Status Review Report:
Porbeagle Shark (*Lamna nasus*)

2016

National Marine Fisheries Service
National Oceanic and Atmospheric Administration

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EXECUTIVE SUMMARY

This status review report was conducted in response to two petitions to list the Porbeagle (*Lamna nasus*) under the Endangered Species Act (ESA) (petitioners: Humane Society of the United States on January 21, 2010; WildEarth Guardians on January 20, 2010). NMFS evaluated the petitions to determine whether the petitioners provided substantial information as required by the ESA to list a species. Additionally, NMFS evaluated whether information contained in the petitions might support the identification of a distinct population segment (DPS) that may warrant listing as a species under the ESA. NMFS determined that the petitions presented substantial scientific and commercial information, or cited such information in other sources, that the petitioned action may be warranted and, subsequently, NMFS initiated a status review of the Porbeagle. This status review report is comprised of two components: (1) the "Status Review" of the species, a document that compiles the best available information on the status of the Porbeagle as required by the ESA, and (2) the "Assessment of Extinction Risk" for the species, a document that provides the methods and conclusions of the NMFS Extinction Risk Analysis (ERA) team on the current and future extinction risk of the Porbeagle.

The Porbeagle is a coastal and oceanic pelagic shark species that ranges in cold-temperate waters across the North Atlantic, and in a continuous band around the southern hemisphere. Like other members of the family Lamnidae, it is regionally endothermic (warm-blooded), allowing it to maintain high activity levels in cold waters. Porbeagles have low productivity, with ages at maturity of 8 years for males and 13 years for females, an 8-9 month gestation period, and litter size averaging 4 pups. These life history traits make the populations vulnerable to overfishing and slow to recover from depletion.

Stock assessments for the Porbeagle indicate that some populations have declined by up to 90% due to overfishing. While stocks around the world are considered overfished, declines have been halted and recoveries are apparent in some regions due to improved local, regional, and international fisheries management. Rebuilding is projected to take multiple decades.

Based on a review of the best available information, the ERA team determined that there are two distinct population segments (DPSs) of Porbeagle, as defined by the joint U.S. Fish and Wildlife Service-NMFS interagency policy of 1996 on vertebrate distinct population segments under the ESA. One DPS is in the North Atlantic, and the other is in the southern hemisphere. As such, the ERA team evaluated the extinction risk of each Porbeagle DPS.

The ERA team ranked the demographic parameters of abundance, growth rate/productivity, spatial structure/connectivity, and diversity in terms of their risk to the species' continued existence. Low abundance and life history traits (e.g., growth rate, late maturity, productivity rates, and low fecundity) were ranked as moderate risks to the species' continued existence, meaning these demographic parameters pose a significant risk to the species' continued existence. Spatial structure/connectivity and diversity, however, were not found to pose significant risks to the Porbeagle's continued existence.

The ERA team also ranked the ESA section 4(a) threats to Porbeagle, and concluded that overutilization and inadequate regulatory mechanisms are likely to contribute to the decline of the species, but only in combination with other threats or factors, whereas the other threats (habitat destruction, modification or curtailment, disease or predation, and other natural or manmade threats) were identified as having either low or very low effects on the extinction risk.

Based on an evaluation of abundance trends, growth and productivity, spatial structure, and diversity, as well as the ESA section 4(a)(1) threats listed above, the ERA team evaluated the current level of extinction risk as well as extinction risk in the foreseeable future (which was defined as 40 years) for each Porbeagle DPS. The ERA team concluded that both Porbeagle DPSs have a low risk of extinction currently, or in the foreseeable future. Due to improved fisheries management and documented rebuilding in some regions, foreseeable future extinction risk was considered to be lower than it is currently. These analyses and conclusions will be factored into NMFS' decision on whether or not ESA listing is warranted for the Porbeagle.

