**The Evergreen State College**

**Graduate Program on the Environment**

### Thesis Prospectus

|  |  |  |  |  |  |
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**STUDENT AGREEMENT:**

**SIGNATURE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ DATE\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**FACULTY READER APPROVAL:**

**SIGNATURE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ DATE\_\_\_12/11/2020\_\_\_\_**

**MES DIRECTOR APPROVAL:**

**SIGNATURE:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ DATE\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. **Provide the working title of your thesis[[1]](#endnote-1).**

Population Structure, Residency, and Inter-island Movements of Common Bottlenose Dolphins (*Tursiops truncatus*) off O‘ahu and Maui Nui (Maui, Lāna‘i , Kaho‘olawe, Moloka‘i)

1. **In 250 words or less, summarize the key background information needed to understand your research problem and question.**

Accurate descriptions of population structure are critical to inform effective management of protected species. Previous studies of photo-identification and genetic data have shown that resident common bottlenose dolphins (*Tursiops truncatus*, hereafter “bottlenose dolphins”) in the main Hawaiian Islands live in four island-associated populations that are likely demographically isolated (Baird et al., 2009; Martien et al., 2011). At the time these studies were conducted no animals had been documented moving between populations either through photo-identification or satellite-tag data, and the populations around each island appeared to be genetically distinct (Baird et al., 2009; Martien et al., 2011). Separate populations are centered around Kaua‘i/Ni‘ihau, O‘ahu, Maui Nui (Maui, Lāna‘i , Kaho‘olawe, and Moloka‘i), and Hawai‘i, and have been designated as separate stocks by the National Marine Fisheries Service (NMFS) for management as directed by the Marine Mammal Protection Act of 1972 (MMPA).

However, long-term photo-identification and tagging data has since shown that some individuals do occasionally move between islands, especially between O‘ahu and Maui Nui (CRC unpublished data). These movements may have important consequences, as even a small number of dispersing individuals can homogenize genetic diversity between populations and allow for the transmission of culturally-mediated behaviors. The aim of this work will be to reassess the population structure and residency patterns of bottlenose dolphins for the O‘ahu and 4-islands (Maui Nui) stocks, using photo-identification and satellite-tag data from Cascadia Research Collective. Particular attention will be directed towards describing inter-island movements and quantifying how they impact dispersal rates between the two stocks.

1. **State your research question(s).**

Are the O‘ahu and Maui Nui resident bottlenose dolphin populations demographically independent (i.e., do movements between these populations significantly impact their population structure)? How do individual movements between populations affect dispersal rates? To what degree do individuals show site fidelity to specific island areas in each population?

1. **Situate your research problem within the relevant literature. What is the theoretical and/or practical framework of your research problem?**

Accurate population parameters are critical for the effective management of protected species. However, the precise definition of a “population” has been hotly debated in biological science for many years, and two major paradigms have emerged (Waples & Gaggiotti, 2006). The most relevant paradigm for marine mammals is the ecological paradigm, which states that demographic factors (shared habitat space, and the ability to interact socially) serve as the binding force in a population. This stands in contrast to the evolutionary paradigm, in which proximity and mating opportunity are the key factors governing the population, with genetic relatedness hence standing as the best measure to define the population (Waples & Gaggiotti, 2006). The ecological paradigm is highly relevant to cetaceans in the parvorder Odontoceti, at least some of whom share complex social structures and behavioral traits described as cultures that are often habitat specific and cannot be explained by genetics alone (Rendell & Whitehead, 2001). Division into populations by culture may in fact influence genetic evolution through gene-culture coevolution, the best example of which by far is the genetic differentiation between different killer whale ecotypes (Whitehead, 2017).

To delineate populations from one another, the ecological paradigm primarily applies the concept of Demographically Independent Populations (DIPs), in which birth and death rates influence the abundance of the population more than immigration and emigration. Knowing which individuals are contained in a DIP is of critical importance, especially in areas that contain multiple DIPs, as conservation threats frequently have spatial variation, and different DIPs may require different management strategies. The MMPA mandates that NMFS designate different “stocks” of marine mammals for management, which are operationally defined as DIPs. DIPs can be identified for odontocetes using any combination of several different available methods, which include studies of morphology, genetics, movement and distribution, contaminant ratios, habitat selection, acoustics, and association data (Martien et al., 2019). However, all methods usually culminate in the calculation of a dispersal rate, which measures how many individuals move between populations. If the dispersal rates between two populations fall below a certain threshold, then any conservation threats that heavily impact one of the populations is likely to result in severe decreases in abundance or even its local extinction, because too few individuals are immigrating from the other population to compensate for the losses (Taylor 1997).

Among bottlenose dolphins, population structures can vary widely even within the same ecotype and geographic area, with spatial use of localized populations ranging from highly site-specific to migratory, and the degree of interaction between localized populations ranging from non-existent to substantial. For example, on the U.S. West Coast a large, migratory population of coastal bottlenose dolphins exists in virtual panmixia off of the California coast, with frequent large-scale movements and a high degree of genetic interchange (Carretta et al., 2013; Defran et al., 2015). In contrast, while the U.S. East Coast population of coastal bottlenose dolphins was once thought to exist in a similar structure due a high degree of migration among some individuals, genetic studies indicated that there were in fact several distinct populations (Rosel et al., 2009). Currently there are 16 recognized populations of coastal ecotype bottlenose dolphins along the U.S. East Coast, two of which are migratory like the U.S. West Coast population, and 14 of which are resident populations (Hayes et al., 2018). Resident populations have a much higher degree of site-fidelity than migratory populations, and frequently live within easily distinguishable habitats like estuaries or lagoons where they often develop unique behavioral traits suited to their distinct habitats (e.g., Duffy-Echevarria et al., 2008; Torres and Read, 2009).

