

## Swimming, diving, and respiration patterns of a Northern bottlenose whale (*Hyperoodon ampullatus*, Forster, 1770)

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### Summary

In July 1990 an adult Northern bottlenose whale strayed into the industrial harbour of East Flushing, Holland. During the period that the animal was in the harbour, dives and respirations were recorded for 5 hours. The data show that the number of respirations before a dive is correlated positively to the length of that dive. This could be explained in 2 ways: either the animal anticipates long dives and therefore stores extra oxygen before diving, or the animal subconsciously stores oxygen and, while diving, notices that it can remain submerged for a long time. When the whale was cruising, an average dive lasted for 6.23 min (N=8). On average 7.7 respirations were taken between dives in, on average, 1.47 min. Near areas where the animal had to make a navigational choice, it swam in circles, and took relatively short dives. It seemed to investigate its surroundings acoustically. On one occasion the animal swam under water at a minimum speed of 5.0 km/hr. Potential reasons why the animal was present in the harbour are discussed.

**Key words:** Northern bottlenose whale, *Hyperoodon ampullatus*, dive pattern, respiration pattern, stranding, orientation.

### Introduction

On 25 July 1990, at about 09.00 hrs a whale was sighted in the East Flushing industrial harbour (Sloehaven), Holland. This harbour is located on the border of the Westerschelde, a branch of the Dutch North Sea (3°40'E longitude and 51°27'N latitude). When a pilot boat approached the animal it swam into a dock area of the harbour, which contained a dry-dock and a moored ship. It injured its head and tail slightly by swimming against the concrete pillars of the quay. At about 09.45 hrs the animal almost beached itself on the shallow NW end of the dock area, but was able to free itself with a strong body movement towards a deeper area and swam circles calmly until 12.00 hrs. Then it became restless and hit its head against the moored ship several times.

Around 12.30 hrs the whale almost beached itself again on the shallower end of the harbour. A person tried to help it, but eventually the animal freed itself (Fig. 1). It became trapped for a while between the moored ship and the quay, which were both covered with barnacles, and grazed its back. The animal escaped by swimming under the ship, and swam more calm circles until around 14.00 hrs. At this point it suddenly left the dock area and swam into the centre of the harbour. Here it remained floating in the same position until 15.30 hrs.

At 11.00 hrs immigration officers of Flushing contacted the Harderwijk Marine Mammal Park. The Harderwijk Park is the rehabilitation centre for cetaceans stranded on the Dutch coast (Kastelein *et al.*, 1990). A rescue team had been sent out from the park, arrived at the scene at 14.30 hrs and identified the animal as a male Northern bottlenose whale (*Hyperoodon ampullatus*). An initial survey, using a coast guard vessel, provided the following information about the external characteristics.

The length of the whale was estimated to be 6.2 m and the width of the tail fluke 1.7 m (Figs 1 and 2). The animal was pale greyish-brown in colour and had a large bulging forehead (melon) which was paler than the rest of the body (Fig. 3). There were superficial injuries on the right rostral part of the melon, on the right side of the tip of the dorsal fin (Fig. 4), on the upper left tip of the tail fluke, and the whale had a 2 to 3 cm deep, 20 cm long cut on the left side of its head running from the blowhole towards the angle of the gape (Fig. 5). The skin on the animal's back was grazed (Figs 1 and 2). All injuries were probably caused when the whale was trapped in the dock area. The blowhole was relatively large and appeared to be a symmetrical lens-shaped slit running from left to right (Fig. 5), not a semi-circle as seen for instance in Harbour porpoises (*Phocoena phocoena*), Bottlenose dolphins (*Tursiops truncatus*), False killer whales (*Pseudorca crassidens*) and Killer whales (*Orcinus orca*).

It was decided that this whale was disorientated rather than sick, because the injuries were only superficial (considering that the blubber layer is 15 to

25 cm thick (Ohlin, 1893)), the respirations strong, and because the animal was not emaciated like most stranded cetaceans (Kastelein *et al.*, 1990; Kastelein & van Battum, 1990). It did not seem necessary to attempt to catch the animal for treatment. The boat carrying the team from Harderwijk did remain near the animal to: (1) evaluate its health status for a longer period; (2) intervene if it were to strand itself; and (3) prevent collisions with ocean vessels entering or leaving the harbour.

