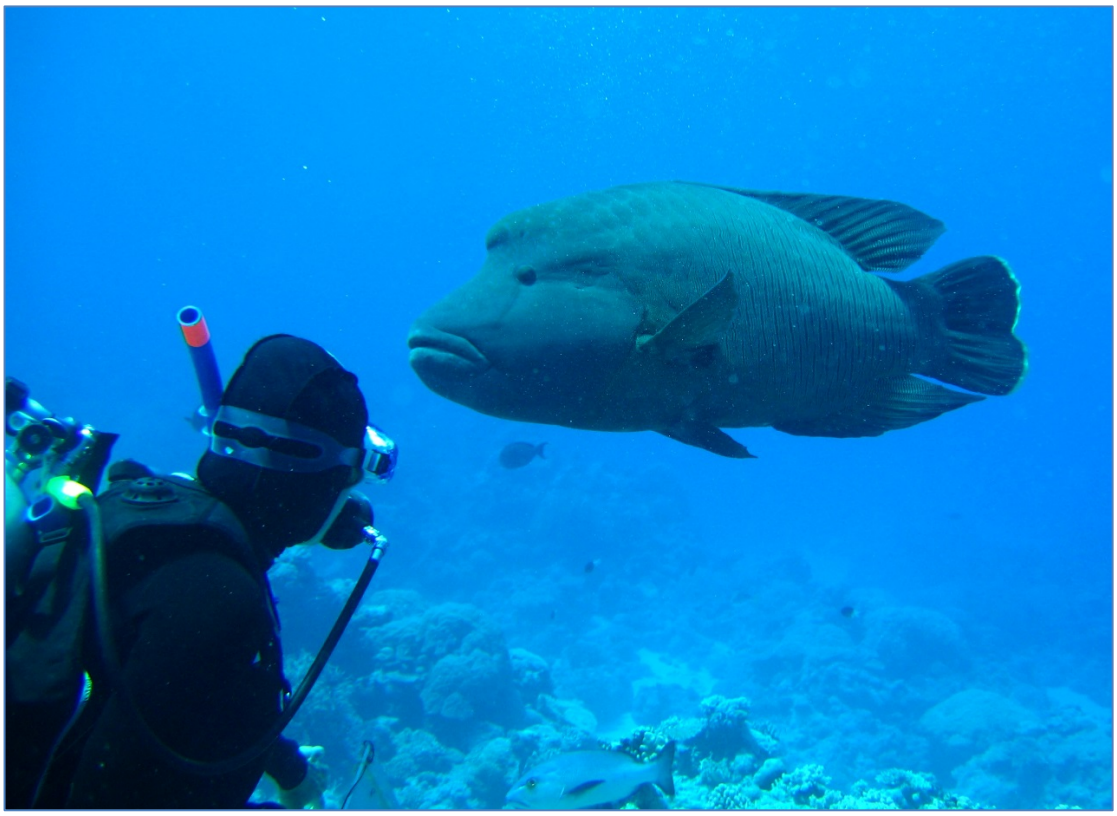
Australian Government

Australian Institute of Marine Science

Visual census of reef fish

Long-term Monitoring of the Great Barrier Reef
Standard Operational Procedure Number 3

Michael J. Emslie and Alistair J. Cheal



AIMS: Australia's tropical marine research agency

SOP3 – Edition 2 (2018)

Australian Institute of Marine Science

PMB No 3
Townsville MC Qld 4810

PO Box 41775
Casuarina NT 0811

Indian Ocean Marine Research Centre
University of Western Australia, M096
Crawley WA 6009

This report should be cited as:
Emslie MJ, Cheal AJ (2018) Visual census of reef fish. Australian Institute of Marine Science, Townsville, Australia

DISCLAIMER

Revision History:		*Name*	*Date*	*Comments*
1	Prepared by:	Michael J. Emslie	1/10/2018	
	Approved by:	Britta Schaffelke	1/10/2018	
2				

Cover photo:
Maori wrasse (*Cheilinus undulatus*) are one of the reef fish species counted and lengthed during fish surveys. Photo: Mike Emslie.

CONTENTS

LIST OF TABLES

1 PREFACE

The Australian Institute of Marine Science's Long-term Monitoring Program (LTMP) monitors benthic and reef fish assemblages, crown-of-thorns starfish populations and other agents of coral mortality (bleaching, coral diseases and *Drupella*) on a biennial basis. In alternate years when LTMP surveys are not conducted, there is a monitoring program to assess the effectiveness of management within the Great Barrier Reef Marine Park (GBRMP) under the Representative Areas Program (RAP). In both survey programs, reef fish and benthic communities are monitored along permanently marked transects in a standard reef slope habitat on selected reefs. This Standard Operational Procedure is Volume 3 in a series of seven, produced by the Long-term Monitoring Program at the Australian Institute of Marine Science. It details the standard procedure used to estimate reef fish abundance and lengths along these permanent transects. Training protocols and data management procedures are also detailed.

