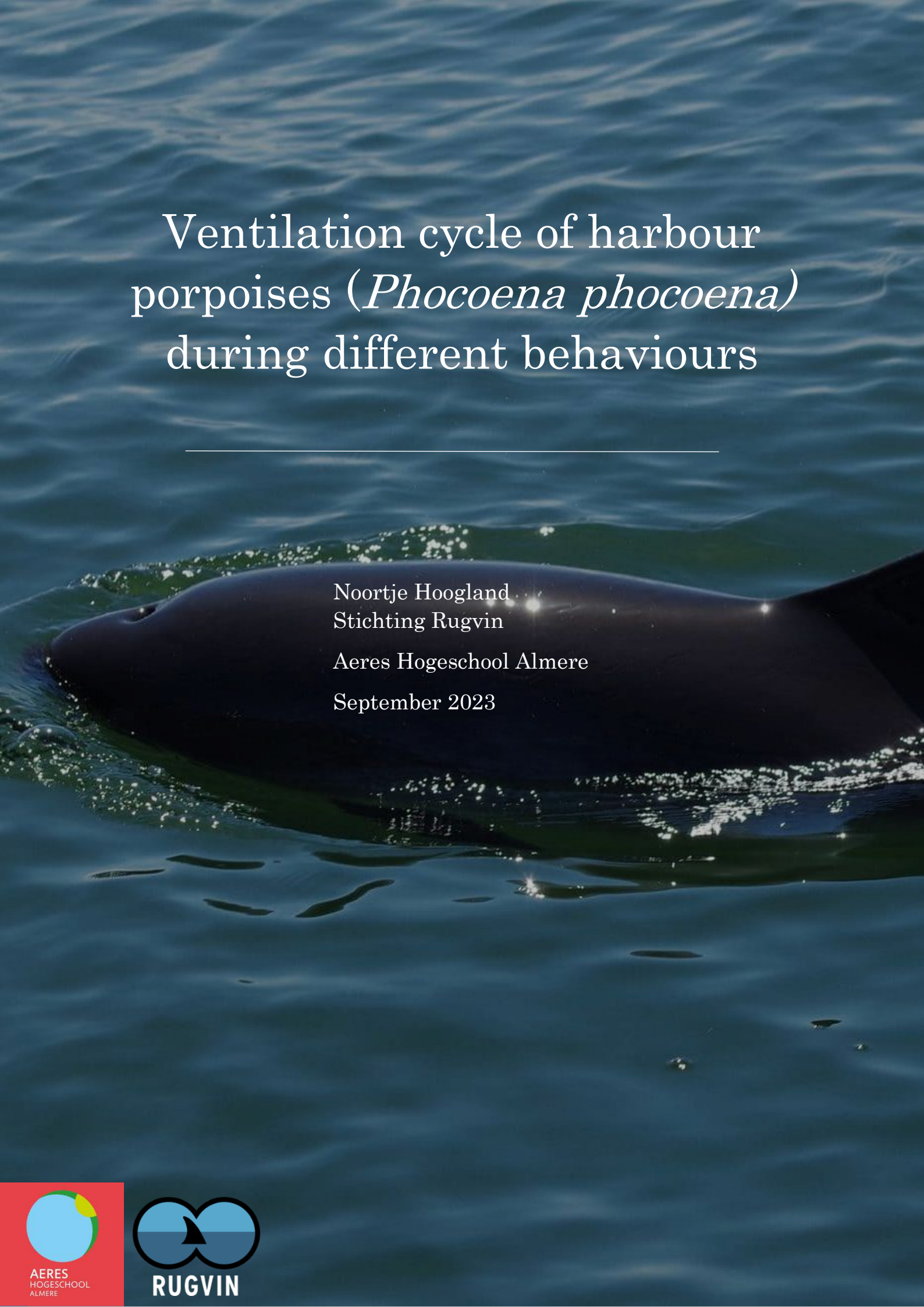

Ventilation cycle of harbour porpoises (*Phocoena phocoena)* during different behaviours

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AERES HOGESCHOOL ALMERE

RUGVIN

Ventilation cycle of harbour porpoises (*Phocoena phocoena*) during different behaviours

A advisory report about how to research the ventilation cycles of harbour porpoises (*Phocoena phocoena*) during traveling, surface hunting, and deep-sea hunting in the Eastern Scheldt.

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Cover photo: Frank Zanderink, Stichting Rugvin

Preface

This advisory rapport has been written as a part of my bachelor internship for the Applied Biology education program at Aeres Hogeschool Almere, and it has been conducted on behalf of the Rugvin Foundation.

