Humpback whale (*Megaptera novaeangliae*):

Summary of review of AquaMaps predictions for WCR undertaken by Kristin Kaschner & Randall Reeves, February 2012

Revision of AquaMaps predictions based on available regional data (KK)

Default AquaMaps predictions represent a compromise between winter and summer occurrence of species and are therefore generally suboptimal for capturing seasonal occurrence of highly migratory species such as most baleen whales in specific areas representing breeding or feeding grounds. All available data, including the > 2000 occurrences from OBIS and information about breeding area habitat usage (Jefferson et al. 1993, Ersts & Rosenbaum 2003, Findlay et al. 2004) indicate that humpback whales are restricted to very shallow waters on their winter breeding grounds and I therefore adjusted the depth envelope accordingly. In addition, I adjusted the temperature envelope to reflect the species' preference for subtropical and tropical waters during this time of the year. Finally, I increased the upper threshold of the salinity envelope slightly, to capture occurrence north of the actual Caribbean better (i.e. the important breeding grounds on Silver and Navidad Banks and in Samana Bay, all of which are outside the Caribbean, per se).

Final input parameter settings can be seen in Table 1 and resulting gradient predictions, generated using the AquaMaps model (Kaschner et al. 2008), are shown in Figure 1. To show the most likely known and probable occurrence of the species in the WCR I applied a presence threshold of 0.4. While known species occurrence during the winter months was captured relatively well along the Caribbean island chain, large areas of false predicted presence remained throughout the Gulf of Mexico, where the species is only rarely seen and where no humpback breeding aggregation area is known to exist or to have existed historically. This is an indication that the distribution of humpback whales in the WCR is not driven or determined solely by the environmental parameters included in the AquaMaps model. Therefore the only way to arrive at a map that reflects actual species occurrence in the region is to use the map shown in Figure 1 as a starting point from which areas of known absences and missing presences are identified and added

manually following a Delphic process. Lines and circles on Figure 1 represent a first attempt at this (by KK and RR). However, it was not judged appropriate to start modifying the data layer at this point, since final decisions about exact positions etc. will only come after consultation with species experts (the process to be led by RR).

Mapping parameters for Megaptera novaeangliae (humpback whale)_4
FAOAreas: 4 | 5 | 18 | 21 | 27 | 31 | 34 | 37 | 41 | 47 | 48 | 51 | 57 | 58 | 61 | 67 | 71 | 77 | 81 | 87 | 88
Pelagic: True

Bounding Box (NSWE):	90	-90	-180	180
	Min	Pref Min (10th)	Pref Max (90th)	Max
Depth (m)	0	10	200	6000
SST (°C)	25	27	34	34
Salinity (psu)	20	31.82	36	37.95
Primary Production	81	192	1361	3160
Sea Ice Conc.				
Distance to Land (km)				

Table 1: AquaMaps input parameter settings for revised map generation

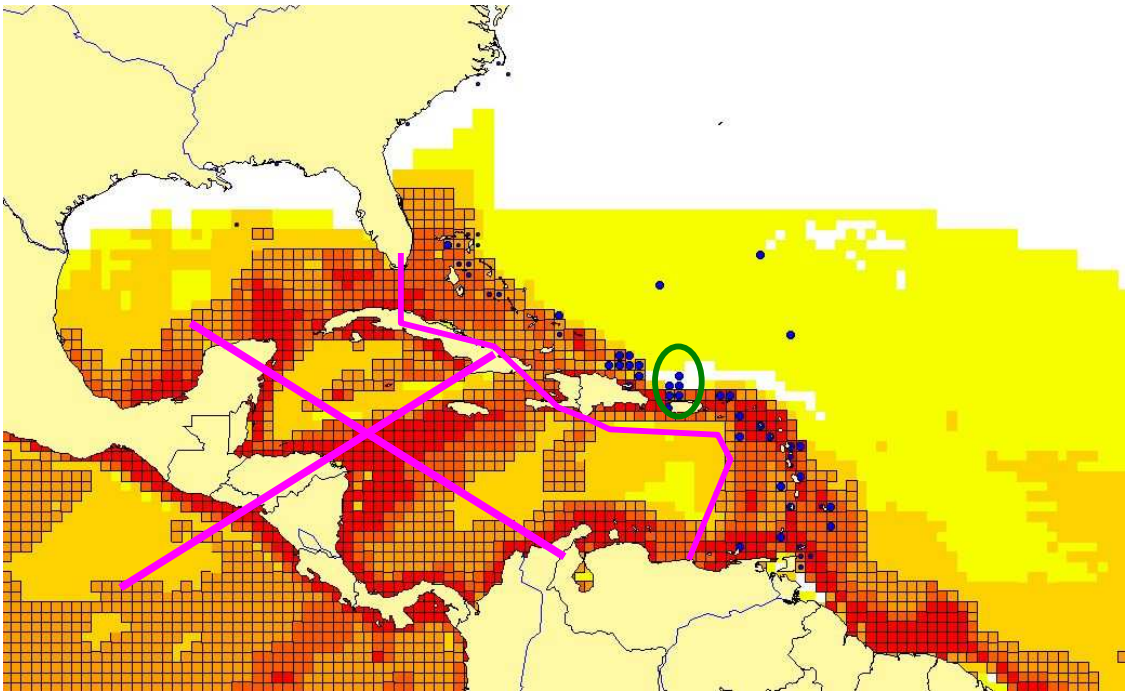

Fig 1. Predicted relative habitat suitability based on envelope settings in Table 1 and calculated relative encounter rates based on available sightings from OBIS (blue). Cells with probability values above the selected threshold are shown with boundaries. *Note that not all occurrences are available/accessible through online data repositories, such as

