Updated, annotated bibliography for Hector's (*Cephalorhynchus hectori hectori*) and Māui (*C. hectori maui*) dolphins, 2018

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Contents

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Abstract

This is the fourth in a series of annotated bibliographies published for Hector's (*Cephalorhynchus hectori hectori*) and Māui (*C. hectori maui*) dolphins, following on from those in 2003, 2012, and 2014. This report presents an updated bibliography of scientific publications relating to the two subspecies, including information on biology, ecology, conservation and management. In total, eight peer-reviewed publications, three graduate theses (two PhD and one MSc), and 11 reports (combination of published and unpublished) have been produced since August 2014. Several other relevant works in progress were also identified so it is recommended that this resource continues to be updated in the future. Every attempt has been made to include all relevant material, and any omissions are inadvertent.

1. Introduction

This annotated bibliography of Hector's (*Cephalorhynchus hectori hectori*) and Māui (*C. hectori maui*) dolphins provides an update to the previous bibliographies (Martinez & Slooten 2003; du Fresne et al. 2012; Miller 2014) and is intended to be read in conjunction with them. Together, they provide a comprehensive overview of scientific publications relating to the biology, ecology, conservation and management of these two subspecies.

The motivation for this update to the bibliography is to inform the upcoming review of the Hector's and Māui dolphin Threat Management Plan[1], including a science-based risk assessment, later in 2018.

2. Methods

All scientific works published on Hector's and Māui dolphins since August 2014 (when the previous bibliography was completed; Miller 2014) were identified using standard internet searches. All submissions to the International Whaling Commission's Scientific Committee (IWC-SC 66a-67b) were also reviewed. Additionally, researchers and staff of government departments who had been working on Hector's or Māui dolphin research projects in recent years were consulted.

The references are listed alphabetically by author, and then chronologically. The format of each entry closely follows that of the previous bibliographies as outlined below:

1. **Full citation** in Department of Conservation (DOC) publications format
2. **Focus**: The main focus of the report selected from the following general subject areas: abundance; behaviour; distribution; ecology; general biology; genetics; threats, impacts and management
3. **Summary:**
   Aim
   Methods
   Results
   Recommendations for management and future research (*when applicable)*
4. **Who:** Organisation type (selected from: Academic; Conservation organisation; Consultant; Government; Research organisation) and name

[1] http://www.doc.govt.nz/our-work/our-work-with-maui-dolphin/review-of-the-hectors-and-maui-dolphin-threat-management-plan/

5. **Type** of publication (selected from: Peer-reviewed journal; Thesis – Honours, Masters, Doctoral; Book; Conference proceedings; Published report; Unpublished report).

Every attempt has been made to present results, recommendations and conclusions in an abbreviated format that is consistent with the original documents and standardised across all entries. No critical analysis is offered by the author of this update, and unpublished reports are clearly identified as such.

3. Results

In total, eight peer-reviewed publications, three graduate theses (two PhD and one MSc), and 11 reports (combination of published and unpublished) have been produced since August 2014. The compilation of these works is an indication of the continuing high-quality research being carried out on both Hector's and Māui dolphins.

4. Bibliography

Baker, C.S.; Steel, D.; Hamner, R.M.; Hickman, G.; Boren, L.; Arlidge, W.; Constantine, R. 2016: Estimating the abundance and effective population size of Māui dolphins using microsatellite genotypes in 2015–16, with retrospective matching to 2011–16. Department of Conservation, Auckland. 75 p.

Focus: Genetics; abundance.

Summary

Aim: Estimate the abundance and effective population size of Māui dolphins in 2015–16 and document movements of individuals, including migrant Hector's dolphins using DNA profiling.

Methods: Small-boat surveys were carried out from Kaipara Harbour to Mokau River, Taranaki during the summers of 2015 and 2016. A total of 48 and 44 biopsy samples were collected in 2015 and 2016 respectively. DNA profiling included genotyping microsatellite loci, sex identification and mtDNA control region sequencing. Combination of these samples with those from previous surveys in 2010 and 2011 and 2001–07, and those collected opportunistically from beachcast individuals, provides a record of DNA profiling extending across 16 years.

