CORAL REEF MONITORING IN EASTERN AFRICA
A GUIDE FOR COMMUNITIES

J. Kawaka, M. Samoilys, M. Murunga,
G.W. Maina, J. King & F. Michelmore

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Foreword

I am pleased to present this user-friendly manual for communities, fisheries managers and conservation practitioners interested in improving community participation in coral reef and fisheries monitoring.

Small-scale fisheries provide important contributions to the livelihoods of people in developing countries through employment, income and food security. Most of these fisheries are facing serious threats from overfishing, damaging fishing practices, and climate change among others. However, tools to support community participation in monitoring and management of these fisheries are limited, particularly in developing countries.

This guide fills a critical gap by providing a carefully thought through and practical approach for community-led coral reef and fisheries monitoring. It provides guidance on how local communities, with minimal support, can independently undertake simple coral reef habitat and fisheries monitoring, data collection, analysis and interpretation of their data to improve understanding of the status of their resource and be able to devise appropriate management actions.

I applaud TNC, NRT, CORDIO and fisher communities in coastal Kenya for working cooperatively to create a tool that will provide a strong basis for adaptive and participatory management to benefit people and nature. The manual complements ongoing fisheries co-management initiatives in Kenya and around the world by providing a tool that can be adopted across different regions.

It is our hope that this document will be of value to local communities and practitioners that are seeking to strengthen sustainable, community-led fisheries monitoring and management.

Matthew A Brown

October 2016
Matthew A. Brown
Africa Conservation Director
The Nature Conservancy

Acknowledgements

Our gratitude goes to representatives of Kuruwitu Community Conservation Area, Mkunguni, Mwaepe, Chale-Jeza and Mnarani Beach Management Units (BMUs), Kiunga and Pate Marine Community Conservancies and NRT-Coast who trialled applicability of this tool and provided valuable information on making this manual accessible for local fishing communities.

Our appreciation also to Mr. Jamen Mussa of AMA Mozambique, Hassan Yussuf of NRT-Coast, Leonard Njehia and Misbahu Ali Awadh of Lamu County Fisheries Department for their support and contributions during deliberations and training in the methods. Thanks to Munira Bashir, Kenya Program Director for her continued support throughout the project.

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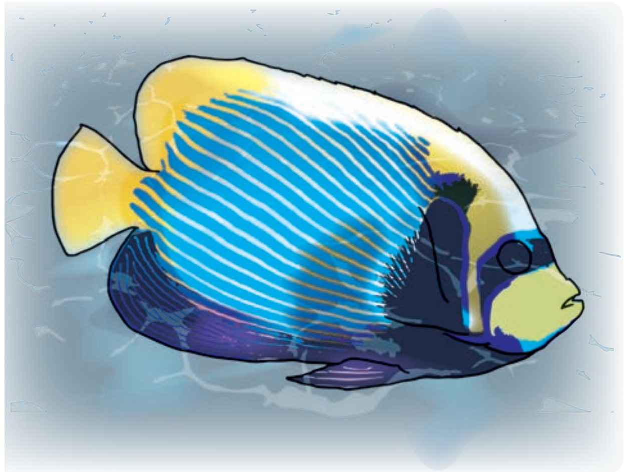
Lastly, we would like to thank the UNDP-GEF Small Grants Programme and The Nature Conservancy for funding this work.



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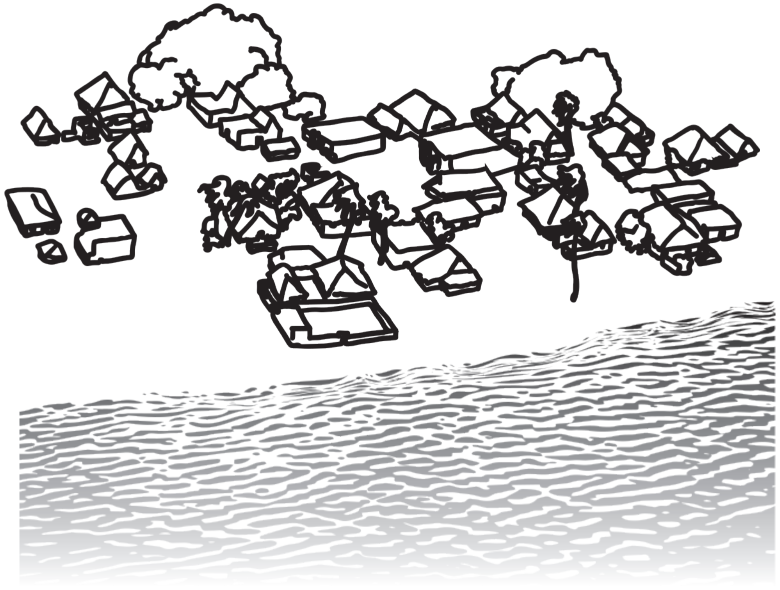


1.0 Introduction

This coral reef monitoring manual has been developed in Kenya to support implementation of fisheries co-management and provide practical methods for coastal community members to monitor their coral reefs. These monitoring methods are a tool for assessing the effectiveness of Locally Managed Marine Areas (LMMAs) or other community based marine management approaches.

The methods selected are based on a wide review of available methods and an extensive body of knowledge.

Objectives

i) train and equip coastal communities with tools and skills to carry out regular, cost effective underwater monitoring of coral reefs, with minimal supervision;

ii) guide communities in the collection and analysis of ecological and fisheries data on coral reefs; and

iii) introduce indicator species that can be used to determine the health and status of corals reefs.

Users

The manual is primarily for trainers and covers the following:

- concepts behind monitoring
- detailed explanation of the underwater survey methods
- indicator species and why they have been selected for this manual
- shore-based collection of fisheries catch and effort data and
- the collection, storage and analysis of monitoring data.

The entire procedure of training and trialing these methods was tested with fishers and Community Conservancy rangers from different villages in Kenya in 2014 and 2016. Their collective input, feedback and advice has been incorporated in the methods described here

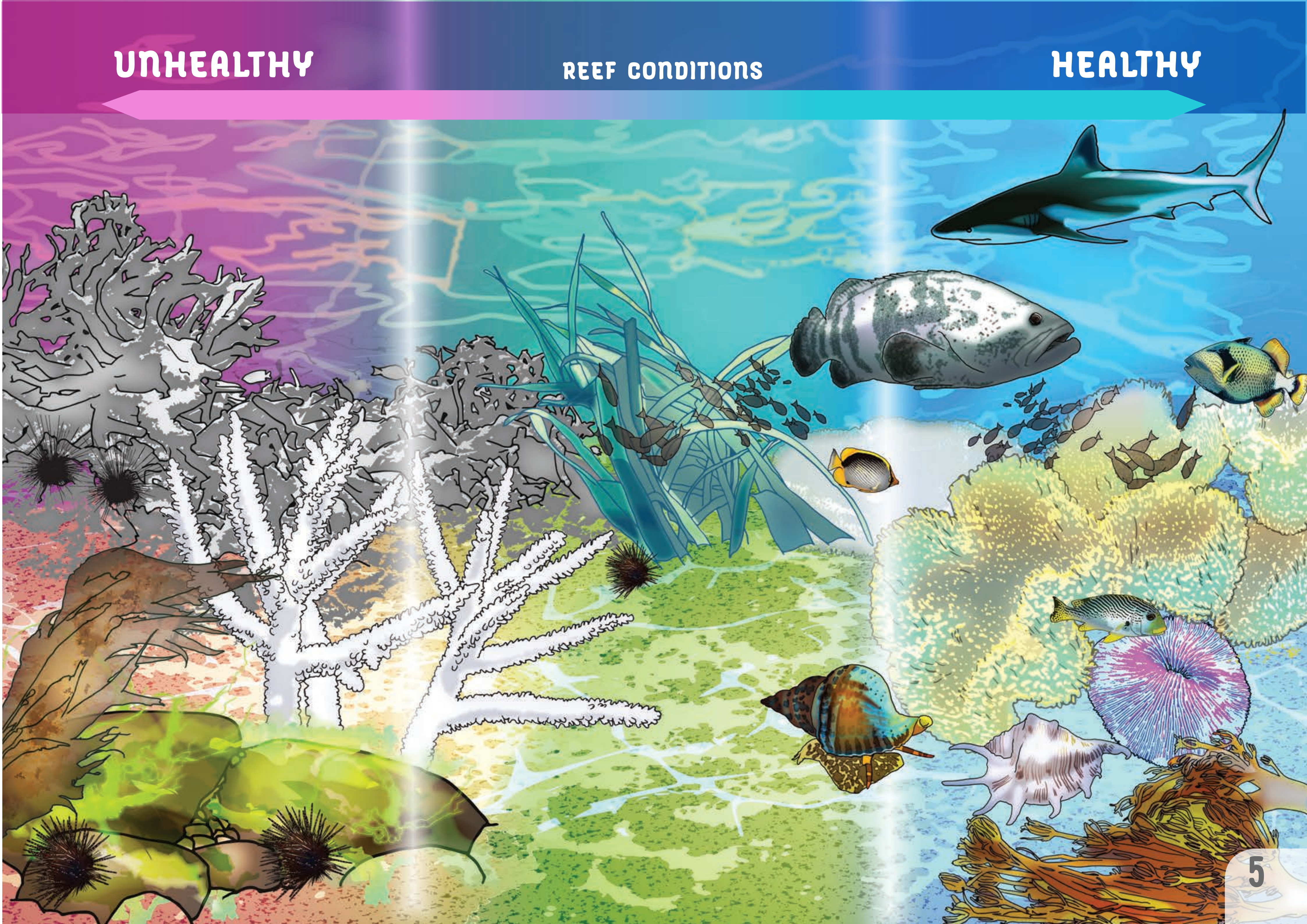
2.0 Survey design – where, when & how often

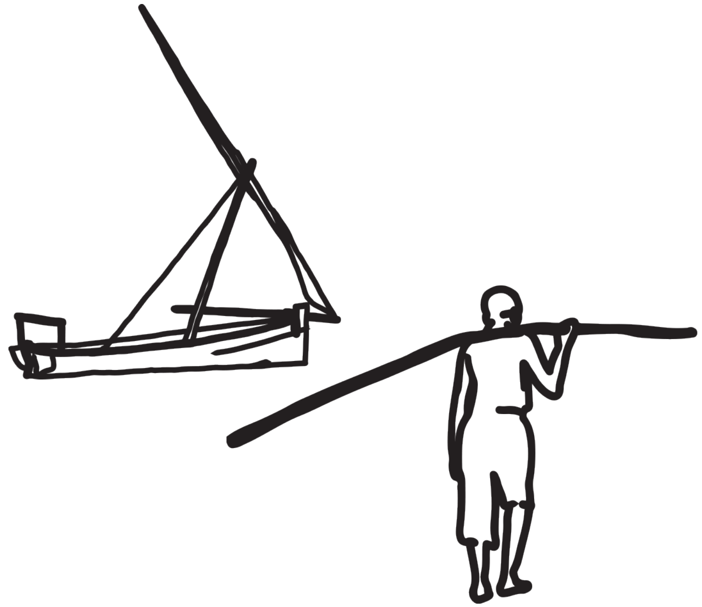
Before initiating monitoring surveys it is important to discuss the objectives of the survey with the relevant community and why they might want to monitor their coral reefs and fisheries. Do they have management measures for their fisheries in place and, if so, what changes are they looking for in their marine ecosystem? Any survey design (where and how often to survey) will consider these objectives.

A coral reef monitoring survey is often done by community members to monitor their Locally Managed Marine Area (LMMA), sometimes called a Community Conservation Area (CCA), or co-management area. For simplicity, the generic term LMMA is used here. Such local management may include certain conservation activities or fishery restrictions, such as a closed zone where no fishing is allowed, or illegal fishing gear controlled through community enforcement. Such activities aim to increase fish populations and the health of coral reefs upon which they depend. The objectives of a survey therefore may be to monitor changes in fish numbers, coral cover or specific macro-invertebrates over time, anticipating an increase in reef health due to conservation and good management practice. Any improvement here is also likely to affect populations of sea urchins and brown macro-algae, organisms that can be indicators of unhealthy coral reefs. These are likely to decline over time as coral cover increases.

Community members from Pate and Kiunga Conservancies identified the following as indicators of healthy and unhealthy reefs:

Unhealthy Reef	Healthy Reef
Dead seagrass	Seagrass
Dead and broken coral, pale coral (bleached), algae covering coral	Live coral
Few fish, or no fish	Many fish – diversity of species, many colourful fish, different sizes of fish, predatory species such as sharks
Dead or broken shells	Diversity of other species such as sea cucumbers, shells, octopus, lobster
Coral covered in sediment or sand	'clean' habitat – i.e. no sediment or sand covering coral, coral not broken, no dead sea grass
Sea urchins	Soft corals
Presence of small flat red crabs	

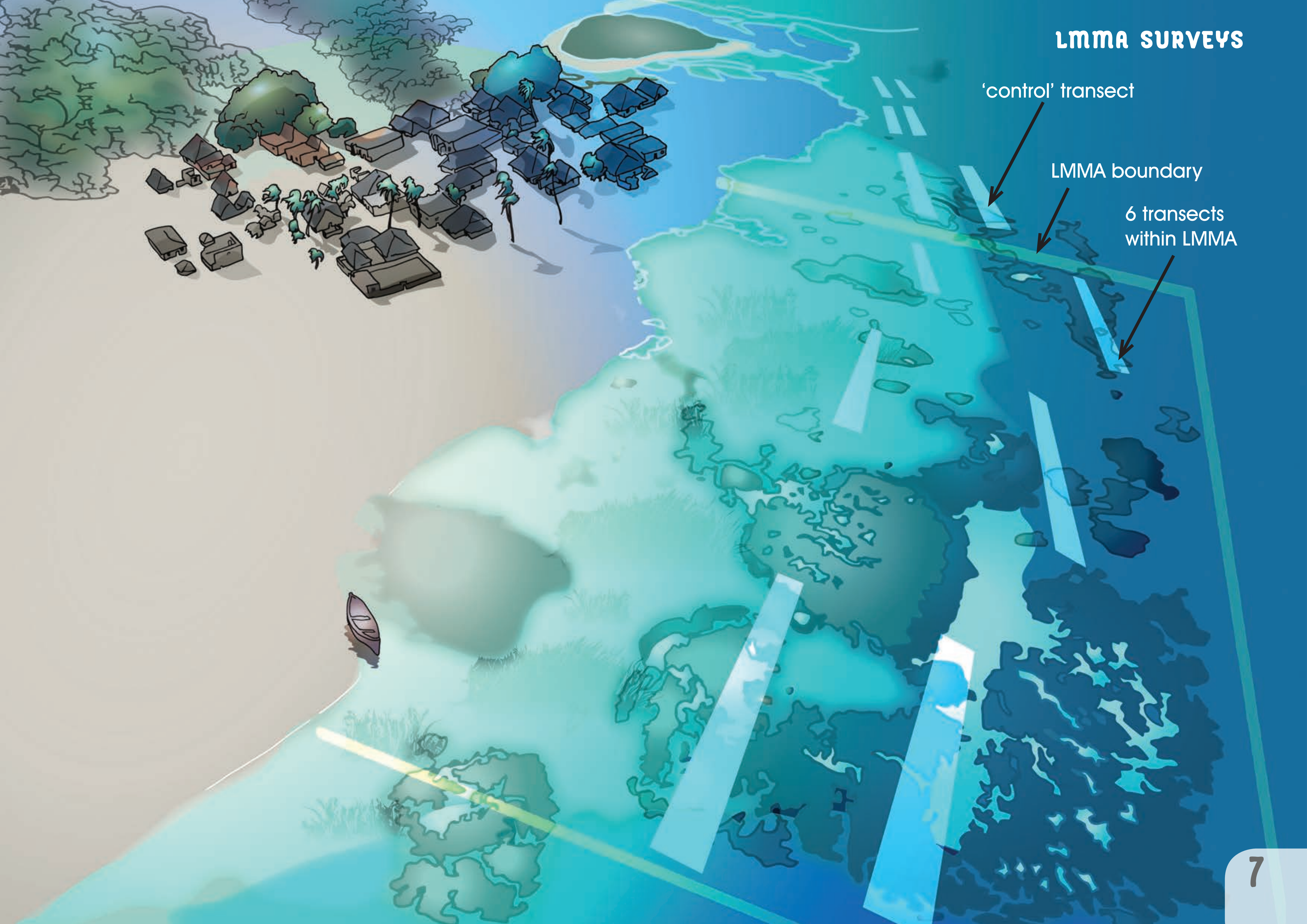

UNHEALTHY
REEF CONDITIONS
HEALTHY



Monitoring, where?

Monitoring surveys are done within the LMMA site and if possible outside the LMMA to act as a control site, where no management is being done. It is important to chose control sites that are as similar as possible to the LMMAs in terms of their habitat type. The same number of replicate surveys are done outside the LMMA as are done inside the LMMA, giving a "balanced" design in the data collected, ensuring the results can be interpreted meaningfully.

Each survey consists of ***six replicate 50m transects per site***. The position of the first transect must be placed in such a way that there is plenty of room to move to the next location for the second transect, and so on to the sixth transect. This is defined by the reef site. Some are narrow strips of reef in which case replicates may end up being in a line, with the end of one transect then leading on to the beginning of the next transect with a gap of 20m or so. Other sites are very wide, in which cases transects can be laid parallel to each other with increasing distance from the shore or reef edge. Selection of the starting position for placing the transect is done randomly to avoid any bias. This avoids picking the spots that are full of fish or that have the best coral cover, as this will not give you the average condition of your site.


'control' transect
LMMA boundary
6 transects
within LMMA

Time - when and how often?

Monitoring surveys of coral reefs in Eastern Africa are preferably done during the northeast monsoon winds (kaskazi) when the water is calm and clear. It is recommended that monitoring be done twice a year, at least in the early years of an LMMA. This could be in the beginning of the kaskazi and towards the end of the kaskazi, about 4-5 months apart. Such surveys should then be repeated every year to build up a strong picture of how the reef is changing over time.

Surveys are done with a mask and snorkel (scuba diving equipment is not necessary) therefore water depth is important. Surveys should be carried out when water depth is between 1-3m. The best timing for the survey will depend on how shallow the reef is, so this will vary from site to site; in some sites it may be at low tide and others at high tide. The decision of what tide to survey in must be made by the survey team who are familiar with each site.

Once observers are familiar with the survey process, they can expect to take about 15 minutes per transect, that includes all three methods (fish, benthic substrate and macro-invertebrates). Thus all six transects in a site should be completed in one day. If a second site is nearby a further six transects could be completed in the same day. The main restriction on the number of transects completed in a day is the tide.

UNHEALTHY

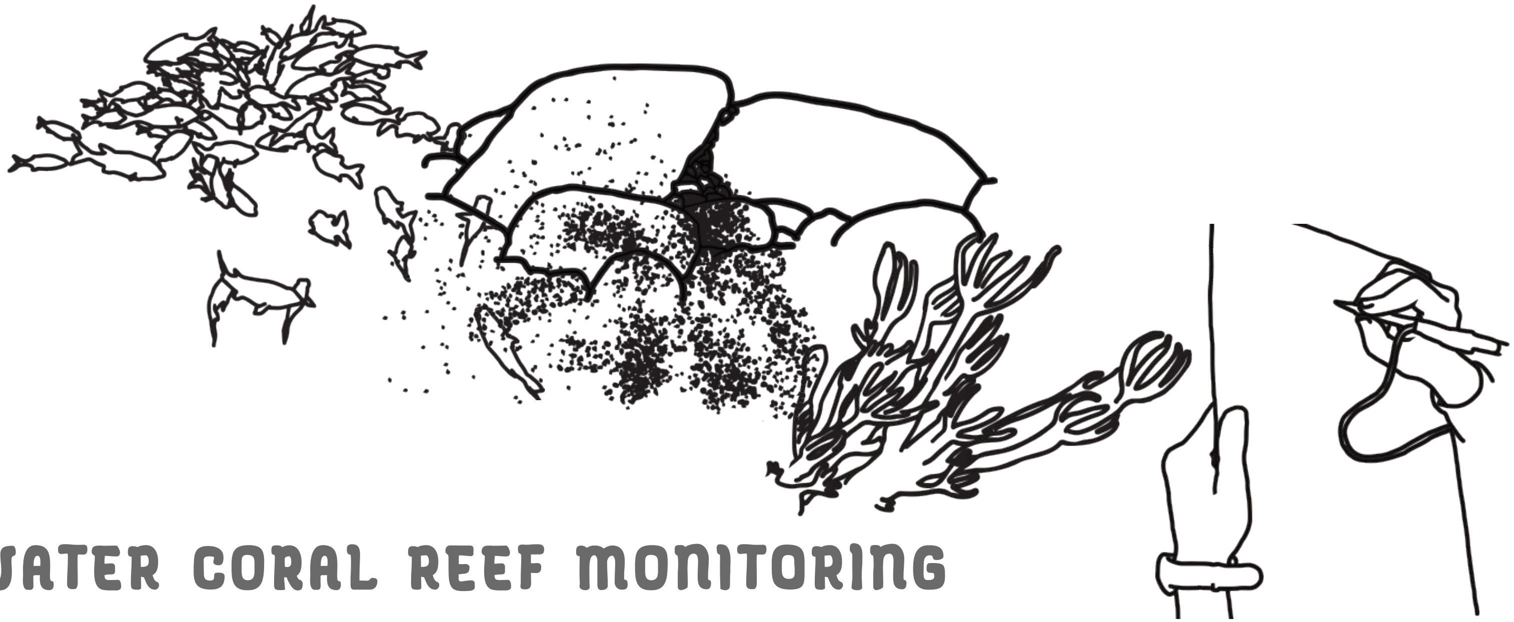
MANAGEMENT OPTIONS TO IMPROVE OR MAINTAIN A HEALTHY REEF

HEALTHY

Enforce illegal gear regulations
Restrict destructive fishing gear

Fish size limit (max or min) through gear modifications
Seasonal closure, rotate fishing zones

Restrict fishing of certain species to specific zones
Create no-take areas or closure areas



3.0 Underwater coral reef monitoring

This manual covers three underwater survey methods for measuring the health of coral reefs. They are done by a team of 4 people (observers) within a 250m^2 survey area marked by a 50m tape measure or rope laid on the sea bed.

