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Handbook for data collection on recreational fisheries in the Mediterranean and the Black Sea

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Preparation of this document

This handbook has been prepared by the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) to address the priorities identified by Mediterranean and Black Sea countries in the context of existing international commitments and regional strategies. The impetus for the handbook development originated with the GFCM's mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (mid-term strategy), namely its Target 2 which aims at supporting livelihoods for coastal communities through sustainable small-scale fisheries. In particular, one output of this target was the collection of robust and timely information on the impacts of small-scale fisheries and recreational fisheries on marine living resources and on their interactions with other human activities in coastal communities. This document addresses this output by providing a clear methodological framework to allow Mediterranean and Black Sea countries to implement suitably harmonized sampling and survey monitoring schemes for recreational fisheries and is foreseen to support continued improvement in recreational fisheries data collection, as foreseen in the GFCM 2030 Strategy for sustainable fisheries and aquaculture in the Mediterranean and the Black Sea.

The collection of recreational fisheries data is limited in many countries and the lack of reliable estimates of catch, effort and socio-economic data has led to the exclusion of recreational fisheries data from stock assessments, with implications for fisheries management. The GFCM Scientific Advisory Committee on Fisheries (SAC) has highlighted the potential issues posed by this lack of data, particularly for stocks which are overexploited by commercial fisheries and for which recreational fisheries might be an additional component of fishing mortality. At the same time, it has been observed that the data-poor nature of recreational fisheries also undermines the sustainable development of this sector, in light of its potential for positive socio-economic contributions to coastal communities. In light of this, this handbook provides information on the basic set of information necessary for monitoring recreational fisheries and presents a framework for the implementation of harmonized regional data collection, based on a standard methodology, in order to facilitate the comparison of results in the Mediterranean and Black Sea region.

The handbook was elaborated under the expert guidance and overall coordination of Fabio Grati (GFCM Recreational Fisheries Specialist), who prepared the first draft, ensuring consistency with GFCM priorities and existing methodologies in place, as well as applicability across the region. Anna Carlson (GFCM Fishery Officer for Socio-Economic Issues), Paolo Carpentieri (GFCM Fishery Resources Monitoring Specialist) and Jacopo Cerri (Consultant) also provided expert inputs to the handbook's preparation and revision.

At the suggestion of the twentieth session of the SAC (FAO, 2018a), the experience from select pilot studies in the Mediterranean and the Black Sea was incorporated into the handbook. The handbook also benefitted from extensive revisions from the experts of the GFCM Working Group on Recreational fisheries (WGRF) in 2020. These consultations contributed to fine-tune the methodology and adapt the handbook to the different characteristics and recreational fisheries scenarios found in the Mediterranean and the Black Sea, so that it could be useful and replicable in different countries and areas. The handbook was endorsed on the occasion of the first meeting of the WGRF (GFCM, 2021).

The publication of this work was coordinated by Dominique Bourdenet (GFCM Scientific Editor) who ensured editing, layout and publishing, with the assistance of Ysé Bendjeddou (GFCM Publication and Documentation Specialist) and Matthew Kleiner (GFCM Editing and Communications Intern). The overall graphic design and layout of the publication was managed by Chorouk Benkabbour.

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Abstract

Marine recreational fisheries are an integral part of Mediterranean and Black Sea coastal life and are commonly practiced throughout the region. However, despite their ubiquity and potential socio-economic contribution, recreational fisheries are a data-poor sector. Data collection programmes to monitor their impact are limited and can vary widely from one country to another, thus impairing proper consideration of the recreational fisheries sector in policy-making and undermining efforts towards sustainable fisheries management at the regional level.

The main goal of this handbook is therefore to provide a clear methodological framework to allow Mediterranean and Black Sea countries to implement suitably harmonized sampling and survey monitoring schemes for recreational fisheries. The handbook consists of five parts. A first section provides an introduction to the recreational fisheries sector in the Mediterranean and Black Sea region, including the rationale for improving data collection. The second section provides guidance on how to set up a data collection programme, including how to define the target population – particularly in the absence of an up-to-date census or complete licensing system – as well as how to select a sample for data collection. Next, in section three, the handbook provides a comprehensive explanation of the harmonized regional methodology for carrying out data collection, including through a combination of on-site and off-site techniques. This section also presents a minimum set of necessary information allowing for monitoring recreational fisheries (namely, fishing effort data, catch data and economic data), while, at the same time, allowing for flexibility to accommodate national specificities and data collection needs. Section four then provides a short primer to guide readers through the data analysis process. A final section highlights the importance of engaging stakeholders in the data collection process and provides advice on how to do so.

Acknowledgements

This document was prepared under the overall direction of Abdellah Srour (GFCM Executive Secretary) and benefitted from the expert guidance of Miguel Bernal (GFCM Fishery Resources Officer) and from the support of Margherita Sessa (GFCM Fishery Liaison Officer), as well as the staff of the GFCM Secretariat. Special appreciation goes to the national focal points involved in the recreational fisheries pilot studies for taking the time to provide highly detailed feedback, share their experience and help improve the methodology proposed so as to enhance its practicality and usefulness. In particular, Marouene Bdioui, Luca Bolognini, Murat Erbay, Naciba Labidi Neghli and Imad Lahoud are warmly thanked. Valuable comments were also received from numerous experts, in particular Jorge Baro, Valerio Crespi, Arnau Luk Dedeu Dunton, Teresa García, Bruce Hartill, Matías Lozano, Sofiane Mahjoub, Ariadna Purroy Albet, Valerio Sbragaglia, the members of the Mediterranean Advisory Council, as well as other members of the GFCM Working Group on Recreational Fisheries; their contribution to enhance the quality of this product is fully recognized. The guidance of the members of the GFCM Scientific Advisory Committee on Fisheries and of the GFCM Working Group on the Black Sea is also gratefully acknowledged.

Abbreviations and acronyms

ABS	address-based sampling
CPCs	contracting parties and cooperating non-contracting parties (GFCM)
CPUE	catch per unit effort
FAO	Food and Agriculture Organization of the United Nations
GFCM	General Fisheries Commission for the Mediterranean
GSA	geographical subarea (GFCM)
ICES	International Council for the Exploration of the Sea
MEDAC	Mediterranean Advisory Council
Mid-term stategy	mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (GFCM)
RDD	random digit dialing
RPAS	remotely piloted aircraft systems
SAC	Scientific Advisory Committee on Fisheries (GFCM)
SCESS	Sub-Committee on Economic and Social Sciences (GFCM)
WGRF	Working Group on Recreational fisheries (GFCM)

Definitions

Angling	Fishing with handlines, fishing rods and/or poles using natural and/or artificial baits.
Avidity	The frequency of fishing trips undertaken over a commonly defined period.
Catch	The total number or weight of individuals caught during fishing operations, including fish that were caught and released.
Catch-and-release	The process of capturing a fish, usually by angling, and releasing it alive. Catch-and-release procedures range from legally required to mandatory release of protected sizes and species to voluntary catch-and-release of fish that could have been retained.
Fishing effort	The amount of fishing gear of a specific type used on the fishing grounds over a given unit of time (e.g. total number of fishing days by fleet segment).
Geographical subareas (GSAs)	Geographical subareas were established by the GFCM within its area of application (Mediterranean and Black Sea) in order to compile data, monitor fisheries and assess fisheries resources in a georeferenced manner (see Annex 1).
Harvest	The part of the catch that is kept, not released.
Jurisdiction	A province or territory with recreational fisheries management responsibility.
Logbook survey	A survey of recruited fishers who are asked to record their effort and/or catch in supplied logbooks.
Mail survey	Data collected through questionnaires sent to recipients by post asking for information about previous fishing activity, catch or expenses.
Non-resident	Someone that fishes in a particular area, but is excluded from the resident sampling frame for surveys in that area.
Off-site sampling	Selecting respondents outside of areas where fishing activity takes place or can be observed, e.g. household and/or over the phone.
Online survey	Questionnaire that can be completed over the internet. Online surveys are usually created as web forms with a database to store the answers and a statistical software to provide analytics.
On-site sampling	Selecting respondents at principal areas of activity, e.g. fishing sites.

Panel survey	An ongoing survey of a group of fishers who have been enrolled in a panel for a fixed period.
Random digit dialing (RDD)	A method of selecting people for telephone statistical surveys by generating telephone numbers at random.
Recreational fisheries	A non-commercial fishing activity exploiting marine living resources for recreation, tourism or sport.
Screening survey	A survey to identify the target population of recreational fishers and their fishing characteristics.
Sport fishing	An organized activity involving free competition between fishers to catch the largest fish of certain species, the largest number of specimens or the largest total weight, depending on the rules of each particular competition.
Survey	A method of gathering information from a number of individuals, known as a sample, in order to learn something about the larger population from which the sample is drawn.

Background

Marine recreational fisheries, including sport fishing, is an integral part of Mediterranean and Black Sea coastal life and communities. It has high cultural importance in the region and represents an important economic component of coastal tourism, which constitutes one of the region's main maritime sectors in terms of gross value added and employment. Nevertheless, despite the perceived socio-economic benefits, the lack of reliable catch estimates has resulted in recreational fisheries being excluded from stock assessments. This can be challenging for assessing stocks that are already overexploited by commercial fisheries and for which recreational fisheries might present an additional component of fishing mortality. Such a shortage of catch data, coupled with the limited availability of data on the socio-economic impact of recreational fisheries, impairs proper consideration of this sector in policy-making and undermines efforts toward the sustainable management of fish stocks (Hyder *et al.*, 2014). The data-poor nature of the recreational fisheries sector also compromises the potential of its development for positive socio-economic contributions to coastal communities (Arlinghaus *et al.*, 2019).

Considering that the main objective of the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) is to ensure the conservation and the sustainable use, at the biological, social, economic and environmental levels, of marine living resources, as well as the sustainable development of aquaculture in the Mediterranean and in the Black Sea, recreational fisheries activity needs to be duly considered. Catch mortality should include all reported or estimated commercial fishing landings, plus landings from recreational fisheries and subsistence fisheries and, ideally, estimates of post-release mortality too. Such data boasts a wide range of existing or potential end users, including national governments, the scientific community, as well as the GFCM.

Improved information on this sector will help to design effective and enforceable control measures and to support the development of long-term regional management plans and marine spatial planning. These are crucial issues that should be urgently addressed in order to foster better management of marine living resources in the Mediterranean and the Black Sea.

1. Introduction

1.1 OBJECTIVES OF THE HANDBOOK

Mediterranean and Black Sea fisheries face serious challenges, with approximately 75 percent of the scientifically assessed stocks considered to be fished outside of safe biological limits (FAO, 2020). To take concerted action towards improving this situation, the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) developed a programmatic multiannual mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (mid-term strategy) (GFCM, 2017a).

The implementation of the mid-term strategy sought to reverse the trend in the status of commercially exploited stocks by means of a series of targets, outputs and activities. In this context, Output 2.1 of Target 2, "Robust and timely information on the impacts of small-scale fisheries and recreational fisheries on living marine resources and on their interactions with other human activities in coastal communities," foresaw the establishment of a permanent working group on recreational fisheries and the assessment of the impacts of recreational fisheries, providing the impetus for preparing this handbook. The collection of recreational fisheries data is still a recent development in many countries and there exists no clear framework for the integration of these data in stock assessments or fishery management.

The main goal of this handbook is therefore to provide a clear methodological framework to allow Mediterranean and Black Sea countries to implement suitably harmonized sampling and survey monitoring schemes for recreational fisheries. The information that this handbook suggests collecting is considered as the basic set necessary for monitoring recreational fisheries. At the same time, it is important to take into account national specificities and data collection needs when implementing a recreational fisheries monitoring programme, including whether the collection of additional information, such as social data or data on interactions with vulnerable species, would be necessary.

1.2 DEFINITION OF RECREATIONAL FISHERIES

In order to understand each other and communicate using a common language, recreational fishers, managers, politicians and scientists need a proper definition of recreational fisheries for research, management and legal purposes. Past discussions on recreational fisheries within the context of GFCM statutory and technical meetings have primarily focused on the identification of a harmonized definition for recreational fisheries. Deliberations from the Transversal Workshop on the Monitoring of Recreational Fisheries in the GFCM Area (GFCM, 2010a) and the eleventh session of the former Sub-Committee on Economic and Social Sciences (SCESS) (GFCM, 2010b) agreed on the following definition for recreational fishing: "Fishing activities exploiting marine living aquatic resources for leisure or sport purposes, from which it is prohibited to sell or trade the catches obtained". It was further specified that "leisure purposes" refers to "fishing practiced for pleasure", whereas "sport purposes" refers to "fishing contests practiced within an established institutional framework which sets rules, collects data on catches and informs on the outcomes of the event" (GFCM, 2010a). Building on these discussions, the following definition has been adopted within two GFCM recommendations (Recommendation GFCM/43/2019/2 on a management plan for the sustainable exploitation of blackspot seabream in the Alboran Sea (geographical subareas 1 to 3) and Recommendation GFCM/42/2018/1 on a multiannual management plan for European eel in the Mediterranean Sea) (GFCM, 2019):

> *"Recreational fishing means a non-commercial fishing activity exploiting marine living resources for recreation, tourism or sport"*

This definition is considered to be the working definition of the GFCM, barring further decision-making by the GFCM.

It must be noted, however, that there exists an array of definitions in the literature and within national legislations pertaining to recreational fisheries and its constituent parts and related sectors (Pawson, Glenn and Padda, 2008), with subsequent implications for the regulation of these sectors at the national level. For example, in general, there are some discrepancies between national legislations over the term "sport fishing". In some countries, "recreational" and "sport" fishing have different meanings, while in others, they are used interchangeably (EAA, 2004). However, as in the GFCM definition, some definitions interpret "sport fishing" as a type of recreational fishery that is more sportive, competition-oriented and technically complex than general recreational or leisure fishing (Pawson, Glenn and Padda, 2008).

Furthermore, national definitions differ over the role of subsistence fishing within recreational fisheries. In reality, not all non-commercial fishing can be described as purely recreational. In the Mediterranean and Black Sea region, it is common for fishing activity to meet both recreational and personal consumption needs, with the catch directly consumed by the fisher and/or his/her family. The FAO Technical Guidelines for Responsible Fisheries touch on this issue by defining recreational fishing as "fishing of aquatic animals (mainly fish) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets" (FAO, 2012).

Nevertheless, there is overwhelming consensus among various definitions at the regional level that recreational fisheries have a non-commercial, non-profit purpose and expressly exclude the sale of the catch (Hyder *et al.*, 2017a).

1.3 STATUS QUO

In the Mediterranean and the Black Sea, some countries already collect specific types of data, including estimates of recreational catch and release of bluefin tuna (*Thunnus thynnus*), European eel (*Anguilla anguilla*) and elasmobranchs (European Commission, 2016). However, standard and harmonized monitoring programmes for recreational fisheries, with statistically robust sampling designs, are not yet regularly implemented in most countries. Therefore, with a view to moving towards an assessment of recreational fisheries in the GFCM area of application, the GFCM proposed a roadmap to pilot recreational fisheries assessments towards the development of a harmonized regional methodology (GFCM, 2017b).

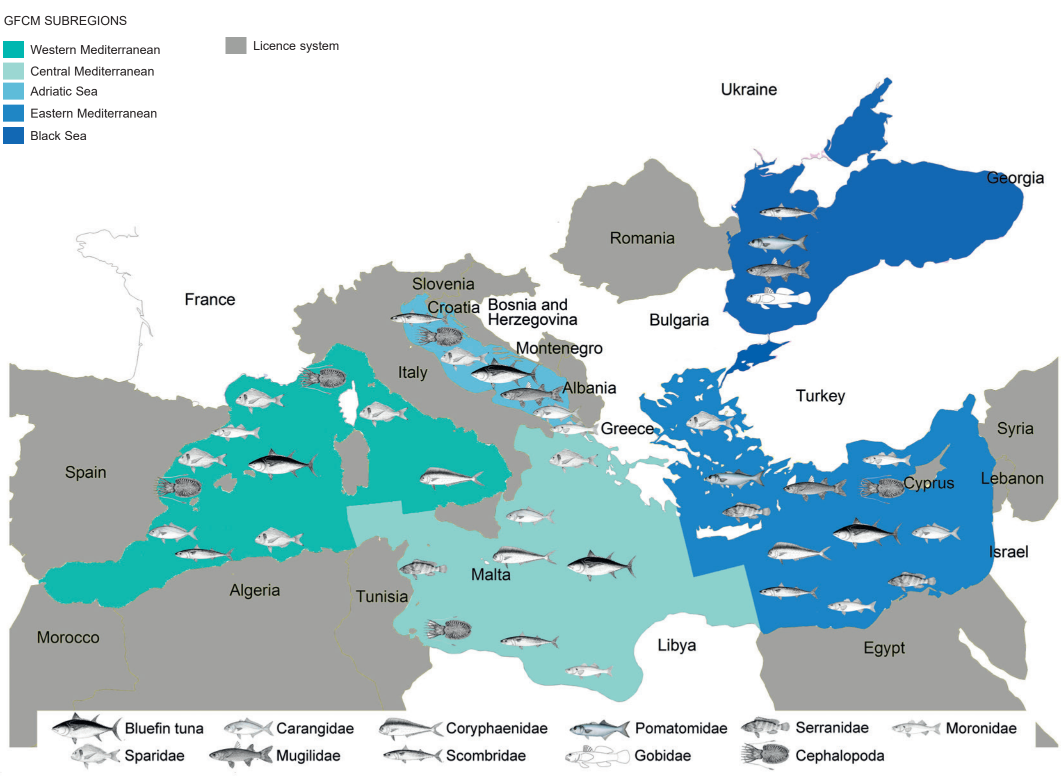
As a first step, in 2017, the GFCM circulated a questionnaire on national marine recreational fisheries among its contracting parties and cooperating non-contracting parties (CPCs). Preliminary information collected within the context of this questionnaire shows that marine recreational fisheries in the Mediterranean and the Black Sea involve many different techniques such as rod and line, speargun, traps, longlines and hand-gathering (see Annex 2) that can be employed from different locations (i.e. shore, boat, underwater) and target a broad range of taxa (e.g. finfish, shellfish, crustaceans, etc.).

In the Black Sea, recreational fishers primarily target four taxa: Scombridae, Gobidae, Mugilidae and Pomatomidae (primarily bluefish (*Pomatomus saltatrix*)).

In the Mediterranean, however, the catch composition includes a higher number of taxa, and slight variations in the target species are observed among the four GFCM Mediterranean subregions (Annex 1). The following are targeted in all Mediterranean subregions: bluefin tuna; small pelagics, particularly Scombridae such as Atlantic mackerel (*Scomber scombrus*) and Atlantic bonito (*Sarda sarda*); large pelagics, particularly Carangidae such as greater amberjack (*Seriola dumerili*) and leerfish (*Lichia amia*); Coryphaenidae, particularly dolphinfish (*Coryphaena hippurus*); Sparidae, particularly gilthead seabream (*Sparus aurata*) and common dentex (*Dentex dentex*); and Cephalopoda, particularly European squid (*Loligo vulgaris*), common cuttlefish (*Sepia officinalis*) and common octopus (*Octopus vulgaris*).

As noted above, subregional variations do occur, for example: Serranidae are mostly represented by different species of grouper, which are targeted along the western coast of the Adriatic Sea and on the rocky bottoms of the western, central and eastern Mediterranean; Mugilidae and bluefish are mainly exploited in the eastern Mediterranean and the Adriatic Sea; and Moronidae, which are represented exclusively by the European seabass *(Dicentrarchus labrax)*, are targeted in all countries bordering the Adriatic, as well as in Egypt, Libya, Spain and Turkey. A summary of the main nekton taxa targeted by recreational fisheries in the GFCM area of application is provided in Figure 1. Contracting parties and cooperating non-contracting parties for which national licensing systems for marine recreational fisheries are in place are highlighted in dark gray.

FIGURE 1
Distribution of the main taxa targeted by recreational fisheries across the GFCM subregions



Note: based on responses to the GFCM questionnaire on national marine recreational fisheries (2017).
Source: FAO, 2018b.