Results: A total of 40 and 28 individual dolphins were identified in 2015 and 2016 respectively. 17 individuals were recorded in both surveys. One male and one female were identified as Hector's dolphin migrants. The census abundance of Māui dolphins aged 1+ was estimated to be 63 (95% CL = 57–75) which is comparable to, but slightly larger than the previous estimate of 55 (95% CL = 48–69) from 2010/11. Effective population size, representing only breeding individuals of the parental population, was estimated as 34 (95% CL = 24–51).

Recommendations: Continued genetic monitoring is recommended as part of the Māui dolphin recovery program.

Who: *Academic* (Oregon State University; University of Auckland; Texas A&M University); *Government, NZ* (DOC).

Type: Published report.

Buckle, K.; Roe, W.D.; Howe, L.; Michael, S.; Duignan, P.J.; Burrows, E.; Ha, H.J.; Humphrey, S.; McDonald, W.L. 2017: Brucellosis in endangered Hector's dolphins (*Cephalorhynchus hectori*). *Veterinary Pathology 54:* 838-845.

Focus: Threats, impacts and management.

Summary

Aim: Investigate the prevalence of *Brucella* spp. infection in stranded Hector's dolphins and determine whether this contributes to mortality in this species.

Methods: Twenty-seven Hector's dolphins (including two of the Māui subspecies) which were all found beachcast between Nov 2006 and Oct 2010 were examined using histological immunohistochemical and molecular (PCR) techniques.

Results: Seven of the 27 dolphins had at least one tissue which tested PCR-positive for *Brucella* spp. and two of these were diagnosed with active reproductive brucellosis, suggesting that this disease has the potential to affect reproductive success.

Recommendations: Future collection of tissues from beachcast Hector's dolphins should focus on minimising delays in recovery and transport to optimise the chance of obtaining good quality DNA and allow full genetic characterisation of Hector's dolphin *Brucella* spp.

Who: *Government, NZ* (MPI); *Academic* (Massey University); *Conservation organisation* (Marine Mammal Center, CA, USA).

Type: Peer-reviewed journal.

Constantine, R.; Steel, D.; Baker, C.S. 2016: Estimating the abundance of Māui dolphins using microsatellite genotypes: Report of the 2016 biopsy sampling survey. Paper SC/66b/SM/13 presented to the *IWC Scientific Committee.*

Focus: Genetics; abundance.

Summary Reviews the history of genetic monitoring of Māui dolphins and provides an update on boat-based surveys in the summers of 2015 and 2016 which were intended to update the 2010 and 2011 genotype mark-recapture surveys. During Feb–Mar 2016, 13 small-boat surveys totalling 1552 km of survey effort encountered 66 groups of Māui dolphins. A total of 44 biopsy samples were collected which will be used for DNA profiling and estimation of abundance in combination with genotype data from 2015.

Who: *Academic* (University of Auckland; Oregon State University).

Type: Unpublished report.

Currey, R.; Lundquist, D. 2015: Māui dolphin: current status and 2015 update on New Zealand's research and management approach. Paper SC/66a/SM/3 presented to the *IWC Scientific Committee.*

Focus: Threats, impacts and management.

Summary: Outlines the current status of Māui dolphins and provides an annual update of data collected in the last 12 months on sightings, necropsies, captures, ship strikes and observer coverage. Describes research priorities identified at two recent stakeholder meetings as part of the new Māui dolphin five-year strategy and research plan. It is recommended that surveys of abundance should be conducted at intervals of not more than five years.

Who: *Government, NZ* (MPI; DOC).

Type: Unpublished report.

Currey, R.; Lundquist, D. 2016: Māui dolphin: 2016 update on New Zealand's research and management approach. Paper SC/66b/SM/12 presented to the *IWC Scientific Committee.*

Focus: Threats, impacts and management.

Summary: Provides an annual update on Māui dolphin research and management, including all sightings, necropsies, captures, ship strikes and observer coverage. Ahead of the next scheduled review of the Threat Management Plan in 2018, a

programme of ongoing data collection and prioritised research is underway. Two field seasons were completed for a revised abundance estimate. A pilot study exploring the use of CPODs was undertaken for investigating offshore distribution and variation in habitat use. The results of this will aid in planning a wider study. Another priority was to assess alongshore distribution in the southern range. Monthly aerial surveys during Jan–Apr 2016 were conducted, with no Māui dolphin sightings.

Who: *Government, NZ* (MPI; DOC).

Type: Unpublished report.

Dawson, S.; Fordyce, R.E.; Ridgway, S.H.; Brough, T.E.; Slooten, E. 2017: Observations of a New Zealand dolphin (*Cephalorhynchus hectori*) breathing via its mouth. *Marine Mammal Science 33:* 350–355.

Focus: Behaviour.

Summary Describes observations of unusual respiration behaviour in an adult Hector's dolphin during 49 min in December 2015 at Lyttleton Harbour. During more than 38 surfacing sequences the dolphin appeared to breath mostly via its mouth.

Who: *Academic* (University of Otago).

Type: Peer-reviewed journal.

de Jager, M.; Hengeveld, G.; Mooij, W.; Slooten, E. 2018: Modelling the spatial dynamics of Māui dolphins using individual based models. Paper SC/67b/HIM/02 presented to the *IWC Scientific Committee.*

Focus: Distribution.

Summary

Aim: Develop an individual based model of Māui dolphin movement and create probability distribution maps for use in conservation efforts.

Methods: Models hourly movement of individual dolphins over 90 days as a function of dolphin swimming activity, water depth, distance to home-range centres and distance to nearby conspecifics. Parameter combinations are validated using survey data.

Results: Results from the model demonstrate that Māui dolphins stay close to

shore and are found in highest densities around Kaipara Harbour and Manukau Harbour. The model also estimates that most dolphins are found within the gillnet restricted zone, yet the dolphin distribution extends far beyond the current limits of this area.

Recommendations: Such models can be used to project the impact of fishing activities on the Māui dolphin population under alternative policy scenarios. More data on dolphin and fish distribution would help to further improve the model.

Who: *Academic* (Wageningen University; Netherlands Institute of Ecology; University of Otago).

Type: Unpublished report.

Derville, S.; Constantine, R.; Baker, C.S.; Oremus, M.; Torres, L.G. 2016: Environmental correlates of nearshore habitat distribution by the Critically Endangered Māui dolphin. *Marine Ecology Progress Series 551*: 261–275.

Focus: Ecology; distribution.

Summary

Aim: Describe nearshore summer distribution of Māui dolphin in relation to the environment.

Methods: Boat-based surveys were carried out along the North Island west coast over the periods Feb–Apr 2010, 2011, 2013 and 2015, including photo-identification and genetic sampling. Boosted regression trees were then used to compare the presence of dolphins relative to environmental predictors.

Results: Sea surface temperature, turbidity, distance to watersheds, water depth, and distance to the coast were the strongest predictors of dolphin distribution. Predicted areas of suitable nearshore habitat had 76% overlap with historical sightings of Māui dolphins, highlighting potential areas of recovery.

Recommendations: It is critical to assess whether current conservation efforts are adequate for protecting Māui dolphins year-round, or whether the offshore extent of their range increases in the winter. Including predator-prey and intra-specific relationships in models will help further clarify Māui dolphins' habitat selection.

Who: *Academic* (Université de Lyon; Université de La Réunion; Université Paris; Oregon University; University of Auckland).

Type: Peer-reviewed journal.

Dittmann, S.; Dawson, S.; Rayment, W.; Webster, T.; Slooten, E. 2016: Hector's dolphin movement patterns in response to height and direction of ocean swell. ***New Zealand Journal of Marine and Freshwater Research*** **DOI: 10.1080/00288330.2015.1119165.**

Focus: Distribution; ecology.

Summary

Aim: Investigate whether swell height and direction are important factors in explaining day-to-day variability in abundance of Hector's dolphins in Akaroa Harbour.