2 INTRODUCTION

The method adopted by the Long-term Monitoring Program (LTMP) to survey reef fish populations is underwater visual census. This technique has been used for many years to assess reef fish populations and is regarded as relatively accurate and cost effective (Sale 1980, Thresher & Gunn 1986). Underwater visual census is ideally suited to monitoring the abundance of coral reef fish as it allows for the collection of community level data without the disturbance inherent in other more destructive sampling techniques.

Visual census encompasses many techniques used to quantify reef fish populations (Thresher & Gunn 1986). The more traditional belt transect method, as first described by Brock (1954), has been adopted by the LTMP to assess reef fish populations. This method has been widely used in the past and provides similar estimates of precision and accuracy to other methods (Samoilys & Carlos 1992). In its simplest form the belt transect method for visual census of fish populations involves an observer, equipped with SCUBA gear, estimating the abundance of fish within a given area (the belt transect). A multitude of factors, including fish mobility and habitat complexity, have been shown to affect the precision of the counting technique. Additional errors in abundance estimates are likely to be introduced through observer bias. Therefore, any program using more than one observer must ensure that differences in bias between observers are minimised, to allow comparisons of data collected by different observers.

The following protocol has been adopted by the LTMP as the standard methodology for undertaking visual census. Strict adherence to this protocol, combined with annual inter-observer training and standardisation ensures that the resulting data are of high quality with maximal power to detect change over time.

3 SAMPLING DESIGN

Reef fish communities on 46 reefs were mostly surveyed annually up until 2005. Since then reefs have been surveyed as part of the LTMP in alternating years, within six sectors of the Great Barrier Reef (Cooktown/Lizard Island, Cairns, Townsville, Whitsunday, Swain and Capricorn-Bunker sectors). In each of these sectors (with the exception of the Swain and Capricorn-Bunker sectors) three shelf positions (inner, mid and outer) have been identified for sampling. Three reefs are nested within each of these shelf position/sector combinations except in the inner shelf of the Cooktown/Lizard Island sector where two reefs are surveyed and in the mid-shelf of the Cairns sector where four reefs are surveyed. In the Swain sector only the outer shelf (two reefs) and mid-shelf (five reefs) are surveyed. In the Capricorn-Bunker sector, only outer shelf reefs are represented, with four reefs being surveyed. Shelf position is determined by the position of the reef relative to the coast and continental slope, with inner shelf reefs closest to the coast.

Since 2006, surveys on 46 different reefs and ten of the initial reefs are conducted in alternate years to LTMP surveys as part of the Representative Areas Program (RAP) to assess the effectiveness of the rezoning of the GBRMP in 2004. RAP surveys are conducted in five offshore latitudinal sectors (reefs >30 km from the coast in the Cairns, Townsville, Pompey, Swain and Capricorn-Bunker sectors) of the GBRMP. This program surveys No-Take Marine Reserve reefs that are paired with similar reefs open to fishing.

In both LTMP and RAP surveys, a single habitat is surveyed on each reef, typically situated on the north-east flank. It is described as the first stretch of continuous reef with a slope less than vertical, going in a clockwise direction from the back reef zone towards the front reef. The selection of a common habitat allows comparisons to be made between reefs both within and among sectors. Within this habitat three sites are surveyed, each containing five, permanently marked, 50 metre long transects, lying approximately parallel to the reef crest.

Transects are set along the middle of the reef slope (usually at a depths between 6 and 9 metres, depending on the tidal state). For the LTMP, the centre line of each transect is marked with a star-picket at each end and sections of steel reinforcing rod (10 mm diameter) at 10 metre intervals. However, transects of the RAP program are only marked with star pickets at the start of each transect, so transect bearings are followed for each 10m segment of transect to ensure year to year consistency in transect position. Each star-picket is labelled with an aluminium tag identifying them as belonging to AIMS project 221. The star-picket at the beginning of the first transect of each site is marked with a subsurface buoy to aid in locating the site.

Counts of large mobile demersal species from a nine families are conducted on 50 metre by 5 metre transects while small site attached reef fishes in the family Pomacentridae are counted on 50 metre by 1 metre transects (Appendix I).

For all surveys only fishes estimated as belonging to the year 1+ age class are included in counts. The reason for excluding 0+ fish is that recruitment can be highly variable both in space and time. It is also likely that there are high mortality rates as well as considerable repositioning of recruits within the first year. These factors would contribute unreasonable variability in abundance estimates of the

stocks being monitored.

