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Estimating the offshore mortality of birds killed by DWH oil

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ESTIMATING THE OFFSHORE MORTALITY OF BIRDS KILLED BY DWH OIL

INTRODUCTION

The U.S. Fish and Wildlife Service (USFWS) implemented several studies to assess the impacts of the *Deepwater Horizon*/ Mississippi Canyon 252 oil spill on birds. For example, dead and live debilitated birds were collected from shorelines. These bird collections provided information used to estimate birds that died in the nearshore environment, including birds that died or became incapacitated (and captured for rehabilitation) on shorelines or that died at sea and later came to rest on shorelines (IEc, 2015). Recognizing that birds could be exposed to oil far out at sea, the USFWS collected data to facilitate the evaluation of the impact of the spill on birds offshore (Bird Study #6; Trustee Pelagic Bird Technical Working Group - BTWG, 2010). Birds that succumb to the effects of oil far out at sea may not ever come to rest on shorelines due to factors such as decomposition and carcass sinking. Therefore, the BTWG developed a methodology specifically for estimating avian mortality occurring offshore.

This document describes the approach utilized to estimate bird mortality that occurred offshore in the northern Gulf of Mexico (nGOM) (i.e., greater than 40 km from shore) as a result of exposure to oil from the *Deepwater Horizon* (DWH) spill. Oil was continually released from DWH beginning on April 20, 2010 and until the well was capped on July 15, 2010. Additionally, oil remained on the surface of the nGOM beyond the 87 days of release (Chapter 5, PDARP). Any time oil was present on or near the water surface (i.e., during and in the weeks following the release), offshore birds, including pelagic species, had the potential to become oiled and suffer adverse oiling effects.

The approach described below utilized Bird Study #6 and other information sources to estimate the number of offshore seabirds, including pelagic species, which likely died in the offshore area due to DWH oiling. Pelagic birds are those birds that spend most of their life on open water. We utilized an exposure-based model that estimated the portion of the bird population that was likely exposed to DWH oil offshore and applied fate estimates for those birds in order to estimate the number of birds that died offshore. The bird mortality determined from this method estimated an impact to a group of oil-exposed birds that, due to their distant off-shore habitat usage, were likely not quantified in other estimation methods such as the shoreline deposition model (SDM; IEc, 2015) or the simplified live-oiled bird model (LOBM; USFWS, 2015).

BIRD DENSITY ESTIMATES

As part of the DWH natural resource damage assessment (NRDA), 5,665 transect surveys and 386 point count surveys were conducted between July 8, 2010 and July 17, 2011 to gather information on bird abundance and oiling rates for birds in the offshore area (Bird Study #6; Haney, 2011). Haney (2011) observed more than 23,000 individual birds and identified 45 different species, including numerous pelagic bird species (Table 1). Some birds were only identified to genus level in the surveys and while those unidentified species are included in the density estimates they are not included in Table 1. Transect surveys totaled over 950 hours (Haney, 2011) and surveyors documented the number and species of birds observed within 300 m abeam of the ship (Haney, 2010). Point count surveys totaled over 341 hours and surveyors documented the number and species of birds within a 360 degree arc with a 300 m radius (Haney, 2010). Data collected from these surveys formed the basis for estimating seabird density in the offshore area of the nGOM. We limited the number of species considered to those identified in Table 1. These species are similar to those identified by U.S. Department of Interior reports (1996; 2000) as seabird species in previous surveys conducted in the nGOM. The list of species also includes numerous bird species of conservation concern to the U.S. Fish and Wildlife Service (USFWS, 2008) as well as the federally-listed threatened roseate tern (*Sterna dougallii*; USFWS, 1987). Additional bird species that were collected by either wildlife response operations or NRDA searches as carcasses or live birds and used in the shoreline deposition model are also identified in Table 1 (IEc, 2015). Collection of these birds supported that seabird species were injured by the DWH oil spill.

