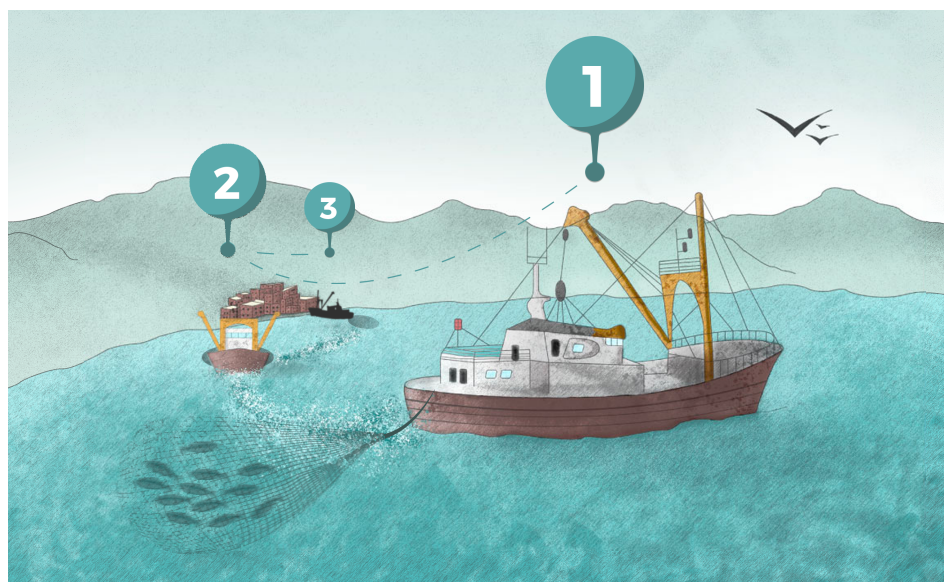




IMPLEMENTATION OF THE INTERNATIONAL PLAN OF ACTION TO PREVENT, DETER AND ELIMINATE ILLEGAL, UNREPORTED AND UNREGULATED FISHING

**1. Methodologies and indicators for the estimation
of the magnitude and impact of illegal, unreported
and unregulated fishing**

1.2 A practical guide to delivering an estimate



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PREPARATION OF THIS DOCUMENT

This document is a product of the Food and Agriculture Organization of the United Nation's (FAO) global programme to support the implementation of the Agreement on Port State Measures (PSMA), complementary international instruments, and regional mechanisms and tools to combat illegal, unreported and unregulated (IUU) fishing. The guidance in this second volume, along with the other volumes in this series of technical guidelines on methodologies and indicators for estimating the magnitude and impact of IUU fishing, is designed to meet the specific, practical needs of fisheries authorities.

This volume is published under the Technical Guidelines for Responsible Fisheries series to support the principles of the Code of Conduct for Responsible Fisheries (CCRF), which call for effective fisheries management. Article 7.3.1 of the CCRF specifically refers to managing fish stocks to account for all removals and Article 7.4.4 notes the importance of complete and reliable statistics on catch and fishing effort. Understanding the full extent of fishing mortality, from both legal and IUU fishing, is critical for ensuring that the level of fishing permitted is commensurate with the state of fisheries resources as called for in Article 7.6.1. Furthermore, knowledge of the type and amount of IUU fishing can be critical in assessing the effectiveness of monitoring, control and surveillance (MCS) systems (Article 7.7.4).

This document was prepared by the Fisheries Global and Regional Processes Team of FAO's Fisheries and Aquaculture Division. It was written by Duncan Souter and David Agnew, with contributions from Shelley Clarke, and technical backstopping by Matthew Camilleri and Alicia Mosteiro.

ABSTRACT

Applying the principles and approaches from Volume 1 of this series, this practical guide details the steps necessary to plan, execute and present estimates of illegal, unreported and unregulated fishing. For the initial planning phase, the guide provides information on how to work with stakeholders to define objectives, examine and catalogue available data, and then match the objectives with the available data to determine the most useful estimation methods. Also discussed are subsequent steps involving designing a conceptual model, triangulating alternative approaches, dealing with data gaps and biases, and accounting for uncertainty. For the execution phase, guidance is provided for developing and running models, including checking preliminary outputs with stakeholders and experts, before refining and finalizing results. Guidance for the final presentation phase focuses on how to ensure the methodology, data inputs and gaps, and assumptions are clearly explained. As in the first two phases, allowing for feedback from stakeholders on the study results, and refining the outputs as necessary, will strengthen both the quality of the work and its uptake by decision-makers.

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ABBREVIATIONS

AIS	Automatic Identification System
FAO	Food and Agriculture Organization of the United Nations
IUU	illegal, unreported and unregulated (fishing)
MCS	monitoring, control and surveillance
SAR	synthetic aperture radar
VMS	vessel monitoring system

BACKGROUND

- 1 From ancient times, fishing from oceans, seas, lakes and rivers has been a major source of food and a provider of employment and other economic benefits for humanity. Living aquatic resources, an essential part of the aquatic ecosystem, are finite and their use, like that of other renewable natural resources, needs to be properly managed if their contribution to the nutritional, economic and social well-being of the growing world's population is to be sustained.
2. The adoption of the United Nations Convention on the Law of the Sea (UNCLOS) in 1982 was instrumental in the protection of living marine resources in the sea. The legal regime of the oceans gave coastal States rights and responsibilities for the management and use of fishery resources within the areas of their national jurisdiction.
3. After a long period of growth, capture fisheries landings began to level off from the end of the 1980s, due to sustainability issues, including overfishing, marking the end of the continued development paradigm of global fisheries. Overfishing has negative implications for food and nutrition security and for economic development, whilst also reducing social welfare in countries worldwide. This is especially the case for small-scale fishers and fish workers in developing countries who depend upon fish as their main source of essential nutrients, animal protein and income, while other fishers and fish workers employed in the medium and industrial sectors are reliant on these fisheries for income and livelihoods. The exploitation and use of living aquatic resources need to be properly managed and overfished and depleted stocks need to recover, ensuring that they can continue to benefit society.
4. Following rapid development, aquaculture started to play an increasing role in supplying fish for human consumption in the 1990s.
5. The 19th Session of the FAO Committee on Fisheries (COFI), held in March 1991, recommended the development of new approaches to fisheries and aquaculture management, embracing conservation and environment, as well as social and economic considerations. FAO was asked to develop the concept of responsible fisheries and elaborate a code of conduct to disseminate its principles and foster its application.

6. The Declaration of Cancun, endorsed at the International Conference on Responsible Fishing in Cancun in May 1992, and the United Nations Conference on Environment and Development Summit in Rio de Janeiro in June 1992, reinforced the concept of responsible fisheries and supported the preparation of a code of conduct for responsible fisheries. The FAO Technical Consultation on High Seas Fishing held in September 1992 further recommended the elaboration of a code to address the issues regarding high seas fisheries.
7. In November 1992, the FAO Council formally approved the preparation of a draft of this code. The formulation was carried out through a participatory process involving FAO Members and designed so as to be interpreted and applied in conformity with the relevant rules of international law, as reflected in the 10 December 1982 United Nations Convention on the Law of the Sea. It was also formulated in line with the Agreement for the Implementation of the Provisions of the 1995 Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks and, *inter alia*, the 1992 Declaration of Cancun and the 1992 Rio Declaration on Environment and Development, in particular Chapter 17 of Agenda 21.
8. At its 27th Session in November 1993, the FAO Conference adopted the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, which, as stated within the FAO Conference Resolution 15/93, should form an integral part of the code of conduct for responsible fisheries.
9. The Code of Conduct for Responsible Fisheries (the Code) was adopted on 31 October 1995 during the 28th Session of the FAO Conference through Resolution 4/95. The same Resolution requested FAO *inter alia* to elaborate appropriate technical guidelines in support of the implementation of the Code in collaboration with FAO Members and interested relevant organizations. This document is one of a series produced in response to this request.
10. The Code is voluntary. However, certain parts of it are based on relevant rules of international law, and it also contains provisions that have already been given binding effect by means of other obligatory legal instruments amongst the Parties.

