

JCU ePrints

This file is part of the following reference:

Mannering, Thomas (2008) *Benefits of marine protected areas beyond boundaries: an evaluation for two coral reef fishes*. Masters (Research) thesis, James Cook University.

Access to this file is available from:

<http://eprints.jcu.edu.au/5140>



**Benefits of marine protected areas
beyond boundaries: an evaluation for
two coral reef fishes**

Thesis submitted by
Thomas Dixen Mannering
in 2008

**For the research degree of Master of Science
in Marine Biology
within the School of Marine and Tropical Biology
James Cook University**

Abstract

Increases in the numbers and sizes of predatory fishes in well established no-take marine protected areas (MPAs) on coral reefs are well-known. However, few studies have investigated whether adult spillover or recruitment subsidies lead to higher adult and juvenile densities in fished areas adjacent to MPAs, compared with fished sites further away from MPAs. Our understanding of these phenomena has been limited because most MPA studies have been restricted to comparisons of MPAs and fished areas, and do not consider fished areas that do not benefit from MPAs. On the Great Barrier Reef, adults of two recreationally important coral reef fish (*Plectropomus maculatus* and *Lutjanus carponotatus*) have been observed to increase in numbers in inshore no-take areas (“green zones”). In this thesis I made a preliminary investigation of the potential for adult spillover and recruitment subsidies by comparing fished areas, near to and distant from green zones. Firstly, I examined the early age and growth of juvenile fishes at the Keppel Islands, in order to define the size of young-of-the-year (0+) and estimate settlement and spawning periods. I used this information to estimate the densities of adults and 0+ year fish within green zones, fished areas within 1km from green zones and at sites greater than 5km from the nearest protected area.

The size-age relationships for the 0+ year cohorts were determined by studies of sectioned sagittal otoliths. Juveniles were collected between October and November in 2006, and May and June in 2007. The youngest *P. maculatus* and *L. carponotatus* recruits caught were 63 (53mm FL) and 66 days old (49mm FL) respectively, but ages extended to 334 days (220mm FL) for *P. maculatus* and 345 days (183mm FL) for *L.*

carponotatus. Juvenile growth was rapid in both species, with *P. maculatus* and *L. carponotatus* averaging 0.96 mm d^{-1} and 0.72 mm d^{-1} respectively. The estimated PLD of *P. maculatus* was 28.6 days, while *L. carponotatus* was 33.6 days. Based on the observations from this study, recruitment surveys approximately two months after spawning would be sufficient, however, in order to include additional 0+ age cohorts, surveys would ideally take place 160 days after initial spawning.

The potential for local benefits of MPAs were examined by comparing adult and recruit densities outside MPAs, both near to and distant from the MPA boundary. Adults and juveniles of *P. maculatus* and *L. carponotatus* were surveyed at both the Keppel Islands and Palm Islands, two inshore networks of no-take MPAs on the Great Barrier Reef. Within each region, the abundance and biomass of adults and recruits were compared for three treatments: (1) Within MPAs; (2) Nearby fished areas (< 1km from MPA boundaries) and (3) distant fished areas (> 5km from MPA boundaries). Site variation accounted for the majority of differences in both adult and recruits of *P. maculatus* and *L. carponotatus*. Hence, no significant differences were found for any of the treatments. Low densities of juveniles and patchiness in their distribution appear to combine to make detecting recruitment subsidies extremely difficult. I suggest refinements of the sampling technique, as well as alternative approaches to solving this problem.

STATEMENT OF ACCESS

DECLARATION

I, the undersigned, author of this work, understand that James Cook University will make this thesis available for use within the University Library and, via the Australian Digital Theses network, for use elsewhere.

I understand that, as an unpublished work, a thesis has significant protection under the Copyright Act and;

I do not wish to place any further restriction on access to this work.

Signature

Date

STATEMENT OF SOURCES

DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education.

Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

Signature

Date

ELECTRONIC COPY

DECLARATION

I, the undersigned, the author of this work, declare that the electronic copy of this thesis provided to the James Cook University Library is an accurate copy of the print thesis submitted, within the limits of technology available.

Signature

Date

STATEMENT OF CONTRIBUTION TO OTHERS

DECLARATION

This thesis includes some collaborative work with Prof. Geoff Jones and Dr. Craig Syms. While undertaking these collaborations, I was instrumental in the project concept and responsible for the project design, analysis and interpretation, as well as the final synthesis of results into a form suitable for publication. Data from 2006 was provided by Richard Evans and David Williamson. My collaborators provided intellectual guidance, financial support, technical instruction and editorial assistance.

