

Status for havpattedyrturismen i Danmark

November 2022

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By Christian Riisager-Simonsen and David Lusseau

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Preface

This report presents the results of a mapping of marine mammal focused tourism activities to provide a “Status of marine mammal tourism in Denmark” carried out by DTU Aqua. The project is commissioned research financed by the Danish Environmental Protection Agency, which is a part of the Ministry of Environment.

The motivation for this report originates from the recent update in management plans for harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*) from 2020, in which a new national management objective was added, i.e. to ensure a sustainable development in seal focused tourism (Forvaltningsplan for Sæler 2020, 2020). To achieve this, management plans are expected to be focused on relevant scientific knowledge and continuously implement research results. To support this effort, the present report provides an updated status of the present level and character of marine mammal tourism and public attention to marine mammals in general, covering both cetaceans and pinnipeds to support the agency’s work including the group tasked to draft code of conducts for commercial marine mammal tourism operators, and general advice for the public.

Kgs. Lyngby, November 2022

Christian Riisager-Simonsen & David Lusseau
DTU Aqua

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Summary

This report presents the results of a mapping of marine mammal focused tourism activities to provide a “Status of marine mammal tourism in Denmark” commissioned by the Danish Environmental Protection Agency, to provide updated status of the present level and character of marine mammal tourism and public attention to marine mammals in general, covering both cetaceans and pinnipeds to support the agency’s work including the group tasked to draft code of conducts for commercial marine mammal tourism operators, and general advice for the public. Compared to the mapping of commercial marine mammal tourism activities in 2015, it appears that the sector over the past six years has grown in terms of number of operators, geographical distribution, diversity of focal species, number of sold tickets and revenue generated. Using data from social media including search patterns, it was additionally shown that such footprints indeed could be used to track when people seek out information in terms of specific species, just as certain platforms with georeferenced data allowed likely observation sites by the wider public to be identified.

While the effectiveness of recently launched voluntary guidelines for the sector is unknown, the use of social media data to map people’s engagement with marine mammals in Denmark offer a cue to options for using social media platforms proactively to educate the wider public about how they or commercial operators could reduce their potential negative impacts at locations. Monitoring of the development in the sector and its impacts, will likely be relevant to ensure the adaptive management of the species are successful in meeting conservation goals of the focal populations which are exploited.

1. Introduction

1.1 Commercial exploitation of wild marine mammals in Denmark

Marine wildlife tourism can be considered subcategory or nature-based tourism, and occur as a commercial activity in coastal areas throughout the world, often with cetacean (O'Connor et al., 2009) or pinnipeds (Kirkwood et al., 2003) as the focal species. In some areas the economic contributions from such activities to the local 'blue' economy can be substantial, particularly where tourism activities have included so called "swim-with" encounters (Wiener et al., 2020). However, while tourism-based exploitation of marine mammals may seem more benign than historical types of catch-based exploitation, negative impacts on the focal animals have been identified for multiple marine mammal species, which could jeopardize the long-term conservation targets of the populations in question (Senigaglia et al., 2016).

The motivation to develop regulatory measures to ensure the long-term sustainability of the tourism-activities goes beyond concerns for the conservation status and welfare of the exploited animals, as the operators themselves depend on the continued availability of their focal animals yet is faced with a potential 'tragedy of the commons' situation, as marine wildlife is a common pool resource (Moore & Rodger, 2010). To highlight the implications in a management context, it has therefore been suggested to characterize commercial marine mammal watching or similar wildlife-tourism activities as an example of non-lethal consumptive exploitation (Higham et al., 2016). In response international governance bodies such as the International Whaling Commission (IWC), formerly focusing on whaling now additionally put emphasis on the demand for regulating marine mammal tourism, have supported development e.g. of whale watching guidelines (<https://wwhandbook.iwc.int/en/responsible-management/guidelines-and-regulations>), and continues to map and communicate international efforts within this area (<https://wwhandbook.iwc.int/en/responsible-management/case-studies>) to support progress.

In Denmark, the first national mapping of marine mammal-focused tourism was carried out in 2016-2017 (Riisager-Pedersen, 2017). In this questionnaire-based study it was possible to engage all identified commercial Danish marine mammal tourism operators, allowing relatively precise data to be extracted about the status of the Danish marine mammal watching sector, based on their 2015 activities. In summary 17 operators were found to focus tours on seal watching activities, 4 operators on porpoises and one operator who used both porpoises and seals as focal animals of the tours. The focal species included all three common Danish marine mammal species in Inner waters: harbour seals (*Phoca vitulina*), grey seals (*Halichoerus grypus*) and harbour porpoises (*phocoena phocoena*).

The total ticket revenue (in 2015 prices) exceeded DKK 6,7 million, based on 28,890 sold tickets for seal watching related tours and 12,581 tickets for tours related to harbour porpoises. Geographically seal watching tours took place throughout the country with the highest concentration of operators in the Wadden Sea while Bornholm in contrast had no operators, despite its proximity to a well-known grey seal haul out site. In terms of the locations 16 out of 17 operators focused on seal haul out sites in Natura 2000 areas.

1.2 Sampling social media footprint to understand where and when people engage with marine mammal viewing

People can use marine mammal recreationally without the services of tour operators. These interactions contribute to the cumulative exposure of marine mammals to tourism and recreation and the behavioral and physiological disturbances they can cause. They also need not take place in the vicinity of tourism centers and therefore may be unnoticed. It is therefore useful to gain an insight of the overall patterns of marine mammal recreation and tourism use by sampling the

broader population of marine mammal users (Bejder et al., 2022). A large proportion of the population, indeed the human species, spend now a significant amount of time online (Edelmann et al., 2020; Lazer et al., 2009). People visit websites, and particularly social media platforms and search engines, to engage across a range of social, economic, educational, and entertainment interactions with other users and companies. The advent of social media platforms has offered a public space where people can report to friends, acquaintances, and strangers their daily activities through text, images, and videos (Steinert-Threlkeld, 2018). These public posts have proven a useful source of data and information about the way people use nature, revolutionizing our ability to estimate the exploitation (Erskine et al., 2021; Fox et al., 2021; Mancini et al., 2019) of 'cultural ecosystem services' (CES) which include e.g. direct, and indirect interactions with nature for recreational purposes (Haines-Young & Potschin, 2018).

We now can use social media sampling to understand where and when people engage with nature (Fox et al., 2022; Mancini et al., 2019), what features of nature they are seeking (Erskine et al., 2021; Ros-Candeira et al., 2020), and the wellbeing benefits they are receiving (Lusseau and Baillie, 2022; Plunz et al., 2019; Wartmann & Mackaness, 2020).

Yet, most of the studies to date have had an international focus, aiming to understand CES macroecology, or have taken place in countries where social media for which structured and reproducible access via an application programming interface is available for academic research has a high market penetration rate. Here we aim to integrate insights across platforms to assess the feasibility to engage in social media sampling to make inferences about where and when people engage with marine mammals in Denmark as well as qualify the value of these interactions.

1.3 Updating knowledge to enable adaptive management of marine mammals in Denmark

Based on the 2017 mapping, the latest revision of the seal management plans in Denmark, included a target of addressing the need for sustainable management of the seal watching activities, to ensure the sector's long term sustainability (Forvaltningsplan for Sæler, 2020). This constituted a shift in focus from previous management plans, which had revolved particularly around the need to minimizing the negative impacts of seals on fisheries, through depredation (i.e. ecosystem disservices), towards management plans which now also address the conservation of direct socio-economic benefits related to cultural CES from the Danish seal populations. The extended coverage of both ecosystem services and disservices provided by Danish seal populations in the present management plans, can therefore been seen as a step towards a more adaptive ecosystem-based management, which is aiming to address management of a wider stakeholder landscape than previous (Riisager-Simonsen et al., 2020). To support the work of the Danish Environmental Agency in it's work including the development of future code of conducts this commissioned report aims to provide an updated status of the Danish marine mammal watching activities both in terms of commercial activities and a deeper understanding of where and when the wider public engage with marine mammals in Denmark.

This includes a:

1. Geographic mapping of where and how commercial marine mammal tourism was carried out in Denmark in 2021
2. Economic mapping of the number of sold tickets and revenue generated by commercial operators in 2021
3. Mapping of the commercial operator's own perspectives on potential future code of conducts
4. Mapping of feasibility to use social media data to understand where and when people engage with marine mammals in Denmark

2. Method

Two overall approaches were applied in the mapping of tourism activities. One survey-based approach targeting commercial operators, and one using social-media data to map the wider public's behaviour.

2.1 Mapping of commercial activities

Mapping of commercial operator activities was performed using a questionnaire-based approach inspired by e.g. DiGiovanni & Sabrosky (2010), and based on the experiences from the mapping of the same stakeholder group in 2016-2017 (Riisager-Pedersen, 2017).

The study area and inclusion criteria for operators were similar to the mapping in 2017 and included any person, company or institution that sells tours advertised as including the chance to encounter marine mammals in nature, with departure of tours from a Danish location.

As a study area this meant that an operator which e.g. had a Danish harbour as tour departure location would be included as it would be considered a "Danish operator", even if they sailed into German waters in the Wadden Sea to get close to a seal haul out site.

The mapping was performed in four steps:

2.1.1 Survey development

A questionnaire (annex A) was developed based on the template from the 2016-17 mapping, allowing comparisons with data from 2015, while also exploring new questions related particularly to the operators' perspectives on potential future guidelines. Additional input to survey questions was requested from Aarhus University's Section for Marine Mammal Research to support potential future synergies with parallel projects related to tourism impacts and overall development in seal abundance also funded by the Environmental Protection Agency. Similarly, the questions aimed to cover aspects taken up by the Environmental Protection Agency's working group on marine mammal tourism code of conducts who worked in parallel.

Given the sensitive nature of sharing data related to income generated by ticket sales, no. of sold tickets etc. operators were guaranteed that data would be summarised and reported to the agency on a national level, so that no single operator could be identified. Similar clauses apply to any further publications or presentations related to the mapping.¹

2.1.2 Identification of commercial operators

An initial online identification of commercial operators was performed using web-based Google searches. Key words included: 'sælture', 'sæl ture', 'sælsafari', 'sæl safari', 'svøm med sæl', 'sælturisme', 'hvalsafari', 'marsvinsafari', 'delfinsafari', 'svøm med delfiner'. If operators identified in the 2016-17 mapping were not identified, additional Google searches were performed using company names to verify if the company had stopped their activities.

2.1.3 Distribution of questionnaires

Identified operators were contacted by telephone in May and June 2022. Each operator was provided with a brief introduction to the project and asked if they would be willing to answer the questionnaire. Upon acceptance, an email was sent containing additional background information as well as the questionnaire. The level of background information given by telephone corresponded to the information in the email forwarded after the conversation (annex B).

¹ To support future studies on the development of the sector additional questions related to e.g., the history of the companies and availability and capacity to share historic data were included but remains outside the scope of this report and will not be covered.

Depending on the response, phone calls and emails were used twice, in July/August and November 2022 to increase the response rate.

Compared to the approach used in the 2016-17, this mapping relied on the operator's willingness to allocate time to answer the questionnaires in a Microsoft Word document and email it back, while the approach in 2016-17 allowed operators to answer the questions over the phone.

2.1.4 Data compilation and analysis

Upon receiving questionnaire answers, each answer was quality checked, and operators contacted if answers or representation of data were not easily understood. To enhance the coverage of the mapping, basic information related to observation locations and focal species was extracted from websites in cases where operators did not answer the questionnaire.

Where answer categories were provided, but not used by the respondents, answers were categorised as 'no answer' where this category existed.

If respondents reported intervals, e.g., 3-5 tours per week, an average of the interval was used to calculate the total number of tours. However, in cases where operators reported e.g. distances to animals the lowest number was used. For answers related to average time spent with the animals, the highest reported number was used for each operator to illustrate the diversity of operator approaches to this question.

In open ended questions, answers were compiled as a list on anonymous quotes, and where possible categorised in terms of their focus.

For all answers a response rate was calculated, based on the number of answered divided by the total number of identified operators.

2.2 Mapping social media footprints of people engaging with marine mammals

Flickr and Twitter, two platforms regularly used for social media CES sampling, are not used pervasively in Denmark. Globally, Flickr is particularly often used because through its unrestricted application programming interfaces are possible to sample visitation patterns by counting how many photos are posted by how many users for any given locations. That is because photos posted on this avid photographer social media site are to be georeferenced before uploading. While georeferencing is sparser on Twitter, the daily volume of posts available through the application programming interface, including its archive through the academic track access, offers the opportunity to understand temporal patterns in discussions about particular CES features or activities. Benchmarking studies show that Flickr can be used to understand spatial patterns in visitation up to a scale of 5km², while twitter, for popular destinations or CES features, can provide a daily resolution for temporal patterns (Mancini et al., 2018; Muñoz et al., 2020; Plunz et al., 2019; Steinert-Threlkeld, 2018). With significantly fewer postings in Denmark on these platforms, we need to assess whether other online sites may be useful to assess marine mammal use for tourism and recreation.

One advantage in Scandinavian countries is that the language used to interact online is geographically well-defined. People visiting sites that are specifically in Danish are virtually all located in Denmark; the same goes for Sweden and Norway for example. It is therefore possible to make use of other platforms to assess when marine mammals are generating more interest online in these countries in these respective countries (Ronen et al., 2014).

We therefore developed a new approach, using multiple online sites, to generate insights about the use of marine mammals in Denmark for tourism and recreation from the online footprint of these interactions (Figure 1). In this approach we aim to sample the online footprint of people seeking encounters with marine mammals in Denmark. Throughout this process we sampled online data about harbour porpoises, grey seals, harbour seals, minke whales, killer whales and bottlenose dolphins.

2.2.1 Temporal patterns

We first sampled Google Trends (<https://trends.google.com>) to assess when people searched for these species in Denmark over the past seven years (2016-2022) (Phillips et al., 2022), a period

over which Google trends reports were algorithmically stable. Over this period, the reporting unit is a week and the measure is a search intensity measure, scaled so that the week that received the most searches took a value of 100 and the search intensity values range from zero to one hundred. We then sampled how often the Danish Wikipedia page for each species was visited each week. In our hypothesized “CES journey” (Figure 1), people would be more likely to visit these Wikipedia pages after the encounters with these species in order to find out more about them. We would therefore anticipate that if any intra- and inter- annual temporal patterns were detected over the past seven years in Google Trends, then the same patterns would emerge in Wikipedia visits, but exhibiting a short lag capturing the temporal directionality of user’s online access to CES knowledge (in our case marine mammal species). To further challenge this hypothesis, we replicated this sampling for neighbouring countries with varied opportunities to access marine mammals nearshore (Hammond et al., 2021).

