Pacific Community
Communauté du Pacifique

Creel and market surveys:

A manual for Pacific Island fisheries officers

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Prepared by the Fisheries, Aquaculture and Marine Ecosystems Division
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Noumea, New Caledonia, 2016

Original text: English

Pacific Community Cataloguing-in-publication data

Creel and market surveys: A manual for Pacific Island fisheries officers / prepared by the Fisheries, Aquaculture and Marine Ecosystems Division of the Pacific Community

1. Fishes — Oceania.
2. Fisheries — Oceania.
3. Fishery resources — Oceania.
4. Fisheries — Catch effort — Oceania.
5. Fishery management — Oceania.

I. Title II. Pacific Community

338. 37270995 AACR2

ISBN: 978-982-00-1028-4

Prepared for publication at
Pacific Community, BP D5, 98848 Noumea Cedex, New Caledonia

2016

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Cover photos by Brad Moore.

Acknowledgements

The development of this manual was only possible through the concerted efforts of many people. In particular, the Pacific Community (SPC) wishes to thank the Heads of Fisheries in SPC member countries for their continued interest, support and patience. SPC would like to extend a particular thanks to Heads of Fisheries staff in those countries where the techniques and methodologies described in this manual were trialled: Valentin Martin and the staff at the Department of Resources and Development and Office of Fisheries and Aquaculture in Pohnpei, Federated States of Micronesia; Suresh Chand and the staff of the Fisheries Department in Fiji; Raikaon Tumoa and the staff of the Fisheries Division in Kiribati; Glen Joseph and the staff of the Marshall Islands Marine Resource Authority; Monte Depaune and the staff of the Nauru Fisheries and Marine Resources Authority; Percy Rechelluul and the staff of the Bureau of Marine Resources in Palau; John Kasu and the staff at the National Fisheries Authority in Papua New Guinea; Nunia Mone and the staff of the Fisheries Department in Tonga; and Samisoni Finikaso and the staff at the Tuvalu Fisheries Department. Special thanks go to the fishers and communities who participated in the trials, for providing access to their catch, and sharing information about their past and present fishing activities.

SPC also acknowledges the many people involved in drafting and commenting on this manual, in particular Franck Magron (Reef Fisheries Information Manager) and Lindsay Chapman (Deputy Director Coastal Fisheries) from SPC's Fisheries, Aquaculture and Marine Ecosystems Division. This publication is based on the draft, 'Creel and Market Manual for Fisheries Officers' prepared by Ursula Kaly, Garry Preston and Being Yeeting, and developed for SPC through consultancy number 11/75. This earlier draft was revised and chapters rewritten based on extensive field testing and the development of the SPC Creel and Market Survey Database designed to support the manual. Our warm thanks to Stuart Roberts, Angela Templeton and Kim Des Rochers for editing the manual, and to Boris Colas who was responsible for the illustrations, layout and cover design.

The Pacific Community (SPC) gratefully acknowledges the European Union for its partnership on the Scientific Support for the Management of Coastal and Oceanic Fisheries in the Pacific Islands region project (SciCOFish, coastal component), and for funding the field trials and drafting of this manual. SPC would also like to thank Australia's Department of Foreign Affairs and Trade for funding the final production, printing and distribution of the manual.

This publication has been produced with the assistance of the European Union and Australia's Department of Foreign Affairs and Trade.

Abbreviations and terms used in this manual

Abbreviations

cm	centimetres
CPUE	catch per unit of effort
FAO	Food and Agriculture Organization of the United Nations
FL	fork length
FO	frequency of occurrence
HIES	household income and expenditure survey
kg	kilograms
m	metres
mm	millimetres
PICTs	Pacific Island countries and territories
SciCOFish	Scientific support for the management of coastal and oceanic fisheries in the Pacific Islands region
SD	standard deviation
SE	standard error
TL	total length

Terms

Creel survey	Estimate of fishers' catches and effort, usually by a sampling programme involving interviews and measures of individual catches.
Data	Plural for datum. Data are measurements taken of some aspect of the real world (e.g. number of fish, length of fish, or number of crabs on a market table).
Extrapolation	Extending a method or inference based on statistics to an unknown situation by assuming that existing trends will continue or similar methods will be applicable.
Frequency	In statistics, this is the number of times an event occurs in a sample or study, and is often represented graphically in histograms.
Market survey	A survey focusing on the fish being traded through a fish market, stall or shop, to capture information from people who are either selling fish directly to the public or those who sell to buyers.
Mean or average	A way of summarising a set of individual measurements by adding all readings together to form a total, and then dividing by the number of readings. The terms average and mean are used interchangeably; average is typically used when writing a report, and mean is used when doing statistics. In Microsoft Excel, the formula is =average(data range) e.g. =average(A1:A20)
Optimisation	Using statistics to obtain the best value out of a sampling survey. The idea is to balance getting the best precision or power for different levels of sampling effort (and hence cost of the survey in time and/or money).
S^2	Variance. A measure of the spread of values around their mean. Units are squared values and, therefore, not often used in reporting. Calculated as the average of the squared distance measures from their mean.
Sampling	Collecting information (data) on an unbiased subset of information. The whole set of information is the 'population' and if information is known for the whole population, it is called a census (this does not refer to just the human population, but could be a census of all trees >5m on an island). For most kinds of surveys, the whole population cannot be censused, especially for natural populations such as fish. In that case, the population should be sampled and that information should be used to infer what the whole population is like.
SD	Standard deviation. A standardised measure of spread of values around their mean. Values are in the same units as the mean. In Microsoft Excel, the formula is =stdev(data range) e.g. =stdev(A1:A20)
SE	Standard error. The standard deviation of a sample of means from the true mean.
Statistic	A single measure of some attribute of a sample (e.g. its arithmetic mean value, variance, standard deviation or standard error).

Stratified sampling	Where the sampling design is divided into non-overlapping groups or strata (e.g. types of fishing, age-groups of fishers). A sample is taken from each stratum, often in proportion to the size of each stratum.
x	Symbol to refer to any single measurement or reading

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1. Introduction

1.1 The role of surveys in fisheries management

Coastal fisheries resources have sustained Pacific Island peoples for thousands of years.. Today, coastal fisheries contribute significantly to the food security, livelihood and culture of both rural communities and urban populations throughout the Pacific. However, in many areas, the benefits of coastal fisheries have been undermined by habitat degradation or loss, poor land management practices and pollution, destructive fishing practices and overexploitation of harvested species; while in other regions, a lack of understanding of the status of resources is a recognised shortfall in the ability to manage resources over time. With pressures on coastal fisheries projected to increase across the Pacific region due to the effects of increased population growth, climate change and other anthropogenic stressors on coastal ecosystems, there is an urgent and growing need for information that will assist with developing well-informed fisheries management strategies.

Assessment and monitoring is essential to successful fisheries management. Without basic data on the status of fisheries resources, it is not possible to monitor changes in a fishery, undertake adaptive management measures, determine whether management strategies are working, or avoid the 'shifting baselines' phenomenon (i.e. an incorrect shift in perceptions of the baseline population). A range of survey types exist for examining the status of fisheries resources, and their socioeconomic values, including:

- in-water underwater visual census-based approaches;
- tagging or catch-and-release studies;
- experimental/independent fishing (e.g. depletion studies to estimate catch rates and gather biological information);
- creel surveys, sometimes referred to as fisher surveys or landing site surveys;
- market and buyer surveys, including commercial and subsistence markets;
- biological assessments (e.g. assessments of age frequencies, size- and age-at-maturity, mortality rates); and
- socioeconomic surveys (e.g. surveys of households, fishers groups), including household income and expenditure surveys (HIESs).

1.2 Purpose of this manual

This manual provides a guide to the design, planning and implementation of two types of surveys commonly used to assess and monitor artisanal and subsistence fisheries: creel and market surveys. The manual simplifies the conduct of these surveys by suggesting some simple approaches that could be applied by fisheries officers and built upon if more information is required for management or more locations need to be assessed. The focus is on a question-and-answer approach, only suggesting what might be necessary (and yet sufficient) to produce meaningful results using resources (time and money) sparingly. This is based on experience gained and lessons learned from past work and real examples of data that the authors of this manual have collected with the assistance of Pacific Island fisheries agencies.

1.3 Who this manual is intended for

This manual is intended for Pacific Island fisheries officers and managers. However, it will also be useful to a wide range of practitioners tasked with assessing and monitoring coastal fisheries resources in data-poor, tropical fisheries, including:

- staff from non-governmental organisations (NGOs);
- research institutions and universities; and
- international and regional organisations.

The more people or agencies that use this standardised approach to collect creel and market data, the better the understanding of how finfish and invertebrate resources respond to fishing pressure and management approaches, which in turn allows for adaptive management measures as new results are made available from the data.

1.4 How this manual is organised

This manual helps you design your own creel or market sampling programme to help answer questions about a fishery, the state of fished resources, and the contribution of fisheries to livelihoods and local economies. The approach used begins defining the question that you need to answer (i.e. what do you want to know from your survey?), and then shows you how to design a survey, collect the relevant information, and analyse the results to find the answers to your question. The manual also provides information on logistics, sample datasheets, step-by-step calculations that you can do yourself, access to a database for data storage and analysis, and guidelines on how to use the data for management purposes.

The approach used is flexible and focuses on *slices* of data collected in *modules*. Data from creel and market surveys can be used for a range of purposes, in differing situations, and may be needed to collect current-status and/or long-term information of a particular resource. To do this, data are grouped so that one set of techniques (e.g. counting) are separate from those data that require different techniques (e.g. measuring, weighing or interviews), and which will lead to additional time and resources. These are the data slices we will be using. A module is the sampling you will do in one place at one time (i.e. when, where and how many landings you will collect data for, based on the slices you have chosen to do). Doing this means that the survey is efficient because the time and resources required for the survey are actively selected by you on the basis of the type(s) of information you need.

In this manual, the minimum module that can be used at one place and time is defined, and the manual shows you how to expand that module when answers to your questions require more information. There are several advantages to doing things this way and sticking to it:

- a one-off status report can be produced (if required) and results can be gained quickly;
- surveys could be repeated at a later date even if there is no funding or plans to do so right now, and if you follow the same basic module you would end up with a valid and useful longer term survey (called a time series);
- if other fisheries offices in your country or in other countries follow the same basic design, the results can be examined by you and/or others to examine patterns within and across places, and to gain a broader geographic perspective; and
- even if the same basic design is not used, you can use historical data to get a rough idea of how the state of resources or the fishery has been changing over longer time periods (e.g. decades).

This manual contains four chapters, plus support material in the appendices that provide a guide on how to use the tools in the manual. The Introduction (Chapter 1) provides a brief overview of the rationale, objectives, scope and design of this manual. Chapter 2 introduces the reader to initial planning and survey design considerations. Chapter 3 provides tips for undertaking a survey, including advice on species identification and interviewing fishers. Chapter 4 provides information on some of the basic analytical techniques and interpretations of typical data recorded by surveys. In this chapter, we also provide an example of a report outline to show you what kinds of information you could include in your report. Following these is a series of appendices with information and supporting material to help guide you in your surveys, including a workbook to help you design and plan your survey, datasheet templates for creel and market surveys, completed example datasheets for each type of survey, and more information on the statistical concepts introduced in the manual.

Ideally, you would also use the SPC Creel and Market Survey Database designed to accompany this manual to make your work easier. This database has been designed to match the survey datasheets, and helps you store your data safely. It also produces a range of reports (or 'queries') to help you analyse and present your data quickly and in a manner consistent with other surveys.

2. Designing a creel or market survey

2.1 What are creel and market surveys, and why conduct them?

It is clear that after years of trying to establish effective monitoring programmes for coastal fisheries throughout Pacific Island Countries and Territories (PICTs), it is time for simpler, more affordable approaches that are:

- flexible yet standardised;
- driven by need within PICTs;
- able to produce outputs that are useful to fishery decision-makers in a timely manner;
- designed to be started and stopped if required to get instantaneous information; and
- able to build a picture of the resource or fishery, and monitor management measures over time (the ideal scenario).

There are many ways to obtain information on fisheries, including from fishing vessel logsheets, export and other trade data, household surveys, agricultural censuses, experimental fishing trials and biological sampling. Creel and market surveys are ideal assessment and monitoring tools for PICTs because they are inexpensive, require little specialist equipment, can provide information on the state of resources from a single survey, and focus on the heart of food security and livelihoods for Pacific Island populations.

2.1.1 Creel surveys

Creel surveys, which are sometimes called fisher surveys or landing site surveys, collect information on the catch landed by fishers. Creel surveys are usually carried out at ports or boat ramps, although in some cases you may be able to intercept individual fishers when they land their catch at their house, at the the fish market, or at a fish buyer's door. These types of surveys produce very useful information on catch and fishing effort, and allow for the sampling of large quantities of fish concentrated into relatively few landing sites. The information collected can include areas and/or habitats fished and fishing method used, species composition of the catch, length or weight frequencies, amount of effort taken to catch the fish (i.e. number of fishers and hours spent fishing), costs of the fishing operation (e.g. fuel, ice, wages), and the income received from the sales of fish, invertebrates and other seafood.

The term 'creel' is an Irish word that refers to a wicker basket traditionally used by anglers to hold their catch.

Creel surveys are often used to estimate the condition of a resource, but it is necessary to be aware that any characteristic you measure during a creel survey (such as length of individual fish in the catch) may not be representative of the actual resource. Fishers target certain sizes, species, or sexes of the species they are catching. Creel surveys are a 'fisheries-dependent' form of sampling (see boxed text on page 4) , meaning that the resulting data are influenced by the practice of fishing. 'Fisheries-independent' sampling methods, such as in-water survey approaches, can be better for getting data on a population without the influence of fishing, but are often more expensive and difficult to do. In addition, at best they only provide information on the relative abundance, density and/or biomass of resources in the water, and tell us nothing about the fishers that are part of the 'fishery' and very little about how a fishery is impacting a population.

2.1.2 Market surveys

As the name suggests, market surveys focus on the fish and invertebrates that are traded or sold through a fish market (either the whole market, or a subset of a seller's tables), stall or shop. A market survey captures information from people who are either selling fish directly to the public at markets (such as those commonly found throughout the Pacific), or those who sell to buyers on a more commercial basis. Like creel surveys, market surveys can include the collection of data on the fish themselves (such as species composition, numbers and size), but instead of focusing on fishing patterns, such as location(s) fished, gear type used, and effort spent fishing, market surveys focus more on the economic value of fishery products.

While market surveys are an excellent way of gathering data about the economics of a fishery and the importance of particular species or fisheries to the local economy, and may provide information on the species and sizes of fish and invertebrates harvested, they are generally not very good at estimating the condition of a resource. In addition to the 'filtering' that occurs in creel surveys from the actions or preferences of fishers, market surveys include even more filtering. Vendors may choose not to buy certain species from fishers based on their customers' preferences, and so these species will very likely not show up in your survey. Vendors may keep less marketable fish for themselves and only offer higher value or legal species or sizes for sale. Vendors may also have standing orders for specific kinds of fish and invertebrates, and these may be sold before the market day begins. In many markets, fish products may be processed to varying degrees by salting, smoking, cutting into pieces, and combining with other food products. In addition, customers prefer certain species and sizes over others, so if you conduct your survey after the market has opened, these species will be under-represented in your survey because they have already been purchased and taken home by customers. So, the fishery that is observed via a market survey is likely to be quite different from the wild population, or the proportion of the population that is observed in a creel survey. This should be kept in mind when interpreting the results of both types of surveys.

Fisheries survey methods are generally grouped into two categories: fisheries-dependent and fisheries-independent approaches. Fisheries-dependent approaches are where the data come from the fishery itself (e.g. creel surveys, logbooks, port sampling) while in fisheries-independent sampling the information is collected independently of the fishery (e.g. in-water surveys, experimental fishing).

2.2 Deciding which survey to use

Before beginning a survey, it is essential to be clear about how the information will be used, and by whom. Creel and market surveys can be designed to estimate many types of fisheries information for a range of reasons and interested parties. This may include gathering information to advise government officials and fishers on the state of a particular resource, as well as reporting on compliance for international agreements. This manual focuses on localised data collection by fisheries staff for use in advising fisheries managers, fishers and communities about the status of fisheries resources. Mastering these techniques will lead to a good understanding of the principles of sampling, and open the way for a more complex survey should that be needed in the future. Some typical questions that are often asked, and the recommended survey methods that can be used to address them, are given in Table 1.

Table 1. Survey types and the questions that can be answered by each one

Questions	Survey type(s) to use
1. Do you want to know about the fishers themselves, find out what they are catching and what methods they are using?	Creel
2. Do you want to know about the fisheries resources, the species involved, how they are caught, and the state of the fished species?	Creel
3. Do you want to know about how fishery products are being sold, at what price(s), and how they contribute to local food supplies and the economy?	Market
4. Do you need an overview of the whole process of small-scale fishing in an area, including the state of the resource, the fishers, and the marketers?	Creel + Market surveys used together

Appendix 1 contains a workbook for helping you plan your survey. Once you have decided what type of survey you want to do, write it down in this workbook. For example:

Step 1: Decide on what type of survey you need

Step 1: Decide on which type of survey you need to do (you will need to fill out this form for each type)		
Type		Include? (✓ or ✗)
Creel survey	Creel survey Pacifica 2015	✓
Market survey		

Asking who and what the survey is for is one of the most basic questions to ask when designing a survey. Making decisions on what the data will be used for, and by whom, sets the stage for the rest of the design, the work you do, and how you analyse and present the results. If you do not get this step right, the rest of the survey may be of limited use. Knowing *what* you want out of the survey will determine what slices of data you need to collect, and (if you repeat the survey) how much sampling effort you should apply and how you will analyse and present your data. This manual guides you through all the steps for each type of survey.

Knowing *who* the information is for will help you design a survey that will meet their needs. If you are informing your Minister or Director of Fisheries on the status of resources and providing management recommendations, you will need to provide clear evidence for the need, suggest actions, and then monitor outcomes of those actions (usually by repeating your surveys). If you are informing fishers or communities, you may need to adjust the type of information you gather in order to meet their needs and convince them to assist with the process.

Of course, there may be multiple uses for the data you collect, and several groups of stakeholders who could benefit from it. Additionally, the user group may change over time. For instance, a fishery that is not being actively managed at present might need more stringent management measures if it becomes overexploited. There is a need to retain flexibility in data collection approaches, although it is still important to consider which people are the most likely users of the information, and then tailor the survey design to their needs.

2.3 What questions will your survey answer?

Designing your survey starts with a decision on what fisheries information you want to obtain; that is, what are the specific questions that need to be answered for your management requirements? Table 2 and Table 3 will help you choose the slices of data you may want to get information on. The slices are coded as Slice C1 to C7 or M1 to M6, in order to identify them as either creel (C) or market (M) questions. Questions are grouped according to the approach or set of survey equipment to be used, and next to each slice is a rough guide on approximately how long each will take to complete. Column 3: 'What information to record,' provides an idea of the kinds of data you will need to collect for each survey type. Once you have decided on what slices of data you need to collect, write these down in the workbook in Appendix 1. For example:

Step 2: Decide on what questions you need answers to and which slices of data to collect.

Step 2: What questions do you need answers to, and which slices of data will you need to answer your questions?		
Slices	Time (minutes)	Include? (✓ or ✗)
C1 or M1 - Basic information on fishers and vendors	10	✓
C2 or M2 - Species composition	10	
C3 or M3 - Species sizes	30+	✓
C4 or M4 - Species weights	30+	
C5 - Catch effort data	30+	✓
C6 or M5 - Prices	10	
C7 or M6 - Perceptions of fishers and vendors	20	
Total time per replicate	Total =	70 minutes

Table 2. Choosing slices of data for a creel survey

Slice	Questions you can answer	What information to record
C1: Basic Information on fisher(s) (10 mins)		
	• How many, and who are the fishers that land in the area? Where do they come from? • How often do they land there? Where else do they land? • How many other fishers worked with them? • How often do they fish? • How do the fishers catch fish? • What form of livelihood does fishing provide? • What is the average overall weight of the catch (estimated by eye)? • What is the average income earned from fishing per trip?	• Name of fisher(s) • Age of fisher(s) • Whether the fisher is fishing alone, or with others, and if, fishing with others, how many fishers were there • Address (village, town or city) of fishers • How often the fisher(s) go fishing • What fishing methods they use • Where they land their fish, and how often at each location • Why they go fishing (for subsistence, income, or both) • Eye estimate of the weight of the catch • Estimated income expected from the catch
C2: Species composition (not needed if you do C3, C4 or C3+C4) (10 mins+)		
	• What is the catch composition of fish, invertebrates and other species? • What is the total number (by species or group) landed? • Are there any changes in this number over time?*	• Count of all items caught by species, family or major group (e.g. reef fish, sea cucumbers, clams) • Total weight by species, family or major group (e.g. reef fish, sea cucumbers, clams)
C3: Species sizes (30 mins+)		
	• What is the catch composition of fish, invertebrates and other species (by abundance)? • What is the size frequency distribution of species landed? • What percentage of the catch is under or over the size at maturity? • What is the average size? • Are there changes in sizes over time?*	• Fork length, carapace or shell measures of all items landed
C4: Species weights (30 mins+)		
	• What is the catch composition of fish, invertebrates and other species (by weight)? • What is the weight distribution by species landed? • What is the weight landed by family? • What is the total weight landed? • Are there any changes in the weights landed over time?*	• Weights of all items landed
C5: Catch effort data (for CPUE) (30 mins+)		
	• What gear types were used and for which species? • Which areas were fished? • What is the distance travelled to fish? • How much time was spent fishing? • What type of boat or engine was used? • What is the CPUE (several measures)? • Are there any changes in CPUE over time?* • What safety gear (e.g. life jackets) is being used?	• Fishing gear used during the trip • Gear type used to harvest each species/species group • Time spent fishing (by gear type) • Cost of gear and any losses or damage • Cost of fuel • Other costs • Distance travelled to fish • How many sites were fished, and where fishing took place • The boat and engine type used and safety equipment on board
C6: Prices (10 mins)		
	• Where are the fish sold? • What is the price per item or weight at sale? • How does the price change over time?*	• Where the fish are sold • Whether items are sold by the piece or unit of weight • What the prices are for each category sold
C7: Perceptions of fishers (20 mins)		
	• What are the changes in fishing conditions and benefits over time? • What are the fisher's perceptions over time?*	• How long the fisher has been doing this type of fishing (for this species or group, and gear used) • What other types of fishing they do • Whether they are fishing in the same places now as they were five years ago • Whether they are catching the same quantities and sizes as they were five years ago • Whether they have any concerns about the resource

C8: Totals for annual reporting (for this you will need multiplier data)	
• How often do people go fishing?	• The total number of fishers and boats operating in the area
• What is the total number of fish caught? (requires C2 or C3/C4)	
• What are the number per species or family (C2, C3 or C4)?	
• What is the total weight of fish caught (C3 or C4)?	
• What is weight per species or family (C3 or C4)?	

* These depend on repeating your survey over time (see Section 2.3 for more details)

Table 3. Choosing slices of data for a market survey

Slice	Questions you can answer	What information to record
M1: Basic information on marketer(s) (10 mins)		
	• How many marketers are operating in the area (separate companies from individuals)? • How long people or companies have been selling seafood? • How many people are working together in different enterprises? • Where is marketing done? • Where do marketers live in relation to the market? • What is the average income per day of a vendor?	• The type of vendor: buyer, company, stall at a market, or other • Name of company or individual • How long the person has been marketing • Age of company or individual • The number of people involved in the marketing endeavour (company or market stall) • The address of marketer (village, town or city) • The location of the market operation (village, town) • The expected income from today's sales
M2: Species composition (10 mins+)		
	• What is the species composition of marketed products? • How much of each species or group is marketed per day, per month, per year, per operator and overall?	• Count of all items on sale at that time
M3: Species sizes (20 mins+)		
	• What is the size distribution of species marketed? • Are crustaceans in berry being sold? • What is the size distribution by family or species of the individuals on sale? • What is the proportion of population over size at first reproduction?	• Fork length, carapace length or shell measurements of all items marketed • Sex and berry condition for crustaceans
M4: Species weights (30 mins+)		
	• What is the weight distribution of species marketed? • Are crustaceans in berry- or spawning-state being sold? • What is the weight sold (total, or by family or species)? • What is the total tonnage per day, per month, per year?	• Weights of all market items • Sex and berry condition for crustaceans (if not doing M3)
M5: Income from marketing (10 mins)		
	• What is the source of the marine products on sale? • What is the average income from marketing activities for each type of marine product? • What are the costs of marketing? • What is the contribution of fishing to livelihoods in the area? • What types of processing methods are used on the marine products on sale?	• Where the marine products come from • Whether the vendor pays for fish from fishers • The costs per species or group • The costs of marketing (e.g. rental of tables, electricity, salaries) • Whether the vendor processes the fish. The types of processing for each species or group • Costs of wages or salaries to workers • Prices per species or group
M6: Perceptions of marketers (10 mins)		
	• What are the changes in markets and income over time?	• How long the vendor has been marketing • Whether they have marketed elsewhere • Whether they have any other job or source of income • If marketing is not their only source of income, why they do other jobs • Whether their income from marketing has changed over time, and if so, in what ways • Whether they have any concerns for this activity in the future (explain)
M7: Totals for annual reporting (for this you will need multiplier data)		
	• What is the total number of fish and invertebrates sold through markets (requires M2, M3 or M4)? • What are the number per species, per family (M2, M3 or M4) being sold? • What is the total weight of fish sold (M4)? • What is the weight per species or per family (M4)?	• Number of marketers operating in the area • Values from M2, M3 and/or M4

Slices C1 and M1 are the only mandatory slices; that is, they are required for each landing you meet or market stall you visit. These slices collect basic information on the 'lead' fisher or marketer (i.e. those in charge of the trip or market stall), and on other fishers or vendors involved.

Slices C2 and M2 are designed to obtain counts of species caught or sold. As a bare minimum, you could use Slices C1+C2 or M1+M2 for the simplest survey that answers questions on who the fishers or vendors are, and on the type and abundance of the species they catch or sell. You can see from column 2 in Table 2 that collecting these data will give you answers to at least eight or nine fisheries questions. This should take around 20 minutes per catch landing or market stall surveyed (although this depends on the number of fish in the catch or on the table), and only requires a datasheet and pencil. These slices (C1+C2 or M1+M2) and most of the others can also be used to expand on questions concerning changes in any of the measures over time (and in response to management actions).

Slices C3 and M3 involve measuring the lengths of the individual fishes or invertebrates you encounter. If you include C3 or M3 in the survey you will obtain much more information for management, but you will need more time and additional equipment (such as a fish measuring board) to do this. It is strongly recommended that you include size measurements in any creel or market survey, especially if you repeat your survey over time, because fish size can be a key measure for detecting overfishing or improvements in the state of resources. A reduction in the sizes of fish or invertebrates being landed and/or sold can indicate that there is too much pressure on the breeding population, while comparing your size data with known records of size at maturity will provide an instant measure that could be used to guide management decisions. You could also combine the information with legal size limits in your country or territory and detect infringements to fishing regulations. It is recommended that when you collect data for Slice 3 you **measure the entire catch or contents of the table**, or at least an unopened cooler, that comprises a sample. It is best if you do not actively subsample (i.e. choose which individuals of the catch to measure) because this carries a large risk of introducing new bias into your data.[1] When including C3 in your survey you do not have to count and measure the fish separately; because you have recorded the lengths of each individual fish you can simply count them to get the total number of each species for the landing.

We strongly recommend that you include Slices 1 + 3 + 5 for a useful minimum creel or market survey. This combination focuses on the minimum measurements that will give you good returns for detecting fisheries management issues.

In slices C4 and M4, weight data are collected. You could collect these measurements in addition to the length measurements in C3 and M3 above, or collect weights (C4 and M4) instead of lengths (C3 and M3). This may be a particularly good idea if the fish in your area are sold by weight instead of by the piece. Individually weighing all fish will add considerable time to your survey and require the use of extra equipment such as scales. There are published length–weight relationships for most commercially-important species, and these are embedded into the SPC Creel and Market Survey Database to assist with calculating weights from length data. Recording weight is therefore less critical if you are short on funding and time. As with measuring the catch, if you choose to use C4 or M4, it is important that **you weigh the entire catch** or at least the contents of an unopened cooler for any single landing or table, if possible. As with Slice C3, if you weigh the entire contents of the catch or table you do not then have to count the individuals as well — you can simply tally your counts at the end of the replicate.

[1] It is very difficult to select individuals from a sample for measuring size or weight without bias. You will unconsciously tend to pick large or small animals, or base your choice of the next individual to measure on the size of the previous fish selected. These will cause a bias in the values, as the length or weight frequencies of those individuals measured are unlikely to be representative of the entire catch. Measuring the entire catch or the contents of whole, unopened coolers may actually be quicker and will not introduce these biases.

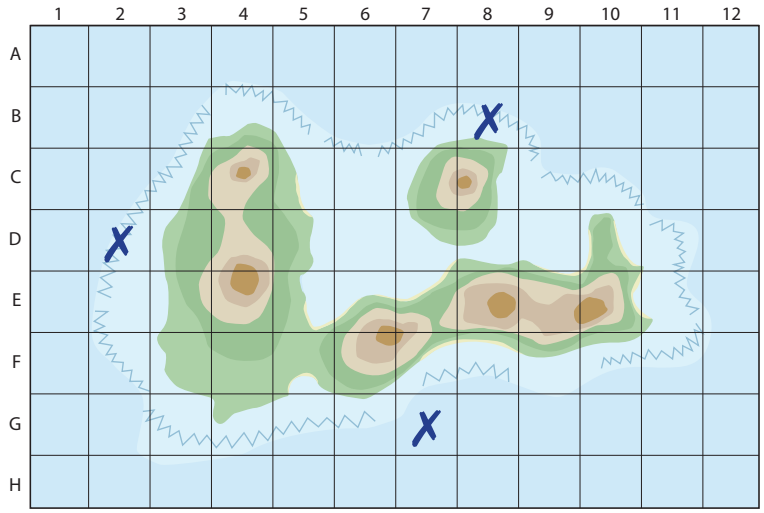
Slice C5 concerns the location where fishing took place and the amount of effort spent fishing, which can be used to calculate catch per unit of effort (CPUE). CPUE data are generally considered reflect abundance. By collecting effort data through interviews with fishers, it is possible to calculate simple estimates of how easy or hard it is to catch fish, and therefore whether fish may be becoming scarer or more plentiful. The measures could include the number or weight of fish caught per trip, per fisher for each hour fished, per litre of fuel, or the distance fishers travelled in order to catch fish. If the fishery becomes stressed, the number (or weight) of fish caught per unit of time or litre of fuel would decline, while the time spent fishing or the distance fishers had to travel would likely increase. These are often good indicators that a fishery is becoming overexploited and that management measures may be needed or adapted. The data you collect in this slice is actually just the 'effort' component; you would combine this information with catch data from C2, C3 or C4 in order to get CPUE. Data collection can take time and can be subject to error if fishers remember things incorrectly, or deliberately give misleading information. It may be worth printing out the datasheets for this slice and giving them to fishers to fill out as logsheets when they go on fishing trips. This strategy could save you time in the field and may make it easier for fishers to collect and organise the data. You would still need to meet fishers at the landing sites in order to get information for the remaining slices. At the end of the month you could hold a raffle and give fishers who returned completed logsheets the chance to win a prize. This may turn out to be less expensive than doing the survey yourself. If you do meet the landings and collect these data yourself, it is worth bringing a map or aerial photo of the area so the fisher can point at the locations fished. Beyond this, the only equipment needed for this slice is the datasheet and a pencil.

Consider giving logsheets to fishers to complete as a way of getting effort data for C5.

Information on prices (C6 and M5) and perceptions (C7 and M6) provide insight on how fishers and vendors benefit from their fishing or selling, and what their perceptions are about the state of resources they are harvesting and selling. This information is part of the broader picture of what might be happening with the fishery, but is less focused on detecting the state of the resource(s) from direct observations. These two slices are collected during the interview and do not require any additional equipment. They also do not need to be done often, perhaps around once per year for each fisher.

Some fisheries agencies are assembling information for the Food and Agriculture Organization of the United Nations and other regional agencies on an annual basis and need ways of estimating total annual catch or total annual sales. If you know the average number and/or weight landed per fisher or sold per vendor, and the number of days spent fishing or selling (i.e. the number of fishers or boats operating, and the number of days they go out fishing; or the number of market stalls and the number of days they operate) you can multiply the values to get an estimate of total catch or total annual sales. Your estimates will depend on how much area you survey (which may be quite small), the time period over which you survey and how much variability there is in the catch. You may be able to use census or HIESs to find out how many fishing or marketing days there are, although it is recommended that those data be fairly recent (i.e. five years or less). If you need to find out the total number of fishing days or marketing days directly (rather than from a survey or census), you will need to do an additional survey to obtain these 'multiplier data'. Appendix 2 provides more information on obtaining and using multiplier data to estimate total catches from an area or time period, and a form for conducting special household surveys to obtain multiplier data.

Some fishers may be unwilling to provide their exact fishing location during the survey. A good way around this is to create a map of the area with standardised grid squares overlaid on it, such as in the example on the right. Fishers will then be able to indicate the grid square where they fished without giving away their secret spot.



Example of a map overlaid with grid squares to determine approximate fishing location.

You should occasionally carry out additional surveys to understand how important fishery resources are to local commerce. More information on these types of surveys, including a brief survey form, can be found in Appendix 3.

2.4 Defining the area for one sampling site

The slices of data you selected above give you the first part of your survey design, as they link to the fisheries questions you want to answer. To complete the design, you need to consider exactly how, when and where those measurements would be collected. This will provide the structure for your creel or market survey, and allow you to determine how much sampling you need to do in order to detect patterns and changes in the fishery, and how much your survey might cost.