2. Data collection

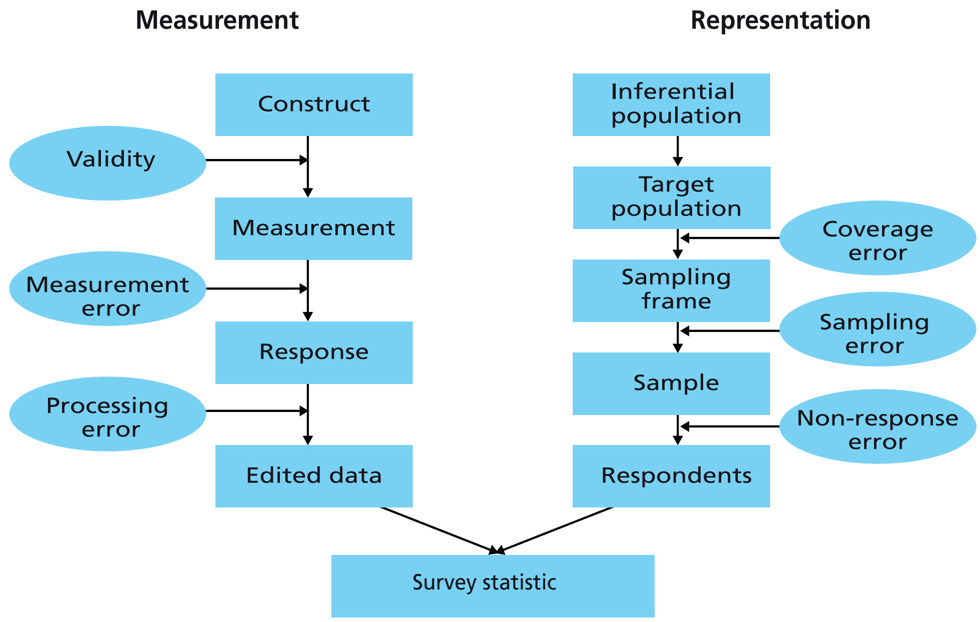
Decisions on how to monitor recreational fisheries depend on various factors, including the goals of the survey, its geographical scale, available sampling frames, the spatial distribution of fishing effort and the types of fishing methods used (Hartill *et al.*, 2012). Multiple methods exist to perform this task, each one with its advantages and limitations, and various designs are available to obtain representative estimates. As measuring the entire study area is impossible, survey sampling, in its various forms (e.g. catch analysis, questionnaires) is usually the favoured approach; by collecting a sample of observations, researchers try to obtain a comprehensive representation of the phenomenon of interest.

A good conceptual framework for understanding how to design a survey, and where eventual problems can arise, is the total survey error framework (Groves and Lyberg, 2010) (Figure 2). This framework can be divided in two components: representation and measurement.

Representation refers to the study's potential for generalization: how well do the interviewed fishers represent the whole fishing community in the study area? This question presents two different approaches:

- **Census surveys** collect information from all the statistical units in the target population (e.g. from all the recreational fishers that exist, at a certain time, in the Mediterranean and the Black sea).
- **Sample surveys** collect information from a small group of statistical units in the target population (e.g. only from some of the recreational fishers that exist in the Mediterranean and the Black sea). When certain conditions characterize data collection, findings from sample surveys can be generalized to the whole population of statistical units.

FIGURE 2
Total survey error components linked to the steps in the measurement and representational inference process



Source: Groves and Lyberg, 2010.

While census surveys paint an exhaustive and representative picture of a certain phenomenon, sample surveys are far more common, for many different reasons:

- selecting a sample is less time-consuming than selecting every item in the population;
- selecting a sample is less expensive than performing a census;
- census surveys are often unfeasible in practice and sometimes they are unethical; and
- sample surveys can be easily repeated over time to track changes in the phenomena they investigate, while censuses cannot be easily repeated.

On the other hand, the measurement component of the total survey error framework (Figure 2) refers to the ability to adequately measure the relevant phenomenon, in this case recreational fishing effort, catch and economic data. Various methods are available to perform this task, ranging from in-depth qualitative interviews to simple questionnaires (Vaske, 2008). These methods will be described in further detail in Section 3.

In recreational fisheries, effort, catch and economic data are frequently collected by means of sample surveys all around the world (Sparrevohn and Storr-Paulsen, 2012; Bellanger and Levrel, 2017). This handbook will guide readers through the implementation of such a survey, as it is considered the most relevant approach for harmonized data collection by all countries in the Mediterranean and the Black Sea region. It is important to note that in the implementation of a sample survey, errors may be introduced at different stages. As such, it is useful to consider the total survey error framework (Figure 2) when conceptualizing the survey design in order to minimize error to the greatest possible extent. A combination of multiple data collection methodologies and different sampling approaches can help minimize the total survey error, while providing researchers with considerable flexibility in monitoring recreational fisheries. To this end, it may be useful to consider complementing a traditional sample survey with on-site data collection and/or any number of new monitoring technologies being used for recreational fisheries, such as mobile applications for data collection (Venturelli, Hyder and Skov, 2017) and social media data mining (Sbragaglia *et al.*, 2019).

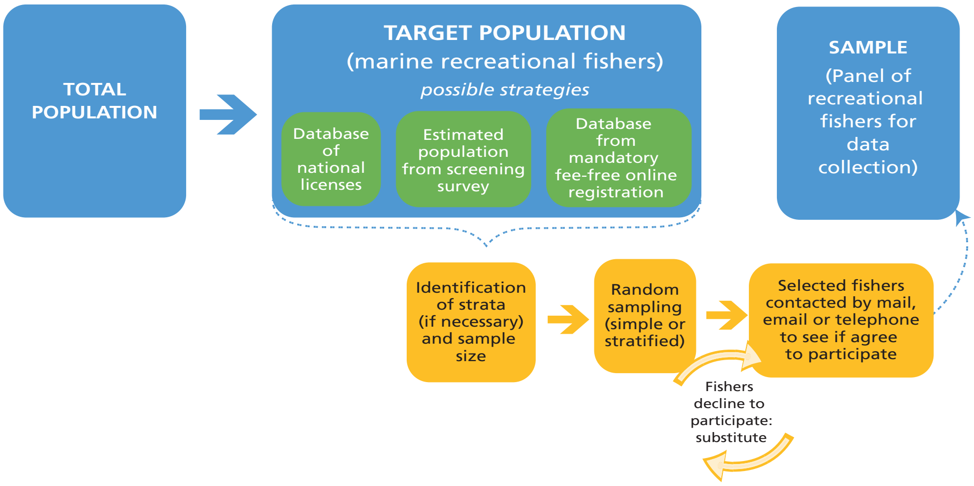
In the Mediterranean and the Black Sea, this methodological flexibility is important in order to adapt to the different characteristics and recreational fisheries scenarios found.

This handbook presents a harmonized framework for data collection in the Mediterranean and the Black Sea, while facilitating the necessary flexibility to adapt to the different specificities of the region. The subsequent sections of this handbook will guide readers through the process of defining a sample of recreational fishers to participate in data collection, as outlined in Figure 3, as well as provide guidance on the data to be collected and analysed.

Adaptability and flexibility

During the early years of data collection, it is best to focus on developing a complete understanding of the methodology and being flexible enough to make customizations as required. Setting up a simple but effective method will allow a country to move to more advanced survey techniques in due course.

FIGURE 3
Process for the identification of a sample of recreational fishers to participate in data collection

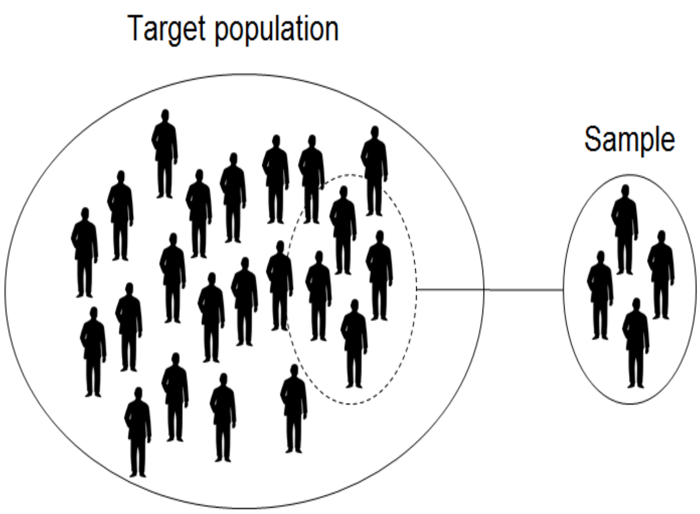


2.1 DEFINING THE TARGET POPULATION

In order to set up a sample survey, a sample should be selected by isolating some statistical units from the target population, also known as the statistical universe (Figure 4). The ultimate goal of sampling is to obtain an overview of a certain target population from a subset of units.

The first step of any sampling strategy is therefore defining the target population to which the results of the survey will be generalized. The population is the full list of units for which the survey will be conducted and about which conclusions will be drawn, in this case, the full population of marine recreational fishers. Sometimes, a complete list of all the units comprising the population is available, though this is not always the case: sampling methods therefore differ between populations with and without lists.

FIGURE 4
Extraction of a sample from the target population



Data sources for target populations may vary across Mediterranean and Black Sea countries, and some methods for identifying the target population that may be practical for some countries may not be feasible or cost-effective for others. Many countries do not have licensing programmes and databases that can provide a complete list of all recreational fishers. In fact, most of the compulsory recreational fisheries license systems in force either grant registration exceptions for some participants or do not ensure that all participants actually register or renew their licenses when they expire. Similarly, while some countries boast active recreational fisheries federations or associations which include a high number of fishers, the membership of these organizations should only be considered as completely representing the target population when membership is obligatory for all recreational fishers. With that said, recreational fisheries federations and associations can serve as valuable partners in engaging stakeholders in data collection (see Section 5).

Where recreational fisheries license programmes do exist, are obligatory and cover all types of recreational fisheries, it is still worthwhile to consider the level of compliance with the relevant license regulations. If non-compliance is high and fishing without a permit is common, then alternative data sources for the target population may need to be found to account for this higher overall number of fishers. In general, it is important that data collection accounts for the peculiarities of each country's sector, while at the same time ensuring that national datasets are organized in a way so as to eventually allow for their combination at the desired level in a statistically valid way.

On the other hand, sampling from populations without a list is more complex and less straightforward, as it requires careful designs to estimate inclusion probabilities through time-consuming methods of field sampling, such as aerial surveys, point-counts or capture-recapture models (Zischke and Griffiths, 2014). It is therefore suggested that, where complete national licensing systems or similar registries do not exist, a simple sampling frame should be adopted, such as the general population or all national households, for which lists are typically readily available. This approach is considered more effective and more easily tailored to the specificities of the Mediterranean and the Black Sea region than approaches based on sampling without a list. In this light, the following sections outline three possible strategies that have been identified as appropriate for defining the target population of recreational fishers in Mediterranean and Black Sea countries, each one with its advantages and limitations.

2.1.1 National license system

The identification of recreational fisher populations is much easier and cost-effective when information can be obtained from national marine recreational fisheries license systems and registration databases. Direct list frames of fishers, or fishing vessel operators, can be constructed from fishing license programmes, fishing permit programmes or fishing club memberships (when registration with these programmes/clubs is obligatory). Some fishers may participate in more than one list frame by being, for example, both a license holder and a fishing club member. It may also be the case that a list frame includes fishers who have not fished during the survey reference period; this issue can, however, be accounted for at later stages in the study. A list frame of fishers should identify license holders, when appropriate, by postal mailing address, e-mail address, telephone number, mobile telephone number and, possibly, a national identity (ID) or social security number. Ideally, fishing licenses should cover all possible recreational fisheries categories and should identify the fishing category (or categories) practiced by each license holder, namely fishing from the coast, a boat and/or underwater fishing.

As of 2017, based on the data collected through the GFCM questionnaire on national marine recreational fisheries, most license systems in force in the Mediterranean and the Black Sea were dedicated to boat fishing, while coastal and underwater fishing, in many cases, did not require a license. Such data sources face potential limitations, however, in the form of national confidentiality protection requirements, which might impede the use of contact lists for survey purposes. Researchers should make all attempts to avoid potential pitfalls related to these limitations, including through familiarization with existing legal frameworks for data collection. For countries that do not have a complete license system in place, alternative options are described below. Suggested options include performing a screening survey or a mandatory fee-free online registration. A screening survey could also be valid for those countries without a complete license system in place (e.g. licenses are mandatory only for boat fishing) to cover the missing portion of the recreational fisher population (e.g. shore and underwater fishing).

2.1.2 General population screening survey

When a list of recreational fishers from a license system is not available or is incomplete, it is possible to conduct a screening survey, sampling from a broad coverage system, such as a complete frame of resident households. It may not be necessary to conduct a screening survey every year; every two to three years would be sufficient. It is preferable to use a screening survey only as a means to identify recreational fishers for a more detailed follow-up survey. A flow chart outlining this process is provided below (Figure 5). Therefore, the first correspondence could be limited to determining if any household residents participate in recreational fisheries, collecting their contact information and recruiting them for participation in a more detailed follow-up survey. The survey should collect the minimal data needed to define and profile the fishing population.

A template for the enrollment of fishers for data collection from a screening survey is shown in Annex 3. First of all, there is a need to collect information on the gender and age of all members of the household. The second question concerns who went fishing at sea during the last year and how many times they went per fishing mode (a rough estimate is sufficient). The last question is perhaps the most important and concerns the respondent's availability to enroll in a panel that will be contacted by phone (mobile phone number would be ideal) every month for data collection. Respondents agreeing to participate in this panel would then be provided with a logbook (Annex 5) in order to keep records of requested information (as described in Section 3.1.1).

When requesting this information, privacy concerns must be considered and so it is recommended to consult national privacy laws prior to initiating this work. Common principles for data sharing and dissemination should always be respected when carrying out data collection, in line with the concept of privacy constituting a basic human right as recognized by the United Nations.[1]

At the global level, both address-based sampling (ABS), i.e. complete lists of residential mailing addresses for mail or face-to-face surveys of recreational fisheries, and random-digit-dialing (RDD), i.e. directory-based telephone surveys that provide access to a majority of a resident fishing population, have been widely used. For over 30 years, RDD telephone surveys have served as the mainstay of the survey research industry (Link *et al.*, 2008). Over the past decade, however, participation in most RDD telephone surveys has declined due, most likely, to factors such as the growth of call-screening technologies, heightened privacy concerns in the face of frequent telemarketing calls and the proliferation of non-household telephone numbers, which are typically non-voice and unassigned numbers (Link *et al.*, 2008).

[1] Article 12 of the Universal Declaration of Human Rights (General Assembly of the United Nations, 1948) states "No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence, nor to attacks upon his honour and reputation. Everyone has the right to the protection of the law against such interference or attacks."

Additionally, RDD frames may exclude households without a landline telephone (e.g. due to increased use of cellular telephones). Increasingly, though, these RDD surveys are conducted using computer-assisted telephone interviewing technology or, where georeferenced mobile phone information is available, computer-assisted mobile interviewing, which help circumvent the problems associated with fewer and fewer people having landline telephones. However, probability sample design alternatives to RDD that are comparable in speed, efficiency and cost are scarce. Address-based sampling is one such alternative that may provide survey research with a cost-effective alternative to RDD, as the growth of database technology has allowed for the development and maintenance of large, computerized dwelling address databases. In New Zealand, an advanced face-to-face survey from a dwelling list is already performed, although this may not offer an optimal solution for all Mediterranean and Black Sea countries due to the high budgetary requirements for its implementation.

In the event that both approaches are possible, ABS and RDD directory frames should be compared and evaluated to determine which provides the most complete coverage for an effective screening of resident recreational fishers in each country. Ideally, in order to reduce biases that may result from the undercoverage of any one list frame, it would be best to use a dual frame approach. In this way, it is possible to assess the coverage of the list frame by comparing recreational fishers occurring in both frames to those appearing only in one. Furthermore, one could consider stratifying coastal and non-coastal municipalities and applying design weights (e.g. 70 percent coastal, 30 percent non-coastal) in order to oversample coastal municipalities, where a higher number of marine recreational fishers are expected to be found.

The screening approach described in this section would therefore provide access to the resident population, excluding non-resident (i.e. tourist) marine fishers. In countries where tourists represent an important component of recreational fisheries, it is necessary to implement a supplementary survey frame dedicated to non-residents. A possible solution for creating a list of non-resident marine recreational fishers could be to enforce a mandatory fee-free online registration as described in the following section.

FIGURE 5

Process for the identification of recreational fishers from a general population screening

2.1.3 Mandatory fee-free online registration

When a complete list of recreational fishers is not available, a list of non-resident fishers does not exist, and a screening survey is not feasible, then the third solution would be to enforce the registration of participants through the implementation of an online fee-free registration programme, which collects a valid name, address, e-mail address and telephone number for each participant. This approach has been recently endorsed by the Mediterranean Advisory Council (MEDAC) as a valid method for the assessment of recreational fisheries in the Mediterranean (MEDAC, 2016). Such registration should be mandatory for both residents and tourists, regardless of age and of whether recreational fishing takes place from the shore, from a boat or underwater. The word "license" should not be used in this case in order to avoid conflict and refusal from the part of the population (ICES, 2010); the word "census" could be suggested instead. The use of an online registration offers many advantages, including ease of access, time saving and efficient data management. However, a possible source of bias could arise from the internet not being user-friendly for certain groups of recreational fishers, such as the elderly – although this was not found to be the case in a study in Spain by Gordoa, Dedeu and Boada (2019). To avoid such bias, it is recommended that fishing shops assist fishers in online registration and print a copy of the document for the fishers, certifying their registration.

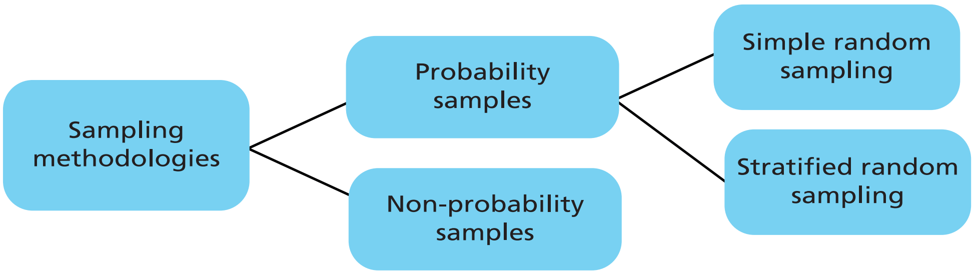
The first step in implementing such an approach would be to create a dedicated online platform, which should be endorsed by the national administration in charge of managing fishing activity, such as a ministry for example. This step entails minor costs, as internet domains are relatively low-cost. Recreational fishers planning to pursue their fishing activities in marine national waters should register online by completing a number of mandatory fields with some general details (name, e-mail, place and date of birth, nationality, etc.). Once the general profile has been filled in, an ID number, valid for a lifetime, should be assigned to each fisher. Afterwards, fishers should be required to complete a second form requesting a list of compulsory supplementary data: type and avidity for every type of recreational fishing practiced and name of an eventual affiliation to a marine recreational fisheries association. In some cases, such as the Balearic Islands registration system, users are also required to specify the main areas in which they fish. Once the fishers have completed the compulsory data entry, a certificate should be delivered, either directly through the registration website or sent via e-mail. This certificate should be fee-free but mandatory, in order to perform any kind of marine fishing in national waters. Fishers should be requested to print this certificate and keep it with them whenever carrying out marine recreational fishing activities. A template for a mandatory fee-free online registration is shown in Annex 4. It is desirable that the online registration be linked to a national database, where all information collected is organized and stored.

2.2 SAMPLING STRATEGY

Once the target population has been defined, observations (i.e. recreational fishers) can be sampled according to two criteria: probability and non-probability sampling (Figure 6).

FIGURE 6

Process for the identification of recreational fishers from a general population screening



2.2.1 Non-probability sampling

Non-probability sampling, also known as purposive sampling, describes a family of sampling techniques (e.g. convenience sampling, haphazard sampling, purposive sampling, expert sampling, diversity sampling, modal instance sampling, quota sampling, etc.) where the odds of any member being selected for a sample cannot be calculated and sampling relies on the subjective judgement of the researcher (Sabatella and Franquesa, 2003). These methods present some advantages, such as convenience, speed and low cost. However, with these surveys, it is impossible to know how well the population is represented, as the results cannot be generalized. A further bias comes from the fact that confidence intervals and margins of error cannot be calculated, rendering the results meaningless (Cochran, 1977; Lohr, 1999; Levine *et al.*, 2008). This is the main reason why non-probability sampling should not be considered in the quantification of recreational fisheries in the Mediterranean and the Black Sea. Non-probability sampling should be considered only when some particular conditions apply. For example, the use of online registration constitutes a form of non-probability sampling, which does not allow for any formal inference. However, on some occasions where the sampling frame is unavailable, it may be the only feasible approach.

