Investigating Specific Groups of Killer Whales (*Orcinus orca*) Through Photo Identification in Norway

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Foreword

The aim of this study is to investigate specific groups of killer whales through photo identification in Norway and to locate the relatives of a wild Norwegian killer whale Morgan. New photographs of Norwegian killer whales will also be identified and added to a digital photographic identification database (Ocean Sounds database of Northern Norwegian Killer Whales, unpublished data).

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ABSTRACT

Wild killer whales (*Orcinus orca*) are identified and sorted into photographic databases for uses of long term studies of social, acoustic, and behavioral studies. Natural markings are used to identify individuals and changes over time. The objective of this study is to investigate specific groups of killer whales through photo identification in Norway and find photographic matches to Pod P, a relative pod to Morgan, a captive wild Norwegian killer whale. 4848 photographs were collected from photographers in Lofoten, Vesterålen, Stø, Vestfjord, Andfjord, and Møre during 2003-2012 (excluding 2009). The photographs were sorted and analyzed manually using a computer and placed into the Norwegian Killer Whale Database. All Norwegian killer whales were Northeast Atlantic Type 1 fish eating ecotypes. 16 pods, 16 sightings, and 4 re-sightings of 119 individuals were observed. No matches were made to Pod P. Plausible explanations could be that Pod P was not located in the study area, missed encountering Pod P, not enough data was collected and analyzed, pod fission due to illness or death, or Pod P could have moved to a different location. Based on captive wild killer whales reports adoption of Morgan can be plausible to a not so closely related pod.

INTRODUCTION

Biological Aspects of Killer Whales

Killer whales (*Orcinus orca*) are the largest member of the family Delphinidae and are part of the suborder Odontoceti and the subfamily Orcininae (Mann *et al*. 2000 pg. 127). The two tone colors of black and white make the killer whales blend into their environment when viewed from the top or bottom (Stenersen & Simila, 2007 pg. 10). Killer whales have white eye patches (large oval patches around their eyes) and grey or white saddle patches (colored patch behind the dorsal fin) (Riesch *et al*. 2012). Saddle patch shape differences are independent of age and gender (Baird *et al*. 1988). Secondary sexual dimorphic characteristics are displayed such as the adult male's exceedingly longer dorsal fin and body size. Some markings on killer whales may be due to boat propellers or fishing nets that can injure the dorsal fin although the injuries are merely cosmetic. Calves express a light yellow pigmentation that transforms to white during the nursing period (Stenersen & Simila, 2007 pg. 8, 85).

Adult male's body span can be up to 9.1 m and the dorsal fins up to 1.5 m long. Males reach sexual maturity at age 15 but the dorsal fin continues to grow until age 25. Adult's weight ranges from 4.5 to 7.0 tons. Norwegian killer whales are smaller than Antarctic and Pacific Ocean killer whales (male's body length up to 7 m and female's up to 6 m). The growth span of killer whales is for 10 years and then slows, completing at age 20 to 25 years old. The life span for males is 50 to 60 years old and much longer for females, 80 years old. Adult females can be up to 7.9 meters long with significantly shorter dorsal fins (Stenersen & Simila, 2007 pg. 8). Female sexual maturity is established at the birth of her first calf at the age of 12 to 15. The gestation period lasts 16 months and nursing occurs longer than a year. Females may become pregnant when nursing (Mann *et al*. 2000 pg. 144, 221). A sexually mature female can give birth to a calf every 5 years during her life time until menopause (Bjorge *et al*. 2010). A post reproductive stage, menopause is present at age 35 years old and females live for a projected 14 years or more. (Mann *et al*. 2000 pg. 231).

Killer whales are second to humans as the most abundantly spread mammal on earth, living in all of the world's oceans with the majority located in the temperate and polar areas. No seasonal north to south global migrations has been reported and sightings are rare in tropical areas. They have no natural predators but sick whales can be harmed by sharks. Killer whales are top predators with a vast diet of squid, octopus, fish, sea turtles, sea birds, otters, dugongs, pinnipeds, cetaceans and rarely deer, moose, and pigs (Mann *et al*. 2000 pg. 127, 131, 138, 142).
The term pod is defined as a group with stable membership (Bigg *et al.* 1990), shares a repertoire of discrete vocal calls, and have social bonds (Filatova *et al*. 2009). A pod is a matrilines group that spends at least 50% of their time together (Bigg *et al.* 1990). Pods form based on maternal relativeness consisting of a female and her offspring and her offspring's offspring. The composition of the pod depends on the type of population of killer whales.

Killer whales inhabit a range of ecological niches and form ecotypes based on prey preferences (Foote *et al*. 2011). The Northeastern Pacific Ocean has three types of genetically and socially different killer whale populations; residents, transients, and offshores (Ford *et al*. 2000).

Resident populations specialize on fish and live in long term stable pods. Individuals include a grandmother, her adult son, her adult daughter, and her daughter's offspring. The Eastern North Pacific resident killer whale populations recorded no dispersal or immigration for over 21 years in the natal pods (Mann *et al.* 2000 pg. 127, 129). Natal philopatry by both genders has only been recorded in resident killer whales and pilot whales. Matrilineal pods consist of at most four generations and two to nine individuals (Mann *et al*. 2000 pg. 243, 259-260, 263). The death of the eldest female destabilizes a pod and it may result in pod fission. Stable pods such as residents change in structure by birth, death, or rare separations of large groups (Big *et al.* 1990).

Transient populations specialize on marine mammals and are socially dispersed. Transient male offspring leave their maternal pod (with the exception of the first born male). Transient females leave the pod when sexually mature or after the birth of their first calf to create their own pod. The transient pods group size is smaller than residents; the optimum group size for hunting seals is three individuals (Mann *et al*. 2000 pg. 133, 135).

Both resident and transient pods differ in prey specialization and also behavior, acoustics, morphology, color patterns, and genetics. Group specific vocal dialects are present between killer whale populations (Bjorge *et al.* 2010). In the Eastern North Pacific the morphology variances include the dorsal fin form, saddle patch coloration, and the eye patch coloration. Both transient and resident killer whales represent sympatric non mingling populations. (Filatova *et al.* 2009). Specialization in prey creates differences in social composition between resident and transient pods that typically have a smaller pod size (Riesch *et al.* 2012).

A third type of population of killer whales is the offshores. They live in the pelagic zone a far distance from the shore. Less is known about them as it is harder to study at a distance. Offshores are smaller in body size (Ford *et al.* 1992, Ford *et al.* 2000, Dahlheim *et al.* 2008) but genetically distinct. They are more closely related to residents (Barrett-Lennard *et al.* 2000, Hoelzel *et al.* 2002, Morin *et al.* 2010) and may consume fish (Ford *et al.* 2011). They travel in groups of 50 or more individuals and are very vocal. The offshores produce a long range of pulsed calls and echolocation clicks (Ford *et al.* 1992, Ford *et al.* 2000). Northeastern Pacific offshore killer whales were observed feeding on Pacific sleeper sharks. Extreme tooth wear to the gums was observed in offshores that comes from rigid shark skin (Ford *et al.* 2011).

Behavior and Social Organization

Behavior can be spread vertically (from parent to calf), obliquely (a member of the pod to a younger generation), and horizontally (within the same generation) through social learning. Behaviors such as acoustic communication, social behavior, and feeding methods are culturally spread throughout social learning (Riesch *et al.* 2012). Social learning occurs between mothers and calves or other members of the pod (Mann *et al.* 2000 pg. 239, 243-244).

An example of vertical transmission is the vocal dialects (vocal variations) learned by killer whales.