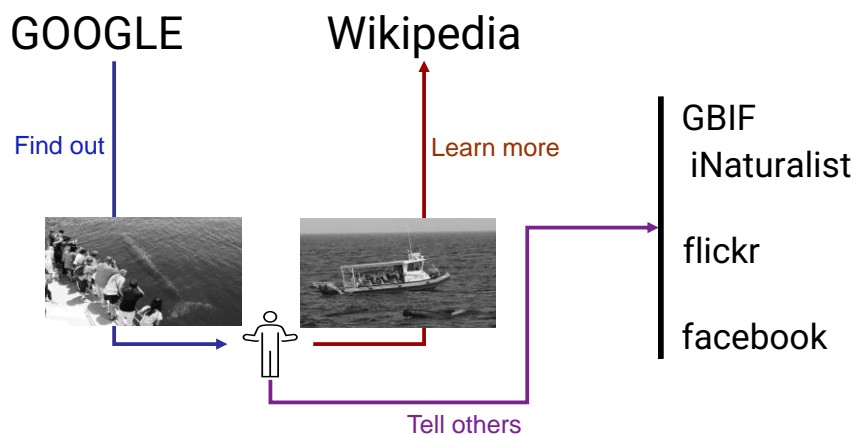


Figure 1. Conceptual figure outlining the source of information used in this study and how they relate to the “CES journey”: the processes people use online as they seek cultural ecosystem services and experience them. In this CES journey, tourists seek information on search engines and may seek educational material to further make sense of their experience. They also become source of information for others by posting about their interactions on social media which may have specialized audiences (e.g., iNaturalist) or more generalist audiences (e.g., twitter, facebook).

2.2.2 Analytical approach

As we deal with multiyear non-stationary time series which can be influenced by multiple complex behavioural processes at varied timespans, we used wavelet analysis to decompose the time series and estimate which observable patterns are likely to be significantly different from patterns that could emerge by chance (Mancini et al., 2018). We particularly focus on intra-annual patterns, therefore limit the periods explored to a maximum of a year (365 days when the unit of time series is a day and 52 weeks when the unit is a week). We estimated Morlet wavelets using WaveletComp in the programming software R (R Core Team, 2022) to simulate random times series comparable to the ones studied and estimate the patterns (wavelets) likely to occur more often than expected by chance in the observed time series (Roesch and Schmidbauer, 2014).

When significant seasonal components were detected, we further explored their patterns by decomposing the times series into its trends, season and random components. The trend is first estimated using a moving average. The time series is then detrended and the seasonal component is estimated by averaging, for each day or week depending on the time series unit, over all possible periods. The random component is then estimated by removing the trend and season components from the time series. This was estimated using decompose in R.

Finally, as our proposition assumes that Google searches and Wikipedia visits will be temporally associated, we estimated the cross-wavelet power for the two time series (Mancini et al., 2018). This assesses whether significant patterns in the time series power spectra are associated. In other words, when we observed a significant temporal pattern in one time series, it is also observed in the other. This approach also estimates potential lags between the two time series, hence whether patterns are associated but occurring in one time series before the other. The advantage of this wavelet approach is the ability to provide a disaggregated picture across the

time span of the times series and over all possible estimated periods (in our case within a year) of this potential coherence.

2.2.3 Spatial patterns

Specialised and generalist social media

All cetacean (GBIF.Org User, 2022a) and pinniped (GBIF.Org User, 2022b) records in Denmark, made by human observation held on GBIF, to which all major Danish naturalist databases report, were downloaded. We further censored records to cases where location of the sighting was known with less than 10km of uncertainty and restricted the years of observations for cetaceans to match our study period (2016-2022) and for pinnipeds to years when the currently used haul out sites were occupied (2010-2022). This resulted in 4055 cetacean and 543 pinniped sightings. We sampled the Flickr application programming interface using photosearcher in R (Fox et al., 2019) for cetacean and pinniped photos taken in a rectangular area bounded by coordinates (7.3170 E, 54.4445 N) and (15.31 E, 57.8915 N) from 1 Jan 2010 to 31 Oct 2022. We looked for keywords 'porpoise', 'marsvin', 'dolphin', 'delfin', 'seal', 'sæl', and 'hval' in the text describing the photos. We retrieved 350 seal, 210 dolphin, 20 porpoise, and 11 whale photos following quality control procedures to ensure that photos were relevant to the searches. As expected, this was a much lower volume than in other studies focused on countries which are more photographed by Flickr users living or visiting those countries.

Analytical approach

We estimated kernel density maps for each platform and for each taxa. For pinnipeds, we estimated the Euclidean distance between sightings and haul-out sites to assess whether pinnipeds were more frequently reported sighted at haul-out sites or encountered in other locations.

2.2.4 Other platforms

As with most other countries, Facebook has a high market penetration rate in Denmark as 72% of the eligible Danish population (>13 years old) are Facebook users and 80% of those use the platform daily (95% weekly) ("Social Media Stats Denmark," n.d.). Indeed, there are several marine mammal dedicated facebook groups to discuss sightings and best locations to see various species (e.g. <https://www.facebook.com/groups/hvaler.dk>) which are therefore likely playing a role in shaping visitation volume at key marine mammal viewing sites. However, it is not possible to sample posts of Facebook Groups without violating the rights of users. So, information and observations posted to these groups are not available.

3. Results

3.1 Commercial activities 2021

In total 28 operators were identified, of which all accepted to answer the questionnaire, except for one whom never answered either telephone calls or emails. However, through a third party, confirmation was provided that the operator indeed had sold tours in 2021, as the third party had co-organized the activity.

While acceptance to answer questionnaires in principle was 100% based on telephone conversations only 15 out of 28 operators filled out the questionnaire, providing a total response rate of 53,6%. Additionally, not all operators answered all questions, and thus response rates are reported for each question and related data. Among the respondents three were focused on cetaceans and 10 on seals, and two with both seals and cetaceans, which roughly corresponds to the relative numbers of operators. Thus data were not expected to be skewed towards either type of tourism operators.

3.1.1 Geographic distribution of commercial marine mammal tourism activities in 2021 and focal species

In 2021 operators with seals as primary focal animals were present throughout Denmark, though with a particularly high concentration in the Wadden Sea, generally centred around known haul out sites (Figure 1). In terms of focal species, seals are the main attraction within the sector, based on both the species reported in the questionnaires (response rate 53,6%) (Figure 2), and when supplemented with data from operator's websites, for those operators who did not respond to the questionnaire.

In terms of harbour porpoise focused tours, most operators were located around Little Belt. In comparison seal focused tours were primarily found in the Wadden Sea though operators focused on these species were also present in most other parts of the country though at a lower density. Finally, common bottlenose dolphins (*Tursiops truncatus*) are now being targeted at two separate locations, which three operators having dedicated tours focusing on this species.

Based on the initial telephone conversations with operators to establish if they were active in 2021, it was possible to identify that three operators in addition to those active in 2021 had initiated tours in 2022, bringing the total number of operators in 2022 up to 31².

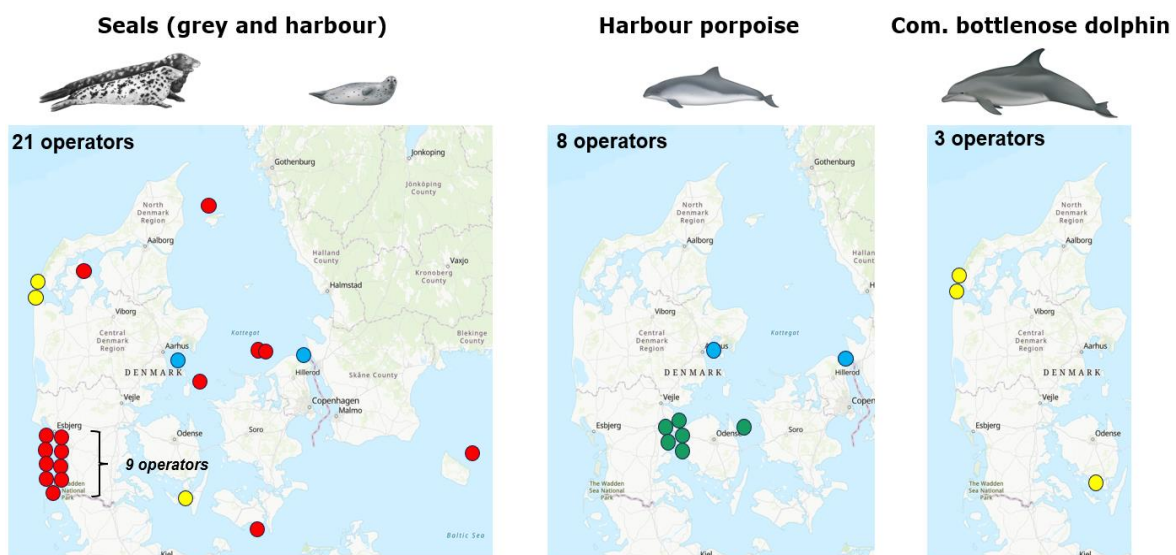


Figure 1: Maps illustrating the distribution of locations in 2021, where commercial marine mammal tourism was conducted. Each dot represents one operator. Red dots represent operators targeting primarily seals, blue dots operators targeting both seals and harbour porpoises, yellow dots operators targeting both seals and common bottlenose dolphins, and green dots operators targeting primarily harbour porpoises. Maps were produced based on questionnaire answers supplemented with publicly available information on websites about focal species, in cases where questionnaires were not answered by operators. In the telephone conversations all operators confirmed they were active in 2021 and their focal species. (Marine mammal illustrations by U. Gorter).

² The three operators included a) one focusing on harbour porpoises in Little Belt, b) one focusing on seals in Øresund, and c) one focusing on swimming with seals near Bornholm.

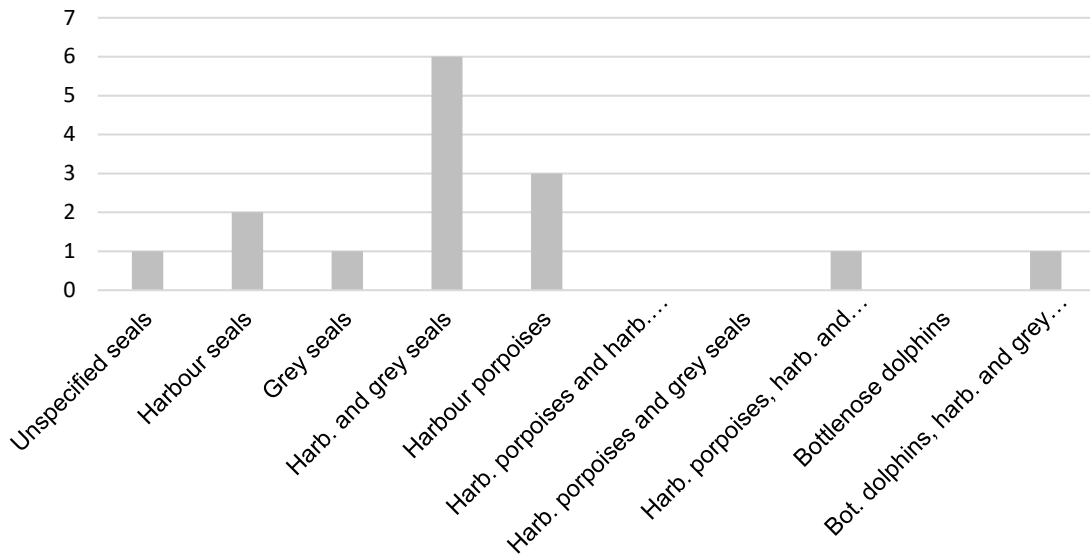


Figure 2: Primary observed species reported by operators in questionnaire.

As a note, several operators focused on harbour porpoises mentioned that occasional observations of harbour seals were common, though not the primary focus of the tours.

3.1.2 Number of sold tickets and revenue

Among the provided answers in the questionnaire those related to the number of sold tickets (1a) and revenue (table 1b) had the lowest response rate, as two operators omitted answers. In terms of the reported data a few operators were unable to estimate revenue from 'private tours' outside their normal tour programs and did not report data for this subcategory of their income. Overall the total national revenue (table 1b) should thus be considered a minimum estimate.

The average ticket price was estimated to be 293,2 DKK (median 198,6 DKK). The difference between the mean and median number of tickets and ticket price shows that those distributions are developing a long-tail. That is, the industry is developing diversity in business models.

Table 1: Summary of operator's ticket sales and revenue

A) Ticket sale		B) Revenue from ticket sale	
No. of operator answers	13	No. of operator answers	13
Response rate	46,4%	Response rate	46,4%
No. of sold tickets among the 13 respondents	38.451	Total revenue of the 13 respondents	11.375.313 (DKK)
Average no. of sold tickets per operator	2.957,8	Average revenue per. operator	875.024,1 (DKK)
Median no. of sold tickets per operator median	787	Median revenue per operator	160.000,0 (DKK)

Table 1: Summary of results for the questions a) "How many tickets did you sell in total in season 2021" and b) "How much money in total did you earn on ticket sales in 2021 (If you are uncertain about specific numbers then provide your best estimate)".

In terms of the financial sustainability of the operator's activities, operators were asked to report the presence of financial substitutes and potential surplus from tours (table 2).

	Response rate	Yes	No
Financial support	39,3% (11)	3	8
Operating surplus	46,4% (13)	10	3

Table 2: Financial support to and surplus of tours. Column one represents the compiled answers for the question “Do the tours provide an operating surplus in itself or do you receive some type of financial support, and if yes from where”.

Regarding financial support most operators reported none, though a few added comments that it had been the case in the past. Among those who reported they had received financial support two out of three were public institutions. The listed types of funding schemes included EU nationally implemented program FLAG (local actions groups in the fisheries area), and direct support to museums as a part of their core funding from the Ministry of Culture. One operator did not report the source of the financial support.