Financial support for the project was provided by my supervisor Prof. Geoff Jones, MTSERF and ARC Centre of Excellence.

Signature

Date

TABLE OF CONTENTS

ABSTRACT.....	2
STATEMENT OF ACCESS.....	4
STATEMENT OF SOURCES.....	5
ELECTRONIC COPY.....	6
STATEMENT OF CONTRIBUTION TO OTHERS.....	7
TABLE OF CONTENTS.....	8
LIST OF FIGURES.....	9
LIST OF TABLES.....	10
ACKNOWLEDGEMENTS.....	11
1.0. INTRODUCTION.....	12
2.0. EARLY LIFE HISTORY OF TWO CORAL REEF FISH ON THE GREAT BARRIER REEF.	20
2.1. ABSTRACT	20
2.2. INTRODUCTION	21
2.3. MATERIALS AND METHODS	23
2.3.1. <i>Study Species</i>	23
2.3.2. <i>Fish collection and examination</i>	24
2.4. RESULTS.....	26
2.4.1. <i>Age and growth</i>	26
2.4.2. <i>Settlement and spawning periods</i>	30
2.5. DISCUSSION	33
3.0. EVALUATION OF POTENTIAL LOCAL ADULT SPILLOVER AND RECRUITMENT SUBSIDIES FROM NO-TAKE MARINE PROTECTED AREAS ON THE GREAT BARRIER REEF.....	37
3.1. ABSTRACT	37
3.2. INTRODUCTION	38
3.3. MATERIALS AND METHODS	42
3.3.1. <i>Study site description</i>	42
3.3.2. <i>Fish surveys</i>	45
3.3.3 <i>Data analysis</i>	46
3.4. RESULTS.....	47
3.4.1. <i>Keppel Islands</i>	47
3.4.2. <i>Palm Islands</i>	56
3.4.3. <i>Benthic cover</i>	64
3.5. DISCUSSION	66
4.0. CONCLUSION	72
5.0. BIBLIOGRAPHY	76

LIST OF FIGURES

FIGURE 1. RELATIONSHIP BETWEEN AGE AND FORK LENGTH OF <i>P. MACULATUS</i> FROM THE KEPPEL ISLANDS.	28
FIGURE 2. RELATIONSHIP BETWEEN AGE AND FORK LENGTH OF <i>L. CARPONOTATUS</i> FROM THE KEPPEL ISLANDS.	29
FIGURE 3. SPAWNING AND SETTLEMENT DATES FOR <i>P. MACULATUS</i> MOST RECENT COHORTS (1^0).	31
FIGURE 4. SPAWNING AND SETTLEMENT DATES FOR <i>L. CARPONOTATUS</i> MOST RECENT COHORTS (1^0).	32
FIGURE 5. MAP OF STUDY SITES FROM THE KEPPEL ISLAND REGION.	43
FIGURE 6. MAP OF STUDY SITES FROM THE PALM ISLAND REGION.	44
FIGURE 7. MEAN TOTAL AND LEGAL-SIZED ABUNDANCE AND BIOMASS FOR <i>P. MACULATUS</i> (A + B) AND <i>L. CARPONOTATUS</i> (C + D) FROM THE KEPPEL ISLAND AND REGION.	50
FIGURE 8. SIZE DISTRIBUTION OF <i>P. MACULATUS</i> FROM THE KEPPEL ISLAND REGION.	53
FIGURE 9. SIZE DISTRIBUTION OF <i>L. CARPONOTATUS</i> FROM THE KEPPEL ISLAND REGION. .	53
FIGURE 10. MEAN ABUNDANCE OF <i>P. MACULATUS</i> (A + C) AND <i>L. CARPONOTATUS</i> (B + D) RECRUITS FROM THE KEPPEL ISLAND AND PALM ISLAND REGION.	54
FIGURE 11. MEAN TOTAL AND LEGAL-SIZED ABUNDANCE AND BIOMASS FOR <i>P. MACULATUS</i> (A + B) AND <i>L. CARPONOTATUS</i> (C + D) FROM THE THE PALM ISLAND REGION.	59
FIGURE 12. SIZE DISTRIBUTION OF <i>P. MACULATUS</i> FROM ALL ZONES IN THE PALM ISLANDS REGION.	62
FIGURE 13. SIZE DISTRIBUTION OF <i>L. CARPONOTATUS</i> FROM ALL ZONES IN THE PALM ISLANDS REGION.	62
FIGURE 14. MEAN PERCENT OF LIVE CORAL COVER WITH MEAN ABUNDANCE OF ADULT FISH FROM THE KEPPEL AND PALM ISLAND REGIONS.	65