OBIS (www.iobis.org), and records shown on the map do not necessarily represent the whole extent of documented species occurrence! Everything west of the pink line is considered false predicted presence (or outside the region of interest here) and should be deleted and the green circle highlights an area of false predicted absence where cells should be added to the map.

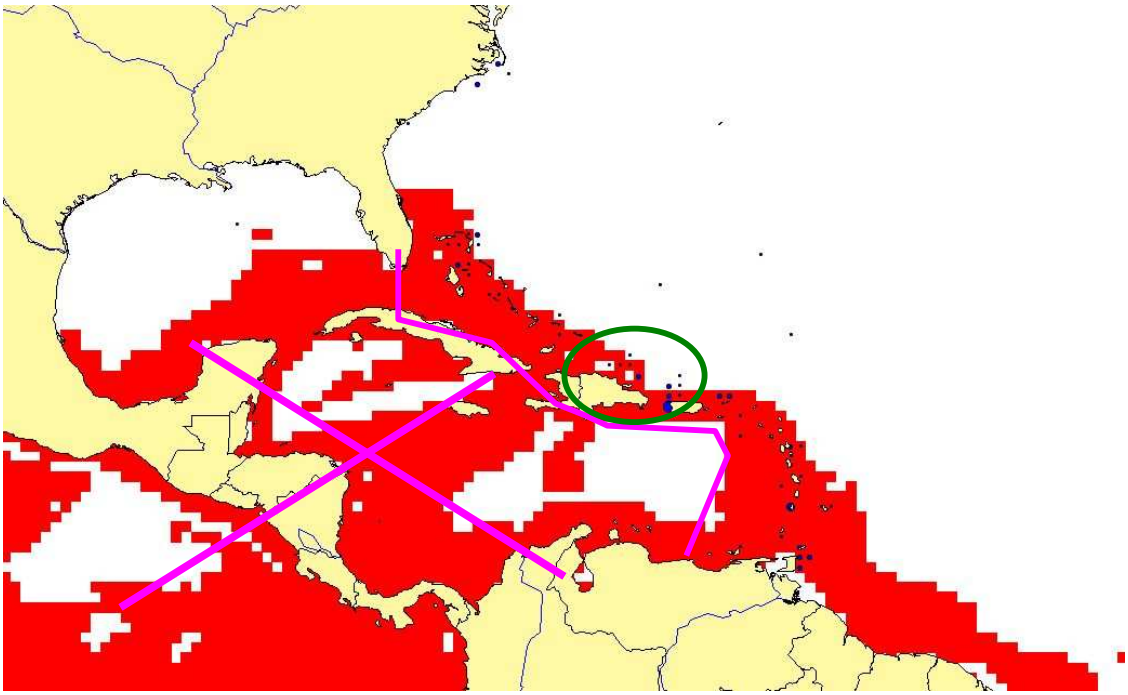

Fig 2: Starting point for consensus map of known and probable occurrence of species in the WCR (including available sightings from OBIS (blue)). *Note that not all records of occurrence are available/accessible through online data repositories, such as OBIS (www.iobis.org), and therefore the records shown on the map do not necessarily represent the whole extent of documented species occurrence. Also note that point records shown include a few positions of animals migrating to and from winter breeding grounds.

Review of outputs by independent experts (Randall Reeves)

KK was well aware of the problems with her initial humpback whale maps for the WCR. It seemed clear that for a species such as this, which is strongly migratory and moves seasonally between shallow equatorial 'breeding' areas and high-latitude feeding areas, crossing a wide range of water depths en route, the methodology does not work well at the global scale. Even with the regional/seasonal environmental envelope of 'expert settings' presumably meant to limit the envelope to habitat features typical of the breeding end of the annual migration when humpbacks tend to congregate on or near islands, banks and reef systems, it does not work well for the WCR. Keith Mullin (NOAA/NMFS, Southeast Fisheries Science Center) and Howard Rosenbaum (Wildlife Conservation Society) agreed with this conclusion. The predictions showing such an extensive coastal distribution around the Gulf of Mexico and Caribbean Sea are of academic interest but do not have any obviously immediate or practical relevance. Humpback whales are effectively absent (though occasionally do occur) in the Gulf of Mexico, and there is no historical evidence to suggest they *regularly* used this water body as a winter breeding area in times before whaling or before there was a large human footprint in the region. Historical developments and 'culture' within the whale populations themselves may play a large role in determining where concentrations of humpbacks become established, and therefore environmental characteristics alone may not be sufficient for predictions.