11. On the implementation of the provisions of the Code, the application of the Ecosystem Approach to Fisheries, as reinforced in the Reykjavik Declaration (2001), provide strategies for the actual implementation of the Code, contributing to the further development and management of sustainable capture fisheries in the marine and freshwater environments and of the interaction between capture fisheries and aquaculture for sustainability, thereby supporting the technical, ecological, economic and social sustainability of the sectors.
12. Despite significant progress in places where capture fisheries management is implemented, the continued prevalence of illegal, unreported and unregulated (IUU) fishing and the ongoing use of ineffective management measures, means that the global percentage of fish stocks that are classified as overfished has not declined.
13. Since its adoption in 1995, the Code has been supplemented, within its framework, by other internationally negotiated instruments addressing specific provisions of the Code and other related matters on responsible fisheries and aquaculture, in the form of International Plans of Action, Voluntary Guidelines and Strategies. In addition, in 2009, the 36th Session of the FAO Conference adopted the Agreement on Port State Measures to Prevent, Deter and Eliminate IUU Fishing which later came into force in June 2016.
14. Whilst contributing smaller volumes to the global fish catch than marine fisheries, inland fisheries contributes fundamentally to food and nutrition security, livelihoods and rural economies, especially in many developing countries. The existence of a broad range of interests outside the inland fisheries sector emphasizes the need for States to establish negotiation mechanisms to protect inland fisheries under multi-purpose use regimes. The importance and the challenges of ensuring the sustainable and responsible use of inland fisheries are clearly acknowledged in the Rome Declaration which emerged from the Global Conference on Inland Fisheries in 2015: The ‘Ten Steps to Responsible Inland Fisheries’ emphasize cross-sectoral approaches to sustain livelihoods, food and nutrition security, and aquatic ecosystems.

15. The role of aquaculture in supplying fish for human consumption has continued to increase, reaching approximately 50 percent of global fish available for human consumption in 2018. This has allowed fish to contribute to the transition to more healthy and nutritious diets while not increasing the pressure on capture fisheries. However, aquaculture development, when inadequately managed, has also shown the potential to cause environmentally or socially adverse impacts. The outstanding issue in aquaculture is that, unlike in capture fisheries, the existing applicable principles of international law and treaty provisions provide little guidance on the conduct of aquaculture operations. The importance of sustainable aquaculture development and management for securing food and nutrition security, alleviating poverty and maintaining the integrity and sustainability of aquatic resources and environments was reinforced in the Bangkok declaration (2000) and the Phuket consensus (2010).
16. Elements of the Code and the subsequent framework of international instruments were reinforced through the United Nations Conference on Sustainable Development held in Rio de Janeiro in 2012, which launched a process to develop a set of Sustainable Development Goals (SDGs). The 2030 Agenda for Sustainable Development was adopted with 17 SDGs at the United Nations Sustainable Development Summit in 2015. In particular, SDG 14 “Conserve and sustainably use the oceans, seas and marine resources for sustainable development” includes targets, *inter alia*, for sustainable management of fisheries and aquaculture, ensuring access to resources and markets for small-scale fishers, ending of overfishing, destructive fishing practices, IUU fishing and the implementation of science-based plans to restore fish stocks.
17. FAO produces Technical Guidelines for Responsible Fisheries to assist the international community in taking the necessary practical steps to implement the provisions foreseen in the Code.

1. INTRODUCTION AND CONTEXT

Volume 1 in this Technical Guidelines series presents the issues that should be considered by practitioners preparing estimation studies of illegal, unreported and unregulated (IUU) fishing. It also provides a compendium of specific examples from previous studies that practitioners can apply in their own study.

Now in Volume 2, the steps involved in carrying out a study are set out in a logical sequence to ensure the study is successful. Additional information is also provided on how to examine and catalogue data that may be available, and how to match them with the study objectives to arrive at a sensible and robust suite of estimation methods.

The components of this practical guide are consistent with the guiding principles and best practice study design measures set out in Volume 1. Although there is some flexibility around the ordering of some components, the best IUU fishing estimation studies will incorporate each of these features at a minimum. In particular, in the planning stages researchers will need to ensure there is a clear relationship between the objectives of the study, the nature of the data available, and the approach and methodology chosen for estimation.

We recommend that studies follow a plan involving three phases: planning, execution and presentation (Figure 1).

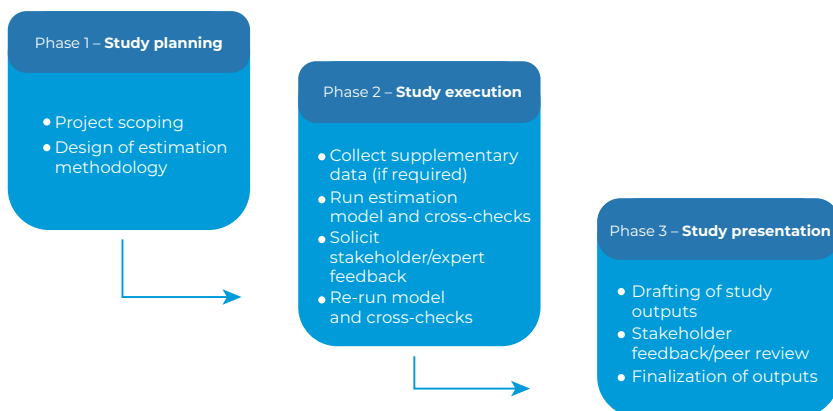


Figure 1. High-level overview of illegal, unreported and unregulated (IUU) fishing estimation study process

The study planning phase focuses on defining the scope and objectives of the exercise, identifying available data and other information, and designing appropriate estimation methods. This phase is essential in setting up the study properly.

The study execution phase focuses on the development and running of estimation models to generate preliminary results, soliciting feedback on these from stakeholders and experts, and refining and re-running models as necessary. In practice, most models (and model inputs) are likely to be refined across multiple iterations before arriving at an “accepted” version.

The study presentation phase focuses on drafting the outcomes of the study (including clearly explaining the methodology, data inputs and gaps, and assumptions used), seeking feedback from stakeholders (and peer reviewers if appropriate), and producing a final version for publication. This phase may also incorporate a range of other measures to ensure uptake of results.

Across each of these phases, the best studies will incorporate robust processes for stakeholder participation and expert review. The following sections set out the critical tasks in each of the three phases.

2. PHASE 1: STUDY PLANNING

An overview of the study planning stage is provided in Figure 2.

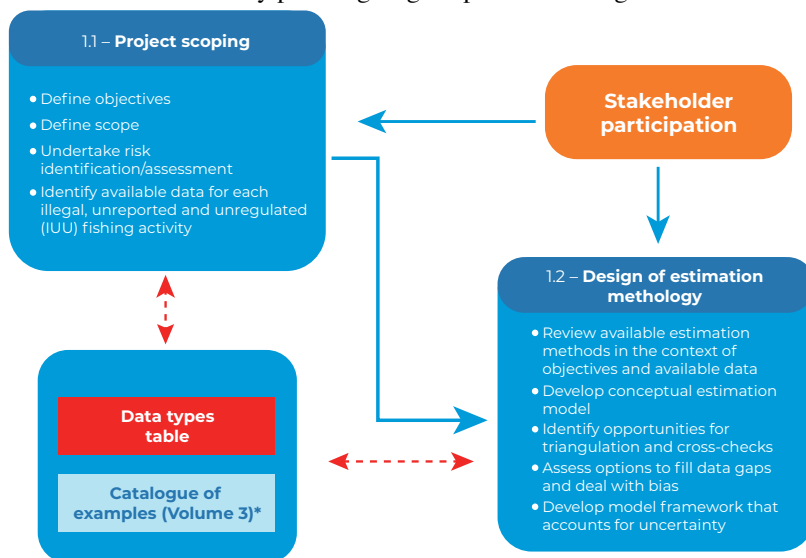


Figure 2. Overview of the study planning stage

Notes: *See FAO, 2023b, Implementation of the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing – 1. Methodologies and indicators for the estimation of the magnitude and impact of illegal, unreported and unregulated fishing: 1.3 A catalogue of examples. FAO Technical Guidelines for Responsible Fisheries, No. 9, Suppl. 1, Vol. 3. Rome.