2.2.2 Probability sampling

Within probability sampling, sample unit selection is based on known probabilities calculated from demographic data collected during the initial screening survey and from data provided by the most recent national census. This approach allows the researcher to make unbiased and mathematically sound inferences about the population of interest (Levine *et al.*, 2008). In sampling designs for populations with a list, the two most common forms of probability sampling are simple random sampling and stratified random sampling. These sampling methods have two features in common: i) every element of the population has a known non-zero probability of being sampled; and ii) random selection of the sample is applied (Pinello, Gee and Dimech, 2017).

Simple random sampling

In simple random sampling, all the units from the target population have the same probability of being chosen. For example, if there is a list of all the recreational anglers who fish in a certain coastal area and the annual number of gilthead seabream caught by an angler within a fishing season must be determined, the procedure is as follows: extract a random sample of anglers, ask them the number of gilthead seabreams they landed over the course of the fishing season, calculate an estimator (Hankin, Mohr and Newman, 2019) expressing the total or the average number of gilthead seabreams that were landed and then calculate the associated variance of the estimate. Provided the sample is large enough, it can be reasonably claimed that simple random sampling offers an adequate picture of the recreational gilthead seabream fishery in the coastal area being investigated.

Stratified random sampling

Stratified random sampling, on the other hand, represents a suitable choice when the target measurements vary between the units being sampled. Using the example of a situation where a list of recreational fishers exists at the national level and the goal is to estimate how many people are exclusive sea fishers (i.e. they do not fish in freshwater), if simple random sampling is adopted, the sample of fishers might contain respondents from only inland areas. This sample is therefore likely to be biased, as it would underestimate the total number of sea fishers, as sea fishing is almost certainly more common in coastal areas. Instead, respondents could be divided on the basis of their geographical provenance, for example by creating two subgroups of respondents, one from inland and one from coastal areas. Then fishers can be randomly sampled from each one of these two groups: the estimates will be correct, as the observations are correctly weighted. The two groups of respondents, from inland and from coastal areas, are called strata and they have to be mutually exclusive: a fisher cannot be a resident, at the same time, of a coastal area and an inland area.

Both simple random sampling and stratified random sampling are correct, meaning that, if sampling is well designed, they provide researchers and managers with unbiased estimates of the phenomenon of interest, and that the standard error of the estimates can be calculated correctly (Hankin, Mohr and Newman, 2019). If the variable of interest – say the probability of being an exclusive sea fisher – is strongly associated to the strata, then stratified random sampling can provide researchers with more accurate estimates. On the other hand, if there is no strong variation between strata, simple random sampling is preferred, as inference from stratified random sampling might be inaccurate. Choosing each one of these approaches should be carefully predicated on the basis of evidence at hand.

Statistical weighting of survey data

A final approach is called weighting. Weighting offers a way to account for unbalanced sampling, once data has been collected. This procedure is particularly useful when simple random sampling is adopted but can also be applied to stratified random sampling schemes. Weights are calculated for target populations catalogued in lists; they cannot be calculated for populations without a list. As an example, imagine a random sample of recreational boats, from which the total seasonal catch of common cuttlefish is to be estimated. Random sampling is carried out, collecting a sample of 410 boats. It is realized, however, that the sample is unbalanced in terms of fishing activity: while 40 percent of fishing boats in the whole study area use specialized gear to catch common cuttlefish, only 10 percent of boats in the sample use specialized gear to target common cuttlefish. Recreational boats targeting common cuttlefish are therefore under-represented within the sample, while boats targeting other species are over-represented, with consequent errors (i.e. a deflated value) in estimated harvests of cuttlefish.

Weights could be estimated as (Vaske, 2008):

$$Weight = \frac{Population\ percentage}{Sample\ percentage}$$

Therefore, weights for boats that target common cuttlefish correspond to: 40/10 = 4, while weights for boats that are targeting other species are equal to 60/90 = 0.66. By multiplying each boat's reported catch by its corresponding weight, the estimates are adjusted.

Weighting is a powerful tool to correct estimates but requires accurate knowledge of the target population and is not always feasible. Multiple approaches are available, including the use of multiple variables, or the use of weighting to correct non-response bias. Relevant references, including survey method texts, can provide further details (Vaske, 2008; Groves *et al.*, 2009; Dillman, Smyth and Christian, 2014).

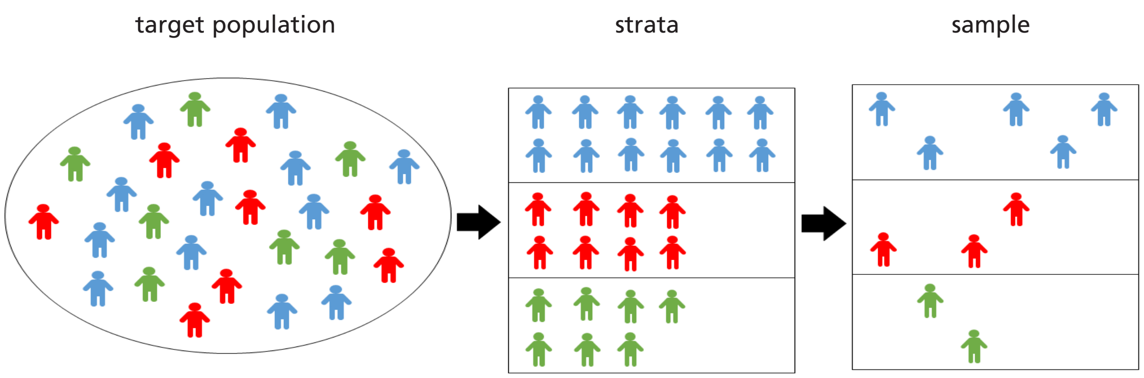
2.3 STRATIFYING THE POPULATION

Once the target population has been defined, either through a national license system, a screening survey or a mandatory fee-free online registration, the sample size can be estimated (i.e. number of observations) and the sample of recreational fishers can be selected. However, in the case of a stratified random sampling, one further step is required: there is a need to identify the strata. As previously mentioned, an important principle is that strata should be mutually exclusive, as simply illustrated in Figure 7.

For example, if the respondents were divided equally between residents of coastal and inland areas and a sample of 640 units was needed, 320 respondents (50 percent) would therefore have to be sampled at random from the inland stratum and 320 respondents (50 percent) from the coastal stratum.

Therefore, stratification could be based on residents' spatial provenance, grouping by criteria such as area of residence or specific jurisdiction (e.g. GFCM geographical subarea (GSA) – see Annex 1, subnational, region, port, etc.) rather than on fishing habits (e.g. boat fishing, shore fishing or underwater fishing), as the same recreational fisher may engage in various different types of fishing activities. Fishing habits could be taken into account to weight observations, but it is recommended to make sure that this choice is motivated by: i) a good rationale for why recreationists with different fishing habits might differ; and ii) evidence on the soundness of existing data on recreational fisheries. Any bias in estimated proportions of recreationists will further affect estimates made through weighting.

FIGURE 7
Stratification of the target population



2.4 ESTIMATING THE SAMPLE SIZE

The biggest advantage of probabilistic survey sampling lies in its capacity to provide accurate representations of large populations from surveys of small groups of units; a minimum number of units, however, is required to make inferences about the target populations. The minimum number of observations necessary is usually defined on the basis of the desired sampling error, the size of the target population and the variability of the trait of interest: a higher number of units is needed to make inference about a large and heterogeneous population than for a tiny and homogeneous one. Similarly, to obtain highly accurate estimates, a greater number of units is needed than for coarser estimates. Table 1 provides an example from Salant and Dillman (1994).

TABLE 1
Example of sample sizes needed by population size and level of sampling error

Population size	± 3% Sampling error		± 5% Sampling error		± 10% Sampling error	
	50/50 split	*80/20 split*	*50/50 split*	*80/20 split*	*50/50 split*	*80/20 split*
100	92	87	80	71	49	38
250	203	183	152	124	70	49
500	341	289	217	165	81	55
750	441	358	254	185	85	57
1 000	516	406	278	198	88	58
2 500	748	537	333	224	93	60
5 000	880	601	357	234	94	61
10 000	964	639	370	240	95	61
25 000	1 023	665	378	234	96	61
50 000	1 045	674	381	245	96	61
100 000	1 056	678	383	245	96	61
1 000 000	1 066	682	384	246	96	61
100 000 000	1 067	683	384	246	96	61

Source: Salant and Dillman, 1994.

Sample size for random sampling may be easily estimated in cases of populations with lists of units. Here follows an example of the formula provided by Vaske (2008):

$$Ns = \frac{(Np)\times(p)\times(1-p)}{\left[(Np-1)\times(B/C)^2\right]+\left[(p)\times(1-p)\right]}$$

where:

Ns = the sample size

Np = the size of the target population (e.g. the number of recreational fishers reported on a list)

p = the prevalence of the target variable (e.g. the number of recreational fishers who are exclusive sea fishers, who do not fish in freshwater)

B = the desired level of sampling error which can be accepted (e.g. 5 percent = 0.05)

C = the Z-statistic associated with the confidence interval (e.g. for a 95 percent confidence interval, Z = 1.96)

For stratified random sampling, the number of observations within each stratum can be obtained through proportionate stratification. The procedure requires the following steps:

1. Compute the desired sample size (see formula above).
2. Calculate the proportion of each stratum in the target population.
3. Assign the number of observational units proportionally to each stratum.

This procedure is called proportionate stratification and takes the following formula:

$$n_h = \left(\frac{N_h}{N}\right) \cdot n$$

where:

n_h = the number of observations in each stratum of the sample
N_h = the number of observations in each stratum of the population
N = the total number of observations in the population
n = the total number of observations collected with sampling

2.5 SELECTING THE SAMPLE

Once the target population has been defined (see Section 2.1) and stratified (see Section 2.3) and the sample size determined (see Section 2.4), the sample of recreational fishers to be enrolled in subsequent data collection can be selected. In order to initiate this process, each fisher must possess a unique ID, identifying him or her from all other fishers. In the case of a licensing system, this unique ID could be the license number, whereas in the case of screening surveys or mandatory fee-free online registration, each member of the target population should be assigned a unique ID. Following the methodology of random sampling, the basic condition required for the selection of the sample is randomness. To avoid human error, this process should be carried out by a computerized routine, ensuring that all members of the population share an equal chance of appearing in the sample, thereby guaranteeing randomness. This computerized routine can be performed simply in Microsoft Excel, following these steps (Figure 8):

1. Enter the complete target population list frame in the Excel file, ensuring that each fisher is identified by a unique ID.
2. Assign a random number to each ID by means of the RAND function in Microsoft Excel by typing =RAND() and hitting enter. A randomly generated number will appear in the cell.
3. To ensure the RAND function does not continue to change the value of the randomly generated numbers, copy and paste all random numbers generated using "paste special – value" to insert the value only in the column with the random number.
4. Sort the list of IDs by their random number, from smallest to largest.
5. According to the chosen sample size (*n*), select the first *n* rows of the list: they constitute the randomly selected sample units.

This simple and straightforward procedure guarantees the perfect randomness of the sample (Pinello, Gee and Dimech, 2017).

Once the sample population has been selected, the fishers should be contacted (by e-mail or telephone) in order to determine whether or not they are willing to participate in the data collection. If they agree to participate in the data collection, then they should be enrolled in the panel survey; fishers who decline to participate shall be substituted by other fishers randomly selected from the database. All attempts should be made to encourage participation and to avoid replacement whenever possible, as replacement can result in a less representative sample. When feasible, it is useful to collect demographic and fishing avidity data from those who refuse to participate, as this information can facilitate adjusting statistical weights to account for non-response error.

FIGURE 8

Example of computerized routine to select random samples

STEP 1

	A	B	C	D
1	ID			
2	1			
3	2			
4	3			
5	4			
6	5			
7	6			
8	7			
9	8			
10	9			
11	10			
12	11			
13	12			
14	13			
15	14			
16	15			
17	16			
18	17			
19	18			

STEP 2

	A	B	C	D
1	ID	Random numbers		
2	1	0.40795484121		
3	2	0.12845466897		
4	3	0.65770634522		
5	4	0.07759856331		
6	5	0.46540075623		
7	6	0.87541332138		
8	7	0.97566432311		
9	8	0.73242430743		
10	9	0.54786965421		
11	10	0.56359821065		
12	11	0.37664809832		
13	12	0.89467563297		
14	13	0.48675094327		
15	14	0.98006574344		
16	15	0.04567895		
17	16	0.18657965643		
18	17	0.3678954321		
19	18 = Rand ()			

STEP 3

	A	B	C	D
1	ID	Random numbers		
2	1	0.4079548421		
3	2	0.5409865742		
4	3	0.02439870		
5	4	0.396948965		
6	5	0.659354280		
7	6	0.196493582		
8	7	0.6573209382		
9	8	0.7692759202		
10	9	0.874027539		
11	10	0.657098365		
12	11	0.39672892		
13	12	0.496492174		
14	13	0.002975662		
15	14	0.856743020		
16	15	0.376950281		
17	16	0.948677433		
18	17	0.759207512		
19	18	0.645839734		

STEP 4

	A	B	C	D
1	ID	Random numbers		
2	1	0.3849454491		
3	2	0.756328737		
4	3	0.09634201		
5	4	0.483920188		
6	5	0.295824718		
7	6	0.981839539		
8	7	0.739291029		
9	8	0.392093754		
10	9	0.285386549		
11	10	0.387652915		
12	11	0.498286423		
13	12	0.73954201		
14	13	0.297163209		
15	14	0.875927542		
16	15	0.2954310865		
17	16	0.021783974		
18	17	0.297493214		
19	18	0.536839202		

STEP 1: the total population includes 18 recreational fishers (each assigned an ID number and entered into the Excel file) and the objective is to randomly select 50 percent of them (nine fishers). STEP 2: with the RAND function, create 18 random numbers. STEP 3: copy and paste as values these numbers. STEP 4: sort the fisher ID by the random numbers from smallest to largest and select the first nine fisher IDs (i.e. 8, 2, 12, 7, 1, 6, 16, 18 and 11). These nine fisher IDs constitute the sample.

2.6 ADDITIONAL CONSIDERATIONS

Selecting a sample goes beyond sampling design and the random extraction of statistical units. In practice, many other decisions are involved in the process, governing coverage error, sampling error and non-response error (see Figure 2). Notably:

- The sampling frame might not fully overlap with the range of statistical units in the population. Some units, given certain sampling mechanisms, may not be covered by the survey, thereby biasing the estimates. A famous case involves the use of online surveys: not every person has access to the internet, meaning not every person can be recruited in an online survey and, therefore, online surveys are often biased compared to other survey administration modes (Vaske, 2011). Considering that internet usage may be limited in rural areas and developing countries and among the elderly, estimates from online surveys risk strong biases for recreational fisheries surveys in the Mediterranean and the Black Sea where these three groups make up a significant portion of the target population.
- Sampling error: as discussed in Section 2.2, sampling might be biased. For example, simple random sampling may fail to be balanced in terms of relevant groups of units (strata), biasing subsequent inferences.
- Non-response error: certain mechanisms adopted for unit selection might produce problems due to people not responding to the survey; self-administered surveys, if overly time-consuming and cognitively demanding, may be rejected by less motivated respondents, or by respondents with a lower level of literacy. In turn, non-respondents might differ from respondents in relation to the target variable that researchers aim to estimate, thereby biasing final estimates. A simplified example is a self-administered mail survey, delivered to a random sample of fishers, which asks them many different questions about seasonal catch. The questionnaire is well-designed and protects privacy, but it is too long and difficult to understand. Therefore, those fishers with low literacy

levels (and – for the sake of this simplified example – correspondingly lower income levels) do not respond. As a result, responses come from those fishers with higher literacy rates (and correspondingly higher income levels). Owing to this latter group's higher income, they likely use more expensive and more efficient fishing gear, resulting in an overestimation of the average seasonal catch.

Defining a sample frame and an administration mode are two practical aspects of survey implementation that affect the estimation of recreational fishers in the Mediterranean and the Black Sea.

3. Methodology

Once the sampling frame of recreational fishers has been identified – regardless of the data source (i.e. license system, screening survey or mandatory fee-free online registration) – there are a number of different methods for contacting recreationists and collecting effort, catch and economic data.

Each method comes with its advantages and disadvantages in terms of species and geographical coverage, measurement accuracy and scalability of results (Wynne-Jones *et al.*, 2014). Ideally, data collection procedures should minimize coverage, sampling, and non-response bias. Moreover, data collection should refrain from asking sensitive questions and should avoid making respondents feel uncomfortable about their answers (Krumpal, 2013). If these two conditions are met, data collection can provide catch statistics that are unbiased and sufficiently precise for use in stock assessments and for informing fisheries management.

There are two broad types of approaches to data collection:

- off-site surveys; and
- on-site surveys.

Off-site surveys are characterized by researchers drawing observational units without going into the field. This context implies that they are inevitably conducted for target populations whose lists are known and available and that they collect mostly self-reported measurements.

On-site surveys, on the other hand, involve sampling fishers by going into the field and approaching and interviewing them.

As a general recommendation, both off-site and on-site surveys should aim to ask as few questions as possible in order to minimize the cognitive burden for respondents. Furthermore, sensitive questions should be avoided and all efforts should be made to build a trust-based relationship with respondents, particularly in the case of economic data collection (see Section 3.3.4). Available evidence indicates that sharing detailed information about the scope of the questionnaire and providing feedback on the scientific findings to the respondents is useful in promoting trust (Vaske, 2008).

3.1 OFF-SITE SURVEYS

Off-site surveys offer a means of measuring all forms of fishing activity across large spatial areas to produce total harvest estimates. There are certain potential advantages to such methods, particularly in terms of geographical coverage and their ability to reach all the various types of recreational fishers, even those who are the hardest to recruit in on-site surveys. Respondents can be asked about fishing over defined periods (e.g. day by day or over an extended period), especially when enrolled in a panel-type survey (Wynne-Jones *et al.*, 2014). However, it is important to note that off-site surveys always rely on self-reported information. Off-site surveys can take two forms:

- logbook surveys; and
- recall surveys.

3.1.1 Logbook surveys

Logbooks provide a very cost-effective means of collecting both fishing effort, catch and economic data. A template of a logbook is included in Annex 5. The logbook could be delivered to selected recreational fishers as a paper book/diary at the beginning of the survey period. Alternatively, online logbooks or a dedicated application for mobile phones could be developed. As a first step, delivering paper logbooks is suggested as they ensure maximum coverage. Each page of the logbook should correspond to one fishing trip. Should a fisher engage in multiple fishing modes (e.g. from a boat, from the shore or underwater) within the same day, each fishing mode should be considered a separate fishing trip and a separate logbook should be completed. Fishers should be asked to complete the logbook with:

- general information (Annex 5.a), including:
  - name and surname of the panel participant;
  - whether the logbook information is reported for a single fisher (the panel participant) or multiple fishers (in the case that the panel participant pools his/her catch with other fishers during the fishing trip and it is not possible to determine the panel participant's individual catch). In the case of multiple fishers, the number of fishers (gender disaggregated) and their ages should be reported;
  - location of the fishing ground, such as the GFCM GSA, the city or distance from the coast: this can be reported through geographical coordinates (if available through GPS or mobile phone data) and/or by describing the location (e.g. by reporting the basin and distance from the nearest harbor);
  - total fishing time: the date and time of the fishing trip's start and the date and time of the fishing trip's end;
  - fishing mode: whether fishing took place from a boat, from the shore or underwater;
  - information about the fishing effort: fishing gear used, time spent fishing per gear (fishing time), number of units used for each fishing gear (e.g. number of rods, hooks, etc.). In case "multiple fishers" was selected at the top of the logbook, then the cumulative fishing effort for all fishers should be reported;
  - catch by gear code: in case "multiple fishers" was selected at the top of the logbook, then the cumulative catch for all fishers should be reported;
- retained species information (Annex 5.b), including:
  - biological data of the retained catch, including length, weight and sex (if known);
- released species information (Annex 5.c), including:
  - information on the released catch, including the length and post-release status; and
- expenditures (Annex 5.d), including:
  - the value of all expenditures made in relation to the fishing trip, including any expenditures incurred prior to the fishing trip (e.g. the purchase of new equipment) since the last logbook was completed.