In comparison 10 out of 13 operators reported that tours provided an operating surplus. Among the three who do did not have an operating surplus for these activities, their company age spanned both new (less than 5 years) and older companies (+ 10 years)³. Thus no clear pattern was observed.

3.1.3 Operator’s experience of recent developments in their sector and their expectations for the future

In general, most operators reported that demand for marine mammal focused tours had increased over the past five years and expected increasing ticket sales in 2022, with a stabilizing or positive trend in the coming years both in terms of number of sold tickets and demand for tours (table 2).

Table 2: Recent development and expectations in terms of future demand

	1) Development in demand over the past five years	2) Short term expectations sales in 2022	3) Long term expected sales	4) Expected demand for tours/trips
Increasing	10	7	8	6
No Change	0	3	5	6
Changing	2	1	0	0
Decreasing	0	1	0	1
<i>Response rate</i>	42,9%	42,9%	46,4%	46,4%

Table 2: Recent development and expectations in terms of future demand. Column one represents the compiled answers for the question “How did you experience the development in demand for such tours over the past five years”. Column two represents the compiled answers for the question “What are your expectations in terms of the number of sold tickets in 2022 compared to the last three years”. Column three represents the compiled answers for the question “What are your general expectations for the future in terms of number of tourists”. Column four represents the compiled answers for the question “What are your general expectations for the future in terms of number of tours”

3.1.4 Characterisation of tourism activities

For all 15 respondents the observation of marine mammals was the main attraction on the tours. Tours were mainly offered from May to October, with a few operators working during the winter (figure 3). While the summer period had the highest number of active operators, it is noteworthy

³ Data are not reported directly due to the nature of these sensitive data and the agreement with respondents on not to share data which could be linked to specific companies.

that one operator noted they stopped tours in June and July to avoid potential disturbance of newborn harbour seals.

In total the 15 operators (response rate 53,6%) visited their primary observation sites 6.563 times, with an average of 468,8 visits per operator (median 106,5 visits), a minimum of 8 and maximum of 1425.

The average number of tourists per trip ranged from about 3 to 47, with operators carrying more trips out tending to take small groups of tourists on average.⁴

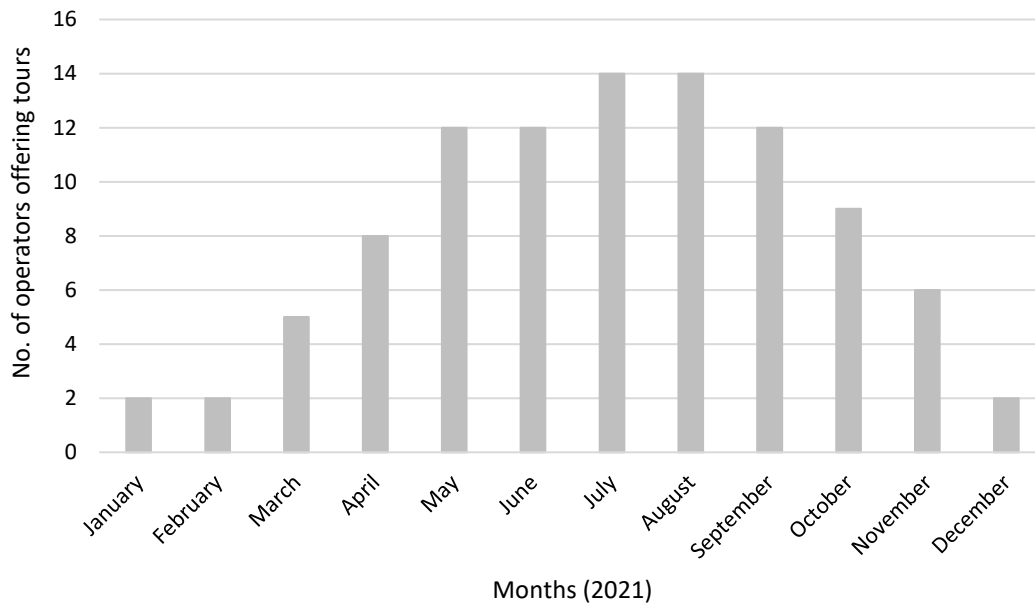


Figure 3: Annual distribution of no. of marine mammal operators offering tours, based on survey respondents answer to the question “In which months do you offer tours”.

Among the respondents none had shifted their primary area of observation within the last couple of years. However, it should be noted that several operators visited multiple sites both due to changing weather conditions, with one operator also suggesting that it was their approach to reduce impact on seals at haul out sites.

Regarding means of transportation to the observation sites, the majority (12) offered boat tours, two walked and one used a barge.

In terms of the overall process of interacting with the marine mammals on the observation sites, answers are summarized in table 3. Overall answers varied substantially, based on the distances kept to the animals and maximum amount of time spent with encountered animals.

⁴ Numbers are not plotted, nor described at lower geographical levels due to the demand for not disclosing data, which could be identified at the level of single operators.

Table 3: Self-reported characteristics of interactions between the operators and the animals on the observation sites

	Response rate	Average	Median	Minimum	Maximum
Maximum amount of time spent with encountered animals	53,6%	22,6 min.	20 min.	4 min.	45 min.
Distance kept to animals by operators	50%	96m	75m	1m	330m
Percentage of times where >25% of seals flush haul out sites due to operator presence	57,1*	0,1%	0%	0%	10%

Table 3: Summary of results related to three distinct questions in the questionnaire on the interactions between operators and animals at the observation sites. The data for 'Maximum amount of time...' was derived from answers to the question "How long do you on an average stay at the primary observation site". The data for 'distance kept by operators' was derived from answers to the question "What distance do you most often have to the marine mammals (reply in meter)". The data for 'Percentage of times...' was derived from answers to the question "If you observe seals at the haul out sites, how often do you observe that more than 25% of the animals leave the beach and enter the water in relation to you presence. (reply in % of times)."

*Response rate for this category was calculated based on the total number of operators performing seal focused tours.

In addition to the potential use of minimum distances operators were asked to report how they evaluated if they got to close to the animals (table 4). For this question 15 operators (response rate 53,6%) provided their answers, which for reporting were categorized based on whether they referred to behavioral cues or not. From this categorization it appears that most operators use some level behavioral cues including e.g. flushing, raising of heads for seals and diving behavior for cetaceans.

Table 4: Operator's reports on approaches to evaluate distance to animals

Answers related to seals	Report use behavioral cues	Do not report use behavioral cues
"Vi har vandrenden i mellem os så det vurderer vi endelig ikke på en normal dag. Skulle de hoppe i vande uden vi kan se anden årsag til det end vores tilstedeværelse trække vi væk. Men det har jeg ikke været udsat for på vores "standart sæltur"	1	0
"Vi undgår altid at få sælerne ud i vandet"	1	0
"Vi holder øje med sælernes adfærd"	1	0
"Der er en tidevandsrende mellem sælerne og gæsterne på 150 meter, som medfører at sælerne ikke reagerer på tilstedeværelsen"	0	1
"Hvis sælerne reagerer på vores tilstedeværelse er vi for tæt på."	1	0
"Sælerne rejser hovederne og bliver observante"	1	0
"Alle guider er grundig oplært i dyrenes adfærd og kan straks se hvis de bliver urolige"	1	0
"Vi holder altid god afstand"	0	1
"Vi kan tydeligt se at sælerne bliver nervøse, når vi kommer for tæt. Vi ligger stille med X (ed.) i god afstand og der er altid en eller to sæler der så selv bliver nysgerrige og fra læ side af X (ed.) kommer tættere på os.....det har somme tider været 20-30 meter"	1	0
"Hvis de bliver urolige og nogle går i vandet. Sker sjældent, tror de har vænnet sig til båden."	1	0
"Dybde og sten"	0	1
Answers related to cetaceans		
"Skipperne har stor erfaring i at bedømme afstand til flokke. Som regel kommer især X (ed.) selv hen til båden"	0	1
"Det er helt enkelt, hvis vi kommer for tæt, dykker X (ed.), så vi er godt trænet i ikke at sejle for tæt, for så for hverken marsvin eller gæster noget ud af det 😊"	1	0
"De kommer til båden"	0	1
"Hvis X (ed.) søger væk og/eller ændrer adfærd."	1	0
Total	10	5

Table 4: Anonymized summary of quotes from the open ended question "How do you evaluate if you are to close" in the questionnaire. The categorization was based on the author's interpretation of the quotes.

In relation to the management of tourist expectations operators were asked to answer three questions. Firstly, in terms of the tourists' expectations to the proximity of animals at the observation site, 15 operators (response rate 53,6%) provided an answer (table 5). Among these, three did not believe to know the tourists' expectations well enough to answer the questions, while the remaining twelve did. Here the answers vary, yet with at least two stating that tourists likely expect to get closer than what they can offer. However, 6 out of the 15 operators also mentioned the role of their own communication in terms of shaping customer expectations.

Table 5: Operator's reports on customer's expectations in terms of proximity to animals

Answers by operators
"Forskelligt men mange har ikke læst vores turbeskrivelse og forventer at komme tættere på."
"Tættere på end vi sælger – men vi påpeger ALTID at vi er på BESØG hos sælerne!"
"Disse forventninger kender vi ikke."
"De ved på forhånd, at vi ikke kommer tættere på end 150 m og at det er en god afstand for sælerne"
"50-100 meter, jeg har indtryk af at vi opfylder gæsternes forventninger"
"ved ikke"
"De fleste ved der vil blive holdt afstand og har fuld forståelse når vi har den rette formidling ombord"
"Nogle forventer at komme tættere på, men vi plejer i vores velkomstinformation at fortælle om code of conduct og hvad de kan forvente. Så vi har en form for forventningsafstemning og giver gæsterne forståelse for at vi er på besøg og skal genere dyrene mindst muligt."
"10m"
"Det ved jeg ikke"
"Så tæt som muligt. Revet under vand sætter en naturlig begrænsning for X (ed.)."
"Meget tæt. Indenfor 20 meter af X (ed.)."
"Tæt"
"De forventer at man ser dem på lang afstand"
"De vil gerne tæt på, men vi forklarer gæsterne at vi må lade sælerne komme til os. Vi ønsker ikke at forstyrre deres liv der."

Table 5: Anonymized summary of quotes from the open ended question "How close do the customers expect to get to the animals" in the questionnaire.

Asked directly whether operators inform customers about appropriate behavior and distance to the animals 11 out of 15 replied positively and four either no or that it was not relevant for them. However, when asked directly if operators had specific guidelines and what they constituted, answers varied considerably (table 6), with at least three reporting that they did not, and several reporting content of guidelines very different from e.g. the examples provided by IWC.

Table 6: Operator's reports on customer's on their use of guidelines and the content of the guidelines

Answers by operators
Ja og ja. Kort sagt er vi her på sælernes primisser og derfor skal di ikke forstyrres (som hoppe i vandet).
Altid - mikrofon slukkes, der er ingen der taler og ingen foto med blitz
Ja, hvis der mod forventning skulle være sælunger på den side af renden, hvor vi står, så hold mindst 150 m afstand, gerne mere
Vi har en factsheet som vores passagerer kan læse på.
Ja. Alle guider er oplært i at kende dyrenes adfærd og det fortælles til gæsterne hvad der gøres
Ja
Nej
Ja, Vi er stille
Forklarer vi er glade for sælerne tit og ofte dårligt gider løfte hovedet fra stenene når vi kommer. Forklarer det er vores levebrød og vi gerne vil passe på sælerne. De udlånes kikkerter til alle ombord, således man fint kan se dem. Største problem kan være havkajakker, speedbåde og andet der kommer for hurtigt/ alt for tæt på.
Ikke udover sund fornuft og at vi ikke følger efter dyrene.
Nej
I øjeblikket fortælles det inden turen og under turen men vi regner med at fortælle det på hjemmesiden og el. bookingssiden også i 2022.
Vi forklarer at vi ikke må være forstyrrende for sælerne og at det som sagt er sælerne der må komme til os, hvis de er nysgerrige. Men vi sælger ikke tæt på dem.

Table 6: Summary of quotes provided by operators to the question "Do you have any guidelines in relation to the behaviour around the animals you observe, and if yes which, and are the guests introduced to these as a permanent part of the tours?"

3.1.5 Operator's opinion on the level of tours and the demand for management interventions

To explore the operator's perspective on the future development of their sector three questions were asked in terms of their opinion related to present levels of tourism tours, if guidelines were needed and if such guidelines ought to be embedded in future environmental laws in contrast to e.g. voluntary guidelines.

Most operators reported that present levels of tours were good, and a smaller group that more trips could be initiated easily. None of the operators found the present level to be problematic (table 7).

Regarding the opinion of future guidelines most operators preferred a voluntary solution, yet with a few preferring a law (table 8).

Table 7: Operator's opinion on the level of tourism tours

	Response rate	There can easily be more trips	The level of tours is good	There are too many tours
Present level of tourism tours at site	46,4%	4	9	0

Table 7: Summary of results related to the question "In relation to your experience with the response of the animals to your and other tourist operators in 2021, what do think of the level of tourism at the site you visit (choose an answer)"

Table 8: Operator's opinion on whether future guidelines for commercial marine mammal tourism should become law

	Response rate	Voluntary	Law
Operator's opinion on future guidelines	35,7%	8	2

Table 8: Summary of results related to the question "If national guidelines were to be developed for commercial marine mammal tourism would you then like these to be voluntary or embedded in a law?"

As a final point, operators were asked to reflect on their experiences and ideas related to options for supporting their sector, particularly in terms of issues which the Environmental Protection Agency should be made aware. To this question answers (response rate 35,7%) addressed a diversity of issues. As an example three operators highlighted the disturbance from the maritime traffic in general, one argued for increased enforcement of present regulation in protected areas, and one found the information campaign on appropriate behavior in nature from the local municipality to be beneficial. Finally, one operator suggested a general information campaign on where to find marine mammal watching operators, and one found the need to emphasize that marine mammal tourism needed to be respected as an important tourist attraction where private actors risked their savings, which is challenging when public institutions compete with financial support.