At around 15.30 hrs the animal started to swim further into the harbour until it reached the end at 17.05 hrs. There it swam in circles and later in ovals for 2 hrs, after which it swam towards the harbour mouth. The coast guard boat slowly followed the animal. At 21.30 hrs the animal was seen for the last time, in the Westerschelde. It was 20 km from the open sea and going west with the outgoing tide. The maximum low tide was at 24.00 hrs, so the current was towards the North Sea for several more hours.

Accurate recordings were made of the respiration and diving patterns of the whale between 16.18 and 21.30 hrs. This report concerns that data.

### Materials and Methods

Starting at 16.18 hrs a record was made of the pattern of respiration and diving in the following way: Four people were constantly on the look-out in 4 directions and signalled when the animal surfaced and exhaled. This could often be heard, and a vapour cloud of up to 1.5 m high was visible. A researcher with a digital clock recorded the times of these observations. Short, shallow dives of less than 30 sec occurred during the breathing periods, and were recorded as dips. A gap between two exhalations of more than 30 seconds was counted as a dive. After a long dive in time and distance, it was sometimes necessary to use binoculars to count the next group of respirations. Observations continued until 21.30 hrs when the animals was last seen. The air temperature was about 20°C, the windforce around Beaufort 2 and there was some cloud cover.

### Results

#### *Swimming, diving, and respiration patterns*

The approximate swimming pattern between 09.00 and 21.30 hrs is shown in Figure 6. After the entrapment in the dock area between 09.00 and 14.00 hrs, the animal swam out into section A of the harbour and floated in front of the dock entrance. At 15.30 hrs the animal started to zig-zag slowly towards the far end of the harbour, cruising through section C. From the first recordings at 16.18 hrs until the animal reached the far end of section D of the harbour, the dives were regular and lasted about 5 min. There were around 5 respirations in each

breathing period between dives. Before arriving at the entrance of section D it took one longer dive of 8.23 min (Figs 6 and 7).

The animal's stay in section D can be divided into 2 periods. The first period (17.05–18.04 hrs) was spent describing small circles in the NW corner. The dives were short and irregular and the number of breaths between dives was also variable. In the second period (18.05–19.06 hrs) the dives were longer and more regular. The circles had changed into ovals (Figs 6 and 7). Having spent 2 hours in section D, the whale suddenly left and cruised towards the harbour mouth, taking relatively long dives. While cruising back through section C, the dives lasted for 6.23 min on average ( $N=8$ ), the breathing periods between dives were on average 1.47 min long and with, on average, 7.7 respirations. In front of the entrance of section B the whale circled a few times, resulting in several short dives (20.19–20.38 hrs), after which it continued its journey with a long dive with which it reached the harbour mouth. Here it circled once more, which again resulted in short dives (20.46–20.57 hrs). With a long dive at 20.58 hrs the animal left the harbour and entered the Westerschelde, where it swam circles which resulted in dives of various lengths. It breathed 7 times before it took a long dive at 21.30 hrs after which it was out of sight (Fig. 7).

In between long dives the animal usually surfaced and then breathed several times and took short dips to a depth of around 1 metre. When under water, the animal's path could be followed by its 'footprints', the flat circular patches of water which indicate the wake of the tailfluke. Often the animal swam a slow curve during this breathing period. The whale did not seem to make quick direction changes like False killer whales and other small odontocetes. Before a long and relatively deep dive, the tailfluke did not show above the water, but the angle of descent was steeper than in short dips during a breathing period. The footprint was also larger, indicating intensified propulsion. In some cases the whale did not dip between breathing, but floated throughout the respiration period. No correlation was found between the number of respirations and the length of the preceding dive. A significant positive correlation was found between the number of respirations and the duration of the following dive (Spearman Rome correlation coefficient:  $r=0.56$ ,  $p=0.0001$ ).

#### *Swimming speed*

On one occasion, when the whale swam out of section D of the harbour, it was possible to record its swimming speed. The animal covered a minimum distance of 750 m in 9.00 min. The swimming speed was 5.0 km/hr (presuming that it was swimming in a straight line under water).