Another relevant and complementary concept is metapopulation theory, in which distinct localized populations may remain connected through periodic dispersal, forming a larger metapopulation. The degree of separation between localized populations effectively determines how homogenous a population is, and can be described quantitatively as the dispersal rate, though additional methods for assessing connectivity have been developed (Calabrese & Fagan, 2004; Waples & Gaggiotti, 2006). Several possible metapopulations of bottlenose dolphins have been described in the literature, usually in the form of neighboring resident stocks with infrequent individual movements and genetic dispersal between stocks, though higher degrees of mixing have been reported (e.g. Caballero et al., 2012; Gaspari et al., 2015; Gladilina et al., 2018).

Previous studies of association and genetic data for resident insular bottlenose dolphins from the main Hawaiian Islands have shown that there are four demographically independent island-associated populations, one each centered around Kaua‘i and Ni‘ihau, O‘ahu, Maui Nui, and Hawai‘i (Baird et al., 2009; Martien et al., 2011). These populations are also designated as separate stocks by NMFS (Carretta et al., 2019). However, in the time since these studies were published additional photo-identification and satellite-tag data has revealed that individuals occasionally move between areas, especially between O‘ahu and Maui Nui, meaning that these populations may not be demographically independent (CRC unpublished data). Inter-island movements may have important consequences, as even loose connections between resident populations can homogenize genetic diversity and facilitate the social transmission of behaviors.

1. **Explain the significance of this research problem. Why is this research important? What are the potential contributions of your work? How might your work advance scholarship?**

This research will provide an updated assessment of the residency patterns and possible connections between the O‘ahu and Maui Nui populations of bottlenose dolphins in the main Hawaiian Islands, something which has not been undertaken in almost a decade. This research is merited for two reasons. First, newly detected inter-island movements between stocks may impact the degree of genetic exchange between populations and allow for the social transmission of behaviors, which may have long-term consequences for population health. Secondly, a recent abundance estimate has shown that the O‘ahu and 4-islands (Maui Nui) stocks of bottlenose dolphins are in decline, though the trend is not significant for the O‘ahu stock (Van Cise et al., in review). As a top marine predator species with a long lifespan and high degree of site fidelity, bottlenose dolphins are a sentinel species for the health of the marine ecosystem, and potential declines in their abundance are cause for concern. In the main Hawaiian Islands, the type and severity of anthropogenic impacts on the marine environment vary significantly between island areas, and an accurate understanding of which bottlenose dolphins are exposed to threats will be helpful in assessing the overall health of the marine ecosystem (Baird et al., 2009). This research will directly address this issue by providing detailed information on whether or not animals from the O‘ahu and Maui Nui populations are regularly exposed to anthropogenic pressures specific to both areas. This information can feed directly into management plans for these populations.

1. **Summarize your study design[[2]](#endnote-2). If applicable, identify the key variables in your study. What is their relationship to each other? For example, which variables are you considering as independent (explanatory) and dependent (response)?**

Existing long-term photo-identification and satellite tag data will be analyzed using a variety of methods to explore population structure, residency, and inter-island movements of the O‘ahu and Maui Nui populations of bottlenose dolphins.

Sampling effort will be quantitatively and spatially analyzed to ensure consistent and thorough photo-identification coverage of both populations. Discovery curves will be constructed to determine the proportion of each population captured by photo-identification efforts.

Photo-identification data will be used to assign a residency class (core resident, resident, or visitor) for all individuals, including tagged animals, of sufficient distinctiveness and photo quality within each island-area. Sampling biases may artificially alter residency class distributions, especially in infrequently sampled areas. To account for this, sampling effort will be quantitatively and spatially evaluated alongside residency classes, and social networks (explained below) will be constructed to provide additional context for any visitors. Independent variables are the number of times an individual has been seen, as well as the span of years over which an individual has been seen. Residency is the dependent variable.

Social networks will be constructed using photo-identification data to determine whether there are demographic connections between populations. Core residents, residents, and visitors will be identified within the social network, and the potential role of inter-island individuals in connecting clusters will be evaluated qualitatively. Any visitors that link by association to the main population clusters will be identified and have their residency class reassigned as “associative resident”. The composition of any peripheral clusters will be evaluated to examine whether they are artifacts of quality control or sampling, or may represent demographically independent groups.

Residency classifications will be compared against demographic and encounter data to look for any patterns. Independent variables will include age class, sex, group size, season, and depth. Residency is the dependent variable.

Photo-identification data will be used to calculate average interannual travel distances, for different residency classes within each population, and for each population as a whole. Argos satellite tag data will be used to calculate average daily distance travelled for each individual tagged, and compared between residency classes as possible. Greatest observed distances travelled will be compared between photo-identification and satellite-tag data for different residency classes, individuals, and populations as applicable. Residency class is the independent variable, and interannual travel distance, average daily distance travelled, and greatest observed distance travelled are the dependent variables.

Sighting locations from photo-identification studies will be used to construct occurrence heat maps on a 5x5km grid as well as kernel densities showing core areas (50%) and ranging areas (95%) for different residency classes. Satellite tag data will also be used to construct occurrence heat maps and kernel densities for different residency classes, and results will be compared between the photo-identification data-generated maps and the satellite tag data-generated maps to evaluate their consistency.

Dispersal rates and measures of connectivity will be calculated and compared against previously calculated dispersal rates for these stocks from the literature (i.e., Baird et al., 2009; Martien et al., 2011). Rates and measures will be calculated with and without inter-island movements included where applicable to determine their relative impact. Sighting histories are the independent variable, and dispersal rate and connectivity are the dependent variables.