Table 9: Operator's reflections on options for supporting the industry

Answers by operators
"Naturstyrelsen kunne starte med at håndhæve de reservatbekendgørelser der ligger på området (stor hjælp og fremskridt!). Og der næst kunne de reservatbekendgørelser der ligger blive opdateret så de passer bedre med hvor sælerne befinder sig i dag mm."
"Respekter aktiviteten SælSafari som en vigtig turistattraktion og vær særlig opmærksom på os private aktører, som sætser penge og jobs på aktiviteterne i forhold til offentligt støttede aktører (naturcentre, porte til... m.v.)"
"X (ed.) kommune gør et godt stykke arbejde med gode råd til god opførsel i naturen, herunder også i forhold til sæler"
"Set fra vores ståsted, er båden X (ed.) overhovedet ikke forstyrrende for sælerne. De ignorerer som oftest båden fuldstændig, når vi driver i tomgang forbi sælbanken. Det største problem er efter vores mening, fritidsejere. Vi har

<i>ofte været ude for, at jetscootere og speedbåde passerer med høj fart mellem X og sælerne. Sælerne går i panik og flygter fra banken og der kan gå dage inden de returnerer"</i>
<i>"Udpeg stillezoner til marsvin, hvor de er i fred for den generelle trafik"</i>
<i>"De kunne prøve det selv"</i>
<i>"Vi synes vores model fungerer fint"</i>
<i>"Bedere oplysning til private der selv sejler ud at kigger på sæler. Vi lever af at kigge på dem og passer på ikke at stresse. En lystbåd, speedbåd, havkajak og andre har ikke altid samme hensyntagen. Vi har før snakket med lystsejlere der selv sejler ud og kommer alt for tæt på. Det er en del af vores forretning at kigge på disse dyr og passe på dem. – Det er der egentlig god forståelse for når vi forklarer det."</i>
<i>"Evt. en off. side hvori man kan overskue hvor i DK man kan komme på havsafari el. lign. Evt. indføre en certificeringsordning så alle ikke bare sejler turister ud ulovligt."</i>
<i>"Nej"</i>
<i>"Som professionel turudbyder har vi naturligvis stor respekt for dyrenes adfærd og trivsel og vi gør rigtig meget ud af at omgås dem på den rigtige måde. Vi har med til at udarbejdet et etisk sæt retningslinjer for sejlads hos havpattedyr som vi også uddeler til andre sejlere i nærliggende havne."</i>

Table 9: Summary of anonymized quotes provided by operators to the question "Do you have ideas for actions which authorities / state / municipalities could take to support you and your activities, or do you have good examples of this which the Environmental Protection agency should be made aware of?"

3.2 Social media footprints of people engaging with marine mammals

Temporal patterns in Google searches

In order to retrieve weekly visit estimates, we limited the trends search to 1 Nov 2017- 31 Oct 2022 as this level of resolution is only available for a 5-year period at most. For each species, we decomposed these time series using wavelet decomposition and test significant trends in the wavelet power spectrum to assess what patterns were more likely to be supported by the year replicates. We find that only harbour porpoises exhibited a significant annual cycle in searches (black line, the significant wavelet, at 52 weeks over the high power level in green in Figure 4a) within the testable period (non-shaded area in Figure 4a). there was significant added complexity in temporal dynamics mid-2020 (intrusion of the significance border, in white, from 16 to 4 weeks). There was a 6-monthly seasonal component in the first half of the study period. Overall, there was no increasing or decreasing trend over the study period. Temporal dynamics for all other species is marked by episodic events, best exemplified by the month long event (4-week period) in early 2022 for killer whales (Figure 4d) concurrent with the month-long live stranding of a killer whale in the Limfjord.

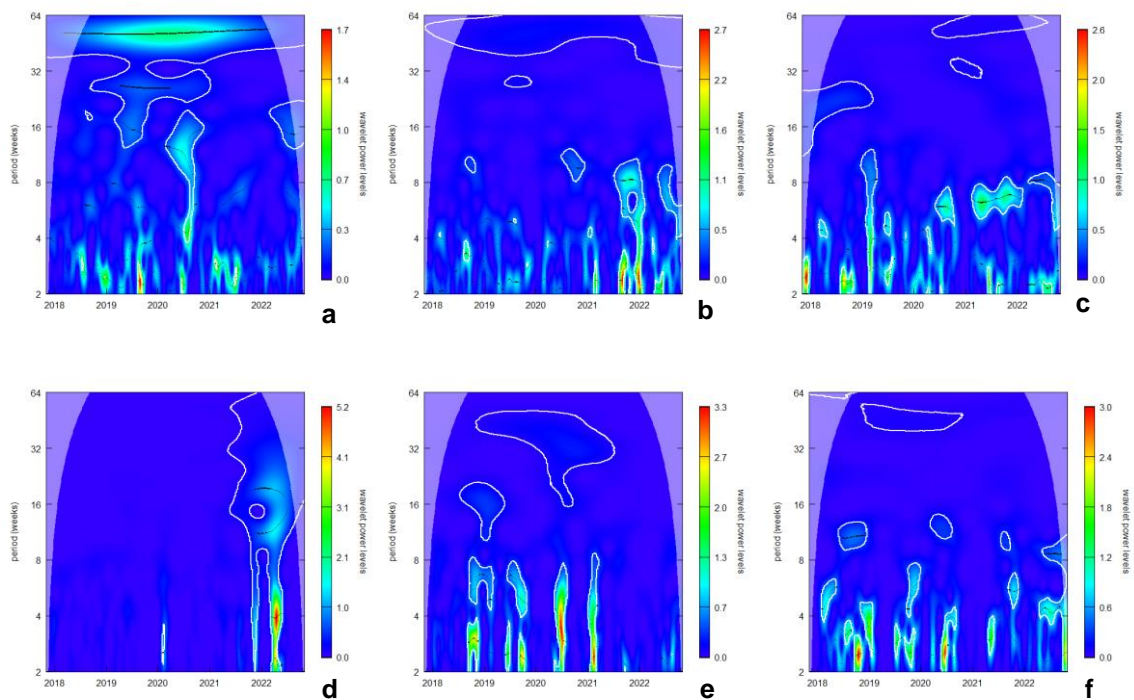


Figure 4: Wavelet power spectrum of Google searches for a) harbour porpoises, b) harbour seal, c) grey seal, d) killer whale, e) bottlenose dolphin, f) minke whale. Periods are in weeks (52 weeks in a year, y-axis) and the power spectrum level (colour) is estimated for each day (x-axis). Black lines are significant wavelet, significant temporal patterns in the time series. White lines correspond to the area of confidence in these significant periods, here based on 1000 simulations of each time series.

We replicated the decomposition process for google searches about harbour porpoises in neighbouring countries (Figure 4). We estimate a significant annual cycle in searches in Denmark, Sweden, Norway and the United Kingdom. An annual cycle emerges in Germany in 2020 (Figure 4g)

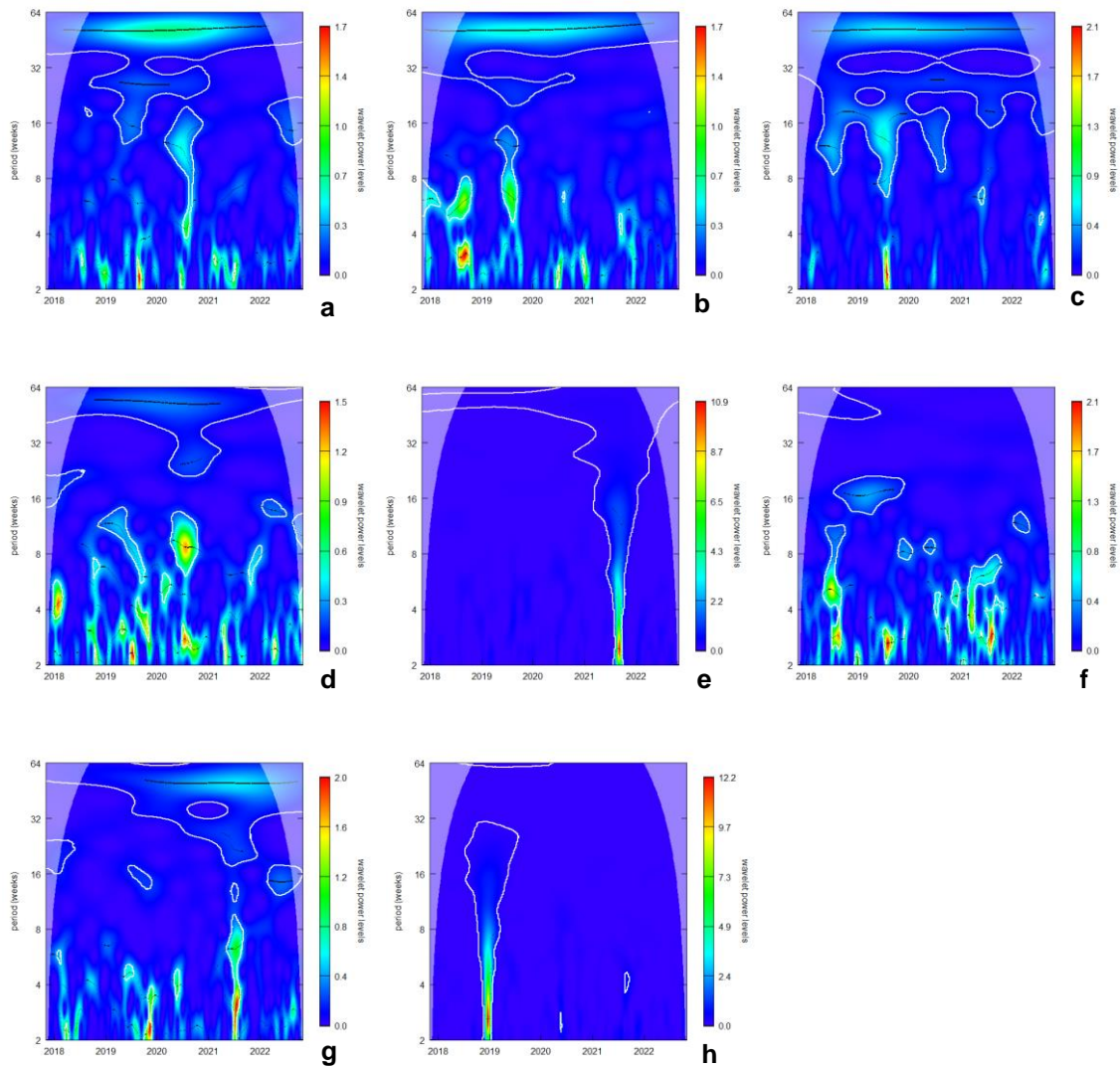


Figure 5: Wavelet power spectrum of harbour porpoise Google searches for a) Denmark, b) Sweden, c) Norway, d) United Kingdom, e) Netherlands, f) Poland, g) Germany, and h) Finland. Periods are in weeks (52 weeks in a year, y-axis) and the power spectrum level (colour) is estimated for each day (x-axis). Black lines are significant wavelet, significant temporal patterns in the time series. White lines correspond to the area of confidence in these significant periods, here based on 1000 simulations of each time series.

We decomposed the Danish Google search for harbour porpoise time series in its trend, season and random components to retrieve the significant annual cycle (Figure 5). The cycle peaks in summer and has another mode in May (Figure 5). This pattern is very similar to the self-reported number of tours offered by tour operators (Figure 3).

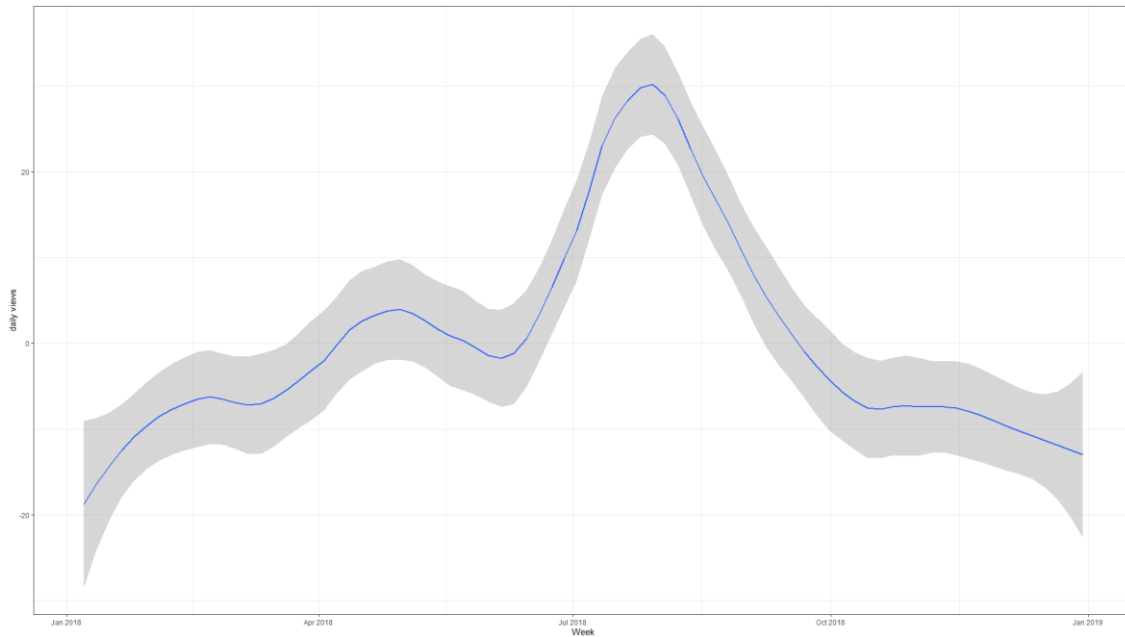


Figure 6: Seasonal component of the Danish Google searches for harbour porpoises smoothed using the loess method (band is standard error given the weekly observations). This seasonal pattern is estimated to be the same for all years (the year on the x-axis is just one example of it).

Temporal patterns in Wikipedia visits

The Danish Wikipedia pages for harbour porpoise and killer whale were consistently the most visited over the seven-year period (Figure 7). The number of daily visits to the harbour porpoise Wikipedia page exhibited a consistent seasonal pattern (Figure 7). This pattern seems consistent across a number of neighbouring countries for which a language-specific Wikipedia page exist for harbour porpoises (Figure 8). Once we decompose these time series into their trend, seasonal and random components, we find indeed inter-annually consistent seasonal component to the time series for five countries (Figure 9).