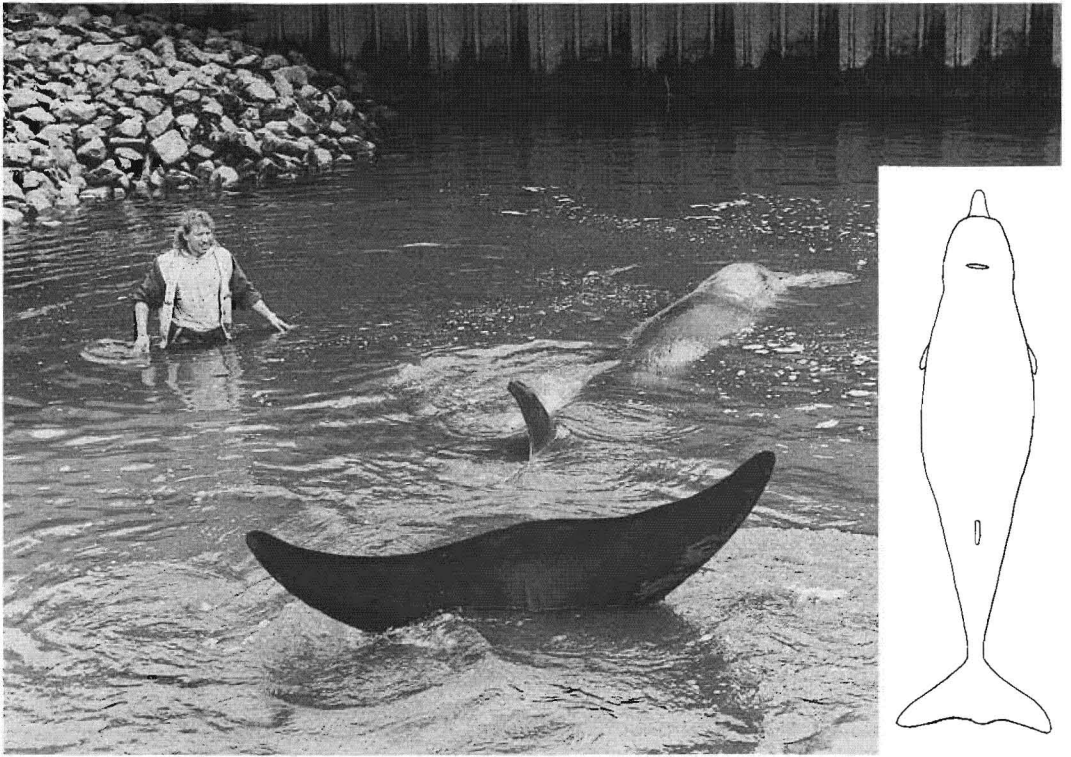


Figure 1.

