



KARIN LOUISE HARTMAN



PATTERNS OF SOCIAL ECOLOGY
OF RISSO'S DOLPHIN'S (*GRAMPUS GRISEUS*)
OFF PICO ISLAND, AZORES



TESE DE DOUTORAMENTO
UNIVERSIDADE DOS AÇORES

PATTERNS OF SOCIAL ECOLOGY OF RISSO'S DOLPHIN'S (*GRAMPUS GRISEUS*) OFF PICO ISLAND, AZORES

KARIN LOUISE HARTMAN
SANTA CRUZ DAS RIBEIRAS, JUNE 2014



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Submitted in fulfilment of the requirements for the degree of doctor at the University of the Azores, Biology Department, Ponta Delgada, Portugal.



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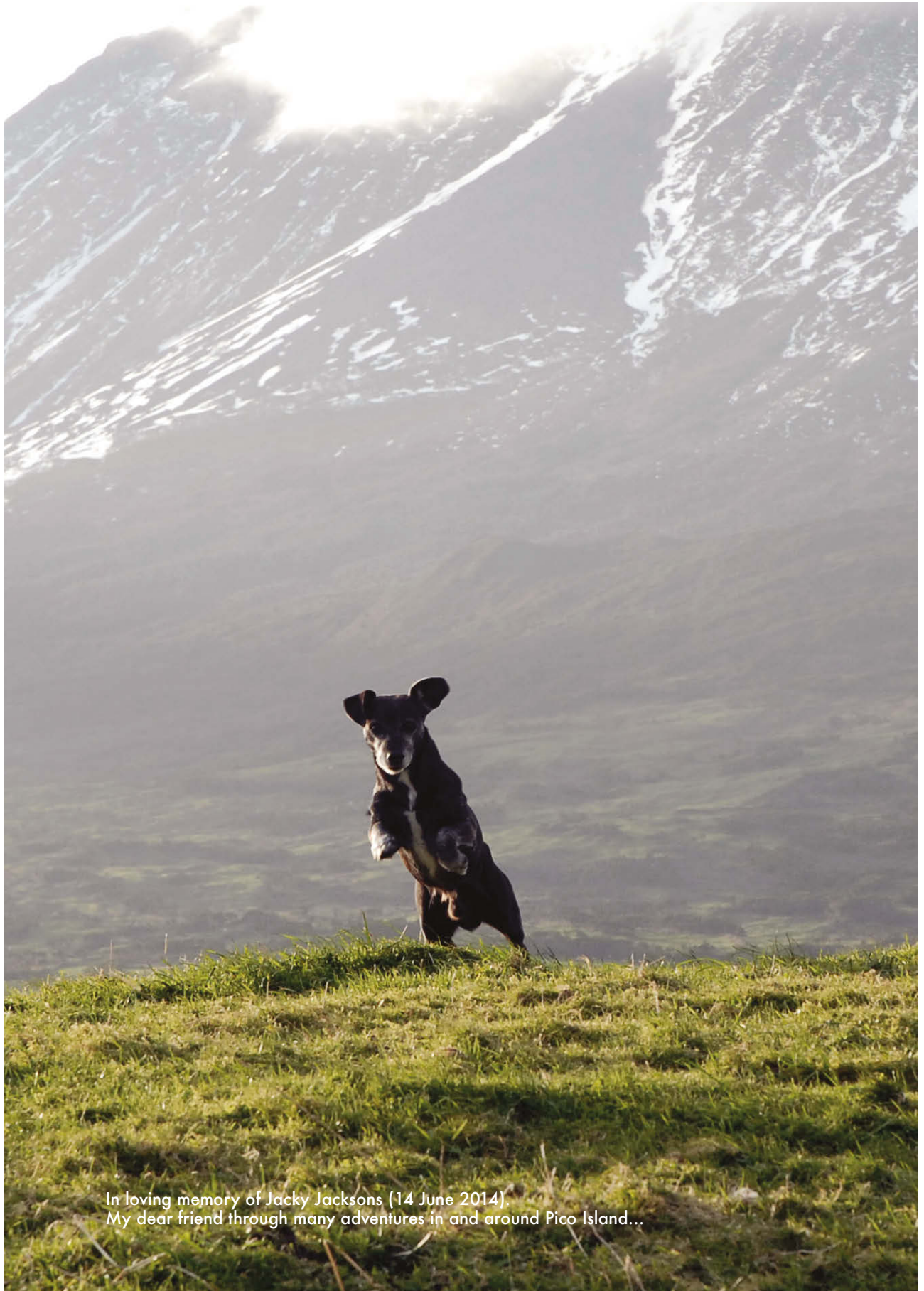
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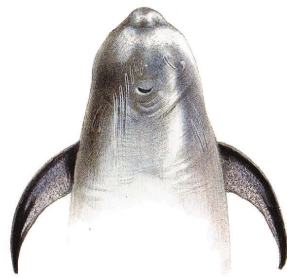
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In loving memory of Jacky Jacksons (14 June 2014).
My dear friend through many adventures in and around Pico Island...