2.1 Task 1.1 – Project scoping

2.1.1 Define the objectives

A key initial task for any IUU fishing estimation study is to define the objectives of the exercise. Study practitioners should start by being explicit about why they wish to identify IUU fishing activities. Some key reasons (see Volume 1, Section 2.2) include:

- improving stock assessments to inform policy advice;
- improving socioeconomic conditions for fishers;

- better targeting of monitoring, control and surveillance (MCS) resources, or monitoring of their effectiveness;
- advocacy; and
- monitoring changes in IUU fishing activity over time.

At this stage, practitioners should also have some idea of what level of information they are interested in. For instance, some studies may be interested only in generating a single estimate of overall missing catch to inform stock assessments, while others may be interested in a granular analysis of the nature and scale of each type of IUU fishing to assist in compliance planning.

The nature of the objectives chosen will greatly influence the types of methodology that can be used. Ideally, the objectives should be chosen with the participation of interested stakeholders and relevant experts. Clearly defined objectives serve to keep the project on track, and can then be used at the conclusion to judge whether the exercise has been a success.

2.1.2 Define the scope

The scope of the estimation exercise should be defined with as much precision as possible. With reference to Volume 1, Section 3.1.2, practitioners should aim to decide the following:

- Which fisheries/sectors?
- Which species – some specific species, or all?
- Which area/region?
- Which time frame?
- Which parts of IUU fishing (refer to Volume 1, Table 1)?

These questions should be answered in the context of the objectives defined above, and with a clear eye towards practicality, feasibility and resource availability. In order to quantify IUU fishing activity with as much precision as possible, every attempt should be made to limit ambiguity. The “boundaries” around each component of the scope should be clearly defined (e.g. “We are including only these species”; “The geographical boundaries of the study will be X, Y and Z”) and structured to minimize the potential for overlaps and double counting, or alternatively to exclude key areas of IUU fishing activity.

The nature of the various IUU fishing components to be estimated should be considered in the context of both the objectives of the study – e.g. when attempting to estimate only one form of IUU fishing (such as illegal foreign fishing) rather than all forms of IUU fishing within a fishery or area – and the legal frameworks in place in the study area. Activities which are deemed IUU fishing in one place may not be so in another. As with the study objectives, the scope of the project should ideally be decided with the participation of interested stakeholders.

It is very important at this stage to be explicit about what different types of activities will be considered IUU fishing, and what different types of IUU fishing the study practitioners are interested in estimating. Legal frameworks can be complex or require some interpretation/agreement when identifying what is illegal and what is not, so drawing on the expertise of local experts in the prevailing legal frameworks within the study area is often highly valuable at this stage. Where multiple IUU fishing activities are estimated within a particular fishery or area, clear definitions of each IUU fishing activity should be provided to limit ambiguity and the risk of double counting.

Pay particular attention to unreported discarding (see Volume 1, Table 1, row 6). This is often not strictly “illegal” or against regulation, and even when it is, it may not be considered “unreported” under the narrow FAO definition of IUU fishing (which requires that non-reporting or misreporting of catches should be deemed illegal in order to be considered IUU fishing). However, unreported discarding is increasingly considered to be an important part of describing IUU fishing, and therefore practitioners should explicitly state how their study will consider this issue.

There are other elements in unreported fishing, such as unreported recreational or artisanal/subsistence fishing. These are much less frequently considered IUU fishing unless the actions are strictly against regulation. Again, be explicit about whether these issues will be considered.

2.1.3 Undertake a risk assessment

Where the objective of the study is to assess total (or at least multiple forms of) IUU fishing activity within a defined fishery unit, a formal process of risk identification and/or risk assessment can assist in ensuring the full scope of IUU fishing activities is captured and appropriate distinctions/definitions are

made between each activity. In the context of IUU fishing estimation, risk identification is the process of identifying and defining actual and potential IUU fishing activities within a fishery unit (e.g. unlicensed fishing, underreporting of target species, non-reporting of bycatch, illegal transshipment). An example categorization of common types of IUU fishing activities relevant to estimation studies is provided in Volume 1, Table 1, although the specific risk types of relevance will be influenced by the legal frameworks in place for the study area.

The process of clearly defining IUU fishing activities through a formal risk identification exercise can help ensure comprehensiveness as well as minimize opportunities for double counting. Where the objective of the study is to estimate total IUU fishing volume and species composition within a fishery area, the process of risk identification also has the very practical benefit of helping break the IUU fishing “problem” down into its component parts, each of which can be estimated individually and aggregated to arrive at an overall estimate. Where resources are limited, a process of risk assessment may help to focus the study on the main activities contributing to the overall IUU fishing problem.

Where the objective of the study is simply to estimate the total missing catch (without quantifying the contribution of each IUU fishing activity), a process of risk identification may not be necessary.

2.1.4 Identify available data for each IUU fishing activity

Once the full range of IUU fishing activity has been identified within the study’s scope, the next main task is to identify the types of available data which can be used to help quantify the scale of each activity. The four components of design – objectives, scope, data and methodology – need to work together. To this end, practitioners need to understand what data are available for each scope element, and what combinations of estimation methods and data types can be used to estimate a particular type of IUU fishing.

For example, the best information to estimate the scale of unlicensed fishing within a given area may be aerial or at-sea surveillance data combined with vessel monitoring systems (VMS) for licensed vessels and average catch rates for the licensed fleet (assuming unlicensed vessels are of similar size and use similar gear). In contrast, the best information to estimate underreporting of

target species by licensed vessels may be vessel catch logs compared against independent observer reports, at-sea or dockside inspection reports, or e-monitoring.

To assist in identifying the main types of data that might be available, Table 1 provides a summary of the data types most commonly used in IUU fishing estimation studies, together with their potential uses and the main considerations for using each. We recommend that practitioners use the table to systematically understand and document the types of data that are available for estimating each of their particular IUU fishing scope elements. To this end, space is provided in the second column of Table 1 to note the extent of each data holding in relation to the sectors, species, areas and time frames identified in Section 2.1.2. This process should be undertaken in the context of the different types of estimation methods as well as the potential uses for each data type (Volume 3).

Table 1. Main data types commonly available for use in IUU fishing estimations, along with potential uses and key considerations

Type of data	Availability by scope element ¹ (refer to Section 2.1.2)	Data content and potential use	Considerations
Licensing / vessel registry information		Numbers of licensed vessels, types, gear/spatial/temporal authorizations, vessel characteristics, capacity, hold sizes, etc.	
Catch and effort data		Reported catch and effort from the licensed fleet. - Catch and effort data can serve as baseline data against which estimates of illegal, unreported and unregulated (IUU) fishing catch are compared. - These data can help estimate typical catch rates for particular combinations of area, gear type and target species that would be applied to “unseen” activity.	- Practitioners should consider the impact of any IUU fishing activity (e.g. underreporting, non-reporting) on the integrity of baseline data. - Where catch and effort data from licensed vessels are used to estimate likely catch rates / species compositions from unseen activity either of licensed or unlicensed vessels, practitioners should consider any likely differences in vessel characteristics, type of gear used and fishing operations between licensed and unlicensed vessels.

¹ This column provides space to make notes about the data available in the study: i.e. whether the data are available for all sectors, species, areas and time frames, as well as any data gaps.