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Greater Atlantic Regional Fisheries Office
National Marine Fisheries Service
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INTRODUCTION

Scope and Intent of the Present Document

This document is the status review in response to two petitions from Wild Earth Guardians (WEG) and the Humane Society of the United States (HSUS) to list the Porbeagle (*Lamna nasus*, Bonnaterre 1788) under the Endangered Species Act (ESA) in January, 2010. Under the ESA, if a petition is found to present substantial scientific or commercial information that the petitioned action may be warranted, a status review shall be promptly commenced (16 U.S.C. 1533(b)(3)(A)). In response, the National Marine Fisheries Service (NMFS) published a “negative” 90-finding in July, 2010, in which NMFS concluded that, due to increasing numbers and stability in some stocks, coupled with new and continuing national and international management efforts, the petitions to list this species under the ESA were not warranted.

In August of 2011, the petitioners filed complaints in the U.S. District Court for the District of Columbia challenging NMFS’ denial of the petitions. On November 14, 2014, the Court published a Memorandum Opinion granting the plaintiffs’ requests for summary judgment in part, denying NMFS’ request for summary judgment, and vacating the 2010 90-day finding for Porbeagle. The Court ordered us to prepare a new 90-day finding. The Court entered final judgment on December 12, 2014 (remand). The new 90-day finding, which published on March 27, 2015, was based primarily on information that had become available since 2010, including a new Canadian assessment of the NW Atlantic stock and new information in recent proceedings from the International Convention for the Conservation of Atlantic Tunas (ICCAT), regulatory documents, published literature, and *Federal Register* notices as well as the information contained in the original petitions. NMFS accepted the petitions and initiated a review of the status of the species, as the ESA stipulates that listing determinations should be made on the basis of the best scientific and commercial information available.

This report will comprise the best scientific and commercial information available on the species. The purpose of this document is to comprehensively review the best available scientific information on the status of Porbeagles throughout their range, evaluate the factors contributing to the species’ proposed threatened or endangered status according to the petitions and other available information, conduct an assessment of the species’ risk of extinction, and provide the information necessary for NMFS to make a determination on the potential listing of this species (or its distinct population segments) under the ESA.

Key Questions in ESA Evaluations

In determining whether a listing under the ESA is warranted, two key questions must be addressed:

1) Is the entity in question a “species” as defined by the ESA?
2) If so, is the “species” threatened or endangered?

The ESA (section 3) defines the term "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." The term "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." NMFS considers a variety of information in evaluating the level of risk faced by a species in deciding whether the species is threatened or endangered. Important considerations include 1) absolute numbers of fish and their spatial and temporal distribution; 2) current abundance in relation to historical abundance and carrying capacity of the habitat; 3) any trends in abundance; 4) natural and human influenced factors that cause variability in survival and abundance; 5) possible threats to genetic integrity; and 6) recent events (e.g., a drought or a change in management) that have predictable short-term consequences for abundance of the species. Additional risk factors, such as disease prevalence or changes in life history traits, may also be considered in evaluating risk to populations.

NMFS is required by law (ESA Sec. 4(a)(1)) to determine whether one or more of the following factors is/are responsible for the species' threatened or endangered status:

> (A) The present or threatened destruction, modification or curtailment of its habitat or range;
> (B) overutilization for commercial, recreational, scientific, or educational purposes;
> (C) disease or predation;
> (D) inadequacy of existing regulatory mechanisms; or
> (E) other natural or human factors affecting its continued existence.

According to the ESA, the determination of whether a species is threatened or endangered should be made on the basis of the best scientific and commercial information available regarding its current status, after taking into consideration conservation measures that are being made.

Summary of the Porbeagle Listing Petitions

The petitions submitted by HSUS and WEG argue that Porbeagles should be listed as endangered or threatened under the ESA. The HSUS petition requested endangered listing for only the NW Atlantic stock, while the WEG petition requested listing for Porbeagles across their North Atlantic populations or throughout their range. Their assertions were primarily based on evidence of population declines resulting from overfishing, the species' inherent biological vulnerability to overexploitation, habitat destruction or modification via pollution, climate change, and ocean acidification, and the alleged inadequacy of existing regulatory mechanisms. As described above, this document will evaluate all of these factors and how they affect the Porbeagle's risk of extinction throughout all or significant portions of its range.

