Analyzing the Role of Sound in the Endangered Species Act: A Petition for Sperm Whale (*Physeter macrocephalus)* Critical Habitat in the Gulf of Mexico

by

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Executive Summary

The Endangered Species Act (the ESA) is recognized as one of the strongest statutes in the world for protecting species and their habitat. One key feature of the ESA is the designation of critical habitat for species, which broadly requires that federal agencies consult with the U.S. Fish and Wildlife Service or National Oceanic and Atmospheric Administration to ensure that a proposed federal activity does not cause “adverse modification” or “jeopardy” to species and their habitat. Designating critical habitat for marine taxa is often particularly challenging due to their transboundary nature, the lack of spatial separation of key activities, and existing knowledge gaps on many species. The acoustic component of habitat is particularly important for marine mammals, which rely on sound for communication and other essential life functions. Incorporating an acoustic component of habitat into the critical habitat designations of threatened and endangered marine mammals is particularly challenging, and has only been done once to date.

Sperm whales (*Physeter macrocephalus)* are listed under the ESA as an endangered global species. Sperm whales communicate using culturally-specific patterns of vocalizations, known as codas, and use echolocation to find prey at depth. A distinct stock of resident sperm whales exists in the Gulf of Mexico, where their range overlaps significantly with industrial activity, particularly oil and gas exploration and extraction. This Master's Project includes a petition to the National Marine Fisheries Service to designate critical habitat under the ESA for sperm whales in the Gulf of Mexico, based largely on their acoustic habitat in the Gulf. In focusing on this subject in the critical habitat petition, this project aims to better incorporate sound into the ESA framework.

I. Introduction

A. Background on the Endangered Species Act

The United States' Endangered Species Act ("the ESA," "the Act") of 1973 (16 U.S.C. § 1531 *et seq.*) is arguably one of the most important statutes for protecting biodiversity and species vulnerable of extinction (Hoekstra, Clark, Fagan, and Boersma, 2002). Today, it is the primary statute in the U.S. that governs endangered species and their habitat, and acts as a "blueprint" for coexistence between people and the natural environment (Houck, 1993). The original intent of the Act had its grounding in preventing extinction, particularly since President Nixon signed the Act into law at a time when concern about international wildlife trade received considerable attention (Doremus and Pagel, 2001). Today, the overarching goal of the ESA, as amended, does not differ vastly from its original intent; overall, the goal of the Act is the conservation and recovery of endangered and threatened species and their habitat, to the extent that they do not need legal protections under the ESA (Bean, 2009; NOAA, 2015; USFWSb, 2016). The overarching intent of the Act is stated in its definition of conservation: "[…] the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary" (16 U.S.C. § 1532).

Today, there are over 2,300 listed plants and animals under the ESA (USFWS, 2017). The U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) are the two federal agencies that administer the ESA (deemed collectively as "the Services" in this context or "implementing agencies"). USFWS monitors terrestrial and freshwater species, while NMFS monitors marine and anadromous species (Heokstra et al., 2002, Bean, 2009). There are, however, some notable exceptions, such as FWS managing polar bears and both FWS and NMFS jointly managing sea turtles, if they nest in the U.S. Today, most listed species occur under FWS' jurisdiction. In addition to these agencies, several others play significant roles in the monitoring and management of imperiled species. For example, the Department of Agriculture enforces trade of terrestrial plants, and the Department of Justice both enforces "criminal provisions" of the Act and defends the implementing agencies when taken to court over their application and implementation of the ESA (Bean, 2009). By default, however, particularly via Section 7 as discussed below, all federal agencies carry a responsibility to protect endangered species (Brand, 2009).

B. History and Statute Overview

The first major federal wildlife statute in the U.S., the Lacey Act, passed into law in 1900, largely to regulate interstate wildlife commerce (Earthjustice, 2003). The Migratory Bird Treaty Act, passed in 1918, followed the Lacey Act, and aimed to protect migrating birds between the U.S. and Canada at the time (Earthjustice, 2003). By the mid-20th century, the Fish and Wildlife Service and other federal agencies were undertaking efforts to prevent extinction of severely imperiled species, like the whooping crane and California condor, without a direct legislative mandate to do so (Bean, 2009). Eventually, the Department of Interior—which houses USFWS—began seeking legislative assistance for its efforts on preventing extinction. In turn, Congress passed the Endangered Species Preservation Act in 1966 (Bean, 2009). This statute authorized listing of endangered species and called for species' conservation (Bean, 2009), and charged the Departments of the Interior, Agriculture, and Defense to work to protect listed species and preserve their habitat (USFWS, 2011). It, however, lacked regulatory teeth, and mainly operated as a paper listing repository (Bean, 2009).

At the same time, an environmental movement and public shift towards protecting the environment was taking hold: The first Earth Day celebration took place in 1970, and was followed by the passage of a suite of environmental laws, including the Marine Mammal Protection Act (1972), National Environmental Policy Act (1970), and Coastal Zone Management Act (1972) (Bean, 2009). In 1971, in response to growing public outcry, Congress strengthened the Endangered Species Preservation Act by prohibiting the import and sale of species most at risk, as well as calling for an international convention on endangered species (USFWS, 2011). At this time, Congress also renamed the statute the Endangered Species Conservation Act. An international conference took place in 1973, and led to 80 nations signing the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which today monitors imperiled species worldwide affected by trade (USFWS, 2011). The U.S. was the first nation to ratify CITES (Bean, 2009).

Then, in December 1973, President Nixon signed the Endangered Species Act into law in response to the growing number of species threatened with extinction, concerns regarding global wildlife trade, and mounting public pressure (Earthjustice, 2003; Malcom and Li, 2015). The ESA unanimously passed in the Senate, and with only four dissenting House votes (119 Cong. Record, 25, 694, 42, 915 (1973), as cited in Salzman, 1990). Several key aspects of the original ESA text included: definitions for endangered and threatened species; take prohibitions on all endangered species; requirements for federal agencies to consult with implementing agencies on actions that "may affect" listed species, and more. Congress has made many amendments since, with significant changes occurring in 1978, 1982, and 1998, but the core framework and provisions of the ESA have remained resolute (Earthjustice, 2003). One aspect of the 1978 amendments, the designation of critical habitat, forms the backbone of this paper and is discussed in greater depth below.

C. Overview of the Act

The Act contains many interrelated components that all work to promote species recovery. A broad survey of the ESA's various prohibitions and sections is as follows: Definitions of key terminology in the ESA in Section 3; determinations for listing and delisting processes, critical habitat designations, and recovery in Section 4 (Earthjustice, 2003, 16 U.S.C. §§ 1533); a mandate for cooperation with states and funding of grants to states and landowners in Section 6 (U.S.C. §§ 1535); requirements for interagency cooperation and consultation processes to ensure federal actions don't harm listed species and their critical habitat in Section 7 (16 U.S.C. §§ 1536); Section 9, which prohibits take and other unlawful activity of listed species (16 U.S.C. §§ 1539), and, finally, Section 10 allows for specific permits to incidentally take species and other mandated exceptions (16 U.S.C. §§ 1540). Once listed, species are granted a variety of both regulatory and non-regulatory benefits (Taylor, et al., 2005), including recovery plans (16 U.S.C. §§ 1533), the possibility of critical habitat (16 U.S.C. §§ 1536), take prohibitions (16 U.S.C. §§ 1539), and more (Taylor, et al, 2005). Of the ESA's many prohibitions on actions concerning listed species, the provisions regarding take (16 U.S.C. §§ 1539), jeopardy, and adverse modification prohibition (16 U.S.C. §§ 1536) are the strongest (Owen, 2012).

Under the ESA, an endangered species is defined as being in danger of extinction, “throughout all or a significant portion of its range” (16 U.S.C. § 1532(6)) and a threatened species is defined as, “likely to become an endangered species within the foreseeable future” (16 U.S.C. § 1532(20)) (Houck, 1993). For regulatory purposes, “species” listed under the ESA can include subspecies, varieties, or distinct population segments (DPS) for vertebrates, and thus is not limited to an entire species (USFWS, 2013; Bean, 2009). Listing is based on the best biological and commercial science at the time, and a species must meet any one of these five factors for listing: (1) “The present or threatened destruction, modification, or curtailment of a species’ habitat or range” (2) “Overutilization for commercial, recreational, scientific, or educational purposes” (3) “Disease or predation” (4) “The inadequacy of existing regulatory mechanisms” and (5) “Other natural or manmade factors affecting a species’ continued existence” ((16 U.S.C § 1533(a)(1)); Perry, DeMaster, and Silber, 1999). A listing triggers consideration of critical habitat (16 U.S.C. § 1533(a)(3)(A)), consultation to avoid jeopardy or adverse modification (16 U.S.C. § 1536(a)(1)), limitations on take, transport and selling species (16 U.S.C. § 1538(a)(1)), planning for conservation (16 U.S.C. § 1539(a)(2)(A)) and execution of recovery plans (16 U.S.C. § 1533(f)) (Houck, 1993; USFWS, 2016b). Unlike other portions of the Act, listing determinations are to be made fully on scientific evidence—not economic or social factors, as are other portions of the Act (Bean, 2009).

The listing process begins via two mechanisms: a citizen-initiated, formal petition process, or a review initiated by the relevant Secretary (Brand, 2009). In broad terms, the regulatory procedure is as follows: the relevant Service has three months to determine whether the listing has “substantial information,” and will publish a notice in the Federal Register about the proposal (Houck, 1993). Then, within 12 months, the Secretary is to decide whether the listing is warranted, not warranted if the data does not support the listing, or warranted but “precluded” by proposals for other species ((16 U.S.C. § 1533(b)(3)(B)); Houck, 1993). If a petition is found to be “warranted” following the 12-month status review, a proposed rule to list the species is published in the Federal Register (USFWS, 2016). This triggers a 60-day public comment period, as well as a peer review from independent specialists (USFWS, 2016). The final rule is published in the Federal Register, and if the listing is positive, the species is added to the list of endangered and threatened species within 30 days of the announcement (USFWS, 2016).

D. Controversy Surrounding the Act

Despite its seemingly simple objective—to protect the most vulnerable species and their habitat from extinction—the ESA is one of the most contentious statutes in the U.S. (Stokstad, 2005; Bean, 2009). Some have praised it as one of the strongest statutes for wildlife and the biodiversity in any nation, hailed as, "undeniably the most innovative, wide-reaching, and successful environmental law which has been enacted in the last quarter century” (Statement of Senator Graham, as referenced in Peterson, 1999), but others view the ESA as economically and regulatory burdensome and would like to see the Act eradicated. Reflecting this latter view, many lawmakers and industries have sought to undermine the Act and have attempted repeals and amendments for decades (Malcom and Li, 2015). Since 2015, there have been over 100 amendments and riders proposed in attempts to weaken the Endangered Species Act (Defenders of Wildlife, 2016).

Controversy surrounding the ESA often stems from polarization of public opinion, rather than from systematic evaluations of its efficacy in meeting its goals (Malcom and Li, 2015). Additionally, political meddling is known to impact how the ESA is implemented and carried out. In particular, politics influence the listing and delisting practices, as well as the extent of listings (Greenwald, Suckling, and Taylor, 2006; Greenwald et al., 2012). Of all sections of the ESA, critical habitat and the consultation process described in Section 7 (Malcom and Li, 2015) and take prohibitions mandated in Section 9 (Petersen, 1999) have spurred the most controversy. With critical habitat, it appears that the extent of meddling is in the area of proposed designation (Greenwald et al., 2012).

The “success” of the ESA in recovering species is also a subject of contention, one that proponents of rollbacks or regulatory changes have relied on in their arguments (Bean, 2009). It is, however, difficult to access “success” of the Act, because recovery is subjective (due to the lack of quantitative listing and delisting criteria), can take decades or more, and may be near impossible for some species, depending on their life history and other factors (Doremus and Pagel, 2001; Bean, 2009). One point that ESA critics sometimes rely on when discounting the Act are the slow rates of recovery and delisting, compared to the rate of listing (Doremus and Pagel, 2001). Some argue that the ESA has only led to recovery of only a handful of listed species. Substantial evidence exists that the ESA is successful in preventing species from reaching extinction (Stokstad, 2005), but as of fiscal year 2006, only about a tenth of listed species were improving, a third were stable, a third were declining, and the status of the remaining species are unknown (USFWS, 2008; Bean, 2009). Funding has been a limiting factor in enabling recovery; one study found that if a species is listed but not met with state or federal funding, these species can fare worse than unlisted species (Ferraro, 2007). Other issues discussed in measuring ESA success include agency backlogs in rates of listing species and low rates of improvement and/or reaching goals listed in recovery plans (Stokstad, 2005). Overall, however, the fact that the Act does not contain quantitative metrics for measuring its success makes it difficult to actually analyze its efficacy (Ferraro, 2007).

II. Critical Habitat

A. General Overview

One key feature of the Endangered Species Act is the mandate to designate critical habitat for listed species (16 U.S.C. § 1533(a)(3)(A)(i)), one of several tools afforded by the ESA to conserve species (50 CFR 424). Section 3 defines the text for critical habitat, while Section 4 mandates that critical habitat be designated for listed species, and Section 7 discusses its application (Owen, 2012). Section 3 defines critical habitat as: “the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 4 of this Act, on which are found those **physical or biological features** (I) **essential to the conservation of the species** and (II) which may **require special management considerations or protection**” (emphasis added) (16 U.S.C. § 1532(5)(A)(i)). Furthermore, critical habitat consists of, “specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species” (16 U.S.C. § 1532(5)(A)(ii)). Critical habitat cannot include a species’ entire range ((16 U.S.C. §1532(5)(C)), and certain areas can be excluded, if designating them is more economically burdensome than not designating them, if including it will affect national security, and if the benefits of excluding it outweigh the benefits of including the area (16 U.S.C. § 1533(b)(2); USFWS, 2016c). Furthermore, the Secretary cannot designate critical habitat or other areas owned by the Department of Defense without a special permit (16 U.S.C. § 1533(3)(B)(i)).

Arguably, the heart of critical habitat is not in the designation itself, but in the statutory text concerning interagency cooperation in Section 7. This states, "Each Federal agency shall confer with the Secretary on any agency action which is likely to **jeopardize the continued existence** of any species proposed to be listed under section 4 or **result in the destruction or adverse modification** of critical habitat proposed to be designated for such species" (emphasis added) (16 U.S.C. § 1536(a)4)). Thus, critical habitat essentially adds an extra blanket of regulatory review for a federal agency to go through if their proposed action overlaps with critical habitat. More specifically, these federal agencies must ensure that their activity will not lead to destruction or adverse modification of species' habitat, and must not cause jeopardy to the species (USFWS, 2016c). Critical habitat is one of the most commonly misconceived portions of the Act, with members of the public often believing that a critical habitat designation may affect their daily activity. This is not the case, however, as critical habitat in and of itself does not impact private landowners and citizens (USFWS, 2016c). In other words, the only "regulatory benefit" provided under a critical habitat designation is the consultation process under section 7(a)(2) of the Act, where federal agencies must consult with the Service in ensuring their actions do not cause adverse modification or jeopardy, which are nearly identical standards (Salzman, 1990).

There are inherent benefits to a critical habitat designation beyond those of regulatory nature. Habitat loss is a significant factor in the decline of many terrestrial species, so critical habitat acts as a tool to counteract that trend by identifying areas most important to recovery and conservation of a species (50 CFR 424). In doing so, critical habitat also provides benefits for "early conservation planning" for newly listed species, and helps focus conservation efforts for agencies and partners (50 CFR 424). Critical habitat can also be used as a "tool" used in federal planning, with an overall value of seeking to protect those physical and biological features most pertinent to a species' recovery (USFWS, 2016c).

B. History of Critical Habitat throughout the Act

Critical habitat designations were a part of the original 1973 ESA framework, including prohibitions on federal agencies jeopardizing or modifying a species' critical habitat (USFWS, 2011). There was, however, only one mention in the 1973 ESA text of critical habitat, which was then broadly defined (James and Ward, 2016). Perhaps arguably the most significant amendment concerning critical habitat occurred in 1978, which required the Services to review and, when appropriate, designate critical habitat in tandem with the listing process (16 U.S.C. §1533(b)(2); Petersen, 1999; USFWS, 2011). Furthermore, the amendment also mandated that economic implications of the designation be considered in the designation process—the only portion of the Act requiring considerations of economic implications (USFWS, 2011).

In the 1982 amendments, the Services defined terms for "prudent" and "determinable," which have been the two terms most loosely interpreted and have been the main reason FWS has not designated critical habitat in certain circumstances (Brand, 2009). In these amendments, critical habitat was deemed not "prudent" when identifying critical habitat increases the potential for take or increased human activity around a species, or if the designation of critical habitat would not have a benefit on species (50 CFR 424.12(a)(1), as cited in Brand, 2009). Critical habitat is deemed not "determinable" when one or both of the following criteria is not met: "(i) data sufficient to perform required analyses of the impacts of the designation is lacking, or (ii) the biological needs of the species are not sufficiently well known to permit identification of an area as critical habitat" (50 CFR 424.12(a)(2), as cited in Brand, 2009).