Dialects are carried through matrilineal pods and are stable over several generations (Mann *et al.* 2000 pg. 243-244). Cultural processes are exceedingly important in matrilineal based social systems such as killer whales (Yurk *et al.* 2002). Due to the lack of geographical barriers a separation of the two groups may be solely related to a stable vertical transmission of prey culture populations and give insight on the causes of nonconforming mass standings, decreased genetic diversity, and menopause (Mann *et al.* 2000 pg. 243-244).

Vocalization and Communication

Killer whales make three types of sounds: echolocation clicks (for finding prey), pulsed call and whistles (both used for communication signaling) (Ford *et al.* 1989). The usage and composition differs in populations and social groups (Riesch *et al.* 2012). Social calls are in the form of discrete calls with higher frequency whistles and click trains (Mann *et al.* 2000 pg. 139, 148). Pulsed calls and whistles are common and easily assigned a type. A vocal tradition (learned behavior) for a group or nearby group of mammals forms a dialect and isolation makes them distinct (Conner *et al.* 1982; Ford *et al.* 2002). Acoustic clans are pods that share part of their repertoire (Ford *et al.* 1991). Vocal clan calls are learned socially from maternal relatives (Yurk *et al.* 2002).

Social groups can be recognized by dialects (Bigg *et al.* 1990). Differences in dialects vary in social groups and within a population. Vocal dialects are spread by vocal learning instead of genetics. Acoustic dialects can be used as a family signature that conveys genetic relatedness which prevents inbreeding (Riesch *et al.* 2012). Clans are founded on mutual calls and are evidence of previous pod separation (Mann *et al.* 2000 pg. 261). Dialect similarities convey kinship between pods (Stenersen & Simila, 2007 pg. 24). Pod specific dialects are reported for the Norwegian killer whales and many of the call types have been described (Strager, 1993).

Northeast Atlantic Killer Whales

Three distinct populations are identified in the Northeast Atlantic killer whales based on feeding ecology and genetic sampling. The different populations are based on fish prey; herring, mackerel, and bluefin tuna feeding populations. The herring populations are located in Norway and Iceland, mackerel feeding populations in Scotland and the North Sea, and bluefin tuna feeding populations in Gibraltar (Figure 1). The structure of the population is dependent on the prey movement (Foote *et al*. 2010).

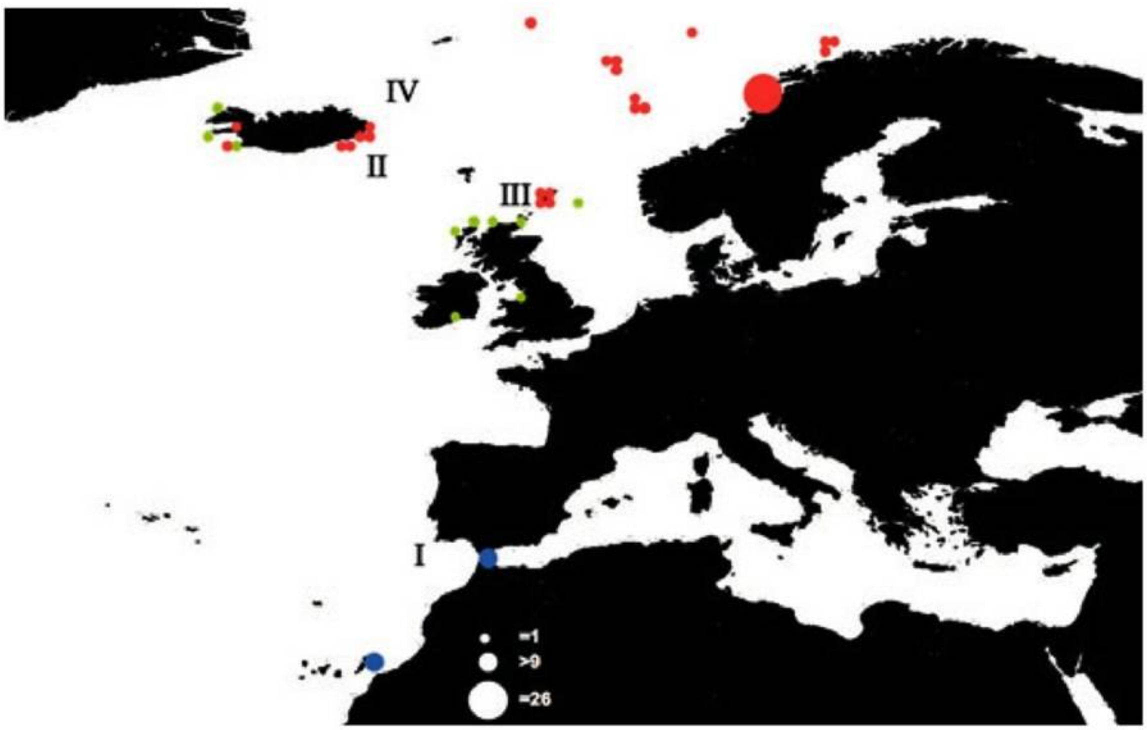


Figure 1. The Northeast Atlantic killer whale populations are based on feeding ecology and genetic sampling (taken from Foote *et al.* 2010). Red dots indicate herring feeding populations (Norway and Iceland), green dots indicate mackerel feeding populations (Scotland and the North Sea), and the blue dots indicate the tuna feeding populations (Gibraltar). The size of dot refers to the sampling size, larger dots refers to a large population sample (key located in the bottom center).

The North Atlantic killer whales have been sorted into two types based on appearance characteristics. The Type 1 populations have parallel eye patches when compared to their body and their eye patches are orientated in front of the blowhole based on photographic data from Norway, Iceland, Shetland, and the North Sea. The Type 2 populations have angled eye patches when compared to their body and their eye patches are orientated behind the blowhole based on photographic data from western Scotland and Azores (Foote *et al.* 2009).

Killer Whales in Norway

Rough estimates of 3100 killer whales are located in the Norwegian, Barents Sea, and Norwegian coastal waters combined (Luque *et al.* 2006). Icelandic and Norwegian killer whales have the same structured calls and therefore are close relatives that may have been a collective population previously (Stenersen & Simila, 2007 pg.40-41, 83).

An estimate of at least 1500 killer whales may be present in Norwegian waters during abundant herring populations occurring October to January in the Lofoten and Vesterålen area (winter location of herring) and in February to March in Møre area (herring spawning location). The movement between Lofoten, Vesterålen, and Møre are documented in photo identified pods. Only in the Lofoten and Vesterålen area of Northern Norway have killer whales have been reported all year round. Since 1987 the herring migratory area has changed from oceanic to coastal waters due to the herring collapse and main winter areas of herring and killer whales are located in Tysfjord and Ofotfjord, Northern Norway (Simila *et al.* 1996). It has changed again in 2007 and the wintering grounds have moved further north to Vesterålen (personal communication Vester, 2012). The satellite tagged killer whales in Norway traveled further than expected with some individuals leaving the herring spawning area and swimming directly to the other spawning grounds with direct precision. (Stenersen & Simila, 2007 pg. 42, 61). Norwegian killer whales forage by carousel feeding, a type of group feeding of herding fish into a tight ball close to the surface enabling the killer whales to hit the ball with their flukes (tail fin) to stun the fish. They then eat the stunned fish one by one.

Stable pods in Norway range from 6 to 30 individuals (Simila *et al.* 1996). Photo identification in Norway has existed since 1983 in Lofoten and Vesterålen. 550 individual whales have been identified. Continuous upkeep of a photo identification database is essential to long term studies of Norwegian killer whales in Tysford, Ofotfjord, and Vestfjord. Markings change, whales grow, and new births occur in the pods continuously (Stenersen & Simila, 2007 pg. 36).

