Collection and Analysis of Data on Occurrence, Distribution and Abundance of Cetaceans in the Southern Ocean Following International Standards

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by

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Short Version

Information on local densities, spatial distribution and habitat use of cetaceans in Antarctic waters is important for the assessment of effects of human activities within the habitat of the animals. Seismic explorations in particular yield high potential for severely disturbing cetaceans. Any application of seismic surveys as well as scientific investigations in the Antarctic is subject to official authorisation according to the German act on implementation of the Protocol on Environmental Protection to the Antarctic Treaty (PEPAT 1991). For the according appraisal of proposed activities by the responsible authorities, reliable data are needed as a basis for judgement, e.g. data on distribution, density and habitat use of cetaceans.

Several survey methods for cetacean population assessment were employed by the Alfred-Wegener-Institute, Helmholtz-Centre for Polar and Marine Research (AWI) and the Institute for Terrestrial and Aquatic Wildlife Research (ITAW) during two expeditions of RV Polarstern in the Austral summers of 2008 (ANT25-2) and 2010 (ANT27-2). Besides a general advance in knowledge on cetacean occurrence and densities in the Antarctic, a main aim of these assessments focused on testing the applicability of different survey methods for mitigation, especially with respect to seismic experiments.

Within the framework of this project, the ITAW conducted shipboard (i.e. crow’s nest) and aerial (helicopter) distance sampling surveys as well as a tracking study. In addition, the ITAW drafted a concept for concomitant biological investigations in the Antarctic (Konzept für "Biologische Begleituntersuchungen in der Antarktis"), in order to provide a tool for standardisation as well as baseline data necessary for the optimisation of future cetacean assessments, especially to ensure data quality standards and provide a potential framework for joint analyses. Within the framework of the partner project "Implementation of the monitoring agreement between AWI and UBA for the protection of whales" (FKZ 3708 91 10 1), the AWI tested an infrared camera system for the automated detection of whale blows. Additionally, the AWI analysed opportunistic data on cetacean sightings systematically recorded by nautical personnel on board of RV Polarstern (Walog). The results of all applied survey methods were suitably compared in order to assess the efficiency of each method as well as to evaluate its applicability within different contexts, e.g. mitigation. This report is solely devoted to the work and analyses conducted by the ITAW, their corresponding results as well as the results stemming from the comparison of methods. The concept "Konzept für "Biologische Begleituntersuchungen in der Antarktis" was drafted as a separate document in German only and is not part of this summary.

Distance sampling is a widely established method for the assessment of population parameters of wildlife populations, such as density and abundance. Dedicated observer teams travel along previously designed transect lines across a certain period of time and record all sightings of the
target species and the exact (bound within the available resolution) distance of the recorded sighting to the transect line. The probability of detecting an animal at any given distance from the transect line can then be estimated numerically. Based on a model distribution, a detection function is then applied to the recorded data and enables error estimation as well as the integration of covariates within the model (typically environmental parameters and sighting conditions). Using the modelled detection function, the effectively covered area can be calculated, which, in combination with recorded sighting numbers, provides a base for density estimation. The shipboard surveys by the ITAW were conducted along transect lines defined by the ship course. The helicopter surveys provided the opportunity to cover expanded areas around the ship comparably autonomous of the vessel’s course. Ideally, line transects are spatially placed following a design to representatively cover a predefined survey area. Equal coverage allows spatial population parameters such as density and abundance to be estimated and to represent the whole of a given survey area. If spatial coverage of a certain survey area cannot be obtained, the estimated population parameters can only describe the locally recorded population along the surveyed strip.

By defining appropriate survey areas along the ship’s track, survey effort was assigned to different strata. Based on geographical and ecological criteria, 5 strata were defined: (SA: South Africa to 60°S, NM: Area around Neumayer Station III to 60°S, WS: Weddell Sea, AAS: Antarctic Sound, WAP: West Antarctic Peninsula, Figure 1).

Figure 1: Survey strata: South Africa (SA), Neumayer (NM), Weddell Sea (WS), Antarctic Sound (AAS) and West Antarctic Peninsula (WAP).
Tracking of single sightings of cetaceans or cetacean groups was conducted along with the shipboard distance sampling survey. During tracking periods, the observer tries to follow a sighting for as long as possible, by means of high powered binoculars (“Big Eyes”), recording every sighting / resighting of animals or groups, noting their angle and their distance to the ship. Using this information, the approaching or avoidance behaviour of animals towards the ship can be assessed.