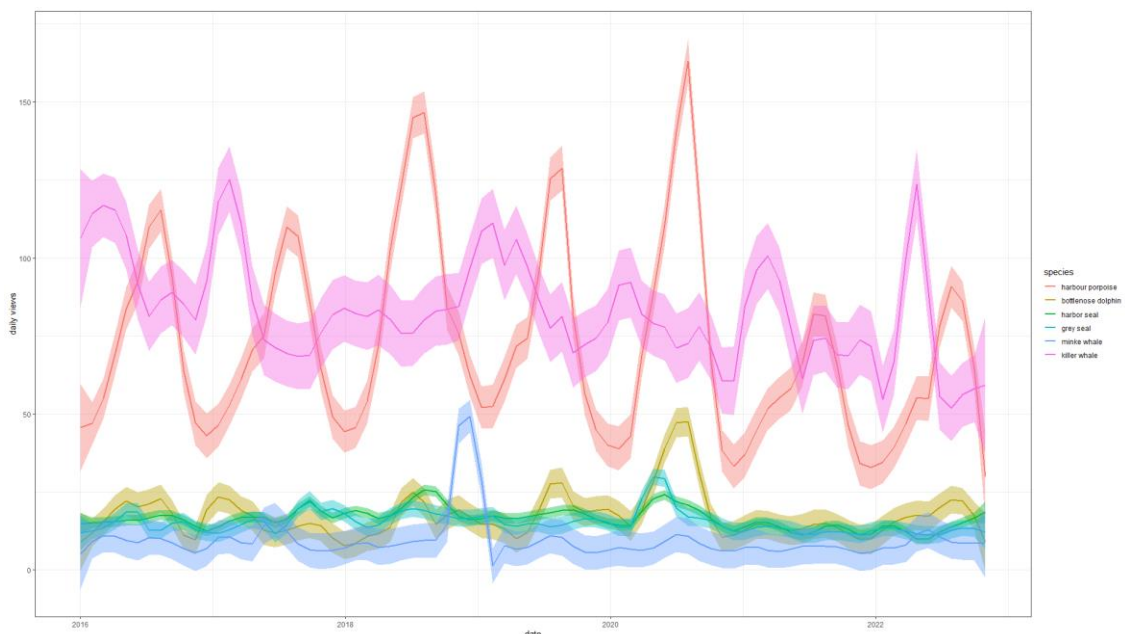


Figure 7: Smoothed (loess estimate, error band is the standard error) temporal variation in the number of daily visits to Wikipedia Danish pages dedicated to each species from 1 January 2016 to 31 October 2022.

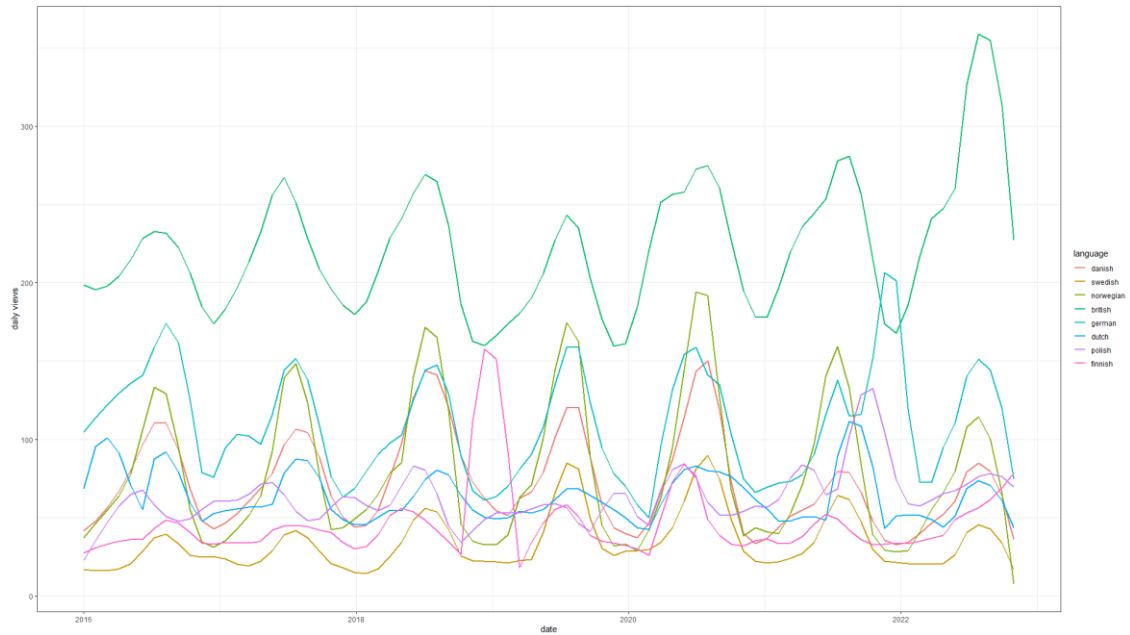


Figure 8: Smoothed (loess estimate) temporal variation in the number of daily visits to harbour porpoise Wikipedia pages from 1 January 2016 to 31 October 2022 for eight languages neighbouring Denmark.

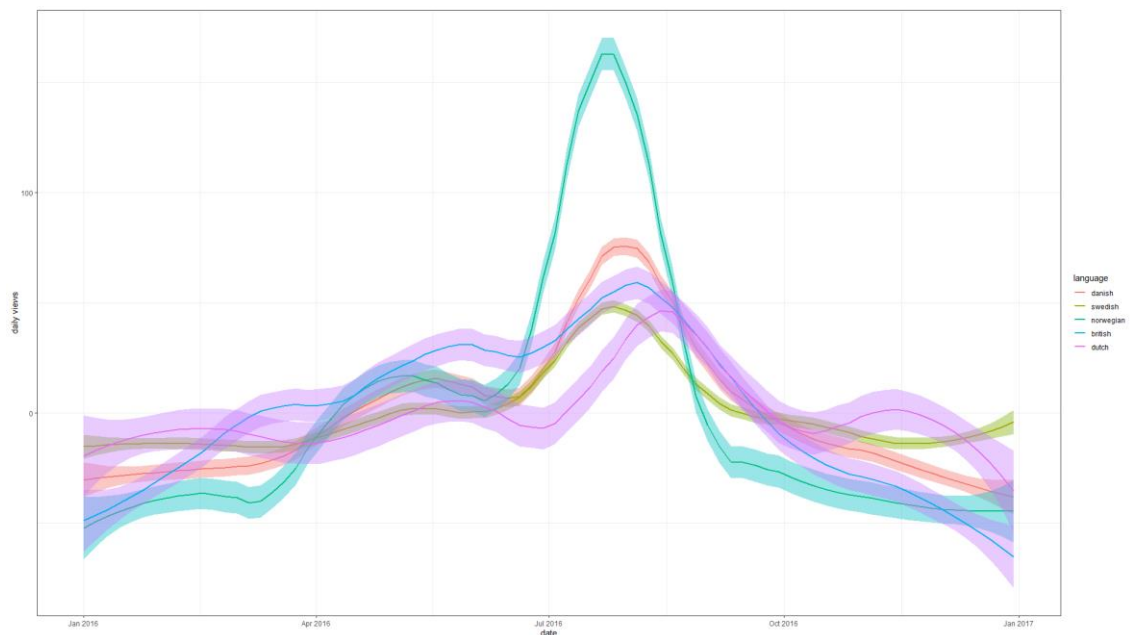


Figure 9: Inter-annually consistent annual seasonal component of Wikipedia visits in Danish, Swedish, Norwegian, British, and Dutch. Loess smoothing of daily seasonal component estimate (band is standard error).

We used wavelet decomposition to test more robustly these exploratory findings. We find consistent annual patterns in Danish, Swedish, and Norwegian and a developing annual pattern in British (Figure 10). Consistent with the Google search temporal dynamics for the species in the relevant countries.

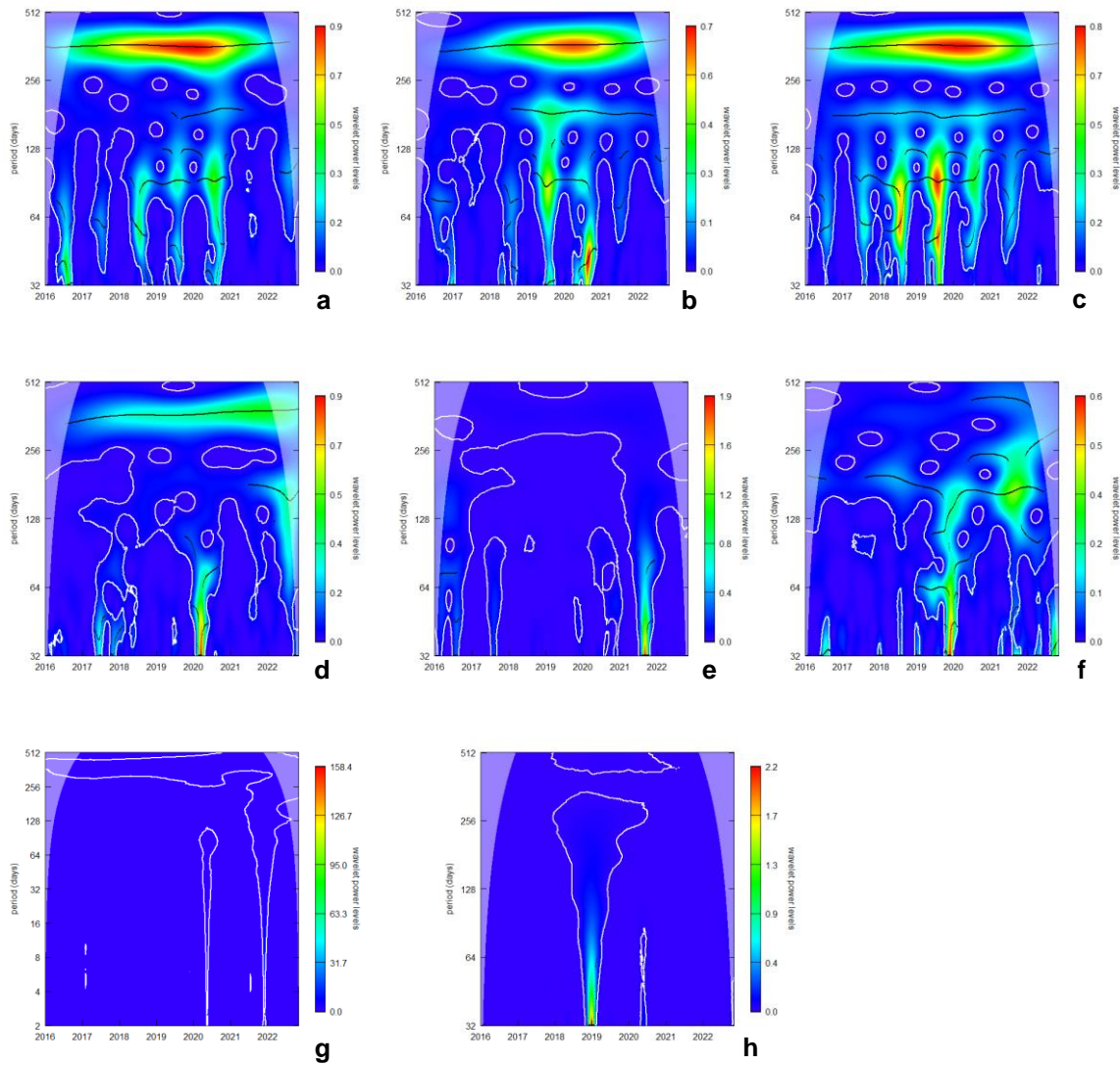


Figure 10: wavelet power spectrum of daily visits to the Wikipedia page for harbour porpoise in a) Danish, b) Swedish, c) Norwegian, d) British, e) Dutch, f) Polish, g) German, and h) Finnish. Periods are in weeks (52 weeks in a year, y-axis) and the power spectrum level (colour) is estimated for each day (x-axis). Black lines are significant wavelet, significant temporal patterns in the time series. White lines correspond to the area of confidence in these significant periods, here based on 1000 simulations of each time series.

Coherence between Google searches and Wikipedia visits

The inter-annually consistent seasonality in online behaviour on both platforms is consistent with our hypothesis that people search for opportunities to see marine mammals and try to learn more about them on Wikipedia. If these observations emerge from this process, we would expect a short lag between the volume of searches on Google and the number of visits on Wikipedia during which time the marine mammal experiences would occur. We therefore tested for coherence between the two time series for each species in Denmark, and for harbour porpoises in Denmark, Sweden, Norway and the United Kingdom. Firstly, we had to reduce the temporal resolution of the Wikipedia data to match the weekly time unit of the Google Search data. We then scaled both time series to ease comparison. We then estimated the cross-wavelet power spectrum to assess whether the significant temporal patterns observed in both time series occurred at the same time and if so whether they are in-phase, out-phase and in which case which time series starts the pattern.

All major temporal patterns of harbour porpoise time series in Denmark, Sweden, Norway and the United Kingdom were concordant (Figure 9??) and in phase. It is likely that the week time unit is too coarse to capture the potential directionality in search and Wikipedia visits.

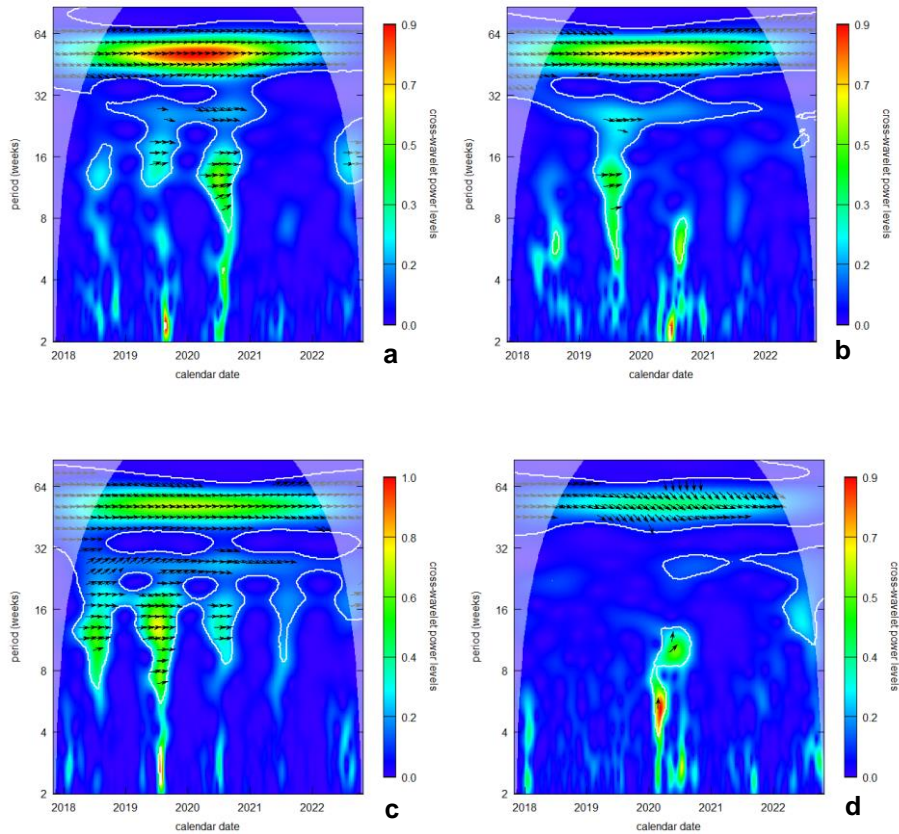


Figure 11: Cross-wavelet power spectrum for the Google search and Wikipedia visit time series: a) Denmark, b) Sweden, c) Norway, d) United Kingdom. Significant concordance between the two time series are delineated by the white significance line. Arrows describe the phase difference between the two times series over the significant cross wavelet power spectrum. If the arrow points right, the time series are in phase, if it points left, they are out of phase. If it points right and up Google searches start the pattern.