Type of data	Availability by scope element (refer to Section 2.1.2)	Data content and potential use	Considerations
Fisheries observer data		Independent source of catch, effort and other information against which vessel reporting can be compared. - Along with electronic monitoring data, fisheries observer data is often one of the only information sources that can be used to measure the level of discarding. - In addition, along with electronic monitoring, this data type is often one of the only information sources that can be used to quantify impacts on the ecosystem (e.g. incidental mortality of birds, mammals, reptiles and fish, and impacts on sensitive benthic habitat). - The data are most useful for providing an estimate of the frequency of unseen activity, either by unlicensed vessels or by licensed vessels that are not being observed. - The data may provide direct observations of some IUU fishing activities engaged in by the observed vessel – e.g. fishing with illegal gear types, fishing in closed areas, shark finning – but are not usually reliable for identifying other vessels that might be engaged in IUU fishing activity.	Where observer coverage is partial (i.e. observers are not present on all boats, or on all trips), there will often be a bias in the data because the behaviour of vessels having observers and those not having observers – or trips on which observers are present and those where they are not present – may be different. These potential biases need to be explored. They can both be controlled for, for instance by comparing logbooks and landed catch from observed and unobserved boats operating in the same fishery at the same time and place; or by comparing the logbooks of a vessel when it has an observer with the logbooks from when it does not. If observer data are intended to be used with only partial coverage, practitioners should consider asking for statistical help to separate observer effects.

Type of data	Availability by scope element (refer to Section 2.1.2)	Data content and potential use	Considerations
			It may not be possible to use observer data to generate information on activities involving prohibited gear types. For instance, if the legal fleet is required to have seal escape panels in its nets and the unlicensed fleet does not have them, observer data will not allow for estimation of the impact of this unseen activity.
Electronic monitoring data		The uses for this data type are similar to those for fisheries observer data, but will vary according to coverage, technical capability and objectives of electronic monitoring systems.	Practitioners need to consider the implications of coverage, camera placement and image quality on the ability to detect different types of IUU fishing activity (e.g. whether cameras are operating on all operational areas of the vessel, or only at the site of gear deployment and retrieval; whether cameras are operating at all times, or only when gear is being actively deployed and retrieved; whether or not image quality is sufficient to detect and identify undersized or prohibited species).

Type of data	Availability by scope element (refer to Section 2.1.2)	Data content and potential use	Considerations
			- As with fisheries observer data, practitioners need to consider the impacts of any biases in coverage (e.g. whether all vessels in the fleet have cameras, and if not, whether some vessel/gear types are over- or under-represented) and/or the proportion of fishing activity reviewed. - Practitioners should consider potential changes in fisher behaviour where electronic monitoring is present – i.e. there should be effective comparisons between trips with electronic monitoring and those without.
Dockside catch monitoring data		Provides an independent record of catch. Landed catch records can be compared with vessel logbook data to identify misreporting or underreporting.	- These data provide information on landed catch only (i.e. no information on discards). - The data can be useful in creating an independent baseline dataset for when underreporting of catch (for example to evade quotas) or misreporting of species is suspected.

Type of data	Availability by scope element (refer to Section 2.1.2)	Data content and potential use	Considerations
Vessel monitoring system (VMS) data		High-resolution position information for the licensed fleet. - These data can be used to identify IUU fishing activity with a spatial/temporal component (e.g. fishing in an exclusive economic zone without a valid licence, or fishing in a closed area). - VMS data from multiple vessels (e.g. fishing vessels and carrier vessels) can be used to highlight potential illegal transshipment.	- This data type provides position information, but cannot be used by itself to confirm whether fishing is taking place. Additional analysis of VMS track history or "signatures" may be required to detect whether fishing is likely to be occurring, and usually a high temporal frequency of reporting (polling) is required for this. - The influence of polling rates on the capacity of VMS to detect offences should be considered. For example, a vessel with a polling rate of once per day may be polled outside a closed area on consecutive days, but spend a portion of its (non-poll) time within it.

Type of data	Availability by scope element (refer to Section 2.1.2)	Data content and potential use	Considerations
At-sea surveillance and dockside or at-sea inspection data		Reports from inspections conducted dockside or at sea, using standard procedures. - These reports provide independent, quantitative and (usually) standardized data on rates of non-compliance across IUU fishing activities (e.g. rates of offence/inspection for different offences; rates of unlicensed vessel detection per patrol hour). - At-sea inspections can provide data on infringements not easily detected through land-based or aerial surveillance (e.g. use of illegal gear, possession of prohibited species); they may also detect discarding.	- As surveillance by sea-borne assets (inspection vessels) is costly, monitoring, control and surveillance (MCS) authorities generally try to maximize their efficiency by targeting vessels with a history or behaviour that suggests a high risk of non-compliance with some regulation. Non-compliance levels derived from such data cannot therefore be applied uncritically across the fleet. Data need to be stratified, and should be analysed after consultation with MCS authorities. - The effectiveness of inspections – i.e. the proportion of offences likely to be detected – may also need to be considered.

Type of data	Availability by scope element (refer to Section 2.1.2)	Data content and potential use	Considerations
Prosecution data		- Prosecution data can provide a record of volume and species composition per infringement. - The data may be used in combination with other approaches (e.g. expert judgement) to extrapolate incidence rates across the sector.	- These data may consist of only small datasets and be influenced by single, large enforcement events. - Practitioners need to consider the extent to which available prosecution data are likely to be representative of all illegal activity – e.g. whether only large infringements are prosecuted, or whether the compliance effort is only focused on higher-level crimes.
Aerial surveillance data		Reports on positions/activities of vessels seen from overflights. - Aerial surveillance data can provide some quantitative basis for infringement rates (e.g. rates of uncensored vessels detected per patrol hour or numbers in a particular area), which may be used to scale up coverage across a wider area or time period. - The data can provide information on some infringement types (e.g. use of some illegal gear types detectable from the air) but not others (e.g. possession of illegal species in vessel holds).	- As above, practitioners need to consider the impact of compliance strategies and targeting – i.e. non-randomness of compliance effort – on the dataset, although this impact is less likely than with sea-borne assets. - Practitioners also need to consider the effectiveness of inspections – i.e. the proportion of different types of offences likely to be detected. For instance, sea-borne inspections may detect discarding or slipping of the catch, but aerial surveillance is unlikely to do so. - Aerial surveillance data may not be sufficient to detect whether vessels are engaged in fishing activity.

Type of data	Availability by scope element (refer to Section 2.1.2)	Data content and potential use	Considerations
Satellite: passive visual images or synthetic aperture radar (SAR)		• Satellite imagery requires complex processing and real-time images are costly, but historical images are often available at low cost. • This method can detect the presence of vessels across large areas of remote ocean. • Satellite imagery can be coupled with other forms of data (e.g. VMS data, Automatic Identification System data) to identify unauthorized vessels and transshipment.	• Satellite surveillance is restricted by the type of imagery required, the availability of satellites, the area covered by the image, and the resolution delivered. • Passive visual satellite images can be hindered by clouds. SAR is not hindered by clouds, but is not able to detect small vessels or those with a low radar image (e.g. wood, fiberglass), and it can be confused by certain sea states and floating objects (e.g. icebergs). • Satellite surveillance may be able to detect vessels, but it cannot distinguish between fishing and other vessel types (except by size), nor determine if fishing is taking place.

Type of data	Availability by scope element (refer to Section 2.1.2)	Data content and potential use	Considerations
Stock assessments		Estimates of unreported catches from stock assessments, using inconsistencies found between modelled stock trajectories and the source data: i.e. reported catch, age/length distributions in the catch, and independent indicators of stock abundance (such as catch per unit effort or independent surveys). • These can be compared against reported catch data to estimate total missing catch. • The data can be used as a cross-check to determine plausibility of IUU fishing estimates given known biological productivity of stocks.	• Robust, reliable stock assessments are required. • Although good estimates of unreported catch can often be made, these methods cannot determine the source of unreported catches. • This method works best when there are periods of high contrast, for instance when a period of high compliance is followed by a period of low compliance.

