LIFE HISTORIES OF COMMERCIALLY IMPORTANT TROPICAL SHARKS FROM THE GREAT BARRIER REEF WORLD HERITAGE AREA

Thesis submitted by
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in August 2011

For the degree of Doctor of Philosophy
in the School of Earth & Environmental Sciences
James Cook University
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CONTRIBUTIONS OF OTHERS TO THIS THESIS

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- Fisheries observer data for the Queensland East Coast Inshore Finfish Fishery (Chapter 2)

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- Eleven *Sphyrna lewini* vertebrae samples (Chapter 4)

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- Vertebrae samples and reproductive data from 43 *S. lewini* and 12 *S. mokarran* (Chapter 4)

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- Vertebrae samples from one *S. mokarran* (Chapter 4)

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- Vertebrae and reproductive samples from fourteen *S. lewini* and seven *S. mokarran* including an individual injected with calcein for age validation (Chapter 4)

Funding sources:

- Department of Education, Employment and Workplace Relations for an Australian Postgraduate Award research stipend
- Marine and Tropical Scientific Research Facility for research funding and top-up research stipend
- Great Barrier Reef Marine Park Authority for funding through the Science for Management scheme
- School of Earth & Environmental Sciences for three small grants through the Postgraduate Research Grants scheme
- Oceania Chondrichthyan Society for a travel award
- Australian Society for Fish Biology for a travel award

PUBLICATIONS ARISING FROM THIS THESIS

First-authored publications:

Chapter 2. Harry, A.V., Tobin, A.J., Simpfendorfer, C.A., Welch, D.J., Mapleston, A., White, J., Williams, A.J., Stapley, J., **2011**. Evaluating catch and mitigating risk in a multi-species, tropical, inshore shark fishery within the Great Barrier Reef World Heritage Area. Mar. Freshw. Res. 62, 710-721.

Chapter 3. Harry, A.V., Simpfendorfer, C.A., Tobin, A.J., **2010**. Improving age, growth, and maturity estimates for aseasonally reproducing chondrichthyans. Fish. Res. 106, 393-403.

Chapter 4. Harry, A.V., Macbeth, W.G., Gutteridge, A.N., Simpfendorfer, C.A., **2011**. The life histories of endangered hammerhead sharks (Carcharhiniformes, Sphyrnidae) from the east coast of Australia. J. Fish Biol.78, 2026-2051.

Chapter 5. Harry, A.V., Ovenden, J.R., Morgan, J.A.T., Welch, D.J., Tobin, A.J., and Simpfendorfer, C.A. **In Prep.** Vertebral counts highlight a disparity in current genetic methods used to distinguish between morphologically similar Australian blacktip shark (*Carcharhinus tilstoni*) and common blacktip shark (*C. limbatus*). J. Fish Biol.

Chapter 6. Harry, A.V., and Simpfendorfer **In prep.** Age, growth and reproductive biology of two commercially important Carcharhinid sharks from the Great Barrier Reef World Heritage Area. Mar. Freshw. Res.

Chapter 7. Harry, A.V., and Simpfendorfer, C.A. **In prep.** Evaluating the perils and possibilities associated with sex-biased harvesting of widely distributed sharks. Conserv. Biol.

Co-authored publications:

Morgan, J. A., **Harry, A. V.**, Welch, D. J., Street, R., Geraghty, P. T., Macbeth, W. G., Tobin, A., Simpfendorfer, C. A. & Ovenden, J. R. (Accepted). Detection of interspecies hybridisation in Chondrichthyes: First generation hybrids (and offspring of hybrids) between Australian (*Carcharhinus tilstoni*) and Common blacktip shark (*C. limbatus*) found in the Australian fishery. Conserv. Genet.