The concordance we observe in time series for which clear and consistent seasonal patterns existed (Figure 11) is also present in time series best described by the occurrence of episodic events with varying latencies (Figures 4 and 7). Those episodes have a footprint in both google searches and wikipedia visits which are in phase and concurrent (Figure 13). In cases were strong (power level) episodes emerged coherently in both time series and those were not concurrent, then Google searches led wikipedia visits (Figure 12e and f). however, those incidence are rare.

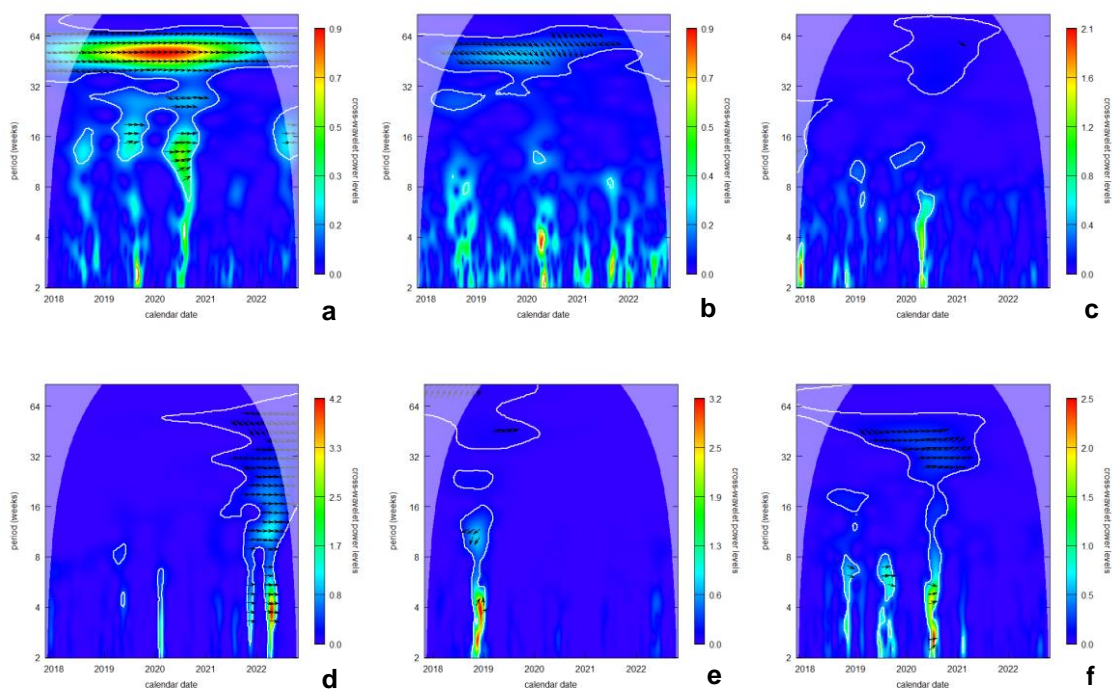


Figure 12: Cross-wavelet power spectrum for the Danish Google search and Wikipedia visit time series: a) harbour porpoise, b) harbour seal, c) grey seal, d) killer whale, e) minke whale, and f) bottlenose dolphin. Significant concordance between the two time series are delineated by the white significance line. Arrows describe the phase difference between the two times series over the significant cross wavelet power spectrum. If the arrow points right, the time series are in phase, if it points left, they are out of phase. If it points right and up Google searches leads Wikipedia in the pattern.

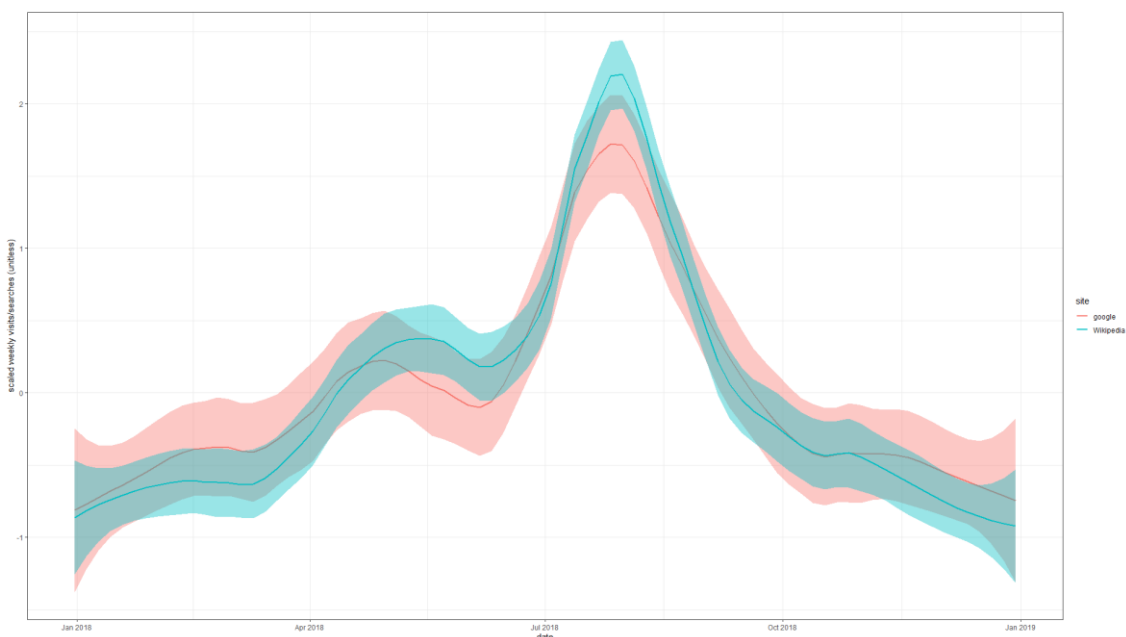


Figure 13: Detected significant seasonal component of Wikipedia weekly visits and Google weekly searches (scaled to their respective variance and centered on their respective mean so that both time series can be compared on the same unitless y-axis). Smoothed estimates using loess method, band is standard error.

The significant inter-annually consistent seasonal patterns for harbour porpoises in Denmark detected by the wavelet analysis shows a peak during the summer holidays in Denmark (mid-July to mid-August) which is concurrent in Google searches and Wikipedia visits and a second mode at the end of April and beginning of May (the Google peak in searches leading the Wikipedia visits

by about 2 weeks) (Figure 13). This phase difference appears to shrink as we progress towards the second mode, however the uncertainty around these temporal changes is too large for this phase difference to be significant; probably because we are sampling at a week temporal unit and the temporal process associating google searches and Wikipedia visits is likely taking place at a shorter time scale.

Spatial patterns in sightings reported to GBIF and posted on Flickr

Cetaceans

15 cetacean species were reported in GBIF sightings (Table 3) with the most frequent species being harbour porpoises (3428 sightings) followed by bottlenose dolphins (192 sightings). The spatial distribution of Flickr (241 photos) and GBIF cetacean reports differed (Figure 13), with Flickr reports being more frequent around higher human population density areas. One Flickr hotspot represents photos taken at Fjord&Bælt (Figure 14), which we felt important to keep in the data representation as it is an important mean by which people can encounter harbour porpoises. Hotspots of GBIF reported cetacean sightings remain broadly consistent over the past seven years (Figure 14).

Table 10: Number of occurrences of cetacean species.

species	n	species	n	species	n
<i>Phocoena phocoena</i>	3428	<i>Balaenoptera acutorostrata</i>	53	<i>Hyperoodon ampullatus</i>	10
<i>Tursiops truncatus</i>	192	<i>Balaenoptera borealis</i>	33	<i>Globicephala melas</i>	9
<i>Orcinus orca</i>	168	<i>Lagenorhynchus albirostris</i>	16	<i>Lagenorhynchus acutus</i>	2
<i>Delphinus delphis</i>	125	<i>Megaptera novaeangliae</i>	15		

Table 10: Sightings reported on GBIF 2016-2022 for species sighted more than once

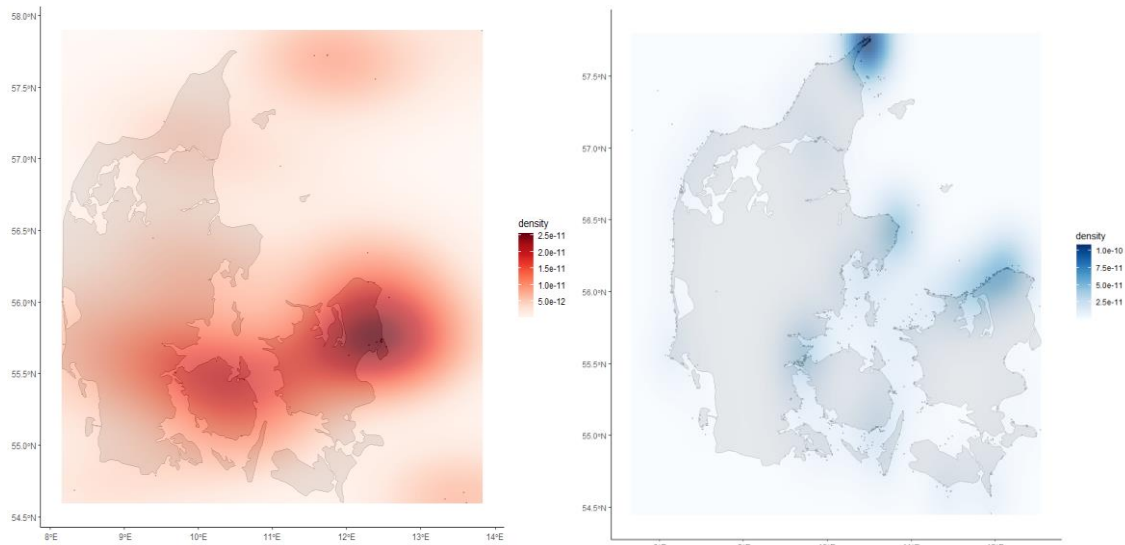


Figure 14: Spatially-explicit density estimates (kernel density estimates) of cetacean Flickr photos (red, 2010-2022) and GBIF sighting reports (blue, 2016-2022)

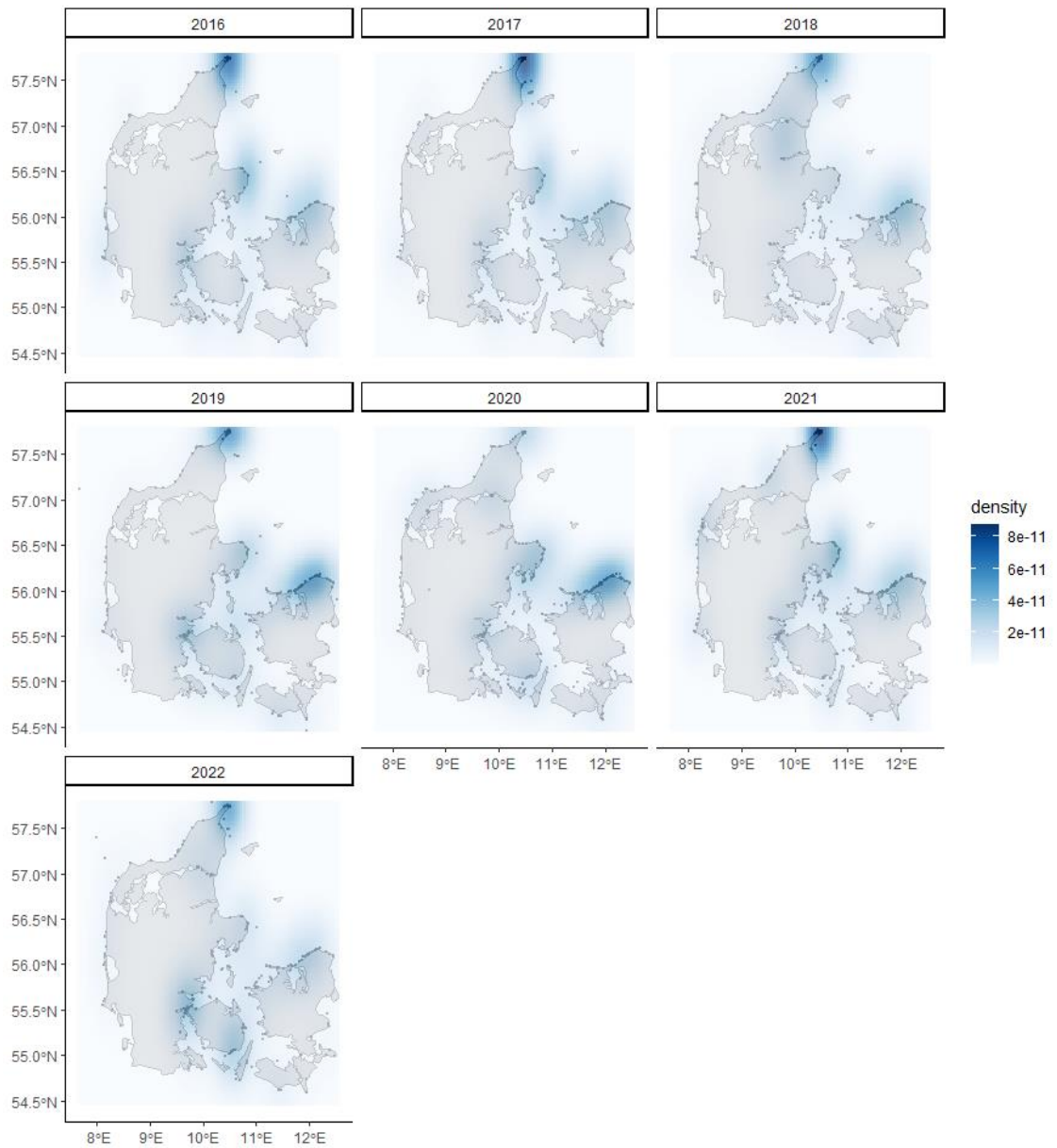


Figure 15. Annual density map for all cetacean sightings reported to GBIF (blue surface) overlaid on sighting location (black dots).