Type of data	Availability by scope element (refer to Section 2.1.2)	Data content and potential use	Considerations
Trade/market data		Trade/market data regularly collected by authorities in many jurisdictions. Data on exports or imports can be matched against catch reports from legal fishers to identify any discrepancies.	- Trade-based approaches work best where a high proportion of the product is exported, preferably to a limited number of destination markets, and where the species is easily identified and recorded in trade. For instance, bluefin tuna is individually recorded, but most gadoids are simply whitefish. - These approaches rely on having clear customs codes matchable between import and export destinations. - Practitioners should consider issues such as different product types, different factors for converting to whole fish, potential for double counting, fish re-exports, latency in the supply chain, and the possibility of misclassification under generic product names.
Expert judgement		Expert judgement can be used to “fill in the blanks,” by triangulating or scaling up estimates using other data.	- Expert judgement may be the main or only source of information where empirical data are limited. - This method requires robust elicitation processes to ensure information is credible and replicable where necessary.

Type of data	Availability by scope element (refer to Section 2.1.2)	Data content and potential use	Considerations
Stakeholder surveys		Specific surveys of stakeholders designed as part of an IUU fishing study. • These surveys can be used to infer the collective views of stakeholders on the nature and scale of IUU fishing activities. • They can be used to identify likely IUU fishing activities and may serve as a cross-check on estimates.	• Survey design should seek to limit subjectivity and ensure replicability. • Surveys are rarely the primary data source for estimates, but may serve as a useful cross-check for data-based estimates.
Confidential informants		• Confidential informants may be used to generate "inside" information where publication of the source would otherwise mean the information is not available. • This method is best used during a risk assessment when planning the IUU fishing study rather than as a source of information for the study itself, except when it is used as a means of triangulation of other IUU fishing estimates derived by the study.	• Confidential informant data are not easily verified by a third party, and are subject to individual bias on behalf of the informant. • Confidential informants should not be used as a primary source of information in an IUU fishing estimation study. They should be used sparingly and only for the purposes of corroboration or triangulation of alternative sources of information/ data.

Type of data	Availability by scope element (refer to Section 2.1.2)	Data content and potential use	Considerations
Media reports/ anecdotes		- These reports can be used to identify high-profile IUU fishing activities and cases in different areas. - Like confidential informants, these are best used during a risk assessment when planning the IUU fishing study rather than as a source of information for the study itself, except when it is used as a means of triangulation of other IUU fishing estimates derived by the study.	These data are typically of limited value for estimation given that reporting tends to focus on high-profile cases (e.g. large-scale enforcement events, detention of foreign flagged vessels, large successful prosecutions), with limited reporting on more “mundane” IUU fishing and limited access to the details of cases settled out of court.
Independent field surveys		Studies specifically designed to quantify elements of IUU fishing. - Independent field surveys can be targeted towards IUU fishing activities of interest (e.g. presence of illegal gear in the water). - Well-designed surveys can support robust, data-driven estimates of IUU fishing activity.	Practitioners need to consider the relationship between the sample surveyed and the broader population/fishery if results are to be extrapolated.

Type of data	Availability by scope element (refer to Section 2.1.2)	Data content and potential use	Considerations
Gear trials		Studies specifically designed to examine the performance impacts of illegal gear. - Gear trials can be used to estimate the catch rates of target and bycatch fish species for different gear types, including those likely to be used in IUU fishing, as well as their impacts on non-fish bycatch and the seabed. - The trials complement fisheries observer data.	Trials must be managed well, and the judgement made that acquiring data on the impacts of illegal gear types justifies the adverse environmental impact of the trial itself.
Local market surveys		- Local market surveys can be used to identify the prevalence of illegal products (e.g. prohibited species, undersized individuals) in local markets. - They are best used during a risk assessment when planning the IUU fishing study rather than as a source of information for the study itself, except when it is used as a means of triangulation of other IUU fishing estimates derived by the study.	- It is unlikely that survey data can be used for quantitative estimates of IUU fishing, unless coverage across the entire fishery is high. - Practitioners need to ensure representativeness and rigour in survey design. - Practitioners need to consider local social factors (e.g. willingness to reveal or display prohibited species) and the extent to which relevant species are traded through local markets vs other supply chains.

One data type which is sometimes used in IUU fishing estimates but not shown in Table 1 is AIS (Automatic Identification System) data. These data are derived from transponder-based tracking systems maintained by larger vessels for safety-at-sea purposes. Although they are potentially useful in detecting vessel positions and/or inferring vessel behaviour, and are available in near real-time from multiple providers, they are commonly used to cross-check other data types (e.g. VMS, SAR) rather than as the sole basis for an analysis. Reasons for this include:

- Coverage varies across fleets and areas (AIS is compulsory on vessels > 300 gross tons under the International Maritime Organization, but required for smaller vessels in some jurisdictions only), and therefore it may not be representative of the full set of fishing vessels of interest.
- Transmitters may be switched off or tampered with, or may fail, and even when operating properly signal transmission varies in quality – all of which can lead to further data gaps and biases.
- The use of AIS data for other than its intended purpose could discourage vessels from using it and thus have a negative effect on safety at sea.

The process of identifying the data available is best worked through with the participation of interested stakeholders (Box 1), including fisheries managers and MCS practitioners who will likely have a detailed familiarity with the nature and quality of the information available. Depending on the nature of the study, the involvement of industry at this stage can be helpful in identifying potentially useful sources of privately held data.

Bearing in mind that triangulation is highly desirable in IUU fishing studies, the combined use of different datasets is recommended. For instance, satellite surveillance on its own is of limited use, but when combined with vessel tracking data and observers, it may be possible to make a good estimate of the number of unlicensed vessels operating in an area and the likely catch rates they experience. Table 1 will help in understanding which data are available to assist with triangulation.

Box 1

Stakeholder participation

The active participation of stakeholders in the design and execution of IUU fishing estimation studies can be highly valuable for a range of reasons, including identifying key IUU fishing risks and activities, identifying and providing information to support estimates, providing expert judgement to help fill data gaps, and verifying preliminary outcomes. The involvement of stakeholders at all stages of the estimation process also helps build “ownership” and acceptance of the outcomes, thus ensuring a greater likelihood that recommendations stemming from results will be adopted. Conversely, studies completed in isolation from interested stakeholders run the risk of focusing on the wrong aspects or areas, overlooking important IUU fishing activities, and arriving at conclusions that may not be plausible.

A range of options exists to facilitate stakeholder participation in the study process. These options include the establishment of a study steering committee or advisory committee to oversee the process, holding a series of workshops (e.g. project scoping, checking results), involving stakeholders on study teams where appropriate, or undertaking stakeholder interviews.

The mechanisms to allow for stakeholder participation may differ based on the nature and objectives of the study, but should be sufficient to give key stakeholders confidence their input has been heard and to adequately incorporate their knowledge. These mechanisms should be decided at the earliest practical time in the study process to ensure relevant stakeholders have an opportunity to contribute to the project scoping tasks in the planning stage.

2.2 Task 1.2 – Design of estimation methodology

2.2.1 Review available estimation methods in the context of study objectives and available data

Once the study objectives have been decided and available data identified and reviewed, the different types of estimation approaches should be reviewed to identify those most appropriate for the circumstances of the study. There are many ways of classifying estimation approaches, and no “right” or “wrong” way to map methodologies.

Volume 1 of this series (FAO, 2023a) uses two groups of approaches, referred to as “top-down” and “bottom-up”. Top-down approaches are those which estimate a proportion of the catch that is likely to represent IUU fishing, or that use stock assessment or trade information to estimate an overall level of missing catch. Where the necessary data exist, these approaches can often be used cost-effectively, but they provide no information on the relative contribution of different types of IUU fishing activity to the overall IUU fishing problem. Bottom-up approaches, on the other hand, typically involve detailed analyses of information at a more granular scale in an effort to build a more accurate picture of IUU fishing activity. Bottom-up approaches can be helpful when quantifying the extent of specific IUU fishing activities; however, they can be time consuming, and often require work-arounds for patchy and incomplete data.

Volume 3 of this series (FAO, 2023b) provides a catalogue of 26 estimation methodologies, with guidance for each in terms of the key elements needed and how they can be sourced, the specific steps involved in constructing the estimate, and the applicability of the method. Two types of methodology maps are presented, one organized by approach type (including top-down and bottom-up) and the other by data source. If a certain approach type is preferred *a priori* (e.g. due to precedent or expertise), or if the methodology is to be built on a preselected dataset, then this can help determine the estimation methodology that will be more useful. If not, Volume 3 advocates using both approach and data source mapping to maximize the chances of finding an appropriate example methodology to follow.

