Project plan on analysing marine debris and its impacts on marine mammals in German waters

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Abstract

Germany is planning to conduct an analysis of all available data on marine debris, collected during aerial and ship surveys as well as mapping of findings of debris on beaches. As part of this evaluation the Institute for Terrestrial and Aquatic Wildlife Research (ITAW) of the University of Veterinary Medicine in Hannover, Foundation, Germany is going to evaluate data from aerial surveys for harbour porpoises conducted since 2002, during which sightings of marine debris have been recorded. Spatio-temporal distribution patterns of floating marine debris shall be investigated and possible trends and hotspots over the years identified. Furthermore, by the integration into a drift model, aggregations of debris shall be back-tracked to their origin. In order to gain information on the impacts of marine debris on marine mammals, findings of marine debris in stranded marine mammals collected along the coast of Schleswig-Holstein, Germany and during necropsies at the ITAW will be evaluated. Additionally, faeces of marine mammals (harbour porpoises, harbour and grey seals) will be examined for micro debris to prove the existence of smallest particles of marine debris in top predator species.
A first analysis of data on floating marine debris has been conducted for the NATURA 2000 area 'Sylt Outer Reef' (German EEZ) and showed encouraging results with respect to the planned approach. Annual and seasonal variations could be detected, while further analysis will be necessary to see the results in a greater context. Here we present an outline of the planned project as well as results from the assessment for the SCI 'Sylt Outer Reef'.

Introduction

For the implementation of the Marine Strategy Framework Directive (MSFD) Germany is obliged to obtain a "good environmental status" (GES). In the course of this commitment, Germany has to work out the dimensions of the problems caused by marine debris to provide a foundation on which effective protecting measures can be created.
The quantity of marine debris in the world's oceans is increasing due to the continuous growth of the world's population and its rising demand of packaging materials (Katsanevakis, 2008; Hammer, 2012). Therefore, investigations on distribution, locations, sources and impacts of marine debris gain in importance in order to define the problem and find solutions to counteract the increasing amount of debris.
The amount of marine debris in the German Exclusive Economic Zone (EEZ) in all compartments (sea floor, water column, surface) is widely unknown. Thiel *et al.* (2011) conducted ship surveys to investigate the spatio-temporal distribution of floating marine debris in the German Bight. The study revealed up to 50 items per km² with floating plastics making up the largest part of sighted marine debris (70%). It is estimated, that the total amount of debris on the sea floor of the North Sea forms a volume of 600.000 m³; 70.000 m³ are being added annually (OSPAR, 2000). Furthermore, 75 % of the whole marine debris amount in the southern North Sea is thought to consist of plastics (OSPAR, 2009). The determination of the origin of marine debris is difficult to track as items can be transported over large distances (Hammer, 2012; Kukulka *et al.*, 2012).
As described by Scheidat and Feindt-Herr (2012) sighting data on marine debris collected during aerial surveys for marine mammal assessments can be a valuable data source for analyses of marine debris distribution.

The ITAW has been collecting data on floating marine debris during aerial line transect surveys for cetaceans in German waters since 2002 (Gilles *et al.*, 2009). Apart from a pilot study by Herr (2009) these data have not been analysed yet. The pilot study used data from 2002-2006 for identification of marine debris densities and distributional patterns and found an association of the distribution with densities of sea traffic. The complete data

set shall now be analysed and shall answer the question of spatio-temporal distribution of marine debris in German waters, as well as potential annual and seasonal trends.
Marine debris is known to impact marine mammals by entanglement (Page *et al.*, 2004; Allen *et al*., 2012; Moore *et al.*, 2013), suffocation (de Stephanis *et al.*, 2013), starvation (Sheavly & Register, 2007) and accumulation of micro plastics in the food web (Farrell & Nelson, 2013).
The ITAW has been collecting carcasses of marine mammals since 1990 (harbour porpoises, *Phocoena phocoena*) respectively 1995 (harbour seals *(Phoca vitulina)* and grey seals *(Halichoerus grypus)*). Findings of marine debris have been documented during necropsies. In the course of this research project, the whole database will be analysed to extract all entries concerning marine debris and to make a statement on quantities and identified effects (e.g. injuries, cause of death).