Fishing effort will be estimated taking into account the total fishing time of the trip (ending time minus starting time, including travel to/from the port in the case of boat fishing). In the example shown in Figure 9.a, the total fishing time is eight hours. Data on fishing effort must be reported for each gear/technique used during the trip. The effective fishing (soak) time per gear should be differentiated from total fishing time since the catch should be standardized using effective fishing time. In this example, five hours were dedicated to fishing with hooks (three hooks in total), and three hours for traps (two traps in total). With regard to hook fishing, it is important to know how many hooks were used; if, for example, a total of three rods/handlines were used and each rod/handline had a tackle with three hooks, then the total number of hooks will be nine.

When more than one person participates in the fishing trip and the individual effort and/or catch of each person cannot be determined (e.g. when several people are fishing on the same boat, collectively using the same gear and the catch is pooled together), then fishing effort should reflect the cumulative effort of all participants and the total cumulative catch should be reported. During the data analysis phase, the catch and effort of the logbook owner can be estimated as the mean of the effort and the mean of the catch of all fishers participating in the fishing trip. For this reason, the number of fishers is requested.

The catch must be recorded by gear typology. A list of gear codes is recorded in Annex 2 as well as in Annex 5.a and Annex 6.a. The gear code is needed to ensure that the respondent is referring to the correct gear and to facilitate the work of the researcher in identifying the gear without errors. In the first column, the gear code must be reported (see Annexes 5.a, 5.b and 5.c), while in the column titled "Species," a valid name of the species should be written. The scientific name would be the ideal way to report a catch, but recreational fishers do not usually know the scientific name of each species. Therefore, it would be better to ask for the common name and, in case such a name is ambiguous, then it would be advised to contact the fisher and ask for an explanation. Following the example in Figure 9.b, the first species recorded is the common pandora (*Pagellus erythrinus*), one specimen has been kept (total length = 25 cm, corresponding to a weight of 0.3 kg) and one specimen has been released. In the template for released catch (see Annex 5.c) it would be important to report whether the released fish was alive, almost dead, dead or not known, when released back into the sea. For example, in Figure 9.c, in the case of the Mediterranean horse mackerel (*Trachurus mediterraneus*) under the "catch information" logbook template (see Annex 5.b), it is noted that three specimens were caught, with total lengths indicated for each one, followed by their three respective weights. In the case of the abundant catch of black gobies (*Gobius niger*) reported in Figure 9.a, it is sufficient to write the total number of fish (40) and the total weight (1.2 kg) in the "general information" logbook template (see Annex 5.a). For cephalopods, the mantle length in cm must be recorded in the "catch information" logbook template (see Annex 5.b), as in the case of the common cuttlefish recorded in Figure 9. Crustaceans must be measured for carapace length in mm. For other taxa (i.e. echinoderms), it would be sufficient to report number and total weight in the "general information" logbook template (see Annex 5.a). For further details on measuring catch, see Section "3.3.2 Catch".

Some fishers might not update their logbooks on a regular basis, which could ultimately bias the study. In this case, follow-up by the researcher would be necessary to determine why the relevant fishers did not fill out their logbook every month. Regular communication and follow-up with panel participants could help increase the proportion of completed logbooks. Another source of bias is the so-called "prestige bias", which involves fishers exaggerating catch size or numbers and providing deliberately false information to make a better impression on others. On the other hand, certain political or cultural contexts may lead fishers to understate their catch to avoid management repercussions or due to superstitions believing in bad luck derived from sharing information about the size of the catch. Both forms of bias might be reduced by emphasizing that data will be reported anonymously, that it will be combined with other means of data collection (e.g. on-site surveys), that honesty is important for the ethics of fishing and that exaggerating data might have negative consequences for the management of fish stocks (Ayal *et al.*, 2015).

It would be useful to train recreational fishers in filling out the logbooks by means of training courses (e.g. online tutorials, seminars, etc.). Within such training courses, it is important to emphasize that logbooks should be completed on a regular basis, rather than just before they are to be collected by researchers, as the latter routine might introduce recall bias and present negative consequences for fisheries management. Logbooks should be collected regularly, for instance every month, and data should be entered into a database for subsequent analysis.

FIGURE 9.a

Example of how to compile a logbook (general information)

Logbook and recall template – general information

Logbook [x] Recall [ ] Reference month and year ____________________

Name and surname of panel participant *Mario Rossi*

Information reported for:

Only the panel participant [ ]

Multiple fishers (in case the panel participant's catch is pooled with other fishers on the same trip) [x]

If multiple fishers:

No. Fishers: ♂ *2* age *45* *51*; ♀ *1* age *35*

Fishing location

Geographical subarea (GSA) *17*

City *Venice*

Distance from the coast (in nm) *3*

Total fishing time

	Start	End
Date	*13 May 19*	*13 May 19*
Hour	*06:00*	*14:00*

Fishing mode* Boat [x] Shore [ ] Underwater [ ]

Gear	Gear code	Fishing time per gear (in hours)	Number of units used per gear
Hand implements	MHI		
Harpoons	HAR		
Diving	MDV		
Diving (speargun)	MDS		
Diving (hand)	MDH		
Cast nets	FCN		
Boat seines	SV		
Beach seines	SB		
Hooks and lines (not specified)	LX	*5*	*9*
Handlines and hand-operated pole and lines	LHP	*5*	*3*
Traps (not specified)	FIX	*3*	*2*
Pots	FPO		
Gillnets and entangling nets (nei)	GEN		
Gillnets	GNS		
Trammel nets	GTR		
Longlines (not specified)	LL		
Lift nets (not specified)	LN		
Scoop nets	MSP		
Gear not known	NK		
Gear not specified	MIS		

Catches

No.	Gear code	Species	No. Retained	Weight (kg) Retained	No. Released
1	*LX LHP*	*common pandora*	*1*	*0.3*	*1*
2	*LX LHP*	*horse mackerel*	*3*	*1.1*	
3	*LX LHP*	*gilthead seabream*	*1*	*1*	*1*
4	*LX LHP*	*black goby*	*40*	*1.2*	
5	*FIX*	*cuttlefish*	*2*	*1.2*	
6					
7					
8					
9					
10					

Comments:

** Complete one logbook/recall template per fishing mode*

*** Provide a description of the fishing gear in the comments section*

FIGURE 9.b

Example of how to compile a logbook (retained species information)

Logbook and recall template – retained species information

Logbook [x] **Date** *13 May 19*	**Recall** [ ] **Reference month and year** ____________

No.	**Gear code**	**Species (retained)**	**Length***	Weight (kg)	Sex**	**Fishing mode*****		
						Boat	Shore	Under water
1	*LX LHP*	*common pandora*	*25*	*0.3*	*nd*	*x*		
2	*LX LHP*	*horse mackerel*	*25*	*0.3*	*nd*	*x*		
3	*LX LHP*	*horse mackerel*	*30*	*0.4*	*nd*	*x*		
4	*LX LHP*	*horse mackerel*	*30*	*0.4*	*nd*	*x*		
5	*LX LHP*	*gilthead seabream*	*40*	*1*	*nd*	*x*		
6	*FIX*	*cuttlefish*	*14*	*0.5*	*male*	*x*		
7	*FIX*	*cuttlefish*	*16*	*0.7*	*female*	*x*		
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

** Total length for fish (cm), mantle length for cephalopods (cm), carapace length for crustaceans (mm)*
*** If known (M: male; F: female; ND: not determined)*
**** Select only one fishing mode (boat, shore, underwater) per row*

FIGURE 9.c

Example of how to compile a logbook (released species information)

Logbook and recall template – released species information

Logbook [x] **Date** *13 May 19* **Recall** [ ] **Reference month and year** ____________

No.	Gear code	Species (released)	Length*	Post-released status**				Fishing mode***		
				Alive	Almost dead	Dead	Not known	Boat	Shore	Under water
1	*LX LHP*	*common pandora*	*12*	*x*				*x*		
2	*LX LHP*	*gilthead seabream*	*15*		*x*			*x*		
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

** Total length for fish (cm), mantle length for cephalopods (cm), carapace length for crustaceans (mm)*

*** Mark the corresponding cell*

**** Select only one fishing mode (boat, shore, underwater) per row*

Logbook surveys are also an effective way to measure economic expenditures. Once reliable economic baseline data have been established, less frequent economic data collection could be foreseen (e.g. every two to five years, rather than annually), in order to simplify data collection and to avoid overburdening respondents. Selected recreational fishers should be asked to register the money they spent to carry out their fishing activity during each fishing trip, including for fishing equipment (e.g. rods, reels, hooks, lines, swivels, spearguns, underwater accessories, traps, etc.), bait (e.g. natural or artificial bait), travel and accommodation (e.g. train, plane, car, hotels, etc.), boat expenses (e.g. charter, rental, boat ownership expenses such as fuel costs, mooring fees and taxes, boat maintenance, etc.), electronics (GPS, echo sounder, radar, etc.), license fees and other costs. In the case of underwater fishing, boat expenditures should also be included if the fishing is performed using a boat. A more detailed description of the information to be collected is recorded in Section 3.3.3, and a template for collecting this information through the logbook can be found in Annex 5.d. The monetary value to be inserted in each cell should be indicated in the local currency. To facilitate regional comparison, the survey coordinator should convert those values into a common currency, such as EUR or USD, by applying current conversion rates.

3.1.2 Recall surveys

An alternative to logbook surveys is the recall survey, which relies on contacting, via e-mail and/or telephone, selected recreational fishers and asking them to recall information about their catch, effort and expenditures over a specific timeframe. Extended timeframes (e.g. one-time surveys with a six- or 12-month recall period) can significantly overestimate total recreational fishing effort. Typically, an average catch per trip is recalled and then multiplied by the assumed number of trips. This can potentially lead to a severe overestimation of the catch, as there is a general tendency to exaggerate participation rates in recreational events (Tarrant and Manfredo, 1993; Connelly and Brown, 1995; Vaske, Huan and Beaman, 2003). This is not always the case, however, as noted in Connelly and Brown (2011); therefore, anglers and recreational fishers should, in general, be treated as a heterogeneous group (Arlinghaus, Bork and Fladung, 2008; Johnston, Arlinghaus and Dieckmann, 2010). Respondents generally prefer to recall the catch in numbers, in which case converting those numbers into weight can present issues. A specific problem with recall surveys is that the longer the timeframe over which respondents are supposed to recall, the more the results tend to be biased (Tarrant and Manfredo, 1993), so a short recall period would be preferred to minimize possible recall errors. A one- to two- month recall period is suggested as it is feasible yet not too long. At a more advanced stage in implementing recreational fisheries monitoring programmes, it could be worthwhile to contact more avid fishers more often during the peak season, although that may not be necessary in the early stages of trialing these methods in a country.

The same information is required for the recall survey and for the logbook, meaning that interviewers can use the same template as the logbook survey for catch and effort data (see Annexes 5.a, 5.b, 5.c), filling in one template per fishing trip. As is the case with the logbook, when a fisher engages in more than one fishing mode (e.g. fishing by boat, shore or underwater) in the same day, each fishing mode should be considered a separate fishing trip and therefore a separate logbook should be completed. For economic expenditures, the information to be collected is identical between the logbook and the recall survey, however, the reference period differs. The logbook (see Annex 5.d) should include all expenditures made in relation to the specific fishing trip, including any expenditures since the last fishing trip. On the other hand, the recall survey (see Annex 5.e) should collect information in relation to all expenditures made during the recall survey's reference period (e.g. the previous one to two months). In all cases, it is helpful to supply the fisher with a copy of the logbook template in advance, so that he or she may keep notes and to facilitate jogging his or her memory at the time of the recall survey interview.

Recall surveys can also be used as a complement to logbook surveys. Selected fishers who are involved in the logbook programme should be contacted on a monthly basis by telephone in order to verify the information reported in the logbook over the previous month. Logbook information requiring verification could include the fishing areas (e.g. wrong or questionable geographical coordinates, doubtful locations, etc.); the number of gear used (e.g. verifying that the number of hooks is reported rather than the number of rods, etc.); the common name of the target species (e.g. matching the correct scientific names to the species); eventual peculiar numbers or weights of catch (e.g. very high number of fishes, wrong correlation between length and weight, etc.); and other eventual anomalies observed in the logbook.

3.2 ON-SITE SURVEYS

On-site surveys entail sampling fishers by going directly into the field and interviewing them. On-site methods potentially represent a more accurate and direct approach as fishery-independent staff members follow randomized probabilistic designs to collect the data, usually soon after any fishing effort has taken place. Detection of, and correction for, any bias are also potentially more feasible given the direct and verifiable nature of the data collected. Unfortunately, on-site methods tend to be comparatively expensive and logistically onerous, thus limiting the scale at which they can be applied (Hartill, Watson and Bian, 2011). This type of survey could therefore be useful as a means of validating and integrating the data acquired through off-site surveys (e.g. logbook, recall), providing additional data on catch size and species composition. In this way, an off-site logbook or recall-based survey method could function as the primary means of estimating mean catch rates and effort, with on-site sampling conducted by trained interviewers only used to validate the self-reported off-site data. On-site surveys can therefore contribute to the detection of discrepancies between self-reported data and data measured in the field.

In some countries, such as those with limited coastlines or a limited number of access sites, it may be possible to conduct on-site surveys as the primary means of collecting fishing effort and length data directly from fishers, in view of estimating catch per unit of effort (CPUE) (see Section 3.3.1). In other countries this may not be a feasible or cost-effective option.

Whether using an on-site survey as the primary means of data collection or simply to validate off-site surveys, the main purpose of an on-site survey is to collect data on as much recreational catch as possible, for as many species as possible. Engaging recreational fisheries stakeholders through federations and associations is one way to reach a high number of fishers (see Section 5). Interviews can be carried out at harbors, beaches, ramp sites, slip ways, etc. The locations can vary, so it is important to include all specific locations with fishing participants in the sample frame. The catch data to be collected should include the species of fish, the number of fish caught of that species, the number of fish kept and the number of fish released. In addition, interviewers should attempt to obtain length and weight measurements from a random sample of the kept fish that the angler is willing to make available.

Biases may arise within the on-site survey when fishers are selected for sampling based on accessibility or convenience (e.g. by sampling only vessels that arrive in port within certain hours). This selection would not constitute a random sample of the population because the probability of selection would be unknown, thereby invalidating the interpretation of the data (Grafton *et al.*, 2006). The probabilities associated with sampling at different times of day should be controlled consulting expert knowledge of fishing patterns in different areas and seasons. See Section 3.2.1 for information on other on-site data collection methods, beyond this traditional approach.

How the interviewer introduces himself or herself to the fisher is one of the most important considerations and can frequently determine the success of the interview. It is important to establish a relationship of trust with the interviewee in order to promote honest responses. It is therefore recommended to use the following approach when introducing oneself to a potential interviewee on-site:

> *"Hello, my name is ____ and I am doing a recreational fisheries scientific research survey for _____ (institution) on behalf of _______ (e.g. Ministry of Fisheries). Can I ask you a few questions about your fishing today?"*

If the fishers wish to know the objective of the study, it should be clearly explained that the main aim of the survey is to collect information on local recreational fisheries in order to foster their sustainable management and that the anonymity of the participant is ensured.

The information listed below should be annotated during in the interview.

General information (Annex 6.a)

- Date of interview
- Whether information is being reported for a single fisher or for a group of fishers (in the case that gear/catch are pooled and it is not possible to determine one fisher's individual catch). In this latter case, the number of fishers (gender disaggregated) and their age should be reported.
- Fishing location: the location of the fishing ground should be requested. Questions can be formulated in the following manner: "Roughly, where did you fish today? Could you please estimate the distance from the coast?" It can indeed be useful to bring a map and ask fishers to indicate directly on the map where the fishing ground is located. In the event that fishers are particularly collaborative, they could be asked to provide the exact fishing location by geographic coordinates (latitude and longitude).
- Total fishing time: the time spent during the whole fishing session should be recorded. For example, in the case of a boat trip, this also includes the navigation time. The time should be clearly written in order to understand whether it refers to before (a.m.) or after (p.m.) noon. The date should be reported for both starting time and ending time of the boat trip to avoid errors for fishing sessions taking place over multiple calendar days.
- Fishing time and number of gear: for each gear used, it is necessary to ask the fishing time (how long the gear was in the water) and the number of gear (e.g. number of rods and total number of hooks).
- Number and weight of retained species, as well as the number of released species, by gear. Each species must be recorded using the local name or the scientific name (if possible). In case there are doubts about the correct identification, it is advisable to take a picture, using the timestamp on the photo to associate the pictures with the interviews. For each species, register the number of specimens and their total weight, as well as the number of released individuals.
- Fishing trips performed during the previous year – in order to roughly estimate the avidity of the fisher, the fisher should be asked to guess how many fishing trips they performed over the previous year. This can sometimes be a difficult question for a fisher to answer and it may be necessary to prompt the fisher with potential responses (e.g. "was it five, 20 or 50 times?"). This question should be asked to all fishers of the party and should refer to the fishing mode (boat, shore or underwater fishing).

- Willingness to participate in a panel survey: as it is important to collect contacts for subsequent diary/logbook or recall surveys, interviewed fishers should be asked whether they are willing to be contacted in the future. If their answer is in the affirmative, then contact information, including name and mobile phone number (preferable to a landline phone number), should be collected. This information should be requested at the end of the interview, once fish have been measured and a rapport established with the fisher.
- Comments: any comments the interviewer may have regarding the interview should be noted here. These annotations can help to understand eventual oddities that may emerge during the survey and could include, for example, the bait used or whether each fisher is listed in the national list of household telephone numbers.

Retained species information (Annex 6.b)

- Total length, weight (and sex if possible) of retained species by gear: to facilitate completing this task, it is useful to ask: "Can I please measure your fish?" If the fisher agrees, then every retained species must be measured, rounding down to the closest half cm for total length. Although useful, weight and sex are not mandatory, as weight can be estimated subsequently by means of the length/weight relationship, and it is usually required to open the belly of the fish in order to determine the sex.

Released species information (Annex 6.c)

- The length of each released specimen should be requested, as well as information on the post-release status (e.g. alive, almost dead, dead, unknown).

3.2.1 Other on-site methods

In countries where more extensive on-site data collection is considered feasible (e.g. in countries with limited coastlines), two alternative survey methods, in addition to the traditional on-site data collection approach described above, could be considered to estimate catch and effort: the bus route method and aerial-access surveys.

Bus route method

Robson and Jones (1989) developed a procedure for collecting recreational fisheries catch and effort, which is analogous to a "bus route" and allows for a limited number of interviewers to sample a high number of access sites. Instead of visiting just one or two access sites a day (the traditional approach), each interviewer makes a complete circuit of all access sites over the course of each sampling day (Jones *et al.*, 1990). The agents have a precise schedule to follow each day and they arrive and depart from each site on a predetermined timetable. Because the starting point along the circuit is chosen randomly each day, each site is visited randomly throughout the day over the survey period. This method is particularly appropriate when there are many access sites to be sampled. For example, if the study area consists of 12 access sites, it would be unreasonable to spend a full day at only one of so many access sites as each site would then be sampled infrequently over the whole survey period. With the bus route method, one interviewer (or one crew of interviewers) covers all 12 sites within a single day. Following a traditional approach, the same number of interviewers would visit only one to two sites per day.

Aerial-access surveys

The use of observers in aircraft flying at low altitudes (150 to 300 m, depending on the minimum-permissible altitude under civil aviation regulations) offers an additional means of counting recreational fisheries vessels or fishers from the shore. There are two forms of aerial-access design: the random-count design (described by Pollock, Jones and Brown, 1994 and used by English, Shardlow and Webb, 1986; English, Searing and Nagtegaal, 2002; Coutin, Conron and MacDonald, 1995; and Soupir *et al.*, 2006) and the less commonly reported maximum-count design (Parker, 1956; Dauk, 2000; Dauk and Schwarz, 2001; Lockwood, Peck and Oelfke, 2001).