It is not always necessary to select a single, best approach. Where necessary resources and data exist (or could be collected), the best studies will use multiple approaches to triangulate estimates (see Section 2.2.3). This could involve either using multiple independent data sources to triangulate estimates within a single methodology – for example, to inform best estimates, maximum and minimum ranges and distributions within a Monte Carlo simulation based on a bottom-up based approach – or using multiple methodologies (e.g. stock assessment and trade-based approaches) to arrive at independent estimates of the same problem (i.e. the total volume of unaccounted for catch).

2.2.2 Develop conceptual estimation model

Once a basic approach has been chosen based on objectives and data availability, a valuable first step is to develop a high-level conceptual model that sets out the logic of the estimation approach. Ideally, conceptual models should be relatively straightforward, describing in plain terms how the researcher intends to estimate IUU fishing (for each activity/sector and at the aggregate level, if relevant). Models should also identify the main data sources and, importantly, the key assumptions used at each stage of the estimation process. Conceptual models should be succinct and avoid the use of jargon, and thus can be very useful to help check and refine the “basic thinking” behind the proposed estimation methodology with stakeholders and independent experts.

Figure 3 sets out two very simple examples of conceptual models for estimating illegal harvest, including the approach, basic logic and main data sources.

(a) Estimation of illegal harvest by unlicensed vessels using a bottom-up approach**Approach:**

Estimated number of
fishing days by
unlicensed vessels

×

Average catch rate and
species composition
per day

=

Estimated volume
and species
composition of unlicensed
fishing

Basic logic:

The volume and species composition of fish harvested by unlicensed vessels in area X during time period Y is estimated by multiplying the estimated number of fishing days undertaken by unlicensed vessels by the average catch rate and species composition for similar vessels using similar gear types in the area. The number of days fished by unlicensed vessels is estimated primarily by scaling up aerial surveillance data (accounting for any biases in targeting and coverage). These are then supplemented by, and checked against, surface surveillance data, industry intelligence (e.g. sightings of unlicensed vessels) and vessel monitoring system (VMS) records of licensed vessels. Average catch rates for unlicensed vessels are estimated primarily from catches and species composition of licensed vessels fishing in the same area using the same gear type at the same time. These estimates are then checked and adjusted where necessary against boarding and inspection reports for prosecuted vessels and other relevant information (e.g. size of vessels and amount of gear in comparison to licensed vessels).

Data sources:

- Aerial surveillance data
- Surface surveillance data
- Industry intelligence
- VMS data (for licensed vessels)
- Catch rates and species composition for licensed vessels
- Boarding and inspection reports for unlicensed vessels
- Industry or enforcement officer intelligence

Assumptions:

- Catch rates and species composition for unlicensed vessels are similar to those for licensed vessels using the same gear type.
- Gear types used by unlicensed and licensed vessels are similar, or can be adjusted (e.g. based on inspection data).
- A combination of aerial, VMS, satellite and other data provides reasonable estimates of unlicensed activity by sector/species/area.

(b) Estimation of illegal harvest by unlicensed fishing operations using a trade-based approach**Approach:**

Export volume of
species X from country
Y in time period Z

−

Total catch of species X
reported by licensed
fishers in country Y in
time period Z

−

Estimated volume of
unlicensed fishing

Basic logic:

The catch of species X is almost entirely exported live from country Y, with very little domestic consumption. Country Y keeps good records of export volumes. The estimated volume of unlicensed catch of species X from country Y in time period Z is estimated by subtracting the total reported catch of species X by licensed fishing operations during the time period from the total reported export volume during the same period (accounting for any likely lags in the supply chain – e.g. product in stock at the start of the period and remaining in stock at the end of the period). Export volumes are determined from official trade statistics. Total reported catches are determined from logbook records for all fishing operations authorized to harvest species X.

Data sources:

- Official trade statistics
- Exporter information on stock at the start and end of the period
- Conversion factors
- Licensed fisher logbook records

Assumptions:

- There is minimal domestic consumption.
- Conversion factors are available for all traded products.
- The time windows of catches and trade are comparable.
- There is minimal re-export, or none at all.
- Products of unlicensed fishing pass through legal export channels.

Figure 3. Examples of basic conceptual models for (a) estimating overall catch and species composition by unlicensed vessels using a bottom-up approach, and (b) estimating illegal harvest using a trade-based approach

Where multiple forms of IUU fishing activity are estimated using a bottom-up approach, the development of a detailed conceptual model setting out each of the IUU fishing activities and the approach to estimation can highlight areas of potential overlap between IUU fishing activities, and also minimize the risk of double counting.

2.2.3 Identify opportunities for triangulation and cross-checks

Following (or in parallel with) the development of the “base” conceptual model to estimate IUU fishing, study coordinators should consider whether opportunities exist to cross-check or triangulate outputs using independent sources of data or alternative estimation approaches. Here we use “triangulation” to describe a practical means of testing the plausibility of model outputs using alternate sources of data or alternative analytical models (see Volume 1, Section 3.1.5).

Where necessary data and resources exist, the best studies will aim to use a number of estimation methods to triangulate estimates of the same IUU fishing problem. For example, estimates of the likely catch of an unlicensed vessel (Figure 3, panel a) could be generated by multiplying the catch per effort of licensed vessels by the estimated number of days fishing; or it could be generated by estimating the hold capacity of the fishing vessel and using information from port visits, combined with the time between port visits or transshipments (see Oozeki et al., 2018). VMS records could be used as a primary source of data to estimate the extent of fishing in closed waters in a trawl fishery, and aerial and surface surveillance reports could then be used to help verify the VMS data and/or extent of infringements. Bottom-up estimates of illegal harvest from a particular stock could also be cross-checked against stock assessment results to determine whether estimates of illegal harvest (when combined with legal harvests) are biologically plausible given the known productivity of the stock.

2.2.4 Assess options to fill data gaps and deal with bias

Once the basic approach and conceptual estimation model have been decided, study coordinators should examine the likely implications of any data gaps on the integrity/robustness of estimation outputs, as well as options to fill them. These options will often be determined by the time and resources available, but can be broadly categorized into two types: i) additional data collection, and ii) statistical approaches.

The capacity to undertake additional data collection will often be influenced by the types of data used for estimation. For example, where the primary source of data used is aerial surveillance, the chances of contracting additional flights for the purposes of estimation are likely to be small. Similarly, where pre-existing datasets are used as the primary basis for estimations (e.g. trade figures, historical logbook records) there may be little prospect of gathering additional data (unless the scope is changed – e.g. to add additional years). Nevertheless, where the estimation is based on current sources of data (e.g. observer or electronic monitoring coverage, dockside inspections) or independent surveys, it may be practical to target additional data collection to address keys gaps.

Where data biases and gaps cannot be solved by new data acquisition, a second option is to address them statistically. For instance, gaps in temporal or spatial series may be filled using interpolation, and biases in sampling design (particularly with observers and inspections) can be dealt with through post-sampling stratification. Ideally, options to address data gaps should be reviewed with the involvement of an experienced statistician to ensure the approaches used are robust, and are undertaken in the most cost-effective manner.

Where no practical options exist to fill data gaps, any uncertainty should be reflected in final estimates of IUU fishing activity (e.g. by having a wider range of plausible estimates and/or broader statistical confidence intervals).

2.2.5 Develop model framework that accounts for uncertainty

Once the approach and conceptual estimation model have been decided and the main features of the available data understood, study coordinators should move on to developing a detailed model framework including estimation algorithms for each relevant IUU fishing component as well mechanisms to account for uncertainty. In practice, these algorithms and mechanisms will often be considered together as part of an integrated model.