The next step is to define the area of a single sampling site. To do this for a creel survey, you need to decide on a focal spot, plus a certain radius of area around it. For example, you may choose to visit landings in a certain village or town, and so may decide on a 2-km radius around the main boat ramp, jetty or market (e.g. Figure 1). Or, you may only need a 1-km radius if the fishers tend to land all of their catch on the same beach or jetty. Whatever the size of a single site, it needs to include all landings in that general area, thus making them all part of the same landing site.

Figure 1. Examples of landing sites: A landing site in Pohnpei, Federated States of Micronesia (left) and Faua wharf in Tongatapu, Tonga (right).

It is simpler to define your sampling site for a market survey because a sampling site will usually be a single market area. This could be a large informal main market where goods are displayed on temporary tables or groundsheets, a formal market with permanent stalls or buildings, or a series of tables assembled on a

roadside. In some cases, the survey may consist of separate shops or buyers in a town. In such a case, your area of interest would be the town as a whole, and the replicate sampling units would be shops instead of tables. Once you have defined your site of interest, record it in the workbook in Appendix 1:

Step 3: Define the area you will cover for one sampling site

Step 3: Define the area you will cover for one sampling site		
1 module will centre on:	Radius	
A town, village or place ☑ | One whole market ☐ | Paddletail Port	1	km

2.5 Ensuring your landings are replicates: Stratified vs. random sampling

Coastal fisheries in the Pacific are highly variable in terms of species caught, fishing behaviour, the dynamics of individual fishers, areas or habitats fished, and the fishing methods used. This is challenging for creel and market surveys because it leads to data that can vary widely from catch to catch, or stall to stall, with one landing being dominated by, for example, deepwater snappers, while another is dominated by invertebrates such as octopus. One way of dealing with this variation is to break your landings down into distinct categories, of which individual landings will be 'replicates'. Separating your survey into distinct categories of factors is termed 'stratification'. One stratification approach commonly used in fisheries is to examine results on the basis of fishing method, such as night spearfishing, bottom fishing and trolling. In the creel survey design above, a stratified approach by fishing method as your distinct category would be identifying the 20 landings that relate to a single fishing method (e.g. night spearfishing). You could then conduct additional surveys (e.g. handlining, netting) to cover other individual fishing methods. The opposite of this is random sampling, in which no consideration is given to sampling within distinct categories (categories are sampled randomly).

Stratifying your design (e.g. by different fishing methods or day types (such as weekday vs. weekend)) is highly recommended because it has two main advantages: 1) it provides the ability to separate the results of various activities, allowing for more detailed assessments of each activity; and 2) it provides more reliable statistical estimates for each activity (due to lower variances and subsequent standard error (SE)). However, if stratifying, you *may* need to complete more replicates than you would for unstratified surveys in order to cover all of the different categories you wish to examine (although this would be balanced out by having lower variances and SEs than unstratified approaches).

2.6 Conducting a pilot survey

There is a tendency for people to want to jump straight into the field and start sampling as soon as possible. The problem with doing that is you might use up all of your resources (i.e. time and budget) collecting data that are not good enough to answer the questions you need answers to. If, for example, you decide that a 20% decline in CPUE in a certain fishery is important, conducting a survey that cannot detect any decline unless it was at least 50% would be a waste of time and money, and would not lead to effective management. It is necessary to be strategic and thoroughly plan the survey, so that it can detect the trend or pattern you are interested in, should it occur.

An important consideration when designing a survey is to consider how many replicate landings are needed to detect patterns and changes in fishery measures. If you could meet every single landing and speak to every fisher, you would be conducting a census rather than a sampling, and could just report the total number of fish, their sizes, and the characteristics of the fishers or vendors as complete data of all activity in the area. In practice, most fisheries agencies in the Pacific cannot afford to do that; there may be hundreds of landings or market tables in one place per month. The whole point of sampling is to get information from a few representative samples, and use those results to infer what is going on overall, without having to meet every landing or survey every market stall.

This is where pilot sampling and optimisation come in. Once you have decided on your slices (the types of data you are going to collect) and modules, you need to collect some test data. Print out 10–20 datasheets and go to at least one site and conduct a survey. You may be able to use those data as part of your survey later, unless you find some problems with the survey, in which case, it was good that you tested the survey first. To assist with this, a blank creel survey datasheet is included as Appendix 4, while an example of a completed creel survey datasheet is included as Appendix 5. Similarly, a blank market survey datasheet is included as Appendix 6, while an example of a completed market survey datasheet is included as Appendix 7.

During your pilot survey you will be able to:

1. check that your equipment works and collect some data with it so that you know whether you can continue on with the main survey;
2. practise conducting the survey;
3. get some initial data so that you can optimise the survey design;
4. find out if there are any problems that need to be fixed (do you need to meet landings at a certain time? Are vendors happy with you handling their fish while they are trying to sell them? Do they want you to use gloves? Have you informed the community that you will be conducting surveys? Are community members cooperating? If not, what do you need to do to gain their cooperation?
5. determine what sites you will need to sample. For creel surveys conduct an initial walk-through of the entire sampling area you have defined, and make sure that you know where all of the landing sites are.

Make sure you keep track of your time and become good at estimating how long it takes to do a single replicate. This information will help you determine how long it will take to complete your module.

Once you have completed a pilot survey at your site of interest, record the main outcomes in the workbook in Appendix 1:

Step 4: Conduct a pilot survey

Step 4: Conduct a pilot survey	
Pilot survey outcomes	Result or description
Dates of pilot survey	1 May – 6 May 2015
How many test replicates did you do?	20
How many sites did you visit?	1
Do you have all the equipment you need?	Yes
Do you need to buy or repair any equipment?	No
Are there any problems to solve?	Yes, inform community and fishers
What landing places are included in the modules?	Several areas close to each village
How long, on average, did it take you to survey a single landing given the slices you selected?	C1/M1 = 10 minutes C2/M2 = C3/M3 = 30 minutes C4/M4 = C5 = 30 minutes C6/M5 = C7/M6 =
Total time for selected slices	70 minutes

2.7 Optimising the survey design

Once you have conducted the pilot survey, think about the experience you have just gained. Have you defined the area well? Do you know where the fishers will land their catch? Were there any problems that need to be fixed?

Understanding how much sampling you need to do is a critical component of a survey design. With too little sampling you may not be able to detect changes in key variables, while too much sampling could be of little value and a waste of time and money.

This manual focuses on using estimates of precision for optimising your sampling design. Choose some actual measures you took on the pilot survey, such as the total number of individual fishes in each catch, the number or weight of individuals of a particular species or family of interest in each catch, or CPUE for each landing. For example, in the cases of handlining or spearfishing this could be the number or weight of individuals caught by each fisher per hour spent fishing. Calculate the average (avg) and standard deviation (SD) for each of these measures from your pilot dataset. To determine how many replicate landings you need to survey for each level of precision use the following formula:

$$n = \left(\frac{SD}{P \times avg}\right)^2$$

where in this case: n = number of replicates required;
SD = standard deviation;
P = your desired precision level; and
avg = average of the measure you are calculating precision for.

Appendix 8 contains more in-depth information on precision, including an example of calculating precision from CPUE data. Once you have done some precision calculations on the pilot data, look through all the measures you tested (such as average catch or CPUE) and choose a precision level that you think is reasonable for all of them — one that has a reasonable and realistic number of replicates you would need to conduct per module. Ideally, you should meet enough landings to gain a precision level of at least P=0.2, or better yet P=0.1. Obtaining precision levels less than this (e.g. P=0.01 or 0.001) for a module would require surveying hundreds to thousands of landings, which is likely far more than there are boats fishing in the area.

Step 5: Optimise the design

Step 5: Optimise the design						
Optimisation results			Result or description			
How many sites did you use for the optimisation?			1			
How many test replicates did you use?			20			
What measures did you test? / What were the results for each level of precision?						
Precision level =	0.01 (i.e. 1%)	0.1 (i.e. 10%)	0.2 (i.e. 20%)	0.3 (i.e. 30%)	0.4 (i.e. 40%)	0.5 (i.e. 50%)
1. CPUE (no. fish per fisher per hour)	4422	44	11	5	3	2
2. CPUE of red snapper (no. fish per fisher per hour)	5959	60	15	7	4	2
3.						
4.						
5.						
What level of precision did you accept?						20%
What difference among means will you be able to detect?						40%
What number of replicates did you decide to use overall?						20

2.8 Expanding the survey geographically and through time

So far, you have decided on your minimum module, which establishes what kind of work you would do in one site at one time. This is called a module because it can be repeated in its entirety in other places and over time to expand the context of the questions you defined in the slices; for instance, if you want to know whether the number or size of *Lutjanus gibbus* being landed or sold is the same (or not) at other sites, and whether the number is changing over time. You do not have to expand your survey all at once, although it is highly recommended that you do so in order to include all of the sites you plan to repeat. This allows you to plan your budget better and will enable you to answer more questions than you might when simply conducting a one-off survey. Expanding the survey will cost more time and money, but it will also tell you more about what is going on with the fishery and the state of resources. Getting information from one site is not likely to be good enough to generalise patterns of landings or sales for a whole region or country. Also, getting data only once will not tell you if the state of the resources is improving or getting worse. Answering the questions in Table 4 will help you decide how to expand your survey.

Table 4. Expanding questions to include different locations and times

Question	Expansion needed
1. Do you need (or only have resources for) a one-off survey (a 'snapshot') of what is going on in one place? A particular problem may have arisen there and you want enoughw information in a status report to take some action now. If more funds become available later you could expand the question using the same module design. For now, however, you cannot do it.	None: Just do the module
2. Do you need to provide snapshot information on several villages that have requested it? Or do you need information across the country?	More sites
3. Do you need to monitor changes at one place in relation to seasons or changes in management (e.g. surveying inside and outside of seasonal closures)?	More times (e.g. repeat sampling weekly, monthly, bimonthly, quarterly, every six months)
4. Do you need to monitor differences among sites and over time? That is, do you need to know how the state of resources is changing over time at several places?	More sites + More times

In the creel survey example provided in Figure 2, the basic module of surveying 20 landings for data slices C1+C3+C5 was repeated at three sites, and at two times (one year apart). The design could be expanded to as many sites and for as long as resources (time and money) allow, or could be done more regularly. For example, you may have enough resources to survey each week, or survey a few replicates per month, or every 6 months. Once you have determined whether you need to survey other sites or other times, note this in the workbook in Appendix 1.

Step 6: Do you need to add other sites and/or times to the survey?

Step 6: Do you need to add other sites and/or times to the survey?			
Do you need:	More sites	More times	Tick one ✓
A snapshot	No	No	
More sites, just a snapshot	Yes	No	
More times, but just one site	No	Yes	
More sites and times	Yes	Yes	✓
If you need more sites, what are they?	1. Jighead Jetty 2. Barracuda Beach 3. Wrasse Wharf		
If you need more times, what sampling interval?			Tick one ✓
Monthly?			
Bimonthly?			
Quarterly?			✓
Six-monthly?			
Yearly?			
Other? (Explain)			

2.9 Calculating the cost of your survey

Understanding what resources you have available to do the work is key when designing a survey. Using the workbook in Appendix 1, follow the steps to work out how many sampling days you need for each module. Multiply that estimate by the total number of days required to complete all of the sites you have in mind for one time. What does it come to? If you planned, for example, to survey 10 sites, and it takes four person-days to complete each module, you need 40 person-days to complete a single survey. Is that realistic? If only one person is available to conduct the survey and they can only do it monthly, there is a problem because 40 days of work every month would be needed to conduct the survey.

Now is the time to examine the resources you have and ensure that the survey design is practical. In the case of the example above, you may be able to get more staff to help with the survey, or you may choose to repeat the survey less often (e.g. conduct it only every six months). If you can estimate the time needed to conduct a survey, you will then be able to calculate a partial budget for that survey.

Consider whether you will need to pay allowances, provide lunches, or arrange work plans with your manager to allow people to do this survey. What will it cost? You may need to submit a budget in order to get approval for the survey.

Step 7: Calculate the cost of your survey

Step 7: Calculate the cost of your survey		
Total cost of your survey as time	**Number**	**Units**
a. Time to do a single replicate given your slices and the estimates suggested in this manual [Step 2]	1.2	hrs
b. Time to do a single replicate given your selected slices and your pilot data [Step 4]	1.2	hrs
c. Time to do a single replicate given your slices and pilot data [Step 4] in days = b/8	0.15	days
d. What precision level are you working with?	20%	% of average
e. Number of replicates for selected precision [Step 5]	20	replicates
f. Multiply c by d to get days per module	3	days/module
g. How many sites do you propose to survey at a single time?	4	sites
Subtotal: Multiply e by f to get total days for all sites or markets at one time	12	**days/survey**
Budget for your planned survey	**Number**	**Units**
i. Total number of days to do all sites at one time (from subtotal above)	12	people days
ii. Number of staff available to do one full survey (all sites, one time)	4	people
iii. Divide i by ii to work out how many calendar days would be needed	48	days
iv. Allowance per person per day	10	AUD
v. Multiply i by iv to get total allowances needed	480	AUD
vi. Cost of printing datasheets	50	AUD
vii. Cost of equipment	100	AUD
viii. Other costs	100	AUD
Total: Add v+vi+vii = viii for total budget to do 1 survey	730.00	**AUD**
(all sites, one time)		
Do you have time and funding for this design? (Circle one)	(Yes)	No
If no, go back and adjust the slices, number of sites or precision you will accept (and hence the number of replicates). When done, fill out this table again.		

2.10 Using a design tree to visualise and communicate your design to others

In this step draw your design in the form of an organisation chart like the one you see below. This will give you a good reference to visualise the design, communicate it to your team and managers, and can be included as part of the methods section in your reports. You can hand-draw the design in your workbook in Appendix 1 (Step 8) for future reference.

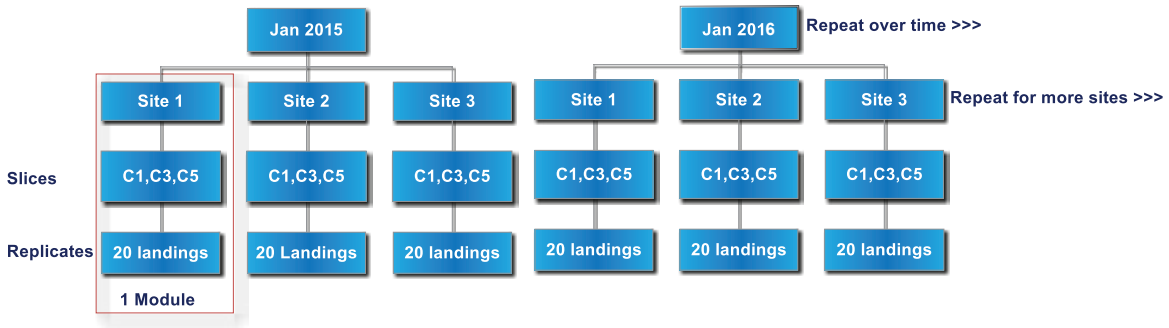


Figure 2. Example of creel a survey design.

Figure 2 is a graphical representation of the layout of a simple survey design for a creel survey. At its core, this design is formed by repeating a single module of sampling in three different sites and at yearly intervals. A module is the work you will do at a single place and time (i.e. the slices of data you will record, and how many replicates you will do). In this case, it would be to survey 20 replicate landings and collect all required information for slices C1, C3 and C5. In this example, surveys are completed at yearly intervals. You could alter this to twice a year, seasonal, monthly, weekly or daily intervals, depending on your time and budget.

2.11 Logistics

Now that you have decided on a survey design, you need to determine what is needed to put your survey into action. Logistics refer to all of the practical aspects of completing the survey, and can include:

- establishing a work plan and timetable and setting survey goals;
- identifying all staff members who will be involved, and training them to work as a team;
- arranging for wages, daily allowances, lunches;
- informing the community or fishers of your survey (this can be done through radio, newspapers, meetings);
- printing datasheets;
- assembling and checking any equipment you need; and
- calculating travel to and from sites.

Someone should be appointed as the team leader for the survey. This person should be responsible for:

- ensuring survey equipment is available and brought along on the survey, including datasheets, pencils, erasers, clip boards, measuring boards, scales, fish identification books;
- ensuring that a vehicle has been arranged to transport the survey team to and from the landing site, if required, and that the vehicle has sufficient fuel;
- ensuring that the community has been notified of the survey;
- supervising the conduct of the survey itself; and
- checking the datasheets and overseeing data entry at the completion of the survey.

It is recommended that you set up your creel or market survey with set goals, a timetable and targets for how many fishing boats, fishers or vendors you will intercept over several days to complete one module. These need to be realistic, and need to be in line with the likely number of fishers who land at a certain site each day. For example, there is no point in planning to meet 10 landings per day if only 5 boats typically use the site each day.

If you are surveying different landing sites you should try to randomise your efforts among the sites; that is, do not spend several days surveying all of Site 1 before moving on to Site 2, then Site 3 and so on. Try to mix the days across sites. For example, spend one day at Site 1, then one day at Site 3, then Site 2, then Site 4, and finally returning to Site 1. This is done to ensure that bias is not introduced into the sampling. In the first few days you may still be unsure of what you are doing, or you may not yet be working together properly as a coordinated team, or there may be a particularly windy or rainy period for a few days, or any number of other factors that influence the behaviour of fishers, vendors or the resource being studied. Any of these factors (and many others) can influence your results, and if they occur at one site, this may affect the values significantly. Spreading the effort across the sites and mixing the days you survey will ensure that any biases are likely to be equally distributed over the sites. A simple way of randomising your sites is to write down the site names on bits of paper and place these into a hat. Then pull the papers out of the hat to assemble your timetable. Alternately, a web-based automated scheduling application may be an option. Figure 3 is an example of the result of a randomised approach to selecting which sites to survey over the course of a month's sampling.

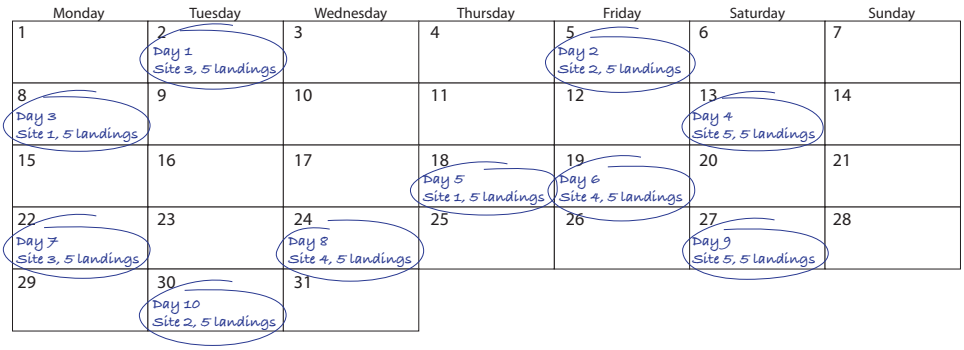


Figure 3. Example of results from a randomised approach to selecting which sites to survey over a monthly-period.

You can see in this timetable that the work to be done on any day could be at any of the five sites included in this example. If there were three windy days over the time period, no single site is likely to be the only one influenced by the wind. In total, five sites have been surveyed over a 10 survey-day period, 10 landings were met or 10 stalls were visited at each site. Once you have developed your work plan, note it down in the workbook in Appendix 1 (Step 9).

2.11.1 Ensuring local community support

In most places it will be necessary to inform the public of your survey. This is to gain their cooperation, and is also basic courtesy. You will be delaying fishers and/or vendors when they are landing their catches or trying to sell their fish, and if they do not know who you are or what you are doing, they may not be cooperative with you or your survey team. In many locations, you will need to meet with village chiefs, elders, council members or the community as a whole to gain their permission and support for the survey. Consider the best way to do this for the area you are working in. To inform the community of your survey perhaps you need to put an announcement on the local radio station or newspaper or hold a public meeting.

2.11.2 What equipment to bring?

You do not need much technical or specialist equipment to conduct a creel or market survey. However, bringing the following gear is mandatory or highly recommended:

- datasheet and clipboard
- pencil and eraser
- measuring board (if measuring individual fish or invertebrates)
- hand scale or small weighing balance (if weighing individual fish or invertebrates)
- identification books or digital camera
- head torches (if surveying at night)
- maps, charts or aerial photos of the fishing grounds

Many fishers will be willing to let you to handle (i.e. identify, count, measure and weigh) their catch, particularly if the catch can be stored on ice while you are collecting the data. While most fishers take ice with them on fishing trips, many arrive at a landing site with no ice left, and appreciate having their catch put on ice while the survey takes place. If possible, bring a cooler with ice to store fish in while the survey is being conducted. It is a good idea to bring a digital camera to photograph any unidentified species for later identification or to take photos to include in your report.

Datasheets are at the heart of data collection for every survey. Some datasheets that work well are included in this manual and are consistent with the SPC Creel and Market Survey Database. Keep in mind that if you change the datasheets in any way, the data you collect may not be compatible with the database. You will need one datasheet for each landing you meet or market stall you visit, plus some extras just in case. Special data control sheets for both creel and market surveys are provided in Appendix 5 and Appendix 7, respectively, to help you keep track of all the data you collect, and to make sure you do not miss anything. Once you have decided on all of the equipment needed note it down in the workbook in Appendix 1 (Step 9).

3. Conducting a creel or market survey

3.1 Get to know your fish and invertebrates

Many different species of finfish and invertebrates are harvested in coastal fisheries in the Pacific. The distribution, life history and susceptibility to fishing of the species involved can be very different; therefore, in order to understand the impact of fishing or the importance of each species to a fishery, it is necessary to look at each species separately. When gathering information during creel and market surveys, it is important that you are able to recognise and identify the different species that make up the fisheries you are looking at. Collecting information by species will enable you to use your data to provide management advice to sustainably manage your fisheries.

As part of your preparations before undertaking a creel or market survey, it is highly recommended that you spend some time ensuring that your survey team members are able to identify the fish and invertebrate species they are likely to encounter. To help you with this, there are a number of very good identification books with photos and descriptions of different species. Details of some relevant fish and invertebrate books for the Pacific Islands region can be found in Section 5. SPC has also produced some fish and invertebrate identification cards to use in the field, including a guide to the common coastal food fishes in the Pacific Islands region that has been designed specifically to help you during creel and market surveys (available to download at http://www.spc.int/coastfish/en/publications/465).

A useful training exercise for your survey team is to spend a few days going to the landing site or fish market and recording the different fish and invertebrate species. Becoming familiar with and being able to identify the commonly landed species to their scientific names will provide the survey team with an initial list of species that they will likely encounter when they conduct the surveys.

Photos are very useful for identifying and verifying species. Taking pictures of fish and invertebrates in the field is a good practice that is highly encouraged. The species photos from different sites could be stored electronically as a reference library to assist with future identifications.

Using the scientific names for fish and invertebrates – rather than their common or local names – minimises problems of misidentification. Most fisheries officers, however, tend to use local or common names, which can be misleading when a local or common name refers to several different fish or invertebrate species, or when the names vary from one location to another. The use of scientific names becomes easier with practice. Local names can also be used, but only when they refer to one particular species.

Taking a digital camera with you on the survey is a good idea as you can use it to take photographs of unidentified species for later identification in the office, rather than spending time at the landing site trying to identify the species with guidebooks (and delaying the fishers !). Alternately, you could purchase any individual fish or invertebrates you are unable to identify and take them back to the office to identify at the end of the survey day.

3.2 Tips for interviewing fishers and vendors

The success of a creel or market survey depends on the cooperation of the fishers or vendors at your survey site. When interviewing a fisher or vendor, the surveyor should try to establish a relationship that is based on trust, politeness and mutual respect. This will help ensure that reliable data are collected, and that the person is willing to be surveyed in the future. (Remember: the person is giving up their time to help you with the survey!) Upon meeting a fisher or vendor, the surveyor should identify themselves, explain the purpose and objective of the survey, explain how the data will be used, and politely ask if the team can survey the catch and conduct the interview. In many cases, this will be sufficient to secure cooperation and confidence; a relaxed manner, along with common politeness, respect and genuine curiosity, will do the rest.

To conduct the interview, the interviewer should select a quiet place that is free of distractions and ideally away from onlookers. Sometimes the answers given by the person being interviewed are influenced by whoever is listening.

Asking the questions the way they are written on the survey form will help ensure data are collected in a repeatable, consistent manner that is compatible with SPC's Creel and Market Survey Database. Interviewers should familiarise themselves with the questions before conducting the interview; this will help with the flow of the interview and help convey confidence. However, you may wish to include your own questions that relate to a specific management issue in your province or country. Take time to ensure that your question is worded in a way that will provide the information you need. There are several types of questions that should be avoided when conducting interviews:

- **Confusing or wordy questions.** Try to avoid combining multiple questions into a single sentence. Instead, break the questions down individually. For example, instead of asking several questions all at once — 'Did you lose any gear during the trip, and if so, how much will it cost to replace or repair this gear, and are there any other costs associated with this trip?' —ask each question separately.
- **Double-barrelled questions.** This is asking a question in such a way that there is a single response to essentially two different questions. For example: 'What species do you catch using handlines and traps?'
- **Leading, loaded or biased questions.** A leading or loaded question is one asked in such a way that it is easier for the respondent to choose a particular answer over another. For example: 'How do you usually catch this species — with a net?'
- **Hypothetical questions.** Try to avoid asking questions that begin with: 'What if...?". These types of questions tend to produce unreliable results because people tend to answer them from different assumptions.

It is important to remember that fishers returning from fishing may be tired, wet, cold or hungry, and just want to offload their fish at the market and go home as quickly as possible. In these instances, while you may be able to collect information on the catch (such as length or weight data, it is often possible to arrange a better time later in the day to interview the fisher (i.e. after they are refreshed). Do not leave this too long, however, and try to get the most important details straight away (such as locations fished, number of people fishing, and time spent fishing). The longer the time between the fishing trip and the interview, the more details the fisher will forget about the trip's activities. Of course it is far better to do everything possible to obtain all the information at the landing site.

3.3 Tips for measuring and weighing fish and invertebrates

Using standardised protocols for measuring and weighing fish and invertebrates during your surveys is critical for ensuring that data are collected in a consistent manner over time and among sites and surveys.

If you have decided to measure and weigh individual fish and invertebrates in the catch or on the market table (slices C3 and C4 for creel surveys, M3 and M4 for market surveys), then it is recommended that four people be involved in this process: one person to measure, one person to weigh, another person to fill in the datasheet, and a fourth person to provide general assistance (e.g. sorting the catch, taking photos of species for identification purposes). Of course, this could be done with as few as two people: one person to measure and/or weigh, and another person to record the data. It is recommended that someone sort the catch into species-specific groups prior to measuring and weighing. This will save a lot of time and effort for the person filling in the datasheet because they will not have to repeatedly write down the same species name.

Fish and invertebrates should be recorded in terms of cm to one decimal place (e.g. 10.7 cm). Ideally, whole weights should be recorded to at least the nearest 0.01 kg, depending on the type of scale you use. The type of length measurement will vary, depending on the species being measured. A standardised set of approaches for measuring different invertebrate species is included in Appendix 9. For fish, fork length (FL – measured from the anterior-most point of the fish [typically the tip of the lips or snout] to the middle or 'V' of the caudal fin) should be collected for species with forked tails, and total length (TL – generally measured from the anterior-most point of the fish [typically the tip of the lips or snout] to the end of the caudal fin) should be collected for species with lobate tails (Figure 4; see boxed text on page 24 for more tips on measuring fish).

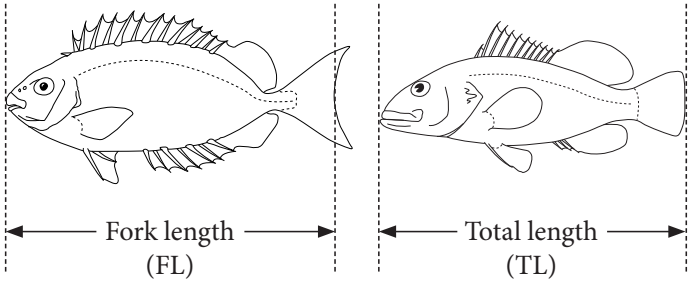


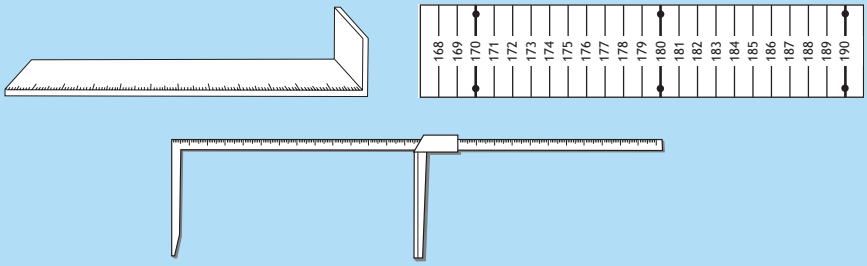
Figure 4. Examples of measurements of fork length (for fish with forked tails, left) and total length (for fish with lobate tails, right).

Measuring fish takes much less time than weighing them. The person who is measuring may get ahead of the person who is weighing. Instead of waiting for the person who is taking the weights to catch up, the person measuring may want to move ahead. This is okay, provided the fish are measured and weighed in a way that allows the correct length and weight to be assigned to a specific individual. One good way of doing this is to ensure fish are measured and weighed in the exact same order. After measuring, the person doing the measuring should line the fish up in the same order in which they were measured. The person weighing should weigh the fish in this order. This will allow the person who is recording the information on the datasheet to put an individual fish's weight right next to its length.

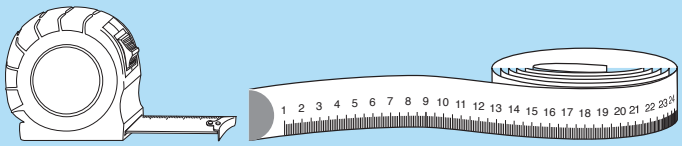
Measuring fish may seem easy, but it actually takes some thought to make sure you are measuring in a standardised and repeatable way.

The equipment you use to measure will have a significant influence on your results. Measurements should be made using a measuring board, deck tape, or caliper (for large individuals); builder's tape and tape measures are not appropriate, and should not be used. Builder's tape will bend over the fish and the length measurement you get will be longer than the actual length. Similarly, never use a fabric tape measure to measure a fish. The tape measure may stretch and give an incorrect reading.

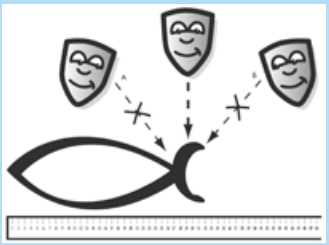
Appropriate measuring tools:

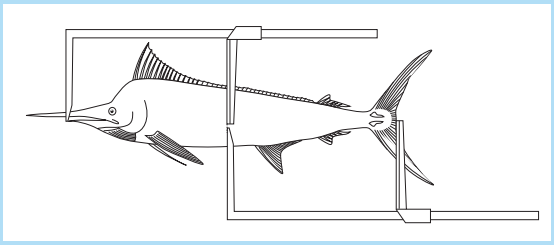


Not appropriate:



When measuring a fish, first make sure the fish is flat and horizontal before you measure it. Be careful that the 'nose' or front-most part of the fish is aligned with the "zero" on your measuring instrument. If using a measuring board, make sure the fish sits properly on the board and that the front end of the fish is properly aligned with the vertical or upright portion of the board. Make sure your eyes are directly over the tail of the fish, otherwise you might record an incorrect measurement. Damaged fish should not be measured; rather these should be identified to species and recorded as counts. If your fish is longer than your measuring instrument, you could take multiple measurements, and add these together to get the full length of the fish.





3.4 Filling out the datasheets

This section provides information on how to fill in the datasheets provided. A completed example follows each question on the datasheet. Additionally, a blank creel datasheet is included in Appendix 4, while an example of a fully completed creel survey datasheet is included in Appendix 5. Similarly, a blank market survey datasheet is included in Appendix 6, while an example of a fully completed market datasheet is included in Appendix 7. Ensuring that data are collected and that datasheets are filled out consistently among surveys or locations will enable you to make comparisons against other surveys. Below are details of what data to collect for each section.

3.4.1 Creel survey datasheets

Section 1

The first section of the creel survey datasheet deals with who, what, when and where with regards to the landing. In some ways, this is the most important section of the datasheet; if you do not know where or when the landing was surveyed took place, the data collected may be meaningless!

What information to collect

Creel survey carried out by: Enter the organisation that is completing the replicate (e.g. the name of your fisheries agency, non-governmental organization [NGO] etc).

Landing no.: Give the landing a unique identifying code that will distinguish it from other replicate landings in your survey. It is recommended that you use a number sequence, such as Landing 1, Landing 2, etc.

Creel survey carried out by: [enter organisation or department]	Landing no:
Pacifica Fisheries	1

Survey name: Enter your chosen survey name. If using the SPC Creel and Market Survey Database to analyse your data, the survey name will be your highest level of aggregation in your analysis (you also have the option to group by combinations of landing site and month). If you have decided to stratify your survey design by fishing method, for example, enter the type of fishing method you are surveying (e.g. 'Pacifica spearfishing survey 2014' or 'Pacifica handlining survey 2014'). If you have decided not to stratify your survey, you could choose names that reflect when the survey was conducted (e.g. 'Pacifica creel survey 1st quarter 2014' or 'Pacifica pilot creel survey 2015').

Survey name:	Pacifica Pilot creel survey October 2015

Province / Island + Country: enter the name of the province/island + country where the interview takes place.

Province / Island + Country:	Pacifica Island

Date of this replicate: the date the catch or market stall was surveyed.

Currency used: the currency that applies to the landing (e.g. AUD, USD, PGK).

Date of this replicate (day/month/year):	05/10/2015	Currency used:	AUD

Survey site: the specific landing site for that replicate (e.g. name of boat ramp, beach, wharf).