Morgan, J. A. T., Welch, D. J., **Harry, A. V.**, Street, R., Broderick, D. & Ovenden, J. R. (2011). A mitochondrial species identification assay for Australian blacktip sharks (*Carcharhinus tilstoni*, *C. limbatus* and *C. amblyrhynchoides*) using real-time PCR and high-resolution melt analysis. Mol. Ecol. Resour. 10.1111/j.1755-0998.2011.03023.x

Technical publications:

Tobin, A. J., Simpfendorfer, C. A., Mapleston, A., Currey, L., **Harry, A. V.,** Welch, D. J., Ballagh, A. C., Chin, A., Szczecinski, N., Schlaff, A. & White, J. (2010). A quantitative ecological risk assessment of sharks and finfish of Great Barrier Reef World Heritage Area inshore waters: A tool for fisheries and marine park managers identifying species at risk and potential mitigation strategies. p. 44. Cairns: Marine and Tropical Scientific Research Facility.

Welch, D. J., Ovenden, J., Simpfendorfer, C., Tobin, A., Morgan, J. A. T., Street, R., White, J., **Harry, A. V**., Schroeder, R. & Macbeth, W. G. (2010). Stock structure of exploited shark species in north eastern Australia. Report to the Fisheries Research & Development Corporation, Project 2007/035. Fishing & Fisheries Research Centre Technical Report No. 12,. p. 130. Townsville, Australia: James Cook University.

PRESENTATION OF RESEARCH FROM THIS THESIS

Research from this thesis was presented at the following conferences or forums:

- 2008. Poster presentation, Oceania Chondrichthyan Society. "Reproductive biology of Queensland's tropical inshore Carcharhiniformes. Preliminary findings on six commercially important species and a comparison with northern Australian populations."
- 2008. Oral presentation. School of Earth & Environmental Sciences Postgraduate Research Conference. "The life of the scalloped hammerhead, *Sphyrna lewini*, in Queensland waters."
- 2009. Oral presentation. School of Earth & Environmental Sciences seminar series. "The life history of hammerhead sharks in the GBRWHA."
- 2009. Oral presentation. 8th Indo Pacific Fish Conference."The life history of two hammerhead species in the GBRWHA."
- 2009. Poster presentation. Marine and Tropical Scientific Research Facility Conference. "The life history of two hammerhead species in the GBRWHA."
- 2009. Poster presentation. Australian National Network in Marine Science "The life history of two hammerhead species in the GBRWHA."
- 2010. Oral presentation. Australian National Network in Marine Science "Assessing and mitigating the risk of overexploitation to tropical Carcharhiniform sharks posed by inshore fisheries."
- 2010. Oral presentation. Sharks International conference. "Assessing and mitigating the risk of overexploitation to tropical Carcharhiniform sharks posed by inshore fisheries."

ACKNOWLEDGEMENTS

Doing a PhD has been a thoroughly enlightening, but undeniably self-indulgent experience. After four years satisfying my passion and curiosity for things that swim, there is a long list of people that I need to thank for the opportunity. Not putting my parents at the top of this list would be a great disservice; they have always given me unconditional love and support and I can't imagine how challenging it would have been without their help.

Over the course of my PhD I have had three supervisors, all of who have been pleasures to work with and who have supported and facilitated my professional development in every way possible. Ashley Williams, my original supervisor, welcomed me to JCU and offered me an adequately resourced, adequately funded, and well-planned research project. I rapidly came to realise that PhD projects of this nature are a rare commodity and I am glad to have had one. Andrew Tobin took over from Ash in 2008 and I feel privileged to have had him as a supervisor. I don't know any other researcher whose work is so firmly grounded and guided by empirical observation, and this has been a great asset. I am especially grateful to my main supervisor, Colin Simpfendorfer who has been unceasingly generous in sharing with me his time and knowledge, and who has opened countless doors to new opportunities for me. I look forward to working with all of you in the future.

My research project itself would not have been possible without the support of everyone at the Fishing & Fisheries Research Centre who helped with my endless amount of both lab work and field work. Specifically I would like to thank Dave Welch, Amos Mapleston, Cynthia Awruch, Ann Penny, Leanne Currey, Aaron Ballagh, Audrey Schlaff and Olivier Bittar. I would also like to thank my fellow graduate students who have helped me out along the way, especially Andrew Chin, Jimmy White, Ron Schroeder, Natasha Szczecinski, Danielle Knip, Mike Kinney and Saskia Dejong, as well as Adrian Gutteridge for providing moral support during my write-up. So many volunteers helped out during our research sampling, and while I can't name everyone, I am grateful for their help. Beyond the FFRC, I would also like to express my gratitude to the School of Earth & Environmental Sciences for providing a supportive environment for research students. In particular I would like to thank Paul Dirks, Glen Connolly, Beth Moore, Clive Grant, Ralph Botting, Rob Scott and Paul Givney for all your assistance throughout my PhD.