In this advisory rapport you will find an introduction about the high metabolic needs of the harbour porpoise and why it is interesting to research their ventilation cycle during different behaviours. You will find a setup of how to conduct this study, as well as some advice.

Unfortunately, this study did not go as planned and there was some trouble on the way. I planned to conduct this study as well, but due to bad weather and trouble with the camera, there was not enough time to collect enough data to give a solid conclusion. But because I did some (field) research and experienced the humps and bumps, I could turn the research into a preliminary research and write a method so the person how will conduct this study can focus on the study itself instead of method.

I would like to thank my supervisors Nynke Osinga and Nicolle van Groningen for their help and support during this project. They were always there to answer my questions and were open to give feedback whenever needed.

Enjoy reading this rapport and if you have any questions, do not be shy to contact me!

Noortje Hoogland
Purmerend, 09-09-2023

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Chapter 1. Introduction

The harbour porpoise (*Phocoena phocoena*) is the smallest cetacean in the North Sea and one of the most commonly seen whale species (Noordzeeloket UK, n.d. & Porpoise.org, n.d.). The harbour porpoise population in the North Sea is estimated to be between 300.000 and 450.000 (Noordzeeloket UK, n.d.). They are found throughout the entire Northern Hemisphere in waters not deeper than 200 meters (North Atlantic Marine Mammal Commission, n.d.). There is also a harbour porpoise population living year-round in the Eastern Scheldt in Zeeland (the Netherlands) (Nationaal Park Oosterschelde, n.d.). The Eastern Scheldt is a tidal bay, semi closed-off from the North Sea by the storm-surge barrier. The Eastern Scheldt is a good place to observe harbour porpoises in the wild, which is often difficult in other places due to its small size and elusive behaviour (Stichting Rugvin, n.d.).

The harbour porpoise has been described as “living life in the fast lane” (Read & Hohn, 1995). In comparison to other odontocetes, they are sexually mature at an earlier age, they reproduce faster, and have a shorter lifespan (Read & Hohn, 1995). Harbour porpoises reach lengths between 1.40 and 1.90 meters and weigh between 50 kg and 70 kg (North Atlantic Marine Mammal Commission, n.d). Because of their small size, harbour porpoises have a higher body surface to body volume ratio in comparison to other odontocetes, which causes them to lose a significant amount of energy through radiation and conduction (Gaskin, 1992). Because of this, and because harbour porpoises live in the cold waters of the Northern Hemisphere and need to maintain an internal temperature, thermoregulation is extremely important for the porpoise (Kastelein et al., 1997; Gaskin, 1992). Yasui & Gaskin (2012) found that annually 814.000 kcal is lost through heat loss. To ensure a high rate of heat production, a high metabolic rate is needed (Splitz et al., 2012). And to support their metabolic requirements, harbour porpoises need to have high feeding rates (Kastelein et al. 2019). Wisniewska et al. (2016) found that a harbour porpoise can hunt up to 550 small fish (3 cm-10 cm) per hour with a 90% capture success rate. A research done by Hoekendijk et al. (2018) contradicted this study. They said that 550 small fish per hour would indicate that a porpoise (that weighed 50 kg) would eat 25% of its bodyweight. Hoekendijk et al. (2018) suggest that the high feeding rate could be caused by the way the experiment of Wisniewska et al. (2016) was conducted. Wisniewska et al. (2018) caught the porpoises in a pound net for 24 hours and observed their feeding behaviour after releasing them. It is possible that the porpoises were compensating for the lost foraging time while being in the pound net (Hoekendijk et al., 2018). Instead, Hoekendijk et al. (2018) suggested that porpoises eat 5% - 10% of their bodyweight in normal conditions, which is in line with an earlier study that estimated an amount of 2,5 kg – 5 kg per day (Santos and Pierce, 2003, Santos et al., 2014).

Porpoises feed primarily on fish that live in the demersal and pelagic habitats (Santos & Pierce, 2003.) The diet of harbour porpoise is closely related to the geographical distribution (Spitz et al., 2012; Santos and Pierce, 2003; Kroon, 2020; Leopold, 2015). In Belgium the preferred prey fish are gobies, sand eels and gadoids whereas in Scotland the preferred prey fish are whiting and herring (Santos & Pierce, 2003; Leopold, 2015). The most eaten prey group in the Eastern Scheldt, are gobies (Schelling et al., 2014). Aside from gobies, porpoises in the Eastern Scheldt also consume schooling fish like herring and whiting (Leopold, 2015). Schelling et al. (2014) noted that they have not observed a trend in their diet, but this is probably because of the fluctuation in prey availability. To hunt the demersal fish species like gobies, porpoises dive down to the seabed (van Beest et al., 2018). Van Beest et al. (2018) found that as some porpoises moved into deeper water, their dives became longer and deeper. Other porpoises in their study covered a much wider bathymetry gradient, targeting both pelagic and demersal fish. Stichting Rugvin (n.d.) observed porpoises displaying surface hunting behaviour. They described this behaviour as followed: the porpoise is seen frequently at the surface,

going in all directions, and it cannot be predicted where to porpoise comes up next. It is likely that this behaviour is shown when the porpoise is hunting pelagic fish like sprat.

Harbour porpoises (and other cetaceans) spend their life mostly underwater and only come up to the surface to ventilate their lungs (Reed et al., 2000). Porpoises have the ability to exchange a high percentage of their lung gas in a very short moment when surfacing (Kastelein et al., 2018). They are also able to distribute the oxygen quickly throughout their body because of their high heart rate and respiratory arrhythmia (Andersen, 1965; Kastelein & Meijler, 1989). Respiration rate reflects the metabolic state and activity levels. When the porpoise has higher activity levels, the respiration rate becomes more frequent. For example, when a harbour porpoise increases their food intake, their metabolism will also increase (Perry, 1949; Kastelein et al., 2018). Their increased metabolism requires oxygen; therefore, their respiration rate will also increase. Another example by Perry (1949) and Kastelein et al. (2018), when the water temperature increases, their respiration rate declines because their thermoregulation requires less energy and as a result, their metabolism declines.

Besides the respiration rate, it is also possible to look at the ventilation cycle. Ventilation is the way air moves in and out of the lungs. Ventilation cycle includes inspiration, expiration and a rest period (Osmosis, 2023). It can be said that the ventilation cycle is almost the same as the diving pattern, because it is likely a porpoise ventilates once when it surfaces. Watson & Gaskin (1983) researched the ventilation cycle of the harbour porpoise in Canada. They concluded that there were two ventilation patterns: pattern A - traveling, characterized by short submerge periods (24.4 s) and pattern B, foraging, characterized by long submerge periods (1.44 m). They employed the following definitions: *Roll interval*: the time between two consecutive breaths during a respiratory sequence. *Surface time*: the total time of one breath take in a sequence. *Dive time*: the time between two respiratory sequence. *Respiration rate per respiratory sequence*: the number of respirations during a respiratory sequence. Silber et al. (1988) adopted the same definitions for their research on the vaquita (*Phocoena sinus*). Silber et al. (1988) looked at the ventilation cycle of two adult and two juveniles. For example, the roll interval for Adult A was 6.4 seconds, surface time was 20.3 seconds, dive time was 83.1 seconds and there were 4 rolls per respiratory sequence.

Watson & Gaskin (1983) found that the respiratory rate per minute with both pattern was similar (2.4 and 2.3), concluding that traveling and foraging have the same energetic demands. Frank Zanderink (personal communication, July 20, 2023) made a personal observation that the respiratory rate differs between the harbour porpoises in the Eastern Scheldt while conducting different behaviours. Therefore, not agreeing with the conclusion of Watson & Gaskin (1983). Watson & Gaskin (1983) also didn't observe the ventilation cycle of the harbour porpoise while surface hunting.

To know if there is a difference in the ventilation cycle between the different behaviours of the harbour porpoise in the Eastern Scheldt and therefore a difference in the metabolic needs, the following research question has been formulated:

"*What is the ventilation cycle of the harbour porpoise (Phocoena phocoena) in the Eastern Scheldt during traveling, deep dive hunting and surface hunting?*"

It is hypothesized that there is a difference in dive time, respiration rate, and roll interval between the different behaviours. The surface time will not make a difference between the different behaviours. And the respiration rate per respiratory sequence will differ per porpoise but not per behaviour.

Chapter 2. Materials and methods

2.1. Study area

This study will be conducted in the Eastern Scheldt. The Eastern Scheldt is a semi enclosed estuary in Zeeland and is with its 350 km^2 the largest national park of the Netherlands and also part of the Natura2000 network (Nationaal Park Oosterschelde, 2017). The storm surge barriers, that separate the Eastern Scheldt from the North Sea, are almost always open. They will only close when there is a threat of flooding (Rijkswaterstaat, n.d.). The Eastern Scheldt consist of dikes, estuary, and swamps. Because of the salt and freshwater fluxes, tides and currents, the area is versatile and has many ecotypes (Nationaal Park Oosterschelde, 2017). The waters of the Eastern Scheldt are, besides the harbour porpoises, home to the grey seal *(Halichoerus grypus*) and the harbour seal (*Phoca vitulina*). The area is also an important foraging and breeding site for migratory bird species such as the red shank (*Tringa tetanus*) and Kentish plover (*Charadrius alexandrines*) (Nationaal Park Oosterschelde, n.d.).