TABLE 1. COMPLETE LIST OF OFFSHORE SEABIRD SPECIES IDENTIFIED DURING SURVEYS CONDUCTED BETWEEN JULY 8, 2010 AND JULY 17, 2011.

COMMON NAME	SPECIES
Audubon's Shearwater[1]	*Puffinus lherminieri*
Band-rumped Storm-Petrel	*Oceanodroma castro*
Black Tern[1]	*Chlidonias niger*
Black-capped Petrel	*Pterodroma hasitata*
Bonaparte's Gull	*Chroicocephalus philadelphia*
Bridled Tern[1]	*Onychoprion anaethetus*
Brown Booby[1]	*Sula leucogaster*
Brown Noddy[1]	*Anous stolidus*
Brown Pelican[1]	*Pelecanus occidentalis*
Caspian Tern[1]	*Hydroprogne caspia*
Common Tern[1]	*Sterna hirundo*

Cory's Shearwater[1]	*Calonectris borealis*
Forster's Tern[1]	*Sterna forsteri*
Great Black-backed Gull	*Chroicocephalus ridibundus*
Great Shearwater[1]	*Puffinus gravis*
Gull-billed Tern[1]	*Gelochelidon nilotica*
Herring Gull[1]	*Larus argentatus*
Laughing Gull[1]	*Leucophaeus atricilla*
Leach's Storm-Petrel[1]	*Oceanodroma leucorhoa*
Least Tern[1]	*Sternula antillarum*
Long-tailed Jaeger	*Stercorarius longicaudus*
Magnificent Frigatebird[1]	*Fregata magnificens*
Masked Booby[1]	*Sula dactylatra*
Northern Gannet[1]	*Morus bassanus*
Parasitic Jaeger	*Stercorarius parasiticus*
Pomarine Jaeger	*Stercorarius pomarinus*
Red-billed Tropicbird	*Phaethon rubricauda*
Red-footed Booby	*Sula sula*
Ring-billed Gull[1]	*Larus delawarensis*
Roseate Tern (threatened)	*Sterna dougallii*
Royal Tern[1]	*Thalasseus maximus*
Sandwich Tern[1]	*Thalasseus sandvicensis*
Sooty Tern[1]	*Onychoprion fuscatus*
White-tailed Tropicbird[1]	*Phaethon lepturus*
Wilson's Storm-Petrel	*Oceanites oceanicus*

[1] Includes those species collected live or dead during the DWH spill.

Species in **Bold** include those identified as birds of conservation concern or Federally listed as threatened.

AREA OF CONSIDERATION

USFWS utilized several approaches to quantify the number of birds killed by exposure to DWH oil (e.g., SDM). One of those approaches was the SDM that utilized the number of dead and live birds collected along the shoreline to estimate a portion of the total number of birds killed by the oil spill. The SDM took into account various factors such as the time a carcass is assumed to persist on a shoreline following death, the assumed efficiency of searchers to locate a carcass (or live bird), and birds lost at sea (carcass drift). Carcass drift is an estimate of the likelihood that a dying or dead bird in the water would float or drift to a shoreline so that it could be found during searches. A carcass drift assessment was conducted as part of the NRDA for birds (Ford, 2014). Bird carcasses with radio transmitters were deployed in the water throughout the nGOM and they were tracked until either transmitter signals were lost or the carcasses reached shore and were found by searchers. We used information from that report to determine the furthest perpendicular distance from shore that a bird was deployed and reached shoreline; conversely, we also used the information to determine the distance beyond which a bird killed by oil would not likely reach shore and thus would not be included within the SDM. The approach eliminates double-counting (i.e., counting a single seabird death twice – once within the SDM and once in this estimate). The furthest perpendicular distance to shore for a deployed bird that reached shore was just over 39 km. Therefore, we assumed that all birds dead or dying within a 40 km band of nGOM shoreline would be accounted for in the SDM. This 40 km estimate is similar to Haney et.al. (2014).