Morgan the Northern Norwegian Killer Whale

Morgan, a young killer whale female was lost from her family and was found swimming off the coast of the Netherlands in the Wadden Sea on 23, June 2010. Due to her underweight condition she was captured and transported to the Dolfinarium Harderwijk, Netherlands. The proposed plan was to rehabilitate Morgan and then release her into the wild. The Dolfinarium Harderwijk involved scientists that suggested that a successful release of Morgan is only possible if her natal pod can be found. Even after identifying her close relatives and the preparation of a release plan by independent researchers (Free Morgan Foundation, http://www.freemorgan.org) the Netherland’s courts ruled to keep Morgan in lifetime captivity and sent her to a Spanish aquarium, Loro Parks in Tenerife 29, November 2011.

Due to Morgan's young age, she has learned most of the language but like a small child she has not learned her pod's entire language (Bowles *et al.* 1988). Finding Morgan's natal pod may be essential to her release and survival in the wild, since killer whales are very social animals and thrive in pods. Acoustics are killer whale's primary sense, similar to human's eyes and it is essential for them to not be confined to a small tank. Placing a killer whale in a small tank has been compared to blindfolding a human or compared to putting the killer whale in a jail cell for life. It is known that a wild female killer whale has a much longer lifespan of at least fifty years, in captivity her life will be reduced an average eight and a half years. Morgan may also be used in breeding more captive whales and further add more whales into captivity (Anonymous, 2011).

Morgan's Acoustic Analysis

Samarra *et al* (2010) made a plausible match of 3 out of 9 stereotyped calls of Morgan to the Norwegian herring-feeding pod, Pod P using all available North Atlantic killer whale acoustic recordings (Strager, 1993). Morgan and Pod P also make other unmatched and unidentified calls that indicate that Pod P is not her natal pod but possibly a close relative.

Vester and Samarra (2011) further compared the acoustics of Morgan during her rehabilitation at the Harderwijk Dolfinarium to the Ocean Sounds call database of wild northern Norwegian killer whales (contains 115 calls from 17 different pods) (Ocean Sounds database of Northern Norwegian Killer Whales, unpublished data). Pod P was confirmed the closest match to Morgan's repertoire with 6 out of 9 possible matching calls. Similar calls were also a likely possibility but the recordings were of poor quality with background noise. This shows that

Morgan’s natal pod is a known northern Norwegian herring feeding pod. Possible reasons for the incomplete acoustic matches are due to Morgan’s young age (1 ½ to 2 years old when found) and her development of learning her natal pod’s repertoire may not have developed fully. Current acoustic and photographic data collected near Andenes is greatly needed to find Morgan’s natal pod (Vester & Samarra, 2011). Further research needs to be conducted to find Morgan’s relatives, Pod P by using photo identification.

Objective of This Study

The aim of this study is to find Morgan’s relatives, Pod P from recent photographs of killer whales along the Norwegian coast in order to aid her release into the wild. Based on the report by Vester & Samarra (2011) Pod P would be the most likely pod that Morgan would belong to.

Photographs were collected from different photographers from the 2003-2012 (excluding 2009) (Table 1). The photographs were taken near Lofoten and Vesterålen in Northern Norway (Stø, Vestfjord, and Andfjord) and the Møre area in Southern Norway (Figure 2).

In addition to finding a specific group within the photographic database it will be used to update an existing photo identification database of Norwegian killer whales (Ocean Sounds database of Northern Norwegian Killer Whales, unpublished data).

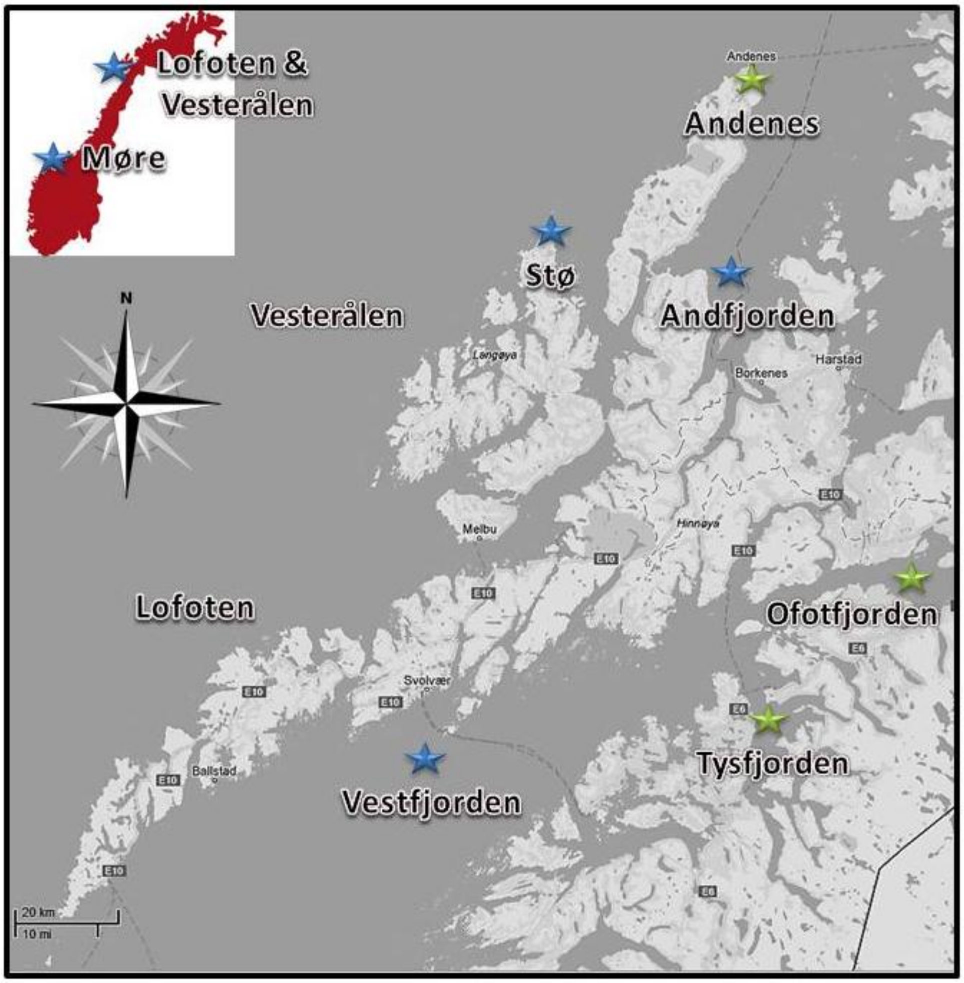


Figure 2. Map of Norway (left top corner image) and Lofoten and Vesterålen Islands (large image) (image originates from www.maps.google.com). Blue stars indicate photographs taken (Stø, Vesterålen , Vestfjord, Andfjord and the Møre area). References to surrounding areas (green stars).

MATERIALS AND METHODS

Killer whale photographs were taken on an opportunistic basis from photographers around Lofoten and Vesterålen Islands (Stø, Vestfjord, and Andfjord) in northern Norway and the Møre area in southern Norway (Figure 2). In total 4848 photographs were taken during 2003-2012 (excluding 2009) (Table 1).

Table 1: Outline of dates, locations, GPS coordinates, camera models, and photographers of photographs taken.