LIFE HISTORY AND ECOLOGY

Taxonomy and Distinctive Characteristics

In determining whether to list a species, the first issue is whether the petitioned subject is a valid species. The petitioned subject, the Porbeagle (*Lamna nasus* Bonnaterre, 1788), is a valid species for listing. The species description history and synonyms are provided by Compagno (2002). The taxonomic breakdown of *L. nasus* is as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Chondrichthyes
Subclass: Elasmobranchii
Order: Lamniformes
Family: Lamnidae
Genus: *Lamna*
Species: *nasus*

Range and Habitat Use

The Porbeagle has a wide-ranging anti-tropical distribution, occurring in the North Atlantic and southern Atlantic, Indian, and Pacific Oceans (Figure 1). There are no known records of this species from equatorial areas. It is absent from the North Pacific where its congener the Salmon Shark (*Lamna ditropis*) occurs. The porbeagle, like other lamnid sharks, is regionally endothermic (warm-blooded) (Carey et al. 1985), and prefers cold, temperate waters less than 18 °C, but has been documented in a temperature range of 1-26 °C (Compagno 2002, Francis et al. 2008, Skomal et al. 2009). It most commonly occurs in epipelagic waters over the continental shelf, shelf edges, offshore banks, and in the open ocean reaching depths of at least 1300 m (Compagno 2002, Francis et al. 2008, Campana et al. 2010a). Additional details on distribution are provided below.

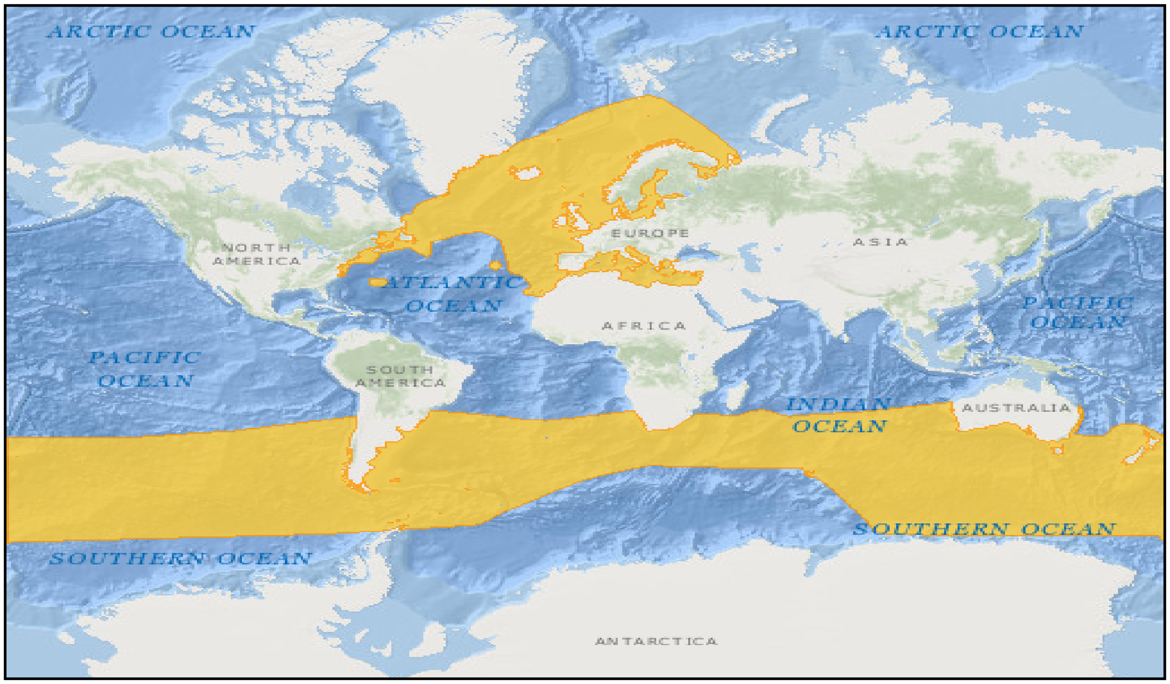

Figure 1. Global range of the Porbeagle, *Lamna nasus* (source: www.iucnredlist.org; 2015).

