8. SHOW ME YOUR BODY AND I TELL YOU HOW OLD YOU ARE: A NON-INVASIVE METHOD TO DEFINE 6 LIFE HISTORY- CLASSES IN RISSO'S DOLPHINS (*GRAMPUS GRISEUS*) USING AN IDENTIFIED TRIAL POPULATION IN THE ATLANTIC.

Karin L. Hartman[1,2,*], Anja Wittich[2] and José Manuel N. Azevedo[1]

[1] Department of Biology, University of the Azores, Rua Mãe de Deus 13, 9501-801, Ponta Delgada, Azores, Portugal
[2]Nova Atlantis Foundation, Risso's Dolphin Research Center, Rua Dr. Freitas Pimentel 11, 9930-309, Santa Cruz das Ribeiras, Lajes do Pico, Azores, Portugal
Corresponding author; email: karinlouisehartman@gmail.com

INTRODUCTION

Kruse (1989): "The ability to estimate the ages of animals is a critically important tool in the study of mammalian life history. Knowledge of growth rates, age at sexual maturity and longevity are needed to assess the health and productivity of populations. Ages of animals can be determined by knowing birth dates of individuals and following them throughout life."

However, determining age for cetaceans is a difficult task. Current methods used include body length, teeth, ear plugs, bones and even eye lenses (e.g. Klevezal and Klejnenberg 1967; Lockyer 1972; George *et al.,* 1999; Fearnbach *et al.,* 2011). The standard delphinid technique of estimating age is obtained by counting dental growth layer groups (GLGs). Each layering group represent one year (e.g. *Tursiops truncatus*, Hohn 1980; Globicephala macrorhynchus and *G. melas*, Kasuya and Matsui 1984; and *Stenella longirostris*, Myrick *et al.,* 1986). All these are invasive methods and cannot be applied to live animals restricting data collection considerably (exception of body length).

In marine mammals other proxies besides the GLGs technique have been used to determine age classes of populations, mainly analyzing variations over time in skin colour. Narwhals (*Monodon mococeros*), e.g., lighten with age (Silverman 1979, Hay 1984, Hay and Mansfield 1989). Auger-Méthé *et al.* (2010) investigated the amount of white marks on the skin of narwhals as a proxy for age but no relationship was found. For spotted dolphins (*Stenella frontalis*) four phases of spotting, subdivided into early and late stages, have been correlated with age (Herzing 1997). By closely monitoring individuals over the years, the development of the color patterns and the durations of the phases were used to categorize dolphins by age class. The ontogenetic development of color patterns was also used in a long term study in Indian Ocean bottlenose dolphin (*Tursiops aduncus*) (Ross and Cockroft 1990, Smolker *et al.,* 1992). For other marine mammals such as grey seals, (*Halichoerus grypus*), the natural pelage markings on the head and neck tend to darken with age and seem to progress more quickly in the first years of life. Overall females tend to be lighter in color than males (Vincent *et al.,* 2001).

Grampus Teeth Function and Skin Coloration

The skin of cetaceans is more sensitive to cuts and scratches than the skin of other mammals, since they are lacking natural protection or fur. Numerous factors, such as accidents, parasites, predators and intraspecific tooth rakes, leave their marks on the skin (McCann 1974; Lockyer and Morris 1990; MacLeod 1998). Scarring from teeth tends to be long and parallel (Heyning 1984). The amount of unpigmented scarring varies widely among cetacean species but is mainly observed in odontocetes. This scarring is extremely visible in Risso's dolphins, accumulate primarily on the animals' dorsal and lateral surfaces (Wursig and Jefferson 1990; Kruse 1999; MacLeod 1998; Hartman *et al.,* 2008) and is also observed in other species such as the narwhal, the sperm whale (*Physeter macrocephalus*), and several beaked whales species (MacLeod 1998). The skin of the Risso's dolphin changes during different life stages: calves are born silvery grey, turn dark brown or black as sub adult and may become almost white as older adult (Lien and Katona 1990; Hartman *et al.,* 2008; Bearzi 2010). This unique discoloration process is mainly caused by the teeth of other Risso's dolphins during social interactions, leaving linear marks on the skin and the dorsal fin. These scars turn white, which is possibly caused by reduced skin pigmentation in this species (MacLeod 1998). Through evolution, some cetacean species became specialized cephalopods hunters, a diet that does not require teeth (Clarke 1986). The teeth in Risso's dolphins are reduced to only three to seven pairs at the front of the lower jaw (Clarke 1986; Lien and Katona 1990) and present in all age classes and for both sexes (Wursig and Jefferson 1990; MacLeod 1998). The function of teeth in teuthophagous cetaceans is believed to be a weapon. This is the case for Risso's dolphins. MacLeod (1998) found evidence that un-pigmented scars have an important function for this species': it may function as an indicator of 'male quality' or male dominance and is therefore used to avoid risks of escalating aggressive encounters between unevenly matched individuals. Results from a social structure study in the Azores indicate that stable cluster pods, consist of whiter animals who are assumable males (Hartman *et al.,* 2008).

Life History at Present: Age and Body Length in Risso's Dolphin

Risso's dolphins (male and females) can reach over 30 years of age by counting GLGs. (Kruse 1999; Taylor *et al.,* 2007; Bloch 2012). The oldest reproducing female found known to date was determined to be 38 years old (Taylor *et al.,* 2007). Risso's dolphins reach a body length of about 3 to 4 meters long with no significant sexual size dimorphism (Kruse *et al.,* 1999; Bearzi 2010). Whitehead and Mann (2000) report a median birth length of 1.3m, a median adult length of 3.3m and a mean length at female sexual maturity of 2.8m. The literature reviewed concerning morphological data of Risso´s dolphins suggest that morphological differences in body sizes occur between populations (Ross 1984; Kruse *et al.,* 1999; Amano and Miyazaki 2004; Bloch 2012).

Objectives

Hartman *et al.* (2008) defined 5 scarification classes for different stages of scarification on the dorsal fin (from "very limited" to "very severe") using the percentage of visible white scars versus the density of dark skin. The unpigmented scars on the dorsal fin of resighted individuals in the Azores remained stable for at least 3 years leaving a unique opportunity here to investigate the scarring processes in more detail using other parts of the skin on the body. In summary it is ethically impossible to know the correct age of wild living Risso's dolphins. Therefore it is certainly an essential tool to determine the age class composition of a population, in order to understand and interpret fundamental aspects of marine mammal biology. The objective of this paper is to present a new non-intrusive and inexpensive method to classify six life history stages in Risso's dolphins: from newborn calf to old-adult. We propose an age-class indicator model using the scarification patterns and the species unique discoloration process. We developed two methods and tested these among 52 rankers to examine if our proposed methods could be applied by anybody and if they would conform with our age class model. We also investigated the possible differences in the scarification patterns between genders. We used a long-term followed identified population of Risso's dolphins in the Azores to set up our test methods and report our present results.

