The ecology and conservation of green turtles (*Chelonia mydas*) in New Zealand

A thesis submitted in partial fulfilment of the requirements

for the degree of

Doctor of Philosophy in Marine Ecology

at Massey University, Albany, New Zealand

Daniel A. Godoy

2016

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Frontispiece

In the southwestern Pacific Ocean at the edge of their range, post-pelagic green turtles (*Chelonia mydas*) recruit into neritic developmental habitats of northern New Zealand. Photo cover of New Zealand Journal of Marine and Freshwater Research 2016, 50(4), 549-565, courtesy of Steve Hathaway.

Abstract

Historically, little consideration has been given to the occurrence, ecology or conservation of the green turtle (*Chelonia mydas*) in temperate New Zealand. Located geographically at the southern boundary of the distributional range of green turtles in the southwestern Pacific, reports of this species in New Zealand are often overlooked as occasional visitors or stragglers incidentally carried by ocean currents. This convention may be reasonable when considering the temperature constrained distribution of this poikilothermic marine reptile. Despite this, green turtles have been reported in New Zealand waters for more than 100 years, yet no study has undertaken any in depth investigation as to their occurrence in this region. Therefore, this thesis investigated the presence of green turtles in New Zealand waters to test the hypothesis that their occurrence is ephemeral and incidental.

Opportunistic data and samples collected between 1895 and 2013 was collated, reviewed and analysed to investigate several lines of empirical enquiry, including spatio-temporal distribution, population structure, genetic origin, diet composition and anthropogenic effects. Sighting, stranding, and incidental capture revealed a year round presence of post-pelagic immature juveniles to large sub-adult green turtles across northern New Zealand (ca. 34°-38° S). Such occurrence exists despite sea surface temperatures averaging only 14 °C during austral winters. The aggregation exhibited a female:male sex ratio of 1.7:1 which is similar to that reported from proximate warm temperate foraging grounds in eastern Australia. Size frequency data indicated that green turtles recruit to neritic habitats of the North Island at ca. 40.8 cm curved carapace length. This reflects a natural post-oceanic settlement pattern rather than oceanic-phase stragglers incidentally blown ashore by storm and other stochastic events. Supporting this rationale for natural recruitment, diet component data demonstrates that once green turtles settle into New Zealand's nearshore coastal habitats, they transition to a benthic foraging strategy. Notably, green turtles in New Zealand do not ontogenetically transition from omnivory to obligate herbivory with age, but instead consume a variable diet of primarily macroalgae and benthic macro invertebrates. Overall, the confirmation

of feeding in New Zealand substantially extends the southern foraging limit for green turtles in the Pacific Ocean.

Genetic analyses of ~770 base pair sequences of mitochondrial (mt) DNA was conducted on 42 stranded green turtles to characterize the genetic structure of this aggregation. Results identified 15 haplotypes including one orphan haplotype from widely dispersed green turtle stocks across the western, central, and eastern Pacific Ocean. When compared to other regional nesting rookeries and foraging grounds, the New Zealand aggregation exemplified its unique composition, predominantly due to the large proportion of haplotypes from the endemic eastern Pacific clade. These results provide a genetic link to east Pacific stocks in the southwestern Pacific; identifying previously undefined regional connectivity and trans-oceanic dispersal for eastern Pacific green turtles.

In order to assess potential human impacts, gross necropsies were conducted on green turtles found stranded in northern New Zealand between 2007 and 2013. Anthropogenic effects predominantly associated with the ingestion of plastic marine debris were identified as the likely cause for the majority of strandings in the North Island. Propeller strike and incidental capture in recreational fisheries were further shown to impact green turtles, particularly for turtles inhabiting neritic habitats adjacent to densely populated urban centres of northeastern New Zealand.

Overall, data presented here supports the hypothesis that New Zealand northern neritic habitats provide a transitional developmental habitat for immature green turtles at the edge of their range in the southwestern Pacific Ocean. Genetic analysis reveals this aggregation is unique when compared to other regional foraging grounds, exhibiting links to discrete genetic stocks from across the Pacific Ocean. In addition, the cause of the exponential increase in records observed over time remains unclear, therefore warrants further research and monitoring of this endangered marine reptile; particularly in light of climate-mediated environmental change presently experienced in the region.

Acknowledgements

"If you change, the world changes."

It's hard to know when my journey began, maybe it was when I was young when I watched the undersea adventures of Jacque Cousteau or David Attenborough's *'The Living Planet'*; maybe it evolved later, during the long night watches aboard the *R Tucker Thompson* as we sailed to protest French nuclear testing in Moruroa. Whatever the catalyst, it has led me to this point, a culmination of many years work and stubborn determination to make a difference. Getting this far was no small feat, and certainly would not have been achievable without the support, inspiration and belief of many people along the way. At its inception, the research would have never got off the ground were it not for Craig Thorburn and Mike Bhana who dusted off my satellite tracking proposal and made it part of *'Ocean Zoo'*. Like me, you both saw its research and awareness potential; and let's face it we all love a good adventure. Thanks also to Andrew Baker and Andrew Christie (AJ) for the support and laughs along the way. A big thanks to Kelly Tarlton's and its staff for all the support (and laughs) and rehabilitation of marine turtles over the years – how things have changed for the better! As the project gained momentum, thanks to Steve Cook (Cookie) and Steve O'Shea from Auckland University of Technology (AUT) for pushing me to take on the PhD; looking back now I can thank you although a few years ago I wasn't so sure.

