions 2–5 separately for each season).
2. How many days per week on average do you eat wild-caught fish?
    - Never
    - 1–2 days per week
    - 3–4 days per week
    - 5–7 days per week
3. How many days per week on average do you eat farmed fish? (Can ask the same question for meat from livestock or meat from wild animals)
    - Never
    - 1–2 days per week
    - 3–4 days per week
    - 5–7 days per week
4. Where do you obtain wild-caught fish for consumption? Please select all that apply.
    - I or my family member catches it directly
    - Buy fish from a fisher
    - Buy fish from a market
    - Other source:_____
5. What percentage of the wild-caught fish that you consume comes from each of sources listed above?
6. What proportion of the fish that you consume is wild-caught (from a river/stream/wetland)? What proportion of the fish that you consume is farmed (like tilapia)?
7. What influences your decision to eat wild fish? (mark all that apply)
    - If there is wild fish available to catch or purchase, I will eat it
    - If I am too busy with non-fishing livelihood activities, then I won't catch wild fish to eat
    - If I can buy farmed fish from the market, then I prefer farmed fish to wild fish
    - If other types of meat are available, then I prefer to eat other meat rather than wild fish
    - Other reason (please describe)
8. Are there fish species that you prefer for household consumption?
9. Have you observed changes in the amount of wild fish available for consumption in the community since the FCZ was established (Has it increased? Decreased? Stayed the same?)
10. Do you feel the FCZ is having an effect on the amount of fish available for consumption in the community? Why?

A more technical method would be to use a 10-point ladder scale described under Indicator S2, *Perceptions of local fish catch*. Questions to ask the person being interviewed include:

1. Which step on the ladder represents your family's consumption of fish this year?
2. Which step on the ladder represents your family's consumption of fish before the FCZ was established?

Examples of how to interpret results

- A single survey of this indicator can give you information about the relative importance of fish in the community compared to other types of protein. However, like many indicators, information about household fish consumption can be most valuable when measured over time to assess changes.
- Graphs can be made to compare different aspects of fish consumption between groups of interviewees (such as full-time fishers

compared to part-time fishers) or track fish consumption over time.

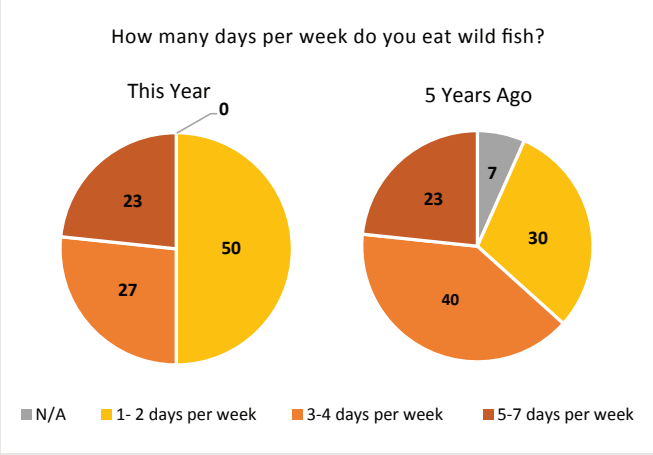
- If the indicator is measured over time and the assessment documents a decrease in wild fish consumption, but the respondents report that the amount of wild fish available for consumption in the community has stayed the same or increased since the FCZ was established, then this may indicate that another factor is affecting the community's decision to eat wild fish. In this case, look at the respondents' answers to the question, "What influences your decision to eat wild fish?"
- If the indicator is measured over time and the assessment documents an increase in wild fish consumption, and the respondents also report that the amount of wild fish available for consumption in the community has increased since the FCZ was established, then this may indicate that the FCZ is having a positive effect on the household fish consumption.

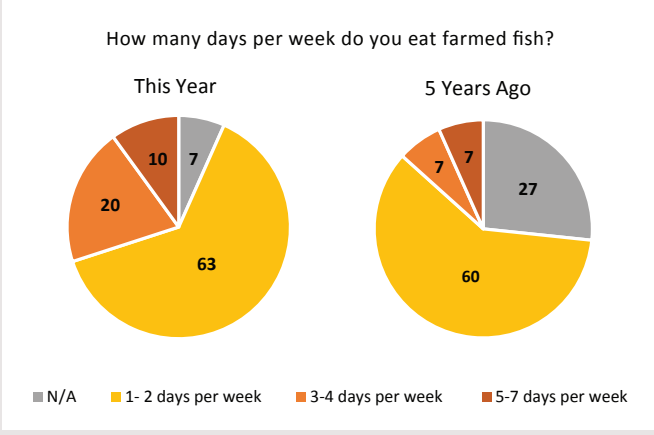
Questions to consider:

1. How important are fish as a source of protein and nutrients in the community compared to other food sources?
2. Is the amount and type of fish that people are consuming in the community changing over time?
3. If people are consuming more or less fish since the FCZ was established, is this showing a trend over time that is similar to the availability of wild fish? (based on other indicators such as E5, *Total catch per unit of fishing effort*; or S2, *Perceptions of local fish catch*)
4. If people are consuming less fish since the FCZ was established, could supporting community fish farming activities be beneficial?

Case Study Example: Konglor FCZ

The assessment team interviewed 30 people in Konglor Village (about 2% of the village population) about their household fish consumption. The interviewees included 10 fishers and 20 other villagers. Interviewees were asked how frequently they consumed wild-caught fish and farmed fish this year (2017) as well as 5 years ago (2012). For each question, interviewees were asked to select from the following answers: 1–2 days per week; 3–4 days per week; 5–7 days per week, or none of the above. Answers to these questions are shown below.





The results indicate that wild fish consumption is quite common in the community, with all interviewees reporting that they eat wild fish at least once a week, and nearly a quarter of the interviewees reporting that they eat fish as frequently as 5–7 days per week. However, interviewees also reported eating wild fish less frequently today than they did 5 years ago: 5 years ago, the largest portion of respondents (40%) ate fish 3–4 days per week, whereas today the largest portion of interviewees (50%) ate fish only 1–2 days per week. The results also indicate that eating cultured fish is more common today than it was 5 years ago, especially among people who eat fish 3 days or more per week.

These patterns suggest that it is valuable to distinguish between cultured fish and wild fish when asking this community about fish consumption to try to differentiate between changes in wild fish consumption related to the availability of wild fish compared to changes in farmed fish consumption that may be related to increased fish farming or other access to farmed fish in the community. Although fewer people reported eating farmed fish than wild fish, both today and 5 years ago, it would be useful to continue to monitor these trends over time to try to determine if the FCZ eventually contributes to increased wild fish consumption, or if an increased availability of farmed fish is offsetting decreased wild fish consumption. Other indicators may also help explain if the decrease in wild fish consumption is related to a decline in wild fish availability or if it is due to another factor.

S4. Perception of benefits derived from the FCZ

Description (What is this?)

This indicator looks at whether community members feel the FCZ has had a positive or negative impact on their lives, and whether they feel like they have benefited from the FCZ in some way. Benefits may include food, income, or other benefits.

Why measure this?

If local people feel they have benefited from the FCZ and their perceptions are positive, they may be more supportive of FCZ management. If local people feel they have been negatively impacted by the FCZ, they may be less supportive of FCZ management, and changes in management may be needed, or increased outreach may be needed to explain that the benefits of FCZs may take time to occur.

General considerations for data collection

- This indicator can be measured using a semi-structured interview or closed-questions survey of individuals or households.
- This indicator can be most useful when measured together with related indicators such as S2, *Perceptions of local fish catch* or S3, *Patterns of household fish consumption*. This indicator asks community members whether they think patterns that they have observed in fish catch or fish consumption are related to the FCZ.
- Benefits provided by the FCZ may go beyond food and income to include things like the opportunity to participate in fisheries management, the ability to enforce regulations against illegal fishing methods both inside and outside the FCZ, or the opportunity to teach children about the importance of conservation and sustainability.
- The interviewer should explain that there is no one "correct" answer, and the value of the interview depends on the interviewee being as open and honest as possible. Because of this, it would be best if the interviews were conducted by a person who is viewed as independent of the FCZ management process. Effort should be made to help the interviewee feel comfortable and at ease with being interviewed, and to keep responses confidential.
- The benefits or impacts that the community members perceive may not actually be caused by the FCZ. However, these perceptions are still important because they likely influence the person's overall support for the FCZ.
- Ideally, perceptions of FCZ benefits should be assessed at least once every three years.

Example methods

Examples of questions for semi-structured interviews include:

1. What benefits have you personally experienced as a result of the FCZ? (Please list them all)
2. What negative impacts have you personally experienced as a result of the FCZ? (Please list them all)

3. Do you think the community has generally benefited as a result of the FCZ? Why or why not?
4. Do you think the community has generally suffered as a result of the FCZ? Why or why not?
5. Do you think the benefits or negative impacts from the FCZ have been experienced equally by the community? Why or why not?
6. Do you think the FCZ is helping to conserve fish for future generations? How does that make you feel?

Examples of questions for closed-question surveys include:

1. Do you think having the FCZ has provided you access to more wild fish to eat, either caught or purchased? (Yes or No)
2. How do you think your access to wild fish for eating has changed as a result of the FCZ?
   a. increased a lot
   b. increased a little
   c. stayed the same
   d. decreased a little
   e. decreased a lot
   f. I don't know/I don't have an opinion
3. Do you think having the FCZ has provided you access to more wild Other Aquatic Animals (OAA) to eat, either caught or purchased? (Yes or No)
4. How do you think your access to wild OAA for eating has changed as a result of the FCZ?
   a. increased a lot
   b. increased a little
   c. stayed the same
   d. decreased a little
   e. decreased a lot
   f. I don't know/I don't have an opinion
5. Do you think having the FCZ has provided you with more income? (Yes or No)
6. How has your income changed as a result of the FCZ?
   a. increased a lot
   b. increased a little
   c. stayed the same
   d. decreased a little
   e. decreased a lot

Examples of how to interpret the results

A narrative report can be prepared that summarizes the perceived benefits and negative impacts that community members shared in open-ended questions.

The results of closed-answer questions can be graphed to show the percent of respondents that gave a particular answer. As the assessment is conducted over time, these percentages can be compared (such as comparing different years of assessment, like 2015 vs. 2020). This comparison can help resource managers understand if there is a change in perceived benefits as the FCZ gets older. Tables can also be prepared that show the percentage of respondents who gave a particular answer.

Questions to consider:

1. Are there changes that can be made to increase benefits or reduce negative impacts of the FCZ in the community?
2. Are there recommendations that can be made to make the benefits of the FCZ more widespread or equitable?

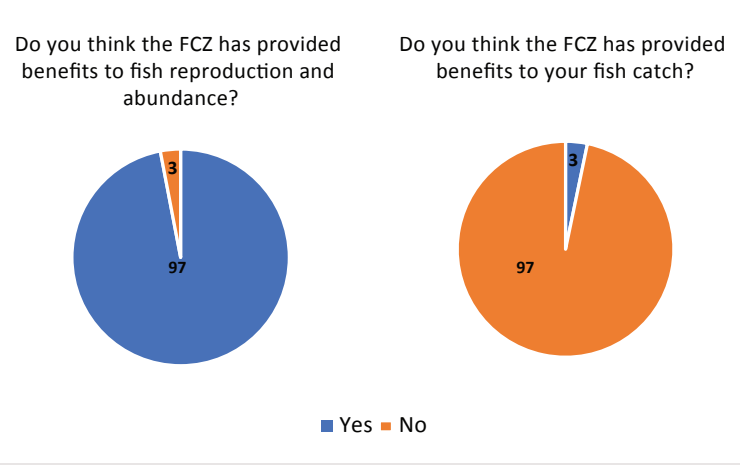
References

General references are listed in the Introduction to the Socioeconomic Indicators section.

Chomchanta, P., P. Vongphasouk, S. Chanrya, C. Soulignavong, B. Saadsy, and T. J. Warren. 2000. A preliminary assessment of Mekong Fishery Conservation Zones in the Siphandone area of Southern Lao PDR, and recommendations for further evaluation and monitoring. Data & Information Unit, Living Aquatic Resources Research Center, Vientiane, Lao PDR.

Case Study Example: Northern Laos FCZs

The FCZ assessment team interviewed a total of 123 people from the three villages that manage the Northern Laos FCZs (60 people from Houaykhoualouang Village, 37 people from Korkfak Village, and 26 people from Pakpee Village), representing about 14% of the population in all villages combined. The interviewees were a mix of elders, women, fishers, and other villagers. Almost all of the elders and fishers were male, and the fishers were those who typically fished in the river from boats. The interviewees were asked whether they thought the FCZ has benefited fish reproduction or abundance, and whether they thought the FCZ had benefited their fish catches. The results of this question are shown below.



These results illustrate potential complexities in the benefits derived from FCZs. Nearly all of the people interviewed thought that the FCZ was providing benefits to fishes by increasing fish reproduction or abundance. However, nearly all of the people interviewed also indicated that they did not personally experience the benefits of this increased fish abundance in their own fish catches. It would be valuable to have further discussion with the community about this indicator to understand if they still support and value the FCZ for benefiting fish populations even if they may not personally experience this benefit. It can take many years for the benefits that fish populations experience from an FCZ to be reflected in fish catches outside the FCZ, and this FCZ had only been established for four years at the time of the survey. It could also be that the FCZ only benefits particular species of fish that are caught by only a few fishers. It would be valuable to measure this indicator in the future to see how community perceptions of FCZ benefits may have changed. It would also be valuable to compare this indicator directly to observations of the fish populations using ecological indicators (E1, E2, or E3) to verify if such changes in abundance or reproduction are actually occurring.

S5. Household income/effort distribution by source

Description (What is this?)

This indicator measures the primary livelihood activities and sources of income for local households.

Why measure this?

This indicator can help measure how heavily local people depend on aquatic resources such as fish for their livelihoods. It can help document whether the FCZ is causing people to shift their livelihood activities, and whether there has been an impact on their income after the FCZ was established. It can also provide background information for establishing alternative livelihood projects with communities.

General considerations for data collection

- Data for this indicator can be collected by conducting semi-structured interviews with a sample of households in the community.
- Interviews should consider input from both male and female members of the household, and should also consider whether children are involved in any livelihood activities.
- This indicator can rank livelihood activities in terms of the income generated, and in terms of the time or effort required.
- If villagers being interviewed are not familiar with reporting in percentages, you can give them objects (such as beans or rocks) that they can divide up to show the proportion of their time or income related to different livelihood activities.
- Villagers can also report the total amount of time or money associated with each activity (such as total hours or total kip per day, week, month, etc.) and the assessment team can calculate the percentages.
- The ability of the FCZ to improve income generation for community members depends not just on the abundance of fish, but on access to markets.
- It may be appropriate to ask about livelihood activities by season.
- Data on household income sources should be collected at least once every five years.

Example methods

Examples of questions that may be asked during semi-structured interviews include:

1. What are all the livelihood activities in your household?
2. What is the relative contribution of each livelihood activity to your income? Please provide percentages.
3. What are the relative amounts of time that members of your household spend on each livelihood activity? Please provide percentages.
4. Has the income from your livelihood activities changed since the FCZ was established? If yes, how? Is the FCZ related to these changes, and if yes, how?
5. Has the amount of time spent on your livelihood activities changed since the FCZ was established? If yes, how? Is the FCZ related to these changes, and if yes, how?
6. Have there been other activities or events since the FCZ was established that may have influenced your income or time spent on livelihood activities, and that are unrelated to the FCZ (such as a new industry in the region)?

Examples of how to interpret the results

Tables and graphs can be made to display the average contribution of each livelihood to the community.

<u>Questions to consider:</u>

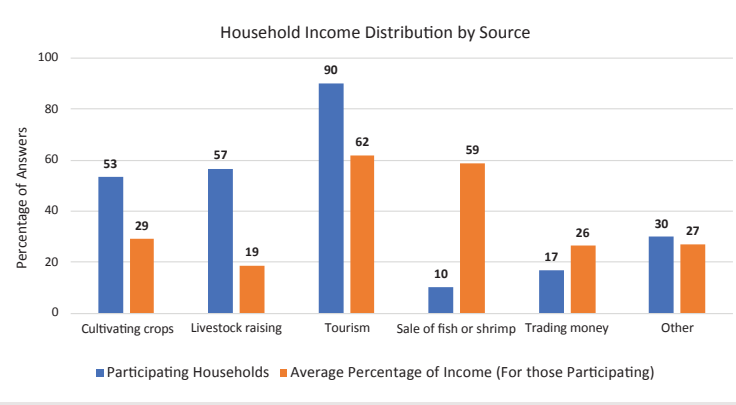
1. Which livelihood activities have the highest average percent of effort or income for the community? Are any activities associated with aquatic resources?
2. What percentage of households have primary livelihood activities (or important

livelihood activities) related to aquatic resources, based on income or effort?

3. What percentage of community members have sources of income that are associated with FCZ management (such as ecotourism or patrolling)?
4. If data have been collected during more than one assessment survey at this FCZ:
   a. Has overall household income increased or decreased over time?
   b. Has household income derived from aquatic resources increased or decreased over time?
   c. Has household effort spent on harvesting aquatic resources increased or decreased over time?
5. Could the FCZ be contributing to changes in household income or effort?
6. Are there opportunities for expanding livelihood options related to FCZ management, such as enforcement or ecotourism?

Case Study Example: Konglor FCZ

The assessment team interviewed 30 people in Konglor Village (about 2% of the village population) about their perception of fish catches. The interviewees included 10 fishers (all part-time fishers) and 20 other villagers. The interviewees were asked to report their household's total annual income in Lao Kip for the past year, and how much of that income came from various livelihood activities. Because households could report more than one livelihood, the responses add up to more than 100%. The percentage of participating households was calculated for each livelihood activity. For those households that reported a particular livelihood activity, the average contribution of that livelihood activity to their annual income was also calculated. The results of the survey are shown below.



The results show that tourism was the most common livelihood activity among the respondents, and it made up more than half (62%) of their income on average. All of the 10 fishers interviewed participated in tourism activities, and it made up 74% of their income on average (data not shown), which suggests that fishers are benefiting from the FCZ. Livestock raising and cultivating crops are also common livelihood activities, with more than half of the households surveyed participating in these activities. While the sale of fish or shrimp was not a very common livelihood activity (with only 10% of surveyed households participating), it was an important livelihood activity for those families that did participate in it, and made up 59% of their annual income on average.

Based on these results, it appears that tourism is an important source of livelihoods for the community. One of the goals of the Konglor FCZ is to increase community income through ecotourism. Assuming that most of the tourism income in the community is related to the FCZ and Konglor Cave, it appears that the FCZ is helping to achieve this goal.

S6. Local values and beliefs about aquatic resources

Description (What is this?)

A ***value*** is a social norm or understanding of what is important or good that has been shaped by history and culture. A ***belief*** is a shared understanding of how the world works. This indicator measures how local values and beliefs may shape how people view and interact with the aquatic environment.

Why measure this?

Communities may have local values and beliefs about aquatic animals, plants, or aquatic habitats that influence where, when, how, and why they harvest or do not harvest aquatic resources. Additionally, some FCZs in Lao PDR are established to respect and protect places of spiritual significance, and should be managed with cultural values and beliefs in mind. Measuring this indicator can help ensure that FCZ management is compatible with local cultural values and beliefs, and can help resource managers understand the behavior of fishers and other aquatic resource users. This indicator can also help measure how cultural values and beliefs about aquatic resources may change over time.

General considerations for data collection

- Data for this indicator can be collected using semi-structured interviews with households or individuals, as well as key informants such as cultural or spiritual leaders in the community, including monks, elders, or the village head.
- Because questions about values and beliefs can be very personal, effort should be made to help the interviewee feel comfortable and at ease with being interviewed.
- Household or individual interviews may be conducted with people from different stakeholder groups, and should include both men and women (the gender of each respondent should be recorded).
- Ideally, data on local values and beliefs about aquatic resources should be collected at least once every three years.

Example methods

Examples of questions that may be asked during semi-structured interviews include:

1. Why is the river/wetland/other aquatic habitat culturally important to you?
2. Which aquatic species are culturally important to you and why?
3. Are there traditional stories in your village related to aquatic habitats or species?
4. Are there traditional practices in your village related to aquatic habitats or species?
5. Why is fishing culturally important to you?
6. Are there cultural beliefs or traditions that influence your fishing practices?
7. Is protecting the aquatic environment through FCZs culturally important to you? Why?

8. Do you think the FCZ management is compatible with local cultural beliefs and traditions?

Examples of how to interpret the results

A narrative report can be prepared that describes local values and beliefs, and any stories or anecdotes that help to illustrate those beliefs.

Respondent answers to questions can be listed in tables (Table 8), where the number of people who gave similar answers is tallied.

Questions to consider:

1. Are traditional cultural beliefs and practices widespread, or only held by a few individuals?
2. If the survey has been conducted during a previous assessment at this FCZ, has there been any change in the cultural beliefs and practices over time?
3. How do local beliefs and practices influence how people fish or harvest aquatic resources?
4. Are there any recommendations to improve the compatibility of FCZ management with local cultural values and beliefs?
5. Can management activities of the FCZ help to honor or revive cultural beliefs or practices?