Also in 1978, the Services issued regulations that clarify what criteria the Secretaries should focus on when designating critical habitat (50 C.F.R. § 424.12(b), as referenced in Brand, 2009). This criteria, deemed Primary Constituent Elements (PCEs), are the "principal biological or physical constituent elements within the defined area that are essential to the conservation of the species," and can include feeding, spawning and nesting sites, and water quality (50 C.F.R. § 424.12(b)). The regulations further defined PCEs as factors including, but not limited to: "(1) space for individual and population growth, and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, rearing of offspring; and (5) habitats that are protected from disturbance or are representative of the historic geographical or ecological distribution of a species" (50 C.F.R. § 424.12(b)). Since then, these PCEs and "principal biological or physical features" have formed the backbone on which to designate critical habitat. This, however, has left considerable room for ambiguity and wide interpretation, though Congress's original intent "seems to have been to have the Services consider carefully what features of occupied areas are most important to the well-being of the species" (Bean, 2009). There have been no "comprehensive amendments" to the Act since 1988 (50 CFR § 424).

In recent years, however, the Services have published several important rules concerning critical habitat. Most pertinent to the present paper, the Services removed the term PCEs and all references to it in implementing regulations (CFR § 424.12) in a March 11, 2016 final rule (81 FR 7413). The Services found that PCEs and "physical and biological features" were repetitive, and invited confusion rather than clarity in determining habitat designations as the factors on which to base habitat (81 FR 7413).

Indeed, since the 2016 rule change to the implementing regulations for critical habitat, NMFS has issued several critical habitat designations and a proposed rule for critical habitat without mention of PCEs. The actual designations—expansion of critical habitat for North Atlantic right whales (NMFS, 2017), lower Columbia River coho salmon (*Oncorhynchus kisutch*) and Puget Sound steelhead (*O. mykiss*) (NMFS, 2017)—were designated before the rule changes to PCEs became effective on March 11. A proposed rule to designate habitat for the Carolina Distinct Population Segment of Atlantic sturgeon, which came after the Services' final rule, did not contain reference to PCEs, though it did mention the term "physical and biological features" (81 FR 36077).

C. Process of Designating Critical Habitat

There are two general avenues to initiate a critical habitat review and possible designation: either through the Services themselves or from a citizen petition. Through the first outlet, the Secretaries must designate critical habitat at the time of proposed and final rules for listing species to the "maximum extent prudent and determinable" (see above definitions), although the Secretaries have one year from the date of listing to designate habitat (CFR § 424.12(a)). In reality, the Services rarely review critical habitat within a year, which have led to series of lawsuits (Stokstad, 2005). For species listed before the 1978 concurrent listing-habitat amendments, designation "is at the discretion of the Secretary" (§ 424.12(e)). The second option is for citizens to file a petition to designate critical habitat for either listed or unlisted species (USFWS, 2016c).

In either case, the Service or the petitioner proposes specific areas for the designation, which is then published in the Federal Register for public review and a comment period depending on whether the Services found a positive 90-day and 12 month review of the petition. The Service then reviews the comments and alters the proposal as necessary, and then either deems to designate critical habitat or not. This decision comes via a final rule published in the Federal Register, after considering the best scientific data, economic implications, and other impacts (USFWs, 2016c). As described in (CFR § 424.12(1)(i-iv)), specific steps on which to base habitat designations on include:

(i) "the geographical area occupied by the species at the time of listing"

(ii) "physical and biological features essential to the conservation of the species [...] using the best available scientific data. This analysis will vary between species and may include consideration of the appropriate quality, quantity, and spatial and temporal arrangements of such features in the context of the life history, status, and conservation needs of the species"

(iii) "specific areas within the geographical area occupied by the species that contain the physical or biological features essential to the conservation of the species." These features, "are to be described at an appropriate level of specificity, based on the best scientific data available at the time of designation" (64 CFR 424)

(iv) "Determine which of these features may require special management considerations or protection."

The Secretary may also designate areas outside of their geographic range if it can be shown that such a designation will advance the conservation of the species (§ 424.12(b)(2)). The specific requirements include that critical habitat be outlined in maps, and all evidence for critical habitat must be based on the best available science at the time (§ 424.12(a-h)). The process does not necessarily have to follow in that sequence, but this serves as a general rule of thumb in designating critical habitat.

D. How Does Critical Habitat Actually Work?

It is important to re-emphasize that a designation of critical habitat only impacts federal activity. Any federal agency authorizing an activity that involves a federal permit, license, lease, contracts, easement or grants that may overlap with critical habitat must consult with NMFS or FWS (50 C.F.R. § 402.02). Through this consultation process, the action agency must work with the implementing agency (NMFS and/or FWS) to ensure that the action does not "adversely modify" critical habitat (Greenwald, Suckling and Pimm, 2012). Consultations typically start informally with discussions between the relevant Service and a federal agency (Owen, 2012). If this initial consultation determines that the proposed activity is “not likely to adversely affect” a listed species, the consultation process ends and the federal agency may proceed, in broad terms, with the activity (Malcom and Li, 2015). If adverse effects seem possible, a formal consultation ensues. This may result in the Service issuing a biological opinion (BiOp) on the scope and extent of impacts to critical habitat and the relevant species, a method for federal agencies to analyze whether a federal action will affect critical habitat or jeopardize the species (16 U.S.C. § 1536(a)–(b)) (Owen, 2012). If adverse modification seems possible, the BiOp identifies “reasonable and prudent alternatives” for mitigating impact and avoiding adverse modification and jeopardy, eventually culminating in an Environmental Impact Statement from the relevant action agency (Owen, 2012). Alternately, if the Service only expects species’ take rather than jeopardy or adverse modification, the Service assigns “reasonable and prudent measures” to minimize impacts and reduce species take from the action (Malcom and Li, 2015).

E. Criticism of Critical Habitat

Since the ESA’s passage, the concept of critical habitat has received extensive criticism from both ESA proponents and skeptics (Bean, 2009). This criticism ranges from an argument that critical habitat is not a strong enough conservation tool to the contrary position that is hinders economic growth and development (Salzman, 1990). Critical habitat arguably first gained negative attention in 1975, when construction on the near-complete Tellico Dam in eastern Tennessee was halted because of the importance of this habitat for snail darters, a tiny freshwater fish (Bean, 2009). When the Supreme Court ruled that protection of this habitat needed to be upheld despite the dam being near-complete, the concept of critical habitat and its implications gained consideration attention (Bean, 2009). Many of the efforts to undermine or deconstruct the ESA have been targeted at Section 7, because it can restrict federal activity and contains some of the “strictest prohibitions” of the Act (Malcom and Li, 2015).

At the same time, conservation groups argue that the implementing agencies are not restrictive enough because of mounting pressure to consider the economic impacts of Section 7 decisions (Malcom and Li, 2015). This is despite analyses which show that species with critical habitat designation showed improved trends towards recovery (Taylor, et al., 2005). To date, most of the controversy has stemmed from critical habitat designations, rather than how the agencies actually protect habitat once designated (Owen, 2012). The fact that it this the only provision of the ESA that requires economic aspects be taken into consideration in designation also invites debate (Bean, 2009), and critical habitat, like the rest of the ESA, has not been immune to political interference (Houck, 1993).

Even the Services have debated the efficacy of critical habitat, and what value it adds to the protection under the ESA. Particularly given how many lawsuits the Services face over their decisions regarding critical habitat—including the geographic extent and the timeline in which they designate critical habitat—the agencies have questioned the value of critical habitat designations, particularly as they are only relevant to federal activities (64 FR 31871). In 1999 for example, the Department of the Interior published a Notice in the Federal Register asking for public input as to the importance of critical habitat, and stated, “We believe the present system for determining and designating critical habitat is not working” (64 FR 31871).

As with the rest of the ESA, there have been few systematic and quantitative analyses of Section 7 (Malcom and Li, 2015). In one recent evaluation by Malcom and Li (2015), the authors found that out of 6,829 formal consultations by FWS from 2008 to 2015, only two resulted in jeopardy, and one resulted in adverse modification of habitat. Previous studies, however, that examined outcomes of consultations found higher rates of jeopardy and adverse modification findings (Malcom and Li, 2015). This difference could be due to many factors, including that consulting agencies may have already considered substantial edits to their project at the time of application to avoid later scope changes, a looser interpretation of jeopardy and adverse modification by FWS than in earlier years, and insufficient funding and personnel resources within FWS (Malcom and Li, 2015).

Today, most listed species still do not have designated critical habitat. As of January 2015, roughly just over 700 species listed species had received this designation (USFWS, 2015). The rationale for not designating critical habitat vary widely, and include factors such as not choosing to publicly expose a species' location for fear of vandalism or poaching, to sociopolitical and economic pressures (Salzman, 1990). Overall, the Services have been described as being slow and reluctant to designate critical habitat (Stokstad, 2005). In the judiciary branch, the designation of critical habitat is often upheld, although there is still considerable discrepancy between the statutory text and execution surrounding critical habitat (Owen, 2012).

F. Critical Habitat in the Marine Environment

The application of critical habitat to marine environments is particularly challenging. Far fewer critical habitat designations exist in the ocean than on terrestrial landscapes. As of 2007, FWS estimated that 36 percent of terrestrial species had critical habitat designated (USFWS, 2005), but NMFS estimated that only 21 percent of marine species have a designation of critical habitat (NMFS, 2017). Consequently, more case law exists on terrestrial conservation, which is difficult to apply in the marine environment (Brand, 2009). Additionally, the way that humans use the marine environment is very different than on land. In terrestrial environments, citizens, states, or institutions can own land that may include critical habitat and support a federal activity—unlike in the open ocean which is not owned by anyone. Thus, Brand (2009) argues that every activity in the ocean "can be classified as a federal activity," which has considerable overlap with critical habitat.

Similar to the process described above in Section II.C, NMFS' process to designating marine habitat includes a two-part process (Brand, 2009). First, NMFS must identify the areas eligible for a critical habitat designation, and then conducts an analysis that determines the "impacts of the designation, the benefits of designation and exclusion, whether the benefits of exclusion outweigh the benefits of designation, and whether exclusion will result in the extinction of the species" (Brand, 2009). Identification of habitat that is important to marine species is difficult for many reasons; collecting data on marine species, particularly in the open ocean, is inherently difficult (Brand, 2009). For example, challenges in studying and specifically delineating the PCEs important to Southern resident killer whales is one reason NMFS did not designate critical habitat for this taxon in 2006 (see Section III.E.ii for more information) (Brand, 2009). This carries less relevance following the removal of PCEs from the implementing regulations, but the level and amount of "best available science" required to establish PCEs remains unclear (Brand, 2009).

III. The Role of Sound in the Endangered Species Act

A. Importance of Sound to Species

An animal's soundscape is comprised all of forms of sound—biotic and abiotic—at a specific time (Pijanokski, B.C. et al., 2011, as cited in Hatch et al., 2016). This definition could arguably be taken to constitute an animals "acoustic habitat" (Clark et al., 2009). One key feature of many species' habitat, both terrestrial and marine, is that they rely on sound for many of their key biological features. To have access to and interact with many of the key features listed above, such as the ability to avoid predators or find mates, many species interact with "sound" in two broad spectrums: first, using sound to communicate, find food, and escape predators; and second, having a certain threshold of acoustic habitat unaltered by anthropogenic noise so that it can continue to execute these basic biological functions.

The role of sound in marine environments is well documented for marine mammals (Firestone and Jarvis, 2007; Hatch et al., 2016). Marine mammals rely on sound for nearly all of their life history functions, including foraging, finding mates, avoiding predators, and communication (Firestone and Jarvis, 2007; Moore et al., 2012). Anthropogenic noise has the potential to disrupt many of these key behaviors (i.e. migration and breeding), to mask key biological functions, cause temporary or permanent hearing loss, lead to physiological stress, and disrupt ecosystem functioning and prey availability (Moore et al., 2012).

Levels of anthropogenic noise are increasing in all ocean environments (Hatch et al., 2016). In general, anthropogenic noise inputs into marine environments decrease the extent of "acoustic communication space" and disrupts acoustic habitats over very large spatial scales (Hatch et al., 2016).

B. Global Regulatory Overview of Sound

Both the U.S. and global regulatory frameworks lack a uniform approach to describing or protecting acoustic habitat for imperiled species (Ross, et al., 2011). Similarly, there is no single regulatory scheme for monitoring and addressing noise (Firestone and Jarvis, 2007; Nowacek et al., 2015). This can lead to lawsuits, particularly related to critical habitat under the Endangered Species Act (Ross et al., 2011). Cetaceans are particularly vulnerable to the impacts of anthropogenic, and there is a need for develop protections of acoustic habitat that are specific to cetaceans (Ross et al., 2011).

The United Nations Convention on the Law of the Sea (UNCLOS) provides a broad backbone of basic principles that govern member States when operating on the high seas, holding them to a set of provisions of laws. UNCLOS does not direct its member states to specifically address noise, but does contain several articles with directives to address items related to ocean noise, such as the requirement that States address coastal pollution (Firestone and Jarvis, 2007). In the UNCLOS text, Firestone and Jarvis (2007) argue that noise can be considered as coastal pollutant, given the definition of "pollution of the marine environment in Article 1(4):

> introduction by man, directly or indirectly of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health,

> hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities (UNLCOS 1994, as cited in Firestone and Jarvis, 2007)

Despite this link between UNCLOS' definition of marine pollution and sound (e.g. it is introduced by man into the environment, can lead to "deleterious" effects on marine life, etc.) ocean noise is not yet recognized globally as a marine pollutant. Nowacek et al. (2015) suggest that an annex to the International Convention of the Prevention of Pollution from Ships with an analytical approach to regulating noise may be the best global approach as a starting point for addressing ocean noise from a regulatory perspective (Nowacek et al., 2015).

There is no overarching global or domestic regulatory structure for directly managing noise, but there is increasing attention to impacts of anthropogenic noise on marine life, both from a policy and scientific perspective, in the U.S. and elsewhere (Horowitz and Jasny, 2007; Williams et al., 2015). In the U.S., federal policy towards ocean noise has gained more traction in recent years. In 2009, the National Science and Technology Council's Joint Subcommittee on Ocean Science and Technology released a report, "Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. Federal Agencies,' that outlined a roadmap for federal agencies to address ocean noise (Southall et al., 2009). In 2016, NOAA published their an "Ocean Noise Strategy Roadmap" to implement an ocean noise management plan for the next decade (NOAA, 2016a). NOAA also published "Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing" in 2006, which sought to delineate more accurate thresholds for assessing masking in marine mammals. Both of NOAA's 2016 reports followed guidelines by the IUCN that sought to increase mitigation measures and standards for seismic testing, an important global noise input (Nowacek and Southall, 2016). Despite these improvements, significant gaps remain in our scientific and regulatory knowledge regarding how marine mammals are impacted by noise, and how best to address this in a policy and legal context (Horowitz and Jasny, 2007).

C. Regulatory Tools to Manage Sound

The U.S. does not have any statute in place that directly address ocean noise, but NOAA has historically relied on the legal framework of the ESA and MMPA to regulate this form of disturbance (Hatch et al., 2016, NOAA, 2016a), together with aspects of the National Environmental Policy Act (NEPA), Magnuson-Stevens Fishery Conservation and Management Act, and the National Marine Sanctuaries Act (NOAA, 2016a). In particular, the ESA, MMPA, and NEPA provide a broad framework for ensuring that noise impacts are minimal and mitigated (Nowacek et al., 2015). In addition to these statutes, the National Ocean Policy also directs federal agencies to take an ecosystem-based approach to management, which inherently tasks NOAA with considering "[...]widespread degradation of natural acoustic habitat for a broad range of acoustically-sensitive species due to increasing noise from accumulated anthropogenic sources." (NOAA, 2016a). NOAA and other federal agencies recognize the growing importance of first characterizing acoustic habitat and its anthropogenic noise inputs, as well as managing that effectively (Southall et al. 2009; Hatch et al., 2016). NOAA, in particular, also recognizes the need for addressing and understanding cumulative impacts from noise (Hatch et al., 2016).

D. The Role of Noise Regulation under the ESA

At the surface, the ESA does not have appear to have a clear structure for regulating noise. However, many of the ESA's key features, such as the development of recovery plans and the designation of critical habitat based on key biological or physical features, provide opportunities for sound to be incorporated in species recovery planning. Furthermore, the ESA finds that federal agencies cannot cause adverse modification or destruction of critical habitat, and nor can their activity jeopardize species. But, these prohibitions can be interpreted ambiguously, and the lack of quantitative metrics within the ESA make it difficult to assess impacts from not only a single sound source, but cumulative noise in an environment (Moore et al., 2012).

The marine environment poses a particular set of challenges when attempting to designate "fixed boundaries to a mobile organism that inhabits a fluid medium" (Gregr and Bodtker, 2007), particularly since many of these statutes are rooted in protections designed for the terrestrial environment (Ross et al., 2011). Designating this sort of management and legal framework to protect cetaceans is particularly difficult, given their extensive ranges that may cross political and international boundaries, and their overlap with human activities in marine environments (Ross et al., 2011).

