Migration and local movements of common minke whales tracked by satellite in the North Atlantic during 2001 - 2010

Gísli A. Víkingsson[1], Mads Peter Heide-Jørgensen[2]
[1] Marine Research Institute, Reykjavik, Iceland
[2]Greenland Institute of Natural Resources, Nuuk, Greenland

Abstract

During 2001-2010 experiments were made to instrument and track the movements of common minke whales summering in Icelandic waters. We were able to monitor the movements of six whales of which three moved out of Icelandic waters during autumn. The start of the autumn migration was stretched over a period of at least one month, somewhat later than previously assumed. The southbound migration appears to take place in the middle of the North Atlantic far from coastal areas. Signals were received from one minke whale off the west coast of Africa in early December 2004, 101 days after tagging and 3700 km from the tagging site off SW Iceland. This study provides the first documentation of the autumn migration route and destination of common minke whales in the North Atlantic.

Introduction

The common minke whale (*Balaenoptera acutrostrata*) is a migratory species spending the summer at productive feeding areas at high latitudes, where they are believed to fulfil most of their annual food requirements during 4-6 months. It is generally assumed that minke whales and other species of the family Balaenopteridae migrate to warmer waters at lower latitudes for breeding although migration routes and wintering areas in the North Atlantic are virtually unknown.

Common minke whales are the most numerous species of baleen whales in the Icelandic continental shelf area. They belong to the so-called Central North Atlantic stock distributed from the coast of East Greenland, through Iceland to Jan Mayen in summer (Donovan, 1991). This stock delineation is, however based on limited data and actual stock boundaries and must therefore be considered uncertain. According to sightings surveys conducted during 1987-2009 abundance estimates have varied between 10,000 and 44.000 minke whales in the Icelandic continental shelf area during summer (Borchers et al., 2009; Pike et al., 2011). Most of these animals are believed to leave Icelandic waters during autumn but the whereabouts of the species during the winter breeding season is virtually unknown**.** Little information exist on the timing of the migration, although data from the small-type whaling in the late 20th century indicate a presence of the species in coastal Icelandic waters at least during March-November with relatively high densities during April-September and peaking in July (Sigurjónsson and Víkingsson, 1997).

One way to elucidate the offshore movements of minke whale is to use satellite telemetry. Satellite telemetry has in recent years been identified as an important tool to address important management questions concerning stock identity and migration (Heide-Jørgensen et al., 2006; Zerbini et al., 2006; Heide-Jørgensen et al., 2011).

Compared to other baleen whales, very few minke whales have successfully been tracked by satellite telemetry. Heide-Jorgensen et al., (2001) reported from tracking of two minke whales in Norwegian waters in 1994 and 1999 for 31 and 19 days, respectively. Kishiro and Miyashita, (2011) tracked a single minke whale for 27 days in Japanese waters in 2010.

First attempts to monitor movements of baleen whales in Icelandic waters by satellite telemetry were in 1994, when a single fin whale (*Balaenoptera physalus)* was tracked for 45 days in the Denmark Strait (Watkins et al., 1996). Experiments on satellite telemetry of minke whales in Icelandic waters were initiated in 2001 with increased effort from 2003 as a part of a wide ranging research programme (Marine Research Institute, 2003).

In this study we use satellite telemetry to monitor the local movements of minke whales around Iceland and to gather information about the migratory destination of the fall movement out of Icelandic waters.

Material and methods

Two types of satellite transmitters were deployed on minke whales. In 2001 and 2002 a ST-15 (Telonics Inc.) an external transmitter unit equipped with two lithium thianyl batteries cast in epoxy in the shape of a cylinder 110 mm in length and 28-55 mm in diameter was used. It was pre-programmed to be on for 24 hours and off for 72 hours. The antenna extended from one end of the transmitter while the other end was glued to a stainless steel cup that was mounted on an 8mm diameter titanium dart equipped with three barbs. The barbs acted to anchor the dart in the blubber and muscle layers below the skin. The stainless steel cup acted as a flange that stopped the transmitters from penetrating through the skin.