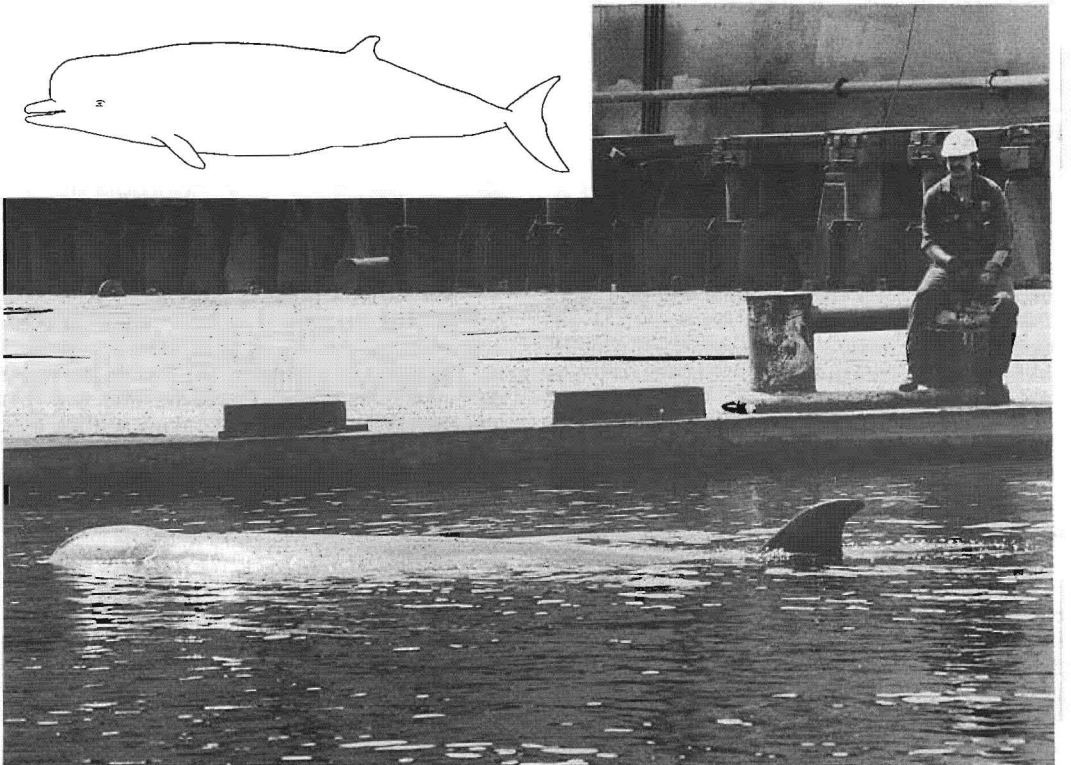


Figure 2.



**Figure 3.** The head of the male Northern bottlenose whale. Note the prominently bulging forehead and well-defined beak. Also note the rough skin on the melon (Photo: Lex de Meester).

## Discussion

### Measurements

The length of the Northern bottlenose whale in the present study was estimated at 6.2 m, the width of the tail fluke at 1.7 m, and the maximum girth between pectoral fins and dorsal fin at 2.75 m. These estimates were made by comparing the animal with humans on photographs. The weight, calculated with a formula developed for Killer whales (*Orcinus orca*) by Kastelein & Vaughan (1989), is 2400 kg. This weight assessment seems reasonable compared to weights and measurements found in the literature. A 6.6 m

long specimen was reported to weigh 2200 kg (Ridgway, 1972). A male with a length of 611 cm and a girth of 270 cm was estimated at 2500 kg (de Smet, 1986). Camm & Stonehouse (1982) report a 7 m long female that weighed nearly 3000 kg. Fraser (1963) describes a 378 cm long young female that weighed 660 kg.

Although it was impossible to see the whale's genital area, the animal in the present study was most probably a mature male because of the pale bulging forehead, which is not present in females (Gray, 1883; Ohlin, 1893). This is a conspicuous sexual dimorphic characteristic. Adult male Bottlenose

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**Figure 1.** The male Northern bottlenose whale while almost stranded in the NW end of the dock area. Note the posterior position of the dorsal fin, which is positioned two-thirds of the way down the back (see drawing). Also note the tailfluke without a notch in the middle of the hind margin, and the scratches on the back of the animal which were caused by impacts with objects infested with barnacles (Photo: Lex de Meester).

**Figure 2.** The male Northern bottlenose whale swimming alongside the dry-dock. Note the posterior position of the dorsal fin, which is positioned two-thirds of the way down the back. This is also shown in the drawing (Photo: Lex de Meester).



**Figure 4.** The dorsal fin of the male Northern bottlenose whale. Note the falcate shape. The tip was roughened by impact with barnacle infested objects (Photo: Lex de Meester).

whales can reach a length of 9.8 m and females 8.7 m. It is thought that males reach sexual maturity at a length of 7.5 m and females at 6.9 m (Mead, 1989). This suggests that the around 6.2 m long male in the present study was sexually immature. However, the large bulging forehead is believed to occur only in mature males (Gray, 1882; Mead, 1989). Boschma (1951) shows a 5.29 m long male which had a bulging forehead, so together with the observations in the present study, it appears that the bulging forehead is already present in some males that are not yet sexually mature.

#### *Swimming, diving, and respiration patterns*

It seems unlikely that this whale's swimming pattern was altered by the presence of the boat, as it allowed the vessel to come within 5 m during respiration periods. As long as the approach was slow and careful, the animal showed no signs of being alarmed. Ohlin (1893) and Mead (1989) describe the same species even showing curiosity for boats, especially during the spring.

The swimming, diving, and respiration patterns show that in areas of potential conflict the animal swam in small circles, which resulted in relatively

short dives. The three easily recognizable areas where the animal had to decide which direction to go in were: the end of section D, the entrance of section B, and the harbour mouth. It is conceivable that the animal circled in order to investigate the areas acoustically.

