TITLE PAGE

The structure and dynamics of spawning aggregations of coral reef fish

Thesis submitted by

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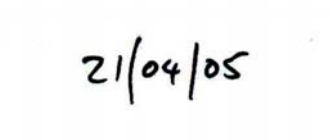

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STATEMENT ON CONTRIBUTION OF OTHERS

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ABSTRACT

The broad objective of this thesis is to improve the general understanding of the structure and dynamics of spawning aggregations of coral reef fish The specific aims are to identify and characterise: (1) the species of coral reef fishes that formed spawning aggregations, (2) the locations where spawning aggregations were formed, (3) the periodicity with which these aggregations were formed, and (4) individuals' patterns of migration to spawning aggregation sites. All fieldwork was conducted on the inshore reefs of Kimbe Bay, New Britain, Papua New Guinea ($5^{o}30'$S $150^{o}6'$E).

Spawning aggregations of reef fish were located by intensively searching areas of reef on snorkel at all times of the day from before dawn to after dusk. After >2,000hours of observations made between June 2001 to May 2004, 37 species from 6 families were observed forming spawning aggregations at 38 sites spread over 7 reefs. All species were relatively large (none <10cm max T.L.) and all but one species spawned pelagically. There was no relationship between a species' population density and whether it formed spawning aggregations, nor was spawning aggregation formation itself a density dependent phenomenon, with aggregations ranging in size from 3 to 2000 individuals. Most spawning aggregation sites were used by multiple species, with a maximum of 27 species spawning aggregatively at one site of <10x10m.

A selection of spawning aggregation sites were monitored on 3 reefs in order to establish the periodicities with which different species spawned. Of the 13 species for which such periodicities could be established, spawning occurred year round, and all but one species spawned during all 4 lunar quarters. Spawning occurred more often during high tides, but no species spawned predictably more often during either ebb or flood tides. Aggregative spawning was seen at times ranging from dawn (05:45hrs) to dusk (18:00hrs). However, each species had a fixed diel interval during which it spawned. For all species this interval spanned no more than 6 hours, but for most it was less than 2. For the one species with enough data for analysis, *Ctenochaetus striatus*, this diel spawning interval differed significantly between sites within reefs.

The physical and biotic characteristics found at spawning aggregation sites of *Ctenochaetus striatus* were compared to those found at alternative sites. Within spawning aggregation sites, characteristics that varied temporally were compared between times of spawning and times of no spawning. It was predicted that spawning aggregations would be formed at sites and times with characteristics that limited predation on both spawning adults and their pelagically spawned eggs. Characteristics predicted to reduce predation on eggs included: seaward projecting margins of reef, steep slopes, currents flowing rapidly off-reef (as measured by purpose-built devices), and low densities of planktivores. Characteristics predicted to reduce predation on adults included: topographically complex substratum with a large number of holes providing refuge from predators, and low densities of piscivorous fish. The only physical feature consistently distinguishing spawning aggregation sites from alternative locations was that they were found on margins of reef that projected seawards, rather than flatter or concave margins. However, many seaward projections were not used as spawning aggregation sites, and any potential anti-predatory benefit from this feature was likely to be outweighed by: (1) the greater biomasses of planktivores found at spawning aggregation sites, (2) the frequently observed predation on recently spawned eggs, and (3) certain species of egg predator being attracted to spawning aggregation sites at times of spawning. Spawning aggregations were not formed at distinctive sites with regard to current speed or direction, and there was no difference between the currents at times of aggregative spawning and those at other times within sites.

Individuals' patterns of migration from home ranges to spawning aggregations were documented following an extensive tagging program of *Ctenochaetus striatus*. Tagged individuals were consistently resighted within limited home ranges (max. diameter averaging <13m). Tagged individuals were seen in spawning aggregations on a total of 549 occasions at 13 sites on 3 reefs. The maximum distance migrated was 291m. No tagged individuals were witnessed spawning at more than one site. Most resighted individuals migrated to the spawning aggregation site that was closest to their home range. However, the few individuals that migrated to sites further away always spawned at sites where the spawning aggregation was larger than that found closest to their home

range. Neither the size nor the sex of individuals limited migration distance. However, males migrated more frequently than females, and larger females migrated more frequently than smaller ones. Migration distance did not affect the frequency with which individuals spawned.

The notion that spawning aggregations are formed at intrinsically beneficial sites and times is not supported by the results of this study. Strong theoretical arguments are proposed that question the mechanisms by which such adaptation could arise. It is concluded that the sites and times of spawning aggregation formation in *Ctenochaetus striatus* in Kimbe Bay are not adaptive beyond their clarity as cues that enable conspecifics from home ranges with limited or no overlap to synchronise spawning in space and time. Patterns of spawning aggregation formation and migration suggest that tradition plays a more significant role than resource assessment in determining where and when individuals spawn. The use of small species of aggregative spawners as biological models has the potential to greatly enhance understanding of spawning aggregation formation in certain species of commercially exploited reef fish.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES