Methodology for producing consensus maps of known and probable occurrence of cetaceans in the Wider Caribbean Region in support of the Caribbean LifeWeb Project

Kristin Kaschner & Randall Reeves, March 2011

Study area definition:
We defined the IUCN-WCPA Marine Region 7 for the Wider Caribbean Region as our study area, since this fully covers the Cartagena Convention Area, but also allows direct comparison with other efforts visualizing cetacean data availability (e.g. Williams et al. 2011). The Cartagena Convention (Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region) forms the basis of this study and Article 2 defines the Convention Area as the "marine environment of the Gulf of Mexico, the Caribbean Sea and the areas of the Atlantic Ocean adjacent thereto, South of 30 degrees North latitude and within 200 nautical miles of the Atlantic coasts of the Member States".

Taxonomic coverage:
For the purpose of this study we limited ourselves to those marine mammal species known or documented to occur regularly in the Wider Caribbean Region. We specifically did not include species, such as harbour porpoises (*Phocoena phocoena*) or fin whales (*Balaenoptera physalus*), for which only fringes of the known distribution overlap with the study area as defined above. We mapped known and probable occurrence of 25 marine mammal species in the Wider Caribbean Region using available information from the literature about species occurrence and regional habitat usage (Table 1). For the majority of species (n=22), we used the AquaMaps approach (Kaschner et al. 2008) to produce consensus maps of regional distributions, however, due to time constraints, an in-depth review of AquaMaps input parameter settings, incorporating regional information, was restricted to only 17 species. For five species, default global predictions were kept, which were, however, comparable in quality to reviewed outputs. For three species (the long-beaked common dolphin, the West Indian manatee and the humpback whale) maps were produced relying solely on published information on regional species occurrence and improved based on input from experts. To allow easy and direct

comparison and the generation of species richness maps, all species distribution maps were converted to 0.5 degree cells (see below).

AquaMaps approach

Aquamaps is an online species distribution model (www.aquamaps.org) that allows the generation of standardized digital range maps of aquatic species, currently covering more than 11 000 species. Maps are generated using a modified version of the relative environmental suitability model (RES) developed by (Kaschner et al. 2006) that uses available information about habitat usage of a given species, projected into geographic space, to help visualize its distribution. Habitat usage is quantitatively described with the help of so-called environmental envelopes defining a species' preference with respect to a set of pre-defined environmental conditions, including depth, sea-ice, temperature, salinity and primary production. By default, envelopes are derived from occurrence records available through GBIF (www.gbif.org) supplemented by additional information obtained through online species databases such as FishBase (www.fishbase.org) and SeaLifeBase (www.Sealifebase.org). Acknowledging the sampling biases of currently available online occurrence data, however, AquaMaps explicitly also allows for experts to review and modify environmental envelopes manually. Map outputs represent gradients of relative habitat suitability or species occurrences (ranging from 0.00 – 1.00), predicted for each 0.5 degree latitude by 0.5 degree longitude cells, from which binary range maps may be derived using presence thresholds ideally defined by validation analysis (Kaschner et al. 2011) (see below). AquaMaps predictions for different species have been validated using independent data sets (Kaschner et al. 2006, Ready et al. 2010, Kaschner et al. 2011) and generally capture existing knowledge of large-scale, long-term annual average species occurrence reasonably well. However, given the overall paucity of data and the frequently large sampling biases in the marine environment, produced outputs should be regarded as hypotheses of species occurrence, based on a clearly defined set of assumptions that can be tested and further refined as new data become available. Moreover, since cetacean habitat usage often varies across seasons and ocean basins, global predictions should not be used without further review to describe regional species occurrence (and should ideally be checked against independent data) and the overall limitations of data availability, model biases and assumptions etc. should be kept in mind when using produced outputs for management purposes.

Regional review of AquaMaps predictions

In the context of the LifeWeb WCR project we tried to optimize available global AquaMaps predictions by incorporating regionally available data and information using the following procedure:

As a first step, Kaschner analysed all regional point occurrence records of cetaceans that were available for download through OBIS (www.iobis.org) in November 2011. It should be noted, however, that OBIS data sets are by no means comprehensive and do not currently include anywhere near to all known occurrences of all species in the WCR. Data availability (particularly density data) varies greatly for different species and is heavily biased towards US waters in the northern Gulf of Mexico. To determine regional habitat usage of the species based on the regional point data, Kaschner started off by trying to correct for the lack of available effort information by calculating so-called species-specific ***relative encounter rates (REnc)*** (ranging from 0.0 – 1.0) for each 0.5 degree cell by lumping all occurrence records across all seasons and years and then determining the proportion of sightings attributed to the species in question. The basic idea behind the REnc is that proportionally higher sighting rates of species should be expected in areas corresponding to their preferred habitat. Using this information, she calculated the 10th and 90th percentile of environmental parameter distribution of all cells where the calculated relative encounter rate was greater than 50% (i.e. at least 50% of all sighting events lumped across all seasons and years in this cell were of that given species) and excluding all cells where there was just a single sighting event. Using these values and whatever information about habitat usage could be found in the literature, she adjusted global default envelope settings as needed and subsequently re-generated predictions of relative habitat suitability/species occurrence. If the available information was judged inconclusive or inadequate in some way, several hypotheses of species occurrence were generated and the gradient maps were shared with Reeves before selecting the best fit with known occurrences and documented absences for the species.

