REGIONAL SEAS

UNITED NATIONS ENVIRONMENT PROGRAMME

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In association with:

AUSTRALIAN INSTITUTE OF MARINE SCIENCE

Monitoring coral reefs for global change

Reference Methods For Marine Pollution Studies No. 61

Prepared in cooperation with:

LCR ASEAN AIDAB IOC IAEA

UNEP 1993

NOTE: This document was prepared as a consequence of the UNEP-IOC-WMO-IUCN Meeting of Experts on a Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change, Pilot Projects on Mangroves and Coral Reefs, Monaco, 9-13 December 1991 (UNEP-IOC-WMO-IUCN/GCNSMS-II/3). The meeting agreed to adopt the methods and protocols of the ASEAN-Australia Marine Science Project: Living Coastal Resources (LCR) which were developed under funding from the Australian International Development Assistance Bureau (AIDAB).

This compilation has been prepared in cooperation between the ASEAN-Australia Living Coastal Resources project (LCR), the International Atomic Energy Agency (IAEA), the Intergovernmental Oceanographic Commission (IOC) of Unesco and the United Nations Environment Programme (UNEP) under project FP/5102-88-03.

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PREFACE

The Regional Seas Programme was initiated by UNEP in 1974. Since then the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans. The Regional Seas Programme at present includes ten regions and has over 120 coastal States participating in it (1),(2).

One of the basic components of the action plans sponsored by UNEP in the framework of the Regional Seas Programme is the assessment of the state of the marine environment and of its resources, and of the sources and trends of the pollution, and the impact of pollution on human health, marine ecosystems and amenities. In order to assist those participating in this activity and to ensure that the data obtained through this assessment can be compared on a world-wide basis and thus contribute to the Global Environment Monitoring System (GEMS) of UNEP, a set of Reference Methods and Guidelines for marine pollution studies is being developed as part of a programme of comprehensive technical support which includes the provision of expert advice, reference methods and materials, training and data quality assurance (3). The Methods are recommended to be adopted by Governments participating in the Regional Seas Programme.

The methods and guidelines are prepared in co-operation with the relevant specialized bodies of the United Nations system as well as other organizations and are tested by a number of experts competent in the field relevant to the methods described.

In the description of the methods and guidelines the style used by the International Organization for Standardization (ISO) is followed as closely as possible.

The methods and guidelines, as published in UNEP's series of Reference Methods for Marine Pollution Studies, are not considered as final. They are planned to be periodically revised taking into account the development of our understanding of the problems, of analytical instrumentation and the actual need of the users. In order to facilitate these revisions the users are invited to convey their comments and suggestions to:

Marine Environmental Studies Laboratory
IAEA Marine Environment Laboratory
BP. No. 800
MC 98012, MONACO

which is responsible for the technical co-ordination of the development, testing and intercalibration of Reference Methods.

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(1) UNEP: Achievements and planned development of the UNEP's Regional Seas Programme and comparable programmes sponsored by other bodies. UNEP Regional Seas Reports and Studies No. 1 UNEP, 1982.

(2) P. HULM: A Strategy for the Seas. The Regional Seas Programme: Past and Future, UNEP 1983.

(3) UNEP/IAEA/IOC: Reference Methods and Materials: A Programme of comprehensive support for regional and global marine pollution assessments. UNEP 1990.

CONTENTS

1. GENERAL INTRODUCTION

Coral reefs are economically vital to many developing countries in the tropics, providing an essential source of protein for the growing populations, and income through the tourism industry. Predictions that 70% of the world's coral reefs will collapse in the next 10 to 40 years, with the remainder threatened by global climatic change (Wilkinson, C.R. 1993. Proceedings 7th International Coral Reef Symposium, University of Guam, Mangilao, in press), threaten the viability of coral reefs as economic components of these countries, and the quality of life of the peoples supported by these resources.

The development and growth of coral reefs are closely controlled by environmental factors impacting on the atmosphere, the oceans and the adjacent land masses, and any localised or global changes in these factors will affect coral reefs. Therefore, it is essential that possible changes in coral reefs be monitored as soon as possible for the effects of climate change.

While climate-induced changes to coral reefs are likely to be gradual and imperceptible in the short term, their effects may be irreversible and catastrophic in the longer term. In order to detect changes in ecosystems which have a high degree of natural variability, long-term monitoring programs must be established over broad geographical (global) scales. With a better understanding of the natural fluctuations in the system, it will be possible to discriminate between the effects of global climate change and anthropogenic stresses, such as pollution, over-exploitation and sedimentation. A global monitoring system must have the ability to detect change and to identify questions which require closer examination. All the baseline data must be collected in the same way from all monitoring sites to ensure that comparisons are possible.

The methods in this handbook are recommended for gathering baseline data to monitor coral reefs for the effects of global climate change and other impacts. They have been specifically selected to be easily repeatable, and they use inexpensive, accessible equipment. While these methods are the minimum requirement for data collection, it is both possible and desirable to expand the methods to provide a more detailed analysis of the resources.

The methods were developed through a collaborative project between scientists from five ASEAN countries (Indonesia, Malaysia, the Philippines, Singapore and Thailand) and from the Australian Institute of Marine Science. This collaboration was begun in order to assess the extent and degradation of the living coastal resources of these countries. The ASEAN-Australia Marine Science Project: Living Coastal Resources has continued to monitor and research the coastal resources of the region since 1984, and has developed a large regional database.

Before choosing reefs for routine monitoring for the effects of global climate change and anthropogenic disturbance, the following set of criteria should be considered:

Selecting reefs

- Reefs chosen should be as isolated from other influences as possible. Select a reef site that is remote from land-based pollution and not heavily exploited, particularly by destructive methods.

2. MEASUREMENT OF AMBIENT ENVIRONMENTAL PARAMETERS

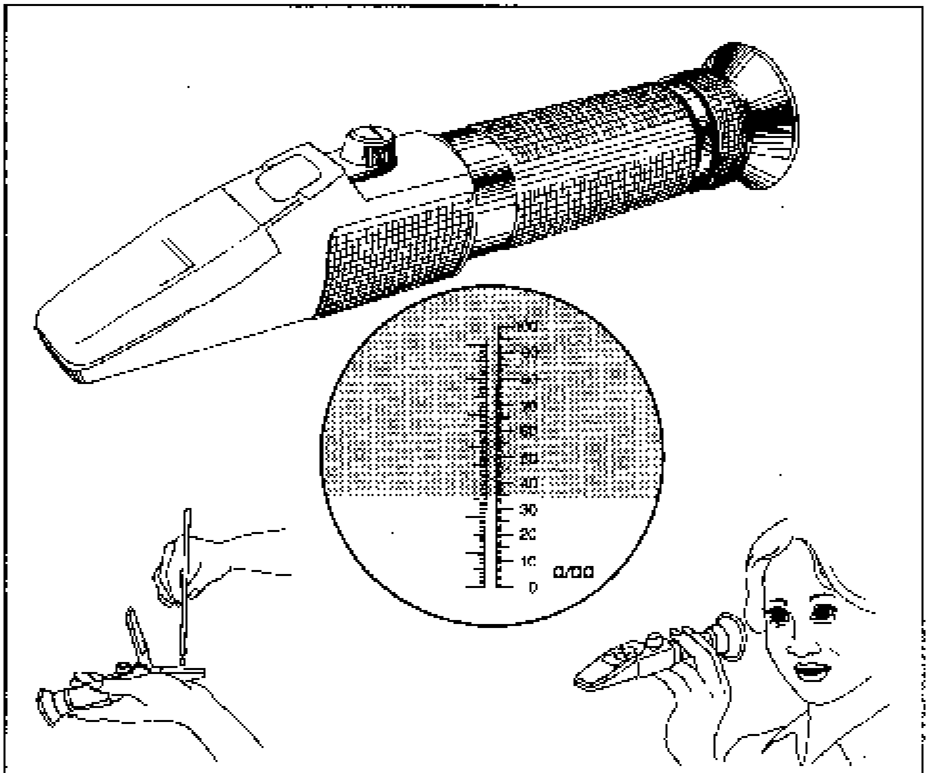
Introduction

All surveys of living resources of coral reefs should include environmental parameters which characterise the conditions at the site when the data were collected. The parameters to be included with the survey methods described in this handbook have been selected because they are important to the 'health' of the reef and they do not require expensive, sophisticated equipment. The environmental parameters that should be measured are: temperature, salinity, light penetration, cloud cover and wind. These parameters, together with data on the benthos and fishes, characterize a particular reef site/zone. The recommended equipment is easily obtained and will provide standardised measures in all countries.

Logistics

Equipment

- Mercury thermometer enclosed in a protective casing - used to measure temperature with an accuracy of 0.5 degrees Celsius.
- Refractometer - used to determine salinity (Fig. 1).



Put one or two drops of sample on the prism.

Look at the scale through the eyepiece.

Figure 1. A diagram of a refractometer showing its use for measuring salinity.

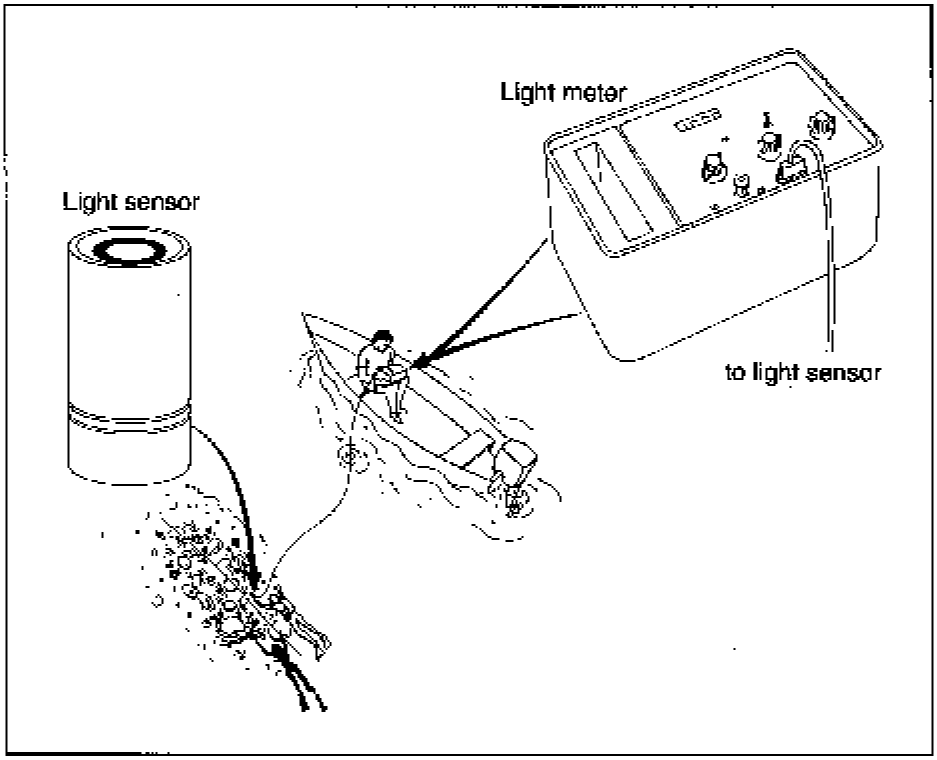


Figure 3. The sensor is held at the required depth while the light level measurements are recorded from the meter on the boat.

General procedure

Temperature

- Take the readings before commencing transects.
- Read the thermometer in the water just below the surface (30 centimetres) and at the depth of the transects ('transect depth').
- When thermoclines are encountered take a series of measurements, recording the depth and the temperature.

Salinity

- Obtain water samples at the surface and at 'transect depth' using small plastic vials. These samples are taken back to the shore for measurement using a refractometer. Put a small sample of water under the cover. Hold the cover down and looking through the eyepiece, face the instrument to the light so that the salinity can be read (Fig. 1).
- A series of salinity measurements should be made at sites near freshwater discharge to determine the extent of any gradient in salinity caused by the freshwater input.

Visibility

- Use the Secchi disc to measure vertical visibility in deeper water. The disc is attached to a weighted rope which is marked at intervals along its length. Lower the disc until you can no longer see it, then pull it slowly back toward the surface until it is just visible. Record the distance to the disc from the marks on the rope (Fig. 2).

3. MANTA TOW SURVEY

Introduction

The manta tow technique is used to assess broad changes in the benthic communities of coral reefs where the unit of interest is often an entire reef, or large portion thereof. It enables visual assessment of large areas of reef within a short time and is highly recommended for determining the effects of large-scale disturbances such as those caused by cyclonic storms, coral bleaching and crown-of-thorns starfish (COTS). The technique is also useful for selecting sites that are representative of large areas of reef.

The technique involves towing an observer, using a rope and manta board, behind a small boat powered by an outboard motor. Tows are carried out at a constant speed around the perimeter of a reef and are broken into units of 2 minutes duration. During each 2-minute tow, observations are made on several variables (e.g. percent cover of live coral, dead coral and soft coral). These are recorded onto data sheets as categories or integer values. Additional information may be collected, dependent on the survey objectives, e.g. percent cover of sand and rubble, and numbers of Tridacnid clams, *Diadema* or COTS. However, Fernandes (1989), cautions against recording data on too many variables, and the technique is not recommended for fish counts.