The nature and complexity of the algorithms used will depend on the methodology adopted and underlying data. “Simple” estimates of a single IUU fishing activity may be relatively straightforward, while estimates of multiple IUU fishing activities across multiple sectors may be computationally complex, with large numbers of parameters. In all cases, algorithms used should be described in sufficient detail to allow a reader to make an informed judgement of their reasonableness.

A number of mechanisms to account for uncertainty have been used in studies to estimate IUU fishing. While we do not seek to be prescriptive, the key requirement is that the mechanisms be statistically robust and ultimately present an accurate reflection of uncertainty given the information available to the study. Two of the most common approaches are detailed below. (Bayesian frameworks may also be used, but require considerable specialist knowledge.)

- **Monte Carlo simulation:** Monte Carlo simulation is a widely used analytical technique for calculating probability distributions of possible outcomes by performing a large number of trial runs, in which variables are substituted randomly from within a specified range. This simulation has previously been used by a number of authors in attempts to estimate IUU fishing activity (e.g. Pitcher et al., 2002; Ainsworth and Pitcher, 2005; Agnew et al., 2009). The approach has a number of benefits over “single point” or deterministic models in that it generates probabilistic results. Monte Carlo simulations can be performed by writing bespoke code in a number of programming packages, or alternatively through a number of commercially available software packages.
- **Bootstrapping:** Bootstrapping is a similar technique to Monte Carlo simulation, although it differs in that it resamples only from pre-existing data – i.e. whereas a Monte Carlo simulation samples from a theoretical distribution within defined parameters, bootstrapping resamples the data as given over and over. Bootstrapping has the advantage of not requiring assumptions about the underlying distribution of the data or their properties, and might be used instead of Monte Carlo simulation where a strong dataset exists. Nevertheless, as the data available for IUU fishing estimations are often patchy, Monte Carlo simulations may have more utility.

An example of how one study dealt with uncertainty is given in Box 2.

Box 2

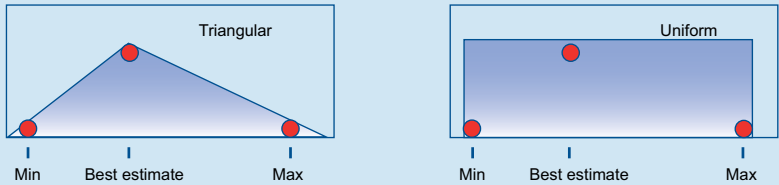
Dealing with uncertainty

In their studies estimating IUU fishing in Western Central Pacific tuna fisheries, MRAG Asia Pacific used a bottom-up approach to calculate regional-scale estimates of the volume and value of IUU fishing. This involved first breaking down the IUU fishing problem into discrete, quantifiable units, and then aggregating these up to calculate a regional-scale estimate. The process consisted of five main stages:

- 1 Identifying IUU fishing risks.** The first stage involved identifying the main IUU fishing risks (e.g. unlicensed fishing, mis- and underreporting, illegal transshipment) in each of the main fishing sectors (purse seine, tropical longline, southern longline). These were identified using previous studies in the region and through discussions with key stakeholders, and then agreed on at an initial planning workshop.
- 2 Determining best estimate and minimum/maximum ranges.** The next stage involved identifying the information available to support estimates of IUU fishing activity, and then using that information to determine a “best estimate” level of activity and the most plausible minimum and maximum values. Given the highly variable nature of the IUU fishing risks, a basic calculation to quantify likely IUU fishing volume and species composition was tailored to each risk based on the information available. As a general rule, this consisted of an uncertain value (e.g. the number of days fished by vessels on the Pacific Islands Forum Fisheries Agency [FFA] Regional Register in exclusive economic zones for which they were unlicensed) being multiplied by a known value (e.g. the average catch rate and species composition per day in the relevant sector) for each risk. Best estimates and minimum/maximum ranges could then be assigned to the uncertain value based on the nature and quality of the information available. Minimum and maximum ranges were then used to gauge the uncertainty of the available information base (i.e. risks with more certain information had narrower ranges, and risks with limited information had wider ranges).
- 3 Assigning likely probability distribution.** Once best estimate and minimum/maximum values were assigned, a likely probability distribution of IUU fishing activity within this range was determined. In general, triangular distributions were used where there was a reasonable level of confidence that the actual level of IUU fishing activity was likely to be closer to the best estimate than

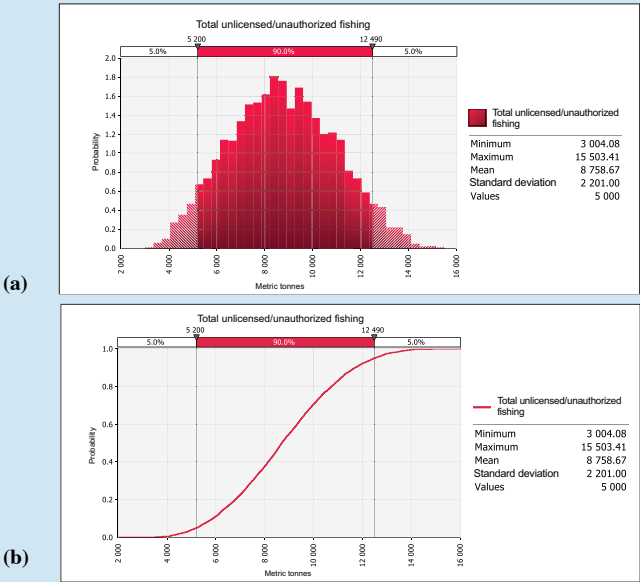
either the minimum or maximum value. Uniform distributions were used where the information base was highly uncertain, although in general these were avoided.

Figure A. Triangular and uniform distributions



4 Monte Carlo simulations. Monte Carlo simulation was then used (using @Risk software) to define the relative probability that IUU fishing volumes were within certain ranges, based on the best estimate and minimum/maximum values as well as the probability distribution assigned. Where a triangular distribution was assigned, randomly selected simulations involving values around the best estimate were assigned a higher probability than simulations involving either the minimum or maximum values. In this way, the best estimate value would be given higher weight in the ultimate probability distribution (see Figure B, panel a).

Figure B. Monte Carlo simulation



To that end, uncertainty was factored into the estimates in three ways:

- The width of the minimum/maximum range: In most cases, the narrower the minimum/maximum range around the best estimate, the more certain the inputs.
- The probability distribution chosen for the Monte Carlo simulations: For risks in which the best estimate was relatively strong, triangular distributions around the best estimate were chosen – i.e. the probability of the actual level of IUU fishing being close to the best estimate was assumed to be higher than it being closer to the minimum or maximum value.
- The probability distribution produced by the Monte Carlo simulations: This gives estimates of the likelihood that the actual IUU fishing estimate would be above or below chosen benchmarks (see Figure B, panel b).

5 Quantifying ex-vessel value. Based on the likely volumes and species compositions associated with each risk, the ex-vessel value of IUU fishing activity was calculated by assuming likely markets (sashimi grade for longline yellowfin, canning grade for purse seine yellowfin) and market values based on known trade and market data. From this, the likely ex-vessel value of fish caught through IUU fishing was calculated both collectively and each sector.

Sources: MRAG Asia Pacific. 2016. *Towards the quantification of illegal, unreported and unregulated (IUU) fishing in the Pacific Islands region. A report prepared for the Pacific Islands Forum Fisheries Agency (FFA).* Brisbane, Australia.; MRAG Asia Pacific. 2021. *The quantification of illegal, unreported and unregulated (IUU) fishing in the Pacific Islands region – a 2020 update. A report prepared for the Pacific Islands Forum Fisheries Agency (FFA).* Brisbane, Australia.

3. PHASE 2: STUDY EXECUTION

An overview of the study execution stage is provided in Figure 4.