Table 8. *Example results of an aquatic values and beliefs survey of 20 respondents.*

Why is protecting the aquatic environment through FCZs important to you?	**Number of answers**
It will benefit the next generation by allowing them to have fish to catch and eat	14
It will improve fish breeding and survival	10
It will improve fish breeding, and if the fish come out of the FCZ then we can catch them	8
It will benefit all aquatic animals by increasing their numbers, especially fishes	7
Having more fishes will generate more income, and the village can consume aquatic animals easier	3
The FCZ can protect fishes from extinction	2
The community benefits by managing the fishing area	1

S7. Level of environmental awareness and understanding of conservation

Description (What is this?)

This indicator measures to what extent people understand basic ecological relationships in the environment, as well as how human actions can harm or help the natural environment.

Why measure this?

Understanding how human actions can harm or help the environment can motivate people to adjust their behavior in a more sustainable way. FCZ management activities may include community outreach and environmental education. Identifying where people have inaccurate, incomplete, or accurate perceptions can help design outreach to be most effective, or identify other ways to improve community understanding of human impacts on the environment. Measuring this indicator over time can assess the effectiveness of such outreach on improving environmental awareness in the community. If outreach is not currently part of FCZ management, this indicator can provide guidance on management actions for increasing environmental awareness in the community, which could be added to the FCZ management plan in the future.

General considerations for data collection

- Data for this indicator may be collected using semi-structured interviews or closed-question surveys with households, individuals, or focus groups.
- Ideally, data on environmental awareness and understanding of conservation should be collected once every three years.

Example methods

Semi-structured interviews can be used to help identify threats to the natural environment and assess people's understanding of conservation. Example questions include:

1. What activities, events, or changes are negatively impacting the aquatic environments in your community?
2. What level of importance would you give each of these threats? (Can rate the threats on a scale of 1 to 5, with 1 being not important and 5 being very important.)
3. What level of difficulty would you give to reducing these threats (Can rate the diffi-

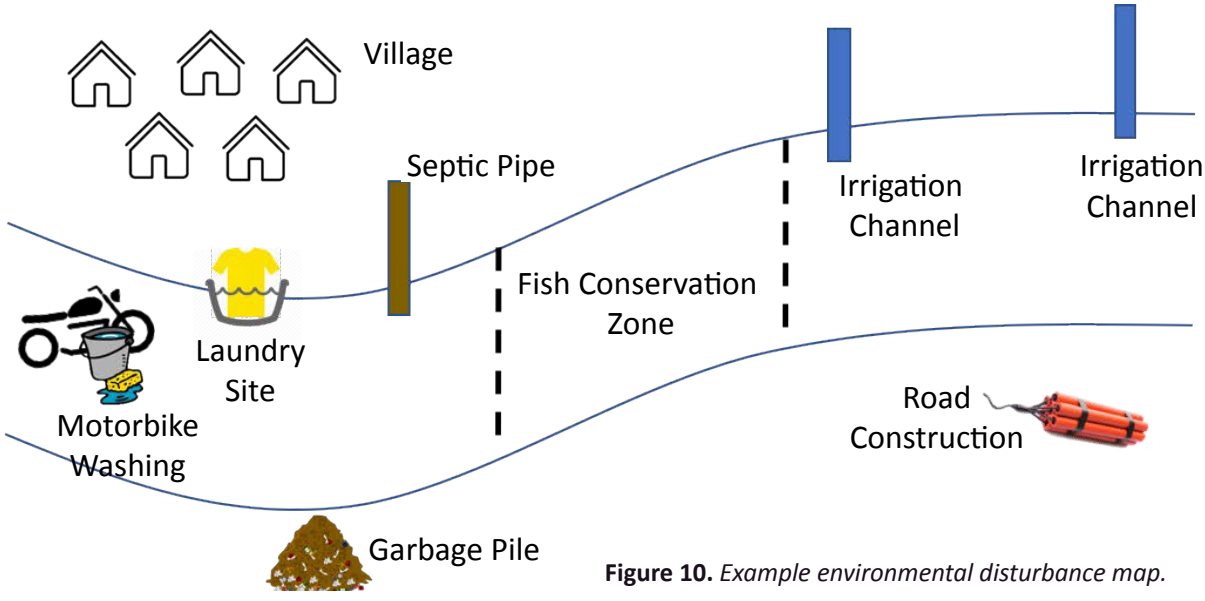


Figure 10. *Example environmental disturbance map.*

culty of addressing threats on a scale of 1 to 5, with 1 being very easy and 5 being very difficult)

4. What could be done to reduce these threats?
5. What will happen to fish populations if we harvest too many fish?
6. What threats does the FCZ help address?
7. What actions can we take to prevent fish populations from declining?
8. Who have you learned about conservation topics from?

Disturbance mapping: Community members can be asked to produce a map of their village identifying potential threats or disturbances to the FCZ (Figure 10).

Closed-answer surveys could also be used to assess the community's level of understanding about basic environmental relationships, sustainability, or conservation. Example questions include:

1. Is it more sustainable to harvest spawning fishes before or after they lay their eggs? (Correct answer: after they have laid eggs).
2. Which type of fishing is more harmful to the environment, gill net fishing or dynamite? (Correct answer: dynamite)

Examples of how to interpret the results

A summary can be produced that describes the community's level of understanding about how human actions can harm or help the aquatic environment. A summary of the threat analysis can be produced as a map (Figure 10) or a table (Table 9) showing the average ranking given to each answer.

For closed-answer questions, the percentage of respondents who gave each answer can be displayed in a table or graph. For open-ended questions, the percentage of respondents who gave similar answers can be displayed as a table or graph.

Table 9. *Example results of threat ranking survey with 20 respondents.*

Threat to Aquatic Resources	Average Importance (1 = not important) (5 = most important)
Illegal electrofishing	4.90
Road construction	4.75
Septic runoff	4.65
Agriculture runoff	4.45
Motorbike washing runoff	2.50
Laundry washing	1.50

Questions to consider:

1. Does the community generally have an accurate understanding about how human activities impact the aquatic environment?
2. Are there recommendations for improving people's understanding of human impacts on the aquatic environment?
3. If this indicator has been used during a previous assessment at this FCZ, has the map or ranking of potential threats changed over time? Are there new threats? Have some threats been removed?

Case Study Example: Konglor FCZ

The community in Konglor wanted their FCZ to help future generations learn about the importance of the sustainability of natural resources. To measure this, the FCZ assessment team interviewed 21 students in grades 3 and 4 in Konglor Village to assess their level of environmental awareness and understanding of conservation. The students were asked a range of open-ended questions to explain about the benefits of FCZs, the harms of overfishing, and to identify where they learn about conservation topics. The results of these surveys are shown below, and similar answers are grouped together.

What benefits does the FCZ provide to your community?

Answer	# of Responses out of 21 (Percentage of Responses)
The FCZ is a place for breeding to increase fish abundance	6 (28.5%)
The FCZ conserves fish and other aquatic species	4 (19%)
The FCZ is a place for ecotourism	3 (14%)
The FCZ is an area of natural abundance	2 (9.5%)
The FCZ is a refuge for fish	2 (9.5%)
The FCZ has a diversity of fish that attracts tourists	1 (5%)
The FCZ makes fish easier to eat	1 (5%)
No answer	2 (9.5%)

How would you explain the concept of "overfishing"?

Answer	# of Responses out of 21 (Percentage of Responses)
It makes fish decline rapidly and not be abundant	16 (76%)
It means hunting fish for sale	2 (10%)
No answer	3 (14%)

What ideas do you have to conserve fish species for sustainable harvesting in the future?

Answer	# of Responses out of 21 (Percentage of Responses)
Help protect fish from illegal fishing by reporting any incidents in the village	13 (62%)
Participate in cleaning up the environment near the FCZ and tell friends not to go fish in the FCZ	2 (10%)
Explain to other students about the benefits of the FCZ to help us conserve fish	1 (4.5%)
Increase fish species and their abundance	1 (4.5%)
No answer	4 (19%)

Where do you learn about conservation topics? (Respondents were allowed to give more than one answer, so percentages add up to more than 100%)

Answer	# of Responses (out of 21) (Percentage of Responses)
From parents	20 (95%)
From school	16 (76%)
From the village chief	8 (38%)
From relatives	2 (9.5%)
Other sources	3 (14%)

Based on these results, it appears that students generally have a good understanding about how the FCZ functions and the benefits it can provide. Since parents and school are the most important sources that the students identified for learning about conservation topics, the fisheries management committee could encourage parents and teachers to continue to teach children about FCZs and conservation.

Ecological Section

Introduction

Many people in rural Lao PDR depend directly on fishes and other aquatic animals (OAA) for food and income. Because of this, the primary goals of many FCZs in the country are to protect and increase aquatic biodiversity and the abundance of fish and OAA species. If this is true for your FCZ, it is important to assess ecological indicators related to these goals. FCZs in Lao PDR may have one or more desired benefits related to aquatic ecology, which can generally be categorized under four different goals: 1) protecting individual aquatic species, 2) protecting or increasing biodiversity, 3) sustaining the productivity of aquatic resources, and 4) protecting habitat (Table 10).

Table 10 describes a checklist of FCZ ecological goals and desired benefits with a list of related indicators. The first step in deciding which indicators are best to use for your assessment is to identify the goals and desired benefits that are relevant to your FCZ (please see the guidebook Introduction on page 8 about the importance of defining clear goals before the assessment). The checklist will help you narrow down and focus on the indicators that are most useful for your specific FCZ goals. Some FCZ ecological indicators are related to the goal of protecting a particular species, while others are related to goals of more broadly protecting aquatic biodiversity or protecting all fishes in general. There are seven ecological indicators included in this guidebook, and some indicators are relevant for multiple goals and desired benefits (Table 10).

Many potential indicators exist, and it is not possible to cover all indicators in this guidebook. Table 10 includes indicators that were identified as most relevant to FCZs in Lao PDR. Other potential indicators are listed in Appendix 1. Stakeholders consulted during the design of this guidebook expressed interest in a few FCZ indicators that provide valuable information, but require thorough or difficult ecological studies that are beyond the scope of this guidebook. These include "recruitment success within the fish community" and "food web integrity" (well-integrated food web). If these are important goals of your FCZ, we recommend you seek technical expertise in these areas to help your assessment team develop appropriate methods for measuring these indicators.

The description of each ecological indicator in this section includes a list of example methods that may be used to measure that indicator, and some also include sample data sheets. Please keep in mind that these are just examples, and other or additional methods may be appropriate for your assessment. Measuring ecological indicators may require special scientific expertise, and this guidebook attempts to include a range of difficulty levels. Whenever possible, low-difficulty level (basic) and inexpensive methods are included as options. Each data collection method may have advantages, disadvantages, and biases. It is important to keep these biases in mind when selecting methods, and it is possible to test different methods to directly compare the resulting catch (e.g., Ochwada-Doyle et al. 2016). There is sometimes a clear link between ecological indicators and the socioeconomic indicators (such as fishing effort or changes in fish populations, whether perceived or documented), and we have noted where information for these indicators may be collected at the same time.

General Considerations for Ecological Data Collection

Fishing inside an FCZ

Many of the surveys described in this guidebook are most informative if some direct sampling is done with fishing gears inside the FCZ. You will

Table 10. *List of desired FCZ ecological benefits, related indicators, and example questions that can be answered by measuring each indicator.*

Desired Ecological Benefits and Outcomes		Indicators	Questions to Consider
Protect Individual Species	□ Increase the abundance of a particular key species	□ Presence/absence of key species (E1a)	• Is the key species found inside the FCZ?
		□ Abundance of key species (E1b)	• Is the population of the key species increasing over time?
		□ Population structure of key species (E2)	• How many of the key species are able to reproduce? Is there evidence of young fish joining the population?
		□ Total catch per unit of fishing effort (E5)	• Are members of the community catching the key species? Are their catches increasing or decreasing over time?
Protect Biodiversity or "All Fishes" Generally	□ Increase total abundance of all fishes (or other aquatic animals)	□ Total abundance by group (such as "fishes") (E3)	• Is the abundance of all fishes (or other aquatic animals) increasing over time?
		□ Total catch per unit of fishing effort (E5)	• Are catches of fish (or other aquatic animals) in the community increasing or decreasing over time?
	□ Protect or increase the biodiversity of aquatic species	□ Composition and structure of the aquatic community (E4)	• How many species of fish or other aquatic animals are there in the FCZ? How many are there of each species? How has the composition of the species changed over time? Are there species that are more common and species that are rarer?
		□ Total catch per unit of fishing effort (E5)	• What is the diversity of local fishing catches in the community? Is it changing over time? Are there species that are no longer captured or species that are new in the fishery?

Desired Ecological Benefits and Outcomes		Indicators	Questions to Consider
Protect the Aquatic Environment	□ Protect important habitats inside the FCZ (e.g., spawning habitat, deep pool refuges)	□ Habitat distribution and quality (E7)	• Where are important habitats that are targeted for protection (such as spawning areas) located inside the FCZ? Is the size of the habitat targeted for protection increasing or decreasing?
		□ Water quality (E6)	• Is there good water quality inside the FCZ for aquatic species to survive?
		□ Composition and structure of the aquatic community (E4)	• Which species are found in which habitats inside the FCZ?
		□ Population structure of key species (E2)	• If the FCZ protects spawning habitat, then are there key species using the habitat that appear ready to reproduce?

need to get permission from the appropriate community and government authorities to sample aquatic species within the boundaries of the FCZ. It is also good to tell the villagers who live near the FCZ that you are sampling for research and not fishing illegally. We recommend that you identify your boat as a research boat using a sign or a flag, so people can tell you are sampling for science and not fishing. In some cases, FCZs are established in sacred spaces, or it is otherwise not possible to sample within the FCZ. In these situations, appropriate sampling sites can be selected just outside of the FCZ boundary, or alternative sampling methods should be considered. If the assessment team has selected sites that are adjacent to the FCZ to represent "inside" the FCZ, this is treated as inside the FCZ for the purposes of this chapter.

While this guidebook intends to provide as much guidance as possible on sampling in and around FCZs, it is not possible to address all unique circumstances. Occasionally, an FCZ may be in a habitat that is difficult to sample (such as a deep pool that may be difficult to assess due to swiftly moving water), or in areas with rapidly changing hydrology (such as below a hydropower release point with daily fluctuations in flow). In these cases, sampling in only the shallow areas of the FCZ or just outside the FCZ boundaries may be required.

Selecting control or reference sites

Many external factors that are unrelated to the FCZ can influence the abundance, distribution or size classes of fish in an FCZ. To understand if a species is benefiting specifically from the protection of the FCZ, you need to separate the influence of external factors (which are outside the control of FCZ management) from the influence of the FCZ. In an ideal situation, the relevant indicators for an FCZ would be assessed *before* an FCZ is established in order to provide baseline information on these indicators. This type of study is called a Before-After impact study. In this case, the "impact" is the establishment of an FCZ. Having information on the indicators before an FCZ is established can help separate the influence of the FCZ from other factors that influence fisheries. However, in many cases the FCZs have already been established and there is no information available from before the FCZ existed.

If this is the case, then another way to account for non-FCZ influences on fisheries is by measuring the same indicators at nearby unprotected locations, and comparing this to results collected inside the FCZ. The location outside the FCZ is often referred to as a ***control site*** or a ***reference site***, because it is used to control for the effects of outside factors unrelated to the FCZ. The characteristics of the control site (such as size and habitat) should be as similar as possible to the FCZ, but the location of the control site needs to be far enough away from the FCZ to not be influenced by the FCZ protection (Comchanta et al. 2000). This may mean selecting a site that is in another nearby village with similar conditions. For example, if the FCZ is a deep pool, finding another deep pool that is not protected may require sampling in another village nearby. It is also important to note other factors in the environment that may contribute to differences between two sampling locations, such as their distance from a village, dam, farm activity, or other disturbances. It can be helpful to gather information at more than one control or reference site for your FCZ to provide more evidence, and in case one reference site becomes impacted (such as by development of hydropower or bridge construction) and you can no longer use it. Finding appropriate control sites may be a challenge, but this step should be considered important.

How to Survey

Direct sampling and indirect sampling

Many indicators can be measured using either ***direct sampling*** or ***indirect sampling.*** In ***direct sampling***, the assessment team collects data for an indicator through first-hand surveys or observations. For example, fisher catch can be measured directly by weighing the amount of fish caught by each fisher over time. The amount of fishing effort from boats can be measured directly by observing the number of boats fishing on the water each day. In contrast, ***indirect sampling*** involves collecting data for an indicator by asking people to report it from their memory. For example, fisher catch can be measured indirectly by interviewing fishers to ask how much they typically catch. The amount of fishing effort from boats can be measured indirectly by asking community members how many boats are typically fishing on the water each day. Direct sampling is preferred for assessments whenever possible because it is considered less biased, and the results can be used in more types of statistical analysis. However, direct sampling can be more expensive and time consuming than indirect sampling. Direct sampling can also be more biased than indirect sampling if the sampling only takes place at certain times of the year or in specific locations. For example, if you only went out to observe the number of fishing boats during rice planting season, your count may be low because all the fishers are busy planting rice. The assessment team should consider these costs and benefits when choosing a sampling method.

Fishery-dependent and fishery-independent sampling

Direct sampling techniques may be considered ***fishery-dependent*** or ***fishery-independent. Fishery-dependent*** techniques collect data based on fishers' catches, and this can reduce costs because fishers are already doing the "sampling." One advantage of fishery-dependent methods is that fishers can typically collect data over larger areas and longer time frames than an assessment team can. ***Fishery-independent*** techniques gather data using standardized sampling that is designed to be as unbiased as possible, and independent of fisher preferences. Both approaches can provide valuable, complementary data to assess the status of fish populations. Furthermore, different species may be best sampled using one method or the other (e.g., Ochwada-Doyle et al. 2016), and each approach has tradeoffs in bias, cost, and accuracy. These tradeoffs should be considered when selecting approaches to measuring indicators of management effectiveness, and having access to both fishery-dependent and fishery-independent data can be helpful.

This guidebook recommends using fishery-independent sampling for several ecological indicators. Fishery-independent sampling requires fishing consistently with specific gear during specific times in specific locations. It does not have to be performed by experts, but can be done by trained fishers who are sampling with fishing gear specifically for an assessment, separately from catching fish to eat or sell. If you are using fishery-independent sampling, once you have selected a gear type to use for a particular indicator, you should continue to use this gear type for all sampling surveys. This allows you to compare the results from different sampling events. Using the same gear type consistently is important because some gear types are more effective or less effective at capturing certain species, which can change the results.

Species identification is important for accurately measuring many ecological indicators. Care should be taken to ensure that assessment team members are identifying species correctly, and that they are in agreement on their species assignments. All team members should receive the same species identification training and refer to the same identification information sources.

Measuring effort

Some survey methods for relative abundance (as described for indicators E1 and E3) require a measure of ***sampling effort*** to standardize relative fish abundance by effort (i.e., catch per unit effort; CPUE). This type of standardization by effort can be used for both fishery-independent and fishery-dependent sampling. The appropriate measure of effort depends on the type of gear used, but is often recorded in "hours of fishing per unit of fishing gear" (such as number of hours per trap or number of hours per gill net). It is important to accurately record the effort in hours (or minutes) in order to standardize the catch metric. Effort only includes the amount of time that the gear is actively fishing in the water, and does *not* include the time it takes to prepare for fishing or to travel to the fishing site. For example, if you are using a gill net, the effort is the number of hours the gill net is in the water soaking.

When to survey

Surveys of ecological indicators should be conducted consistently at the same time of year during future assessments. It is important to consider that many species are migratory, and may only occupy an FCZ during certain times of the year. If the life history and movement patterns of the species or group of interest are well known, then the data can be collected during the particular season when the species/taxon is expected to be present. If the key species is resident in the FCZ (occupies the habitat year-round), then data can be collected at a particular time of year when the abundance may be highest, such as when juveniles are large enough to sample. If life-history information for the species of interest is not well known, then data should be collected year-round until an appropriate sampling period can be identified. In some cases, migratory species pass through the FCZ for brief periods of time (e.g., one or two days), which can make direct sampling challenging. If this species is important to

the goals of the FCZ, then measuring this species may require indirect sampling (such as fisher interviews).

How much to survey

Deciding on the amount of sampling effort (or sample size) is an important part of designing an assessment. Many resources in the scientific literature provide advice on sample sizes for surveying aquatic species abundance. It is not enough to set one net or one trap for one day; this sample size would be too small to be meaningful. The ideal sample size depends on many factors specific to your context (such as sampling method, size of the FCZ, abundance of the key species, gear type, the diversity of fish in the river, etc.). Appropriate sampling effort is especially difficult to determine in aquatic ecosystems like those in Lao PDR with a large amount of biological and hydrological variability. Statistical textbooks, such as Krebs (1999) offer chapters on calculating the best sample size for a study. Once you know the context of your study site and have selected your sampling methods, we recommend you consult with someone familiar with statistical analyses to decide the level of precision required for your study, and to find the appropriate equation to calculate the sample size needed. For example, if you plan to compare the average catch-per-unit-effort of a key fish species inside and outside of the FCZ, there are equations available to calculate the sample sizes needed to detect the difference between these two averages.