Within the framework of this project, four methods were compared by the ITAW to assess their respective advantages and disadvantages:

a) Helicopter survey (distance sampling) vs. crow’s nest survey (Distance Sampling)

b) crow’s nest survey (distance sampling) vs. bridge personnel (WALOG)

c) Tracking sightings (distance sampling) vs. bridge personnel (WALOG)

d) crow’s nest sightings (distance sampling) vs. IR camera detections

We used the respective density estimates as well as measures of efficiency of both helicopter and crow’s nest surveys for a comparison between the two distance sampling methods. To assess the quality and scope of bridge personnel and IR camera data, we compared the limited time periods where both, crow’s nest surveys and the above-mentioned methods, were on effort. Overlapping time intervals between IR detections / bridge personnel and crow’s nest sightings were plotted and, after manual inspection of each time interval, verified as possible concordances or falsified, respectively. Using each method’s number of definite detections during that period of time, we could estimate the success rate of each of the three methods in relation to each other.

The combined effort of the helicopter surveys was 28,273 km. 268 observations were made comprising 753 animals of various cetacean species. Total combined effort of crow’s nest surveys was 2,885 km, along which 105 observations comprising 198 cetaceans were made. Humpback whales (*Megaptera novaeangliae*) accounted for the majority of sightings in both survey methods (helicopter: 98 sightings, 215 individuals; crow’s nest: 39 sightings, 75 individuals), followed by Antarctic minke whales (*Balaenoptera bonaerensis*) (helicopter: 63 sightings, 86 individuals; crow’s nest: 30 sightings, 39 individuals). Robust minimal densities could be obtained for humpback whales, large whales (defined as sperm whales, unidentified large whales and all baleen whales except minke whales) and Antarctic minke whales.

The Western Antarctic Peninsula (WAP) and the Antarctic Sound yielded the highest density estimates in large whales (stratum WAP: helicopter: 0.0149 ± 0.0035 animals / km²; crow’s nest: 0.0496 ± 0.0248 animals / km; stratum AAS: helicopter: 0.0103 ± 0.0098 animals / km²; crow’s nest: 0.1519 ± 0.0311 animals / km²). Minke whale density was highest within the Weddell Sea (stratum WS: helicopter: 0.0115 ± 0.0053 animals / km²; crow’s nest: 0.0281 ± 0.0192 animals / km²).
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km²). During helicopter surveys, the stratum WAP yielded the highest estimated density of humpback whales (helicopter: 0.0119 ± 0.0031 animals / km²; crow's nest: 0.0281 ± 0.0192 animals / km²). The highest estimated density of humpback whales was based on crow’s nest data from the Antarctic Sound (AAS; 0.1392 ± 0.0446 animals / km²).

During crow’s nest surveys, the encounter rates (sightings / km) increased in all three whale groups towards the south / west and mostly reach their peak within the Antarctic Sound. The encounter rates of the helicopter survey indicate a similar pattern, however, there were no sightings of large whales within NM, WS and AAS.

Due to the adequate coverage of the stratum WAP by the helicopter survey and a sufficient sample size, a minimal estimate of abundance and density could be estimated for humpback whales, fin whales and minke whales. We estimate the 322,303 km² area to host a minimum abundance of 3,960 [95% CI: 2,396 – 6,523] humpback whales, 200 [33 – 1,065] fin whales and 3,228 [832 – 12,280] minke whales.

During the crow’s nest survey, a total number of 11 humpback whale and 4 minke whale pods could be tracked subsequently. Using results from generalized additive modelling, first evidence of humpback whales approaching the vessel was found, while minke whales seemed to be more erratic and their behaviour did not indicate any directed movement towards or away from the vessel.

A comparison between crow’s nest surveys and helicopter surveys showed significant differences in encounter rates and local densities in all species. Densities based on crow’s nest data were on average higher, albeit associated with larger errors. We tested for significant differences between the estimates using a two sided z-test. Only the large whale estimate in the Antarctic Sound (AAS) was significantly different between crow’s nest and helicopter surveys (p < 0.05, z-score: 4.3426). In minke whales, only the densities in NM were significantly different (p < 0.05, z-score: 2.3988).

The results of this project underline the little statistical difference between the different survey methods. The emphasised advantage of higher encounter rates in shipboard surveys compared to aerial surveys is immediately counterbalanced by the benefits of the helicopter survey:

- high spatial coverage in lesser amount of time
- larger sample size in shorter time
- independence from vessel course
- independence from behavioural reactions to the platform by target species (as demonstrated in tracking study)
- higher rate of species identification (as unidentified sightings can be approached)
effective usage of small weather windows of adequate sighting conditions
- results associated with lower statistical errors

The comparison between bridge personnel and the crow's nest survey identified 39 sightings by bridge personnel that fell into periods of a concurrent distance sampling survey from the crow's nest. 25 of these were also recorded by the crow's nest observers. The crow's nest detected a total of 147 sightings during the same time, of which the bridge personnel was able to detect 33 sightings. A total of 114 of all 128 sightings recorded on the ship were made from the crow's nest (omitting the duplicates in both surveys). A total of 22.45% [95% CI: 15.98% - 30.06%] of all crow's nest sightings could be detected by bridge personnel, while 64.10% [47.18% - 78.80%] of all detections recorded by the bridge personnel were also observed by the crow's nest observers. 89.06% [82.33% - 93.89%] of all sightings within the time of overlapping bridge personnel and crow's nest survey were made by the crow's nest survey. The comparison of tracking sightings and bridge personnel sightings yielded a success rate of 31.58% [95% CI: 12.58% - 56.55%] by the bridge personnel.

