Spatial patterns in population biology of a large coral reef fish: What role can movement play?

Thesis submitted by

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Abstract

Recent empirical studies have demonstrated significant spatial variation in the population biology of coral reef fish. The scales at which this variation occurs often depend on the species and processes that are examined. Most research on coral reef fish population biology has focussed on relatively small, site-attached species and results from such research often indicate variations in population biology at localised spatial scales, such as 10's to 100's or 1000's of meters. There have been fewer studies of large reef fish species and, consequently, little is known of the spatial patterns in population biology of large reef fish. Large reef fish are generally thought to be more mobile and have larger home ranges than small reef fish species. Therefore, the spatial scales that define intermixed populations of large reef fish may differ from those at which small reef fish vary. Furthermore, large reef fish species are often the targets for commercial and recreational fisheries. Information on the spatial patterns in population biology of harvested species will be of particular importance for fisheries management, as population responses to fishing pressure and different management strategies will vary among populations with different dynamics. Within this context, the broad objectives of this thesis were to:

1) Estimate a number of reproductive parameters, including spawning season, maturity schedules and size and age at sex change for the red throat emperor (*Lethrinus miniatus*) and compare the parameters between the northern and southern areas of the distribution of *L. miniatus* on the Great Barrier Reef (GBR);

2) Estimate rates of growth and mortality for *L. miniatus* and compare these parameters within and among three regions of the GBR over a temporal scale of five years; and

3) Explore the potential for large-scale movement of post-settlement *L. miniatus* to explain the observed spatial patterns in population age structures.

Estimates of population parameters for these objectives required reliable estimates of age. Accordingly, age estimates of *L. miniatus* were first validated using marginal increment analysis (MIA) and captive rearing of chemically tagged fish. The MIA was achieved by obtaining monthly samples of *L. miniatus* from commercial line fishing vessels from the northern and southern areas of the GBR. Fish that were chemically tagged and reared in an aquarium were also collected from a commercial fishing vessel. Opaque increments in the otoliths of *L. miniatus* were found to be deposited on an annual basis, but the timing of formation varied slightly between years and areas.

Reproductive parameters (Objective 1) were derived from the monthly samples collected from the commercial fleet. A peak spawning season was observed between July and October in both the northern and southern areas of the distribution of *L. miniatus* on the GBR. The proportion of spawning females, however, was greater in the northern area than in the southern area. The size at which *L. miniatus* changed sex from female to male was significantly larger in the southern area, but there were no spatial differences in the age at sex change. The size and age at maturity were estimated to be 180 mm FL and 1.2 years respectively, but data were insufficient to allow spatial comparisons of these parameters.

Spatial patterns in growth and mortality of *L. miniatus* (Objective 2) were estimated from annual samples of populations of *L. miniatus* from four reefs within three regions of the GBR (Townsville, Mackay and Storm Cay) over a period of five years. Growth rates were found to vary among years but this variation was consistent among regions and reefs. Mortality rates were consistent among cohorts within each region and reef. Rates of growth and mortality were relatively similar at the spatial scale of individual reefs within regions but differed significantly among regions. This regional variation was consistent over years. The Townsville (northern-most) region was characterised by the smallest maximum size, and lowest rates of mortality. In contrast, the Mackay region was characterised by the largest maximum size, and highest rates of mortality. Rates of growth and mortality for the Storm Cay (southern-most) region were intermediate between the other two regions.

The potential for migration of *L. miniatus* to contribute to the observed patterns in population parameters (Objective 3) was explored by developing an age structured model for *L. miniatus* populations from the Townsville, Mackay and Storm Cay regions of the GBR, using the empirical data collected from the annual regional samples. Model age structures were compared with observed age structures to determine the net movement that would be required to explain the significant regional variations in age structure. The model predicted significant immigration to the Townsville region of fish aged from three to 10 years and significant emigration of fish aged three and four years from the Mackay region. Predicted net movement in the

Storm Cay region was negligible, although immigration of a small number of seven year old fish was predicted under some model scenarios. A number of hypotheses that might explain the model results are discussed. The results from this thesis highlight the need to determine the spatial scales at which all demographic processes operate, including movement, to obtain reliable estimates of population structure and provide the most useful information with which to optimise harvest strategies for reef fish.

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