There are many limitations to sampling fishing effort (such as budget, time constraints, site access and assessment team availability) that will influence the design of any assessment program. Often, it is not possible to sample as much as technical experts or statistical textbooks suggest is ideal. In these situations, the assessment team must use their best judgment on how much sampling is sufficient and possible, and then clearly report the limitations of the assessment with the results. If sufficient sampling is not feasible for a certain method, then the assessment team may need to reconsider the method and use a more indirect measure of the indicator (such as fisher interviews instead of daily fisher logbooks).

Reducing sampling mortality

Care should be taken to reduce fish mortality while conducting fishery-independent sampling during an assessment, and all fishes in good condition should be released. This is especially important when sampling inside the FCZ, where harvesting fish is otherwise not allowed. The gear and fishing method selected should cause as little damage to the animal as possible. For example, gill nets are an effective method to capture many fish species, but the nets should be set for a short amount of time (such as 1 hour) and monitored consistently to reduce the amount of time a fish is caught in the net. You can also consider using a trammel net, which is similar to a gill net, but is often less damaging because it tangles the fish rather than catching the fish by the gills.

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Ecological Indicators

E1 (a). Presence/absence of key species and (b). Abundance of key species

Description (What is this?)

Many different types of ***key species*** (or "species of interest") may be relevant to an FCZ. These include endemic species (those native to a limited area around the FCZ), endangered species (such as the Mekong giant catfish), bioindicator species (such as macroinvertebrates), and invasive species (such as tilapia or common carp). If a goal of the FCZ is to support sustainable fisheries, then economically important fishes may be key species of the FCZ (such as *Probarbus* spp. or *Pangasius* spp.). If there is a particular species of interest for the FCZ, this should be identified when an FCZ is established; otherwise, they should be selected when planning an assessment. An FCZ may have many key species, but assessments should focus on a smaller number of important key species that are thought to use the FCZ habitat, and that can be realistically monitored. A key species should be one that occupies the protected habitat for extended periods of time, and would therefore benefit from the FCZ. Thus, a highly migratory species that only passes through the FCZ briefly during a migration would not be an ideal key species.

The ***presence*** of a species is whether it is found in the FCZ during at least part of the year. The ***absence*** of a species is when it is never found in the FCZ.

Abundance is a general ecological term that may refer to numeric abundance (number of individuals, such as "20 catfish"), biomass (mass/weight per a unit of surface area or volume of water, such as "10 kg of catfish per m^3"), or density (number of individuals per unit of surface area or volume of water, such as "5 catfish per m^3"). It is generally not possible to count every single individual of a species (called "absolute abundance"). Therefore, most methods compare abundance values that are *relative* to other times or locations (called "***relative abundance***"), which is generally sufficient for management purposes.

Why measure this?

If the primary goal of the FCZ is to protect a particular key species (such as protecting spawning habitat for *Probarbus jullieni*), then the presence of that key species in the FCZ may be the single most important indicator of success. However, in most cases, it is not enough to just confirm the species is present in the FCZ; it is also essential to measure the relative abundance of a species to assess "how many" of this key species may be protected by the FCZ. Monitoring abundance over time will give resource managers an idea of whether a population is increasing or decreasing, which is more informative than just the presence or absence

of the species. We have combined both options as a single indicator because measuring species abundance will automatically provide a measurement of species presence/absence.

General considerations for data collection

- At minimum, the assessment team members will need to have a basic understanding of relative abundance, and have access to common fishing or fish sampling gears and a scale for weighing fish.
- If the assessment team is planning to sample within the FCZ, they will need to obtain permission to sample within the boundaries of the FCZ. If they are planning to sample adjacent to the FCZ boundary instead of "inside" the FCZ, then they should still select a control or reference site for comparison that is in similar habitat also outside the FCZ.
- Surveys of abundance of key species should be conducted at least once a year, with each survey occurring at the same time of year.
- Numerous resources in the scientific literature provide advice on surveying aquatic species abundance. In marine habitats, key species abundance is often measured using visual underwater census techniques, where divers or snorkelers count and measure species. This technique is often preferred because it does not require handling the animals and will cause minimal disturbance. However, in freshwater habitats, visual census is not used frequently (for an example see Sweke (2013)), likely because of low visibility. Instead, this metric is often measured using traps and nets (such as gill nets or seine nets).
- Although numeric abundance is frequently used in freshwater studies, some scientists consider biomass to be a more effective indicator of aquatic protected area performance (Soykan 2015). Biomass depends on the size of fish as well as the number of fish, so can account for changes in individual fish size that would not be detected by only measuring numeric abundance.

Example methods

Presence/absence, relative biomass (e.g., kg/unit of effort) or numeric abundance (e.g., number of fish/unit of effort) of a key species (less technical): Similar methods can be used for collecting information on key species abundance or presence/absence using fishery-independent sampling inside and outside the FCZ. Communities may be trained in how to conduct fishery-independent scientific surveys using a standardized sampling design, which is done separately from any regular fishing (see the Introduction to the Ecological Section for more information).

If the key species that you are interested in comes to the surface, such as *Pangasius macronema*, or if the water transparency is clear enough, it may be possible to conduct visual surveys that do not require any handling of the animal. While visual survey approaches are ideal, if this is not possible you can use fishing gears that are selective for the key species (e.g., bottom or surface long line (*bet phiakjom* or *bet phiak hi*), gill or trammel nets of specific mesh sizes (*mong*), seine nets (*kouat mong*), fyke or hoop nets). It may be possible to select gear types or sizes that specifically target the species of interest and avoid bycatch (unintended catch) of other species. This targeted sampling approach is different from the approach you would use for measuring Indicators E3, *Total abundance by group (such as "fishes")* and E4, *Composition and structure of the aquatic community*, which may seek to sample all fish species using a broader approach.

Presence or absence of a species may also be determined using a fisher logbook to monitor a checklist of fish species from fisher catches just outside the FCZ boundaries in similar habitats. This approach is not ideal because it is not possible to know for certain if a fish caught outside the FCZ is spending time in the FCZ habitat. A fisher logbook is also biased by the collection methods that the fishers are using, which may not be appropriate for targeting the species of interest. However, fisher data from logbooks can help identify the best timing for fishery-independent surveys to collect data on a key species.

Measuring presence/absence simply requires noting whether or not a species was sampled. In contrast, measuring relative abundance requires identifying and counting key species (if abundance by number is used as the metric) or weighing key species (if biomass is used as the metric) in order to fill out a data sheet like Table 11. Collecting data for both fish counts and weight would provide flexibility in the future to examine either number or biomass, and determine which is the most useful abundance metric for the species of interest. If you can only collect data for one metric, then biomass is the metric preferred by some researchers. Occasionally, it could be useful to include some sub-sampling of the length and/or weight of individual fish of the key species to assess population structure (Indicator E2, *Population structure of key species*). In some cases, the relative biomass of the key species in the FCZ may not be changing, but the number of individuals and their average size could be changing in ways that are not evident from the overall biomass (for example, a small number of large fish could have a similar total biomass as a large number of small fish). The appropriate measure of effort depends on the type of gear used. For gill nets and traps, the effort can be "hours fished," or "days fished" (where a day is 24-hour period, and the catch is summed for that period).

Absolute abundance (mark and recapture) of a key species (more technical): Capture-recapture (also known as mark-recapture) methods are commonly used for estimating absolute animal abundances in fisheries (e.g., Seber 1982, Williams et al. 2002). This technique requires both technical field and office expertise to mark fish (while avoiding unnecessary mortality) and to analyze the recapture data. Animals may be externally or internally marked in several ways, including laminated vinyl tags for shellfish and fish, or monofilament and vinyl tubing tags for crustaceans and fish (for examples, see products offered by Floy Tag & Mfg. Inc., Seattle, WA, USA; or Hallprint Fish Tags, Hindmarsh Valley, SA, Australia). Data analysis (such as estimating abundance and survival) can be conducted using the software MARK (White and Burnham 1999) or other packages (R and "RMark" package; Laake 2013) using methods described in Williams et al. (2002). Tagging fish for mark-recapture studies within the FCZ can also provide information about

Table 11. *An example of a data sheet for recording total weight (in kilograms) of key fish species using a standardized gill net sample.*

Site Data	Date: 03. 11. 2013	Surveyor's name: Ms. K	
	Village Name: Ban Ang Noi	Indicator: E1	
	River Name: Mekong River	X Inside FCZ	
	Secchi Depth (cm): 30	☐ Outside FCZ	
	Sampling Site Description (Explain habitat condition): The sampling site is a deep pool inside the FCZ. We sampled near the bank of the pool.		
	Latitude: 18.147349 Longitude: 102.198809		
Gear 1 Data	Time Set: 08:04	24hr (ex. 13:15)	Length of Net (m): 50
	Time Retrieved: 09:12	24hr (ex. 13:15)	Net Mesh Size (cm): 15
	Max. Water Depth of Gill Net (cm): 500		
Key Species Catch Only	Key Species Scientific Name	Key Species Local Fish Name	Total Weight (kg) of Catch in Gear 1
	Hemibagrus wyckioides	Pa Kheung	26
	Probarbus jullieni	Pa Eun Deng	16

the movements of fish inside and outside of the FCZ, which can help understand the potential for fish from the FCZ to spillover into other areas.

Examples of how to interpret results

Relative or absolute abundance data can be collected each year and graphed over time to examine trends both inside and outside (control site) of the FCZ.

Questions to consider:

1. Is there a trend in abundance in the FCZ or in the control site outside the FCZ (is abundance increasing or decreasing)?
2. Is the trend inside the FCZ similar to the trend in the control site outside the FCZ?
3. Is the overall relative abundance of the key species inside the FCZ greater than, similar to, or less than its abundance outside the FCZ?
4. If both numeric abundance and biomass were measured, do the answers to the questions above differ between these two measurements?

Regardless of the trends over time, if relative abundance does not differ between the control sites and the FCZ sites, then this may indicate that the FCZ is not benefiting the abundance of the key species. However, if the control sites are too close to the FCZ sites, then you may see a "spillover" response, where increased abundance inside the FCZ leads to increased abundance in nearby waters, which may make interpretation of this indicator more difficult. If both numeric abundance and biomass were measured and there has been a change over time in biomass but not in numeric abundance, then it may be that the size of the key species is changing over time, even if the number of key species is not changing. In this case, it may be helpful to examine Indicator E2, *Population structure of key species.*

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General fisheries survey methods for freshwater:

Bonar, S., W. A. Hubert, and D. W. Willis. 2009. Standard Methods for Sampling North American Freshwater Fishes. American Fisheries Society, Bethesda, Maryland.

- Provides a convenient, clear summary of standard sampling methods for North American warm-water freshwater fishes, many of which are relevant to the Mekong River and its tributaries. The text describes how to use the sampling gear and how to record effort.

Mark-recapture models:

Laake, J. L. 2013. RMark: An R interface for analysis of capture-recapture data with MARK. Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, Washington.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters, 2nd edition. Griffin, C., Macmillan, New York.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46:S120-S139.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2002. Analysis and management of animal populations. Academic Press, San Diego, California.

Examples of using this indicator in freshwater:

Cucherousset, J., J. M. Paillisson, A. Carpentier, V. Thoby, J. P. Damien, M. C. Eybert, E. Feunteun, and T. Robinet. 2007. Freshwater protected areas: an effective measure to reconcile conservation and exploitation of the threatened European eels (Anguilla anguilla)? Ecology of Freshwater Fish 16:528-538.

Ochwada-Doyle, F. A., D. D. Johnson, and M. Lowry. 2016. Comparing the utility of fishery-independent and fishery-dependent methods in assessing the relative abundance of estuarine fish species in partial protection areas. Fisheries Management and Ecology:1-17.

Soykan, C. U., and R. L. Lewison. 2015. Using community-level metrics to monitor the effects of marine protected areas on biodiversity. Conservation Biology 29:775-783.

Srinoparatwatana, C., and G. Hyndes. 2011. Inconsistent benefits of a freshwater protected area for artisanal fisheries and biodiversity in a South-east Asian wetland. Marine and Freshwater Research 62:462-470.

Sweke, E. A., J. M. Assam, T. Matsuishi, and A. I. Chande. 2013. Fish diversity and abundance of Lake Tanganyika: comparison between protected areas (Mahale Mountains National Park) and unprotected areas. International Journal of Biodiversity:1-11.

E2. Population structure of key species

Description (What is this?)

The ***population structure*** describes how many individuals in a population fall into different size or age categories (also called a "size class" or "age class"). This indicator gives resource managers information on how many fish are adults (able to reproduce) and how many are juveniles (future reproductive adults). This indicator is appropriate for key species where there is knowledge of the approximate size at which the species may be capable of reproducing. If this information is unknown, then the species would not be suitable for this indicator.

Why measure this?

This indicator provides a detailed perspective of how the population of a species of interest is responding to the FCZ. It is valuable to know the proportion of the population that are adults capable of reproducing. If the FCZ is intended to help maintain the spawning population of adult fishes, then this indicator can provide information on whether the age group of spawning adults is present in the population, whether new offspring are adding to the population (births), and how the abundance of adults is changing over time.

General considerations for data collection

- Many best practices for measuring this indicator are the same as those for E1*, Presence/absence of key species and abundance of key species,* and are listed in the Introduction to the Ecological Section.
- At minimum, the assessment team members will need to have a basic understanding of relative abundance and size structure of fish populations, and have access to common fishing gears, a scale for weighing, and/or a measuring board or measuring tape.
- The assessment team will also need to obtain permission to sample aquatic species within the boundaries of the FCZ and select a control site for comparison.
- Juveniles and adults of the same species often occupy different habitats within the river; therefore, it is important to understand the habitat requirements of the key species before developing surveys to ensure you survey all potential habitats for the species. If you only sample habitats preferred by adults, the data will be skewed towards adult size classes.
- The size structure of the key species may shift seasonally if some or all of the population is migratory (and individuals of different sizes pass through the FCZ at different times of year), or if there are seasonal periods when juveniles recruit into the adult population. Therefore, it is important to regularly conduct the surveys at the same time of the year, or throughout the year, to account for seasonal changes in size structure.
- It is also useful to know at what size (length or weight) the key species becomes mature to differentiate juveniles from adults, especially when it is not easy to tell if an individual is a juvenile or adult based on its visual appearance. It is also useful to differentiate between male and female fish whenever possible.
- Collecting data on the population structure of a key species requires a sampling method that is not size selective, meaning it can capture a wide range of fish sizes and does not just target small or large individuals. This will ensure that all sizes of the key species have an equal chance of being captured and included in the data analysis.
- If gill nets are the most appropriate sampling gear for your FCZ, there are nets specifically designed for scientific surveys that have multiple panels of connected nets with a range of different mesh sizes.

Example methods

Percentage of individuals categorized as "large" or "adult" (less technical): These data can be collected from fishery-independent surveys conducted inside and outside of the FCZ as described under Indicator E1b, *Abundance of key species.* Sampling can collect information for both indicators E2 and E1b at the same time. The metric "percentage of large individuals" can be based on individual fish weight or length. If length is used, a measuring stick can be marked with a line to show the cut-off length for a "large" fish. The number of individual fish larger and smaller than the cut-off length would be counted and recorded without needing to measure the exact length of each fish (Table 12).

The assessment team would need to determine the cut-off length that they consider to be a "large" individual during the study design phase for each species of interest. This cut-off length should stay the same each year to allow for direct comparisons. Ideally, the cut-off length would be the same as the size at maturity for the species, so that the percentage of large fish is an estimate of the percentage of adults. Managers would then calculate the percentage of individuals in the large and small size classes, and compare this to results of comparable

Table 12. *An example of a data sheet for gathering counts of large and small fish for key fish species using a standardized gill net set inside the FCZ. Note that because gill nets are size-specific, you would need to sample with more than one mesh size to gather adequate information about the whole size range of a key species.*

Site Data	Date: 03. 11. 2013	Surveyor's name: Ms. K		
	Village Name: Ban Ang Noi		Indicator: E2	
	River Name: Mekong River		X Inside FCZ	
	Secchi Depth (cm): 30		☐ Outside FCZ	
	Sampling Site Description (Explain habitat condition): The sampling site is a deep pool inside the FCZ. We sampled near the bank of the pool.			
	Latitude: 18.147349 Longitude: 102.198809			
Gear 1 Data	Time Set: 08:04	24hr (ex. 13:15)	Length of net (m): 50	
	Time Retrieved: 09:12	24hr (ex. 13:15)	Net Mesh Size (cm): 3	
	Max. Water Depth of Gill Net (cm): 500			
Fish Catch Data for Gear 1	Key Species Scentific Name	Key Species Local Fish Name	Count of Large Individuals*	Count of Small Individuals
	Amblyrhynchichthys truncatus	Pa Mang	I (1)	IIII IIII (9)
	*Cut-off lengths for key species are: [list each species and the cut-off point for "large" individuals]			

previous assessments. If the size at maturity is used as the cut-off, this would provide an estimate of the percentage of mature fish in the population.

Length-frequency distributions of key species (more technical): These data can be collected from a random sample of the catch from fishery-independent surveys. Data can be collected at the same time as sampling for key species abundance, but this metric requires collecting either exact length (cm) or weight (g) measurements of each individual of the key species, or a sub-sample of the individuals (Table 13). There are many different ways to measure aquatic animals. It is important to select one or two dimensions (such as total length and fork length), and then consistently use the same dimensions each year. See FAO (1974) for a description of the different measures for common aquatic animals. Measuring the length-frequency (or weight-frequency) metric will require more skills than measuring the percentage of large individuals because the assessment team needs to graph and interpret length histograms (see Figure 11), and understand what size distribution would be expected for a key species at a given time of year (that is, knowing the life history of the key species).

Age structure of the key species: This metric is commonly used for fisheries management, but due to its difficulty it will not be covered in this guidebook. Estimating the ages of individuals of a key species requires expert knowledge of ageing techniques.

Table 13. *An example of a data sheet for gathering individual length and weight data of key fish species using a standardized gill net set inside the FCZ.*

Site Date	Date: 03. 11. 2013	Surveyor's name: Ms. K		
	Village Name: Ban Ang Noi		Indicator: E2	
	River Name: Mekong River		X Inside FCZ	
	Secchi Depth (cm): 30		☐ Outside FCZ	
	Sampling Site Description (Explain Habitat Condition): The sampling site is a deep pool inside the FCZ. We sampled near the bank of the pool.			
	Latitude: 18.147349 Longitude: 102.198809			
Gear 1 Data	Time Set: 08:04	24hr (ex. 13:15)	Length of Net (m): 50	
	Time Retrieved: 09:12	24hr (ex. 13:15)	Net Mesh Size (cm): 15	
	Max. Water Depth of Gill Net (cm): 500			
Fish Catch Data for Gear 1	Key Species Scentific Name	Key Species Local Fish Name	Total Length (cm)	Weight (g)
	Amblyrhynchichthys truncatus	Pa Mang	12	100.3
	Amblyrhynchichthys truncatus	Pa Mang	14	110.7
	Amblyrhynchichthys truncatus	Pa Mang	11	90.2
	Amblyrhynchichthys truncatus	Pa Mang	16	130.2
	Probarbus jullieni	Pa Ern Deng	19	620.1

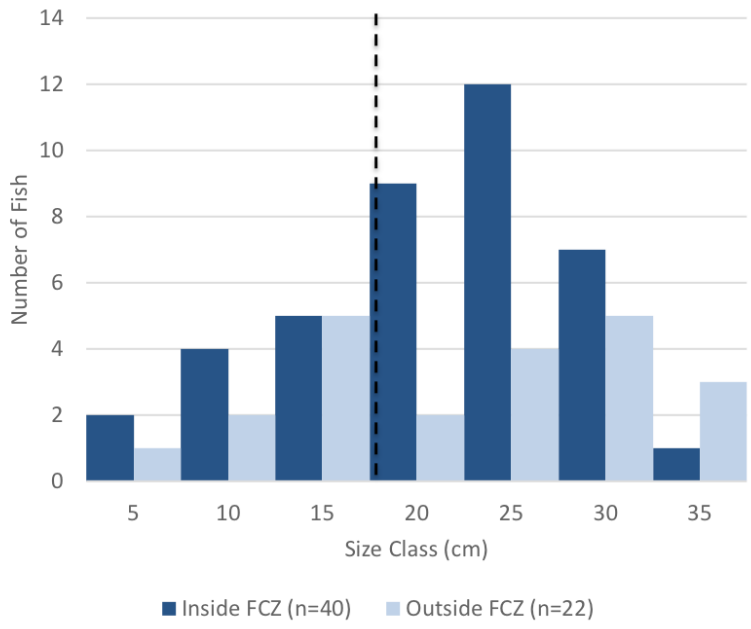


Figure 11. *Hypothetical example of length-frequency histograms for catch of a key species inside and outside of the FCZ. The dashed vertical line indicates the median size at maturity.*

Examples of how to interpret the results

To interpret results for this indicator, it is useful to know the size at maturity of the species of interest. This will allow resource managers to understand what percentage of the catch is made up of adults that can reproduce. The percentage of large individuals in the population could be graphed, or it could be communicated visually by using a collection of objects, such as rocks, and dividing them into piles to show the percentages of "large" and "small" fish. To graph length-frequency histograms, the size or weight categories for the species should be grouped into size classes (e.g., 5-cm increments, 1-kg increments). Then the number of individuals within each category should be counted – this is the "frequency" of each length or weight category. Size frequencies should be recorded separately for fish sampled inside and outside the FCZ. Histograms can be made of the size (or weight) frequencies for inside and outside the FCZ each year (Figure 11). If the median size at maturity (an estimate of the size at which half of the individuals in a population are mature) is known for the species, you can draw this as a vertical cut-off line in the histogram (see Figure 11).