MATERIALS AND METHODS

Study Area and Field Observations

This study was carried out in the coastal waters (approximately 0-6 kilometers offshore) around Pico Island, in an area of approximately 540 km^2, belonging to the Azores Archipelago.

Boat-based surveys were conducted yearly from 2000 till 2012. Observations were carried out up to sea state ≤ 4 (Douglass scale, ds). Risso's dolphins were located with guidance from 12 fixed look-out posts situated around the island, with the main look-out located in Santa Cruz das Ribeiras (Figure 1). At the start of every ocean observation environmental conditions, such as wind force, wind direction, sea state, visibility and GPS co-ordinates, were recorded.

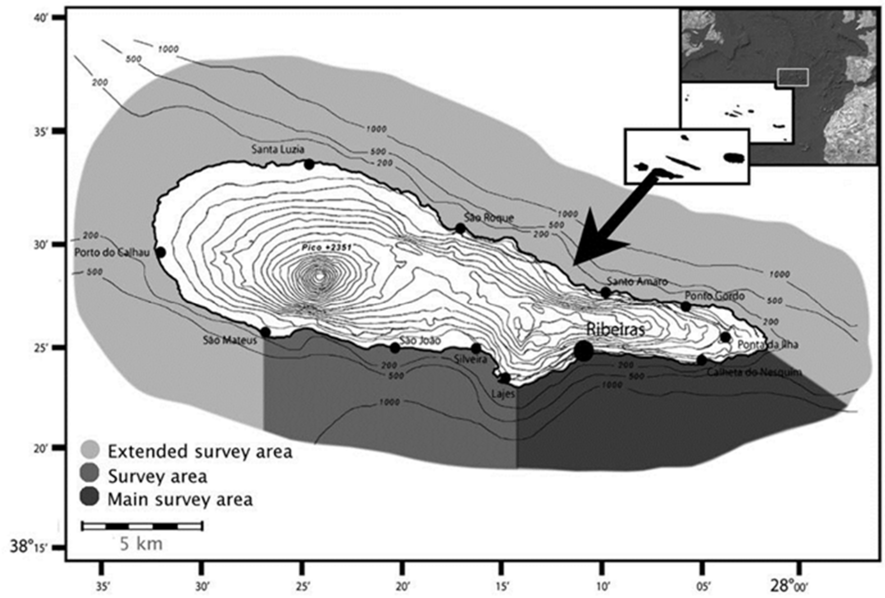

Figure 1. Detailed map of survey area (Pico Island).

Main Database

Risso's dolphins were individually identified using distinctive characteristics like notches, nicks, amputations and the unique scarification pattern on the dorsal fin (See Hartman *et al*. 2008 for a detailed overview of the photo-identification methods used). Identifications photographs were taken from May 2000 till June 2012, during dedicated ocean surveys, using analogue (Minolta X700, 70-200 mm 36/400 ISO slide films) and SRL digital camera's (Nikon D70-D200-D300, 70-300 mm zoom lens).

Age Classes and Gender Determination

For the determination of six life history based-age classes the skin of the frontal part of the back (behind the blowhole and in front of the dorsal fin) was photographed and used as main measure area (Figure 2). The fact that the dolphin needs to surface in order to breath, creates good recapturing opportunities, since it will lift up its head, meanwhile showing the frontal back part.

On average we used high quality pictures: 100% sharp, taken approximately between 10 - 20 meters from the dolphin, showing a clear view of the back part, head and dorsal fin area, hardly no interferences of water or sunlight glimmerings on the measurable parts. Occasionally we used medium quality pictures defined as not 100% sharp, some interference of water and or sunlight, not all parts 100% visible.

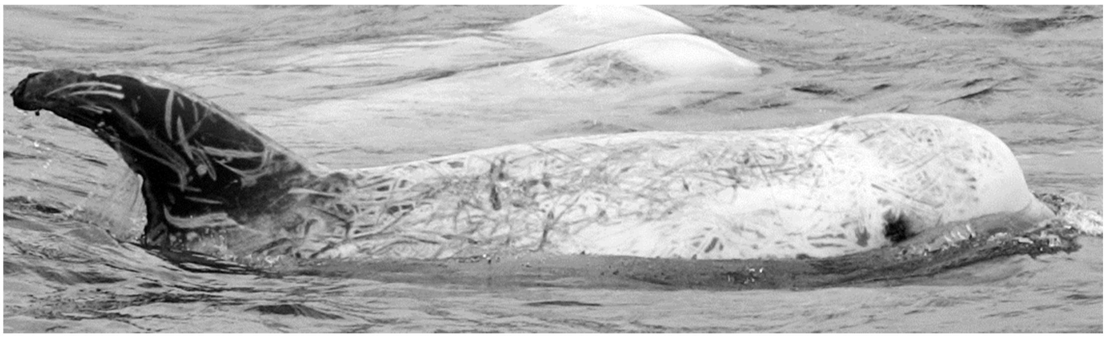

Figure 2. Example of a picture of the frontal area of the back, after the blowhole and before the dorsal fin, which was used for age class determination.

Trial Phase

At the start of this study we tried to develop a precise standard to quantify the amount of visible scars (white) versus the original skin (black). We used several computer-assisted methods in order to define a correct % but these methods failed (Figure 3). After our quality selection, pictures needed to be adjusted to grey tones when using Adobe Photoshop software.

Additionally the clearness and contrast tool was used in order to create the best possible balance between the inner species scarring (white parts) versus the original skin (black parts). Furthermore, we were unable to create a solution to remove natural irregularities appearing on our pictures like areas with glimmering sunlight, and droplets of water from waves or blows. When pictures were converted to black and white these areas were treated as "white area"- counting as a natural scar and therefore intensively influencing the measurement process, showing false values of scarifications percentages. Although we had promising results in the older classes, we run into trouble when analyzing the material of the younger animals. Their skin wasn't always dark brown or black but also greyish, hence the original and unscarrified skin was quantified as "white areas", again giving false values of scarification. Since we had to deal with our free-ranging and natural obtained photo material we looked for a method were we would not adjust the pictures after a secure selection of the picture quality.