Methods: Boat-based visual sightings over the period 2000–12 and passive-acoustic detections from 2007-2008 of Hector's dolphins in Akaroa Harbour were modelled in relation to swell height and swell direction.

Results: The rates of visual and acoustic detections in Akaroa Harbour were significantly lower on days after big swell events, and in some models, after swell events from the south.

Recommendations: Further research is needed to understand the ecological connection between swell and dolphin movement. This information could be used both to predict daily dolphin movement and suggest how dolphins may react in future if extreme weather events become more frequent.

Who: *Academic* (University of Otago; Universität Hamburg)

Type: Peer-reviewed journal

Dittmann, S.; Slooten, E. 2016: Photogrammetry using in-field calibration: a non-invasive tool for predicting sex and life stages tested on Hector's dolphins in the wild. ***New Zealand Journal of Marine and Freshwater Research*** **DOI: 10.1080/00288330.2016.1144624.**

Focus: General biology.

Summary

Aim: Develop and validate a new technique of stereo-photogrammetry. Assess the potential for predicting dolphin sex and life stage using these measurements.

Methods: This technique was validated via measurements of Hector's dolphin dorsal fins in the wild from a boat and measurements (to test precision and accuracy) of an object of known length from a boat and the land. Dorsal fin dimensions were also analysed for necropsied dolphins and correlated with sex and life stage.

Results: Seven independent measurements of one dolphin gave a CV of 1.39% and 2.33% for fin base and height respectively. Test measurements from shore at varying distances (up to 10 m) and angles (up to 40°) gave a mean error of <1%. Dorsal fin shape was significantly related to sex but not accurately enough to replace traditional sexing methods. Fin base length was significantly related to female life stage.

Recommendations: Traditional visual methods for sex estimation should continue to be used, but stereo-photogrammetry of dorsal fins is recommended for estimating which females are reproductively mature.

Who: *Academic* (University of Otago; Universität Hamburg).

Type: Peer-reviewed journal.

Hamner, R.M.; Steel, D.; Constantine, R.; Morrissey, M.; Ogle, M.; Weir, J.; Olavarria, C.; Baxter, A.; Arlidge, W.; Boren, L.; Baker, C.S. 2016: Local population structure and abundance of Hector's dolphins off Kaikoura – 2014 and 2015. Report to the New Zealand Department of Conservation. 24 p.

Focus: Genetics; abundance.

Summary

Aim: Assess the population structure and abundance of Hector's dolphins near Kaikoura using DNA profiling.

Methods: Biopsy samples were collected during 15 dedicated small-boat surveys conducted in 2014 and 2015. Two local populations were targeted, north and south of the Kaikoura Canyon. A total of 86 and 71 biopsy samples were collected in 2014 and 2015 respectively. DNA profiling was carried out, including microsatellite genotyping, sequencing on mtDNA control region haplotypes and sex identification. Two-sample capture-recapture was used to estimate abundance.

Results: DNA profiles were used to identify 117 individuals (80 from north and 37 from south of the Kaikoura Canyon). Significant genetic differentiation was found between the two regions. The abundance of Hector's dolphins aged 1+ was estimated to be 314 (95% CL: 216–483; CV = 0.32) for Kaikoura-North and 102 (95% CL: 68–175; CV = 0.4) for Kaikoura-South. The overall combined abundance of dolphins aged 1+ was estimated to be 480 (95% CL: 342–703; CV = 0.29).

Recommendations: Additional surveys and biopsy samples from Kaikoura-South would allow a more robust abundance estimate for this region. Conducting similar studies of the local populations to the south of this area

would provide information on the degree of connectivity or isolation of the small Kaikoura-South population.

Who: *Academic* (University of Auckland; Oregon State University); *Government, NZ* (DOC); *Conservation organisation* (Kaikoura Ocean Research Institute).

Type: Unpublished report.

Hamner, R.M.; Constantine, R.; Mattlin, R.; Waples, R.; Baker, C.S. 2017: Genotype-based estimates of local abundance and effective population size for Hector's dolphins. *Biological Conservation 211*: 150–160.

Focus: Genetics; abundance.