This metric will not provide much information for a single year (at a single point in time), but after several years of data collection, you can begin to look for patterns in size structure. Is the median size of fish (or number of large fish) greater inside the FCZ than outside the FCZ? If so, this may indicate that the population is recovering inside the FCZ. In the hypothetical example data set provided in Figure 11, the histograms reveal that the overall catch was lower outside the FCZ, and the mean size of the fish was also smaller. In this example, the majority of the fish caught inside the FCZ are mature, and the majority of the fish caught outside of the FCZ are immature.

References

General fisheries survey methods for freshwater:

Bonar, S., W. A. Hubert, and D. W. Willis. 2009. Standard Methods for Sampling North American Freshwater Fishes. American Fisheries Society, Bethesda, Maryland.

FAO. 1974. Manual of Fisheries Science Part 2 – Methods of Resource Investigation and their Application. Food and Agriculture Organization of the United Nations, Rome, Italy.

Examples of studies using population structure as an indicator:

Cucherousset, J., J. M. Paillisson, A. Carpentier, V. Thoby, J. P. Damien, M. C. Eybert, E. Feunteun, and T. Robinet. 2007. Freshwater protected areas: an effective measure to reconcile conservation and exploitation of the threatened European eels (Anguilla anguilla)? Ecology of Freshwater Fish 16:528-538.

Sanyanga, R. A., C. Machena, and N. Kautsky. 1995. Abundance and distribution of inshore fish in fished and protected areas in Lake Kariba, Zimbabwe. Hydrobiologia 306:67-78.

Sarkar, U. K., A. K. Pathak, L. K. Tyagi, S. M. Srivastava, P. Singh, and V. K. Dubey. 2013. Biodiversity of freshwater fish of a protected river in India: comparison with unprotected habitat. Revista De Biologia Tropical 61:161-172.

Srinoparatwatana, C., and G. Hyndes. 2011. Inconsistent benefits of a freshwater protected area for artisanal fisheries and biodiversity in a South-east Asian wetland. Marine and Freshwater Research 62:462-470.

E3. Total abundance by group (such as "fishes")

Description (What is this?)

A taxon (plural: ***taxa***) refers to a group of species that are closely related. The taxa grouping may be broad, such as "fish" or "invertebrates," or it may be more specific, such as "catfishes," depending on what is the most useful indicator for the FCZ. This total abundance metric is a measure of the total relative amount (by count or weight) of a certain taxon within the FCZ. Abundance is a general term that may refer to relative numeric abundance (number of fish), relative biomass (mass of fish per unit of surface area or volume of water) or relative density (number of fish per unit of surface area or volume of water). Whether the assessment team chooses to measure numeric abundance or biomass may depend on the desired benefits of the FCZ. Biomass measures the mass of all fish combined, regardless of the number of fishes in the sample or catch. The overall biomass of a group may be more important to the resource managers (e.g., from a food security perspective) than the total number of individuals. As described for Indicator E1b, *Abundance of key species,* the term "relative" is used here because it is generally not possible to count every single individual of a species (called ***absolute abundance***); therefore, most methods compare abundance values that are *relative* to other times or locations (called ***relative abundance***).

Why measure this?

The total abundance (or total biomass) of a certain group of interest (such as fish or invertebrates) can be an indicator of the sustainability of this resource as a whole within the FCZ, and can assess the potential for this group of animals to spill over and benefit fishers outside of the FCZ. This indicator is useful if the resource managers are more concerned about the overall abundance of all fish species, and not as concerned about the abundance of individual fish species. The total abundance monitored over time will give resource managers an idea of increasing or decreasing trends that can guide management of the FCZ and nearby fisheries.

General considerations for data collection

- At minimum, the assessment team members will need to have a basic understanding of relative abundance, and have access to common fishing gears and a scale for weighing catch.
- The assessment team will need to obtain permission to sample aquatic species within the boundaries of the FCZ and choose a control site to compare to the FCZ.
- Once you have selected a gear type, you should continue to use this gear type for all sampling surveys, because gear types differ in how well they catch different species.

- Surveys of abundance by group should be conducted at least once a year, with each survey occurring at the same time of year to avoid bias because of changes in fish abundance that are due to different seasons.
- There are many resources in the scientific literature that provide advice on surveying for aquatic species abundance. This section will only discuss a few relevant examples.

Example methods

Relative total biomass (such as kg/unit of effort) of fishes or other aquatic animals (less technical): Surveying total biomass can be done using standardized fishery-independent sampling with gear such as nets and traps, as described above under Indicator E1b, *Abundance of key species.* This activity may be completed by training communities to conduct scientific surveys that are separate from regular fishing, to identify aquatic animals to the correct group, and to weigh total catch for the group. The individual animals do not need to be identified and separated by species, but only by the taxon category of interest. All individuals within one net or trap from a particular group can be weighed together, which makes this indicator relatively easy to measure. In this case, CPUE could be measured as kg of taxon per trap per hour, or kg of taxon per net per hour (such as kg of shrimp per trap per hour, or kg of catfish per net per hour).

Fisher interviews on total biomass estimates (kg/unit of effort): If direct sampling methods are not possible, then indirect measures of total fish abundance can be estimated from interviews with local fishers. Interviewers can record harvest estimates from fishers who fish nearby the FCZ. This indirect method assumes that the total abundance of the taxon group (e.g., fish) in the FCZ is related to (positively correlated with) the quantity of fish caught in nearby areas. Fishes can also be measured using hydroacoustic surveys by someone who has this type of expertise and training. We do not go into detail on this methodology in this guidebook because it requires expert skills and expensive equipment.

Examples of how to interpret the results

Abundance data can be graphed over time to examine trends both inside the FCZ and outside of the FCZ (in the control site).

Questions to consider:

1. Is there a trend in abundance of this taxon in the FCZ or in the control site? (Is it increasing or decreasing?)
2. Is the trend inside the FCZ similar to the trend at the control site outside the FCZ?
3. Is the overall relative abundance of the taxon inside the FCZ greater than, similar to, or less than its abundance outside the FCZ?
4. If both numeric abundance and biomass were measured, do the answers to the questions above differ between these two measurements?

Regardless of the trends over time, if relative abundance does not differ between the control site and the FCZ site, this may indicate that the FCZ is not affecting the overall taxon abundance, or that different species within the taxon are responding in different ways that complicate interpreting the results (if this is the case, then it would be helpful to examine the species composition – see Indicator E4*, Composition and structure of the aquatic community*).

References

General fisheries survey methods for freshwater:

Bonar, S., W. A. Hubert, and D. W. Willis. 2009. Standard Methods for Sampling North American Freshwater Fishes. American Fisheries Society, Bethesda, Maryland.

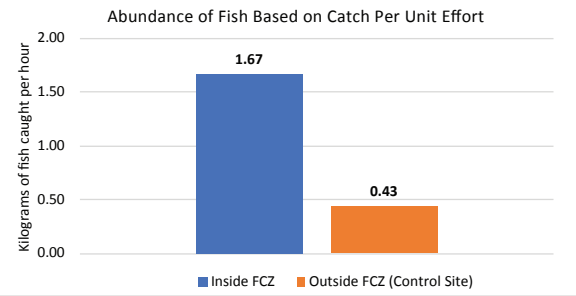
Examples of studies using total abundance by taxa as an indicator:

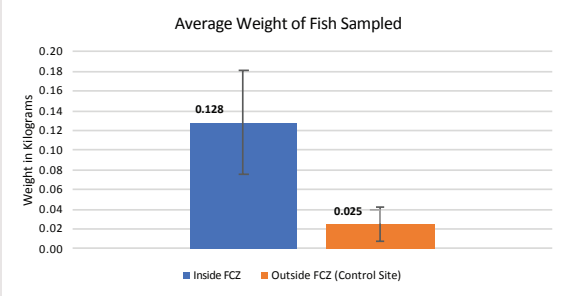
Srinoparatwatana, C., and G. Hyndes. 2011. Inconsistent benefits of a freshwater protected area for artisanal fisheries and biodiversity in a South-east Asian wetland. Marine and Freshwater Research 62:462-470.

Warren, T. J. 2003. Report on the 2000 – 2003 FCZ CPUE Study: Final Report. Prepared for the Living Aquatic Resources and Research Center (LARReC), Vientiane, Lao PDR.

Case Study Example: Kengmeaw FCZ

The FCZ assessment team conducted a fishery-independent fish sampling survey at the Kengmeaw FCZ to assess the abundance of all fishes. A control site with a similar habitat (rocky and muddy river bottom with underwater vegetation) was chosen outside of the FCZ for comparison, and was located 50 m downstream from the FCZ. The team fished four different sized gill nets (2-cm, 4-cm, 8-cm, and 10-cm mesh size) inside and outside of the FCZ for one hour. They fished inside the FCZ with permission from the village committee, and kept their fishing time very short to avoid harming the fish. At the end of one hour of sampling, the team caught 13 individual fish representing 9 species inside the FCZ, and 17 individual fish representing 10 species outside the FCZ. Results of the sampling based on fish weights are shown below, including standard error bars for average fish weights.





While more individuals and fish species were caught outside the FCZ, the weights of individual fish were larger inside the FCZ on average, as was the catch per unit effort (kilograms of fish caught per hour of fishing). This was likely because multiple large individuals of two large-bodied species (*Hypsibarbus malcolmi* and *Puntioplites falcifer*) were caught inside the FCZ. This fish sampling session would support the conclusion that there is a greater biomass (weight) of fish, and generally larger bodied fish, inside the FCZ. However, this was only a single sampling session, and a full survey with several sampling sessions would be necessary to see if these results are repeated.

E4. Composition and structure of the aquatic community

Description (What is this?)

Species ***biodiversity*** is the number and type of all living things that exist in a specified area. For the purposes of this guidebook, an ***aquatic community*** is defined as the collection of aquatic animals and plants that interact with each other in the same place and time. This community will reflect the overall biodiversity of the FCZ. The term "aquatic community" in this guidebook refers to animals and plants, not to human communities. An ***assemblage*** is a portion of the aquatic community that is closely related, for example the fish assemblage or the macroinvertebrate assemblage. The ***aquatic community structure*** refers to the relative abundance of the different species that make up the community, and how they are organized.

Why measure this?

If the goal of the FCZ is to protect or increase aquatic biodiversity, then it is valuable to monitor changes in the composition of the aquatic animals and plants. The structure and composition of the aquatic community can help indicate whether the environment is experiencing a disturbance that has caused changes in the aquatic community. For example, if a new fish species invades the FCZ and it eats or pushes out many of the native fish species, then assessments may show this change in the aquatic community composition. Another example would be a decline in the water quality, which could change the species composition of macroinvertebrates and result in a macroinvertebrate assemblage that is more tolerant of poor water quality.

General considerations for data collection

There are many metrics that can be used to measure "composition and structure of the aquatic community;" however, ***species richness*** (the total number of species in the aquatic community) is by far the most common. In most cases, the true species richness will be difficult or impossible to measure, just as it is not possible to count the absolute abundance of fish or invertebrates. This is because it is likely that you will not be able to sample all the very rare species that are difficult to catch, but are still present. However, estimates of species richness can be made by experts with technical training using various mathematical methods such as the rarefaction method, jackknife estimates, bootstrap procedure, and species-area curve estimates (Krebs, 1999).

While species richness is a common indicator, it is not good at detecting changes in the aquatic community composition, since species richness can be influenced by the size of the FCZ (a larger area is more likely to have rare species than a smaller area), the history of an area, and food web interactions. Another consideration is that total species richness includes both native and non-native species. Thus, one non-native species could replace one native species in a protected area, but this change would not necessarily be detected using total species richness because the total number of species would stay the same. If invasive species are a concern, ***native species richness*** can be used as a metric (Chessman 2013) instead of total species richness.

Evenness is a measure of how equally represented different animals are in the aquatic community. ***Dominance*** is a measure of the degree to which a species is more dominant than others (e.g., more numerous or more abundant by biomass). Soykan and Lewison (2015) suggest using evenness and dominance to measure community composition, since aquatic communities that are dominated by one species are often less stable (as is usually the case in environments that have experienced a disturbance). Diversity indices are mathematical calculations commonly used by scientists to combine information on species richness and evenness. The Shannon-Wiener (also called Shannon-Weaver) Index is one of the most common diversity indices used by researchers.

Using this indicator requires some basic understanding of the species that make up the aquatic community, and how these species interact in a healthy river system. The assessment team will

need to be able to tell the difference between species as much as possible in the field, which can be difficult in Lao PDR due to the high diversity of species in the aquatic environment. It is important to consider the challenges of species identification, especially if different people are identifying species each year. Care should be taken to ensure that all assessment team members that are identifying species are identifying them correctly, and are in agreement on their species assignments. All team members should receive the same species identification training and refer to the same identification information sources.

This indicator requires similar resources and equipment as for measuring abundance indicators E1b and E3, as described in the previous sections. Since some species may be migratory and only occupy the FCZ during certain times of the year, it will be necessary to do the surveys at the same time each year to avoid bias created by sampling at different times or seasons. It would be ideal to sample for this indicator at the time of the year when local people believe the aquatic diversity is highest (such as the late wet season), if the sampling method allows.

Ideally, the sampling should cover as many of the habitats represented in the FCZ as possible because some rare species may only be found in certain habitats. Sampling should also be thorough enough that the assessment team members feel confident they recorded as many species as possible. Unlike previous indicators, this indicator requires collecting information on *all* living organisms within the FCZ, not just key species or taxa of interest. The need for both accurate species identification and thorough sampling make this indicator more difficult to measure than others.

Example methods

Collecting information on the composition and structure of an aquatic community generally involves directly sampling aquatic organisms. This information is often collected at the same time as collecting species abundance data using standard sampling equipment, such as visual census techniques, traps, and nets for fishes (see indicators E1 and E3).

Species richness estimates derived from interviews with fishers (less technical): The most basic and rapid form of information gathering involves interviewing local fishers who fish very close to the FCZ. The interviewers can ask the fishers to list the fish species they catch, with the help of photos from identification books and posters. This method is not ideal because 1) the fishers will be describing catch outside of the FCZ, which may not reflect the aquatic community inside the FCZ, and 2) the fishers will be describing fish caught by particular fishing methods and gear that are influenced by the fishers' target species choices and their fishing behaviors. Fishers may also forget to mention rare species that they do not catch every day. However, in some cases interviews may be the only feasible way to gather species information.

Native fish species richness (total number of native species): Collecting data on the species richness of fish or OAA can be done using standardized fishery-independent sampling (such as nets or traps), which is described for abundance indicators E1 and E3. However, unlike the approach for Indicator E1, the objective for Indicator E4 would be to sample using as many methods as possible to capture as many different types of species as possible. This requires training the assessment team to conduct fishery-independent scientific surveys (separate from regular fishing), and identify the fish catch to species level. This would not require the assessment team to count the individual animals, but only to make a list of all the different fish species that were captured. This sampling can be conducted at the same time as sampling for abundance indicators. However, it is important to consider that species richness can be strongly affected by the sample size and size of the area surveyed (Magurran 1988; Fausch et al. 1990 as cited in Williams and Zedler 1999). Changes in species richness over time can be examined by comparing the list of species recorded during each sampling event.

Macroinvertebrate assemblage: Information on the composition of aquatic macroinvertebrates can be collected using The Asia Foundations (TAF) sampling protocols (see Indicator E6, *Water quality*).

Evenness and diversity metrics: The following metrics require that all individuals of each species are counted, and can be difficult to calculate and interpret for non-scientists. Data can be collected for these metrics using similar methods to abundance sampling (e.g., fishery-independent sampling using nets or traps).

Evenness of fish or OAA assemblages: Evenness can be calculated based on catch from standardized fishery-independent sampling (such as nets or traps) as described above; however, this requires that the assessment team has counted each individual within each species. This measure can give the resource managers a sense of whether there is a change in the dominance structure of the assemblage over time. Several equations can be used as measures

of evenness, such as Simposon's measure of evenness, and many are described in Krebs (1999).

Shannon-Wiener Diversity Index of fish or OAA assemblages: The Shannon-Wiener (also called Shannon-Weaver) Index is one of the most common diversity indices used by researchers. It can be calculated based on catch from standardized fishery-independent sampling (such as nets or traps), and it requires calculations that can easily be performed in a statistical software program, so the assessment team should have technical expertise in diversity indices.

Examples of how to interpret the results

Metrics of diversity can be used to interpret the results of the sampling, including native (or invasive) species richness and evenness. Species richness is the most common metric to assess composition and structure of the community, but the Shannon-Weiner Diversity Index is another commonly used metric. For macroinvertebrates, indices such as the species richness of the key groups Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), which are collectively referred to as "EPT" (e.g., Paz et al. 2008), are often used as a general indicator of freshwater health.

Interpreting the composition and structure of the aquatic community requires several years of data collection for informative comparisons. Species diversity metrics can be compared inside the FCZ with the control site outside of the FCZ using a t-test. Numbers (frequency) of each species can be graphed to visualize the dominance or evenness of the species that make up the aquatic community.

Questions to consider:

1. Do the data indicate a difference in the species diversity inside the FCZ compared to the control site outside of the FCZ?
2. Are there changes over time in the relative abundance of different species? Is there a dominant species?

References

General references:

Krebs, C. J. 1999. Ecological Methodology. 2nd edition. Benjamin Cummings, New York, New York.

Magurran, A. E. 1988. Ecological Diversity and Its Measurement. Princeton University Press, Princeton, New Jersey.

Examples of studies using composition and structure of the aquatic community as an indicator:

Casado, C., L. Losada, and S. Molla. 2011. Effect of special protected areas in the macroinvertebrate community in the Manzanares upper basin (Sierra de Guadarrama, Madrid). Limnetica 30:71-88.

Chessman, B. C. 2013. Do protected areas benefit freshwater species? A broad-scale assessment for fish in Australia's Murray-Darling Basin. Journal of Applied Ecology 50:969-976.

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E5. Total catch per unit of fishing effort

Description (What is this?)

A unit of ***fishing effort*** describes the time and number of people involved in fishing with a particular type of gear. Total catch per unit effort (CPUE) describes how efficiently fish are caught, such as kilograms of fish caught per hour of trap fishing. In this guidebook, ***fishing*** refers to any kind of harvest of plants or animals near the FCZ. This is a ***fishery-dependent*** method of sampling that relies on monitoring the catch of local fishers.

Why measure this?

FCZs are often established to help protect and increase the abundance of fish populations to support a more sustainable fishery. The term ***spillover*** is often used to describe the increased abundance of fish (or OAA) that can occur just outside of an FCZ due to increased abundance of fish inside the FCZ. Protected juveniles and adults within the FCZ may increase in numbers so much that they move outside the FCZ to seek additional habitat. Spillover may also occur when reproductive fish populations increase in number inside the FCZ, and they produce larvae that disperse outside of the FCZ. Spillover effects are commonly cited as one of the important benefits of FCZs to the fishing community; however, they are difficult to study and measure. This indicator attempts to measure the effect of spillover through the return on fishing effort in nearby areas.

General considerations for data collection

- Fishing effort can be very different depending on the season in Lao PDR, and is influenced not only by the environment, but also by social activities such as holidays and Buddhist days. It is recommended that fishing effort be measured on a regular basis, such as daily or weekly.
- Fish catch surveys should represent a range of fishing time periods and locations.
- This indicator is related to a few socioeconomic indicators. Indirect information on S1, *Local fishing patterns and practices* can be collected during household interviews with fishing families. Likewise, some data relevant to the quantity of catch sold and sales profits, may be gathered during harvest surveys.
- Fish catch surveys (measuring the CPUE of certain gear types) outside of the FCZ can be conducted directly through logbooks or creel surveys, or indirectly through household surveys and key informant interviews that ask fishers to estimate their fish catches from their memory. Direct methods are preferred over indirect methods.
- The methods described in this section require basic training and simple common equipment (such as a scale to weigh catch).
- The methods can be conducted by trained community members or by CSO staff. However, these methods produce a large amount of data. These data will need to be managed, analyzed, and interpreted by

someone with expert training in fisheries data analysis.