To Dr. Karen Stockin, my sincerest gratitude for not only being my primary supervisor, but also for being a great mentor and continually believing in me and the project. Also a special thanks to you for having my back when things did not progress as planned. A big thanks to Prof Dianne Brunton, my co-supervisor, who, after a casual catch up in 2010, invited me to rekindle the research at Massey. Without your initial support, this thesis simply would not have eventuated. There have also been a number of people and organisations that have supported the research over the years including staff from the New Zealand Centre for Conservation Medicine at Auckland Zoo, the Department of Conservation (DOC)

particularly staff from the Marine Conservation Unit, permitting, Auckland Conservancy/ field office and the Kaitaia field office. A special thanks to Clinton Duffy for the official and unofficial support over the years – now I'll hopefully have time to dedicate to the *Bigfish* project. A sincere thanks to all the Iwi across the country for their ongoing support for the research and conservation of marine turtles in New Zealand, particularly to the tangata whenua of Te Tai Tokerau (Northland): Ngāti Kuri, Te Aupōuri, Ngai Takoto, Te Rarawa, Te Roroa, Te Uri-o-Hau, Ngāti Wai; and Tamaki Makaurau: Ngāti Whatua, Ngāti Manuhiri.

My thanks also extend to the wider community of the North Island who have been pivotal in the success of the project through their ongoing support, interest and actively reporting sightings of marine turtles and rescuing stranded animals. Such support would not have gained such traction if it were not for the TVNZ, Wild Film, TV and print media journalists and filmmakers who provided a platform to raise awareness and highlight the plight of marine turtles and the ocean. I also thank the many school kids around the country that I have been lucky enough to share stories with and inspire, because in turn, they have been a major source of inspiration to me, their honesty and appreciation is humbling. A massive thanks also go to those who fighting the good fight, the likes of Hayden and Ben from Sea Cleaners; Sam and Camden from Sustainable Coastlines, Samara and Kim from Experiencing Marine Reserves (EMR)/ Whitebait Connection; Schannel, Sue and Olive from Conservation International, and the huge number of teachers who inspire their students.

A project of this magnitude could not be possible without the logistical and academic support of many people and organizations, so thanks to AUT for their support early on, and Massey University during the course of this PhD. Griffith University for the opportunity to undertake genetics lab work. To the International Sea Turtle Society (ISTS) and its members, as an independent and often isolated researcher, the opportunity to attend such great international symposiums to present my work and meet with inspiring and helpful scientists has been invaluable. It many ways it has certainly kept me going. To my fellow students and colleagues of the Coastal-Marine Research Group, thanks for the support and

friendship, particularly to Krista Hupman (yes you beat me to it but I'm still the Don ☺), Sarah Dwyer, Sonja Clemens, Manue Martinez, Emma Betty, Cheryl Cross, Anna Meissner, Gabriel Machosvsky Capuska, Jochen Zaeschmar. To my collaborators, thanks for your contributions your help was invaluable and indeed beneficial to the quality and depth of the research. Adam and Mat, many thanks for the statistical analyses despite your own commitments. Ken Mackay, thanks for your interest in all things turtle down under. To Wendy Nelson (NIWA), Richard Willan Rick Webber (Te Papa Museum), Colin Mclay (Te Papa Museum), Clinton Duffy (DOC), Emma Betty (C-MRG) for identifying diet items and Brian Gill (ex-Auckland Museum) for sharing his historical data. Thanks to Michael Jensen (NOAA) for all the help with green turtle genetics and reference sequences. A very special thanks to my collaborators and mentors Dr. Colin Limpus and Dr. Nancy FitzSimmons, your continued support was invaluable. My deepest gratitude also goes to a friend and fellow scientist, Dr. David Feary who gave his time to review my drafts and provide great advice. Mate, you have made me a better scientist and pulled me out of so many writing holes! Those who volunteered endless hours with necropsies also deserve sincere thanks including Ale Bielli, Cat Lea, Blair Outhwaite, Zoe Lyle, and Joanna Crawford. I am also very grateful to the Institute of Natural and Marine Sciences for awarding me a Fee Scholarship, logistical support, and satellite tracking costs; AUT for initial research funding; Kelly Tarlton's for funding and supporting the satellite tracking programme; DOC for logistical support and permit waivers; for travel support to present at the PEW symposium; EMR and Dargaville Intermediate; travel grants from ISTS, the Zoological Society of Auckland, and Karen Baird (New Zealand Forest and Bird).

On a personal level, a huge amount of gratitude is owed to my friends far and wide. They have supported (and distracted me) over the years. I thank my immediate and extended family for all their support and endless belief in me despite my own uncertainties. I am forever grateful. In particular, to my dearest Cara, you are my rock, my safe anchorage, my endless source of inspiration and laughter, this work is just as much yours as it is mine. It quite literally is…who else would want to go on a date to necropsy smelly dead turtles and willingly read endless drafts!? ☺. Cara, I'm eternally grateful for your unwavering support.

Table of contents

List of figures

Chapter 5

List of tables