The method described in this manual is not only useful for assessing the distribution and abundance of corals, but is also widely used for the study of COTS. Details of the COTS assessment have been included because of the extensive destruction to many reefs in the Indo-Pacific which has been caused by these starfish. The technique may also be used to assess other organisms of particular interest to a survey region, however, it should be noted that estimates of the accuracy and precision of the technique have only been made in relation to coral cover and COTS (Kenchington and Morton 1976; Fernandes 1989, 1990; Fernandes 1990, in press; Moran and De'ath 1992).

Background

In general, the manta tow technique has been used to investigate issues at a broad level (Kenchington 1978). Since Chesher's study (1969) to assess the effects of COTS on coral reefs in Micronesia, similar surveys have been conducted on reefs within the Red Sea (Roads and Ormond 1971) and the Great Barrier Reef (GBR) (Endean and Stablum 1973; Moran *et al.* 1988). The technique has also been used for more general, broadscale surveys of coral reef systems (Done *et al.* 1982; Kenchington 1984).

While manta tow techniques have been used extensively since the early 1970's, the details of the method have varied between the different studies (Kenchington 1975; Kenchington and Morton 1976; Done *et al.* 1982; Nash and Zell 1982; Kenchington 1984). Work by Moran *et al.* (1988, 1989) to assess the broadscale distribution and abundance of COTS and their effect on the GBR has greatly refined the technique.

More recently, studies have focussed on the precision of the manta tow technique for estimating coral cover and COTS abundance (Fernandes 1989, 1990; Fernandes *et al.* 1990, 1992; Moran and De'ath 1992). These studies have shown the technique to be particularly useful for assessing broad changes in the distribution and abundance of coral cover (especially live coral) and COTS. The studies also show that, despite under-estimating the number of COTS,

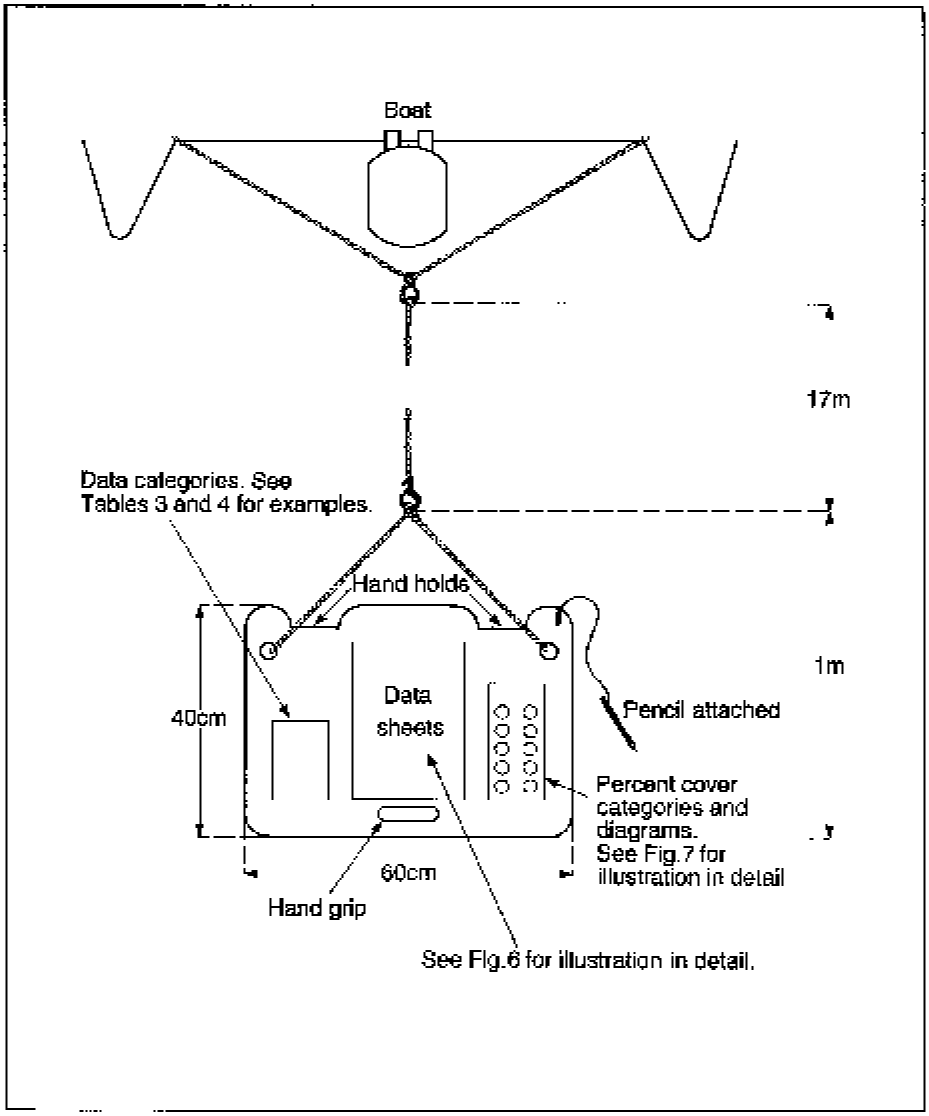


Figure 5. Detail of the manta board, and associated equipment. Summaries of the categories are attached to the board for easy reference by the observer.

- A data sheet (A4 underwater paper is recommended) is held in position within a recess on the centre of the board. The data sheets should be pre-printed to assist the observer record a set of biological variables and other significant observations (Fig. 6).
- Diagrammatic representations of coral cover categories (Fig. 7) are attached to the board for observer reference. Any other list which may assist the observer may also be attached, e.g. if survey will include COTS then categories used to record feeding scars and COTS size (Tables 3 and 4) should be provided.
- A pencil(s) is attached with light twine to the board.
- The observer wears snorkelling equipment (mask, snorkel and fins) and preferably a full-length dive suit or nylon ("stinger") suit.

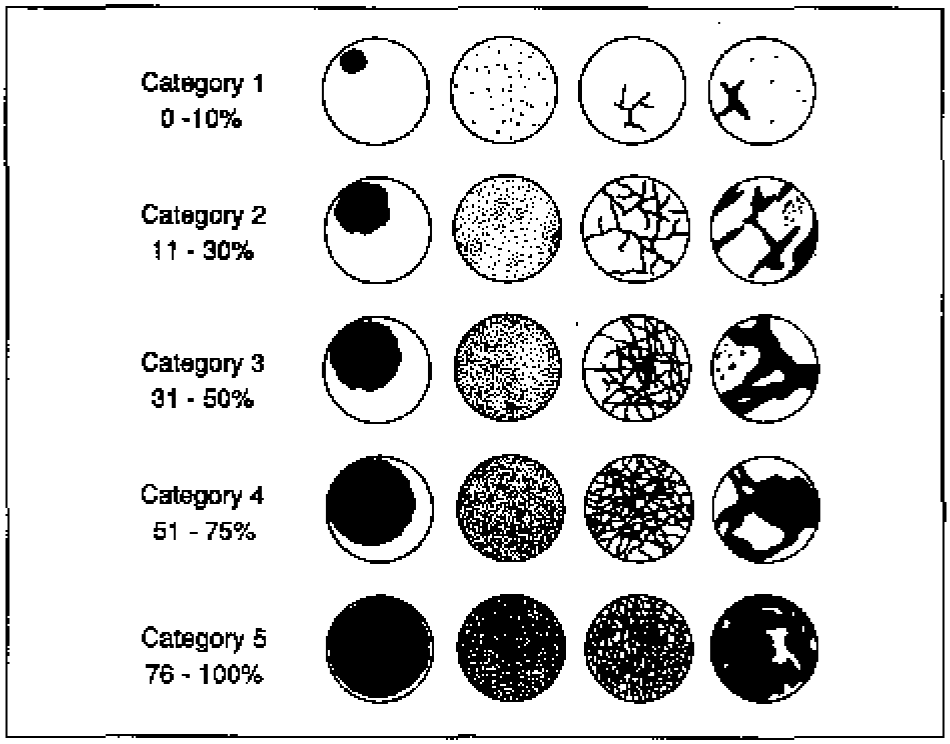


Figure 7. Schematic representations of percent cover used for the estimation of live and dead coral, soft coral and sand/rubble (after Dahl 1978).

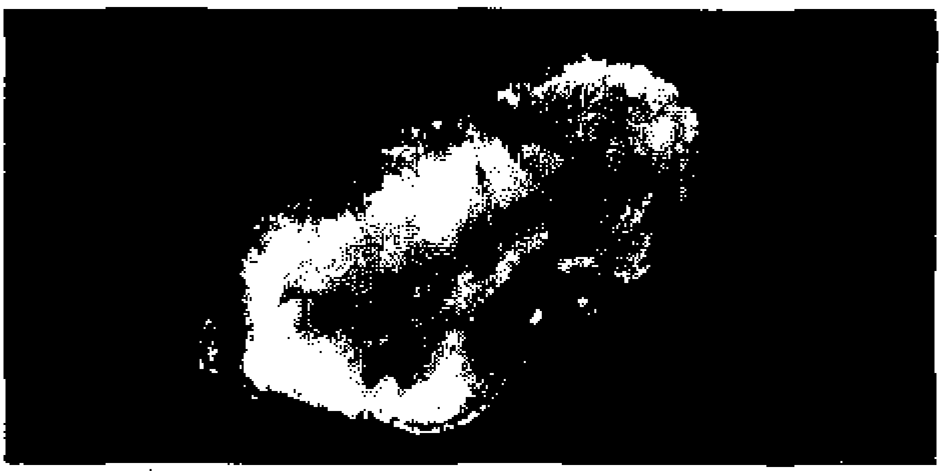


Figure 8. An aerial photograph of the reef is used by the driver to record the location of the manta tows.

Site selection

- Whole (unbroken) reef perimeters are surveyed where possible. Shoals and ill-defined areas of reef, separated by deeper water, are not usually surveyed.
- Tows are begun from an easily identifiable point on the reef. This is particularly important when resurvey of the reef is intended. A GPS (Global Positioning System) can be very useful for relocating sites if available.
- For long sections of coastline with fringing reefs allocate a section of the length as a reef, e.g. headland to headland.

- Observations are generally made from the surface. Manta towing below the surface may be necessary when the substratum is not clearly visible or closer inspection is required. Prolonged diving should be avoided.

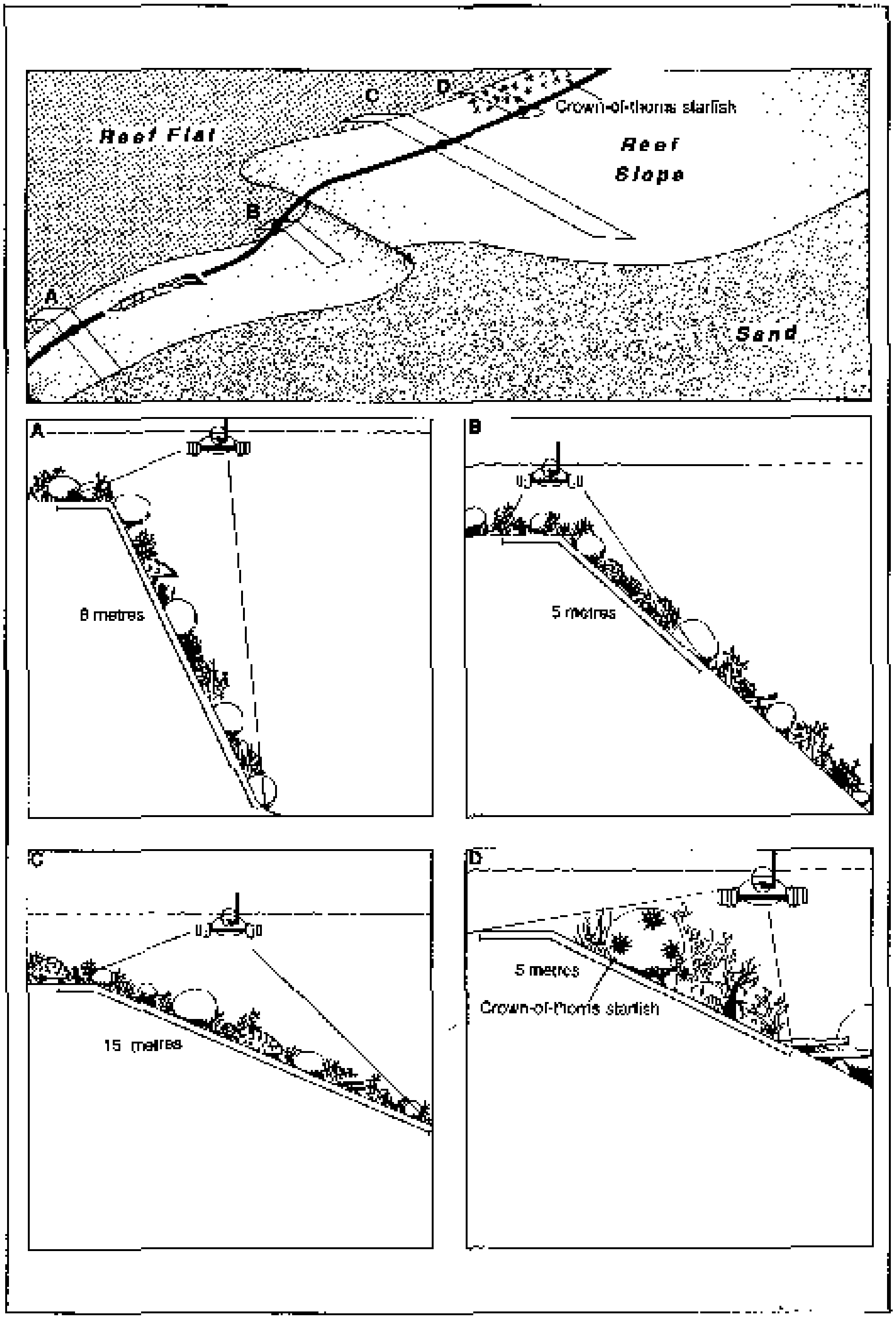


Figure 9. Diagram showing how both the search path and width vary according to the angle of the slope, the position of the observer relative to the perimeter and the presence of starfish (taken from Moran and De'ath 1992). The solid line indicates the tow path and the rectangular boxes the search path and width.