Winn *et al.* (1970) observed dive times of 3 to 15 min for Bottlenose whales. During their observations the whales were not seen to lift their tailflukes out of the water when starting to dive. These observations correspond with the findings in the present study. Mörzer-Bruyns (1971) reports that Bottlenose whales breathe many times during several minutes spent near the surface, then dive for 10 to 20 minutes. The animal in the present study took shorter dives, this could have been due to the limited depth of the harbour (10 to 16 m deep depending on the location and tide), or the fact that the animal was investigating its surroundings to find an exit. Ohlin (1893) observed Bottlenose whales that blew every 30–60 sec while at the surface, and then dived for as long as 1–2 hours. These animals were probably feeding. Benjaminsen & Christensen (1979) recorded diving times of between 14 and 70 min. These were obtained from animals in the open ocean, where the water was



**Figure 5.** A rear view of the head of the male Northern bottlenose whale. Note the 20 cm long, 3 cm deep wound and the symmetrical lens-shaped blowhole (Photo: Lex de Meester).

much deeper than in the harbour of the present study, and the animals could have been feeding during their observations. Under stressful conditions these whales can stay submerged for a very long time. One harpooned animal submerged for 2 hours and came to the surface in apparent good condition. Harpooned animals surface at approximately the same place where they submerged (Gray, 1883; Ohlin, 1893), and a dive to a depth of 1100 m has been recorded for a harpooned animal (Mörzer-Bruyns, 1971).

In the present study the respiration rate during a respiration period was found to be significantly correlated to the length of the subsequent dive. Leatherwood & Ljungblad (1979) described hyperventilation before descent on long dives in a radio-tagged Spotted dolphin (*Stenella attenuata*). The same respiration and dive pattern was observed in a Common dolphin (*Delphinus delphis*), a Pacific pilot whale (*Globicephala*) (Leatherhead & Evans, 1979), Sperm whales (*Physeter macrocephalus*), (Scoresby, 1820), and Bottlenose dolphins (*Tursiops truncatus*) (Ridgway *et al.*, 1969; Dral & Verwey, 1977). This

suggests that hyperventilation before a dive may be a general physiological adaptation in odontocetes. The correlation between the number of respirations between dives and the length of the subsequent dive in odontocetes could be explained in 2 ways: (1) They anticipate long dives and take up enough oxygen to prevent them from depleting their oxygen reserve and having to recuperate afterwards, or (2) they subconsciously store extra oxygen when staying longer at the surface and, while submerged, notice oxygen stress only after a long period. The first explanation seems the most likely, especially when the breathing records are compared to the swimming pattern: during long dives the animal swam in long and relatively straight lines, seemingly on a determined course.

Another adaptation, for diving, is respiratory arrhythmia. This is an accelerated heart rate found in toothed whales while they are respiring near the surface. This might serve to accelerate the oxygen uptake in the blood (Irving *et al.*, 1941; Andersen, 1969; Kanwisher & Ridgway, 1983; Kastelein & Meijler, 1989).