1. **Describe the data that will be the foundation of your thesis. Will you use existing data, or gather new data (or both)? Describe the process of acquiring or collecting data[[3]](#endnote-3).**

I will be using existing long-term bottlenose dolphin photo-identification and satellite-tag datasets from Dr. Robin Baird of Cascadia Research Collective (hereafter “CRC”) as the foundation of my thesis (**Table 1**). Photo-identification data for the O‘ahu and Maui Nui areas spans from the late 1990s to early 2019, and includes almost 3000 identifications of 694 individual dolphins. Sightings are compiled from CRC field projects, and contributions from other researchers and community scientists that CRC has permission to use in scientific research. All Argos satellite tag data are available for 5 different individual dolphins (1 from O‘ahu, and 4 from Lāna‘i), tagged between December 2012 and March 2017, all of which are known members of the resident communities of these islands and are also included in the photo-identification data. I will also be using sex information derived from genetic samples taken as part of CRC’s field efforts.

Dr. Baird can be reached at rwbaird@cascadiaresearch.org

CRC does expect that I submit the findings of my thesis to a journal for publication, with appropriate acknowledgement of all co-authors. I will take the lead on adapting any findings for publication.

**Table 1.** Data and their intended uses for the thesis. Primary data is in its raw form; derived data are directly derived from primary data; calculated data are calculated from either derived or primary data.

|  |  |  |
| --- | --- | --- |
| **Data** | **Primary/Derived/Calculated** | **Will be Used for** |
| Argos satellite tag data locations (from CRC field efforts) | Primary | Movements (average daily distance travelled; greatest observed distance travelled)  Heat maps  Kernel densities |
| Genetic samples (from CRC field efforts) | Primary | Demographic information (sex) |
| Photographs and locations (from CRC field efforts, Pacific Whale Foundation field efforts, and contributed photos from community scientists) | Primary | Individual sighting histories/associations  Demographic information (sex/age class/group size)  Movements (average inter-annual travel distances; greatest observed distance travelled)  Dispersal rates  Heat maps  Kernel densities |
| Demographic information (age/sex/group size) | Derived | Tested against residency, movements, depth, and season |
| Individual sighting histories/associations | Derived | Residency |
| Heat maps of locations | Derived | FINAL PRODUCT |
| Residency | Calculated | Tested against movements and demographic variables; FINAL PRODUCT |
| Dispersal rates | Calculated | FINAL PRODUCT |
| Kernel densities | Calculated | FINAL PRODUCT |
| Movements (average daily distance travelled) | Calculated | Tested against residency; FINAL PRODUCT |
| Movements (average interannual travel distance) | Calculated | Tested against residency; FINAL PRODUCT |
| Movements (greatest observed distance travelled) | Calculated | Tested against residency; FINAL PRODUCT |

1. **Summarize your methods of data analysis. If applicable, discuss specific techniques that you will use to understand the relationships between variables (e.g., interview coding, cost-benefit analysis, specific statistical analyses, spatial analysis) and the steps and tools (e.g., lab equipment, software) that you will take to complete your analyses.**

Part I: Effort Data and Sampling Consistency

CRC effort data will be described numerically, and tracklines plotted using R or GIS. Non-CRC encounter locations will be plotted using R or GIS and used to construct heat maps, and described numerically. Sampling consistency will be evaluated using several different metrics, including comparing seasonality and depth of encounters across different years. Locations where tags have been deployed will also be plotted on a map. Discovery curves will be constructed to determine the proportion of each population captured by photo-identification efforts.

Part II: Residency Patterns

All individuals of sufficient photo-quality and distinctiveness will be assigned an island-associated residency based on the number of times they’ve been seen in either area following the protocols outlined in Mahaffy (2012). For each island, “Core residents” will be defined as individuals seen over ≥5 times in ≥3 years, “residents” will be defined as individuals seen more than once but ≤5 times, and “visitors” will be defined as individuals seen only once. Individuals that have been seen in both areas will be designated as “Inter-island”. Sampling biases may artificially alter residency class distributions, especially in infrequently sampled areas. To account for this, sampling effort will be quantitatively and spatially evaluated alongside residency classes, and social networks (explained below) will be constructed to provide additional context for any visitors.

Social networks will be constructed for high-quality, distinctive identifications from both areas using the social network analysis software SOCPROG and the network drawing program Netdraw, in order to assess whether inter-island individuals link the Oahu and Maui Nui social networks, as well as to contextualize any individuals classified as visitors. Core residents, residents, and visitors will be identified within the social network, and the positions of inter-island individuals will be evaluated qualitatively. Any visitors that link by association to the main population clusters will be identified and have their residency class reassigned as “associative resident”. The composition of any peripheral clusters will be evaluated to determine if they are artifacts of quality control or sampling, or may represent demographically independent populations.

Residency will be tested against several variables to identify influential factors, including the season and depth during which encounters tended to take place, group size, age class and sex as available, using either ANOVAs, chi-squared tests, or non-parametric equivalents as necessary based on the data.

Lagged Identification Rates will be calculated using SOCPROG to determine the probability of individuals remaining in the study areas, as in Mahaffy 2012.

Part III: Movements and Spatial Use

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Photo-identification data will be used to calculate average interannual travel distances, for different residency classes within each population, and for each population as a whole. Argos satellite tag data will be used to calculate average daily distance travelled for each individual tagged, and compared between residency classes as possible. Greatest observed distances travelled will be compared between photo-identification and satellite-tag data for different residency classes, individuals, and populations as applicable. Differences between interannual travel distances, average daily distance travelled, and greatest observed distance travelled for different residency classes will be tested for significance using an ANOVA if all assumptions are met, or a non-parametric equivalent if necessary.