Summary

Aim: Estimate abundance and effective population size for Hector's dolphins in Cloudy Bay using genetic sampling in comparison to concurrent photo-identification recapture.

Methods: Small-boat surveys were conducted in Cloudy Bay during the summers of 2011 and 2012 to collect both skin biopsies and photo-identification data. DNA profiling for individual identification included markers for sex, mtDNA control region and microsatellite genotyping.

Results: A total of 263 biopsy samples were collected from which 147 individuals were identified. A total of 28 dolphins were photo-identified. No genetic differentiation was found between the two survey years and no migrants were identified from other regional populations. Abundance of individuals in Cloudy Bay aged 1+ was estimated to be 269 (95% CL = 233–319; CV = 0.12), which was similar to but more precise than estimates from photo-identification: 230 (95% CL=130−407, CV = 0.30)). The effective population size of the parental generation was 191 (95% CL = 23–362).

Recommendations: Additional investigation of home ranges and spatial use patterns by Hector's dolphins in Cloudy bay would be informative.

Who: *Academic* (Oregon State University; University of Auckland); *Consultant* (Marine Wildlife Research); *Government, USA* (NOAA).

Type: Peer-reviewed journal.

Lundquist, D.; Sharp, B. 2017: Māui dolphin: 2017 update on New Zealand's research and management approach. Paper SC/67a/SM/15 presented to the *IWC Scientific Committee.*

Focus: Threats, impacts and management.

Summary: Provides an updated review of Māui dolphin research and management in the previous year, including all sightings, necropsies, captures, ship strikes and observer coverage. Ahead of the next scheduled review of the Threat Management Plan in 2018, a programme of ongoing data collection and prioritised research is underway. Two field seasons were completed for a revised abundance estimated of 63 individuals (95% CI: 57–75) over 1 year of age. Following the successful completion of a pilot study on the use of CPODs to explore offshore distribution, further planned research is outlined.

Who: *Government, NZ* (DOC; MPI).

Type: Unpublished report.

Maas, B. 2015: Estimated population size and decline of Maui's dolphins. Paper SC/66a/SM/21 presented to the *IWC Scientific Committee.*

Focus: Abundance; Threats, impacts and management.

Summary

Aim: Provide estimates of Māui dolphin abundance based on population data and bycatch mortality estimates and project timelines for short- and long-term population recovery or decline.

Methods: Māui dolphin abundance is projected across four scenarios: maximum population growth, 50% population growth, zero population growth, and zero anthropogenic mortality.

Results: Under the current fisheries protection regime, Māui dolphin abundance is likely to decline to an estimated 32–35 individuals and just 7–10 breeding females by 2019/20. If anthropogenic mortality had been reduced to zero in 2010/11, population numbers could have grown to 69 individuals (17 mature females) by 2019/20. Under maximum population growth and zero human impact, Māui dolphin population recovery to 250 mature individuals (the size required for reclassification from Critically Endangered to Endangered under the IUCN) is estimated to take 87 years.

Recommendations: These results highlight the extreme urgency of the IWC Scientific Committee's repeated calls for habitat-wide fisheries protection for Māui dolphins. If current protection levels persist, Māui dolphins could face

extinction in just 15 years. To successfully protect this subspecies, bycatch risk must be reduced to zero and this can only be achieved by extending existing fishing closures for gillnets and trawling to cover the entire habitat of Māui dolphins offshore to the 100 m depth contour, including harbours. Additionally, the risk of seismic exploration in Māui dolphin habitat is discussed.

Who: *Conservation organisation* (NABU International – Foundation for Nature).

Type: Unpublished report.

Miller, E.J. 2014: Ecology of Hector's dolphin (*Cephalorhynchus hectori*): Quantifying diet and investigating habitat selection at Banks Peninsula. PhD Thesis. University of Otago.

Focus: Ecology; distribution; behaviour; general biology.

Summary

Aim: Quantify Hector's dolphin dietary preferences and investigate the influence of prey availability on Hector's dolphin habitat selection at Banks Peninsula.