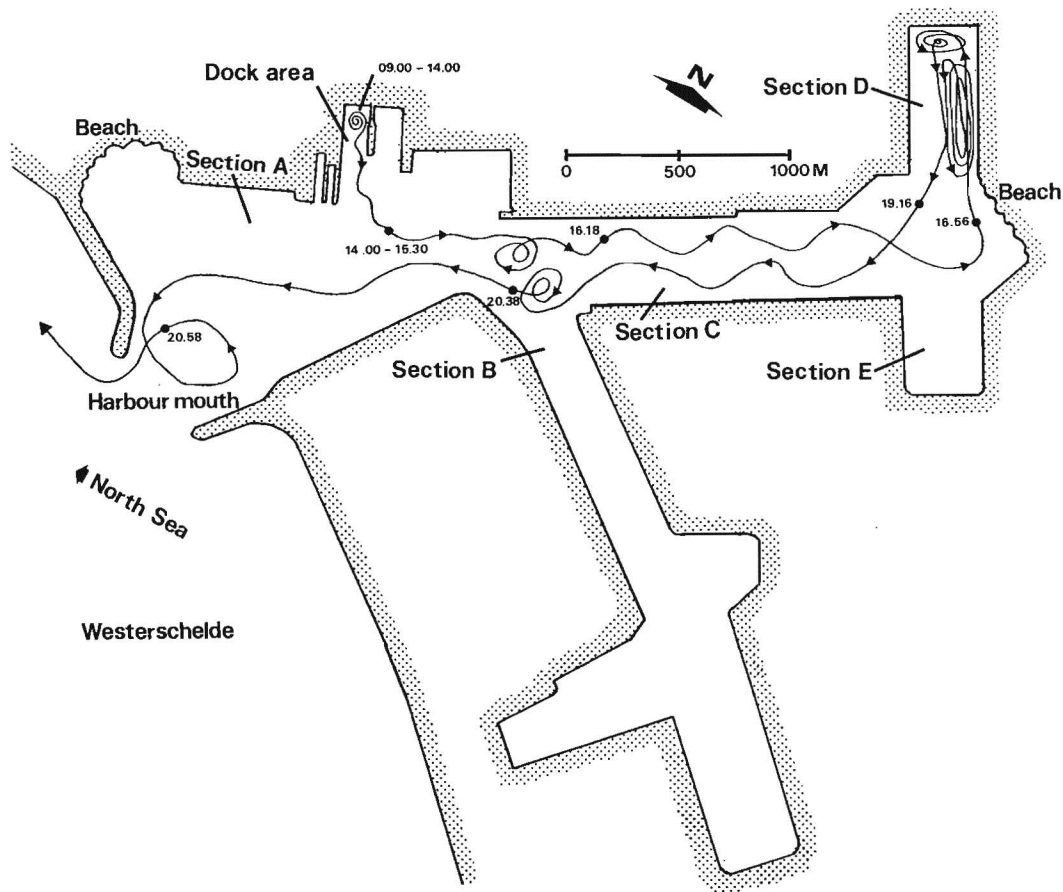


Figure 6. East Flushing industrial harbour, showing the approximate swimming pattern of the male Northern bottlenose whale on 25 July 1990. The arrows indicate the swimming direction. Near the black dots on the swimming route the time is shown. Harbour depth: 10 to 16 m depending on the location and tide (Graph: Ron Kastelein).

#### Swimming speed

The swimming speed of 5 km/hr which was calculated for the whale in the present study corresponds with the cruising speed of 3.7 to 5.6 km/hr observed for Bottlenose whales in the open ocean (Mörzer-Bruyns, 1971). However, when under stress they can swim much faster; once a harpooned Bottlenose whale took out 915 m of line in less than 2 min. (Ohlin, 1893). This would require a swimming speed of more than 27 km/hr. As a comparison, a trained Bottlenose dolphin (*Tursiops truncatus gilli*), which is a much smaller species, was recorded to reach a top speed of 29.9 km/hr for 7.5 seconds, and could cruise at a speed of 11.1 km/hr for an indefinite period (Lang & Norris, 1966).

#### Historic strandings and whaling

The Northern bottlenose whale is rarely found in the coastal waters of Holland. Only 17 strandings were

recorded before 1958 (van Bree, 1974). Not including the animal in the present study, only one Bottlenose whale was found stranded between 1970 and 1990. It was a 611 cm long male which stranded alive on the beach near the harbour dam of Breskens, on 10 September 1984. The animal had lung problems and died the same day during a rescue operation (de Smet, 1986; Smeenk, 1989).

Between 1913 and 1953, 46 strandings have been recorded evenly distributed around the British coast. The whales strand more commonly in autumn, which is when their southward migration takes place, from arctic waters in the summer, towards more temperate waters in the winter (Fraser, 1953; Fraser & Parker, 1953).

Between 1891 and 1900 this species was hunted extensively by Norwegians and by a few Scots in the Greenland Sea for the blubber and the spermaceti from the bulging forehead. In that period, 2100 to 2900 Bottlenose whales were killed annually. Later