Sighting locations from photo-identification studies will be used to construct occurrence heat maps on a 5x5km grid as well as kernel densities showing core areas (50%) and ranging areas (95%) for different residency classes. Satellite tag data will also be used to construct occurrence heat maps and kernel densities for different residency classes, and results will be compared between the photo-identification data-generated maps and the satellite tag data-generated maps to evaluate their consistency.

Part IV: Dispersal Rates and Connectivity

Dispersal rates and connectivity will be used to explore connections between the two populations. Planned dispersal rate calculations are the annual dispersal rate based on observed data, and the annual dispersal as calculated using a Bayesian analysis based on the methods from Baird et al., 2009 (this approach is based on the assumption that there are unobserved movements between stocks). All dispersal rates will be compared against previously determined dispersal rates from previous studies (i.e., Baird et al., 2009; Martien et al., 2011). Additionally, connectivity between populations will be evaluated by comparing movement and spatial use data from Part III against the shortest distance between core ranges and ranging areas from kernel density maps for each population, and any overlaps between core ranges/ranging areas will be evaluated quantitatively as a percentage. Permeability of the deep-water channel between populations will be assessed by comparing its depth against the depth distribution of encounters with different residency classes.

1. **Address the ethical issues[[4]](#endnote-4) raised by your thesis work. Include issues such as risks to anyone involved in the research, as well as specific people or groups that might benefit from or be harmed by your thesis work, perhaps depending on your results. List any specific reviews you must complete first (e.g., Human Subjects Review or Animal Use Protocol Form).**

The data being used for this thesis have already been collected, following protocols approved by CRC’s IACUC, and with the appropriate permits for various aspects of fieldwork. As this project will be restricted to analysis of existing datasets, no additional permits or review are required.

This thesis will benefit the agencies that manage bottlenose dolphins in Hawai‘i by providing accurate information regarding population structure and dispersal between populations. Following completion of the analyses this work will also be written up for journal publication, allowing any conclusions to be disseminated to the broader scientific community as well. Through this project, CRC will also gain the benefit of having a long-term dataset analyzed and published at no cost. Finally, I will also benefit from this process through the expansion of my research skillsets, and the attainment of my master’s degree.

Theoretically, no groups should be harmed by this research. Stock designations and concurrent management strategies are unlikely to be influenced by the conclusions of this study alone, and better informed management is generally beneficial in meeting conservation goals.

1. **List specific research permits[[5]](#endnote-5) or permissions you need to obtain before you begin collecting data (e.g. landowner permissions, agency permits).**

The data for this project have already been collected. I am using CRC’s long-term bottlenose dolphin photo-identification and satellite-tag datasets from O‘ahu and Maui Nui, which includes data from CRC field efforts and contributed photographs from other researchers and community scientists. Permission has been granted from Dr. Baird for me to use these datasets.

1. **Reflect on how your positionality as a researcher could affect your results and how you will account for this in the research process[[6]](#endnote-6).**

My connection to the animals being studied in this project is largely conservation-oriented and this project will directly benefit me through the expansion of my skillsets and the attainment of my masters’ degree. However, I do not anticipate that my positionality will strongly influence the results due to the robust study design. Multiple lines of evidence are being evaluated, which should counter any inherent bias that could skew results. I am committed to presenting the full picture of results that this work shows.

Over the past three years I have had the privilege of working with the bottlenose dolphin photo-identification data at CRC, eventually becoming the primary curator of the catalog in mid-2018. This work has involved both professional and emotional investment, and over time I have gradually formed a deep appreciation for these animals, as well as some hypotheses about their population structure. Any unusual patterns in the proportion of residents for the O‘ahu population would essentially validate a personal suspicion that there is an additional resident population of bottlenose somewhere around O‘ahu that has yet to be characterized, but that occasionally crosses into the range of the well-known resident Waiʻanae population. Should my hypothesis be disproved I would feel slightly disappointed, but I consider the full disclosure of my results to be of paramount importance, regardless of whatever they may show.

Another layer of positionality that I have put thought into is the fact that I am not from the Hawaiian Islands, nor am I a Native Hawaiian, meaning that I have no direct stake in the conservation status of these animals beyond my professional work. While I do have some loose familial connections to the Waiʻanae coast on O‘ahu, I am approaching this work from the position of an outsider, which effectively renders my work a form of scientific colonialism. To reduce the Western/colonialist character of this work, I will include all relevant Hawaiian names for species and places alongside common and scientific names, acknowledge the role of the Hawaiian people as traditional stewards of the animals that I am studying in my acknowledgements section, and may incorporate a Hawaiian story or proverb into my literature review to illustrate the role of dolphins in traditional Hawaiian culture if I can locate one that is appropriate. I will also make use of appropriate diacritical marks in all Hawaiian names (e.g. ‘okinas).

1. **Provide at least a rough estimate of the costs associated with conducting your research.  Provide details about each budget item so that the breakdown of the final cost is clear.**

Data - $0, courtesy of CRC

Software for analysis:

R and R Studio - $0, open-source

SOCPROG - $0, open-source (compiled version)

Netdraw - available at CRC office

ArcGIS - available at CRC office

Gephi - $0, open-source version of Netdraw

1. **Provide a detailed working outline of your thesis.**

Title Page

Signature Page

Acknowledgements

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Abstract

Ch. 1 Literature Review

* Introduction + Thesis Statement
* Population Biology of Odontocetes
  + - * + Factors that influence the division of populations
        + Population definitions
        + Datasets that are useful in evaluating population structure
* Legislative Definitions and Applications of Population Structure for Managing Odontocete Populations
* Common Bottlenose Dolphins – Globally Observed Population Structures
  + Offshore populations
  + Migratory Coastal Populations
  + Transient Archipelago-associated Populations
  + Resident Coastal Populations
  + Resident Island-Associated Populations
  + Metapopulation Structures
* Common Bottlenose Dolphins in Hawai‘i
  + Ecotypes, Distribution, Population Structures, and Status
  + Figure – map of the stocks
  + Anthropogenic Threats
  + Figure - images of gunshot wound, mouthline injury, line wrap injury, association with fish farm
* Conclusion