In short, the role of regulating sound under the ESA remains debatable. However, one key area where sound has potential to play a role, particularly for marine mammals, is in the designation of critical habitat. Critical habitat is based on, in large part, "physical or biological features essential to the conservation of the species." For marine mammals, there is a strong argument to consider sound as "essential to the conservation of the species", particularly for cetaceans which rely on sound for many key life history functions. It is not possible to designate the entire "acoustic habitat' of a species, but there are several examples of incorporating sound or other novel approaches into critical habitat designations.

E. Case Studies on Sound and Critical Habitat

The following section reviews five case studies of critical habitat for marine vertebrates in order to help inform how NMFS has decided upon critical habitat areas, PCEs used to make these decisions, and other information to guide best practices for critical habitat for marine mammals. See Table 1 for more information.

i. Cook Inlet Beluga Whale

In 2008, NOAA listed Cook Inlet beluga whales as endangered under the Endangered Species Act, and in 2011, issued the final critical habitat designation (76 FR 20180). In this designation, NMFS listed five PCEs, or physical and biological features within the proposed area:

"(1) Intertidal and subtidal waters of Cook Inlet with depths less than 30 feet (MLLW) (9.1 m) and within 5 miles (8 km) of high and medium flow anadromous fish streams.
(2) Primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole.
(3) Waters free of toxins or other agents of a type and amount harmful to Cook Inlet beluga whales.
(4) Unrestricted passage within or between the critical habitat areas.

(5) Waters with in-water noise below levels resulting in the abandonment of critical habitat areas by Cook Inlet beluga whales."

This is the only known designation of a sound-related PCE in the designation of critical habitat. In addition to directly including a reference to acoustic habitat in this PCE, there were several other comments and responses relating to noise and sound throughout the final rule of note.

One commenter stated that NMFS did not identify existing empirical data or explain "science and rationale" behind creating noise as a PCE. NMFS responded and referenced NMFS' 2008 Conservation Plan for Cook Inlet belugas, which detailed research surrounding noise and Cook Inlet belugas (76 FR 20180). Another comment said that the noise PCE is stated too vaguely, and that NMFS should provide an objective, measurable value for assessing noise level. To that, NMFS responded that PCEs were developed based on the best available scientific evidence, which is currently the only requirement for PCEs (76 FR 20180). NMFS referenced harassment levels as mentioned in MMPA implementing regulations, but found it "unnecessarily restrictive" to include those specific thresholds as a PCE to this environment. NMFS did state, however, that quantified standards for this could be amended and added to this PCE for belugas when such information became available (76 FR 20180).

Another commenter stated that the noise PCE should be removed, referencing NMFS' 2006 final rule on critical habitat for southern resident killer whales (described below). NMFS noted that at the time of the former rule, NMFS claimed that they did not have enough information to designate noise as a PCE, but stated that they would consider noise for marine mammals in future critical habitat designations (76 FR 20180). NMFS also argued several points, including the importance of sound for marine mammals and that noise can impact marine mammals, that they agree with their 2006 decision and still lack sufficient information specific to Southern Residents, and that the ESA nor its supporting regulations provide rationale for "quantifiable thresholds" for PCEs, and rather just require using the best available science, which NMFS has done here (76 FR 20180). Finally, several other comments urged rewording of the noise PCE to include the term "adverse modification" or "adverse impact" but NMFS said that the purposes of PCEs are to establish essential features, not to act as a tool to limit activity. In a later comment response, NMFS stated that "Our intent is to avoid having the mere presence of noise, or even noise which might cause harassment, be deemed adverse modification" (76 FR 20180). This reply in particular, raises questions about the intent of this statement and how or why they do not wish to have noise become related to adverse modification.

In the actual text of the designation, NMFS includes two paragraphs related to sound. One is a paragraph on the role of the biological function of sound for belugas. The second describes potential impacts of anthropogenic noise, and why maintaining relative quiet waters in Cook Inlet beluga habitat is so important to their biology. This paragraph, in turn, provided the rationale for noise being included as a PCE.

Specifically, the first paragraph states (76 FR 20180):

> *Beluga whales are known to be among the most adept users of sound of all marine mammals, using sound rather than sight for many important functions, especially in the highly turbid waters of upper Cook Inlet. Beluga whales use sound to communicate,*

locate prey, and navigate, and may make different sounds in response to different stimuli. Beluga whales produce high frequency sounds which they use as a type of sonar for finding and pursuing prey, and likely for navigating through ice-laden waters. In Cook Inlet, beluga whales must compete acoustically with natural and anthropogenic sounds. Man-made sources of noise in Cook Inlet include large and small vessels, aircraft, oil and gas drilling, marine seismic surveys, pile driving, and dredging.

The preceding paragraph goes onto say (76 FR 20180):

Anthropogenic noise above ambient levels may cause behavioral reactions in whales (harassment) or mask communication between these animals. The effects of harassment may also include abandonment of habitat. At louder levels, noise may result in temporary or permanent damage to the whales' hearing. Empirical data exist on the reaction of beluga whales to in-water noise (harassment and injury thresholds) but are lacking regarding levels that might elicit more subtle reactions such as avoiding certain areas. Noise capable of killing or injuring beluga whales, or that might cause the abandonment of important habitats, would be expected to have consequences to this DPS in terms of survival and recovery. We consider ''quiet'' areas in which noise levels do not interfere with important life history functions and behavior of these whales to be a necessity. Therefore, we consider the assurance of in-water noise levels that do not cause beluga whales to abandon or fail to access important critical habitat areas, such as foraging sites at river mouths, to be an essential feature. This feature is found in both areas 1 and 2.

ii. Case Study on Southern Resident Killer Whale

In 2006, NMFS designated critical habitat for the Southern Resident killer whale distinct population segment (DPS) after it listed this DPS as endangered in 2005 (71 FR 69054). NMFS designated critical habitat in three areas of the inland waters of Washington State. NMFS originally identified sound as a potential PCE in NMFS' listing determination for killer whales, and also mentioned it as a concern in NMFS' 2004 Southern Resident status review and Conservation Plan (71 FR 69054). The agency did not, however, include sound or noise as a PCE in the final critical habitat rule (71 FR 69054). In response to public comments that encouraged the inclusion of sound as a PCE, NMFS argued that noise affects animals, and not their habitat. The agency mentioned ongoing Section 7 consultations to ensure noise impacts were mitigated, arguing that these consultations sufficed for considering impacts from noise (71 FR 69054). Furthermore, while the agency noted that sound can disrupt echolocation and communication, NMFS stated that the Service "lack sufficient information to include sound as a PCE of killer whale critical habitat," and stated that they would "continue to consider sound in any future revisions of the critical habitat designation" (71 FR 69054). Ultimately, NMFS designated the following as PCEs for Southern Resident killer whales:

"(1) Water quality to support growth and development;
(2) Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth;
(3) Passage conditions to allow for migration, resting, and foraging" (71 FR 69054)

In 2014, the Center for Biological Diversity filed a petition to revise the 2006 critical habitat designation to expand it to other areas, and to adopt protective in-water sound levels as a PCE. The Center also explained that there had been substantial research conducted since 2006 on impacts of noise on cetacean habitat, and that this, combined with the how vital sound is to Cook Inlet belugas, that is should be a PCE. Specifically, the Center urged that the PCE: "(1) do not exceed thresholds that inhibit communication or foraging activities, (2) do not result in temporary or permanent hearing loss to whales, and (3) do not result in the abandonment of critical habitat areas" (Center for Biological Diversity, 2014). In 2015, NMFS issued a "12-month finding" Notice in the Federal Register in response to the petition (80 FR 9692). NMFS did not include anything specific to sound in the section, "How We Intend to Proceed," they did list comments they received on sound as a PCE, most of which supported the notion, although a few commenters opposed it. It is unclear how NMFS will proceed with this, particularly under a new Administration and the February 2016 removal of PCEs from the implementing regulations.

While the U.S. did not designate sound as a PCE for Southern resident killer whales (National Marine Fisheries Service, 2008), Canada did so in its 2008 critical habitat designation under the Species at Risk Act, the Canadian equivalent of the ESA (Fisheries and Oceans Canada, 2011). Specifically, the designation identifies acoustics in one of two critical habitat attributes for Southern Residents, stating, "[...the lack of acoustic disturbance or chemical contamination which would prevent the area from being used by the species for foraging, socialising, mating, resting, and in the case of the northern residents, beach rubbing" (Fisheries and Oceans Canada, 2011). Acoustic degradation was recognized as a threat to resident killer whales, and the designation makes it illegal to introduce noise that could destroy habitat (Williams et al., 2013).

iii. North Atlantic Right Whales

In 1994, NMFS designated critical habitat for right whales in the North Atlantic Ocean off the coasts of Massachusetts, Georgia, and Florida—areas that represent key feeding, nursery, and calving habitats for the species (81 FR 4837). The agency revised this provision in 2006, adding critical habitat for right whales in the North Pacific Ocean in the Bering Sea and the Gulf of Alaska (81 FR 4837). At the same time, the agency formally recognized three separate phylogenetic species of right whales, each listed as endangered under the ESA: North Atlantic right whales, North Pacific right whales, and southern right whales (81 FR 4837).

NMFS received a petition in 2009 to revise the 1994 critical habitat designation in the North Atlantic (81 FR 4837). Six years later, the agency issued a proposed rule to replace the 1994 designation, and in 2016, issued a final rule. The final rule contains two critical habitat areas. Area 1 constitutes foraging habitat off New England, stretching from Cape Cod to Georges Bank and to the U.S.-Canadian maritime boundary. Area 2 encompasses the calving area, and includes marine waters from Cape Fear, North Carolina to just south of Cape Canaveral, Florida (81 FR 4837).

By the time the final rule was published, NMFS had made the change to ESA implementing regulations regarding the removal of PCEs. Thus, the final critical habitat designation did not reference PCEs, and instead referred to them simply as physical or biological features. NMFS identified critical habitat for both foraging and calving habitat, each with its unique suite of these features (81 FR 4837). These include:

Foraging habitat:
"(1) The physical oceanographic conditions and structures of the Gulf of Maine and Georges Bank region that combine to distribute and aggregate *C. finmarchicus* for right whale foraging, namely prevailing currents and circulation patterns, bathymetric features (basins, banks, and channels), oceanic fronts, density gradients, and temperature regimes;"
"(2) Low flow velocities in Jordan, Wilkinson, and Georges Basins that allow *diapausing C. finmarchicus* to aggregate passively below the convective layer so that the copepods are retained in the basins;"
"(3) Late stage *C. finmarchicus* in dense aggregations in the Gulf of Maine and Georges Bank region; and"
"(4) *Diapausing C. finmarchicus* in aggregations in the Gulf of Maine and Georges Bank region."

Calving habitat:
"(1) Calm sea surface conditions of Force 4 or less on the Beaufort Wind Scale;"
"(2) sea surface temperatures from a minimum of 7 °C, and never more than 17 °C; and"
"(3) water depths of 6 to 28 meters, where these features simultaneously co-occur over contiguous areas of at least 231 nm2 of ocean waters during the months of November through April."

The agency did not include sound in the proposed or final rule, despite receiving many comments on sound, particularly in the calving critical habitat area. Many commenters urged the agency to restrict Navy activity, oil and gas exploration, and other potential anthropogenic threats (81 FR 4837). One specific commenter cited the Cook Inlet beluga whale sound-related PCE, arguing that the agency did not recognize potential noise impacts on right whale mothers and calves. In response, the agency explained their final decisions in the Cook Inlet and Southern resident final rules, indicating that belugas are "the most adept users of sound of all marine mammals," and that like southern resident killer whales, the agency lacked "sufficient information to include noise an essential feature for North Atlantic right whale calving area critical habitat" (81 FR 4837). NMFS also said they did not have information on specific acoustic levels that facilitated calving. The agency noted that they received multiple comments on concerns for North Atlantic right whales from oil and gas exploration, and its potential effects including habitat displacement, injury, mortality, acoustic making, and more (81 FR 4837). The agency responded by not referring back to the potential direct impacts themselves, but indicating that it did not anticipate oil and gas activity in areas offshore in Unit 1 (North Carolina to Florida). The agency also mentioned that they would collaborate with BOEM to determine if BOEM-sponsored activities (such as oil and gas exploration) could affect the species (81 FR 4837). Another commenter encouraged the agency to expand physical and biological features to include "acoustic qualities" for right whale communication. In turn, NMFS stated that "The acoustic qualities or features of the habitat that are essential to the conservation of North Atlantic right whales are currently unknown." NMFS cited a study that referenced existing knowledge gaps in large whale communication and threats to them ocean noise. Another commenter encouraged NMFS to include "acoustic habitat necessary for whale communication or other essential whale behavior" as physical or biological feature, as well as discussing noise-producing impacts like seismic airguns, pile driving, etc. in the special management considerations (81 FR

4837). NMFS found this feature to not be appropriate for reasons described above, and noted that referencing the actual impacts does not fit into an actual habitat designation (81 FR 4837).

Thus, in this designation, it appears that the NMFS position was similar to that taken with Southern Resident killer whale critical habitat, by emphasizing uncertainty regarding the importance of sound in the species' calving habitat.

iv. Loggerhead Sea Turtles

Loggerhead sea turtles were first listed under the Endangered Species Act in 1978, and relisted in 2013 as part of a reclassification from a single, global threatened species to nine DPSs (79 FR 39856). NMFS designated critical habitat in 2013 for one of these DPSs: the Northwest Atlantic Ocean Distinct Population Segment (DPS) (79 FR 39856). This was a rather extensive designation, consisting of 38 areas consisting of one or more habitat types: nearshore reproductive habitat, winter area, breeding areas, constricted migratory corridors, and *Sargassum* habitat (79 FR 39856). Each of these five habitat types had their own PCEs, which are outside the scope of discussion in this report.

The latter habitat area, *Sargassum*, does have relevance to the present discussion because of the novel approach taken by the agency. Personal communications indicate that designating *Sargassum* as a habitat area is more of a novel approach by the agency, and thus is discussed here.

Sargassum was not included as an actual habitat area in the Proposed Rule (79 FR 39856), but rather NMFS asked for comments on whether or not to include *Sargassum* as an actual habitat area. One commenter argued that the ESA does not requires a PCE to be static, unlike the nature of *Sargassum* that shifts spatiotemporally in the Atlantic; NMFS responded by stating that it is indeed possible to designate ephemeral or wetland habitat (79 FR 39856). Other comments are not reviewed here because of the lack of reference to cetaceans and sound.

It is important to note that it is not *Sargassum* in and of itself that is designated as critical habitat, as this is a dynamic feature that shifts over time and a space, but rather NMFS designated a fixed boundary where *Sargassum* density seems to be highest (79 FR 39856). Two *Sargassum* habitats were identified: The Western Gulf of Mexico to the edge of the Loop Current, and in the Atlantic from the northern/western boundary of the Gulf Stream to the edge of the U.S. EEZ. The PCEs for *Sargassum* are as follows (79 FR 39856):

"(i) Convergence zones, surface-water downwelling areas, the margins of major boundary currents (Gulf Stream), and other locations where there are concentrated components of the Sargassum community in water temperatures suitable for the optimal growth of Sargassum and inhabitance of loggerheads;"
"(ii) Sargassum in concentrations that support adequate prey abundance and cover;"
"(iii) Available prey and other material associated with Sargassum habitat including, but not limited to, plants and cyanobacteria and animals native to the Sargassum community such as hydroids and copepods; and"

"(iv) Sufficient water depth and proximity to available currents to ensure offshore transport (out of the surf zone), and foraging and cover requirements by Sargassum for post-hatchling loggerheads, i.e., >10 m depth."

v. Polar Bears

USFWS listed polar bears as threatened under the ESA in 2008, and issued a final critical habitat designation in 2010 (75 FR 76086). The final critical habitat designation included three main habitat areas, which were also considered their PCEs: (1) sea ice habitat, (2) terrestrial denning habitat, and (3) barrier island habitat.

The final critical habitat designation did not include reference to sound, although one commenter noted that PCEs should be more robust to decrease disturbance from people. NMFS responded that the barrier island PCE provided a sufficient buffer to protect polar bears from noise and other disturbance (75 FR 76086).

Noise, however, is not the focus of the polar bear critical habitat case study; instead, polar bears are discussed here because of their sea ice critical habitat. Both their listing, which was largely predicated on the threat of climate change to their habitat, and the designation of sea ice habitat, can be viewed as novel approaches to critical habitat designations in U.S. policy, because they are based on a threat that is both contentious and still under study (75 FR 76086). The sea ice critical habitat area encompasses one PCE, "feeding, breeding, denning, and movements that are essential for the conservation of polar bear populations in the United States" (75 FR 76086). This rule has gone through several court challenges, but was ultimately upheld in 2016 by the 9th Circuit Court (Center for Biological Diversity, 2016).

The polar bear critical habitat designation is significant for several reasons, including setting a precedent within the ESA for recognizing climate change and for recognizing that specific features within critical habitat can be based on dynamic features, rather than static physical features.