From the beginning of the 2017 field season, protocols were changed to include estimates of the length of each fish, into 2cm bins for Pomacentridae and 5cm bins for all others fishes, as this does not affect counts and provides important information on fish biomass (Emslie et al. 2018).

4 DATA COLLECTION

4.1 Equipment

The following equipment is required for the collection of fish abundance data;

1. four complete sets of scuba diving equipment
2. underwater slate, pencil and data sheets (Appendix II)
3. six 50 metre fibreglass measuring tapes
4. hand held Geographical Positioning System (GPS) to aid in site location

4.2 Personnel

A minimum of four people are required for the collection of visual census data using this technique. Two trained observers conduct the surveys, while two people are required to lay and wind up measuring tapes along the centre line of each transect. A pair of divers must remain in the tender as surface support at all times.

4.3 Sampling procedure

The following section outlines the procedure for undertaking visual census of a permanent monitoring site.

1. The site is located from the surface using a GPS and past knowledge of a site's location in relation to surrounding reef or island structures. On reaching the general area a dump weight with a surface float is deployed to mark the approximate location. The boat is anchored slightly away from the site so that divers entering the water do not swim across transects and disturb fish before the census begins. The exact location and beginning of the first transect may be determined by snorkel before anchoring or by scuba after anchoring.

2. Two divers enter the water. The first diver (observer) is equipped with a slate, pencil, data sheets (Appendix II) and one tape. The second diver (tape layer) carries the remaining five tapes. Before each transect the observer estimates an object (e.g. coral colony) thought to be 2.5 metres away. The actual distance is measured by the tape and recorded on the data sheet to allow the observer to calibrate their estimates against the desired transect width.

3. The observer conducts the 50 metre by 5 metre surveys by swimming along the transect centre line using compass bearings taken every ten metres and reinforcing rods as guides where

available. The observer counts all large, mobile fishes from the target list (Appendix I) sighted within the area 2.5 metres either side of the centre line. The length of each fish is also estimated in 5cm bins. Labrids are further recorded as terminal or initial phase.

4. The tape layer follows approximately 5-10 metres behind the observer, laying a tape along the centre line of the transect. The tape is attached to the star-picket at the beginning of the transect then wrapped once around a convenient attachment point every 10m (reinforcing rod or convenient outcrop) with the end at 50m attached to, or as close as possible to, the last star-picket or suitable reef structure.

5. On completion of the five, 50 metre by 5 metre transects, the observer and the tape layer ascend and exit the water. A second observer and tape winder then enter the water and return along the same transects (which are now marked with a tape along the centre line) undertaking a survey of the family Pomacentridae (Appendix I). All Pomacentrids occurring in a 1 metre wide strip up the reef slope from the tape are surveyed and lengths estimated in 2cm bins.

6. Before each 50 metre by 1 metre transect the observer calibrates their estimation of the transect width as described for the 50 metre by 5 metre transects except the distance estimation is for 1.0 metre. These data provide the observer with a regular reference to the desired transect boundaries.

7. When the tape does not contact the substrate an imaginary line is dropped to the substrate directly below the tape and fish counted within the belt up-slope and perpendicular to this line.

4.4 Census technique

A visual census aims to record an instantaneous estimate of abundance and length for the target species present within the transect bounds. Unfortunately this theoretical goal can never be realised due to factors such as the time taken to count, length and record each individual, and commonly, the inability to scan the entire transect area at any one time. Consequently there is a need to employ a sampling technique which best approximates this ideal.

Although it is impossible to census the entire transect in a given instant, it is possible to treat each transect as a series of instantaneous counts, such that each portion of the transect area is only viewed once for any given target species. In practice this is achieved by viewing ahead and counting target species in an area of the transect contained well within the bounds of visibility (often the next reinforcing rod serves as an appropriate break point). During the first scan of the section the most mobile target species should be counted and recorded, with progressively less mobile species recorded in consecutive counts. Fish entering the transect during, or after, that area of transect is sampled are not included as they were not present during the initial count. Once the most mobile species have been counted the observer moves along the centre of the transect searching for the more cryptic and slower moving target species, being careful to include individuals of the most mobile species which were obscured from view by the structure of the reef during the initial count of the area.

4.4.1 Timing of census

In an attempt to reduce variability in fish densities (due to diurnal influences in behaviour) sampling excludes the high activity periods of early morning and late afternoon. Sampling is limited to between 0900 and 1630 hours during winter months and between 0830 and 1700 hours during summer months. This time window also excludes periods of poor visibility caused by low sun angle.

4.5 Data recording

In addition to abundance and length estimates of target species, a number of ambient parameters are recorded which describe the physical environment at the time of census. Before entering the water a number of parameters relating to weather conditions and location are recorded on the data sheets (Appendix II), these are:

Reef
The reef name as shown in the Great Barrier Reef Gazetteer.