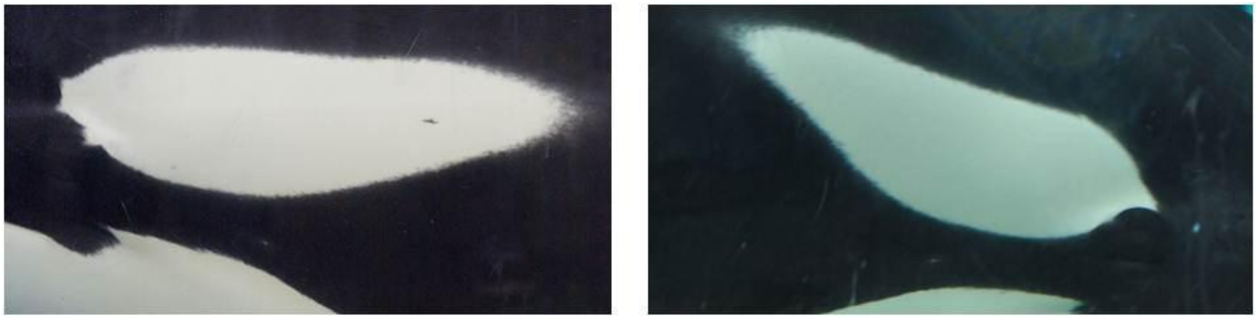
Date	Location	GPS latitude	GPS Longitude	Camera	Photographer
31.10.2003	Vestfjord / Andfjord	n/a	n/a	Nikon D100	Marco von der Schulenburg
06.11.2004	Vestfjord / Andfjord	n/a	n/a	Nikon D100	Marco von der Schulenburg
26.10.2005	Møre area	n/a	n/a	Cannon EOS 20D	Pierre Robert de Latour
09.11.2005	Vestfjord / Andfjord	n/a	n/a	Nikon D2H	Marco von der Schulenburg
13.11.2006	Vestfjord / Andfjord	n/a	n/a	Nikon D2H	Marco von der Schulenburg
16.11.2007	Vestfjord / Andfjord	n/a	n/a	Nikon D2X	Marco von der Schulenburg
14.11.2008	Vestfjord / Andfjord	n/a	n/a	Nikon D2X	Marco von der Schulenburg
08.07.2010	Stø, Vesterålen	n/a	n/a	Canon E0S 450D	Dieter Schwab
08.07.2010	Stø, Vesterålen	n/a	n/a	Canon E0S 450D	Fredrik Broms
21.12.2010	Vestfjord / Andfjord	n/a	n/a	Nikon D2X	Marco von der Schulenburg
29.05.2011	Stø, Vesterålen	69° 22'N 47° 91'E	15° 32'N 56° 77'E	Nikon D3	Fredrik Broms
02.07.2011	Stø, Vesterålen	69° 23'N 26° 59'E	15° 45'N 3° 50'E	Nikon D3	Fredrik Broms
09.07.2011	Stø, Vesterålen	69° 19'N 37° 22'E	15° 49'N 8° 20'E	Nikon D300S	Camilla Ilmoni
08.12.2011	Vestfjord / Andfjord	n/a	n/a	Nikon D3S	Marco von der Schulenburg
29.01.2012	Møre area	n/a	n/a	Cannon EOS 5D	Pierre Robert de Latour

Photographer	Date	Location
Ilmoni	9.7.2011	n/a
Schwab	8.7.2010	Stø, Vesteralen
Broms	2.7.2011	Stø, Vesteralen
Broms	8.7.2010	Stø, Vesteralen
Broms	29.4.2011	Stø, Vesteralen
von der Schulenburg	8.11.2003	Vestfjord / Andfjord
von der Schulenburg	6.11.2004	Vestfjord / Andfjord
von der Schulenburg	27.10.2005	Vestfjord /

		Andfjord
von der Schulenburg	10.12.2006	Vestfjord / Andfjord
von der Schulenburg	26.11.2007	Vestfjord / Andfjord
von der Schulenburg	6.12.2008	Vestfjord / Andfjord
von der Schulenburg	21.12.2010	Vestfjord / Andfjord
von der Schulenburg	13.12.2011	Vestfjord / Andfjord
Robert de Latour	26.10.2005	Møre area
Robert de Latour	29.1.2012	Møre area

Opportunistic photographs were taken by the photographers were collected and captured in 2003-2012 (excluding 2009) (Table 1). The photographs were taken by various cameras that produced digital photographs and were collected from the photographers.

The individual killer whales were identified by unique fin shapes, saddle patches, nicks, scars and saddle patches by comparing primarily left side photographs according to Bigg *et al*. (1982). In addition shape and position of eye patches are used which show uniqueness to each individual (Gill *et al.* 2000). Well marked individuals are present in all pods enabling easier methods for identifying and organizing pod data (Simila *et al.* 1996). Bigg *et al*. (1982) points out that the calves (young whales) and young individuals most likely have unique features besides the scars. The eye patches on calves are more obvious than saddle patches although they are yellowish in pigmentation and the eye patches are more developed than the saddle patch. In conclusion Morgan's eye patches would be the only characteristic marking that will make it possible to find matching photographs (Figure 3).



Morgan's Left Eye Patch **Morgan's Right Eye Patch**

Figure 3. Left and right eye patches of Morgan (taken from http://www.freemorgan.org/).

Becoming acquainted with both sides of the individual is advantageous in identification (Gill *et al.* 2000). Natural markings assist in long-term and reliable details to be studied in the field over time in movement patterns, population size, dynamics, and social structure. Subtle or small markings require maximum resolution to identify individuals. Some natural markings are present at birth but many new natural markings will be added during the whale's life (Mann *et al.* 2000 pg. 69, 73).

Photo identification of the killer whales was performed by comparing photographs of killer whale dorsal fins to a classified database to identify each individual (Ocean Sounds database of Northern Norwegian Killer Whales, unpublished data). The individuals are then grouped into pods. Individuals of the pods were then classified into gender groups; males (presenting a large < 80 cm dorsal fin), females and juveniles (dorsal fin ≤ 80 cm), and juveniles less than 3 years (calves). The association of a calf encountered persistently with a female may conclude that the female may be the mother to the calf. The digital photographic database (Ocean Sounds database of Northern Norwegian Killer Whales, unpublished data) consists of images showing congenital and acquired characteristics of individual dorsal fins, and saddle patches. All individuals were added to the database. The database is organized by two methods for finding individuals 1. pods and 2. natural markings.

1. The organization of the database by pods is first sorted by different pod names (eg. Pod A). Second the pod folders are sorted in years the photographs were taken (eg. 2003). Then arranged by gender (eg. Females and juveniles, calves, and males). Within these folders the individual killer whales are listed.
2. The organization of the database by natural markings is sorted by gender and age. Within these folders the individuals are sorted by different marking types (eg. High nicks, low nicks open saddle patches, scars, etc.) and then sorted by the left or right side photographs of the killer whale (Figure 4 & Figure 5).

The naming system of the individuals consists of the pod name, individual number, and the date this individual was seen the first time: Norwegian Killer Whales (NKW), pod name (BA), individual number (01), and date (20110907): NKW-BA-01-20110907 (Figure 5).