The methods cover the main animals (fauna) and plants (flora) that dominate coral reefs, namely the reef building corals and fish, seagrass and algae, large invertebrates such as sea cucumbers, shells and starfish. Together these give a measure of the state or health of the reef and its biodiversity. Included in the invertebrates are sea urchins, which are well known indicators of poor reef health because large numbers can cause a decline in reef condition.

The three methods are as follows and are described in detail below:

- Belt transect for **fish** density and sizes
- Point intercept transect for **coral** and other **substrate** cover
- Belt transect for **macro-invertebrate** density.

A description of how to analyse and interpret your results is also given for each of the three methods. Templates of datasheets, tables and graphs for data analyses are given in the Appendices.


observer 1 and 2 survey fish, macro-invertebrates and sea urchins
four observers are needed to conduct the surveys
observers 3 and 4 survey the benthic substrate together

3.1 Belt Transect for fish abundance

The *Belt Transect* used for counting fish is a 50 x 5m transect, laid parallel to the shore, or reef edge, to give a 250m^2 survey area. Fish are counted within this area. A random point on the reef is chosen as the start point of the transect. The fish observer swims 50m in a straight line from the start point, counting key fish species observed 2.5m either side of them to give a total count width of 5m. Total numbers of fish of different species or families, and their approximate sizes, are recorded on the slate. The key fish species selected for recording are described on the next page.

Estimating fish lengths

This requires tallying fish into one of four size classes, shown on the datasheet:

A : **small** (hand length < 15cm)

B : **medium** (half arm length to the elbow, 15-45cm)

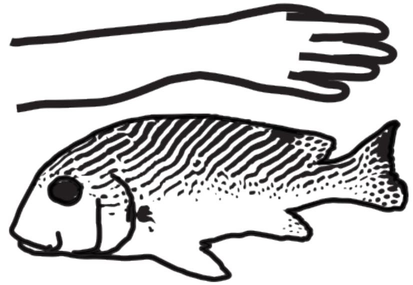
C : **large** (full arm length 45-60cm)

D : **very large** (greater than full arm length > 60cm)

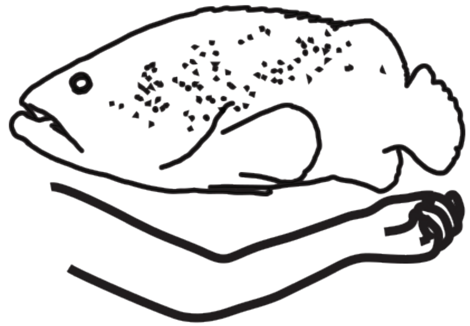
This requires training and practice but is not difficult, especially for fishermen already used to estimating fish size using this hand or arm length method.

A

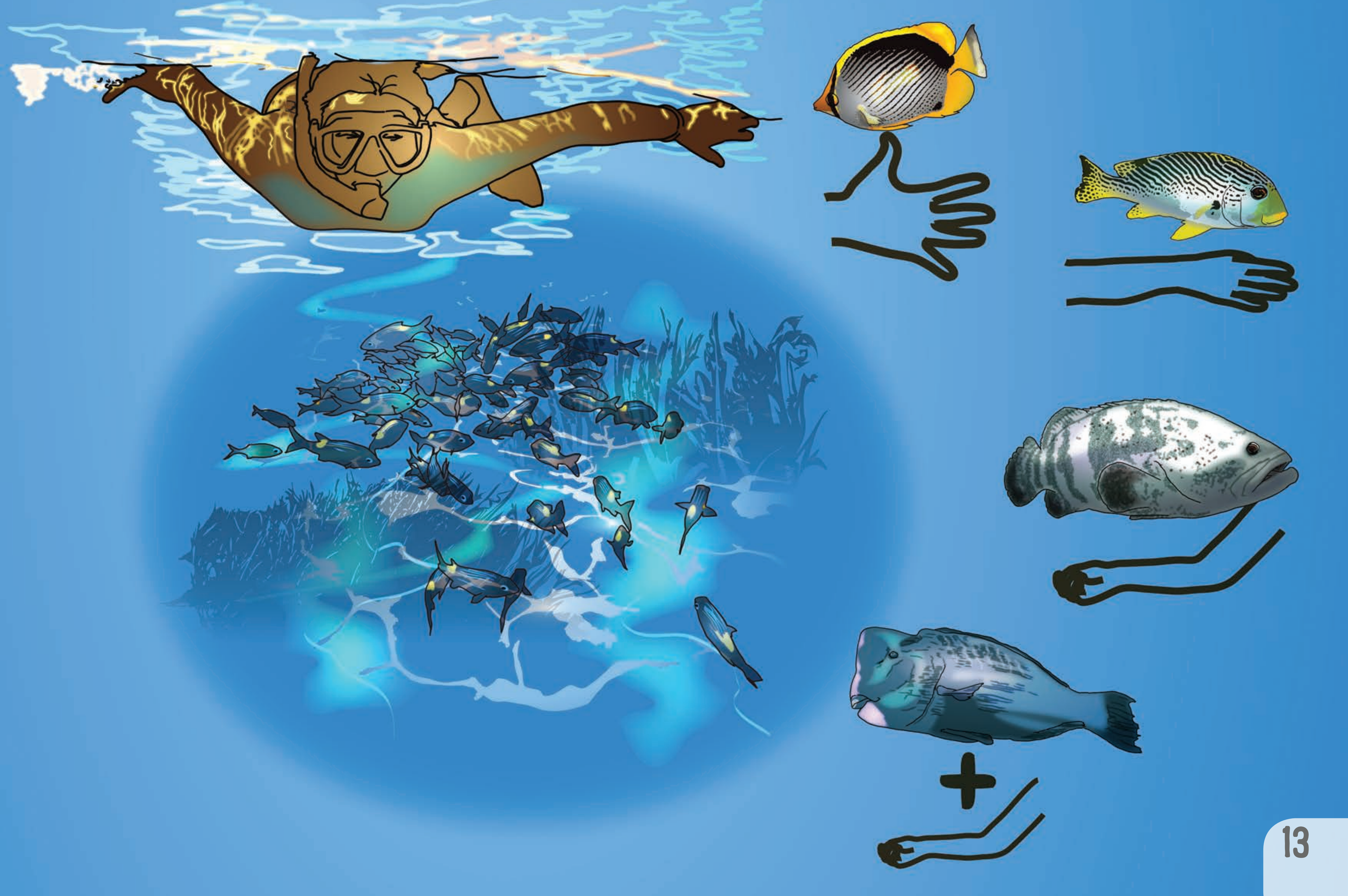
B

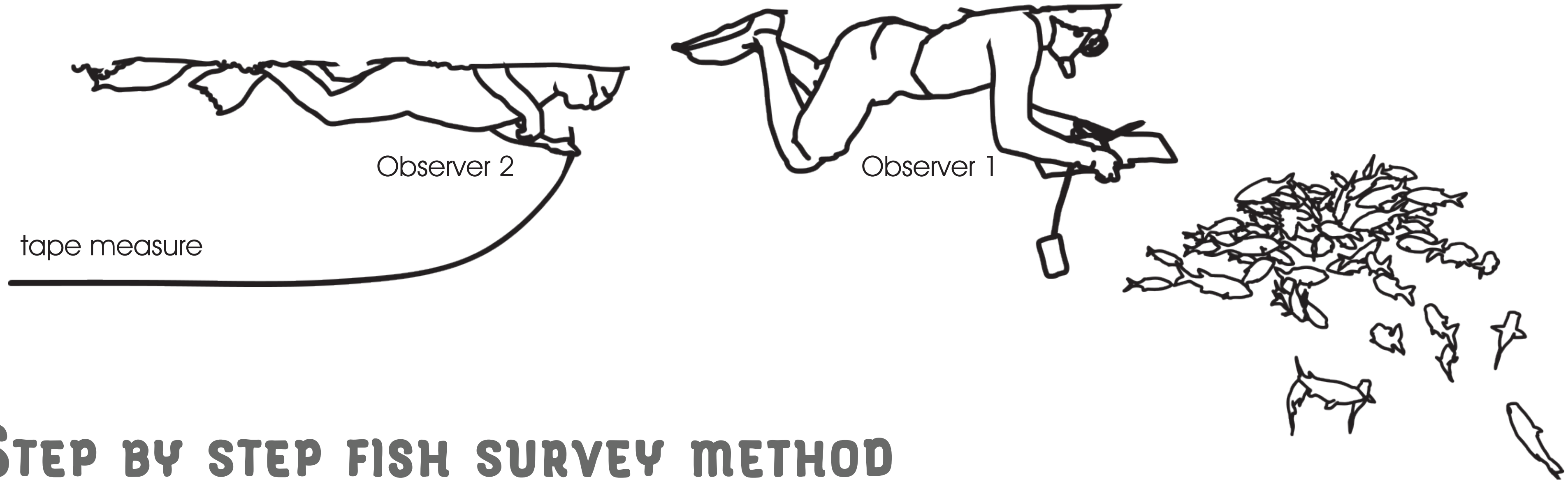


C



D



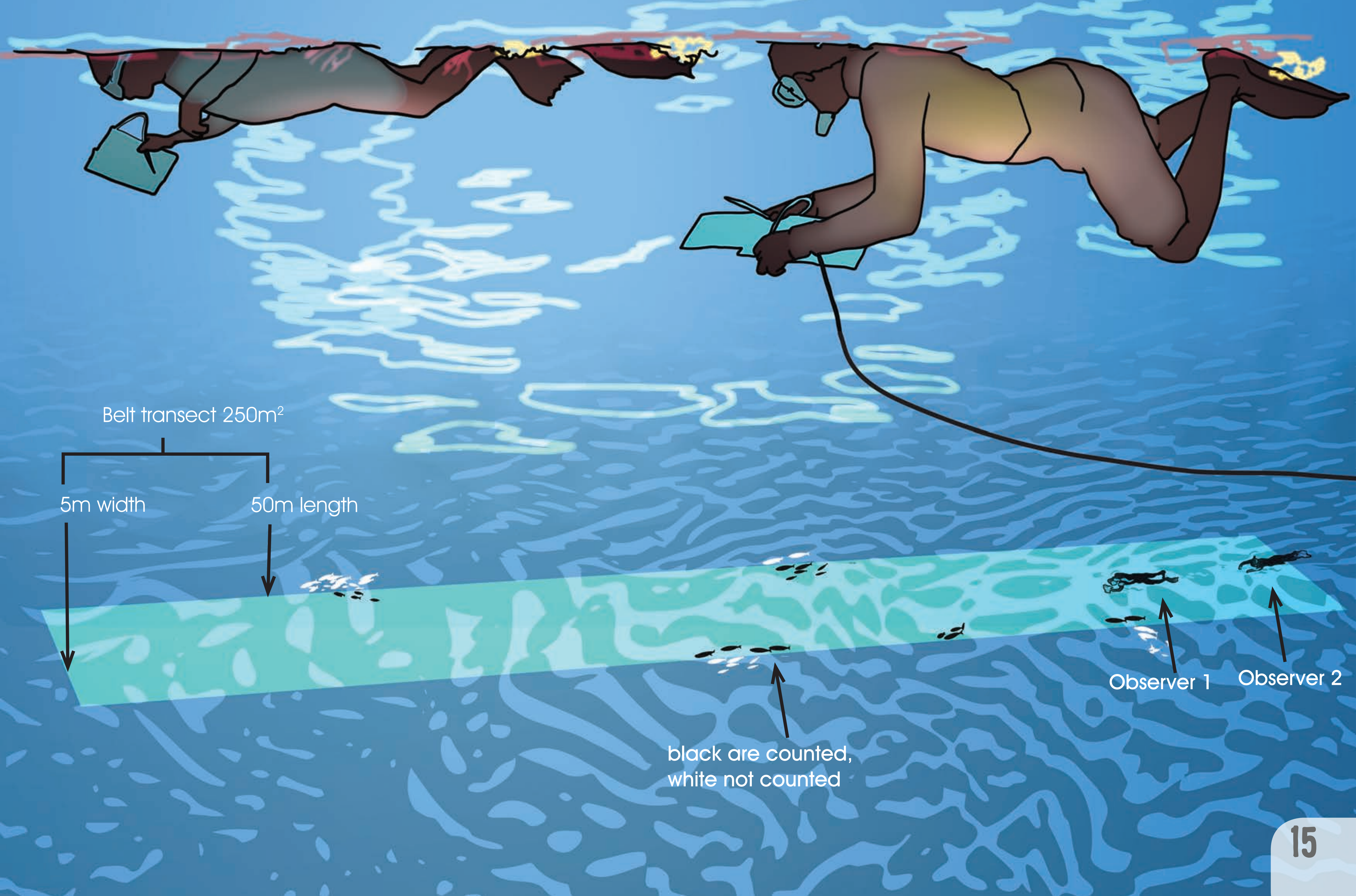


Step by step fish survey method

1. Observers 1 and 2 select any starting point on the reef. They then measure 2.5m either side of this point with the tape measure to line up the edge of the 5m width of the transect. Observer 2 securely ties the end of the tape measure to the reef.
2. Observer 1, the fish recorder, then begins swimming in a straight line from this start point and records the numbers and estimates the size of key fish species observed within a 5m width. The transect line should be parallel to the shore or reef edge.
3. Observer 2 swims just behind Observer 1 laying out the 50m tape measure. Observer2 lets Observer 1 know when the 50m point is reached to stop the fish count. The tape measure is then left on the sea bed and held down by a weight.

TIPS: *Swimming should be slow but at a regular speed, taking around 10 minutes to cover the 50m line. Once the end of the 50m transect is reached,* Observers *1 and 2 switch to recording macro-invertebrates, returning back along the transect. This process is repeated on six separate transects in a site.*

Fish survey method



Fish indicator species

The fish species recommended for monitoring in this manual provide a good cross section of the fish community on a coral reef. Key, or indicator, species were selected based on a several criteria including trophic level in the food chain, fishery value and type, and general reef health indicators, with the understanding that a healthy reef should support a diversity of fish from piscivores (fish eaters) to herbivores and plankton eaters. The key/indicator species and criteria are shown below.

Certain species of fish are large and rare partly due to their natural life history and partly due to over-fishing or loss of habitat. These are shaded grey. Any sightings of these outside the survey transects should also be recorded as an additional note. Additional species identified as a priority for your site may be added to this list.

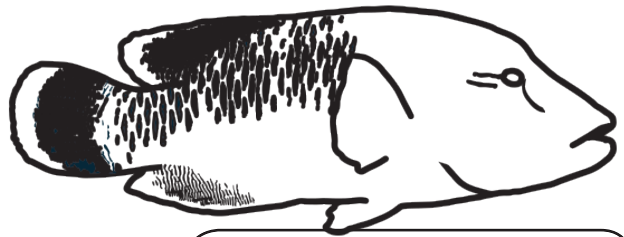
species	trophic level	criteria: Fishery importance, ecological role, vulnerability
Rabbitfish / *Tafi*	*Herbivores*	Fisheries. Reduce algal cover which helps with coral recruitment and growth
Parrotfish / *Pono*	*Herbivores*	Fisheries. Reduce algal cover which helps with coral recruitment and growth
Triggerfish / *Gona*	*Omnivores*	Fisheries. Known to eat sea urchins and important in control of sea urchin populations
Emperor / *Changu*	*Omnivores*	Fisheries
Snapper / *Mbavaa*	*Omnivores*	Fisheries
Sweetlip / *Fute mnyea*	*Omnivores*	Fisheries
Goatfish / *Mkoma/ Mkundaji*	*Omnivores*	Fisheries
Unicornfish / *Puju*	*Planktivores herbivores*	Contribute to biodiversity, reduce algal cover which helps with coral recruitment and growth
Butterflyfish / *Kipepeo*	*Corallivores invertivores*	Indicators of good coral cover and diversity; tourism value
Trevally / *Kolekole*	*Piscivores*	Fisheries. Top predators, help maintain balanced fish community
Grouper / *Tewa*	*Piscivores*	Fisheries. Top predators, help maintain balanced fish community *
Shark / *Papa*	*Piscivores*	Top predators, help maintain balanced fish community *
Napoleon wrasse/ *Badu chore/ Shambaro*	*Omnivores*	One of the largest fish on the reef; high tourism value *
Bumphead parrotfish / *Pono mtungi*	*Herbivores*	Key role in keeping reefs healthy *

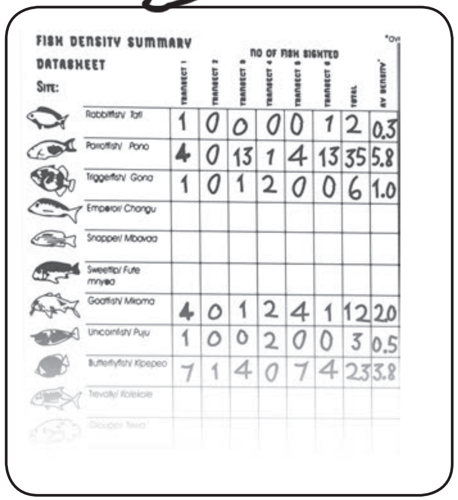
* Vulnerable to over-fishing, or threatened species

Fish indicator species

Data analysis and presentation

Data analyses help us determine fish density and size classes. Data may be analysed by hand or using a computer spreadsheet or database. Results are presented as graphs and passed into spreadsheet form to be presented through graphs. Templates for the manual analysis and presentation of results are given in Appendix 4.





FISH DENSITY SUMMARY DATASHEET

SITE:

	NO OF FISH SIGHTED							
	TRANSECT 1	TRANSECT 2	TRANSECT 3	TRANSECT 4	TRANSECT 5	TRANSECT 6	TOTAL	AV DENSITY*
Rabbitfish/ Tafi	1	0	0	0	0	1	2	0.3
Parrotfish/ Pono	4	0	13	1	4	13	35	5.8
Triggerfish/ Gona	1	0	1	2	0	0	6	1.0
Emperor/ Changu								
Snapper/ Mbavaa								
Sweetlip/ Fute mnyea								
Goatfish/ Mkoma	4	0	1	2	4	1	12	2.0
Unicornfish/ Puju	1	0	0	2	0	0	3	0.5
Butterflyfish/ Kipepeo	7	1	4	0	7	4	23	3.8
Trevally/ Kolekole								

Fish Density

Fish density is commonly measured as numbers of fish per $250m^2$

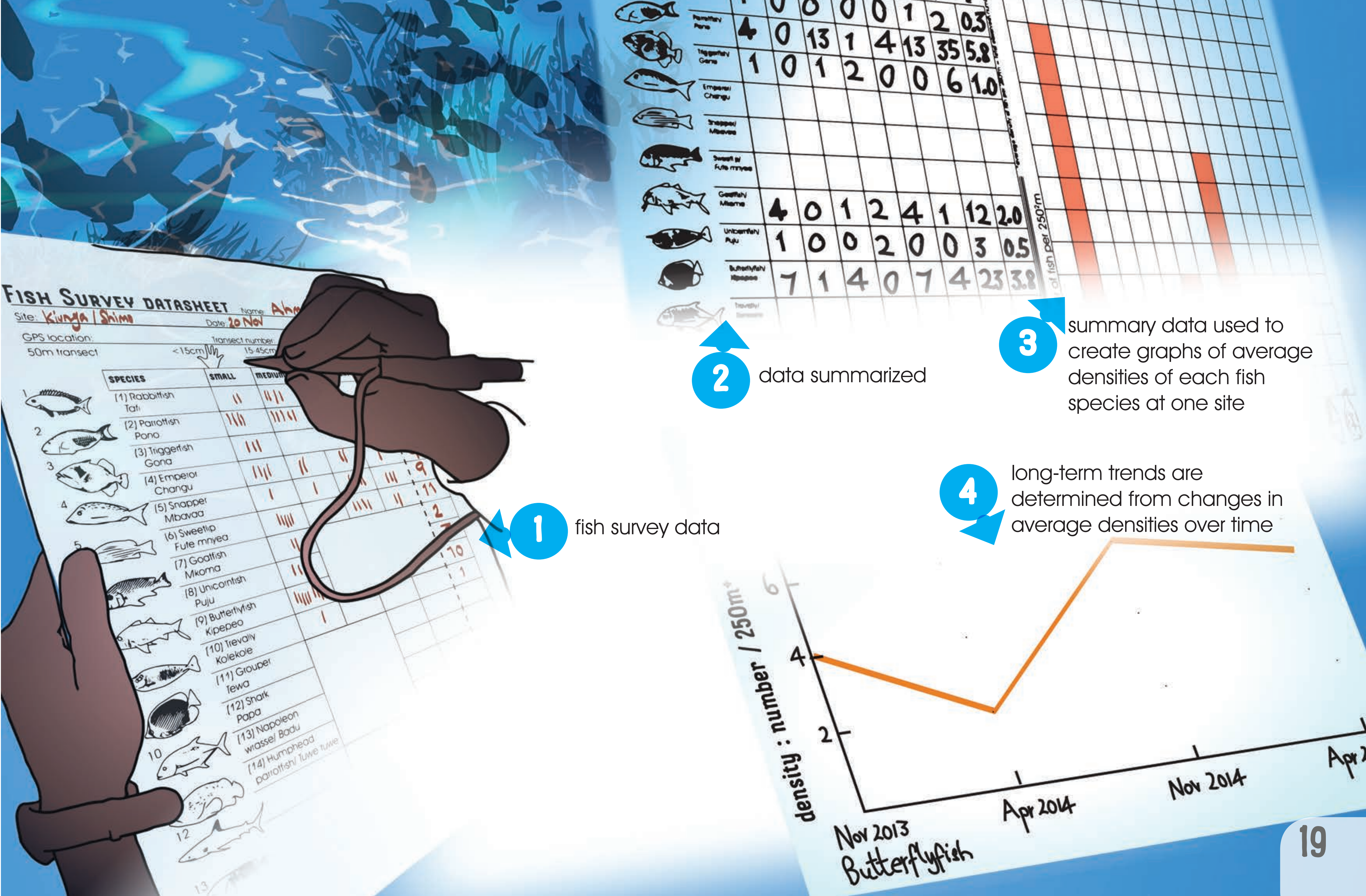
1 Survey: A *Fish Survey Datasheet (see Appendix 3)* is completed for each transect in your site. Whilst swimming you record the number and size of each indicator species of fish observed.