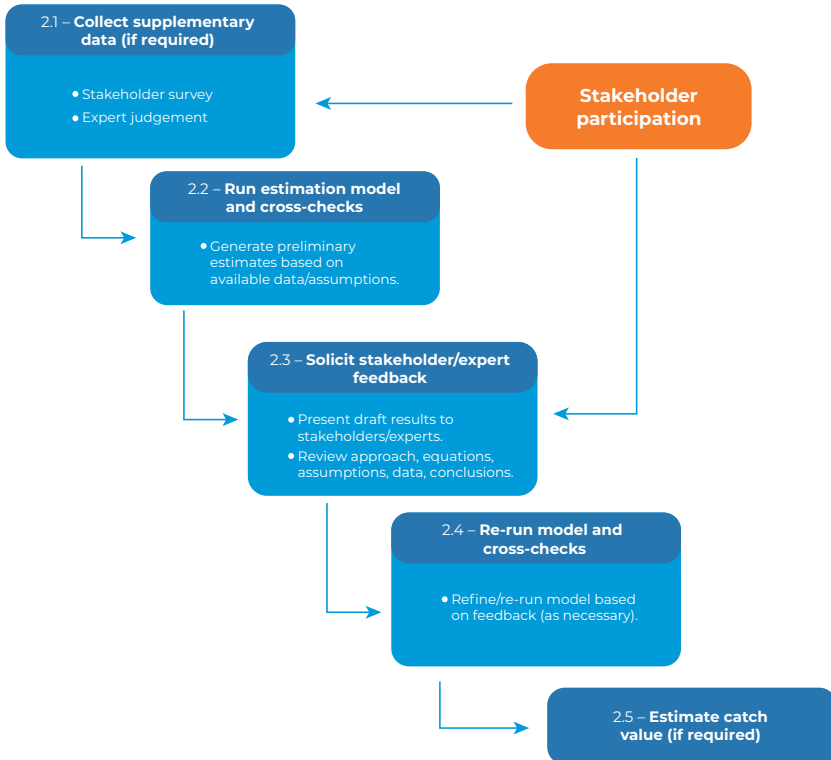


Figure 4. Overview of the study execution phase

3.1 Task 2.1 – Collect supplementary data (if required)

Where the analysis in Task 1 determines that additional data collection is required (or desirable), study coordinators should make arrangements for the necessary data to be collected before running estimation models. Efforts around additional data collection should involve people with statistical expertise (to ensure maximum robustness in the data collected) and stakeholders (to facilitate ease of collection and to point out possible sources of data) as required. All additional sources of data and methods of collection should be well documented.

3.2 Task 2.2 – Run estimation model and cross-checks

Once model algorithms have been developed and data entered, the estimation model should be run to generate preliminary results. Where possible, multiple iterations of the model should be run to test sensitivity to different data inputs and alternative plausible assumptions.

Model cross-checks should also be run to allow the plausibility of preliminary model outputs to be tested.

3.3 Task 2.3 – Solicit stakeholder/expert feedback

Following the generation of preliminary results, model outcomes (and cross-checks) should be presented to key stakeholders/experts for review. This can be done either in written form or, ideally, through a more interactive process such as a Steering Committee or workshop. Where stakeholders have not previously been introduced to the model structure, data inputs and assumptions, these should be outlined in detail to ensure familiarity with the approach and model, such that all are able to provide constructive input.

Whether feedback is sought in written form or orally, study coordinators should seek feedback that is practical with clear justification. Where stakeholders believe an assumption or outcome is implausible for some reason, a clear rationale should be provided, ideally with a more plausible alternative.

All outcomes from feedback exercises should be recorded to allow study coordinators to demonstrate how the model inputs, outputs and assumptions have been refined in response to feedback.

3.4 Task 2.4 – Re-run model and cross-checks

Following feedback from key stakeholders/experts, the estimation model and cross-checks should be re-run incorporating any suggested refinements to model structure, inputs and assumptions. Changes should be well documented and outputs compared with the original version to demonstrate the impact of changes.

Importantly, this process of checking and refining model inputs and assumptions may be repeated multiple times before a “final” version of the model, inputs and assumptions is achieved.

3.5 Task 2.5 – Estimate catch value (if required)

Once final estimates of IUU fishing volume and species composition have been obtained, estimates of IUU fishing catch value can be generated using the approaches outlined in Volume 1, Section 4.3. Researchers should clearly specify whether they are generating estimates of ex-vessel or market value, as well as the data sources and the justification for each estimate. Where the economic consequences of IUU fishing are discussed in the context of the results, care should be taken not to confuse the value of IUU fishing catch with losses to interested parties, including coastal states.

4. PHASE 3: STUDY PRESENTATION

An overview of the study presentation stage is provided in Figure 5.

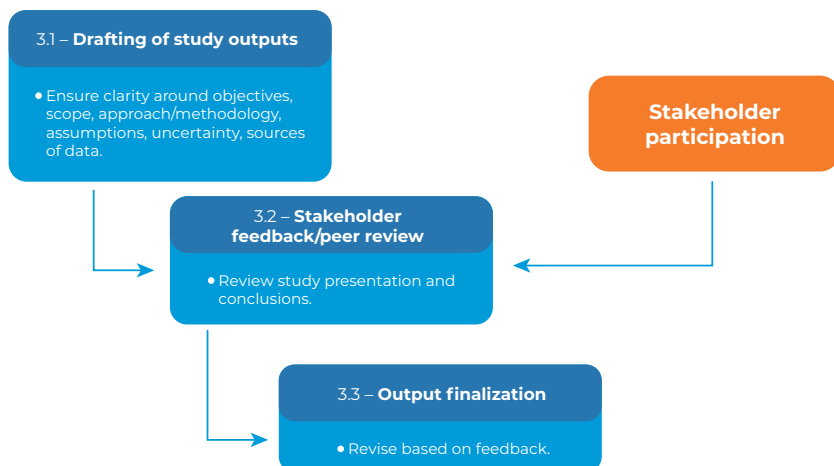


Figure 5. Overview of the study presentation phase

4.1 Task 3.1 – Drafting of study outputs

Once final estimates have been generated, study coordinators should begin the process of drafting the main study outputs (see Volume 1, Section 5). Many previous IUU fishing estimation reports lack clarity around key features of the approach and methodology used, with the net result that readers are not in a position to make an informed judgement about the reasonableness of the outcomes, or their potential implications (FAO, 2023b, Annex 1).

The checklist in Volume 1, Table 2 should be used to ensure the inclusion of all key elements necessary to understand the basis for a study, its results, and the estimates of confidence around those results. All IUU fishing studies should fully document the decisions taken during project scoping (Section 2.1) and the methodologies and assumptions that were used to estimate IUU fishing, as well as the relevant triangulation studies and the approach to handling uncertainty and bias (Section 2.2).

The presentation of model outputs will depend on the approach and methodology used, but should provide the reader with a clear sense of relative certainty in the outcomes (e.g. by providing a best estimate and statistically derived probability distribution of likely results). The implications of any key assumptions, data weaknesses and interpretations of IUU fishing activity for the purposes of estimation should be discussed.

4.2 Task 3.2 – Stakeholder feedback / peer review

Once the main study outputs have been drafted, feedback should be sought from key stakeholders/experts or through peer review, as required. The key task here is to ensure the approach and methodology have been presented with clarity, there are no obvious errors or omissions, and any conclusions or interpretations drawn are reasonable and justified.

4.3 Task 3.3 – Output finalization

Following the receipt of stakeholder or peer review comments, study outputs should be finalized, taking into account the feedback received.

5. REFERENCES

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Illegal, unreported and unregulated (IUU) fishing activity is a persistent and pervasive problem in many different types of fisheries around the world. Understanding the nature and magnitude of these activities is an important, but often daunting, step toward combatting them.

As part of a series of technical guidance documents on estimating IUU fishing activity, this practical guide to study design outlines a logical, step-by-step progression from planning to execution to presentation of results. At its core, it focuses on establishing a coherent alignment between study objectives, available data and appropriate methodologies to generate robust, data-driven estimates of IUU fishing activity.

Key concepts such as designing a conceptual model, triangulating alternative approaches, dealing with data gaps and biases, and accounting for uncertainty are explored. The importance of including explicit feedback loops for stakeholders and experts in each phase of the study are also discussed.