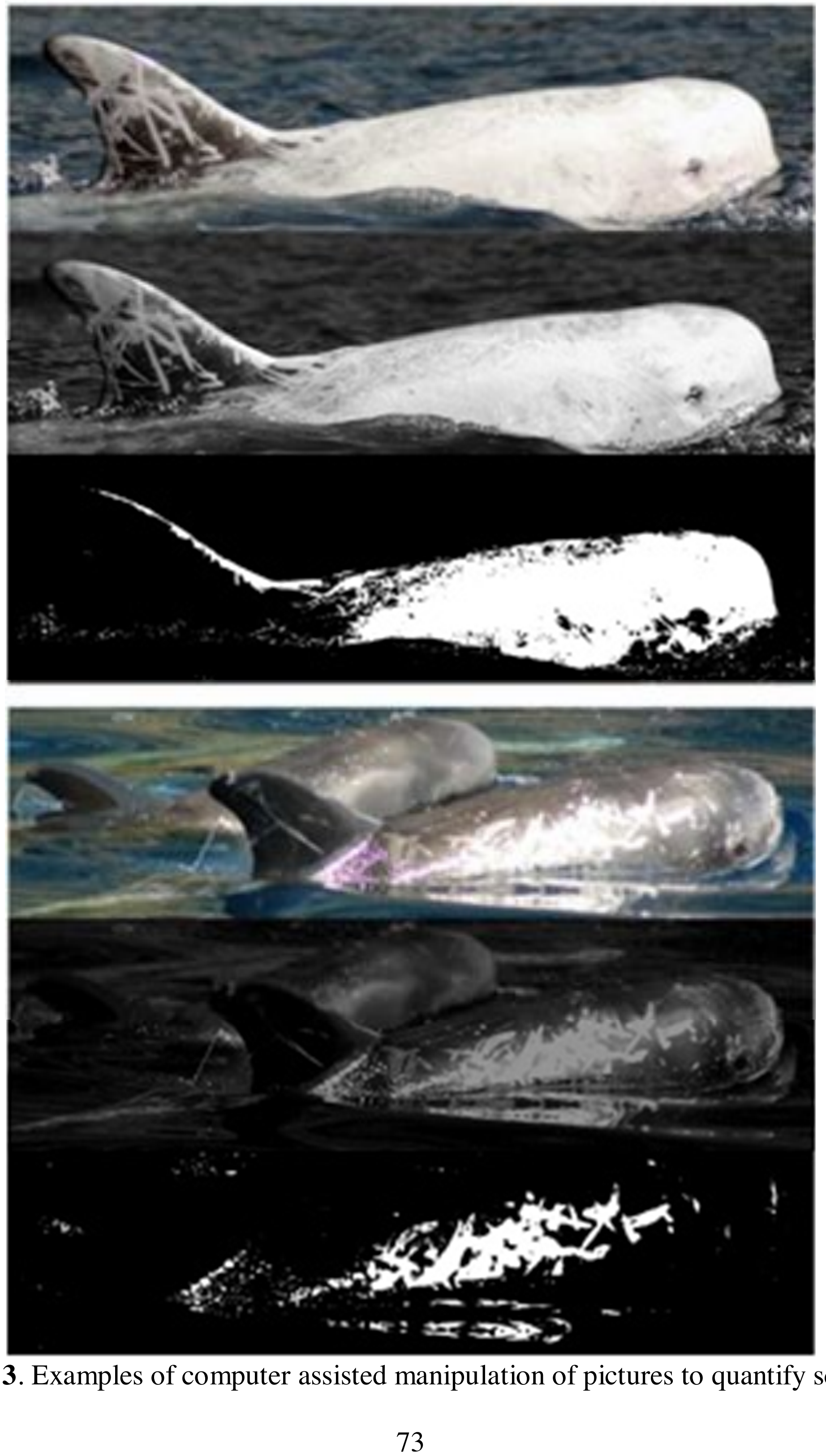

Figure 3. Examples of computer assisted manipulation of pictures to quantify scars

Life History Scar Type Determination Model: Scarification Guide

First, six classes were defined: calf, juvenile, sub-adult, adult-1, (female/male) adult-2 (marbled-female/male) and adult -3 white-female/male) (Figure 4).

Figure 4. Age classes, using six scarification categories.

For the development of a life history-age class determination model, photographs of long term resighted individuals were selected using data from 2000 until 2012. From several individuals, the age was known since they were followed as newborn calves. In our model this is the case for the life cycle "calf" and the "calf to sub-adult". Examples for the following life cycles were determined by comparing photographs of individuals over time with overlapping scarification patterns (Figure 5).

The scarification processes were compared among animals categorized in the same age class. Since the coloration processes were documented in detail a subdivision of 12 sub stages was made and used (Figure 7).

Furthermore, an overview of observed morphological characteristics per age class was summarized for this observed population. Behavioral aspects were determined using unpublished data (Hartman). Social structure characteristics were defined after Hartman *et al*. (2008**Error! Reference source not found.**).

Gender Determination

Males and females were distinguished whenever possible. Adults accompanied by a calf were defined as females. A calf was defined when observed in "calf position" next to the mother (Mann and Smuts 1999). Males were defined based on the long-term absence of accompanying calves, corroborated by behavioral and genital area observations, severity of scarification patterns on the skin, robust body build and the appearance in stable cluster pods (Hartman *et al*. 2008). Molecular sexing from an ongoing unpublished study confirmed observational determinations in most cases (Hartman unpublished data).