Methods: Diet was quantified for the first time, using the stomach contents from 63 dolphins which were found beachcast or bycaught throughout New Zealand between 1984 and 2006. Stable isotope analysis compared the $\delta^{13}C$ and $\delta^{15}N$ signatures of 42 dolphins from the South Island east coast with 19 potential prey species using mixing models. Concurrent dolphin, demersal prey and oceanographic surveys were carried out at Banks Peninsula to assess habitat selection.

Results: The dolphins were found to feed throughout the water column on a variety of 29 prey taxa. Prey were mostly <10 cm long, but ranged from <1 cm to over 60 cm. The most commonly consumed prey were red cod (*Pseudophycis bachus*), ahuru (*Auchenoceros puncatatus*), arrow squid (*Nototodarus* sp.), sprat (*Sprattus* sp.), sole (*Peltorhamphus* sp.) and stargazer (*Crapatalus* sp.). Red cod contributed most in terms of mass (37%) while ahuru and Hector's lanternfish (*Lampanyctodes hectoris*) were consumed in large numbers. Stable isotope analysis revealed that bony fish contributed most to the dolphins' diet, and that while demersal prey are seasonally important, epipelagic fish may have the greatest long-term contribution. The relative abundance of dolphins was found to be strongly positively correlated with red cod mass at Banks Peninsula. Dolphin distribution offshore was also associated with more saline surface water, and alongshore, dolphins were found in areas of higher prey diversity, higher salinity, and warmer water.

Recommendations: Further monitoring of the red cod population at Banks Peninsula would be valuable given that this species is a target species of the

inshore trawl fishery and has been in decline since the mid-1990s. Further research on Hector's dolphin habitat selection for additional populations, assessing overlap with a wider variety of prey species as well as predation risk, would strengthen the predictive capacity of such habitat models.

Who: *Academic* (University of Otago).

Type: Thesis - PhD

Palliser, A.; Dodson, G. 2017: Uncertainty, complexity and controversy in dolphin threat management: A role for post-normal science? *Environmental Science and Policy 78:* 74–80

Focus: Threats, impacts and management.

Summary

Aim: To examine how knowledge about Hector's and Māui dolphins was produced and utilised during development of the Threat Management Plan (TMP) and assess whether the presentation and dissemination of these results could contribute to a lack of social legitimacy for dolphin management.

Methods: Three examples of risk assessment and modelling which relate to fishing bycatch are examined, focussing on the science-policy interface. Stakeholders were interviewed in 2008 and 2015-2016. The authors examine this research as well-informed non-experts, to assess how it informs policy and the wider community and whether it fits the post-normal science approach, which advocates transparency about uncertainty and stakeholder peer review.

Results: The authors conclude that while the TMP shows evidence of the post-normal science approach, more is required for durable and socially legitimate dolphin management policy. Masked uncertainty in presented results appears to have contributed to erosion of trust and social legitimacy between the government and stakeholders.

Recommendations: Decisions have to be made despite uncertainty and use of the precautionary principle is essential. It is recommended that where inevitable uncertainty exists, results be presented more qualitatively so that they are not morphed to appear more certain than they really are. Greater emphasis should be placed on producing socially robust research that fully discloses assumptions and uncertainty in ways that are comprehensible to stakeholders. Stakeholder involvement in the production and assessment of knowledge should also be extended.

Who: *Academic* (Southern Institute of Technology; Unitec Institute of Technology).

Type: Peer-reviewed journal.

Rodda, J.L. 2014: Analysis and geovisualisation of Hector's dolphin abundance and distribution patterns in space and time. PhD Thesis. University of Otago.

Focus: Distribution; abundance.

Summary

Aim: Quantitatively test whether the population of Hector's dolphin in Te Waewae Bay, Southland is in decline and examine its distribution within the bay.

Methods: Seasonal patterns of distribution and density were assessed from over 24 consecutive months of data along four alongshore transects within Te Waewae Bay. Individual spatiotemporal movement patterns were examined from geo-tagged photographic data of 58 dolphins. Mark-recapture photoidentification provided seasonal estimates of abundance of dolphins using the bay.