Reproduction, Growth, and Demography

The Porbeagle is an aplacental viviparous species. Females appear to have a one-year reproductive cycle, with gestation lasting 8-9 months (Jensen et al. 2002, Francis et al. 2008). Litter size averages four pups, but ranges from one to five (Jensen et al. 2002, Francis et al. 2008). Embryos are oophagous, consuming the available eggs *in utero* for nutrients during gestation and development (Jensen et al. 2002).

Life history parameters are well-summarized in ICCAT (2009) and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (2013). Size at birth is approximately 58-67 cm (Francis et al. 2008, Forselledo 2012). In the NW Atlantic, female size at maturity is 200-219 cm (~13 years), and male size at maturity is 155-177 cm (~8 years) (Jensen et al. 2002, Natanson et al. 2002, CITES 2013). In New Zealand, Porbeagles mature at smaller lengths: 170-180 cm (15-18 years) for females and 140-150 cm (8-11 years) for males (Francis et al. 2008, CITES 2013). Size at maturity in the South Atlantic is similar to New Zealand: > 170 cm for females and ~147 cm for males (Forselledo 2012). Females reach larger maximum sizes than males, with the largest documented specimen measuring 357 cm total length (Francis et al. 2008, CITES 2013). In the southern Pacific, Porbeagles appear to reach smaller maximum sizes than in the North Atlantic (~236 cm; Francis et al. 2008). Longevity for the Porbeagle is estimated to be up to 46 years in an unfished population, but may exceed 65 years in the southern hemisphere (Natanson et al. 2002, ICCAT 2009, CITES 2013).

In an analysis of demographic patterns across 38 species of sharks by Cortes (2002), NW Atlantic Porbeagles were determined to be on the lower end of the spectrum with a population growth rate (λ) of 1.022 (values below 1 indicate negative population growth rates) and a mean generation time ($\bar{A}$) of 17.9 years. However, juvenile survival rates were among the highest of any species, resulting in high overall natural survival rates (84-90%). High survival rates will tend to result in positive effects on populations. An updated Ecological Risk Assessment of pelagic sharks (Cortes et al. 2015) conducted by ICCAT found that the population growth rate of Atlantic Porbeagle ranked 13 out of 20 stocks (r=0.052) and generation time was on the order of 20 years. This suggests that recovery from population declines will tend to be slow, possibly on the order of decades, since it would take the population close to a generation to double in size.

Population Structure

Tagging Information

Tagging data show Porbeagles are highly-mobile and capable of making long-distance migrations (thousands of kilometers), though individuals often remain within the range of a particular stock. These data indicate there is little exchange between the geographically dispersed populations in the NW and NE Atlantic (COSEWIC, 2004; Stevens et al., 2006). Likewise, conventional tagging data (approximately 200 recaptures from three separate studies) and recent pop-up satellite archival tag (PSAT) data indicate that transatlantic migrations are limited, though a single transatlantic migration has been recorded (citing International Council for the Exploration of the Sea (ICES)/ICCAT, 2009). While such data appear to indicate there is little movement between populations in the North Atlantic, which could lead to limited genetic exchange (ICES/ICCAT, 2009; Stevens et al., 2006; COSEWIC, 2004), the value of the conventional tagging data used to demonstrate whether populations overlap geographically and whether they interbreed is limited, as discussed below. The genetic data, however, indicates that there is interbreeding between populations (see below).

For several reasons, conventional tagging data are less reliable than genetic data for demonstrating whether populations of Porbeagles are discrete. First, it is reliant on recaptures and reporting (commercial/recreational fishermen or surveys may report catch of a tagged fish) and the information available is generally only the location where the fish was recaptured in relation to where it was originally tagged (Kohler et al., 2002, Skomal et al. 2009). It does not show migrations or the movements of the fish outside of those two locations. Second, the information from conventional tagging is limited by the small number of Porbeagles tagged and recaptured.