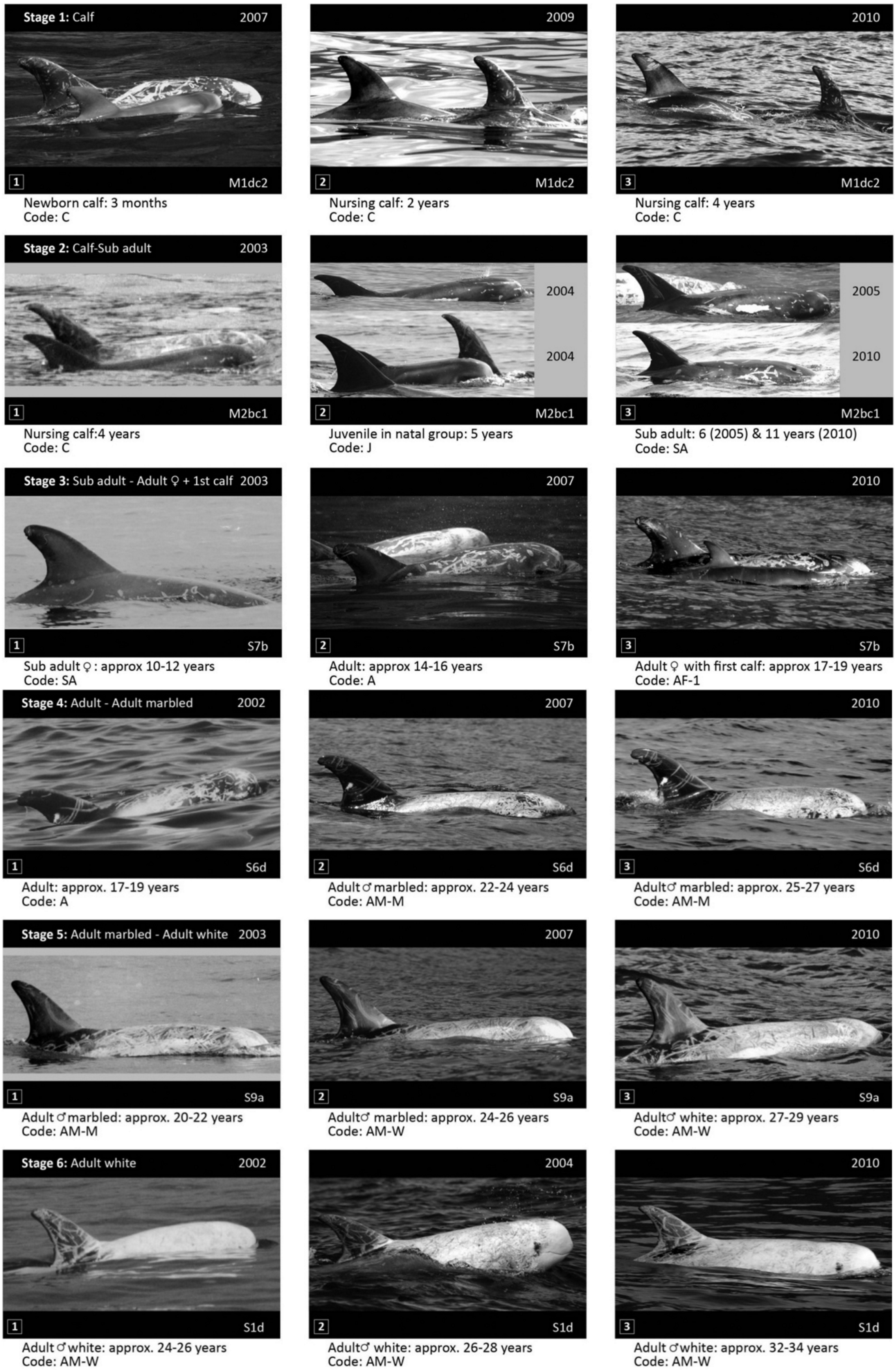

Figure 5. Age Class Determination Model, based on six scarification stages and 6 long term followed individual Risso's dolphins.

Table 1. Characteristics of coloration and scarification in Azorean) Risso's dolphins.

Picture Number	Age class	Age	Size	Colouration	Scarification pattern	Behavioural description
1	Calf	0-4 years	1-2.2 m	New-born calves have a typical yellow snout and 6-10 vertical foetal folds covering their central body.	Overall unscratched and pale-greyish (original) skin.	Surfacing in typical calf position next to the mother.
2	Juv-enile	4-6 years	2.2-3 m	Pale-greyish to dark brown skin.	Very few and thin linear marks visible.	From 4-6 years, dispersed from mother. May be observed in close proximity to natal group.
3	Sub-Adult	6-12 years	2.5-3.3 m	Overall dark brown to black skin. Dark appearance.	Several single layered linear marks visible, mostly original skin.	Living in typical bachelor groups, mixed gender possible. Not well connected at social structure level.
4	Adult stage 1	10-18 years	3.2-4 m	First covered layer of white scarified skin. Mixed appearance of black and white.	Clear first layered scarification pattern visible, original skin clearly visible.	Nursing females use crèche system. Males may form very stable cluster pods.
5	Adult stage 2	15-25 years	3.2-4 m	Marbled to marbled-white skin. Overall whitish appearance.	Almost no original skin visible.	Nursing females use crèche system. Males may form very stable cluster pods.
6	Adult stage 3	>25 years	3.2-4 m	Overall white skin. Overall whitish appearance.	Double layered skin scarification pattern on whole body visible.	Nursing females use crèche system. Males may form very stable cluster pods.

Body-Sizes

In this study, all body sizes were estimated using subjective personal estimations, based on 13 years of observation effort and experience. Average body size for calves and juveniles were estimated by comparing their length with the estimated body size of the accompanying adult. The size of a newborn calf normally excites about 40% of the size of an adult (Whitehead and Mann 2000). (One observation was made of a premature calf of approximately 1 meter of length (Hartman unpublished data.) For the other age classes' size was determined by eye, also using the length of the two working platforms (a 4.2 m. semi ridge and 7.2 m. fiberglass boat) to estimate body length of adult individuals swimming a side of it.

Pictures Used for Rater Test Set ("By Eye" and "Ruler")

An even distribution of different age class and gender classes was sought of as well as a sample size which would lead to robust results. For each method 120 pictures were chosen which consisted of 12 different age/gender classes (
Table **1**). There were a minimal number of duplicate pictures between the two test sets but as all pictures were in random order recognition was deemed minimal. The data set does not allow for gender identification prior age class A1 and we hypothesize that a difference in scarring is not likely to occur prior reaching adulthood. There was an emphasis on the adult age classes as this new distinction was a main focus of this test. We split the adult classes up by gender as we hypotheses that males will be more heavily scared in contrast to females at the same age. Animals of unknown gender were also included.

Table 1. Number of pictures in Test Set split up by age/gender class

# of pictures	Age class (gender)
10	Calves (gender unknown)
10	Juveniles (gender unknown)
10	Sub-Adults (gender unknown)
10	A1 (gender unknown)
10	A2 (gender unknown)
10	A3 (gender unknown)
10	A1 (female)
10	A2 (female)
10	A3 (female)
10	A1 (male)
10	A2 (male)
10	A3 (male)
120	**TOTAL**

The majority of the calves, juveniles and sub adults were closely monitored animals, for which the age was known. Females categorized as an Adult1 were nursing their first calf and were followed since sub-adulthood. Females categorized as an Adult2 had at least 2-3 confirmed calves during the study period, while females in the Adult 3 class were substantial "whiter" in appearance than the Adult2 females, mostly still nursing with at least 2 confirmed nursing periods, and/or consorting younger females displaying assumable post-fertile and allo -maternal behavior. Male Adult 1– were followed since sub-adulthood , 2 and 3 individuals were classified by gender based on molecular sexing (Hartman unpublished data), long term followed behavior and cluster pod formation.

Since our main goal was to test whether these proposed classes could be determined by others, two groups of rankers were invited to test the two methodologies. The first group consisted of **biologists** which were mainly people who work with cetaceans. The second group consisted of people from the **general public**. This distinction was made in order to recognize if prior knowledge, expertise or training are required to establish this method.

By Eye Classification

For the Bye Eye classification method we ranked the overall scarification patterns of the back part using additional features like the coloration of the head, the scarification on the dorsal fin and the saddle patch (Figure 6).

Figure 6. Body areas used in for "By Eye" method as described in Table 1, 1: dorsal fin; 2: saddle patch (a saddle patch in Risso's dolphins is a darker area below the dorsal fin); 3: back-part; 4: head.

