The following supplement accompanies the article

Density and exposure of surface-pelagic juvenile sea turtles to *Deepwater Horizon* oil

Trent L. McDonald, Barbara A. Schroeder, Brian A. Stacy, Bryan P. Wallace, Leigh Ann Starcevich, Jonathan Gorham, Mandy C. Tumlin, Dave Cacela, Matthew Rissing, Danya B. McLamb, Eric Ruder, Blair E. Witherington

*Corresponding author: tmcdonald@west-inc.com

Endangered Species Research 33: 69–82 (2017)

Additional details of density estimation: Line-transect methods

When observers made a sighting, they recorded the perpendicular distance from the vessel's path using the graduated pole or computed the distance based on sighting angle and the observer's eye height above water (typically 3-10 m). Assuming h was the observer height (meters), and θ was the angle below horizontal read from an inclinometer (degrees), we calculated perpendicular distance (in meters) as,

$$d = h \tan(90° - \theta)$$

Assuming turtles were randomly distributed in the search area relative to the vessel's path, we estimated sightability functions by maximum likelihood (Buckland et al. 2001). For each oiling category, we postulated 5 sightability functions (Table S1, this document) and fitted them to perpendicular sighting distances. We used Akaike's Information Criterion (AIC) to choose the best fitting function (Burnham & Anderson 2002). We performed all calculations using R (R Core Team 2015) and the add-on package Rdistance (McDonald et al. 2015).

Following estimation of sightability functions, we estimated density in searched areas from the total length of sampled transect, the re-allocated number of turtles observed in each oiling category, and the best-fitting distance function. Assuming L was the total length of on-transect (kilometers) effort covered by vessels during the study period, and n_{ij} was the total individuals of species j in oiling category i after allocation of non-captured turtles to oiling categories, we calculated density of species j turtles (in units of number per square kilometer) in searched habitat in oiling category i as,

$$D_{ij} = 1000 \frac{n_{ij}}{2L(ESW_i)} \tag{S1}$$

where ESW_i (meters) was the effective strip width of the best-fitting distance function for oiling category i. The effective strip width for oiling category i was

$$ESW_i = \int_0^w g_i(x)dx,$$

where w was an assumed maximum sighting distance or right truncation, and $g_i(x)$ was the best-fitting distance function for oiling category i (Buckland et al. 2001). Based on inspection of perpendicular sighting distance histograms it was clear that sighting probability was functionally zero well before 100 meters (Figure S1, this document), and hence maximum sighting distance was set to w = 100 meters. All distance functions except the Gamma assumed probability of detection on the transect line (i.e., at x=0) was 1.0. The Gamma distance function assumed that probability of detection was perfect at its maximum which typically occurred a few meters (4 to 10) from the transect (Figure S1).

Confidence intervals for density estimates were computed by bootstrap resampling transects and all associated data 1000 times. Distance function selection was not re-performed during bootstrap iterations, but each iteration re-estimated parameters in the best fitting distance function for each oiling category. Bias corrected 95% confidence intervals (Efron 1987) were computed from the 1000 bootstrap estimates of D_{ij}.

We estimated separate distance functions for turtles in each oiling category except for the two highest categories. Due to the relatively low number of turtles observed in the "moderately oiled" (n = 35) and "heavily oiled" (n = 31) categories, these categories were combined and a common distance function was estimated. Among the five distance functions fitted, the best-fitting form for "non-oiled," "minimally oiled," and the combined "moderately and heavily oiled" categories was Gamma (Figure S1). The Gamma functions assumed perfect detection at 9.6 m for "non-oiled" turtles, 8.4 m for "minimally oiled" turtles, and 4.0 m for "moderately and heavily oiled." The best-fitting distance function for the "lightly oiled" category was the hazard rate form (Figure S1). The effective strip widths (ESW) associated with each oiling category declined consistently from 24.3 meters for the "non-oiled" class to 21.4 meters for the "moderately and heavily" oiled categories (Table 3, main text).

Supplementary references

Buckland, S. T., Anderson, D. R., Burnham, K. P., and Laake, J. L. (2001) Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press.

Burnham, K. P., and Anderson, D. (2002) Model Selection and Multi-Model Inference. 2nd edn. Springer.

Efron, B. (1987) "Better Bootstrap Confidence Intervals". Journal of the American Statistical Association, **82** (397): 171–185.

McDonald, T. L., Nielson, R., and Carlisle, J. (2015) Rdistance: Distance Sampling Analyses. R package version 1.3.2. https://cran.r-project.org/web/packages/Rdistance/

R Core Team (2015) R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. www.r-project.org

Table S1: Distance functions fitted to histograms of perpendicular distance from vessel track to turtle sighting. Minimum sighting distance was 0. Maximum sighting distance was set to w = 100 meters. Symbols a, b, and c are parameters to be estimated. Actual distance function fitted was $g(x)=f(x)k(x)$, scaled appropriately. A total of 9 distance functions were fitted to each histogram in R using the `F.automated.CDA` in the `Rdistance` package.