Of all large cetacean species, the humpback's current (and for that matter, historical) distribution and relative density in the WCR is probably the best known (see, for example, Winn et al. 1975, Ward et al. 2001, Swartz et al. 2003) Under these circumstances, the mapping for this species should incorporate expert knowledge directly (thus the proposed 'Delphic process'). For some areas, such as the northeastern Caribbean off Santo Domingo, Puerto Rico and the Virgin Islands and the eastern Caribbean islands of the Lesser Antilles all the way south to Trinidad, historical whaling records and modern photo-identification and strandings data (supplemented by the few line transect sightings and listening surveys) can be used in combination to map the

important areas. The recent paper by Acevedo et al. (2008) provides a good summary of what is known about humpback whale distribution along the Venezuela coast, which is the only additional part of the WCR that I think contains important habitat. Those authors refer to inshore and very near-shore waters of the Los Frailes Archipelago, near Margarita Island, as the most likely true 'breeding' area in Venezuela at present, though they rightly caution that the data are not effort-corrected (and in my view, they have not necessarily accounted for the evidence from whaling data for the entire Venezuela coast). There seems to be little justification for predicting high-density occurrence of these animals in waters deeper than 200 m in the WCR, although they certainly swim across deeper areas and it is probably fair to say that the expert settings in Table 1 allow for this.

We obtained useful advice from four experts with much experience studying humpback whales in the WCR – Carole Carlson (Research and Education Program, Provincetown Whale-watch Fleet), Phil Clapham (NOAA/NMFS, Alaska Fisheries Science Center), David Mattila (NOAA/International Whaling Commission), and Nathalie Ward (NOAA, Stellwagen Bank National Marine Sanctuary). Their input helped assure us that no important areas had been overlooked in our own search for information. It should be noted that all of them cautioned us regarding the possibility that insufficient effort in some areas with suitable habitat (e.g. Cuba, Colombia) could be used regularly by humpback whales even though this is not reflected in the current literature. They also encouraged us to use a more elaborate mapping scheme, e.g. showing known current distribution vs known historical distribution, showing areas of known occasional occurrence (e.g. a few strandings or sightings) vs known regular occurrence. Although we agreed in principle, we concluded that not only would this require more time and effort than we could afford, but it would also make the humpback whale map inconsistent with those of other species mapped as part of this project.

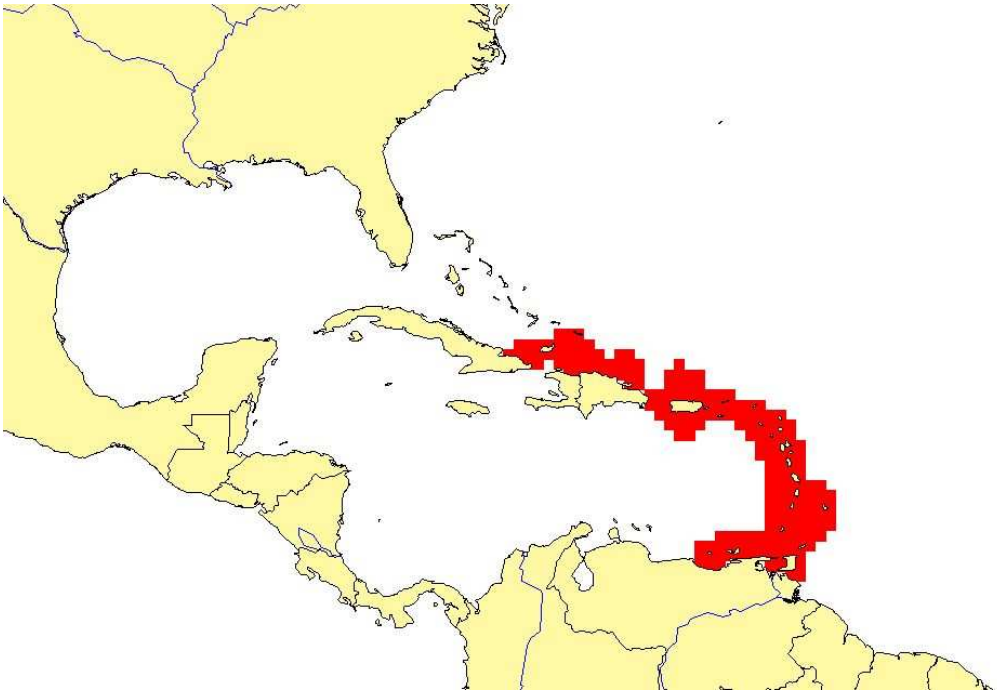

Fig 3: Approximate known regular occurrence of humpback whales (*Megaptera novaeangliae*) in the Wider Caribbean Region during winter breeding season.

Quality of outputs: ★★★

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