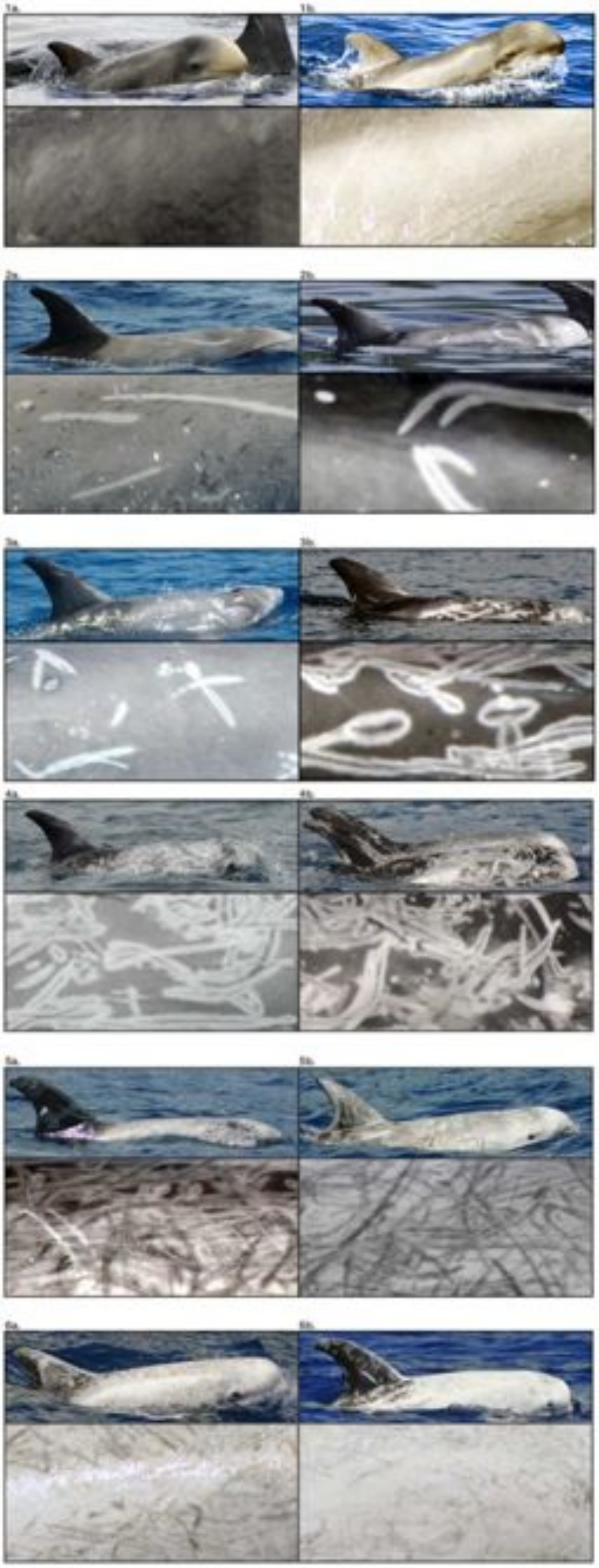

Figure 7. Example of beginning (a) and End stage (b) of Age class for "By Eye" method.

Raters had a detailed manual with descriptions and example pictures to help them assess the pictures. Overall there are 6 age classes (Calves, Juveniles, Sub-Adults, A1, A2 & A3) but the raters were asked to score each picture with a number between 1-12. Since there scarification patterns overlap per class, due to aging within a class- the 6 proposed scarification classes were subdivided in a “start” (a) and an “end” (b) phase, generating a total of 12 subclasses (Figure 7).

Furthermore they were asked to do a second judgment if the animals were in the adult phase (A1-A3). This second test was a judgment between pictures of known females and known males and will be referred to as the gender test. This test was blind as raters were not aware of the purpose of this second test.

Figure 8. Age classes for Ruler.

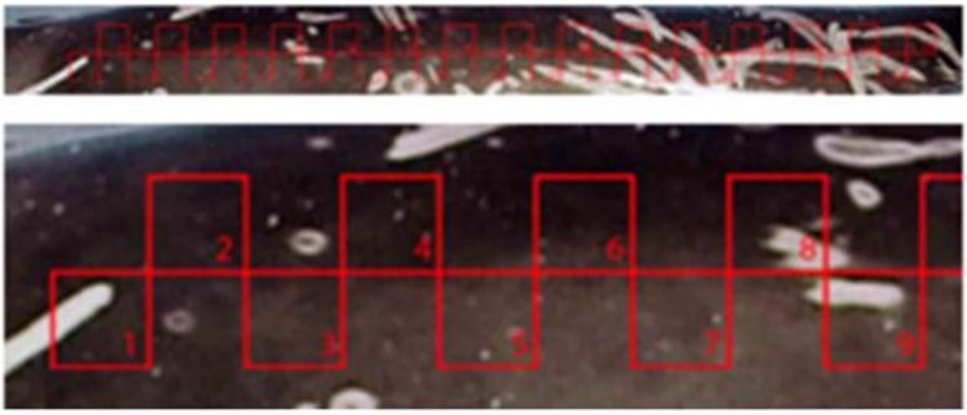

Figure 9. Ruler placed on back of animal.