2 Summarise: The next stage is to transfer the total numbers of each species from your *Fish Survey Datasheet* into the *Fish density summary sheet (see Appendix 4)*. Calculate the average density of each species by simply dividing the total number of fish by the number of transects (normally six).

3 Graph: Next, transfer your summary data into graph format. This will enable the average densities of fish species to be seen much more easily.

4 Review: To compare long term data, draw a graph for each species that shows the average densities over consecutive surveys. Such graphs, made after every survey, enable you to look at the long-term trends in fish abundance and their implications for your site.

Fish density analysis

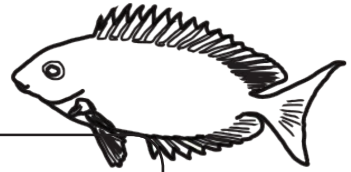


1 fish survey data

2 data summarized

3 summary data used to create graphs of average densities of each fish species at one site

4 long-term trends are determined from changes in average densities over time



Transects (T)	small
T1	4
T2	4
T3	10
T4	10
T5	9
T6	10
Total fish	47
Fish / transects	47/6
Average* =	8

Fish species size distribution

Fish species size distribution is analysed for each species separately, according to the four category sizes, (this is not done for small fish species which never grow larger than the small category size).

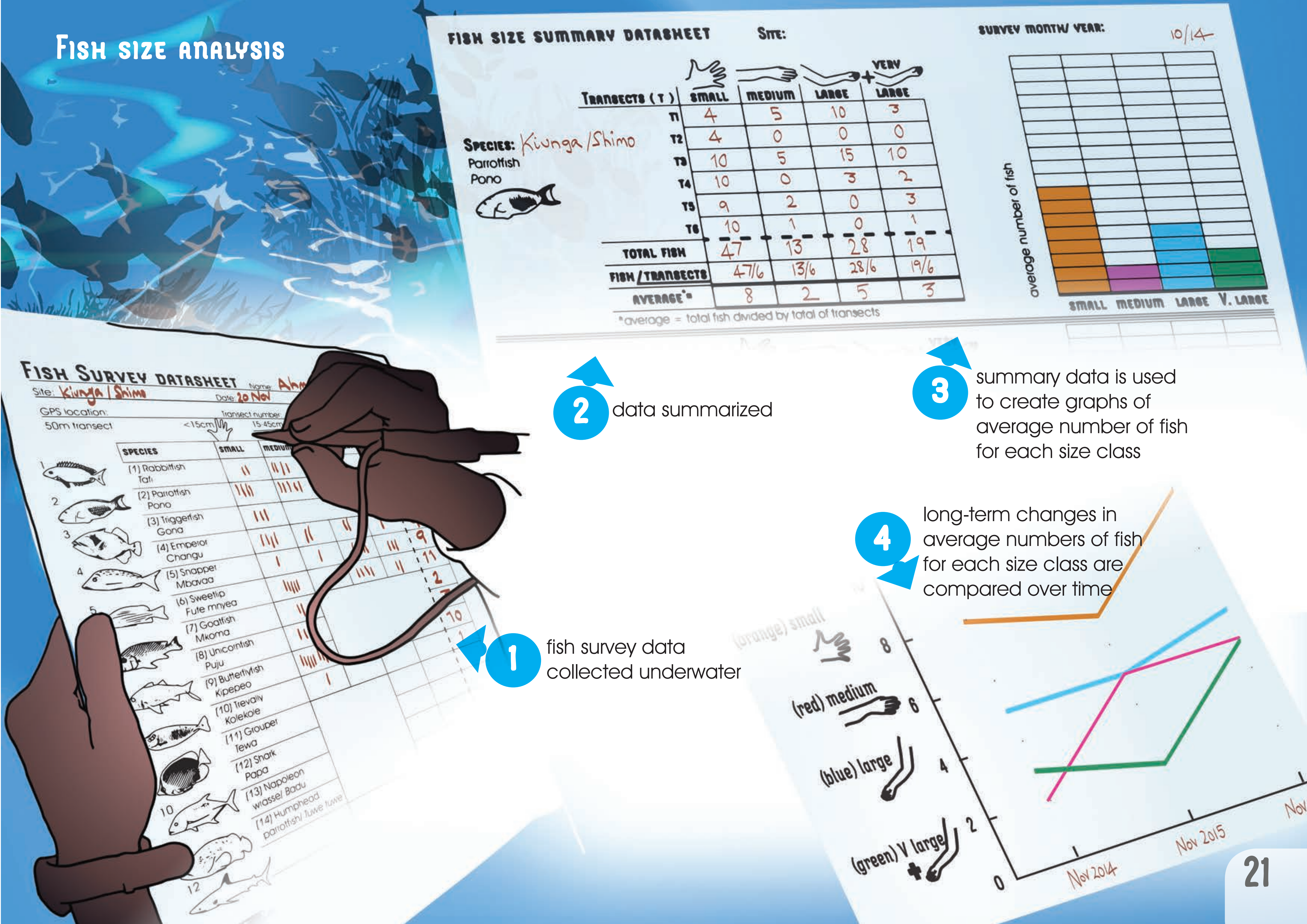
1 **Survey:** Complete a *Fish Survey Datasheet* recording the number of and different sizes of fish for each indicator species in your transect.

2 **Summary:** Transfer your survey data for each medium and large species into the rows and columns of the *Fish Size Summary Sheet (see Appendix 4)*. Total each size category and calculate the average number of fish (by dividing the total number by the number of transects and rounding this up to the nearest whole number).

3 **Graph:** Compile your summary data into a separate graph, one for each species, to show the average number of fish in each size category (shading each category with a different colour). This will summarise the survey data for a site.

4 **Review:** To determine long term trends in fish sizes, transfer your summary data into a separate graph for each species showing the average number of fish for each size category in consecutive surveys. Since all size categories can be shown in the one graph (each size category using the same colours as the previous step) then the result will show how the numbers and sizes of fish vary over time.

Fish size analysis



Transects (T)	small	medium	large	very large
T1	4	5	10	3
T2	4	0	0	0
T3	10	5	15	10
T4	10	0	3	2
T5	9	2	0	3
T6	10	1	0	1
Total fish	47	13	28	19
Fish / transects	47/6	13/6	28/6	19/6
Average*	8	2	5	3

*average = total fish divided by total of transects

1 fish survey data collected underwater

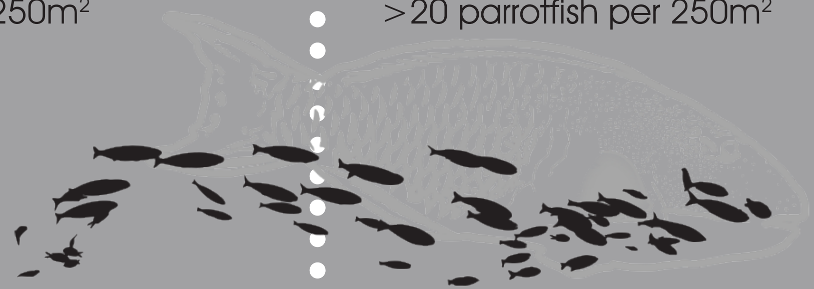
2 data summarized

3 summary data is used to create graphs of average number of fish for each size class

4 long-term changes in average numbers of fish for each size class are compared over time

Interpreting Fish Survey Results

Unhealthy	Fair		Healthy
Over-fishing & destructive fishing methods			Low fishing pressure
<10 parrotfish per 250m^2	10-20 parrotfish per 250m^2		>20 parrotfish per 250m^2
few fish, no fish in some places; few species; only small fish	small, few medium and no large fish	increasing numbers, sizes & types of fish	abundant, diverse fish species; sizes from small to very large



Interpreting Fish Survey Results

UNHEALTHY

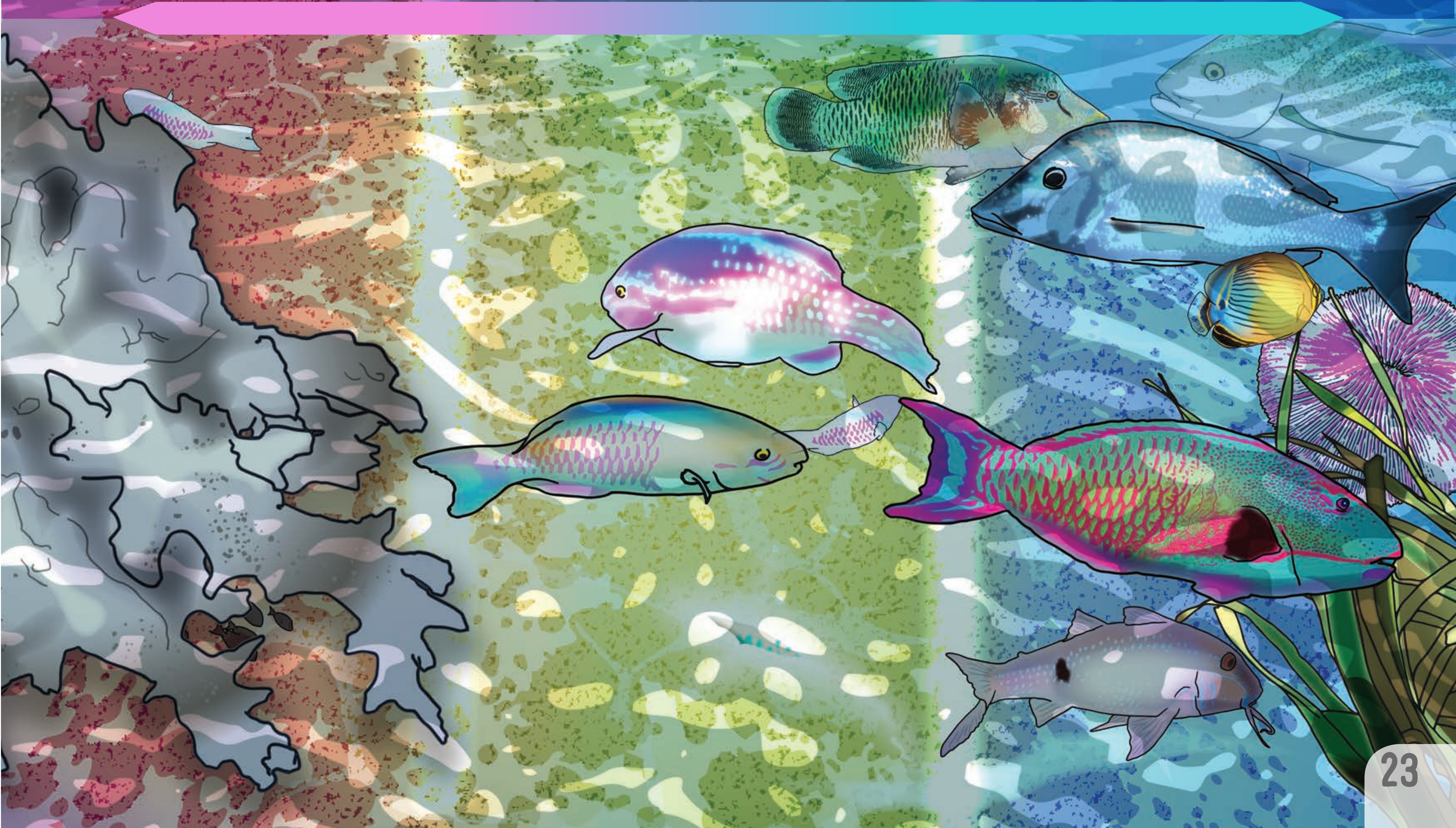
less than 10 parrotfish per 250m^2

FAIR

10-20 parrotfish per 250m^2

HEALTHY

more than 20 parrotfish per 250m^2

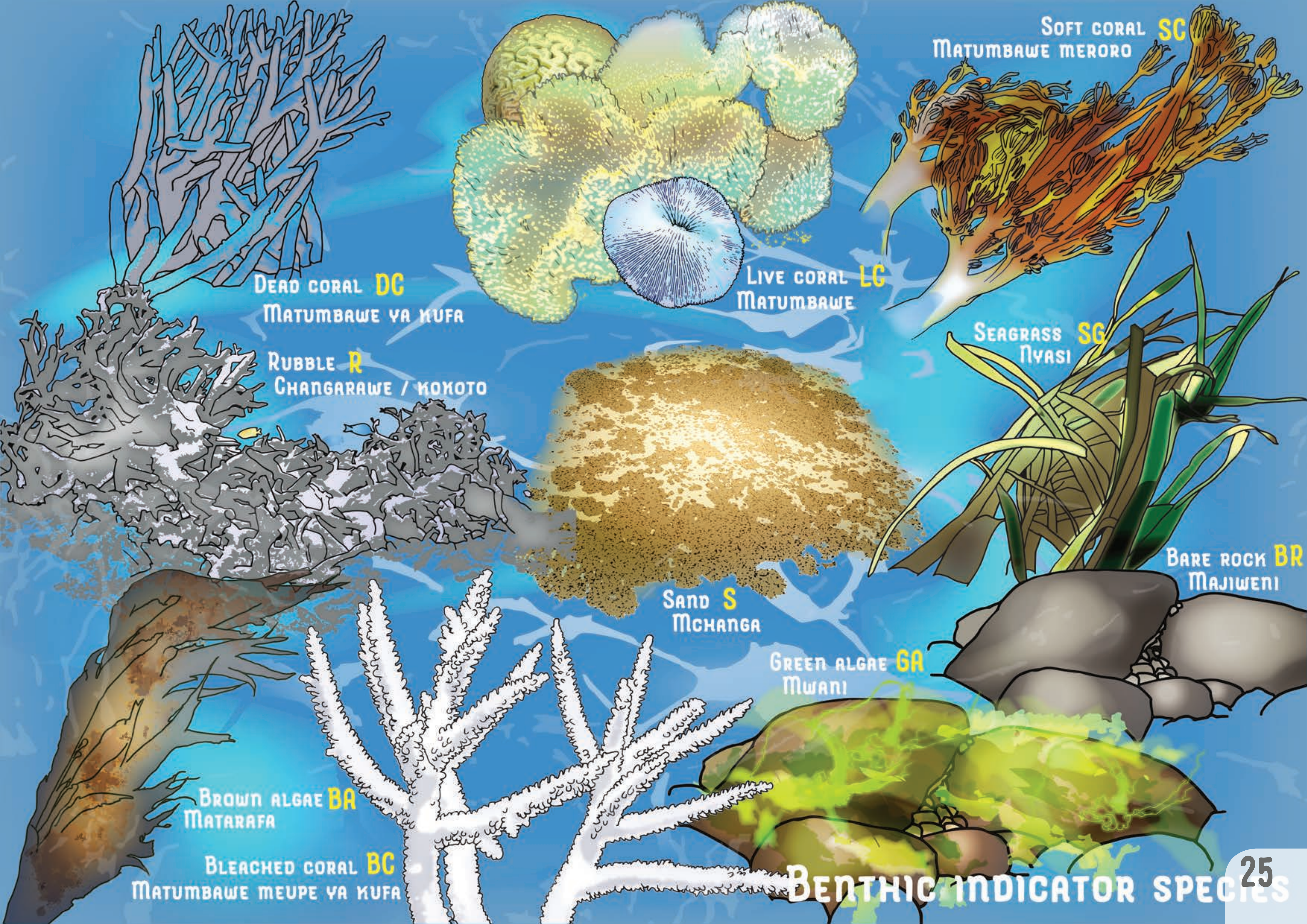


3.2 Point Intercept Transect for benthic substrate

Benthic substrate refers to the type of seabed on which plants and animals live. The *Point Intercept Transect* is used to measure the cover and type of benthic substrate on the seabed, which are then converted to percentages for each category. Ten categories of substrate cover on coral reefs are used in this manual and, in particular, live coral, dead coral, bleached coral, algae and rubble are key benthic indicators for measuring the health of coral reefs.

Benthic substrate categories	Relevance
Live coral (LC) / *Matumbawe*	Primary indicators of reef health*. Hard corals are the main reef builders
Dead coral (DC) / *Matumbawe ya kufa*	Indicator of the state of deterioration of a reef. May result from coral bleaching, predation by crown of thorns, dynamite fishing or storms
Bleached coral (BC) / *Matumbawe meupe ya kufa*	Indicates stress from increasing water temperature. Indicator of the effect of climate change on coral reefs
Soft coral (SC) / *Matumbawe meroro*	Natural components of coral reefs. Early colonisers of reefs recovering from damage
Rubble (R) / Changarawe / kokoto	Can indicate the state of deterioration of a reef caused by dynamite, trampling by humans or dragging of fishing gear. Also caused by storms and natural coral mortality
Bare rock (BR) / *Majiweni*	Bare rock indicates hard substrate on the seabed. This is suitable for coral recruits
Sand (S) / *Mchanga*	Sand is a natural component of shallow coral reefs particularly in lagoons
Brown algae (BA) / *Matarafa*	Competitor and prevent the growth of hard corals. Sign of degraded reef, colonise dead reefs. Once brown algae take over an area it is very hard for corals to return
Green algae (GA) / *Mwani*	Competitor and prevent the growth of hard corals
Seagrass (SG) / *Nyasi*	Provides food and habitat for fish and invertebrates

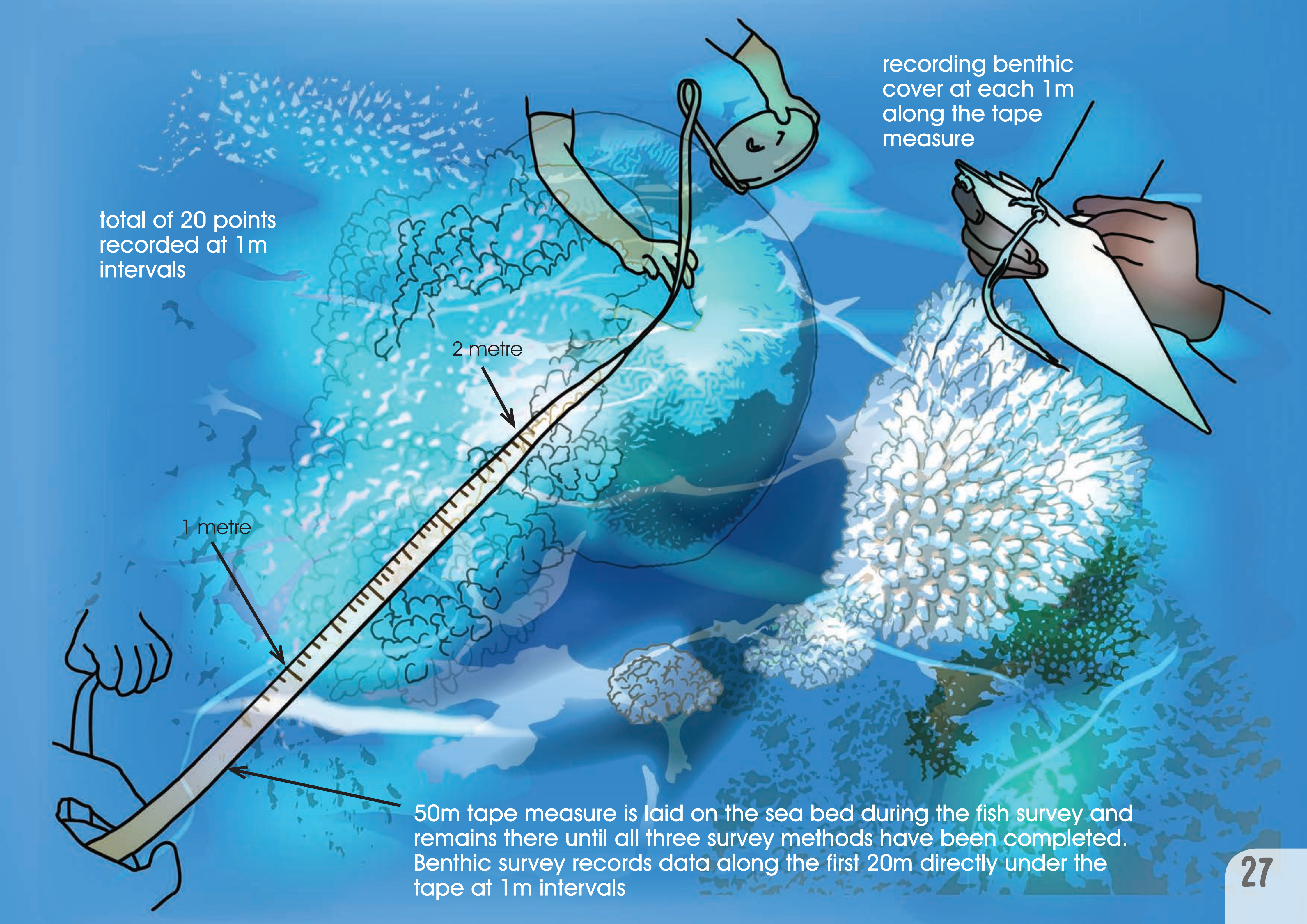
* Kenya's reefs on average have a live hard coral cover of around 20%. This was around 40% and above before the widespread coral bleaching event caused by the 1997/1998 El Nino, which was attributed to global warming


Soft coral SC
Matumbawe meroro
Dead coral DC
Matumbawe ya kufa
Live coral LC
Matumbawe
Seagrass SG
Nyasi
Rubble R
Changarawe / kokoto
Bare rock BR
Majiweni
Sand S
Mchanga
Green algae GA
Mwani
Brown algae BA
Matarafa
Bleached coral BC
Matumbawe meupe ya kufa
Benthic indicator species

STEP BY STEP METHOD FOR BENTHIC SURVEY

The method involves recording the benthic categories onto the datasheet every 1m along the transect, up to the 20m mark. The total number of records of each benthic category for each transect is summarised, and the % of each category for the site is then calculated. This part of the survey is done by observers 3 and 4.