Ch. 2 Methods

* Introduction to the data being analyzed and methods
  + Photo Identification Data
    - Description of encounter sources (CRC surveys [include leeward bias explanation], contributor encounters)
    - Photo-identification methods
    - Figure - comparisons of different degrees of distinctiveness/photo quality
    - Figure - example of a match over time (HITt0228, or HITt1091)
    - Description of catalog
  + Description of satellite tag data

Brief background

Possible figure – image of an attached satellite tag

* Residency Patterns
  + - * + Social Networks

Social network basics

Examples of where these have been previously used to evaluate population structure in bottlenose

* + - * Movements and Spatial Use
* Dispersal Rates and Connectivity Measures
  + Justification and merits of each approach utilized

Ch. 3 Results

* Introduction to and brief summary of the results
* Effort Data
  + O‘ahu
    - Numerical description of CRC effort, # of contributed encounters
    - Plotted CRC effort tracklines
    - Heatmap of km effort with locations of CRC encounters plotted
    - Seasonality and depth histograms of CRC effort
    - Extent of location data for contributed encounters
    - Plotted locations of contributed encounters with GPS coordinates
    - Seasonality and depth histograms of contributed encounters
    - Discovery curve of identified animals
  + Maui Nui
    - Numerical description of CRC effort, # of contributed encounters
    - Plotted CRC effort tracklines
    - Heatmap of km effort with locations of CRC encounters plotted
    - Seasonality and depth histograms of CRC effort
    - Extent of location data for contributed encounters
    - Plotted locations of contributed encounters with GPS coordinates
    - Seasonality and depth histograms of contributed encounters
    - Discovery curve of identified animals
* Residency Patterns
  + # of individuals that passed QC standards for both islands
  + Table with residency results for both islands
    - * + Social Networks

Qualitative description of network structure

Identify any inter-island individuals and describe their position

Identify and describe any peripheral clusters

Identify any main cluster visitors and reassign as “associative resident”

Figure: Social network of Maui Nui/O‘ahu animals with inter-island individuals noted

* + O‘ahu
    - Include graphical representations of data (histograms, etc.) where appropriate
    - # of core residents/residents/visitors/associative residents
    - Residency Class vs seasonality (Chi-squared test or equivalent – remove pseudoreplicates)
    - Residency Class vs depth (ANOVA or equivalent – remove pseudoreplicates)
    - Residency Class vs group size (ANOVA or equivalent – remove pseudoreplicates)
    - Residency Class vs sex for genetically confirmed individuals (Chi-squared test or equivalent). If not enough data then just present in a table
  + Maui Nui
    - Include graphical representations of data (histograms, etc.) where appropriate
    - # of core residents/residents/visitors/associative residents
    - Residency Class vs seasonality (Chi-squared test or equivalent – remove pseudoreplicates)
    - Residency Class vs depth (ANOVA or equivalent – remove pseudoreplicates)
    - Residency Class vs group size (ANOVA or equivalent – remove pseudoreplicates)
    - Residency Class vs sex for genetically confirmed individuals (Chi-squared test or equivalent). If not enough data then just present in a table
  + Inter-island Movements
    - Detailed description of all inter-island movements
    - Table - summary of inter-island movements with photographs of individuals
    - Plots of all documented inter-island movements + calculated distance traveled between furthest points
      * + Analysis of all islands/residency classes (including inter-island). Include graphical representations of data (histograms, etc.) where appropriate

# of core residents/residents/visitors/inter-island

Plotted locations of different residency classes (need to remove all pseudoreplicates)

Residency Class vs seasonality (Chi-squared test: need to remove all pseudoreplicates)

Residency Class vs depth (ANOVA: need to remove all pseudoreplicates)

Residency Class vs group size (ANOVA: need to remove all pseudoreplicates)

Residency Class vs sex for genetically confirmed individuals (Chi-squared test: need to remove all pseudoreplicates). If not enough data then just present raw numbers in a table

* + - * + Lagged Identification Rates
      * Movements and Spatial Use
        + Basic measures of tag data presented in a table – signal contact, individual tagged, time intervals, # locations, etc.
        + # of locations from photo-identification data (+ number of locations by residency class with pseudoreplicates removed)
        + Average interannual travel distances from photo-identification data (also by residency class)
        + Average daily distance travelled from satellite-tag data (also by residency class if possible)
        + Greatest observed distances travelled from photo-identification and satellite-tag data (also by residency class)
        + Figure: Plotted locations of photo-identification encounters by residency class/island
        + Figure: Tracklines of satellite-tagged animals
        + Heatmaps of photo-identification data locations for both islands/residency classes?
        + Kernel density maps – 50% core areas and 95% ranging areas
      * Dispersal and Connectivity (include calculations both with and without inter-island individuals for all calculations where applicable)
        + Calculated dispersal rates using observed data
        + Calculated dispersal rates using Bayesian approach from Baird et al., 2009?
        + What proportion of the distribution of average interannual distances traveled occurs at distances greater than the shortest possible inter-island distance? What proportion of the greatest observed distances travelled occurs at distances greater than the shortest possible inter-island distance? (spatial connectivity)
        + To what degree do the core areas/ranging areas overlap? (spatial connectivity)
        + Permeability of the channel between populations assessed using depth distributions?