Figure 1

Map of the Eastern Scheldt with the three locations. The two locations at the top have similar parameters and are both good places to observe surface hunting.

Note. Reprinted from Google Maps

To increase the chances of observing the different behaviours, it is recommended to observe at two locations from ashore (see Figure 1). The observation of the ventilation cycle while deep-sea hunting, can be observed at the Havenhoofd Zierikzee. This place is known to be a hotspot. This is because the water is about 53 meters deep, which makes it one of the deepest points in the Eastern Scheldt. Because of this deep pit, a lot of prey fish occur here, and therefore attract harbour porpoises. Goby, black goby, herring, sprat, and whiting are fish species that occur here (Neitzel & Niemeijer, 2020). Therefore, it is the best place to observe deep-sea hunting behaviour. This can be confirmed with the preliminary research that has been conducted.

The observation of the ventilation cycle while surface hunting, can be observed at Plompe Toren or Burghsluis, depending on your personal preference. The water depth of Plompe Toren and Burghsluis is about 13 – 30 meters. The fish species that occur here are goby, black goby, herring, sprat, and whiting (Neitzel & Niemeijer, 2020). These locations were not included in the preliminary research, but Rugvin Foundation have had multiple encounters with the porpoises here. Because of the shallow waters and the fish species that occur here, it is likely that surface hunting can be observed at these locations.

Observations of the ventilation cycle while traveling can be taken at place both places.

2.2. Data collection

2.2.1. Field observation

Weather is an important factor in the field observations. The only part of a porpoise that is visible when surfacing is their small dorsal fin, that is why the presence of high waves pose a challenge in observing these elusive animals. The observations are done when the wind is under Beaufort 3 and the waves are a maximum of 30 centimetres. If the waves are higher, it is also harder to discern them on the video. It is recommended to observe with two people, so the chances were higher of spotting the porpoise. To help spot the animals, binocular can be used. An 8-42 Bushnell binoculars was used during the preliminary research. Because the ventilation cycles can go very quickly and some movements last only a few deciseconds, a video camera is used. Start filming the moment the porpoise surfaces for the first time. To record the diving time, keep on filming until the porpoise is gone longer than 15 minutes. For observation close to shore (maximum of 40 meters) a wide-angle lens can be used to capture all movements. If the porpoise is further away, it is recommended to use a tele lens. During the preliminary research, it was observed that when a porpoise was further away than 40 meters and captured using a wide-angled lens, it becomes challenging to discern them in the video during the playback. A tripod is also highly recommended because of the long filming sessions and to prevent shaking of the video.

During the preliminary research it was also observed that it can take a long time for the porpoises to been seen from shore. And when they were observed, they would be sometimes too far away to film them. It is also not possible to follow them. In other research like the research from Silber et al. (1988), the researchers would follow the animals with a boat. This can also be done in the Eastern Scheldt. This way you can come closer to the animals and search for them. When considering this, keep in mind that the boat may potentially disturb the animals, potentially leading to different results.

While filming, the sound is also recorded. By means of voice-recording, information can be provided about when the porpoise surfaces, its approximate location, and the distance from the shore. If there is a long gap between two sightings, the approximate time the porpoise surfaced is noted on paper, so you know the approximate timing the porpoise surfaced when playing back the video.

2.2.2. Parameters of the ventilation cycle

To answer the research question, this study adopts the parameters used by Watson and Gaskin (1983) who researched the ventilation cycle of the harbour porpoise in Canada and Silber et al. (1988) who researched the ventilation cycle of the vaquita (*Phocoena sinus*).

1) Roll interval: the time between two consecutive breaths during a respiratory sequence.
2) Surface time: the total time of one breath take in a sequence.
3) Dive time: the time between two respiratory sequence.
4) Respiration rate per respiratory sequence: the number of respirations during a respiratory sequence.
5) Respiration rate per five minutes: the number of breaths taken in five minute.

2.2.3. Observation of the behaviours

To know what the ventilation cycle is during the different behaviours, it's important to recognise the behaviours and to know the difference between them.

Traveling: The harbour porpoise moves in a directional line. After a few sightings, you can guess where the animal will come up next. The porpoise has surfaces regularly. It's likely that the animal

will disappear after a few seconds. A study done by Watson and Gaskin (2011) showed that the average submerge period of travelling, was 24 seconds.