1. Use the same 50m transect as that used for the fish survey, with the tape measure laid on the seabed (see section 3.1).
2. Observer 3 swims and records the type of substrate at every 1m mark directly under the tape measure starting at the 1m mark up to the 20m mark giving a total of 20 points. Observer 4 can assist by swimming alongside Observer 3 and recording this information.
3. Recording on the data sheet is done using initials for each category.
4. This is repeated on each of the six transects per site.


recording benthic cover at each 1m along the tape measure
total of 20 points recorded at 1m intervals
2 metre
1 metre
50m tape measure is laid on the sea bed during the fish survey and remains there until all three survey methods have been completed. Benthic survey records data along the first 20m directly under the tape at 1m intervals

BENTHIC SUBSTRATE DATA ANALYSIS & PRESENTATION

Benthic susbtrate cover for a site is expressed as percent cover for each substrate type based on the average frequency for 20 points recorded for each of the six transects in a site (a total of 120 points).

1 **Datasheet:** Complete the *Benthic substrate datasheet (see Appendix 3)* using the initials of each substrate type. There should be 20 points within each transect

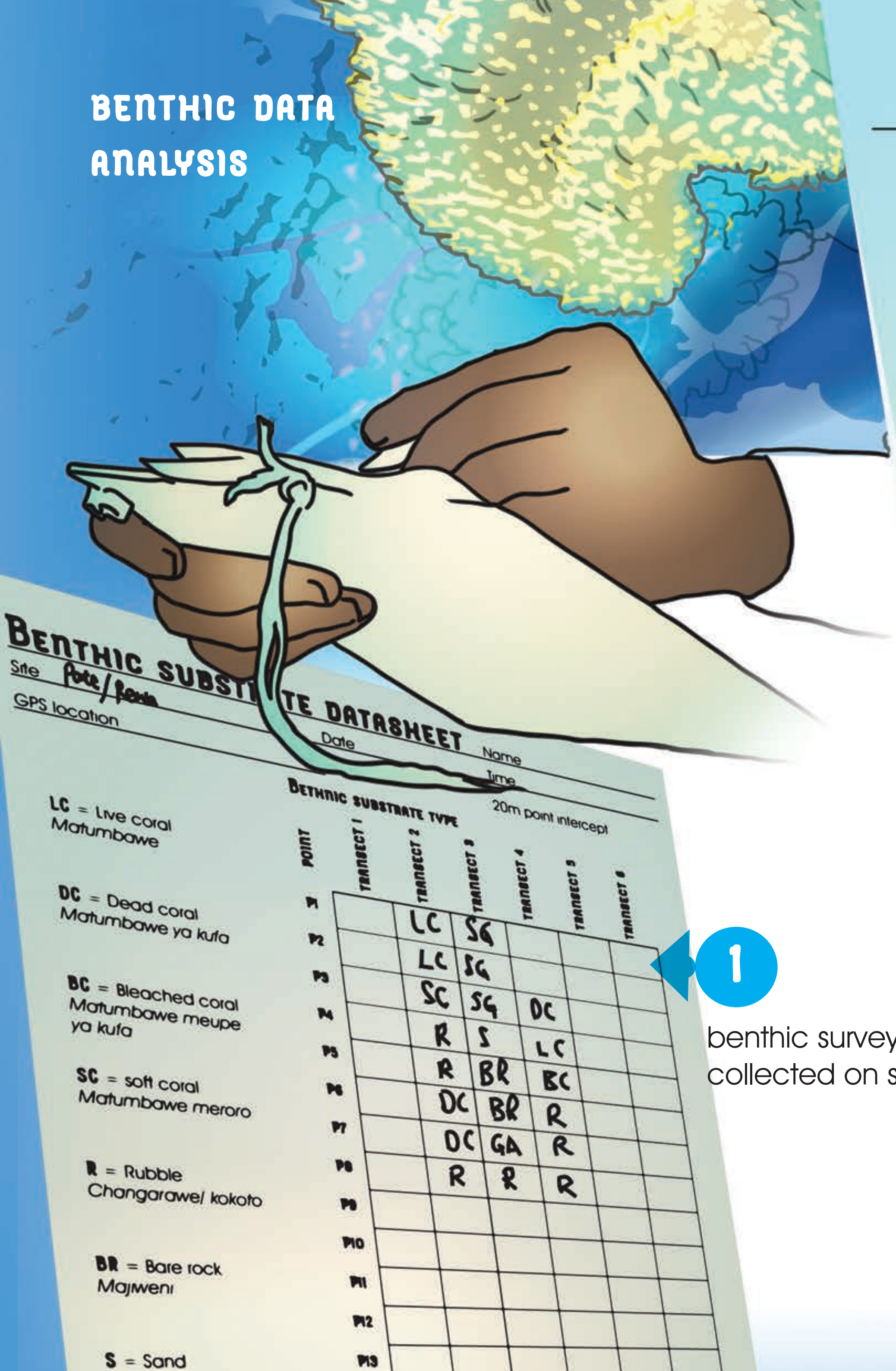
2 **Summary:** In the *Benthic summary sheet (see Appendix 4)* total the frequency of points for each substrate type within each transect (i.e. the number of times each substrate type has been recorded). In the same table calculate for each substrate type:

- *total frequency* (for all transects combined)
- *average frequency* (total frequency divided by the number of transects)
- *average percent cover* (average frequency divided by 20 and multiplied by 100).

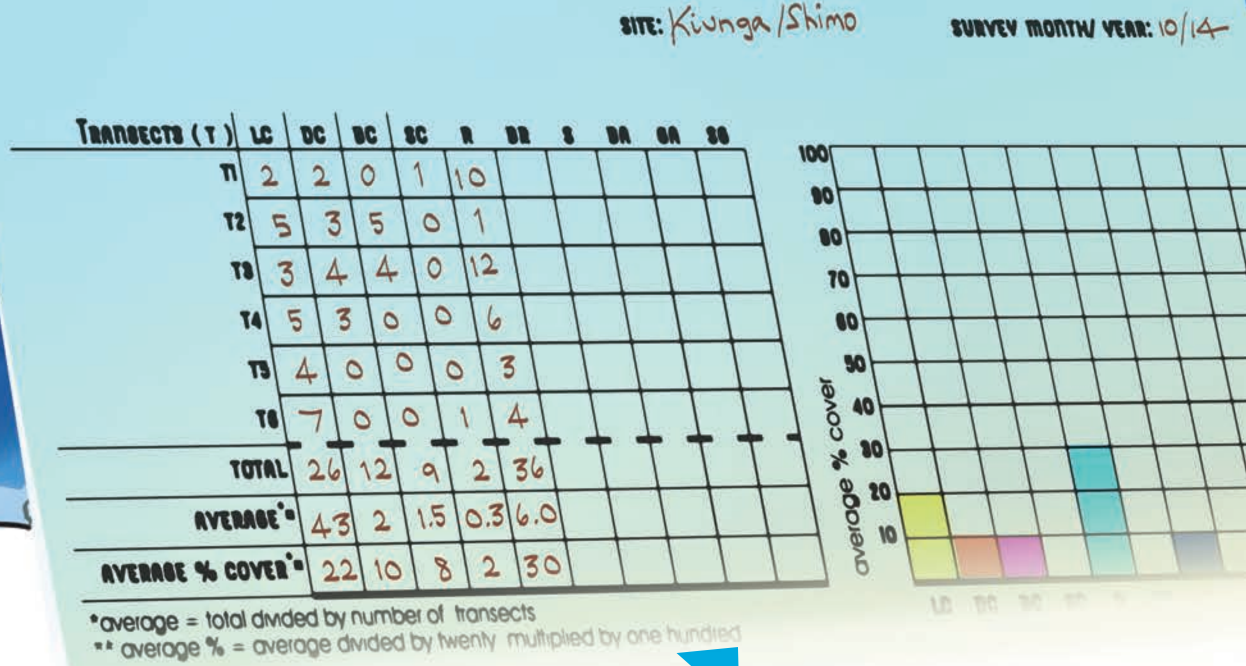
3 **Graph:** Compile your data into a graph for each site to show percentage cover for each substrate type. This will summarise the data of a site for each survey.

4 **Review**: To compare yearly survey data for a site, each substrate type needs reviewing. You may wish to review only substrates of particular management importance (e.g. live coral, dead coral, bleached coral, algae, rubble and seagrass). If so, draw a separate graph for each substrate type that displays the average percent cover from consecutive surveys (filled in after each survey) and the result will enable you to review long-term trends in benthic substrate cover.

BENTHIC DATA ANALYSIS



1 benthic survey data collected on site



SITE: Kiunga/Shimo SURVEY MONTH/ YEAR: 10/14

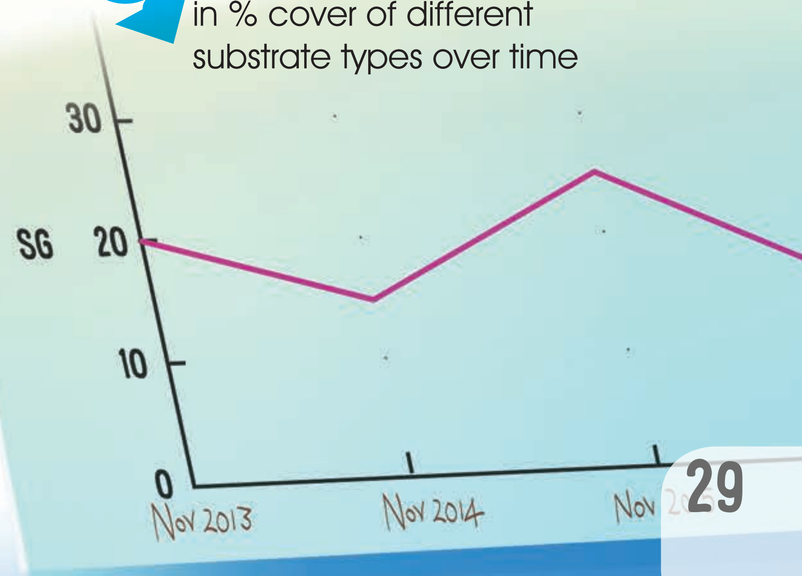
TRANSECTS (T)	LC	DC	BC	SC	R	BR	S	BA	GA	SG
T1	2	2	0	1	10					
T2	5	3	5	0	1					
T3	3	4	4	0	12					
T4	5	3	0	0	6					
T5	4	0	0	0	3					
T6	7	0	0	1	4					
TOTAL	26	12	9	2	36					
AVERAGE*	4.3	2	1.5	0.3	6.0					
AVERAGE % COVER**	22	10	8	2	30					

*average = total divided by number of transects
** average % = average divided by twenty multiplied by one hundred

2 data summarized

3 summarized data is used to create graphs of average % cover for each substrate type

4 long-term trends are determined from changes in % cover of different substrate types over time

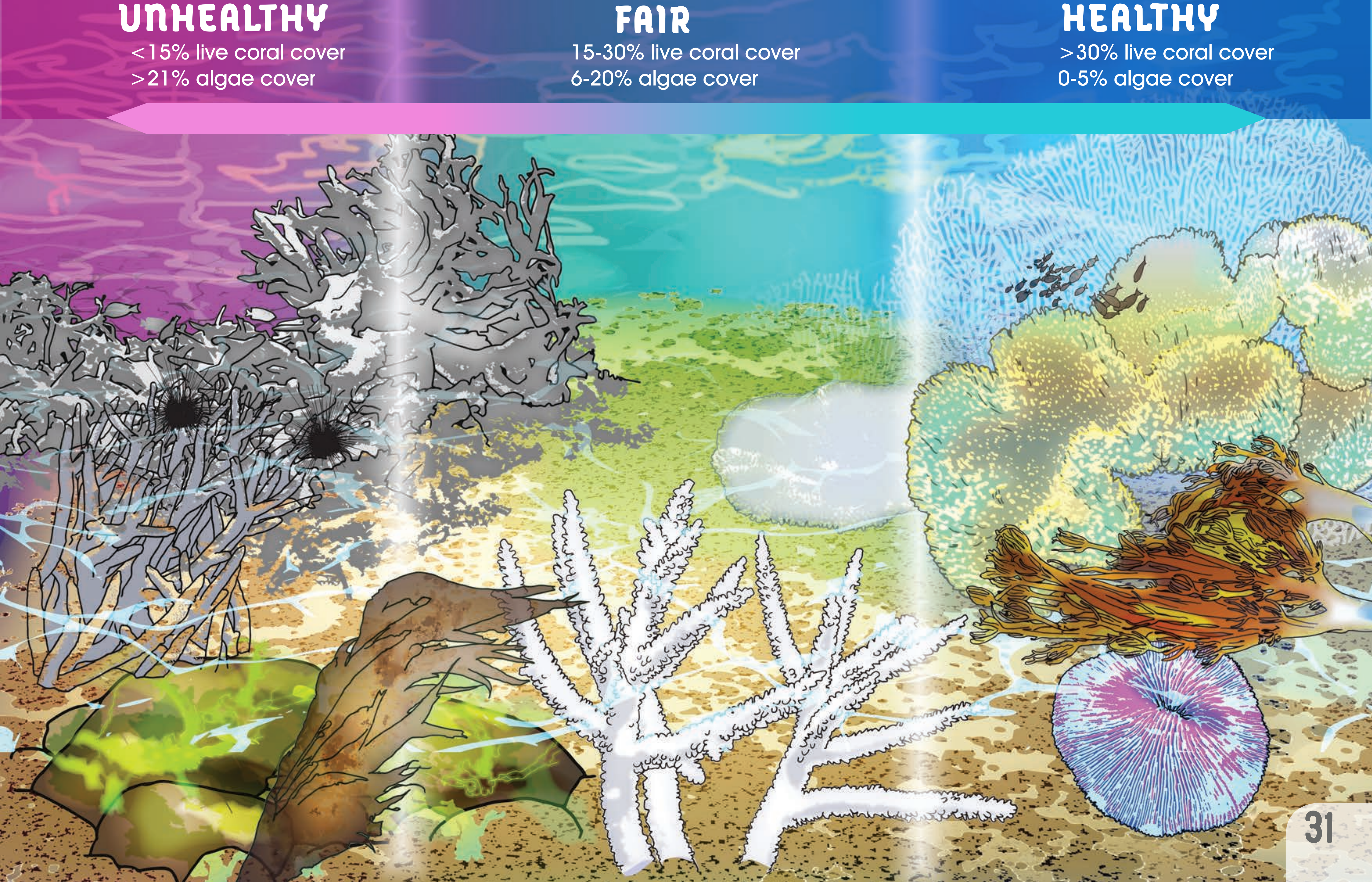


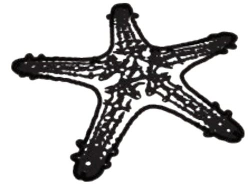
Interpreting benthic survey results

The coral cover and algal cover thresholds illustrated are generalized figures for eastern Africa. Different geographic areas of reef should be evaluated to determine more precise thresholds, for example, the far north Kenyan coast where coral reefs are marginal and have never had high coral cover will have lower thresholds for coral cover in healthy and unhealthy reefs

UNHEALTHY OVER FISHING, DESTRUCTIVE FISHING METHODS & INCREASED SEA TEMPERATURE	FAIR		HEALTHY LOW FISHING PRESSURE, NON-DAMAGING FISHING METHODS
<15% live coral cover >21% algae cover	15-30% live coral cover 6-20% algae cover		>30% live coral cover 0-5% algae cover
mainly rubble, broken, dead coral, bleached coral covered by algae	soft corals begin to grow on bare rock, some live coral	increasing proportion of live and soft coral, less rubble, dead and bleached coral	high proportion of live & soft coral, very little rubble or bare rock, no brown or green algae covering coral

Interpreting benthic Survey Results





3.3 Belt Transects for macro-invertebrates

The species selected as large invertebrate indicators are starfish, shells (molluscs), crown of thorn starfish, sea cucumber, clams and sea urchins. Octopus, although common in coral reef ecosystems, are not recorded in this method because of their cryptic nature and are therefore easily missed during a visual survey that counts a number of different animals.

The Belt Transect for counting large invertebrates is a 50 x 5m transect, giving a 250m^2 survey area. Macro-invertebrate data is a measure of density, meaning the number of invertebrates per 250m^2. This area is used for all macro-invertebrates except sea urchins. Because sea urchins can occur in high numbers and hide under the coral they require more search time and are therefore surveyed for only 10m of the transect. This gives a smaller area of 10m x 5m, or total area of 50m^2.

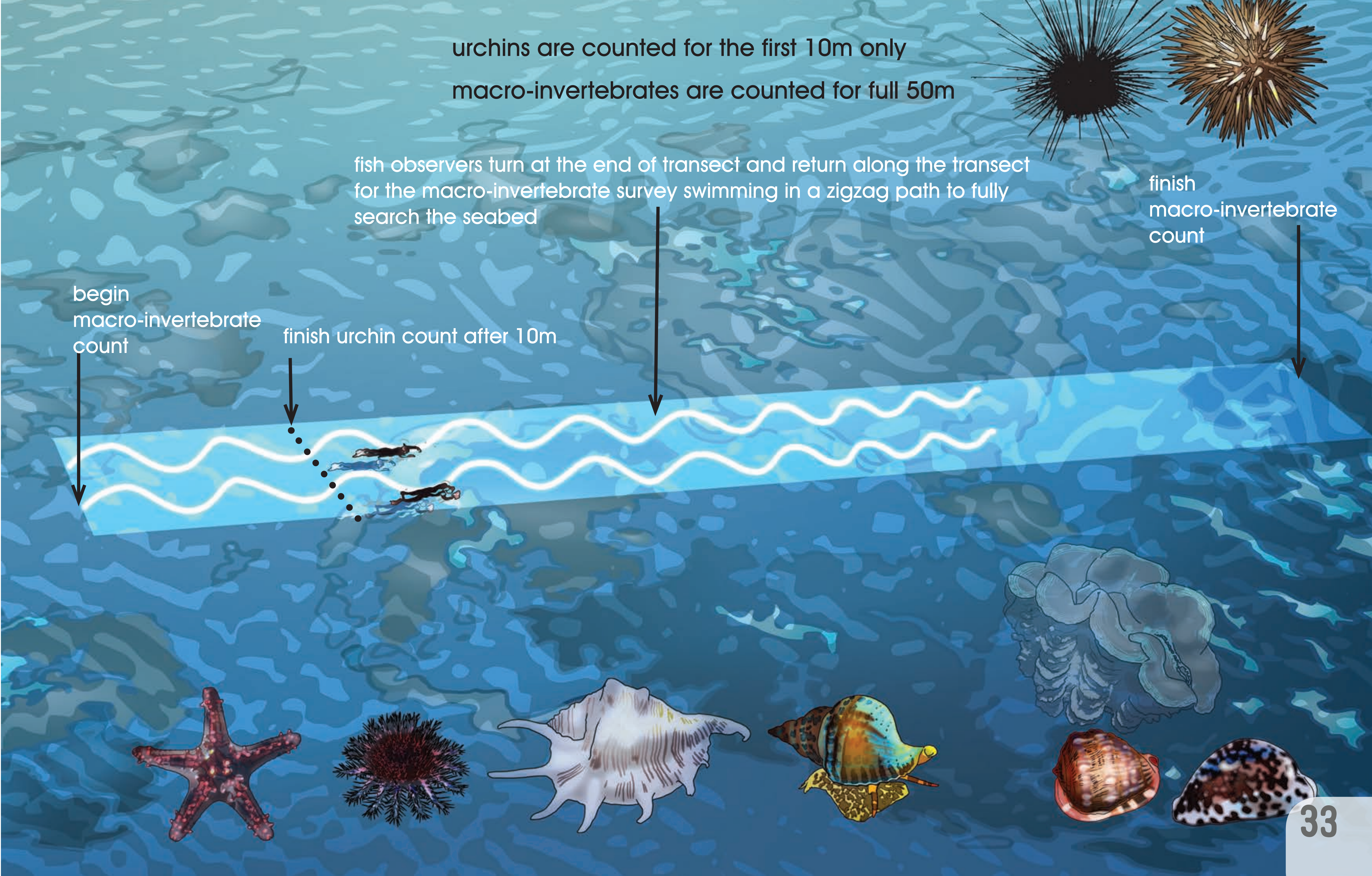
Two Observers swim along the 50m transect each counting on one side of the tape measure, and recording every macro-invertebrate seen within 2.5m of the tape measure.

