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**POPULATION STRUCTURE, ABUNDANCE AND REPRODUCTIVE
PARAMETERS OF BOTTLENOSE DOLPHINS (*TURSIOPS
TRUNCATUS*) IN THE BAY OF ISLANDS (NORTHLAND, NEW
ZEALAND)**

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A thesis submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy in
Biological Sciences

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2009

ABSTRACT

Bottlenose dolphins (*Tursiops truncatus*) occupy a wide range of coastal and pelagic habitats throughout tropical and temperate waters worldwide. Around New Zealand, bottlenose dolphins inhabit three discontinuous regions in the north-eastern coast of the North Island, Marlborough Sound and Fiordland in the South Island. All these populations are subject to anthropogenic activities including dolphin-based tourism industry. Along the north-eastern coast of the North Island, the Bay of Islands presents a unique opportunity to study this population because of regular occurrence year-round and a history of long-term studies conducted in the region. This study examines the population structure and genetic diversity of the three New Zealand bottlenose dolphin populations to define their boundaries. Second, it focuses on the Bay of Islands subpopulation to investigate the dynamics of dolphin groups, pattern of habitat use, abundance and trends over time. Finally, it estimates reproductive parameters of female bottlenose dolphins to predict the long-term viability of the Bay of Islands subpopulation.

To investigate the population structure and genetic diversity of bottlenose dolphin, skin samples were collected using a remote biopsy dart from the three New Zealand populations. Analysis of the molecular variance (AMOVA) from mitochondrial DNA (mtDNA) control region sequences ($n = 193$) showed considerable differentiation among populations ($F_{ST} = 0.17$, $\Phi_{ST} = 0.21$, $P < 0.001$) suggesting little or no female gene flow or interchange. All three New Zealand populations showed higher mtDNA diversity than expected given their small population sizes and apparent isolation. To explain the source of this variation, 22 control region haplotypes from New Zealand were compared to 108 haplotypes worldwide representing 586 individuals from 19 populations and including both 'inshore' and 'offshore' ecotypes as described in the Western North Atlantic. All haplotypes found in the Pacific, regardless of population habitat use (i.e., coastal or pelagic) were more divergent from populations described as 'inshore' ecotype in the Western North Atlantic than from a population described as 'offshore' ecotype. Analysis of gene flow indicated long-distance dispersal among coastal and pelagic populations worldwide, except for those haplotypes described as 'inshore' ecotype in the Western North Atlantic; suggesting that these populations are interconnected on an evolutionary time scale. This finding suggests that habitat specialization has occurred independently in different ocean basins, perhaps with *T. aduncus* filling the ecological niche of the 'inshore' ecotype in some coastal regions of the Indian and Western Pacific Oceans.

The dynamics of dolphin groups in the Bay of Islands and their use of the habitat were investigated using two standardised datasets of consistent effort (1997-99 and 2003-05). The 1997-99 dataset contained a total of 1,711 sighting records of 258 individual dolphins, of which 39% were newly added to the photo-identification catalogue ($n = 101$) and the rest ($n = 157$), were re-sightings of previously catalogued dolphins. The 2003-05 dataset included a total of 1,889 sightings records of 159 individual dolphins. Overall, 98 dolphins sighted during 1997-99 were resighted during 2003-05. Encounters with dolphins increased significantly ($P < 0.001$) from 69.5% during 1997-99 to 87.1% encounters during 2003-05. There were more individually identified dolphins using the Bay of Islands during 1997-99 when compared to 2003-05; despite a lower number of sightings and groups encountered. There were annual variations in the number of groups encountered including a lower number of dolphins sighted during winter. Analysis of resighting rates suggested a very dynamic pattern of habitat use with fewer individuals sighted in the area more often than expected (i.e., frequent users; ~20%) while most dolphins were occasional or infrequent visitors. Additionally, a change in use of the area was detected, with 40 frequent users out of 67 using the Bay of Islands differentially. Changes in habitat use over time may be attributed to foraging (changes in prey distribution or abundance), reproductive strategy, competition for resources, a consequence of anthropogenic impacts or a combination

of all or some of the above. During 2003-05 there were relatively few frequent users ($n=37$) found in the Bay of Islands regularly. Therefore, the exposure of frequent users to tour-boat operators should be closely monitored to avoid cumulative impact and potential detrimental effects on survival or reproductive fitness.