Survey Site:	Paddletail Port

Latitude and Longitude (DD): the GPS coordinates of the landing site (in decimal degrees (DD)). This is not so important if the landing site is well known (e.g. a main wharf in town), but is important if it is in a remote place, so it can be located in future surveys.

Latitude (DD):	15.63087	Longitude (DD):	155.10052

Interviewers' or surveyors' names: The names of the people surveying the landing (i.e. you and your team members).

Interviewers' / surveyors' names:	1. Bob Pomoko	3. Maria Bentanu
	2.	4.

Slice C1: Basic information on fishers

This slice collects information on the fisher(s) themselves, including how many fishers participated in the fishing trip, their demographics (e.g. sex, age), current fishing patterns and reasons for fishing. Types of questions answered in this section can be found in Table 2.

What information to collect

Lead fisher's name. Record the full name of the lead fisher of that fishing trip (usually the skipper or boat master).

Lead fisher's name:	Paul Pakitua

Date of birth (DOB) and gender. Record the lead fisher's date of birth and gender (M or F).

Date of birth (DOB):	06/05/1969	Gender:	M

Address (name of village, town or city). Record the name of the village, town or city the lead fisher lives in.

Address (name of village / town / city:	Tunapapa village, Pacifica

Vessel ID/Name. The name (in full) or registration number of the vessel used for fishing on that trip. Do not abbreviate the name because this may not be understood by others. If the vessel does not already have a name (such as a canoe), discuss this with the vessel owner. The name of the vessel will be recorded on the logsheets, so consider this if it is necessary to come up with a new vessel name (You could use the person's name as part of the vessel name (e.g. Malakai's canoe)). If no vessel was used during the trip write 'no vessel used'.

Vessel ID/Name:	Mako

Was the lead fisher fishing with other people (Y/N)? Check the relevant box if the lead fisher was fishing with others.

Is the fisher fishing with other people?	Yes ☑ | No ☐

Total number of fishers (including lead fisher). Total number of fishers that were actively participating in this fishing trip.

Total number of fishers?	2

Names, DOB and gender of other fishers. Record the names, DOB and gender for all other fishers involved in the fishing trip.

→ (data on other fishers in the landing today)			
Name of other fisher 1:	John Pakitua	DOB: 17/10/1990	Gender: M
Other fisher 2:		DOB:	Gender:
Other fisher 3:		DOB:	Gender:
Other fisher 4:		DOB:	Gender:

How often do you go fishing per month? How many days a month does the lead fisher go fishing? They may give the answer in terms of times per week. This is okay because it can be extrapolated to give the number of times per month.

How many months a year do you fish (i.e. excluding closed fishing seasons)? How many months a year does the lead fisher go fishing? For example, they may spend three months off the island each year, and fish for nine months.

How many days per month do you go fishing?	How many months a year do you fish (i.e. excluding closed fishing seasons)?
20 days /month	12 months fished

What fishing methods do you usually use (not just on this fishing trip)? List the various fishing methods the lead fisher uses, including (but not limited to) the method they used on the current trip. Methods could include bottomfishing, handlining, collecting using a mask and snorkel, collecting on foot, day or night spearfishing, drive gillnetting, trolling, or others.

What fishing methods do you usually use (not only this fishing trip)?	Method 1: Night spearfishing
Method 2: Handlining	Method 3: Trolling

Where else do you land your fish? List by priority. List all of the *other* sites that the lead fisher lands their catch at, in order of most to least times per month. A landing site is where the fisher brings their catch to land (e.g. a boat ramp, beach, jetty). This question is designed to help you understand where other landing sites may be in your study area so that you can include them in your current survey or in future surveys.

Where else do you land your fish? What other sites)? List by priority				
Other site 1: (most often)	Barracuda Beach	How often?	2	/month
Other site 2:		How often?		/month
Other site 3:		How often?		/month
Other site 4: (least often)		How often?		/month

Why do you fish? Select why the lead fisher goes fishing, not just for this trip, but in general (e.g. for subsistence, for income, or for other reasons). The fisher may suggest all three reasons. If 'other', provide details on the specific reasons (e.g. for ceremonial purposes, to barter fish for vegetables).

Why do you fish?	Subsistence ☒ | Income ☒ | Other ☒
Please provide details:	Sometimes goes fishing for gifts for relatives

How much of today's catch will be eaten at home and how much will be sold? Have the fisher provide a rough percentage of how much of this catch will be eaten at home or sold.

About how much of this catch will be eaten at home or sold?	10 % kept	90 % sold

What would you expect as income from this catch overall? Provide a rough indication of how much income will be generated by this catch.

How much do you expect to earn from this catch overall?	Value: AUD 80

What is your estimate of the total weight of the day's catch, in kilograms (estimated by you, not the fisher)? Record the interviewer's (i.e. your) estimate of the total weight of the catch. Note this is a rough estimate; if you are weighing all individuals in the catch (C4 or M4) you do not need to complete this question because you can simply tally the individual weights to obtain a more precise account of total weight.

What is your estimate of the total weight of this catch (estimated by you, not the fisher)?	15 kg

Slice C2: Species composition and counts

This slice collects information on the number of individual species in the catch.

What is the total count by species of all fish, invertebrates, or other seafood landed? Count the total number of each species in the catch (e.g. *Naso unicornis*, n = 9; *Naso lituratus*, n = 4; *Lutjanus gibbus*, n = 7; *Acanthocybium solandri*, n = 1). It may be easier to arrange the catch by species prior to starting, or you could tally your results and add up the final number at the end. There is space on the datasheet for recording the total weight of each species or species group, and for recording the fishing method used to capture the individual species or species groups, if known (this is particularly useful when surveying mixed-method fishing trips).

C2: Species composition and/or counts

What is the total count by species of all fish, invertebrates and other seafood landed?

Species name or group	Fish product	Total number	Total weight (kg)	Fishing method
Naso unicornis	Reef fish	9	8.77	Night spearfishing
Naso lituratus	Reef fish	4	1.27	Night spearfishing
Lutjanus gibbus	Reef fish	7	2.40	Handline
Acanthocybium solandri	Pelagic fish	1	6.15	Trolling

Slice C3: Species sizes, and Slice C4: Species weights

This slice collects information on the length and weight of individual fish or invertebrates in the catch. For each individual, record the length (if completing Slice C3), weight (if completing Slice C4), and the method of capture, if known (this is particularly important for mixed-fisheries), for each individual in the catch.

C3: Species sizes, and C4: Species weights

Record all sizes in the catch in cm (to nearest 0.1 cm) and all weights in kg
(Repeat this page if you need more space)

Species name	Size type	Size (cm)	Weight (kg)	Fishing method
Naso unicornis	FL	31.1	0.61	Night spearfishing
Naso unicornis	FL	46.7	1.83	Night spearfishing
Naso unicornis	FL	34.1	0.78	Night spearfishing
Naso unicornis	FL	39.5	1.04	Night spearfishing
Naso unicornis	FL	41.0	1.32	Night spearfishing
Naso unicornis	FL	29.4	0.55	Night spearfishing
Naso unicornis	FL	33.7	0.82	Night spearfishing
Naso unicornis	FL	36.1	0.92	Night spearfishing
Naso unicornis	FL	35.7	0.90	Night spearfishing
Naso lituratus	FL	23.0	0.25	Night spearfishing
Naso lituratus	FL	23.8	0.34	Night spearfishing
Naso lituratus	FL	22.5	0.33	Night spearfishing
Naso lituratus	FL	24.3	0.35	Night spearfishing

Lutjanus gibbus	FL	22.4	0.22	Handline
Lutjanus gibbus	FL	27.3	0.47	Handline
Lutjanus gibbus	FL	28.2	0.49	Handline
Lutjanus gibbus	FL	24.9	0.27	Handline
Lutjanus gibbus	FL	24.2	0.23	Handline
Lutjanus gibbus	FL	25.2	0.32	Handline
Lutjanus gibbus	FL	26.4	0.40	Handline
Acanthocybium solandri	FL	96.3	6.15	Trolling

Slice C5: Effort data for CPUE

This slice quantifies the time spent fishing, fishing method(s) used, location(s) fished, costs and gear losses associated with the trip, type of boat used, and whether the fishers were using safety gear. Much of the information collected here will help you determine CPUE for the fishing trip, be it in terms of number of fish or weight of fish caught per time spent fishing, per fisher per time spent fishing, per unit cost, or per distance travelled.

How many hours were spent on the fishing trip today (includes travel time)? Record the entire duration of the trip, from the time of departure to the time arriving at the landing site.

How many hours were spent on the fishing trip today?	6 hrs

Fishing method and gear used for each fish product and how much time spent doing each activity. Here, quantify what fish products (e.g. reef fish, pelagic fish, baitfish, shellfish) were caught using which methods, how many sets of gear were used, how long the fishers spent using the method, and over what period of the day. An example could be: reef fish, spearfishing, 4 hours, 2 sets of gear (i.e. 2 spearguns), night. It is important to record whether a certain number of fishers use one method for a given period of time and whether other fishers use other methods. For example, on our above trip with two people, say one person was night spearfishing on the reef while the other was bottom fishing, and both fished for three hours. After daybreak, one person trolled a lure on the way home. In this example, you would fill in three lines on the datasheet: one for the night spearfishing event (e.g. reef fish, spearfishing, 1 set of gear, 3 hours, night), one for the bottom fishing event (e.g. reef fish, bottom fishing, 1 set of gear, 3 hours, night) and one for the trolling event (e.g. pelagic fish, trolling, 1 set of gear, 1 hour, day).

Fishing method and gear used for each fish product (separate pelagic fish, reef fish, crabs, lobsters, etc.), how many sets of gear were involved and how much time spent doing each activity				
Fish product	Methods / gear used	No. gears	No. hours	Day or night?
1. Reef fish	Night spearfishing	1	3	Night
2. Reef fish	Handline	1	2	Night
3. Pelagic fish	Trolling	1	1	Day
4.				

Did you lose or damage any gear during this fishing trip? What was lost or damaged, and how much will it cost to replace or repair it? Note any gear that was lost or damaged and how much it would cost to replace or repair each item (e.g. sinkers, AUD 5).

Did you lose or damage any gear during this fishing trip? What was it? How much will it cost to replace or repair the item?		
Gear item	Lost or damaged?	Cost to replace or repair
1. Sinkers	Lost	AUD 5
2. Speargun	Lost	AUD 100
3.		
4.		

Please list any other costs of this fishing trip, including fuel, wages, bait, ice, food, drink, or any other items: List all costs associated with this particular fishing trip. Include items such as fuel, wages, bait, food, drinks, and ice but not capital costs such as the cost of the boat, engine, registration and licensing.

Please list any other costs associated with this fishing trip, including fuel, wages, bait, ice, food, drink, or any other items.	
Item	Purchase price:
1. Fuel	AUD 40
2. Ice	AUD 8
3. Wages	AUD 50
4. Bait	AUD 15

What is the distance to the farthest site you fished at today? The distance to the farthest site fished (in km), either from the point of departure or to the landing site.

What is the distance to the farthest site you fished at today?	12 km

Where did you leave from? Record the location of the departure point of this fishing trip. This may not always be the same as the landing site, and is useful for helping to calculate or confirm the distances travelled to the fishing sites.

Where did you leave from?	Paddletail Port

How many sites did you stop and fish at? Where are they? A description of all the sites fished during the fishing trip, and how long fishing took place there. Try to get as much information as possible, recognising the fact that the fisher may be wary of giving out their fishing spots! Another good way to obtaining information on the fishing location is to have a map that is divided into grid squares - the fisher can identify the grid square(s) where they fished, without giving up the secret spot.

How many sites did you stop and fish at? Where are they?		
Site	Location (on map, lat/long, or distance to each fishing ground)	Time spent at location (hrs)
1. North pass	10 km	1
2. Frigate Island	12 km	3

What kind of boat was used today? Describe the type of boat used on the fishing trip. Options include: No boat, motor boat, sail boat, canoe.

How is the boat powered? Select how the boat is powered from the following options: paddle, sail, inboard, outboard (2-stroke or 4-stroke).
Length (m). The length of the boat used, in metres.
Engine (hp). The size of the engine used to propel the boat, in horsepower.

What kind of boat was used today?		
Construction:	Wood ☐ | Fibreglass ☒ | Plastic ☐ | Steel ☐ | Concrete ☐	
Type of boat:	No boat ☐ | Motor boat ☒ | Sail boat ☐ Canoe ☐	
How is the boat powered?	Paddle ☐ | Sail ☐ | Inboard ☐ | Outboard: 2 stroke ☒ 4 Stroke ☐	
Length (m): 6		Engine (hp): 50

What safety gear do you have on board today? Tick all types of safety equipment that were on board during the fishing trip.

What safety gear do you have onboard today (tick all that apply)?	Oars ☒ | Life jackets ☐ | Anchor ☒ | Mirror ☐ | Water ☐ | EPIRB ☐ GPS ☐ | Flares ☐ | Bailer / Bilge ☐ | Extra fuel ☐ | Other (please specify) ☐

Slice C6: Catch prices

This slice collects information on where the catch is used or sold, and the price per item or weight at sale.

Where will you use or sell this catch? Tick the options that apply to where the catch will be used or sold (e.g. at home, local market, domestic buyer or export buyer).
How are the items sold (units of sale) and what prices can you expect? Detail how the items in the catch are sold and for what price (e.g. fish may be sold by the individual piece or fish, or by unit of weight).

C6: Catch prices				
Where will you use or sell this catch?	Home ☐ | Market ☒ | Buyer domestic ☐ | Buyer export ☐ | Roadside ☐ Resort/Restaurant ☐ | Retail Shop ☐ |			
How are the items sold (units of sale) and for what price?				
Fish product	Unit of sale	No. per unit	Price per unit of sale	Price per item
1. Reef fish	kg	1	AUD 1.25	
2. Pelagic fish	kg	1	AUD 5.00	

Slice C7: Perceptions of fishers

This slice assesses the lead fisher's historical fishing patterns and their perceptions on whether they have seen changes in the fishery in the last five years. Because these are the fisher's long-term perceptions, you only need to collect data for this slice from each lead fisher once every year or so because we would not expect the fisher's long-term perceptions to change from week to week!

What is the fisher's 'main' fishery? Check the box that applies for the current landing. Options for 'main' fisheries are: clam/trochus fishery, nearshore/oceanic fishery (e.g. trolling for tuna), other invertebrates fishery, reef/lagoon fishery (e.g. for finfish), deepwater snapper fishery (for deepwater snapper and associated species), and sea cucumber fishery.

What is the main fishing activity for this landing? Clam/Trochus fishery ☐ | Nearshore/Oceanic fishery ☐ | Other invertebrates fishery ☐ Reef/Lagoon fishery ☒ | Deepwater snapper fishery ☐ | Sea cucumber fishery ☐

How long have you been fishing? Record the number of years the fisher has been fishing (not just the type of fishing the fisher just returned from, but all types).

How long have you been fishing?	20 Years

How long have you been fishing in this fishery? The number of years the lead fisher has been fishing in their 'main' fishery (i.e. clam/trochus fishery, nearshore/oceanic fishery [e.g. trolling for tuna], other invertebrates fishery, reef/lagoon fishery [e.g. for finfish], deepwater snapper fishery [for deepwater snapper and associated species], and sea cucumber fishery)?

How long have you been fishing in this fishery (e.g. nearshore/oceanic fishery, reef/lagoon fishery, deepwater snapper fishery, sea cucumber fishery)?	15 Years

What other types of fisheries have you been involved with in the past? List any other 'main' fisheries that the lead fisher has participated in in the past.

What other types of fisheries have you been involved with in the past (e.g. nearshore/oceanic fishery, reef/lagoon fishery, deepwater snapper fishery, sea cucumber fishery)?	Sea cucumber fishery

Are you fishing in other fisheries now (Y/N)? Select the option (Y/N) that applies to the lead fisher. If they are fishing in other 'main' fisheries, list them.

Are you fishing in other fisheries now?	Describe:
Yes ☒ | No ☐	Nearshore/oceanic – trolling around FADs

Are you fishing in the same areas as you were five years ago? Select the option (Y/N) that applies to the lead fisher. If they are no longer fishing in the same areas as they were five years ago, have them explain why.

Are you fishing in the same areas as you were five years ago?	Please explain:
Yes ☐ | No ☒	Used to fish at Tunapapa Reef but there are no fish there anymore

Are you catching the same quantities of fish as you were five years ago? Select the option that applies to the lead fisher. Three different options are available for the fisher's response: are they catching the same amount, or have their catches increased or decreased? Space is available on the survey form for the fisher to explain their perception.

Are you catching the same quantities as you were five years ago?	Please explain:
Same ☐ | Increase ☐ | Decrease ☒	Catch less fish now

Are you catching the same size fish as you were five years ago? Select the option that applies to the lead fisher. Three different options are available for the fisher's response: are they catching the same sized individuals, or have the sizes of individuals increased or decreased? Space is available on the survey form for the fisher to explain their perception.

Are you catching the same size as you were five years ago?	Please explain:
Same ☐ | Increase ☐ | Decrease ☒	Size of fish, especially unicornfish, has decreased

If catches are different, what has changed? If the fisher has stated they have seen changes, either in quantities or sizes of fish caught, have them explain why they think this may be.

If catches are different, what has changed?
Some species which were common (e.g. groupers) are now rarely caught

Do you have any concerns about the resource(s)? Let the fisher share any concerns or advice they have regarding the state of the resource(s).

Do you have any concerns about the resource(s)?
Worried about overfishing – too many people fishing now. Better management is needed – maybe in the form of protected areas or size. Also worried about erosion – lots of mud in the sea after heavy rain; need to manage this e.g. plant banana trees along sides of streams to hold soil.

Creel survey data control sheet

The purpose of this datasheet is for you to manage the data coming in for a survey and to ensure that all of the replicates are done (landings met) for each site. Each day, as the data come in, collect the datasheets used for the data collection and tick each replicate off until they are all complete. Your design will probably need a sheet that is different to this one — the layout is not important — depending on whether you are working at several sites and whether you are repeating the survey over time. The data for each landing you meet will be on their own individual datasheets, which are separate from this.

Creel Survey Data Control Sheet																					Department: Pacifica Fisheries
Location / Island / Province: Pacifica Island																					Sheet filled in by (surveyor's name): Bob Nui
Type of creel survey (if separating strata):																					
Survey time: (circle)																					Jan 15 Feb 15 Mar 15 Apr 15 May 15 Jun 15 Jul 15 Aug 15 Sep 15 Oct 15 Nov 15 Dec 15
↓ Site	Replicates →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Site 1:	Paddletail Port	X	X	X	X	X	X														
Site 2:																					
Site 3:																					
Site 4:																					
Site 5:																					
Notes:																					

3.4.2 Market survey datasheets

The first section of the market survey datasheet deals with who, what, when and where of the market unit (i.e. table, stall or other replicate) being surveyed. As with the creel survey datasheet, in some ways this is the most important section.

What information to collect:

Market survey carried out by: Enter the organisation completing the replicate (e.g. the name of your fisheries department or NGO).

Serial/ID number: Give the replicate a unique identifying code that will distinguish it from other replicate units in your survey. It is recommended that you use a number sequence, such as Sheet 1, Sheet 2, etc.

Market survey carried out by: [enter organisation or department]	Serial/ID number:
Pacifica Fisheries	1

Survey name: Enter your pre-selected survey name. If using the SPC Creel and Market Survey Database to analyse your data, the survey name will be your highest level of aggregation in your analysis (you also have the option to group by combinations of landing site and month). If you have decided to stratify your survey design by market type (for example), enter the type of market stall or vendor you are surveying (e.g. 'Pacifica main market survey' or 'Pacifica roadside stall survey'). If you have decided not to stratify your design by market stall or vendor you could choose names that reflect when the survey was conducted (e.g. 'Pacifica market survey 1st quarter 2015' or 'Pacifica pilot market survey 2015').

Survey name:	Pacifica Market Survey October 2015

Province / Island + Country: enter the name of the province/island + country where the interview takes place.

Province / Island + Country:	Pacifica island

Date of this replicate: the date the interview takes place.
Currency used: the currency that applies to the market unit (e.g. PGK, AUD, USD).

Date of this replicate (day/month/year):	05/10/2015	Currency used:	AUD

Survey site or market name: the specific site for that replicate (e.g. name of the market).

Survey site or market name:	Pacifica main fish market

Latitude and Longitude (DD): the GPS coordinates of the market site (in decimal degrees). This is not important if the market is well known (e.g. a main fish market in town such as in this example), but is important if it is in a remote place because it will help people who want to survey there in the future to locate it.

Latitude (DD):	15.63087	Longitude (DD):	155.10052

Interviewers' or surveyors' names: The names of the people completing the survey for this replicate (i.e. you and your team members).

Interviewers' or surveyors' names:	1. Maria Hughes	2. Joseph Beru
	3.	4.

Slice M1: Basic information on vendors

This slice collects information on the vendor(s), including the company, names of individual vendors, vendors' relationship to the company and to other vendors, their demographics (e.g. sex, age) and current patterns of marketing. Types of questions answered in this section can be found in Table 3.

What information to collect:

Is this vendor part of, working for, or the owner of a formal company (Y/N)? Select the option that applies to the replicate.

Is this vendor part of, working for, or the owner of a formal company?	Yes ☒ | No ☐

Company name, address and number of years operating. If yes to above, record the name of the company, its address and how long it has been operating.

Name of company (if applicable): Pacifica Fine Seafoods	Years operating: 12 years
Company address (if applicable): 5 Harbour Rd, Tunapapa, Pacifica	

Lead vendor's or manager's full name. Record the full name of the lead vendor or company manager.

Lead vendor's or manager's full name: John Wallis

Date of birth (DOB) and gender. Record the lead vendor's or manager's date of birth and gender (M or F).

Date of birth (DOB): 15/05/1975	Male ☒ | Female ☐

Address (name of village, town or city). Record the name of the village, town or city the lead vendor lives in.

Address (name of village, town or city):	Tunapapa, Pacifica

Is the vendor working with others (Y/N)? Check the relevant box if the lead vendor is working with others.

Is the vendor working with others?	Yes ☒ | No ☐

Names, relationship to lead vendor, DOB and gender of other vendors. Record the names, relationship to lead vendor, DOB and gender for all other vendors working at that replicate market unit (stall or table).

➔ Data on other vendors working at the table, stall or shop today (include children only if they are working)			
Full name	Relationship to lead vendor	Date of birth	Gender
1. Maria Wallis	Wife	10/06/1979	Male ☐ | Female ☒
2.			Male ☐ | Female ☐
3.			Male ☐ | Female ☐
4.			Male ☐ | Female ☐

How many days per month do you sell at the market? How many days each month does the lead vendor sell at the market? They may give the answer in terms of times per week; this is okay because it can be extrapolated to give the number of times per month.

How many months per year do you sell at the market? How many months a year does the lead vendor operate the market stall? For example, they may sell only seasonally, or they may sell year round.

How many days per month do you sell at the market?	How many months per year do you sell at the market (i.e. exclude closed months)?
15 /month	12 months working

Do you have any other sources of income (Y/N)? Record any other sources of income the lead vendor may have. Other sources of income may include handicraft sales, fishing, local produce, paid job, salary, taxi driver, tourism, etc.

Do you have any other sources of income?	Yes ☐ | No ☒
Please describe:	

Where else do you sell? Have them list by priority. List all the other sites where the lead vendor markets their seafood, in order of most times to least times per month. This question is designed to help you understand where other market sites may be in your study area, so you can include them in your survey.

Where else do you market? What other locations? List by priority.			
Other location 1: (most often)	Mackerel Market	How often?	6 /month
Other location 2: (most often)		How often?	/month
Other location 3: (most often)		How often?	/month
Other location 4: (most often)		How often?	/month

How much do you expect to earn from today's sales? Have vendor provide a rough indication of how much income will be generated from today's sales.

What would you expect as income from today's sales?	Value:	AUD 200

What is your estimate of the total weight of the marine products on sale, in kg (estimated by you, not the vendor)? Record the interviewer's (i.e. your) estimate of the total weight of marine products on sale. Note this is an estimate - if you decided to weigh the fish at the market stall or table you do not need to complete this question.

What is your estimate of the total weight of the marine products on sale (estimated by the surveyor, not the vendor)?	10 kg

Slice M2: Species composition and/or counts

This slice collects information on the number of individual species at the market stall or table.

What is the total count by species of all fish and invertebrates, or other seafood on the market table now? Count the total number of each species on the table (e.g. *Lethrinus harak*, n = 6; *Scylla serrata*, n = 4; *Octopus cyanea*, n = 5). It may be easier to sort the catch by species prior to starting, or you could tally your results and add up the final number at the end. You will need to complete this part **before** any items are sold, otherwise your results will be biased towards non-preferred species or sizes.

M2: Species composition and/or counts

What is the total count by species of all fish, invertebrates, and other seafood on the market table now?

Record the sex, whether the species is in berry (F=Female; FB=Female in berry; M=male for crustaceans).

Species name or group	Fish product	Sex/In berry	Total number	Total weight	Weight unit
Lethrinus harak	Reef fish		6	1.71	kg
Scylla serrata	Mud crab	F	2	1.26	kg
Scylla serrata	Mud crab	M	2	2.90	kg
Octopus cyanea	Octopus		5	3.94	kg

Slice M3: Species sizes, and Slice M4: Species weights

This slice collects information on the length and weight of individual fish or invertebrates at the market stall. For each individual, record the length (if completing Slice M3) and weight (if completing Slice M4). For crustaceans, record the sex (M, F), and whether females are in berry. As with M2, you will need to complete this part of the survey before any items are sold, otherwise your results will be biased towards species or sizes that have not been sold.

M3: Species sizes (in cm) | M4: Species weight (in kg) | Sex | In berry

(Repeat species on a new line if you need more space). Use: F=Female; FB=Female in berry; M=male for crustaceans

Species name	Sex/In berry	Size type	Size (cm)	Weight (kg)
Lethrinus harak		FL	22.8	0.25
Lethrinus harak		FL	23.5	0.26
Lethrinus harak		FL	29.1	0.48
Lethrinus harak		FL	24.0	0.28
Lethrinus harak		FL	19.5	0.19
Lethrinus harak		FL	23.5	0.25
Scylla serrata	F	Carapace width	16.2	0.85
Scylla serrata	FB	Carapace width	12.7	0.41
Scylla serrata	M	Carapace width	19.3	1.48
Scylla serrata	M	Carapace width	17.7	1.42

Octopus cyanea		Mantle height	14.1	1.72
Octopus cyanea		Mantle height	10.5	0.75
Octopus cyanea		Mantle height	11.1	0.82
Octopus cyanea		Mantle height	7.6	0.32
Octopus cyanea		Mantle height	7.5	0.33

Slice M5: Income from marketing

This slice gathers information on income that results from marketing by exploring the sources of products and the income generated from marketing, the costs of marketing, types of processing, and the contribution of fishing to the local economy.

Product origin: Where did you get the marine products that are on sale today? Check the box that applies for the market stall or table, and provide the percentage amount that was contributed that way (e.g. fisher in family: ☐ Percent: 80; Bought: ☐ Percent: 20). Options are: fisher in family, bought, bartered, caught by you, gift and other. An explanation box exists in which to gather more information.

Where did you get the marine products on sale today?			
Fisher in family:	☒ Percent: 80	Gift:	☐ Percent:
Bought:	☒ Percent: 20	Caught by you:	☐ Percent:
Bartered:	☐ Percent:	Other (explain):	☐ Percent:

What are your marketing costs today? List each item individually, its cost, and whether the item was hired or bought. This could include the cost of purchasing fish, wages, food, tables, stalls, ice, power and water. When conducting the survey, look around the table or stall for items that the vendor may have forgotten, and prompt the vendor for their costs.

What are your marketing costs today (include wages, food, table or stall hire, ice, cost of purchasing fish)? Look around the table or stall or shop for items the vendor may have forgotten.		
Item	Cost	Buy or hire
1. Market fee	AUD 20	Buy ☐ | Hire ☐
2. Ice	AUD 10	Buy ☐ | Hire ☐
3. Seafood	AUD 50	Buy ☐ | Hire ☐
4. Wages	AUD 50	Buy ☐ | Hire ☐
5.		Buy ☐ | Hire ☐
6.		Buy ☐ | Hire ☐
7.		Buy ☐ | Hire ☐
8.		Buy ☐ | Hire ☐
9.		Buy ☐ | Hire ☐
10.		Buy ☐ | Hire ☐

How are the items sold (units of sale), what processing method was used, and what prices can you expect? For each marine product on the market table or stall, record its unit of sale, number per unit, price per unit of sale, price per item or weight, and the method used to process it. There is a separate column for the price of fish that were purchased directly from the fisher. A detailed example can be found in the example market survey datasheet in Appendix 7.

How are the items sold (units of sale), what processing method was used, and what prices can you expect? Processing: F=Fresh; Gu=Gutted; Gi=Gilled; H=Headed; S=Scaled; F=Filleted; D=Dried; S=Smoked; C=Cooked; L=Live						
Fish product	Unit of sale	No. per unit	Price per unit	Cost to purchase from fisher	Price per item or weight	Processing method
1. Reef fish	kg	1	AUD 4.00	AUD 2.00		F
2. Mud crab	piece	1	AUD 10.00	AUD 5.00		L
3. Octopus	piece	1	AUD 5.00	AUD 3.50		Gu
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Slice M6: Perceptions of vendors

This slice assesses the lead vendor's perceptions on whether they have seen changes in the fishery or market conditions in the last five years. Because these are the vendor's long-term perceptions, you only need to collect data for this slice from each lead vendor once every year or so because we would not expect the vendor's long-term perceptions to change from week to week.

How long have you been marketing? Record the number of years the lead vendor has been marketing (in general, not just seafood).
How long have you been marketing seafood? Record the number of years the lead vendor has been marketing seafood.

How long have you been marketing?	How long have you been marketing seafood?
15 years	15 years

Do you have other types of work now (Y/N)? Record any other sources of income the lead vendor may have. Other income sources may include the sale of handicrafts, fish, local produce, or a paid job, salary, or from tourism.

Do you have other types of work now? Yes ☐ | No ☒			
Please give approximate percentage of each type of livelihood:			
1.	%	4.	%
2.	%	5.	%
3.	%		%

Are you selling the same species now as you were five years ago (Y/N)? Select the option (Y/N) that applies to the lead vendor. If they are not selling the same species as they were five years ago, have them explain what has changed.

Are you selling the same species now as you were five years ago? Yes ☐ | No ☒	Please explain: Used to sell tuna but this is now unprofitable as fuel price has gone up resulting in less fishing now

Are you selling the same quantity of seafood as you were five years ago (Y/N)? Select the option that applies to the lead vendor. If they are not selling the same quantity as they were five years ago, have them explain what has changed. Have quantities increased or decreased?

Are you selling the same quantity of seafood now as you were five years ago?	Please explain:
Same ☐ | Increase ☐ | Decrease ☒	Less fishes are landed by fishers now

Are you selling the same size of individuals as you were five years ago (Y/N)? Select the option that applies to the lead vendor. If they are not selling the same size of individuals as they were five years ago, have them explain what has changed. Have sizes increased or decreased?

Are you selling the same sizes as you were five years ago?	Please explain:
Same ☐ | Increase ☐ | Decrease ☒	Fish sizes are smaller now

If the items being sold are different, what has changed? If the lead vendor has stated they have seen changes — in the types of species, quantities or sizes of fish sold — have them explain why they think this may be.

If the items being sold are different, what has changed?	Used to sell sea cucumbers to exporters but this is now unprofitable as too few sea cucumbers around. Also sells more herbivores and fewer carnivores now

Do you have any concerns about the resource(s)? Let the vendor share any concerns or advice they have regarding the state of the resource(s).

Do you have any concerns about the resource(s)?
Fish are smaller and there are fewer – maybe stocks are overfished

Do you have any concerns about marketing conditions now and for the future? Let the vendor share any concerns or advice they have regarding marketing conditions now and for the future.

Do you have any concerns about marketing conditions now and for the future?
There is a high demand from hotels and too many fishers fishing now

Market survey data control sheet

The purpose of this datasheet is for you to control the data coming in for a survey and to ensure that all of the replicates are done (tables or stalls or buyers sampled) for each site. Each day, as the data come in, collect the datasheets used for the data collection, and tick each replicate off until they are all complete. Your design will probably need a sheet that is different to this one — the layout is not important — depending on whether you are working at several sites and whether you are repeating the survey over time. The data for each landing you meet will be on their own individual datasheets, which are separate from this.

Market Survey Data Control Sheet												Department: Pacifica Fisheries									
Location / Island / Province: Pacifica Island												Sheet filled in by (surveyor's name): Maria Hughes									
Type of market survey (if separating strata): Pilot																					
Survey time: (circle)												Jan 15	Feb 15	Mar 15	Apr 15	May 15	Jun 15	Jul 15	Aug 15	Sep 15	Oct 15	Nov 15	Dec 15
Site	Replicates	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Site 1:	Pacifica main fish market	X	X	X	X	X	X	X	X	X	X										
Site 2:																					
Site 3:																					
Site 4:																					
Site 5:																					
Notes:																					

4. Data entry and analysis to answer management questions

Conducting the field survey is only half the job. As a rough guide, you can expect to spend at least the same amount of time entering, checking and analysing your data and reporting your results as you did conducting the survey. This section presents the stages of processing, analysing and presenting your data for fisheries management purposes. This manual does not attempt to describe the specific outputs of the SPC Creel and Market Survey Database (hereafter termed the 'SPC Database'), but rather to describe some of the key analyses you could perform on your data, including:

- the rationale (i.e. why you are examining the data, and the importance of knowing the information for your assessment and management);
- the names of the queries in the SPC Database (correct at the time of writing) that can provide the information;
- formulas (where relevant) to show you how to calculate the statistic; and
- suggestions on how to present the information for reporting.