Haney (2011, pg. 13) stated that offshore bird densities vary with changes in water depth and that "it was not unusual for observers on occasion to go for an entire day without seeing any birds at all, especially far offshore on the middle and outer continental shelf, or in very deep waters far from any edges of the Loop Current or other prominent oceanographic features." Because of the decrease in bird observations as water depth increased, we used the continental shelf as a geographic reference point (200 m deep) in which to classify bird surveys. We grouped bird surveys into those that were conducted in 1) water less than or equal to 200 m deep but more than 40 km from shore and 2) those conducted in water greater than 200 m deep.

OFFSHORE DENSITY

Data considered: Using the NRDA transect survey data (Bird Study #6), we estimated two separate bird densities; 1) beyond the 40 km boundary of the nGOM coast as described previously but in water less than 200 m deep (referred to as mid-zone hereafter) and 2) in water greater than 200 m deep (referred to as deep hereafter). Additionally, for the purposes of estimating the number of offshore seabirds killed from exposure to DWH oil, we only considered those species identified in Table 1 and that were observed during the surveys conducted in July, 2010 and August, 2010. We used a two month time period because; 1) July and August surveys contain the data closest to when oil was continuously released into the nGOM, 2) using data from these two months increased the number of usable surveys and provided more data to better estimate average density, and 3) limiting the data to these two months and to 2010 surveys avoided much of the seasonal and annual fluctuations in bird species and numbers within the area of interest.

Haney (2011) identified that in addition to water depth, densities of offshore birds also differ by season which supports our approach to limiting transect data to only the months of July and August, representing the summer season during which the spill occurred.

Point-count abundance surveys were also conducted (Bird Study #6; Trustee Pelagic Bird Technical Working Group, 2010); however, point-count surveys have a time dependent variable (i.e., length of time an observer looked for birds). In reviewing the data for this analysis, some of the observational time periods appeared errant (almost a day long). Therefore, point-count survey data was not used for this analysis.

Calculations: To estimate density, we divided the total number of offshore seabirds observed on an individual transect by the total area covered by that transect survey. The area observed during the transect survey was calculated by multiplying the length of the transect by the width of the transect (width of transect equals 300 m if only one side of the ship was surveyed or 600 m if both sides of the ship were surveyed). This approach follows the transect survey methods identified by Haney (2010). Observation distances were defined to be 300 m in the study plans and therefore any observations of birds at greater than 300 m could be considered random and opportunistic and not applicable to estimating offshore bird densities. Therefore, any birds observed beyond 300 m were excluded from the analysis. Density estimates were grouped as described previously, mid-zone and deep, and then the average density for each group was calculated. Results are provided in Table 2. The mid-zone density is comparable to the density determined by Haney (2014) using literature information from several different studies. The deep water bird density is about one third of the mid-zone bird density and supports the observations of Haney (2011) regarding the lack of bird observations in deep waters.

TABLE 2. AVERAGE DENSITY OF OFFSHORE BIRDS FOR EACH AREA OF CONSIDERATION.

NORTHERN GULF OF MEXICO - AREA OF CONSIDERATION	BIRD DENSITY
Mid-zone (≥40 KM FROM SHORE TO 200 M DEEP)	1.53 birds per km^2
Deep (> 200 M DEEP)	0.56 birds per km^2

EXTENT OF OIL ON WATER

The approach to estimating offshore mortality required an average daily extent of oil coverage on the water during the month of July. We selected July, 2010 oiling data since it was similar to the time period when seabird surveys were conducted. The National Oceanic and Atmospheric Administration (NOAA) convened a panel of remote sensing experts that modeled the spatial extent of oil on the nGOM for 68 days (April 25 to July 28, 2010; Graettinger et.al. 2015). We used the daily extent of oil for July, 2010 and determined the overall average daily oil extent that was for the mid-zone and deep areas. There was one small area (about 840 km^2) that was less than 40 km from the nGOM coast but in water deeper than 200 m and we included that area in our oiled area approximation.