Site
The site number, where site 1 is the first site encountered when moving in a clockwise direction around the reef.

Transect
The number of the transect, where transect 1 is the first transect of a site encountered when swimming around the reef in a clockwise direction.

Date
The date of census in the format DD/MM/YY.

Observer
Initials of the observer carrying out the census.

Tide
Tide is recorded as either Low, High, Falling or Rising as determined from tide tables. The tide state is entered as one of the categories shown in Table 1.

Table 1: Tide states

State	Description
Low	One hour either side of Low water
High	One hour either side of High water
Falling	The period between High and Low water
Rising	The period between Low and High water

Cloud
Measured as the fraction of the sky covered by cloud and expressed in eighths (oktas) e.g. 0/8 indicates a cloudless sky, 3/8 indicates approximately three eighths of the sky is obscured by cloud.

Wind
Wind strength is recorded as a category described in Table 2.

Sea state
Sea state is recorded as a modified Beaufort scale described in Table 3.

Once in the water, the following data is recorded prior to commencing the survey of each transect.

Time
Recorded at the start of each transect.

Depth
Recorded to the nearest metre at the start of each transect.

Start
The time at which the census begins for each transect, recorded in 24 hour notation e.g. 3.15 p.m. is recorded as 1515.

Visibility
Recorded in metres distance when the observer first enters the water, prior to census. Visibility is the estimated distance to the point where objects become indistinct. This is only recorded once unless it changes.

Complexity
Habitat complexity is an important determinant of reef fish assemblage structure (Gratwicke & Speight 2005, Graham & Nash 2013, Emslie et al. 2014) and is subjectively estimated on each transect using a grading from 0 to 5, where 0 = no vertical relief, 1 = low and sparse relief, 2 = low but widespread relief, 3 = moderately complex, 4 = very complex with numerous fissures and caves, and 5 = exceptionally complex with numerous caves and overhangs (Polunin & Roberts 1993). Two estimates are obtained: 1. Substrate complexity in which the complexity of the underlying reef matrix is estimated by imagining the reef without any live or dead coral skeletons, and 2. Habitat complexity in which the complexity attributable to both the underlying reef matrix plus that of live and dead coral skeletons is estimated.

Table 2. Wind strength categories

Category	Wind strength (knots)
0	0
1	1-5
2	6-10
3	11-15
4	16-20
5	21-25

Table 3: Sea state description

Sea state	Description
Calm	Mirror-like to small ripples
Slight	Large wavelets, crests breaking
Moderate	Many white caps forming
Rough	Large waves, 2-3m, white caps

5 DATA MANAGEMENT

Due to the large volume of data collected during each survey trip, strict data management procedures must be followed to ensure safe and efficient storage of data.

5.1 Equipment

Lap top computer running Windows 10 and current data entry software.

5.2 Procedure

5.2.1 Field

On the same day data are collected, conduct the following procedure:

1. Rinse data sheets in fresh water and then dry.
2. Assign sample identification numbers[1] to each transect.
3. Enter data onto a laptop computer using current data entry software. Fish species names are entered in the database as a seven digit fish code. The first three letters represent a genus code, and the following four letters represent the species code (e.g. DAS.RETI is *Dascyllus reticulatus*, Appendix I).

5.2.2 Office

After the field trip, data are checked and added to the main data base using the following procedure:

1. Give laptop to database manager to synchronise.
2. Print raw data entered at sea and check against field data sheets. This checking procedure requires two personnel. One person reads out the species, abundance, length and phase (labrids only) from the field sheets while the other person checks these values against the print out of field entered data.
3. Correct any errors in the data using the java reefmon interface and save.

[1] Sample identification numbers consist of a two letter 'trip code' which is incremented for successive survey trips followed by a unique number for each site. Census data taken from the 5 and 1 metre wide transects within a given site are assigned the same sample identification numbers starting from 101 (the first site surveyed during a trip) and incrementing upwards for each new site e.g. OD101.

4. Inform database manager that corrections have been made into the ORACLE database.
5. File field data sheets and data printout.

6 TRAINING

The LTMP uses a bipartite program to train personnel in visual census of fish populations. Firstly, new observers are trained, *in situ*, in the identification of the target species (Appendix I), and in the standard technique for visual census of belt transects. Secondly, experienced observers are continually assessed to minimise inter-observer bias.

6.1 Fish identification

The level of expertise required for identification of reef fish is achieved with the use of reference texts in conjunction with field training. Initial familiarity with the target species is gained by regular perusal of relevant field guides e.g. Allen (1991), Allen et al. (2003), Myers (1989) and Randall et al. (1997). Texts such as these provide a comprehensive photographic record of the species targeted in the annual reef fish surveys. Identification skills are further enhanced with underwater tuition where an experienced observer points out target species and highlights physical characteristics, habitat preferences and behavioural patterns that will aid in quick and accurate identification.