The analyses described here are a great start, but if you want to examine your data further, you can always do additional analyses. By copying the data from the database to Microsoft Excel (hereafter Excel) or suitable analytical program you could carry out many more investigations and answer additional questions than those addressed here. The use of the standardised SPC Database is highly recommended as the main data management tool, however, because it has been designed to make data analysis easier through the inclusion of several reports, or 'queries' that users can select which provide information on a range of questions related to management, and provides safe storage of data for future comparisons. More information on some of the statistical concepts introduced here is presented in Appendix 9.

The majority of reports generated by the SPC Database provide summaries for unstratified surveys (i.e. all fishing methods combined), which can be arranged by combinations of survey, month and landing site. However, you may have adopted a stratified approach whereby you have designed your survey to intercept fishers and capture data from different fishing methods; you may, therefore, want to examine your data for each fishing method separately (this is highly recommended!). To do this, you could import the raw data for each landing from the database into Excel and analyse according to the various fishing methods or vendor types you wish to examine. Another option is to use different survey names for each fishing method you want to separate when you set up the survey in the database (e.g. 'Pacifica spearfishing survey 2015' or 'Pacifica handline survey 2015') and then run your queries from the database as required.

4.1 Data entry and quality control

After each landing visit, the datasheets should be checked for correctness and legibility. Any common or local names used for species identification should be replaced with scientific names written out in full with the correct spelling. Datasheets should be written in neat handwriting so that anyone can read the sheet and enter the data.

Before any analyses are possible, data must be entered into the computer and checked for correctness. This important step ensures that errors as a result of incorrect data entry are avoided, and that the data entered matches the data recorded. Data entry can either be done by an individual, or by two people cross-checking the entered data against the original datasheets. This latter approach is considered more useful because errors are more easily detected.

4.2 Analysis of selected creel survey questions

4.2.1 Selected analyses for information collected in Slice C1

Average number of fishers per trip

Knowing who and how many fishers there are operating in an area is central to management. Fishers' behaviour determines the fishing pressure on the resource, and fishers are part of the system you are trying to manage. Further, you will need their cooperation if you want to manage any marine resource. This question describes one aspect of the people accessing the resource. Are they operating alone, or in pairs or groups? Are you dealing with small landings or boats with only one or a few fishers, or larger groups that go out fishing together?

How many fishers were there per landing? Answers to these questions describe some of the characteristics of the types of fishing being undertaken. The information is largely descriptive — these questions are part of understanding the fishing capacity of the local area, what kinds of management measures might be useful in the area and how many people would be affected by them.

The query in the SPC Database, 'Average number of fishers per trip', provides averages (±SE) of the number of fishers per trip that can be exported to Excel for graphing. If not using the SPC Database, you would calculate the average number of fishers per trip using the standard formula for calculating averages:

$$avg = \frac{\sum_{i=1}^{n} x_i}{n}$$

Or more simply:

$$avg = \frac{sum(x_1 + x_2 + x_3 + \ldots + x_n)}{n}$$

where in this case: avg = average number of fishers per trip,
x_1 = the number of fishers in landing 1;
x_2 = the number of fishers in landing 2;
x_3 = the number of fishers in landing 3 etc.;
x_n = the number of fishers in the last landing; and
n = the total number of landings met for the survey you are calculating the average for.

You could graph the average with the SE as error bars, such as in Figure 5. From there you can decide whether the means for different times and landings are likely to be significantly different. In the example below there is no overlap in SE, so you could conclude that the average number of fishers per boat is different for boats landed at the main boat ramp compared to those landed at the small boat ramp. Advice on calculating SE values can be found in Appendix 9.

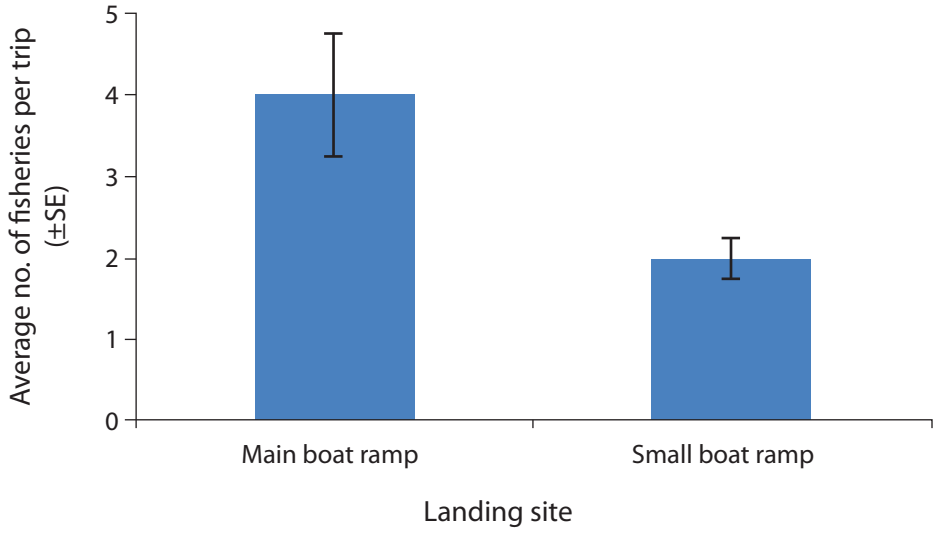


Figure 5. Average number of fishers (±SE) per trip at a hypothetical Pacific Island site

Number of fishers by survey and landing site

Instead of displaying the averages, you may choose to describe the number of fishers per landing as the frequency of landings with a certain number of fishers in them (e.g. 1, 2, 3, 4 etc.). This includes the lead fisher, plus any others he or she has with them at that landing. This analysis is included in the SPC Database as the following query:

- 'Number of fishers (frequency)'.

This analysis (Figure 6) is a variant on Figure 5, which allows you to visualise the information in terms of the frequency of the number of fishers per landing, instead of averages and standard errors. Again, this information is largely descriptive, and should form part of understanding the fishing capacity of the local area, what kinds of management measures might be useful in the area and how many people would be affected by them, so that any future management actions are appropriate.

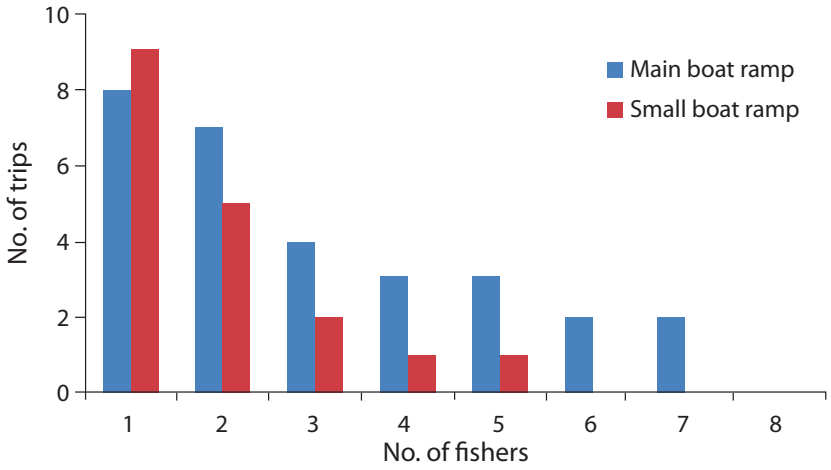


Figure 6. Frequency plot of number of fishers per trip at a hypothetical Pacific Island site.

Reasons for fishing and catch use

Understanding why people fish and what they do with the catch is key to assessing and managing a fishery. This indicator describes how the catch will be used as part of the fishers' livelihood and how it will enter and impact the economy. In some places and times the catch may be used to feed the household, or is part of a social obligation, while at other locations and times the catch may be sold for income. Over time, changes in how the catch is used may be related to socioeconomic factors (e.g. people may need money for school fees), which may in turn lead to increased pressure on the resource.

Two queries exist in the SPC Database for examining reasons for fishing and the use of the catch:

- 'Reasons for fishing and catch use – Details' (provides a tabulated list of information from all landings met); and
- 'Reasons for fishing and catch use – Average' (provides an average for the desired combination of survey, landing site and month).

Data collected for this question could be displayed in your report as text (e.g. 'On average, fishers sold 90% of their catch, and kept the remaining 10% for home consumption'), or plotted as a bar, column or line chart displaying average ± SE, such as in example Figure 7.

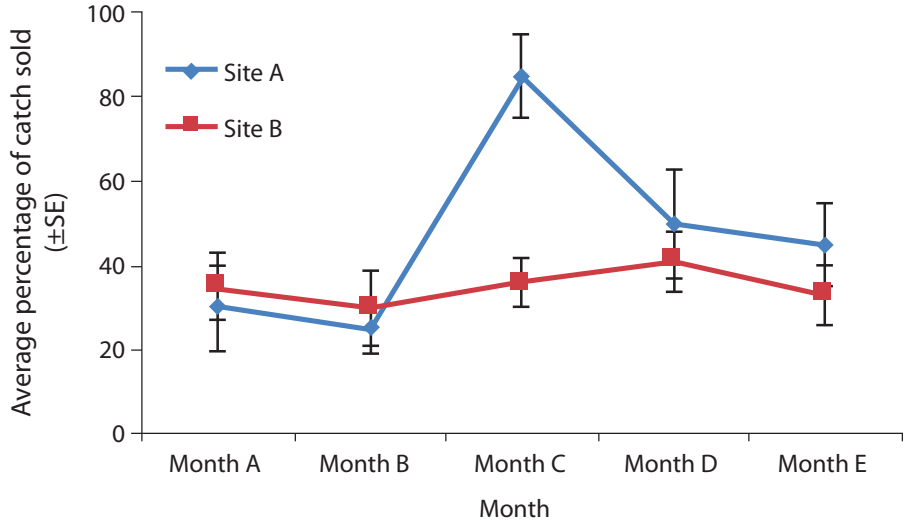


Figure 7. Average percent of catch that is sold at two hypothetical Pacific Island sites over time.

4.2.2 Selected analyses for information collected in Slices C2, C3 and C4

This set of analyses examines the species that are caught and the condition of the resource(s). There are a range of outputs available from the SPC Creel and Market Survey Database to help you with your analyses and reporting, depending on what slices you have chosen to collect data for. If you chose to meet the landings and only *count* all the catch, your data will be derived from Slice C2. If you went ahead and measured and/or weighed all of the catch, you will use the information from Slices C3 and C4, which are based on summarising length and/or weight data.

Catch composition

Understanding which species or species groups are targeted is a key requirement in fisheries assessment and management. Such data could be used to examine species- or family-specific trends, explore changes in fisheries over time, identify user groups, or help direct management initiatives. If the top species or families change over time, you may be seeing 'fishing down the food web,' a process whereby fisheries in a given ecosystem turn to increasingly smaller sized species after having depleted large predatory fish. Look for decreases in the number of carnivorous fish and a shift to herbivorous fish and/or pelagic species. Be careful when interpreting these data, however, because changes may result from both fisher and fish behaviour, and a shift to different species could also be an economic decision. For example, if the price of a particular species increases, fishers may target them specifically. So, a decline in other species may have nothing to do with the state of the resource. You may have to do some extra investigating to make sure you understand what is going on with the fishery.

Several queries exist in the SPC Database to directly examine the catch composition of your fisheries from your creel survey data. These include:

- 'Species composition – details (incl zeros)' (provides total number and total weight of each species observed at each landing based on information collected under Slice C2);
- 'Catch composition by species – avg number (incl zeros)' (provides total number and average number [±SE] of individual species for the desired combination of survey, landing site and month, based on information collected under Slice C2); and
- 'Catch composition by species – avg weight (incl zeros)' (provides average weight [±SE] of individual species for the desired combination of survey, landing site and month, based on information collected under Slice C2).

Catch compositions can also be indirectly calculated from the following queries:

- 'Catch size/weights by species – Totals by landing (incl zeros)'
- 'Catch size/weights by species – By landing and method (incl zeros)'
- 'Catch size/weights by species – Landing avg number and weight'
- 'Catch size/weights by family – Landing avg number and weight'

The formula to calculate the percent composition of a given species or family to your total catch of a given landing or entire survey (based on counts) is expressed as:

$$P_{SpA} = (Count_{SpA}/Count_{AllSpp}) \times 100$$

where in this case: P_{SpA} = the percentage contribution of Species A to the total catch of the individual landing or entire survey;
$Count_{SpA}$ is the total count of individuals of Species A in your landing or entire survey; and
$Count_{AllSpp}$ is to total count of all individuals in the landing or entire survey.

The catch composition of your fishery could be displayed as a simple pie chart showing the number of each observed species or family, or the percentage each species or family contributes to the fishery relative to the total number of all individuals observed (see Figure 8). If you collect data on fishing methods, you could chart your results by individual fishing method, such as in Figure 8. This will give you a finer-scale look at the effect of different fishing methods, and better enable you to identify trends among locations or over time. Alternately, if you have collected data across different years or seasons, you could explore the contribution of species or families over time, such as in Figure 9. In this example there is a decrease in the percentage of Lethrinidae, Lutjanidae and Serranidae over time, and an increase in Carangidae, Holocentridae and Priacanthidae.

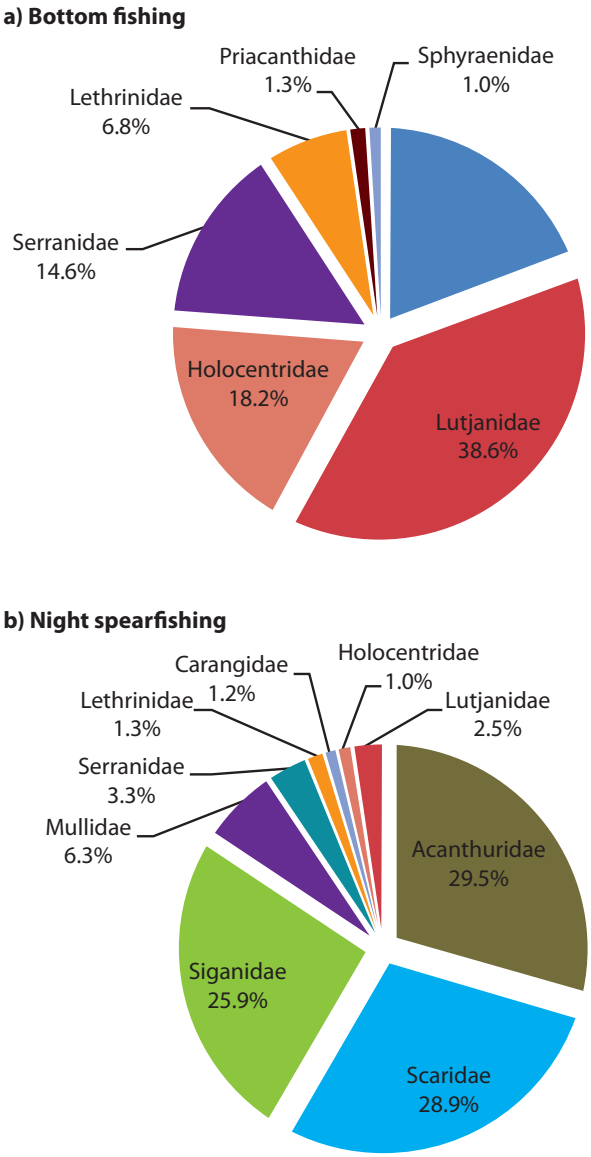


Figure 8. Pie charts of species composition by fishing method from a creel survey at a hypothetical Pacific Island site.

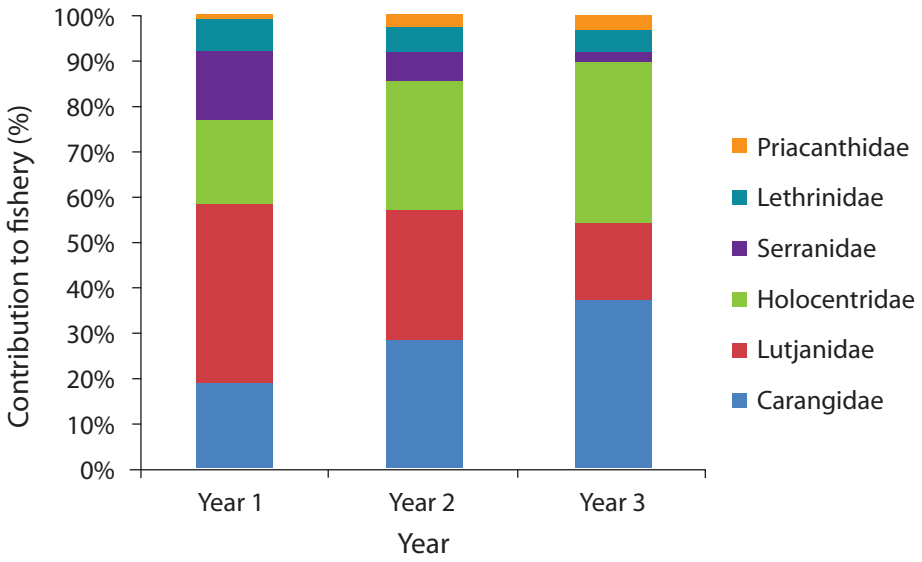


Figure 9. Percent contribution by fish family to a bottom-fishing fishery at a hypothetical Pacific Island site.

Pie charts are an excellent way of presenting data on percentages (or proportions) from total numbers; however, because they rely on text and colours, they can become cluttered and confusing with large amounts of data. They can also make it difficult to display trends over time. Moreover, they lack the option to include SE or other variance measurements (e.g. standard deviation, or SD). Thus, other approaches are needed (e.g. column or bar charts) in circumstances where you wish to display large amounts of data, trends over time, or averages ± SE.

Frequency of occurrence

Another way to explore catch compositions is to examine the frequency with which an individual species or family occurs in the catches; this is termed the frequency of occurrence (FO). FO shows how regularly a species is caught. FO can be calculated as an absolute number (e.g. Species A occurred in 15 of the 30 landings surveyed) or as a percentage (e.g. Species A occurred in 50% of the landings surveyed), calculated either over the survey as a whole, or as a daily average (i.e. the average of the percent of landings where a species was present for each day). The formula is expressed as:

$$FO = \left(\frac{L_O}{L_T}\right) \times 100$$

where in this case: FO = the frequency of occurrence
L_O = the number of landings where a particular species or family was observed; and
L_T = the total number of landings met.

As an example, if you wanted to calculate the FO of Lethrinidae in your survey, which occurred in 47 of 85 landings met, your FO would therefore be:

$$FO = \left(\frac{47}{85}\right) \times 100$$

$$= 55.3\%$$

Results could be calculated as either the FO of all methods combined, or by individual fishing method, such as shown in Table 5.

Table 5. Frequency of occurrence (FO, percentage of landings where a species was observed) of harvested species by fishing method at a hypothetical Pacific Island site

Family	Species	FO (%)		
		All methods (n=30)	Night spearfishing (n=10)	Bottom fishing (n=20)
Lethrinidae	*Lethrinus atkinsoni*	47	20	60
	Lethrinus obsoletus	63	70	60
	Monotaxis grandoculis	3	10	0
Lutjanidae	*Lutjanus bohar*	37	10	50
	Lutjanus gibbus	77	60	85
	Lutjanus kasmira	43	0	65
Serranidae	*Cephalopholis urodeta*	13	0	20
	Epinephelus merra	30	0	45
Scaridae	*Scarus dimidiatus*	23	70	0
	Scarus rivulatus	27	80	0

Species richness

Species richness is a measure of how many species were observed in your survey. This could be calculated as an average (±SE) — e.g. the average number of species per landing for your survey, or as a total number — e.g. the total number of species observed during your survey), and could be based on all species, or the number of species in a particular family or groups in the survey — e.g. species richness of parrotfish in your landings. For certain fisheries, this measure can indicate serious problems with the fishery. A decline in species richness can indicate that the resources are overfished and may require management action. For example, if sea cucumber species richness declines, this indicates overfishing has likely been occurring for some time and significant damage has been sustained by the resource. This information is best used along with other indicators to arrive at an overall picture for the resource(s) you are assessing.

The SPC Database has two dedicated options for calculating species richness from your creel survey data:

- 'Species richness from catch counts' (this query uses information from Slice C2); and
- 'Species richness from catch detail' (this query uses information from Slices C3 or C4).

Alternatively, you could calculate and present the species richness yourself. To calculate average species richness per landing or fisher (±SE), you would use using the standard formula for calculating averages:

$$avg = \frac{sum(x_1 + x_2 + x_3 + \ldots + x_n)}{n}$$

where in this case:

avg = average species richness of a survey;

x_1 = the number of species observed in landing 1;

x_2 = the number of species observed in landing 2;

x_3 = the number of species observed in landing 3 etc.,

x_n = the number of species observed in the last landing; and

n = the total number of landings met.

Species richness could be compared between two sites using a column or bar chart, while producing a line chart — such as the one in Figure 10 — is an easy way to see trends if data have been collected over time. Figure 10 is based on the total number of species observed during each survey; thus, there are no error bars.

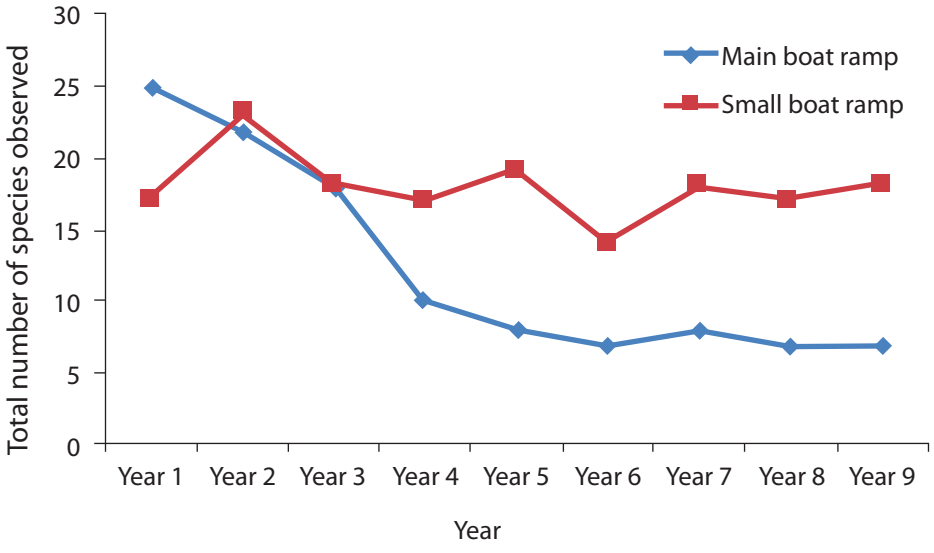


Figure 10. Species richness of finfish during a creel survey at two hypothetical sites over time.

Average catch (overall, or by individual families or species)

Examining the average number or weight of fish or invertebrates caught per landing at your site should be a key component of your assessment. This will reveal which are the more important species in your fishery at a more rigorous, finer-scale level, rather than looking at just catch composition or FO data, and provides a basis for comparing catches among sites or over time. These data will also form the basis of your estimations of total annual catch (see Appendix 3).

Declines in the catch of an individual species or family could suggest that there are fewer individuals in the wild population to be caught, and could also indicate overfishing. However, differences in average catches or changes in average catches over time, can be the result of numerous factors, and you need to be careful when interpreting these data. Fishers shifting to a different species may be an economic decision, and may have nothing to do with the state of the resource. For example, if the price of a particular species increases, fishers may target that species specifically, and so their catches may *appear* to reflect a decline in other species. Changes in the number or weight of fish caught may also reflect differences in fishing behaviour or effort, such as fishing in different locations, involving more or fewer fishers on fishing trips, or fishing for different amounts of time. You may need to do some extra investigating, such as examining your CPUE information, to make sure you understand what is going on with the fishery.

Average catch information can be extracted from the SPC Database through a number of queries, depending on what slices of data you have collected, and at what precision level you wish to examine the data (e.g. overall catches or by individual families or species). These queries include:

- 'Catch composition by species – Avg Number (incl zeros)' (based on information collected under Slice C2);
- 'Catch compositions by species – Avg Weight (incl zeros)' (based on information collected under Slice C2);
- 'Catch size/weight by species – Totals by landing (incl zeros)' (based on information collected under Slice C3 or C4);
- 'Catch size/weights by species – By landing and method (incl zeros)' (based on information collected under Slice C3/C4);
- 'Catch size/weights by species – Landing avg number and weight' (based on information collected user Slice C3/C4); and
- 'Catch size/weights by family – Landing avg number and weight' (based on information collected under Slice C3/C4).

When deriving average catches — be it overall catches, or catches by individual species or family — your average should be calculated based on the total number of individuals of interest observed in each landing, divided by the number of landings met, including those landings where the overall catch or the catch of the family or species of interest was zero. The formula for this is:

$$avg = \frac{\sum_{i=1}^{n} x_i}{n}$$

or more simply:

$$avg = \frac{sum(x_1 + x_2 + x_3 + \ldots + x_n)}{n}$$

where in this case: avg = average catch;
x_1 = the number of individuals of interest observed in landing 1;
x_2 = the number of individuals of interest observed in landing 2;
x_3 = the number of individuals of interest observed in landing 3, etc.;
x_n = the number of individuals of interest observed in the last landing; and
n = the total number of landings met.

For example, say you wanted to calculate the average number of *Naso lituratus* in your landings from a single survey, you surveyed seven landings and had counts of *N. lituratus* of 30, 17, 0, 19, 31, 15 and 24. The average number of *N. lituratus* in your landings would therefore be:

$$avg = \frac{sum(30 + 17 + 0 + 19 + 31 + 15 + 24)}{7}$$

$$= 19.4$$

Again, average catch could be calculated for all landings, regardless of fishing method, or for each individual fishing method you surveyed, provided you collected data on how the fish were caught. The results could be presented as plots of the average number of weight of a species or family over time to see if the catch is changing, such as in Figure 11 and Figure 12, or as a comparison among sites, if you have surveyed multiple sites, such as in Figure 13.

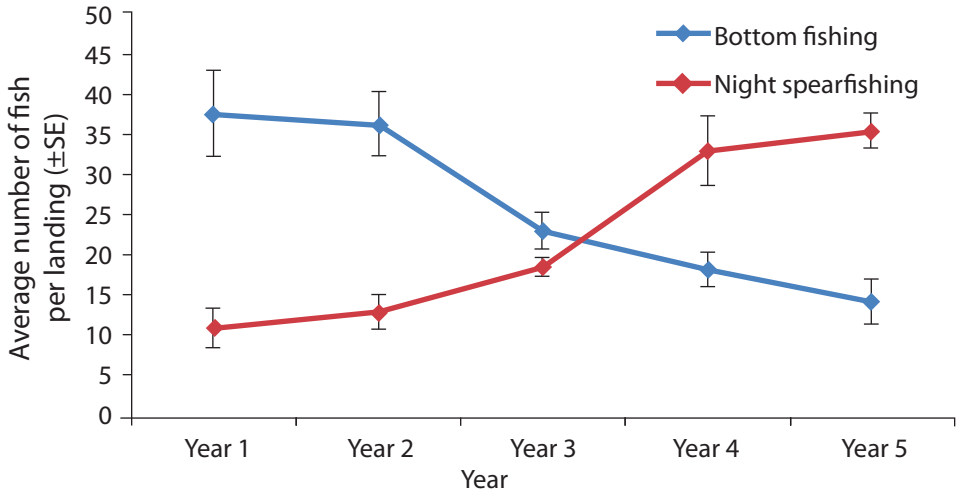


Figure 11. Average overall catch (±SE) for two fishing methods from creel surveys at a hypothetical Pacific Island site over time.

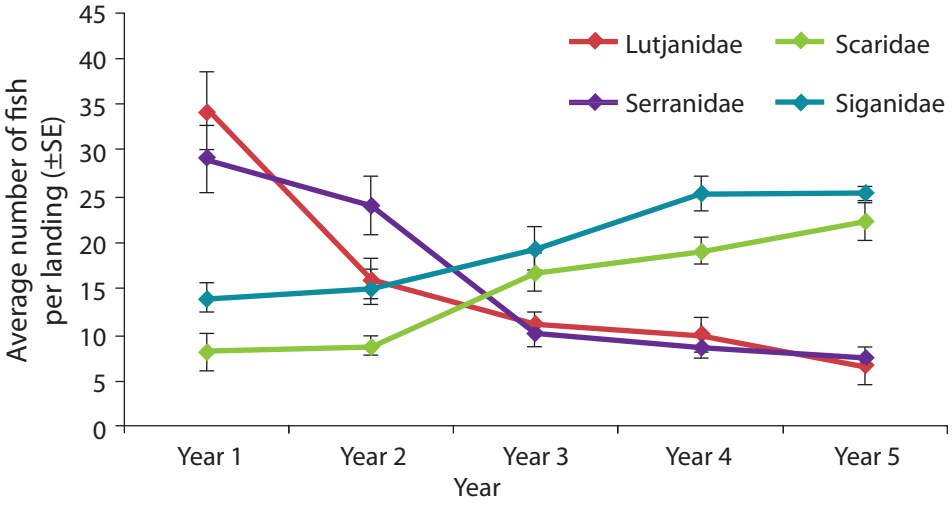


Figure 12. Average catch by family (±SE) from creel surveys at a hypothetical Pacific Island site over time.

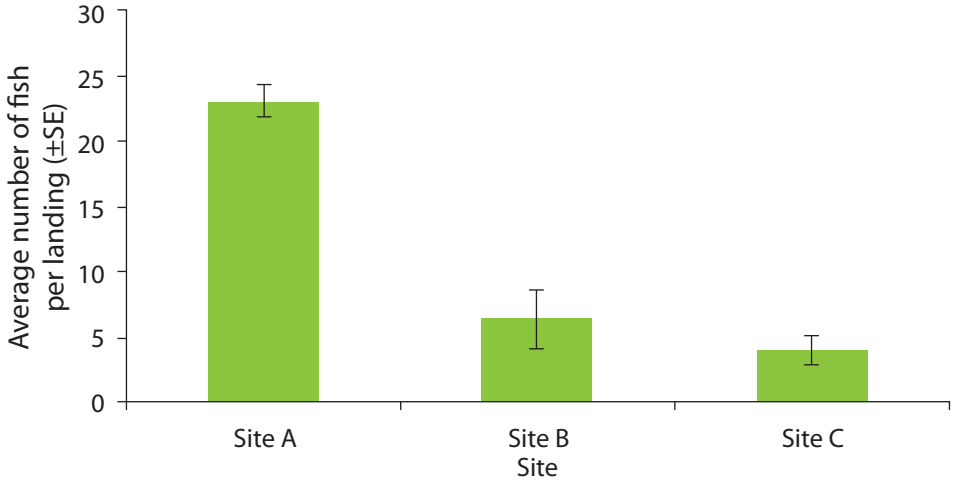


Figure 13. Patterns of average catch of orangespine unicornfish (*Naso lituratus*) (±SE) from creel surveys among three hypothetical Pacific Island sites.

Average size of individuals

Average size (either length or weight) can be an important indicator for assessing the health of fishery resources. One of the first signs of overfishing is a reduction in the size of individuals being caught (assuming all other factors, such as fishing gear used and areas fished, have remained the same). A reduction in the size of larger individuals (or the loss of larger individuals) may substantially affect the reproductive capacity of a population. Smaller sizes also mean that more individuals need to be caught to feed a household or provide income. Conversely, a significant increase in size over time might indicate improvements in the state of a resource, while no change in average size may indicate that the fishery is stable (again, provided all other factors have remained the same).

The SPC Database provides two queries for examining the average size (±SE) of individual species or families:

- 'Catch size/weights by species – avg size and weight'; and
- 'Catch size/weight by family – avg size and weight'.

These queries use the data collected under Slice C3 (size) or Slice C4 (weight), or both, if both slices of data were collected. Alternately, if you were not using the SPC Database and wanted to calculate average size of a particular species during a particular survey, you would use the standard formula for calculating averages

$$avg = \frac{\sum_{i=1}^{n} x_i}{n}$$

or more simply:

$$avg = \frac{sum(x_1 + x_2 + x_3 + \ldots + x_n)}{n}$$

where in this case: avg = average size of your species of interest;
x_1 = size of the first individual;
x_2 = size of the second individual;
x_3 = size of the third individual, etc.;
x_n = size of the last individual; and
n = the total number of individuals measured.

For example, if you wanted to calculate the average size of *Lethrinus harak* in your landings from a single survey, and you measured the fork lengths of nine individuals, which were 26.4, 28.1, 19.4, 22.5, 19.0, 28.5,

31.0, 29.5 and 33.0 cm FL, the average size of *L. harak* in your landings would therefore be:

$$avg = \frac{sum(26.4 + 28.1 + 19.4 + 22.5 + 19.0 + 28.5 + 31.0 + 29.5 + 33.0)}{9}$$

$$= 26.4 \text{ cm FL}$$

Comparing average sizes (±SE) of a species among sites will provide an indication of its status relative to other sites, while comparing average sizes at a site over time (e.g. by month or year), such as via a line graph (as in Figure 14) will allow you to detect trends or changes in average size.