JACKSONS



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FOREWORD

I have been sailing around the Dutch “Wadden- Sea” with my family from my infancy until I was 23 years old. I think it was due to this background that my general interest in marine life, oceans and islands was born. After I finished my degree in Art (1998) I could never imagine that I would ever conduct a PhD in marine biology. However, “life is what happens when you’re busy making other plans”.. and it seems that John Lennon was right.

When backpacking with 2 girlfriends across the Azores in 1997 (as a “female-sub adult”), I simply fell in love with the islands and their natural beauty. It was aboard a private yacht that pilot whales and common dolphins showed up at once and left their “footprint” in my soul. Two years later I returned to The Central Group, this time with my former boyfriend. We visited a place called “Ribeiras” at Pico Island and we went alone to the ocean in a 2,1 meter zodiac with 10 liters of fuel. It was during this “pirate” trip that we saw these strange looking animals, covered with scars and with a huge dorsal fin. I thought that we were surrounded by a pod of killer whales, but back on land they seemed to be called “Risso’s dolphins”, or “Moleiros” (Millers). The “Risso Project” was born one year later...

Year after year we discovered the richness of Ribeiras Bay and its inhabitants. We started to recognize individual animals and gave them names: Hook, Pointer, Fish, Iron, Simmer and Chicco. Most of them are still around today...some have disappeared.

A foundation was established in 2002 in order to gain money for the project. Biology students came and helped us to develop better methodologies. With the introduction of the digital camera in 2004, the project was lifted up towards a new level (being able to study Photo ID material straight after a trip), and therefore creating the base for in-depth studies.

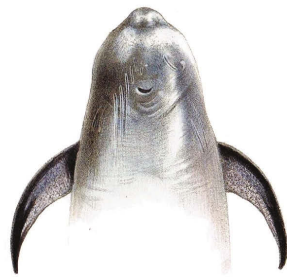
In the spring of 2008, I started to run the project without my partner and after an accident with my ankle I almost left Pico. However, it was at the same moment that Dr. Jose Azevedo started to launch the idea that the collected data could be presented as a PhD study. And also, that he was willing to take the risk of being the supervisor of a non-biologist. And here we are. It is written.

I have been spending many hours at sea with the illusive animal called *Grampus* and I am grateful for their patience of having me and other team members around them for over 15 years. I hope that by submitting this thesis I can make a little contribution to a better general understanding of this species and thereby to their conservation.

Keep on Gramping!

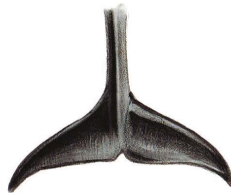
Karin Louise Hartman, June 2014





CHAPTER 1

INTRODUCTION



1. INTRODUCTION

This PhD thesis is focusing on the ecology of a medium sized and poorly studied oceanic dolphin species: The Risso's dolphin (*Grampus griseus*). In this Introduction, I give a general description of this species, followed by current knowledge at the start of this PhD study on its ecology, social structure, and conservation status. After this I present the study design, thesis outline and the literature cited.

1.1 GENERAL DESCRIPTION OF THE SPECIES

MORPHOLOGY

The Risso's dolphin is the fifth largest member of the family Delphinidae (Baird et al. 2008), named after Antoine Risso whose description formed the basis of the first public description of this animal, by Cuvier (1812). This dolphin is also commonly named *Grampus*, which means "*grandis piscis*" in Latin or "*grand poisson*" in French, both meaning big fish.