The IR camera detected 22 of 53 sightings made by the crow’s nest (41.51% [28.14% - 55.87%]) during concurrent effort periods. As the camera detections cannot yet be aggregated to reflect cetacean individual or group numbers, but instead represent records of cues, it was not possible to conduct the comparison between IR camera and crow’s nest survey in the other direction, checking how many of the animals detected by the IR camera have also been recorded by the crow’s nest.

Both, aerial as well as shipboard surveys showed the ice covered Weddell Sea as well as the area around the Neumayer Station III to host comparably high numbers of minke whales. The western Antarctic Peninsula displayed a higher species diversity, however dominated by humpback whales.

The often highlighted disadvantage of low encounter rates in aerial surveys due to the high survey speed of aircrafts, resulting in low density estimates compared to ship based surveys could not be validated. Even though aerial surveys did yield lower encounter rates, the density estimates based on the surveys did not differ statistically significantly from each other. On the contrary, the associated errors of the results of the aerial surveys were much smaller than those of the crow's nest survey. In addition, helicopter surveys allowed to cover large areas in short time and autonomously from the vessel’s course. The abundance estimates for the West Antarctic Peninsula can be regarded as robust minimal estimates and provide a valuable addition to the current knowledge on the distribution and abundance of whales in Antarctica.

The successful tracking study shows the feasibility of such a study and provides first indications for possible effects of whale behaviour on detectability during ship-based line transect surveys.
However, due to the small sample size, the results as presented here are but strong plead to further investigate the effect of observer vessels on whale behaviour. Since detectability on the transect line and is crucial to distance sampling surveys, incorporation of such information is vital for the assessment and analyses and for the planning of future surveys (e.g. through adopting double platform surveys).

The comparison of methods showed specific advantages of each approach. Distance sampling as the only method can provide density and abundance estimates. The results from the helicopter surveys in particular underline the feasibility of design-based line transect surveys in Antarctica. It is therefore recommended to maximize the effort to enable dedicated distance sampling surveys during expeditions to Antarctica. Other than the distance sampling survey, the IR camera and the bridge personnel are available at all times. The camera can operate day and night and thus provide valuable data especially when light conditions prevent visual surveys. This is especially useful for mitigation at all times. However, the IR camera is not (yet) able to identify species and to aggregate recorded cue detections to reflect individual numbers and can thus not provide information on population parameters. The bridge is “on effort” 24 hours per day and therefore able to collect comparably large numbers of opportunistic sightings over time. The sighting records of the bridge personnel however do not represent a dedicated survey. They lack effort information and miss a high share of animals, as shown by distinctively lower sighting numbers compared to the crow’s nest survey during the same time periods of time. Bridge personnel sightings thus do not allow any estimate of abundance due to the lack of real measures of effort, thanks to their permanent availability however, bridge personnel records are a valuable data source for habitat suitability modelling.

Concerning the mitigation of seismic explorations, the IR camera is irreplaceable. Permanent availability, 360° coverage of the sea surface and high detection rates of all blows guarantees quick alerts on whale presence for mitigation procedures. As long as the conditions allow, a dedicated cetacean survey may be able to detect more animals and to guarantee appropriate mitigation. Especially small cetaceans and those not producing detectable blows can only be detected by human observers. A combined effort of both methods would therefore provide an ideal procedure for mitigation.

The surveys conducted during this project produced estimates of density and abundance of cetaceans in Antarctica. A long term result and temporal comparisons however can only be obtained through regular surveys of the same areas over a larger period of time. Surveys in other parts of the ocean are needed to add more abundance and density information on cetaceans in Antarctica and extend the coverage of dedicated cetacean surveys in the Southern Ocean. Using distance sampling data in spatial models such as density surface models would provide valuable information for extended areas, and, in combination with congruently
developed habitat suitability models, could inform on actual usage of proposed key habitats. We therefore recommend to maximise efforts to incorporate *distance sampling* surveys during expeditions to the Antarctic. Cetacean assessments should become standard and follow procedures as outlined in the concept for concomitant biological investigations in the Antarctic.