The composition of maternal lineages of biopsy sampled frequent users ($n=23$) was not significantly different from other dolphins in the Bay ($n=108$) suggesting that social affiliations, as opposed to direct kinship, play a more important role in the maintenance of long-term relationships between individuals. The sex ratio of the population was estimated at 1.3:1 males: females with no significant differences between sexes. Sex information was available for 37 frequent users and no differences ($P = 0.099$) between sexes were detected, indicating no sex-segregation within frequent users in the Bay of Islands.

Four Cormack-Jolly-Seber models were used to estimate survival and capture probabilities over different temporal scales. An open population model that allows for variation in capture probabilities and survival over time best describes this subpopulation with the pooled annual dataset. This is because the effects of migration, heterogeneity and higher capture probabilities observed in the Bay of Islands dataset. Results suggested a 38% decline from 204 ($CV=0.03$) individually identified adult dolphins using the Bay of Islands in 1998 to 126 ($CV=0.02$) in 2004. The abundance of the larger north-eastern North Island population was estimated at 428 adult dolphins. A decline in apparent adult survival was observed in the Bay of Islands, with lower values than those reported for other regions (0.907 in 1999 and 0.717 in 2004). Several documented deaths among the frequent users of the Bay of Islands have contributed to this lower survival rate. Despite the decline in estimated abundance, dolphins continue to be found regularly in the Bay of Islands, suggesting a change from more individuals using the area irregularly, to fewer individuals using the Bay of Islands more regularly. Consequently, it seems that a shift in habitat use as well as some combination of emigration, mortality and low recruitment could underlie the estimated decline. Although the cause of these changes requires further investigation, a precautionary approach to manage all anthropogenic disturbances is recommended throughout the range of the north-eastern North Island population.

A total of 53 dolphins were observed to be reproductive females over ≥ 2 consecutive and independent encounters. Additionally, 11 females were sexed using molecular methods and direct observation but were never sighted with a calf. Since 1994, 52 young of the year were successfully assigned to individually identified mothers; the fates of 41 of these were documented over differing periods of time. Similarly to studies conducted in other regions, and consistent with the estimated calving rate ($0.25 \text{ calf (reproductive female)}^{-1} \text{ yr}^{-1}$; $CI = 0.16-0.35$), average calving interval was estimated at 4.25 years (range 2.20-6.78; $SD = 1.54$). Conversely, mortality rates to age 1+ (0.42; $CI = 0.27-0.57$) and 2+ (0.22; $CI = 0.08-0.58$) were higher than reported elsewhere. The high calf mortality observed here in conjunction with a decline in abundance highlight the vulnerability of this utilised subpopulation.

The present study provided substantial evidence to suggest that dolphins using the Bay of Islands are genetically differentiated from the other populations in New Zealand. Further analyses suggested a decline in abundance, high calf mortality and a decline in adult survival. Long-term monitoring in the Bay of Islands is needed to examine the causes of decline; which could threaten the persistence of this population and the sustainability of dolphin-related tourism activities. Different management conservancies throughout the bottlenose dolphin range along the coast of the north-eastern North Island need to coordinate their conservation efforts in a consistent manner and implement a precautionary approach to manage all sources of anthropogenic disturbances.

DEDICATION

Dedico esta tesis:

*A quienes me dieron el ser
A quien unió a mi ser su destino
A quien ha continuado mi ser*

Celina y Pablo de Tezanos Pinto

Daniel Mario Pouwels

Rawiri Luciano Pouwels

ACKNOWLEDGEMENTS

I am very grateful with my supervisor, Dr Charles Scott Baker, who took me onboard on this project and supported me until the end. Thank you Scott for your patience and for the time you have spent teaching me things...from backing up a trailer, interpret a PCR, shot a biopsy gun or write a scientific paper (to name a few). I am honestly surprised you did not go bold while reading this thesis! It has been an incredible journey and I was very fortunate to have you as my supervisor. I have great respect for your knowledge, integrity and humanity.