6.2 Census technique

Training of observers in the visual census technique involves an experienced observer and trainee undertaking concurrent surveys using the standard procedure. At the end of each site, data are compared and possible sources of discrepancy discussed. For 50 metre by 5 metre transects, the trainee and experienced observer swim side by side down the centre line of the transects. At the end of each transect they swap sides to control for any position related bias. As the 50 metre by 1 metre transects are too narrow for observers to swim abreast, they swim in single file. The observers swim approximately 10 metres apart and swap positions at the end of each transect, again to control for any position related bias.

6.3 Inter-observer standardisation

Observers undertake annual standardisation exercises to maintain close concordance in their counts. The procedure used for inter-observer standardisation is identical to that outlined above for the training of observers in the visual census technique.

6.4 Fish length calibration

In addition to estimates of abundance of fishes, the LTMP also estimates the lengths of fishes in 2cm bins for damselfishes, and 5cm bins for all other species. To ensure that length estimates are valid, lengthing calibration should be conducted at the start of every trip using plastic fish models of known lengths. Observers estimate the length of each model held up randomly, and calibration continues

until estimates are consistently within 2 cms of the known lengths. Estimates are also compared among observers to ensure that there are no consistent biases.

7 REFERENCES

Allen GR (1991) Damselfishes of the world, Mergus, Germany

Allen GR, Steene R, Humann P, DeLoach N (2003) Reef fish identification: tropical Pacific. New World Publications, Jacksonville, USA

Brock VE (1954) A preliminary report on a method of estimating reef fish populations. Journal of Wildlife Management 18: 297-308

Emslie MJ, Cheal AJ, Johns KA (2014) Retention of habitat complexity minimizes disassembly of reef fish communities following disturbance: a large-scale natural experiment. PLoS ONE 9(8): e105384. doi:10.1371/journal.pone.0105384

Emslie MJ, Cheal AJ, MacNeil MA, Miller IR, Sweatman HPA (2018) Reef fish communities are spooked by scuba surveys and may take hours to recover. Peer J 6: e4886; DOI 10.7717/peerj.4886

Graham NAJ, Nash KL (2013) The importance of structural complexity in coral reef ecosystems. Coral Reefs 32: 315-326

Gratwicke B, Speight MR (2005) Effects of habitat complexity on Caribbean marine fish assemblages. Marine Ecology Progress Series 292: 301–310

Myers RF (1989) Micronesian Reef Fishes. Coral Graphics, Guam, USA

Polunin NVC, Roberts CM (1993) Greater biomass and value of target coral-reef fishes in two small Caribbean marine reserves. Marine Ecology Progress Series 100: 167–176

Randall JE, Allen GR, Steene RC (1997) Fishes of the Great Barrier Reef and Coral Sea. University of Hawaii Press, Hawaii, USA

Sale PF (1980) The ecology of fishes on coral reefs. Oceanography and Marine Biology an Annual Review 18: 367-442

Samoilys MA, Carlos G (1992) Development of an underwater visual census method for assessing shallow water reef fish stocks in the south west Pacific. Queensland Department of Primary Industries, Cairns, Australia

Thresher RE, Gunn JS (1986) Comparative analysis of visual census techniques for highly mobile, reef-associated piscivores (Carangidae). Environmental Biology of Fishes 17: 93-116

8 APPENDICES

8.1 Appendix I: Transect species lists

8.1.1 50 metre by 5 metre transect species list

Fish code	*Fish species* (* = surveyed in RAP years only)
ACANTHURIDAE	
ACA.ALBI	*Acanthurus albipectoralis*
ACA.AURA	*Acanthurus auranticavus*
ACA.BLOC	*Acanthurus blochii*
ACA.DUSS	*Acanthurus dussumieri*
ACA.GRAM	*Acanthurus grammoptilus*
ACA.LINE	*Acanthurus lineatus*
ACA.MATA	*Acanthurus mata*
ACA.NANS	*Acanthurus nigricans*
ACA.NUDA	*Acanthurus nigricauda*
ACA.NCUS	*Acanthurus nigrofuscus*
ACA.OLIV	*Acanthurus olivaceus*
ACA.PYRO	*Acanthurus pyroferus*
ACA.THOM	*Acanthurus thompsoni*
ACA.TRIO	*Acanthurus triostegus*
ACA.XANT	*Acanthurus xanthopterus*
CTE.GROP	*Ctenochaetus* spp. (grouped)
NAS.LITU	*Naso lituratus*
NAS.TONG	*Naso tonganus*
NAS.UNIC	*Naso unicornus*
PCT.HEPA	*Paracanthurus hepatus*
ZEB.SCOP	*Zebrasoma scopas*
ZEB.VELI	*Zebrasoma veliferum*
CHAETODONTIDAE	
CHA.AFAS	*Chaetodon aureofasciatus*
CHA.AURI	*Chaetodon auriga*
CHA.BARO	*Chaetodon baronessa*
CHA.BENN	*Chaetodon bennetti*
CHA.CITR	*Chaetodon citrinellus*
CHA.EPHI	*Chaetodon ephippium*
CHA.FLAV	*Chaetodon flavirostris*
CHA.GUEN	*Chaetodon guentheri*
CHA.KLEI	*Chaetodon kleinii*
CHA.LINE	*Chaetodon lineolatus*
CHA.LUNS	*Chaetodon lunulatus*
CHA.LUNU	*Chaetodon lunula*
CHA.MELO	*Chaetodon melannotus*