Working with the fishers of the Queensland East Coast Inshore Finfish Fishery has been a rewarding experience that has broadened my perspective on my research and my life. I would like to thank all commercial fishers who contributed samples or allowed us onto their boats. Obtaining samples and data was probably the greatest challenge of this PhD, but would have been much harder if not for the generosity of a larger number of fishermen. In particular I would like to thank Greg Radley and Tony Wiseman for regularly having me onboard the Sandalee and allowing me to sample their catch to my heart's content.

Finally I wish to thank all of my family/friends in Townsville. Townsville is not always the most exciting place in the world to live, and surrounding yourself with good people is essential for maintaining a stable mental state. Thank you to my girlfriend Daniela especially, for putting up with my general grumpiness on a day to day basis, and tolerating me even when I insist on doing work on the weekends. Thank you also to Tom, Pip and Fernanda in particular for the good times already had and those still to come.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Abstract

Elasmobranchs (sharks and rays) are captured by a number of coastal fisheries operating across tropical northern Australia. As they are typically not targeted by these fisheries, accurate data on their biology and composition in the catch is often lacking, impeding sustainable use and management. Effective fisheries management is particularly important for elasmobranch populations as they often have biological characteristics that make them susceptible to overfishing and slow to recover once overfishing has occurred.

The largest extractive fishery for sharks in Queensland waters is the East Coast Inshore Finfish Fishery (ECIFF). In 2011 the commercial gillnet sector of this fishery had a total allowable catch (TAC) of 600 t, although catches rates were as high as 1400 $t.yr^{-1}$ in 2004, prior to the introduction of a TAC. The large geographic area, relatively low value, and disparate nature of the ECIFF mean monitoring of the catch is difficult. Yet as the fishery occurs predominantly within the Great Barrier Reef World Heritage Area (GBRWHA), it is closely scrutinised by the general public and stakeholder groups (e.g. marine park management, tourism, conservation groups). Effective and defensible science-based management is therefore especially important for the ECIFF.

Between 2006 and 2009 an onboard vessel observer survey program was undertaken on the ECIFF with the goal of obtaining biological information that could be used to help manage, in particular, the shark component of the fishery. The observer survey was the most extensive ever undertaken on the fishery and covered the three major habitats in which the fishery operates; river (estuarine), intertidal (0 – 2 m depth) and inshore coastal (2 – 25 m depth). At least 38 species of elasmobranchs were found to occur within the fishery, however the catch was dominated by Carcharhiniformes; 95% of individuals were from 25 species of the families Carcharhinidae, Hemigaleidae and Sphyrnidae. The main carcharhinform taxa could be qualitatively categorised into four groups based on similar catch characteristics and life history traits: small coastal species (<1000 mm) were captured primarily as adults, moderate sized coastal species (1000–2000 mm) were captured at all sizes, large coastal semi-pelagic species (>2000 mm) were captured primarily as neonates or juveniles, and hammerheads were captured at all sizes.

The life history characteristics of five species occurring in the fishery were investigated in detail using biological samples collected during the observer program, from fishery-independent

sampling, and from purchase or donation from commercial fishers. The milk shark, *Rhizoprionodon acutus* was the fourth largest component of the elasmobranch catch by number in the ECIFF, making up 7.8 % of all carcharhiniform sharks caught. Growth was rapid in this species; von Bertalanffy growth parameters for males were L_∞ = 821 mm, k = 0.94 and L_0 = 424 mm and for females were L_∞ = 859 mm, k = 0.63 and L_0 = 423 mm. Females and males attained a maximum age of 8.1 and 4.5 years, respectively. The size at which 50% of females and males were mature was 780 and 742 mm, respectively. The age at which 50% of females and males were mature was 1.8 and 1.1 years of age, respectively. Despite being widely distributed globally and heavily exploited throughout its range, these are the first comprehensive estimates of age, growth and maturity for this species.