LIST OF TABLES

Table 1a. ABUNDANCE OF <i>P. MACULATUS</i> FROM THE KEPPEL ISLANDS	51
Table 1b. LEGAL ABUNDANCE OF <i>P. MACULATUS</i> FROM THE KEPPEL ISLANDS.....	51
Table 2a. BIOMASS OF <i>P. MACULATUS</i> FROM THE KEPPEL ISLANDS.....	51
Table 2b. LEGAL BIOMASS OF <i>P. MACULATUS</i> FROM THE KEPPEL ISLANDS.....	51
Table 3a. ABUNDANCE OF <i>L. CARPONOTATUS</i> FROM THE KEPPEL ISLANDS.....	52
Table 3b. LEGAL ABUNDANCE OF <i>L. CARPONOTATUS</i> FROM THE KEPPEL ISLANDS.....	52
Table 4a. BIOMASS OF <i>L. CARPONOTATUS</i> FROM THE KEPPEL ISLANDS.....	52
Table 4b. LEGAL BIOMASS OF <i>L. CARPONOTATUS</i> FROM THE KEPPEL ISLANDS.....	52
Table 5a. ABUNDANCE OF THE 1° <i>P. MACULATUS</i> 0+ AGE COHORT FROM THE KEPPEL ISLANDS.....	54
Table 5b. ABUNDANCE OF THE 2° <i>P. MACULATUS</i> 0+ AGE COHORT FROM THE KEPPEL ISLANDS.....	54
Table 6a. ABUNDANCE OF THE 1° <i>L. CARPONOTATUS</i> 0+ AGE COHORT FROM THE KEPPEL ISLANDS.....	54
Table 6b. ABUNDANCE OF THE 2° <i>L. CARPONOTATUS</i> 0+ AGE COHORT FROM THE KEPPEL ISLANDS.....	54
Table 7a. ABUNDANCE OF <i>P. MACULATUS</i> FROM THE PALM ISLANDS.....	60
Table 7b. LEGAL ABUNDANCE OF <i>P. MACULATUS</i> FROM THE PALM ISLANDS.....	60
Table 8a. BIOMASS ABUNDANCE OF <i>P. MACULATUS</i> FROM THE PALM ISLANDS.....	60
Table 8b. LEGAL BIOMASS ABUNDANCE OF <i>P. MACULATUS</i> FROM THE PALM ISLANDS.....	60
Table 9a. ABUNDANCE OF <i>L. CARPONOTATUS</i> FROM THE PALM ISLANDS ..	61
Table 9b. LEGAL ABUNDANCE OF <i>L. CARPONOTATUS</i> FROM THE PALM ISLANDS.....	61
Table 10a. BIOMASS OF <i>L. CARPONOTATUS</i> FROM THE PALM ISLANDS.....	61
Table 10b. LEGAL BIOMASS OF <i>L. CARPONOTATUS</i> FROM THE PALM ISLANDS.....	61
Table 11a. ABUNDANCE OF THE 1° <i>P. MACULATUS</i> 0+ AGE COHORT FROM THE PALM ISLANDS.....	63
Table 11b. ABUNDANCE OF THE 2° <i>P. MACULATUS</i> 0+ AGE COHORT FROM THE PALM ISLANDS.....	63
Table 12a. ABUNDANCE OF THE 1° <i>L. CARPONOTATUS</i> 0+ AGE COHORT FROM THE PALM ISLANDS.....	63
Table 12b. ABUNDANCE OF THE 2° <i>L. CARPONOTATUS</i> 0+ AGE COHORT FROM THE PALM ISLANDS.....	63
Table 13a. KEPPEL ISLANDS HABITAT.....	65
Table 13b. PALM ISLANDS HABITAT.....	65

ACKNOWLEDGEMENTS

This study was funded by MTSERF and ARC Centre of Excellence. I am indebted to Geoffrey Jones and Craig Syms for their help in planning this study and comments on the thesis; to Richard Evans, Jacob Johansen, Heidi Luter, Yui Sato, Niklas Taylor and David Williamson for their assistance in the field and to Dong Lou for showing me how to prepare and examine otoliths.