The random-count design divides the day into two or more time bins, and flights are scheduled to take place at a random time within one or more diurnal strata on each survey day. The estimated number of hours fished in a given time bin is defined as the product of the number of hours occurring within that time bin and the aerial count. This estimate is then multiplied by a catch rate estimate for the same period to provide a catch estimate for this time interval (Hartill, Watson and Bian, 2011). Flights can be scheduled to take place during all time bins within a day, and the estimates of catch and effort obtained for each time bin can then be summed to provide total estimates for that day. Estimates from a random subsample of available days can then be averaged and generalized to provide catch end effort estimates for a larger temporal stratum, such as an entire summer season. Alternatively, time bins can be randomly sampled at a lower intensity across all survey days over a larger temporal stratum. Care must be taken, however, to ensure that at least one time bin is selected from each survey day and that sufficient replicates are sampled for each time bin across all surveyed days. Regardless of which random-count design is used, the high number of flights required to adequately estimate the total level of effort occurring on a sample day and across all sample days is potentially prohibitive, yet unavoidable, as these flights offer the sole means of estimating levels of effort when this design is used (Hartill, Watson and Bian, 2011).

Maximum-count aerial-access designs, such as that described in Hartill, Watson and Bian (2011), represent a more cost-effective option as only a single flight is required per survey day. A count of fishing vessels made during this flight is used in conjunction with creel survey data to describe the distribution of effort throughout the day. The substantial reduction in flight costs is offset to some extent by the need to station creel survey clerks at selected access points throughout the day. Nevertheless, results from this study (Hartill, Watson and Bian, 2011) suggest that catch rates vary throughout the day, and the best means of correctly accounting for these changes is to interview fishers throughout the day. The same study showed that it would be preferable to combine aerial count and fisher interview data together at the level of the primary sampling unit, i.e. the day. Estimates of total effort and catch were calculated for each randomly selected survey day and then averaged over their respective temporal strata. Hartill, Watson and Bian (2011) observed that the advantages of linking data from the aerial survey and fisher interviews on each survey day to estimate levels of effort are twofold: i) fewer flights are required to assess levels of effort, which can significantly reduce aircraft operating costs; and ii) a defined relationship between these two data sources can be used to estimate levels of effort on those days when flights are cancelled, which is a common problem with aerial-access surveys.

Both the above-mentioned forms of aerial-access surveys are rather high-cost data collection methods. With rapid advances and decreasing prices, however, in the field of remotely piloted aircraft systems (RPAS) – colloquially known as drones – researchers have access to a potentially innovative and cost-effective tool for implementing this kind of survey. In addition to improved cost-efficiency over existing techniques and the potential for highly replicable flight routes and for accessing remote or inaccessible locations, RPAS also boast the added advantage of being able to produce high-resolution mapping and capture footage beyond the visible spectrum, as well as providing non-invasive survey techniques for marine fauna. However, this technology is hindered by several important limitations, including range, logistical considerations when operating over water, regulatory requirements and battery life (Desfosses *et al.*, 2019). Furthermore, it must be noted that only limited studies have evaluated the suitability of RPAS as a recreational fisheries data collection tool to date (Desfosses *et al.*, 2019). While these tools offer a number of potential benefits, it is important that they be adequately evaluated in order to provide researchers with a more complete understanding of the potential biases they may introduce (Beckmann *et al.*, 2019) and their eventual suitability for the sustainable management of marine living resources (Desfosses *et al.*, 2019).

3.3 TYPE OF INFORMATION TO BE COLLECTED

Independent of the chosen survey method (logbook, recall or on-site), in order to define the relationship between the sample and the statistical universe, it is necessary to collect basic personal data, such as gender, age and residence. Place of residence is required to spatially allocate the fisher within the sampled population. For off-site surveys (logbook and recall) it is also recommended to collect names and the mobile phone numbers. Other personal information is not relevant for the specific aims of this study (e.g. profession, education), unless the study has specific socio-economic objectives.

3.3.1 Fishing effort

Fishing effort is a measure of the fishing activity deployed by a certain fishing segment and can be useful to calculate CPUE, which is needed to analyse changes in catch quantities. This information is crucial for developing multiannual management plans.

Fishing effort can be calculated through a combination of inputs related to capacity, gear and time.

In particular, it is useful to collect the following data:

- Number of fishing trips: the number of fishing trips conducted during the interview period. A fishing trip is defined as a single fishing session, either performed from the shore, from a boat or underwater (i.e. starting from the shore or from a boat).
- Total fishing time (hours): the total duration (in hours) of a fishing trip (including navigation in the case of boat fishing).
- Fishing time (hours): the number of hours using a specific gear (e.g. for set nets, longlines and traps, the time from setting to pulling in; for hooks and spearguns, the fishing time, etc.).
- Number of gear used: the number of nets (e.g. scoop net, cast net, beach seine, etc.). This also refers to the number of panels for gillnets (or length of total set nets used), the number of hooks used with rods or handlines and the number of traps.

Guidance on how to measure fishing effort by fishing gear is provided in Annex 7.

3.3.2 Catch data

The objective of collecting catch data is to monitor and investigate the population dynamics of the most important species in the area of study. Knowledge of the biomass (by species) removed from the ecosystem by fishing operations is fundamental to monitoring the status of stocks, as well as the impact of fishing on fish populations, gear selectivity and catch at age.

In particular, it is useful to collect the following data:

- Species caught: identify the valid common name in order to define the scientific name of each species caught.
- Number of specimens kept: the number of specimens caught and retained by species (including all taxa, such as molluscs, crustaceans, echinoderms, etc.).

- Number of specimens released and their post-release status: the number of specimens caught and released by species (including all taxa, such as molluscs, crustaceans, echinoderms, etc.).
- Status of specimens after release: i) "alive" – strong body movements and none or only minor injuries; ii) "almost dead" – weak body movements and major injuries; iii) "dead"; and iv) "not known" – when the status was not observed.
- Length (cm): length measurements are easy to make but require a well-defined and standardized notation to allow for comparison of results. The length measurements to be made depend on the group of species under study. The lengths of fish and cephalopods should be generally measured, whenever possible, with graduated fish measuring instruments, called ichthyometers, while calipers are used for crustaceans (see below).
- Weight (kg): the weight of each single individual. If it is not possible to collect this information, it is possible to convert length into weight by consulting the length-weight relationship.
- Sex: determining the sex of caught individuals ranges from easy to extremely difficult. For most fish, it would be necessary to open its belly and check the gonads, and this operation should be authorized by the recreational fisher. Macroscopic observations can distinguish four sex categories: male (M); female (F); undetermined (U) – when, after dissection, it was not possible to determine the species' sex with the naked eye; and not determined (ND) – for individuals that have not been examined. For some fish taxa (e.g. some gobies, elasmobranchs, etc.), it is possible to determine the sex by observing some external morphological features (e.g. fins, claspers, etc.).

Data on catch can be combined with effort data to estimate the CPUE, which is a relative measure of fish stock abundance. Catch per unit effort can be used to estimate absolute abundance and could be an indicator of fishing efficiency (GFCM, 2018). In its basic form, the CPUE could be expressed as the captured biomass per each unit of effort applied to a species/stock (e.g. total catch of a species divided by the total fishing: kg/number of fish per longline hook days, or numbers retained or caught per trip). Declining trends of this estimator could indicate overexploitation, while steady values could indicate sustainable fishing.

Further consideration must also be made for the role of catch-and-release – when fish are unhooked or set free from a trap or net and returned to the water alive – as a considerable portion of fish caught by recreational fisheries can be released (Ferter *et al.*, 2013). The rates of released specimens, including species- and fishery-specific catch-and-release mortality rates, are unknown for most recreational hook fisheries, and therefore there is a need to estimate these mortality rates for use in stock assessments. A mixture of desk-based study and experimental work is required to compile data on the mortality of hook-and-line-caught fish and to bolster the evidence base in order to account for survival. Such studies should consist of reviewing existing literature, assessing the potential for extrapolation between species and fisheries, setting up generic mortality profiles, and conducting species-specific mortality studies to fill existing data gaps (ICES, 2014). This information is lacking for most target species in the Mediterranean and the Black Sea and, until such information becomes available, a precautionary approach could be adopted, assuming a survival rate of zero for those released species with no survival estimate.

How to measure fish, crustaceans and cephalopods

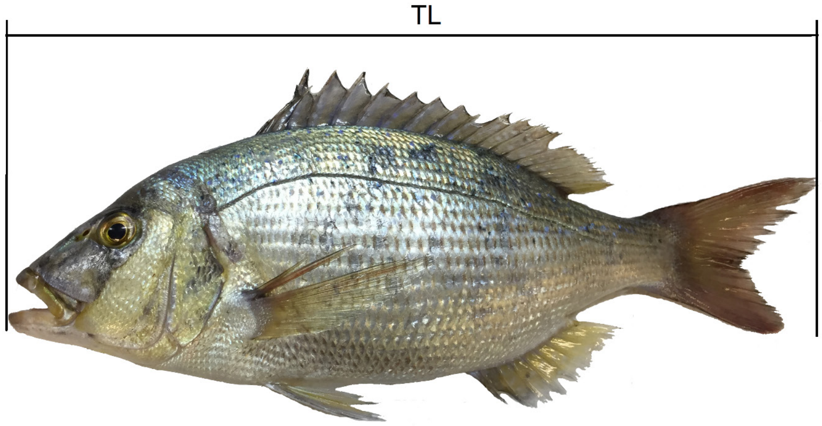
Bony fish and elasmobranchs: for bony fish, sharks, skates and rays, the length should be considered as the total length. The fish is measured, rounding down to the closest half cm, from the tip of the snout to the end of the caudal fin (Plate 1).

The length classes should be reported in cm (as a whole number, or half cm, e.g. 0.5, 1.0, 1.5 etc.).

Crustaceans: for crustaceans (lobsters, crawfish, shrimps, prawns, stomatopods), the standard measurement is the minimum carapace length. The length classes should be reported in mm (as a whole number, e.g. 1, 2, 3, 4 etc.). The crustacean is measured, rounding down to the nearest mm, from the back border of the eye orbit (inside of the eye socket) to the posterior margin of the carapace (Plate 2). All measurements are taken with calipers.

PLATE 1

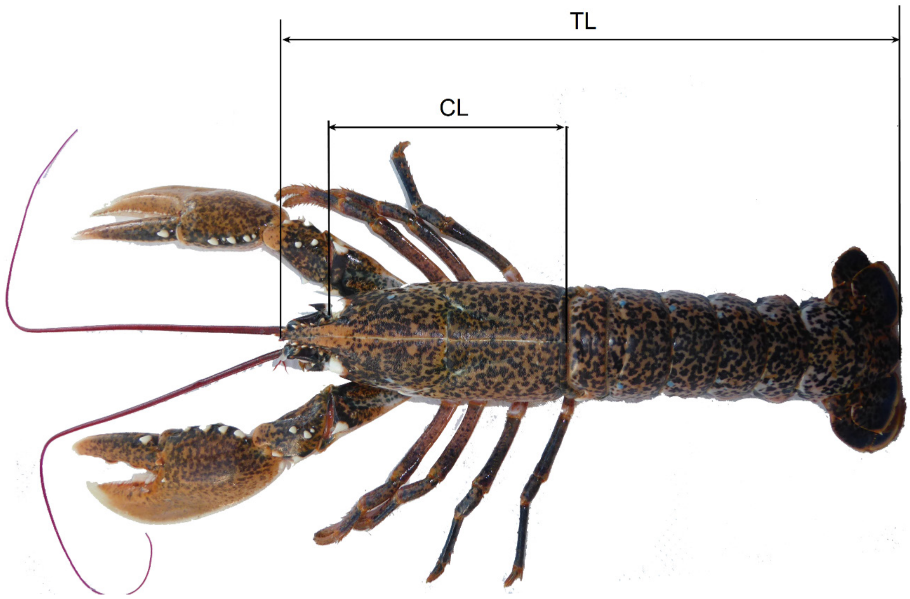
Measurement of total length in bony fish



Common dentex (*Dentex dentex*) © A. Lucchetti

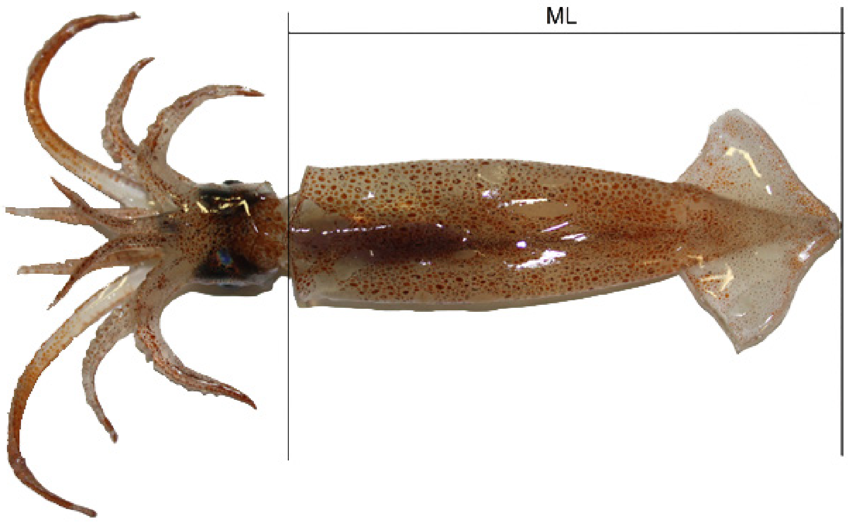
PLATE 2

Measurement of total length and carapace length in crustacean's decapoda



European lobster (*Homarus gammarus*) © A. Lucchetti

PLATE 3
Measurement of dorsal mantle length in cephalopods



Broadtail shortfin squid (*Illex coindetii*) © A. Lucchetti

Cephalopods: for cephalopods, the length is defined as the dorsal mantle length. The length classes should be reported in cm. The cephalopod is measured rounding down to the nearest half cm. The size should be reported in cm (as a whole number, or half cm, e.g. 0.5, 1.0, 1.5 etc.). For decapoda, measurement is made along the dorsal midline from the mantle margin to the posterior tip of the body, excluding long tails (Plate 3).

3.3.3 Economic data

Although recreational fisheries do not generate a direct commercial output, it has been shown that these fisheries generate significant economic value, through, for example, their contribution to the tourism sector (Gaudin and De Young, 2007). For this reason, the assessment of the economic impact of this sector is essential and economic data are an important component of any recreational fisheries data collection programme. Considering that recreational fisheries are, by definition, non-commercial, meaning that it is prohibited to sell or trade the catch obtained, non-market valuation techniques must therefore be applied. While both revealed and stated preference methods can be used to assess the value of recreational fisheries, revealed preference methods, such as the travel cost method and the hedonic pricing method, are most commonly used. These methods assess expenditures made as a proxy for economic value. Data on the costs recreational fishers incur help to explain their behavior and are useful in understanding the wider economic impact of this fishing activity. A simple method for calculating recreational fisheries expenditures is through a logbook or recall survey, by asking recreational fishers to report or recall the expenses incurred to carry out their leisure activity over the reference period. In the case of a logbook, fishers should include all expenditures in relation to the current fishing trip, as well as any expenditures made since their last fishing trip (e.g. purchase of a new rod, etc.). In the case of a recall survey, all expenditures within the recall period should be reported. Templates are provided in Annex 5.d, for logbooks, and Annex 5.e, for recall surveys. A description of the variables to be collected for which expenditures should be calculated is listed below:

- Equipment: the costs incurred for the purchase of equipment. For shore fishing and boat fishing, these may include the purchase of rods, hooks, reels, cast nets, etc., whereas for underwater fishing, these may include the purchase of a speargun, fins, mask, wetsuit, etc.
- Bait: the expenditures for both artificial baits (jigs, lures, spinner baits, etc.) and natural baits (worms, sardines, anchovies, shrimps, etc.).
- Travel and accommodation: the travel costs to/from the fishing site. These may include the costs of staying in a hotel (for the days spent fishing), roundtrip expenses to/from the fishing site, such as train or airplane tickets or expenses for travel by car (fuel costs, highway and parking fees, rental car expenses, etc.).
- Fishing license fees: it should be indicated whether the license is an annual, semi-annual, quarterly, monthly, weekly or daily license.
- Boat expenses: these may include, the purchase of a boat, boat rental or charter fishing fees, fuel costs (including two strokes lubrication oil), boat taxes (mooring, ramp, etc.), boat maintenance costs (engine maintenance, antifouling, etc.), as well as electronics (echo sounder, GPS, radar, etc.).

4. Data analysis

4.1 DATA QUALITY CHECK

Once data have been collected, they should be analysed and generalized to describe the total population. Before these actions can be completed, however, a critical step is to carry out a data quality check and the necessary data treatments. The accuracy of a survey estimate refers to the proximity of the estimate to the true population value and the difference between the two is referred to as the error of the survey estimate. This latter value is a fundamental component in the following steps for making estimates. Unfortunately, in practice, a true measure of sampling error can never be obtained, only an estimate (Pinello, Gee and Dimech, 2017).

Sampling errors refer to those errors encountered in the estimate of a particular parameter of the universe resulting from the fact that not all of the population, but only a subset (the sample), is the object of observation.

Non-sampling errors can be defined simply as all other errors in the estimate arising during the course of any survey activities other than sampling (e.g. the way you run the survey). Unlike sampling errors, they can be present in both sample surveys and censuses and are extremely difficult, if not impossible, to measure mathematically. With this in mind, both survey designers and data quality evaluators must ensure that non-sampling error is avoided to as great an extent as possible, or at least either randomly distributed in order to eliminate its effect on the calculation of population estimates or brought under statistical control.

The most common non-sampling errors result from poor coverage and selection bias, low response rates, non-responses, interviewer errors and data entry errors. Non-sampling errors are systematic errors, which tend to accumulate over the course of the entire survey and these types of errors often lead to a bias in final results. While sampling errors decline with an increase in sample size (disappearing completely for censuses), the same is generally not true for non-sampling errors.

It is worth noting that, even for well-designed and well-implemented surveys, non-response represents a serious threat to the validity of estimates. It is fundamental to ensure that non-respondents do not belong to a specific segment of the target population, thereby limiting the validity of the inferences. This point is of utmost importance and non-responses must be investigated to ensure that they have the same characteristics as respondents. The likely reason for each non-response should be recorded for each non-respondent, so that appropriate weighting and calibration methods are applied to correct for non-response.

Prior to producing estimates for end-users, a certain amount of data checking and monitoring must be performed to confirm the completeness and quality of primary data (FAO, 2002). Such control functions involve:

- Monitoring: providing summary lists and reports offering quick indications as to the availability of samples on boat activities and catch in each estimation context.
- Data range check: providing lists that record “extreme” values (the range of values) for catch, sample effort and prices. Values that appear too high or too low should be verified.
- Sample size check: providing lists showing expected sample size and accuracy level for boat activities and landings.

To guarantee quality assurance of recreational catch estimates from national surveys and to document bias in data collection, the Working Group on Recreational Fisheries Surveys of the International Council for the Exploration of the Sea (ICES) has developed a quality assurance toolkit for evaluation (ICES, 2013). The aim of this evaluation is to provide statements of quality of recreational data for end-users, including stock assessment scientists, and to identify potential improvements to survey design. The quality assurance toolkit consists of three modules – sampling designs, implementation and data analysis – with the objective of minimizing bias and supporting an accurate estimate of precision, in order to make the most efficient use of sampling resources.

4.2 RESPONSE AND COMPLETION RATES

Among the most important rates is the so-called "response rate". When data are collected through a nationwide screening survey, the first step of data analysis is to identify the fraction of recreational fishers out of the total population who responded to the survey. The percentage of this active fraction is defined as the response rate (Arlinghaus, Tillner and Bork, 2014; Hyder *et al.*, 2017b). For self-administered surveys, like mail surveys, a response rate can be calculated by dividing the number of fishers who took part in the survey by the total number of fishers contacted. The rate can then be converted to a percentage, by multiplying it by 100. For example, when 200 persons answer a telephone survey out of a sample of 1 000 individuals, the response rate is 0.2 (i.e. 20 percent). The response rate can likely be increased by sending out multiple reminders, especially if units are surveyed through self-administered questionnaires. In this case, it is important to record the rates for each wave of reminders, to obtain a more nuanced overview of the survey effectiveness. For example, a survey could have a 0.8 response rate in the first wave, a 0.6 rate in the second wave (following the first reminder), a 0.3 rate in the third wave (following the second reminder), and so on. Response rates generally decrease over time, wave after wave, and reminders might draw on a considerable proportion of the budget. It is highly recommended to account for reminders when planning the financial resources for a survey.