- While the methods are generally straightforward, a substantial amount of effort is required to conduct fish catch surveys, which requires a long-term commitment by all who are involved. This is an important consideration when selecting this indicator.

Example methods

Creel surveys of fishers: ***Creel surveys*** are interviews conducted by trained assessment team members with fishers that are returning from fishing. This approach is easier to use in areas that have distinct fish landing sites where fishers bring in their catch. This method is much more difficult to use when fishing is dispersed. Data collected from a random selection of fishers should include:

- ☐ Names of key species (if any)
- ☐ Location of fishing
- ☐ Harvest methods
- ☐ Gear type and number
- ☐ Any additional support gear, such as boats
- ☐ Number of fishers involved
- ☐ Total hours spent fishing (Hours gear was in the water)
- ☐ Number of fish caught
- ☐ Weight of the catch

The assessment team should try to randomly or systematically select fishers to interview to avoid bias that may be introduced by the selection process. For example, if you plan to sample roughly one third of the fishers, then you could interview every third fisher that arrived at the landing site. A random selection of fishers is suggested if the goal is to understand the overall catch per type of fishing gear for all fishers in the village. While it may be informative to interview fewer, more experienced fishers as a whole, the information they provide will not reflect the general population of fishers. Using data from only experienced fishers to estimate the total catch per unit of fishing effort for the whole village would produce an estimate that would likely be too high (because you are assuming all fishers are as good at catching fish as the most experienced fishers).

Fisher logbook programs: Fisher logbook programs train local fishers to gather fishery-dependent data, a strategy that directly involves fishers in the monitoring. This takes advantage of the fishers' local ecological knowledge (such as the amount of each species caught and fishing effort). There are a few drawbacks to this approach. The primary drawback is that it relies on information collected by a small group of selected fishers; therefore, it is extremely important to select fishers that are representative of the fishery around the FCZ (e.g., use common fishing methods and fish regularly). Another con-

sideration is that it will not be possible to collect as much data using logbooks, as it is not reasonable to request the fishers to fill out large amounts of data each day. Asking fishers to collect too much data may negatively affect the quality of the data.
Fishers participating in a logbook program can be trained to record essential data on their fishing catch and gear for each day they spend fishing (Table 14). Trained fishers should be asked to maintain their normal level of fishing effort, and to not modify their fishing behaviors or methods based on their participation in the assessment program.

The gear data can include:

- ☐ Description (or local name) of the gear
- ☐ Type of gear used (e.g., net, long line, hook, trap, or other)
- ☐ Size dimensions of the gear
- ☐ Habitat where the gear was set (such as main stream, tributary, floodplains, wetlands, estuaries, or rice fields)
- ☐ Number of hours the gear was fished (i.e., fishing effort)

The fishing effort is particularly important to record. It is very important to record how long the fisher spent fishing even if the fisher did not catch anything (i.e., unsuccessful fishing trips, Table 14). For passive gears that are set in the water and left for a period of time, such as gill nets or bamboo traps, the hours the gear was fished are the number of hours the gear sat in the water (from when the gear was placed in the water to when the gear was pulled out of the water). This does not include the time it takes to travel to the fishing site, or the time it takes to prepare the fishing gear before it enters the water. For active fishing gears, such as seine nets, lift nets, or scoop baskets, the hours spent fishing includes the time that was spent actively fishing with the gear. This does not include the time it takes to travel to the fishing site or any time that was spent resting during fishing. Example fish catch data collection protocols are provided in Appendix 2 and Appendix 3.

Illegal fishing methods monitoring: Illegal fishing methods such as electrofishing and dynamite fishing are a common problem in Lao PDR. If these fishing efforts are occurring near the FCZ, they should also be documented to understand possible trends in how they could affect fish abundance (such as, is the number of illegal fishers increasing over time?). This would require a boat and possibly shore monitoring at night or in the evenings, and may be done with an FCZ enforcement team. These data may be difficult to gather, as illegal fishing is often conducted in secret.

Examples of how to interpret the results

Ideally, each species should be analyzed separately, since grouping the catch into total fish catch can hide trends of individual species. However, if the focus of the assessment is on how much effort fishers spend to catch fish (or OAA) overall, then the catch may be grouped by taxon. CPUE is calculated separately for each gear type. Calculate CPUE for each fisher each day as total kilograms of catch for each species divided by the number of hours spent fishing with all units of a particular gear (such as all drop door traps or all gill nets of the same size). If it is too difficult to separate catch by gear type, then a total CPUE for all gear types could be calculated; however, there will be considerable variation associated with this measure, since one fisher may be using only gill nets and another may be using only hook and line, and their CPUE would not be comparable. Likewise, if gear types change over time, then this could shift the apparent combined CPUE even if the actual CPUE of each gear type remains the same.

Example CPUE calculation: A fisher reports that 8 kg of *Hemibagrus wyckioides* was captured during 5 hours of fishing three gill nets.

CPUE = 8 kg/(5 hours*3 nets) = 0.53 kg/net/hour

Trends in the average CPUE can be examined over time to see if there are increases or declines in the catch near the FCZ. The average fisher CPUE can also be compared with the CPUE of the species collected for Indicator E1b, *Abundance of key species* inside and outside of the FCZ (i.e., collected through fishery-independent methods).

Questions to consider:

1. Has the amount of catch per unit effort been increasing or decreasing over time?" (i.e., is it getting easier or harder for fishers to catch fish?)
2. Are trends in how much fishers are catching similar to the trends found in fishery-independent sampling? Is there a correlation between the two?
3. Have there been changes in the gear types used over time?
4. Have there been changes in the number of fishers or number of gears deployed over time?
5. Has there been an increase or decrease in the instances of illegal fishing over time?

References

Examples of using total catch per unit of fishing effort as an indicator in freshwater:

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Table 14. *Example of a form filled out by a fisher who was using a long line but did not capture anything. It is very important to make sure that the fishers still document their effort even if they do not catch any fish. In this case, catch per unit effort is "zero." This zero value would be included in the calculation of an average CPUE.*

SITE DATA				
Village Name: Ban Ang Noi		Fisher Name: Mr. H		Indicator: E5
Fisher ID: 00134		Date (DD/MM/YY): 24. 03. 2013		
Water Level:	Rising X	Static ☐	Falling ☐	
Weather:	Full Sun ☐	Partly Cloudy X	Cloudy ☐	Raining ☐
GEAR 1:			Number of gear units:	
Gear Type (Check One):	☐ NET Length (m):	Height (m):	Mesh Sizes (cm):	
	X LONGLINE # of hooks: 15		Hook Size (cm): 10	
	☐ SINGLE HOOK Hook Size (cm):			
	☐ TRAP:		☐ OTHER GEAR TYPE:	
Start Time: 08:13			Total Hours Fishing: 5.5	
Fishing Method: Bottom long line				
Habitat Fished: Fished in the deep pool				

FISH CATCH FOR GEAR 1:				
Total Catch Weight (kg):	Local Fish Name:	#	Weight (kg):	Photo?
0	Did not catch any fishes			☐
				☐
Sub-sample Catch? YES ☐				☐
				☐
				☐
				☐

E6. Water quality

Description (What is this?)

Aquatic animals fully depend on the quality of the water they live in, and therefore water quality can greatly influence the health of the aquatic community in an FCZ (Pomeroy et al. 2004). If the quality of the water in the FCZ is not adequate, then fish populations may not benefit from protection in the FCZ. In this guidebook, ***water quality*** generally refers to conditions of the water that may influence the animals and plants inside the FCZ. Water quality conditions that are frequently measured in freshwater studies include:

- temperature
- conductivity (salinity)
- pH
- dissolved oxygen
- turbidity or transparency

There are many other relevant water quality conditions that require more expertise to measure, and are therefore not included in this guidebook (such as *E. coli,* fertilizers, pesticides, nutrients, sedimentation, and phytoplankton).

Why measure this?

Water quality inside FCZs in river systems is generally influenced by factors outside the FCZ boundaries, such as nearby agriculture practices or discharge from factories. Therefore, water quality is not usually an indicator of how well FCZ protections are working, but is instead used to understand other factors that may cause changes in aquatic species composition or abundance (e.g., Silvano et al. 2009). Changes in water quality can have negative effects on fish health and behavior. Water quality indicators may be more informative when data are collected over time (before and after FCZ establishment) to clarify whether a difference in water quality is related to FCZ management actions. This indicator may also be more useful for FCZs that have specific management actions to address water quality, such as creating buffer areas between agricultural lands and the FCZ. For other FCZs, this indicator may be more useful for assessing external threats to FCZ effectiveness. For example, erosion upstream of the FCZ can cause increased levels of sedimentation in the river and lower water transparency. This can be especially true in areas where water flow has increased due to hydropower discharge. Similarly, if there are significant water diversions or inputs upstream from the FCZ, it may be useful to monitor the stage height of the water. These data may not be useful as an indicator of FCZ management success, but rather can be used to identify issues created by external factors that could affect the performance of the FCZ.

General considerations for data collection

- Extensive scientific literature and textbooks are available on the best practices for sampling water quality conditions; therefore, we will only discuss them briefly.
- Conditions commonly measured for aquatic protected areas include: temperature, dissolved oxygen, conductivity, turbidity/transparency, and other standard analyses using regular sampling with a multi-parameter device (such as a YSI).
- Trained community members can collect simple observational data that relate to the quality of the water. These observational data will be most helpful in identifying potential problems with water quality and developing hypotheses, which would then need to be tested using more rigorous technical methods. Trained community members can also use some of the more inexpensive, simple tools for water quality monitoring, such as thermometers or a Secchi disk.
- Water quality conditions can change hourly, daily, and seasonally, so it is very important that these conditions are measured frequently and compared between years at the correct time scale. For example, water temperature can be collected daily or weekly and then averaged by month, and months can be compared between years. All water quality conditions will need to be collected more than once a year to be informative.

- It would be useful to find sources of water quality data from nearby areas that can suggest how much you should expect water quality to change in your area throughout the year. The Lao government has several programs that regularly collect water quality data throughout the country. It may be possible to partner with the government or other organizations that are already conducting water quality sampling in a standardized way.

Example methods

Observational data collected on water quality: Observations on general water quality characteristics can be made by trained community members. These observations can be recorded as qualitative data (detailed notes) or they can be ranked and recorded as quantitative data (given a score), or both. Examples of this kind of data include unnatural smells or characteristics of the water surface:

Unnatural Water Odors
(Choose one: normal/none; some odor; strong odor)

If present, please circle:

- Sewage
- Petroleum
- Chemical
- Fishy
- Other: _____

Water Surface Oils
(Choose one: normal/none; some surface oils, a lot of surface oils)

If present, please circle:

- Slick
- Sheen
- Globs
- Flecks
- Other:_____

Basic temperature, stage height, and transparency data (less technical): Community members can be trained to use a mercury thermometer, staff gauge, and Secchi disk to regularly collect and record temperature, stage height, and transparency conditions inside and outside of the FCZ (or only inside the FCZ, in the case of the stage height). These data should be collected frequently enough to document how water quality may change in the environment throughout the year. Collecting these data just once a month will likely not be sufficient in Lao PDR, because there is high variability in water conditions between seasons.

Macroinvertebrate assemblage as bioindicators (less technical): Monitoring of macroinvertebrate (aquatic insect) assemblages can provide information on water quality by using the invertebrates as biological indicators. This can be conducted regularly by communities following The Asia Foundation's (TAF) biomonitoring sampling protocols. The steps below are adapted from TAF's macroinvertebrate sampling protocol and are reproduced here with permission; additional details are provided in Gaurino (2012).

Step 1: Site Selection

First, we need to know where to find macroinvertebrates in the water.

Macroinvertebrates like places where:

- It is not too deep (they like shallow water)
- There is vegetation cover (so the water doesn't get too hot)
- There are aquatic plants in the water (to eat and hide in)
- There are places to hide from predators (such as under rocks and logs)
- There is sandy or rocky substrate (river bed)

Step 2: Collecting the Macroinvertebrates

One way of collecting macroinvertebrates is called the KICK SAMPLE. This technique collects water bugs that are bottom dwellers, found in the sediment and mud. It is best used in running water. Select an area in the waterway that is shallow

enough to stand in (ideally knee deep), and that has an area of at least 5 meters that you can walk, upstream, in a straight line. To begin, face down stream and submerge your sampling net so that it is positioned directly in front of your feet, on the floor of the river bed, with the mouth of the net facing upstream. Shuffle and kick the ground as you WALK BACKWARDS upstream for 5 m. As you kick the ground, sediment, mud, and rocks will be disturbed; the flow of the water will wash dislodged invertebrates into the net. Try not to collect too much mud, silt or organic matter.

Step 3: Sorting the Macroinvertebrates

Before you can identify the water bugs you have collected, you will need to sort them first. Follow these steps:

- Half fill your white sorting tray with water.
- Turn your net inside out and empty your sample into your sorting tray. Wash down the sides of your net with some water to make sure you get your entire sample into the tray.
- Be careful not to overfill your sorting trays with sediment and leaves, as you won't be able to see the macroinvertebrates. If necessary, spread your sample over multiple trays.
- Place your sorting trays in the shade, as macroinvertebrates do not like to be exposed to strong light.
- If there is a lot of mud in your sample, let it settle for about 10 minutes; this will make it easier for you to find the water bugs.
- Pick and sort through the collected material. Look very hard, some water bugs are great at camouflage and it may take time to find them.
- When you spot an animal, use tweezers, a tea strainer, spoon, or pipette to remove it and place it into the petri dish with clear water from your site.
- Now that you've sorted the water bugs, it's time to identify them.

Step 4: Identify the Macroinvertebrates

First, let's look at the different parts of macroinvertebrate bodies that help us identify them. Some macroinvertebrates are so small we need a magnifying glass to see them. For the others, here are some simple things to tell them apart.

Different species can have:

- Shells or no shells. A single shell or double.
- Legs or no legs. Six legs or eight.
- Wings or no wings. Soft wings or hard wings.
- A tail or no tail. Two tails or three.

Use the TAF Identification Key to identify each individual bug collected.

Different water bugs can tolerate different levels of pollution in water. They are divided into three sensitivity groups that are color-coded as green, yellow, and red. This is what helps us to know if water is good, ok, or bad. Insects with a low tolerance to polluted water are in the GREEN group. Insects with a moderate level of tolerance to polluted water are in the YELLOW group, and insects with a high level of tolerance to polluted water are in the RED group.

Each species in the TAF Identification Key has a sensitivity score from 1 to 10. A score of 8–10 means a species is very sensitive to pollution, and you will ONLY find it in good quality water. A score of 4–7 means a species is moderately sensitive to pollution, and you can find it in moderate to good quality water. A score of 1–3 means a species is not very sensitive to pollution, and you can find it in poor to good quality water.

Step 5: Record your Findings, and Calculate the Sensitivity Score

Now that we have identified each of the macroinvertebrates, we need to determine their sensitivity to pollution in the water. On the Aquatic Macroinvertebrate Record Sheet (Figure 12), place a tick mark next to all the types of macroinvertebrates you identified AND write the number of how many you found. Only place one tick mark for each taxa found (for example, if you have more than one stonefly, you still only put one tick mark). We also need to write in the sensitivity number for each macroinvertebrate present. Remember, this is the sensitivity number between 1 and 10 that lets us know the water quality.

At the bottom of the record sheet, add up the total number of tick marks. This gives you the Taxa Richness. Remember, there should only be one tick mark for each species collected. Then add up the total sensitivity score. This gives you the Pollution Index. Please remember to use one record sheet per site. After you have identified all the macroinvertebrates in your sample and have completed the record sheet, return the macroinvertebrates back to the waterway.

Step 6: Calculate the Water Quality Score

Now it's time to determine how healthy the waterway is using the Water Quality Score formula. Divide the POLLUTION INDEX by the TAXA RICHNESS to get your WATER QUALITY SCORE.

Follow the formula shown:
Water Quality Score = Pollution Score/Taxa Richness

- A score between 7.0 – 10 is Good.
- A score between 3.0 – 6.9 is Fair (not so bad).
- A score between 1.0 – 2.9 is Poor.
- A score of 0 means there is no aquatic insect life at all and water quality is extremely poor

Aquatic Macroinvertebrate Record Sheet

(Page 1 of 1) *(For use with Aquatic Macroinvertebrate Record Sheet)*

	Common name	Scientific Order (unless otherwise indicated)	Pollution Sensitivity	Total no. found	Tick if present ✓	Put the sensitivity no. here
SENSITIVE	Mayfly nymph	*Ephemeroptera*	10			
	Caddis fly larva	*Trichoptera*	10			
	Stonefly nymph	*Plecoptera*	9			
	Riffle beetle adult	*Coleoptera*	8			
	Riffle beetle larva	*Coleoptera*	8			
	Crane fly larva	*Diptera*	6			
	Water mite	*Acariformes*	6			
TOLERANT	Water flea	*Cladocera* (suborder)	5			
	Whirligig beetle adult	*Coleoptera*	5			
	Whirligig beetle larva	*Coleoptera*	5			
	Black fly larva	*Diptera*	5			
	Water measurer	*Hemiptera*	4			
	Damselfly larva	*Odonata*	4			
	Dragonfly larva	*Odonata*	4			
	Freshwater prawn	*Decapoda*	4			
	Scud	*Amphipoda*	4			
	Freshwater shrimps & prawns	*Decapoda*	4			
	Biting midge larva	*Diptera*	4			
	Copepod	*Copepod* (subclass)	4			
	Water strider	*Hemiptera*	4			
	Seed Shrimp	*Ostracoda*	4			
	Soldier fly larva	*Diptera*	4			
VERYTOLERANT	Water scorpion	*Hemiptera*	3			
	Freshwater slater (isopod)	*Isopoda*	3			
	Freshwater mussel	*Bivalvia* (class)	3			
	Scavenger water beetle adult	*Coleoptera*	3			
	Scavenger water beetle larva	*Coleoptera*	3			
	Mosquito larva/pupae	*Diptera*	3			
	Flatworm	*Turbellaria* (class)	3			
	Non-biting midge larva	*Diptera*	3			
	Freshwater crab	*Decapoda*	2			
	Freshwater snail	*Gastropoda* (class)	2			
	Back Swimmer	*Coleoptera*	2			
	Hydra	*Hydrozoa*	2			
	Leech	*Hirudinea* (class)	2			
	Predacious diving beetle adult	*Coleoptera*	2			
	Predacious diving beetle larva	*Coleoptera*	2			
	Roundworm	*Nematoda* (phylum)	2			
	Water boatman	*Hemiptera*	1			
	Segmented worm	*Oligochaeta* (class)	1			

Species Richness	How healthy is your site's environment?
0 - 5	This site is a very poor environment for aquatic macroinvertebrates.
6 - 10	This site provides an environment that only a few different types of aquatic macroinvertebrates can live in.
11 - 15	This site provides a moderately healthy environment for many aquatic macroinvertebrates.
15 - 23	This site provides a fairly healthy environment for many aquatic macroinvertebrates to live in.

Water Quality Score	
0	No life
1.0 – 2.9	Poor
3.0 – 6.9	Fair
7.0 - 10	Good

1. Add up all the ticks (✓) and write here.
This is the **SPECIES RICHNESS**

2. Add up the total for the sensitivity score and write here.
This is the **POLLUTION SCORE**

3. To get the Water Quality Score; divide the Pollution Score by the Species Richness

Water Quality Score = $\frac{\text{Pollution Score}}{\text{Species Richness}}$ =

Figure 12. *The Asia Foundation's Aquatic Macroinvertebrate Record data sheet used for biomonitoring.*

Table 15. *Example of data sheet for collecting water quality data using a multiparameter meter.*

SITE DATA	
DATE:	INDICATOR:
VILLAGE NAME:	DISTRICT:
LATITUDE:	LONGITUDE:
ASSESSMENT TEAM MEMBER NAMES:	
START TIME	
END TIME	
INSTANTANEOUS WATER QUALITY	
Left Bank:	Temperature (C):
	Dissolved Oxygen (mg/L):
	Secchi Depth (cm):
	pH:
	Conductivity (mS/m):
	Depth (m):
Middle River:	Temperature (C):
	Dissolved Oxygen (mg/L):
	Secchi Depth (cm):
	pH:
	Conductivity (mS/m):
	Depth (m):
Right Bank:	Temperature (C):
	Dissolved Oxygen (mg/L):
	Secchi Depth (cm):
	pH:
	Conductivity (mS/m):
	Depth (m):
NOTES	

Multi-parameter water quality meters (more technical): Water quality data can generally be collected at the same time as doing other sampling by using multi-parameter water quality meters. These water quality meters are expensive devices that require maintenance and calibration, and therefore should only be used by people with specialized training. Conducting additional water quality measurements inside and outside of the FCZ using technical expertise may be necessary if there are human land-based activities upstream that are known to impact water quality, such as factory discharge or mining operations. Furthermore, expert sampling can be conducted at the same time as community-level sampling in order to spot-check the results. Measuring conductivity may be particularly informative to understand the possible impacts of fertilizers and factory discharge. Dissolved oxygen is an important factor that affects most aquatic animals, and should be measured if using an appropriate meter.