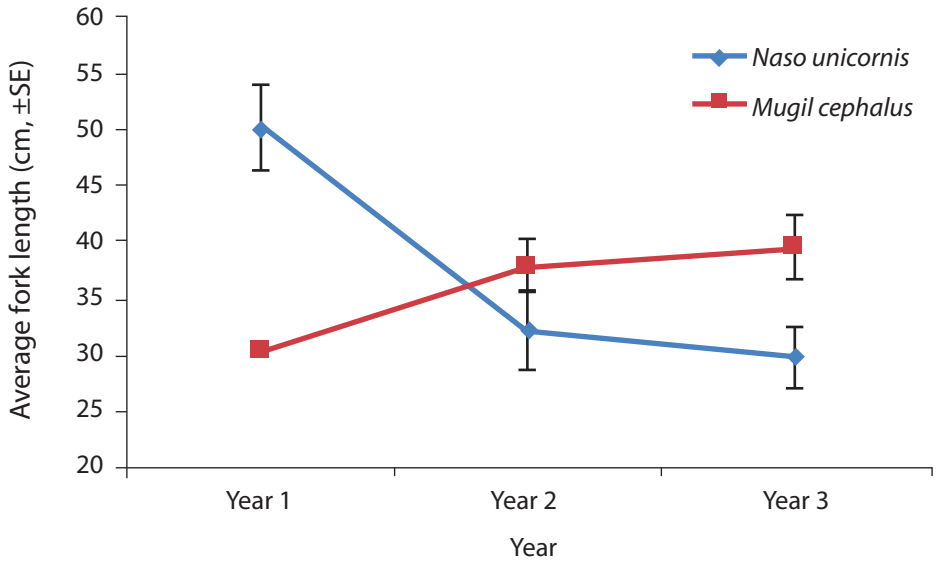


Figure 14. Average fork length (±SE) of bluespine unicornfish (*Naso unicornis*) and sea mullet (*Mugil cephalus*) during a creel survey at a hypothetical Pacific Island site over time.

Size frequency

Size frequency distribution can provide critical information for understanding the health of a resource. As with average size, changes in the size frequency over time or among sites can be used to monitor the status of resources or assess the effectiveness of management strategies. Comparisons among different fishing methods can show which methods are impacting a species at different stages in its life history, while examining size frequencies from even a single survey can tell you whether too many immature individuals are being harvested by particular fishing methods. Size frequency data can give a more detailed assessment of the population than average size because it allows you to look at changes, particularly among cohorts or individual size classes that may otherwise not be apparent from an analysis of average size.

The SPC Database provides a dedicated query for examining size (length) frequencies of individual species, based on data collected under Slice C3:

- *'Size frequency by species'.*

Size frequencies are best displayed as either a bar graph or column chart (Figure 15). In your report, you could plot the minimum legal size or size at maturity for a species onto its size frequency graph, such as in Figure 15, and recommend management intervention if a large number of undersized or immature individuals are observed in catches.

When comparing sizes (either frequencies or averages) it is important to account for the selectivity of different fishing methods. Different fishing methods can select for different sizes of fish, as seen in Figure 15. Not

accounting for different fishing methods may confound your results of comparisons among surveys or years, and limit the detection of real trends.

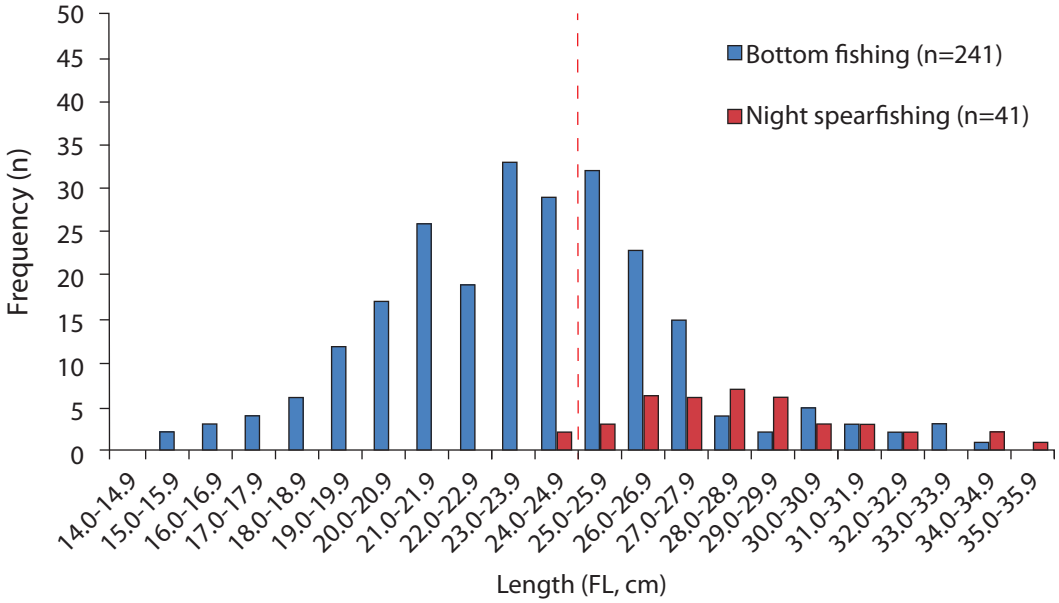


Figure 15. Length frequency of humpback red snapper (*Lutjanus gibbus*) during a hypothetical creel survey at a Pacific Island site. The vertical dashed line indicates the estimated length at which 50% of the female population becomes mature (i.e. able to reproduce).

4.2.3 Queries for information collected in Slice C5

Average costs per fishing trip

Knowing what the consumable costs are, forms an important part of your overall assessment. As costs such as fuel continue to rise, there might be more pressure on nearby resources resulting in localised overfishing. Or, there may be a drop in fishing effort and catch because people can no longer afford to go fishing. Conversely, decreases in costs such as in fuel prices may result in an increase in the number of people going fishing.

There are two queries in the SPC Database that assist with the analysis of this information:

- 'Average trip cost', and
- 'Average trip cost per cost type'.

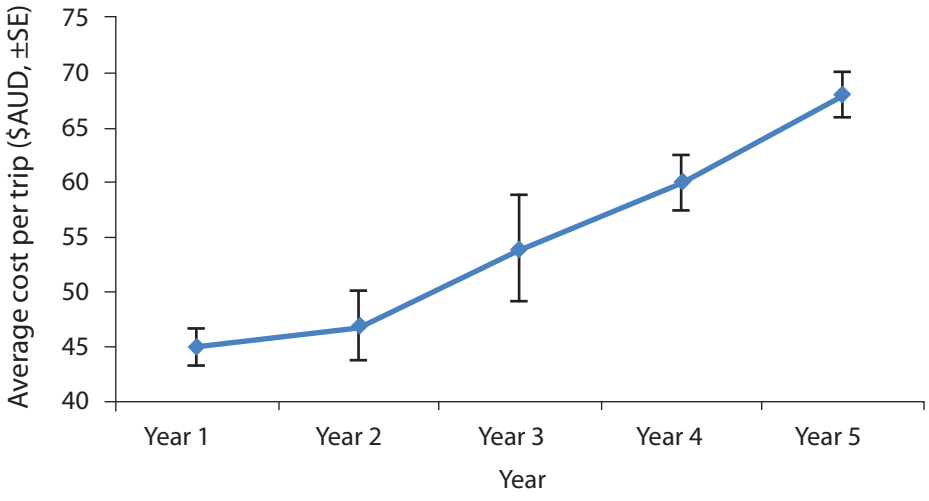


Figure 16. Average cost per fishing trip at a hypothetical Pacific Island site over time.

Average distance to the farthest site

Examining average distances fishers travel can provide a useful indication of fishing activities and the status of resources. If the survey is repeated over time, you may see that fishers have to go farther away to catch more or larger fish, which indicates that there could be localised problems of overfishing.

The SPC Database provides a single, dedicated query for examining average distance travelled:

- 'Average distance to the farthest site'.

Whether using the database or Excel, you could display the data as mean distance travelled at each survey time, such as in Figure 17.

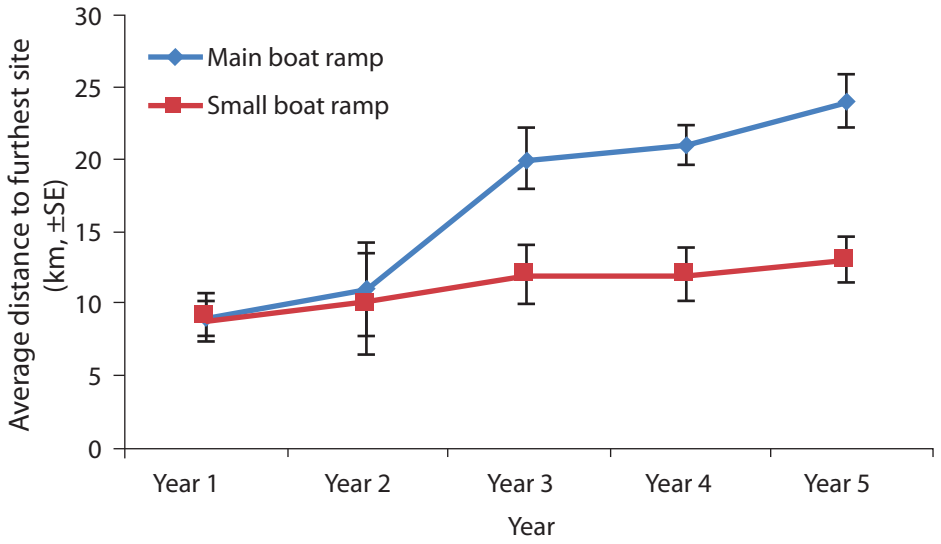


Figure 17. Average distance travelled to the farthest fishing site over time.

Catch per unit of effort

Catch per unit of effort (CPUE) is considered to be one of the key indicators of the health of a fishery, biologically and economically, and is used to assess both data-rich and data-poor fisheries around the world. At its core, CPUE is a measure of how many fish (in terms of either number or weight) were caught for a given amount of effort. A decline in CPUE potentially indicates that there are less fish available than before, and could signal issues in the fishery that might require management actions. Increases in CPUE may reflect an improvement of a stock (although see boxed text on page 59).

From the data collected during creel surveys, CPUE can be examined in a number of different ways, such as the amount of fish caught per distance travelled, amount of fish caught per amount of fuel used, or the amount of fish caught per time spent fishing. The SPC Database provides two options for calculating CPUE from either catch counts (if completing Slice C2) or size or weight data (if completing Slices C3 and/or C4):

- 'CPUE from counts'; and
- 'CPUE from size or weight'.

For each option, you can choose whether you want to extract average CPUE (±SE) — which can be grouped by any chosen combination of survey, landing site and month — or whether you want a list of CPUE for each individual landing met.

For both queries, CPUE information is provided in two simple terms. The first calculates CPUE based on the catch (total number or total weight) per hour spent on the fishing trip, such as in the formulas below:

$$CPUE_N = \frac{N}{T}$$

or

$$CPUE_W = \frac{W}{T}$$

where in this case: $CPUE_N$ and $CPUE_W$ = the CPUE in terms of number of fish caught (N) or weight of fish caught (W); and
T = time spent fishing.

This approach is ideal for fisheries where the number of people involved has little bearing on the overall catch (e.g. set gillnetting or longlining).

The second approach takes into account the number of fishers that were involved in the fishing activity. The formulas used are:

$$CPUE_N = \frac{N}{T \times F}$$

or

$$CPUE_W = \frac{W}{T \times F}$$

where in this case: $CPUE_N$ and $CPUE_W$ = the CPUE in terms of number of fish caught (N) or weight of fish caught (W);
T = time spent fishing; and
F = number of fishers.

This method is ideal for fishing activities where the amount of fish caught is affected by the number of people fishing, such as spearfishing, handlining, bottomfishing and reef gleaning.

Average $CPUE_N$ or $CPUE_W$ would then be calculating by summing the individual $CPUE_N$ or $CPUE_W$ estimates for each landing, and dividing this by the total number of landings met, as expressed in the formula below:

$$avg\ CPUE_W = \frac{sum(CPUE_{W1} + CPUE_{W2} + CPUE_{W3} + \ldots + CPUE_{Wn})}{n}$$

where in this case $avg\ CPUE_W$ = the average CPUE in terms of weight of fish caught,
$CPUE_{W1}$ = the $CPUE_W$ for landing 1,
$CPUE_{W2}$ = the $CPUE_W$ for landing 2,
$CPUE_{W3}$ = the $CPUE_W$ for landing 3, etc.,
$CPUE_{Wn}$ = the $CPUE_W$ for the last landing; and
n= the total number of landings met.

Even if you are not using the SPC Database, it is highly recommended that you examine your data in these terms. This will allow for standardisation of reporting, and will allow you to compare your results against CPUE values from other studies conducted in the region.

CPUE estimates could be graphed to either show differences in CPUE among different sites or fishing methods, using a column chart (as in Figure 18 below), or changes in CPUE over time using a line chart if you have surveyed the same site more than once, such as in Figure 19.

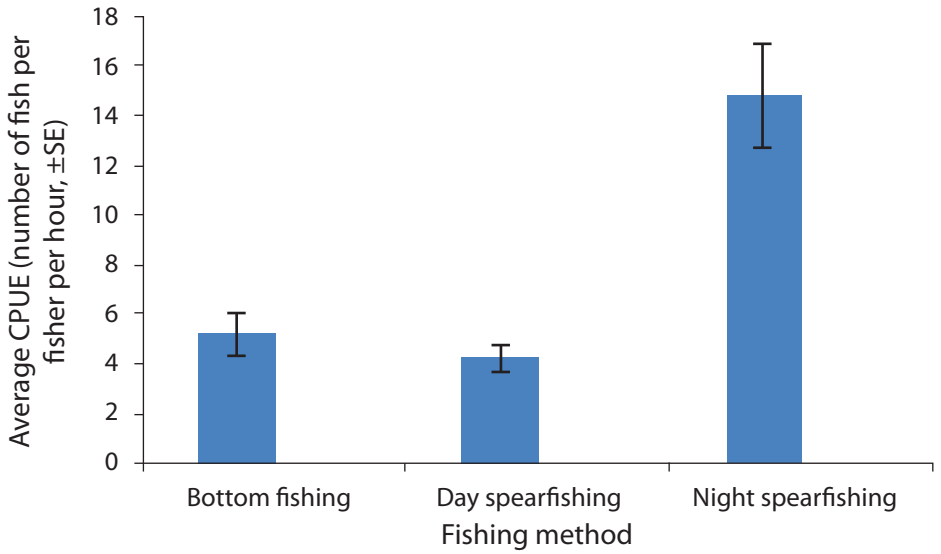


Figure 18. Average catch per unit of effort ($CPUE_N$) among different fishing methods at a hypothetical Pacific Island site.

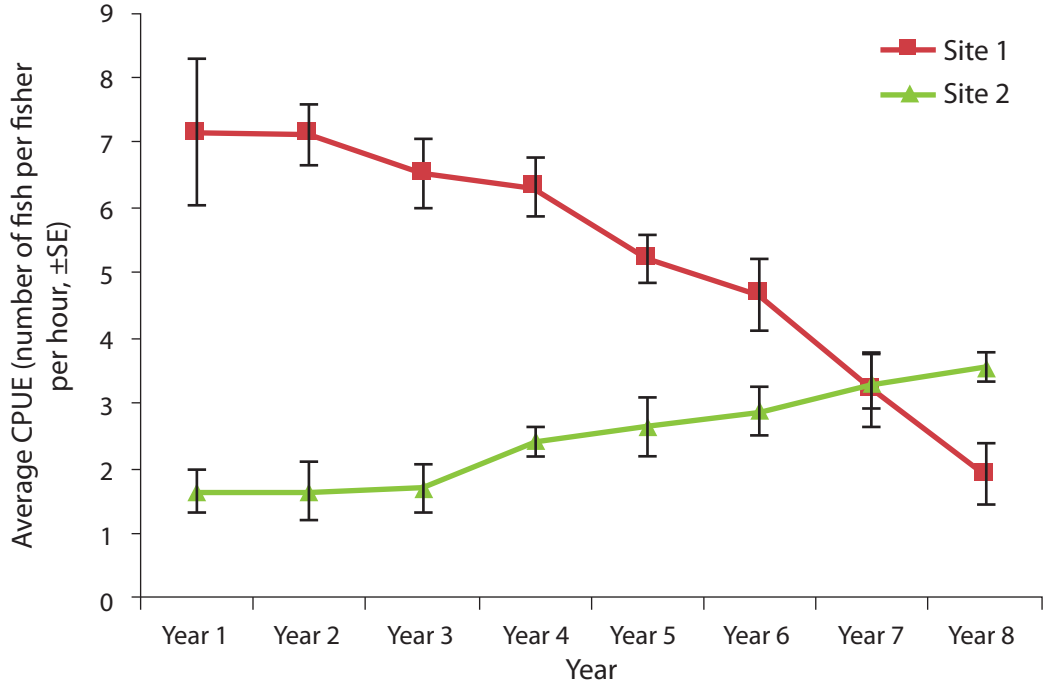


Figure 19. Average catch per unit of effort (CPUE) in terms of number of fish caught per fisher per time spent fishing at two hypothetical Pacific Island sites over time.

While catch and CPUE data are commonly used to infer the status of fish populations, these measures need to be interpreted with caution. Care is needed to examine factors that could possibly influence catch or CPUE independently of the actual status of the stock, such as advances in technology, changes in areas fished or gear used, or differences in skill and knowledge of individual fishers. Fish behaviour can also influence catch and CPUE estimates, such as in species that form spawning aggregations. For example, fishers targeting spawning aggregations would tend to have increased catch rates relative to those not targeting aggregations, with declines in catch rates not apparent even though the true abundance of the population has declined.

4.2.4 Analyses for information collected in Slice C7

Fisher perceptions: Are fishers fishing in the same areas, catching the same amounts of fish and the same sizes of fish as they were five years ago?

Fishers' knowledge of past fishing conditions can provide valuable insight into longer-term trends that you may not be aware of, even with extensive and thorough surveys. The information can sometimes be biased, but listening to what fishers think is a great way of finding out information that you would not otherwise learn from sampling alone.

The SPC Database provides two queries for the perception of data collected under Slice C7 of the creel survey datasheet:

- 'Fisher perceptions – details' (this query details the results from each landing met); and
- 'Fisher perceptions – summary' (this report provides the percent of respondents that indicated whether or not they were fishing in the same or different areas, catching the same amount, less or more fish than they were five years ago, and were catching the same size, smaller or larger fish than they were five years ago).

Perception data could be tabulated in your report or graphed. A simple way of presenting the data from a single survey is as a pie chart (or charts), showing the percentage of respondents in each category, such as in Figure 20.

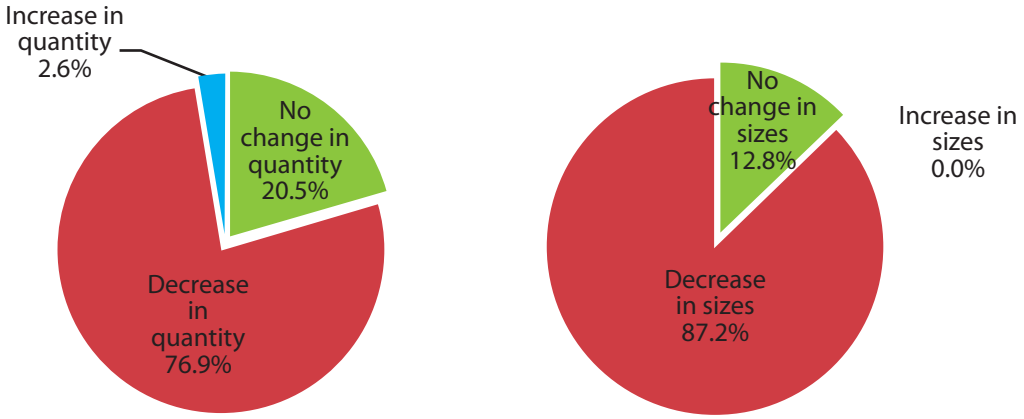


Figure 20. Responses of lead fishers to perception questions on whether catch quantities (left) or fish sizes (right) have changed over the last five years at a hypothetical creel survey site.

4.3 Analysis of selected market survey questions

4.3.1 Queries for information collected in Slice M1

How many vendors per table or stall?

This question is used to describe how many vendors are involved in selling per sampling unit (table or stall). This question helps with understanding the fishery in terms of the people involved in marketing. This information would be part of your assessment of what management measures could work and how they might impact the community.

The data are provided in the SPC Database under the following queries:

- 'Number of vendors by stall – Details'; and
- 'Number of vendors by stall – Average'.

You could plot the average number of vendors per stall (±SE) as a simple column graph, such as in Figure 21.

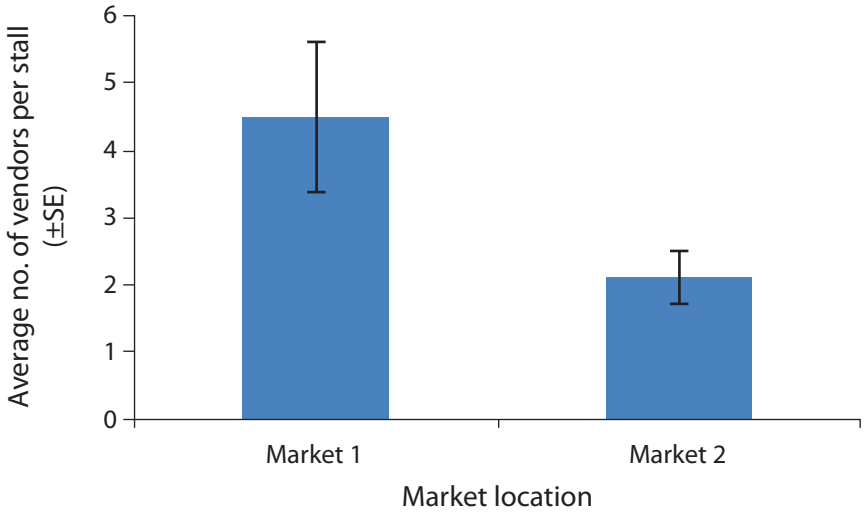


Figure 21. Average number of vendors per stall at two hypothetical Pacific Island market sites.

Average expected income from today's sales

This question is based on the vendor's overall assessment of how much income can be expected from the current day's sale. It is only an estimate, and may be inaccurate, so you should use this information as a guide only. This question allows you to examine and compare the benefits obtained from the marketing of marine products in your survey area. Taken with information on the amount of products sold and used elsewhere, this information enables you to assess how important and valuable selling fish and invertebrates is as a livelihood in the area, and compare it with other sites and over time.

You could display these data as a column graph comparing average income among sites, such as in example Figure 22, or as a column or line chart comparing different times.

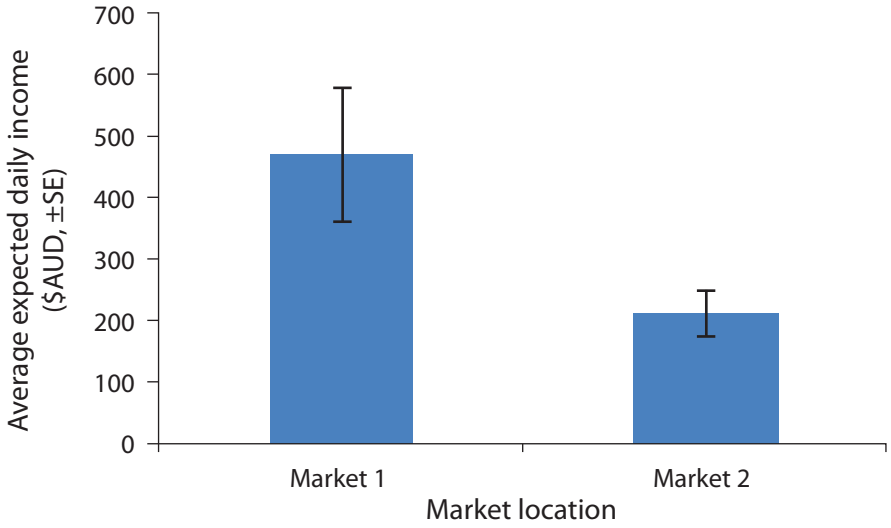


Figure 22. Average daily expected income (±SE) at two hypothetical market sites.

4.3.2 Queries for information collected in Slices M2, M3 and/or M4

Species compositions

Understanding which species or families are sold is a key requirement in fisheries assessment and management. Such data could be used to examine species- or family-specific trends over time or among markets, identify user groups, or help direct management initiatives. If the types of species or families changes over time, you may be seeing declines in wild populations. Look for decreases in carnivores and a shift to herbivores and/or pelagic species (i.e. 'fishing down the food web'). However, be careful when interpreting these data, because changes may be a behavioural response by both fisher and fish, which you would not be aware of when conducting a market survey. Fishers shifting their focus to a different species could also be an economic decision. If the price of a particular species increases, fishers may target that fish specifically. So, a decline in other species may have nothing to do with the state of the resource. You may have to look at other types of information to make sure you understand what is going on with the fishery.

Several queries exist in the SPC Database to directly examine the species compositions of the stall or table from your market survey data. These include:

- *'Market - Species composition – details (incl zeros)'* (provides the total number and total weight of each species observed at each stall or table surveyed based on information collected under Slice M2);
- *'Market - Catch composition by species – avg number (incl zeros)'* (provides total number and average number (±SE) of individual species for the desired combination of survey, market site and month, based on information collected under Slice M2);
- *'Market - Catch composition by species – avg weight (incl zeros)'* provides average weight (±SE) of individual species for the desired combination of survey, market site and month, based on information collected under Slice M2); and
- *'Market – Product composition – Details (incl zeros)* (provides the total number and total weight of each fish product (e.g. crayfish, reef fish etc.) observed at each stall or table surveyed based on information collected under Slice M2.

Species composition may also be indirectly calculated from the following queries:

- *'Market - Catch for sale size/weights by species – Avg size and weight'*; and
- *'Market - Catch for sale size/weights by family – Avg size and weight'*.

As with creel survey analyses, the species composition at your markets could be displayed as a simple pie chart showing the number of each observed species or family group, or the percentage that each species or family contributes to the overall fishery relative to the total number of all individuals sold. In addition, if you have collected data across different years or seasons, you could explore the contribution of species or families over time, such as in Figure 23.

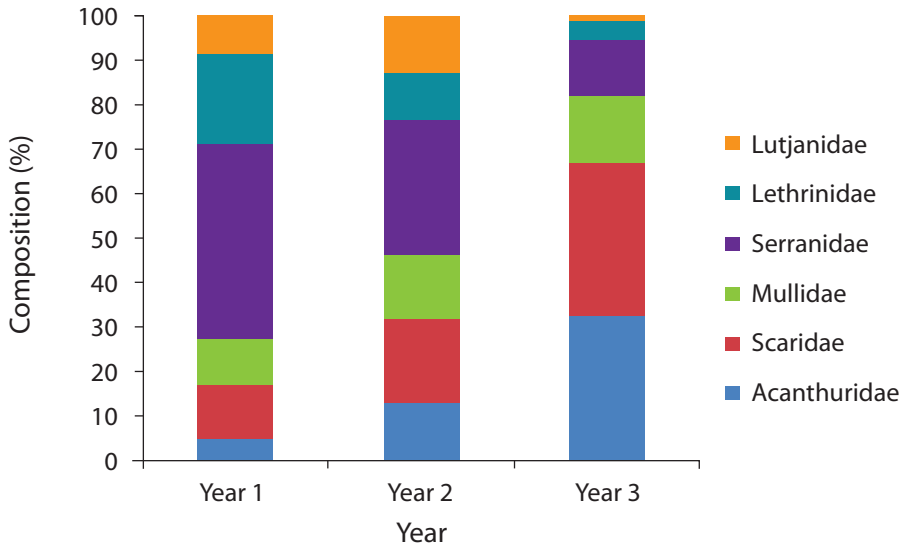


Figure 23. Species composition at a hypothetical Pacific Island market survey site over time.

Average amount of products sold by species or group

Examining the average number or weight of fish or invertebrates sold at market stalls or tables will be a key component of your assessment because it will reveal which are the more important species in your markets at a more rigorous, finer-scale level than provided by species composition information alone. Note that you will be describing the amounts being sold under any number of filtering that might occur between the landed catch and the products at the market (e.g. customer preferences for certain species or sizes, fish removed for standing orders). Be careful of your interpretation of these data; changes in the number or weight of fish at the market may also reflect differences in fishing behaviour or effort, such as fishing at different locations, involving more or less fishers on fishing trips, or fishing for different amounts of time than previously, which you will not be able to assess unless you talk directly with the fishers themselves. You may need to do some extra investigating, such as examining your CPUE information, to ensure you understand what is going on with the fishery.

There are a number of queries in the SPC Database that can be used to extract data on the average amount of fish or individuals sold (in terms of number or weight, depending on which slices you have collected data for):

- *'Catch composition by species – Avg Number (incl zeros)'* (based on count data collected for Slice M2);
- *'Catch composition by species – Avg Weight (incl zeros)'* (based on weight data estimated in Slice M2);
- *'Market - Catch for sale size/weights by species – Avg size and weight'* (based on length and/or weight data collected in Slice M3/M4); and
- *'Market - Catch for sale size/weights by family – Avg size and weight'* (based on length and/or weight data collected in Slice M3/M4).

If you choose to only count all of the marine products being sold, your data will be derived from M2. If you measure and/or weigh all of the items, you will use the information from Slices M3 and M4, which are based on summarising the length and/or weight data. There is, however, another issue that affects these data: seafood processing. Some of the seafood at the market will no longer be whole animals, and in some cases, the species may no longer be identifiable, so these data should be interpreted with these issues in mind.

Remember that when deriving your average amounts from a table or stall, be it overall or by an individual family or species, your average should be calculated based on the total number of individuals (of that family or species you are interested in) observed at each stall, divided by the number of stalls surveyed, including those

stalls where the species was not recorded (i.e. those stalls with zero individuals).

The data could be presented as plots of the average number or weight of a species or family over time to see if the relative amounts of species sold are changing (such as in Figure 24), or as a comparison among sites, if you have surveyed multiple sites, using a bar or column chart. For your report you could present overall data (average of all species combined) or averages of the most common species or families in your survey.

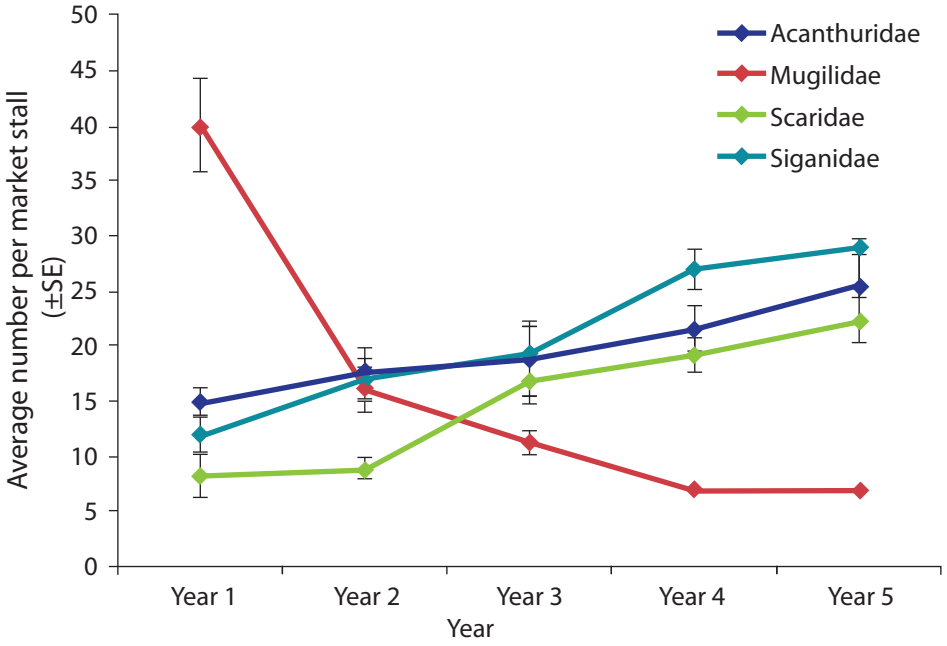


Figure 24. Average number of fish by family (±SE) at a hypothetical Pacific Island market survey site over time.

Average size or weight (or both) of products by species or family

Average size can be an important indicator for assessing the health of fishery resources, as discussed in Section 4.2.2. One of the first signs that a species is becoming overfished, is a reduction in the size of individuals. This is a concern because reductions in size and the loss of larger individuals may substantially affect the reproductive capacity of a population, particularly egg production by females. Smaller sizes also mean that more individuals need to be caught in order to feed a household or provide an income. Conversely, a significant increase over time might indicate an improvement in the state of the resource, while no change in average sizes may indicate that the fishery is stable (again, provided all other factors are the same).

The SPC Database provides two queries for examining the average size (±SE) of individual species or families from your market survey data:

- *'Catch for sale size/weights by species – Avg size and weight'*; and,
- *'Catch for sale size/weights by family – Avg size and weight.*

These queries use the data collected from Slice M3 on size, or Slice M4 on weight, or both, if you have collected both slices of data.

Comparing the average size (±SE) of a species among sites will provide an indication of its status relative to other sites, while comparing average sizes (length or weight) at a site over time (e.g. by using a line graph, such as that in Figure 25) will allow you to detect trends and changes in average size. For your report, you could plot the average size of the most commonly found species at your market, and compare the sizes based on standard error values.

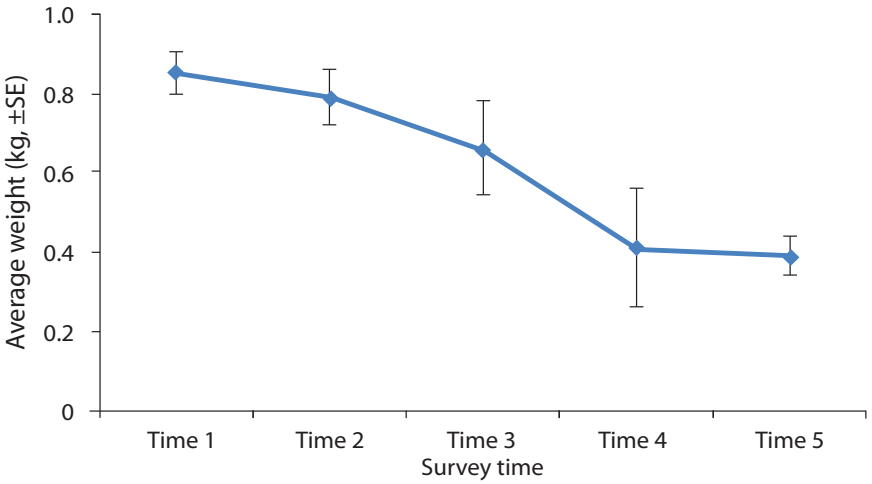


Figure 25. Average weight (±SE) of octopus (*Octopus cyanea*) at a hypothetical Pacific Island market survey site over time.