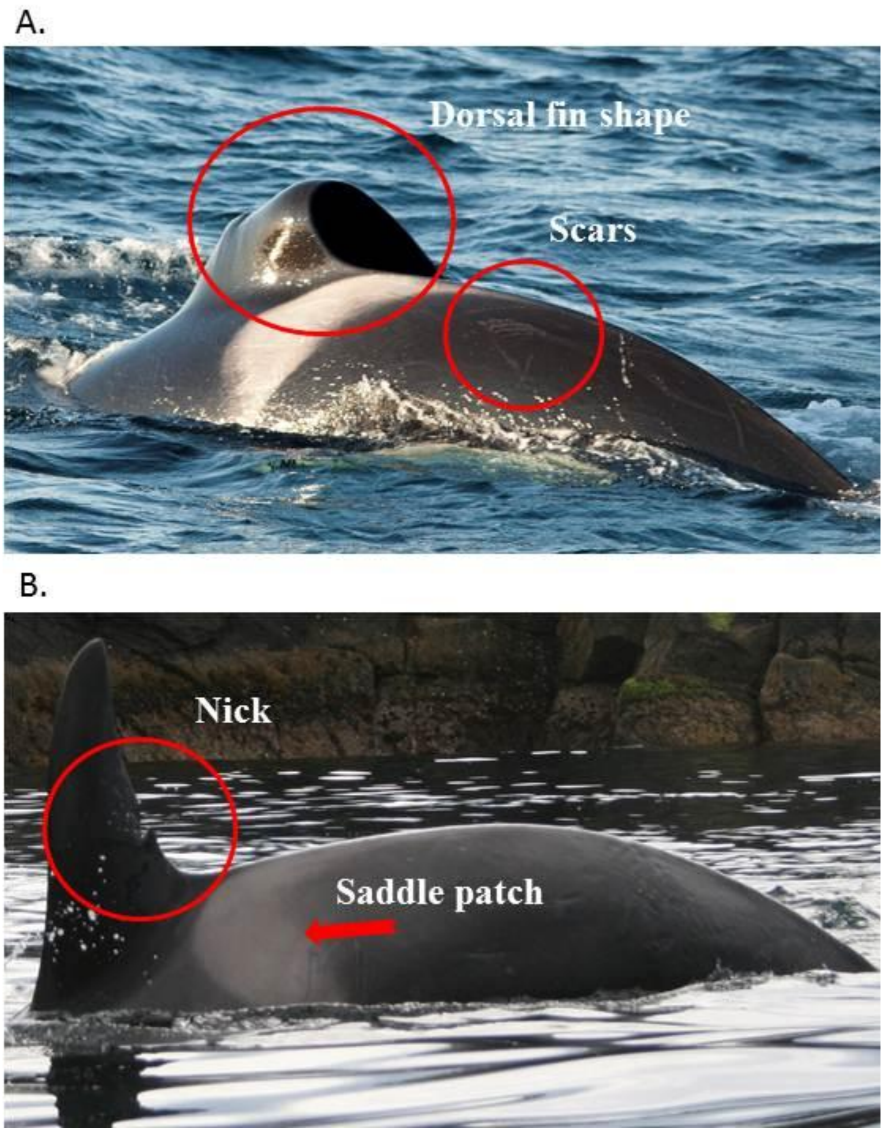


Figure 4. Specific natural markings of individuals NKW-X-058-20123001 (A) and NKW-BC-05-20100708 (B). Natural markings such as the size and shape of the dorsal fin and the presence of scars aid in individual identification (A). Nicks on dorsal fin and saddle patch appearance is also documented (B).

Figure 5: Left side, right side, and eye patch photographs of NKW-BA-01-20110907 used in photo identification. The appearance of natural markings such as the saddle patch, scars, dorsal fin, and nicks are used as characteristics to identify each individual. Eye patches are also used in identifying Type 1 or Type 2 killer whales (Foote *et al.* 2009) and individuals.

Photographs were analyzed based on the quality and distinctive features of the individuals. Photographs of poor quality were excluded from the database. The collected photographs were enlarged on a computer monitor for detailed analysis using FastStone Image Viewer (http://www.faststone.org/index.htm). The best photograph of each killer whale displaying identifiable markings was magnified and named (Figure 5). The unidentified photographs were manually compared to the database of natural markings.

Unidentified photographs are then compared with Pod P photo identification (Figure 6). Pod P consisted of 9 individuals; 4 males and 5 juveniles more than 3 years old as of 2004-2005 (based on the Ocean Sounds database of Northern Norwegian Killer Whales, unpublished data).

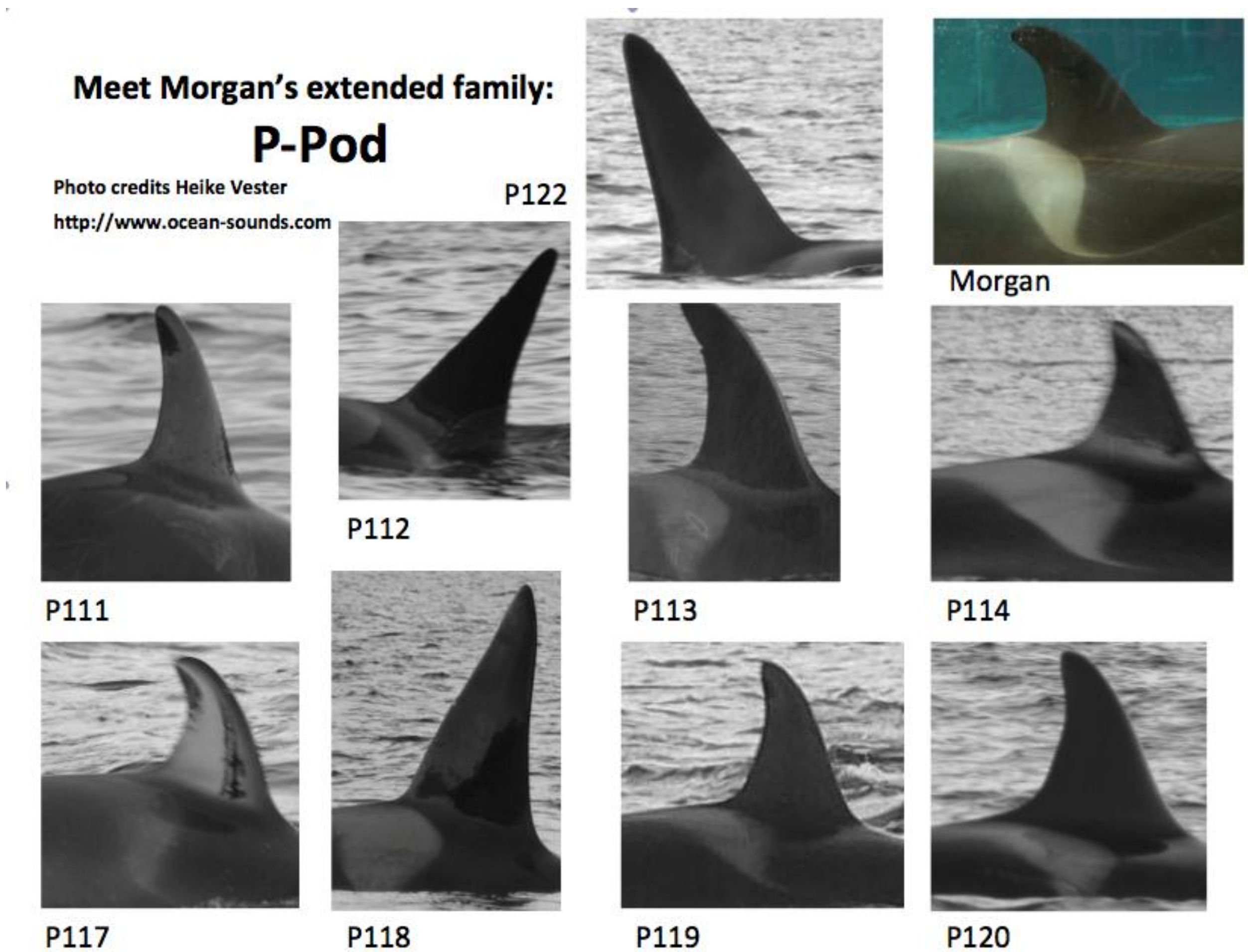


Figure 6. Photo identification of Pod P dorsal fins of each individual and Morgan (taken from Ocean Sounds http://www.ocean-sounds.com/eng/wp-content/uploads/2012/02/Group-P-Ocean-

Sounds.bmp).