Material and Methods

Aerial surveys were conducted from 2002 to 2014 in the German EEZ and 12 nm zone of the North and Baltic Sea (e.g. Scheidat *et al.*, 2008, Gilles *et al.*, 2009, Dähne *et al.*, 2013). Aerial surveys were conducted following standard line transect distance sampling methodology (Buckland et al., 2001). While the surveys focused on marine mammals, data on marine debris were recorded alongside, however not noting the declination angle. Declination angles are used in aerial surveys to calculate the distances of the detected objects to the transect line in order to identify the effectively covered strip width. For marine debris, the data do not allow for a calculation of the strip width as they lack the information on the distances to the transect line.

To obtain information on floating marine debris, the database on aerial surveys has to be analysed and debris sightings extracted. The different categories (debris [plastic, wood]; net debris [nets, fishing gear, lost buoys]) has to be counted and divided through the flown distance (sighting rates: items/km). Data have then to be inserted into ArcGIS 10.1 (Esri) to evaluat spatio-temporal distribution patterns of marine debris in the German North Sea.

To gain information about the density (item/km²) of marine debris at a later stage of the planned project, it is intended to conduct at least two survey flights dedicated to marine debris only, measuring the declination angle for each detected item of marine debris. These data would allow for strip width calculation which might provide a basis for retrospective analysis of the sighted debris.

Furthermore, the results will then be incorporated into a drift model for a first approach to identify possible sources and future whereabouts (Yoon *et al.*, 2012). The data will then be correlated statistically with collected debris on beaches in the course of the OSPAR beach monitoring (OSPAR, 2009).

The database of macro debris findings during necropsies will be analysed to gain more information on the impacts of debris on the three marine mammal species in German waters. Therefore, information on marine debris will be extracted and analysed with a special focus on debris type, trend over the years and most affected age-groups.

During necropsies conducted on strandings and by-catches collected along the coast of Schleswig-Holstein marine debris is recorded on macroscopical and histological level (Siebert *et al.*, 2001) and effects are assessed. Samples of faeces are going to be analysed to learn more about the possible amount of the smallest compounds of marine debris. The impacts of micro debris on marine mammals are mostly unidentified. The samples will be analysed with the Fourier-Transform-Infrared-Spectrometer (FT-IR Imaging; Löder & Gerdts, 2013).

First results

First preliminary results provide an insight on varying seasonal and annual relative densities and distribution of marine debris in the NATURA 2000 site of community interest (SCI) 'Sylt Outer Reef' (Unger *et. al.*, 2014). Analysis revealed annual and seasonal variations in the amount of sighted debris. Compared by years, the highest amount of both, debris and net debris was recorded in **2006**, the lowest in **2009** (see table 1).

Table 1: Comparison of sighting rates for **years**

	Average sighting rate	Proportion (%)	2006	2009
Debris	0.17	86	0.81	0.049
Net debris	0.019	14	0.03	0.017

Compared by seasons, the amount of sighted debris for both, debris and net debris was highest in **summer**, the lowest in **autumn** (see table 2; winter was excluded due to insufficient data for this season).

Table 2: Comparison of sighting rates for **seasons**

	Average sighting rate	Proportion (%)	Summer	Autumn
Debris	0.4	89	1.25	0.15
Net debris	0.06	11	0.23	0.02

Conclusion

The high amount of debris in 2006 might be explained by the storm "Gudrun" of the preceding year. The high quantity in the summer months might be on account of the location of the nature reserve. Due to its spatial proximity to the holiday island of Sylt (tourists at the beaches, cruise liners, pleasure crafts and vessels of recreational fisheries) and the nearby priority area for ship traffic, the high amount in summer is striking compared to the other seasons.

This first analysis for a pilot area shows that spatio-temporal variations of marine debris occurrence are likely to be detected in the German North Sea. Furthermore, the results have to be put into a larger context to reveal whether the analysed area is exceptional in its variations and how striking the amount of marine debris is compared to other areas in the greater North Sea.

References

Allen, R., Jarvis, D., Sayer, S., Mills, C. (2012) Entanglement of grey seals *Halichoerus grypus* at a houl out site in Cornwall, UK. *Mar. Pollut. Bull.* 64:2815-2819.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L., Thomas, L. (2001) Introduction to distance sampling. Estimating abundance of biological populations. *Oxford University Press, New York*: 448 pp.

Dähne, M., Gilles, A., Lucke, K., Peschko, V., Adler, S., Sundermeyer, J., Siebert, U. (2013) Effects of pile-driving on harbour porpoises (*Phocoena phocoena*) at the first offshore wind farm in Germany. *Environ. Res. Lett.* 8:16 pp.