In 2004 a long flat box-shaped implantable tag (two M1 lithium cells, Wildlife Computers) with a harpoon head tip and two barbs along the body of the transmitter (flat box) was used. It had a stop plate that prevented penetration deeper than 10 cm and was delivered with a release cup that slid backward after it hit the whale. The transmitter had 20.000 transmissions and was duty cycled with 'one day on – three days off', 300 transmissions/day (w/o carry over) and it transmitted between 0600 and 2300 local time. In 2008 and 2010 a cylindrical implantable tag was used. All three transmitter models provided data on voltage of the transmitters, number of transmissions used, and geographic positions through the ARGOS system (Service Argos 1989, Harris et al. 1990).

The deployment system used for attaching the tags to whales was the Air Rocket Transmitter System (ARTS) a device now widely used internationally for tagging of baleen whales (Heide-Jørgensen et al. 2001). The ARTS consists of an air gun with adjustable air pressure delivered by a scuba tank. It has a barrel large enough to carry a plastic tube that acts as both a carrying rocket for the transmitter as well as a floatation device in case the tag misses the whale. The tag is attached to the carrying rocket with a nylon wire and when the tag is implanted the carrying rocket is released from the tag. The 'rocket' consisted of the transmitter in combination with a finned tailpiece. The tailpiece provides stabilization during flight as well as flotation, ensuring retrieval of the transmitter in case of a missed hit. The pressure and distance to the minke whales when the rocket was launched was 10-17 bars and 10 m.

In 2001-02 the tagging operation was conducted from 10 m cutter 'Einar í Nesi' in the Skjálfandi Bay in North Iceland in August. In 2004 an 18 m small-type whaling vessel 'Njörður' (36 tons) was used for tagging in Faxaflói Bay, Southwest Iceland, in August-September. The whales were spotted when breaking the surface and usually within 500 m from the vessel. Whales were pursued from the tagging vessel and upon arrival at the site where the whale last dove; the vessel slowed the speed and waited for indications of the next surfacing. Sometimes the whales could be seen underwater but there was usually only one chance for making a shot at the whale.

Positioning was facilitated through Service Argos Data Collection and Location Service. Location data were obtained from five classes of precision: 2, 1, 0, A and B. Positions of class 1-2 have an estimated precision (standard error) of < 1km with class 2 being the best (Service Argos, *in litt.*). Experimental studies however indicate that for tracking of marine animals, slightly lower precision can be expected for all three location classes (Hays *et al.*, 2001; Vincent *et al.*, 2002). For tracking of marine mammals, it is important to note that the precision of class 0, A and B locations has not been specified by Service Argos. Precision of location class 0, A and B has been tested experimentally in two studies and apparently class A has a higher precision than both class 0 and class B and the precision of class A position may approach the precision of class 1 positions (Hays *et al.*, 2001; Vincent *et al.*, 2002). Hays *et al.* (2001) found that the distance of class 0 and B positions to the actual position was 10 and 7km on average, however, the longitudinal error is usually larger than the latitudinal (Vincent *et al.*, 2002). In any case all three classes of low precision positions contribute important information to the tracks of the whales and the errors seem insignificant relative to the scale of the movements.

In order to reduce the importance of the errors in the low-precision location data, an average position was calculated on the basis of all positions for each day (24hr periods) with data.

Results

During 2001-2011, 12 minke whales were instrumented with satellite tags in Iceland. Of these, six provided information useful for describing movement and will be described in more details here (Table 1). One 6m long minke whale was tagged at Skjálfandi Bay, north Iceland, on 12th August 2001 (#13280). The whale was tracked through 29th August where it travelled a minimum of 153 km along the coast of northern Iceland (Fig. 1). Occasional signals were received through 6 September.