Data recording

- Before the observer enters the water physical variables should be recorded at the top of the data sheet (Fig. 6). Weather conditions are described by cloud cover and wind strength, the latter including sea state:
  - The amount of cloud is estimated according to the number of eighths of sky (celestial dome) that is covered by cloud (Fig. 12). The unit of measure is the okta. Observation should be made from a position where the entire sky can be seen. Commence by subdividing the sky into quadrants (1 quadrant = 2 oktas), and estimate the amount of cloud in each quadrant. Finally, combine these quadrant estimates to give the total amount. If the sky is completely free of cloud it is recorded as '0'. If there is only a small amount of cloud which is recorded as '1'. See Table 1 for cloud categories.

Table 1. Categories of cloud cover.

Category	Amount of Cloud
0	cloudless
1	1 okta or less, but ≠ 0
2	2 oktas
3	3 oktas
4	4 oktas
5	5 oktas
6	6 oktas
7	7 oktas
8	8 oktas

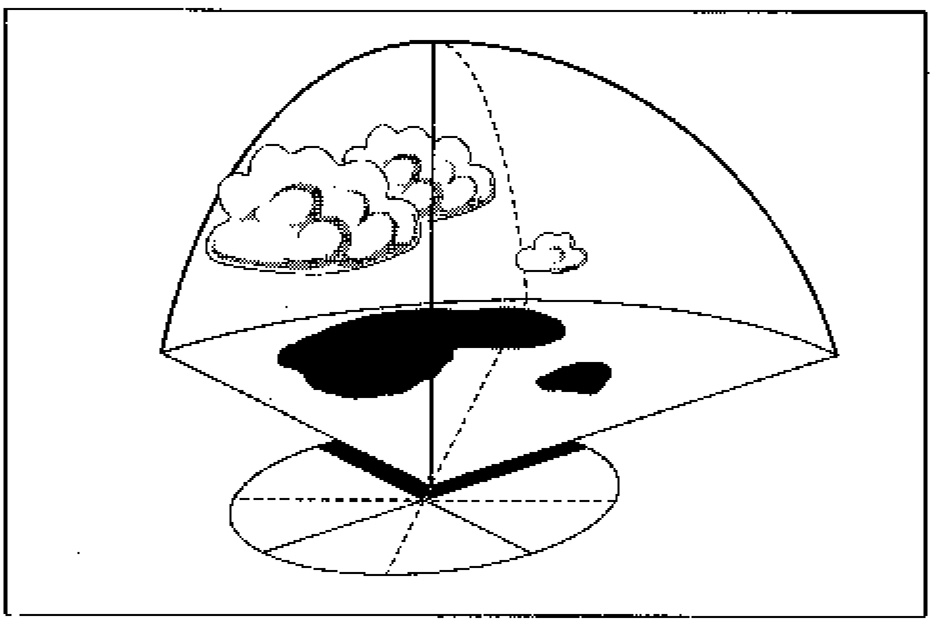


Figure 12. Estimation of cloud cover using oktas.

- It must be emphasised that the percent cover of live and dead coral are the minimum requirements for the manta tow survey data. Where distribution and abundance information is required for COTS, the data categories used for the GBR studies should be followed.
- Other variables may be included which are specific to the survey aims (e.g. *Diadema*), but accuracy and precision of the counts should be verified.

Note: Where surveys are to include estimates of COTS abundance, the observer should follow the categories used in studies of these starfish on the GBR. This will allow comparison of the COTS throughout their distribution. The categories include:

1. ***The number of feeding scars** (Table 3);*
2. ***The number of COTS** - observations are given as integer values, or where values are greater than this as 100;*
3. ***The average size of the COTS** (Table 4).*

Table 3. Categories for feeding scars.

Category	Number of Scars
Absent	0
Present	1 - 10
Common	> 10

Table 4. Size categories for crown-of-thorns starfish

Category	Average Size
Small	1 - 15 cm
Large	> 15 cm

Standardisation

- All personnel should be trained in the manta tow method. This is done by repeatedly towing observers over the same area of a reef until all team members have developed consistency in all aspects of the methodology (e.g. tow speed, observer recording). Re-training in the field should be conducted regularly (twice a year) and may be supplemented by laboratory-based training using video footage and colour transparencies. A useful piece of equipment for training is a manta board that can accommodate more than one observer.
- The variability in recording between observers should be checked at the beginning of each survey trip by towing each observer over the same section of reef and comparing the data collected. Surveys of this section of reef should be repeated until comparable data are recorded by all observers. It is particularly important to test inexperienced observers against experienced team members.

Advantages

- Large areas of a reef can be surveyed in a relatively short time. This reduces the possibility of overlooking population changes or disturbances which can be variable in space and time (e.g. dynamite fishing, COTS, bleaching, storm damage).
- It is relatively simple to perform after some training.
- It does not require the use of expensive or specialised equipment which require the observer to have special qualifications (e.g. SCUBA apparatus).
- It can be performed in remote locations with minimal support.
- The observer can cover great distances with little fatigue.

Disadvantages

- The survey may be conducted over inappropriate sections of the reef (e.g. large areas of sand or deep water) because the tow path is controlled by the driver who views the reef from above the water.
- If the animals are not obvious they may be overlooked.
- The observer may have too much information to remember, particularly if many variables are being recorded.
- The method is not suitable for areas with poor visibility (less than 6 metres).

Worked example

Resurvey of reefs is an essential part of any monitoring programme. It is therefore important that data entry of manta tow information follows a strict protocol. Any deviation from the protocol must be corrected before entry of data into the database. All tow data should be entered from a fixed starting point, following a set direction (clockwise), along the reef. An outline of the reef should be stored with the data marking the starting point, tow direction and tow numbers for each set of data. This will allow the identification of sections of reef for comparison through time.

If circumstances arise which prevent the collection of data in the preferred format (e.g. weather conditions, availability of more than one team) the data must be corrected before entry into the database. Examples are given using data collected as part of the crown-of-thorns starfish surveys on the GBR (Bass *et al.* 1989). A variety of sampling situations are presented:

- Tows conducted clockwise around the reef - no adjustment to data necessary (Fig. 14).
- Tows conducted anti-clockwise around the reef - adjust data (Fig. 15).
- Two boats surveying the same reef (Fig. 16).
- Different starting point from a previous survey - adjust data (Fig. 17).

Data from a reef may be summarised as median values (see below). Such summaries allow quick comparison of data collected from reefs (Fig. 18).

Reef	Date	SAMPLE_ID	No. tows	Median live coral	Median dead coral	Median soft coral	No. COTS
Trout	10/11/87	AURMA0098	28	3	1	1	0
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.

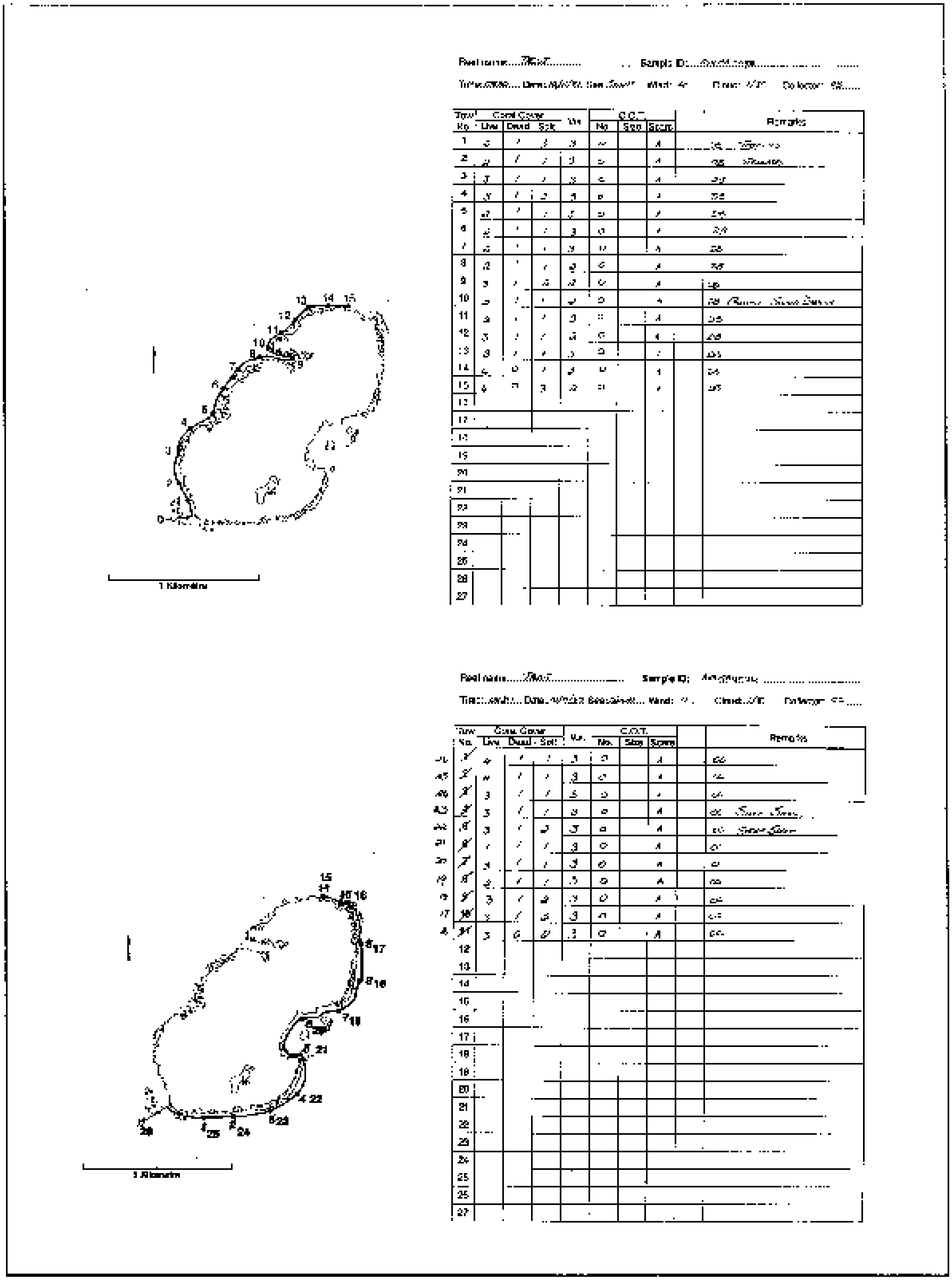


Figure 16. Survey of the reef was conducted by 2 teams (A and B). Data are combined to reflect the agreed starting point and the clockwise direction of tows.

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4. LINE INTERCEPT TRANSECT

Introduction

Line intercept transects are used to assess the sessile benthic community of coral reefs. The community is characterized using lifeform categories which provide a morphological description of the reef community. These categories are recorded on data sheets by divers who swim along lines which are placed roughly parallel to the reef crest at depths of 3 metres and 10 metres at each site. For future monitoring, the location of each site is recorded and marked on the reef. If the expertise of the observer allows the identification of coral species, this methodology may be expanded to include taxonomic data in addition to the lifeform categories. Monitoring should be repeated each year where possible, and at least every 2 years.

