Spatial and temporal patterns of reef-fish assemblages in the Solitary Islands Marine Park and their utility for protected area management

Hamish Alexander Malcolm
Bachelor of Science, University of Waikato, New Zealand
Post Graduate Diploma of Tropical Marine Ecology, James Cook University, Australia

A thesis submitted for the degree of Doctorate of Philosophy of the University of New England

April 2010

Candidates Declaration

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification. I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

....
Signature

Acknowledgements

I dedicate this study to my late father, Frank Malcolm.

This study was carried out through my position as research officer at the Solitary Islands Marine Park (SIMP), NSW Marine Parks Authority, NSW Department of Environment, Climate Change and Water (DECCW), and was internally funded as part of the core research program in the SIMP.

I would particularly like to thank my supervisor Associate Professor Steve Smith and co-supervisor Alan Jordan for their friendship, support, and everything they have taught me. I have also learnt a considerable amount from the other authors on the journal papers comprising the chapters in this study. This includes Bill Gladstone, Tim Lynch, Steve Lindfield, James Wraith, Peter Davies, Edwina Mesley, Sam Hesse, and Tim Ingleton. I am greatly indebted to you all.

Massive thanks to the many people who have assisted with the field work in this study. In particular, Rob Thorman and Toby Waters, my main dive crew, who've made many days at sea over the past 6 years good fun. I've also had the great fortune to work in the field with Nicola Johnstone, Brett Vercoe, Pat Sachs, Matt Carr, Libby Sterling, Jackie Corlass, Vanessa Mansbridge, David Greenhalgh, Ben Quigley, Christo, Rick and Greg from DiveQuest, Daniella Marks, Paul Butcher and many others who've also been a fantastic help. Thanks those who have helped with technical advice and support, including Mike Cappo and the Australian Institute of Marine Science (AIMS) for baited video (BRUV); Ray Berkelmans (AIMS) for sea-temperature monitoring; Edwina Mesley and Sam Hesse for GIS and spatial analysis; graphics support by Deb Wall; and Marxan support from the Ecology Centre, University of Queensland, especially Lindsay Kircher. Sea temperature monitoring has included collaborative projects with SURG (Solitary Islands Underwater Research Group), AIMS, Northern Rivers Catchment Management Authority (NRCMA) and the National Marine Science Centre (NMSC). Thank you examiners for your time in marking this thesis and the constructive criticism you have provided.

I would also like to thank Libby Sterling, my original manager when I commenced this study, Nicola Johnstone, my manager for the past 3 years, and the whole SIMP team for their ongoing support and friendship. My father and mother, Moira, provided me with a sense of self-belief and a good work ethic, essential

ingredients for completing a PhD. My wife Carol, and my children Kate and Jack, have provided me the determination to complete this study and to look on the bright side of life. A lot has gone down over the past six years for us personally and completing this body of work has taken some deep breaths at times with ‘harden up’ as a mantra (or a couple of teaspoons of cement as Toby would say). Luckily the sea and its inhabitants are an incredible source of inspiration.

ABSTRACT

Understanding of biotic patterns is essential to effectively plan for biodiversity conservation in a marine park. Reef fish are an important component of biodiversity in coastal systems, but were poorly known within the Solitary Islands Marine Park (SIMP). Their patterns, determined at the marine park scale, have utility in testing a Habitat Classification System (HCS) used in conservation planning. No other biota has been studied comprehensively at this scale in the SIMP.

Reef fish assemblages were broadly sampled across the SIMP using diver timed counts and baited video. Assemblage patterns correlated with environmental factors were used to refine categories in the HCS. The refined-HCS and patterns of species-richness, abundance, and biogeography were assessed for representation in sanctuary zones (SZ). Temporal stability was examined and bioregional comparisons were made with other studies. Surrogate families representing assemblage patterns were objectively selected. An algorithm approach (Marxan) was used to systematically evaluate solutions in zone planning.

Over 330 reef fish species were recorded; 90% rarely. Many were not previously recorded from the SIMP. More than 50% were tropical, although the most-abundant were predominantly temperate or subtropical. Distinct cross-shelf patterns in assemblages were incorporated as refined-HCS categories (inshore <1.5 km, mid-shelf, and offshore >6 km from the coast) for shallow reef. Inshore had the strongest temperate-influence and the highest levels of endemism. Offshore had the strongest Indo-Pacific tropical-influence and the highest species-richness, particularly associated with islands. Intermediate-depth assemblages separated from shallow at 25 m and showed a cross-shelf pattern. Deep assemblages, only found offshore,

separated from intermediate assemblages at 50 m. There is no representation of deep reef in SZ. Assemblage patterns were found to be stable at the marine park scale over years. An assemblage recorded in the SIMP was different from marine parks in bioregions further south, supporting this regionalisation. The families Labridae and Pomacentridae combined were an effective surrogate to represent assemblage patterns of reef fish. From Marxan analyses, some areas are 'hotspots' for representation. Areas of deeper habitat should be included in SZ with a large cross-shelf transect in at least one of the two positions at which the SIMP is broadest.

TABLE OF CONTENTS