When the response rate is below one, a certain amount of non-response has occurred. Non-response can be easily imagined, in self-administered questionnaires, as fishers who received a questionnaire and never sent it back. Non-response can represent a severe bias affecting estimates. Accounting for non-response is complex and can be achieved through one of four available approaches (Fox, Negrete-Yankelevich and Sosa, eds., 2015):

- Resampling: it addresses non-response by replacing non-respondents with a corresponding number of randomly re-sampled units. In stratified random sampling, replacements are taken from the same strata as the missing observations.
- Data imputation: it is based on model fitting and "fills" missing observations with predicted data from a model, but only when observations are missing completely at random, which is rarely the case in practice.
- Calibration: it incorporates information from auxiliary variables associated with non-response into estimators.
- Weighting: it assigns varying importance to collected observations on the basis of the proportion of non-respondents in the sample. Weighting is particularly common in survey studies (Vaske, 2008) and merits a short explanation. For example, a self-administered mail survey of 1 000 households, asking about the presence of recreational fishers in the household and collecting data about seasonal catch, could have a response rate of only 30 percent and find that 80 percent of households contain at least one recreational fisher. In this

case, a non-response check should be carried out by knocking at the door of 90 percent of non-respondents: in this non-response check, only 40 percent of households host recreationists. This finding suggests that the likelihood of answering the questionnaire was linked to the presence of recreational fishers in the household, as they were interested in the survey and motivated to respond. For example, a previous census revealed that only 50 percent of households contain recreational fishers. So, the sample probably includes too many households containing recreationists. Observations might therefore be weighted on the basis of pre-existing information on the statistical population. Weights can be expressed as:

weight = population percentage / sample percentage

In this case, the catch from households containing fishers would be weighted by a factor of 0.63 (0.5 / 0.8 = 0.63), while the catch from households which do not contain fishers would be weighted by a factor of 2.5 (0.5 / 0.2 = 2.5). The potential of weighting the data to adjust for non-response makes clear the importance of non-response checks, to appreciate differences between respondents and non-respondents. It is important that strata that are represented and under-represented are identified carefully, just as when weighting observations: weighting for strata that are not relevant will further bias findings. Moreover, researchers are encouraged to pay attention to the quality and the sample size of non-response checks.

Another fundamental rate is the completion rate. In most quantitative surveys, respondents answer structured questionnaires, each containing a fixed number of questions. The completion rate represents the proportion of respondents who answered each question and can also be calculated as a geometric mean for all the questions in the survey. Low completion rates usually indicate that a questionnaire is too cognitively demanding for respondents, that perceived privacy protection is low or that the reporting burden is too high on the fishers. Piloting might provide researchers with valuable insights, which can contribute to increasing completion rates. The completion rate should be calculated for each question as the fraction of the total number of questionnaires administered in which the question was answered. In addition, multiple completion rates can be averaged by calculating their geometric mean, which summarizes the overall extent to which questionnaires were completed.

For example, a questionnaire could be designed to measure three common forms of non-compliance affecting recreational fisheries, each of a different sensitivity level and with different potential sanctions: throwing away leftover fishing lines into the sea (low sanctions), catching undersized fish (medium sanctions) and fishing within a commercial harbour, which is often forbidden for safety reasons but is also quite common (high sanctions). In the case of this example, from over 1 000 questionnaires collected, not surprisingly, it is discovered that 896 respondents answered the first question, 451 answered the second question and only 86 respondents answered the third question. Completion rates for the three questions are, respectively, 0.89, 0.45 and 0.09.

$$Geometric\ mean = \sqrt[n]{X_1 * X_2 * \ldots * X_n}$$

In this case, the average completion rate is 0.32. Of course, completion rates are usually equal to 1.0 when surveys do not include self-reported information but instead simply measure certain traits of the observational units. In a field survey where technicians count fishing boats, there is no such thing as a response rate. Response rate is a common issue in self-administered surveys, like mail, online or telephone surveys.

4.3 MEASURING CENTRAL TENDENCY AND DATA DISPERSION WITHIN A SAMPLE

Once data have been collected, it is fundamental to characterize the sample in terms of its centrality measures and in terms of its variability.

Centrality measures provide values around which observations are organized. The most well-known measure is the arithmetic mean, defined as the sum of all measurements divided by the number of observations in the data set:

$$\overline{x_a} = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i$$

The arithmetic mean can also be calculated for a quantitative character *x*, divided into *K* classes, as:

$$\bar{x_a} = \frac{1}{n} \cdot \sum_{j=1}^{K} c_j \cdot n_j$$

where *K* is the number of classes in the frequency distribution, c_j is the central value of each class and *n* is the absolute frequency of the character in the class. This procedure correctly estimates the mean if each class's central value corresponds to the mean of that class's values. This situation occurs when the character is equally distributed among classes.

In case it is desirable to assign different weights to the various observations, it is possible to compute the weighted arithmetic mean:

In this case, x_i represents values of the character within each class and p_i the weights to be assigned to each class. For example, three groups of fishers that might buy fishing licenses to go fishing around a protected area are surveyed: exclusive recreational shore anglers (n = 1 200), exclusive recreational spearfishers (n = 500) and exclusive boat anglers (n = 100). Each of these three groups pays a different fee for a seasonal fishing license: EUR 20, EUR 50 and EUR 100 respectively. If the goal is to estimate average expenditures, the different sizes of the various classes must be taken into account: (EUR 20 × 1 200 + EUR 50 × 500 + EUR 100 × 100) / (1 200 + 500 + 100) = EUR 32.7.

Two alternative measures of central tendency are:

- the mode, the value of the distribution which appears with the highest frequency; and
- the median, the middle value that splits the distribution of the measurements into two equal halves.

It is worth noticing that the median and the mode are the only measures of central tendency that can be used for ordered variables, where values are ranked relative to each other but not measured absolutely.

For a series of quantitative measures, with an uneven number of elements, the median can be calculated as $(n + 1) / 2$, where n is the number of observations. On the other hand, the median for a series with an even number of elements can be calculated as the semi-sum of the two central units, $n/2$ and $(n + 1) / 2$. The median is far more robust than the arithmetic mean against extreme values. If the sample of recreational fishers is highly heterogeneous, with few respondents boasting extremely high/low catch, using the median will provide a more accurate measure of the data centrality, compared to the arithmetic mean.

$$\bar{x_a} = \frac{\sum_{i=1}^{n} x_i \cdot p_i}{\sum_{i=1}^{n} p_i}$$

Variability indexes, on the other hand, represent the tendency of observational units to take different values of the same measure. Typically, variability indexes have two characteristics:

- their minimum value occurs when all observations have the same value of a certain measure; and
- they increase with higher diversity of observations in the sample.

The most common indexes are based on differences between values for observational units and their respective arithmetic means. The variance, for example, can be expressed as the average squared difference between units and the mean:

$$Variance = \frac{1}{n} \cdot \sum_{i=1}^{n} (x_i - \bar{x})^2$$

The variance is always positive, and it can be converted to the original scale, by a square root. This procedure generates another measure of variability: the standard deviation. As it is obtained through a square root, the standard deviation can be both positive and negative: if a sample of seasonal fish catch has a standard deviation of 40 kg, this means that measured fish catch are distributed within 40 kg above or below the arithmetic mean. Sharing the same measurement scale as the mean, standard deviation is usually preferred to the variance. It is possible to measure the variability of observations in terms of percentage, through the coefficient of variation (CV):

$$CV = \frac{Standard\ deviation}{Arithmetic\ mean} \cdot 100$$

The coefficient of variation represents the ratio of the standard deviation to the mean, and it is useful for comparing the degree of variation between two or more distributions, even if their means are drastically different from one another. For example, if a distribution has a coefficient of variation of 37.3 and another distribution has a coefficient of 61.3, the second distribution is more heterogeneous than the first one.

It is a common feature of recreational catch that a select few people catch most of the fish while others catch no fish at all, and consequently catch distributions are generally skewed highly positive. The sampling distribution of mean catch rate estimated from such a distribution becomes more normal with increasing sample size, and when the sample size is large enough, the standard error can be used to define the confidence interval around the estimated parameter. However, in many surveys, sample sizes are too small for normality to be assumed. In these situations, the bootstrapping technique provides an appropriate alternative to parametric methods (Efron and Tibshirani, 1993). The basic idea of bootstrapping is that inferences about a population from sample data can be modelled by resampling the sample data and performing inferences about a sample from resampled data. As the population is unknown, the true error in a sample statistic against its population value is unknown. In bootstrap-resamples, the population is in fact the sample, and this is known; hence the quality of inference of the "true" sample from resampled data is measurable. A comparison of bootstrapping methods for calculating confidence intervals on catch estimates from recreational fisheries surveys is explained in further detail in Hoyle and Cameron (2003).

4.4 ESTIMATORS: ESTIMATING POPULATION MEAN, TOTALS AND VARIANCE

For most applications, researchers and practitioners need to make minimal adjustments to proceed with the information obtained from their samples. Two routine operations that are performed in every form of survey research are the estimation of participation rates, which should always be reported, and the use of raising factors in order to shift from sample totals to population totals. Calculating these two forms of information is straightforward and does not pose any particular problem to practitioners and researchers.

4.4.1 Simple estimations

Participation rate

In case the data source comes from a nationwide screening survey, the first step of data analysis is to identify the fraction of recreational fishers from the total population. The percentage of the active fraction is called participation rate (Arlinghaus, Tillner and Bork, 2014; Hyder *et al.*, 2017b). The participation rate is calculated by dividing the number of active recreational fishers by the total number of people constituting the population, then multiplying the resulting quotient by 100 to get the percentage.

Example: if by means of a telephone survey, 1 000 people are randomly contacted and it is obtained that 200 of them perform marine recreational fishing, then the participation rate is 20 percent.

Raising factor

The raising factor is the factor by which the numbers in the sample have to be multiplied to give the total numbers in the population sampled (FAO, 1966). This is a vital step in combining and analysing sample data.

Example: assume that n catch units (or fishing effort) are sampled randomly from N made by a segment/stratum (e.g. boat fishing) during a quarter of a year, and total numbers of fish (or fishing days) is denoted by y. The mean number (or mean weight) per trip is:

$$\bar{y} = \frac{\sum y}{n}$$

and the estimated total caught number (or weight) Y for the segment/stratum is:

$$Y = \bar{y}N$$

The raising factor is thus:

$$\frac{N}{n}$$

This approach could be used also for raising length frequency distribution of catches (ICCAT, 2016).

4.4.2 In-depth estimations

For most types of data collection procedures, such as non-probabilistic sampling, working with sample statistics is enough: they are easy to calculate and highly informative about the data at hand. However, for making rigorous inference from probabilistic sampling, considering information in the sample is not enough, for two reasons.

First, a practitioner or researcher needs to understand if, and how, collected information must be treated, accounting for those units that were not observed. While sample means may coincide with population means in simple random sampling, this does not hold for other forms of sampling designs.

Moreover, measuring the uncertainty associated with a certain estimate presents another daunting task: this calculation differs among different sampling designs.

A complete overview of statistical estimators is needed to address these two issues. The following section is more technically demanding than the previous one and briefly introduces how statistical estimators can be constructed. This text refers to a design-based paradigm, which is covered in detail in Hankin, Mohr and Newman (2019). Complete understanding of this paradigm is not necessary if using non-probabilistic sampling or if simply aiming to measure means and totals in simple random sampling.

This short section introduces statistical estimation of population parameters, following design-based inference. It serves three purposes: first, it shows how it is possible to move from sample statistics to population-level estimates; second, it explains the properties characterizing good estimation; and finally, it explains why estimates always come with uncertainty. Until now, it has always been explained how to calculate population measures, such as the mean, without focusing on their accuracy. Well-designed random sampling, such as simple random sampling, enables one to do this: the mean of the sample corresponds to the population mean. However, this approach ignores the fact that when moving from samples to populations, estimates are also characterized by uncertainty. Ignoring uncertainty is dangerous and it is encouraged to better understand estimators, to better interpret information at hand.

An estimator is a statistic used to estimate a population parameter and incorporated in a formula that can be applied to sample data to generate a numerical estimate of a chosen population parameter. For example, estimating the average seasonal catch of a certain fish species by recreational fishers in a certain area is based on the arithmetic mean, which is then calculated over the sample:

$$M\hat{e}an = \sum_{i \in S} y_i / n$$

However, it is important to note that population mean is an estimated value. It is different from sample mean, which comes with no uncertainty, because its calculation is exclusively based on observed data only. Estimated population mean is uncertain, because its value depends on *S*, which is the overall sample space containing all the samples that can be extracted. Given a realized sample selection $S = s$, the population mean will be calculated as:

$$M\hat{e}an = \sum_{i \in s} y_i / n$$

Therefore, it will be calculated using the sample *s* and *y* values of its units. While *y* values are fixed, the population mean is a random variable, because several different samples could be extracted from the target population. If different recreational fishers are sampled and their average catches are calculated, these will differ slightly: estimators account for this variability. The probability distribution of the estimator, as a random variable, is the distribution generated by all the possible samples that could be extracted, the sampling distribution. The sampling distribution of the population parameter is essential to assessing the performance of a certain estimator in estimating a population parameter.

The sampling distribution of an estimator depends on, at least, three elements: the distribution of the population variable, the sampling design and the estimator itself. Just as the location and spread of the distribution of the observed values can be characterized, they can also be characterized for a sampling distribution, in terms of expectation and sampling variance. Expectation is a measure of the average value of the

$$Bias = Expected\ value\ of\ the\ estimator - Real\ value\ of\ the\ population\ parameter$$

estimator, and variance is inversely related to its precision: the higher the variance, the lower the precision of the estimate. A good estimator has a low, or nonexistent, bias:

Bias is the difference between the expected value of the estimator and the real value of the population parameter: if bias is zero, the estimator is unbiased, and its expected value is centered on the real value of the population parameter. This does not mean that the estimation will be precise, but rather that its distribution will always be sampled on the real value which it is attempting to estimate. For example, in a simple random sampling survey estimating average seasonal catch from recreational fishers, the estimator is unbiased if its distribution has an expected value centered on the real average catch of fish that all the recreational fishers in the study area attain. This may seem like an obvious concept, but it is not: only few statistical designs guarantee unbiased estimates and an analytical, not approximated, estimation of the variance.

$$MSE = Variance + (Bias)^2$$

Another important metric is the mean squared error (MSE), which corresponds to:

The mean squared error is a sum of the variance and the squared value of the bias and it provides an overall measure of estimator precision. It is possible to calculate the standard error (SE) and the coefficient of variation (CV) of the estimator:

$$SE = \sqrt{Variance\ of\ the\ estimator}$$

$$CV = Standard\ error / Expected\ value$$

Finally, because of the central limit theorem, which states that the distribution of a sample mean converges to a Gaussian distribution when $n \to \infty$, regardless of the shape of the sampled distribution, it is possible to compute confidence intervals for the estimator. It is important to note that it is not always possible to obtain an exact expression of the variance of an estimator; in many situations, variance can only be approximated with the Delta method, based on Taylor series.

For simple random sampling without replacement, where n observations are extracted from a population of N units, estimating sample mean (μ, e.g. the average seasonal catch of a certain species among anglers), proportion (π, e.g. the proportion of recreational fishers among the inhabitants in a certain area, for y_i which is 1 or 0) and total (τ, e.g. the total number of recreationists which fish in a certain area) is straightforward through the use of mean per unit estimators (mpu):

From population mean $\mu = \frac{\sum_{i=1}^{N} y_i}{N}$ sample mean is estimated as: $\hat{\mu} = \frac{\sum_{i=1}^{N} y_i}{N}$

From population proportion $\pi = \frac{\sum_{i=1}^{N} y_i}{N}$ sample proportion is estimated as:

$$\pi_{\hat{mpu}} = \frac{\sum_{i \in S} y_i}{n}$$

From population total $\tau = \sum_{i=1}^{N} y_i = N\mu$ sample total is estimated as:

$$\tau_{\hat{mpu}} = N \cdot \sum_{i \in S} y_i / n = N\mu_{\hat{mpu}}$$

Similarly, it is possible to estimate the sampling variance for the averages (μ), proportions (π) and totals (τ). In this case, the parameter of interest will be denoted as θ:

$$V_{\mu_{\hat{mpu}}} = V_{\pi_{\hat{mpu}}} = \frac{(1-f) \cdot \sigma^{\hat{2}}_{mpu}}{n}$$

or

$$V_{\tau_{\hat{mpu}}} = N^2 \cdot \hat{V} \cdot \left(\mu_{mpu}\right)$$

where f is the sampling fraction, the fraction of the N units that appear in the sample of size n.

$$\sigma^{\hat{2}}_{mpu} = \frac{\sum_{i \in S}\left(y_i - \mu_{\hat{mpu}}\right)^2}{n-1}$$

When using stratified random sampling, the situation is slightly more complex. Units are divided into L strata of size N_h, $h=1, 2, \dots, L$, such that the sum of their observations equals N, the size of the population. Samples are selected independently from each of the L strata, usually through simple random sampling. With any particular stratum, it is possible to obtain unbiased estimates of means, proportions and totals. Moreover, by using properly weighted stratified estimators it is also possible to obtain unbiased estimates of the overall parameters, across strata. The main advantage of stratified random sampling lies in its capacity to significantly reduce the variance of estimated parameters, compared to simple random sampling. However, if strata are not correctly identified, estimation will be biased. In the next few lines there will be references to stratified estimators of a population parameter, denoted by the lowercase "*st*" (e.g. μ_{st}) and combining information from multiple strata, and to stratum-specific estimators, denoted by the lowercase "*h*" (e.g. μ_h).

The overall population mean (μ) can be expressed as:

$$\mu = \sum_{h=1}^{L} W_h \cdot \mu_h$$

It corresponds to the weighted average of the stratum means, weighted on the basis of the stratum weights, the fraction of the total number of units which are contained in a certain stratum ($W_h = N_h/N$). Then the stratified estimator of the population mean is:

$$\hat{\mu}_{st} = \sum_{h=1}^{L} W_h \cdot \hat{\mu}_h$$

Individual stratum means are estimated using the mean-per-unit estimator, obtained from Sh which is a random set of sample units selected from stratum h.

$$\hat{\mu}_{st} = \sum_{j \in Sh} y_{hj}/n_h$$

For simple random sampling within strata, the expected value of the mean for each stratum (μ_h) corresponds to the mean of sampled variables in the stratum (μ):

$$E(\hat{\mu}_h) = \mu_h$$

Therefore, the expected value of the overall mean (μ_{st}) is also unbiased:

$$\hat{\mu}_{st} = \sum_{j \in Sh} y_{hj}/n_h$$

The stratified estimator of the variance of the mean is:

$$V(\hat{\mu}_{st}) = \sum_{h=1}^{L} W_h^2 \, V(\hat{\mu}_h)$$

And considering that the stratum-specific estimator of the variance of the mean is:

$$V(\hat{\mu}_h) = \left(\frac{N_h - n_h}{N_h}\right)\left(\frac{\sigma^2{}_h}{n_h}\right)$$

Then the stratified estimator of the variance of the mean is:

$$V(\hat{\mu}_{st}) = \sum_{h=1}^{L} W_h^2 \left(\frac{N_h - n_h}{N_h}\right)\left(\frac{\sigma^2{}_h}{n_h}\right) \text{ where } \hat{\sigma}^2{}_h = \sum_{j=1}^{N_h} \frac{(y_{hj} - \mu_h)^2}{N_h - 1}$$

For estimating population proportions (π), the same procedure is applied, assuming that y_j is always 1 or 0:

$$\hat{\pi}_{st} = \sum_{h=1}^{L} W_h \cdot \hat{\pi}_h$$

$$V(\hat{\pi}_{st}) = \sum_{h=1}^{L} W_h^2 \left(\frac{N_h - n_h}{N_h}\right)\left(\frac{\sigma^2{}_h}{n_h}\right) \text{ where } \hat{\sigma}^2{}_h = \left(\frac{N_h}{N_h - 1}\right)\pi_h(1 - \pi_h)$$

Finally, for totals (τ), the procedures are almost identical:

$$\hat{\tau}_{st} = N\hat{\mu}_{st} = \sum_{h=1}^{L} \hat{\tau}_h \text{ and also } E(\hat{\tau}_{st}) = E(N\hat{\mu}_{st}) = NE(\hat{\mu}_{st}) = N\mu = \tau$$

And the variance is:

$$V(\hat{\tau}_{st}) = \sum_{h=1}^{L} V(\hat{\tau}_h) \text{ then } V(\hat{\tau}_{st}) = \sum_{h=1}^{L} N_h^2 \left(\frac{N_h - n_h}{N_h}\right)\left(\frac{\sigma^2{}_h}{n_h}\right)$$

5. Stakeholder engagement

Recreational fisheries stakeholders include all parties with an interest in the development of sustainable recreational fisheries. The term "stakeholder" is most often employed to refer to the recreational fishers themselves, including the federations and associations of recreational fishers and charters (e.g. Federazione Italiana Pesca Sportiva e Attività Subacquee in Italy, Federación Española de Pesca y Casting in Spain, etc.). However, the term "stakeholder" can also include the public authorities at both the local and national levels (e.g. port authorities and ministries in charge of fisheries management, respectively), environmental associations, non-governmental organizations and research institutes. This list is by no means exhaustive and other organisms/stakeholders, such as other users of the aquatic resources and representatives from secondary industries (e.g. the gear and tourism industries) could be included (Gaudin and De Young, 2007). In this context, the relevant advisory councils in European Union countries (European Commission, 2013) that also work on recreational fishery issues (e.g. MEDAC for the Mediterranean) play an important role, since their opinion includes mediation efforts with recreational fishers and other fisheries sectors sharing and exploiting the same fishing resources.