	Cook Inlet Beluga Whales	**Southern Resident Killer Whales**	**North Atlantic Right Whales**	**Loggerhead Sea Turtles**	**Polar Bears**
Year Designated	2011	2006	1994; revised in 1996	2014	2010
Habitat Areas	Two	Three	Two	38	Three
PCEs	"(1) Intertidal and subtidal waters of Cook Inlet with depths less than 30 feet (MLLW) (9.1 m) and within 5 miles (8 km) of high and medium flow anadromous fish streams.	"(1) Water quality to support growth and development; (2) Prey species of sufficient quantity, quality, and availability to	Seven total; four in foraging areas and three in calving areas	Many	"Feeding, breeding, denning, and movements that are essential for the conservation of polar bear populations in the United

	(2) Primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole. (3) Waters free of toxins or other agents of a type and amount harmful to Cook Inlet beluga whales. (4) Unrestricted passage within or between the critical habitat areas. (5) Waters with in-water noise below levels resulting in the abandonment of critical habitat areas by Cook Inlet beluga whales."	support individual growth, reproduction, and development, as well as overall population growth; (3) Passage conditions to allow for migration, resting, and foraging"			States" (just for sea ice)
Sound Inclusion as PCE?	Yes, PCE 5	No	No	No	No
Public Comments Referencing Sound?	Yes	Yes	Yes	No	No
Other Notes	Only marine mammal with sound as a PCE/in the critical habitat designation.	Sound included as original PCE but not as final; NMFS issued a positive 12-month finding in 2015 on a CBD petition to revise critical habitat based on sound	Critical habitat broken up into two distinct areas with	*Sargassum* area designated as critical habitat; seen as a novel designation in the sense that *Sargassum* is a dynamic feature	Sea ice habitat designation recognized as being novel and significant

Table 1: Comparison of critical habitat designations for five species.

F. Conclusion

Broadly speaking, there are several areas within the ESA where sound can be incorporated. The ESA does not yet have a specific framework for directly incorporating the importance on soundscapes into decision making directly through statutory text or implementing regulations, but there are avenues to highlight the importance of soundscapes or the threat of anthropogenic noise to listed species. This can be highlighted in recovery plans, habitat conservation plans, Section 7 consultations, and, as shown here, in critical habitat designations (Seney et al., 2013). If done, sound then can be used in Section 7 consultations and, possibly, in jeopardy and adverse modification findings. The use of prohibitions on take in Section 9 could, in theory, allow one to argue that cumulative, continuous noise could meet the definition of take, if an individual was harassed, harmed, wounded, or killed from a noise input.

The five critical habitat case studies reviewed here vary widely and reveal considerable latitude in agency decision-making. Several of the case studies, however— particularly Cook Inlet Belugas, loggerhead sea turtles, and polar bears—prove that, at a minimum, critical habitat need not be based on static features, and that it may be based on threats that pose ongoing risk to habitat (e.g. polar bears). The 2011 Cook Inlet beluga critical habitat designation acts as the first incorporation of sound into a critical habitat designation for any marine vertebrate (Williams et al., 2013). By including noise as a PCE, NMFS has elevated sound to the point where it provides legal leverage. Furthermore, NOAA mentioned the PCEs for beluga whales in the Ocean Noise Strategy Roadmap, perhaps indicating its intention to provide more attention to this issue in the future (NOAA, 2016a). And, although southern resident killer whales currently lack a sound-related PCE, NMFS may have set a precedent for considering sound and noise in future critical habitat designations when they stated that they would "continue to consider sound in any future revisions of the critical habitat designation" (71 FR 69054). Still, the incorporation of sound into these designations is in its infancy, and it is likely that the implementation of such an approach will vary with the political climate.

In recent years, climate change and its threat to species is gaining widespread attention both in the scientific and policy sphere; consequently, more stakeholders are calling for climate science to be considered in species recovery and conservation (McClure et al., 2013; Seney et al., 2013). This concept was supported by a recent court decision to uphold NMFS' determination to list bearded seals as threatened under the ESA because of climate change and the threats it may pose to sea ice habitat (Alaska Oil and Gas Association vs. Penny Pritzker). Thus, between this and the polar bear climate change-related PCE, it appears that there may be an avenue to incorporate a variety of novel threats under the ESA, potentially lending for a case to include sound in critical habitat and elsewhere under the ESA.

IV. Developing a Critical Habitat Petition

As discussed above, there are two avenues to designating critical habitat pursuant to the 1978 amendments: synchronously with species' listing, or through a citizen petition. For species listed before the 1978 amendments, there are two pathways: an initiation by the relevant Secretary, or again, through a citizen petition. Petitions to designate critical habitat for species without existing habitat are subject to provisions under the Administrative Procedure Act and not the ESA review provisions (50 C.F.R. § 424.14(d)). Thus, it appears NMFS and FWS are not held to the same 90-day and 12-month review and finding timelines set under synchronous listings or critical habitat expansions (81 FR 7413). Instead, the APA requires that agencies give "prompt notice of review" and notify the petitioner of any decision making, but the Services are not required to go provide Federal Register notice or public comment as they are for petitions to list species or revise critical habitat (Division of Endangered Species and Endangered Species Division, 1996). It appears that petitions to create critical habitat for listed species without preexisting habitat designations are exempt from ESA procedures, but the following describes general petition guidelines for submitting petitions under the ESA (USFWS, 2016d). In theory, these guidelines should still be followed to create a robust and reputable petition:

- The petition must be evident that it is being submitted under the ESA with a corresponding date
- It must contain the following criteria: name, signature, address, telephone number and affiliation of the petitioner

For petitions to revise critical habitat, the petitioner should include the following information (USFWS, 2016d):

- Petitions should contain "physical or biological features essential to, and that may require special management to provide for, the conservation of the species involved"
- Information on how areas currently designated as critical habitat do not contain factors essential to conservation or that don't require special management for the conservation of the species
- A description and maps of the relevant area
- A description of the benefits of including species habitat
- Within the area occupied by the species when it was listed, information on specific areas that contain "the physical or biological features that are essential to the conservation of the species and may require special management considerations or protection"
- Information on why areas outside the geographic area occupied by the species are not "essential for the conservation of the species"
- The scientific name of the species
- Clear descriptions of the proposed administrative measure
- Detailed justification for the recommended measure
- Contain substantial scientific evidence

In developing actual critical habitat designations, there are a number of questions that NMFS frequently references in their considerations of specific area for habitat. These include (74 FR 63080):

- "What areas are occupied by the species at the time of listing?"
- "What physical and biological features are essential to the species' conservation?"
- "Are those essential features ones that may require special management considerations or protection?"
- "Are there any areas outside those currently occupied that are 'essential for conservation? What economic, national security, and other relevant impacts would result from a critical habitat designation?"
- "What is the appropriate geographic scale for weighing the benefits of exclusion and benefits of designation?"
- "Will the exclusion of any particular area from the critical habitat designation?"

After reviewing a wide variety of petitions related to critical habitat, including revising critical habitat for North Atlantic right whales (Center for Biological Diversity, et al., 2009), southern resident killer whales (Center for Biological Diversity, 2014), and Hawaiian monk seals (Center for Biological Diversity, 2008), it is clear that there is considerable variation in the presentation, delivery, and content of such petitions. Of these, NMFS issued final rules revising North Atlantic right whale and Hawaiian monk seal critical habitat, and issued a positive 12-month finding on the southern resident killer whale petition.

Petitioning for critical habitat as a stand-alone designation (*i.e.* separate from listing or not as a revision) occurs less frequently than revising or actions associated with the listing process. The only known example of such an action is the 2010 petition to designate critical habitat for Kemp's ridley sea turtles (WildEarth Guardians, 2010). NOAA has not yet issued any action on this petition, nor has critical habitat been referenced in its revised recovery plan or 5-year review that have been published since receipt of the petition (NOAA, 2015b). There have been no petitions to designate critical habitat for marine mammal species without the nexus of another administrative measure, and consequently there have been no agency actions related to such actions. The most relevant petitions seem to involve decisions to list species or consider them as distinct population segments (i.e. Bryde's whales and humpback whales) which, in turn, triggers a critical habitat revision. Nevertheless, it is still possible to file a petition pursuant to Title 50 of the Code of Federal Regulations (50 C.F.R. § 424.14(d)).

Next Steps

The remainder of this document contains an ESA petition to designate critical habitat for sperm whales in the Gulf of Mexico. Currently, sperm whales are listed as a single global, endangered species under the ESA, and are listed without any designation of critical habitat (NOAA, 2015). In 2011, WildEarth Guardians submitted a petition to designate sperm whales in the Gulf of Mexico as a Distinct Population Segment (WildEarth Guardians, 2011), but NMFS issued a "not warranted" 12-month finding in 2013 (NOAA, 2017). If this petition had been accepted, a review process of critical habitat would have been triggered. Regardless of the finding, due to the multiple anthropogenic threats to sperm whales in the Gulf of Mexico, the genetically distinct nature of this stock of whales, and their residency in the region, the remainder of this document serves as petition to designate critical habitat for sperm whales in the Gulf of Mexico.

V. Sperm Whale Critical Habitat Petition

PETITION TO DESIGNATE CRITICAL HABITAT IN THE GULF OF MEXICO FOR SPERM WHALES (*PHYSETER MACROCEPHALUS*) UNDER THE U.S. ENDANGERED SPECIES ACT

Photo: Shane Gross/Shutterstock

Petition Submitted to the U.S. Secretary of Commerce, Acting through the National Oceanic and Atmospheric Administration and the National Marine Fisheries Service

Petitioner:
Brianna Elliott
Duke University

April 27, 2017

NOTICE OF PETITION

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I. Action Requested

Pursuant to the Endangered Species Act ("the Act," "ESA") of 1973 as amended (16 U.S.C. § 1533(b)(3)(D)), the ESA's implementing regulations (50 C.F.R. § 424.14(a)), and Section 553 of the Administrative Procedure Act ("the APA") (5 U.S.C. § 553(e)), the Secretary of Commerce must designate critical habitat for species concurrently with their listing under the Act to the "maximum extent prudent and determinable" (16 U.S.C. § 1533(a)(3)(A)). NMFS listed sperm whales (*Physeter macrocephalus*) under the Endangered Species Conservation Act in 1970 (35 FR 18319)—the precursor to the Endangered Species Act (NMFS, 2010)—prior to the 1978 amendments that mandated concurrent critical habitat review with listing. This listing thereby exempting sperm whales from the possibility of a review of critical habitat at the time of listing. Because Section 3 of the ESA allows the Secretary to designate critical habitat for species which do not have critical habitat ((16 U.S.C. § 1532(5)(b)), this petition acts as official notice to the Secretary of Commerce, via the National Marines Fisheries Service (NMFS), to review and consider critical habitat for sperm whales in the Gulf of Mexico under the ESA and APA.

The areas proposed for designation below are based on the best available science, and meet all criteria required for a critical habitat designation pursuant to Section 3 of the ESA (16 U.S.C. § 1532(5)), including "specific areas within the geographical area occupied by the species" that include "physical or biological features" "(I) essential to the conservation of the species and (II) which may require special management considerations or protection."

I hereby request critical habitat in the Gulf of Mexico ("the Gulf") be designated for sperm whales because a distinct, resident stock of sperm whales exist within the northern Gulf of Mexico, particularly along unique geological features of the Mississippi and De Soto Canyons and offshore of the Mississippi River Delta. Given the extent of oil and gas extraction and exploration, other anthropogenic activity in the Gulf of Mexico, and the history of pollution in the Gulf—from events such as the Deepwater Horizon explosion in 2010 and runoff from the Mississippi River—this habitat requires a unique management framework to mitigate harm to sperm whales.

II. Introduction

Sperm whales have a global distribution—the widest distribution of any marine mammal (Jaquet and Whitehead, 1996). They range from pack ice at each pole to the equator (Whitehead, 2002), although they are generally found in continental slope waters offshore (Taylor et al., 2008). Sperm whales are predominantly found in deep water, generally in depths exceeding 500 meters (NOAA Fisheries, 2017). Females and their young tend to stay is lower latitudes, typically in waters warmer than 15 degrees Celsius (Rice, 1989).

Current population estimates for sperm whale global population size vary widely (Taylor et al., 2008). Whitehead (2002) estimated a global population of roughly 360,000 individuals (confidence value (CV) = 0.36). NMFS suggests a wider population range, stating that the global population of sperm whales is relatively unknown, estimated to be anywhere from 200,000 to 1,500,000 (NOAA Fisheries, 2017). Historically, commercial whaling was the largest threat to sperm whales, and is estimated to have killed up to one million sperm whales. Today, threats include anthropogenic noise, vessel strikes, entanglement with fishing gear, and pollution (Taylor et al., 2008; NOAA Fisheries, 2017).

Within this global distribution, one distinct stock of sperm whales exists in the Gulf of Mexico. Here, they are the most common large whale in the Gulf (Jochens et el., 2008). These sperm whales are year-round residents of the Gulf (NOAA, 2015), are genetically distinct (Engelhaupt et al., 2009; NMFS, 2010), have a unique vocalization structure (Jochens et al., 2008; NOAA, 2015), and are generally smaller than sperm whales elsewhere (Jaquet, 2006; Jochens et al., 2008). Taken together, these lines of evidence indicate that the Gulf is particularly vital to the persistence of this specific stock of sperm whales. At the same time, the Gulf has a unique set of threats, particularly from oil and gas activity, that require "special management considerations" (16 U.S.C. § 1532(5)).

Consequently, I request that NMFS designate critical habitat for sperm whales in the Gulf of Mexico under the Endangered Species Act, specifically in the De Soto Canyon, Mississippi Delta, and from the 800 to 1000-meter contour line east of the Mississippi River delta to the De Soto Canyon.

III. Legal and Factual Background

A. Critical habitat and the ESA

The ESA gives legal status to the species most vulnerable to extinction, with an overall goal of their conservation and recovery (16 U.S.C. § 1531). One vital aspect in species conservation is protection of habitat. Congress recognized the importance of habitat by clearly giving reference to habitat in Section 1 of the ESA, which states:

> The purposes of this chapter are to provide a means whereby the **ecosystems upon which endangered species and threatened species depend** may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in subsection (a) of this section (emphasis added) (16 U.S.C. § 1531(b)*,* as cited in Center for Biological Diversity, 2014).

The importance of habitat protection to the species' recovery is also evident through the ESA's inclusion of critical habitat designations in Section 4 (16 U.S.C. § 1533(a)(3)). By designating critical habitat, species are afforded with several additional protections. This includes ensuring that federal agencies consult with NMFS under Section 7 of the ESA, and do not authorize, fund, or carry out any activity that could "jeopardize the continued existence" or "result in the destruction or adverse modification" of species' habitat. In doing so, protections for listed species are advanced beyond just direct take to the species themselves. In addition to regulatory requirements, critical habitat helps managers at the federal, state, industry, and local level better understand which specifics areas and its corresponding elements that are most vital to species' recovery.

The ESA defines critical habitat as:

> the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those **physical or biological features** (I) **essential to the conservation of the species** and (II) which **may require special management considerations or protection** (emphasis added) (16 U.S.C § 1532(5)(A)(i)).

The ESA implementing regulations further go on to describe the "physical or biological features" in designations for species:

> This analysis will vary between species and may include consideration of the appropriate quality, quantity, and spatial and temporal arrangements of such features in the context of the life history, status, and conservation needs of the species 50 C.F.R. § 424.12(b)(1)(ii) (2016).

In previous versions of ESA implementing regulations, guidance on selecting these "physical or biological features" included the following examples:

> (1) Space for individual and population growth, and for normal behavior;
> (2) Food, water, air, light, minerals, or other nutritional or physiological requirements;
> (3) Cover or shelter;
> (4) Sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and generally;
> (5) Habitats that are protected from disturbance or are representative of the historic geographical and ecological distribution of a species" 50 C.F.R. § 424.12(b) (2012).

Additionally, former implementing regulations specifically required that the Secretary identify "primary constituent elements" (PCEs) for species, which could include, "roost sites, nesting grounds, spawning sites, feeding sites, seasonal wetland or dryland, water quality or quantity, host species or plant pollinator, geological formation, vegetation type, tide, and specific soil types" (50 C.F.R. § 424.12(b)) (2012).

These terms have been removed from the implementing regulations via 2016 amendments, but they still provide a sound starting point in aiding with selection of important features in designating critical habitat.

B. Sperm whale's ESA history

NMFS listed the global population of sperm whales as endangered in 1970 under the Endangered Species Conservation Act of 1969 (35 FR 18319). Other than five-year status reviews and the creation of a recovery plan in 2010, NMFS has had little ESA regulatory involvement with sperm whales (NOAA Fisheries, 2017). NMFS has issued negligible impact determinations for sperm whales in several commercial fisheries outside of the Gulf of Mexico, but under the jurisdiction of the MMPA, rather than the ESA.

In 2011, WildEarth Guardians submitted a petition to NMFS to designate sperm whales in the Gulf of Mexico as a Distinct Population Segment (DPS) (WildEarth Guardians, 2011). WildEarth stated that "the Gulf of Mexico DPS deserves separate listing as it is a discrete population that is also significant to the species and faces additional unique threats to its survival" (WildEarth Guardians, 2011). WildEarth went on to summarize a range of factors describing why sperm whales in the Gulf of Mexico are discrete and significant—two required standards in defining and designating a DPS—including unique vocalization to the Gulf, genetic distinctness, behavioral differences to other sperm whale populations, residency, and more (2011).