Finally, using this best-fit hypothesis, Kaschner applied a presence threshold of 0.6, as suggested by recent validation analyses (Kaschner et al. 2011), to generate a consensus map showing the most likely representation of known and probable occurrence of the species in the WCR.

For all species including those listed in Table 1 as 'non-reviewed', Kaschner and Reeves at least conferred with each other to decide how far to go with the process of reviewing and revising the outputs generated in the manner described above. For most species, Reeves carried out a quick review of literature (in close consultation and collaboration with Kaschner) to help tweak envelope settings and evaluate interim outputs. In addition, for selected species, Reeves asked experts on the species or geographical area to provide advice, overlooked literature, and in some cases iterative evaluations of the model outputs. We refer to this aspect of the work as a Delphic process even though most of the consultations with experts were one on one (i.e. Reeves either met and talked with the individual or corresponded with him/her via e-mail) rather than in an interactive group format.

Species richness maps

Kaschner subsequently produced species richness maps by overlaying consensus maps of known and probable occurrence of all 25 species and then counting the number of species present in each 0.5 degree cell. Please note that resulting species richness maps are intended to highlight those areas where highly suitable habitat of many species spatially overlaps, but, because of the selected threshold settings, do not represent a complete inventory of species known to occur in each cell (see also Kaschner et al, 2011 & Kaschner et al, 2011, Supplementary online material for more background information on the effects of threshold settings.)

Scientific name	IUCN status	AquaMaps - reviewed	AquaMaps - non-reviewed	Delphic range map	Quality of output maps
Balaenoptera edeni/brydei	DD	1			3
Delphinus sp.	DD			1	4
Feresa attenuata	DD	1			2
Globicephala macrorhynchus	DD	1			3
Grampus griseus	LC		1		3
Kogia breviceps	DD		1		2
Kogia sima	DD		1		2
Lagenodelphis hosei	LC	1			2
Mesoplodon densirostris	DD	1			2
Mesoplodon europaeus	DD	1			1
Megaptera novaeangliae	LC			1	3
Orcinus orca	DD	1			2
Peponocephala electra	LC		1		2
Physeter macrocephalus	VU	1			3
Pseudorca crassidens	DD	1			3
Sotalia guianensis	DD	1			4
Stenella attenuata	LC		1		3
Steno bredanensis	LC	1			4
Stenella clymene	DD	1			2
Stenella coeruleoalba	LC	1			2
Stenella frontalis	DD	1			3
Stenella longirostris	DD	1			3
Trichechus manatus	VU			1	4
Tursiops truncatus	LC	1			4
Ziphius cavirostris	LC	1			3
Total		**17**	**5**	**3**	

Table 1 – List of species covered by the analysis and type of output map (IUCN status abbreviations: DD = data deficient, LC = least concern, VU = vulnerable; note that this refers only to global species status)

References

Kaschner K, Ready JS, Agbayani E, Rius J, Kesner-Reyes K, Eastwood PD, South AB, Kullander SO, Rees T, Close CH, Watson R, Pauly D, Froese R (2008) AquaMaps: Predicted range maps for aquatic species. World wide web electronic publication, www.aquamaps.org, Version 08/2010

Kaschner K, Tittensor DP, Ready J, Gerrodette T, Worm B (2011) Current and future patterns of global marine mammal biodiversity. PLoS One 6:e19653

Kaschner K, Watson R, Trites AW, Pauly D (2006) Mapping worldwide distributions of marine mammals using a Relative Environmental Suitability (RES) model. Marine Ecology Progress Series 316:285-310

Ready J, Kaschner K, South AB, Eastwood PD, Rees T, Rius J, Agbayani E, Kullander S, Froese R (2010) Predicting the distributions of marine organisms at the global scale. Ecological Modelling 221:467-478

Williams R, Kaschner K, Hoyt E, Reeves RR, Ashe E (2011) Mapping large-scale spatial patterns in cetacean density: Preliminary work to inform systematic conservation planning and MPA network design in the northeastern Pacific. , Whale and Dolphin Conservation Society, Chippenham, UK