Out of 1,300 Porbeagles tagged with conventional tags between 1962-2000 in the NE and NW Atlantic, only 143 were recaptured (Kohler et al., 2002). As of 2015, the NMFS Cooperative Shark Tagging Program in the NW Atlantic has tagged 1,778 Porbeagles, with 185 (10.4%) recaptured (N. Kohler, NMFS, unpublished data). The greatest distance documented between tag and recapture locations in this program is 1,957 km. However, Kohler & Turner (2001) reported a maximum displacement distance of up to 4,260 km for a Porbeagle tagged by

Ireland’s Inland Fisheries Board Marine Tagging Program. One Porbeagle tagged in the NE Atlantic was recaptured off Newfoundland, Canada, identifying the potential for trans-Atlantic movements in this species (ICES 2007). The time at liberty between when the fish was tagged/released to being recaptured has been as long as 16.8 years (N. Kohler, NMFS, unpublished data), but there is no information on where the fish was during that intervening time period. Therefore, while conventional tag/recapture data indicate that Porbeagles are capable of making significant large-scale movements, they are not a reliable indicator of exact fish migrations (Kohler et al., 2002).

Other tagging technologies, which record location and habitat data while attached to the fish, such as pop-up satellite archival tags (PSATs) can provide a better view of migration patterns. Use of these tags is limited due to the expense and relative newness of the technology. However, several recent studies have used PSATs to describe Porbeagle movements and habitat use in the NW and NE Atlantic and SW Pacific (Pade et al. 2008, ICCAT 2009, Skomal et al. 2009, Campana et al. 2010a, Saunders et al. 2011, Bendall et al. 2013, Francis et al. 2015). Some of these individuals were tracked for up to one year, and had maximum displacements over 4,400 km from the tagging location. However, the majority of Porbeagles that have been tracked with PSATs to date (N=69 in the North Atlantic, N=10 in the South Pacific), generally showed relatively restricted movements and fidelity to the region in which they were tagged. Mature female Porbeagles tended to display the largest movements, with several sharks tagged off Canada swimming southward to the subtropical Sargasso Sea and northern Caribbean region, presumably to pup (Campana et al. 2010a, Figure 2). However, males and immature sharks have also made significant movements (Saunders et al. 2011, Francis et al. 2015, J. Sulikowski, University of New England, unpublished data).

In sum, the available tagging data remain somewhat limited, particularly in the southern hemisphere. PSAT studies revealed that Porbeagles generally remain within the region where they were tagged, at least within the available tracking durations (< 1 year). This suggests that mixing rates across large ocean areas may be limited. However, a few individuals swam thousands of kilometers from the tagging area, and therefore the species has the biological potential to move between distant stock regions (Figures 2-4). This information, combined with the one recorded trans-Atlantic migration, indicates that Porbeagles can and do occasionally move between the NW and NE Atlantic, but also shows that the tagging data available may not necessarily the most reliable indicator of whether DPSs of Porbeagles exist (Kohler et al. 2002; Pade et al. 2008; ICES/ICCAT, 2009; Campana et al. 2010a; Bendall et al. 2013).