In 2013, NMFS issued a “Not Warranted” 12-month finding, stating, “the best available information on genetics, size, behavior, and regulatory mechanisms does not indicate the sperm whales in the GOM are discrete from other populations of the sperm whale” (78 FR 68032).

Thus, sperm whales remain as one global, endangered species under the ESA. NMFS argued that scientific evidence did not warrant sperm whales being “discrete” and “significant” enough from other stocks to warrant a DPS designation, but a compelling case remains for recognizing certain areas within the Gulf that are “essential to the conservation of the species and (II) which may require special management considerations or protection” ((16 U.S.C § 1532(5)(A)(i)). Here, should sperm whales continue to be listed as one global species, I find that certain regions within the Gulf of Mexico are essential to sperm whales in the Gulf given their residency, genetic distinctness, unique vocalization structure, and abundance in very specific habitat areas related to bathymetry, physical processes, and prey availability. Furthermore, given the unique set of anthropogenic threats to sperm whales in the Gulf, particularly from activity associated with oil and gas exploration and extraction, I argue that certain areas and features within the Gulf of Mexico do indeed “require special management considerations or protection” that are worthy of a critical habitat designation.

IV. Overview of Sperm Whales

A. General species description

As Taylor et al. (2008) stated, “The sperm whale is an animal of extremes.” Other than killer whales, they have the most extensive distribution of any marine mammal (NMFS, 2010; Rice, 1989). The sperm whale (*Physeter macrocephalus*) is the largest species of toothed whale, and their brain is the largest of any species on Earth, though it is considered negligible in size compared to its body length (NMFS, 2010). Their massive head comprises about 25 to 35 percent of their body length, containing structures that produce the sounds used by whales to generate echolocation signals used to find prey (Cranford, 1999). The size of this massive nasal complex is what gives sperm whales such a peculiar appearance (Madsen, et al., 2002b). This complex is substantially different from homologous sound-producing structures in other toothed whales (Mohl, 2001). In sperm whales, the sound-generating structures are positioned forward above the melon. What is the right posterior bursa in other toothed whales is significantly larger in sperm whales, known as the spermaceti organ, and is filled with fluid wax (Mohl, 2001). It is this wax that made sperm whales attractive to commercial whalers for two and half centuries (NMFS, 2010). The species is highly sexually dimorphic, with males averaging about 15 meters long and females 11 meters (Best, 1979). Females reach sexual maturity around age 10, but males do not mature until their twenties (Jochens et al., 2008). Sperm whales are thought to live from about 60 to 80 years (Whitehead, 2003). The species is also behaviorally dimorphic (Marcoux et al., 2006), with females and juveniles distributed in tropical and temperate areas while males spend more time in subpolar regions, as referenced above.

Sperm whales are deep-water predators that spend over two-thirds of their time below the ocean’s surface (McDonald et al., 2017). They dive to about 400 to 1200 meters in submergences that last up to an hour (Watkins et al., 1993; Watwood et al., 2006), with exceptional dives lasting for up to 138 minutes (Watkins, Moore, and Tyack, 1985). In a study employing archival acoustic tags, sperm whales spent 72 percent of their dive times foraging (Watwood et al., 2006). Their diet consists primarily of cephalopods (Clarke, 1980), but also includes fish (Clarke, Martins and Pascoe, 1993). Diet varies with location; sperm whales off Hawaii and the Azores are known to feed at least occasionally on giant squid (Whitehead, 2003), but in other areas sperm whales eat smaller squid or a fish (Kawakami, 1980). Males have broader diets than females, given their deeper dives, wider range, and migrations to find mates (Whitehead, 2003).

Sperm whales use echolocation to find prey, producing regular clicks on descent to locate prey items in mesopelagic and bathypelagic habitats (Miller et al., 2004; Watwood et al., 2006). The inter-click intervals decrease as the whales hone in on prey, creating creaks or buzzes during the terminal phase of prey capture (Miller et al., 2004). Sperm whales produce clicks at depth, and continue during the early onset of their ascents (Watwood et al., 2006). Their ecological success as widespread, abundant predators, may be due to their catholic diet (Watwood et al., 2006; Whitehead, MacLeod, and Rodhouse, 2003), and their long-range echolocation capabilities, locomotion and large body size that promote long aerobic foraging periods (Watwood et al., 2006).

B. Taxonomy

Scientists have long agreed that only one species of sperm whale exists. Their nomenclature, however, has received much more debate. The following depicts the currently recognized taxonomy:

Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Order: Cetacea
Suborder: Odontoceti
Family: Physeteridae
Genus: *Physeter*
Species: *Physeter macrocephalus*

C. Population structure and status

The ESA lists sperm whales as a single global, endangered species, while the MMPA divides sperm whales into different stocks for management purposes. The global species and all stocks are believed to exhibit relatively little genetic variation, apart from stocks in the Mediterranean Sea and Gulf of Mexico (NMFS, 2010). Analysis based on mtDNA and nuclear DNA find that the Gulf stock is genetically distinct from other sperm whales, particularly the North Atlantic Ocean Stock (Engelhaupt et al., 2009; NMFS, 2010). Evaluating global population structure of this species is inherently difficult due to their wide distribution and the low sample sizes available for molecular analysis, and is complicated by male dispersal, female site fidelity, and other factors (NMFS, 2010).

D. Distribution and Abundance

Sperm whales occur from polar pack ice to the tropics (Figure 1) (Rice, 1989; Whitehead, 2002). They are predominantly found in deep-water areas, especially off steep continental slopes (Taylor, et al., 2008, NOAA, 2015). Global population estimates range from roughly 360,000 (CV=0.38) (Whitehead, 2002) to 1,500,000 (NOAA Fisheries, 2017).

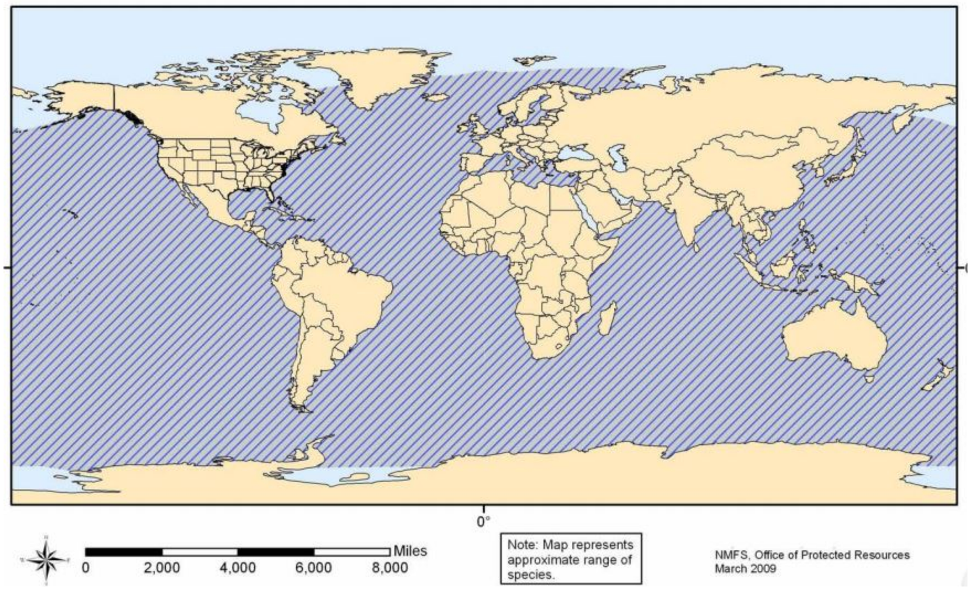

Figure 1: Sperm whale's global distribution. (Source: NOAA, 2017)

E. Social Structure

Sperm whales have a complex social structure. Long-term, matrilineal social units generally consist of 10-12 adult females and immature offspring of both sexes; these groups form the backbone of sperm whale social structure (NOAA, 2015). Males leave their matrilineal groups around age six (Best, 1979, Richard et al., 1996). Adult males have relatively unstructured social lives and do not form close associations, but often cluster with other males (Lettevall et al., 2002). Younger males aggregate may into bachelor groups before becoming more solitary (Best, 1979). When males reach sexual maturity, they migrate from foraging grounds in temperate and sub-polar regions to the tropics searching for females in estrus, and then remain with female groups for hours to days (Whitehead & Weilgart, 2000; Jochens et al., 2008).

Female sperm whales form very close associations that last year years to decades, spent foraging together (Lettevall et al., 2002). Female groups can consist of one or more matrilines, although typically one matriline appears to dominate the group (Richard et al., 1996). These social groups are typically identifiable by their unique codas, described below. Social units often join together to form larger temporary groups in tropical or subtropical waters.

F. Prey and Foraging

Sperm whales' main prey source are cephalopods (Clarke, 1996), and sperm whales' habitat use and distribution correlates with prey availability (Jaquet and Whitehead, 1996; Jaquet and Gendron, 2002; O'Hern and Biggs, 2009). The Ommastrephid, Onychoteuthid and Cranchiid cephalopod families are commonly preyed on by sperm whales (Clarke 1996 as cited in Judkins, et al., 2015). The distribution of their prey is linked to bathymetry, temperature gradients, and presence of oceanographic fronts, so many studies have attempted to determine how these factors affect sperm whale distribution (Jaquet and Whitehead, 1996), as detailed below.

Sperm whales use "echolocation-mediated foraging" (Watwood et al., 2006). As described above, sperm whales forage in mesopelagic and bathypelagic waters (Clarke, 1980; Kawakami, 1980). Sperm whales forage "asynchronously," lending to larger group sizes at the surface

(Maze-Foley and Mullin, 2006). See Section H below for more information on foraging behavior.

G. Reproduction

Sperm whales have very slow life histories. Females begin ovulating around 7 to 13 years of age (Rice, 1989). Males begin maturing at this age but do not reach full maturity until their late twenties (Rice, 1989; NMFS, 2010). Females in matrilineal groups enter estrous synchronously (Best and Butterworth, 1980, as cited in NMFS, 2010). Therefore, roving males may encounter breeding female groups for only a few hours at a time. Gestation lasts for 14 to 16 months (NOAA Fisheries, 2017), and the inter-calving interval lasts for about four to six years (Best et al., 1984, as cited in NOAA Fisheries, 2017). Sperm whales exhibit alloparental care in which dependent calves may accompany adult females and sub-adults at the surface while their mothers are foraging at depth (Whitehead, 1996).

H. Vocalization

Sperm whales rely on sound for communication and foraging. In sperm whale communication, different matrilineal groups produce unique, short repeated click sequences—known as codas—that are used in intergroup communication (Rendell and Whitehead, 2005). Codas consist of 3-40 broadband clicks that typically last for a few seconds (Watkins and Schevill, 1977, as cited in Rendell and Whitehead, 2003). Sperm whale calls, codas in particular, vary in space and, perhaps, time (Rendell and Whitehead, 2005). This variation can be caused by genetic drift, cultural evolution, or adaptation to local ecological niches (Deecke et al., 2000; Barrett-Lennard, 2000, as cited in Rendell and Whitehead, 2005). Groups of whales with distinct codas are likely to be genetically distinct, and groups with similar codas likely to share mtDNA haplotypes. It is likely, however, that culture is more important to this variation in codas than genetics or geography (Rendell and Whitehead, 2003). Thus, codas are culturally transmitted vocalizations, distinct to particular social groups. For this reason, scientists are able to identify clans of sperm whales based on their codas (Rendell and Whitehead, 2003).

Sperm whales produce ‘regular’ clicks on descent on dives, which act as a long-range biosonar to help them find prey at depth (Watwood et al., 2006). These clicks occur at intervals of 0.5-2.0 seconds during descent (Jaquet, Dawson, & Douglas, 2001) and are impulsive broad-band signals (Jaquet, Dawson, and Douglas, 2001). These clicks are directional, creating a “forward-directed beam” (Mohl et al., 2003; Miller, Johnson and Tyack, 2004). As sperm whales hone in on prey, the clicks become more rapid—termed “terminal buzzes” or “creaks” (Miller, Johnson and Tyack, 2004; Watwood et al., 2006). In general, buzzes or creaks are very rapid with 220 clicks per second; and regular clicks occur roughly every .5-7 seconds, but there is high variation among both signal types (Jaquet, Dawson, & Douglas, 2001).

Sperm whales produce broadband sounds, used for communicating and foraging, with most energy below 4 kHz, although some signals may extend above 20 kHz (Thode et al., 2002, as referenced in NMFS 2010). Source levels are extremely loud, at 236 dB re 1 μPa-m (Møhl 2003). As noted above, sperm whales’ large heads are highly adapted to create this acoustic energy, indicating the importance of sound to basic life functions (NMFS, 2010).

I. Hearing

Sperm whale inner ear anatomy is similar to that of other odontocetes, and is tailored for ultrasonic (>20 kilohertz (kHz)) reception (NMFS, 2010). There is no audiogram for the species and only limited information on their hearing ranges. Like many other cetaceans, their size makes it impossible to study evoked hearing potential measurements in a laboratory setting, and the only known data on sperm whale hearing comes from a stranded male neonate (Ridgway and Carder, 2001; NMFS, 2010). Observations of this individual suggest that neonatal sperm whales can hear sound in the 2.5 to 60 kHz range (Ridgway and Carder, 2001).

Sperm whales are mid-frequency specialists (150 Hz to 160 kHz), like most odontocetes, although NMFS notes that sperm whales occur in the lower portion of this spectrum (NMFS, 2010; NOAA, 2016a). In a recent NOAA report, "Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing," NOAA noted that they considered classifying sperm whales separately from other mid-frequency cetaceans, but that not enough data exists to make this classification (NOAA, 2016a). Conversely, Southall et al. (2007) divided marine mammal hearing into five groups, and based on that structure, listed sperm whales in the mid-frequency cetacean group, along with toothed whales, beaked whales, and bottlenose whales (Southall et al., 2007; NMFS, 2010).

V. Sperm whales in the Gulf of Mexico

A. Distinctness

Sperm whales in the Gulf of Mexico constitute a distinct stock of sperm whales, different from those in Atlantic Ocean (Jochens et al., 2008; NOAA, 2015). In the Gulf of Mexico, sperm whales are about 1.5 to 2 meters smaller than other sperm whales (Jaquet, 2006; Jochens et al., 2008). Furthermore, sperm whales exhibit high residency to the northern Gulf. Of 39 satellite satellite-tagged sperm whales in a Minerals Management Service (now BOEM) study, only one moved outside the Gulf of Mexico, with the remainder remaining along the northern continental slope (Jochens et al., 2008). This study also attempted to match photographs of whales from the Gulf with those from the Atlantic and Mediterranean, but found no matches. The discrete nature of this stock is supported by an analysis of mitochondrial DNA, which found genetic differentiation between sperm whales in the northern Gulf with those from the western North Atlantic, North Sea, and Mediterranean Sea (Engelhaupt, 2009). Finally, Gulf of Mexico sperm whales have a unique set of codas that make them a "distinct acoustic clan" (Jochens, et al., 2008; NOAA, 2015).

B. Population status

Sperm whales in the Gulf received little dedicated scientific attention until the late 1970s (Jochens et al., 2008). NOAA's latest population estimate is 763 individuals, based on a 2009 line-transect survey (CV=0.38) (NOAA Fisheries, 2015). Recent modeling estimates, however, suggest that more than 2,000 sperm whales exist in the Gulf (CV=0.08) (Roberts et al., 2016). NOAA has not conducted a trend analysis for the Gulf of Mexico stock. There were eight strandings of sperm whales in the Northern Gulf from 2009 to 2013, although this may underestimate the total number of strandings (NOAA, 2015). NOAA declared an "Unusual Mortality Event" (UME) for cetaceans in the northern Gulf from February 2010 to July 2014, caused in large part by the Deepwater Horizon oil spill (NOAA, 2015; NOAA, 2016b).

Furthermore, it is important to note that between October 2016 to January 2017 alone, four sperm whale calves stranded in the Gulf of Mexico (Masson, 2017). The cause of these strandings remain unknown.

C. Prey

One suggested reason for the residency of sperm whales in the Gulf of Mexico is a reliable source of prey (Judkins, et al., 2015). A recent study found that cephalopod richness was "relatively evenly distributed" in the western and northeastern Gulf of Mexico (Judkins, et al., 2015). This study also found that sperm whales occurred more frequently in the northeastern portion of the Gulf, where cephalopod densities were highest (Judkins, et al., 2015). Furthermore, a high density of one of the largest cephalopods in the Gulf was found along the outer De Soto Canyon area, indicating a strong relationship between the occurrence of giant squid and sperm whales (Judkins, et al., 2015). Overall, this latter study noted a common presence of cephalopods and sperm whales in the northern Gulf along the continental slope (Judkins, et al., 2015). Other research has noted that cephalopods are responsive to environmental conditions and their spawning grounds is thought to lie in areas of high productivity, thus linking sperm whale habitat with cephalopod availability and productivity (O'Hern and Biggs, 2009).