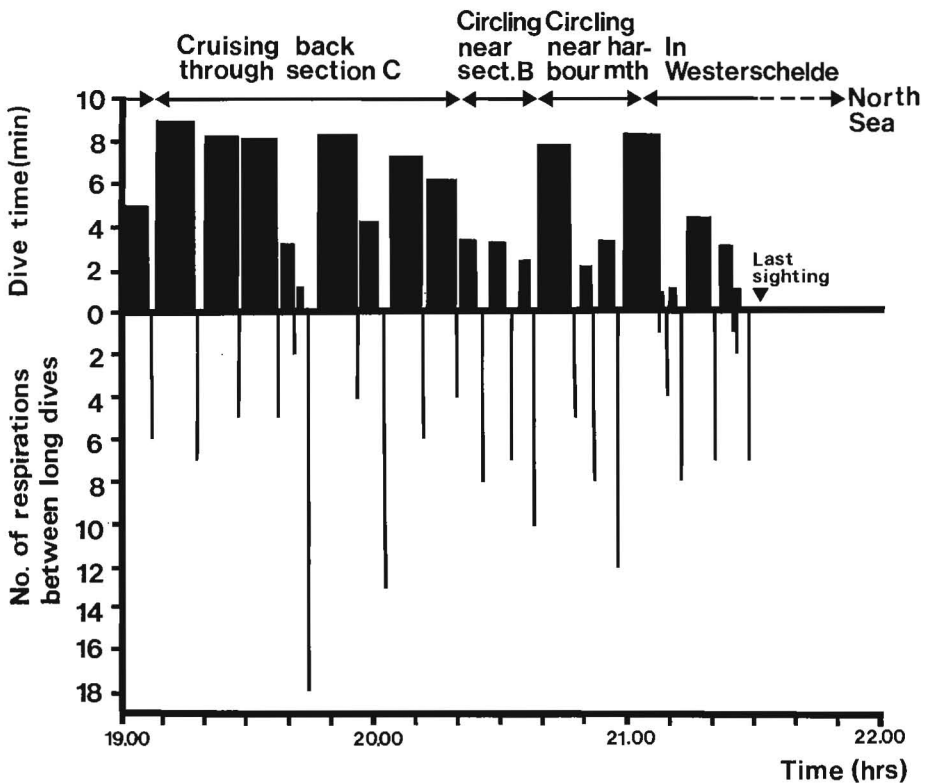
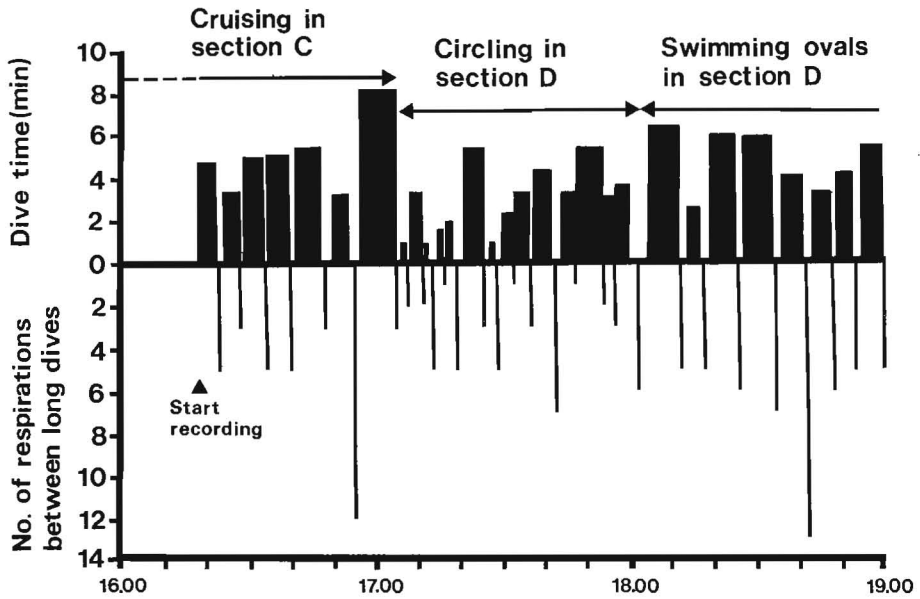


Figure 7. The dive and breathing patterns of the male Northern bottlenose whale during the observation period (Graph: Ron Kastelein).



the large herds disappeared so the hunt stopped after 1930, but was resumed at a much lower level after 1945 and continued until 1973. During this last year, only 3 animals were caught, making it uneconomic to continue to catch this whale species (Palm, 1946; Mead, 1989).

#### *Potential reasons for disorientation*

The Northern bottlenose whale of the present study should not have been in the East Flushing harbour for three reasons:

- (1) It is a marine and oceanic deep water species (Mörzer-Bruyns, 1971; Benjaminsen, 1972). It rarely enters waters shallower than 180 m (Leatherwood *et al.*, 1976).
- (2) At this time of year Bottlenose whales usually occupy the Arctic Ocean (Fraser & Parker, 1953).
- (3) Bottlenose whales eat mostly squid (mainly *Gonatus fabricii*) and Herring (*Clupea harengis*) which live in deep water. Sometimes starfish are found in their stomachs, suggesting that they sometimes forage near the bottom (Ohlin, 1893; Clarke & Kristensen, 1980; Mead, 1989). In the stomach of one Northern bottlenose whale the remains of 10,000 squid were found (Vrolik, 1848).