Water temperature using a submersible thermo-logger: Relatively inexpensive thermo-loggers can be deployed inside and outside of the FCZ to monitor water temperature at regular intervals. These devices must be secured to solid surfaces, and require special training to download and summarize the data.

Examples of how to interpret the results

To visualize seasonal changes in water quality inside and outside the FCZ, data for each condition can be summarized (by calculating the average, maximum, and minimum) by month and then graphed for

each year (x axis = month, y axis = condition). Also, monthly averages can be compared among years. A more technical analysis is to statistically compare trends over time between the inside and outside of the FCZ, and examine correlations between these trends. Correlations can also be examined between water quality trends and trends in biological data (e.g., fish abundance). A few years of data collection would be needed to interpret trends and understand the link between these trends and other indicators.

If persistent water quality issues are uncovered and are determined to be outside the scope of the FCZ management, then this indicator may be useful to determine whether the FCZ is in a poor location and should be moved to a location with adequate water quality.

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E7. Habitat distribution and quality

Description (What is this?)

The habitat inside the FCZ is the area where aquatic animals live, and includes features that are alive (such as aquatic plants) and non-living (such as rocks, sand, pools, or waterfalls). The term "habitat" is very broad, and can include the type of substrate (such as rocks, sand, or mud), the shape of the river bed, and the aquatic plants. The distribution of habitat within the FCZ can refer to the location and size of the habitat, and the relationship between different habitat elements (Pomeroy et al 2004). Aquatic habitats of FCZs can differ widely in Lao PDR. In some FCZs, the habitat may be very similar throughout ("homogeneous") and the area of the FCZ may be small; in other FCZs the habitat may be diverse ("heterogeneous"), and the area of the FCZ may be large. The habitat complexity within the FCZ is the diversity of distinct zones or habitat types that exist in the FCZ. Most FCZs are designed to protect the deep-pool habitat type, as described in the Lao Fisheries Law (2009), but FCZs might also include other habitat types, such as lakes and wetlands. The quality of the habitat for a species of interest can vary from very good to very poor, based on the requirements of that species.

Why measure this?

If one of the FCZ objectives is to protect critical habitats (such as spawning habitat or deep pool refuges), then measuring this indicator is recommended. Habitats in rivers are constantly in motion, and can change through time. Natural or human disturbances may alter aquatic habitats, and these changes can affect the abundance and distribution of the animals and plants in the FCZ. For example, sedimentation could reduce the depth of deep-pool habitats, which could reduce their quality and usefulness as a refuge for fish during the dry season. As another example, harvesting aquatic plants along the riverbank may reduce the food available for certain aquatic animals. Large hydrologic events such as floods can move rocks and shift the river bottom materials.

Another reason to examine habitat during FCZ assessments is that the habitat inside the FCZ may influence your interpretation of the results of other indicators. Since it is rare to have baseline data collected before the FCZ was established, most studies are "inside vs. outside" designs that compare protected areas to control sites. When making such comparisons, it is necessary to consider differences in habitat distribution and quality that may exist at sites inside and outside of protected areas. FCZ boundaries are not selected randomly, and are often chosen because they contain habitat that is relatively good quality or diverse. This is an important consideration when selecting control sites to evaluate the effectiveness of protection. In some cases, the most appropriate control sites for sampling may not be similar in habitat, in which case this can be addressed during the analysis stage. Several studies of the effectiveness of river protected areas (Sarkar 2013; Srinoparatwatana 2011) compared the protected area with an unprotected river reach nearby, and found that the dif-

ference in habitat between the two sites made it difficult to identify whether protection or habitat has more influence on fish populations. Therefore, it is crucial to account for the effect of habitat during comparisons of fish abundance inside and outside of the FCZ.

There may also be an issue of a statistical interaction between protection and habitat. Increased habitat quality and complexity is often considered an expected benefit from protection (which is why it is used as an indicator of FCZ effectiveness). However, protected areas are often sited at locations that already have relatively good habitat quality or diversity. Thus, if the protection leads to improvements in habitat inside the FCZ compared with outside areas, it may not be possible to know whether a greater abundance of fish inside the FCZ is due to a pre-existing difference in habitat inside vs. outside the FCZ, or due to habitat improving in an FCZ (a result of effective FCZ management). As with water quality indicators, it is ideal to have datasets from before and after protection to clarify whether differences in habitat are related to protection or whether they existed previously.

General considerations for data collection

- Habitat should be surveyed both inside and outside of the FCZ, as described above. The selection of a control site outside of the FCZ may be challenging if the FCZ represents a unique or relatively rare habitat type. In some cases it may be helpful to select several control sites to compare to the FCZ.
- As much of the habitat in the FCZ should be surveyed as possible, and ideally, the full FCZ should be surveyed for habitat.
- This survey should be done every year during the same month or season. The timing of the surveys may depend on whether there is an important biological component to the habitat, such as aquatic plants that occur seasonally.
- If there is a large event that would likely cause a change in the habitat, such as flooding or road construction, it would be ideal to conduct a survey after this event to note any significant change.
- The assessment team should be trained to identify different habitat types and attributes. They will need to be trained to use simple equipment such as a tape measure, range finder, and depth measure (rope attached to a weight).

Example methods

Observational data (less technical): Community members can be trained to collect observational data on habitat based on protocols developed by The Asia Foundation (Table 16). These include:

- ☐ Land use near river bank
- ☐ Presence of houses
- ☐ Channelization of the river bank
- ☐ Bank stability on each side
- ☐ Riparian vegetation (e.g., trees, shrubs, herbaceous materials)
- ☐ Aquatic vegetation (e.g., attached algae, rooted vegetation, floating vegetation)
- ☐ Visible trash
- ☐ Water odors
- ☐ Water surface appearance

Additionally, river habitat types within the FCZ can be characterized as a run (deep area of fast-moving water), riffle (a rocky area with fast-moving water) or pool (deep area of still water). If there is more than one habitat type in the FCZ, these can be estimated as the percentage of each habitat type present. Assessment teams can also estimate the percent coverage of various aquatic plant types.

Data collected by community members using common equipment: Assessment teams can measure the cross-sectional width of the river or stream using a long tape measure (if the river is narrow enough) or by using a range finder (if available). The cross-sectional depth can be measured as a transect across the river and graphed on graph paper. The average river depth can be recorded and compared over time. If the FCZ is in a stream that is shallow enough to cross on foot, then surveys of the substrate type can be conducted using a gravelometer (which is a board

Table 16. *Example habitat data sheet developed by FISHBIO and The Asia Foundation.*

SITE DATA:		
DATE:		
VILLAGE NAME:		DISTRICT:
LATITUDE:	LONGITUDE:	INDICATOR:
ASSESSMENT TEAM MEMBER NAMES:		
START TIME:	END TIME:	
WEATHER CONDITIONS		
Now ___Storm (heavy rain) ___Rain (steady rain) ___Showers (intermittent) _____ % cloud cover ___Clear/sunny	Past 24 Hours ___Storm (heavy rain) ___Rain (steady rain) ___Showers (intermittent) _____ % cloud cover ___Clear/sunny	Has there been a heavy rain in the last 7 days? NO / YES
WATERSHED FEATURES		
Predominant Surrounding Landuse ___ Forest ___ Commercial ___ Field/Pasture ___ Industrial ___ Residential ___ Agricultural Other _____		
Are there houses or structures within 500 m of the river: YES / NO		
RIVER CHARACTERIZATION / INSTREAM FEATURES		
Avg. river width (m):	Estimated river depth (m):	
Stream system: ___Perennial ___Intermittent	Channelized banks (i.e., riprap, concrete, straightening): YES / NO	
Proportion of Reach by Stream Morphology Types: Riffle_____% Pool_____%	Run_____% Cascade_____%	Irrigation weir(s): YES / NO
RIPARIAN VEGETATION (18 meter buffer)		
Right Side: ___Trees ___Shrubs ___Grasses ___Herbaceous (soft, very little woody tissue)		
Left Side: ___Trees ___Shrubs ___Grasses ___Herbaceous (soft, very little woody tissue)		
AQUATIC VEGETATION		
___Free floating ___Floating algae ___Attached algae ___Rooted emergent ___Rooted submergent ___Rooted floating		
BANK STABILITY		
Left Side: ___No riverbank erosion or areas of erosion are rare ___Occasional areas of riverbank erosion ___Several areas of riverbank erosion ___Severe erosion problems, or bank collapsing in several places		
Right Side: ___No riverbank erosion or areas of erosion are rare ___Occasional areas of riverbank erosion ___Several areas of riverbank erosion ___Severe erosion problems, or bank collapsing in several places		
TRASH		
___No trash visible ___Small trash common ___Large trash common	___Small trash occasional (such as bottles, cans, paper, etc.) ___Large trash visible (such as tires, etc.)	
GENERAL WATER QUALITY		
Water Odors ___Normal/None ___Sewage ___Petroleum ___Chemical ___Fishy ___Other_____	Water Surface Oils ___Slick ___Sheen ___Globs ___Flecks ___None ___Other_____	
NOTES		

Table 17. *An example of a data sheet for conducting pebble counts.*

SITE DATA				
Date:		Surveyor Names:		
Time:		River:		
Transect Start GPS Latitude:		Transect End GPS Latitude:		
Longitude:		Longitude:		
Directions: Randomly pick up 60 pebbles as you walk across the stream by closing your eyes before you reach into the water. Pick up the first pebble your hands touch. If your hands touch wood or vegetation, mark a tally next to that category. For each pebble you pick up, mark a tally next to the largest sized hole the pebble will **not** fit through.				
INCHES	MILLIEMETER	TALLY MARKS	TOTAL COUNT	%
Mud/Silt				
< 5/16	< 8			
5/16	8			
5/8	16			
7/8	23			
1.25	32			
1.75	45			
2.5	64			
3.5	90			
5	127			
7	178			
10	254			
>10	>254			
Vegetation				
Boulder (width in cm)				
Large Woody Debris (measure length/diameter in cm)				
Median Pebble Size:				
NOTES				

with holes used to measure the size of pebbles) and transects (Table 17). Conducting pebble counts over time can provide information on changes in substrate size.

Remote sensing by technical experts: Habitat composition of large FCZs can be assessed remotely with the use of satellite images or aerial photos. This requires a high level of technical expertise, and the results should still be spot-checked on the ground using the tools described above.

Examples of how to interpret the results

For observational surveys, the number of observations in each category can be graphed and compared between years. For example, the average results for "degree of bank stability" can be compared each year to look for trends (is stability increasing or decreasing?) inside and outside of the FCZ. You can make a table of the average percent cover of various aquatic plant types, or of habitat types, and compare this inside and outside of the FCZ.

Questions to consider:

1. Are habitat trends increasing or decreasing over time?
2. Are the habitat trends different inside the FCZ compared to the control site outside the FCZ?
3. Are there changes to the FCZ habitat that reduce the habitat quality for fish and other aquatic animals?

The average depth and width of the FCZ can be recorded in a table and graphed to look for trends over time in these dimensions. If there is a trend towards a wider river at the same point each year, then this may indicate erosion and bank instability. It can be challenging to determine whether changes that occur to the habitat in an FCZ are due to the protection of the FCZ (and are therefore an indicator of FCZ effectiveness) or are due to other natural events or human actions outside the scope of FCZ management.

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Appendix 1: Extended List of FCZ Indicators

This guidebook focuses on a set of indicators that were identified as being most relevant to Fish Conservation Zones in Lao PDR. However, numerous other indicators could also be measured to assess FCZ effectiveness. This Appendix presents a larger selection of indicators that were identified as applicable to monitoring aquatic protected areas in both marine and freshwater environments. These indicators were compiled from a literature review and a 2016 stakeholder workshop in Vientiane, Lao PDR. Indicators that workshop participants identified as important but that were considered too difficult to include in this guidebook are marked with (*). Not all indicators or sampling methodologies may be applicable to a given FCZ assessment.

Indicator Category	Indicator	Measurement	Examples of Sampling Methodologies
Governance	Existence of an active management committee (G1)	Identification of management plan; location of decision-making body; identification of protected area staff; dates and location of meetings	Key informant interviews/surveys; organizational chart construction
	Existence and adoption of a management plan (G2)	Existence of a document with protected area goals and desired benefits, institutional structure of management, and portfolio of management measures	Key informant interviews/surveys; management plan checklist; economic experimental game
	Local understanding of FCZ rules and regulations (G3)	Level of awareness and understanding of protected area rules and regulations	Key informant interviews/ surveys; economic experimental game
	Availability and use of FCZ administrative resources (G4)	Human, financial, and equipment resources available to administer protected area activities (number of staff, training, and experience, budget, equipment inventory), review of record keeping procedures	Key informant interviews; mapping; photographic documentation

Indicator Category	Indicator	Measurement	Examples of Sampling Methodologies
Governance	Level of community participation and satisfaction in management (G5)	Amount of stakeholder active involvement in protected area decisions and activities; satisfaction with participation	Key informant interviews/surveys; stakeholder analysis matrix, ladder scale diagram; index of individual perception
	Clear enforcement procedures and level of patrolling effort (G6)	Existence and descriptions of guidelines and procedures for protected area enforcement; accessibility and availability of enforcement guidelines; number of patrols undertaken for a given time period and area	Key informant interviews/surveys; supporting document review
	Level of compliance with FCZ regulations (G7)	Number of reported violations; number of successful or attempted prosecutions; number and type of infractions per patrol	Key informant interviews/surveys; supporting document review
	Level of resource conflict*	Issues, stakeholders, time period, intensity, scale, and resolution of conflicts associated with the protected area	Key informant interviews/ surveys; ladder scale diagram
	Degree of interaction between managers and stakeholders	Number of regularly scheduled meetings between protected area managers/staff and stakeholders	Key informant interviews/surveys; supporting document review
	Existence and activity level of community organization(s)	Existence and characterization of community organizations	Key informant interviews/surveys

Indicator Category	Indicator	Measurement	Examples of Sampling Methodologies
Governance	Existence and adequacy of enabling legislation	Assessment of laws and instructions associated with natural resource management and protected areas	Key informant interviews/ surveys; legal analysis
	Existence and application of scientific research and input	Presence and characterization of scientific studies; review and accessibility of study outputs	Key informant interviews/ surveys; literature review
	Information dissemination	Number and effectiveness of capacity-building efforts for stakeholders on benefits, rules, regulations and enforcement of the protected area	Key informant interviews/surveys; supporting document review
	Existence of signs and demarcation	Number, location, and quality of protected area signs and boundary markers	Observational survey; key informant interviews
	Level of stakeholder involvement in surveillance and enforcement	Number of stakeholders who participated in patrolling or other surveillance and monitoring activities; description of patrol activities and procedures	Key informant interviews/surveys; supporting document review
	Level of training provided to stakeholders in participation	Amount and effectiveness of capacity-building efforts to empower stakeholder participation; budget allocated for capacity building	Key informant interviews/surveys; supporting document review; observe participation in meetings; focal group discussion

Indicator Category	Indicator	Measurement	Examples of Sampling Methodologies
Governance	Proportion of stakeholders trained in sustainable use	Number of stakeholders who participated in training and who have knowledge about sustainable resource uses	Key informant interviews/surveys; supporting document review
	Community influence over management	Community perception of influence and bargaining power over decision-making and management	Ladder scale diagram
	Community control over aquatic resources	Community perception of ability to monitor and regulate internal use patterns of aquatic resources	Ladder scale diagram
	Fair allocation of access rights	Perceived fairness of allocation of rights to enter and withdraw resources	Ladder scale diagram
	Equal distribution of FCZ effects	Perceptions of equal distribution of protected area benefits/impacts	Key informant interviews/surveys
	Perception of FCZ performance	Whether people agree the protected area is successful or effective	Key informant interviews/surveys

Indicator Category	Indicator	Measurement	Examples of Sampling Methodologies
Socioeconomic	Local fishing patterns and practices (S1)	Characteristics of fishing activities (equipment, methods, organization), resource users (gender, residency status, age); timing, location, and trends of activities	Interviews and focal group surveys (participatory rural diagnostic, productive profile); direct observations; maps of activity locations and use rights; timelines of event occurrence and seasonality
	Perceptions of local fish catch (S2)	Perception of changes in key species abundance today and before protected area establishment	Interviews and surveys with fishers (participatory rural diagnostic, productive profile, social cartography, seasonal analysis); ladder scale diagrams
	Patterns of household fish consumption (S3)	Amount of locally caught wild fish consumed per week	Interviews and household surveys; ladder scale diagrams
	Perception of benefits derived from the FCZ (S4)	Agreement with statement that the protected area has provided benefits	Interviews and surveys with key informants
	Household income/effort distribution by source (S5)	Sources of livelihood/income and their relative importance	Interviews and household surveys (participatory rural diagnostic, income profile, economic experimental game), ladder scale diagrams
	Local values and beliefs about aquatic resources (S6)	Percentage of agreement with value statements; level of agreement with value statements; collection of motivations, beliefs, anecdotes	Interviews and household surveys (economic experimental game, social cartography)

Indicator Category	Indicator	Measurement	Examples of Sampling Methodologies
Socioeconomic	Level of environmental awareness and understanding of conservation (S7)	Anecdotes, stories, observations of apparent causes and effect; opinions of how to use natural environment; ranking of threats in terms of impact.	Interviews and focal group surveys (participatory rural diagnostic, problems and opportunities matrix, economic experimental game); maps and transects; decision trees, Venn Diagrams, flow charts
	Social cohesion and leadership	Observations of social dynamics and interactions	Observation of village meetings; household interviews
	Gender balance in FCZ management	Proportion of women engaged in FCZ management activities and decision making	Observation of FCZ management committee meetings
	Distribution of local ecological knowledge	Pathways that local ecological knowledge is shared within the community and with outsiders	Interviews; focal group discussions
	Distribution of formal knowledge to the community	Ranking the level of awareness about information generated by the scientific community on protected area use and ecosystem impacts	Interviews and household surveys; economic experimental game
	Household occupational structure	List of household members and occupations; ranking of primary, secondary, and tertiary occupations; distribution of occupations and sources of income across households and social groups (ages, genders)	Interviews and household surveys (participatory rural diagnostic, income profile, economic experimental game)

Indicator Category	Indicator	Measurement	Examples of Sampling Methodologies
Socioeco-nomic	Community infrastructure and business	Level of community services and infrastructure; number and type of commercial businesses, esp. those associated with the protected area	Interviews and key informant surveys; infrastructure/ business checklist
	Material style of life	Assessment of assets associated with wealth and poverty	Interviews and household surveys
	Number and nature of markets	List of 10 most important vertebrate, invertebrate, and plant products; time, location, importance, and purpose of harvest; location of sales; degree of demand	Interviews and key informant surveys; participatory rural diagnostic, productive profile; map of market flow or product movement
	Percentage of stakeholder group in leadership positions	Number of individual stakeholders from various groups who have been or are currently in a leadership position related to protected area management	Key informant interviews, review organizational structure of protected area management; experimental economic game
	Perceptions of non-market and non-use values	Level of agreement with value statements related to non-market and non-use values (existence value, option value, bequest value)	Interviews and household surveys; economic valuation; economic experimental game
	Perceptions of wild fish available for consumption.	Number of days reported of insufficient food in past month; number of days reported of insufficient wild fish or other aquatic food in past month; opinions of protected area effects on food availability	Interviews and surveys with household food purchasers/ preparers; participatory rural diagnostic, seasonal analysis

Indicator Category	Indicator	Measurement	Examples of Sampling Methodologies
Socioeconomic	Quality of human health	Infant mortality rate; availability of health services; child weight; occurrence of major diseases; prevalence of vaccinations	Interviews and surveys with key informants; review of secondary sources (health department data)
	Stakeholder knowledge of natural history	Observations, experiences, beliefs, and perceptions of cause and effect; degree to which local knowledge is passed between generations; local names for resources, places, and activities; knowledge of resource location, mobility, population size, interactions, behaviors; protected area manager awareness and use of stakeholder knowledge	Interviews and focal group surveys/discussions; participatory rural diagnostic; historical analysis
	Changes in conditions of ancestral and historical sites/features/ monument	Location, condition, accessibility, and folklore associated with ancestral and historical sites/features/ monuments in or near the protected area	Key informant interviews; mapping; photographic documentation

Indicator Category	Indicator	Measurement	Examples of Sampling Methodologies
Ecological	Presence/ absence of key species (E1a)	Presence of a key species in the protected area	Key informant interviews, literature reviews
	Abundance of key species (E1b)	Key species density in the protected area	**FISH:** Underwater visual census; modified lift net (in wetland)
	Abundance of key species (E1b)	Number of key species in the protected area	**FISH:** Underwater visual census; Point Abundance Sampling electrofishing method; bamboo traps; standardized gill net surveys
	Abundance of key species (E1b)	Biomass (weight) of key species in the protected area	**FISH:** Underwater visual census (use length-to-weight to estimate biomass); bamboo traps; standardized gill net surveys
	Population structure of key species (E2)	Proportion of fish categorized as large	**FISH:** Underwater visual surveys
	Population structure of key species (E2)	Average size of individuals	**FISH:** Standard gill net surveys; underwater visual census
	Population structure of key species (E2)	Size structure	**FISH:** underwater visual surveys; fyke nets trapping; eel pots; bamboo traps; standard gill net surveys
	Total abundance by group (such as “fishes”) (E3)	Total density	**FISH:** Modified lift net (used in a wetland); bamboo trap **INVERT:** Surber Sampler for benthic macroinvertebrates