Ch. 4 Discussion

* Introduction
  + Literature Review Recap
  + Why is this research important?
  + Key Results
* Effort - was sampling consistent enough to draw reliable conclusions?
* Residency Patterns and social networks- are there differences in proportions? Factors that appear to be driving residency status? What does this likely mean? How does sampling coverage impact this? Do inter-island animals link clusters? What is the composition of peripheral clusters? How does the “associative resident” category change residency distributions?
* Movements and Spatial Use – any overlap in movements? How do heat maps compare against sampling effort? Any surprises? How do core areas/ranging areas compare? Any overlap? How does satellite-tag data compare to photo-identification data?
* Dispersal Rates and Connectivity - comparison against previously calculated dispersal rates and analysis of the value of taking different approaches. Discuss risks/ability of shallow-water dolphins to cross the deep-water channel between areas.
* What remains unknown? How complete is the characterization of these populations and what remains unknowable? What level of uncertainty is inherent in the results, and what may be productive areas for future research?
* Conclusion - what is the likely population structure for the O‘ahu and Maui Nui populations, and is any change is management worth advocating for?

Ch. 5 References

1. **Provide a specific work plan and a timeline for each of the major tasks in the work plan. Be as realistic as you can, even though you will probably need to alter this schedule as you complete the tasks. Remember that faculty readers take time to return your drafts and that the final polishing and formatting of your thesis for binding will take longer than you ever imagined.**

Drafts will be formatted in the required MES thesis format as they are written, and will be shared with both Dr. Robin Baird and my thesis reader (Dr. John Kirkpatrick) iteratively, with drafts of completed sections sent first to Dr. Baird, then to Dr. Kirkpatrick. Revisions will be made within each section based on their comments as soon as possible, and always before the next draft is sent out. Additionally, I will send weekly thesis email updates to both Dr. Kirkpatrick and Dr. Baird about my progress, as well as any questions that arise.

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| December 2020 | | | | | | |
| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|  |  | 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 Winter Break Begins |
| 20 Assign Residency Classifications | 21 Assign Residency Classifications | 22 Assign Residency Classifications | 23 Assign Residency Classifications | 24 Holiday | 25 Holiday | 26 Holiday Weekend |
| 27 Holiday Weekend | 28 Residency – writing methods start some tests | 29 Residency – writing methods and start some tests | 30 Residency – writing methods and start some tests | 31 Residency –writing methods and start some tests |  |  |

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| January 2021 | | | | | | |
| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|  |  |  |  |  | 1 Residency – writing methods and start some tests | 2 Residency – writing methods and start some tests; **SEND REVISED LITERATURE REVIEW TO BOTH ROBIN AND READER** |
| 3 Effort Data | 4 Winter quarter begins; Effort Data | 5 Effort Data | 6 Effort Data | 7 Effort Data | 8 Tuition Due; Effort Data | 9 Effort Data |
| 10 Effort Data | 11 Effort Data | 12 Effort Data | 13 Effort Data | 14 Effort Data | 15 Effort Data | 16 **SEND COMPLETE EFFORT METHODS AND RESULTS TO ROBIN** |
| 17 Social Networks | 18 Social Networks | 19 Social Networks | 20 Social Networks | 21 Social Networks | 22 Social Networks | 23 **SEND COMPLETE EFFORT METHODS AND RESULTS TO READER** |
| 24 Satellite Tag Data + Writing Catch Up | 25 Satellite Tag Data + Writing Catch Up | 26 Satellite Tag Data + Writing Catch Up | 27 Satellite Tag Data + Writing Catch Up | 28 Satellite Tag Data + Writing Catch Up | 29 Satellite Tag Data + Writing Catch Up | 30 **SEND COMPLETE SOCIAL NETWORK /RESIDENCY TO ROBIN** |
| 31 Dispersal and Connectivity |  |  |  |  |  |  |

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| --- | --- | --- | --- | --- | --- | --- |
| February 2021 | | | | | | |
| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|  | 1 Dispersal and Connectivity | 2 Dispersal and Connectivity | 3 Dispersal and Connectivity | 4 Dispersal and Connectivity | 5 Dispersal and Connectivity | 6 **SEND COMPLETE SOCIAL NETWORK/RESIDENCY TO READER** |
| 7  Movements | 8  Movements | 9  Movements | 10  Movements | 11  Movements | 12  Movements | 13 **SEND COMPLETE MOVEMENTS METHODS AND RESULTS TO ROBIN** |
| 14 Residency – continue tests; writing | 15 Residency – continue tests; writing | 16 Residency – continue tests; writing | 17 Residency – continue tests; writing | 18 Residency – continue tests; writing | 19 Residency – continue tests; writing | 20 **SEND COMPLETTE MOVEMENTS AND METHODS TO READER** |
| 21 Buffer Week | 22 Buffer Week | 23 Buffer Week | 24 Buffer Week | 25 Buffer Week | 26 Buffer Week | 27 **METHODS AND RESULTS SECTIONS COMPLETE – SEND TO ROBIN** |
| 28 Writing - Discussion |  |  |  |  |  |  |