Another minke whale was tagged at Skjálfandi bay on 15 August 2001 (#13282). It was tracked through 18th October where it moved a minimum of 958km with an average daily travel distance of 16km (range 2-38km/day). Its movements mainly consisted of visits to fjords in northeast Iceland with no apparent offshore activities (Fig. 1).

On 20th August 2002, additional two minke whales were instrumented with satellite transmitters. No signals with positions were received from one of these whales. The other whale was tracked until 8th November, for 88 days (#3960, Fig. 1). Like the minke whale tracked in 2001, it was rather stationary in coastal Northern Icelandic waters beyond mid-October. On 31st October the whale had moved northeast of Iceland, and four days later signals were received more than 350km further south. The last signals were received on 8th November at 56°N 27°W showing continuous fast southward movement (Figs 1 and 2).

During the period 27th August-23rd September 2004 seven minke whales were instrumented with satellite transmitters in Faxaflói Bay, Southwest Iceland. Useful data were received from four of these animals (Table 1). Two of these only transmitted data for few days while they were still in the area where they were tagged.

One minke whale tagged on 14th September (#50683) 2004 stayed within the tagging area in Faxaflói Bay until 22 September, when it moved west to the continental slope area where it stayed for about a week. On 30 September the animal turned southwards along the Reykjanes Ridge, at a mean speed of 10km/hour. The last signal was received from this animal on 8 October at around 50°N, 34°W (Fig. 2).

On 17th November 2004 signals were received from a minke whale that was tagged in Faxaflói Bay 27 August (#50686), the first data received from this animal. The position of the animal was then over the Mid-Atlantic Ridge, 900 km west of Northern Spain. The transmitter provided the next positions on 23 November, where the whale had travelled some 700km to the south, into the Azores area. No useable transmissions were received on the 30th November, but on 5th December the animal had moved further to the south, along the Canary Current and was 1000km northwest of the Cape Verde Islands. This area is 3700km from Faxaflói Bay where the tag was deployed on the whale three months (101 days) earlier.

Tagging attempts during spring have yielded limited results with only one minke whale providing useful, albeit very limited data. This whale was tagged in Faxaflói Bay on May 6th and the first signals were received 45 days later close to the tagging site. During 20th June – 8th July six positions were received, all in Faxaflói Bay except one, probably erroneous location off Greenland's east coast on 23rd June.

Discussion

Compared to larger baleen whales successful tagging of minke whales is clearly a very difficult endeavour and the development of the technique is still in its infancy. A major difficulty is to get close enough to the whales to get a chance for delivering the transmitter whether it is being delivered by crossbow or air gun as in this study. The next problem is to ensure that the tag is well positioned high on the whale to clear the water and allow transmissions when the whale is surfacing. The third problem is to anchor the tag in such a way that it will stay on the animal and it is usually impossible to assess the attachment of the tag because the whales disappear and can rarely be approached to get a second inspection of the success of the deployment. All these factors add to the immense difficulties with tagging minke whales and slow learning from limited successes. Considerable investment in development of better methods is needed before large scale tagging and long-term tracking studies can be initiated.

Of the two tags used in this study the implantable flat box tag provided the longest track lines which could indicate a better performance of the tag, despite the somewhat uncertain deployments, however, the tags are no longer commercially available and they are replaced by smaller and better transmitter units with better battery performance.

The experiments in 2001-2002, although few in numbers, indicated a rather stationary behaviour of minke whales in coastal North Icelandic waters during late summer and fall prior to the onset of migration. They also indicated a somewhat later start of the fall migration than previously assumed from catch data (e.g. Sigurjónsson & Víkingsson 1997) as neither one of the two "long-transmitting whales" had started migration by late-October. However, the only whale tagged in Faxaflói Bay for which the departure date could be determined did leave Icelandic waters one month earlier. The two animals tagged north of Iceland were both estimated as 6m in length (corresponding to immature or pubertal individuals) while the “early” migrant was estimated as 8m long and thus likely mature. Unfortunately no biopsies for determination of gender were obtained from the tagged animals.