The second word "*griseus*" refers to the overall grey colouration of its body. This skin colouration is indeed the most obvious characteristic of this species. A first remarkable description was given by Flower (1872); an anatomist, who examined a dead female Risso's dolphin and her stillborn calf, bought at the fish market in London: "*The most noticeable external character was the very marked and peculiar coloration. The most prevalent tint was grey, varying in some parts of pure white and in others to deep black. The streaks or lines were of various lengths, and running in all directions in a most fantastic manner, some parallel, some crossing each other and some forming sharp angles zigzags and scribble-like patterns*".

The skin and the scarification pattern on the lateral body of a Risso's dolphin changes during its life cycle: calves are born silvery grey and immature individuals turn from pale-grey to dark brown or black as sub adult, and may become almost white as an older adult (Amano & Miyazaki, 2004; Chen et al. 2011; Bloch et al. 2012). The dorsal fin, flippers and the fluke areas remain mostly dark. These scarification patterns are caused by the teeth of other individuals and by confrontations with their main prey, cephalopods (MacLeod, 1998). The patterns, specifically on the dorsal fin, are individually unique, providing a very strong identification key for individual recognition (Kruse, 1999). The anterior body of Risso's dolphins is robust, with a bulbous forehead showing a distinctive V-shaped groove (Fig 1.1). The dorsal fin is one of the tallest in proportion of body length among any cetacean (UNEP, 2004). Teeth are present during all stages of life and in both sexes (Würsig & Jefferson, 1990; MacLeod, 1998).



There are only 3 to 7 pairs of strong, oval teeth on the lower jaw; the upper jaw usually does not contain functional teeth (Clarke, 1986). In the field, these animals are most frequently confused with killer whales (*Orcinus orca*) due to the large size of their dorsal fin (Baird et al.2008).



Fig. 1.1 "Rollo" (S5c), an adult male, showing the main characteristics of the species: blunt head, large dorsal fin and the typical skin scarification.

AGE AND GROWTH

Counts of the growth layer groups (GLGs) in teeth (Kruse, 1999; Taylor et al. 2007; Amano & Miyazaki, 2004), indicate that Risso's dolphins (male and females) can reach over 35 years of age: the oldest individual known to date (female) was determined to be 38 years old (Taylor et al. 2007).

Risso's dolphins can reach a body length of about 2.6 to 4 meters long and adults may weigh between 300-500 kg. Whitehead and Mann (2000) report a median birth length of 1.3 m, a median adult length of 3.3 m and a mean length at female sexual maturity of 2.8 m. The species shows a small degree of sexual dimorphism: adult males are on average 8 cm longer than females (Perrin and Reilly, 1984). However Kruse et al. (1999) state that there are no differences among genders. Present morphological data suggests that morphological differences in body lengths occur between populations (Ross, 1984; Kruse et al. 1999; Amano and Miyazaki, 2004; Chen, 2011; Bloch et al. 2012).



1.2 ECOLOGY

The Risso's dolphin is present worldwide in temperate and tropical waters, from coastal to oceanic habitats (Ross, 1984; Baumgartner, 1997; Balance and Pitman, 1998; Gannier, 1998; Kruse et al. 1991; 1999; Jefferson, 2013). On average, they prefer deep, offshore waters, concentrating on the upper continental slope (Baumgartner, 1997).

Information on the species feeding ecology is mostly obtained from necropsies and examinations of stomach contents of dead animals. *G. griseus* is thought to be a deep diver, feeding mainly on deep-water cephalopods (Cockroft et al. 1993), presumably mainly at night (Kruse et al. 1999). Just like other teutophagous cetaceans, they are able to dive deep, up to 800 meters (Whitehead, 2003).

1.3 SOCIETY

GROUP SIZE AND SOCIAL STRUCTURE

Reported group size ranges from one to several hundred individuals, with a mean of 10-30 animals (Leatherwood et al. 1980; Kruse et al. 1991; Kruse, 1999; Evans, 2008). However, some observations in California were made of large aggregations of several thousands (Dohl et al. 1983). There are a small number of descriptions available of the social organization of the species. During a study along the south-east coast of Spain (1992-1995), during which 281 individuals were identified and 29% of identified individuals were resighted, preliminary results indicated fluid structures along with some evidence of stable associations (A. Cañadas, personal communication 2007). Risso's dolphins frequently associate with other delphinid species (Shane 1995a; b), and wild hybrids with the bottlenose dolphin have been reported (Jefferson et al. 1993; Hodgins et al. accepted). Some evidence of summer inshore movements and site-fidelity of individuals has been reported (Leatherwood et al. 1980; Evans, 1987; Olavarria et al. 2001).