Background

The Line Intercept Transect (LIT) technique was developed in terrestrial plant ecology, and subsequently was adopted by coral reef ecologists (Loya 1978; Marsh *et al.* 1984). The procedure focuses on all types of substrata rather than a single taxonomic group. The LIT is used to estimate the cover of an object or group of objects within a specified area (Gates 1979) by calculating the fraction of the length of the line that is intercepted by the object. This measure of cover, usually expressed as a percentage, is considered to be an unbiased estimate of the proportion of the total area covered by that object if the following assumptions apply: that the size of the object is small relative to the length of the line; and that the length of the line is small relative to the area of interest. For a discussion of the technique see McIntyre (1953), Lucas and Seber (1977), and Mundy (1991).

The LIT has been used for objectives ranging from large-scale spatial problems (Benayahu and Loya 1977; 1981), to morphological comparisons of coral communities (Bradbury *et al.* 1986; Reichelt *et al.* 1986), and studies assessing the impact of natural and anthropogenic disturbances (Moran *et al.* 1986; Mapstone *et al.* 1989). Most studies using this method have used similar techniques (a plastic fibre tape, placed on the substratum parallel with the reef crest) with the following variations: Bouchon (1981) used tape tensioned between two pegs; Rylaarsdam (1983) used 3.75 metre metal chains with 2 cm links; Hughes and Jackson (1985) used 10 metre chains (the size of the links was not stated).

Logistics

Personnel

- All observers should be familiar with the definitions of each lifeform (Fig. 19 a,b,c; Table 7). Branching forms are defined as those with at least secondary branching (see inset, Fig. 19a). Training should be carried out in the field, but may include the use of slides and/or photographs in the laboratory.
- Standardisation between observers, and continuity of observers throughout the project is very important, as observer variability may obscure or complicate any real spatial patterns.
- Observers should spend 30 - 45 minutes in the water at the beginning of each field trip, comparing and standardising their interpretations of the various lifeforms. Particular attention should be given to the following lifeforms: CE, CS, CM, ACB, ACS, ACD, and the algae (see Table 7 for abbreviations).

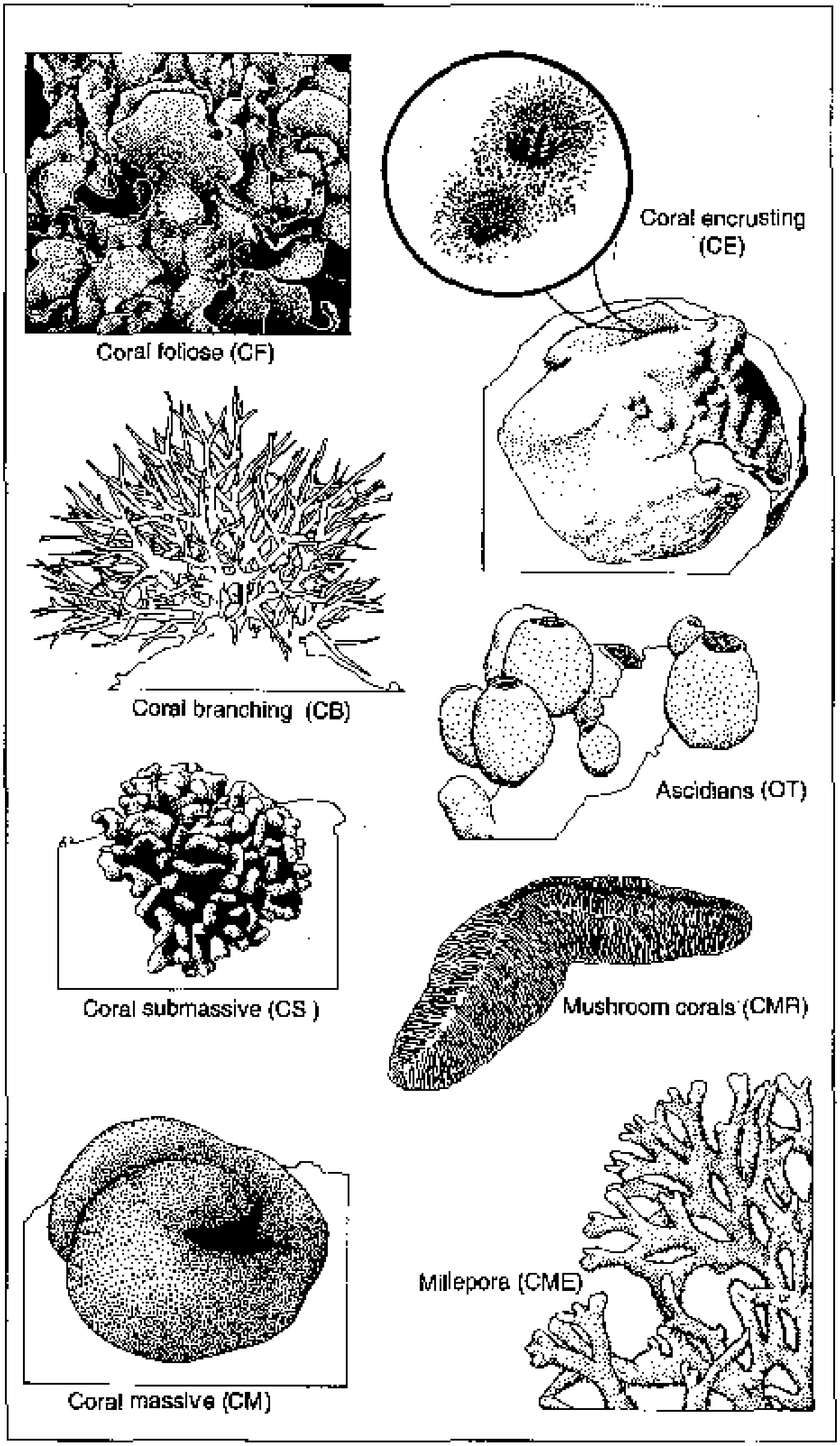


Figure 19 b. Examples of lifeform categories which group benthic communities through the use of morphological characteristics.

Table 7. Lifeform categories and codes. See Figure 19 a, b, c for examples.

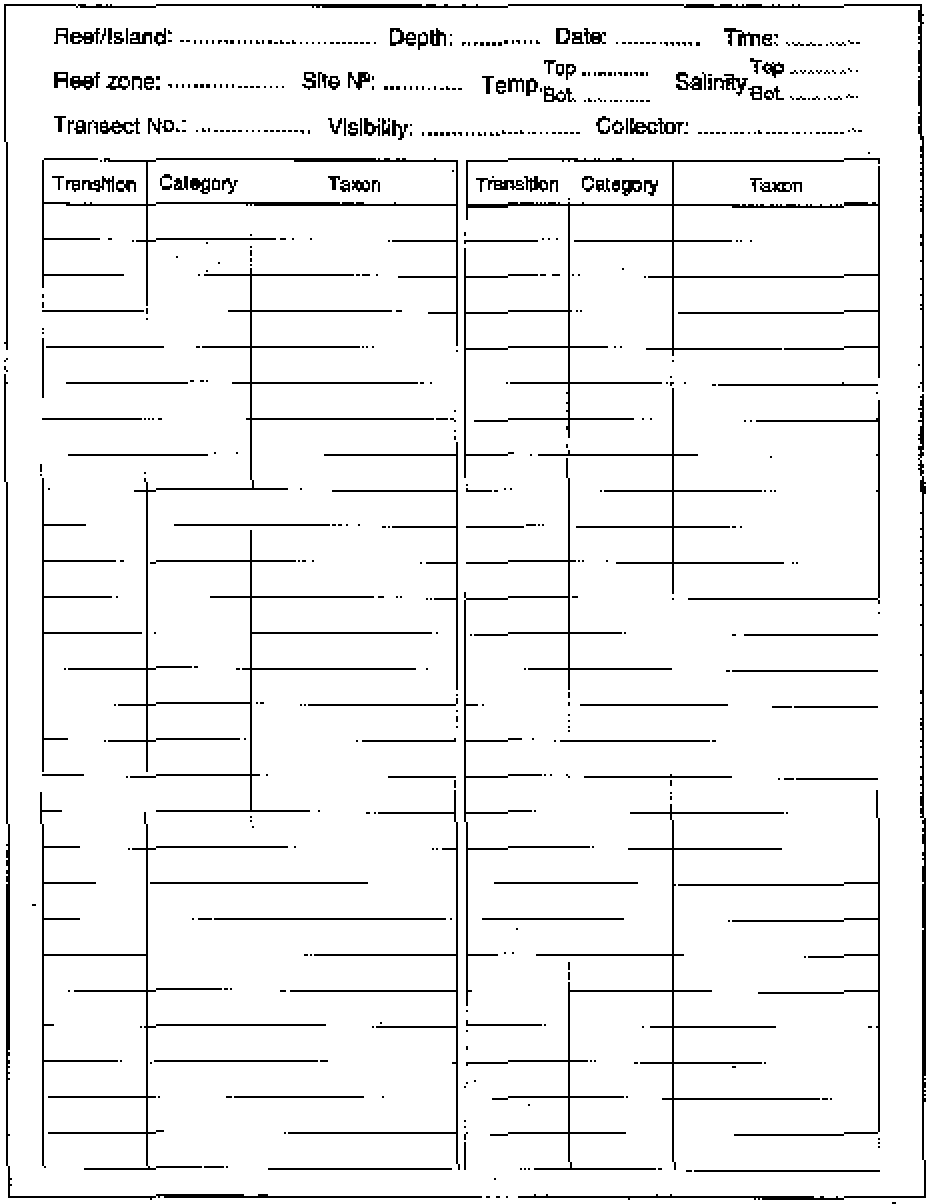
CATEGORIES		CODE	NOTES / REMARKS
Hard Coral:			
Dead Coral		DC	recently dead, white to dirty white
Dead Coral with Algae		DCA	this coral is standing, but no longer white
Acropora	Branching	ACB	at least 2° branching, e.g. *Acropora palmata, A. formosa.*
	Encrusting	ACE	usually the base-plate of immature *Acropora* forms, e.g. *A. palifera* and *A. cuneata*
	Submassive	ACS	robust with knob or wedge-like form e.g. *A. palifera*
	Digitate	ACD	no 2° branching, typically includes *A. humulus, A. digitifera and A. gemmifera*
	Tabulate	ACT	horizontal flattened plates e.g. *A. hyacinthus*
Non-*Acropora*	Branching	CB	at least 2° branching e.g. *Seriatopora hystrix*
	Encrusting	CE	major portion attached to substratum as a laminar plate e.g. *Porites vaughani, Montipora undata.*
	Foliose	CF	coral attached at one or more points, leaf-like appearance e.g. *Merulina ampliata, Montipora aequituberculata.*
	Massive	CM	solid boulder or mound e.g. *Platygyra daedalea.*
	Submassive	CS	tends to form small columns, knobs, or wedges e.g. *Porites lichen, Psammocora digitata*
	Mushroom	CMR	solitary, free-living corals of the *Fungia*
	Millepora	CME	fire coral
	Heliopora	CHL	blue coral
Other Fauna:			
Soft Coral		SC	soft bodied corals
Sponges		SP	
Zoanthids		ZO	examples are *Platythoa, Protopalythoa*
Others		OT	Ascidians, anenomes, gorgonians, giant clams etc.
Algae	Algal Assemblage	AA	consists of more than one species
	Coralline Algae	CA	
	Halimeda	HA	
	Macroalgae	MA	weedy/fleshy browns, reds, etc.
	Turf Algae	TA	lush filamentous algae, often found inside damselfish territories
Abiotic	Sand	S	
	Rubble	R	unconsolidated coral fragments
	Silt	SI	
	Water	WA	fissures deeper than 50 cm
	Rock	RCK	reef pavement including limestone boulders, granite and volcanic rocks

General procedure

- For each site, at least 5 transects of 20 metres length are located haphazardly at each of two depths, identifying shallow (3 metres) and deep (10 metres) coral communities.

Note: If permanent quadrats are monitored in the area, care should be taken to lay transects away from these quadrats in order to avoid damage.

- If a typical reef flat, crest, and slope is present, the shallow transects will be located on the reef slope, approximately 3 metres below the crest. The deeper transects will be located approximately 9-10 metres below the crest. If the site is on a reef without a well-defined crest, then transect depth should be approximated to depth below mean low water.


Reef/Island: .... Depth: .... Date: .... Time: ....

Reef zone: .... Site Nº: .... Temp. Top .... Bot. .... Salinity Top .... Bot. ....

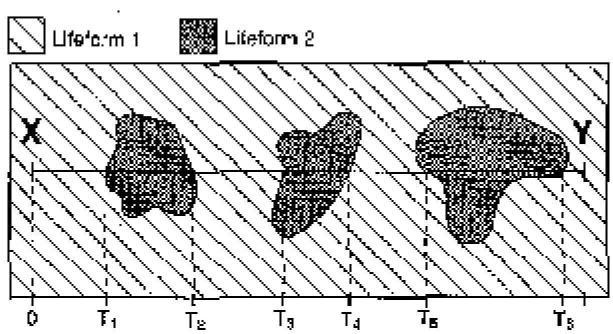
Transect No.: .... Visibility: .... Collector: ....