Distance Function	**Form ($f(x)$)**
Half normal	$f(x) = e^{-0.5(x/a)^2}$
Hazard rate	$f(x) = 1 - e^{-(x/a)^{-b}}$
Uniform	$f(x) = e^{-b(x-a)} \big/ (1 + e^{-b(x-a)})$
Negative exponential	$f(x) = e^{-ax}$
Gamma	$f(x) = \frac{1}{\lambda^a \Gamma(a)} x^{a-1} e^{-x/\lambda}$ where $\lambda = \frac{b}{\Gamma(a)} \left(\frac{a-1}{e^1}\right)^{a-1}$

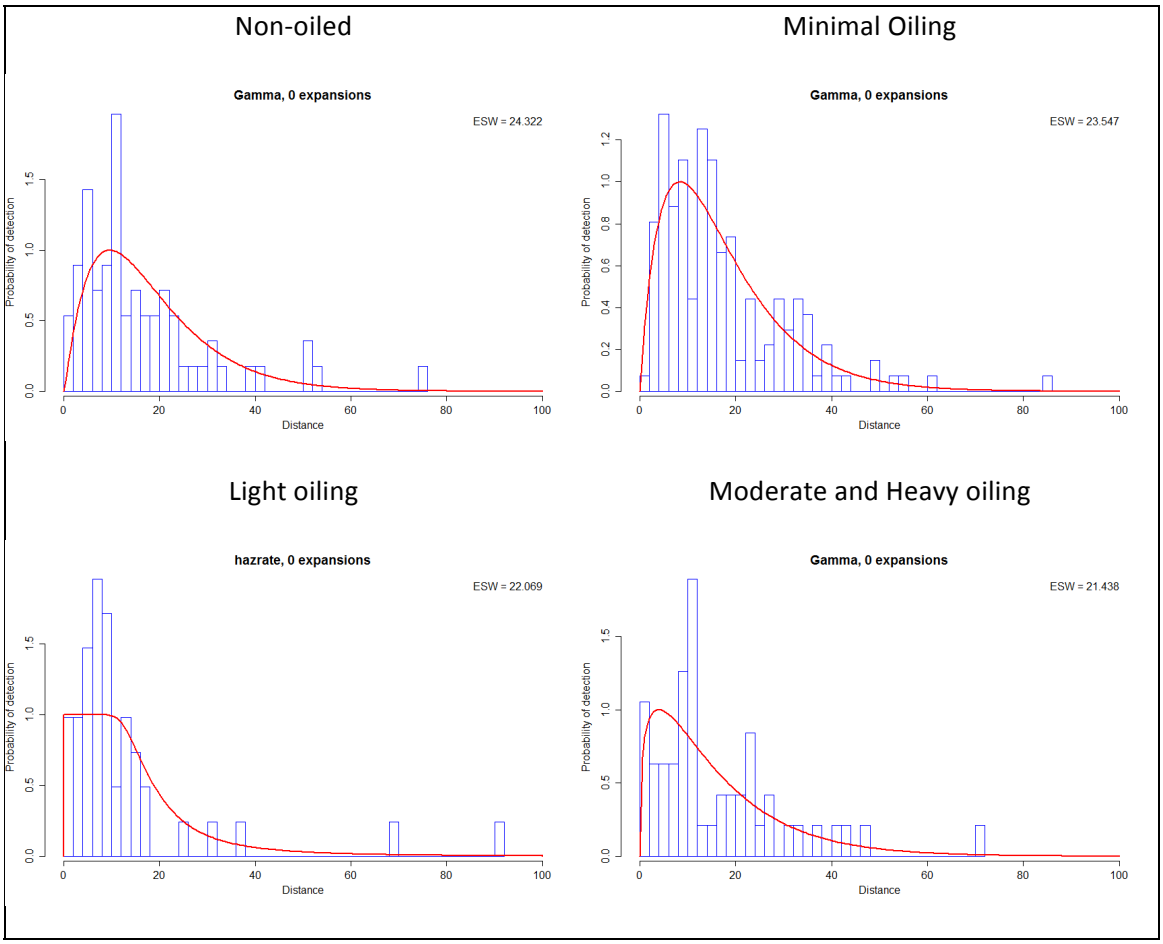

Figure S1: Best fitting distance functions (red lines) for captured turtles by oiling category. Histograms (blue) indicate the distribution of perpendicular sighting distances. Best fitting distance functions were Gamma for all oiling categories except Light Oiling, which best followed the hazard rate form. Effective strip widths appear in Table 3 of the main text.