During the month of July, we determined that on a daily basis about 1,970 km^2 of the nGOM was covered in oil in the mid-zone and about 2,970 km^2 was covered in oil in the deep area. Considering both areas together, we determined that on a daily basis during July, 2010 about 4,940 km^2 of the nGOM was covered in oil in areas where offshore seabirds occurred.

PROBABILITY AND DEGREE OF OILING

DWH oil spread across vast areas of the nGOM and offshore seabirds including pelagic species were exposed. Because of the vast area to consider and the difficulty of finding dead or dying birds in open ocean, there were no offshore surveys conducted to collect birds. However, periodically birds were collected opportunistically but not of sufficient data quantity or quality to estimate the number of dead birds in the offshore nGOM.

There were only a few observations of oiled birds made while transect surveys were conducted (Haney, 2011). These limited, opportunistic observations are unsurprising given the extreme difficulty to identify birds with small, but deleterious, oiling from a moving ship. Further, birds that were heavily oiled likely perished quickly and sank and thus would not be seen at all. We assumed that 100% of those birds in the area covered by oil would become oiled to some degree over a one month time period. This is consistent with the approach described by Haney (2014).

During the DWH oil spill, the USFWS identified four levels of oiling observations; trace (less than 5 % of the body surface), light (5 to 20 %), moderate (21 to 40 %), and heavy (greater than 40 %). The offshore birds exposed to DWH oil were likely oiled at various degrees, spanning from trace to heavy. However, there were no data available to quantify the distribution of oiling categories for seabirds we identified as exposed to oil. Frequently, birds collected dead or live on beach or marsh shoreline were heavily or moderately oiled. This was consistent with our understanding that heavily and moderately oiled birds would die quickly or become sick and be unable to avoid capture. However, observations of live oiled birds not debilitated enough to enable capture primarily consisted of trace and light oiled birds. This observation complemented the idea that moderately or heavily oiled birds quickly die from oiling effects, leaving only birds with trace and light oiling alive for observation, as was found during Bird Study #6. Because of the lack of data for categorizing oiling of offshore birds, we distributed the number of oiled birds evenly across the four oiling levels. For example, if 100 birds were estimated to be oiled, 25 would be considered trace oiled, 25 would be lightly oiled, 25 would be moderately oiled and 25 would be heavily oiled.

ESTIMATED NUMBER OF BIRDS KILLED

Once we identified the approach for estimating both the number of oiled birds and the degree of oiling, we then determined the fate of an oiled bird for each oiling category. As part of its NRDA efforts, USFWS convened an expert panel to identify the expected fate for oiled birds from a number of species and guilds (Dobbs et. al, 2015). The conclusions of this panel effort was reviewed by an avian toxicologist with expertise in petroleum toxicants and were revised based on his understanding of new toxicity data collected specifically for DWH (Ziccardi, 2015). We used the summer fate estimates for each oiling category from the revised conclusions table (Ziccardi, 2015). When a species or genus in our surveys was the same as the species or genus in the table, we used data specific to the species/genus. For species not included in the table, we used the data available for all the seabird species collectively.

The fate table provided a mortality range for each species/genus or guild, and oiling category combination. Due to the variability in the fate estimate, we estimated a mortality range using the first quartile (low) to the third quartile (high) of the overall fate range estimate for that species or group. This is similar to the approach taken in the Quantification of Avian Injury After September 30, 2010 (USFWS, 2015).

A summary of a complete calculation for hypothetical 'species Y' follows:

Estimating number of 'species Y' birds oiled:

Average density of birds (birds/km^2) X Area of oiling (km^2) = Total birds oiled

Total birds oiled X 'Species Y' proportion of total birds = Number of 'species Y' birds oiled

Number of trace oiled 'species Y' birds that died:

Number of 'species Y' birds oiled X .25 (% of birds trace oiled) X Fate (% expected mortality for trace oiled birds) = Estimated number of trace oiled 'species Y' birds killed

For 'species Y', this same calculation is then conducted for each additional oiling category (light, moderate and heavy) and the total number of 'species Y' birds killed is equal to the sum of each oiling category.