Sea urchins are categorised as large and small. Large sea urchin species are *Diadema* and *Echinothrix*, whilst small species are *Echinometra mathaei, Tripneustes gratilla* and *Toxopneustes pileolus*.

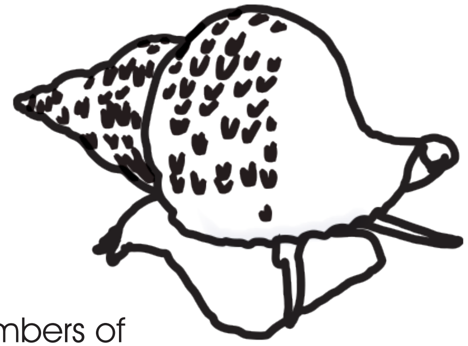
Step by step method for the macro-invertebrate survey

1. Observers 1 and 2 swim on each side of the 50m tape measure placed on the seabed while counting macro-invertebrates 2.5m either side of the tape measure - a maximum width of 5m.
2. In the first 10m sea urchins are also counted, to give an area of 50m^2. The observer stops counting sea urchins at the 10m mark but continues counting the other large macro-invertebrates.
3. The numbers of large macro-invertebrate species are recorded by tallying.
4. This is repeated on each of the six transects per site

MACRO-INVERTEBRATE SURVEY METHOD



Macro-invertebrate indicators

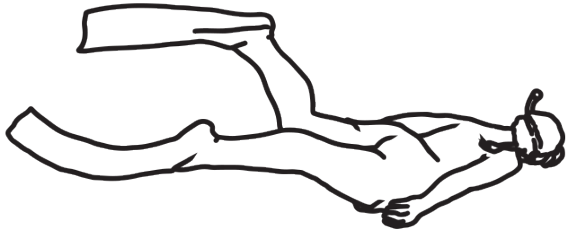


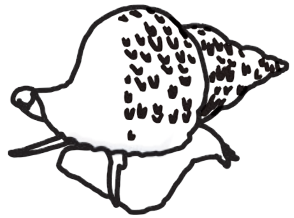
Macro-invertebrates play an important role in the food-chain of the reef. Some macro-invertebrates are targeted for their ornamental value (shells) or for human consumption. A high number of different types of macro-invertebrates is considered to be an indication of a healthy reef, because it suggests healthy population densities and a high diversity of species. In contrast, high numbers of sea urchins can indicate reef damage. The invertebrates surveyed in this method are listed below.

Characteristics of macro-invertebrate species used as indicators for monitoring coral reefs	
Macro-invertebrate	Relevance
Sea cucumbers /*Jongoo*	Feed on organic matter. Important in decomposition in coral reef ecosystem. Some are valued as sea food
Starfish / *Kiti cha pweza*	Feed on organic matter. Important in decomposition in coral reef ecosystem. Some feed on sea urchins and are therefore important in their population control. Collected for aquarium trade
Tiger cowrie / *Dondo mwani*	They feed on algae on rocks and corals. Collected for ornamental value/shell trade
Lambis shell / *Madole*	They feed on algae on rocks and corals. Collected for ornamental value/ shell trade
Clams / *Kihaluba* / *Ukombe*	Filter feeders. Collected for ornamental value/ shell trade
Triton shell / *Pundamilia*	Preys on crown of thorn. Collected for ornamental value/ shell trade
Bull mouth shell / *Dondo la robo*	Feed on sea urchins and starfish. Collected for ornamental value/ shell trade
Crown of thorns (COT) / *Matukombe*	Feed on live corals. Can occur in plagues causing extensive damage to reefs
Large sea urchins / *Mapoe*	Indicators of reef degradation (poor reef health). Large sea urchins scrape the underlying surface as they move, causing erosion of live corals. Populations increase when corals are dead and fishing is heavy. Eaten by several fish species. They feed on algae
Small sea urchins / *Mapoe*	Indicators of reef degradation (poor reef health). Some feed on seagrass others cause erosion of live corals. Populations increase when corals are dead and fishing is heavy. Eaten by several fish species, e.g. triggerfish, emperor, snapper, wrasse, etc. as well as lobsters

MACRO-INVERTEBRATE INDICATOR SPECIES

Macro-invertebrate data analysis and presentation





The density of key macro-invertebrates is commonly measured in numbers per 250m^2. Sea-urchins however are only counted along 10m of any transect and are therefore measured in numbers per 50m^2.

1 **Survey**: Complete a *Macro-invertebrate Datasheet* (*see Appendix 3*) for each transect in your site to record the numbers of key species. Survey sea urchins for 10m of each transect and the full 50m for other macro-invertebrates.

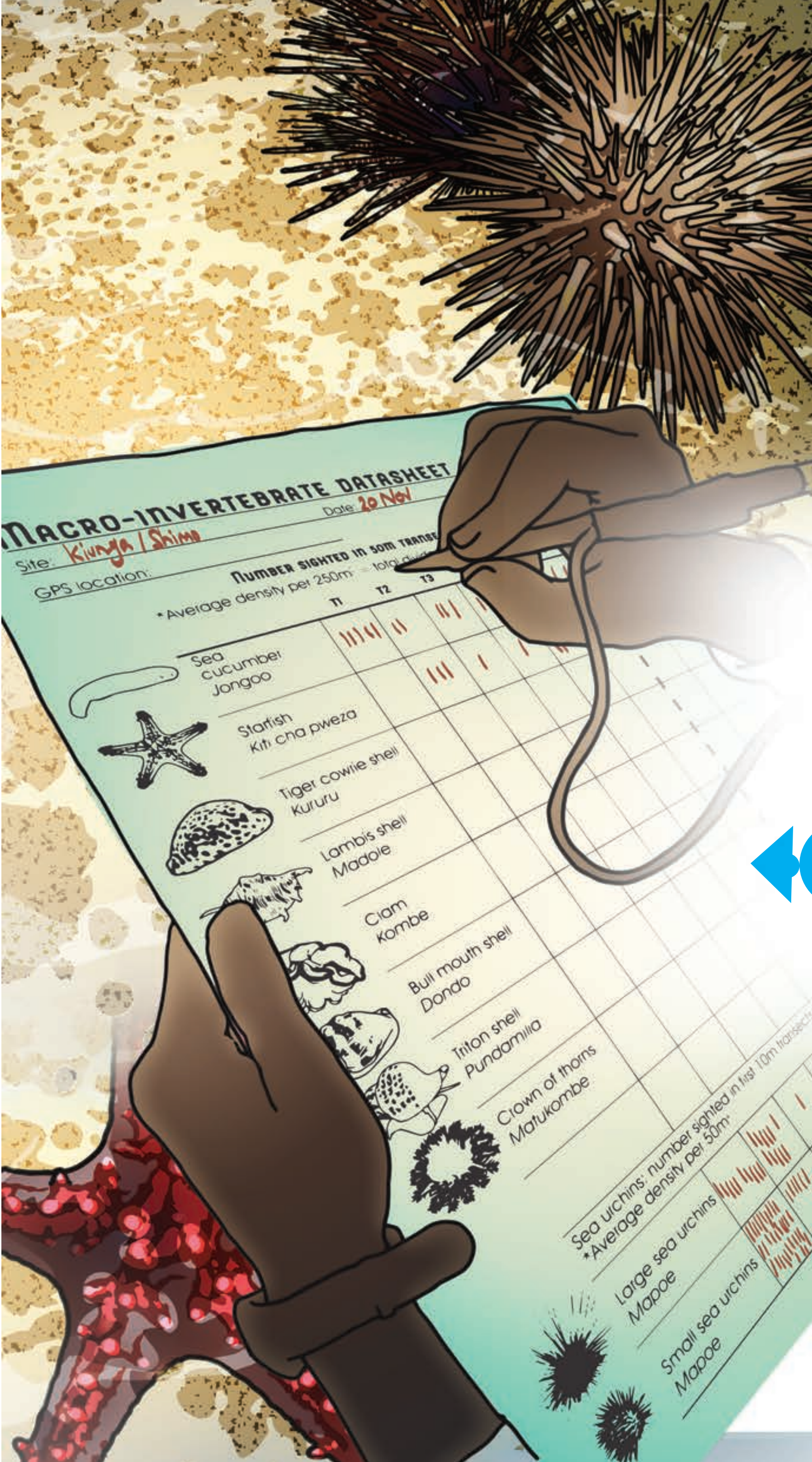
2 **Summary**: Add up the total number of macro-invertebrates for all transects and then calculate the average densities (the total number divided by the number of transects). The result gives you the average density of key invertebrates per 250m^2 (and per 50m^2 for sea urchins).

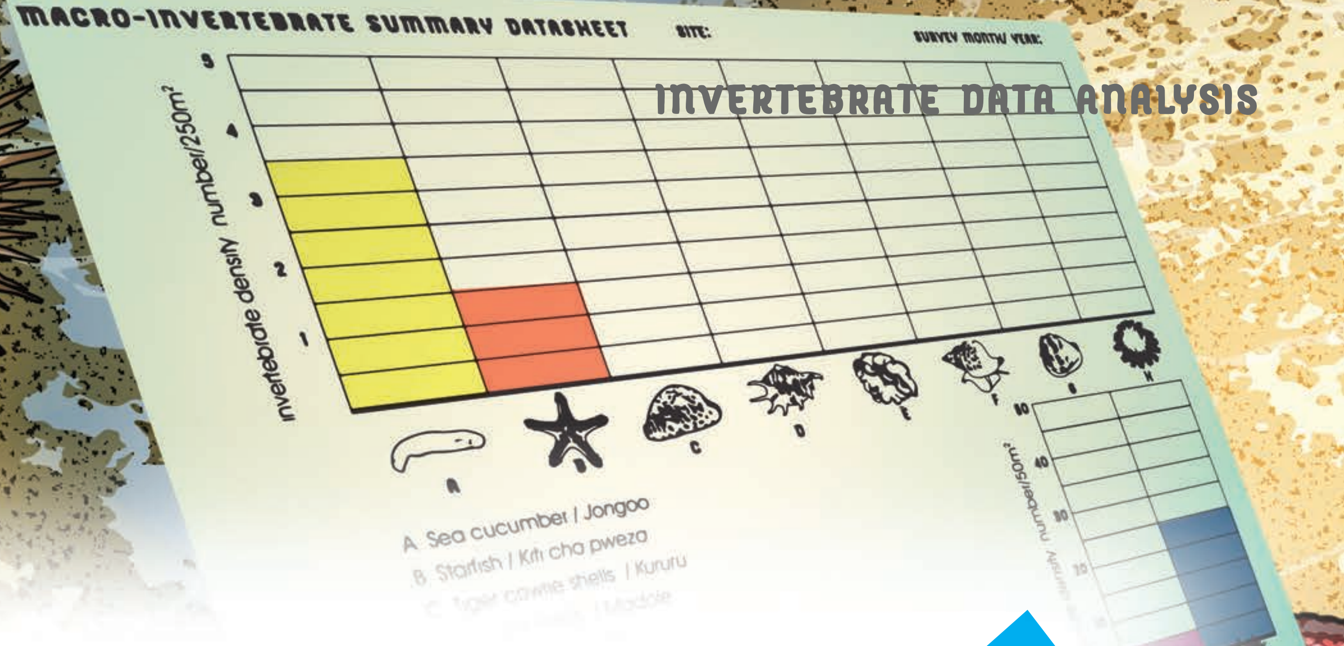
3 **Graphs**: Compiling your data into graphs to show the average density of each macro-invertebrate for the site, with a separate graph for large and small sea urchins (*see Appendix 4*).

4 **Review**: To compare long term data, each species of macro-invertebrate is independently reviewed. Plot separate graphs for each species showing the average densities for consecutive surveys. As these graphs are completed after each survey, the result will enable you to review the long-term trends of all macro-invertebrates for your site.

UNHEALTHY HIGH FISHING PRESSURE, OVER-COLLECTION OF SHELLS	FAIR		HEALTHY LOW FISHING PRESSURE, NO COLLECTION OF SHELLS
many sea urchins, no shells, few macro-invertebrates	fewer sea urchins, some shells & macro-invertebrates	decreasing numbers of sea urchins, increasing numbers of shells and macro-invertebrates	high numbers and diversity of shells and other macro-invertebrates, very low number of sea urchins

INVERTEBRATE DATA ANALYSIS



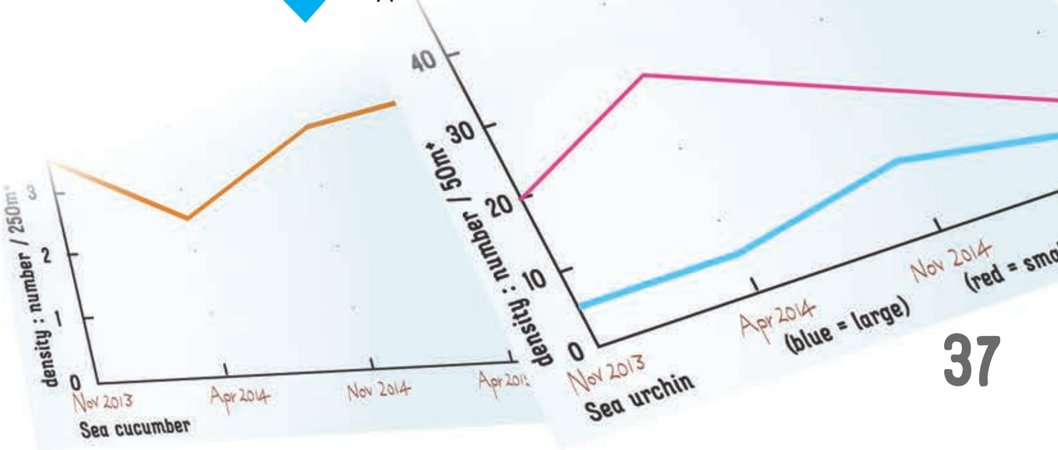


2 data is summarised and average densities calculated

3 graphs made of average density for each invertebrate type

1 invertebrate survey data collected on site

4 long-term trends are determined from changes in average density of different types of invertebrates over time



4.0 Field procedure for conducting the survey methods

The team of four individuals need to be able to swim and snorkel and to have learnt all the indicator species that are recorded during monitoring. Waterproof species' identification guides should be carried into the water for quick reference. Each participant must train in all coral reef monitoring methods. However, during monitoring, certain team members may be allocated certain methods depending on their interest and knowledge.

Since fish can be attracted to, or frightened away by, swimmers in the water, the fish observers need to be the first to start the survey. Once the random start point on the reef has been decided, the fish observers need to move quickly to start their observations to minimise disturbance to the fish. Synchronising the three methods into one field exercise makes the survey efficient and reduces time spent changing over to different methods. The selected site should consist of a seabed that is predominantly coral (dead or alive) or hard substrate where coral once grew. Extensive areas of seagrass or sand should be avoided as these survey methods are designed for coral reefs.

Step by step field guide to all three survey methods

Fish counts

1. Pick a random point within the survey site for laying the transect parallel to the shoreline or reef edge.
2. Using the 50m tape measure visually estimate the 5m width of the transect 2.5m either side of your start point. This can be done with the tape measure, or using features on the reef.
3. Observer 1 swims in a straight line away from the start point and parallel to the shore or reef edge, with the fish survey data sheet to count the fish.
4. Observer 2 securely fastens the beginning of the tape measure to the reef at the start point taking care not to damage any live coral.
5. Observer 2 then swims behind Observer 1 winding out the 50m tape measure to lay the 50 m transect on the sea bed. On reaching the 50 m end of the tape, he/she stops Observer 1 from swimming further on. The end of the tape measure is secured and weighted on the sea bed.

Macro-invertebrate counts

6. Once they have finished the fish survey, observers 1 and 2 swim back along the belt transect in the opposite direction, counting the macro-invertebrates within 2.5m either side of the tape. Sea urchins are counted within the first 10m only, all other invertebrates are counted along the entire 50m transect.

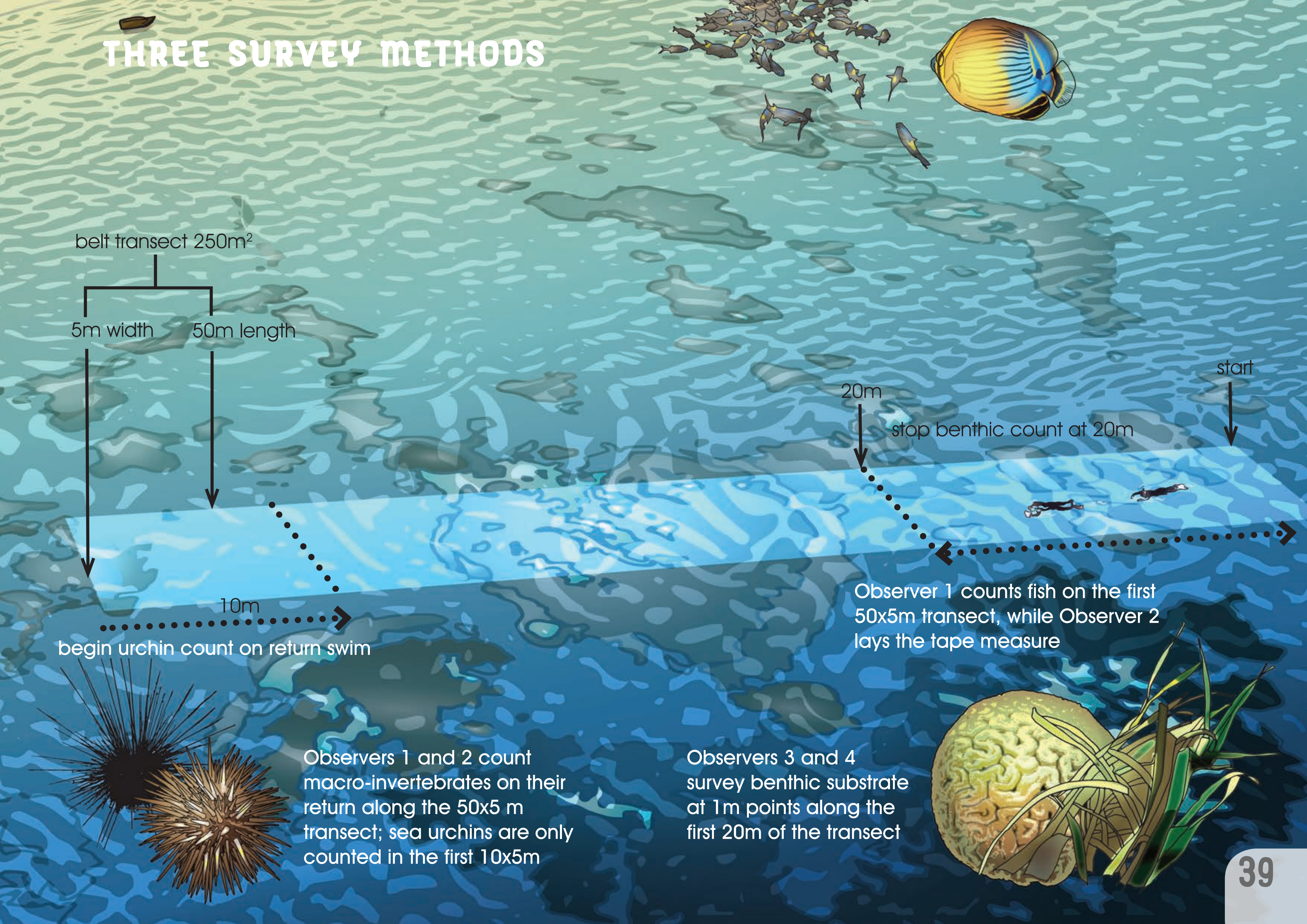
Benthic measures

7. Observers 3 and 4 start the benthic survey after the fish count observers have swum away, they record the benthic substrate category under the tape from the start point, at every 1m interval, up to the 20m mark.

All

8. Once all methods are completed the tape measure is wound up.
9. The Observers re-group at the start point and then proceed to locate a new point to lay out the next transect. This is repeated to give a total of 6 transects.