CHA.MEYE	*Chaetodon meyeri*
CHA.ORNA	*Chaetodon ornatissimus*
CHA.PELW	*Chaetodon pelewensis*
CHA.PLEB	*Chaetodon plebeius*
CHA.PUNC	*Chaetodon punctatofasciatus*
CHA.RAFF	*Chaetodon rafflesii*
CHA.RAIN	*Chaetodon rainfordi*
CHA.RETI	*Chaetodon reticulatus*
CHA.SEME	*Chaetodon semeion*
CHA.SPEC	*Chaetodon speculum*
CHA.TLIS	*Chaetodon trifascialis*
CHA.ULIE	*Chaetodon ulietensis*
CHA.UNIM	*Chaetodon unimaculatus*
CHA.VAGA	*Chaetodon vagabundus*
CHM.ROST	*Chelmon rostratus*
FOR.FLAV	*Forcipiger flavissimus*
FOR.LONG	*Forcipiger longirostrus*
HYS.POLY	*Hemitaurichthys polylepis*

LABRIDAE

CHE.FASC	*Cheilinus fasciatus*
CHE.UNDU	*Cheilinus undulatus*
CHO.FASC	*Choerodon fasciatus*
COR.GAIM	*Coris gaimard*
EPB.INSI	*Epibulus insidiator*
GOM.VARI	*Gomphosus varius*
HAL.HORT	*Halichoeres hortulanus*
HEM.FASC	*Hemigymnus fasciatus*
HEM.MELT	*Hemigymnus melapterus*

Subfamily *SCARINAE*

BOL.MURI	*Bolbometopon muricatum*
CET.OCEL	*Cetoscarus ocellatus*
CHS.BLEE	*Chlorurus bleekeri*
CHS.JAPA	*Chlorurus japanesis*
CHS.MICR	*Chlorurus microrhinos*
CHS.SPIR	*Chlorurus spirulus*
HIP.LONG	*Hipposcarus longiceps*
SCA.ALTI	*Scarus altipinnis*
SCA.CHAM	*Scarus chameleon*
SCA.DIMI	*Scarus dimidiatus*
SCA.FLAV	*Scarus flavipectoralis*
SCA.FORS	*Scarus forsteni*
SCA.FREN	*Scarus frenatus*
SCA.GHOB	*Scarus ghobban*
SCA.GLOB	*Scarus globiceps*
SCA.NIGR	*Scarus niger*

SCA.OVIC	*Scarus oviceps*
SCA.PSIT	*Scarus psittacus*
SCA.RIVU	*Scarus rivulatus*
SCA.RUBR	*Scarus rubroviolaceus*
SCA.SCHL	*Scarus schlegeli*
SCA.SPIN	*Scarus spinus*

LETHRINIDAE

LET.ATKI	*Lethrinus atkinsoni*
LET.ERYT	*Lethrinus erythracanthus*
LET.HARA	*Lethrinus harak*
LET.LATI	*Lethrinus laticaudis*
LET.LENT	*Lethrinus lentjan*
LET.MINI	*Lethrinus miniatus*
LET.NEBU	*Lethrinus nebulosus*
LET.OBSO	*Lethrinus obsoletus*
LET.OLIV	*Lethrinus olivaceus*
LET.ORNA	*Lethrinus ornatus*
LET.RUBR	*Lethrinus rubrioperculatus*
LET.SEMI	*Lethrinus semicinctus*
LET.XANT	*Lethrinus xanthochilus*
MON.GRAN	*Monotaxis grandoculis*