Size distribution of marine products by species

As discussed in Section 4.2.2, size frequency distribution can provide critical information for understanding the health of a fishery. Changes in the size frequency over time or among sites can be used to monitor the status of populations, or to assess the effectiveness of management strategies. Comparisons among different fishing methods can indicate which methods impact a species at different stages in its life history, while examining size frequencies from even a single survey can tell you whether too many immature individuals are being harvested. Examining the size frequency distribution of a species can give a more detailed assessment of a population than average size alone because it allows you to look at changes in particular cohorts or individual size classes that may not be obvious from an analysis of average size.

The SPC Database provides a dedicated query for examining the size (length) frequency distribution of individual species from your market survey data, based on data collected from Slice M3:

- *'Size distribution by species'*.

Size frequency distribution is best displayed as either a bar graph or column chart (see Figure 26). You could also plot the results for the most commonly observed species separately for each market, comparing the sizes sold, or separately over the years to look at how the size distribution has changed (e.g. Figure 26).

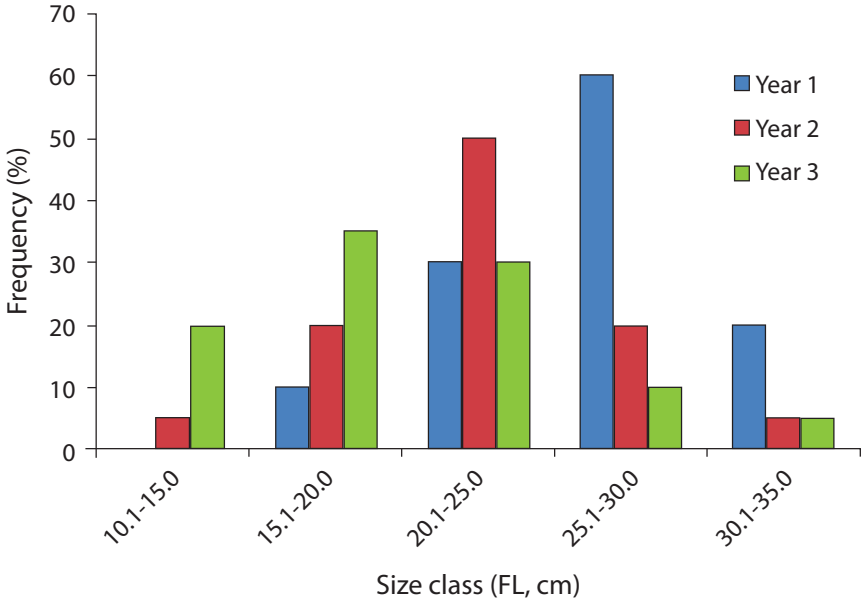


Figure 26. Size frequency distribution of Pacific longnose parrotfish (*Hipposcarus longiceps*) observed at a hypothetical Pacific Island market survey site, 2010–2012.

If collecting data for size-based analyses (either frequencies or averages) from your market survey, in addition to being aware of how the fish were caught (if the marketer knows this information) it is very important to remember that the fish on the table or at the stall have gone through the filters of fishing and selectivity by customers. Just as customers prefer certain species over others, customers may also prefer a particular size of individual over others of a species, and if you conduct your survey after the fish have been purchased, you will inadvertently add another form of bias to your survey — the bias of customer selectivity. If you want to get meaningful size data (or indeed species composition data) from your market surveys, it is highly recommended that you conduct your survey early and before fish have been sold.

4.3.3 Queries for information collected from Slice M5

Product origin: Where did the marine products on sale come from?

This query addresses the source of the products that are being sold. Throughout the Pacific Islands region, many small-scale sellers get their fish and invertebrates from a family member as part of the overall livelihood for the household, but this is changing as the islands become more developed. This indicator tells you much about how fish move through the local economy and how the benefits are distributed. This is key information for management because it helps to identify who the main players in the fishery are.

For those using the SPC Database, this information can be extracted from the query 'Origin of marine products for sale'.

Data collected could be a simple frequency listing for each product origin you encounter in your survey. A simple bar graph (see Figure 27) is an effective way of representing the frequency totalled across all samples, and could be produced separately for each site and/or survey time.

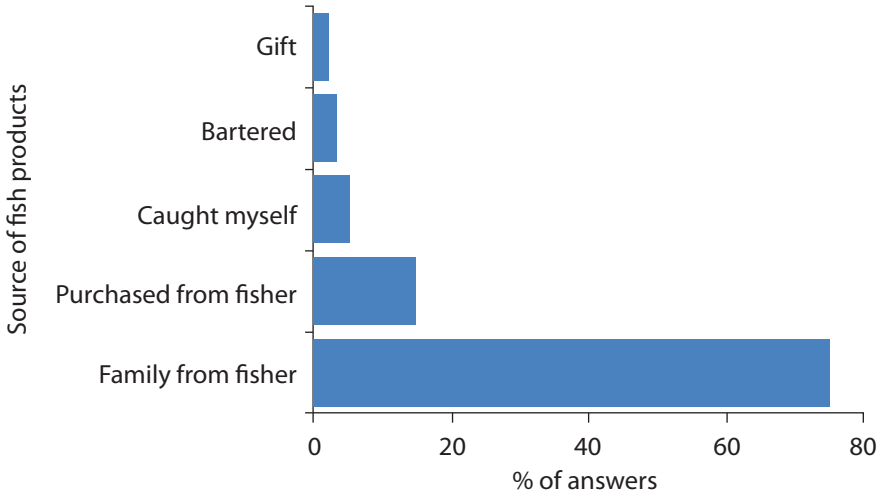


Figure 27. Sources of seafood at a hypothetical Pacific Island market survey site.

Average prices of seafood

This question gets at information on the value of the fishery products in the units by which they are usually sold. Vendors often sell their fish and invertebrates in a variety of ways, such as by piece, weight (e.g. kg, lbs), basket, string, bag or stick. This makes handling these data difficult, but well worth it. Understanding market prices is a key part of understanding both the impact of the fishery on the economy, and the impact of the economy on the resources. When sale prices change suddenly, there can be downstream impacts on the resources as fishing pressure responds to changes in the benefits of fishing. This information could also be used in conjunction with other measures to provide information on the state of resources. As species become rarer, their selling price tends to increase.

For reporting purposes you could present your results for each fishery product as a plot of the average price (±SE) per item, weight or bag, depending on how vendors sell the products in your area (see Figure 28).

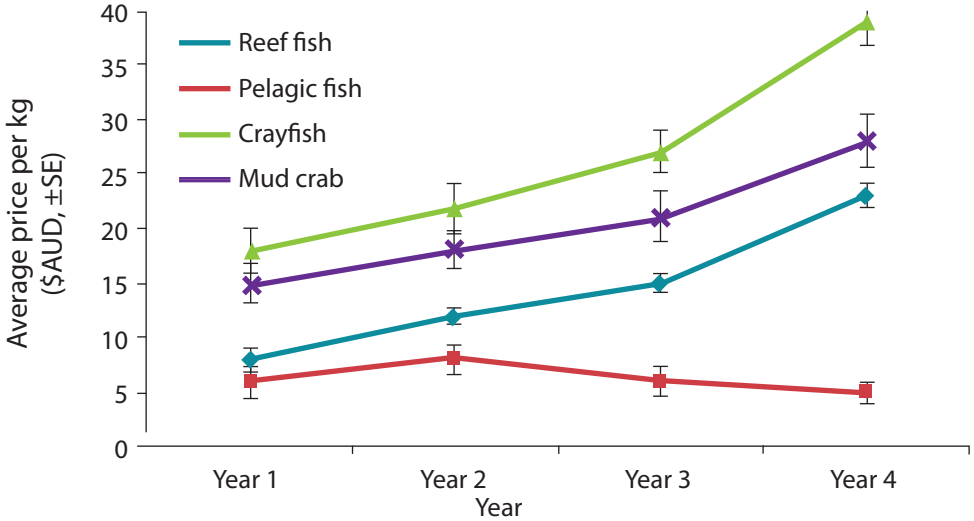


Figure 28. Average price of seafood per kilogram (kg) over a four-year period at a hypothetical Pacific Island market survey site.

Costs associated with selling

Information on the costs associated with selling seafood is an integral part of understanding the economic value of the fishery. Sudden increases in costs are likely to have large impacts on fishing pressure. With these data you can calculate the average cost per day for items the seller must buy (e.g. ice) or hire (e.g. stall) in order to sell their seafood. If you then combine this information with either the selling price data from Slice M5 (see above) or the overall expected income for the day from M1, you can begin to understand some of the economics of seafood selling in your area.

There are two queries in the SPC Database that you can use to extract data for presentation in your reports:

- *'Average selling cost'* (provides the average cost over all cost types) (Figure 29 top plot); and
- *'Average market cost per cost type'* (provide the average cost of each cost type encountered e.g. ice, wages) (Figure 29 bottom plot).

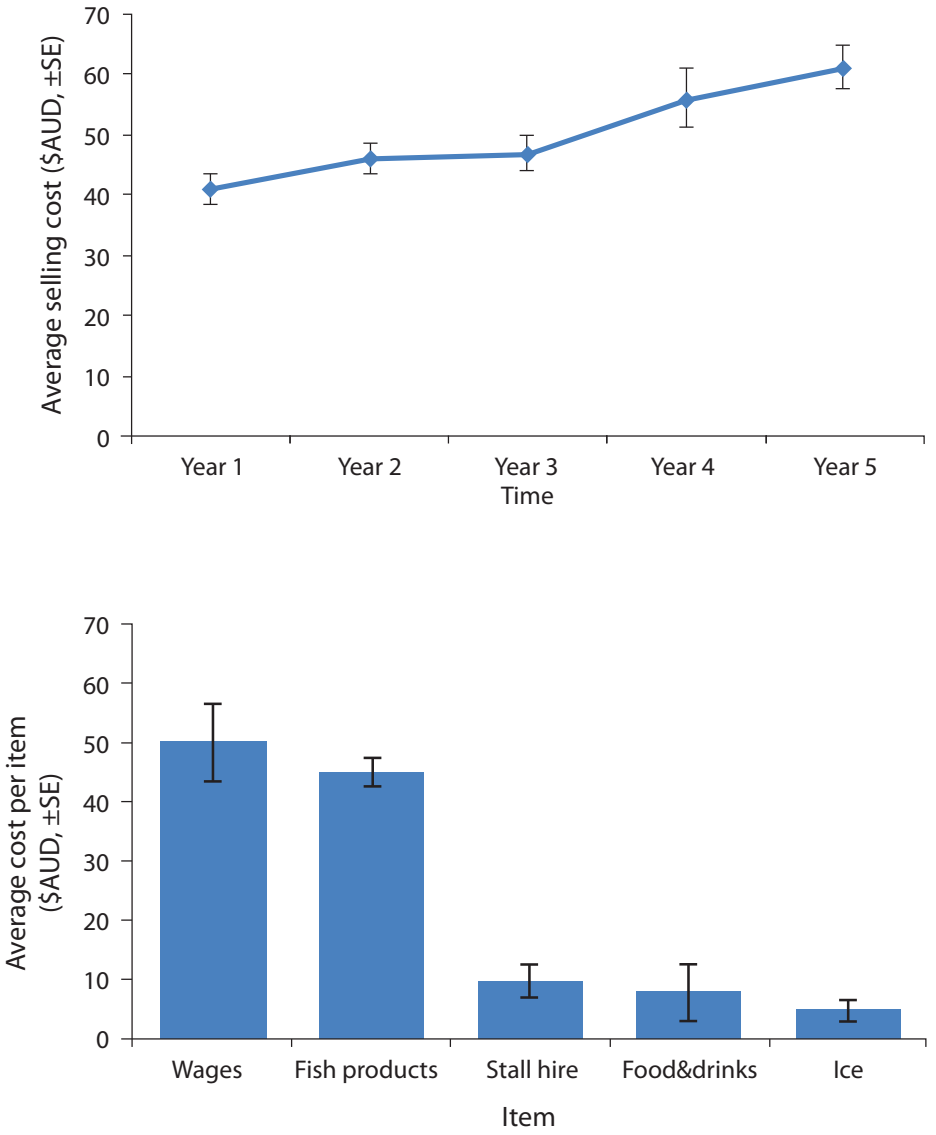


Figure 29. Average overall selling costs (top) and average selling costs by item (bottom) during a market survey at a Pacific Island market site.

4.3.4 Queries for information collected from Slice M6

How long has the vendor been selling?

This question asks vendors how long they have been marketing and how long they have been marketing seafood. For many, these two numbers may be the same, for others the number of years may be different due to changing economic conditions. Understanding this history is critical to fisheries management, and may provide further lines of information that you are interested in and can glean from the fishers themselves. Fisheries that are changing in value or that have large changes in the availability of a particular resource are more likely to involve short-term sellers. Finding a resource for which the majority of sellers have only been involved in for 1–5 years may indicate a problem with past declines in the fishery, or a sudden value increase in the species or species group currently sold. Both indicate that there may be an issue that requires management.

Vendor perceptions: Are you selling the same seafood, quantities and/or sizes as you were five years ago?

This question focuses on vendors' perceptions of marketing as a livelihood, and their ideas on the state of the resources they depend on. Vendors may notice long-term patterns where an occasional observer (such as you) may not. The information can be biased, but a vendors' knowledge of the past and changes in seafood marketing can provide a valuable insight into longer-term trends that may take you years to detect using only surveys.

The SPC Database provides two queries for perception data collected from Slice M7 of the creel survey datasheet:

- *'Marketer perceptions – details'* (this query details the results from each stall surveyed); and
- *'Marketer perceptions – summary'* (this report provides the percentage of respondents who indicated whether or not they were seeing the same species, quantities and sizes in their stall relative to five years ago).

Perception data could be tabulated in your report or graphed. A simple way of presenting the data from a single survey is as a pie chart, bar graph or column chart showing the percentage of respondents in each category (see Figure 30). Note that these will be based on the numbers relative to the total number of vendors surveyed (e.g. of the 20 vendors surveyed, 75% said they were seeing smaller sized fishes in their markets relative to five years ago).

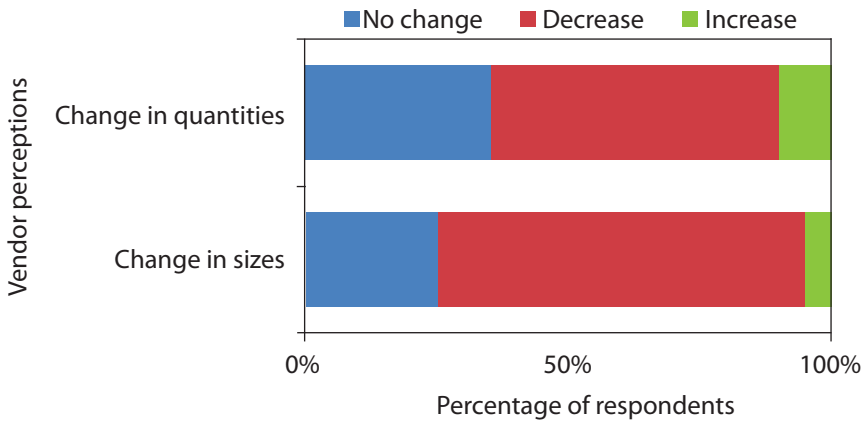


Figure 30. Perceptions of vendors during a market survey at a hypothetical Pacific Island site.

Are there any concerns about the resources?

This question allows vendors to freely mention issues that they feel are important but which you may not have thought to ask about. As with other questions, this slice focuses on what the vendors know or worry about with regard to the resources they sell. Their answers may provide information that you would not otherwise learn through other surveys. Vendors' observations may signal an issue with a resource well before it becomes apparent in the survey data. You could include the most important vendors' perceptions in your report in bullet form.

4.4 Reporting the results

Once you have completed your analyses, it is important to present the results in a format that is useful to stakeholders. The reporting template provided below is designed to guide you in producing a report based on a simplified creel survey using Slices C1, C3, C5 and C7 to survey one or more locations once or repeatedly. The approach would be similar for a market survey and you could use this template to guide the production of a similar type of report. Conducting a survey at more than one location — and repeating it over time — is highly recommended. The more sites you include in your survey, the more you will understand fishery landings and marketing over a wider area. Repeating a survey over time will enable you to detect changes in the fishery.

A creel or market report does not have to be a long, complex document. In fact, for regular reporting and decision-making, a short (e.g. five pages) report may be the most effective way of communicating what you have discovered and any management actions you feel should be taken. If you have a large survey that you want to conduct, one that includes many slices of data, you should modify or expand the template to meet your needs. In general, a report should follow the typical scientific report format as outlined below.

Title

The title should be concise and give a clear idea of what the report is about.

Acknowledgements

Here you should acknowledge all of the people or organisations that assisted with the survey. These may include fisheries managers, funding agencies, fishers, vendors, and anyone else.

Abstract or summary

The abstract or summary of the survey summarises the whole report in less than a page, and usually includes an introductory statement, survey objective, methods used to collect data, results and findings, and a brief conclusion and set of recommendations.

Introduction

This section can include any background information on the fishery you are assessing, including the relevance of the fishery to the national or provincial economy, fishing methods used in this fishery, importance of the fishery to livelihoods, production, exports, current knowledge of the fishery, results of previous resource assessments, current management practices, and the purpose of the survey.

Methods

The methods section outlines the location and timing of the survey, data collection methods (including what slices of data were collected), and how data were analysed. This section should be written with enough detail that someone else could replicate the work.

Results

The results section should contain a series of figures and tables with text to explain the findings presented in the figures. The types of data analysed depends on the data collected, but could include the following:

1) data on fishers and uses of the catch (e.g. total or average number of fishers per landing, how often the fishers landed their catches during the survey);
2) data concerning characteristics of the resources such as species composition, average number and weight of fish landed (total, and/or by individual family or species), species-specific length frequencies;
3) data on effort used, including time spent fishing and distance travelled to fish ground, and CPUE; and
4) data on fishers' perceptions, such as whether they have noticed changes in the quantity or size of fish they catch.

Conclusions and recommendations

Conclusions and recommendations often go together. This section is dedicated to clearly explaining the key findings and their implications to the fishery based on current management measures. Recommendations for alternative management measures to improve the situation should be included, and suggestions for how to improve the survey could also be included in this section of your report.

References

Provide any references to past works or reports that you have cited in your report. Be sure to use a referencing format that makes it possible for anyone reading your report to look up and find the original source materials. Use the same format for every reference you enter.

Appendices

Any information or data that is relevant but too large to include in the main body of the report should be included as an appendix (e.g. a copy of the survey datasheet used or a complete list of species observed during the survey).

5. Further reading

General information

Clua E., Beliaeff B., Chauvet C., David G., Ferraris J., Kronen M., Kulbicki M., Labrosse P., Letourneur Y., Pelletier D., Thebaud O. and Leopold M. 2005. Towards multidisciplinary indicator dashboards for coral reef fisheries management. Aquatic Living Resources 18:199-213.

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Gillett R. 2002. Thoughts on the work of FAO in the fisheries sector of the Pacific Islands. Report prepared for the Food and Agriculture Organization of the United Nations. Port Vila, Vanuatu: Gillett, Preston and Associates Inc.

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Pakoa K. and Barre C. 2013. Identification cards for marine invertebrate surveys in the Pacific Islands. Noumea, New Caledonia: Secretariat of the Pacific Commmunity.

Randall J.E. 2005. Reef and shore fishes of the South Pacific: New Caledonia to Tahiti and the Pitcairn Islands. Honolulu, Hawaii: University of Hawaii Press.

Randall J.E., Allen G.R. and Steene R.C. 1997. Fishes of the Great Barrier Reef and Coral Sea (2nd edition). Honolulu, Hawaii: University of Hawaii Press.

Examples of creel and market surveys conducted in the Pacific based on this manual

Moore B.R., Capelle J., Kabua E., Kiareti A., Lemari L., Liu R. and White M. 2014. Monitoring the Vulnerability and Adaptation of Coastal Fisheries to Climate Change: Majuro Atoll, Marshall Islands. Assessment Report no. 2. Secretariat of the Pacific Community.

Moore B.R., Alefaio S. and Siaosi F. 2014. Monitoring the vulnerability and adaptation of coastal fisheries to climate change: Funafuti Atoll, Tuvalu. Assessment Report no. 2. Secretariat of the Pacific Community.

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6. Appendices

Appendix 1: Creel or market survey design workbook

Step 1: Decide on which type of survey you need to do (you will need to fill out this form for each type)	
Type	Include? (✓ or ✗)
Creel survey	
Market survey	

Step 2: What questions do you need answers to, and which slices of data will you need to answer your questions?		
Slices	Time (minutes)	Include? (✓ or ✗)
C1 or M1 - Basic information on fishers and vendors	10	
C2 or M2 - Species composition	10	
C3 or M3 - Species sizes	30+	
C4 or M4 - Species weights	30+	
C5 - Catch effort data	30+	
C6 or M5 - Prices	10	
C7 or M6 - Perceptions of fishers and vendors	20	
Total time per replicate	Total =	

Step 3: Define the area you will cover for one sampling site	
1 module will centre on:	Radius
A town, village or place ☐ | One whole market ☐ |	km

Step 4: Conduct a pilot survey	
Pilot survey outcomes	Result or description
Dates of pilot survey	
How many test replicates did you do?	
How many sites did you visit?	
Do you have all the equipment you need?	
Do you need to buy or repair any equipment?	
Are there any problems to solve?	
What landing places are included in the modules?	
How long, on average, did it take you to survey a single landing given the slices you selected?	C1/M1 = C2/M2 = C3/M3 = C4/M4 = C5 = C6/M5 = C7/M6 =
Total time for selected slices	

Step 5: Optimise the design						
Optimisation results			Result or description			
How many sites did you use for the optimisation?						
How many test replicates did you use?						
What measures did you test? / What were the results for each level of precision?						
Precision level =	0.01 (i.e. 1%)	0.1 (i.e. 10%)	0.2 (i.e. 20%)	0.3 (i.e. 30%)	0.4 (i.e. 40%)	0.5 (i.e. 50%)
1.						
2.						
3.						
4.						
5.						
What level of precision did you accept?						
What difference among means will you be able to detect?						
What number of replicates did you decide to use overall?						

Step 6: Do you need to add other sites and/or times to the survey?			
Do you need:	More sites	More times	Tick one ✓
A snapshot	No	No	
More sites, just a snapshot	Yes	No	
More times, but just one site	No	Yes	
More sites and times	Yes	Yes	
If you need more sites, what are they?			

If you need more times, what sampling interval?	Tick one ✓
Monthly?	
Bimonthly?	
Quarterly?	
Six-monthly?	
Yearly?	
Other? (Explain)	

Step 7: Calculate the cost of your survey		
Total cost of your survey as time	**Number**	**Units**
a. Time to do a single replicate given your slices and the estimates suggested in this manual [Step 2]		hrs
b. Time to do a single replicate given your selected slices and your pilot data [Step 4]		hrs
c. Time to do a single replicate given your slices and pilot data [Step 4] in days = b/8		days
d. What precision level are you working with?		% of average
e. Number of replicates for selected precision [Step 5]		replicates
f. Multiply c by d to get days per module		days/module
g. How many sites do you propose to survey at a single time?		sites
Subtotal: Multiply e by f to get total days for all sites or markets at one time		**days/survey**
Budget for your planned survey	**Number**	**Units**
i. Total number of days to do all sites at one time (from subtotal above)		people days
ii. Number of staff available to do one full survey (all sites, one time)		people
iii. Divide i by ii to work out how many calendar days would be needed		days
iv. Allowance per person per day		AUD
v. Multiply i by iv to get total allowances needed		AUD
vi. Cost of printing datasheets		AUD
vii. Cost of equipment		AUD
viii. Other costs		AUD
Total: Add v+vi+vii = viii for total budget to do 1 survey		**AUD**
(all sites, one time)		
Do you have time and funding for this design? (Circle one)	Yes	No
If no, go back and adjust the slices, number of sites or precision you will accept (and hence the number of replicates). When done, fill out this table again.		

Step 8: Create a diagram to show your final, affordable design

Step 9: Logistics				
Work plan				
Day	Date	Site	Replicates	Staff
Day 1				
Day 2				
Day 3				
Day 4				
Day 5				
Day 6				
Day 7				
Day 8				
Day 9				
Day 10				
Day 11				
Day 12				
Day 13				
Day 14				
Day 15				
Day 16				
Day 17				
Day 18				
Day 19				
Day 20				
Day 21				
Day 22				
Add more lines as needed ↓				
Do you need transport to reach all of the landings at a site?				Yes ☐ | No ☐
Have you trained any needed staff?				Yes ☐ | No ☐
Have you arranged for daily allowances?				Yes ☐ | No ☐
Have you informed the community and fishers?				Yes ☐ | No ☐
Have you printed enough datasheets?				Yes ☐ | No ☐
Equipment for each slice				**Needed?**
C1/M1	Datasheets			Yes ☐ | No ☐
	Data control sheet			Yes ☐ | No ☐
	Pens, pencils			Yes ☐ | No ☐
	Clipboard			Yes ☐ | No ☐
	GPS (optional)			Yes ☐ | No ☐
C2/M2	Fish ID guide			Yes ☐ | No ☐
	Disposable gloves for handling seafood			Yes ☐ | No ☐
C3/M3	Tape measure			Yes ☐ | No ☐
	Fish measuring board (1 metre long)			Yes ☐ | No ☐
	Callipers (for measuring crustaceans, shellfish)			Yes ☐ | No ☐

C4/M4	Weighing scales 0–2 kg	Yes ☐ | No ☐
	Weighing scales 2–10 kg	Yes ☐ | No ☐
C5	Same as C1	Yes ☐ | No ☐
	Map of fishing grounds	Yes ☐ | No ☐
C6/M5	Same as C1+C2	Yes ☐ | No ☐
C7/M6	Same as C1+C2	Yes ☐ | No ☐
Add other items as needed		
Notes		

Example of a completed workbook for a hypothetical creel survey

Step 1: Decide on which type of survey you need to do (you will need to fill out this form for each type)		
Type		Include? (✓ or ✗)
Creel survey	Creel survey Pacifica 2015	✓
Market survey		

Step 2: What questions do you need answers to, and which slices of data will you need to answer your questions?		
Slices	Time (minutes)	Include? (✓ or ✗)
C1 or M1 - Basic information on fishers and vendors	10	✓
C2 or M2 - Species composition	10	
C3 or M3 - Species sizes	30+	✓
C4 or M4 - Species weights	30+	
C5 - Catch effort data	30+	✓
C6 or M5 - Prices	10	
C7 or M6 - Perceptions of fishers and vendors	20	
Total time per replicate	Total =	70 minutes

Step 3: Define the area you will cover for one sampling site	
1 module will centre on:	Radius
A town, village or place ☑ | One whole market ☐ | Paddletail Port	1 km

Step 4: Conduct a pilot survey	
Pilot survey outcomes	Result or description
Dates of pilot survey	1 May – 6 May 2015
How many test replicates did you do?	20
How many sites did you visit?	1
Do you have all the equipment you need?	Yes
Do you need to buy or repair any equipment?	No
Are there any problems to solve?	Yes, inform community and fishers
What landing places are included in the modules?	Several areas close to each village
How long, on average, did it take you to survey a single landing given the slices you selected?	C1/M1 = 10 minutes C2/M2 = C3/M3 = 30 minutes C4/M4 = C5 = 30 minutes C6/M5 = C7/M6 =
Total time for selected slices	70 minutes

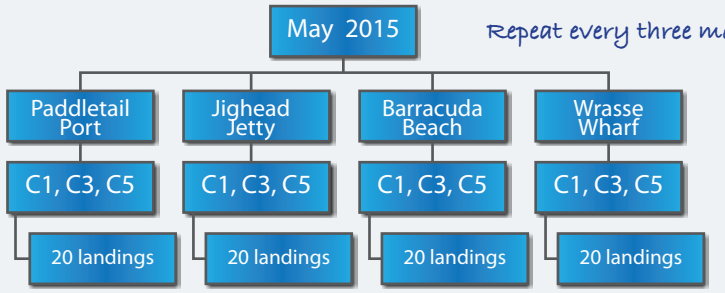
Step 5: Optimise the design						
Optimisation results			Result or description			
How many sites did you use for the optimisation?			1			
How many test replicates did you use?			20			
What measures did you test? / What were the results for each level of precision?						
Precision level =	0.01 (i.e. 1%)	0.1 (i.e. 10%)	0.2 (i.e. 20%)	0.3 (i.e. 30%)	0.4 (i.e. 40%)	0.5 (i.e. 50%)
1. CPUE (no. fish per fisher per hour)	4422	44	11	5	3	2
2. CPUE of red snapper (no. fish per fisher per hour)	5959	60	15	7	4	2
3.						
4.						
5.						
What level of precision did you accept?						20%
What difference among means will you be able to detect?						40%
What number of replicates did you decide to use overall?						20

Step 6: Do you need to add other sites and/or times to the survey?			
Do you need:	More sites	More times	Tick one ✓
A snapshot	No	No	
More sites, just a snapshot	Yes	No	
More times, but just one site	No	Yes	
More sites and times	Yes	Yes	✓
If you need more sites, what are they?	1. Jighead Jetty 2. Barracuda Beach 3. Wrasse Wharf		

If you need more times, what sampling interval?	Tick one ✓
Monthly?	
Bimonthly?	
Quarterly?	✓
Six-monthly?	
Yearly?	
Other? (Explain)	

Step 7: Calculate the cost of your survey		
Total cost of your survey as time	**Number**	**Units**
a. Time to do a single replicate given your slices and the estimates suggested in this manual [Step 2]	1.2	hrs
b. Time to do a single replicate given your selected slices and your pilot data [Step 4]	1.2	hrs
c. Time to do a single replicate given your slices and pilot data [Step 4] in days = b/8	0.15	days
d. What precision level are you working with?	20%	% of average
e. Number of replicates for selected precision [Step 5]	20	replicates
f. Multiply c by d to get days per module	3	days/module
g. How many sites do you propose to survey at a single time?	4	sites
Subtotal: Multiply e by f to get total days for all sites or markets at one time	12	**days/survey**
Budget for your planned survey	**Number**	**Units**
i. Total number of days to do all sites at one time (from subtotal above)	12	people days
ii. Number of staff available to do one full survey (all sites, one time)	4	people
iii. Divide i by ii to work out how many calendar days would be needed	48	days
iv. Allowance per person per day	10	AUD
v. Multiply i by iv to get total allowances needed	480	AUD
vi. Cost of printing datasheets	50	AUD
vii. Cost of equipment	100	AUD
viii. Other costs	100	AUD
Total: Add v+vi+vii = viii for total budget to do 1 survey	730.00	**AUD**
(all sites, one time)		
Do you have time and funding for this design? (Circle one)	(Yes)	No
If no, go back and adjust the slices, number of sites or precision you will accept (and hence the number of replicates). When done, fill out this table again.		

Step 8: Create a diagram to show your final, affordable design



Step 9: Logistics

Work plan

Day	Date	Site	Replicates	Staff
Day 1	3/5/16	Paddletail Port	1–5	JA, LJ, TL, AK
Day 2	4/5/16	Jighead Jetty	1–5	JA, LJ, TL, AK
Day 3	5/5/16	No survey		
Day 4	6/5/16	Wrasse Wharf	1–5	JA, LJ, TL, AK
Day 5	7/5/16	Jighead Jetty	6–10	JA, LJ, TL, AK
Day 6	8/5/16	No survey		
Day 7	9/5/16	Barracuda Beach	1–5	JA, LJ, TL, AK
Day 8	10/5/16	Wrasse Wharf	6–10	JA, TL
Day 9	12/5/16	Paddletail Port	6–10	JA, LJ, TL, AK
Day 10	13/5/16	No survey		
Day 11	14/5/16	Paddletail Port	11–15	JA, LJ, TL, AK
Day 12	15/5/16	No survey		
Day 13	16/5/16	Barracuda Beach	6–10	JA, LJ, TL, AK
Day 14	17/5/16	Jighead Jetty	11–15	JA, LJ, TL, AK
Day 15	18/5/16	Wrasse Wharf	11–15	JA, LJ, TL, AK
Day 16	19/5/16	Paddletail Port	16–20	JA, LJ, TL, AK
Day 17	20/5/16	Jighead Jetty	16–20	JA, LJ, TL, AK
Day 18	21/5/16	Barracuda Beach	11—15	JA, LJ, TL, AK
Day 19	22/5/16	No survey		
Day 20	23/5/16	No survey		
Day 21	24/5/16	Wrasse Wharf	16–20	JA, LJ, TL, AK
Day 22	25/6/16	Barracuda Beach	16–20	JA, LJ
Add more lines as needed ↓				

Do you need transport to reach all of the landings at a site?	Yes ☑ | No ☐
Have you trained any needed staff?	Yes ☑ | No ☐
Have you arranged for daily allowances?	Yes ☑ | No ☐
Have you informed the community and fishers?	Yes ☑ | No ☐
Have you printed enough datasheets?	Yes ☑ | No ☐

Equipment for each slice		Needed?
C1/M1	Datasheets	Yes ☑ | No ☐
	Data control sheet	Yes ☑ | No ☐
	Pens, pencils	Yes ☑ | No ☐
	Clipboard	Yes ☑ | No ☐
	GPS (optional)	Yes ☐ | No ☑
C2/M2	Fish ID guide	Yes ☑ | No ☐
	Disposable gloves for handling seafood	Yes ☑ | No ☐
C3/M3	Tape measure	Yes ☑ | No ☐
	Fish measuring board (1 metre long)	Yes ☑ | No ☐
	Callipers (for measuring crustaceans, shellfish)	Yes ☐ | No ☑

C4/M4	Weighing scales 0–2 kg	Yes ☐ | No ☑
	Weighing scales 2–10 kg	Yes ☐ | No ☑
C5	Same as C1	Yes ☑ | No ☐
	Map of fishing grounds	Yes ☑ | No ☐
C6/M5	Same as C1+C2	Yes ☐ | No ☑
C7/M6	Same as C1+C2	Yes ☐ | No ☑
Add other items as needed		

Notes

Remember to pick up data control sheets from AK by 8am Monday
Ask LJ to make second fishboard for quicker measurements

Appendix 2: Calculating total annual counts and biomass

In cases where you are using your creel or market survey to calculate total numbers or biomass to report — for example, total annual catch production to the Food and Agriculture Organization — you will need to combine the information you collect in your creel survey with broader information on the number of fishers, or boats, or both. This is a consequence of sampling your landed catches or market units, rather than surveying all landings (i.e. a census). This appendix will discuss how to calculate overall annual totals for groups (e.g. fish, crustaceans) as counts and weights for creel and market surveys; however, these same techniques could be used to obtain totals by species or family, too. The types of information that are possible to assess are:

- total number of fish and invertebrates caught per year = average number per catch, multiplied by the number of catches in the year;
- total weight of fish and invertebrates caught per year = average weight per catch, multiplied by the number of catches in the year;
- total number of fish and invertebrates sold in markets per year = average number per table (or stall or shop) per day, multiplied by the number of days marketing; and
- total weight of fish and invertebrates sold in markets per year = average weight per table (or stall or shop) per day, multiplied by the number of days marketing.