De Stephanis, R., Giménez, J., Carpinelli, E., Gutierrez-Exposito, C., Cañadas, A. (2013): As main meal for sperm whales: plastic debris. *Mar. Pollut. Bull.* 59:206-2014.

Farrell, P., Nelson, K. (2013) Trophic level transfer of microplastics: *mytilus edulis* (L.) to *carcinus maenas* (L.). *Environ. Pollut.* 177 (1-3):3 pp.

Gilles, A., Scheidat, M., Siebert, U. (2009) Seasonal distribution of harbour porpoises and possible interference of offshore wind farms in the German North Sea. *Mar. Ecol.-Prog. Ser.* 383:295–307.

Hammer, J., Kraak, M.H.S., Parsons, J.R. (2012) Plastic in the marine environment: the dark side of a modern gift. In: Whitacre, D.M. [Ed.]: Reviews of Environmental contamination and Toxicology. *Rev. Environ. Contam. T.* 220:44 pp.

Herr, H. (2009): Vorkommen von Schweinswalen (*Phocoena phocoena*) in Nord- und Ostsee – Im Konflikt mit Schifffahrt und Fischerei? Dissertation: 120 pp.

Katsanevakis, S. (2008) Marine debris, a growing problem: Sources, distribution, composition and impacts. In: Hofer, T. [Ed.] Marine Pollution: New Research. *Nova Science Pub Inc.*:53-100.

Kukulka, T., Proskurowski, G., Morét-Ferguson, S., Meyer, D.W., Law, K.L. (2012) The effect of wind mixing on the vertical distribution of buoyant plastic debris. *Geophys. Res. Lett.* 39:6 pp.

Löder, M. and Gerdts, G. (2013) FT-IR analysis for monitoring marine microplastics. *YOUMARES* 4, Oldenburg, 11 September 2013 - 13 September 2013.

Moore, M.J., van der Hoop, J., Barco, S.G., Costidis, A.M., Gulland, F.M., Jepson, P.D., Moore, K.T., Raverty, S., McLellan, W.A. (2013) Criteria and case definitions for serious injury and death of pinnipeds and cetaceans caused by anthropogenic trauma. *Dis. Aquat. Org.* 103:229-264.

OSPAR (2000) Quality Status Report 2000. Region II, Greater North Sea:149 pp.

OSPAR (2009) Marine litter in the North-East Atlantic Region: Assessment and priorities for response. London, United Kingdom:127 pp.

Page, B., McKenzie, J., McIntosh, R., Baylis, A., Morrissey, A., Calvert, N., Haase, T., Berris, M., Dowie, D., Shaughnessy, P.D., Goldsworthy, S.D. (2004) Entanglement of Australian sea lions and New Zealand fur seals in lost fishing gear and other marine debris before and after government and industry attempts to reduce the problem. *Mar. Pollut. Bull.* 49:10 pp.

Scheidat, M., Gilles, A., Kock, K.H., Siebert, U. (2008) Harbour porpoise *Phocoena phocoena* abundance in the southwestern Baltic Sea. *Endang. Species Res.* 5: 215–223.

Scheidat, M., Feindt-Herr, H. (2012) Collecting data on marine debris during cetacean aerial survey. IWC Paper SC/64/E15. International Whaling Commission, Cambridge, UK.

Sheavly, S.B., Register, K.M. (2007) Marine debris and plastics: environmental concerns, sources, impacts and solutions. *J. Polym. Environ*. 15:301-305.

Siebert, U., Wünschmann, A., Weiss, R., Frank, H., Benke, H. and Frese, K. (2001) Post mortem findings in harbour porpoises (*Phocoena phocoena*) from the German North and Baltic Sea. *J. Comp. Pathol.* 124:102-114.

Thiel, M., Hinojosa, I.A., Joschko, T., Gutow, L. (2011) Spatio-temporal distribution of floating objects in the German Bight (North Sea). *J. Sea. Res.* 65:368-379.

Unger, B., Feindt-Herr, H., Gilles, A., Siebert, U. (2014) Evaluation of spatio-temporal distribution patterns of marine debris in the SCI Sylt Outer Reef. Poster presentation on the 28th Conference of the European Cetacean Society, Liège, Belgium, 5th – 9th April, 2014.

Yoon, J.-H., Kawano, S., Igawa, S. (2010) Modeling of marine litter drift and beaching in the Japan sea. *Mar. Pollut. Bull.* 60:448-463.