RESULTS

A total of 16 sightings were made of Norwegian killer whales during the period 2003-2012 (excluding 2009) based on the collective gathering of photographs. Unidentified photographs are sorted and identified in pods. No matches were made to Pod P. 16 total pods were identified and 123 total individuals were observed (average of individuals per pod 7.69) with 4 individuals being re-sighted (Table 2).

Table 2. Summary of matched unidentified Norwegian killer whales to the Northern Norwegian Killer Whales photo identification database (Ocean Sounds database of Northern Norwegian Killer Whales, unpublished data) (full table Appendix Table A1). Individuals were identified by the size and shape of the dorsal fin and body. Females are grouped with juvenile males due to the similar size of the dorsal fin; no individuals were identified by pigmentation of the genital area.

							Matches:			
Date	Pod	Location	Individuals in Pod	Female/Juvenile male	Calves	Males	Pod P	Known	New	Individual Resightings
31.10.2003	BM	Vestfjord / Andfjord	8	2	1	5	0	4	4	0
06.11.2004	BG	Vestfjord / Andfjord	13	3	1	9	0	6	7	2
26.10.2005	BN	Møre area	9	3	1	5	0	1	8	1
09.11.2005	BI	Vestfjord / Andfjord	10	3	1	6	0	0	10	0
13.11.2006	BJ	Vestfjord / Andfjord	12	5	1	6	0	0	12	0
16.11.2007	BL	Vestfjord / Andfjord	4	1	1	2	0	0	4	0
14.11.2008	BK	Vestfjord / Andfjord	4	2	0	2	0	0	4	0
08.07.2010	BB	Stø, Vesterålen	11	4	1	6	0	0	11	0
08.07.2010	BC	Stø, Vesterålen	6	3	0	3	0	0	6	0
21.12.2010	BE	Vestfjord / Andfjord	5	1	1	3	0	0	5	0
21.12.2010	BF	Vestfjord / Andfjord	6	2	1	3	0	0	6	0

29.05.2011	BD	Stø, Vesterålen	5	2	0	3	0	0	5	0
02.07.2011	BE	Stø, Vesterålen	8	5	1	2	0	0	8	0
09.07.2011	BA	Stø, Vesterålen	4	2	1	1	0	0	4	0
08.12.2011	BH	Vestfjord / Andfjord	9	4	1	4	0	0	9	0
29.01.2012	BO	Møre area	9	4	0	5	0	1	8	1
Total	16		123	46	12	65	0	12	111	4

The majority of the individuals were not re-sighted and no pods were re-sighted (Figure 7).

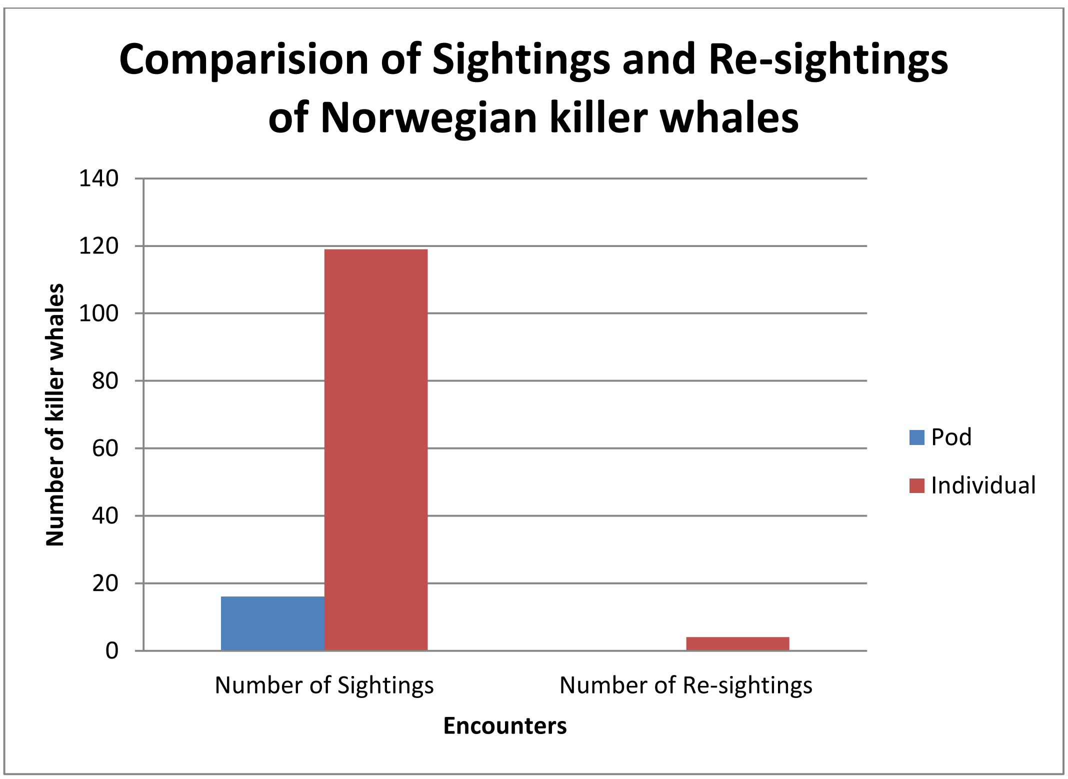


Figure 7. Re-sightings and new sightings of Norwegian Killer Whales

The sample population of Norwegian killer whales was predominantly unmatched to the current photographic identification database. Only 3.252% individuals were matched and the estimated

Norwegian population (0.2666%) and known database population (0,638%) were small (Table 3).

Table 3. The comparison of matched and unmatched estimated and known populations of killer whales in Norway. The estimated population in Norway used was 1500 (Simila *et al.* 1996) and the current known database population (includes new data) used was 627 (Ocean Sounds database of Northern Norwegian Killer Whales, unpublished data).

	Matched	Unmatched
Individuals	3.252%	96.75%
Estimated Population	0.2666%	7.933%
Known Population	0.638%	18.98%

According to Foote *et al.* (2009) all killer whales in Norway can be assigned to Type 1 fish eating ecotypes. The Norwegian killer whales eye patches are parallel in orientation (in reference to the body) and the anterior end of the eye patch is in front of the blow hole (Figure 8 C).

A.

B.

C.

Figure 8. North Atlantic killer whales Type 1 (A) and Type 2 (B) (taken from Foote *et al.* 2009) compared with Norwegian killer whales (C). Norwegian killer whales (C) displays the Type 1 fish eating ecotypes.

DISCUSSION

Morgan's relative pod, Pod P did not match any of the unidentified photographs collected (Table 2). The methods of photo identification are appropriate and made it possible to match unidentified individuals to a database (Table 2). With the current photographs available it was not possible to match Pod P. Plausible explanations could be that Pod P was not located in the study area, missed sighting of Pod P, not enough data was collected and analyzed, pod fission due to illness or death, or Pod P could have moved to a different location in the North Sea similar to where Morgan was found in the Netherlands. Without the availability of permanent hydrophones to record and identify wild killer whales passing and a complete and updated database Pod P was not found.

The 96.64% of new sightings and 3.361% of re-sightings of Norwegian killer whales were observed (Table 3). The re-sightings could be due to a favored location for example an area rich in fish or a migration route. Re-sightings and updating the photographic identification database provides more information on new natural markings, age, calves, illnesses, pod fission, and locations and dates of sightings. For example an updated database will show the growth of a male's dorsal fin and new natural markings.

Overall photo identification is a suitable method to find specific groups and individuals however there is a huge lack of data and cooperation between scientists to create a needed more complete database. In the case of Morgan if such a database existed it would be easier and faster to find relatives and start a release plan. For example if Morgan was a Canadian killer whale it would be much faster to find Morgan's relatives with a heavily studied and identified complete database and with the use of permanent hydrophones to survey the killer whales passing by.
It has been shown that killer whales in the wild do suffer from losses of their pod members, finding Morgan's family group would have helped the entire pod and killer whale societies, which are greatly altered by the removal of an individual. They rely on relationships within family groups for survival and removal of individuals could result in pod fission (Williams & Lusseau, 2006).