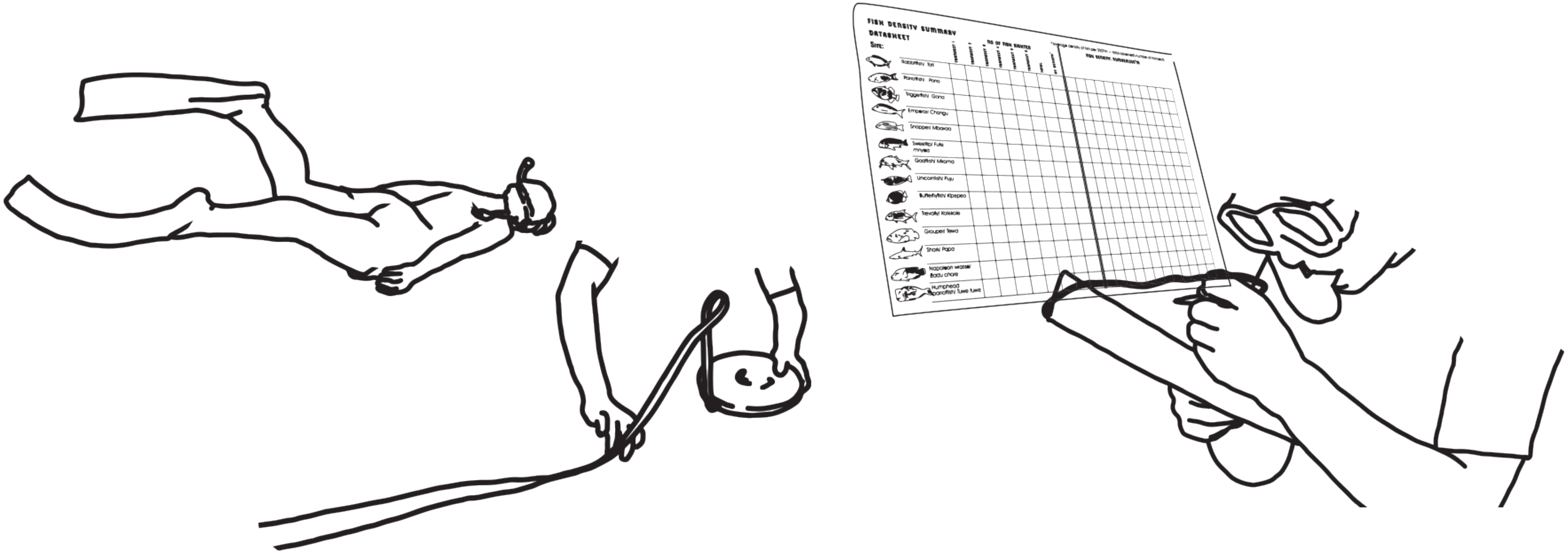
THREE SURVEY METHODS



Observer 1 counts fish on the first 50x5m transect, while Observer 2 lays the tape measure

Observers 1 and 2 count macro-invertebrates on their return along the 50x5 m transect; sea urchins are only counted in the first 10x5m

Observers 3 and 4 survey benthic substrate at 1m points along the first 20m of the transect



Field equipment

Before getting to the monitoring site the team must ensure that it has all equipment and materials required. The following is a list of field equipment for carrying out the three coral reef monitoring methods.

In the water:

- One 50 m tape measure or 50 m rope clearly marked at 1m intervals for the first 20m.
- Printed data sheets (for benthic substrate, fish, macro-invertebrates) or plastic slates with datasheets transcribed onto them.
- 3 plastic slates with pencils and string attached with paper clips or 3 rubber bands for holding data and ID sheets in place.
- Snorkeling gear for each observer: 4 pairs of fins, 4 masks and snorkels
- Set of waterproof species' identification guides for fish, benthic substrate, macro-invertebrates and sea urchins.
- GPS unit.

On shore:

- One community coral reef training manual.
- A second complete set of data sheets as a back up.

5.0 Monitoring of small-scale fisheries

Most fisheries resources are facing threats associated with over-fishing, the use of destructive fishing practices, and the lack of adequate management. Globally, most fisheries that are not monitored or assessed are the worst managed and over-fished. Fisheries monitoring helps to gather useful information for estimating fish stock (population) status, fishing effort, fish-catch and economic value. Catch per unit effort which analyses the number or weight of fish caught and the amount of effort spent in catching fish (time, number of fishers or vessels) is one of the most commonly used indicators in fisheries monitoring, and is used as an indicator of relative fish abundance. This information enables communities to assess the status of their fisheries' resources and therefore put in place management actions to improve livelihoods of people dependent on fishing. This section provides guidance on community-based fisheries monitoring, analysis and reporting.

Fish catch monitoring

Fish catch monitoring entails monitoring daily catch of a sample of individual fishers for a specified number of days per week or month at the fish landing site. Ideally total catch (kg) and number of vessels is also recorded on a daily basis at each landing site.

Not all fishing boats are sampled every time, however monitoring should include a variety of different fishing gear types used by boats at the landing site. The number of boats

sampled should be practical so that monitoring can be done in a timely manner avoiding too much delay and inconvenience to the fishers, it should include boats that are fishing both near and far from the landing site. The most commonly used fishing gear should be sampled including handlines, longlines, fish traps, gillnets, seine nets, monofilament nets, spear guns, harpoons, small purse seines (e.g. ring nets), and other methods if in use.

At the landing site the data collector records the following information from some or all of the fishers using that site. The total landed catch from each fishing boat (vessel) or fisherman is weighed (wet weight) to the nearest kg. The entire fish catch or, if the catch weighs more than 20kg, a sample of the catch, is sorted into species/family and the total number of fish of each species/family determined. The following information is recorded:

- captain's name
- fishing gear used
- crew size
- sites fished
- time of departure and return from fishing
- total catch weight (wet weight)
- fish composition landed (species/family and number of fish of each species)
- total weight of sub-sample (if total catch weight was more than 20kg)
- price of fish at landing site

Digital photos of each species of the landed catch can be taken for later identification and quantification.

Data analysis and presentation

Summaries and analyses may be done by hand or using Excel spreadsheets or the Marine-CoMMS database, and presented using graphs. The data are analyzed to estimate daily, monthly, and yearly averages of catch rates (catch per fisher, catch per fishing gear type and landing site), composition of the landed catch, time spent fishing and fish prices. Additional analyses can also be done to suit local needs.

The **catch rate** or **catch per unit effort** is the weight of fish caught during a fishing trip or day (kg/fisher/trip or kg/boat/trip). This is one of the most important indicators of the health of fish stocks (populations) and the level of effort fishers invest in catching fish. If the average fish price is known you can determine the average income each fisher makes from fishing and track changes in fishing income to community members over time.

The total fishing effort for a landing site is the total number of fishing trips or days multiplied by the number of boats or fishers using that landing site. This is usually calculated for one month or one year. Total catch per month or year at each landing site can then be estimated by multiplying the average catch rate by the total fishing effort.

CATCH RATE PER LANDING SITE

This allows you to compare the catch rate (kg/fisher/trip) between different landing sites.

Step 1: Fill in the *fish catch survey datasheet (see Appendix 5)* for each landed catch (or at landing sites where there are many boats, record as many boats or fishers as is practical in a day ensuring a good range of different fishing gear types are sampled).

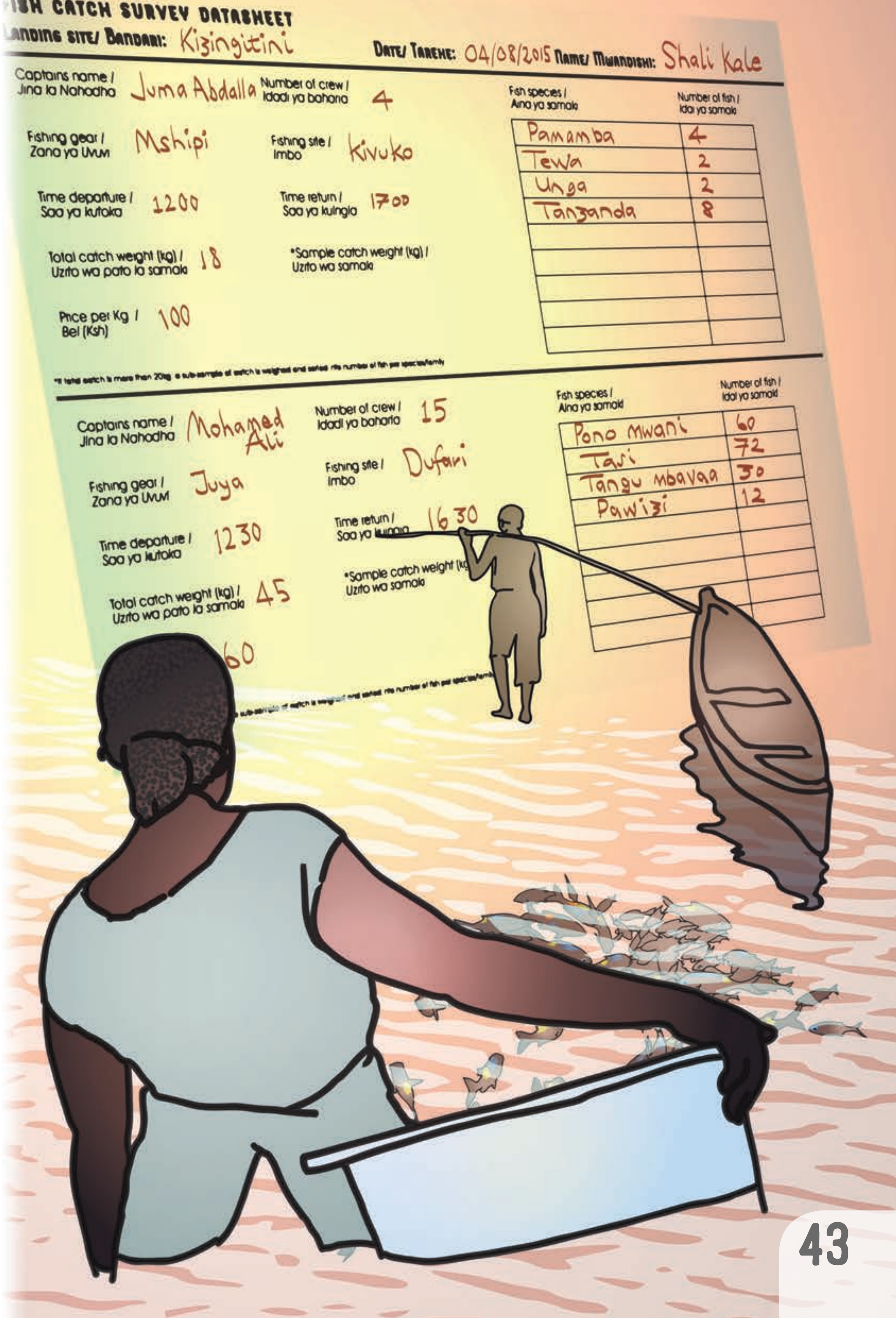
Step 2: Calculate average catch rate per fisher (kg/fisher/trip) by dividing each Boat/Captain's Total Catch (kg) by the number of crew members.

Step 3: Determine the average catch rate per fisher for a day, month or year for each landing site using the daily average catch rate. A comparison of catch rates for different landing sites can be compared over the year or multiple years, as well as looking at changes in catch rate for one site over multiple years.

CATCH RATE FOR DIFFERENT FISHING GEAR TYPES

This enables you to work out which type of fishing gear results in the highest catch rates for fishers.

Step 4: Separate the average catch rate per fisher for each of the main fishing gear types. Determine the average catch rate per fisher per day, month or year for each fishing gear type. Catch rates for different gear types can be compared over the year or multiple years,or for a specific gear type over time.



CATCH PER FISHING GEAR TYPE

This calculation enables you to determine what fishing gear types are being used in different landing sites and how much fish each gear type is catching.

Step 5: To calculate the percentage contribution of each gear type to the total catch, sum-up the total catch (weight) for each gear and express as percentage of the overall total catch for all gears combined. This should be analysed on a monthly or annual basis for each landing site and changes compared over the years.

AVERAGE DURATION OF FISHING

This enables you to look in more detail at the amount of effort (time) that fishers must spend fishing and the return (catch rate) they get as a result. Catch per fisher per hour is a more detailed catch rate index that may be useful in explaining why different fishing gears have different catch rates.

Step 6: Calculate the time spent fishing from the 'time in' and 'time out' recorded for each fishing boat and/or fisher. Use these figures to calculate the average time spent fishing per trip for each gear type. Compare this across different gear types over multiple years.

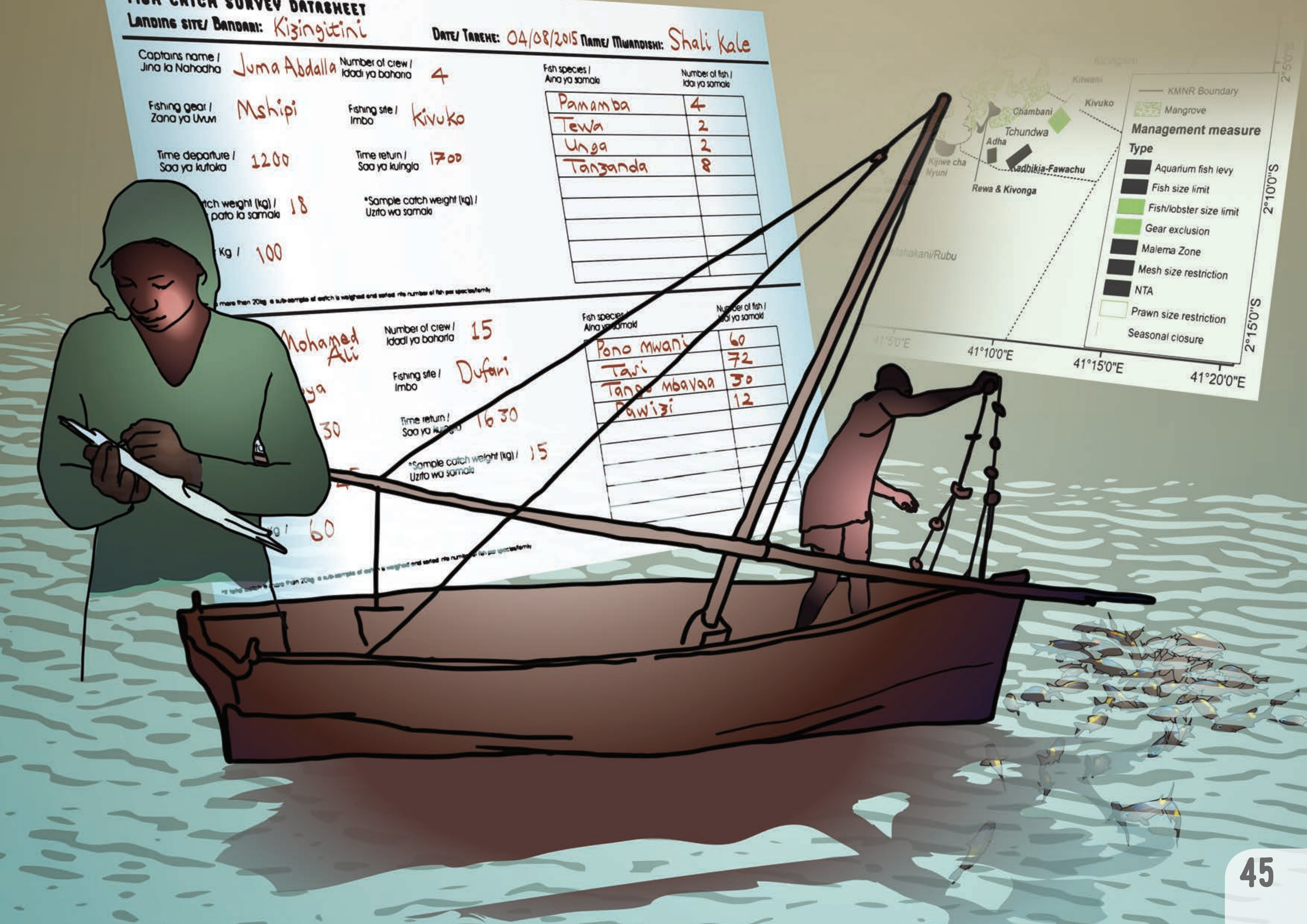
FISH CATCH COMPOSITION

This calculation allows you to monitor the changes in species/family of fish that make up the fish catch and gives an indication of the trends in abundance of different fish stocks or populations.

Step 7: For either the total catch, or sample of the catch, work out the % of each fish species/family in each catch. This is calculated as the total number of fish of each species/family divided by the total number of fish of all species combined, as a percentage. Fish catch composition can be monitored over time at each landing site or compared across landing sites.

TOTAL DAILY FISH CATCH

Calculating total daily fish catch allows you to monitor how overall fish catch at each landing site is changing over time which can also determine the economic value of fisheries production in a given area. For each landing site fill in the *daily fish catch datasheet (see Appendix 5)* each day. This summarizes the total weight for each fish type landed each day (for all vessels combined) and the price per kg for each fish type. A total weight per month or year for each fish type at a specific landing site can then be compared over time, as well as the average price per kg.


FISH CATCH SURVEY DATASHEET
Landing site/ Bandari: Kizingitini
Date/ Tarehe: 04/08/2015
Name/ Mwandishi: Shali Kale
Captains name / Jina la Nahodha
Juma Abdalla
Number of crew / Idadi ya baharia
4
Fishing gear / Zana ya Uvuvi
Mshipi
Fishing site / Imbo
Kivuko
Time departure / Saa ya kutoka
1200
Time return / Saa ya kuingia
1700
18
*Sample catch weight (kg) / Uzito wa samaki
Kg /
100
Fish species / Aina ya samaki
Number of fish / Idadi ya samaki
Pamamba
4
Tewa
2
Unga
2
Tanzanda
8
Mohamed Ali
Number of crew / Idadi ya baharia
15
Fishing site / Imbo
Dufari
Time return / Saa ya kuingia
1630
*Sample catch weight (kg) / Uzito wa samaki
15
60
Pono mwani
60
72
30
12
Kizingitini
Kitwani
Kivuko
Chambani
Tchundwa
Adha
Kijiwe cha Nyuni
Rewa & Kivonga
Madbikia-Fawachu
Ishakani/Rubu
KMNR Boundary
Mangrove
Management measure
Type
Aquarium fish levy
Fish size limit
Fish/lobster size limit
Gear exclusion
Malema Zone
Mesh size restriction
NTA
Prawn size restriction
Seasonal closure
2°5'0"S
2°10'0"S
2°15'0"S
41°5'0"E
41°10'0"E
41°15'0"E
41°20'0"E

6.0 Digital Data management

Paper data sheets are still the most reliable way of gathering data in a community-led monitoring program. There are many electronic apps for data gathering, but these are as yet unproven in long-term monitoring generally and, specifically with regard to community-based monitoring, are inappropriate given their dependency on power and cost. For community areas which do not have the capacity for a computerized data management system, section 3 outlines simple methods for analyzing and presenting your data by hand for each of the monitoring methods. Templates for these summary tables and graphs are given in Appendix 4.

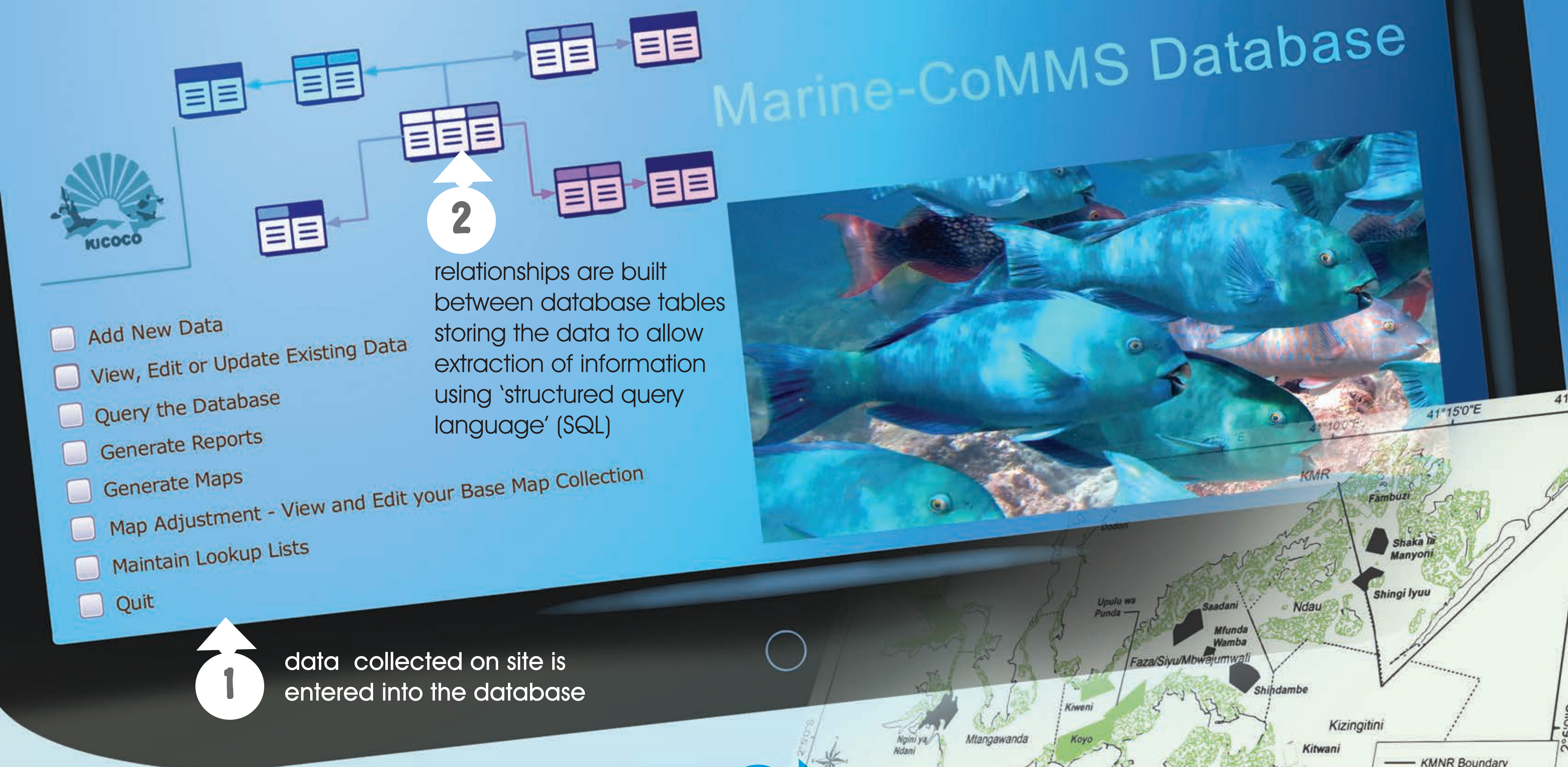
Digital management of your data using a computer and database simplifies analysis and presentation of your data. Data from the paper data sheets is entered in to the database, which can then answer important questions for management purposes at the touch of a button, generating customized reports, graphs and maps as required. A tailor-made database for analysis and reporting of coral reef and fish catch monitoring methods described in this manual has been developed by TNC and NRT and is part of a larger Conservancy Management Monitoring System, called **Marine-CoMMS**. The database has been designed in close consultation with the community conservancies and project managers in order to ensure analysis and presentation of results is in a format that is easily interpreted and understood by the community. Detailed guidance accompanies the database and is not described here.