REPRODUCTION

Knowledge about the reproduction of this species is limited. Age at sexual maturity is thought to be 8-10 years for females and 10-12 years for males (Amano and Miyazaki, 2004). Large testes (3% of the body mass) suggest sperm competition and a promiscuous mating system (Connor et al. 2000). At present, there is little information available on life history data and what is described is taken from killed (i.e. by-caught) animals. Amano and Miyazaki (2004) suggest that gestation takes place over 13-14 months with a calving interval of 2.4 years. This data is based on one killed school in Japan (n=79). There appears to be a peak in calving seasonality during the autumn/winter months in the eastern Pacific (Kruse 1989) and in the summer/fall months in the



western Pacific (Mizue and Yoshida, 1962; Amano and Miyazaki, 2004). Elsewhere, a summer calving season is reported in South Africa (Ross, 1984) and for the North Atlantis (Jefferson et al. 1993). In general, little is known about the genetic population structure of this species. Recent research, comparing genetic material from Risso's dolphins in UK waters and the Mediterranean Sea, has shown no evidence of exchange between these two populations, indicating little long-range dispersal (Gaspari et al. 2007).

1.4 CONSERVATION

GENERAL ISSUES

Essentially nothing is known about the structure and size of this species' populations. There are several reports on local population estimates (e.g. Waring et al. 2007), but global data is lacking. No published population trends are existing, therefore Taylor et al. (2012) ruled out a 30% global reduction over the next 60 years, classifying the species in IUCN's Least Concern category

The Risso's dolphin populations of the North, Baltic, and Mediterranean Seas are listed on Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS). In addition, the Risso's dolphin is covered by the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS), the Memorandum of Understanding for the Conservation of Cetaceans and Their Habitats in the Pacific Islands Region (Pacific Cetaceans MoU) and the Memorandum of Understanding Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (Western African Aquatic Mammals MoU). Risso's dolphins are protected in the United States under the Marine Mammal Protection Act of 1992 and are offered 'strict' protection under the EU Habitats Directive 92/43/EEC.

Risso's dolphins are hunted in various parts of the world with records off Sri Lanka, Japan, and Taiwan (Kruse et al. 1999; Amano & Miyazaki, 2004) and recently off the Faroe Islands (Bloch et al. 2012). Small numbers of by catch through entanglement in long line fishing gear are reported (Kruse et al. 1991; Perrin et al. 2005). The habitat of the Risso's dolphin is increasingly being exposed to noise disturbance from a variety of human activities, such as from presence of recreational crafts (Miragliuolo et al. 2004). Recent studies have revealed that this species suffers and dies from gas embolism caused by military mid-frequency active sonar activities (Fernandez et al. 2003; Jepson et al. 2005).



THE AZORES

Although the Azores are quite isolated in the Central North Atlantic, the influences of human activities could be a threat to the species. Boat traffic in general, using the coastal waters, has been increasing over the years, as well as the number of large container ships, maintaining high speed while crossing areas with high cetacean abundance. Several species have been observed wounded, with prominent scars present across large parts of the body or with shopped-off dorsal fins, caused by boat propellers and ship-collisions.

Around the islands of Pico and Faial, but particularly off the south coast of Pico island, the anthropogenic impact of noise pollution and general impact of commercial whale-watching activities probably constitute the major threats to the population of Risso's dolphins present in the coastal waters (Barradel and Ritter, 2007). Possible impacts may be more serious if individuals are resident in the area and therefore being frequently exposed to these threats. Detailed knowledge on various aspects of Risso's dolphin ecology is one of the vital keys to its conservation and for long-term sustainable management of its habitat. This would be especially important if the Azorean waters prove to be a key area or critical habitat (Hoyt, 2011) for a resident population of Risso's dolphins expressing breeding behaviour.