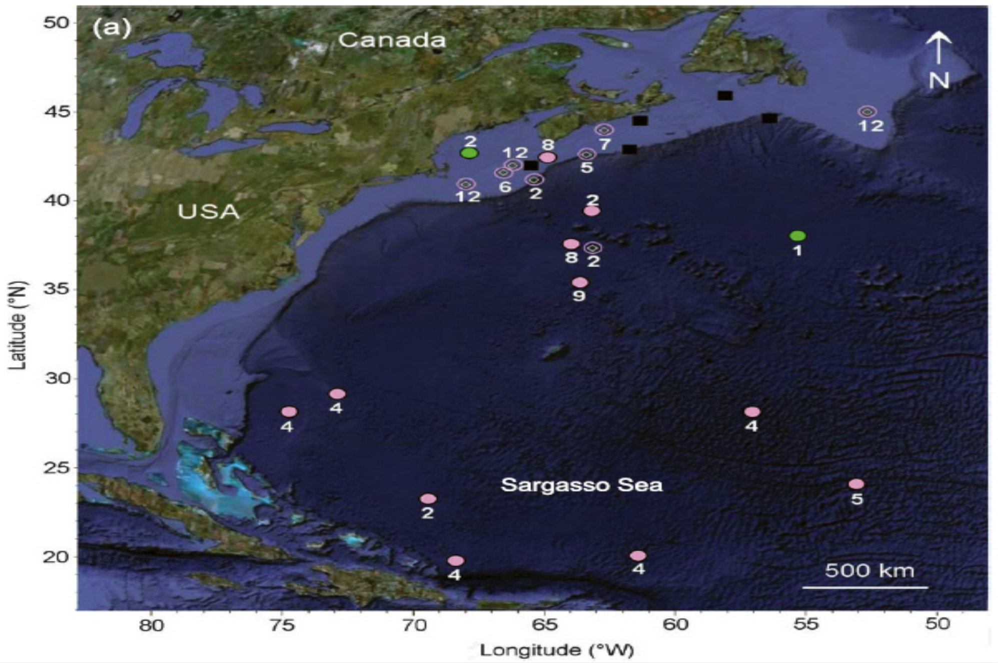

Figure 2. Tagging locations (black squares) and PSAT pop-up locations (circles) from 21 Porbeagles tagged by Campana et al. (2010). Males are represented by solid green circles, immature females – open pink circles, and mature females – solid pink circles. The month of pop-up is indicated by the number next to each circle.

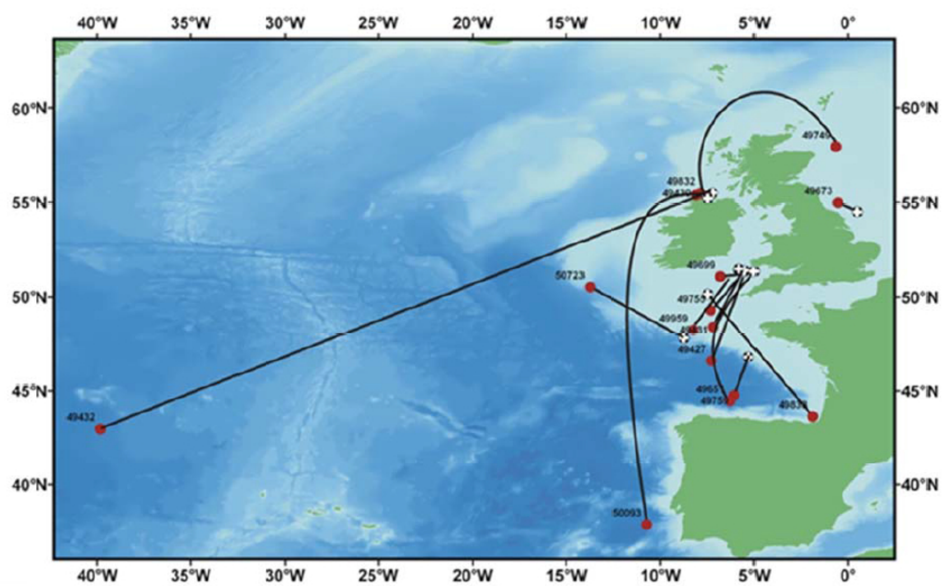

Figure 3. Tagging locations (crosses) and PSAT pop-up locations (circles) from 14 Porbeagles tagged by Bendall et al. (2013).