D. Distribution

Sperm whales inhabit continental shelf and slope waters in the northern Gulf of Mexico (Figure 2, 3, 4, 5) (NOAA, 2015). Sperm whales are found in oceanic waters beyond the U.S. Exclusive Economic Zone (EEZ), although much less is known about their abundance and distribution outside the EEZ (NOAA, 2015). In the Gulf of Mexico, sperm whales show an affinity for the 1000-meter contour (Davis et al., 1998; Davis et al., 2002; Mullin and Fulling, 2004) and steep depth gradients (Davis et al., 1998). Similarly, Judkins et al. (2015) found sperm whales distributed in the northern Gulf along the continental slope, rather than over abyssal plains, suggesting a habitat preference for this type of bathymetry (Judkins et al., 2015).

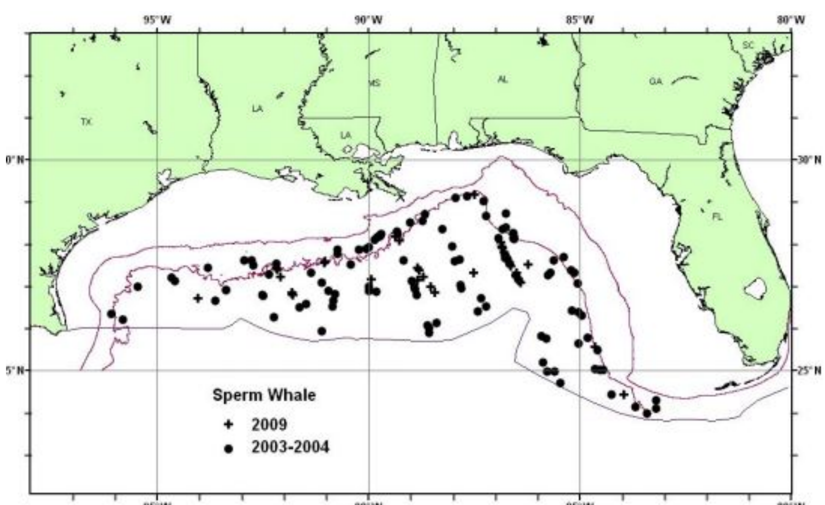

Figure 2: Sperm whale sightings based on NOAA vessel surveys during summers 2003, 2004, and 2009. (Source: NOAA, 2015)

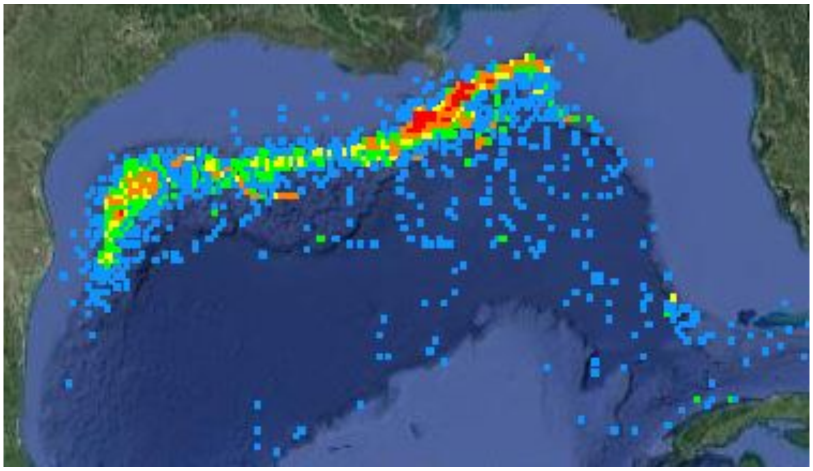

Figure 3: Sperm whale sightings based off of over 50,000 records of visual sightings and satellite telemetry data in the Gulf of Mexico. (Source: OBIS SEAMAP)

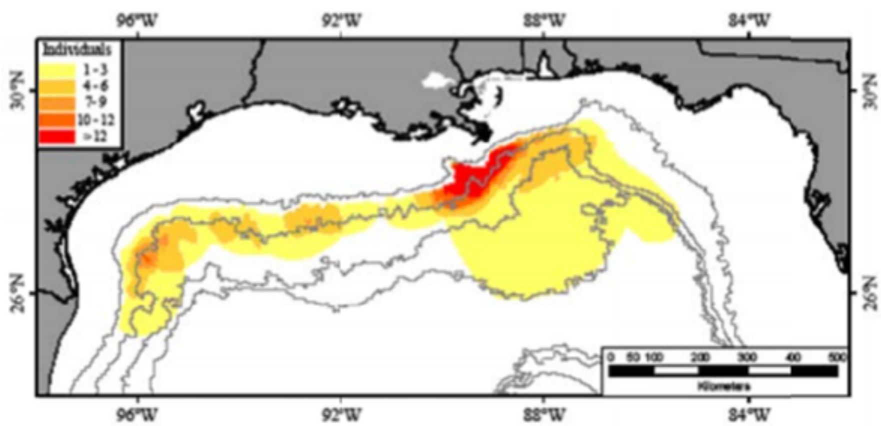

Figure 4: 50% core area of sperm whales (Source: SWSS, as cited in Mate, 2011). Note: image represents 50% core area of sperm whales tagged during the Minerals Management Service Sperm Whale Seismic Study, which "represent the smallest polygons where whales were found either 95% of the time (kernel home range) or 50% of the time (core area) for the subset of the sperm whale population tagged during SWSS," as cited in Mate, B. (2011). Satellite Tracking of Sperm Whales in the Gulf of Mexico in 2011, a Follow-up to the Deepwater Horizon Oil Spill.

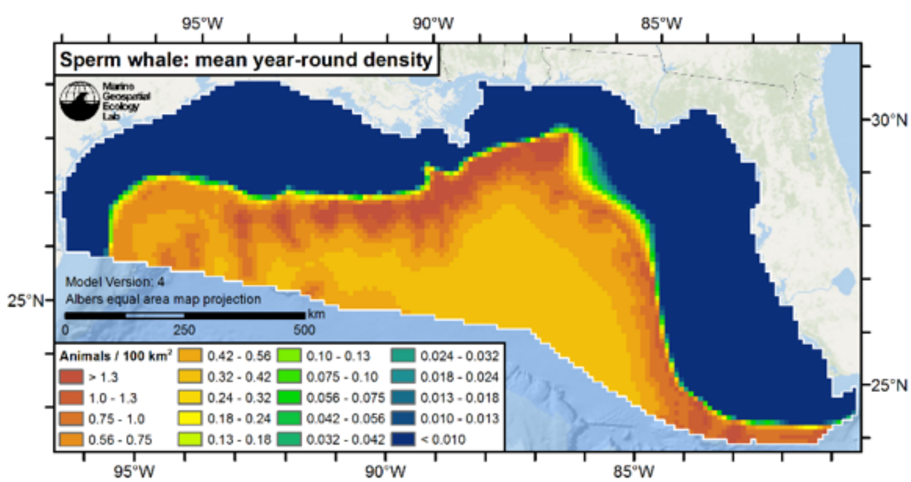

Figure 5: Mean year-round density for sperm whales in the Gulf of Mexico. (Source: Roberts et al., 2016).

Sperm whales are common near the Mississippi Canyon (Davis et al., 1998). Jochens et al., (2008) found that most of the sperm whale population—primarily consisting of females and juveniles—occupied the Mississippi Canyon area (Jochens, et al., 2008; McDonald et al., 2017). Sperm whales are found within 20 km of the Mississippi River Delta, where river discharge may increase the density of prey (Davis, et al., 1998). Vessel surveys in the spring season from 1991-2001 found that sperm whales "were widely distributed but relatively concentrated near the mouth of the Mississippi and the area due west of the Florida Keys" (Maze-Foley and Mullin, 2006). Other studies have supported this, finding lower densities of sperm whales in the Northwestern Gulf (Jochens, et al., 2008; McDonald et al., 2017), as well as predicted modeled concentrations along off-shelf submarine canyons off the Mississippi River and along the continental slope (Roberts et al., 2016).

Male bachelor groups and mixed groups of females are geographically separated in the Gulf (O'Hern and Biggs, 2009). A boundary between females and males occurred offshore of the Mississippi Delta, with females west of the Delta and males east (O'Hern and Biggs, 2009). This distribution likely reflects patterns of primary productivity, discussed in Section E below. This geographic separation by sex occurs elsewhere in the range of the species (Lettevall et al., 2002).

E. Physical Processes affecting distribution in Gulf of Mexico

The physical processes that impact biological productivity in the Gulf of Mexico are complex, and governed by a range of factors, including bathymetry, current systems, and a mid-water eddy field (Biggs et al., 2005; O'Hern and Biggs, 2009). The Loop Current—a warm-water current that travels from the Caribbean, past the Yucatan Peninsula, into the Gulf of Mexico and exits by the Strait of Florida (Biggs et al., 2005)—is a significant driver of physical processes in the Gulf. Eddies associated with the Loop Current affect biological and physical heterogeneity along the continental margin in the northern Gulf (Biggs et al., 2005), and eddies associated with the Loop Current increase primary productivity, which likely supports greater densities of sperm whale prey (Jochens et al., 2008).

Biologically-rich water—which supports squid density and availability—can flow in and off the continental margin depending on eddy patterns (Biggs, et al., 2005). Mid-water and surface eddies impact surface chlorophyll (O'Hern and Biggs, 2009), and create important foraging grounds for sperm whales if they persist for several months at a time (Biggs, et al., 2005). These processes create habitat for sperm whales along the continental margin of the northern Gulf, while "frontal boundaries" with Loop Current Eddies create areas of enhanced surface primary productivity (O'Hern and Biggs, 2009). In addition, sperm whales are distributed along extreme sea surface temperature (SST) gradients, indicating that they may be foraging along thermal fronts associated with nutrient-rich cold-water eddies (Davis, et al., 1998).

A study conducted in 2004 and 2005 examined sperm whale density in the Gulf directly related to these features. The researchers found that habitat utilization in the Gulf, particularly for bachelor groups, is closely tied with surface primary activity "on time scales of one to two weeks" (O'Hern and Biggs, 2009). Males were found in areas of higher surface chlorophyll, which led the authors to assume males were selecting habitat not on productivity but on biological activity, and hypothesized that eddies and cyclones spinning into the Mississippi Delta and De Soto Canyon area created pockets of "secondary mesopelagic productivity" for "males to forage in a manner efficient enough to meet their individual energetic needs" (O'Hern and Biggs, 2009). On the other hand, these authors found that mixed female groups occupied regions of secondary productivity in the western portion of the Gulf. In simpler terms, male aggregations were correlated with high chlorophyll, but mixed female groups were associated with broader productivity (O'Hern and Biggs, 2009). However, these patterns of distribution are likely linked to several other factors, including selection of physical habitat features and perhaps the occurrence of predators, such as killer whales (O'Hern and Biggs, 2009).

The relationship between sperm whale density and areas of high productivity, high topographical relief, and prey availability in the Gulf is complex. No single factor stands out as a key driver to sperm whale distribution, and these factors are all interlinked. This is supported by research outside of the Gulf, where sperm whales in the South Pacific were frequently found in regions of high secondary productivity and steep underwater topography, indicating that it is not just distribution of prey that impacts their distribution over large geographic scales (Jaquet and Whitehead, 1996).

F. Vocalization and behavior in the Gulf of Mexico

Codas produced by sperm whales in the Gulf are distinct (Jochens, et al., 2008; NOAA, 2015). Additionally, sperm whales show evidence of exhibiting different behavioral vocalizations within different areas of the Gulf of Mexico (McDonald, et al., 2017). Sperm whales at a central monitoring point in the Gulf exhibited a "higher acoustic activity index value" than at east or west monitoring sites (McDonald, et al., 2017). One study in the Gulf of Mexico used digital tags to record diving and vocal behavior of 29 sperm whales, and found that the whales began producing regular clicks at 215 meters and dove to 800 meters (Figure 6) (Watwood et al., 2006). These tagged whales spent 72 percent of their time foraging (Watwood et al., 2006).

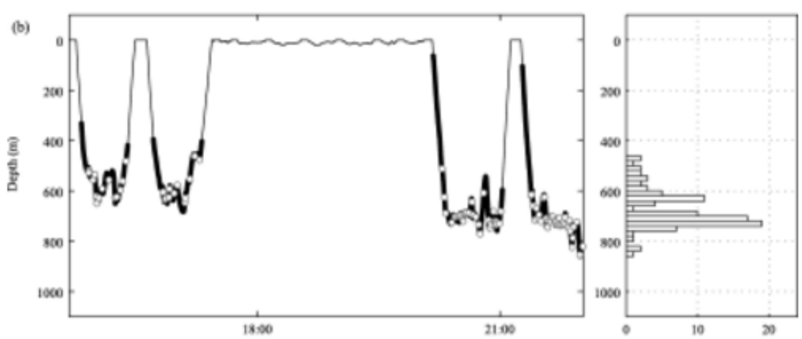

Figure 6: Dive track and buzz production for a tagged sperm whale in the Gulf of Mexico. (Source: Watwood et al., 2006)

Killer whales may prey on sperm whales in the Gulf of Mexico (Whitt, et al., 2015), as they do in other parts of the world (Jefferson, et al., 1991). This predator-prey relationship may affect the distribution of sperm whales at certain spatiotemporal scales.

VI. Threats to Sperm Whales in the Gulf of Mexico

A. Fisheries

A variety of commercial fisheries operate in the Gulf of Mexico, including otter and bottom trawls, hand lines, longlines, purse seines, pots/traps, and gill nets in some regions in the Gulf

(Levesque, 2011; NOAA, 2016c; BOEM, 2016). Of the many commercial and recreational fisheries operating in the Gulf of Mexico, the pelagic longline fishery, which targets swordfish, tuna, and billfish, has the greatest spatial overlap with the Gulf of Mexico sperm whale stock (NOAA, 2015). Pelagic longline vessels typically set their gear along the continental slope (Levesque, 2011). This fishery is closed in the De Soto Canyon all year, as well as two time-area closures elsewhere in the Gulf (NOAA Pelagic Longline Restrictions Doc, n.d.).

In 2008, an adult female, accompanied by her calf, was entangled in pelagic longline gear, although she became disentangled from the main line when she dove. This was the first and only reported interaction of a sperm whale and this fishery (NOAA, 2015). The expansive range of this fishery in the Gulf, and the frequency with which longlines are set along the continental slope, increase the probability of interactions with sperm whales.

In addition to the pelagic longline fishery, other commercial gear types used in the Gulf include bottom trawls, purse seines, gill nets, and pot/traps (BOEM, 2016). Between the five Gulf states, there are over 9,000 U.S.-flagged fishing vessels, at minimum (BOEM, 2016). These vessels use a variety of acoustic sound sources to help locate fish and delineate seafloor counter and composition (see section E below on noise) (BOEM, 2016). Outside of the Gulf of Mexico, sperm whales are frequently caught as bycatch (Barlow and Cameron, 2003)—including sperm whales entangled in long line fishing equipment (Kemper et al., 2005)—and entanglement is a threat to sperm whales globally (Purves et al., 2004; Jacobsen et al., 2010).

B. Pollution

The Deepwater Horizon (DWH) oil rig exploded in April 2010, causing an unprecedented oil spill in which approximately 4.9 million barrels of oil was discharged into the Gulf (NOAA, 2015). The explosion occurred in the Mississippi Canyon, south of Louisiana in the north-central portion of the Gulf (NOAA, 2015). An unprecedented volume of dispersants—1.8 million gallons—were applied at the seafloor and at the surface (Marine Mammal Commission, 2013), despite little being known about their potential ecological impacts (Wise et al., 2014; NOAA, 2015). These dispersants included Corexit 9500A and 9527. Corexit 9500A was applied directly at the oil wellhead at 1500 meters—marking the first time that the Environmental Protection Agency granted responders permission to apply the chemical at depth (Marine Mammal Commission, 2013). Oil flowed from the wellhead for 86 days before it was first capped in July and permanently capped in September (Marine Mammal Commission, 2013). Of the 4.9 million barrels of spilled oil, 17 percent was recovered from the wellhead, eight percent was burned, and 75 percent was chemically or naturally dispersed, evaporated, or remained as residual oil in the water column or sediment.

Research on impacts of the DWH disaster on sperm whales and other cetaceans is ongoing. No direct instances of mortality were observed (NOAA, 2015), but the stranding record is not a good reflection of the mortality of sperm whales or other pelagic cetaceans (Williams et al., 2011). Researchers have estimated that the carcass-detection rate—based on abundance, survival rate, and the stranding record—for sperm whales in the Gulf is very low (3.4 percent), indicating that very few sperm whales impacted from DHW may have been found (Williams et al., 2011). A study measured sperm whale acoustic recordings near the spill site in 2007 and then again after the spill in September 2010, and found that vocalization rates declined by more than half near the site of the spill, although it increased by nearly half at a site 25 miles away, suggesting that sperm whales "relocated" after the spill (Achleh et al., 2012). Additionally, two of the dispersants used in spill clean-up efforts, Corexit 9500 and 9527, were found to be genotoxic to sperm whale skin (Wise et al., 2014a). In another study that measured metal toxicity in sperm whales in the months directly following DWH, researchers found elevated levels of copper and nickel in skin samples (Wise et al., 2014b). However, the impacts of DWH on sperm whales will not be fully understand for decades, if ever.