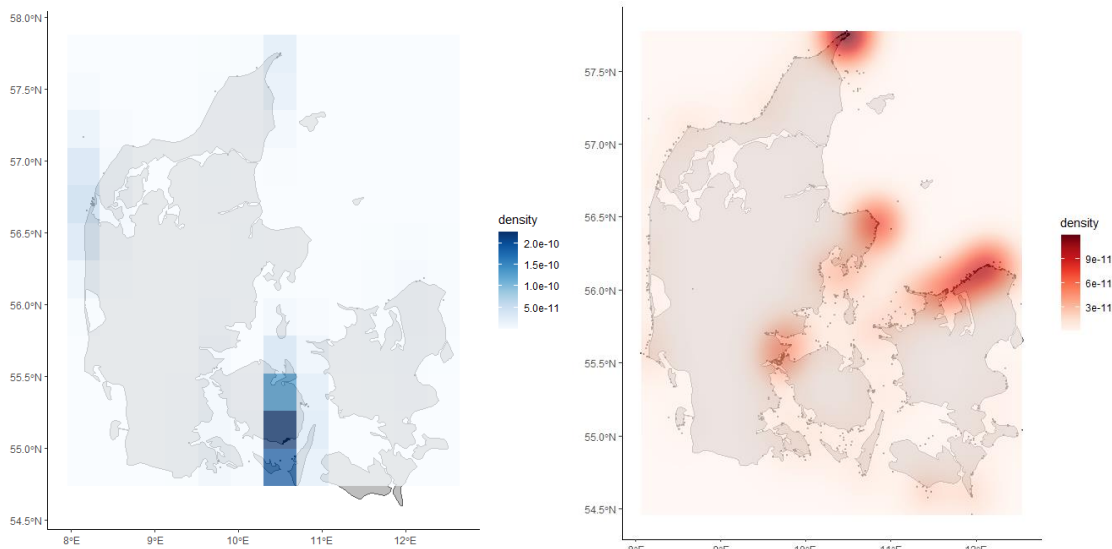


Figure 16: Spatially-explicit density estimate of bottlenose dolphin (left, blue) and harbour porpoises (right, red) sightings reported on GBIF. The resolution of the kernel density estimator was reduced for bottlenose dolphins to account for the relative scarcity of sightings.

The distribution of harbour porpoise sightings dominates the cetacean spatial patterns from GBIF sightings (Figure 16). Bottlenose dolphin sightings are aggregated around locations which are consistent with reports of the species observed on an *ad-hoc* basis on other platforms observed (such as dedicated Facebook Groups).

Pinnipeds

Pinniped species reported on GBIF were all Phocidae but no sightings were reported at the species level. The 543 pinniped sightings reported on GBIF did not concentrate over known haul-out areas (Figure 17). As report numbers are smaller, we can explore temporal variation over time periods for pinnipeds (Figure 18). There appears to be some consistency in sightings patterns over the past decade. The patterns in Flickr posts (350 photos) differed markedly (Figure 16), with hotspots over eastern Sjælland and at sea at the crossroad of the two main ferry paths in the area.

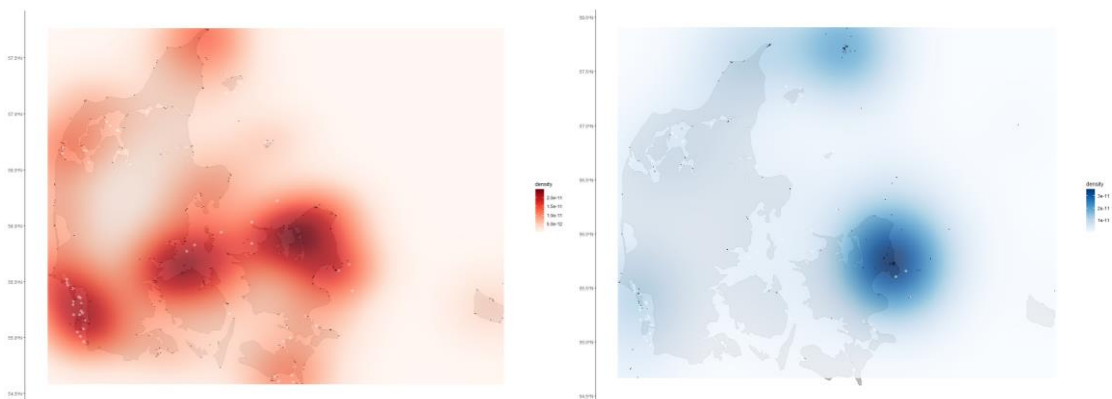


Figure 17: Spatially-explicit density map for all pinniped sightings reported to GBIF (red surface) and Flickr (blue surface) since 2010 overlaid on sighting location (black dots). Known haul-out sites are presented as white circles.

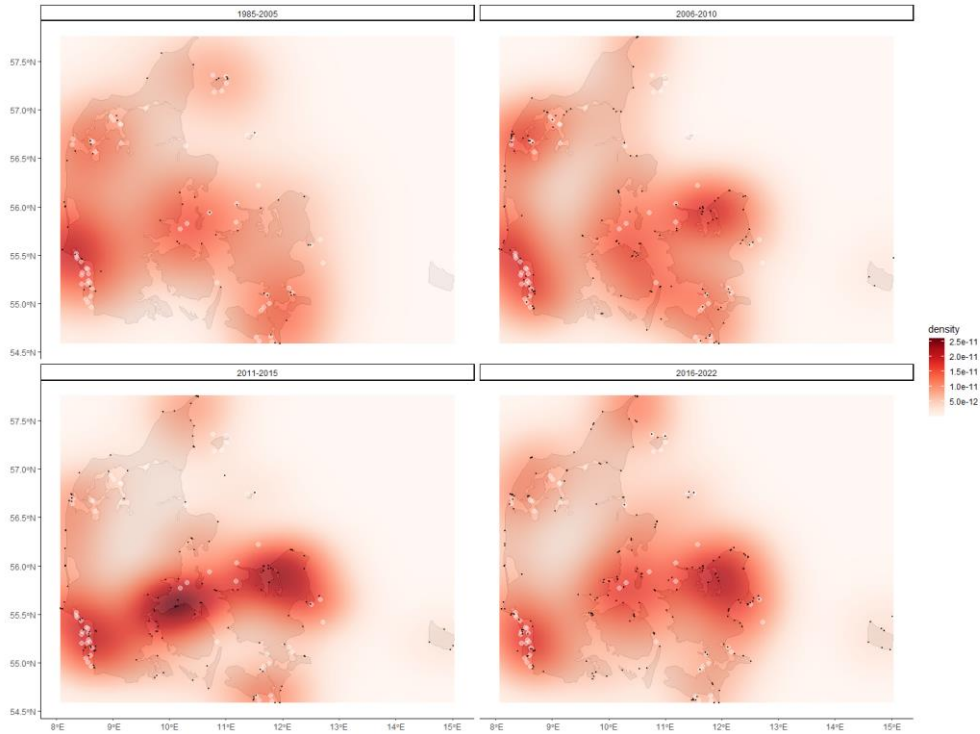


Figure 18: Spatially-explicit density map for all pinniped sightings reported to GBIF reported over 4 periods (red surface) overlaid on sighting location (black dots). Known haul-out sites are presented as white circles.

Overall, most reports on GBIF and posts on Flickr were taken far away from the nearest haul out sites (Figure 19). About 1/4 of Flickr posts were taken at a distance from the center of haul out sites near enough to constitute photos highly likely to be taken at a haul out site (Figure 19). By contrast, GBIF reports are rarely less than 1km from the center of haul out sites (Figure 19).

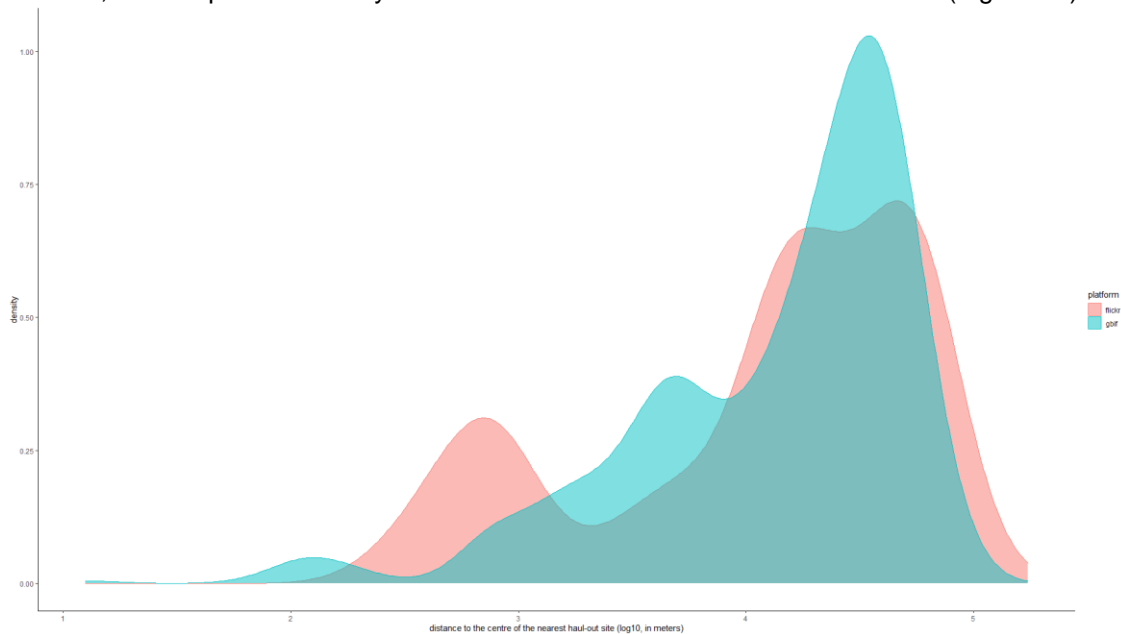


Figure 19: Distribution of distance from sightings (GBIF) and posts (Flickr) to the center of the nearest haul out sites (white circles in Figure 14) in meters on a log₁₀ scale. Given the accuracy of positions, reports within 1km of the center of haul out sites are highly likely to have been taken at haul out sites.

4. Discussion

4.1 Commercial activities

In the present mapping response rates were considerably lower than in the 2016-17 mapping, where all identified operators responded to the questionnaire. This we suggest is caused primarily by the choice to ask operators to fill out the questionnaire, rather than going through each question over the telephone. However, increased competition and therefore hesitancy to share business sensitive knowledge may also have been factor though it is not possible to evaluate this in detail.

When comparing core results (table11??) from the mapping of commercial activities in 2015 and 2021, it appears likely that the sector has indeed seen substantial increases in activities based on numbers of sold ticket and generated revenue, particularly when considering that the majority of operators in 2022 also reported that demand had been increasing over the past five years. Combined with the operator's future expectations, it may also be likely that this growth trend could continue, particularly as the number of operators continue to grow and the addition of new types of tours, e.g. 'swim with seals' which one operator initiated in 2022.

From a sector development perspective, the increase of >70% in average ticket price might not be a relevant indicator as the median price in 2022 was to a much greater extent at the level of the 2015 average. A similar observation can be made for the average revenue per operator and could be explored in depth in future analyses.

Table 11: Summary of key data for the sector in 2015, 2021 and 2022

	2015	2021	Development 2015-2021	2022
Total number of operators	26	28	+ 2	31
Overall geographical distribution in Denmark	Many parts of Denmark	'Most' parts of Denmark	<i>Includes Bornholm</i>	'All' parts of DK incl. Bornholm
Number of focal species	3	4	+ 1	4
No. sold tickets	41.121 <i>- by 100% of operators</i>	38.451 <i>- by 46,4% of operators</i>	-	-
Ticket revenue	*7.087.203 DKK <i>- by 100% of operators</i>	11.375.313 DKK <i>- by 46,4% of operators</i>	-	-
Average price per ticket	*172,3 DKK	293,2 DKK (Mdn. 198,6 DKK)	+ 70,2%	
Average revenue per operator	*272.584,7 DKK	875.024,1 DKK (Mdn 160.000 DKK)	+ 221%	-
Observation sites	Mainly Natura 2000 areas designated to the focal species	Mainly Natura 2000 areas designated to the focal species	-	Mainly Natura 2000 areas*

Table 11: Summary of core results from the mappings of commercial activities in 2015 and 2021, supplemented with most recent data from 2022.

*Prices from 2015 was adjusted based on the consumer price index (1,052) from Danmarks Statistik.

†The addition of bottlenose dolphins as a focal species in 2021, which are not considered native to Denmark means that no Natura 2000 or other species-specific area-based measures apply to this species.

From a regulatory perspective, no operator found the present level of tours at their main location sites to be problematic and that potential guidelines should be voluntary. This is expected from a marine mammal watching industry early in its growth phase (Higham et al. 2016). Here it is worth to note from the quotes firstly that many of the operator's concept of guidelines are likely to be more basic, than the information rich and prescriptive version which the Environmental Agency's published in the autumn of 2022 (<https://mst.dk/media/247809/guidelines-for-kommerciel-saelturisme-i-danmark.pdf>) and secondly that the recent guidelines suggests minimum distances and time spent with the animals which is lower than the present activities. This implies that it is not only tourist's expectations to encounters but also operator's expectations, which might need to be recalibrated if adherence to the new guidelines is to be achieved. Similarly, it might also be a novelty for some operators that behavioural cues such as raised heads by seals, are also to be considered an indicator of negative impact.