The average minimum swimming speeds were considerably faster off the shelf than in coastal waters (Table 1). This is not unexpected as the former represents migratory movements whereas the latter probably represents feeding activity. The average swimming speeds during migration (4,6-7,3 km/h) are similar to those recorded from migrating Gray whales (Swartz et al., 1987; Mate and Urban-Ramirez, 2003).

The tracks of the three minke whales that departed from Icelandic waters provide the first indications of the migration route and possible winter destination of minke whales summering in Icelandic waters. Evidently all three followed an offshore route in the middle of the Atlantic heading south. Contact was lost early with two of the whales but they were all heading in the same direction. The third whale, where contact was maintained past the Azores, continued south to a position in the mid Atlantic at about 28^{o}N. This represents the longest tracking record for a minke whale worldwide both in terms of distance travelled (3700 km) and time (100 days).

There is generally a shortage of winter observations of minke whales in all North Atlantic areas suggesting that these relatively abundant whales are distributed offshore (Slijper et al., 1964; Folkow and Blix, 1991; Mitchell, 1991; Van Waerebeek et al., 1999). There is however some observations that suggest that offshore areas of the southern part of the North Atlantic are a likely winter distribution for minke whales. Although the species identification has been disputed Slijper et al. (1964) reported large numbers of minke whales in an area (see Fig. 2) adjacent to where contact was lost with the southernmost tracked whale (#50686). At the same latitude but further east, van Waerebeek et al. (1999) reported a number of minke whale sightings and strandings around the Canary Islands and along the West African coast. Folkow and Blix (1991) reported two offshore sightings further south than the whales tracked in this study but in the area the whales were heading towards (see Fig. 2).

More and longer trackings of minke whales from Iceland are necessary to reveal the migratory destination during fall of this population. However, these initial tracking attempts add to the evidence that offshore areas of the central or eastern part of the southern North Atlantic is the most likely wintering habitat for this species.

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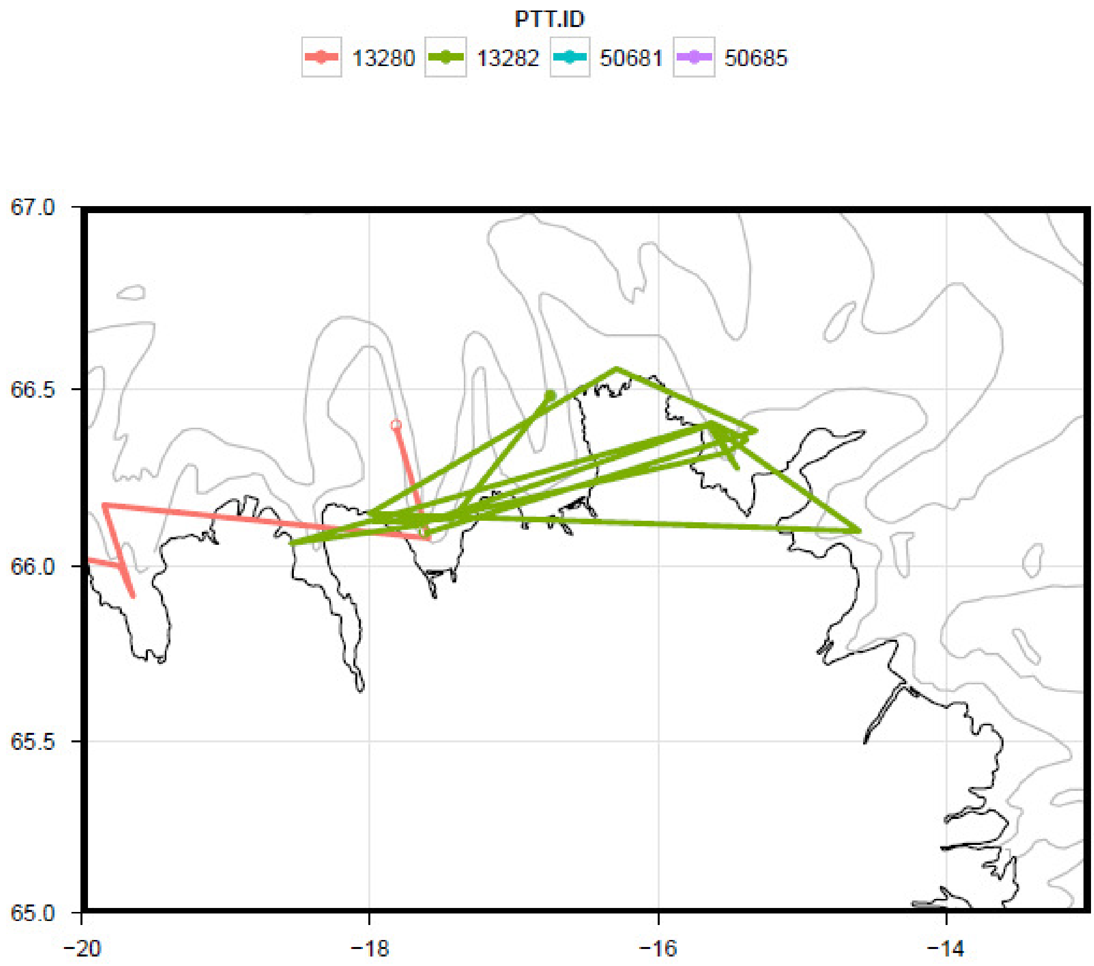