Transition	Category	Taxon	Transition	Category	Taxon

Figure 21. Example of printed sheet used by observers to record line intercept data. The column headed "Taxon" is only used if the observer has expertise in coral taxonomy.

- While the transect is being laid out the observer should record details of the site, depth etc. onto the datasheet. Detailed comments about the condition of the site at the time of survey should be included.

- Once the transect has been laid out, the observer moves slowly along the transect recording onto the data sheet the lifeforms encountered under the tape (Fig. 22). At each point where the benthic lifeform changes, the observer records the transition point in centimetres and the code of the lifeform. Hence, along the length of a transect (XY) a number of transition points (T) are recorded for each of the lifeforms (Fig. 23). The intercept of each lifeform encountered under the transect (I) is the difference between the transition points recorded for each lifeform.



Intercept		Category
$T_1 - 0$	=	lifeform 1
$T_2 - T_1$	=	lifeform 2
$T_3 - T_2$	=	lifeform 1
$T_4 - T_3$	=	lifeform 2
$T_5 - T_4$	=	lifeform 1
$T_6 - T_5$	=	lifeform 2
$Y - T_6$	=	lifeform 1

Intercept		Category
$T_1 - 0$	I_1	Lifeform 1
$T_2 - T_1$	I_2	Lifeform 2
$T_3 - T_2$	I_3	Lifeform 1
$T_4 - T_3$	I_4	Lifeform 2
$T_5 - T_4$	I_5	Lifeform 1
$T_6 - T_5$	I_6	Lifeform 2
$Y - T_6$	I_7	Lifeform 1

Figure 23. Schematic diagram of a transect (XY) showing the transition points (T) for each lifeform crossed by the transect. The difference between consecutive transition points is the intercept of the lifeform.

- To facilitate accurate calculation of the number of occurrences of each lifeform, observers should note instances when the tape intercepts a single lifeform or colony more than once. For example, when a massive *Porites* colony includes both living tissue and dead patches with algal growth, each intercept with living tissue should be recorded as belonging to the same colony (Fig. 24). The (I) identifies the 2 intercepts of CM (Coral massive - *Porites*) as belonging to the same colony.

- Some colonies may be encountered which could be recorded as either of 2 lifeform categories, depending on where the colony is intercepted by the tape. Such colonies should be recorded by their dominant lifeform (i.e. the lifeform displayed by more than 50% of the colony). For example, large digitate *Acropora* species (*A. digitifera*, *A. humulis*) may have secondary and

Data processing

- At the end of each day the data should be entered into the database using the structure described in Appendix I.
- Information about the sample is entered into the sample table (XXCRSAMP.DBF) and a unique sample identifier (SAMPLE_ID) is allocated. The type of data collected in the sample is described by the DATA_TYPE field, which for line intercept data, is denoted by "T".
- The line intercept data are entered into the data table (XXCRTDAT.DBF) using the sample identification allocated in the sample table. The data table has one row or record for each intercept recorded along the transect. Replicate transects have the same SAMPLE_ID but have a unique transect number.
- Each record in the data table should include a sample identifier (SAMPLE_ID), the transect number, the lifeform, the transition point (as read from the tape) and any other information such as the taxonomic code. Each transition along the one transect must have the same sample identifier and the same transect number. In this way all the records belonging to the same transect can be identified in the database and these in turn can be linked to the information in the sample table.
- An entry is made into the sample table (XXCRSAMP.DBF) to describe the ambient data collected in conjunction with the line intercept transect, i.e. DATA_TYPE is "A". The ambient data, e.g. temperature, salinity and visibility, are entered into the ambient table (XXCRADAT.DBF) using the sample identification allocated in the sample table.

Note: The LIT data and ambient data will have different sample identification numbers but are connected through common fields in the sample table e.g. location, reef name, date, latitude and longitude.

- Relatively large amounts of data will be collected, therefore adequate space for data storage and manipulation must be available.

Analysis

- Summary data showing percent cover and number of occurrences of each lifeform may be calculated using the line intercept data. After calculating the intercept from the transition points recorded along the transect (see Fig. 23), the percent cover of a lifeform category is calculated.

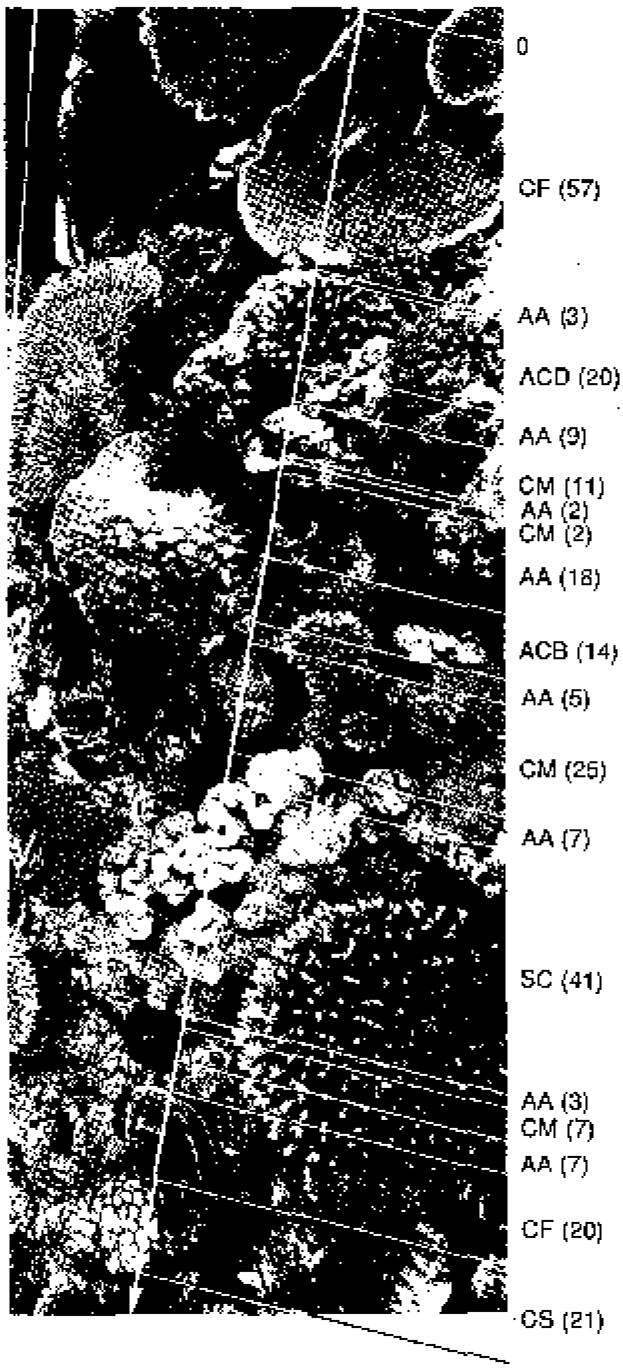
$$\text{Percent cover} = \frac{\text{Total length of category}}{\text{Length of transect}} \times 100$$

Hence, for Figure 23:

$$\text{Percent cover Lifeform 1} = \frac{l_1 + l_3 + l_5 + l_7}{Y} \times 100$$

$$\text{Percent cover Lifeform 2} = \frac{l_2 + l_4 + l_6}{Y} \times 100$$

- Preliminary calculations of percentage cover and number of occurrences can also be made from the data collected using the Lifeform program.



Transition	Category
57	CF
60	AA
80	ACD
89	AA
100	CM
102	AA
104	CM
122	A
136	ACB
141	AA
166	CM
173	AA
214	SC
217	AA
224	CM
231	AA
251	CF
272	CS

Figure 25. A section of a length of transect showing the lifeform categories and the intercept recorded from the transect tape. The taxon is only recorded if the observer has the appropriate expertise.

Moran, P.J., R.H. Bradbury and R.E. Reichelt (1986). Mesoscale studies of the crown-of-thorns/coral interaction: a case history from the Great Barrier Reef. In: Proceedings of the Fifth International Coral Reef Symposium, Tahiti, 5: 321-326.

Mundy, C.N. (1991). A critical evaluation of the line intercept transect methodology for surveying sessile coral reef benthos. MSc. Thesis, James Cook University. 127pp.

Reichelt, R.E., Y. Loya and R.H. Bradbury (1986). Patterns in the use of space by benthic communities on two coral reefs of the Great Barrier Reef. Coral Reefs, 5: 73-79.

Rylaarsdam, K.W. (1983). Life histories and abundance patterns of colonial corals on Jamaican reefs. Mar. Ecol. Prog. Ser., 13: 246-260.

Veron, J.E.N. (1986). Corals of Australia and the Indo-Pacific. Angus and Robertson, Australia. 644pp.

Suggested reading

Bright, T.J. *et al.* (1984). Hermatypes of the flower garden banks, Northwestern Gulf of Mexico: A comparison to other western Atlantic Reefs. Bull. Mar. Sci., 34(3): 461-476.

Cairns, S.D. (1982). Stony corals (Cnidaria: Hydrozoa, Scleractinia) of Carrie Bow Cay, Belize. Smithson. Contrib. Mar. Sci., 12: 271-302.

Sheppard, C.R.C. and A.L.S. Sheppard (1991). Corals and coral communities of Arabia. Fauna of Saudi Arabia, 12: 1-170.

Veron, J.E.N. (1992a). Hermatypic corals of Japan. Australian Institute of Marine Science Monograph Series, 9: 1-244.

Veron, J.E.N. (1992b). A biogeographic database of hermatypic corals: species of the central Indo-Pacific, genera of the world. Australian Institute of Marine Science Monograph Series, 10: 1-430.

Walton Smith, F.G. (1971). Atlantic Reef Corals: A Handbook of the Common Reef and Shallow water corals of Bermuda, the Bahamas, Florida, the West-Indies, and Brazil. University of Miami Press.

APPENDIX I. The Database

Background

The accumulation of information about coastal ecosystems is essential to an understanding of how these systems work. This information can then be used to set up effective management for sustainable development. To be truly useful however, potential users must be able to access the data easily. The use of database management systems such as dBASE® allows the storage and manipulation of vast amounts of information. Effective design of database structure can streamline data management tasks and vastly improve the efficiency of data storage and retrieval.

In the relational model of database design the data collected are broken down into related modules which are referred to as tables (Fig. 26). Each table is subdivided into records (rows), which contain a number of fields (columns). The tables are linked and cross-referenced by relating fields which are common to more than one table. In database terminology these fields are called **relational fields** or joining fields.

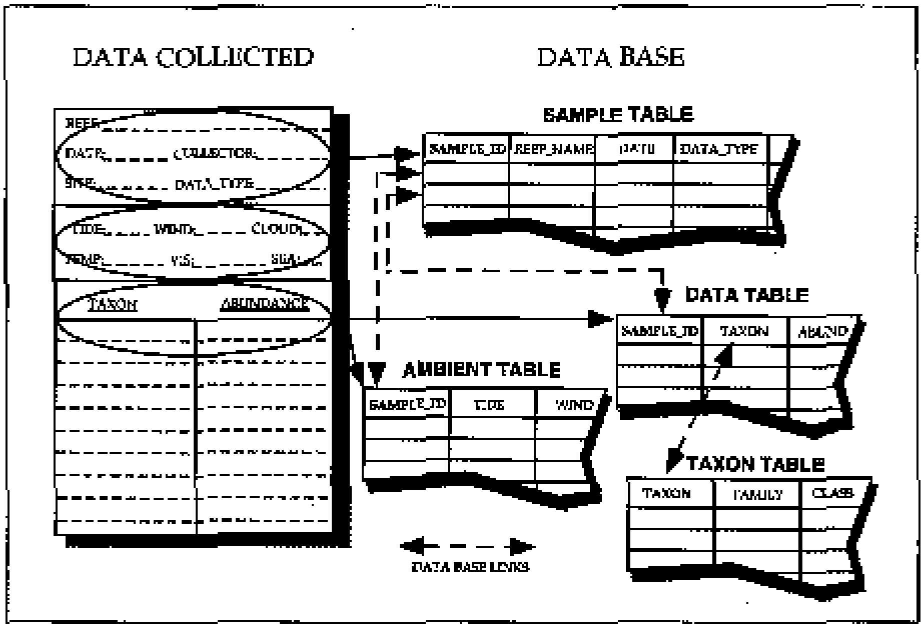


Figure 26. A relational database.

Data collected as part of the ASEAN-Australia project are relational in design. The methodologies detailed in this handbook are a subset of the database developed as part of this project. The overall database structure includes a sample or master table, data tables and reference tables.

After collection of the data using the methods described in this handbook data should be entered into dBASE™ (III+ or higher) using an IBM compatible computer. The structure of the Manta Tow data is shown in Figure 27. Information describing the sample is stored in the sample table and a unique sample identifier (SAMPLE_ID) is allocated. The data collected during manta tows are recorded in the Manta Tow table using the allocated SAMPLE_ID. Ambient data collected also have an entry in the sample table and are allocated a unique SAMPLE_ID. Ambient data are recorded in the Ambient table.