The averages (i.e. average number or average weight per catch) are available from your creel or market survey. The values required for the right-hand side of each equation — called the multiplier data (number of catches or days marketing) — are not found in your survey because you are sampling and do not know how many catches are landed in total or how many days of marketing there were. To obtain the multiplier data, you must use one of the approaches listed below. Once you have your estimates, you can enter the information into the database to calculate the final total annual values you need.

How to get multiplier data for your calculations

You have several options for getting the data you need:

1. *Accumulation method:* Run your creel survey over a long period of time and accumulate a list of all the fishers and marketers you survey, using the data they provide in either Slice C1 or M1 to generate a total number of catches for the year. This method is not very reliable because it depends on building up a picture based on your limited sampling, and can only refer to the sampling area (i.e. this method is not good for national values). After several years, this estimate would improve, but overall, it is not recommended.

2. *Census or household income and expenditure survey (HIES) method:* If you are lucky enough to have a national census or an HIES taking place in your country (one that asks households whether they fish and how often), you may be able to get this information from that source. Many Pacific Island countries and territories have recently been working with the Pacific Community's Statistics for Development Division to standardise and undertake their HIES surveys. So, now would be a good time to work with your Statistics Office and ask them to include some additional fisheries data in their next census or HIES, using the questions suggested below.

3. *Socioeconomic survey method:* Use data collected from socioeconomic fisheries surveys that are conducted by your fisheries office. The SPC 'Socioeconomic fisheries surveys in Pacific Islands: A manual for the collection of a minimum dataset" (Kronen et al. 2007) provides information on collecting the necessary multiplier data.

4. *Special household survey method:* The final option is to carry out your own survey that is designed to collect the multiplier data that you need. You could run a very rapid and short household survey once every five years, for example. The weakness of this method is that you will likely be unable to carry it out at a national level, so you will be extrapolating from a smaller sample. This means that your estimate of

[2] A pivot table is a data summarization tool in spreadsheet software such as Microsoft Excel. A pivot table has many powerful functions, including grouping, sorting, and filtering data, providing total counts or averages, or graphing selected data. There are a number of freely available guides and demonstrations on the internet to help you use pivot tables to manage your data.

average from the creel survey and your estimate of fishing trips or market days will both be based on estimates, and the final errors will be much larger.

How to carry out a special household survey for multiplier data

All surveys need to follow the rules you have learned in this manual, including setting up the questions, choosing and optimising a design, and planning how you will handle the results. Below is a very rapid assessment method:

1. Define the area within which you will collect the data. This is unlikely to encompass the entire country. Instead, you may choose to survey the same areas as the creel and/or market surveys. In any case, define the area you will sample.
2. Organise a number of days (e.g. 5–10) to visit a random subset of households spread throughout your defined area. Try to go to at least 10% of the households in the selected area, although the more households, the better. You can use past census data to see how many households are in your defined area, and to determine how many you would need to visit for at least 10% coverage.
3. Work out a system for choosing households randomly, or at least haphazardly, and ensure that you minimise the risk of bias caused by selecting certain types of households (e.g. those close to main roads are at risk of being over-sampled, and those farther way are at risk of being under-sampled; this would bias your results).
4. Inform communities through the radio, newspapers and other means of your plan to visit homes to ask fisheries-related questions.
5. Train interviewers to interview the heads of households (or other adults if necessary) to fill out the simple questionnaire below. You should only need 10 minutes per household, so you should be able to survey many households in a day.
6. Carry out the survey.
7. Enter the data into a database or an Excel worksheet and use pivot tables[2] to calculate:
    a. proportion of the population that goes fishing
    b. average number of trips done by each lead fisher per year
    c. proportion of the population that is involved in marketing
    d. average number of marketing days per year

Questionnaire for special household survey to collect multiplier data

An example of a special household survey questionnaire can be found below. Like the creel and market survey sheets, each questionnaire should be assigned a unique serial number to identify it from other forms.

Special creel household survey carried out by: [enter organisation or department]				**Serial No. CFS-001**
Province / Island:				
Survey time (month/year):				
Survey site, village, suburb, town: Date of this interview:				
Interviewers' and surveyors' names:	1.		2.	
Latitude (DD):		Longitude (DD):		
Interview				
Name of person interviewed:	First:	Last:		
Person is head of this household?	Yes ☐ | No ☐			
How many people live in this household?		Children <18 years old:	[.....]	
		Adults 18+ years old:	[.....]	

Fishing information			
How many people in this household undertake any form of fishing (include all fishing methods)?		Lead fishers:	[.....]
		Contributing fishers:	[.....]
What types of fishing do you do, and how often? (only record lead fisher's answer)*			
Type of fishing (method/habitat/group)	**Average no. trips/ month**	**How many months a year do you fish (i.e. exclude closures)?**	**= How many trips per year?**
A.1.1 (Netting/lagoon/Fish - reef fish)	3	10	30

Method	Habitat	Group
A. Netting	1. Lagoon	1. Fish – reef fish
B. Vertical longlining	2. Reef	2. Fish – pelagic fish
C. Handlining	3. Beach	3. Fish – deepwater snappers
D. Trolling	4. Mangrove	2. Crustaceans
E. Deep bottomfishing	5. Ocean	3. Molluscs
F. Spearfishing - day	6. Freshwater	4. Beche-der-mer
G. Spearfishing - night	7. Other	5. Other
H. Collecting		
I. Other		

Marketing information			
How many people in this household market any kind of marine products?		Lead marketers: [.....] Contributing marketers: [.....]	
What types of marketing do you do, and how often? (only record lead marketer's answer)*			
Type of marketing (market, group)	**Average no. market days/ month**	**How many months a year to you sell seafood (i.e. exclude closures)**	**= How many marketing days per year?**
e.g. B.5 Stall/Molluscs	20	10	200

Market	Group
A. Local market table	1. Fish – reef fish
B. Stall in controlled market area	2. Fish - pelagic (including tuna)
C. Retail shop / outlet	3. Fish – deepwater snappers
D. Resort or restaurant sales	4. Crustaceans
E. Buyer	5. Molluscs
F. Exporter	6. Beche-der-mer
G. Other	7. Other

* It is important that you do not overestimate the number of fishing or marketing trips or number of days if several household members go out on the same trips or go to market seafood together, or contribute to trips or market stalls run by other households. You need to establish who the lead fishers or marketers of the household are, and only obtain data for them.

How to calculate total numbers and weights (biomass) landed or marketed

Once collected, data can be stored in the SPC Creel and Market Survey Database using the 'Household' survey option, in Excel, or in another suitable database or spreadsheet program. We strongly advise using a database for safe and secure storage of the information. If using Excel, each of the data fields you filled in on the form needs to have its own column and you will enter the data themselves as rows, as in the example below. The rows need to be repeated for a particular household for all the different types of fishing done by lead fishers. It is strongly recommended that you build a separate spreadsheet for the creel and market parts of this household survey to make data management and analysis easier.

The example below demonstrates how the spreadsheet would look in Excel for just the fishing portion of the survey. Notice that the three components of fishing type (method, habitat and group) are spread across three columns so you can organise and summarise the data accordingly, should you want to explore any combination of these three components in greater detail.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	ID	Island	Mo/Yr	Site	Date	First name	Last name	No. in household	No. children	No. adults	No. leadfishers	No. contributing	Method	Habitat	Group	Avg trips / month	Fishing months	Trips / year
2	CFS-001	Pacifica	may-15	Tunapapa	15/06/2015	Slone	Fisher	6	4	2	2	1	Netting	Lagoon	Fish - reef	3	12	36
3	CFS-001	Pacifica	may-15	Tunapapa	15/06/2015	Slone	Fisher	6	4	2	2	1	Collecting	Mangrove	Crustaceans	5	9	45
4	CFS-002	Pacifica	may-15	Tunapapa	15/06/2015	Henry	Wallis	8	5	3	2	3	Handlining	Reef	Fish - reef	10	12	120
5	CFS-002	Pacifica	may-15	Tunapapa	15/06/2015	Henry	Wallis	8	5	3	2	3	Spearfishing- day	Reef	Fish - reef	10	12	120
6	CFS-002	Pacifica	may-15	Tunapapa	16/05/2015	Henry	Wallis	8	5	3	2	0	Trolling	Ocean	Fish - pelagics	7	12	84
7	CFS-003	Pacifica	may-15	Tunapapa	16/05/2015	Micheal	Nuku	4	2	2	1	0	Spearfishing- day	Reef	Fish - reef	7	12	84
8	CFS-004	Pacifica	may-15	Tunapapa	18/05/2015	Samuel	Santo	5	3	2	1	2	Trolling	Ocean	Fish - pelagics	20	12	240
9	CFS-004	Pacifica	may-15	Tunapapa	18/05/2015	Samuel	Santo	5	3	2	1	2	Handlining	Reef	Fish - reef	12	12	144
10	CFS-005	Pacifica	may-15	Tunapapa	18/05/2015	Betty	Birnie	6	4	2	2	2	Collecting	Mangrove	Molluscs	4	12	48
11	CFS-005	Pacifica	may-15	Tunapapa	18/05/2015	Betty	Birnie	6	4	2	2	2	Collecting	Mangrove	Crustaceans	4	9	36
12	CFS-005	Pacifica	may-15	Tunapapa	18/05/2015	Maxwell	Birnie	6	4	2	2	2	Spearfishing- day	Reef	Fish - reef	16	12	192
13	CFS-006	Pacifica	may-15	Tunapapa	18/05/2015	Paul	Palikiti	2	0	2	1	0	Spearfishing- day	Reef	Fish - reef	12	12	144
14	CFS-007	Pacifica	may-15	Tunapapa	19/05/2015	Jonathon	Johnson	7	5	2	1	1	Collecting	Mangrove	Crustaceans	12	9	108
15	CFS-007	Pacifica	may-15	Tunapapa	19/05/2015	Jonathon	Johnson	7	5	2	1	1	Spearfishing- day	Reef	Fish - reef	20	12	240
16	CFS-007	Pacifica	may-15	Tunapapa	19/05/2015	Jonathon	Johnson	7	5	2	1	1	Handlining	Reef	Fish - reef	4	12	48
17	CFS-008	Pacifica	may-15	Tunapapa	19/05/2015	Naomi	Nuku	6	3	3	2	2	Collecting	Beach	Molluscs	16	12	192
18	CFS-008	Pacifica	may-15	Tunapapa	19/05/2015	Naomi	Nuku	6	3	3	2	2	Spearfishing- day	Reef	Fish - reef	12	12	144

To calculate the multiplier data needed and then the annual total production in numbers and biomass, follow the steps below.

1. Calculate the average number of fishing trips made per fisher per year for the Method / Habitat / Group you are interested in, either manually or by using a pivot table. For this particular example, only trips targeting reef fish (irrespective of fishing method used and habitat fished) are examined.

Survey #	No. of trips/yr	No. in household	No. of lead fishers
CFS-001	36	6	2
CFS-002	240	8	2
CFS-003	84	4	1
CFS-004	144	5	1
CFS-005	192	6	2
CFS-006	144	2	1
CFS-007	288	7	1
CFS-008	144	6	2
Total	1272	44	12

Average no. trips per year = (36+240+84+144+192+144+288+144) / 8
= 159

2. Using the information from the same data, calculate the percentage of the population who lead fishing trips. You can use the same pivot table, but add the sum of lead fishers in the population and the sum of the number of people in all households.

% Lead fishers in the population	= Total no. lead fishers divided by the total number of people in all households x 100 = 12 / 44 x 100 = 27.3%

3. Use the national census data in your country to obtain the total population in your area of interest (site, island, province or entire country). For example, assume that the population of the area where you did the creel survey is 2,836.

4. The total number of lead fishers in the area of interest is:

Total no. lead fishers	= 27.3% of 2,836 = 2,836 x 27.3% = 774.2

5. Next, calculate the total number of fisher trips made per year:

Total fisher trips	= Total fishers multiplied by average number fishing trips per year = 774.2 x 159 = 123,102

6. To calculate yearly catches in numbers or weight, multiply the average number or weight landed from your creel survey data by the total number of fisher trips made per year. For example, for the defined area for 2015:

Total number of fish landed	= Average number of fish per landing in 2015 multiplied by the total number of fisher trips in 2015
Total weight of fish landed	= Average weight of catch per landing in 2015 multiplied by the total number of fisher trips in 2015

7. Calculating total numbers or weights sold in markets is done in the same manner, using the average number or weight sold per table, stall or market, and the total number of table, stall, market days per year, i.e. for a defined area in 2015:

Total number sold through markets	= Average number per table in 2015 multiplied by the total number of table days in 2015
Total weight sold through markets	= Average weight per table in 2015 multiplied by the total number of table days in 2015.

The multiplier data you derive from the household survey can be used with creel or market data over several years. However, you will need to update them periodically (e.g. every five years). You could also use the multiplier data calculated for your specific fish or invertebrate group of interest (e.g. reef fish, pelagic fish, sea cucumbers) instead of the overall one in order to improve your estimate, but you could not do this for a family or species because this level of detail was not included in this particular survey.

Appendix 4: Creel survey datasheets

Complete the creel survey sheet below for slices C1–C7

Use **one** sheet for each landing met (replicate).

Creel survey carried out by: [enter organisation or department]			V_Oct2016 **Landing no:**
Survey name:			
Province / Island + Country:			
Date of this replicate (day/month/year):		Currency used:	
Survey Site:			
Latitude (DD):		Longitude (DD):	
Interviewers' / surveyors' names:	1.	3.	
	2.	4.	

C1: Basic information on fishers			V_Oct2016
Lead fisher's name:			
Date of birth (DOB):	Gender:		
Address (name of village / town / city:			
Vessel ID/Name:			
Is the fisher fishing with other people? Yes ☐ | No ☐			
Total number of fishers?			
→ (data on other fishers in the landing today)			
Name of other fisher 1:		DOB:	Gender:
Other fisher 2:		DOB:	Gender:
Other fisher 3:		DOB:	Gender:
Other fisher 4:		DOB:	Gender:
→ (back to lead fisher)			
How many days per month do you go fishing? /month		How many months a year do you fish (i.e. excluding closed fishing seasons)? months fished	
What fishing methods do you usually use (not only this fishing trip)?		Method 1:	
Method 2:		Method 3:	
Method 4:		Method 5:	
Where else do you land your fish? What other sites)? List by priority			
Other site 1: (most often)		How often?	/month
Other site 2:		How often?	/month
Other site 3:		How often?	/month
Other site 4: (least often)		How often?	/month
Why do you fish?	Subsistence ☐ | Income ☐ | Other ☐		
Please provide details:			
About how much of this catch will be eaten at home or sold?		% kept	% sold
How much do you expect to earn from this catch overall?		Value:	
What is your estimate of the total weight of this catch (estimated by you, not the fisher)?		kg	

V_Oct2016

C2: Species composition and/or counts

What is the total count by species of all fish, invertebrates and other seafood landed?

Species name or group	Fish product	Total number	Total weight (kg)	Fishing method

C3: Species sizes, and C4: Species weights

Record all sizes in the catch in cm (to nearest 0.1 cm) and all weights in kg
(Repeat this page if you need more space)

Species name	Size type	Size (cm)	Weight (kg)	Fishing method

V_Oct2016

C5: Effort data for CPUE

How many hours were spent on the fishing trip today? hrs

Fishing method and gear used for each fish product (separate pelagic fish, reef fish, crabs, lobsters, etc.), how many sets of gear were involved and how much time spent doing each activity

Fish product	Methods / gear used	No. gears	No. hours	Day or night?
1.				
2.				
3.				
4.				

Did you lose or damage any gear during this fishing trip? What was it? How much will it cost to replace or repair the item?

Gear item	Lost or damaged?	Cost to replace or repair
1.		
2.		
3.		
4.		

Please list any other costs associated with this fishing trip, including fuel, wages, bait, ice, food, drink, or any other items.

Item	Purchase price:
1.	
2.	
3.	
4.	

What is the distance to the farthest site you fished at today? km

Where did you leave from?

How many sites did you stop and fish at? Where are they?

Site	Location (on map, lat/long, or distance to each fishing ground)	Time spent at location (hrs)
1.		
2.		
3.		
4.		

What kind of boat was used today?

Construction:	Wood ☐ | Fibreglass ☐ | Plastic ☐ | Steel ☐ | Concrete ☐
Type of boat:	No boat ☐ | Motor boat ☐ | Sail boat ☐ Canoe ☐
How is the boat powered?	Paddle ☐ | Sail ☐ | Inboard ☐ | Outboard: 2 stroke ☐ 4 Stroke ☐
Length (m):	Engine (hp):
What safety gear do you have onboard today (tick all that apply)?	Oars ☐ | Life jackets ☐ | Anchor ☐ | Mirror ☐ | Water ☐ | EPIRB ☐ GPS ☐ | Flares ☐ | Bailer / Bilge ☐ | Extra fuel ☐ | Other (please specify) ☐

V_Oct2016

C6: Catch prices

Where will you use or sell this catch?	Home ☐ | Market ☐ | Buyer domestic ☐ | Buyer export ☐ | Roadside ☐ Resort/Restaurant ☐ | Retail Shop ☐ |

How are the items sold (units of sale) and for what price?

Fish product	Unit of sale	No. per unit	Price per unit of sale	Price per item
1.				
2.				
3.				
4.				

V_Oct2016

C7: Perceptions of fishers

What is the main fishing activity for this landing? Clam/Trochus fishery ☐| Nearshore/Oceanic fishery ☐| Other invertebrates fishery ☐ Reef/Lagoon fishery ☐ | Deepwater snapper fishery ☐ | Sea cucumber fishery ☐

How long have you been fishing?	Years
How long have you been fishing in this fishery (e.g. nearshore/oceanic fishery, reef/lagoon fishery, deepwater snapper fishery, sea cucumber fishery)?	Years
What other types of fisheries have you been involved with in the past (e.g. nearshore/oceanic fishery, reef/lagoon fishery, deepwater snapper fishery, sea cucumber fishery)?	
Are you fishing in other fisheries now? Yes ☐ | No ☐	Describe:
Are you fishing in the same areas as you were five years ago? Yes ☐ | No ☐	Please explain:
Are you catching the same quantities as you were five years ago? Same ☐ | Increase ☐ | Decrease ☐	Please explain:
Are you catching the same size as you were five years ago? Same ☐ | Increase ☐ | Decrease ☐	Please explain:
If catches are different, what has changed?	
Do you have any concerns about the resource(s)?	

Creel survey data control sheet

Creel Survey Data Control Sheet																					V_Oct2016
Department:																					
Location / Island / Province:																					
Sheet filled in by (surveyor's name):																					
Type of creel survey (if separating strata):																					
Survey time: (circle)		Jan 15	Feb 15	Mar 15	Apr 15	May 15	Jun 15	Jul 15	Aug 15	Sep 15	Oct 15	Nov 15	Dec 15								
↓ Site	Replicates →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Site 1:																					
Site 2:																					
Site 3:																					
Site 4:																					
Site 5:																					
Notes:																					

Appendix 5: Example of a completed creel survey datasheet

Below is an example of a completed creel survey datasheet for a hypothetical survey at a Pacific Island site. All slices are included here to give you an idea of what data to collect. In reality of course, you wouldn't need to complete all slices. For example, if you are measuring all individuals (Slice C3), you would not need to additionally count all of the individuals separately (Slice C2).

V_Oct2016

Creel survey carried out by: [enter organisation or department] Pacifica Fisheries			**Landing no:** 1
Survey name:	Pacifica Pilot creel survey October 2015		
Province / Island + Country:	Pacifica Island		
Date of this replicate (day/month/year):	05/10/2015	Currency used: AUD	
Survey Site:	Paddletail Port		
Latitude (DD): 15.63087		Longitude (DD): 155.10052	
Interviewers' / surveyors' names:	1. Bob Pomoko	3. Maria Bentanu	
	2.	4.	

V_Oct2016

C1: Basic information on fishers			
Lead fisher's name:	Paul Pakitua		
Date of birth (DOB):	06/05/1969	Gender: M	
Address (name of village / town / city):	Tunapapa village, Pacifica		
Vessel ID/Name:	Mako		
Is the fisher fishing with other people?	Yes ☑ | No ☐		
Total number of fishers?	2		
→ (data on other fishers in the landing today)			
Name of other fisher 1:	John Pakitua	DOB: 17/10/1990	Gender: M
Other fisher 2:		DOB:	Gender:
Other fisher 3:		DOB:	Gender:
Other fisher 4:		DOB:	Gender:
→ (back to lead fisher)			
How many days per month do you go fishing?	20 days /month	How many months a year do you fish (i.e. excluding closed fishing seasons)?	12 months fished
What fishing methods do you usually use (not only this fishing trip)?		Method 1: Night spearfishing	
Method 2: Handlining		Method 3: Trolling	
Method 4:		Method 5:	
Where else do you land your fish? What other sites)? List by priority			
Other site 1: (most often)	Barracuda Beach	How often?	2 /month
Other site 2:		How often?	/month
Other site 3:		How often?	/month
Other site 4: (least often)		How often?	/month
Why do you fish?	Subsistence ☒ | Income ☒ | Other ☒		
Please provide details:	Sometimes goes fishing for gifts for relatives		

About how much of this catch will be eaten at home or sold?	10 % kept 90 % sold
How much do you expect to earn from this catch overall?	Value: AUD 80
What is your estimate of the total weight of this catch (estimated by you, not the fisher)?	15 kg

V_Oct2016

C2: Species composition and/or counts

What is the total count by species of all fish, invertebrates and other seafood landed?

Species name or group	Fish product	Total number	Total weight (kg)	Fishing method
Naso unicornis	Reef fish	9	8.77	Night spearfishing
Naso lituratus	Reef fish	4	1.27	Night spearfishing
Lutjanus gibbus	Reef fish	7	2.40	Handline
Acanthocybium solandri	Pelagic fish	1	6.15	Trolling
t				

C3: Species sizes, and C4: Species weights

Record all sizes in the catch in cm (to nearest 0.1 cm) and all weights in kg
(Repeat this page if you need more space)

Species name	Size type	Size (cm)	Weight (kg)	Fishing method
Naso unicornis	FL	31.1	0.61	Night spearfishing
Naso unicornis	FL	46.7	1.83	Night spearfishing
Naso unicornis	FL	34.1	0.78	Night spearfishing
Naso unicornis	FL	39.5	1.04	Night spearfishing
Naso unicornis	FL	41.0	1.32	Night spearfishing
Naso unicornis	FL	29.4	0.55	Night spearfishing
Naso unicornis	FL	33.7	0.82	Night spearfishing
Naso unicornis	FL	36.1	0.92	Night spearfishing
Naso unicornis	FL	35.7	0.90	Night spearfishing
Naso lituratus	FL	23.0	0.25	Night spearfishing
Naso lituratus	FL	23.8	0.34	Night spearfishing
Naso lituratus	FL	22.5	0.33	Night spearfishing
Naso lituratus	FL	24.3	0.35	Night spearfishing
Lutjanus gibbus	FL	22.4	0.22	Handline
Lutjanus gibbus	FL	27.3	0.47	Handline
Lutjanus gibbus	FL	28.2	0.49	Handline
Lutjanus gibbus	FL	24.9	0.27	Handline
Lutjanus gibbus	FL	24.2	0.23	Handline
Lutjanus gibbus	FL	25.2	0.32	Handline
Lutjanus gibbus	FL	26.4	0.40	Handline
Acanthocybium solandri	FL	96.3	6.15	Trolling

V_Oct2016

C5: Effort data for CPUE

How many hours were spent on the fishing trip today? 6 hrs

Fishing method and gear used for each fish product (separate pelagic fish, reef fish, crabs, lobsters, etc.), how many sets of gear were involved and how much time spent doing each activity

Fish product	Methods / gear used	No. gears	No. hours	Day or night?
1. Reef fish	Night spearfishing	1	3	Night
2. Reef fish	Handline	1	2	Night
3. Pelagic fish	Trolling	1	1	Day
4.				

Did you lose or damage any gear during this fishing trip? What was it? How much will it cost to replace or repair the item?

Gear item	Lost or damaged?	Cost to replace or repair
1. Sinkers	Lost	AUD 5
2. Speargun	Lost	AUD 100
3.		
4.		

Please list any other costs associated with this fishing trip, including fuel, wages, bait, ice, food, drink, or any other items.

Item	Purchase price:
1. Fuel	AUD 40
2. Ice	AUD 8
3. Wages	AUD 50
4. Bait	AUD 15

What is the distance to the farthest site you fished at today? 12 km

Where did you leave from? Paddletail Port

How many sites did you stop and fish at? Where are they?

Site	Location (on map, lat/long, or distance to each fishing ground)	Time spent at location (hrs)
1. North pass	10 km	1
2. Frigate Island	12 km	3
3.		
4.		

What kind of boat was used today?

Construction:	Wood ☐ | Fibreglass ☒ | Plastic ☐ | Steel ☐ | Concrete ☐
Type of boat:	No boat ☐ | Motor boat ☒ | Sail boat ☐ Canoe ☐
How is the boat powered?	Paddle ☐ | Sail ☐ | Inboard ☐ | Outboard: 2 stroke ☒ 4 Stroke ☐
Length (m): 6	Engine (hp): 50
What safety gear do you have onboard today (tick all that apply)?	Oars ☒ | Life jackets ☐ | Anchor ☒ | Mirror ☐ | Water ☐ | EPIRB ☐ GPS ☐ | Flares ☐ | Bailer / Bilge ☐ | Extra fuel ☐ | Other (please specify) ☐

V_Oct2016

C6: Catch prices

Where will you use or sell this catch?	Home ☐ | Market ☒ | Buyer domestic ☐ | Buyer export ☐ | Roadside ☐ Resort/Restaurant ☐ | Retail Shop ☐ |

How are the items sold (units of sale) and for what price?

Fish product	Unit of sale	No. per unit	Price per unit of sale	Price per item
1. Reef fish	kg	1	AUD 1.25	
2. Pelagic fish	kg	1	AUD 5.00	
3.				
4.				

V_Oct2016

C7: Perceptions of fishers

What is the main fishing activity for this landing? Clam/Trochus fishery ☐ | Nearshore/Oceanic fishery ☐ | Other invertebrates fishery ☐ Reef/Lagoon fishery ☒ | Deepwater snapper fishery ☐ | Sea cucumber fishery ☐

How long have you been fishing?	20 Years
How long have you been fishing in this fishery (e.g. nearshore/oceanic fishery, reef/lagoon fishery, deepwater snapper fishery, sea cucumber fishery)?	15 Years
What other types of fisheries have you been involved with in the past (e.g. nearshore/oceanic fishery, reef/lagoon fishery, deepwater snapper fishery, sea cucumber fishery)?	Sea cucumber fishery
Are you fishing in other fisheries now? Yes ☒ | No ☐	Describe: Nearshore/oceanic – trolling around FADs
Are you fishing in the same areas as you were five years ago? Yes ☐ | No ☒	Please explain: Used to fish at Tunapapa Reef but there are no fish there anymore
Are you catching the same quantities as you were five years ago? Same ☐ | Increase ☐ | Decrease ☒	Please explain: Catch less fish now
Are you catching the same size as you were five years ago? Same ☐ | Increase ☐ | Decrease ☒	Please explain: Size of fish, especially unicornfish, has decreased

If catches are different, what has changed?

Some species which were common (e.g. groupers) are now rarely caught

Do you have any concerns about the resource(s)?

Worried about overfishing – too many people fishing now. Better management is needed – maybe in the form of protected areas or size. Also worried about erosion – lots of mud in the sea after heavy rain; need to manage this e.g. plant banana trees along sides of streams to hold soil.

Creel survey data control sheet

V_Oct2016

Creel Survey Data Control Sheet	Department: Pacifica Fisheries
Location / Island / Province: Pacifica Island	Sheet filled in by (surveyor's name): Bob Nui
Type of creel survey (if separating strata):	

Survey time: (circle) Jan 15 | Feb 15 | Mar 15 | Apr 15 | May 15 | Jun 15 | Jul 15 | Aug 15 | Sep 15 | **Oct 15** | Nov 15 | Dec 15

↓ Site	Replicates →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Site 1:	Paddletail Port	X	X	X	X	X	X														
Site 2:																					
Site 3:																					
Site 4:																					
Site 5:																					

Notes:

Appendix 6: Market survey datasheets

Market survey sheet for slices M1–M6

Use **one** sheet for each market unit (e.g. table, stall or other replicate).

Market survey carried out by: [enter organisation or department]		**Serial/ID number:** V_Oct2016
Survey name:		
Province / Island + Country:		
Date of this replicate (day/month/year):	Currency used:	
Survey site or market name:		
Latitude (DD):	Longitude (DD):	
Interviewers' or surveyors' names:	1.	2.
	3.	4.

M1: basic information on vendors V_Oct2016			
Is this vendor part of, working for, or the owner of a formal company?			Yes ☐ | No ☐
Name of company (if applicable):		Years operating:	years
Company address (if applicable):			
Lead vendor's or manager's full name:			
Date of birth (DOB):		Male ☐ | Female ☐	
Address (name of village, town or city):			
Is the vendor working with others? Yes ☐ | No ☐			
➔ Data on other vendors working at the table, stall or shop today (include children only if they are working)			
Full name	Relationship to lead vendor	Date of birth	Gender
1.			Male ☐ | Female ☐
2.			Male ☐ | Female ☐
3.			Male ☐ | Female ☐
4.			Male ☐ | Female ☐
➔ (back to lead vendor)			
How many days per month do you sell at the market? /month		How many months per year do you sell at the market (i.e. exclude closed months)? months working	
Do you have any other sources of income? Yes ☐ | No ☐			
Please describe:			
Where else do you market? What other locations? List by priority.			
Other location 1: (most often)		How often?	/month
Other location 2: (most often)		How often?	/month
Other location 3: (most often)		How often?	/month
Other location 4: (most often)		How often?	/month
What would you expect as income from today's sales?	Value:		
What is your estimate of the total weight of the marine products on sale (estimated by the surveyor, not the vendor)?			kg

V_Oct2016

M2: Species composition and/or counts

What is the total count by species of all fish, invertebrates, and other seafood on the market table now?

Record the sex, whether the species is in berry (F=Female; FB=Female in berry; M=male for crustaceans).

Species name or group	Fish product	Sex/In berry	Total number	Total weight	Weight unit

V_Oct2016

M3: Species sizes (in cm) | M4: Species weight (in kg) | Sex | In berry

(Repeat species on a new line if you need more space). Use: F=Female; FB=Female in berry; M=male for crustaceans

Species name	Sex/In berry	Size type	Size (cm)	Weight (kg)

M5: Income from marketing

Where did you get the marine products on sale today?

Fisher in family:	☐ Percent:	Gift:	☐ Percent:
Bought:	☐ Percent:	Caught by you:	☐ Percent:
Bartered:	☐ Percent:	Other (explain):	☐ Percent:

What are your marketing costs today (include wages, food, table or stall hire, ice, cost of purchasing fish)?
Look around the table or stall or shop for items the vendor may have forgotten.

Item	Cost	Buy or hire
1.		Buy ☐ | Hire ☐
2.		Buy ☐ | Hire ☐
3.		Buy ☐ | Hire ☐
4.		Buy ☐ | Hire ☐
5.		Buy ☐ | Hire ☐
6.		Buy ☐ | Hire ☐
7.		Buy ☐ | Hire ☐
8.		Buy ☐ | Hire ☐
9.		Buy ☐ | Hire ☐
10.		Buy ☐ | Hire ☐

How are the items sold (units of sale), what processing method was used, and what prices can you expect?
Processing: F=Fresh; Gu=Gutted; Gi=Gilled; H=Headed; S=Scaled; F=Filleted; D=Dried; S=Smoked; C=Cooked; L=Live

Fish product	Unit of sale	No. per unit	Price per unit	Cost to purchase from fisher	Price per item or weight	Processing method
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

M6: Perceptions of marketers

How long have you been marketing? years	How long have you been marketing seafood? years
Do you have other types of work now? Yes ☐ | No ☐	
Please give approximate percentage of each type of livelihood:	
1. %	4. %
2. %	5. %
3. %	%

Are you selling the same species now as you were five years ago? Yes ☐ | No ☐	Please explain:
Are you selling the same quantity of seafood now as you were five years ago? Same ☐ | Increase ☐ | Decrease ☐	Please explain:
Are you selling the same sizes as you were five years ago? Same ☐ | Increase ☐ | Decrease ☐	Please explain:
If the items being sold are different, what has changed?	