1.5 RESEARCH OBJECTIVES

The general objective of this PhD study is to broaden the current ecological knowledge and overall understanding of the biology of this species, as well as understand local pressures. To achieve these goals data were collected from an identified population of Risso's dolphin off Pico Island in the Azores, in order to:

1. Define the social structure and organization.
2. Determine temporal and spatial residency patterns.
3. Gain insights in habitat suitability and identify critical habitat.
4. Estimate the age based on skin scarification patterns.
5. Determine behavioural responses to whale watch vessels.

1.6 STUDY DESIGN

This study took place off Pico Island, one of the nine islands belonging to the Archipelago of the Azores (Portugal). The islands are separated by deep waters (ca. 2000 m) with scattered seamounts (Santos et al. 1995) and stretching-out over 480 km, overlapping the Mid-Atlantic Ridge. The Gulf Stream, the North Atlantic, and Azores currents (and their branches) are responsible for the complex pattern of ocean circulation that



characterizes the Azores, and result in the high salinity, high temperature and low nutrient regime waters (Johnson & Stevens, 2000). Due to the upwelling of nutrient-rich deep water currents, the runoff from land and the complex and dynamic oceanic circulation patterns, the area constitutes a food-rich oasis in the oligotrophic central North Atlantic. It concerns a coastal marine habitat where coastal, pelagic and deep-water ecosystems can be found in close vicinity of each other, resulting in a species-rich and highly diverse marine ecosystem (Morton et al. 1998). Therefore, these waters not only constitute a very unique and diverse ecosystem in itself, but also function as an important and valuable link within large scale ocean ecosystems. The Azores form a cetacean hotspot of worldwide importance. Yearly over 25 species of resident and migrating whales and dolphins are observed in inshore waters (Silva et al. 2003). This indicates that the area could form a critical habitat for cetaceans in the North Atlantic Ocean. Research and monitoring in this particular key-area is therefore of great importance for the conservation of a large number of cetacean species and their habitat. Due to the absence of a continental shelf and the steep marine walls (Morton et al. 1998), whales and dolphins species occur very close to the coast, allowing researchers to use land based observations as a highly efficient and cost-effective tool to study species presence, numbers, general behaviour and temporal and spatial patterns of occurrence. Risso's dolphins in the Azores can be found close to shore, creating unique opportunities to study this pelagic dolphin species from both land and at sea (Visser et al. 2007).

A long term research project focusing on the social behavioural and ecology of Risso's dolphins was set up in 2000 by the Nova Atlantis Foundation. Founded in the Netherlands, this Foundation continues to conduct independent research off the south coast of Pico Island. The foundation has its own dedicated research vessel, a land based platform and workstation in Santa Cruz das Ribeiras. Every year the team has been extended with 1-4 students from international (overall) European Universities who are working in the running projects as a part of their bachelor or master thesis. Field seasons have been running mostly from April till October. From 2006 until 2010 winter surveys took place in order to collect specific data concerning Risso's dolphins year round presence. For this PhD project both long term (2000-2013) and short term (2004-2007) data was used for specific analysis, using different methodological approaches. In general for all analysis, photo-identification, focal group, and individual follows were used, combining both land and boat based surveys (Fig. 1.2.) (Altman, 1974; Würsig and Jefferson, 1990; Mann, 1999).





Fig. 1.2 Study site and field methods used for this PhD project: (A) the Bay of Ribeiras; (B) the view from the main lookout at Santa Cruz; (C): Land team scanning with binoculars; (D): the research vessel “Moleiro”; (E): Students collecting data; (F): Photo identification- the animal in the foreground is “Blunt”.

1.7 THESIS OUTLINE

This thesis comprises five research chapters (Chapters 2, 3, 4, 5, 6) with an Introduction (Chapter 1) and a Synthesis (Chapter 7). Chapter 1 gives a general description of the species, its conservation status, the research objectives, study design, and the thesis outline. The principal part of this thesis is formed by Chapters 2-6 where multi-methods approaches have been combined and explored in order to produce present results. The five research chapters have been separately presented to reviewed journals. Three chapters have been published (2, 3, 6) and two are in review at the time of submitting



this thesis (4, 5). The contributing authors of these chapters are listed in Table 1.1.