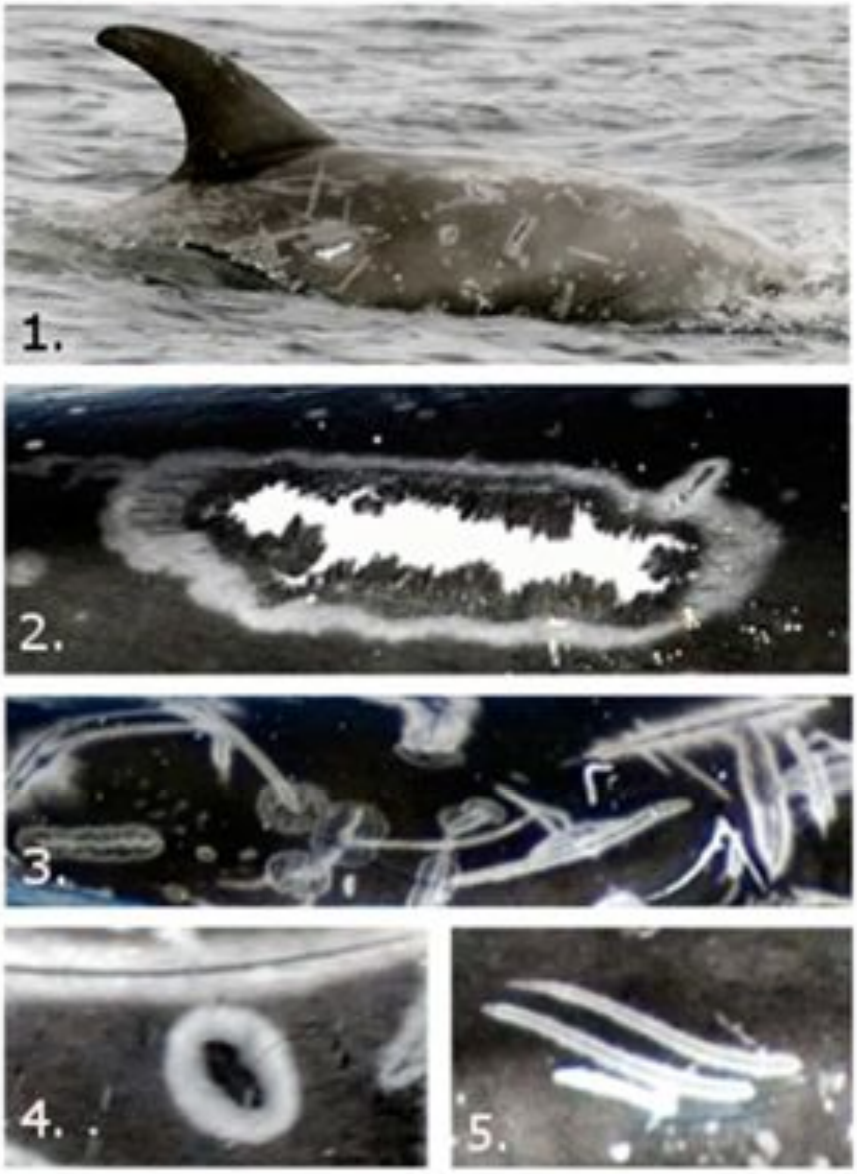

Figure 10. Variations of scar and mark types, **1**: Example of an individual showing various scar and mark types; **2:** Mark of a shark–bite; **3**: Overlapping scar and mark types: several dots, probably suctions cups prey marks, shark bite and linear inner-species tooth marks; **4**: Suction cup mark of a cephalopod prey; **5:** Single linear inner-species tooth marks.

Ruler Classification

For the Ruler classification method we created a ruler where 30 small boxes were placed on the line from the blowhole towards the front of the dorsal fin. Different designs were tested prior with different block number, block sizes and ruler sizes. The design used here is a balance between necessary details within the blocks, block size and feasibility.

A manual with descriptions and example was given to each rater. We used 6 scarification types (Figure 8) to score the density of scars and marks on the skin visible in the boxes (Figure 9). The overall scores were averaged and resulted in 1 of the 6 scar types. We scaled our pictures towards the fixed scale of the ruler size (size of ruler: 1000pt x 68pt), using the software program GIMP. For some pictures we lost sharpness and therefore we could not zoom in more than 300% in order not to lose important details or sharpness.

You may encounter areas with few linear tooth- marks and odd looking marks (Figure 10)._Figure 10 shows different scar and mark types which you will likely encounter during the scoring process.

RESULTS

As main statistic to judge agreement between raters the kappa statistics was used. An interpretation according to Landis and Koch (1977) can be found in Table 2.

Table 2. Interpretation of Kappa value.

K	Interpretation
< 0	Poor agreement
0.01 – 0.20	Slight agreement
0.21 – 0.40	Fair agreement
0.41 – 0.60	Moderate agreement
0.61 – 0.80	Substantial agreement
0.81 – 1.00	Almost perfect agreement

By Eye

The age classes were reduced to 1-6 instead of 1-12 as it was clear that the 12 classes were not well defined neither for rater group 1 (Biologists) nor for rater group 2 (General Public), respectively (Kappa=0.498, Kappa=0.437).

Rater Group 1: Biologists

There were 15 raters which assessed the pictures from the test set "By Eye".

The Fleiss Kappa for multiple raters was used to judge inter rater agreement (Fleiss and Cohen 1973). The software program R was used with the library "irr". The results show an overall substantial agreement between the raters (Kappa =0.734). The results for the different age classes can be seen in (Table 3). The lowest agreement seems to be for age class A2.

Rater Group 2: General Public

The same method was applied for the general public group which had 13 raters in total. There was also substantial agreement between raters (Kappa=0.656) but not as high as in the biologist rater group (Table 3). To identify a difference between the two rater groups a factorial ANOVA was carried out on the score data with the interaction of group and picture which resulted in no significant difference (p=0.884).

Table 3. Age class specific results for Inter Rater agreement of biologist raters and General Public (by eye method)

Age Class	**Biologists**		**General Public**	
	K	**p-value**	**K**	**p-value**
Calves	0.936	<0.001	0.848	<0.001
Juveniles	0.858	<0.001	0.702	<0.001
Sub-Adults	0.797	<0.001	0.701	<0.001
A1	0.692	<0.001	0.632	<0.001
A2	0.606	<0.001	0.551	<0.001
A3	0.710	<0.001	0.632	<0.001
ALL	**0.734**		**0.656**	

Gender Test

If the picture was scored as an adult age class A1-A3 the raters had to score it additionally choosing from examples of pictures. These examples showed an example of a female and a male in that age class. This was a blind trial so the raters did not know what that test was for. From the whole dataset only 59 and 62 pictures were classified by biologist and general public raters respectively in the adult classes and were used for the kappa test. There was moderate to fair agreement (Kappa=0.414, Kappa=0.337) for biologists and general public, respectively. As the prior score determined the choice available for the consecutive score the results were simplified to resemble female or male. The results are very discouraging with slight agreement (Kappa= 0.148) for biologists as well as general public (Kappa= 0.0708). This result indicates that gender cannot be determined using this methodology.

Rater vs. Expert

Although we established substantial agreement between raters, a test against an expert opinion was necessary to not just establish agreement but also verify accuracy of this methodology. We only preceded with the biologists data as the agreement was higher within this group. The average of each picture was taken from all the 15 raters and rounded to the nearest age class. A simple 2 rater Cohen kappa was used to judge agreement which resulted in a moderate agreement (kappa= 0.554) (Table 4).

Table 4. Age class specific results for Inter Rater agreement of Biologists and Expert for the complete data set and without females

Age Class	**All (n=120)**		**Females excluded (n=90)**	
	K	**p-value**	**K**	**p-value**
Calves	0.943	<0.001	0.941	<0.001
Juveniles	0.948	<0.001	0.946	<0.001
Sub-Adults	0.452	<0.001	0.838	<0.001
A1	0.419	<0.001	0.842	<0.001
A2	0.441	<0.001	0.716	<0.001
A3	0.550	<0.001	0.762	<0.001
ALL	**0.554**		**0.823**	

Although this is still moderate agreement we investigated which pictures were "miss-classified". From 120 pictures, 76 were classified correctly and 44 differed from the expert opinion. From these 44, 30 pictures were from the class females (A1-A3). All female animals were classified in younger age class mostly by one sometimes by two age classes. Taking this bias into account and reducing the data set to 90 (excluding all female pictures) resulted in an almost perfect agreement (Kappa= 0.823).

Ruler

Rater Group 1: Biologists
This group consisted of 14 raters. Due to 1 picture duplication the test set was reduced to 119. The Fleiss kappa test resulted in kappa=0.63 which is substantial agreement but is lower in contrast to the by eye method (Table 5).

Table 5. Age class specific results for Inter Rater agreement of biologist raters and General Public (Ruler Method)

Age Class	Biologists		General Public	
	K	p-value	K	p-value
Calves	0.841	<0.001	0.801	<0.001
Juveniles	0.595	<0.001	0.443	<0.001
Sub-Adults	0.639	<0.001	0.436	<0.001
A1	0.558	<0.001	0.453	<0.001
A2	0.573	<0.001	0.560	<0.001
A3	0.613	<0.001	0.625	<0.001
ALL	**0.63**		**0.54**	

Rater Group 2: General Public
There were 10 raters in this category. The inter rater agreement is not as high as in the biologist group and is in the moderate agreement category (Kappa= 0.54).The detailed results indicate a lack in agreement in all age classes except calves (Table 5).