Paper data sheets should be filed in an orderly way and stored in the location/office in which the computer database is used, for the purposes of data entry. This enables cross-referencing and error tracking to be readily carried out as and when required. As closely as possible, database data entry 'forms' on the computer match the coral reef and fish-catch data sheets.

The **Marine-CoMMS** database has been designed using Microsoft Access and interfaced with customized free mapping software (Q-GIS), to allow for mapping of all spatial data gathered using GPS, and/or automated using a 1km square grid or block/location system. The **Marine-CoMMS** database is split into two separate, but linked, databases. The 'front-end' is the interface between the user and the database (the part you see and deal with directly as a user); the 'back-end' is the database that stores the data. Unless the Back End database is set up on a central server, with users linked on a network, all data entry MUST be carried out on only ONE Computer/ Database. The most up-to-date version of the back-end can be attached to front-ends on different computers allowing more than one person to use the database for analysis, reports and mapping.

The key to electronic database use and adoption lies in both good design and usefulness. Conservancy members are trained in database management including data entry, analysis, reporting and mapping. This ensures timely feedback of results, avoiding inevitable delays if this depends on external scientists to analyse the data.

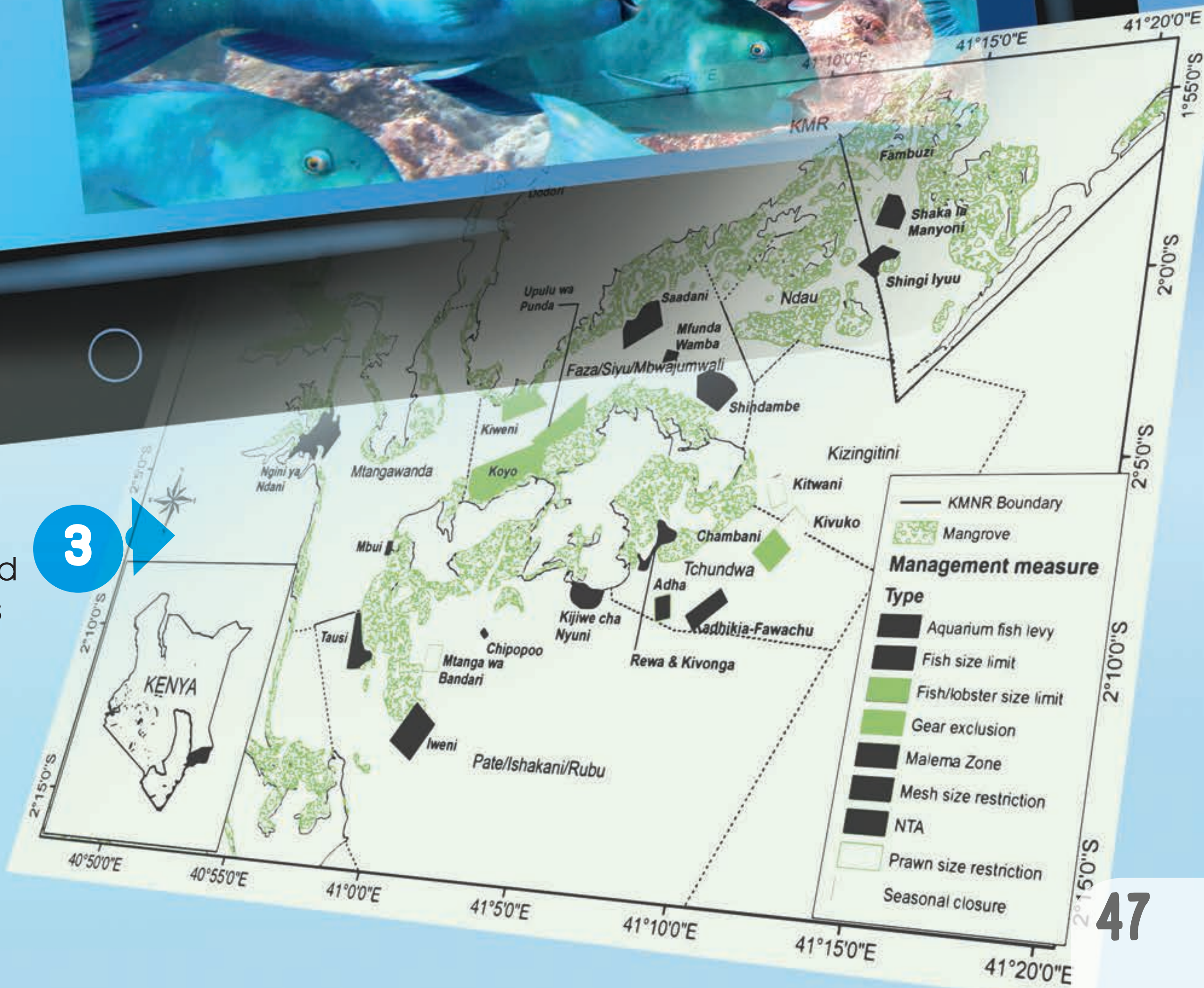
The **Marine-CoMMS** database will be freely available to other communities who are interested in using it for analyzing and presenting their coral reef and fisheries monitoring data.



2 relationships are built between database tables storing the data to allow extraction of information using 'structured query language' (SQL)

1 data collected on site is entered into the database

3 SQL queries are built to analyse the data and create reports and maps as required by managers



The database automatically analyses coral reef and fish-catch monitoring data to provide trends in indicator species or fish-catch over time, and summarises this information at the touch of a button.

7.0 Further reading and references

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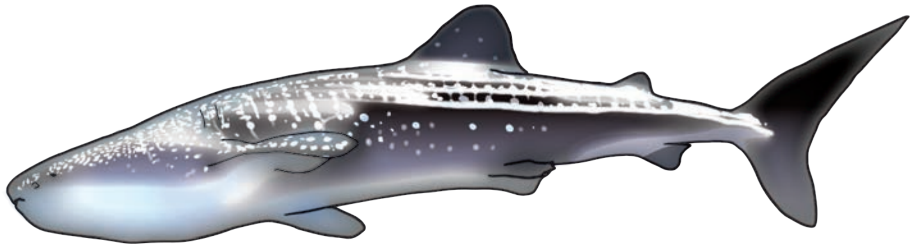

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Appendix 1: Background

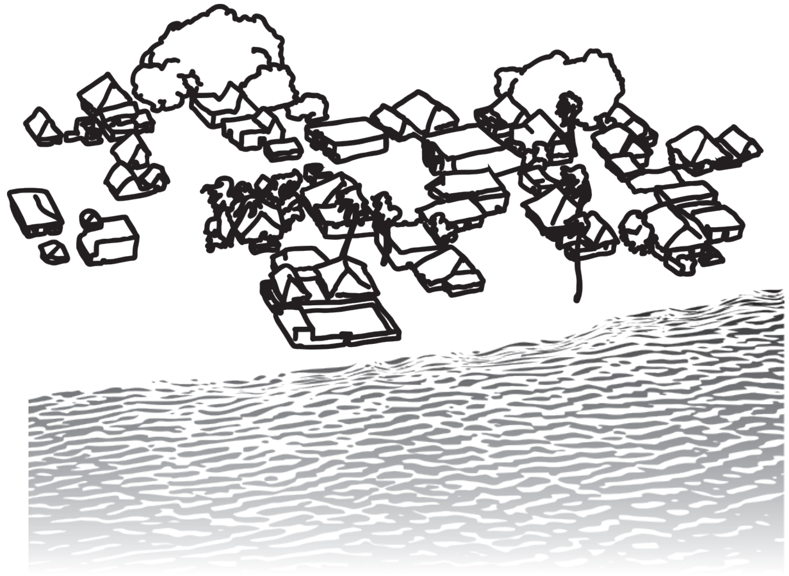
In the last decade co-management of marine resources has been increasingly promoted by government and non-government agencies in East Africa, and with this has come the need for coastal fishing communities to have the skills, tools and expertise to actively engage in the management of their resources. The establishment of coral reef based Locally Managed Marine Areas (LMMAs) is a strategy for communities to manage their marine environment and fishing grounds. LMMAs provide an ideal conservation and management tool bringing community, government and other non-government actors together. Alongside enforcement patrols, the ability of communities to consistently and accurately monitor the marine environment in order to understand the impact of the management they have put in place is key part of effective management of LMMAs.

Historically, data collection on marine resources was largely done by scientists and did not involve local fishing communities. This meant the communities were dependent on research institutions to provide basic information on the status of the marine resources that they use and rely on. However, it is now recognised that when community members participate in obtaining information through direct observation of their marine environment it empowers them with knowledge and gives them a better understanding of the changes taking place in their coastal ecosystem. Regular data collection by fishers can help them understand the effects of fishing on fish populations and may guide them in making appropriate decisions for management. Community-based monitoring is therefore likely to bring greater understanding of the benefits of LMMAs and also an increased sense of ownership by communities.

It is hoped that this manual will streamline data collection allowing comparison across a range of LMMAs or other reef sites over years. This is valuable since new LMMAs are being established every year, thus forming a network of LMMAs along the coast of Kenya, but their effectiveness is still poorly understood due to minimal or no monitoring.

This manual is based on three globally well established and widely used coral reef monitoring methods: Point Intercept Transects for benthic cover including corals, Belt transects for fish and macro-invertebrates. The methods have been combined into a sequence so that all three methods are used in one monitoring survey. The manual is written for both trainers and community members. It covers: the concepts behind monitoring; detailed explanation of the underwater methods; indicator species and why they have been selected for this manual; shore-based collection of fisheries catch and effort data; the collection, storage and analysis of monitoring data (both paper-based and using a database designed specifically for this method); and basic interpretation of monitoring results. It also includes some guidance on training in the underwater methods with a simulated coral reef land-based demonstration and a fish size estimation exercise. The entire procedure of training and trialing these methods in the water was tested with fishers from different villages in Kenya in November 2014 and community conservancy rangers in 2016. Their inputs, feedback and advice have been incorporated in the final methods described here.

Appendix 2: Why monitor?



Monitoring coral reefs is essential for assessing the effectiveness of conservation and management measures. It is also essential for measuring the effects of outside impacts such as pollution, coastal construction, or fishing. Monitoring is needed to determine whether impacts or activities are having a positive or negative effect on the coral reef.

Monitoring is important as it allows communities to:

- Assess the effectiveness of a management measure they have put in place
- Assess changes in species composition and diversity
- Know the fish populations in a fishing ground
- Understand which resources have been overfished or are likely to be overfished
- Determine if community livelihood needs for fish are being met

Monitoring data provides information on which decisions to change management strategies can be based.

Appendix 3: Coral Reef Field Survey Datasheets

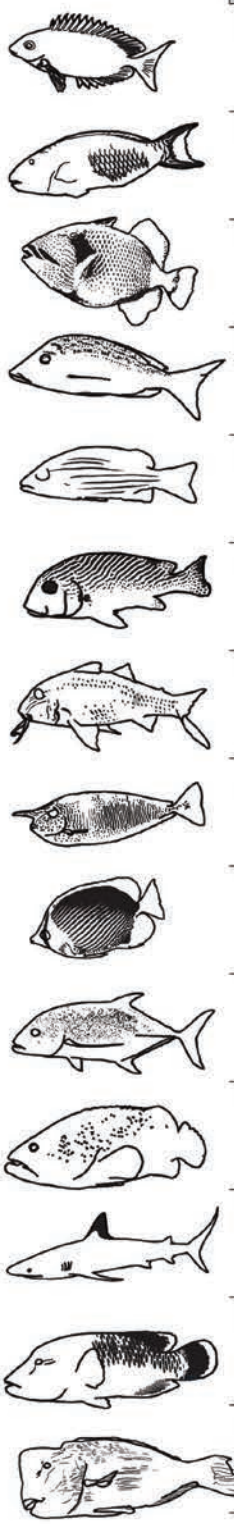
Fish Survey datasheet

Name:

Site: Date: Time:

GPS location: Transect number:

50m transect <15cm 15-45cm 45-60cm >60cm +



SPECIES	SMALL	MEDIUM	LARGE	VERY LARGE	TOTAL
Rabbitfish *Tafi*					
Parrotfish *Pono*					
Triggerfish *Gona*					
Emperor *Changu*					
Snapper *Mbavaa*					
Sweetlip *Fute mnyea*					
Goatfish *Mkoma/ Mkundaji*					
Unicornfish *Puju*					
Butterflyfish *Kipepeo*					
Trevally *Kolekole*					
Grouper *Tewa*					
Shark *Papa*					
Napoleon wrasse/ *Badu chore/Shambaro*					
Humphead parrotfish/ *Pono mtungi*					

Benthic substrate datasheet

Name:

Site: Date: Time:

GPS location:

20m point intercept

LC = Live coral
Matumbawe

DC = Dead coral
Matumbawe ya kufa

BC = Bleached coral
Matumbawe meupe ya kufa

SC = soft coral
Matumbawe meroro

R = Rubble
Changarawe/ kokoto

BR = Bare rock
Majiweni

S = Sand
Mchanga

BA = Brown algae
Matarafa

GA = Green algae
Mwani

SG = Seagrass
Nyasi

Bethnic substrate type

Point	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
P1						
P2						
P3						
P4						
P5						
P6						
P7						
P8						
P9						
P10						
P11						
P12						
P13						
P14						
P15						
P16						
P17						
P18						
P19						
P20						

Macro-invertebrate datasheet

Name:

Site: Date: Time:

GPS location: 50m/10m transect

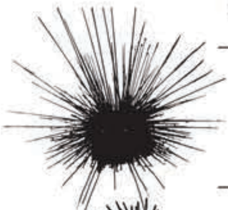
Number sighted in 50m transects (T)

*Average density per 250m² = total divided by number of transects

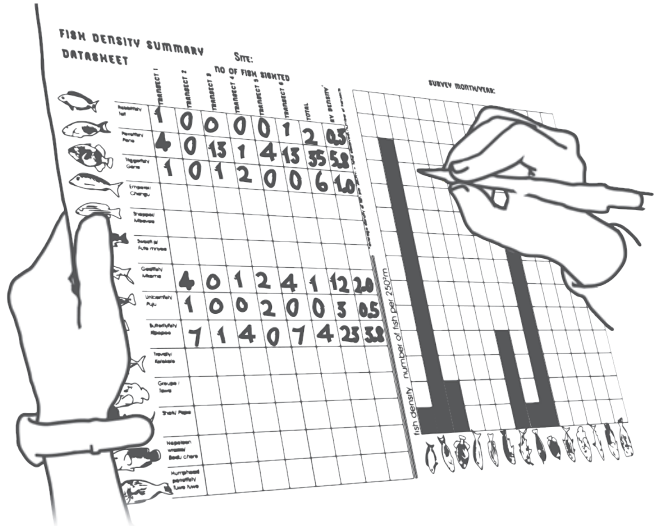
	T1	T2	T3	T4	T5	T6	TOTAL	DENSITY*
 Sea cucumber *Jongoo*								
 Starfish *Kiti cha pweza*								
 Tiger cowrie shell *Kururu*								
 Lambis shell *Madole*								
 Clam *Kombe*								
 Triton shell *Pundamilia*								
 Bull mouth shell *Dondo*								
 Crown of thorns *Matukombe*								

Sea urchins: number sighted in first 10m transects (T)

*Average density per 50m²

	T1	T2	T3	T4	T5	T6	TOTAL	DENSITY*
 Large sea urchins *Mapoe*								
 Small sea urchins *Mapoe*								

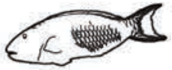
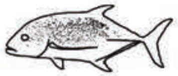
Appendix 4 Coral Reef Summary Templates



FISH DENSITY SUMMARY

SITE: ______________________ **SURVEY MONTH/ YEAR:** ______________________

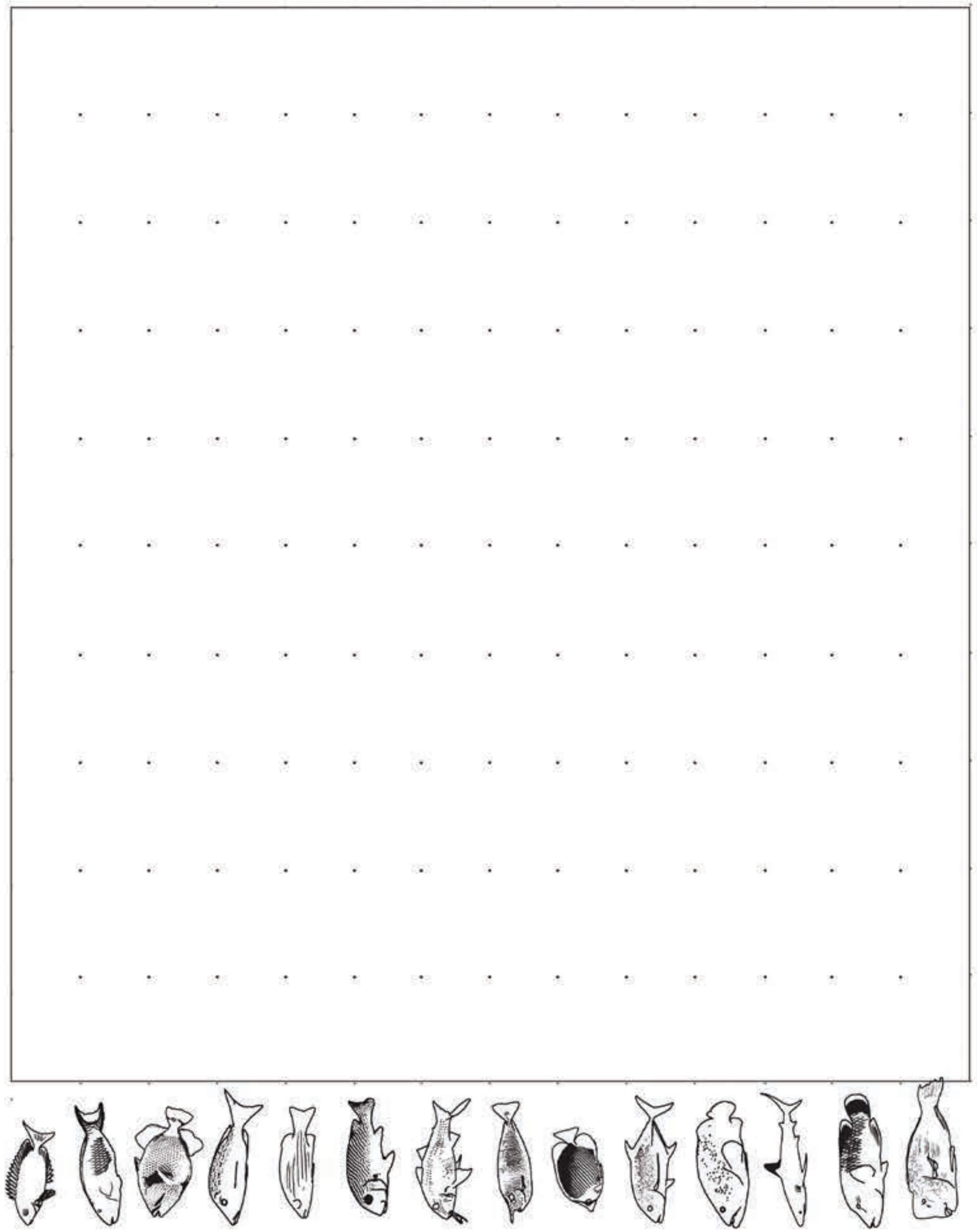
SUMMARY TABLE:

	NO OF FISH SIGHTED: TRANSECT 1	TRANSECT 2	TRANSECT 3	TRANSECT 4	TRANSECT 5	TRANSECT 6	TOTAL	AV DENSITY*
 Rabbitfish/ *Tafi*								
 Parrotfish/ *Pono*								
 Triggerfish/ *Gona*								
 Emperor/ *Changu*								
 Snapper/ *Mbavaa*								
 Sweetlip/ *Fute mnyea*								
 Goatfish/ *Mkoma/ Mukundaji*								
 Unicornfish/ *Puju*								
 Butterflyfish/ *Kipepeo*								
 Trevally/ *Kolekole*								
 Grouper/ *Tewa*								
 Shark/ *Papa*								
 Napoleon wrasse/ *Badu chore Shambaro*								
 Humphead parrotfish/ *Pono mtungi*								

*average density of fish per 250²m = total observed\ number of transects

SUMMARY GRAPH:

fish density : number of fish per 250²m



FISH SIZE SUMMARY SINGLE SURVEY

SITE: ____________________ SURVEY MONTH/ YEAR: ____________________

FISH SPECIES

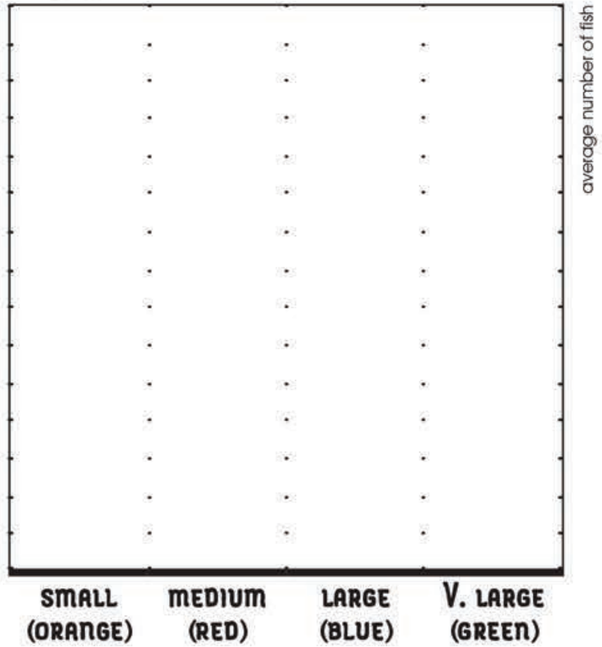
: ____________________

TABLE

TRANSECTS (T)	SMALL	MEDIUM	LARGE	VERY LARGE
T1				
T2				
T3				
T4				
T5				
T6				
TOTAL FISH				
FISH / TRANSECTS				
AVERAGE* =				

*average = total fish divided by total of transects

GRAPH



FISH SPECIES

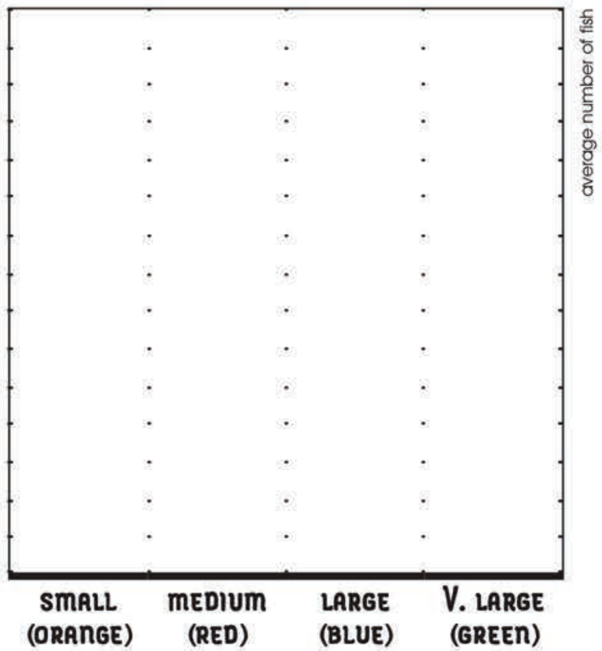
: ____________________

TABLE

TRANSECTS (T)	SMALL	MEDIUM	LARGE	VERY LARGE
T1				
T2				
T3				
T4				
T5				
T6				
TOTAL FISH				
FISH / TRANSECTS				
AVERAGE* =				

*average = total fish divided by total of transects

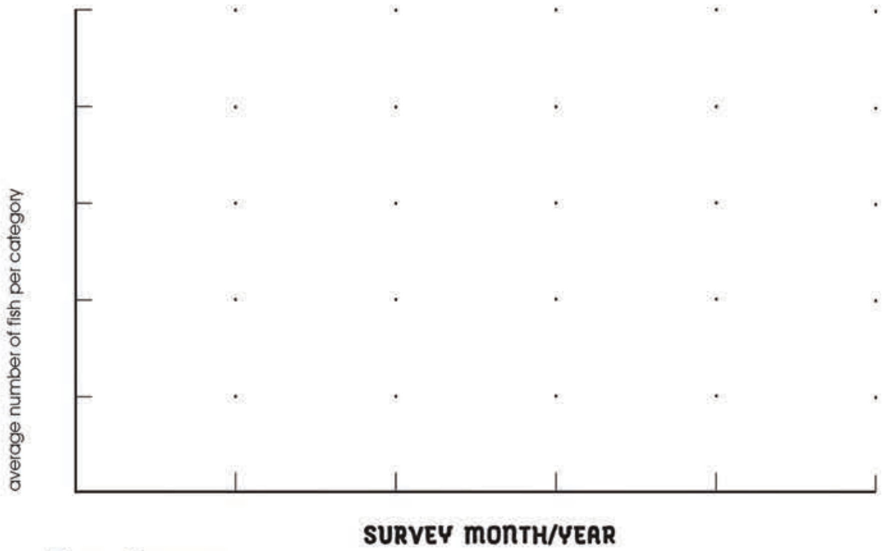
GRAPH



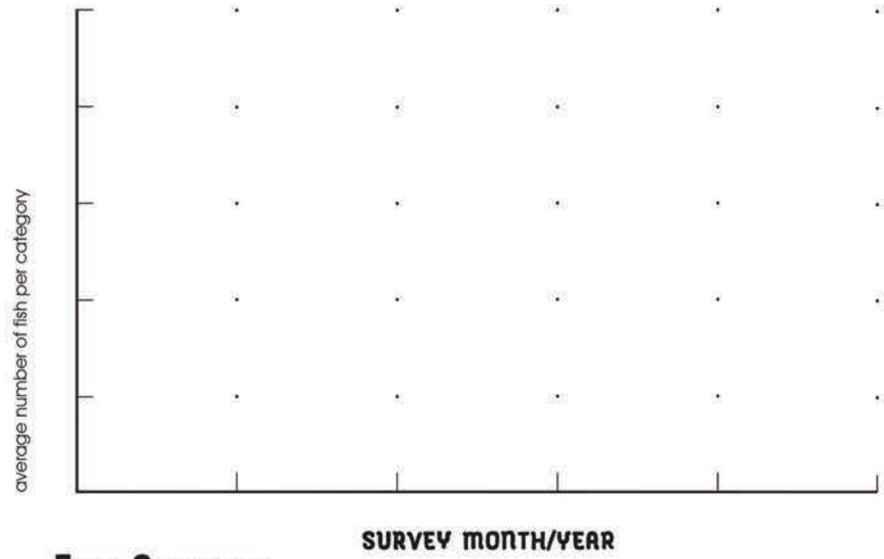
FISH SIZE SUMMARY: MULTIPLE SURVEYS

SITE : ____________________

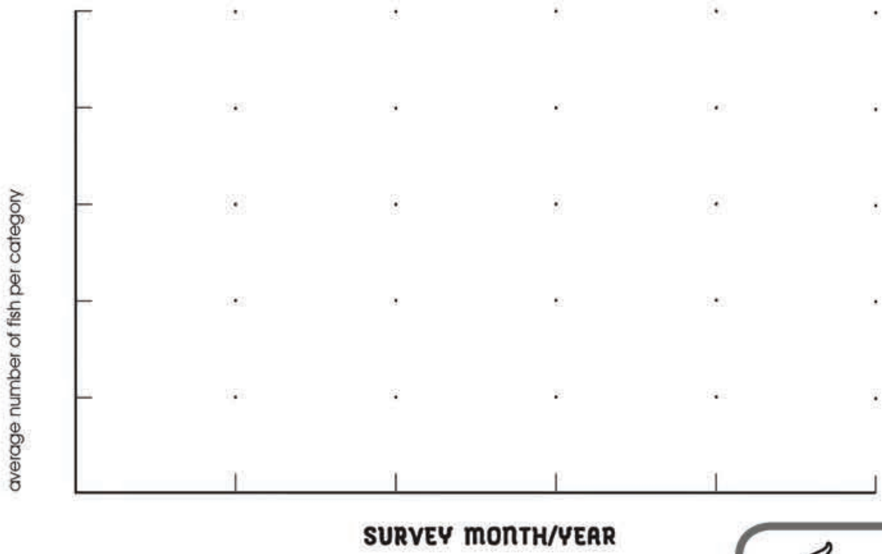
FISH SPECIES: ____________



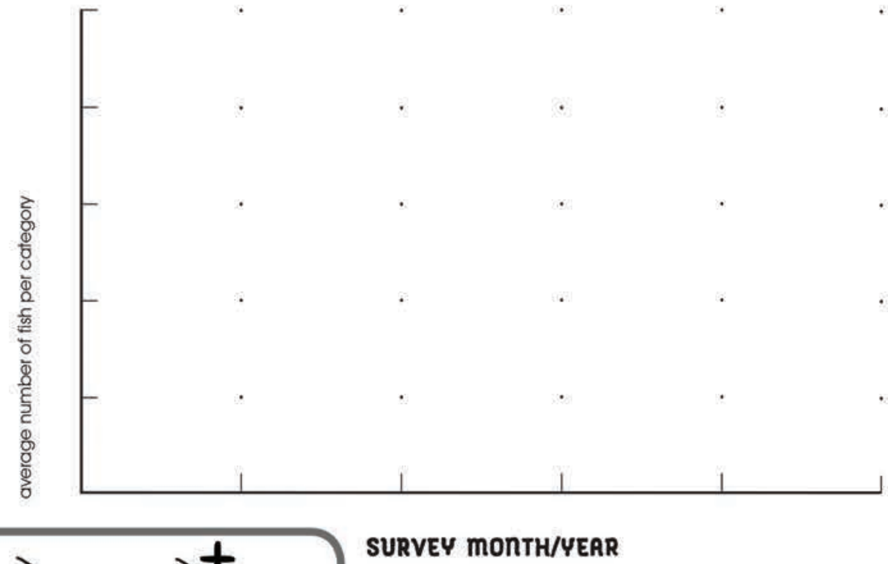
FISH SPECIES: ____________________

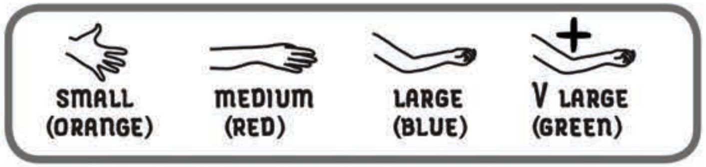


FISH SPECIES: ____________



FISH SPECIES: ____________________





Graphs are designed to show trends in numbers of different size categories for individual fish species over multiple surveys/years: write the survey date on 'X' axis; plot results for one fish species per graph; plot size categories in different colours on the same graph.

BENTHIC SUBSTRATE SUMMARY

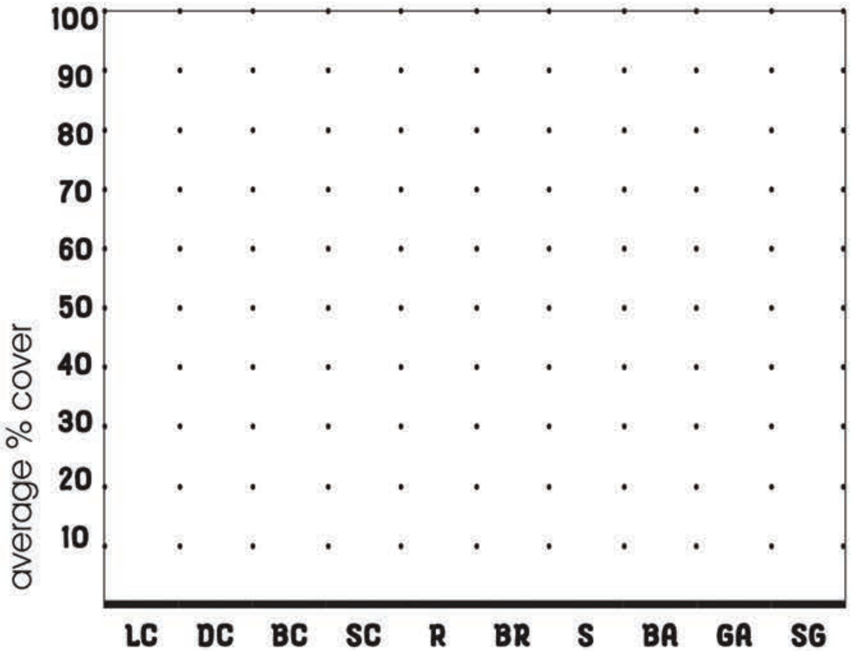
SITE : ____________________ **SURVEY MONTH/ YEAR :** __________

summary table

TRANSECTS (T)	LC	DC	BC	SC	R	BR	S	BA	GA	SG
T1										
T2										
T3										
T4										
T5										
T6										
TOTAL										
AVERAGE*=										
AVERAGE % COVER*=										

*average = total divided by number of transects
** average % = average divided by twenty, multiplied by one hundred

summary graph



KEY

LC Live coral / *Matumbawe*

DC Dead coral / *Matumbawe ya kufa*

BC Bleached coral / *Matumbawe meupe ya kufa*

SC Soft coral / *Matumbawe meroro*

R Rubble / *Changarawe / kokoto*

BR Bare rock / *Majiweni*

S Sand / *Mchanga*

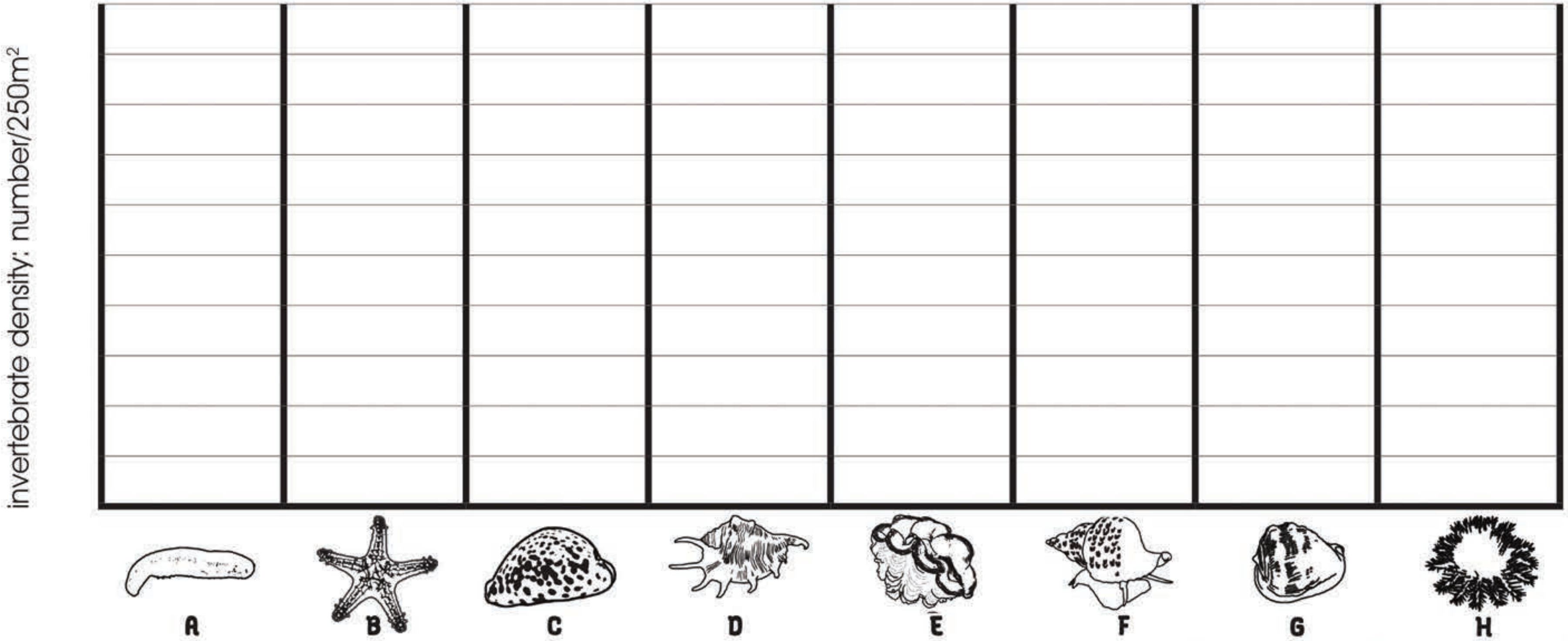
BA Brown algae / Matarafa

GA Green algae / *Mwani*

SG Seagrass / *Nyasi*

MACRO-INVERTEBRATE SUMMARY GRAPHS

SITE: ______________________ SURVEY MONTH/YEAR: ______________



A: Sea cucumber / *Jongoo*

B: Starfish / *Kiti cha pweza*

C: Tiger cowrie shells / *Kururu*

D: Lambis shells / *Madole*

E: Clams / *Ukombe*

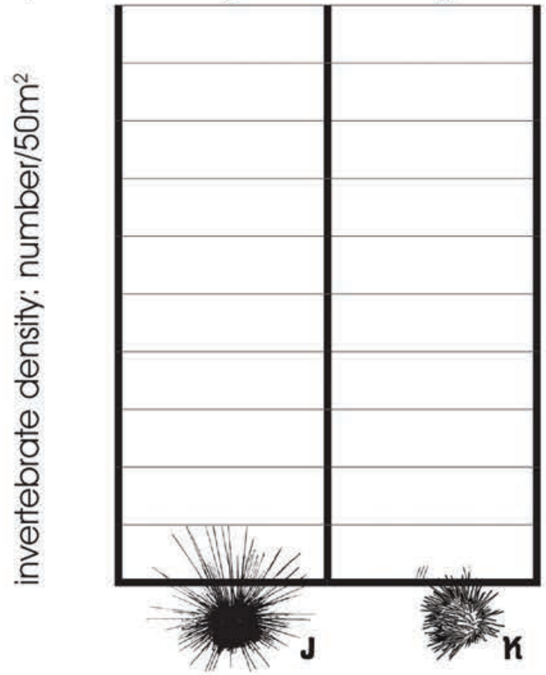
F: Triton shell / *Pundamilia*

G: Bull mouth shell / *Dondo la robo*

H: Crown of thorns (COT) / Matukombe

J: Large sea urchins / *Mapoe*

K: Small sea urchins / *Mapoe*



Appendix 5 Fisheries Monitoring Datasheets

FISH CATCH SURVEY DATASHEET

Landing site/ Bandari: **Date/ Tarehe:** **Name/ Mwandishi:**

Captains name / *Jina la Nahodha*

Number of crew / *Idadi ya baharia*

Fishing gear / *Zana ya Uvuvi*

Fishing site / *Imbo*

Time departure / *Saa ya kutoka*

Time return / *Saa ya kuingia*

Total catch weight (kg) / *Uzito wa pato la samaki*

**Sample catch weight* (kg) / *Uzito wa samaki*

Price per Kg / *Bei (Ksh)*

Fish species / *Aina ya samaki*	Number of fish / *Idai ya samaki*

*If total catch is more than 20kg, a sub-sample of catch is weighed and sorted into number of fish per species/family

Captains name / *Jina la Nahodha*

Number of crew / *Idadi ya baharia*

Fishing gear / *Zana ya Uvuvi*

Fishing site / *Imbo*

Time departure / *Saa ya kutoka*

Time return / *Saa ya kuingia*

Total catch weight (kg) / *Uzito wa pato la samaki*

**Sample catch weight* (kg) / *Uzito wa samaki*

Price per Kg / *Bei (Ksh)*

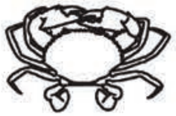
Fish species / *Aina ya samaki*	Number of fish / *Idai ya samaki*

*If total catch is more than 20kg, a sub-sample of catch is weighed and sorted into number of fish per species/family

DAILY FISH CATCH SUMMARY DATASHEET

Bandari/ landing site: Mwezi/ month:

Mwandishi/ data collector's name:



date	fish type	Kg	Price/kg

date	fish type	Kg	Price/kg

"…this (guide) provides guidance on how local communities, with minimal support, can independently undertake simple coral reef habitat and fisheries monitoring, data collection, analysis and interpretation of their data to improve understanding of the status of their resource and be able to devise appropriate management actions."