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| March 2021 | | | | | | |
| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|  | 1 Writing - Discussion | 2 Writing - Discussion | 3 Writing – Discussion | 4 Writing - Discussion | 5 Writing - Discussion | 6 **SEND COMPLETE METHODS AND RESULTS SECTIONS TO READER** |
| 7 Writing - Discussion | 8 Writing - Discussion | 9 Writing – Discussion | 10 Writing - Discussion | 11 Writing - Discussion | 12 Writing - Discussion | 13 **SEND COMPLETE DISCUSSION TO READER AND CRC** |
| 14 Refine Formatting; Buffer Week | 15 Refine Formatting; Buffer Week | 16 Refine Formatting; Buffer Week | 17 Refine Formatting; Buffer Week | 18 Refine Formatting; Buffer Week | 19 Refine Formatting; Buffer Week | 20 **DRAFT COMPLETE – SEND TO ROBIN AND CRC HAWAII OFFICE STAFF** |
| 21 Send out to CRC Hawaii Office for review | 22 Draft out for review – CRC Hawaii Office | 23 Draft out for review – CRC Hawaii Office | 24 Draft out for review – CRC Hawaii Office | 25 Draft out for review – CRC Hawaii Office | 26 Draft out for review – CRC Hawaii Office | 27 Draft out for Review – CRC Hawaii Office |
| 28 Draft out for review – CRC Hawaii Office | 29 Spring Quarter Begins; Draft out for review – CRC Hawaii Office | 30 Draft out for review – CRC Hawaii Office | 31 Draft out for review – CRC Hawaii Office |  |  |  |

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| April 2021 | | | | | | |
| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|  |  |  |  | 1 Draft out for review – CRC Hawaii Office | 2 Tuition Due; All comments and edits back by end of day | 3 Writing - Revisions |
| 4 Writing - Revisions | 5 Writing - Revisions | 6 Writing - Revisions | 7 Writing - Revisions | 8 Writing - Revisions | 9 **Complete Draft of Thesis Due to Reader** | 10 Draft out for review – Thesis Reader |
| 11 Draft out for review – Thesis Reader | 12 Draft out for review – Thesis Reader | 13 Draft out for review – Thesis Reader | 14 Draft out for review – Thesis Reader | 15 Draft out for review – Thesis Reader | 16 Draft out for review – Thesis Reader | 17 Draft out for review – Thesis Reader |
| 18 Draft out for review – Thesis Reader | 19 Draft out for review – Thesis Reader | 20 Draft out for review – Thesis Reader | 21 Draft out for review – Thesis Reader | 22 Draft out for review – Thesis Reader | 23 Draft out for review – Thesis Reader | 24 Draft out for review – Thesis Reader |
| 25 All comments and edits back by end of day | 26 **Last day to submit extension requests**; Presentation prep; revisions | 27 Presentation prep; revisions | 28 Presentation prep; revisions | 29 Presentation prep; revisions | 30 Presentation prep; revisions |  |

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| May 2021 | | | | | | |
| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|  |  |  |  |  |  | 1 Presentation prep; revisions |
| 2 Presentation Prep; revisions | 3 Presentation Prep; revisions | 4 Presentation Prep; revisions | 5 Presentation Prep; revisions | 6 Presentation Prep; revisions | 7 **TEST RUN OF PRESENTATION FOR CRC?** Presentation Prep; revisions | 8 Presentation Prep; revisions |
| 9 Presentation Prep; revisions | 10 Presentation Prep; revisions | 11 Presentation Prep; revisions | 12 Presentation Prep; revisions | 13 Presentation Prep; revisions | 14 Presentation Prep; revisions | 15 Presentation Prep; revisions |
| 16 Thesis Presentations Week | 17 | 18 | 19 | 20 | 21 | 22 |
| 23 Thesis Presentations Week | 24 | 25 | 26 | 27 | 28 **FINAL DRAFT OF THESIS DUE TO READER** | 29 |
| 30 | 31 |  |  |  |  |  |

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| June 2021 | | | | | | |
| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
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| 6 | 7 | 8 | 9 | 10 | 11 **FINAL COPY OF THESIS DUE to MES OFFICE; GRADUATION** | 12 |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| 27 | 28 | 29 | 30 |  |  |  |

1. **Who, beyond your MES faculty reader, will support your thesis? Indicate support both within and outside of Evergreen. Be specific about who they are and in what capacity they will support your thesis. If you are working with an outside agency or expert, be specific about their expectations for your data analysis or publication of results.**

Outside of Evergreen, I will be primarily supported by the staff at CRC, who have curated the datasets that I will be working with, and are well versed in the methods that I will be applying. Among the CRC staff, Dr. Baird will be my primary supervisor. He is a research biologist and the lead scientist for the CRC Hawai‘i project, with over 30 years of experience in studying marine mammals.

Dr. Kirkpatrick is committed to working with Dr. Baird and CRC in a collaborative manner for this project, which I will be facilitating through regular zoom meetings and weekly email updates on my progress to both of them.

CRC does expect that I submit the findings of my thesis to a journal for publication, with appropriate acknowledgement of all co-authors. I will take the lead on adapting any findings for publication.

1. **List the 3-5 most important references you have used to identify the specific questions and context of your topic, help with issues of research design and analysis, and/or provide a basis for interpretation. For each annotated reference, explain how your project specifically connects to the source by extending, challenging, or responding to the conclusions, methods, or implications. For any other sources cited in this document provide a complete bibliographic citation.**

**Baird, R. W., Gorgone, A. M., McSweeney, D. J., Ligon, A. D., Deakos, M. H., Webster, D. L., ... & Mahaffy, S. D. (2009). Population structure of island‐associated dolphins: Evidence from photo‐identification of common bottlenose dolphins (Tursiops truncatus) in the main Hawaiian Islands. Marine Mammal Science, 25(2), 251-274.**

This publication is the first part of the old CRC assessment of bottlenose dolphin population structure in Hawai‘i, which I will be challenging and updating in my thesis. This paper was critical in changing the original NMFS designation of a single bottlenose dolphin stock for the main Hawaiian Islands to a designation of four separate island-associated stocks. However, when this paper was written, the CRC bottlenose photo-identification catalog was still very young, and had only a fraction of the identifications that it now contains (69 O‘ahu identifications in the 2009 paper vs. >700 currently; 147 Maui Nui identifications in the 2009 paper vs. > 800 currently). Photo-identification has also shown that some individuals do in fact move between stock areas, which may have important consequences for population health and management. The span of the data has also increased dramatically, from coverage of the years 2000-2006 to 1996-2019 currently. Satellite-tag data has also been obtained for these populations since the 2009 paper was published, which is another valuable source of information in understanding individual movements in the two stocks. An updated analysis of these long-term datasets therefore seems timely.