Figure 1. Satellite tracking of two minke whales tagged (#50683 and #50686) in the North of Iceland in August 2001. Animals for which signals (2 out of 4) were recovered were constantly visiting fjords in the North of Iceland with no apparent offshore activities.

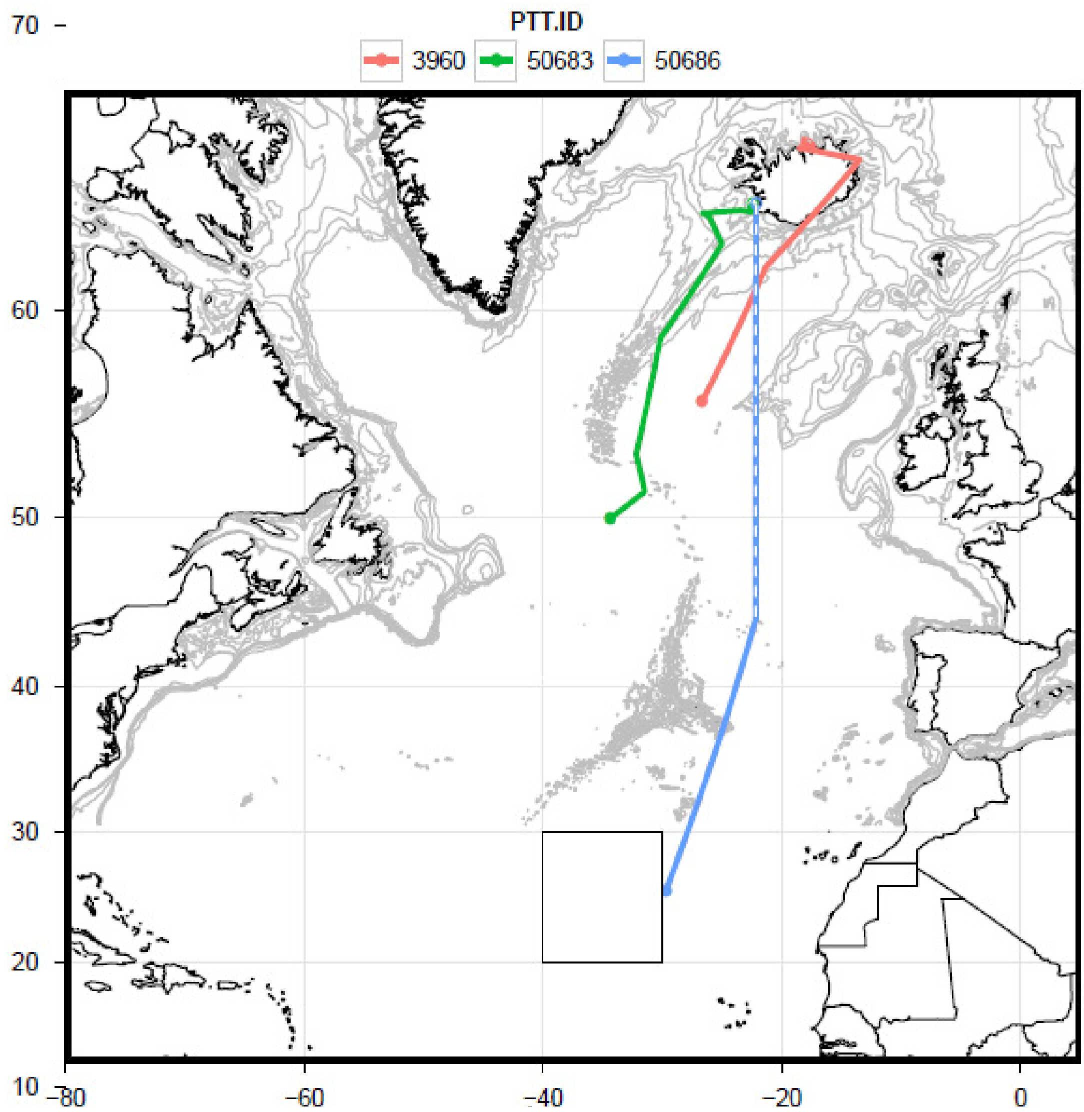

Figure 2. Satellite tracking of two minke whales tagged (#50683 and #50686) in Faxafloí bay from 27th August – 23rd of September effort and of one minke whale tagged (#3960) in the North of Iceland. All three animals turned southwards after having spent some time along the continental shelf of Iceland.

Table 1. Details of instrumentations of eight minke whales off Iceland in 2001-2010. Departure from shelf was defined as the midpoint between the last date on shelf and the first date off shelf. For the locations precision class 2 indicates positions with a nominal precision of 350m, 1 precision of <1,000 m while classes 0, A and B have no assigned precision. Position of the tag on the whale is given by L=left, R=right, M=mid, F=front, H=high.