Results: Hector's dolphin were found throughout Te Waewae Bay, in greater densities close to shore in warmer seasons than cooler seasons. Distributional hotspots occurred in the vicinity of freshwater inputs, and movement patterns of individuals indicated site fidelity within the bay. Seasonal abundance within the bay varied from 380 (95% CI: 300–500) in winter 2005 to 580 (95% CI: 480–700) in summer 2005/06.

Recommendations: Future work would benefit by determining spatial concentrations of prey within the bay. Coastal marine systems require ecosystem-based spatiotemporal monitoring, and data should be cohesively gathered on fauna biodiversity, human maritime activities, and freshwater/contamination levels, for example. Geovisualisation methods could form an integral layer in the process of building better ecosystem-based management.

Who: *Academic* (University of Otago).

Type: Thesis – PhD.

Sharp, B.; Lundquist, D. 2018: Māui dolphin: 2018 update on New Zealand's research and management approach. Paper SC/67b/SM/08 presented to the *IWC Scientific Committee.*

Focus: Threats, impacts and management.

Summary: Provides an updated review of Māui dolphin research and management in 2017, including all sightings, necropsies, captures, ship strikes and observer coverage. As part of the review of New Zealand's Hector's and Māui dolphin Threat

Management Plan (TMP) in 2018, a programme of ongoing data collection and research is underway, including a spatially explicit multi-threat risk assessment. The TMP will be released for public consultation later in 2018. To assess offshore distribution, CPODs and soundtraps have been used out to 12 nm from Hamilton's Gap. Preliminary results indicate that Māui or Hector's dolphins were detected at 8, 10, and 12 km from shore. The final results will contribute to improved estimation of spatial distribution on the west coast of the North Island to inform estimation of risk under different management scenarios.

Who: *Government, NZ* (MPI; DOC).

Type: Unpublished report.

Slooten, E. 2015: How many Hector's dolphins off the east coast of New Zealand's South Island? Paper SC/66a/SM/15 presented to the *IWC Scientific Committee.*

Focus: Abundance; distribution; threats, impacts and management.

Summary: Provides a summary of reviewer critique of an aerial survey of Hector's dolphins conducted on the South Island east coast during 2013 by the NZ government. Key concerns discussed include survey design, the estimation of availability and perception bias, and truncation of data. The implications of survey results for the potential impact of bycatch on this population are explored using an agent-based population model. Results indicate that the rate of population increase/decline is relatively insensitive to population size, but highly sensitive to estimates of fishing effort and catch rate.

Who: *Academic* (University of Otago).

Type: Unpublished report.

Slooten, E. 2015: Effectiveness of partial protection for Maui's dolphin. Paper SC/66a/SM/15 presented to the *IWC Scientific Committee.*

Focus: Abundance; threats, impacts and management.

Summary

Aim: Model the estimated rate of population decline for Māui dolphin under varying levels of fisheries regulation.

Methods: Individual-based models were used to compare the rate of population decline for Māui dolphin under three different scenarios: 1) Past fisheries regulation, 2) Current fisheries regulations and 3) Protection measures

recommended by the IWC, which would extend protection south to Whanganui and offshore to 20 nmi.

Results: Population decline was found to continue under current fisheries regulations, despite two extensions to protection measures implemented in 2012 and 2013. The probability of decline to ≤ 10 individuals has improved from 58% to 48% under current regulations; however, this would improve to 0% under option 3. Implementing the IWC recommendation would improve the probability of population recovery from 0% to 40%.

Recommendations: The protection measures recommended by IWC are much more likely to halt population decline and prevent extinction than current management measures. Models could be broadened to assess not only fisheries-related mortality, but also other potential impacts such as pollution and oil and gas exploration.

Who: *Academic* (University of Otago).

Type: Unpublished report.

Weir, J.S.; Sagnol, O. 2015: Distribution and abundance of Hector's dolphins (*Cephalorhynchus hectori*) off Kaikoura, New Zealand. *New Zealand Journal of Marine and Freshwater Research 49*: 376–389

Focus: Distribution; abundance.