However, Morgan's relatives would be the best outcome for Morgan but adoption into a not so closely related pod could also be plausible. Adoption occurs in the wild killer whales like in the case of Stumpy, a wild Norwegian killer whale with a severely injured spine and dorsal fin as a calf caused by a boat accident. With such severe injuries Stumpy is lacking the majority of his dorsal fin and probably cannot dive. Stumpy is misplaced from his natal pod and is protected and given fish from NE15 group (NE15 group refers to Stenersen & Simila's database, Stenersen & Simila, 2007). Captive killer whales also succeed in being released. In the case of Keiko, an Icelandic captive killer whale captured as a calf, he was in captivity for 19 years and successfully survived for 3 years (Simon *et al.* 2009, Table 4). The most successful release of a captive cetacean was Springer that survived for 9 years after being in captivity for 31 days (Schroeder *et al.* 2007, Anonymous, 2010, Table 4). Being in captivity is stressful and significantly reduces the life span of killer whales. A wild female killer whale has a much longer lifespan of at least fifty years, in captivity her life will be reduced an average eight and a half years (Anonymous, 2011).

Table 4. Examples of captive killer whales (orcas) released (edited version taken from Anonymous, 2010).

SPECIES	COMMON NAME	NAME OR CODE	COUNTRY	NUMBER OF DAYS IN CAPTIVITY	NUMBER OF DAYS TRACKED BY SAT TAG	DISTANCE TRAVELLED	EXTRA NOTES	SOURCE
Orcinus orca	Orca	Keiko	Iceland	19 years 1 Nov 1979-1 July 2000	3 years	Iceland to Norway	Remained free but received supplementary feed in Norway	(Simon et al. 2009)
Orcinus orca	Orca	Springer	USA	31 days 13 June 2002- 14 July 2002	9 years Not satellite tagged		Repeatedly resighted with different group than natal group	(Schroeder et al. 2007)

In conclusion it is not necessary for Morgan to find her relative pod based on successful releases and adoptions of killer whales (Stenersen & Simila, 2007, Simon *et al.* 2009, Schroeder *et al.* 2007, Anonymous, 2010, and Table 4). In my opinion Morgan could be successfully released and adopted by another not closely related pod in Norway. During the summer in a calm fjord such a release would be possible with continued observation.

Improvements for future research would benefit from cooperation between scientists to conduct cooperative studies and compose a complete photo identification database.

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APPENDIX

Table A1. The matching of unidentified Norwegian killer whales to the Northern Norwegian Killer Whales photo identification database (Ocean Sounds database of Northern Norwegian Killer Whales, unpublished data). Natural markings; tn (top nick on dorsal fin), mn (middle nick on dorsal fin), and pn (plenty of nicks).

					Matches:		
Date	**Name**	**Location**	**Gender**	**Natural Marking(s)**	**Pod P**	**Known**	**New**
31.10.2003	BM-01	Vestfjord / Andfjord	Female	none	No	No	Yes
31.10.2003	BM-01A	Vestfjord / Andfjord	Unknown (calf)	none	No	No	Yes
31.10.2003	BM-02	Vestfjord / Andfjord	Female/Juvenile male	none	No	No	Yes
31.10.2003	BM-03	Vestfjord / Andfjord	Male	tn	No	No	Yes
31.10.2003	A-001	Vestfjord / Andfjord	Male	pn	No	Yes	No
31.10.2003	A-002	Vestfjord / Andfjord	Male	tn	No	Yes	No
31.10.2003	K-222	Vestfjord / Andfjord	Male	cut top	No	Yes	No
31.10.2003	X-058	Vestfjord / Andfjord	Male	U shaped bent dorsal	No	Yes	No
06.11.2004	BG-01	Vestfjord / Andfjord	Female	none	No	No	Yes
06.11.2004	BG-01A	Vestfjord / Andfjord	Unknown (calf)	none	No	No	Yes
06.11.2004	BG-02	Vestfjord / Andfjord	Female/Juvenile male	none	No	No	Yes
06.11.2004	BG-03	Vestfjord / Andfjord	Female/Juvenile male	mn	No	No	Yes
06.11.2004	BG-04	Vestfjord / Andfjord	Male	bent dorsal, scars	No	No	Yes
06.11.2004	BG-05	Vestfjord / Andfjord	Male	mn	No	No	Yes
06.11.2004	BG-06	Vestfjord / Andfjord	Male	pn	No	No	Yes
06.11.2004	AC-243	Vestfjord / Andfjord	Male	tn	No	Yes	No
06.11.2004	AH-283	Vestfjord / Andfjord	Male	bent dorsal	No	Yes	No
06.11.2004	BK-500	Vestfjord / Andfjord	Male	mn	No	Yes	No

06.11.2004	K-222	Vestfjord / Andfjord	Male	cut top	No	Yes	No
06.11.2004	X-163	Vestfjord / Andfjord	Male	broken dorsal	No	Yes	No
06.11.2004	V-158	Vestfjord / Andfjord	Male	tn	No	Yes	No
26.10.2005	BN-01	Møre area	Female	scar	No	No	Yes
26.10.2005	BN-01A	Møre area	Unknown (calf)	none	No	No	Yes
26.10.2005	BN-01	Møre area	Female/Juvenile male	scar	No	No	Yes
26.10.2005	BN-01A	Møre area	Female/Juvenile male	tn	No	No	Yes
26.10.2005	BN-01	Møre area	Male	scars	No	No	Yes
26.10.2005	BN-01A	Møre area	Male	bent dorsal	No	No	Yes
26.10.2005	BN-01	Møre area	Male	none	No	No	Yes
26.10.2005	BN-01A	Møre area	Male	bent dorsal	No	No	Yes
26.10.2005	X-163	Møre area	Male	broken dorsal	No	Yes	No
09.11.2005	BI-01	Vestfjord / Andfjord	Female	none	No	No	Yes
09.11.2005	BI-01A	Vestfjord / Andfjord	Unknown (calf)	scars	No	No	Yes
09.11.2005	BI-02	Vestfjord / Andfjord	Female/Juvenile male	tn	No	No	Yes
09.11.2005	BI-03	Vestfjord / Andfjord	Female/Juvenile male	tn	No	No	Yes
09.11.2005	BI-04	Vestfjord / Andfjord	Male	pn	No	No	Yes
09.11.2005	BI-05	Vestfjord / Andfjord	Male	none	No	No	Yes
09.11.2005	BI-06	Vestfjord / Andfjord	Male	tn	No	No	Yes
09.11.2005	BI-07	Vestfjord / Andfjord	Male	none	No	No	Yes
09.11.2005	BI-08	Vestfjord / Andfjord	Male	bent dorsal	No	No	Yes
09.11.2005	BI-09	Vestfjord / Andfjord	Male	tn	No	No	Yes
13.11.2006	BJ-01	Vestfjord / Andfjord	Female	scars	No	No	Yes
13.11.2006	BJ-01A	Vestfjord / Andfjord	Unknown (calf)	none	No	No	Yes
13.11.2006	BJ-02	Vestfjord / Andfjord	Female/Juvenile male	scars	No	No	Yes
13.11.2006	BJ-03	Vestfjord / Andfjord	Female/Juvenile male	scars	No	No	Yes
13.11.2006	BJ-04	Vestfjord / Andfjord	Female/Juvenile male	tn	No	No	Yes
13.11.2006	BJ-05	Vestfjord / Andfjord	Female/Juvenile male	scars	No	No	Yes
13.11.2006	BJ-06	Vestfjord / Andfjord	Male	scars	No	No	Yes
13.11.2006	BJ-07	Vestfjord / Andfjord	Male	scars	No	No	Yes
13.11.2006	BJ-08	Vestfjord / Andfjord	Male	scars	No	No	Yes
13.11.2006	BJ-09	Vestfjord / Andfjord	Male	tn	No	No	Yes
13.11.2006	BJ-10	Vestfjord / Andfjord	Male	none	No	No	Yes
13.11.2006	BJ-11	Vestfjord / Andfjord	Male	none	No	No	Yes
16.11.2007	BL-01	Vestfjord / Andfjord	Female	none	No	No	Yes