Why the animal was lost, remains open to speculation. It is also not clear whether the animal was a late north bound migrant or an early south bound migrant. The animals migrate north in spring and early summer (Mitchell & Kozicki, 1975) and according to Risting (1922) the southward migration begins in July when the animals start to move south from the Norwegian Sea. Most of the strandings of Northern bottlenose whales on the Dutch coast occurred between July and October (van Bree, 1974). Interestingly, many of the Bottlenose whales strandings in Europe and in North America represent lost or strayed, but apparently healthy, animals which swim into fjords, rivers, and streams (Mitchell & Kozicki, 1975). It is not yet clear which sense, or more likely which combination of senses, is used for navigation.

A method of navigation which has been proposed is the use of the geomagnetic field. It could be that Northern bottlenose whales use weak anomalies in the geomagnetic field as cues for orientation and navigation (Kirschvink *et al.*, 1986). Maybe they sometimes follow the wrong marine magnetic lineation and enter the North Sea accidentally. Although Bottlenose whales do not strand in groups as frequently as Sperm whales (*Physeter macrocephalus*), Pilot whales (*Globicephala* sp.) and False killer whales, group strandings have been reported (Ridgway, 1972). Possibly the sensory system (such as proposed by Gerrits & Kastelein, 1990) to detect the geomagnetic field anomalies was not functioning properly in the animal of the present study.

The 17 recorded Northern bottlenose whale strandings are not randomly distributed along the Dutch coast. Seven have stranded in the south western delta area of the Netherlands (Zeeland), and 8 in the Dutch Waddensea (there seems to be no clear seasonal division in the strandings in these two areas). This suggests that the animals have been swimming towards sea arms. In order to find these sea arms and to avoid the sand banks in front of the Dutch coast, they probably used their sonar system. The echolocation system of the animal in the present study seemed to function adequately since it only hit the sides of the harbour in the morning when it was driven into the dock area by the pilot boat. The sides of the harbour were all made of concrete or steel except two parts which were sandy beaches (Fig. 6). The animal made no effort to approach these beaches, which would have been expected if the animal had been ill. The animal circled near places where it had to make a navigational decision, this also suggests that it was using its sonar system. It could not have used its eyes for such decisions, since they were underwater during the respiration periods, and the water was murky.

Another possibility is that animals of this species learn some components of their navigational skills from each other, and that the individual in the present study was separated from his herd at some point in life. Northern bottlenose whales are gregarious animals (Ohlin, 1893). Herds of up to 10 animals have been seen (Gray, 1883), and evidence of strong social ties has been given. For instance, wounded whales are not abandoned by the herd until they die (Ohlin, 1893; Palm, 1946). Also, in 1788 when a mother and calf were trapped in the harbour of Honfleur, France, the mother fought to the death in defence of her calf which fishermen were trying to catch. This social contact and the long life-span of around 37 years (Christensen, 1973) could point to at least partial learning instead of a full genetic programme for navigation.

How did the animal of the present study eventually realize that it had to swim to the west in order to return to the North Sea? Possibly the animal entered the Westerschelde during incoming tide, and therefore did not notice a change in salinity while swimming east. Bottlenose dolphins (*Tursiops truncatus*) have a sensitive gustatory system (Friedl *et al.*, 1990; Kuznetsov, 1990), so possibly Northern bottlenose whales also have a sense of taste. Maybe the animal of the present study noticed the reduction of the salinity during the outgoing tide, which made him swim west.

#### **Acknowledgements**

We thank the following officers of the Flushing immigration (Marechaussee): Mr P. C. Nagtzaam,

Mr K. A. Vergouwen, Mr W. R. Oosterom, Mr J. G. Martens, Mr R. C. M. van Diemen, Mr J. C. Knulst and W. F. Aspert. We also thank the boat personnel: Mr L. van der Kooy, Mr O. Batenburg, Mr D. van der Schilt and Mr M. van der Sluis. Without their help this study and rescue operation could not have been accomplished. Special thanks go to Frans H. H. Hassels for providing information needed for this manuscript. We thank Gert-Jan Fopper for his help with the data recording. We also thank Hans Witte of the NIOZ for providing a sea map, Hans Romberg for the statistics, and Professor Dr P. Wiekema of the Agricultural University of Wageningen and Nancy Vaughan for their comments.

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