Summary

Aim: Investigate the distribution and abundance of Hector's dolphins off Kaikoura.

Methods: A total of 48 boat-based surveys were conducted in 2013 collecting photo-identification data. These surveys were combined with opportunistic data collected from 2005–13 to examine distributional patterns.

Results: A total of 164 groups of Hector's dolphins were sighted, with 47 individuals identified. Results indicate that the dolphins prefer areas of shallow, nearshore waters with poorer water clarity. A greater number of dolphins were sighted to the north of the Kaikoura Peninsula than the south.

Recommendations: The dolphins north and south of the Kaikoura Canyon should be further investigated, as results suggest that the Canyon may act as a natural barrier separating dolphins into two groups.

Who: *Conservation organisation* (Kaikoura Ocean Research Institute).

Type: Peer-reviewed journal.

Wickman, L.M. 2018: Estimating mark rate and its effect on the precision of estimates of survival rate for a long-term study of Hector's dolphins (*Cephalorhynchus hectori*) at Banks Peninsula, NZ. MSc Thesis. University of Otago.

Focus: Abundance.

Summary

Aim: Provide an updated estimate of mark rate of Hector's dolphins around Banks Peninsula and determine whether this has changed since protection measures have expanded. Investigate the implications of low mark rate on estimating survival rate.

Methods: Mark rate for 2016 was estimated using several different estimation strategies. The updated mark rate was compared with that in 1992–96, when fishing restrictions were relatively new. Capture histories were simulated by resampling from the population's original capture history dataset to estimate the effects of a decreasing mark rate on the precision of survival rate estimation.

Results: Whether a change in mark rate was detected between the two periods was method dependent. The frequentist method did not detect a statistically significant difference, but the Bayesian model indicated a 98% probability that the mark rate in 2016 (0.069, 95% HDI: 0.049–0.090) is lower than that from 1992–96 (0.107, 95% HDI: 0.080–0.137). While no evidence was found that mark rate would bias estimates of survival rate, it is likely to reduce precision.

Who: *Academic* (University of Otago).

Type: Thesis – MSc.

5. Other information sources

Other useful information sources are the Department of Conservation Hector's and Māui dolphin Incident Database[2] and the Māui dolphin Sightings Database[3], which are continually updated.

[2] http://www.doc.govt.nz/our-work/hectors-and-maui-dolphin-incident-database/

[3] http://www.doc.govt.nz/our-work/our-work-with-maui-dolphin/maui-dolphin-sightings/

6. Works in progress

There are several publications currently 'in prep' (planned for submission soon). Those identified during this literature review are cited below. It is therefore recommended that this bibliography continues to be updated.

Bury, S.J.; Constantine, R.; Brown, J.C.S; Miller, E.J.; St John Glew, K.; Hamner, R.; Oremus, M.; Boren, L. In prep.: Stable isotope analysis of skin biopsy samples provides insights into the trophic ecology of Māui dolphin.

Miller, E.J.; Bury, S.J.; Slooten, E.; Dawson, S.M. In prep.: New insights into the feeding ecology of Hector's dolphin (*Cephalorhynchus hectori*) inferred from stable isotope mixing models.

Miller, E.J; Dawson, S.M; Slooten, E. In prep: The role of demersal prey and local oceanography in the habitat selection of Hector's dolphin (*Cephalorhynchus hectori*) at Banks Peninsula.

7. References

du Fresne, S.; Burns, D.; Gates, E. 2012: An updated, annotated bibliography for Hector's (*Cephalorhynchus hectori hectori*) and Maui's (*C. hectori maui*) dolphins. *DOC Research and Development Series 332*. Department of Conservation, Wellington. 43 p.

Martinez, E.; Slooten, E. 2003: A selective, annotated bibliography for Hector's dolphin (*Cephalorhynchus hectori*). *DOC Science Internal Series 124*. Department of Conservation, Wellington. 40 p.

Miller 2014: An updated, annotated bibliography for Hector's (*Cephalorhynchus hectori hectori*) and Māui (*C. hectori maui*) dolphins. Report to the Department of Conservation.

8. Acknowledgements

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