This project involved the collaboration of many people to whom I am very grateful to. In this regard, I thank Dr Rochelle Constantine who gave me access to her data and catalogue and provided valuable advice to improve the quality of this work. Thanks to Fabiana Mourão, Jo Berghan and Andrew Ryding for generously contributing with their data. I received support from the Department of Conservation (DoC) in particular Tony Beauchamp, thank you Tony for your patience and friendship. Thanks to Adrian Walker, Tony Beachman, Alan Fleming, Lon Peters, Elke Reufels (Bay of Islands); Karl Macleod, Bill Trusewich, Dan Breen, Hamelia Jamieson (Auckland and Great Barrier Island); Ross Kemper, Beth Masser, Helen Kettles, Rosalyn Colin (Te Anau). Thanks to Clinton Duffy for all the shark info and Anton Van Helden (DoC and New Zealand Museum Te Papa Tongarewa) for access to the *Tursiops* stranding database. Thanks to Uniservices for advice and support, especially Gary Putt. Thanks to the tour operators in the Bay of Islands, who generously provided a platform for field surveys; particularly, Fullers Bay of Islands, Dolphin Discoveries, Kings and Carino. Thanks to the *Tutunui* crew: Floppy, Tammy, Phil, Bronwyn, Natasha and Ross; *Carino's* crew: Vanessa Mackay. Thanks to the crew of *Discovery III* and *IV*, *Orca II* and *Dolphin Seeker* for assistance in locating the dolphins. This thesis was generously funded by the Department of Conservation (Bay of Islands); the Northland Marine Mammal Trust; J. Watson Conservation Trust from the Royal Forest and Bird Society; Postgraduate Tuition Fee Bursary (University of Auckland) and the Whale and Dolphin Adoption Project.

This thesis has been a long and life-changing journey. I came to New Zealand in December 2001 to assist with Maui's dolphin research and ended up staying permanently. I started this PhD research in February 2003, later down the track I got married to an Invercargillian and had a beautiful son. During this long journey, I met Scott's 'older' students: Natalie Patenaude, Franz Pichler, Rochelle Constantine, Merel Dalebout and Tony Hickey. And the 'newbies' with whom I shared some wonderful times: Carlos Olavarria, Susana Caballero, Marc Oremus, Nicky Wiseman, Doro Heimeier, Alana Alexander, Colm Carraher, Fabi Mourão, Murdoch Vant, Emma Carroll, Rebecca Hamner and Renee Albertson. Thanks to Kirsty Russell for teaching me how to drive a boat and use a biopsy sampling gun. Debbie Steel, Murdoch Vant and Hamish McInnes trained me on labwork and helped me with most lab-related issues. Debbie also corrected manuscripts and improved my *espanglish*. Thanks to Shane Lavery and Tony Hickey (and his great sense of humour!) for all the population genetic discussions and general advice. Thanks to Jen Jackson for her friendship and support. I am very grateful to my friend Carlos Olavarria for always been there for me... Gracias Carlitos! I had the pleasure to share the PhD and motherhood journey with my very good friend Susana Caballero, que hubiera sido de mi sin vos Susu! Nicky Wiseman and Dorothea Heimeier started their PhD's at about the same time I did mine and we shared some good times in the water and late nights in the lab. Merci to Marc Oremus for coming along my fieldtrips, always answer my annoying questions and for his friendship. Thanks to Jess Hayward, Andrew Veale, Josh Guilbert, Bjørn Heijstras and Emma Carroll (and Simon Waugh too) for their great sense of humour.

I am very grateful to Jennifer Jackson who took the time to review all the chapters in this thesis and provided valuable comments to improve the quality of this work. Thank you Jen for being

such a nice person; I think the world is a better place because of you! I am grateful with those who took the time to review independent chapters: Emma Carroll and Doro Heimeier (Chapter 1); Carlos Olavarria and Emma Newcombe (Chapter 3); Simon Childerhouse, Andrew Gormley and Karen Stockin (Chapter 4); Marc Oremus (Chapter 5 and Appendix 8.5); Manue Martinez and Danny Pouwels (Chapter 6). Thanks to Jenny Wilcox and Dr Rachel Fuster for the support with statistics.