Indicator Category	Indicator	Measurement	Examples of Sampling Methodologies
Ecological	Total abundance by group (such as “fishes”) (E3)	Total biomass	**FISH:** Modified lift net (in a wetland); underwater visual census; bamboo trap; gill nets and seine nets
	Total abundance by group (such as “fishes”) (E3)	Total abundance	**FISH:** Underwater visual census; gill nets and seine nets **INVERTS:** Hand net sampling
	Composition and structure of the aquatic community (E4)	Species richness (S’)	**FISH:** Underwater visual census; Point Abundance Sampling electrofishing method; modified lift net (in a wetland); bamboo traps; standard gill net surveys; market and creel surveys **INVERTS:** Hand net sampling; kick-net sampling for macroinvertebrates; 50x50 cm quadrats for macrophyte; Surber Sampler for benthic macroinvertebrates
	Composition and structure of the aquatic community (E4)	Multivariate statistics: (PERMANOVA+); detrended Canonical Correspondence Analysis; Principle Components Analysis	**FISH:** Bamboo traps; standard gill net surveys; underwater visual census

Indicator Category	Indicator	Measurement	Examples of Sampling Methodologies
Ecological	Composition and structure of the aquatic community (E4)	Diversity (alpha-diversity = average species richness inside/ outside of protected area; beta-diversity = relationship between average local species richness (a) and the total number of species (S); the relationships between maximum local species richness and the total number of species in the data set; Sorensen's index; gamma-diversity = total species richness)	**FISH:** Underwater visual census; standard gill net surveys; market and creel surveys; **INVERTS:** Kick-net sampling for macroinvertebrates; 50x50 cm quadrats for macrophytes, hand net sampling; Surber Sampler for benthic macroinvertebrates
	Composition and structure of the aquatic community (E4)	Various diversity and composition indices: rarity, dominance, evenness	**FISH:** Point Abundance Sampling electrofishing method **INVERTS:** Surber Sampler for benthic macroinvertebrates
	Total catch per unit of fishing effort (E5)	Harvest CPUE outside of protected area	**FISH:** # of fish per hour per ha, based on fishing licenses and anonymous questionnaires; household survey and key informant interviews (can also be done with logbook, creel surveys or observers); mean catch per trip by gear type
	Water quality (E6)	Temperature, conductivity, pH, dissolved oxygen, turbidity/transparency, other standard analyses	Literature review, mutliparameter meter; monitoring data
	Habitat distribution and quality (E7)	Habitat distribution and composition	Underwater visual line transects or quadrats

Indicator Category	Indicator	Measurement	Examples of Sampling Methodologies
Ecological	Food web integrity*	Characterization of trophic roles and predator prey relationships (qualitative)	Stomach content analysis, stable isotope analysis
	Recruitment success within the community*	Number of juveniles recruiting within a community	Light traps, collection plates
	Area showing signs of recovery	Percent of project area restored (as a % change in structure/biomass/ density/abundance/ total cover)	Aerial photos
	Area showing signs of recovery	Number of fish species that are “direct beneficiaries" of the protected area	Focus group interviews with stakeholders
	Area under no or reduced human impact	Number of fishers or fishing boats (quantitative)	Structured interviews or focus groups; observations
	Area under no or reduced human impact	Presence and level of human activities (qualitative)	Key informant interviews

Appendix 2: Example Fishing Data Collection Protocols developed for the Mekong Fish Network

These procedures were developed in 2015 for the Mekong Fish Network. They may be used to measure Indicator E5, *Total catch per unit of fishing effort*.

Steps for Recording Fisher Catch (each day of fishing):

1. As gear is retrieved, fish are placed in separate baskets by gear type. The fisher proceeds to landing site (if there is a set landing site) and then the fisher records daily site information on data sheet (Figure 1). These data include:
    a. Village name
    b. Fisher name
    c. Fisher ID (an identification number provided to each fisher)
    d. Date (day/month/year)
    e. Water level (rising, static, or falling)
    f. Weather (full sun, partly cloudy, cloudy, raining)
    g. Total number of gear used (types used that day)

Figure 1. *Fisher records daily site information on data sheet.*

* If a fisher does not go fishing, they still need to fill out a data sheet with items a) through d) and write a note that says that they did not go fishing.

2. Gear information for each gear type is recorded on data sheet (Figure 2). If there are more than 4 gear types fished that day, then additional pages (extra data sheets) can be added. Data collected on each gear type include:
    a. Gear name (choose from agreed-upon list of names)
    b. Gear type (net, line, hook, trap, other)
    c. Number of units (of this gear type)
    d. Net or trap length (m)
    e. Net or trap height (m)
    f. Net mesh size (from knot-to-knot) or hook size
    g. Start time and end time (Hours: Minutes, 24-hour clock)
    h. Duration (i.e., total number of hours spent fishing this particular gear type)
    i. Habitat fished (choose from agreed upon list of habitats)
    j. Key species (choose from agreed upon list of species)
    k. Fishing method (choose from agreed upon list of methods)

IMPORTANT: **All** the gear information, especially the start/end time and duration, should be filled out **even if the fisher did not catch any fish** (an unsuccessful fishing trip). This is particularly important for calculating accurate Catch Per Unit Effort values.

Figure 2. *Gear information for each gear type is recorded on data sheet. In this example FISHBIO staff are recording the gill net mesh size.*

Figure 3. *Fish are separated by species, counted and weighed.*

3. For each gear type, the fish are separated by species, counted and weighed, and recorded on the data sheet (Figure 3).

SUB-SAMPLING: If many fish are captured and the fisher does not have the time to sort them all by species and count each fish, then only a sub-sample of the fish will be counted and weighed (Figure 4). In this case, a standard sized basket will be filled with a random sub-sample of the fish. The rest of the fish will be weighed all together, and the total for the rest of the fish will be recorded. This is an important step so that there is still data recorded on the total weight of the catch. The fish in the sub-sample basket will be treated as if they are a complete catch, and count and total weight will be recorded on the data sheet. If sub-sampling is done (and the count and weight on the data sheet are that of the sub-sample and not the entire catch), the fisher must check the appropriate box on the data sheet to indicate that it was a sub-sample. The choice to sub-sample will be at the discretion of the fisher, since this may change depending on the weather, the time of day and the species in the catch.

Figure 4. *If many fish are captured and the fisher does not have the time to sort them all by species and count each fish, then a standard sized basket will be filled with a random sub-sample of the fish. For example in this photo the whole boat was filled with small fish. A sub-sample was taken (e.g., the green basket in this photo) and only a sub-sample of the fish were counted and weighed.*

4. Catch data for each species and each gear type is recorded separately (Figure 5). This is done for the sub-sample basket if a sub-sample is taken. The catch data for each species includes:
    a. Local fish name (agreed-upon name)
    b. Total number of individual fish caught of the species
    c. Total weight of fish of the species
    d. Whether a basket was used to weigh the species (large or small – must be a standard size and the weight of the basket must be known; (Figure 6)
    e. Check the box to indicate whether the weights/counts were a sub-sample of the whole catch for that species
    f. Maximum standard length for each species (following MRC Logbook protocols)
    g. Standard lengths (centimeters) will be recorded for up to 10 randomly selected individuals (in addition to the maximum size – not mandatory)
    h. Whether a photo was taken of the species (check box if yes)

Figure 5. *Fisher technicians will separate the fish by species before weighing the catch of each species. This photo was taken during a training workshop where fisher technicians were trained to separate catch.*

Equipment List

Each fisher technician will be provided with:

- Pre-printed data sheets or a logbook (printed on Rite-in-the-Rain waterproof paper)
- Scales (5-kg and 20-kg capacity scales)
- Digital watch set to the 24-hour clock
- Measuring board (if individual lengths are being measured)
- Fish identification manual with photos

Each team leader will be provided with:

- Digital camera
- Calculator

Figure 6. *Make a note regarding whether or not a basket was used when the fish was weighed. In this photo the fisher is not using a basket on the scale.*

Table 1. *Example Fish Catch Monitoring Data Sheet from the Mekong Fish Network.*

Mekong Fish Network - Participatory Research Project

Village Name:	**Fisher Name:**	**Fisher ID:**	**Date (DD/MM/YY):**
Water Level: Rising☐ Static☐ Falling☐	**Weather:** Full Sun☐ Partly Cloudy☐ Cloudy☐ Raining☐		**Total # of Gear Used:**

GEAR 1:			**Number of gear units:**
Gear Type (Check One):	☐ **NET** Length (m): Height (m): Mesh Sizes (cm):		☐ **LONGLINE** # of hooks: Hook Size (cm):
	☐ **TRAP** Length (m): Height (m):	☐ **SINGLE HOOK** Hook Size (cm):	☐ **OTHER GEAR TYPE**
Start time:	**End Time:**		**Total Hours fishing:**
Fishing Method:			**Habitat Fished:**

Total Catch Weight (kg):	**Local Fish Name:**	**#**	**Weight (kg):**	**Basket Size?**	**Max. Standard Length (cm):**	**Standard Length (cm) of 10 other individuals for each species**										**Photo ?**
						1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
				S☐ L☐												☐
				S☐ L☐												☐
Sub-sample catch? YES ☐				S☐ L☐												☐
				S☐ L☐												☐
				S☐ L☐												☐
				S☐ L☐												☐

GEAR 2:			**Number of gear units:**
Gear Type (Check One):	☐ **NET** Length (m): Height (m): Mesh Sizes (cm):		☐ **LONGLINE** # of hooks: Hook Size (cm):
	☐ **TRAP** Length (m): Height (m):	☐ **SINGLE HOOK** Hook Size (cm):	☐ **OTHER GEAR TYPE**
Start time:	**End Time:**		**Total Hours fishing:**
Fishing Method:			**Habitat Fished:**

Total Catch Weight (kg):	**Local Fish Name:**	**#**	**Weight (kg):**	**Basket Size?**	**Max. Standard Length (cm):**	**Standard Length (cm) of 10 other individuals for each species**										**Photo ?**
						1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
				S☐ L☐												☐
				S☐ L☐												☐
Sub-sample catch? YES ☐				S☐ L☐												☐
				S☐ L☐												☐
				S☐ L☐												☐
				S☐ L☐												☐

Appendix 3: Fish Catch Monitoring Protocols Developed by SciCap in Cambodia

by Vittoria Elliott, Scott Johnson, Pelle Gatke, Uy Sophorn,
Hey Sarun, Nut Savat, Chhouy Samol, and Chheng Phen

As part of a systematic monitoring approach to evaluate Cambodian fish and fisheries that includes both fishery-independent and fishery-dependent monitoring, a network of citizen scientist fishers were trained in two complementary protocols.

The data collected by the network is fisheries dependent. The information obtained from the survey can be used to address Ecological Indicator E5 for a basic assessment that measures total catch per unit effort, as well as indicators E1-E3 by using the comprehensive assessment protocol.

The comprehensive assessment evaluates species composition and proportion of the catch, as well as size distribution by measuring length and weight of individual fish of each species, thus indicating presence-absence, abundance, and population structure of key species, as well as assemblage composition of the fish community. The method also provides an indication of relative species distribution and abundance, as it is conducted at various localities across the country.

Whilst the SciCap network of citizen-scientist fishers produces fishery-dependent data, the survey methods and protocols for catch assessment can be applied to fish caught using a fishery-independent approach. The key distinction is that in the latter, the nets and fishing locations are standardized.

I. Basic Catch Assessment

- The Basic Catch Assessment is performed every day of fishing.
- All the gears used on the day of fishing are included in the Basic Catch Assessment.

II. Comprehensive Catch Assessment

- The Comprehensive Catch Assessment is performed one time per week.
- For the Comprehensive Catch Assessment, the fisher assesses all the fish caught with one type of gear.

Instructions for filling out the Basic Catch Data Sheet

The following information describes how to complete the Basic Catch Data Sheet (Table 1). Please refer to this information if you are not sure about how to complete the Basic Catch Data Sheet correctly.

General Information

In this section of the data sheet please write general information and fishing conditions for each day.

Month: Write the month at the time of fishing.

Fisher Name: Write the name of the person fishing.

Province: Write the name of the province where the fishing is done.

Researcher ID: Please write your researcher ID number. This is the number you have been given by the person who gives you the data sheets.

Data Collator: You do not need to write in this field. The person who collects the data sheet will write their name here.

Date (D/M/Y): Write the date of fishing or the date the fishing gear is collected. Please write it as day / month / year. **Example:** 14 / 01 / 2015.

Time: Write the time that you are completing the Basic Catch Data sheet (write the current time).

Table 1 . *Basic Catch Data Sheet.*

Assessment of Daily Catch Effort			**Month:**		**Fisher Name:**			**Province:**		**Researcher ID #:**		**Data Collator:**			
Date (D/M/Y):			**Time:**	**Name of Nearest Village:**				**Water Level:**	High / Medium / Low			**Water Movement:**	North / South / None		
Name of site(s):								**Weather:**	Clear / Cloudy / Overcast / Strong Wind			**Water Condition:**	Increase / Decrease / Stable		
GPS Co-ordinates Lat:				**Lon**:				**Depth of Waterbody**	**Depth of Gear Placement**	**Gear Reaches the Bottom**	**Direction in Relation to Bank**	**Habitat**	**Start Time**	**Finish Time**	**Total Weight for Gear**
Gear Type		**Type**	**Mesh**	**Height**	**Length**	**No.**	**Total Length**								
□	**Gillnet:**	**S / D**								Yes / No	‖ ⊢				
□	**Gillnet:**	**S / D**								Yes / No	‖ ⊢				
□	**Gillnet:**	**S / D**								Yes / No	‖ ⊢				
□	**Other Net:**									Yes / No	‖ ⊢				
□	**Cast Net:**			Radius:		**X**	**X**		**X**	**X**	**X**				
□	**Cylinder Trap:**						**X**			Yes / No	‖ ⊢				
□	**Trap with Lead Fence:**									Yes / No	‖ ⊢				
□	**Other Trap:**						**X**			Yes / No	‖ ⊢				
□	**Other Gear:**									Yes / No	‖ ⊢				
□	**Hook and Longline:**	Sgl / Multi	No:	Size:						Yes / No	‖ ⊢				

List Most Common, High Value and Rare Species. Take Photo of Rare or Unusual Fish												**Total Weight of Catch for Day (Kg): _____**
	Species Name	**Weight**	**$/kg**	**No. of Fish**	**Common**	**High Value**	**Rare**	**Sell**	**Eat**	**Process**	**Share**	**Notes:**
1												
2												
3												
4												
5												
6												
7												

□ **I did not go fishing Today** **Why I did not go fishing today:** _____

Depth of Gear Placement: Write more depths if the gear is placed at different depths. (e.g. if it goes from a river bank with low water and continues out in deeper water.)
Direction in Relation to Bank: Write "Perpendicular" or "Parallel". (to indicate if the gear is placed perpendicularly or parallel to the river or lake bank.)
Habitat Types: 1) Open water; 2) Forest (trees); 3) Grasses; 4) Scrub/short shrub; 5) Tall shrub/small trees; 6) Cultivated field (e.g. Rice field); 7) Fallow fields; 8) Dry season pond; 9) Deep pool

Name of Nearest Village: Write the name of the village closest to the place where you are fishing.

Water Level: Circle the water level at the time of fishing (choose only one).

Example: High / (Medium) / Low

Water Movement: Circle the direction that the water is moving at the time of fishing (choose only one).

Example: North / South / (None)

Name of Site(s): Write the name of the place or places where you were fishing (maximum 3 places).

Weather: Circle the weather at the time of fishing (choose only one).

Example: Clear / (Cloudy) / Overcast / Strong Wind

Water Condition: Circle the change in the water level (choose only one).

Example: (Increase) / Decrease / no change

GPS Co-ordinates: If a GPS unit is used during the fishing, write the co-ordinates for the main fishing place. Write the number for latitude beside Lat: **Example:** 11.5500° N. Write the number for longitude beside Lon: **Example:** 104.9167° E.

If you do not have a GPS unit then you do not need to write in this field.

Information about the Fishing Gear used

In this section of the data sheet please write all of the information for each different type of fishing gear that you used today.

<u>Gill net/Other Net:</u>

Gill net: Please circle "S" or "D" to indicate how you have used the gill net. Circle "S" if you have used the gill net in one place (stationary) and circle "D" if the gill net was drifting. **Example:** (S) / D

Other Net: Write the type of net used.

Mesh: Write the size of the mesh in centimeters (cm).

Height: Write the height of the net in meters (m).

Length: Write the length of the net in meters (m).

No.: Write how many nets of these dimensions and mesh size were used.

Total Length: Write the total length of all gill nets attached together in meters (m).

Depth of Waterbody: Write the depth of the water where the gear was used in meters (m).

Depth of Gear Placement: Write the depth of the bottom of the gear in the water in meters (m) e.g. the depth of the bottom edge of the net.

Gear Reaches the Bottom: Circle whether the gear touches the bottom of the river/lake (choose only one). **Example:** (Yes) / No

Direction in Relation to Bank: Tick the box to show if the gear was placed parallel or perpendicular to the river bank. You do not need to write in this field if fishing in open water.

Example: ☑ parallel / ☐ perpendicular

Habitat: Write the type of habitat where the gear was used (choose one type from the list of options at the bottom of the sheet). If the habitat does not exist in the list, select the type that is most similar and describe the habitat in the 'notes' section.

Start Time: Write the time when you started to fish or set the net. **Example:** 4:30 pm

Finish Time: Write the time when you finished fishing or removed the net. **Example:** 7:00 am

Total Weight for Gear: Write the total weight of the catch for the gear in kilograms (kg) e.g. 5.45 kg

Cast Net (same as Gill net except):

Radius: Write the radius of the cast net in meters (m). The radius is the distance from the center of the net to the outer edge.

Cylinder Trap (same as Gill net except):

For Mesh: Write the mesh size for traps with mesh, write the distance between slats for traps without mesh.

Other Traps (same as Gill net except): Describe the type of trap used and provide the dimensions of it. Write the total number of traps used even if some traps were empty. **Example:** pot trap, bamboo trap.

Other Gear (same as Gill net except): Please describe any gear used that is not listed in the data sheet as clearly as possible. Write the name, the number used, the size and the dimensions of the gear. **Example:** spear.

Hook and Long line (same as Gill net except):

Type: Circle single for lines with 1 hook or circle multiple for lines with many hooks (choose only one). **Example:** (Single) / Multiple

No.: Write the total number of lines used.

Size: Write the size of the hooks used in centimeters (cm).

Hooks: Write the number of hooks used on each line.

Length: Write the length of one line. If you have many lines of different length please write the different lengths in the 'notes' section.

Total Weight of Catch for Day (Kg): Write the total weight of all the fish caught this day in kilograms (kg). Please include all fish caught from all the different gears combined for this day.

Notes: Please write any information that does not fit in the data sheet here and any other important information or observations for today. Please think about the catch, water conditions, weather and any other conditions that you can see.

Common, High Value and Rare Species

In this section of the data sheet please write about the most common types of fish in the catch today.

Species Name: Write the name of the species of fish.

Weight: Write the total weight for this species of fish - if known.

Price: write the price per kg - if known.

No. of Fish: Write the total number of this species of fish - if known.

Common: Put a tick if this species of fish is usually seen in the catch.

High Value: Put a tick if this species of fish has a high value for sale.

Rare: Put a tick if this species of fish is rarely seen in the catch.

Please note: Rare fish are those fish that you rarely catch, or rarely see, or fish that you have never caught before. Please make sure to take a photo of any rare or unusual fish that you catch, if possible. (Unusual fish may be extra-large fish or any fish that you think is different or interesting.)

Sell/Eat/Process/Share:

Sell: Put a tick if you sold the fish

Eat: Put a tick if you ate the fish

Process: Put a tick if you processed the fish (e.g. for prahok, dried the fish)

Share: Put a tick if you gave the fish to family, neighbors, important people

I did not go fishing today: Put a tick if you did not go fishing today.

Why I did not go fishing today: Please write why you did not go fishing today.

Instructions for filling out the Comprehensive Catch Assessment

The gear type selected for comprehensive assessment will also be recorded in the Basic Catch Assessment indicating the full catch information for the gear type. A star can be used to indicate the gear in the Basic Catch Assessment data sheet.

The Comprehensive Catch Assessment measures the total weight for each species and weight and length for individual fish of each species for all the catch from the selected gear type for the day. The following information is included in the Comprehensive Catch Assessment Data Sheet (Table 2).