The life histories of two globally endangered hammerhead sharks captured by the ECIFF were also examined in detail. The scalloped hammerhead, *Sphyrna lewini* and the great hammerhead, *S. mokarran*, were the fourth and third largest components of the elasmobranch catch by weight in the ECIFF. The catch of *S. lewini* was heavily biased towards males and significant differences in growth and maturity characteristics were found between those occurring within the GBRWHA and individuals sampled from temperate waters off northern New South Wales. The life history of females was difficult to establish as adults could not be sourced from any fishery. The best-fit estimates for a three-parameter von Bertalanffy growth curve fit to both sexes were L_∞ = 3312 mm, L_0 = 584 mm and k = 0.076. Males attained a maximum age of at least 21 years while the longevity of females could not be determined. For *S. mokarran*, the best-fit growth parameters for a two parameter von Bertalanffy growth curve fit to both sexes and assuming a fixed size at birth (L_0) of 700 mm, were L_∞ = 4027 mm, and k = 0.079. Females lived to at least 39.1 years and males to at least 31.7 years. Length and age at 50% maturity was not significantly different between sexes and occurred at 2279 mm and 8.3 years.

The spot-tail shark, *C. sorrah*, is the second most important component of the elasmobranch catch in the ECIFF both by number and weight. For *C. sorrah* the best-fit growth parameters for a two parameter von Bertalanffy growth function with a fixed length at birth (L_0) of 550 mm were L_∞ = 1085 mm, and k = 0 5513 for males and L_∞ = 1265 mm, and k = 0 3389 for females. Growth was not sexually dimorphic prior to reaching maturity and as such 50% maturity occurred at 933 mm and 2.3 years in both sexes. Fifty percent maternity occurred at 1029 mm and 3.4 years indicating females began reproducing 1–2 years after reaching maturity. Males attained a maximum age of at least 9 years and females at least 14 years. Females had an annual, synchronous reproductive

cycle with ovulation occurring in March and parturition in early December after a gestation period of approximately 9 months. Females gave birth to between 1 and 6 pups of approximately 550 mm in length, and there was an increasing relationship between maternal length and fecundity.

The largest component of the elasmobranch catch in the ECIFF was the Australian blacktip shark, *C. tilstoni*. However, analysis of the life history of this species was confounded by the presence of the morphologically similar common blacktip shark, *C. limbatus.* Genetic methods were used to distinguish between these species, however a mismatch was found between identification using genetics and identification by vertebral counts. This mismatch was thought to be due to hybridisation between the two species. As there was no clear way to distinguish between the two species, a multi-faceted approach to species identification was developed.

Following this, best fit growth parameters for *C. tilstoni* using a two parameter von Bertalanffy growth function with a fixed length at birth (L_0) of 619 mm were L_∞ = 1748 mm, and k = 0.137 for males and L_∞ = 2138 mm, and k = 0.099 for females. However, growth was more accurately described by a two-phase variant of the von Bertalanffy growth function that suggested a cessation in growth occurs around 4.1–4.5 years of age. Like *C. sorrah,* growth was not sexually dimorphic prior to maturity and 50% maturity occurred at 1208 mm and 5.5 years in both sexes. Fifty percent maternity occurred at 1374 mm and 7.5 years indicating that females began reproducing approximately 2 years after maturity. *Carcharhinus tilstoni* has an annual, synchronous reproductive cycle, with ovulation occurring in March and parturition in early December after a gestation period of approximately 9 months. Females gave birth to between 1 and 7 pups with a mean size at birth of 621 mm.

The carcharhiniform sharks captured by the Queensland ECIFF display a range of life history characteristics ranging from small (<1000 mm) and rapidly growing (k = 0.94) species such as *R. acutus* to large (>4000 mm) and slow growing (k = 0.079) species such as *S. mokarran*. An appreciation of these life history characteristics is essential in data deficient fisheries such as the ECIFF where the productivity of captured species differs greatly and some species may be more vulnerable to overexploitation than others. This highlights the importance of ongoing studies on life history of sharks. The new life history data from the research should be used to help improve the management of the ECIFF and can help provide a sounder biological basis for decision making.