Another major contributor of pollution in the Gulf of Mexico is runoff from the Mississippi Delta. Each summer, a large region of hypoxia, an area with little dissolved oxygen that causes stress to organisms, forms in the Gulf (Environmental Protection Agency, 2015). This "dead zone" generally occurs from the Mississippi River Delta west to the upper Texas Coast, and can range from one to 125 km offshore (Rabalais, Turner, and Wiseman, 2002). This hypoxic zone is caused by excess nitrogen and phosphorous inputs from the Mississippi/Atchafalaya River Basin (Environmental Protection Agency, 2015). Anthropogenic activity in the Basin is the primary driver of this dead zone, which is exacerbated by channeling and impoundment of the Mississippi River and wetlands, and changes to the hydrologic regime of these rivers (Environmental Protection Agency, 2015). This dead zone can alter habitat, energetic costs, and prey distribution of benthic species in the Gulf (Craig et al, 2001).

C. Shipping and Transportation

The Gulf of Mexico is a major hub for import and export of foreign and domestic goods (BOEM, 2016). In 2012 alone, there were 39,111 vessel trips in the Gulf by seismic survey vessels, 59,334 cargo trips, and 28,112 tanker trips (BOEM, 2016). The Gulf also houses two of the world's largest and busiest ports, Houston and New Orleans (NOAA, 2017), and six of the United States' leading shipping ports are located in the Gulf (National Ocean Service, 2008).

Shipping and other maritime transportation activity in the Gulf carries risk of ship strikes for sperm whales. One vessel strike has been documented for the Gulf of Mexico sperm whale stock, off the Gulf of Grande Isle, Louisiana in 1990 (NOAA, 2015). Many other records of vessel strikes exist elsewhere globally (Laist et al., 2011). Sperm whales spend about 10 minutes at the ocean surface between dives, which can expose them to vessel strikes (Jacquet et al., 1996). In addition to potential effects from ship strikes, shipping-associated impacts like vessel noise, vessel discharge, debris, and fuel spills also pose risks to sperm whales.

Figure 7: Ports and shipping lanes within the Gulf of Mexico. (Photo: National Ocean Service, 2008)

D. Oil and Gas Activity

Offshore oil and gas development began in the late 1940s in the Gulf, as technology for seismic testing and offshore drilling advanced rapidly during and after World War II (BOEM, 2008a). Today, the Gulf of Mexico is responsible for most domestic offshore oil and gas production in the U.S. (BOEM, 2008), and more than a quarter (27 percent) of *all* domestic oil production occurs in the Gulf of Mexico (NOAA, 2008). In 2008, there were about 25,000 miles of active oil and gas pipelines on the Gulf of Mexico seafloor and over 4,000 active oil and gas platforms. To date, 64 oil wells have been drilled in the eastern Gulf alone (Bowman, 2012). As of April 1, 2017, there were 3,001 active oil and gas leases in the Gulf (BOEM, 2017). For comparison, both the Pacific and Alaska have 43 active leases each as of April 1 (BOEM, 2017). Thus, compared to other regions in the United States, the Gulf is a major hub for oil and gas activity (Figure 9).

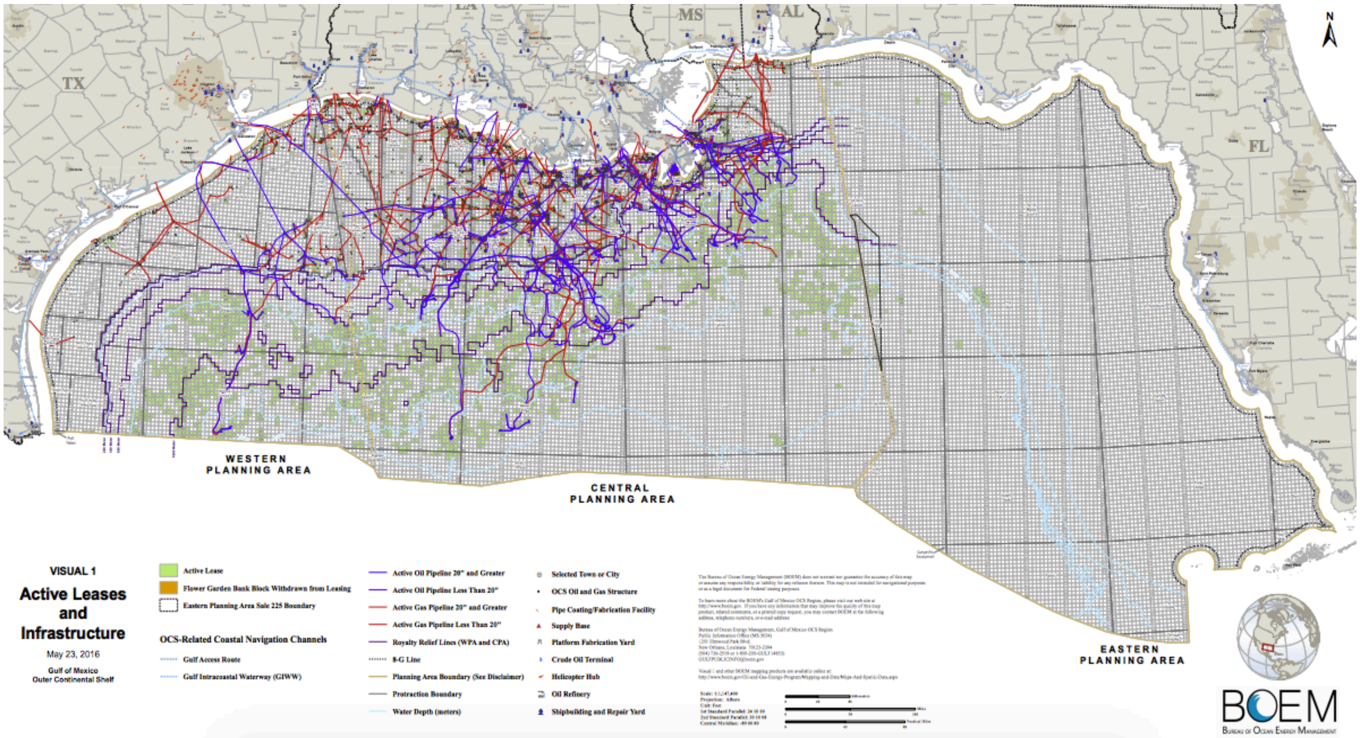

Figure 8: Active oil and gas leases under BOEM as of May 2016. Green boxes represent active leases, blue lines represent active oil pipelines (thick lines are > 20" and thin lines are <20"), red lines are active oil pipelines (thick lines are > 20" and thin lines are <20"), and tan lines are planning area boundaries. (Source: BOEM, 2016)

Seismic surveys are the first step in offshore oil and gas development. These surveys involve firing intense pulses of sound into the seafloor from airguns towed behind a survey vessel; the sound reflects off features in the seabed and return profiles of oil and gas deposits (National Research Council, 2003; Hildebrand, 2009). The low frequency sound waves of seismic airguns experience little attenuation, meaning they can travel great distances and transform soundscapes (Hildebrand, 2009; Castellote, 2012). The Gulf of Mexico is the main region in the U.S. where seismic surveys for oil and gas production are permitted, though there is a history of seismic surveys in the Outer Continental Shelf region off Alaska (Earl, 2016; BOEM, n.d.).

There is growing scientific concern over impacts from seismic surveys to sperm whales and other marine mammals (Parsons et al., 2009; Williams et al., 2015). The risks to marine mammals from seismic surveys include masking, in which the sound of the airgun array impedes the ability of a cetacean to hear or receive sounds for communication, foraging, and predator detection (Gordon et al., 2003; Southall et al., 2007). Evidence exists for masking in several baleen whale species—including blue (Di lorio & Clark 2009), gray (Dalheim & Castellote 2016), and humpback whales (Cerchio et al., 2014). There is also evidence of communication disruption in odontocetes (Finnernan et al., 2002). Other impacts include possible hearing damage, displacement (Weir and Dolman, 2007), or chronic stress leading to physiological consequences (Gordon et al., 2003; Rolland et al., 2012). Given that: (1) NMFS considers sperm whales to be on the low-end of the mid-frequency sound spectrum; and (2) sperm whales produce distinct vocalizations for use in communication, the noise associated with the extraordinary level of industry in the Gulf of Mexico poses a particularly threat to sperm whales.

In the Gulf of Mexico, there is considerable spatial overlap between seismic surveys and sperm whale presence, although very few studies have examined the actual impact of seismic surveys on sperm whales. In a recent study of sperm whales tagged in the Gulf, seven of eight whales did not substantially change foraging behavior before or after the dive during controlled experiments that aimed to expose sperm whales to received sound pressure levels from seismic airguns at140–160 dB re 1 mPa peak-peak at varying distances, although the whale closest to the source delayed its foraging dive and exhibited an unusually long resting period (Miller et al., 2009). Another study found that sperm whale abundance declined throughout the day (from 0.092 whale/km to 0.0 whales/km) in four of five days of seismic surveys south of the Mississippi River (Mate et al., 1994). Researchers note much more information is needed to assess the impacts of seismic testing on sperm whales in the Gulf (Miller et al., 2009).

It is important to note that a landmark lawsuit concerning seismic testing occurred in the Gulf several years ago. In June 2010, the Natural Resources Defense Council (NRDC) sued the Department of the Interior (DOI) in the United States District Court for the Eastern District of Louisiana regarding their policies on seismic testing. NRDC brought the suit for three reasons: (1) BOEM had determined that there was a "Finding of No Significant Impact" (FONSI) on Gulf of Mexico ecosystems from oil and gas activities under NEPA; (2) BOEM determined that the impacts from oil and gas activities in the Gulf of Mexico were not significant enough to warrant an Environmental Impact Statement be undertaken under NEPA; and (3) for allowing seismic testing to continue moving forward without mitigations standards in place before an Environmental Impact Statement was completed (NRDC vs. Kenneth Salazar, 2010).

In the lawsuit, the plaintiffs argued that the Gulf of Mexico is already laden with extreme pollution from existing oil and gas activity, run-off from the Mississippi delta, and saturated with other inputs of anthropogenic noise, especially commercial shipping. Furthermore, they noted many of the most endangered species in the Gulf—such as sperm whales—that are already at-risk from pollution in the Gulf are also most vulnerable to seismic testing. Specifically, the plaintiffs stated, "absent the rigorous analysis of impacts and reasonable mitigation that the EIS process is intended to compel, the surveys that BOEM continues to approve will unnecessarily compromise the same marine species that are already in desperate need of recovery from the Deepwater Horizon spill" (NRDC vs. Kenneth Salazar, 2010). Thus, the plaintiffs argued that BOEM declaring a FONSI and foregoing the NEPA was "arbitrary and capricious," and violated the nation's most fundamental environmental statute. The plaintiffs also argued the federal government's handling of seismic surveys in the Gulf of Mexico juxtaposed their handling of seismic in the Arctic and Atlantic, where in those areas they proceeded cautiously and conducted EISs.

In September 2013, the plaintiffs and defendants reached a Settlement Agreement (NRDC vs. Sally Jewell, 2013). The Agreement implemented a 30-month-long "stay" of mitigation measures to be employed until BOEM submitted a "final action," which involved NMFS permitting BOEM to "take" a certain number of marine mammals under the MMPA as a result of this activity.

BOEM issued their first Preliminary Environmental Impact Statement as a result of this lawsuit in September 2016. Specific to sperm whales, the PEIS estimated that sperm whales will be exposed to injury-producing sound levels (Level A acoustic injury thresholds under the MMPA of sound pressure level exceeding 180 decibels root mean squared)[1] 106.47 times each according to NOAA's abundance estimate (NOAA, 2015; BOEM, 2016). Therefore, seismic testing is an ongoing and primary threat to sperm whales, particularly in the Gulf with the volume of testing that occurs in this ocean basin.

E. Noise

Levels of ocean noise are increasing worldwide, with inputs from shipping (the primary source), naval activity, pile driving and other construction, and oil and gas activity (Hildebrand, 2009; Nowacek et al., 2015). Low frequency noise has the potential to travel across ocean basins and disrupt soundscapes (Hildebrand, 2009). The Gulf of Mexico, as a major shipping and oil and gas hub, is no different. All marine industries in the Gulf—shipping, oil and gas, military activity, and so forth—produce ocean noise that may affect marine mammals.

As discussed above, noise levels associated with seismic surveys pose a particular threat to marine mammals, which rely on sound for feeding, breeding, and predator avoidance (Dolman, Weir, and Jasny, 2009). Seismic testing may lead to "masking"—where marine mammals cannot find prey or communicate (Southall, 2007)—habitat displacement (Weir and Dolman, 2007), chronic stress (Gordon et al., 2003; Rolland et al., 2012), or a combination of these effects.

A primary concern with the level of noise-inducing activity in the Gulf is cumulative noise from all industrial activity (Nowacek et al., 2015). Historically, ocean noise has been managed via single source types, and environmental assessments of noise have not considered cumulative impacts (Nowacek et al., 2015). Therefore, cumulative noise impacts to sperm whales have not been assessed.

F. Other

In addition to the above threats, dredge material is disposed at various sites in the Gulf; in 2015, there were 30 such sites (BOEM, 2016). Dredging and dumping creates noise, vessel traffic, discharge, seafloor disturbance, and the potential for accidental fuel spills (BOEM, 2016). The U.S. Navy also conducts active training in the Gulf of Mexico Range Complex (GOMEX) for military readiness. These activities include bombing and gunnery exercises, which can involve one to 10 vessels at a time (74 FR 19205). As with other activities, Navy testing can contribute to noise impacts, and vessel strikes.

[1] The text of the MMPA defines qualitative harassment levels for marine mammals. In other regulations, NOAA has identified 180 dB RMS as the sound pressure level defining Level A (injury) and 160 dB RMS as the sound pressure level defining Level B (harassment) (NOAA, n.d.a).

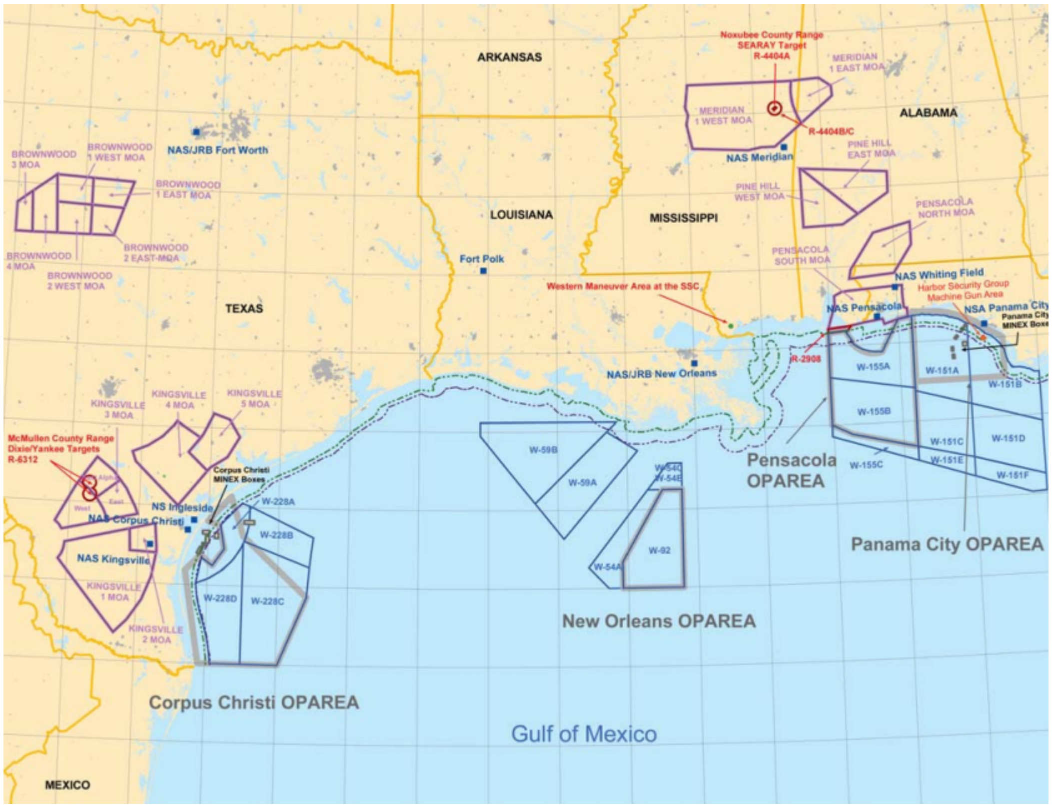

Figure 9: U.S. Navy GOMEX. (Source: United States Fleet Forces Command, 2010)

VII. Proposal for Critical Habitat

A. Proposed areas

I request that three critical habitat areas be designated for sperm whales in the Gulf of Mexico. This includes: Area 1, Stretching from the 800-meter to 1000-meter contour from the Mississippi River Delta to where it meets the De Soto Canyon; Area 2, The Mississippi Canyon; and Area 3, The De Soto Canyon (Figure 10).