Thanks to Dr Lyndon Brooks (Southern Cross University) for helping me with mark-recapture and particularly, the transience models. Thanks to Jennifer Fan from the student learning centre for her support with English grammar. I am grateful with John Wang, Rochelle Constantine, Fabiana Mourão, Michael Ritchlen, Marc Oremus and Monika Merriman for allowing me to use their photos. Thanks to Neve Baker for providing me with the beautiful drawing that illustrates the cover of chapter 6.

I am very grateful with the people that came along my fieldtrips volunteering their time (and patience) in the water. Especially Sarah J. Wells (Poochie-poohs!) who worked long hours, helped matching so many photos and reviewed the photo-ID catalogue. Thanks to Alyson Fleming, Jillian Brueggeman, Catherine Clark, Emma Carroll, Jennifer Jackson, Daniel Pouwels, Fabiana Mourão, Marc Oremus, Kirsty Russell, Karl McLeod, Murdoch Vant, Emma Newcombe, Dorothea Heimeier, Neve Baker, Susana Caballero, Jacky Guerts, Ruma Gosh, Bevan Woodward and Michael Ritchlen. Thanks to Arthur Cozens, Brady Doak and Bill Murray (Leigh Marine Laboratory) who organised the *R. V. Hawere* surveys; thanks also to Arthur and Brady for looking after the *Lancer* and providing support and advice when needed. Thanks to all the people who provided photographs for matching; these are very valuable resources and help in our understanding of the dolphin's biology.

Thanks to my friends outside Uni that kept me sane: Andy Strachan, Carla Grosman, Tania Mallow, Kim Mazur and the Fowler family. My friends at Massey have supported me during the final stages of this PhD: Karen Stockin (*just keep swimming, keep swimming...*), Manue Martinez and Mónica Merriman. Thanks to my good friend Gabriel Machovsky Capuscha and his family (Karen and Sabrina), for always been there for me. *Sos un amigazo y te queremos mucho!* Thanks to my New Zealand in-laws, particularly my sis Chrissy Frizzle Pouwels. Thanks to my dear friends in Argentina: *que están siempre y gracias a quienes, soy hoy:* Beti Froute, Marisa Cerra, Edgar Lacombe, Ale Maiolo, Adri Rosales, Adri Bertol, Pablo Garcia, Lala y Moi, Poli Marronkle y flia., Tin Felix, Silvina Kindgard y flia., Matias Nille, Tania Rogel y flia., Agus Goya y flia...y a todos los que han compartido conmigo parte de este largo viaje.

I have no words to properly acknowledge the support my family provided me along the years. My parents Celina Snopek and Pablo de Tezanos Pinto have generously supported (both financially and emotionally) all my journeys and I am very grateful for your kind love and generosity. *Gracias por estar siempre conmigo y por el apoyo para terminar esta tesis.* My grandparents Guillermo Snopek and María Ángela Valente were my inspiration and one of the reasons I pursued academic studies with marine mammals. I have great respect for their hard work, generosity and integrity. Leaving Argentina meant being away of my dear nephews and nieces: Victoria, Gerónimo, Iñaki, Alejo y Agustina; *pero saben que los quiero con todo mi corazon!* Thanks to my sisters Celina and Verónica (and her husband Gustavo Tulu Zurueta) and my brother Pablo Martín for their support. I am very grateful to Romina Ortiz, who looked after my son with so much love and dedication while I was writing this thesis.

My dear husband and sexy marido, 'el motivador' Daniel Mario Pouwels provided me with so much love and support throughout the different stages of this thesis. It has been a long journey and I could not have done it without you. You are a great companion and I am very lucky for

having you in my life. I love you honey-bunny... con todo mi corazón! My gorgeous son Rawiri Luciano was born while I was writing this thesis and had to share his mami with a computer and big piles of paper!

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