Sample Table

(Filename: XXCRSAMP.DBF)

Field Name	Type	Width	Dec	Description
SAMPLE_ID	Character	9		The standard sample identification. This links the sample table to the data files. Format CCGGXnnnn: CC = country code. See ISO codes in Appendix III. GG = study group code X = subgroup nnnn = running number
LOCATION	Character	30		Location name e.g. Seribu Islands
REEF_NAME	Character	25		Name of the reef surveyed (e.g. Malinjo, which is part of the Seribu Islands)
DATE	Date	8		Date when the data were gathered.
LATITUDE	Character	7		Latitude (AABBCCD) AA = latitude in degrees BB = latitude in minutes CC = latitude in seconds D = N (north) or S (south)
LONGITUDE	Character	8		Longitude (AAABBCCD) AAA = longitude in degrees BB = longitude in minutes CC = longitude in seconds D = E (east) or W (west)
REEF_ZONE	Character	8		The zone of the reef sampled: FLAT = reef flat; CREST = reef crest; SLOPE = reef slope; BASE = base of slope; LAGOON = lagoon. The above zone classifications may be prefixed by F=front, B=back, S=sheltered, E=exposed or P=pass or channel; e.g., EFLAT for exposed reef flat, BSLOPE for back reef slope.
DATA_TYPE	Character	1		A data code denoting the nature of the sample. Codes are listed listed in DATACODE.DBF.
DEPTH_M	Numeric	5	2	Depth (meters) of the sampling site
COLLECTORS	Character	40		Name(s) of the data collectors and their tasks.
REMARKS	Character	50		Additional observations regarding the site and the data.

Line Intercept Transect data [data table]

Filename: XXCRTDAT.DBF

Field Name	Type	Length	Dec	Description
SAMPLE_ID	Character	9		The standard sample identification. This links to the sample table. All replicates transects will have the same sample_id. Format CCGGXnnnn: CC= country code. See ISO codes in Appendix III. GG = study group code X = subgroup nnnn = running number.
REPLICATE	Numeric	2		Number of the replicate transect
BENTHOS	Character	3		Code for benthic lifeform along the transect (Table 7).
TRANSITION	Numeric	5		The transition points along the transect in centimetres
OCCURRENCE	Numeric	1		Number of occurrences for a lifeform. If a single lifeform intercepts the transect more than once, an occurrence value of "1" is given for its first intercept, "2" for its second, "3" for the third and so on. Single occurrences are given the default value of "0"
LENGTH	Numeric	5		Length of the lifeform in centimetres (calculated by the lifeform program). This program is available from the Chairman of the Management Committee, Living Coastal Resources Project*
TAXON	Character	8		Taxonomic code name for the coral listed in the file TAXCODE.dbf (refer to Appendix II)

* Dr. Suraphol Sudara, Chairman, ASEAN-Australia Marine Science Project: Living Coastal Resources, Department of Marine Science, Chulalongkorn University, Bangkok 10500, Thailand.

Taxonomic codes for coral species data [reference table]

Filename: TAXCODE.DBF

Field Name	Type	Length	Dec	Description
TAXON	Character	7		Species code using format XXXYYYY, where: XXX = generic code YYYY = species code.
SPECNAME	Character	40		Scientific name i.e. latin binomial
AUTHORITY	Character	40		The authority for the taxonomy used. This provides information essential in areas of rapidly changing scientific nomenclature.
REF_CODE	Character	25		Reference code for the physical reference specimen. Must have the location and identification code (e.g. museum catalogue number).
FAMILY	Character	40		Higher order classifications to support analysis of groups where the taxonomy is not well understood.
CLASS	Character	40		see Family
PHYLA	Character	40		see Family
REMARKS	Character	20		

APPENDIX II. Coral Codes

Species Name	Code
Acanthastrea echinata	ACA ECHI
Acanthastrea hillae	ACA HILL
Acanthastrea lordhowensis	ACA LORD
Acanthastrea rotundoflora	ACA ROTF
Acrhelia horrescens	ACH HORC
Acropora aculeus	ACR ACUL
Acropora acuminata	ACR ACUM
Acropora anthocercis	ACR ANTH
Acropora aspera	ACR ASPE
Acropora austera	ACR AUST
Acropora brueggemanni	ACR BRUE
Acropora carduus	ACR CARD
Acropora caroliniana	ACR CARO
Acropora cerealis	ACR CERE
Acropora chesterfieldensis	ACR CHES
Acropora clathrata	ACR CLAT
Acropora copiosa	ACR COPI
Acropora cuneata	ACR CUNE
Acropora cytherea	ACR CYTH
Acropora danai	ACR DANA
Acropora dendrum	ACR DEND
Acropora digitifera	ACR DIGI
Acropora divaricata	ACR DIVA
Acropora donei	ACR DONE
Acropora echinata	ACR ECHI
Acropora elseyi	ACR ELSE
Acropora exquisita	ACR EXQU
Acropora florida	ACR FLOR
Acropora formosa	ACR FORM
Acropora gemmifera	ACR GEMF
Acropora grandis	ACR GRAD
Acropora granulosa	ACR GRAN
Acropora horrida	ACR HORR
Acropora humilis	ACR HUMI
Acropora hyacinthus	ACR HYAC
Acropora kirstyae	ACR KIRS
Acropora latistella	ACR LATI
Acropora listeri	ACR LIST
Acropora longicyathus	ACR LONG
Acropora loripes	ACR LORI
Acropora lovelli	ACR LOVE
Acropora lutkeni	ACR LUTK
Acropora magnifica	ACR MAGN
Acropora microclados	ACR MICL
Acropora microphthalma	ACR MICP
Acropora millepora	ACR MILL
Acropora monticulosa	ACR MONT
Acropora multiacuta	ACR MULA
Acropora nana	ACR NANA
Acropora nasuta	ACR NASU
Acropora nobilis	ACR NOBI
Acropora palifera	ACR PALI
Acropora paniculata	ACR PANI
Acropora parilis	ACR PARI
Acropora pruinosa	ACR PRUI
Acropora pulchra	ACR PULC
Acropora rambleri	ACR RAMB
Acropora robusta	ACR ROBU
Acropora samoensis	ACR SAMO
Acropora sarmentosa	ACR SARM
Acropora secale	ACR SECA
Acropora selago	ACR SELA
Acropora solitaryensis	ACR SOLT
Acropora spicifera	ACR SPIC
Acropora stoddarti	ACR STOD
Acropora subglabra	ACR SUBG
Acropora subulata	ACR SUBU
Acropora tenella	ACR TENE
Acropora tenuis	ACR TENI
Acropora teres	ACR TERE

Species Name	Code
Euphyllia yaeyamaensis	EUP YAEY
Favia danae	FAV DANE
Favia favus	FAV FAVU
Favia helianthoides	FAV HELI
Favia laxa	FAV LAXA
Favia lizardensis	FAV LIZA
Favia maritima	FAV MART
Favia matthaii	FAV MATI
Favia maxima	FAV MAXI
Favia pallida	FAV PALL
Favia rotumana	FAV ROTU
Favia rotundata	FAV ROTD
Favia speciosa	FAV SPEC
Favia stelligera	FAV STEG
Favia veroni	FAV VERO
Favites abdita	FVS ABDI
Favites chinensis	FVS CHIN
Favites complanata	FVS COMP
Favites flexuosa	FVS FLEX
Favites halicora	FVS HALI
Favites pentagona	FVS PENT
Favites russelli	FVS RUSS
Fungia concinna	FUN CONC
Fungia corona	FUN CORO
Fungia danai	FUN DANA
Fungia echinata	FUN ECHI
Fungia fralinea	FUN FRAL
Fungia fungites	FUN FUNG
Fungia granulosa	FUN GRAN
Fungia horrida	FUN HORR
Fungia klunzingeri	FUN KLUN
Fungia moluccensis	FUN MOLU
Fungia paumotensis	FUN PAUM
Fungia repanda	FUN REPA
Fungia scabra	FUN SCAB
Fungia scruposa	FUN SCRU
Fungia scutaria	FUN SCUT
Fungia simplex	FUN SIMP
Fungia spinifera	FUN SPIF
Galaxea astreata	GAL ASTR
Galaxea fascicularis	GAL FASC
Gardineroseris planulata	GAR PLAN
Goniastrea aspera	GOS ASPE
Goniastrea australensis	GOS AUSE
Goniastrea edwardsi	GOS EDWA
Goniastrea favulus	GOS FAVL
Goniastrea palauensis	GOS PALA
Goniastrea pectinata	GOS PECT
Goniastrea retiformis	GOS RETF
Goniopora burgosi	GON BURG
Goniopora columna	GON COLU
Goniopora djiboutiensis	GON DJIB
Goniopora fruticosa	GON FRUT
Goniopora lobata	GON LOBA
Goniopora minor	GON MINO
Goniopora norfolkensis	GON NORF
Goniopora palmensis	GON PALM
Goniopora pandoraensis	GON PAND
Goniopora pendulus	GON PEND
Goniopora somaliensis	GON SOMA
Goniopora stokesi	GON STOK
Goniopora stutchburyi	GON STUT
Goniopora tenuidens	GON TENU
Halomitra pileus	HON PILE
Heliofungia actiniformis	HEL ACTI
Heliopora coerulea	HEP COER
Herpolitha limax	HER LIMA
Herpolitha weberi	HER WEBE
Heteropsammia cochlea	HET COCH
Hydnophora exesa	HYD EXES
Hydnophora grandis	HYD GRAD
Hydnophora microconos	HYD MICR
Hydnophora pilosa	HYD PILO
Hydnophora rigida	HYD RIGI
Leptastrea inaequalis	LER INAE
Leptastrea pruinosa	LER PRUI

Species Name	Code
Oulophyllia crispa	OUL CRIS
Oxypora crassispinosa	OXY CRAP
Oxypora glabra	OXY GLAB
Oxypora lacera	OXY LACE
Pachyseris gemmmae	PAC GEMM
Pachyseris rugosa	PAC RUGO
Pachyseris speciosa	PAC SPEC
Palauastrea ramosa	PAL RAMO
Pavona bipartita	PAV BIPA
Pavona cactus	PAV CACT
Pavona clavus	PAV CLAV
Pavona danai	PAV DANA
Pavona decussata	PAV DECU
Pavona explanulata	PAV EXPN
Pavona frondifera	PAV FROF
Pavona maldivensis	PAV MALD
Pavona minuta	PAV MINU
Pavona varians	PAV VARI
Pavona venosa	PAV VENO
Pectinia alcicornis	PEC ALCI
Pectinia lactuca	PEC LACT
Pectinia paeonia	PEC PAEO
Pectinia teres	PEC TERE
Physogyra lichtensteini	PHY LICT
Physophyllia ayleni	PHI AYLE
Platygyra daedalea	PLA DAED
Platygyra lamellina	PLA LAME
Platygyra pini	PLA PINI
Platygyra ryukyuensis	PLA RYUK
Platygyra sinensis	PLA SINE
Platygyra verweyi	PLA VERW
Plerogyra eurysepta	PLE EURY
Plerogyra exerta	PLE EXER
Plerogyra simplex	PLE SIMP
Plerogyra sinuosa	PLE SINU
Plerogyra turbida	PLE TURB
Plesiastrea versipora	PLS VERS
Pocillopora damicornis	POC DAMI
Pocillopora eydouxi	POC EYDO
Pocillopora meandrina	POC MEAN
Pocillopora verrucosa	POC VERR
Pocillopora woodjonesi	POC WOOD
Podabacia crustacea	POD CRUS
Polyphyllia talpina	POL TALP
Porites annae	POR ANNA
Porites aranetai	POR ARAN
Porites attenuata	POR ATTE
Porites australiensis	POR AUSA
Porites cf. evermanni	POR EVER
Porites cumulatus	POR CUMU
Porites cylindrica	POR CYLI
Porites deformis	POR DEFO
Porites eridani	POR ERID
Porites horizontalata	POR HORI
Porites latistellata	POR LATI
Porites lichen	POR LICH
Porites lobata	POR LOBA
Porites lutea	POR LUTE
Porites mayeri	POR MAYE
Porites murrayensis	POR MURR
Porites nigrescens	POR NIGR
Porites rus	POR RUS
Porites sillimaniana	POR SILL
Porites solida	POR SOLI
Porites stephensoni	POR STEP
Porites tenuis	POR TENI
Porites vaughani	POR VAUG
Psammocora contigua	PSA CONT
Psammocora digitata	PSA DIGI
Psammocora explanulata	PSA EXPN
Psammocora haimeana	PSA HAIM
Psammocora nierstraszi	PSA NIER
Psammocora profundacella	PSA PROF
Psammocora superficialis	PSA SUPE
Pseudosiderastrea tayami	PSE TAYA
Sandalolitha robusta	SAN ROBU

APPENDIX III. Country Codes (last updated November 1986)