Rater vs. Expert
The same approach was followed as describe for the "By Eye" method. The agreement was considerable lower in contrast to the "By Eye" method (kappa=0.341). Adjusting it to exclude females improved the agreement (kappa= 0.531) but not to the extent as seen in the "By Eye" method.

DISCUSSION

Estimating age in cetaceans is a difficult task and current methodologies are limited to post-mortem techniques using teeth, ear plugs and/or eye lenses (exception body length) (e.g. Klevezal and Klejnenberg 1967; Lockyer 1972; George *et al.,* 1999; Fearnbach *et al.,* 2011). We propose to use the unique discoloration process in Risso´s dolphins which is caused by the accumulation of scars as an indicator to estimate age. This method is promising due to its non-invasive origin, its simplicity and practicality. By applying this method it is possible to expand the common 3 age class cetacean model (calf, sub-adult, adult) to a reliable 6 age class Risso's dolphin model (calf, juvenile, sub-adult, adult1, adult2 adult3). Due to the long-term data set available, the discolouration process was observed in detail and could be used to establish the proposed life history scar type determination model. This model was determined by using digital photographs from the back of Risso's dolphins in conjunction with behavioural observations. Computer assisted methods to quantify the discolouration were trialled and deemed insufficient which is why this model was created using purely visual judgement and behavioural information. Au *et al*. (2011) used the dorsal fins of several carcasses which were photographed in a lab and converted into grayscale using Photoshop and Image J software. Here the % of scars could be measured precisely and was used to determine 3 classes of scarification. This approach only covers the adult age classes and does not cover the calf-subadult stages. We also tried computer assisted methods which worked fairly well in the older stages but not well in the younger age classes due to the colour conversion process. We believe that the our proposed method is the way forward as it covers the whole life span of the animals and not just part of it. Furthermore we believe that the dorsal fin area is not a good indicator as it stays relatively stable, and that the body accumulates scars more reliably.

This non-quantitative approach is favoured as it is easy to apply, reliable and time efficient. It was necessary to test that the proposed methods can be applied by anybody and is not rater biased. A similar approach is seen in other studies (especially cetacean acoustics) where raters were asked to judge whistle contours and classify groups (Janik 2000).

We proposed two different visual methods. The results clearly show that the "By Eye" method is favoured over the "Ruler" method. The advantages are clear: no prior image manipulation necessary, less time intensive, higher inter-rater agreement in both rater groups and almost perfect agreement with expert opinion. The results prove that anybody can almost perfectly classify Risso´s dolphins according to the proposed 6 class age model.

There was a slightly higher inter-rater agreement observed in the Biologist group in contrast to the general public although it was not significantly different. We believe this is a slight indication that with some training and feedback the obtained results could be improved.

Another interesting result is the observed bias in females. All females were classified younger indicating accumulating scars is gender related proving some sexual dimorphism in Risso's dolphins. Risso's dolphins' diet consists mainly on cephalopods, deeming teeth unnecessary which is seen in the reduction of teeth retained (Clarke 1986). It is believed they are used as weapons and scars are an indicator for male quality and also used in fights for females (MacLeod 1998). Therefore males should be heavier scared then females which has been observed in this study. Females of a similar age are scared less and therefore classified older in contrast to males. Therefore additional information is necessary to apply this methodology accurately as the gender test also proved that it is not possible to identify the gender of an animal based on a picture. Furthermore we proved that the difference in scarring starts when reaching adulthood as earlier age classes (Calf, Juvenile, Sub-Adult) were correctly classified. Sub-Adulthood had a low agreement rate (kappa= 0.452) as A1 females were misclassified as sub-adults which was changed when females were taken out (kappa=0.838). The data set also included animals with unidentified gender. Although they were classified correctly with the model without gender information in the adult age classes there is a 50% chance these are misclassified females. We believe that this method can be applied to other Risso's dolphin populations around the world but caution is necessary when applying this method without extra information.

Preliminary results indicate this method can be used to distinguish between different age classes. Further work into gender differences, robustness and application of this method are going to be tested using long term followed individuals from Pico Island (Azores, Portugal).

It is of great ecological interest to gain insights in the longevity of these animals by using age-classes linked to age. For conservation issues its important have detailed insights in the age class composition of a marine mammal population, especially in area's were certain animals are at risk due to various anthropogenic features.

ACKNOWLEDGEMENTS

Several pictures for this test were kindly provided by Lisa Steiner and João Quaresma. Useful comments on drafts and other reviews were given by Lotte Niemeijer, Lisa Steiner, Marc Fernandez & Peter Telleman. Melina Ruyter designed the Scarification Guides. And last but not least many thanks to all of our volunteers for taking the time to score our test set. This would have not been possible without you!!!

REFERENCES

Amano, M. and Miyazaki, N. 2004. Composition of a school of Risso's dolphin, *Grampus griseus*. *Marine Mammal Science*, 20, 152-160.

Au, V.K., Yu, H. and Chou, L. 2011. Potential sexual dimorphism in the scar/coloration pattern of Risso's dolphin (*Grampus griseus*). Poster presented at the 19th Biennial on the Biology of marine mammals, Tampa, USA

Auger-Méthé, M., Marcoux, M. and Whitehead, H. 2010. Nicks and notches of the dorsal ridge: Promising mark types for the photo-identification of narwhals. *Marine Mammal Science*, 26, 663-678.

Bearzi G., Reeves R.R., Remonato E., Pierantonio N., Airoldi S. 2010. Risso's dolphin *Grampus griseus* in the Mediterranean Sea. *Mammalian Biology*, DOI: 10.1016/j.mambio.2010.06.003

Clarke, M.R. 1986. Cephalopods in the diet of odontocetes. In: *Research on Dolphins* (ed. M.M. Bryden & R. Harrison), pp. 181-321, Oxford: Clarendon Press.

Cockcroft, V.G. and Ross, G.J.B. .1990. Age, growth, and reproduction of bottlenose dolphins *Tursiops truncatus* from the east coast of southern Africa. *Fishery Bulletin,* 88, 289-302.

Fearnbach, H., Durban, J.W., Ellifrit, D.K. and Balcomb III., K.C. 2011. Size and long-term growth trends of Endangered fish-eating killer whales. *Endang Species Resource,* 13, 173–180.

George, J.C., Bada, J., Zeh, J., Scott, L.,Brown,S.E., O´Hara, T. and Suydam, R. 1999. Age and growth estimates of bowhead whales (*Balaena mysticetus*) via aspartic acid racemization. *Canadian Journal of Zoology,* 77, 571-580.