We used this same process for each bird species observed during July and August. With this approach, we estimated that at least between 2,317 and 3,141 offshore seabirds, including many pelagic species, not otherwise accounted for in the damage assessment, were killed during the DWH oil spill.

UNCERTAINTIES

Our approach utilized the available data and various assumptions to quantify the number of offshore seabirds that died due to the DWH oil spill but likely underestimated the total number killed. Bird surveys conducted were too limited to accurately determine the full complement of birds present in the expanse of water that comprises the nGOM. Additionally, birds were not only exposed to external oiling resulting from oil on the surface of the water, but were also exposed to internal oiling resulting from feeding or preening and from vapors when flying over the oil slick or near burning oil; however, our mortality estimates were based on external oiling only. It is also likely that due to wind and water currents, oil accumulated in certain areas. These areas also are likely places where food sources for birds would aggregate, drawing in more birds and thereby increasing their risk for oiling. Finally, we only estimated mortality during July and August of the spill, and oil began leaking into the nGOM on April 20, 2010 and is still present today (Chapter 5 PDARP). All of these various factors contributed to our likely underestimation of the number of offshore birds killed from DWH oil. Our estimates are significantly less than Haney (2014). However, Haney's methodology repopulated the number of birds exposed every four days allowing a completely new population of birds to be exposed and killed nearly twice per week. That approach likely overestimated the number of birds that became oiled and subsequently died.

SUMMARY

For species observed during July and August (2010), Table 3 provides a range for the number of offshore seabirds killed. As previously mentioned, at least between 2,317 and 3,141 offshore birds, including many pelagic species, were killed during the DWH oil spill. Terns (black, bridled, common, Forster's, royal, sandwich and sooty) accounted for over half (about 58%) of the total estimated birds killed. Audubon shearwater (low 660; high 887) and laughing gulls (low 160; high 264) also had a large estimated number of birds killed. Table 4 identifies other offshore seabird species identified during the entire time period that surveys for Bird Study #6 were conducted (July 8, 2010 to July 17, 2011). Given the length of time oil was on water, and the difficulty in accurately observing the species present at any one time on the nGOM, all of the species in Table 3 and 4 should be considered bird species injured by the DWH oil spill although injury was only quantified for a subset of them. As previously noted, this includes numerous bird species of concern to the USFWS as well as the federally-listed threatened roseate tern.

TABLE 3. ESTIMATED NUMBER OF OFFSHORE SEABIRDS KILLED BY THE DWH OIL SPILL FOR BIRDS OBSERVED DURING JULY AND AUGUST.

COMMON NAME	ESTIMATED NUMBER OF BIRDS KILLED[1]	
	LOW	HIGH
Audubon's Shearwater	660	887
Band-rumped Storm-Petrel	16	22
Black Tern	745	988
Bridled Tern	46	62
Brown Booby	2	2
Brown Noddy	15	21
Brown Pelican	12	18
Common Tern	9	12
Cory's Shearwater	13	17
Forster's Tern	3	4
Great Shearwater	18	25
Laughing Gull	160	264
Magnificent Frigatebird	14	20
Masked Booby	6	9
Northern Gannet	3	4

Parasitic Jaeger	4	6
Red-billed Tropicbird	7	9
Royal Tern	306	406
Sandwich Tern	94	124
Sooty Tern	167	221
Wilson's Storm-Petrel	14	19

[1]Number of birds does not total due to rounding.

TABLE 4. OTHER SEABIRD SPECIES LIKELY KILLED DURING THE DWH SPILL.

COMMON NAME	COMMON NAME
Black-capped Petrel	Least Tern
Bonaparte's Gull	Long-tailed Jaeger
Caspian Tern	Pomarine Jaeger
Great Black-backed Gull	Red-footed Booby
Gull-billed Tern	Ring-billed Gull
Herring Gull	Roseate Tern
Leach's Storm-Petrel	White-tailed Tropicbird

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