Engaging stakeholders is vital for delivering a successful survey and, ultimately, for the sustainable management of recreational fisheries. When properly achieved, stakeholder engagement can help develop credibility and trust between researchers, decision-makers and fishers. This trust is essential to ensuring robust participation in studies, facilitating accurate data reporting, building a healthy platform for decision-making discussions and securing buy-in for eventual management measures. The overall objective of stakeholder engagement should be to close the gap between decision-making and practice.

Stakeholders can be engaged at all stages of the survey process. During the planning and development of the survey, the views of the recreational fishing community should be considered, as they know far more about recreational fisheries than most scientists, while scientists know much more about scientific methods than the recreational fishing community. By involving stakeholders in the planning of surveys, clear communication can be established regarding survey objectives and how surveys are designed to produce reliable results, helping to develop credibility and trust. During the data collection phase of the survey, stakeholder engagement is even more crucial. Stakeholder engagement could be promoted by means of panels for data collection, reference groups and committees, distribution of leaflets (via mail, websites or meetings), websites, journals/newspapers and other media (ICES, 2011). It is important to engage stakeholders as early as possible in data collection and monitoring initiatives in order to build trust through open discussions and transparent processes.

Working together leads to all parties' experiences and knowledge being incorporated in the design and implementation of recreational fisheries surveys. This involvement enhances the quality of the data collected, leading to greater utility for scientists and the recreational fishing community alike (ICES, 2012). Finally, efforts should be made to ensure survey results are reported back to stakeholders at the end of the survey. Communicating results empowers stakeholders to actively participate in management and decision-making processes. Recreational fisheries clubs, federations and associations can be particularly useful partners in this regard. In this way, the data collected is useful not only for public authorities, but also for angling organizations that may wish to develop their own policies and regulations (ICES, 2012).

There are many successful examples of such stakeholder engagement in the context of recreational fisheries. These include the Marine Recreational Information Program of the United States, which applied new communication methods in order to re-establish trust in their recreational fishery estimates. The programme achieved this success by providing fact sheets, videos and background information on a website (NOAA, 2021). In this case, a communications team was established to provide expert advice in order to effectively communicate with stakeholders. To improve messaging, videos were chosen as a new communication method. Similarly, the experience from co-management committees (e.g. the case of the Roses Bay in Spain's Catalonia region) has showed that when recreational fishers were included in fisheries co-management committees, providing them with a forum to share their perspectives and engage in decision-making, fishers were surprisingly willing to self-regulate.

References

Arlinghaus, R., Bork, M. & Fladung, E. 2008. Understanding the heterogeneity of recreational anglers across an urban-rural gradient in a metropolitan area (Berlin, Germany), with implications for fisheries management. *Fisheries Research*, 92(1): 53–62.

Arlinghaus, R., Tillner, R. & Bork, M. 2014. Explaining participation rates in recreational fishing across industrialised countries. *Fisheries Management and Ecology*, 22(1): 45–55.

Arlinghaus, R., Abbott, J.K., Fenichel, E.P., Carpenter, S.R., Hunt, L.M., Alós, J., Klefoth, T., *et al.* 2019. *Opinion: Governing the recreational dimension of global fisheries*. Proceedings of the National Academy of Sciences of the United States of America, 116(12): 5209–5213.

Ayal, S., Gino, F., Barkan, R. & Ariely, D. 2015. Three principles to REVISE people's unethical behavior. *Perspectives on Psychological Science*, 10(6): 738–741.

Beckmann, C., Tracey, S., Murphy, J., Moore, A., Cleary, B. & Steer, M. 2019. *Assessing new technologies and techniques that could improve the cost-effectiveness and robustness of recreational fishing surveys*. Proceedings of the national workshop, Adelaide, South Australia, 10-12 July 2018. Adelaide, South Australia, South Australian Research and Development Institute.

Bellanger, M. & Levrel, H. 2017. A cost-effectiveness analysis of alternative survey methods used for the monitoring of marine recreational fishing in France. *Ocean & Coastal Management*, 138: 19–28.

Cochran, W.G. 1977. *Sampling techniques*. Third edition. United States, John Wiley & Sons.

Connelly, N.A. & Brown, T.L. 1995. Use of angler diaries to examine biases associated with 12-month recall on mail questionnaires. *Transactions of the American Fisheries Society*, 124(3): 413–422.

Connelly, N.A. & Brown, T.L. 2011. Effect of recall period on annual freshwater fishing effort estimates in New York. *Fisheries Management and Ecology*, 18: 83–87.

Coutin, P., Conron, S.D. & MacDonald, M. 1995. *The daytime recreational fishery in Port Phillip Bay, 1989-94*. Queenscliff, Australia, Victorian Fisheries Research Institute.

Dauk, P.C. 2000. *Estimation in creel surveys under non-standard conditions*. Department of Mathematics and Statistics, Simon Fraser University. (PhD dissertation).

Dauk, P.C. & Schwarz, C.J. 2001. Catch estimation with restricted randomization in the effort survey. *Biometrics*, 57(2):461–468.

Desfosses, C., Adams, P., Blight, S., Smallwood, C. & Taylor, S. 2019. *The feasibility of using remotely piloted aircraft systems (RPAS) for recreational fishing surveys in Western Australia*. Fisheries Occasional Publication No. 137. Western Australia, Department of Primary Industries and Regional Development.

Dillman, D.A., Smyth, J.D. & Christian, L.M. 2014. *Internet, phone, mail, and mixed mode surveys: the tailored design method*. Fourth edition. Hoboken, New Jersey, John Wiley & Sons.

EAA. 2004. Recreational angling. Definition. A definition on recreational angling agreed by the European Anglers Alliance at the General Assembly 2004 in Dinant, Belgium. Document presented at the tenth General Assembly of the European Anglers Alliance, 25–28 March 2004, Dinant, Belgium, European Anglers Alliance.

Efron, B. & Tibshirani, R.J. 1993. *An Introduction to the Bootstrap*. London, Chapman & Hall.

English, K.K., Shardlow, T.F & Webb, T.M. 1986. *Assessment of Strait of Georgia sport fishing statistics, sport fishing regulations and trends in Chinook catch using creel survey data*. Canadian Technical Report of Fisheries and Aquatic Sciences 1375. Nanaimo, British Columbia.

English, K.K., Searing, G.F. & Nagtegaal, D.A. 2002. *Review of the Strait of Georgia recreational creel survey, 1983-1999*. Canadian Technical Report of Fisheries and Aquatic Sciences 2414. Nanaimo, British Columbia.

European Commission. 2013. Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No. 2371/2002. *Official Journal of the European Union* L354: 22–61.

European Commission. 2016. Commission Implementing Decision (EU) 2016/1251 of 12 July 2016 adopting a multiannual Union programme for the collection, management and use of data in the fisheries and aquaculture sectors for the period 2017-2019 (notified under document C(2016) 4329). *Official Journal of the European Union*, L207: 116–177.

FAO. 1966. *Manual of sampling and statistical methods for fisheries biology. Part 1. Sampling methods.* FAO Manuals in Fisheries Science No. 3. Rome, FAO. (also available at http://www.fao.org/3/X5684E/x5684e00.htm).

FAO. 2002*. Sample-based fishery surveys: A technical handbook.* FAO Fisheries Technical Paper No. 425. Rome, FAO. 144 pp. (also available at http://www.fao.org/3/y2790e/y2790e.pdf).

FAO. 2012. *Recreational fisheries.* FAO technical guidelines for responsible fisheries No. 13. Rome, FAO. 176 pp. (also available at http://www.fao.org/3/i2708e/i2708e00.pdf)

FAO. 2016. *International Standard Statistical Classification of Fishing Gear* [online]. Coordinating Working Party on Fishery Statistics (CWP). [Cited 22 April 2021]. http://www.fao.org/3/bt988e/bt988e.pdf

FAO. 2018a. *General Fisheries Commission for the Mediterranean. Report of the twentieth session of the Scientific Advisory Committee on Fisheries, Tangiers, Morocco, 26-29 June 2018/Rapport de la vingtième session du Comité scientifique consultatif des pêches, Tanger,Maroc, 26-29 juin 2018*. FAO Fisheries and Aquaculture Report No. R1245. Rome, FAO. 225 pp. (also available at http://www.fao.org/gfcm/statutory-meetings/detail/en/c/1158491/)

FAO. 2018b. *The State of Mediterranean and Black Sea Fisheries 2018*. General Fisheries Commission for the Mediterranean. Rome. http://www.fao.org/3/ca2702en/CA2702EN.pdf

FAO. 2020. *The State of Mediterranean and Black Sea Fisheries 2020*. General Fisheries Commission for the Mediterranean. Rome. https://doi.org/10.4060/cb2429en

Ferter, K., Weltersbach, M.S., Strehlow, H.V., Vølstad, J.H., Alós, J., Arlinghaus, R., Armstrong, M., *et al.* 2013. Unexpectedly high catch-and-release rates in European marine recreational fisheries: implications for science and management. *ICES Journal of Marine Science*, 70(7): 1319–1329.

Fox, G.A., Negrete-Yankelevich, S. & Sosa, V.J., eds. 2015. *Ecological statistics: contemporary theory and application*. Oxford, United Kingdom, Oxford University Press.

Gaudin, C. & De Young, C. 2007. *Recreational fisheries in the Mediterranean countries: a review of existing legal frameworks.* GFCM Studies and Reviews No. 81. Rome, FAO. 85 pp. (also available at http://www.fao.org/3/a1500e/a1500e00.htm)

GFCM. 2010a. *Report of the Transversal Workshop on the Monitoring of Recreational Fisheries in the GFCM Area. Palma de Mallorca, Spain, 20–22 October 2010* [online]. [Cited 3 February 2021]. http://gfcmsitestorage.blob.core.windows.net/documents/web/SAC/13/GFCM_SAC13_2011_Inf.18-e.pdf

GFCM. 2010b. *Draft report of the eleventh session of the SAC Sub-Committee on economic and social sciences (SCESS). Saint George's Bay, Malta, 29 November–2 December 2010*. [online]. [Cited 3 February 2021]. http://gfcmsitestorage.blob.core.windows.net/documents/web/SAC/13/GFCM_SAC13_2011_Inf.7-e.pdf

GFCM. 2017a. *Mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries*. Rome, FAO. 24 pp. (also available at http://www.fao.org/3/i7340e/i7340e.pdf)

GFCM. 2017b. *Report of the first meeting of the Working Group on Small-Scale and Recreational fisheries (WGSSF). FAO headquarters, Rome, Italy, 12–13 September 2017*. [online]. [Cited 3 February 2021]. http://www.fao.org/gfcm/technical-meetings/detail/en/c/1061844/

GFCM. 2018. *GFCM Data Collection Reference Framework (DCRF)*. Version: 20.1. [online]. Data Collection Reference Framework [Cited 7 December 2020]. http://www.fao.org/gfcm/data/dcrf/

GFCM. 2019. *Compendium of GFCM decisions* [online]. [Cited 4 March 2021]. www.fao.org/gfcm/decisions/en.

GFCM. 2021. *Report of the first meeting of the Working Group on Recreational Fisheries (WGRF). Online, 25–26 February 2021*. [online]. [Cited 21 April 2021]. http://www.fao.org/gfcm/technical-meetings/detail/fr/c/1402637/

Gordoa, A., Dedeu, A.L. & Boada, J. 2019. Recreational fishing in Spain: first national estimates of fisher population size, fishing activity and fisher social profile. *Fisheries Research*, 211: 1–12.

Grafton, R.Q., Kirkley, J., Kompas, T. & Squires, D. 2006. *Economics for fisheries management*. Hampshire, UK, Ashgate Publishing.

Groves, R.M. & Lyberg, L. 2010. Total survey error: past, present, and future. *Public opinion quarterly*, 74(5): 849–879.

Groves, R.M, Fowler, F.J., Couper, M.P., Lepkowski, J.M., Singer, E. & Tourangeau, R. 2009. *Survey Methodology*. Hoboken, New Jersey, Wiley.

Hankin, D., Mohr, M.S. & Newman, K.B. 2019. *Sampling theory: for the ecological and natural resource sciences*. United Kingdom, Oxford University Press.

Hartill, B.W., Watson, T.G. & Bian, R. 2011. Refining and applying a maximum-count aerial-access survey design to estimate the harvest taken from New Zealand's largest recreational fishery. *North American Journal of Fisheries Management*, 31(6):1197–1210.

Hartill, B.W., Cryer, M., Lyle, J.M., Rees, E.B., Ryan, K.L., Steffe, A.S., Taylor, S.M., West, L. & Wise, B. 2012. Scale- and context-dependent selection of recreational harvest estimation methods: the Australasian experience. *North American Journal of Fisheries Management*, 32(1): 109–123.

Hoyle, S.D. & Cameron, D.S. 2003. Confidence intervals on catch estimates from a recreational fishing survey: a comparison of bootstrap methods. *Fisheries Management and Ecology*, 10:97–108.

Hyder, K., Armstrong, M., Ferter, K. & Strehlow, H.V. 2014. Recreational sea fishing – the high value forgotten catch. *ICES Insight*, 51:8–15.

Hyder, K., Radford, Z., Prellezo, R., Weltersbach, M.S., Lewin, W.C., Zarauz, L., Ferter, K., ***et al***. 2017a. *Research for PECH Committee – Marine recreational and semi-subsistence fishing – its value and its impact on fish stocks*. Brussels, European Parliament, Policy Department for Structural and Cohesion Policies.

Hyder, K., Weltersbach, M.S., Armstrong M., Ferter, K., Townhill, B., Ahvonen, A., Arlinghaus, R., ***et al.*** 2017b. Recreational sea fishing in Europe in a global context – participation rates, fishing effort, expenditure, and implications for monitoring and assessment. *Fish and Fisheries*, 19: 225–243.

ICCAT. 2016. ICCAT Manual. In: *ICCAT* [online]. Madrid, Spain. [Cited 2 February 2021]. https://www.iccat.int/en/iccatmanual.html

ICES. 2010. *Report of the Planning Group on Recreational Fisheries Surveys (PGRFS), 7–11 June 2010, Bergen, Norway*. [online]. [Cited 3 February 2021]. http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2010/PGRFS/PGRFS%202010.pdf

ICES. 2011. *Report of the Planning Group on Recreational Fisheries Surveys (PGRFS), 2–6 May 2011, Esporles, Spain*. [online]. [Cited 3 February 2021]. http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2011/PGRFS%202011/PGRFS%202011.pdf

ICES. 2012. *Report of the Working Group on Recreational Fisheries Surveys (WGRFS), 7–11 May 2012, Esporles, Spain*. [online]. [Cited 3 February 2021]. http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2012/WGRFS/WGRFS%202012.pdf

ICES. 2013. *Report of the ICES Working Group on Recreational Fisheries Surveys 2013 (WGRFS), 22–26 April 2013, Esporles, Spain*. [online] [Cited 5 February 2021]. http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2013/WGRFS%202013/WGRFS%20Report%202013.pdf

ICES. 2014. *Report of the Working Group on Recreational Fisheries Surveys (WGRFS), 2–6 June 2014, Sukarrieta, Spain*. [online] [Cited 5 February 2021]. http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2014/WGRFS/WGRFS%20Final%20Report%202014.pdf

Johnston, F.D., Arlinghaus, R. & Dieckmann, U. 2010. Diversity and complexity of angler behaviour drive socially optimal input and output regulations in a bioeconomic recreational-fisheries model. *Canadian Journal of Fisheries and Aquatic Sciences*, 67(9): 1507–1531.

Jones, C.M., Robson, D.S., Otis, D. & Gloss, S. 1990. Use of a computer simulation model to determine the behaviour of a new survey estimator of recreational angling. *Transactions of the American Fisheries Society*, 119(1):41–54.

Krumpal, I. 2013. Determinants of social desirability bias in sensitive surveys: a literature review. *Quality & Quantity*, 47(4): 2025–2047.

Levine, D.M, Stephan, D.F., Krehbiel, T.C. & Berenson, M.L. 2008. *Statistics for managers: using Microsoft Excel*. Fifth Edition. Upper Saddle River, New Jersey, Prentice Hall, Pearson Education, Inc.

Link, M.W., Battaglia, M.P., Frankel, M.R., Osborn, L. & Mokdad, A.H. 2008. A comparison of address-based sampling (ABS) versus random-digit dialing (RDD) for general population surveys. *Public Opinion Quarterly*, 72(1): 6–27.

Lockwood, R.N., Peck, J. & Oelfke, J. 2001. Survey of angling in Lake Superior waters at Isle Royale National Park, 1998. *North American Journal of Fisheries Management*, 21(3):471–481.

Lohr, S.L. 1999. *Sampling: design and analysis*. Second edition. Boston, USA, Brooks Cole.

MEDAC. 2016. Recreational fisheries in the Mediterranean. MEDAC Advice for a regulatory framework and efficient management for recreational fisheries in the Mediterranean based on "FAO Technical Guidelines on Responsible Recreational Fisheries". Document ref. 155/2016 presented at the Executive Committee, 20 April 2016, Split, Croatia, Mediterranean Advisory Council.

NOAA. 2021. Recreational Fishing Data. In: *NOAA* [online]. Washington, DC. [Cited 22 April 2021]. https://www.fisheries.noaa.gov/topic/recreational-fishing-data

Parker, N.A. 1956. Discussion. In K. D. Carlander, eds. *Proceedings of Iowa state creel survey symposium*, pp. 59–62. Ames, United States, Iowa Cooperative Fisheries Unit.

Pawson, M.G., Glenn, H. & Padda, G. 2008. The definition of marine recreational fishing in Europe. *Marine Policy*, 32: 339–350.

Pinello, D., Gee, J. & Dimech, M. 2017. *Handbook for fisheries socio-economic sample survey – principles and practice.* FAO Fisheries and Aquaculture Technical Paper No. 613. Rome, FAO. 136 pp. (also available at http://www.fao.org/3/i6970e/i6970e.pdf).

Pollock, K.H., Jones, C.M. & Brown, T.L. 1994. *Angler survey methods and their applications in fisheries management*. Bethesda, Maryland, American Fisheries Society, Special Publication No. 25.

Robson, D.S. & Jones, C.M. 1989. The theoretical basis of an access site angler survey design. *Biometrics*, 45(1):83–98.

Sabatella, E. & Franquesa, R. 2003. *Manual of fisheries sampling surveys: methodologies for estimations of socio-economic indicators in the Mediterranean Sea*. Studies and Reviews. General Fisheries Commission for the Mediterranean No. 73. Rome, FAO. 37 pp. (also available at http://www.fao.org/3/y5228e/y5228e00.htm#Contents).