Do you have any concerns about the resource(s)?

Do you have any concerns about marketing conditions now and for the future?

Market survey data control sheet

The purpose of this datasheet is for you to control the data coming in for a survey and to ensure that all of the replicates are done (tables or stalls or buyers sampled) for each site. Each day, as the data come in, collect the datasheets used for the data collection, and tick each replicate off until they are all complete. Your design will probably need a sheet that is different to this one — the layout is not important — depending on whether you are working at several sites and whether you are repeating the survey over time. The real data will be on the datasheets for the actual survey, which are separate from this.

V_Oct2016

Market Survey Data Control Sheet							Department:													
Location / Island / Province:							Sheet filled in by (surveyor's name):													
Type of market survey (if separating strata):																				
Survey time: (circle)							Jan 15	Feb 15	Mar 15	Apr 15	May 15	Jun 15	Jul 15	Aug 15	Sep 15	Oct 15	Nov 15	Dec 15		
Site	Replicates	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Site 1:																					
Site 2:																					
Site 3:																					
Site 4:																					
Site 5:																					
Notes:																					

Appendix 7: Example of a completed market survey datasheet

Below is an example of a completed market survey datasheet for a hypothetical market stall survey at a Pacific Island site. All slices are included, to give you an idea of what data to collect. As with the creel survey sheets, you do not need to complete all slices. For example, if you are measuring all of the seafood products at a particular stall or table (M3) you would not need to also count all of the individual products separately (Slice M2).

V_Oct2016

Market survey carried out by: [enter organisation or department] Pacifica Fisheries		**Serial/ID number:** 1
Survey name:	Pacifica Market Survey October 2015	
Province / Island + Country:	Pacifica island	
Date of this replicate (day/month/year): 05/10/2015	Currency used: AUD	
Survey site or market name:	Pacifica main fish market	
Latitude (DD): 15.63087	Longitude (DD): 155.10052	
Interviewers' or surveyors' names:	1. Maria Hughes	2. Joseph Beru
	3.	4.

V_Oct2016

M1: basic information on vendors

Is this vendor part of, working for, or the owner of a formal company?			Yes ☒ | No ☐
Name of company (if applicable): Pacifica Fine Seafoods		Years operating:	12 years
Company address (if applicable): 5 Harbour Rd, Tunapapa, Pacifica			
Lead vendor's or manager's full name: John Wallis			
Date of birth (DOB): 15/05/1975			Male ☒ | Female ☐
Address (name of village, town or city): Tunapapa, Pacifica			
Is the vendor working with others? Yes ☒ | No ☐			
➔ Data on other vendors working at the table, stall or shop today (include children only if they are working)			
Full name	Relationship to lead vendor	Date of birth	Gender
1. Maria Wallis	Wife	10/06/1979	Male ☐ | Female ☒
2.			Male ☐ | Female ☐
3.			Male ☐ | Female ☐
4.			Male ☐ | Female ☐
➔ (back to lead vendor)			
How many days per month do you sell at the market? 15 /month		How many months per year do you sell at the market (i.e. exclude closed months)? 12 months working	
Do you have any other sources of income? Yes ☐ | No ☒			
Please describe:			
Where else do you market? What other locations? List by priority.			
Other location 1: (most often)	Mackerel Market	How often?	6 /month
Other location 2: (most often)		How often?	/month
Other location 3: (most often)		How often?	/month
Other location 4: (most often)		How often?	/month
What would you expect as income from today's sales?		Value: AUD 200	
What is your estimate of the total weight of the marine products on sale (estimated by the surveyor, not the vendor)?			10 kg

V_Oct2016

M2: Species composition and/or counts

What is the total count by species of all fish, invertebrates, and other seafood on the market table now?

Record the sex, whether the species is in berry (F=Female; FB=Female in berry; M=male for crustaceans).

Species name or group	Fish product	Sex/In berry	Total number	Total weight	Weight unit
Lethrinus harak	Reef fish		6	1.71	kg
Scylla serrata	Mud crab	F	2	1.26	kg
Scylla serrata	Mud crab	M	2	2.90	kg
Octopus cyanea	Octopus		5	3.94	kg

M3: Species sizes (in cm) | M4: Species weight (in kg) | Sex | In berry				
(Repeat species on a new line if you need more space). Use: F=Female; FB=Female in berry; M=male for crustaceans				
Species name	Sex/In berry	Size type	Size (cm)	Weight (kg)
Lethrinus harak		FL	22.8	0.25
Lethrinus harak		FL	23.5	0.26
Lethrinus harak		FL	29.1	0.48
Lethrinus harak		FL	24.0	0.28
Lethrinus harak		FL	19.5	0.19
Lethrinus harak		FL	23.5	0.25
Scylla serrata	F	Carapace width	16.2	0.85
Scylla serrata	FB	Carapace width	12.7	0.41
Scylla serrata	M	Carapace width	19.3	1.48
Scylla serrata	M	Carapace width	17.7	1.42
Octopus cyanea		Mantle height	14.1	1.72
Octopus cyanea		Mantle height	10.5	0.75
Octopus cyanea		Mantle height	11.1	0.82
Octopus cyanea		Mantle height	7.6	0.32
Octopus cyanea		Mantle height	7.5	0.33

M5: Income from marketing

Where did you get the marine products on sale today?

Fisher in family:	☒ Percent: 80	Gift:	☐ Percent:
Bought:	☒ Percent: 20	Caught by you:	☐ Percent:
Bartered:	☐ Percent:	Other (explain):	☐ Percent:

What are your marketing costs today (include wages, food, table or stall hire, ice, cost of purchasing fish)?
Look around the table or stall or shop for items the vendor may have forgotten.

Item	Cost	Buy or hire
1. Market fee	AUD 20	Buy ☐ | Hire ☐
2. Ice	AUD 10	Buy ☒ | Hire ☐
3. Seafood	AUD 50	Buy ☒ | Hire ☐
4. Wages	AUD 50	Buy ☐ | Hire ☐
5.		Buy ☐ | Hire ☐
6.		Buy ☐ | Hire ☐
7.		Buy ☐ | Hire ☐
8.		Buy ☐ | Hire ☐
9.		Buy ☐ | Hire ☐
10.		Buy ☐ | Hire ☐

How are the items sold (units of sale), what processing method was used, and what prices can you expect?
Processing: F=Fresh; Gu=Gutted; Gi=Gilled; H=Headed; S=Scaled; F=Filleted; D=Dried; S=Smoked; C=Cooked; L=Live

Fish product	Unit of sale	No. per unit	Price per unit	Cost to purchase from fisher	Price per item or weight	Processing method
1. Reef fish	kg	1	AUD 4.00	AUD 2.00		F
2. Mud crab	piece	1	AUD 10.00	AUD 5.00		L
3. Octopus	piece	1	AUD 5.00	AUD 3.50		Gu
4.						
5.						
6.						
7.						
8.						
9.						
10.						

M6: Perceptions of marketers

How long have you been marketing?	How long have you been marketing seafood?
15 years	15 years

Do you have other types of work now? Yes ☐ | No ☒

Please give approximate percentage of each type of livelihood:

1.	%	4.	%
2.	%	5.	%
3.	%		%

Are you selling the same species now as you were five years ago? Yes ☐ | No ☒	Please explain: Used to sell tuna but this is now unprofitable as fuel price has gone up resulting in less fishing now
Are you selling the same quantity of seafood now as you were five years ago? Same ☐ | Increase ☐ | Decrease ☒	Please explain: Less fishes are landed by fishers now
Are you selling the same sizes as you were five years ago? Same ☐ | Increase ☐ | Decrease ☒	Please explain: Fish sizes are smaller now
If the items being sold are different, what has changed?	Used to sell sea cucumbers to exporters but this is now unprofitable as too few sea cucumbers around. Also sells more herbivores and fewer carnivores now

Do you have any concerns about the resource(s)?

Fish are smaller and there are fewer – maybe stocks are overfished

Do you have any concerns about marketing conditions now and for the future?

There is a high demand from hotels and too many fishers fishing now

Market survey data control sheet

V_Oct2016

Market Survey Data Control Sheet	Department: Pacifica Fisheries
Location / Island / Province: Pacifica Island	Sheet filled in by (surveyor's name): Maria Hughes
Type of market survey (if separating strata): Pilot	
Survey time: (circle)	Jan 15 · Feb 15 · Mar 15 · Apr 15 · May 15 · Jun 15 · Jul 15 · Aug 15 · Sep 15 · **Oct 15** · Nov 15 · Dec 15

Site	Replicates	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Site 1:	Pacifica main fish market	X	X	X	X	X	X	X	X	X	X										
Site 2:																					
Site 3:																					
Site 4:																					
Site 5:																					

Notes:

Appendix 8: Statistics and optimising designs

Throughout this manual the terms 'averages' or 'means' (and their associated errors, or variation) are used to summarise and optimise the numerical data and report results. Note that the concept of a mean only applies to numerical data (i.e. numbers) and not to text data. Text data comes from asking fishers questions, such as: 'What village do you live in?' There is no such thing as an average village, and those sorts of data can be summarised more in terms of frequency, e.g.: '10 fishers surveyed this month were from Village A, and 12 from Village B'. Some data, such as size (which are numerical), can be summarised both by means and frequencies, which will be discussed in more detail below.

The mean or average (avg or $\bar{x}$)

A mean (or average) is a way of summarising a set of numbers. We will be using the simplest form of an *arithmetic mean*, which is a useful way of representing many measurements as one single number that represents the *magnitude* (how big the value is) of something. A small point about terminology: mean and average are the same thing. They are used in this manual interchangeably. In general, when reporting to non-scientists, you would use the word 'average', because most people are familiar with this term. Statistical texts refer to the 'mean', so it should be used when discussing statistics. In mathematical notation, the mean is calculated as:

$$avg = \frac{\sum_{i=1}^{n} x_i}{n}$$

Or more simply:

$$avg = \frac{sum(x_1 + x_2 + x_3 + \ldots + x_n)}{n}$$

where *avg* = average of the metric of interest (i.e. the piece of information you are interested in such as the number of fish landed or the number of hours spent fishing),
x_1 = the value of the metric of interest (e.g. no. of fish) observed in event 1,
x_2 = the value of the metric of interest observed in event 2,
x_3 = the value of the metric of interest observed in event 3, etc., and x_n = the value of the metric of interest observed in the last event, and n = the total number of events (e.g. landings met or market stalls surveyed).

As an example, suppose you want to calculate the average catch per landing, and say you met five landings at Site A and counted all the fish from each landing, you might get the following counts:

Landing 1 = 12 fish | Landing 2 = 28 fish | landing 3 = 10 fish | Landing 4= 9 fish | Landing 5 = 15 fish

You could report that the number of fish landed in those five landings was 12, 28, 10, 9 and 15. And while that would be true, if you were to survey hundreds of landings it would be next to impossible to present this. We are all used to the idea of summarising these numbers into a mean or average, which gives us an idea of about how many fish are being landed at Site A:

Mean = 12 + 28 + 10 + 9 + 15 divided by the number of landings surveyed:
Mean = (12+28+10+9+15) / 5
Mean = 74 / 5
Mean = 14.8

You now have a single number, the mean (in this instance 14.8), which gives you some idea of how many fish are landed per trip. You could compare this with a mean of 24.2 from another site (Site B), and from this you might conclude that fewer fish were landed, on average, at Site A than Site B. But this is not the whole story, because in addition to the magnitude of the catch (how many fish were landed on average), you also need to consider how much *variation* there is among the landings at a single site. The variation between samples can give you even more insight into the character of the catch by telling you about the spread of values that were used to create the mean. For example, you could examine the number of fish landed for each landing at each site:

Site A: Landing 1: 12 | Landing 2: 28 | Landing 3: 10 | Landing 4: 9 | Landing 5: 15
Site B: Landing 6: 3 | Landing 7: 2 | Landing 8: 104 | Landing 9: 5 | Landing 10: 7

Or more simply:

Site A: 12 | 28 | 10 | 9 | 15 Mean = 14.8
Site B: 3 | 2 | 104 | 5 | 7 Mean = 24.2

The catches in these two samples are very different, with four out of the five boats at Site B landing fewer fish than at Site A, while the average number of fish landed at Site B is much higher than Site A because of one particular landing (Landing 8). If you looked only at the average, you would conclude that fishers at Site B are doing better than those at Site A; however, based on this observation, you might make some very poor management decisions. It is not difficult when there are only five samples, but in a real survey there could be thousands of values, and you cannot avoid the issue by reporting the raw numbers. Clearly, there needs to be a better way of understanding what the numbers are telling you.

Variation or spread

There are simple ways to measure and represent the spread of the data you are reporting. This includes statistics such as variance (S^2), standard deviation (SD) and standard error (SE), which: 1) are all ways of summarising and representing this spread; 2) are easy to calculate (in a spreadsheet or database); and 3) help you to interpret the data more clearly. From now on, you should report an average value along with some measure of the spread. The two values should be inseparable, because there is no other way to get an idea of what a mean standing on its own actually tells you, leaving you with a high risk of misrepresenting what the data are really telling you. In many statistical texts, this spread is called *error*, but do not take this to mean that the numbers are in some way 'wrong' (although that is possible too). Error in this context simply refers to spread or variation in the data, most of which is natural, or even more importantly, relates to some action you may have taken to manage the resource, thus causing your means to shift and your variation to change.

Variation within a sample of landings is caused by many factors, which may include:

- natural patchiness — fish and invertebrates are not evenly distributed at a location; they may form aggregations, or respond to the presence of habitat features such as coral, rocks or seagrass;
- differences in the effectiveness of different types of fishing gear, which may be more efficient at catching fish under some conditions and not others (e.g. fish may be spooked by divers holding spearguns, but not by hooks and lines);
- differences in the skill or knowledge of individual fishers;
- different weather patterns among surveys, which may influence where people are fishing; and
- differences in the skill level of samplers conducting the survey, such as in their fish identification skills (this is a form of variation you should try to minimise).

Going back to our example for Site A:
Site A: 12 | 28 | 10 | 9 | 15 Mean = 14.8

How would you represent the spread among these five numbers? The easiest way is through the use of *deviations*, and all of the methods of describing variation are based on this idea. In Figure A9-1, the five numbers from Site A are plotted onto a graph to show where all the individual readings are in relation to the mean of the numbers (the red line). The arrows show the difference (or distance) of each fish count in landings at Site A from the mean of 14.8.

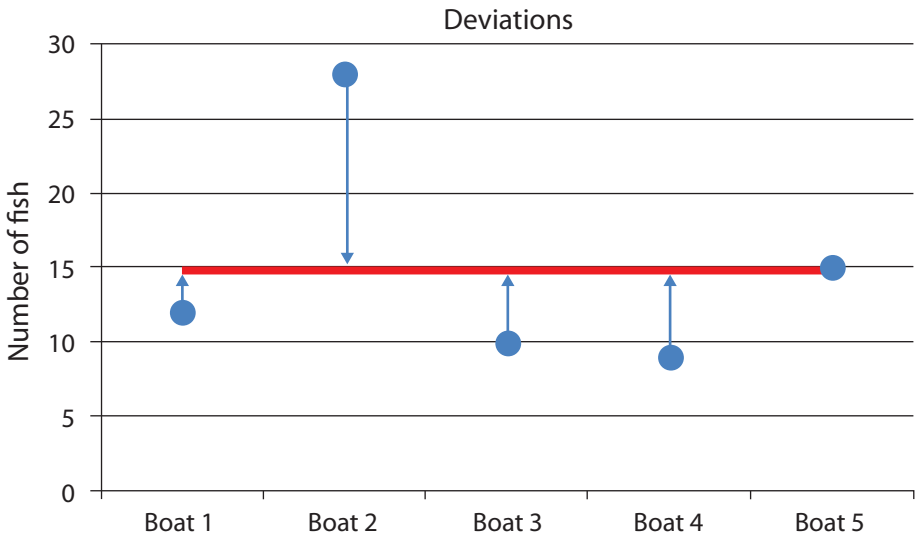


Figure A9–1: Deviations of readings at Site A from their mean.

The values of distance from the mean for Site A are:

Site A	Fish caught	Average catch	Distance from average catch
Landing 1	12	14.8	-2.8
Landing 2	28	14.8	13.2
Landing 3	10	14.8	-4.8
Landing 4	9	14.8	-5.8
Landing 5	15	14.8	0.2
Sum			**0**

Variance (S^2)

In order to get an idea of how spread out the numbers are around their mean, you could simply add up all the distances of the individual numbers to the mean value and report the total. But first, you have to solve the problem that half of the distances are negative (i.e. below the average) and half are positive (i.e. above the average), which would cancel out the total, and result in zero. Also, there is the problem that if you have more samples, this number will continue to increase, so that comparing the variation among the five numbers with a set that includes 10 numbers will be difficult.

The solution is to remove the negative sign so that the values are all positive (termed an 'absolute value'), or, by squaring the values (multiplying each number by itself; the square of any negative number is always positive). The squared distance measures are what statisticians use, and they average them (so it does not matter how many replicates there are) to give what they call *variance*, or S^2. In mathematical notation this is commonly written as:

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

In the example above, the variance estimates are:

Site A	Fish caught	Average catch	Distance from average catch	Absolute value (Xi)	Xi^2
Landing 1	12	14.8	-2.8	2.8	7.84
Landing 2	28	14.8	13.2	13.2	174.2
Landing 3	10	14.8	-4.8	4.8	23.0
Landing 4	9	14.8	-5.8	5.8	33.6
Landing 5	15	14.8	0.2	0.2	0.04
Sum			**0.0**	**26.8**	**238.8**

Thus, the sample variance for the above example is:
$S^2 = \Sigma$ of all squared deviations / (n-1)
$S^2 = 238.8 / (5-1)$
$S^2 = 59.7$

In this example, the average for S^2 is calculated using (n-1 (i.e. the number of landings met minus 1)) as the divider instead of n. If you had conducted a census and counted every landing that came in (i.e. the whole population of boat landings), you could have calculated variance using n, but because a sample was used, you must use degrees of freedom (n-1) instead. You are required to use n-1 as a correction factor for all samples (and for just about everything you do). This is because the sum of squared deviations tends to underestimate the population (real as opposed to sample) standard deviation, so by using n-1 you correct for this. Degrees of freedom are used in sample statistics universally, so you will see it again.

Although variance is used in many statistical tests, for your purposes, you will use a different type of statistic. Variance is like saying: 'The five landings recorded at Site A had an average of 14.8 fish per landing ± 59.7 squared fish'. Units of variation need to be in fish, not squared fish, which makes no sense to anyone!

Standard deviation (SD)

If we take the square root of the variance, we end up with a statistic of variation that is in the same units as the mean, and is called the *standard deviation*, or SD. You can use this statistic along with your mean and provide a good indication of spread in the values.

Standard deviation SD is simply the square root of the variance:

$$SD = \sqrt{[\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x}])^2]}$$

In the above example:
SD = $\sqrt{}$ Σ of all squared deviations / n - 1
SD = $\sqrt{}$ S2
SD = $\sqrt{}$ 59.7
SD = 7.7

In Excel, SD can be calculated using the =stdev(data range) function.

Now it is possible to report that in the five landings there was an average of 14.8 fish ± 7.7 fish, thereby giving a clearer and more accurate view of what is happening, because the same units are being used. About 68% of all the readings taken from Site A fall within the range of the SD.

Standard error (SE)

There is a third commonly used statistic that describes variation for a sample of measures, and it is the one used most widely in this manual: *standard error*. Its definition is tricky: it is derived from variance and SD, but its characteristics make it worth the effort. In theoretical terms, standard error (SE) is the SD of means drawn from many samples of the population. What this means is that if you had the time and money, instead of going to Site A and sampling just five landings, you would sample 20 groups of five landings and calculate all of their averages (Site A: Mean of first group of five landings | Mean of second group of five landings | Mean of third group of five landings and so on...). You could then calculate a SD of all those means from the overall mean of the 20 groups. This value would be the SE. If this sounds confusing, you are not alone, but you also do not need to worry about this much. It has been included here just to inform you what SE actually is. More interesting is that SE is easy to calculate from your single sample of five landings and can be used to make decisions on whether two means are really likely to be different or not, and allow you to improve your survey design.

Standard error to decide whether means are significantly different

SE can be calculated from SD and n, which are two values you have already calculated for Site A:

$$SE = \frac{\mathrm{SD}}{\sqrt{\mathrm{n}}}$$

Using the above example, where SD = 7.7 and n = 5:

$$SE = \frac{7.7}{\sqrt{5}} = 3.5$$

You can use this value, which is more stable than S^2 or SD, to make practical decisions on whether two or more means are significantly different from each other – i.e. if the SE values of two means you want to compare do not overlap, you would consider them to be *significantly different*. For the calculations given in this manual, this will be the approach to use. Figure A9–2 contains two graphs based on the Site A and Site B data. The left-hand graph shows the results of plotting mean and SE for Site A and B using the example data above. In that graph, there is complete overlap of the SE bars of the sites. This tells you two things: 1) that the error bar for Site B is very large and that it might be best to improve the survey design; and 2) given these data, there is no basis for believing that the two means are significantly different. In the right-hand graph, the opposite is shown. While the means are the same, the SE at Site B is smaller, and there is no overlap between them. In this case, the means could be considered significantly different and you could act on that information.

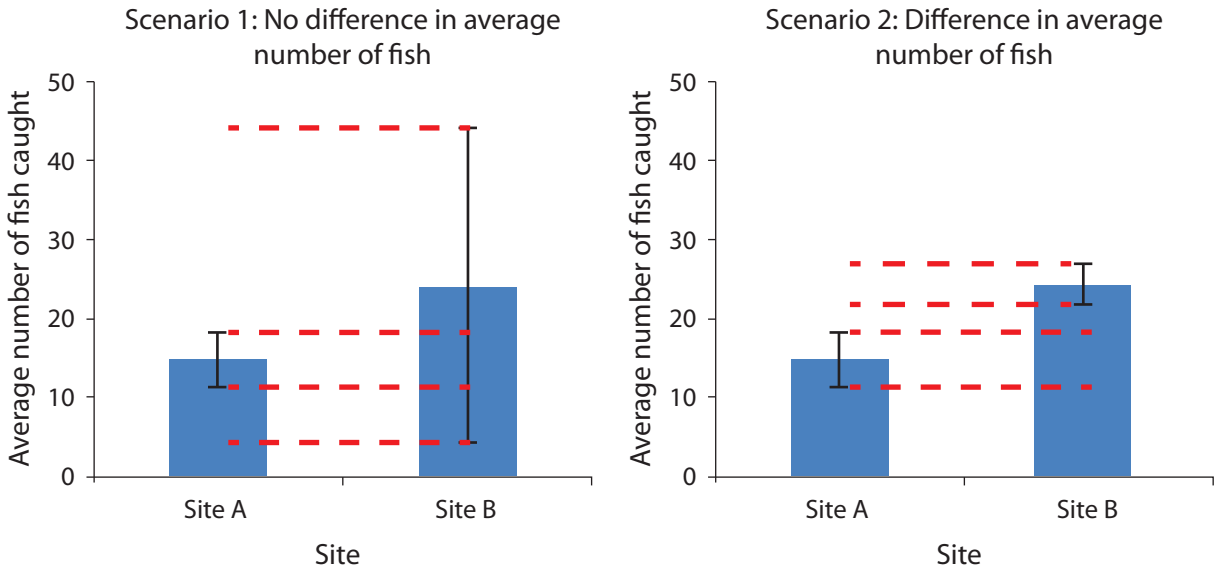


Figure A9–2: Plot of average number of fish caught per landing (±SE) at two hypothetical sites under two different scenarios.

Precision and accuracy

There are two more concepts to understand before proceeding with designing a survey: precision and accuracy. Precision can be understood as getting the *same* answer repeatedly, and accuracy can be understood as getting the *right* answerv repeatedly. They are two different ideas, both of which are important in sampling. Figure A9–3 shows each one, using a target diagram where the centre represents the bullseye, or the true mean you are trying to estimate. Remember, if you could conduct a census, and survey every single catch that is landed from all boats, you could calculate the true mean for the population of all boats in the area. But because you are limited to sampling, you can only get estimates of that mean. How good those estimates of the mean actually are, is represented by these two concepts.

Precision and accuracy are independent of each other. It is possible to have any combination of low and high precision and accuracy.

In the top-left panel of Figure A9–3, you can see that when precision is low, the values are very spread out. That is, each time you sample, you get very different estimates of the mean. These may or may not also be accurate, but that is a different measure. In the bottom-left panel of Figure A9–3, the values are highly clustered, telling you that precision is very good and that all the means you are calculating are similar to each other. In that case you would say you had high precision. But note that although the means are clustered close together, showing high precision, they have terrible accuracy and are all far away from the bullseye or true mean. Precision is estimated and controlled by using the SE-to-mean ratio. This is expressed as:

$$P = SE / Mean$$

If P = 0.1, then the SE is 10% of the size of the mean, which would be considered very good. You can evaluate this for any sample, and work out what sort of precision you would be dealing with. Better still, you can use precision as a way of estimating how much sampling effort is needed to improve your precision to the point that the sampling you do will be able to detect differences among means (see next section).

On the right-hand side of Figure A9–3 is a diagram for accuracy – i.e. the ability to estimate the mean truthfully. The upper panel on the right-hand side shows poor accuracy; the readings are quite far away from the bullseye, even though the level of precision is fairly good (the values are clustered well). In the bottom left panel of Figure A9–3, accuracy is very good, with all of the estimated values of the mean being quite close to the true mean. In this diagram they are also precise, but they do not have to be — they could have been spread out while still being accurate.

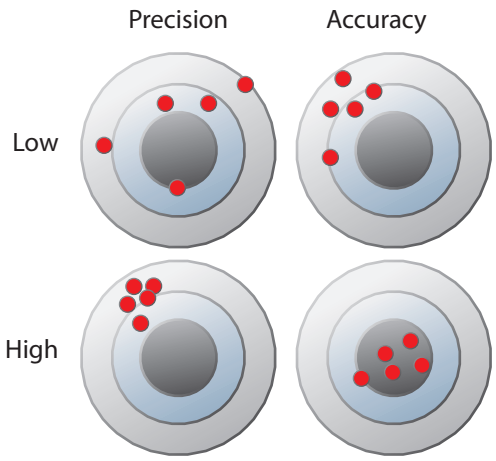


Figure A9–3: Illustration of accuracy and precision

Accuracy cannot be measured in a sampling programme. You will never know (unless you do a complete census) what the true underlying mean is, so you never really know if you are getting the right answer or not. There are, however, many things you can do as part of good survey design to minimise the risks.

1. Test your sampling equipment and make sure it works. For our surveys this may mean checking the weighing scales you use regularly to ensure they are calibrated and giving you accurate weights. Make sure you continue to tare (zero) your scales throughout the landing because they will drift over time.
2. Train all your surveyors to make sure everyone conducts the sampling in the same way. The point of this kind of training is to make sure everyone uses the questionnaires properly, measures in the same way (e.g. using fork length instead of total length for species with forked tails), and identifies species correctly (you will introduce huge inaccuracies if you misidentify fish, and even worse if each sampler uses a different identification). These kinds of errors are true sampling errors and are under your control.
3. Make sure your surveyors fill in all forms completely and accurately. There is nothing worse than having to deal with blank entries because someone forgot to fill in some data.

Using precision to optimise a design

There is another advantage to calculating and using SE for your surveys. SE is dependent on the number of replicates you use and is part of the formula for precision. Using this, you can rearrange the formula for precision to make n the subject, and calculate how many replicates you would need in a module to attain a certain level of precision. This in turn means you can control how big those error bars are on the decision graphs, and this is called *optimisation*. While there are other methods for optimisation, such as Power Analysis, this manual focuses on precision.

Remember the formula for precision:

$P = SE / Mean$
$P = (SD/\sqrt{n}) / Mean$
then
$n = (SD / (P \times Mean))^2$

where n = the number of replicates you would need for each level of precision (P) for each measure, SD = standard deviation of that measure and avg = average of that measure.

To use this formula to your advantage you need to conduct a pilot survey to collect some data in the way you are planning to do it for your survey. You could do this at one place at one time, or at several places if you want to be sure you have covered possible variation among sites. Using the pilot data, you would then evaluate the formula using the SD and mean from the sampling for a range of possible levels of precision.

Working example of calculating precision in Excel

Suppose you want to know how many replicate landings you need to meet to observe a change in the number of fish per landing at Site A (in the above example). Remember that in this case, the average (mean) number of fish landed for Site A was 14.8. While $CPUE_N$ is used here in this example, you could also use this formula to calculate precision for any metric you choose to examine, such as species richness or the number of individuals of a species of interest in each catch.

If you want to do this in Excel, create a separate sheet with the mean (average) in cell B1, the SD in cell B2, the P for 0.001 in cell A5, the P for 0.01 in A6, and the P for 0.1 in cell A7 etc., as shown below:

	A	B	C
1	Mean	14.8	
2	SD	7.7	
3			
4	Precision level needed	Formula to use	Number of replicate requred, n
5	0.001	n=(7.7/(0.001*14.8))^2	270681
6	0.01	n=(7.7/(0.01*14.8))^2	2707
7	0.1	n=(7.7/(0.1*14.8))^2	27
8	0.2	n=(7.7/(0.2*14.8))^2	7
9	0.3	n=(7.7/(0.3*14.8))^2	3
10			

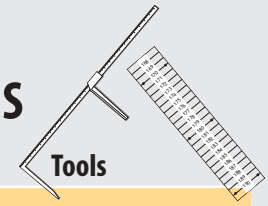
Add the following formula into cell B5 (you will not need Column C if you do this; it has been added to this table only to show the formula and outcome separately):

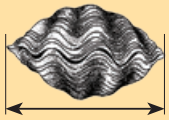
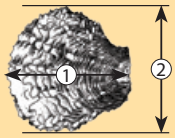
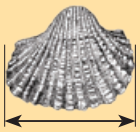
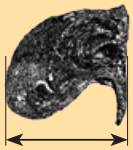
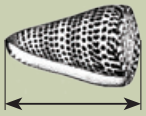
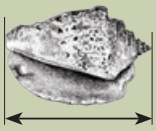
=(B2/(A5*B1))^2

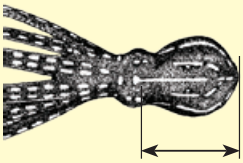
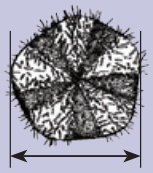
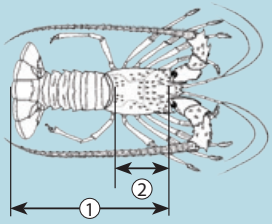
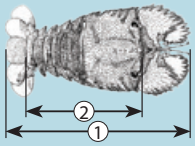
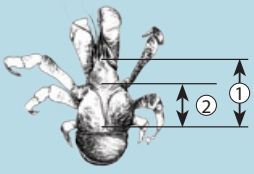
Because the reference to cells B1 and B2 were written using the $ before each part of the cell reference, you can copy this formula down to B9 and it will evaluate each level of precision repeatedly using the single values in B1 and B2. B1 tells Excel to refer to that exact cell, even if the formula is copied.

As you can see, to achieve a precision of 0.001 (i.e. where SE is 0.1% of the mean), you would need to survey 270,681 landings — That is no doubt more boats and landings than you have in your survey area and is clearly out of the question. A good rule of thumb is to try to get a precision of about 0.1 if possible (that is, the SE would be around 10% of the mean). That may not be possible if you have a lot of natural spread in that data. In such cases, you could accept a lower level of precision (e.g. 0.2), but keep in mind you would have to see very big shifts in the values before you would judge two means different (at a SE of 20% of the mean, you would need the means to be 40% different). In the above example, you can get a precision of 10% with 27 landings surveyed, which is easily achievable.

IDENTIFICATION CARDS FOR MARINE INVERTEBRATE SURVEYS IN THE PACIFIC ISLANDS



		Measurements	Tools
Bivalves			
Giant clam		Longest length	Caliper Ruler
Oyster		1: Distance from hinge to opposite edge 2: Shell width	Caliper Ruler
Ark shell (*Anadara* sp.)		Shell width	Caliper Ruler
Penguin's wing (*Pteria penguin*)		Umbo-ventral length	Caliper Ruler
Gastropods			
Sea hare		Total length	Caliper Ruler
Trochus		Basal diameter (measure across the base of the shell)	Caliper Ruler
Cone shell		Total length	Caliper Ruler
Triton shell		Total length	Caliper Ruler
Strombus shell		Total length	Caliper Ruler
Conch shell (*Lambis chiragra*)		Total length (end of shell to end of furtherest spike)	Caliper Ruler
Turban snail (*Turbo setosus*)		Longest width (end of apex to end of outer edge of whorl opening)	Caliper Ruler

		Measurements	Tools
Gastropods			
Green snail		Longest width	Caliper Ruler
Cowry shell		Total length	Caliper Ruler
Cerith (*Cerithium* sp.)		Total length	Caliper Ruler
Cephalopods			
Octopus		Mantle height	Ruler
Echinoderms			
Sea cucumber		Length	Ruler
Sea urchin		Length without spines	Caliper Ruler
Crustaceans			
Spiny lobster		1: Length from front edge of carapace to rear edge of telson 2: Carapace length	Caliper Ruler
Slipper lobster		1: Total length 2: Length from eyeline to front of telson	Caliper Ruler
Coconut crab		1: Cephalo-thoracic length (CL) 2: Thoracic length (TL)	Caliper Ruler
Mangrove crab		Carapace width	Ruler

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