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**ABUNDANCE, DEMOGRAPHY AND POPULATION STRUCTURE OF THE
GREY REEF SHARK (*CARCHARHINUS AMBLYRHYNCHOS*) AND THE
WHITETIP REEF SHARK (*TRIAENODON OBESUS*)
(FAM. CARCHARHINIDAE)**

Thesis submitted by
William David ROBBINS B.Sc (Hons)
April 2006

For the degree of Doctor of Philosophy in Marine Biology
School of Marine Biology and Aquaculture
James Cook University

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CONTRIBUTION OF OTHERS TO THIS THESIS

Corey Green (Primary Industries, Victoria):

- Photography of sectioned oxytetracyclined vertebrae (Chapter 3)

Ashley Williams (James Cook Uni):

- Excel growth model fit macro (Chapter 3)

Mizue Hisano & Sean Connolly (James Cook Uni):

- “R” code for maximum likelihood tests of reef/zone abundance data (Chapter 2)
- “R” code for fitting logistic bootstraps to maturity data (Chapter 4)
- “R” code for fitting saturation curves to *Carcharhinus amblyrhynchos* litter size (Chapter 4)

Sue Reilly (James Cook Uni):

- Histological expertise in preparing and sectioning shark gonads (Chapter 4)

Jenny Giles (CSIRO):

- *T. obesus* tissue samples from Bali (Chapter 7)

Richard Fitzpatrick and Andy Dunstan (MV *Undersea explorer*):

- *T. obesus* tissue samples from Osprey reef (Chapter 7)

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Thesis abstract.

Reef sharks (fam. Carcharhinidae) are high-order predators, found throughout the Indo-Pacific. I examined the abundance, growth, reproduction and demography of two species of reef carcharhinid; the grey reef shark (*Carcharhinus amblyrhynchos*) and the whitetip reef shark (*Triaenodon obesus*), and investigated the genetic stock structure of *T. obesus* across the Indo-Pacific.

Underwater visual census protocols were successfully developed, and provided real-time, fisheries-independent estimates of reef carcharhinid abundances. Visual censusing of a minimally-exploited reef system ascertained that reef crest was the preferred habitat of *T. obesus* and *C. amblyrhynchos*, while the blacktip reef shark (*C. melanopterus*) was more abundant in reef flat and lagoon habitats. Reef carcharhinid densities were low, and even in the most abundant habitat, did not exceed 3.5 sharks hectare⁻¹. Visual censuses across reef systems in the Indian and Pacific Oceans found consistently low numbers of reef sharks, with most regions having less than 0.5 sharks hectare⁻¹. Closer investigation of the Great Barrier Reef (Australia) revealed a significant effect of fishing management on reef shark abundance. All levels of fishing pressure impacted upon reef carcharhinid abundance, with reductions on fished reefs of up to 80% and 97% for *T. obesus* and *C. amblyrhynchos*, respectively. This suggests that reef shark populations are particularly vulnerable to population depletion. The inability of marine protected areas to provide refuge for reef carcharhinids was highlighted and discussed.

Age and growth characteristics of *T. obesus* and *C. amblyrhynchos* populations from the Great Barrier Reef were examined through vertebral thin sections. Both shark species

grew slowly, with longevities of 19 years. Females out-lived males in both species. Both sexes of *C. amblyrhynchos* grew at similar rates, while sexually-dimorphic growth rates were observed in older *T. obesus*. Age estimates were preliminarily validated through oxytetracyclined recaptures of *C. amblyrhynchos*, while characterisation of the vertebral edge provided strong evidence that *T. obesus* also lays annual growth bands.

Females matured 1-2 years later than males, at 8 and 11 years for *T. obesus* and *C. amblyrhynchos*, respectively. Mean litter sizes were comparable with smaller (<1 m) carcharhinids. Litter sizes initially increased with female body size in *C. amblyrhynchos*, reaching 3-4 pups per breeding for most of their reproductive life. Litter sizes ranged between 1-4 pups per breeding in *T. obesus*, with a mean of 2 pups per breeding, irrespective of female somatic size. Breeding occurs biennially in both species, with an offspring sex ratio of 1:1. For the longevities recorded, maximum reproductive output was estimated at 12 pups per female for both species.

Population dynamics of the two species were analysed using age-based (Leslie) matrices. Using two methods of mortality estimation, annual decline rates of 6.3-8.8% year⁻¹ and 10.3-15.2% year⁻¹ were found for *T. obesus* and *C. amblyrhynchos*, respectively. This suggests that reef carcharhinids are overfished on the Great Barrier Reef. Based on current (albeit exploited) demographic parameters, the natural rates of population growth were estimated at 3.4-5.7% year⁻¹ for *T. obesus*, and 0.8-3.5% year⁻¹ for *C. amblyrhynchos*. Elasticity analyses and reproductive values showed that juvenile survival is the most important component of each species lifespan. However, catch analyses revealed that a high proportion of juveniles are taken in both species (especially *C. amblyrhynchos*). At the current rates of decline, abundances of *T. obesus*

and *C. amblyrhynchos* are forecast to decline to 16-27% and 4-12% of current levels on fished reefs in the next 20 years, respectively.

Development of an *in-situ* underwater biopsy probe enabled non-lethal, minimally invasive, collection of reef carcharhinid tissues. High levels of genetic differentiation were found in *T. obesus* across the Indo-Pacific, as well as between two contiguous sites on the Great Barrier Reef. Genetic separation did not correlate with geographic separation, suggesting that *T. obesus* has a high degree of site fidelity on coral reefs, even when migrations are possible. On an evolutionary scale, it was found that the Indian Ocean was invaded first by *T. obesus*, with Pacific Ocean invasion occurring simultaneously with a second Indian Ocean invasion.

The unique combination of fisheries-independent abundance counts, population dynamics and investigation of genetic stock structure provides a comprehensive overview of the low abundance and slow population dynamics of coral reef carcharhinids. Findings from this PhD provide further evidence of the variety of age and reproductive strategies employed by the family Carcharhinidae, and a scientific basis for future decisions regarding reef carcharhinid management.