LUTJANIDAE

LUT.ADET	*Lutjanus adetii*
LUT.ARGE	*Lutjanus argentimaculatus*
LUT.BIGU	*Lutjanus biguttatus*
LUT.BOHA	*Lutjanus bohar*
LUT.BOUT	*Lutjanus boutton*
LUT.CARP	*Lutjanus carponotatus*
LUT.FLMA	*Lutjanus fulviflamma*
LUT.FULV	*Lutjanus fulvus*
LUT.GIBB	*Lutjanus gibbus*
LUT.KASM	*Lutjanus kasmira*
LUT.LEMN	*Lutjanus lemniscatus*
LUT.LUTJ	*Lutjanus lutjanus*
LUT.MONO	*Lutjanus monostigma*
LUT.QUIN	*Lutjanus quinquelineatus*
LUT.RIVU	*Lutjanus rivulatus*
LUT.RUSS	*Lutjanus russellii*
LUT.SEBA	*Lutjanus sebae*
LUT.SEMI	*Lutjanus semicinctus*
LUT.VITT	*Lutjanus vitta*
MCR.GROP	*Macolor* spp. (grouped)

SERRANIDAE

AET.ROGA	*Aethaloperca rogaa**
ANY.LEUC	*Anyperodon leucogrammicus**
CEP.ARGU	*Cephalopholis argus**
CEP.BOEN	*Cephalopholis boenak**
CEP_CYAN	*Cephalopholis cyanostigma**
CEP_MICR	*Cephalopholis microprion**
CEP_MINI	*Cephalopholis miniata**
CEP_SEXM	*Cephalopholis sexmaculata**
CEP_UROD	*Cephalopholis urodeta**
EPI.COIO	*Epinephelus coioides**
EPI.CYAN	*Epinephelus cyanopodus**
EPI.FASC	*Epinephelus fasciatus**
EPI.FUSG	*Epinephelus fuscoguttatus**
EPI.HEX	*Epinephelus hexagonatus**
EPI.HOWL	*Epinephelus howlandi**
EPI.LANC	*Epinephelus lanceolatus**
EPI.MACR	*Epinephelus macrospilos**
EPI.MERR	*Epinephelus merra**
EPI.ONGU	*Epinephelus ongus**
EPI.POLY	*Epinephelus polyphekadion**
EPI.QUOY	*Epinephelus quoyanus**
EPI.SEX	*Epinephelus sexfasciatus**
EPI.SPIL	*Epinephelus spilotoceps**
EPI.TAUV	*Epinephelus tauvina**
EPI.UNDU	*Epinephelus undulatostriatus**
PMS.AREO	*Plectropomus areolatus*
PMS.LAEV	*Plectropomus laevis*
PMS.LEOP	*Plectropomus leopardus*
PMS.MACU	*Plectropomus maculatus*
PMS.OLIG	*Plectropomus oligacanthus*
VAR.ALBI	*Variola albimarginata*
VAR.LOUT	*Variola louti*

SIGANIDAE

SIG.ARGE	*Siganus argenteus*
SIG.CORA	*Siganus corallinus*
SIG.DOLI	*Siganus doliatus*
SIG.JAVU	*Siganus javus*
SIG.LINE	*Siganus lineatus*
SIG.PUEL	*Siganus puellus*
SIG.PMUS	*Siganus punctatissimus*
SIG.PTUS	*Siganus punctatus*
SIG.SPIN	*Siganus spinus*
SIG.VULP	*Siganus vulpinus*

ZANCLIDAE

ZAN.CORN	*Zanclus cornutus*

8.1.2 50 metre by 1 metre transect species list

Fish code	*Fish species*
ACANTHOCHROMIS	
ACN.POLY	*Acanthochromis polyacanthus*
AMBLYGLYPHIDODON	
AMB.AURE	*Amblyglyphidodon aureus*
AMB.CURA	*Amblyglyphidodon curacao*
AMB.LEUC	*Amblyglyphidodon leucogaster*
AMPHIPRION	
AMP.AKIN	*Amphiprion akindynos*
AMP.CHRY	*Amphiprion chrysopterus*
AMP.CLAR	*Amphiprion clarkii*
AMP.MELA	*Amphiprion melanopus*
AMP.PERC	*Amphiprion percula*
AMP.PERI	*Amphiprion perideraion*
CHROMIS	
CHR.ACAR	*Chromis acares*
CHR.AGIL	*Chromis agilis*
CHR.ALIS	*Chromis atripectoralis*
CHR.AMBO	*Chromis amboinensis*
CHR.APES	*Chromis atripes*
CHR.CHRY	*Chromis chrysura*
CHR.FUME	*Chromis fumea*
CHR.IOME	*Chromis iomelas*
CHR.LEPI	*Chromis lepidolepis*
CHR.MARG	*Chromis margaritifer*
CHR.NITI	*Chromis nitida*
CHR.RETR	*Chromis retrofasciata*
CHR.TERN	*Chromis ternatensis*
CHR.VAND	*Chromis vanderbilti*
CHR.VIRI	*Chromis viridis*
CHR.WEBE	*Chromis weberi*
CHR.XANT	*Chromis xanthura*
CHRYSIPTERA	
CHY.BIOC	*Chrysiptera biocellata*
CHY.CYAN	*Chrysiptera cyanea*
CHY.FLAV	*Chrysiptera flavipinnis*
CHY.REX	*Chrysiptera rex*
CHY.ROLL	*Chrysiptera rollandi*

CHY.TALB	*Chrysiptera talboti*

DASCYLLUS

DAS.ARUA	*Dascyllus aruanus*
DAS.MELA	*Dascyllus melanurus*
DAS.RETI	*Dascyllus reticulatus*
DAS.TRIM	*Dascyllus trimaculatus*

DISCHISTODUS

DIS.MELA	*Dischistodus melanotus*
DIS.PERS	*Dischistodus perspicillatus*
DIS.PROS	*Dischistodus prosopotaenia*
DIS.PSEU	*Dischistodus pseudochrysopoecilus*

HEMIGLYPHIDODON

HGY.PLAG	*Hemiglyphidodon plagiometopon*

NEOGLYPHIDODON

NEG.MELA	*Neoglyphidodon melas*
NEG.NIGR	*Neoglyphidodon nigroris*
NEG.POLY	*Neoglyphidodon polyacanthus*

NEOPOMACENTRUS

NEO.AZYS	*Neopomacentrus azysron*
NEO.BANK	*Neopomacentrus bankieri*
NEO.CYAN	*Neopomacentrus cyanomos*

PLECTROGLYPHIDODON

PGY.DICK	*Plectroglyphidodon dickii*
PGY.JOHN	*Plectroglyphidodon johnstonianus*
PGY.LACR	*Plectroglyphidodon lacrymatus*

POMACENTRUS

POM.ADEL	*Pomacentrus adelus*
POM.AMBO	*Pomacentrus amboinensis*
POM.AUST	*Pomacentrus australis*
POM.BANK	*Pomacentrus bankanensis*
POM.BRAC	*Pomacentrus brachialis*
POM.CHRY	*Pomacentrus chrysurus*
POM.COEL	*Pomacentrus coelestis*
POM.GRAM	*Pomacentrus grammorhynchus*
POM.LEPI	*Pomacentrus lepidogenys*
POM.MOLU	*Pomacentrus moluccensis*
POM.NAGA	*Pomacentrus nagasakiensis*
POM.PHIL	*Pomacentrus philippinus*
POM.TRIP	*Pomacentrus tripunctatus*
POM.VAIU	*Pomacentrus vaiuli*

POM.WARD	*Pomacentrus wardi*

POMACHROMIS

PCH.RICH	*Pomachromis richardsoni*

PREMNAS

PRE.BIAC	*Premnas biaculeatus*

STEGASTES

STE.APIC	*Stegastes apicalis*
STE.FASC	*Stegastes fasciolatus*
STE.NIGR	*Stegastes nigricans*
STE.GASC	*Stegastes gascoynei*

8.2 Appendix II: Transect data sheets

8.2.1 50 metre by 5 metre transect data sheet

		Long-term reef fish monitoring (50 by 5 metre)						
Reef:			Site:	Transect:		Date:		Observer:
	Depth:		Start Time:			Vis:		

	5 to 10cm	10.1 to 15cm	15.1 to 20cm	20.1 to 25cm	25.1 to 30cm	30.1 to 35cm	35.1 to 40cm	>40cm
Acanthurus								
Ctenochaetus								
Zeb scopas								
Zeb veliferum								
Chaetodon								
Labrids								
Lutjanus								
Lethrinus								
	5 to 10cm	10.1 to 15cm	15.1 to 20cm	20.1 to 25cm	25.1 to 30cm	30.1 to 35cm	35.1 to 40cm	>40cm
Plectropomus								
Scarus								
Siganus								
Zanclus								

8.2.2 50 metre by 1 metre transect data sheet

	Long-term reef fish monitoring (50 by 1 metre)						
Reef:			Site:	Transect:		Date:	Observer:
	Depth:		Start Time:			Vis:	
	3 to 5cm	5.1 to 7cm	7.1 to 9cm	9.1 to 11cm	11.1 to 13cm	13.1 to 15cm	>15cm
Acanthochromis							
Amb. curacao							
Amb. leuc							
Amphiprion							
Chromis							
Chrysiptera							
Dascyllus							
Dischistodus							
Neopomacentrus							
Neg melas							
Neg nigroris							
Plectroglyph							
Pomacentrus							
Stegastes							