Surface hunting: The harbour porpoise is seen frequently at the surface and going in all directions through the water. It looks like it's going after prey at the surface. The animal does not swim in a straight line. It's hard to predict where the porpoise will come up next. It is common that there are a lot of seabirds around the place the porpoise is hunting.

Deep dive hunting: At first the porpoise takes a few short breaths before going for the dive. The moment the porpoise dives, the back and the tail of the animal will bend significantly (for reference, see Figure 2 and 3). The animal will stay under water for a longer period and will come up at almost the same spot. Keeping in mind that the current can influence the position of the porpoise, causing it to be pulled away a few meters from the last surfacing spot (F. Zanderink, personal communication, July 20, 2023). The study done by Watson and Gaskin (2011) showed that this type of foraging is characterized by the short ventilation periods between the submerge periods. The average of the submergence periods was 1.44 minutes. Seabirds around the hunting spot are a common sight.

Figure 2

An example of a regular respiration movement

Note. Zanderink, F. Copyright 2022 by Stichting Rugvin.

Figure 3

An example of a diving motion

Note. Zanderink, F. Copyright 2022 by Stichting Rugvin

2.3. Data processing

The videos are then transferred onto the computer and viewed in the program VLC media-player. To view the deciseconds, Time v3.2 is used. The video is then put into slow-motion. This way, the movement could be observed at the exact decisecond.

2.4. Data analysis

The data is collected in a datasheet in Excel (see Appendix 1). The start of each movement is written down in deciseconds. The time the porpoise first surfaced for the first respiratory sequence, is counted as second 0. Then the time is noted when the porpoise is fully immersed. This continues throughout the entire respiratory sequence. When the animal is deep-dive hunting, the decisecond the animal is fully immersed after a dive-motion, is noted as the start of the dive. The ventilation cycle is complete when the animal surfaces for the next respiratory sequence.

The main respiratory rate is tracked with every respiratory sequence. As well as the respiratory rate per five minutes.

After all the data is collected in the Excel sheet, it is time to write down the main parameters of each behaviour. What is the main roll interval or surface time during traveling or surface hunting? To get a

clear overview, it is possible to put all the information in a table. Table 1 is an example on how that can look like.

Table 1

Example of a table displaying the finalized parameters. In the columns under Deep dive hunting are the collected data from the preliminary research. N = 2 and recording time 22 minutes. Respiration rate per five minutes could not be filled in because of an error while filming.

	Traveling	*Surface hunting*	*Deep dive hunting*
Roll interval (in sec)	X	X	4,5
Surface time (in sec)	X	X	1,3
Dive time (in sec)	X	X	124,8
Respiration rate per sequence	X	X	3
Respiration rate per five minutes	X	X	X

After that, compare the parameters and see if there are differences in the parameters of each behaviour.

Conclusion and future research

This advisory report is based on a preliminary research. In this report you have read about how to conduct a study about the ventilation cycle of harbour porpoises during different behaviours. This report discussed tips and information to give a good head start for the person who will implement this research in practice. The report is based on former research, but also my personal experience and findings. If in any case, you find that some things do not work for you, do not be shy to change the methodology. After all, there are more ways to bake a cake.

Studying the ventilation cycle of harbour porpoises can be a valuable tool to gain insight into the effect of human presence on harbour porpoises. Porpoises in the Eastern Scheldt live in an estuary in which a lot of boat traffic takes place, both for professional and recreational purposes. When disturbed porpoises may alter their behaviour e.g., deep dives or swimming away at fast speed, such changes in behaviour can be studied when monitoring the ventilation cycle as described in this report and comparing non-disturbed situations versus disturbed situations.

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Appendix

Appendix 1. Datasheet

Observation number:							
Number video:							
Date:			**Environmental conditions during observation**				
Name observer:			Type of weather:				
Location:			Temprature:				
Start time:			Water temprature:				
End time:			Beaufort:				
			Wave height:				
			Water tide:				
Behavioural observations							
Type of behavior:	Relocating / Surface hunting / Deep dive hunting						
<u>Time:</u>	<u>Event:</u>	Total duration of event (in s)		Total surfacing:			
				Mean diving time:			
				Mean roll interval:			
				Mean surface time:			

Appendix 2. Extra information about the environmental conditions

Extra information	
Type of weather:	Sunny / Cloudy / Partly cloudly / Rain / Fog
Beaufort:	0 (0-1 kts) / 1 (1-3 kts) / 2 (4-6 kts) / 3 (7-10 kts) /4 (11-16 kts) / 5 (17-21 kts)
Water tide:	Low / Rising / High / Falling