Full Name	Short Name	Codes CMC	ISO
EUROPE	Europe	AY*	
EUROPEAN ECONOMIC COMMUNITY	E.E.C.	AZ*	
ALBANIA	Albania	BA	AL
ANDORRA	Andorra	BB	AD
AUSTRIA	Austria	BC	AT
BELGIUM	Belgium	BE	BE
BULGARIA	Bulgaria	BF	BG
CZECHOSLOVAKIA	Czechoslovakia	BI	CS
DENMARK	Denmark	BJ	DK
DENMARK - Faeroe Is	Faeroe Is	BK	FO
FINLAND	Finland	BL	FI
FRANCE	France	BM	FR
FRANCE - Corsica	Corsica	BH	FR
GERMAN DEMOCRATIC REPUBLIC	G.D.R.	BO	DD
GERMANY, FEDERAL REPUBLIC OF	F.R.G.	BN	DE
GREECE	Greece	BQ	GR
HUNGARY	Hungary	BR	HU
ICELAND	Iceland	BS	IS
IRELAND	Ireland	BT	IE
ITALY	Italy	BU *	IT
ITALY - Sardinia	Sardinia	CF	IT
ITALY - Sicily	Sicily	CE	IT
LIECHTENSTEIN	Liechtenstein	BV	LI
LUXEMBOURG	Luxembourg	BW	LU
MALTA	Malta	BX	MT
MONACO	Monaco	BY	MC
NETHERLANDS	Netherlands	BZ	NL
NORWAY	Norway	CA *	NO
NORWAY - Svalbard and Jan Meyen	Svalbard	CM	SJ
POLAND	Poland	CB	PL
PORTUGAL	Portugal	CC *	PT
ROMANIA	Romania	CD	RO
SAN MARINO	San Marino	CS	SM
SPAIN (Includes Alboran, not covered by Flora Europaea)	Spain	CG *	ES
SPAIN - Balearic Islands	Balearic Is.	BD	ES
SWEDEN	Sweden	CH	SE
SWITZERLAND	Switzerland	CI	CH

Full Name	Short Name	Codes CMC	ISO
ANGOLA	Angola	PA	AO
BURKINA FASO	Burkina Faso	QQ	BF
BURUNDI	Burundi	PC	BI
CAMEROON	Cameroon	PD	CM
CAPE VERDE ISLANDS	Cape Verde Is.	PE	CV
CENTRAL AFRICAN FREPUBLIC	C. African Rep.	PF	CF
CHAD	Chad	PG	TD
CONGO	Congo	PH	CG
COTE D'IVOIRE	Cote D'ivoire	PS	CI
DJIBOUTI	Djibouti	PJ	DJ
EQUATORIAL GUINEA	Eq. Guinea	PK*	GQ
(includes Rio Muni, Corisco, Elobey Chico and Elobey Grande)			
EQUATORIAL GUINEA - Bioko (Fernando Po)	Bioko	PI	GQ
EQUITORIAL GUINEA - Pagalu	Pagalu *	PO	GQ
ETHIOPIA	Ethiopia	PL	ET
GABON	Gabon	PM	GA
GAMBIA	Gambia	PN	GM
GHANA	Ghana	PP	GH
GUINEA	Guinea	PQ	GN
GUINEA-Bissau	Guinea - Bissau	PR	GW
KENYA	Kenya	PT	KE
LIBERIA	Liberia	PU	LR
MALAWI	Malawi	PV	MW
MALI	Mali	PW	ML
MAURITANIA	Mauritania	PX	MR
MOZAMBIQUE	Mozambique	PY	MZ
NIGER	Niger	PZ	NE
NIGERIA	Nigeria	QA	NG
RWANDA	Rwanda	QC	RW
SAO TOME	Sao Tome	QD *	ST
SAO TOME - Principe	Principe	QB	ST
SENEGAL	Senegal	QE	SN
SIERRA LEONE	Sierra Leone	QF	SL
SOMALIA	Somalia	QG	SO
SUDAN	Sudan	QJ	SD
TANZANIA	Tanzania	QK *	TZ
TANZANIA - Pemba Island	Pemba I.	QL	TZ
TANZANIA - Zanzibar	Zanzibar	QM	TZ
TOGO	Togo	QN	TG
UGANDA	Uganda	QP	UG
WESTERN SAHARA	Western Sahara	QH	EH

Full Name	Short Name	Codes CMC	ISO
CHINA - Shanxi Province	Shanxi	FV	CN
CHINA - Sichuan Province	Sichuan	FW	CN
CHINA - Xinjiang Uygur Zizhiqu A.R.	Xinjiang Uygur	FY	CN
CHINA - Xizang Zizhiqu Autonomous Region	Xizang Zizhiqu	FZ	CN
CHINA - Yunnan Province	Yunnan	FX	CN
CHINA - Zhejiang Province	Zhejiang	GA	CN
MONGOLIA	Mongolia	EY	MN
UNION OF SOVIET SOCIALIST REPUBLICS	U.S.S.R.	EA *	SU
ARCTIC U.S.S.R.	Arctic USSR	ET *	SU
ASIATIC U.S.S.R	Asiatic U.S.S.R.	EC *	SU
EUROPEAN U.S.S.R.	European U.S.S.R.	EB *	SU
U.S.S.R. - Armenia S.S.R.	Armenia	ED	SU
U.S.S.R. - Azerbaydzhan S.S.R.	Azerbaydzhan	EF	SU
U.S.S.R. - Byelorussian S.S.R.	Byelorussian	EG	BY
U.S.S.R. - Estonia S.S.R.	Estonia	EH	SU
U.S.S.R. - Georgia S.S.R.	Georgia (USSR)	EI	SU
U.S.S.R. - Kazakhstan S.S.R.	Kazakhstan	EJ	SU
U.S.S.R. - Kirghizia S.S.R.	Kirghizia	EK	SU
U.S.S.R. - Kurilskye Islands	Kurilskye Is.	EU	SU
U.S.S.R. - Latvia S.S.R.	Latvia	EL	SU
U.S.S.R. - Lithuania S.S.R.	Lithuania	EM	SU
U.S.S.R. - Moldavia S.S.R.	Moldavia	EN	SU
U.S.S.R. - R.S.F.S.R.	R.S.F.S.R.	EO	SU
U.S.S.R. - Sakhalin	Sakhalin	EV	SU
U.S.S.R. - Tadzhikistan S.S.R.	Tadzhikistan	EP	SU
U.S.S.R. - Turkmenistan S.S.R.	Turkmenistan	EQ	SU
U.S.S.R. - Ukranian S.S.R.	Ukraine	ER	UA
U.S.S.R. - Uzbekistan S.S.R.	Uzbekistan	ES	SU
MIDDLE ASIA to INDOCHINA and JAPAN	Middle Asia	GK *	
AFGHANISTAN	Afghanistan	GB	AF
BANGLADESH	Bangladesh	GC	BD
BHUTAN	Bhutan	GD	BT
BURMA - Myanmar	Burma	GE	BU
HONG KONG	Hong Kong	GF	HK
INDIA	India	GG	IN
INDIA - Andhra Pradesh State	Andhra Pradesh	IA	IN
INDIA - Arunachal Pradesh Union Terr	Arunachal Prad.	IB	IN
INDIA - Assam State	Assam	IC	IN
INDIA - Bihar State	Bihar	ID	IN
INDIA - Chandigarh Union Territory	Chandigarh	IZ	IN

Full Name	Short Name	Codes	
		CMC	ISO
PAKISTAN	Pakistan	GU	PK
TAIWAN	Taiwan	GX	TW
THAILAND	Thailand	GY	TH
VIETNAM	Vietnam	GZ	VN
INDIAN OCEAN ISLANDS	Indian Oean Is	LX *	
AUSTRALIA - Christmas Island	Christmas I.	ME	CX
AUSTRALIA - Cocos (Keeling) Islands	Cocos Is.	MF	CC
CHAGOS ARCHIPELAGO (Brit Indian Oc Terr)	Chagos Is	MD	IO
(Includes Diego Garcia I.)			
(BRITISH INDIAN OCEAN TERRITORY)			IO
COMORO ISLANDS	Comoro Islands	MX *	ZZ
(Comprises Mayotte and Comoros)			
COMOROS	Comoros	MG	KM
(Comprises Moheli, Grand Comore and Anjouan)			
FRANCE - Mayotte	Mayotte	MV	ZZ
FRANCE - Reunion	Reunion	MM *	RE
FRANCE - Reunion - Tromelin	Tromelin	MS	RE
INDIA - Andaman Islands	Andamans	MB	IN
INDIA - Lakshadweep Union Territory	Lakshadweep	MH	IN
(Includes Laccadive, Minicoy & Amindivi Islands)			
INDIA - Nicobar Islands	Nicobar	ML	IN
MADAGASCAR	Madagascar	MI *	MG
MADAGASCAR - Glorieuses Islands	Glorieuses Is.	MU	MG
MALDIVES	Maldives	MJ	MV
MAURITIUS	Mauritius	MK *	MU
MAURITIUS - Agalega Islands	Agalega Is.	MT	MU
MAURITIUS - Cargados Carajos	Cargados Carajo	MO	MU
MAURITIS - Rodrigues	Rodrigues	MN	MU
SEYCHELLES	Seychelles	MP *	SC
SEYCHELLES - Coralline Islands	Seychelles: Cor	MA	SC
(Includes Aldabra, Aldabra group, Amirante group, Alphonse group, Providence/Farquhar group, Ile Vache de Mer, Denis I., Coëtivy Is., Platte I.)			
SEYCHELLES - Granitic Islands	Seychesses: Gra	MW	SC
(Includes Mahe group, Praslin group, Silhouette group, Frigate group, Recif I., Mamolle I., The Brisans)			
SRI LANKA	Sri Lanka	MR	LK
YEMEN - SOCOTRA	Socotra	MQ	YD
(Includes Abd al Kuri)			
SOUTH EAST ASIA to PAPUA NEW GUINEA	S.E. Asia to PNG	HW *	
BORNEO	Borneo	HH *	ZZ

Full Name	Short Name	Codes CMC	ISO
AUSTRALIA - Coral Sea Islands Territory	Coral Sea Is	JK	AU
AUSTRALIA - New South Wales	N.S.W.	JF *	AU
AUSTRALIA - NSW - Lord Howe Island	Lord Howe I	JE	AU
AUSTRALIA - Norfolk Island	Norfolk I	JH	NF
AUSTRALIA - Northern Territory	N Territory	JJ	AU
AUSTRALIA - Queensland	Queensland	JL	AU
AUSTRALIA - South Australia	S Australia	JM	AU
AUSTRALIA - Tasmania	Tasmania	JN *	AU
AUSTRALIA - Victoria	Victoria	JP	AU
AUSTRALIA - Western Australia	W. Australia	JQ	AU
NEW ZEALAND	New Zealand	JR *	NZ
(Includes offshore islands, e.g. Three Kings, Hen and Chicken Is., Great Barrier I., The Snares)			
NEW ZEALAND - North Island	N. Island (NZ)	JS	NZ
NEW ZEALAND - South Island	S. Island (NZ)	JT	NZ
NEW ZEALAND - Chatham Islands	Chatham Is	JU	NZ
NEW ZEALAND - Kermadec Islands	Kermadec Is	JV	NZ

PACIFIC ISLANDS	Pacific Is.	JZ *	

Island groups in the Pacific present a problem because geographical and political relationships overlap to a significant extent. Thus these areas are presented as two lists - political and geographical.

Pacific Islands - political list: In this list CMC areas in the Pacific are listed in terms of their political status. The list is in two parts - areas that are political units (including island groups comprising a discreet political unit), and areas that are geographical units only (ie island groups that cross political frontiers). *Political units* that are subdivided by other CMC areas, are in italics, with their subsets indented beneath.