Tag ID	Type	Date	Position at sea (°N/°W)	Dis-tance/ Pres-sure	Where on whale	Size of whale (m)	Dep. from shelf	Av speed (on shelf) km/day	Av speed off shelf (SD)	Last day of transmission	3	2	1	0	A	B	Sum	Comments
13280	ST15	12.8 2001	66°05/17°36	NA/11	LMH	6	NA	10 (10)	NA	29. 08.2001				1	7	13	21	
13282	ST15	15.8.2001	66°07/17°37	NA/11	LFH	6	NA	16(12)	NA	18.10.2001		2	3		17	49	71	Partially implanted
3960	ST15	20.8.2002	66°16/17°54	13/13		6	02.11.2001	6 (7)	164 (23)	08.11.2002	1	6	11	11	50	101	180	
50683	Flatbox	14.09.2004	64°08/22°27	10/10	LFH	8	29.09.2004	28 (30)	176 (101)	08.10.2004		3	5	1	25	52	86	
50686	Flatbox	27.08.2004	64°09/22°11	10/10	RFH	5	NA	NA	110 (77)	05.12.2004			1		2	3	6	Tag implanted too deeply
50685	Flatbox	23.09.2004	64°11/22°17	10/17	LFH	8.5	NA	7 (5)	NA	06.10.2004					5	9	14	
21802	Cylinder	07.11.2008	65°47 18°08	18/22			NA		NA	12.11.2008						3	3	
37278	Cylinder	06.05.2010	64°14 22°22	18/20	RMH	6	NA		NA	08.07.2010					3	3	6	