**Mahaffy, S.D. 2012. Site fidelity, associations and long-term bonds of short-finned pilot whales off the island of Hawai‘i. M.Sc. Thesis, Portland State University. 151 pp.**

This thesis was written by one of the staff at CRC under the supervision of Dr. Deb Duffield, and is one of the primary sources that I have constantly referred to in developing my methods. While this thesis is focused on short-finned pilot whales rather than bottlenose dolphins, and is more directed towards analyzing social structure rather than population structure, several of the methods used are well-suited to my research questions. Methods for determining residency are outlined that were developed with the CRC photo-identification catalogs and Hawaiian delphinids in mind, meaning that these methods won’t require much adaptation for me to apply them to Hawaiian bottlenose dolphins. Additionally, clear methodologies and justifications for calculating lagged identification rates and creating social networks are outlined, both of which are useful in evaluating population structure. As this thesis has already survived defense and the results were later published in a peer-reviewed journal, the methods used have proven to be robust, and extending them to my particular project seems more advisable than attempting to “reinvent the wheel” by developing new methods to answer similar questions. Rather than the journal article, I am citing the thesis version at this point because of its expanded methods section, which will be conducive to replicating some of the methods.

**Martien, K. K., Baird, R. W., Hedrick, N. M., Gorgone, A. M., Thieleking, J. L., McSweeney, D. J., ... & Webster, D. L. (2011). Population structure of island‐associated dolphins: Evidence from mitochondrial and microsatellite markers for common bottlenose dolphins (Tursiops truncatus) around the main Hawaiian Islands. Marine Mammal Science, 28(3), E208-E232.**

This paper is the second part of CRC’s original analysis of the population structure of Hawaiian bottlenose dolphins, and contains the results of the genetic analyses that were performed. I will be challenging this paper’s conclusions about stock structure for the O‘ahu and Maui Nui populations in particular, though I will not be challenging the conclusion that the two stocks are genetically distinct. While this paper does show that there is limited genetic connectivity between stocks, this does not preclude demographic or spatial connectivity, both of which still have important consequences for management. For example, a higher degree of spatial connectivity may mean that either stock could be exposed to human impacts from both island areas, such as the high rate of shipping and military activity off O‘ahu and the high rate of ecotourism off Maui Nui. It is also possible that the observed inter-island movements noted in photo-identification data are a new behavior to these populations, or are so infrequent as to leave little genetic footprint. In any case, perhaps my work will provide evidence for future re-evaluations of updated genetic datasets as well.

**Martien, K. K., Lang, A. R., Taylor, B. L., Rosel, P. E., Simmons, S. E., Oleson, E. M., ... & Hanson, M. B. (2019). The DIP delineation handbook: a guide to using multiple lines of evidence to delineate demographically independent populations of marine mammals.U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-622.**

This is a recent technical report from NOAA that was developed as a resource for scientists working on population structure questions that inform management under the MMPA and NMFS, and to communicate how scientific information is used by NMFS to designate stocks. Many previous CRC analyses are included in this report, helping me to better understand how the datasets I am working with can be approached to derive useful information for managers. In addition to being an excellent resource to consult about questions of methodology, this handbook has also served as a key resource in building my understanding of how stock structures are designated.

**Additional References:**

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Defran, R. H., Caldwell, M., Morteo, E., Lang, A. R., Rice, M. G., & Weller, D. W. (2015). Possible stock structure of coastal bottlenose dolphins off Baja California and California revealed by photo-identification research. *Bulletin, Southern California Academy of Sciences, 114*(1), 1-11.

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Taylor, B. L. (1997). Defining “population” to meet management objectives for marine mammals. *Molecular genetics of marine mammals, 3*, 49-65

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Whitehead, H. (2017). Gene–culture coevolution in whales and dolphins. *Proceedings of the National Academy of Sciences, 114*(30), 7814-7821.

1. You are not locked into this title; its purpose is to help you identify the main point or topic of your thesis at an early stage. [↑](#endnote-ref-1)
2. You might discuss selection of case studies, sampling methods, experimental design, and/or specific hypotheses you will test. You should also address any specialized knowledge or skills that are necessary to complete the research. [↑](#endnote-ref-2)
3. If you are planning to use existing data, explain the specific source, contact information, arrangement with collaborating agencies, and expectations about use of data and final products of your research. If you are planning to gather new data, describe specific methods, time, place, and equipment that will be required. [↑](#endnote-ref-3)
4. If you’re not sure where to start, consult a ‘Code of Ethics’ or other similar document from an academic society in an applicable field of study. [↑](#endnote-ref-4)
5. If you are collecting ANY samples or data, even observational data, on public lands (city, county, state and/or federal) it is your responsibility to find out the permit requirements BEFORE you collect data. Conducting research with tribal members/on tribal lands will have different and additional requirements. [↑](#endnote-ref-5)
6. Your *positionality as a researcher* refers to the fact that one’s “…beliefs, values systems, and moral stances are as fundamentally present and inseparable from the research process as [one]’s physical, virtual, or metaphorical presence when facilitating, participating and/or leading the research project…” (The Weingarten Blog 2017). [↑](#endnote-ref-6)