Areas that are political units:

CHILE - Easter Island	Easter I.	KL	CL
CHILE - Islas Desventurados	Desventurados	KB	CL
CHILE - Juan Fernandez	Juan Fernandez	KE	CL
COLUMBIA - Isla Del Malpelo	I. Del Malpelo	KF	CO
COOK ISLANDS	Cook Is	KK	CK
(Includes Raratonga)			
COSTA RICA - Isla Del Coco	I. Del Coco	KA	CR
ECUADOR - Galapagos	Galapagos	KC	EC
FIJI	Fiji	LQ	FJ
(Includes Rotuma, Conway Reef)			
FRANCE - Clipperton Island	Clipperton Is	KJ	PF
FRANCE - French Polynesia	Fr Polynesia	KM *	PF
FRANCE - French Polynesia - Cambier Is	Gambier Is	KN	PF
FRANCE - French Polynesia - Marquesas Is	Marquesas	KR	PF
FRANCE - French Polynesia - Society Is	Society Is	KW	PF
FRANCE - French Polynesia - Tuamotu Is	Tuamotu Is	KZ *	PF

Full Name	Short Name	Codes CMC	ISO
UNITED STATES MINOR OUTLYING ISLANDS	U.S. - Minor Is	JC	UM
U.S. - Howland Island and Baker Island	Howland & Baker	LC	UM
U.S. - Johnston Island	Johnston Is	KP	UM
U.S. - Line Islands	Us - Line Is	JY	UM
(Includes Kingman Reef, Jarvis Island, and Palmyra Atoll			
U.S. - Midway Islands	Midway Is	KS	UM
U.S. - Wake Island	Wake Island	LP	UM
VANUATU	Vanuatu	LT	BU
(Includes Banks Is and Torres Is)			
WESTERN SAMOA	Western Samoa	LE	WS

Areas that are not political units:

CAROLINE ISLANDS	Caroline Is	LH *	PC
HAWAIIAN ISLANDS	Hawaiian Is	LZ *	ZZ
LINE ISLANDS	Line Islands	JW *	ZZ
MARIANA ISLANDS	Mariana Is	LJ *	PC

Pacific Islands - geographical list: In this list CMC areas in the Pacific are listed in terms of their geographical rather than political relationships. It is a crude and arbitrary representation, as any list would have to be, but a map is available which has been annotated to show the CMC areas. Papua New Guinea has been included in the list for reference, because of the proximity of its eastern island groups to the Solomon Islands, although it is not part of the PACIFIC ISLANDS CMC area. However Australia, New Zealand, the Philippines and Japan are not included, although they could also be considered adjacent to some of these islands. Areas are listed in five bands running approximately N-S, following adjacent island chains. <u>Island groups</u> that are subdivided by other CMC areas are underlined, with their subsets indented beneath.

PACIFIC ISLANDS	Pacific Is.	JZ *	

First band:

JAPAN - Ogasawara-Shoto	Ogasawara-Shoto	LG	JP
JAPAN - Kazan Retto	Volcano I	LO	ZZ
<u>MARIANA ISLANDS</u>	Mariana Is.	LJ *	ZZ
NORTH MARIANA ISLANDS	North Marianas	LY	MP
(Includes Mariana Is except Guam)			
U.S. - Guam	Guam	LI	GU
<u>CAROLINE ISLANDS</u>	Caroline Is	LH *	PC
FEDERATED STATES OF MICRONESIA	MICRONESIA	LV	FM
(Includes Caroline Is [except Palau Islands group], and includes Yap, Kosrae, Truk and Panape)			
PALAU	Palau	LW	PW
<u>PAPUA NEW GUINEA</u>	P.N.G.	HD *	PG
PAPUA NEW GUINEA - Bismarck Archipelago	Bismarck Arch.	HG	PG
(Includes Admiralty Islands)			
PAPUA NEW GUINEA - Bougainville	Bougainville	HI	PG
PAPUA NEW GUINEA - Trobriand Islands	Trobriand Is	HV	PG

Full Name	Short Name	Codes CMC	ISO
U.S. - Hawaii	Hawaiian Is	KO	US
U.S. - Johnston Island	Johnston Is	KP	UM
LINE ISLANDS	Line Is	JW *	ZZ
U.S. - Line Islands	US - Line Is	JY	UM
(Includes Kingman Reef, Jarvis Island, and Palmyra Atoll)			
KIRIBATI - Line Islands	Kirib-Line Is	JX	KI
(Includes Fanning I, Washington I, Christmas I)			
FRANCE - FRENCH POLYNESIA	Fr. Polynesia	KM *	PF
FRANCE - French Polynesia - Marquesas Is	Marquesas	KR	PF
FRANCE - French Polynesia - Tuamotu Is	Tuamotu I	KZ *	PF
FRANCE - French Polynesia - Gambier Is	Gambier IS	KN	PF
FRANCE - French Polynesia - Society Is	Society Is	KW	PF
FRANCE - French Polynesia - Tubai Is	Tubai Is	LA	PF
(Includes Austral Is)			
PITCAIRN	Pitcairn	KV	PN
PITCAIRN - Ducie Island	Ducie I	AA	PN
PITCAIRN - Henderson Island	Henderson I	AB	PN
PITCAIRN - Oeno	Oeno	AC	PN
PITCAIRN - Pitcairn Island	Pitcairn I	AD	PN
CHILE - Easter Island	Easter I	KL	CL
CHILE - Islas Desventurados	Desventurados	KB	CL
CHILE - Juan Fernandez	Juan Fernandez	KE	CL
Fifth Band (American Coast):			
MEXICO - Guadelupe	Guadelupe	KD	MX
MEXICO - Revilla Gigedo	Revilla Gigedo	KG	MX
FRANCE - Clipperton Island	Clipperton I	KJ	PF
COSTA RICA - Isla Del Coco	I. Del Coco	KA	CR
COLOMBIA - Isla Del Malpelo	I. Del Malpelo	KF	CO
ECUADOR - Galapagos	Galapagos	KC	EC
These areas cross geographical groupings (see political list):			
KIRIBATI	Kiribati	KQ *	KI
TRUST TERRITORY OF THE PACIFIC ISLANDS	Pac Trust Ter	LN *	ZZ
(This is apparently no longer a political entity, so use of this code should be used with caution)			
UNITED STATES MINOR OUTLYING ISLANDS	U.S. - Minor Is	JC	UM
NORTH AMERICA	N. America	WT *	
CANADA	Canada	TA *	CA
CANADA - Alberta	Alberta	TB	CA
CANADA - British Columbia	Brit. Columbia	TC	CA

Full Name	Short Name	Codes CMC	ISO
U.S. - Nevada	Nevada	VB	US
U.S. - New Hampshire	New Hampshire	VC	US
U.S. - New Jersey	New Jersey	VD	US
U.S. - New Mexico	New Mexico	VE	US
U.S. - New York	New York	VF	US
U.S. - North Carolina	N Carolina	VG	US
U.S. - North Dakota	N Dakota	VH	US
U.S. - Ohio	Ohio	VI	US
U.S. - Oklahoma	Oklahoma	VJ	US
U.S. - Oregon	Oregon	VK	US
U.S. - Pennsylvania	Pennsylvania	VL	US
U.S. - Rhode Island	Rhode Island	VM	US
U.S. - South Carolina	S Carolina	VN	US
U.S. - South Dakota	S Dakota	VO	US
U.S. - Tennessee	Tennessee	VP	US
U.S. - Texas	Texas	VQ	US
U.S. - Utah	Utah	VR	US
U.S. - Vermont	Vermont	VS	US
U.S. - Virginia	Virginia	VT	US
U.S. - Washington	Washington	VU	US
U.S. - West Virginia	W Virginia	VV	US
U.S. - Wisconsin	Wisconsin	VW	US
U.S. - Wyoming	Wyoming	VX	US
CENTRAL AMERICA	Central America	WA *	
BELIZE	Belize	WB	BZ
COSTA RICA	Costa Rica	WC *	CR
EL SALVADOR	El Salvador	WD	SV
GUATEMALA	Guatemala	WE	GT
HONDURAS	Honduras	WF	HN
MEXICO	Mexico	WG *	MX
MEXICO - Aguascalientes	Aguascalientes	YA	MX
MEXICO - Baja California (Norte)	Baja Calif. (N)	WQ	MX
MEXICO - Baja California Sur	Baja Calif. Sur	WR	MX
MEXICO - Baja California Peninsula (This is a region, not a state)	Baja California	YB *	MX
MEXICO - Campeche	Campeche	YC	MX
MEXICO - Chiapas	Chiapas	YD	MX
MEXICO - Chihuahua	Chihuahua	YE	MX
MEXICO - Coahuila	Coahuila	YF	MX
MEXICO - Colima	Colima	YI	MX

Full Name	Short Name	Codes CMC	ISO
CUBA	Cuba	SG	CU
(Including Isla de Pinos)			
DOMINICA	Dominica	SH	DM
DOMINCAN REPUBLIC	Dominican Rep	SI	DO
FRANCE - Guadeloupe	Guadeloupe	SL	GP
(Including Marie Galante, GrandeTerre, Basse-Terres, Iles des Saintes, Iles de la Petite-Terre, La Desirade)			
FRANCE - Martinique	Martinique	SQ	MQ
GRENADA	Grenada	SJ	GD
HAITI	Haiti	SM	HT
HISPANIOLA	Hispaniola	SN *	ZZ
JAMAICA	Jamaica	SP	JM
(Including Morant Cays and Pedro Cays)			
MONTSERRAT	Montserrat	SR	MS
NAVASSA ISLAND	Navassa I	SS	ZZ
NETHERLANDS ANTILLES	Neth. Antilles	ST *	AN
(Aruba, Bonaire, Curacao)			
NETHERLANDS LEEWARD ISLANDS	Neth. Leeward I	SU	AN
(Saba And St Eustatius)			
PUERTO RICO	Puerto Rico	SV	PR
(Includes Isla Mona, Vieques, Culebra)			
ST CHRISTOPHER - Nevis	St Kitts - Nevis	SW	KN
ST LUCIA	St Lucia	SX	LC
ST MARTIN AND ST BARTHELEMY	St Mart & St Bt	SY	GP
ST VINCENT	St Vincent	SZ	VC
THE GRENADINES	Grenadines	SK	VC
(Bequia, Mustique, Canouan, Union, Carriacou, Ronde)			
TRINIDAD AND TOBAGO	Trinidad/Tobago	WV	TT
TURKS AND CAICOS ISLANDS	Turks & Caicos	WW	TC
(North-, South-, West- and East-Caicos, Middle Caicos, Providenciales, Ambergris Cays, Big Sand Cay, Grand Turk, Salt Cay, Seal Cays)			
VENEZUELA - Venezuelan Islands	Venezuelan Is.	WZ	VE
(Los Monjes, Las Ave, Los Roques, La Orchila, La Tortuga, La Blanquilla, Los Hermanes, La Sola, Los Frailes, Margarita, Coche, Cutagua, Los Testigos, Patos, Isla de Aves (by Dominica)			
VIRGIN ISLANDS OF THE UNITED STATES	Virgin Is (US)	WY	VI
(Includes St Croix)			
SOUTH AMERICA	South America	XA *	
ARGENTINA	Argentina	XB	AR
BOLIVIA	Bolivia	XC	BO
BRAZIL	Brazil	XD *	BR
BRAZIL - Acre State	Acre	XQ	BR

Full Name	Short Name	Codes	
		CMC	ISO
ASCENSION ISLAND	Ascension I	NC	SH
AUSTRALIA - Heard And McDonald Islands	Heard Is	NJ	HM
AUSTRALIA - Tasmania - Macquarie Island	Macquarie Is	NL	AU
BRAZIL - I. da Trindade	Trindade	NU	BR
FALKLAND ISLANDS (Islas Malvinas)	Falkland Is	NI	FK
FRENCH SOUTHERN TERRITORIES	French S Terrs	NO *	TF
FR SOUTHERN TERRITORIES - Ile Amsterdam	Amsterdam I.	NA	TF
FRENCH SOUTHERN TERRITORIES - Iles Crozet (includes Iles des Apotres, Ile aux Cochons, Ile da la Possession, Ile de la L'Est)	Crozet Is	NH	TF
FR SOUTHERN TERRITORIES - Iles Kerguelen	Kerguelen Is.	NK	TF
FRENCH SOUTHERN TERRITORIES - Ile St Paul	St Paul I.	NP	TF
NEW ZEALAND - Antipodes Islands	Antipodes Is	NB	NZ
NEW ZEALAND - Auckland Islands	Auckland Is	ND	NZ
NEW ZEALAND - Bounty Islands	Bounty Is	NE	NZ
NEW ZEALAND - Campbell Island	Campbell I	NG	NZ
NORWAY - Bouvet Island	Bouvet I	NF	BV
SOUTH AFRICA - Price Edward Islands	P.E.Is (SA)	NM	ZA
SOUTH GEORGIA	South Georgia	NQ	FK
SOUTH SANDWICH ISLANDS	S Sandwich Is	NS	FK
ST HELENA	St Helena	NN	SH
TRISTAN DA CUNHA ISLANDS	Tristan d Cunha	NV	SH
ANTARCTIC TREATY TERRITORY	Antarctic T.T.	NX *	ZZ
comprises:			
ANTARCTICA	Antarctica	NW	AQ
ANTARCTIC ISLANDS	Antarctic Is	NY *	ZZ
the latter includes:			
SOUTH ORKNEY ISLANDS	S. Orkney Is.	NR	BQ
SOUTH SHETLAND ISLANDS	S. Shetland Is.	NT	BQ
OCEANS AND SEAS			
ARCTIC OCEAN	Arctic Ocean	OS *	
NORTH ATLANTIC OCEAN	N. Atlantic	OG *	
SOUTH ATLANTIC OCEAN	S. Atlantic	OO *	
CARIBBEAN SEA	Caribbean Sea	OK *	
MEDITERRANEAN SEA	Mediterranean Sea	OI *	
INDIAN OCEAN	Indian Ocean	OD *	
SOUTHERN OCEAN	Southern Ocean	OQ *	
NORTH PACIFIC OCEAN	N. Pacific	OU *	
SOUTH PACIFIC OCEAN	S. Pacific	OW *	

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