Hartman, K.L., Visser, F., and Hendriks, A.J.E. 2008. Social structure of Risso's dolphins (*Grampus griseus*) at theAzores: a stratified community based on highly associated social units. *Canadian Journal of Zoology*, 86, 294 -306.

Hay, K.A. 1984. The life history of the narwhal (*Monodon monoceros* L.) in the eastern Canadian Arctic. Ph.D. Thesis, McGill University, Montreal, Canada

Hay, K. A. and Mansfield, A.W. 1989. Narwhal, *monodon monoceros* Linnaeus, 1758. In: Handbook of marine mammals Vol. 4., pp. 145-176, Academic Press.

Herzing, D.L. 1997. The life history of free-ranging Atlantic Spotted dolphins (Stenella frontalis): Age classes, color phases, and female reproduction. *Marine Mammal Science,* 13, 576-595

Heyning, J.E. 1984. Functional morphology involved in intraspecific fighting of the beaked whale, *Mesoplodon carlhubbsi*. *Canadian Journal of Zoology*, 62, 1645-1654.

Hohn, A.A. 1980. Age determination and age related factors in the teeth of Western North Atlantic bottlenose dolphins. *Scientific Reports of the Whales Research Institure,* 32, 39-66.

Janik, V.M. 2000. Whistle matching in wild bottlenose dolphin (*Tursiops truncatus*). *Science*, 289, 1355-1357.

Kasuya, T. and Matsui, S.1984. Age determination and growth of the short-finned pilot whale of the Pacific Coast of Japan. *Scientific Reports of the Whales Research Institure*, Tokyo 35.

Klevezal, G. A. and Klejnenberg, S. E. Age determination of mammals by layered structure in teeth and bone. 1967. pp. 1—144. Izdatelstvo Nauka, Moscow.

Kruse, S. 1989. Aspects of the biology, ecology, and behavior of the Risso's dolphins (*Grampus griseus*) off the California coast. M.Sc. Thesis, University of California, USA.

Kruse, S., Caldwell, D.K., and Caldwell, M.C. 1999. Risso's dolphin, Grampus griseus (G. Cuvier, 1812). In: Handbook of Marine Mammals, Volume 6. Edited by: S.H. Ridgway and R. Harrison. Academic Press, San Diego. pp. 183-212.

Lien, J. and Katona, K.S. 1990. A guide to the photographic identification of individual whales based on their natural and acquired markings. American Cetacean Society (San Pedro, Calif. and St. John's, Nfld., Canada) ISBN 0920911897: 77pp.

Lockyer, C. 1972. The age at sexual maturity of the Southern Fin Whale (*Balaenoptera physalus*) using annual layer counts in the ear plug. *ICES Journal of Marine Science*, 34, 276-294.

Lockyer, C. and Morris, R. 1990. Some observations on wound healing and persistence of scars in *Tursiops truncatus*. In: Individual Recognition of Cetaceans: Use of Photo-identification and Other Techniques to Estimate Population Parameters. P.H. Hammond; Mizroch S.A. and Donovan, G. P. (eds). pp.113-118. Cambridge.

McCann, C. 1974. Body scaring on Cetacea-odontocets. *Scientific Reports of the Whales Research Institure*, Tokyo, 26, 145-155.

MacLeod, C.D. 1998. Intraspecific scarring in odontocete cetaceans: An indicator of male 'quality' in aggressive social interactions? Journal of Zoology, 244, 71-77.

Mann, J. and Smuts, B.B. 1999. Behavioural development of wild bottlenose dolphin newborns. *Behavior,* 136, 529-566.

Myrick, A. C. Jr, Hohn, A.A., Barlow, J. and Sloan, P. 1986. Reproductive biology of female spotted dolphins, *Stenella attenuata*, from the eastern tropical Pacific. *Fishery Bulletin, U.S,* 84, 247–259.

Ross, G.J.B. 1984. The smaller cetaceans of the south-east coast of southern Africa. *Annual Cape Province Museum (Natural History),* 11, 259-327.

Silverman, H.B. 1979. Social organization and behaviour of the narwhal, *Monodon monoceros* L., in Lancaster Sound, Pond Inlet, and Tremblay Sound, Northwest Territories. M.Sc. Thesis, McGill University, Montreal, Canada.

Smolker, R.A., Richards, A.F., Connor, R.C. and Pepper, J.W. 1992. Sex differences in patterns of association among Indian Ocean bottlenose dolphins. *Behaviour,* 123, 38-69.

Taylor, B.L., Chivers, S.J., Larese, J.P. and Perrin, W.F. 2007. Generation length and percent mature estimates for IUCN Assessments of Cetaceans. Southwest Fisheries Science Center Administrative Report. LJ-07-01.

Vincent, C., Meynier, L. and Ridoux, V. 2001. Photo-identification in grey seals: Legibility and stability of natural markings. Mammalia, 65, 363-372.

Whitehead, H. and Mann, J. 2000. Female reproductive strategies of cetaceans: life histories and calf care. In: *Cetacean societies. Field studies of dolphins and whales*. Edited by J. Mann, R.C. Connor, P.L. Tyack, and H. Whitehead. 433 pp.

Würsig, B., and Jefferson, T.A. 1990. Methods of photo-identification for small cetaceans. In: Individual recognition of cetaceans: Use of photo-identification and other techniques to estimate population parameters. Edited by P.S Hammond, S.A. Mizroch, and G.P Donovan. Reports of the International Whaling Commission, No. 12. 43-52.

PROCEEDINGS OF THE ECS WORKSHOP

GRAMPUS GRISEUS 200TH ANNIVERSARY: RISSO'S DOLPHINS IN THE CONTEMPORARY WORLD

Held at the
European Cetacean Society's 26th Annual Conference
Galway, Ireland, 25th March 2012

K. Hartman, Nova Atlantis Foundation

Editors:
Ing Chen, Karin Hartman, Mark Simmonds,
Anja Wittich and Andrew J. Wright

ECS SPECIAL PUBLICATION SERIES NO. 54
November 2013

Editors:
Ing Chen[1], Karin Hartman[2], Mark Simmonds[3],
Anja Wittich[2] and Andrew J. Wright[4]

[1] **School of Biological and Biomedical Sciences, University of Durham. South Road, Durham, DH1 3LE, UK**
[2] **Nova Atlantis Foundation, Rua Doutor António Freitas Pimentel 11, 9930-309 Santa Cruz das Ribeiras, Lajes do Pico, Azores, Portugal**
[3] **WDCS. Brookfield House, 38 St Paul Street, Chippenham, Wiltshire, SN15 1LJ, UK**
[4] **European Cetacean Society.**

Citation: Chen, I., Hartman, K., Simmonds, M., Wittich, A. and Wright, A.J. (Eds.) 2013. *Grampus griseus* 200th anniversary: Risso's dolphins in the contemporary world. Report from the European Cetacean Society Conference Workshop, Galway, Ireland. European Cetacean Society Special Publication Series No 54, 108 pages.