Salant, P. & Dillman, D.A. 1994. *How to conduct your own survey*. Hoboken, Wiley & Sons.

Sbragaglia, V., Correia, R.A., Coco, S. & Arlinghaus, R. 2019. Data mining on YouTube reveals fisher group-specific harvesting patterns and social engagement in recreational anglers and spearfishers. *ICES Journal of Marine Science*, 77(6): 2234–2244.

Soupir, C.A., Brown, M.L., Stone, C.C. & Lott, J.P. 2006. Comparison of creel survey methods on Missouri River reservoirs. *North American Journal of Fisheries Management*, 26(2):338–350.

Sparrevohn, C.R. & Storr-Paulsen, M. 2012. Using interview-based recall surveys to estimate cod *Gadus morhua* and eel *Anguilla anguilla* harvest in Danish recreational fishing. *ICES Journal of Marine Science*, 69(2): 323–330.

Tarrant, M.A. & Manfredo, M.J. 1993. Digit preference, recall bias, and nonresponse bias in self reports of angling participation. *Leisure Sciences*, 15(3): 231–238.

Vaske, J.J. 2008. *Survey research and analysis: applications in parks, recreation and human dimensions*. State College, Pennsylvania, Venture Publishing.

Vaske, J.J. 2011. Advantages and disadvantages of internet surveys: introduction to the special issue. *Human Dimensions of Wildlife*, 16(3): 149–153.

Vaske, J.J., Huan, T.C. & Beaman, J. 2003. The use of multiples in anglers' recall of participation and harvest estimates: some results and implications. *Leisure Sciences*, 25(4): 399–409.

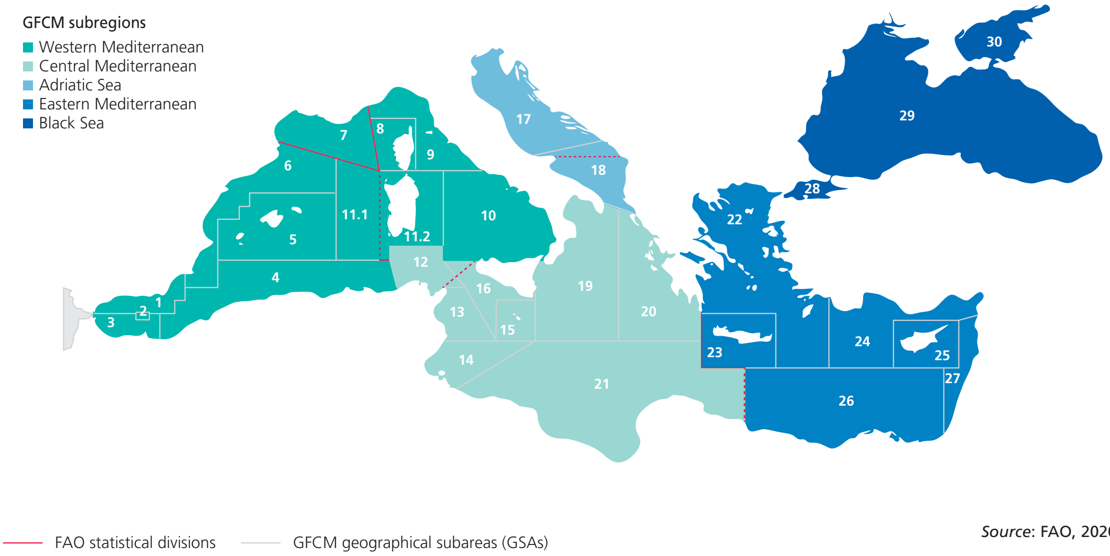
Venturelli, P.A., Hyder, K. & Skov, C. 2017. Angler apps as a source of recreational fisheries data: opportunities, challenges and proposed standards. *Fish and Fisheries*, 18(3): 578–595.

Zischke, M.T. & Griffiths, S.P. 2014. Time-location sampling with capture-recapture to assess specialised recreational fisheries. *Fisheries research*, 157: 136–146.

Wynne-Jones, J., Gray, A., Hill, L. & Heinemann, A. 2014. *National panel survey of marine recreational fishers 2011–12: harvest estimates. New Zealand Fisheries Assessment Report 2014/67.* [online]. [Cited 3 February 2021]. https://www.mpi.govt.nz/dmsdocument/4719/direct

Annexes

ANNEX 1. GFCM AREA OF APPLICATION, SUBREGIONS AND GEOGRAPHICAL SUBAREAS



Source: FAO, 2020.

01. Northern Alboran Sea	07. Gulf of Lion	13. Gulf of Hammamet	19. Western Ionian Sea	25. Cyprus
02. Alboran island	08. Corsica	14. Gulf of Gabès	20. Eastern Ionian Sea	26. South Levant
03. Southern Alboran Sea	09. Ligurian Sea and northern Tyrrhenian Sea	15. Malta	21. Southern Ionian Sea	27. Eastern Levant Sea
04. Algeria	10. South and central Tyrrhenian Sea	16. South of Sicily	22. Aegean Sea	28. Marmara Sea
05. Balearic islands	11.1. Sardinia (west) 11.2. Sardinia (east)	17. Northern Adriatic Sea	23. Crete	29. Black Sea
06. Northern Spain	12. Northern Tunisia	18. Southern Adriatic Sea	24. North Levant Sea	30. Azov Sea

ANNEX 2. CODES FOR RECREATIONAL FISHING TECHNIQUES

Gear name	**Main recreational fishing gear and codes**	
	Code	*Notes*
Hand implements	MHI	Wrenching gear, clamps, tongs, rakes, spears
Harpoons	HAR	Knife, harpoon
Diving	MDV	
Diving (speargun)	MDS*	
Diving (hand)	MDH*	
Cast nets	FCN	
Boat seines	SV	
Beach seines	SB	
Hooks and lines (not specified)	LX	
Handlines and hand-operated pole and lines	LHP	Rod, handline
Traps (not specified)	FIX	
Pots	FPO	
Gillnets and entangling nets (nei)	GEN	
Gillnets	GNS	
Trammel nets	GTR	
Longlines (not specified)	LL	
Lift nets (not specified)	LN	
Scoop nets	MSP	
Gear not known	NK	
Gear not specified	MIS	

Adapted from FAO, 2016.

ANNEX 3. TEMPLATE FOR SCREENING SURVEY AND ENROLLMENT OF FISHERS IN DATA COLLECTION PANEL

Template for screening survey and enrollment of fishers in data collection panel

Phone number ______________________ **City** ___________________________

Number of members of the household ________________________________

Age	Gender		Marine recreational fisher?		Number of fishing trips in the previous year			Panel		
					Boat	Shore	Underwater	Willingness to participate?		If YES. Contact info (phone/email)
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	

ANNEX 4. TEMPLATES FOR MANDATORY FEE-FREE ONLINE REGISTRATION OF MARINE RECREATIONAL FISHERS

Template for online registration

STEP 1 – general information

Name	______________________	
Surname	______________________	
Date of birth	______________________	
Place of birth	______________________	
Nationality	______________________	
Address	______________________	
E-mail	______________________	
Telephone No.	______________________	
Gender	☐ ♂	☐ ♀

Template for online registration

STEP 2 – avidity

ID No. ____________________

Fishing mode	Gear	How many fishing trips did you perform last year?				
Boat	Hand implements	1-5	6-10	11-25	26-50	>50
	Harpoons	1-5	6-10	11-25	26-50	>50
	Diving	1-5	6-10	11-25	26-50	>50
	Diving (speargun)	1-5	6-10	11-25	26-50	>50
	Diving (hand)	1-5	6-10	11-25	26-50	>50
	Cast nets	1-5	6-10	11-25	26-50	>50
	Boat seines	1-5	6-10	11-25	26-50	>50
	Hooks and lines (not specified)	1-5	6-10	11-25	26-50	>50
	Handlines and hand-operated pole and lines	1-5	6-10	11-25	26-50	>50
	Traps (not specified)	1-5	6-10	11-25	26-50	>50
	Pots	1-5	6-10	11-25	26-50	>50
	Gillnets and entangling nets (nei)	1-5	6-10	11-25	26-50	>50
	Gillnets	1-5	6-10	11-25	26-50	>50
	Trammel nets	1-5	6-10	11-25	26-50	>50
	Longlines (not specified)	1-5	6-10	11-25	26-50	>50
	Lift nets (not specified)	1-5	6-10	11-25	26-50	>50
	Scoop nets	1-5	6-10	11-25	26-50	>50
	Gear not known	1-5	6-10	11-25	26-50	>50
	Gear not specified	1-5	6-10	11-25	26-50	>50
Shore	Hand implements	1-5	6-10	11-25	26-50	>50
	Harpoons	1-5	6-10	11-25	26-50	>50
	Diving	1-5	6-10	11-25	26-50	>50
	Diving (speargun)	1-5	6-10	11-25	26-50	>50
	Diving (hand)	1-5	6-10	11-25	26-50	>50
	Cast nets	1-5	6-10	11-25	26-50	>50
	Beach seines	1-5	6-10	11-25	26-50	>50
	Hooks and lines (not specified)	1-5	6-10	11-25	26-50	>50
	Handlines and hand-operated pole and lines	1-5	6-10	11-25	26-50	>50
	Traps (not specified)	1-5	6-10	11-25	26-50	>50
	Pots	1-5	6-10	11-25	26-50	>50
	Gillnets and entangling nets (nei)	1-5	6-10	11-25	26-50	>50
	Gillnets	1-5	6-10	11-25	26-50	>50
	Trammel nets	1-5	6-10	11-25	26-50	>50
	Longlines (not specified)	1-5	6-10	11-25	26-50	>50
	Lift nets (not specified)	1-5	6-10	11-25	26-50	>50
	Scoop nets	1-5	6-10	11-25	26-50	>50
	Gear not known	1-5	6-10	11-25	26-50	>50
	Gear not specified	1-5	6-10	11-25	26-50	>50
Underwater	Hand implements	1-5	6-10	11-25	26-50	>50
	Harpoons	1-5	6-10	11-25	26-50	>50
	Diving	1-5	6-10	11-25	26-50	>50
	Diving (speargun)	1-5	6-10	11-25	26-50	>50
	Diving (hand)	1-5	6-10	11-25	26-50	>50
	Gear not known	1-5	6-10	11-25	26-50	>50
	Gear not specified	1-5	6-10	11-25	26-50	>50

Template for online registration

STEP 3 – certificate

Name ______________________________

Surname ______________________________

Nationality ______________________________

Address ______________________________

ID No. ______________________________

Issuing date ______________________________

Expiration date ______________________________

ANNEX 5. TEMPLATE FOR LOGBOOK AND/OR RECALL SURVEY

5.a. General information for logbook and/or recall survey

Logbook and recall template – general information

Logbook ☐ Recall ☐ Reference month and year ____________________

Name and surname of panel participant ________________________________

Information reported for:
Only the panel participant ☐ Multiple fishers (in case the panel participant's catch is pooled with other fishers on the same trip) ☐

If multiple fishers:

No. Fishers: ♂ _____ age ☐☐☐☐☐☐☐
♀ _____ age ☐☐☐☐☐☐☐

Fishing location

Geographical subarea (GSA) __________

City __________

Distance from the coast (in nm) __________

Total fishing time

	Start	End
Date		
Hour		

Fishing mode* Boat ☐ Shore ☐ Underwater ☐

Gear	Gear code	Fishing time per gear (in hours)	Number of units used per gear
Hand implements	MHI		
Harpoons	HAR		
Diving	MDV		
Diving (speargun)	MDS		
Diving (hand)	MDH		
Cast nets	FCN		
Boat seines	SV		
Beach seines	SB		
Hooks and lines (not specified)	LX		
Handlines and hand-operated pole and lines	LHP		
Traps (not specified)	FIX		
Pots	FPO		
Gillnets and entangling nets (nei)	GEN		
Gillnets	GNS		
Trammel nets	GTR		
Longlines (not specified)	LL		
Lift nets (not specified)	LN		
Scoop nets	MSP		
Gear not known	NK		
Gear not specified	MIS		

Catches					
No.	Gear code	Species	No. Retained	Weight (kg) retained	No. released
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Comments:

** Complete one logbook/recall template per fishing mode*
*** Provide a description of the fishing gear in the comments section*

5.b. Catch information for logbook and/or recall survey

Logbook and recall template – retained species information

Logbook ☐ **Date** ___________ | **Recall** ☐ **Reference month and year** ___________

No.	Gear code	Species (retained)	Length*	Weight (kg)	Sex**	Fishing mode***		
						Boat	Shore	Under water
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

** Total length for fish (cm), mantle length for cephalopods (cm), carapace length for crustaceans (mm)*
*** If known (M: male; F: female; ND: not determined)*
**** Select only one fishing mode (boat, shore, underwater) per row*

5.c. Released species information for logbook and/or recall survey

Logbook and recall template – released species information

Logbook ☐ Date ___________	Recall ☐ Reference month and year _____________

No.	Gear code	Species (released)	Length*	Post-released status**				Fishing mode***		
				Alive	Almost dead	Dead	Not known	Boat	Shore	Under water
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

** Total length for fish (cm), mantle length for cephalopods (cm), carapace length for crustaceans (mm)*
*** Mark the corresponding cell*
**** Select only one fishing mode (boat, shore, underwater) per row*

5.d. Expenditure information per fishing trip for logbook survey

Logbook template - expenditures

Expenditures per fishing trip

(Any expenditures since the last logbook date, such as purchases of new equipment, should be reported)

Start date of fishing trip: ________________________________

Type of expenditure	Value	Currency
Rods and reels		
Nets (set nets, lift, scoop, etc.)		
Accessories (hooks, lines, etc.)		
Speargun		
Underwater accessories (fins, mask, etc.)		
Traps		
Artificial baits (jigs, lures, etc.)		
Natural baits (worms, sardines, etc.)		
Travel and accommodation		
License fee		
Boat rental		
Charter		
Fuel		
Taxes		
Electronics (GPS, radar, etc.)		
Boat maintenance		
Others ____________________		
Others ____________________		
Others ____________________		
Others ____________________		

Comments:

5.e. Expenditure information per month for recall survey

Recall template - expenditures

Expenditures per month

Reference month and year: ________________________________

Type of expenditure	Value	Currency
Rods and reels		
Nets (set nets, lift, scoop, etc.)		
Accessories (hooks, lines, etc.)		
Speargun		
Underwater accessories (fins, mask, etc.)		
Traps		
Artificial baits (jigs, lures, etc.)		
Natural baits (worms, sardines, etc.)		
Travel and accommodation		
License fee		
Boat rental		
Charter		
Fuel		
Taxes		
Electronics (GPS, radar, etc.)		
Boat maintenance		
Others ____________________		
Others ____________________		
Others ____________________		
Others ____________________		

Comments:

ANNEX 6. TEMPLATE FOR ON-SITE SURVEYS

6.a. General information for on-site survey

On-site survey template – general information

Date of interview ______________________________

Information by:

Single fisher ☐ Multiple fishers (in the case that catches are pooled) ☐

No. Fishers: ♂ ____ age ☐☐☐☐☐☐☐
♀ ____ age ☐☐☐☐☐☐☐

Fishing location

Geographical subarea (GSA) ____________________

City ____________________

Distance from the coast (in nm) ____________________

Latitude ____________________

Longitude ____________________

Total fishing time

	Start	End
Date		
Hour		

Gear	Gear code	Fishing mode*			Fishing time per gear (in hours)	Number of units used per gear
		Boat	Shore	Under-water		
Hand implements	MHI					
Harpoons	HAR					
Diving	MDV					
Diving (speargun)	MDS					
Diving (hand)	MDH					
Cast nets	FCN					
Boat seines	SV					
Beach seines	SB					
Hooks and lines (not specified)	LX					
Handlines and hand-operated pole and lines	LHP					
Traps (not specified)	FIX					
Pots	FPO					
Gillnets and entangling nets (nei)	GEN					
Gillnets	GNS					
Trammel nets	GTR					
Longlines (not specified)	LL					
Lift nets (not specified)	LN					
Scoop nets	MSP					
Gear not known	NK					
Gear not specified	MIS					

Catches

No.	Gear code	Species	No. retain	Weight (kg) retain	No. release
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Number of fishing trips performed by the interviewee during the previous year:

Boat	
Shore	
Underwater	

Willingness of interviewee to participate in a follow-up panel? If yes, name and (mobile) telephone number:

Comments:

* *Complete one logbook/recall template per fishing mode*
** *Provide a description of the fishing gear in the comments section*

6.b. Catch information for on-site survey

On-site survey template – retained species information

Date ______________________

No.	Gear code	Species (retained)	Length*	Weight (kg)	Sex**	Fishing mode***		
						Boat	Shore	Under water
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

** Total length for fish (cm), mantle length for cephalopods (cm), carapace length for crustaceans (mm)*
*** If known (M: male; F: female; ND: not determined)*
**** Select only one fishing mode (boat, shore, underwater) per row*

6.c. Released species information for on-site survey

On-site survey template – released species information

Date ________________

No.	Gear code	Species (released)	Length*	Post-released status**				Fishing mode***		
				Alive	Almost dead	Dead	Not known	Boat	Shore	Under water
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

** Total length for fish (cm), mantle length for cephalopods (cm), carapace length for crustaceans (mm)*
*** Mark the corresponding cell*
**** Select only one fishing mode (boat, shore, underwater) per row*

ANNEX 7. FISHING EFFORT MEASUREMENT

Gear name	Effort measurement by fishing gear			
	Code	*Unit of capacity*	*Unit of activity*	*Nominal effort*
Hand implements	MHI	Number	Fishing days	Number x fishing days
Harpoons	HAR	Number	Fishing days	Number x fishing days
Diving	MDV	Number	Fishing days	Number x fishing days
Diving (speargun)	MDS**	Number	Fishing days	Number x fishing days
Diving (hand)	MDH**	Number	Fishing days	Number x fishing days
Cast nets	FCN	Number	Fishing days	Number x fishing days
Beach seines	SB	Net length*	Fishing days	Net length x fishing days
Hooks and lines (not specified)	LX	Number of hooks	Fishing days	Number of hooks x fishing days
Handlines and hand-operated pole and lines	LHP	Number	Fishing days	Number x fishing days
Traps (not specified)	FIX	Number of traps	Fishing days	Number of traps x fishing days
Pots	FPO	Number of pots	Fishing days	Number of pots x fishing days
Gillnets and entangling nets (nei)	GEN	Net length*	Fishing days	Net length x fishing days
Gillnets	GNS	Net length*	Fishing days	Net length x fishing days
Trammel nets	GTR	Net length*	Fishing days	Net length x fishing days
Longlines (not specified)	LL	Number of hooks	Fishing days	Number of hooks x fishing days
Lift nets (not specified)	LN	Number	Fishing days	Number x fishing days
Scoop nets	MSP	Number	Fishing days	Number x fishing days

** Length of net expressed in 100-m units*
*** Adapted from FAO, 2016.*

Office of Communications – November 2020

Handbook for data collection on recreational fisheries in the Mediterranean and the Black Sea

Corrigendum

Updated on 18 October 2021

The following corrections were made to the PDF after it went to print.

Page	Location	Text in printed PDF	Text in corrected PDF
Cover page	Logos	The GFCM logo was added.	
Title page	Authors	Authors'affiliations were added.	
60	Annex 5.b	The table was updated.	
61	Annex 5.c	The table was updated.	
66	Annex 6.c	The table was updated.	

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Marine recreational fisheries are an integral part of Mediterranean and Black Sea coastal life and are commonly practiced throughout the region. Recreational fisheries also represent an important driver of coastal tourism, which constitutes one of the region's most important maritime sectors in terms of gross value added and employment. However, despite their ubiquity and potential socio-economic contribution, recreational fisheries are a data-poor sector and can vary widely from one country to another, thus impairing proper consideration of the recreational fisheries sector in policy-making and undermining efforts towards sustainable fisheries management at the regional level. The main goal of this handbook is therefore to provide a clear methodological framework to allow Mediterranean and Black Sea countries to implement suitably harmonized sampling and survey monitoring schemes for recreational fisheries. This handbook establishes a minimum set of necessary information for monitoring recreational fisheries, while, at the same time, allowing for flexibility to accommodate national specificities and data collection needs. It also provides guidance on the data analysis process as well as advice to successfully engage stakeholders in the data collection process.

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