Table 1.1 Contributing authors for the chapters in the thesis.

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CHAPTER 2: SOCIAL STRUCTURE

A model for the social structure of Risso's dolphins is presented. It was found that individuals form stable, long-term bonds organised in pairs or in clusters of 3–12 individuals. Social structure is stratified based on age and sex classes, with strong associations between adult males and between adult females. Sub-adult associations also occur (pair formation), but are less stable than those observed for adults. I propose a new model for Risso's dolphin societies known as a stratified social organisation, which differs from the fission–fusion and matrilineal society models known from other species such as bottlenose dolphins and killer whales respectively.

This research was published as Hartman et al. 2008.

CHAPTER 3: TEMPORAL AND SPATIAL RESIDENCY PATTERNS

The temporal and spatial results of residency patterns and habitat use of identified Risso's dolphins off Pico Island are described. The dataset covers the period 2004–2007, based on at-sea observations of 1,250 individually identified animals, 303 of known sex. Photo identification and GPS locations were used to analyse temporal presence by calculating the mean monthly sightings and lagged identification rates from frequently and less sighted individuals. For spatial analysis kernel density estimations together with home range overlap were studied. The results support previous suggestions of a resident population, living in a restricted area. The differences found in residency patterns between sexes may be connected to this species' mating system. These findings reinforce the need for a precautionary management approach which would include limiting pressure from commercial activities.

This research has been submitted for publication as Hartman et al., subm.

CHAPTER 4: NURSING AND CALVING HABITAT

I investigated the hypothesis that calving and nursing habitat could be defined for Risso's dolphins off Pico Island. Data were gathered from land-based and dedicated at-sea observations between 2004 and 2007. A total of 694 observed pods were divided into three groups: (1) those with new-born and young calves, (2) those with older calves or juveniles, and (3) those consisting only of adults or sub-adults. Eco-geographical variables were analysed and incorporated into a presence-only spatial distribution model to look at differences in habitat suitability among the groups. The peak of the calving season took place between June and August, and a total of 136 calves, of which 22 were new-born's, were observed during this period. The pods with new-born calves tended to be located closer to shore, whereas the other groups used a wider offshore area. These results support the definition of critical habitat areas for this



species and it is therefore strongly suggested to understand and reduce the anthropogenic impact on a vulnerable component of the Risso's dolphin society (see Chapter 6).

This research was published as Hartman et al., 2014.

CHAPTER 5: AGE

Examining long term photographic skin recaptures gathered over a 14 yr period from 59 wild ranging Risso's dolphins, I propose a skin classification model in six stages starting with no scars (class 1) and ending with a very scarified or white class (6). This model was tested by 28 rankers (experts and non-experts) using Kappa-Fleiss statistics. Bayesian statistical estimations were combined with expert knowledge to calculate the posterior means of duration for each skin stage and the mean age for each stage. The results suggest that animals may reach an age ≤ 50 yrs, which is older than historical data obtained by GLG's (≤ 37 yr). Adult females are less scarified than males and were not observed in the whiter skin classes. Given the overall substantial agreement (79%) among rankers, this model seems promising due to its non-invasive origin and may serve as a base for further studies of population dynamics.

This research has been submitted for publication as Hartman et al subm.

CHAPTER 6: BEHAVIOURAL RESPONSES TO WHALE WATCHING VESSELS

The behavioural responses of Risso's dolphins (*Grampus griseus*) to whale watching vessels off Pico Island were studied from a land-based lookout, enabling observations of groups in the absence and presence of vessels. The number of whale watching vessels showed a clear seasonal pattern, dividing the whale watching period into a low season and a high season. During the high season, Risso's dolphins rested less and did so mainly at noon, when the number of active vessels was lowest. Data analysis using a generalized additive mixed model indicated that this change in resting behaviour was associated with vessel abundance. When more than five vessels were present, Risso's dolphins spent significantly less time resting and socializing. Reduced resting and socializing rates can have negative impacts on the build-up of energy reserves and on reproductive success. I therefore suggest the adoption of precautionary management measures to regulate the timing and intensity of whale watching activities.

This research was published as Visser et al. 2011.

Chapter 7 summarizes the major findings of the research chapters and explains the links between them from an ecological and conservation point of view. Furthermore, recommendations are presented for further research.



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