1. Place and Time of Fishing. The information that is noted in the data sheet includes:

- The date and time of fishing
- The researcher name/fisher name
- The name of the fishing site & GPS co-ordinates
- The village name

2. Weather & Water Conditions. The information that is noted in the data sheet includes:

- The water level at the fishing area
- The weather at the time of fishing
- The water movement at the fishing area
- The water condition at the fishing area

3. Gear Type Used & the Fishing Effort. The information that is noted in the data sheet includes:

- The gear type used for the catch
- The dimensions of the gear used (one gear)
- The number used for this gear this day

4. The Fish Catch. The information that shall be noted in the data sheet includes:

- The total catch weight from the gear assessed
- Names of the species caught that day
- The weight and number of all fish from each species
- The weight and length of the individual fish

Table 2. *Comprehensive Catch Assessment Data Sheet.*

Water Level	High / Low / Medium	**Date**	
Water Movement	North / South / None	**Researcher**	
Water Condition	Increase / Decrease / Stable	**Data Collator**	
Weather	Clear / Cloudy / Overcast / Strong Wind	**Village**	

Name of Site(s)		**GPS Co-ordinates**		**Total Catch Weight (Kg)**	
Gear Type		**No. Of Gear**			
Gear Length		**Gear Height**			
Gear Size (eg. Mesh/Hook size)		**Number of Hooks**			
Time Set		**Time Retrieved**			

Species Name (in Khmer)	**Species**	**Photo No.**	**Weight of Each Species (g)**	**Total No. for Species**	**Weight of Each Fish (g)**	**Standard Length (Cm)**	**Total Length (Cm)**	**Code No.**

As part of the Comprehensive Catch Assessment, each fish is given a unique ID code. This fish ID code may be used in later analysis or to help with species identification. These codes may be printed on the data sheet in advance, or may be written in by the fisher. Each fisher should be provided with a sheet of pre-printed ID code labels to cut out and use during their fish catch monitoring (for an example see Table 3).

Sci-Cap codes follow the format:
Fisher ID code-mm/yy (week # of the month)-###.

For example, the 4th fisher in Kampong Thom province sampling during the 1st week of December 2017 could use codes ranging from:

KgTh4-Dec17(1)-001 to KgTh4-Dec17(1)-150
(or up to whatever number is desired for the data sheets). New codes are created for each week of sampling.

Equipment to be Used

1. Data sheet
2. Pre-printed label sheet
3. Measuring board
4. Scales (kitchen and hanging)
5. Measuring tape
6. Camera
7. Scissors
8. Pencil

Table 3. *Example sheet of fish ID code labels given to a fisher for monitoring during the four weeks of December 2017.*

Fisher code-mm/yy (week#)-specimen#	KgTh4-Dec17(1)	KgTh4-Dec17(2)	KgTh4-Dec17(3)	KgTh4-Dec17(4)
Fisher code-mm/yy (week#)-001	KgTh4-Dec17(1)-001	KgTh4-Dec17(2)-001	KgTh4-Dec17(3)-001	KgTh4-Dec17(4)-001
Fisher code-mm/yy (week#)-002	KgTh4-Dec17(1)-002	KgTh4-Dec17(2)-002	KgTh4-Dec17(3)-002	KgTh4-Dec17(4)-002
Fisher code-mm/yy (week#)-003	KgTh4-Dec17(1)-003	KgTh4-Dec17(2)-003	KgTh4-Dec17(3)-003	KgTh4-Dec17(4)-003
Fisher code-mm/yy (week#)-004	KgTh4-Dec17(1)-004	KgTh4-Dec17(2)-004	KgTh4-Dec17(3)-004	KgTh4-Dec17(4)-004
Fisher code-mm/yy (week#)-005	KgTh4-Dec17(1)-005	KgTh4-Dec17(2)-005	KgTh4-Dec17(3)-005	KgTh4-Dec17(4)-005
Fisher code-mm/yy (week#)-006	KgTh4-Dec17(1)-006	KgTh4-Dec17(2)-006	KgTh4-Dec17(3)-006	KgTh4-Dec17(4)-006
Fisher code-mm/yy (week#)-007	KgTh4-Dec17(1)-007	KgTh4-Dec17(2)-007	KgTh4-Dec17(3)-007	KgTh4-Dec17(4)-007
Fisher code-mm/yy (week#)-008	KgTh4-Dec17(1)-008	KgTh4-Dec17(2)-008	KgTh4-Dec17(3)-008	KgTh4-Dec17(4)-008
Fisher code-mm/yy (week#)-009	KgTh4-Dec17(1)-009	KgTh4-Dec17(2)-009	KgTh4-Dec17(3)-009	KgTh4-Dec17(4)-009
Fisher code-mm/yy (week#)-010	KgTh4-Dec17(1)-010	KgTh4-Dec17(2)-010	KgTh4-Dec17(3)-010	KgTh4-Dec17(4)-010
Fisher code-mm/yy (week#)-011	KgTh4-Dec17(1)-011	KgTh4-Dec17(2)-011	KgTh4-Dec17(3)-011	KgTh4-Dec17(4)-011
Fisher code-mm/yy (week#)-012	KgTh4-Dec17(1)-012	KgTh4-Dec17(2)-012	KgTh4-Dec17(3)-012	KgTh4-Dec17(4)-012
Fisher code-mm/yy (week#)-013	KgTh4-Dec17(1)-013	KgTh4-Dec17(2)-013	KgTh4-Dec17(3)-013	KgTh4-Dec17(4)-013
Fisher code-mm/yy (week#)-014	KgTh4-Dec17(1)-014	KgTh4-Dec17(2)-014	KgTh4-Dec17(3)-014	KgTh4-Dec17(4)-014
Fisher code-mm/yy (week#)-015	KgTh4-Dec17(1)-015	KgTh4-Dec17(2)-015	KgTh4-Dec17(3)-015	KgTh4-Dec17(4)-015
Fisher code-mm/yy (week#)-016	KgTh4-Dec17(1)-016	KgTh4-Dec17(2)-016	KgTh4-Dec17(3)-016	KgTh4-Dec17(4)-016
Fisher code-mm/yy (week#)-017	KgTh4-Dec17(1)-017	KgTh4-Dec17(2)-017	KgTh4-Dec17(3)-017	KgTh4-Dec17(4)-017
Fisher code-mm/yy (week#)-018	KgTh4-Dec17(1)-018	KgTh4-Dec17(2)-018	KgTh4-Dec17(3)-018	KgTh4-Dec17(4)-018
Fisher code-mm/yy (week#)-019	KgTh4-Dec17(1)-019	KgTh4-Dec17(2)-019	KgTh4-Dec17(3)-019	KgTh4-Dec17(4)-019
Fisher code-mm/yy (week#)-020	KgTh4-Dec17(1)-020	KgTh4-Dec17(2)-020	KgTh4-Dec17(3)-020	KgTh4-Dec17(4)-020

The total catch from the selected gear is included in the Comprehensive Catch Assessment.

1. **Weigh the Total Catch from the Gear.** Place the empty container on the scales. Reset to zero. Place fish in the container and place them on the scale together (Figure 1).
2. **Separate the Catch into Species.** It is important to identify the different fish species as accurately as possible (Figure 2).
3. **Measure the Weight of Each Species.** All fish from one species are weighed together (Figure 3). **Then Count the Number of Fish for the Species**
4. **Select 10 Fish from Each Species.** After recording the total species weight and counting the number of fish for each species, select fish for the individual fish measurements. If there are more than 10 fish from the same species, select the largest and the smallest fish from each species, and 8 in between. If there are 10 fish or fewer from the same species, select them all (Figure 4).
5. **Add Labels for Each Fish.** Cut labels from the fish ID code label sheet and place one next to each fish. Take a picture of the measuring board and labeled fish. Collect a small fin clip and label it according to the SciCap fin clip collection procedure. This will facilitate species identification checks.
6. **Measure the Weight and Length of Each Fish.** Measure both standard length and total length (Figure 5).

For more information, please contact Vittoria Elliott: vittoriaelliottemail@gmail.com

Figure 1.*The biomass of the total catch from one gear type is weighed together.*

Figure 2. *Fish catch from one gear type separated by species and labeled.*

Figure 3. *All the individuals from one species are weighed together.*

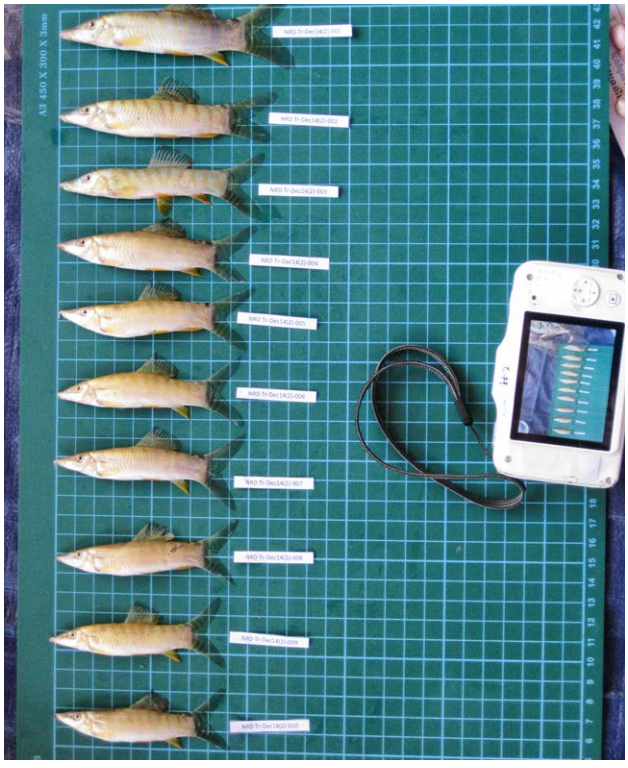

Figure 4. *Ten fish selected from one species.*

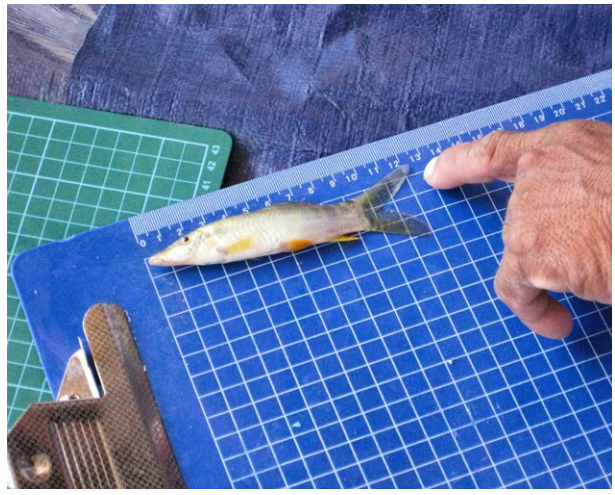

Figure 5. *Measuring and weighing individual fishes.*

Appendix 4: Data Use and Interpretation

By Vittoria Elliott and Scott Johnson, SciCap

Introduction

A key component of monitoring is evaluation and interpretation of the data and application of the results to management and interventions. The data collection is the first step, but appropriate use and interpretation of the data is also key to making the monitoring worthwhile.

There are both simple approaches to evaluating the data for trends, for example, and more complex methods for more comprehensive interpretations. Whether you use simple assessment of the data or carry out more comprehensive analysis, there are some important considerations for avoiding making wrong assumptions, interpretations, and extrapolations.

Quality control and validation

In the first instance, data must undergo thorough quality controls which should include both in-situ independent verifications and post-collection checks as part of the data entry and management process. There are detailed guides available for performing data quality checks, including a specific instruction sheet prepared for the SciCap fish catch monitoring network. In brief, some key checks include ensuring that the data has been entered correctly, verifying species identifications, maintaining certain standards of measurement, and maintaining accuracy. Some of these checks can be performed by looking at the data. For example, checking that the fish size is within the known range for the species could indicate either a misidentification or a decimal place error (i.e. reporting in grams rather than kilograms), making sure that the sum of individuals weighed adds up to the total for the species, checks for simple errors in recording or typing, etc.

Some observers have a tendency to unintentionally or intentionally 'skew' data, meaning they report either on the low side or on the high side (especially when estimating). A few independent checks can help to identify when there is bias in the data, which can sometimes be accounted for in the analysis phase. It is also possible to use independent checks for species identifications. This can be performed by taxonomic experts evaluating the catch, or for many species through the capture of photographs, or using DNA species identification (refer to the factsheet "data verifications" in the SciCap collection handbook). Not every catch needs to be independently verified, but having an observer verify the data and some form of taxonomic checks performed periodically can provide an estimate of the error, bias, or skew in what is being reported. It can also help to identify if a data collector is under performing. All data col-

lectors make errors, but some will be more prone to make errors than others, and you may want to consider how reliant you can be on their data if there are too many errors. Ultimately, the data will tell you a story that you will use to interpret the situation of the fish; if the data reported is not accurate, you can make incorrect interpretations that result in poor management decisions.

Consistency is also a key feature because individuals will introduce different bias (or skew) to the data, adding an extra element of variation that is hard to determine. Keeping the data collectors consistent and standardizing the way it is carried out are important considerations of any data collection that can have a great impact on the quality of the data. For further discussion refer to the handbook 'Understanding Cambodian Community Fisheries Data'.

Context and data limitations

It is also important to understand the context of the data that has been collected and know its limitations. Unless you are taking all the fish out of a system (inadvisable if you want to be able to fish tomorrow and obviously contrary to conservation aims), you are always taking a sample (or a small proportion of the total). Knowing how representative that sample is of the stock (or in the case of fisheries, the total harvest) is challenging but is an all-important part of ensuring accurate interpretation. There are certain aspects of data collection that can help increase how representative your data is and increase the likelihood that you can accurately interpret it. These are called increasing the power or strength of the data.

First, the more data you collect, the greater the 'power' of the data because the more fish you catch the greater proportion of the stock you are observing and the more likely it is to represent the stock. But both costs and the desire not to deplete stocks with your sampling will limit how much data you can feasibly collect. Essentially, how comprehensive you can be in both your collection and the evaluation that you perform is usually a function

of time availability, resources and expertise or access to those with expertise, but it always has a bearing on the interpretations you can make, the inferences, and how you can apply your monitoring results to management decision-making.

Interpretation of the data is often a function of the purpose (and in general, the survey design and data collection should be defined with the purpose in mind before data is collected). Data is (or should always be) collected with a specific question or questions in mind. This will determine how much data, the frequency of collection, and the number of sites etc., you need to collect data at in order to answer the question you are posing of the data. The amount of data you have will also determine the strength (or power) of the data to answer the question. This means, how confident can you be that what the answer to your questions suggested by the data really is the answer to the question. For example, are big fish more common inside or outside a protected area? The data could suggest that outside they are bigger, but if the power is low, then it could be that really there is no difference, but by chance in the sample you took there were more big fish outside. This could be a chance event at the time you sampled or in just the one site. That is why more sampling times and sites will help with your power and help you to be confident in the

answer that the data provides to your question. It's important to be aware of the impact of your type, location, and frequency of sampling for interpreting the rest of the data and answering your question. The impact of frequency and timing for answering your questions is largely due to seasonality, so care must be taken to consider season when deciding when to survey and being consistent about what time of year data is collected.

In general, to understand your data, you will need to make a comparison. Reporting that there were 'more' fish in January 2015 without reporting what you are comparing to is almost meaningless. If you are comparing to January of the previous year, this might suggest that the fishery has improved (but also see below in context); if you are comparing to the day before, it might be an unimportant difference. Furthermore, if the difference is not very large, it could be that it is a random or non-representative difference at the time of your sampling that is ultimately a biologically meaningless difference, which is why it can be useful to determine the significance of the difference.

Once you have good quality data, if you want to infer the causation of differences in your samples, you also need to have an idea of the context, including the conditions in which you collected the data. Thus, another key element determining data interpretation is the context (or circumstances) under which the data was collected. It is therefore also important to collect explanatory data, often referred to as the environmental variables, in order to understand what conditions the data were collected under.

The specific conditions can include the level of the water, the time of year, and the weather, as well as the relative conditions. Below, we explore some examples.

- There is often poor fishing on stormy days; thus, if you sample on a particularly stormy day at the peak of the fishing season in year 1 and then on a clear, blue-sky day at the peak of the fishing season in year 2, the catch would be much greater and you might conclude that stocks are increasing.
- From a seasonal perspective, we may collect data on the same day in year one and year two and find that there are more fish in year two, and conclude that populations are increasing. However, if we look at the hydrology and wet-dry season information, we would discover that the rains started

later in year two, and thus the fish remained aggregated for longer and were therefore easier to catch. There might in fact have been more fish in year one, but because they were able to disperse away from your site, you were able to catch fewer fish.

- Longer-term conditions can also have a large impact. For example, if you collect data in your fishing area in year one and then establish an FCZ in the same area, and sample at the edge of the FCZ a year later, you may conclude that the catch is improving as a result of establishing the FCZ and your protection efforts. However, if year one was a very bad year for fish (because of a drought or very low flood, for example) and in year two the flood was much greater and fishing for everyone was much better, the cause is more likely to be this broader set of conditions and consequences. This is not to say that the FCZ did not help, just that we cannot infer this from our sampling. It is therefore important to be aware of the water conditions in the different years, and it can also be helpful to know the trend in the fishery compared with the site you are sampling and evaluating. If we review conditions of the fishery at the time of our sampling or carry out our own sampling also nearby our target area, we can put our sample from our FCZ into the context of the broader fishing conditions.
- Location and habitat (e.g., open water, among the grasses, along the bank) are also important. We may sample in a habitat that a particular species prefers in year one and find many of that species, and then compare it to an area that they do not prefer in year two, and find very few fish of the target species. From, this we may conclude that the numbers of the species are declining over time, which would not necessarily be correct. Similarly, if we sample in a preferred habitat (e.g., among the grasses) in site A (e.g., along the river) and sample in the open water in site B (e.g., the middle of the lake away from any grasses), we may conclude that the species is present in site A and absent in site B or that the species prefers rivers to lakes, but this would not necessarily be the case, just that they do not spend much time in open waters. Thus, it is also important to try to sample in similar habitats or at least note the differences in order to consider these differences whilst evaluating the data collected.

With these examples, it has been shown that understanding the situation and context of your sampling by collecting explanatory data is key to accurate interpretation.

The magnitude of any difference observed is also an important consideration, and determining whether it is an important (or significant) difference is where the statistical approaches discussed below become extremely valuable. Whilst there are ways to determine the significance of differences between your samples by applying statistical approaches, as briefly discussed below, it is important to acknowledge that there are limitations in what the data can tell us. It is also important to be aware that, although collecting explanatory data can help with making our inferences more accurate, there are also limitations to the accuracy of what the data might tell us about the fish community. This is because we are taking a sample and not surveying the whole system. Any time we sample, especially in a dynamic biological system, there is a chance that we will take our samples on days, in locations, or at time points that are not representative of the usual conditions of the fish community. Collecting environmental and explanatory data, increasing our sample size and using analytical approaches can help with improving our chances of making correct interpretations, but it does not completely overcome them and it is important to accept and acknowledge that certain limitations exist to what can be inferred.

Analysis

The simplest forms of analysis provide an indication of basic comparison and trends. These can be determined graphically by plotting data from different collection periods or different locations against each other and evaluating the differences. Often this is sufficient to infer changes and make comparisons, but does not necessarily provide

us with an indication of causality and/or whether those differences are important (or significant). Inferring causality can be improved by evaluating the fish data along with some environmental variables, for example against a graph of the water level collected at the same time of our sampling. Often these trends in the context of some explanatory variables are sufficient to make simple management decisions, such as, should we continue to protect an area or not? Are stocks continuing to improve?

Other more complex questions about whether the actions are having a significant impact will require more complex evaluation. These assessments of the data will help determine if the trends and differences that are being seen are significant, and ultimately whether the difference between the conditions (i.e., protected or unprotected) are worth continued investment of time and resources, for example.

Whether it is possible to determine significance of the results (trends and comparisons), is generally a function of the 'power' of the data, which as discussed above, is related to sample sizes and determines the confidence you can have in your results and the interpretations.

However, it is necessary to consider not only effect sizes but also biological or economic relevance of results and interventions. Generally, to perform additional statistical analyses that determine the significance of your results will require engaging someone with the expertise to carry out the analysis and accurately interpret the results. The details of the multitude of analytical approaches that can be performed, and the circumstances required for application of the different approaches, are beyond the scope of this document. Further information about general principles can be found in a few key references (Krebs 1999; Dytham 2011).

Interpretation of results and application to management decisions

Once you have results from a basic assessment showing the trend in a given context or receive results that indicate significant differences under various conditions, the next step is to interpret what the trends or differences might mean and determine how you might respond to the results in your decision-making process. The next guide in the series: "Guide to incorporating results into management decisions" provides a selection of examples of results and how you might apply them to different management decisions in fisheries management and biodiversity conservation.

It is incumbent on the users to be able to differentiate between statistical significance and effect size (biological relevance) and to interpret results of statistical analyses appropriately. Statistically non-significant trends may be biologically relevant, while statistically significant results may not have any biological importance. Managers should respond responsibly and prudently to results.

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