16.11.2007	BL-01A	Vestfjord / Andfjord	Unknown (calf)	none	No	No	Yes
16.11.2007	BL-02	Vestfjord / Andfjord	Male	none	No	No	Yes
16.11.2007	BL-03	Vestfjord / Andfjord	Male	none	No	No	Yes
14.11.2008	BK-01	Vestfjord / Andfjord	Female/Juvenile male	scars	No	No	Yes
14.11.2008	BK-02	Vestfjord / Andfjord	Female/Juvenile male	tn	No	No	Yes
14.11.2008	BK-03	Vestfjord / Andfjord	Male	none	No	No	Yes
14.11.2008	BK-04	Vestfjord / Andfjord	Male	bent dorsal	No	No	Yes
08.07.2010	BB-01	Stø, Vesterålen	Female	none	No	No	Yes
08.07.2010	BB-01A	Stø, Vesterålen	Unknown (calf)	none	No	No	Yes
08.07.2010	BB-02	Stø, Vesterålen	Female/Juvenile male	mn, scars	No	No	Yes
08.07.2010	BB-03	Stø, Vesterålen	Female/Juvenile male	mn, scars	No	No	Yes
08.07.2010	BB-04	Stø, Vesterålen	Female/Juvenile male	mn	No	No	Yes
08.07.2010	BB-05	Stø, Vesterålen	Male	scars	No	No	Yes
08.07.2010	BB-06	Stø, Vesterålen	Male	curved dorsal	No	No	Yes
08.07.2010	BB-07	Stø, Vesterålen	Male	mn	No	No	Yes
08.07.2010	BB-08	Stø, Vesterålen	Male	none	No	No	Yes
08.07.2010	BB-09	Stø, Vesterålen	Male	tn	No	No	Yes
08.07.2010	BB-10	Stø, Vesterålen	Male	curved dorsal	No	No	Yes
08.07.2010	BC-01	Stø, Vesterålen	Female/Juvenile male	mn	No	No	Yes
08.07.2010	BC-02	Stø, Vesterålen	Female/Juvenile male	none	No	No	Yes
08.07.2010	BC-03	Stø, Vesterålen	Female/Juvenile male	none	No	No	Yes
08.07.2010	BC-04	Stø, Vesterålen	Male	bent dorsal	No	No	Yes
08.07.2010	BC-05	Stø, Vesterålen	Male	mn	No	No	Yes
08.07.2010	BC-06	Stø, Vesterålen	Male	none	No	No	Yes
21.12.2010	BE-01	Vestfjord / Andfjord	Female	none	No	No	Yes
21.12.2010	BE-01A	Vestfjord / Andfjord	Unknown (calf)	none	No	No	Yes
21.12.2010	BE-02	Vestfjord / Andfjord	Male	none	No	No	Yes
21.12.2010	BE-03	Vestfjord / Andfjord	Male	tn	No	Yes	No
21.12.2010	BE-04	Vestfjord / Andfjord	Male	none	No	No	Yes
21.12.2010	BF-01	Vestfjord / Andfjord	Female	none	No	No	Yes
21.12.2010	BF-01A	Vestfjord / Andfjord	Unknown (calf)	none	No	No	Yes
21.12.2010	BF-02	Vestfjord / Andfjord	Female/Juvenile male	scars	No	No	Yes
21.12.2010	BF-03	Vestfjord / Andfjord	Male	scars	No	No	Yes

21.12.2010	BF-04	Vestfjord / Andfjord	Male	bent dorsal	No	No	Yes
21.12.2010	BF-05	Vestfjord / Andfjord	Male	none	No	No	Yes
29.05.2011	BD-01	Stø, Vesterålen	Female/Juvenile male	scars	No	No	Yes
29.05.2011	BD-02	Stø, Vesterålen	Female/Juvenile male	none	No	No	Yes
29.05.2011	BD-03	Stø, Vesterålen	Male	none	No	No	Yes
29.05.2011	BD-04	Stø, Vesterålen	Male	scars	No	No	Yes
29.05.2011	BD-05	Stø, Vesterålen	Male	none	No	No	Yes
02.07.2011	BE-01	Stø, Vesterålen	Female	scars	No	No	Yes
02.07.2011	BE-01A	Stø, Vesterålen	Unknown (calf)	none	No	No	Yes
02.07.2011	BE-02	Stø, Vesterålen	Female/Juvenile male	scars	No	No	Yes
02.07.2011	BE-03	Stø, Vesterålen	Female/Juvenile male	scars	No	No	Yes
02.07.2011	BE-04	Stø, Vesterålen	Female/Juvenile male	tn	No	No	Yes
02.07.2011	BE-05	Stø, Vesterålen	Female/Juvenile male	scars	No	No	Yes
02.07.2011	BE-06	Stø, Vesterålen	Male	none	No	No	Yes
02.07.2011	BE-07	Stø, Vesterålen	Male	none	No	No	Yes
09.07.2011	BA-01	Stø, Vesterålen	Female	mn	No	No	Yes
09.07.2011	BA-01A	Stø, Vesterålen	Unknown (calf)	scars	No	No	Yes
09.07.2011	BA-02	Stø, Vesterålen	Female/Juvenile male	none	No	No	Yes
09.07.2011	BA-03	Stø, Vesterålen	Male	mn	No	No	Yes
08.12.2011	BH-01	Vestfjord / Andfjord	Female/Juvenile male	scars	No	No	Yes
08.12.2011	BH-02	Vestfjord / Andfjord	Female/Juvenile male	scars	No	No	Yes
08.12.2011	BH-03	Vestfjord / Andfjord	Unknown (calf)	none	No	No	Yes
08.12.2011	BH-04	Vestfjord / Andfjord	Female/Juvenile male	none	No	No	Yes
08.12.2011	BH-05	Vestfjord / Andfjord	Female/Juvenile male	scars	No	No	Yes
08.12.2011	BH-06	Vestfjord / Andfjord	Male	bent dorsal	No	No	Yes
08.12.2011	BH-07	Vestfjord / Andfjord	Male	none	No	No	Yes
08.12.2011	BH-08	Vestfjord / Andfjord	Male	mn	No	No	Yes
08.12.2011	BH-09	Vestfjord / Andfjord	Male	tn	No	No	Yes
29.01.2012	BO-01	Møre area	Female/Juvenile male	scars	No	No	Yes
29.01.2012	BO-02	Møre area	Female/Juvenile male	none	No	No	Yes
29.01.2012	BO-03	Møre area	Female/Juvenile	scars	No	No	Yes

			male				
29.01.2012	BO-04	Møre area	Female/Juvenile male	scars	No	No	Yes
29.01.2012	BO-05	Møre area	Male	tn	No	No	Yes
29.01.2012	BO-06	Møre area	Male	scars	No	No	Yes
29.01.2012	BO-07	Møre area	Male	scars	No	No	Yes
29.01.2012	BO-08	Møre area	Male	none	No	No	Yes
29.01.2012	X-058	Møre area	Male	u shaped bent dorsal	No	Yes	No