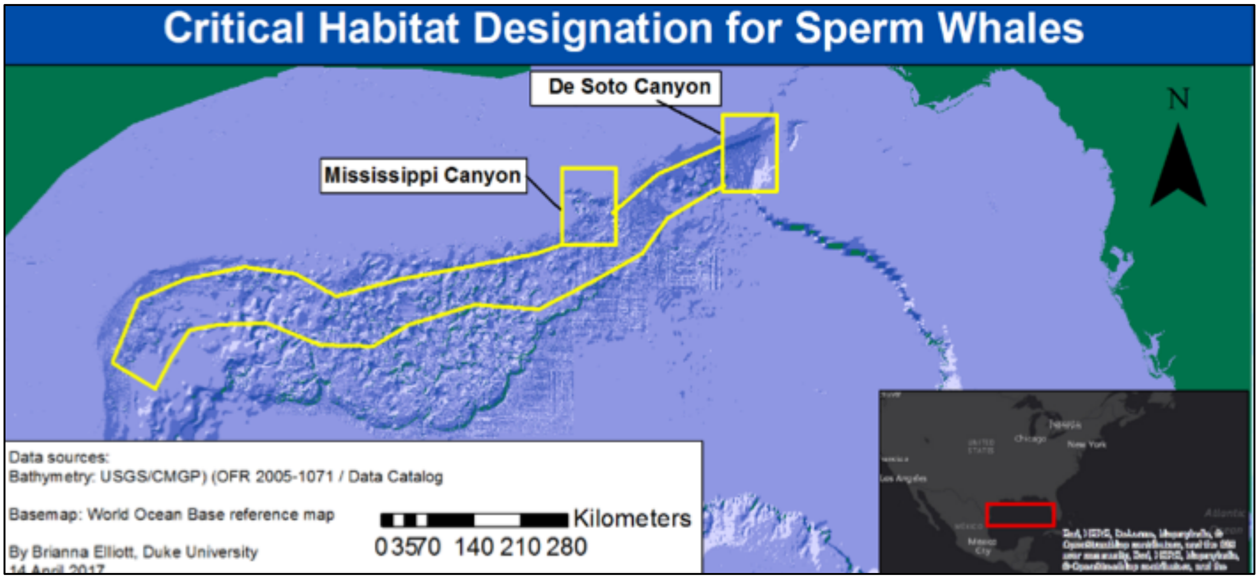

Figure 10: Proposed critical habitat designation for sperm whales: Area 1 (800-1000 meter isobaths), Area 2 (Mississippi Canyon), and Area 3 (De Soto Canyon).

This designation is based on the best available scientific literature and data publicly available on OBIS SeaMap[2] (Figure 12). As described above, sperm whales show an affinity towards steep continental slopes and steep depth gradients (Davis et al., 1998; Davis et al., 2002; Mullin and Fulling, 2004; Judkins et al., 2015), and many sightings have occurred along the Mississippi (Davis et al., 1998) and De Soto Canyons (Jochens et al., 2008; McDonald et al., 2017). Thus, this designation is based on key bathymetric features and sightings data. These areas have considerable spatial overlap with anthropogenic activity in the Gulf, most notably pollution discharge off the Mississippi Delta and DWH disaster in the Mississippi Canyon, thus warranting special management considerations in these areas (NRDC vs. Jewell, 2013; NOAA et al., 2014, NOAA, 2017). The 2013 Settlement Agreement also identified the Mississippi and De Soto Canyons as "Areas of Concern" (NRDC vs. Jewell, 2013). These are some of the only areas identified in the 2016 PEIS to have constant passive acoustic monitoring during seismic surveys (BOEM, 2016), which also indicated the importance of these areas to sperm whales.

[2] SEFSC GoMex Oceanic Survey, 1997; BOEM Sperm Whale Seismic Study (SWSS) MPS sperm whale trackings 2004-2005 (OBIS SEAMAP, 2017)

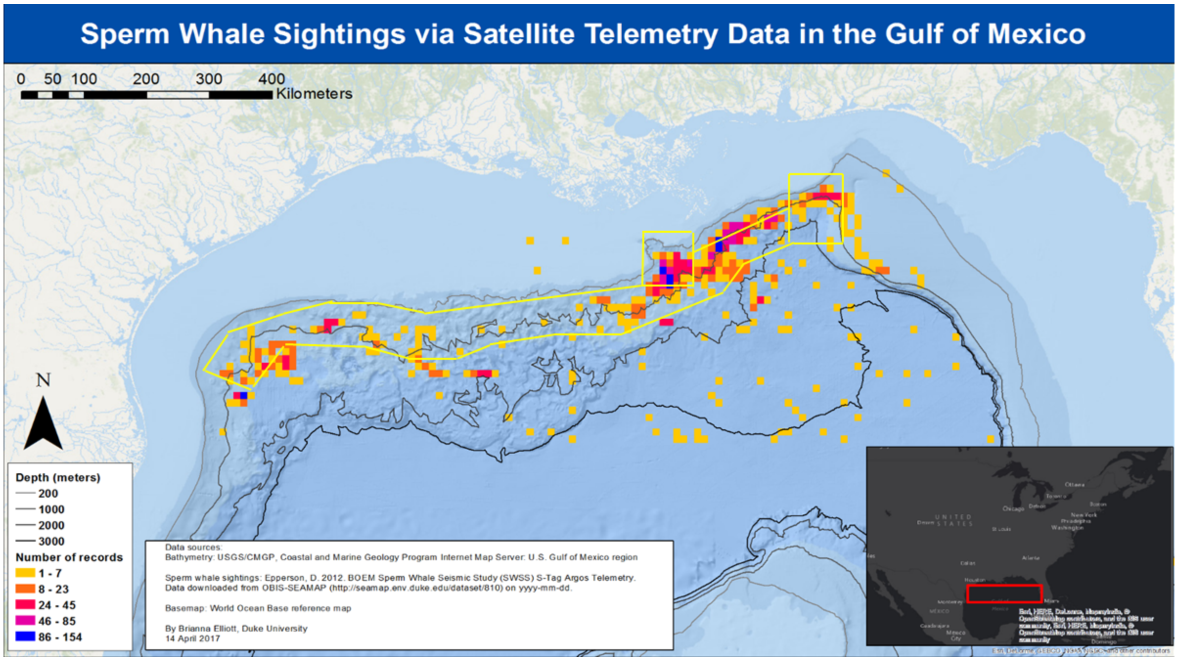

Figure 11: Proposed critical habitat designation for sperm whales (Area 1 (800-1000 meter isobaths), Area 2 (Mississippi Canyon), and Area 3 (De Soto Canyon)) overlaid with shipboard sighting data from the SWSS data.

The proposed areas of critical habitat overlap with many industrial activities in the Gulf, but it is impossible to identify any areas of sperm whale habitat in this region in which such overlap does not occur. Therefore, this proposal includes only minimum areas where such a designation is most prudent. It is important to remember that the goal of critical habitat designation is to ensure that federal activities do not cause adverse harm or jeopardize a species through Section 7 consultations (16 U.S.C. § 1536(a)(1)).

B. Primary Physical and Biological Features

Pursuant to the ESA, critical habitat consists of "[...]those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection" (16 U.S.C. § 1532(5)(A)(i)). Before the 2016 amendments, these "physical or biological features" were identified in designations as "Primary Constituent Elements" (81 FR 7413). Because there are few critical habitat designations to review since the policy changes in 2016 as described above, it is unclear whether NMFS and FWS would like petitions to clearly spell out these physical or biological features the way that PCEs did or not. Thus, I am largely operating off that model for now by listing the physical and biological features, and simply not calling them PCEs. The following four features are outlined as the physical and biological features to form the basis of this critical habitat designation in the Gulf of Mexico:

1. *Acoustic habitat free of anthropogenic noise to the extent where it does not interrupt sperm whale social communication or echolocation (i.e. areas of low sound pollution);*
2. *Room to dive to considerable depths (>1000m) without interruptions from industry, including fishing gear, seismic survey vessel equipment, and oil platform activity;*
3. *Waters free of dispersants, chemical agents, as well as high nutrient input along the Mississippi Delta;*

4. *Adequate cephalopod prey availability to ensure the long-term fitness and ecological health of the Gulf of Mexico stock;*

C. Rational

Evidence for each of identified physical and biology features is as follows:

1. *Acoustic habitat free of anthropogenic noise to the extent where it does not interrupt sperm whale social communication or echolocation (i.e. areas of low sound pollution)*

Sperm whales rely on sound for all aspects of their life history. Codas are vital for communicating amongst individual social clans, with other clans, and for avoiding predators (Watkins, 1977; Rendell and Whitehead, 2005). Furthermore, given that sperm whales produce clicks and then terminal buzzes throughout their dives, which are undertaken to search for prey (Watwood et al., 2006), the ability to have an uninterrupted sound field for echolocation is critical. Not only could extensive anthropogenic noise cause temporary or permanent threshold hearing shifts, but cumulative sound exposure could have deleterious biological and physiological consequences.

2. *Room to roam and dive to considerable depths (>1000m) without interruptions from industry, including fishing gear, seismic survey vessel equipment, and oil platform activity*

Sperm whales spend roughly 75 percent of their time at depth, diving upwards of 1000 meters below the ocean's surface (Watwood et al., 2006). Sperm whales undertake these dives—the deepest of any odontocete species—in search of squid and other prey. Thus, ensuring that sperm whales can adequately reach a prey field without entanglement with fishing gear, seismic survey vessel equipment, dredge dumping sites, and oil platforms and activity is critical for their evolutionary fitness.

3. *Waters free of dispersants, chemical agents, as well as high nutrient input along the Mississippi Delta*

The Gulf of Mexico is one of the most polluted water bodies in the United States, only exacerbated by the 2010 DWH explosion. Effects from DWH are still coming to light and may be long-lasting. Immediate impacts, however, show that dispersants and metal toxicity impacted sperm whale skin (Wise et al., 2014a and 2014b). Furthermore, because sperm whales reach incredibly large sizes and are long-living species, bioaccumulation in sperm whales is quite possible (Savery et al., 2013).

4. *Adequate cephalopod prey availability to ensure the long-term fitness and ecological health of the Gulf of Mexico stock*

Sperm whales' main prey source are cephalopods, which they forage on in mesopelagic and benthic waters. Ensuring that sperm whales have access to an adequate prey source is vital to ensuring their evolutionary and reproductive fitness. Impacts to cephalopods from DHW are largely unknown, but given that dispersants were applied at the sea surface and seafloor, it is likely that cephalopods have overlap with these chemicals.

Furthermore, designation of critical habitat is certainly "prudent" (16 U.S.C. § 1533(a)(3)(A)(i)). The Deepwater Horizon oil explosion occurred in one of sperm whales' key habitat areas, the Mississippi Canyon. Scientific evidence shows that sperm whales relocated, albeit possibly temporarily, from the spill site. Furthermore, the Gulf of Mexico is the only region in the U.S.

where commercial seismic vessels currently operate, and seismic testing carries inherent risk to sperm whales, as well as other cetaceans. Additionally, the Unusual Mortality Event and recent stranding of four sperm whales over a six-month period indicate that this endangered species is still at risk to human harm in the Gulf (NOAA, 2015). Finally, sperm whales' range and occupancy is also well described in the Gulf of Mexico, thereby making it "determinable," as well.

D. Special Management Considerations

Sperm whales' habitat in the Gulf of Mexico requires special management because of the extensive overlap with industry in the Gulf of Mexico. In particular, management must be directed at mitigating acoustic impacts to sperm whales. Given the level of seismic testing in the Gulf of Mexico, special management considerations need to be paid to ensuring that this noise input does not mask or otherwise jeopardize the species or cause adverse harm. This may include evaluating cumulative noise impacts to sperm whales, testing the efficacy of current mitigation standards in place for seismic testing, and ensuring that seismic surveys have greater buffer zones between them to reduce overlap between surveys.

VIII. Conclusion

Sperm whales are an extraordinary species, conducting the deepest dives of any odontocete species, having enlarged heads to aid in their directional biosonar capabilities, and exhibiting extreme sexual and behavioral dimorphism. In the Gulf of Mexico, a distinct, resident stock of sperm whales exists along the northern portion of the U.S. EEZ, known to be both culturally and genetically distinct. This stock of sperm whales is exposed to a range of anthropogenic threats, most notably be oil and gas activity, but also from fishing and shipping activity. The uniqueness of this species and overlap with increasing anthropogenic activity in the Gulf, particularly from noise, make sperm whales worthy of special management considerations of their critical habitat. Though much remains unknown about this species, sperm whales show an affinity for the 1000-meter isobath, as well as the De Soto and Mississippi Canyons. Thus, it is requested that NMFS taken timely action to review this proposal and designate the three main areas listed above as critical habitat.

<End Petition>

VI. Discussion

Petition Writing and Purpose

The original intent of this Master's Project was to produce a critical habitat petition for sperm whales in the Gulf of Mexico, ready to file to the National Marine Fisheries Service at the conclusion of this Master's Project. At first, it seemed that a strong case existed for sperm whale critical habitat in the Gulf of Mexico, given their residency (Jochens et al., 2008), unique vocalization patterns (Jochens et al., 2008), genetic distinctness (Engelhaupt, 2009), and the unique suite of threats (i.e. oil and gas activity). Entering this project, however, I overlooked several key factors that would ultimately make designating critical habitat for sperm whales challenging. These factors included: a regulatory uphill battle because sperm whales were listed in 1970 as a global species, without a critical habitat designation (NMFS, 2010); the fact that sperm whales spend three-quarters of their time at depth (Watwood et al., 2006; NOAA, 2015; Williams et al., 2015), making it more difficult to visualize and understand sperm whale habitat; and the fact that much remains unknown about the exact impacts of certain anthropogenic activities (i.e. seismic testing) (Miller et al., 2006). In the end, these factors compounded to make drafting a petition more challenging that I had originally assumed.

In particular, selecting the actual areas for habitat designation was difficult. At first, I questioned whether habitat should be based on prey availability, oceanographic features, or bathymetry. All of these have relevance to sperm whale distribution, but it was—and still remains—unclear as which factor is most important, and/or how these three items interrelate. Jaquet and Gendron (2012) recommend that sperm whale habitat could be identified using the distribution of main prey items, rather than by identifying areas of primary productivity or "high relief." At the same time, since sperm whales' primary habitat is spent in meso- and bathypelagic habitats feeding on poorly studied cephalopods (Kawakami 1980; Judkins, et al., 2015), so it is difficult to locate exact location of their prey (Jaquet and Gendron, 2012). I also questioned whether it was possible to designate habitat based on sperm whales' "acoustic habitat" in the Gulf. It could be argued, however, that the entirety of their habitat—perhaps excluding the ocean surface—can be considered sperm whales' acoustic habitat, because they are echolocating for prey (Cranford, 1999) and vocalizing to communicate with each other (Rendell and Whitehead, 2005). The acoustic literature proved no more valuable than the literature on bathymetry and physical features in terms of identifying which features are important components of habitat. Thus, the most concrete scientific evidence on which to base critical habitat appeared to be based on static, physical features that are vital to sperm whale life history—essentially, steep gradients of depth and the existence of deep water habitat. I therefore prioritized bathymetry as the feature on which to base the actual habitat designations, which were supported by satellite telemetry and sightings data indicating that the highest sperm whale densities occurred along the 1000-meter contour line, the Mississippi Canyon, and the De Soto Canyon. I realized that I could make a designation based on a static feature, like bathymetry, but then use dynamic features—like prey fields—on which to support this designation as PCEs.

Of course, choosing the actual physical and biological habitat features was challenging, too. I also questioned whether it was necessary to designate habitat along the entirety of the 1000-meter contour line in federal waters in the Gulf, or whether it could be restricted to a smaller area; given the science—that sperm whales prefer these steep depth gradients and evidence exists of them hugging this contour line throughout the Gulf—I decided to start more broadly in this original critical habitat petition. I used the Cook Inlet beluga whale and Southern Resident killer whale area designations, as well as PCEs, as examples to inform which physical and biological features to include. For example, I considered creating a PCE based on a 500-meter exclusion zone from seismic surveys, as well as a PCE that called for anthropogenic noise levels to not exceed the Level A (acoustic injury) and Level B (harassment) thresholds, as identified by NOAA (NOAA, n.d.a). I decided to exclude this after review of public comments for the Cook Inlet beluga where designation, where the agency noted that acoustic thresholds are not an actual *feature of their habitat*, but rather a policy induced on their habitat.

After going through this exercise, however, I do not intend to file the petition at this time. While there does appear to be strong scientific consensus that the three proposed areas I identified are vital to sperm whales in the Gulf of Mexico, the filing would be an uphill battle in the current political climate and the manner in which sperm whales are listed as a single global species. My understanding, based on research for this Master's Project and in talking to several professionals, is that the petition would be more favorably received if the designation process was triggered by a relisting for the entire species, or if critical habitat was also proposed in areas outside of the Gulf of Mexico.

The Endangered Species Act and Acoustics

The incorporation of sound into the ESA framework is still in its infancy. Aspects of the ESA allow acoustics to play an important role, such as in recovery plans, important elements of critical habitat, and through incidental take permits. The ability to incorporate noise in this manner depends on the species, habitat, and management needs. For cetaceans, there is undoubtedly latitude to include acoustic habitat in critical habitat designations, depending on the available science. Furthermore, incorporating sound into the ESA perhaps is most obvious in application of the ESA, such as in Section 7 consultations. To fully answer the question of how sound has been interwoven with the ESA, one would need to review applicable case law, as well as consult reviews of jeopardy and adverse modification findings.

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