The level of uptake of the new voluntary guidelines is therefore uncertain, given that many of the operators expressed satisfaction with their present approach. It is known from many case studies around the world over the past three decades that voluntary guidelines fail when market pressures in encounter types and volume are present (Higham et al. 2016).

Overall, the effectiveness of these guidelines as a measure to support sustainable development of the sector, may therefore not be sufficient, particularly if the recent growth continue in numbers of operators and tourist numbers mainly taking place when harbour porpoises and harbour seals have new born calves and pups, within the protected areas designated to protect the focal species from disturbance. It is crucial to achieve sustainable tourism that the management of marine mammal tourism recognises the socioeconomic pressures constraining tour operator behaviour and tourist expectations (Mancini et al., 2020).

4.2 Social media footprint

People in Denmark are consistently wanting to know more about killer whales and harbour porpoises and search for information about them on Google as well as regularly visit Wikipedia pages dedicated to those species (averaging about 75 visits per day for those two species). Search patterns are more sporadic for the other marine mammal species. While killer whales search patterns are episodic, associated with events occurring in Denmark such as the recent live stranding in the Limfjord, searches for harbour porpoises are consistent and cyclical. People seem to search for harbour porpoises, and try to learn more about them, every year at times when they are more likely to encounter them because more people use the seashore over those periods. This pattern coincides with ticket sales. Importantly, this pattern is replicated in other countries where similar human behavior occurs and there are good chances to observe harbour porpoises nearshore. Crucially, this pattern does not replicate in countries where porpoise density nearshore are lower (Hammond et al. 2021). This counterfactual set of results supports our hypothesis that we can use trends in google searches and visits to dedicated Wikipedia pages to appraise when people are more interested in a marine mammal species and likely seeking encounters (even if not all encounter expectations can be realized). The temporal scale at which we could sample both Google and Wikipedia did not allow us to further confirm the directionality of information access hypothesized in our CES journey framework (Figure 1), even though we can tentatively speculate that results are not contradicting it (Figure 10). Importantly, the coherence between Google searches and Wikipedia visits held not just for species with consistent seasonal patterns, but also for those for which interest peaked episodically.

Wikipedia offers a unique outlet to meaningfully engage with the public about those species. Here we show that people want to know more about marine mammals when they are likely to encounter them, and they turn to online sources to learn more about them. Wikipedia is an open platform to which anyone can contribute and therefore opens the possibility to share crucial information, such as best practices for interactions, with many people.

People dominantly reported encountering seals away from haul out sites. This could be a bias inherent to the GBIF platform: avid naturalists may feel it is more interesting to report unusual sightings of species (i.e., in this case sighting of seals in unexpected locations). However, this pattern is also present for the more generalist Flickr platform. There are more reports of seals at haul out sites on Flickr, however those are at a very small subset of haul out sites that are easily accessible from high human population density areas.

Taken together these results point to all data sources as useful to help understand how tourism and recreation flow could be managed. People are seeking harbour porpoises consistently every year. While available year-round, interest in harbour porpoises peak with May public holidays and in July-August. This search pattern is not solely focused on the recreational value of the species, but as a clear educational value as well. Indeed, all known episodic events in increased encounter probability with cetacean species emerge in Wikipedia visits: people want to learn more about those species when they have the chance to see them. This stresses the added value those species bring to tourism and recreational events and destinations (Lück, 2003; Zeppel & Muloin, 2008). Locations and businesses encouraging marine mammal encounters are missing on this added value if they do not integrate strong interpretation material in the experiences they deliver. Spatial patterns identified in GBIF are likely to be delineating areas where encounters are consistently concentrating. It is likely that a non-trivial number of encounters with seals is taking place away from haul out sites. While we may be able to manage behavior during interactions at haul out sites, these off-site encounters are less likely to be managed. Danish language Wikipedia pages offer an opportunity to help people receive up to date information about marine mammals in Denmark and also advice on how to best interact with them.

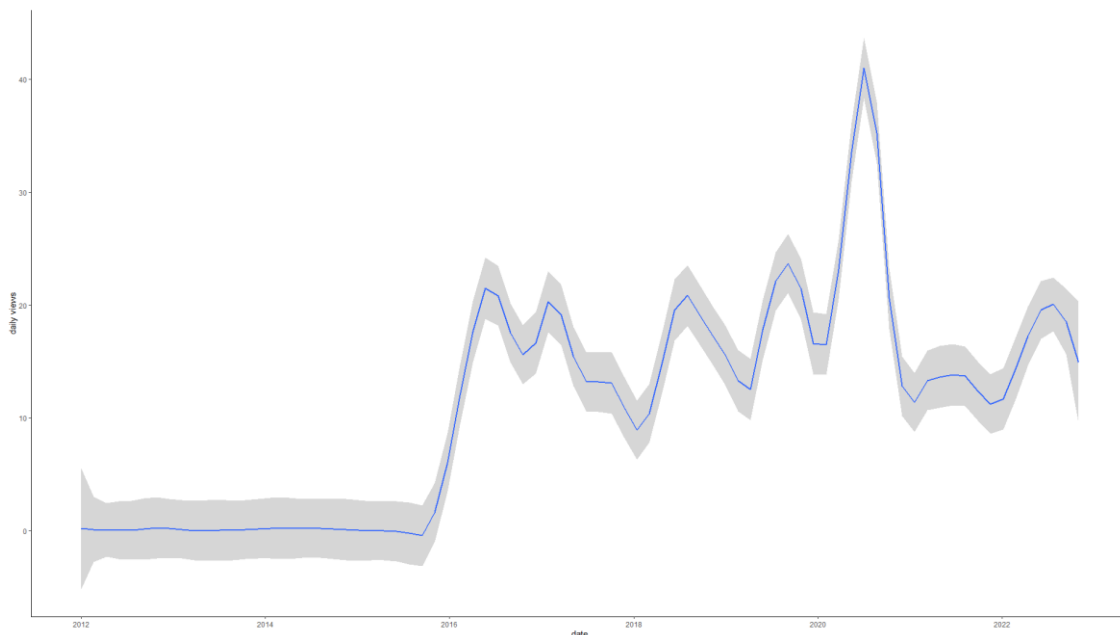


Figure 20. Long-term time series of daily visits to the bottlenose dolphin Wikipedia page (smoothed using loess method) from 1 Jan 2012 to 31 Oct 2022. The page was created Mar 2011. Noticeable increase in sightings of the species near-shore started in Jun 2015.

Temporal data sources can also help prioritize planning for species use. For example, the bottlenose dolphin Danish Wikipedia page was created in March 2011. The longer-term time series for this species shows how interest starts when bottlenose dolphins were first sighted in Denmark nearshore in 2015 (Figure 20). Several species show episodic events in searches and visits to Wikipedia in 2020. Anecdotally, people have been seeking nature more when mobility restrictions were in place as part of the public health response to COVID-19. This would be consistent with people seeking encounters with marine mammals more often over that period.

5. Conclusion

Compared to the mapping of commercial marine mammal tourism activities in 2015, it appears that the sector over the past six years has grown in terms of number of operators, geographical distribution, diversity of focal species, number of sold tickets and revenue generated. While the effectiveness of recently launched voluntary guidelines for the sector is unknown, the use of social media data to map people's engagement with marine mammals in Denmark offer a cue to options for using social media platforms proactively to educate the wider public about how they or commercial operators could reduce their potential negative impacts at locations. Monitoring of the development in the sector and its impacts, will likely be relevant to ensure the adaptive management of the species are successful in meeting conservation goals of the focal populations which are exploited.

6. Annex

6.1.1 Annex A: Questionnaire used in the mapping of commercial operators

Spørgeskemaundersøgelse for virksomheder der udbyder kommercielle havpattedyrrelaterede aktiviteter

Samtykke		
	<p>Jeg er bekendt med undersøgelsens formål og giver hermed min accept til, at projektet må opbevare og anvende både skriftlig og mundtlig information.</p> <p>Informationen vil blive anvendt til at udarbejde et notat til Miljøstyrelsen, samt i relaterede videnskabelige undersøgelser i Danmark på tværs af danske universiteter i forbindelse med turisme og havpattedyr. Resultaterne af disse undersøgelser vil blive formidlet gennem tidsskrifter, konferencer og populær formidling af projektet, inklusiv af Miljøstyrelsen selv.</p> <p>Alt skriftlig og mundtlig feedback vil være fortrolig, således at kun anonymiseret information vil blive afleveret og publiceret. Ligeledes vil alle data vedrørende økonomi, herunder antal solgte billetter kun blive opgjort, afleveret og publiceret på nationalt niveau, således at ingen enkeltvirksomheder vil kunne identificeres.</p>	(Svar ja)
Spørgsmål om jeres historie og forventninger til fremtiden		
1	Hvad er navnet på virksomheden/institutionen, der gennemfører turene?	
2	Hvor længe har I foretaget ture rettet mod at se havpattedyr? (angiv årstal i var aktive)	
3	Hvordan har I oplevet udviklingen i efterspørgslen på sådanne ture over de sidste fem år? (vælg en)	Stigende Uændret Faldende Svingende
4	Hvor mange billetter solgte I samlet set i sæsonen 2021?	
5	Hvor mange af disse var børn/voksne, og udlændige hvordan definerer i dette?	
6	For hvor mange penge solgte I samlet set billetter i 2021? (Hvis I ikke har de specifikke tal, så angiv gerne jeres bedste estimat)	
7	Giver turene overskud i sig selv, eller modtager I nogen form for ekstern økonomisk støtte, i så fald, hvorfra?	
8	Hvad er jeres forventninger i forhold til antallet af solgte billetter 2022 i forhold til de seneste tre år gennemsnit?	Stigende Uændret Faldende Svingende
9	Hvad er jeres generelle forventninger til fremtiden i forhold til antallet af gæster? (vælg en)	Stigende Uændret Faldende

		Svingende
10	Hvad er jeres generelle forventninger til fremtiden i forhold til antallet af årlige ture? (<i>vælg en</i>)	Stigende Uændret Faldende Svingende
11	Har I detaljerede opgørelser og/eller kvalificeret bud på antal gennemførte ture og solgte billetter for de seneste år, som I ville være villige til at dele i forbindelse med turisme-relateret forskning?	
Spørgsmål om hvor og hvornår I gennemfører ture		
12	Fra hvilken lokalitet starter jeres ture?	
13	I hvilke måneder gennemfører I ture?	
14	Hvor mange gange på en uge besøger I i gennemsnit den mest besøgte lokalitet?	
15	Hvor central er observationen af havpattedyr for jeres salg af turene, hvori det indgår? (<i>vælg en</i>)	Det er hovedattraktionen Det er en mindre del af turene Det er udgør kun en lille del af turene
16	Hvilke arter observerer I?	
17	Hvilke lokaliteter besøger I primært for at observere havpattedyrene?	
18	Har I ændret jeres primære observations-lokalitet de seneste par år, og hvis ja hvorfor og hvorfra?	
Spørgsmål om hvad I og jeres gæster oplever på turene		
19	Hvis I transporterer jeres gæster, hvordan gør i så dette (fx båd, bus, til fods eller andet)?	
20	Hvor længe opholder I jer i gennemsnit ved det/de primære observationssted (minutter)?	
21	Hvilken afstand holder I oftest til havpattedyrene (angiv i meter)	
22	Hvordan vurderer I, hvorvidt I er kommet for tæt på?	
23	Hvis I observerer sæler på deres hvilepladser, hvor ofte observerer I så at mere end 25% af dyrene forlader deres pladser og går i vandet i forbindelse med jeres tilstedeværelse? (angiv % af gange)	
24	Hvor tæt forventer gæsterne at komme på dyrene?	
25	Laver I en forventningsafstemning med gæsterne omkring passende adfærd og afstand til dyrene?	
26	Har I nogle retningslinjer i forhold til adfærd omkring dyrene I følger, og hvis ja hvilke, og introduceres gæsterne også for disse som en fast del af turene?	
27	I forhold til jeres oplevelser med dyrenes respons på jeres og andre eventuelle turistoperatører i 2021, hvordan synes i så det turismentiveauet var generelt i de områder i opsøger? (<i>vælg et svar</i>)	Der kan sagtens være flere turistture Det er et godt niveau Der er for mange turistture
Generelt om jeres sektor		
28	Såfremt der skulle blive udviklet nationale retningslinjer/guidelines for kommerciel havpattedyrturisme, ønsker I så at overholdelse bliver frivillig eller ophævet til lov?	
29	Har I ideer til tiltag som myndigheder/stat/kommuner eller andre kunne gøre for at støtte jer og jeres aktiviteter, eller	

	har I gode eksempler på dette som Miljøstyrelsen skal gøres opmærksom på?	
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6.1.2 Annex B: Introduction email to operators

Til virksomheder der udbyder kommercielle havpattedyr-relaterede aktiviteter

Jeg skriver til jer i anledning af, at Miljøstyrelsen ønsker at få udarbejdet en status for omfanget af kommercielle turistaktiviteter rettet mod havpattedyr (sæler, marsvin og delfiner) i Danmark. Kortlægningen gennemføres af Institut for Akvatiske Ressourcer ved Danmarks Tekniske Universitet (DTU Aqua) og Institut for Ecoscience ved Aarhus Universitet og skal følge op på et lignende studie fra 2015, for at opnå et overblik over udviklingen i sektoren i relation til særligt placering, efterspørgsel og bæredygtighed mm.

Jeg håber, at I i den forbindelse vil bruge ca. fem minutter på at besvare spørgsmålene i det vedhæftede skema. Såfremt der er spørgsmål, I ikke mener I kan give detaljerede svar på, er estimer/bedste gæt også værdifuldt.

NOTE: Da besvarelsen af visse spørgsmål kan inkludere delingen af konkurrencemæssigt sensitive data for jer som virksomhed, skal vi understrege at alle resultater inden for økonomisk omsætning, antal solgte billetter mm. vil blive puljet og afrapporteret på nationalt niveau til Miljøstyrelsen, således at ingen enkeltvirksomheder vil kunne identificeres. Kommende videnskabelige publikationer eller præsentationer på baggrund af data vil ligeledes afspejle dette.

Med venlig hilsen

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