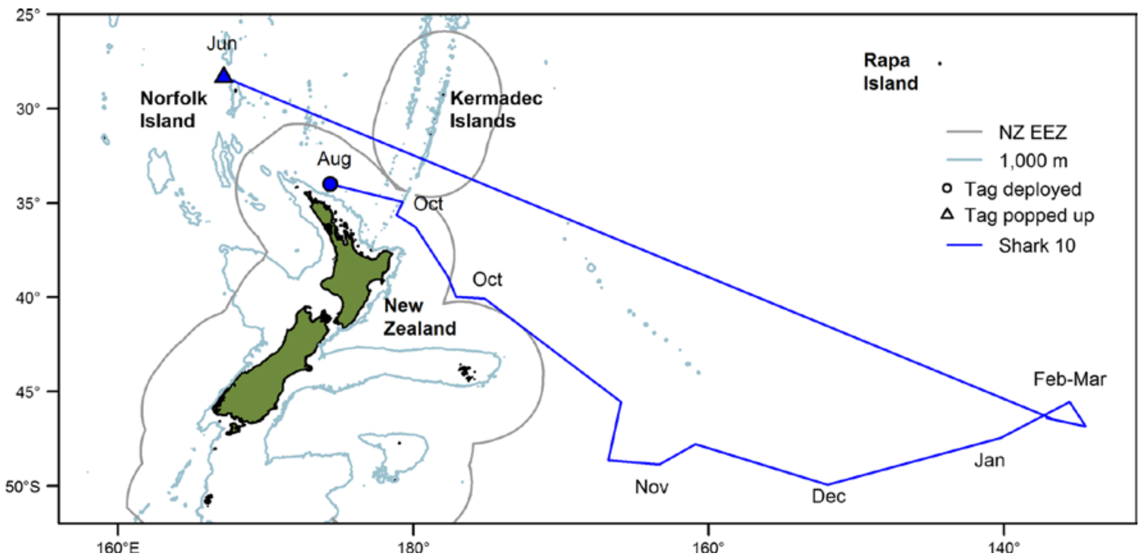

Figure 4. Reconstructed PSAT track of a 140-cm male Porbeagle tagged off New Zealand by Francis et al. (2015). Maximum displacement from the tagging location was approximately 4,475 km.

Genetic Information

Though the available tagging data offer little direct evidence of connectivity between the NW and NE Atlantic populations, genetic analysis shows that the populations in the North Atlantic do mix (Pade et al. 2006, Testerman et al. 2007, ICES/ICCAT 2009, Kitamura & Matsunaga 2010). Mitochondrial DNA (mtDNA) studies indicate that there is no differentiation among the stocks within the North Atlantic, showing that the North Atlantic populations are interbreeding to the extent that they are indistinguishable genetically (Pade et al. 2006, Testerman et al. 2007). Dominant haplotypes were present in porbeagle samples from both the NW and NE Atlantic, indicating that there is, in fact, gene flow within the North Atlantic that tagging studies have not yet clearly identified (Pade et al. 2006, Testerman et al. 2007). Kitamura & Matsunaga (2010) also indicated through genetics that there was no indication of multiple populations in the North Atlantic. The genetics data suggest that genetic interchange is occurring at a level that prevents the species from becoming significantly genetically differentiated; in other words, the NW and NE Atlantic populations are interbreeding. Similarly, genetics information indicates that southern hemisphere Porbeagles are not significantly differentiated within this region (Testerman et al. 2007, Kitamura & Matsunaga 2010).

Several mitochondrial genetic studies do show marked differences in haplotype frequencies between the northern and southern hemispheres, which support the contention that Porbeagle from the North and South Atlantic populations do not interbreed (Pade et al. 2006, Testerman et al. 2007, ICES/ICCAT 2009, Kitamura & Matsunaga 2010). It is likely that the preference of Porbeagle for colder water temperatures and their apparent absence from warm equatorial waters serves to limit the number of Porbeagles moving between the northern and southern hemispheres. The genetic information supports this hypothesis.

Genetic homogeneity across broad regions can be achieved with extremely low mixing rates between subpopulations, even 1% per generation (Ward 2000). The available tagging data, though somewhat limited in sample size as described above, suggests that mixing rates across the North Atlantic or in the southern hemisphere could be very low. However, the lack of differentiation in mtDNA within these regions indicates that female Porbeagles must at least occasionally move between widely separated stock areas (Pade et al. 2006, Testerman et al. 2007). This could be achieved through two hypothesized pathways: 1) Active emigration or vagrancy of mature females from one subpopulation to a neighboring subpopulation (e.g., from the NW to the NE Atlantic), or 2) a lack of philopatry in Porbeagle pups born in subtropical, oceanic waters (e.g., pups born from NW Atlantic mothers in the Sargasso Sea (Camapana et al. 2010) move to the NE Atlantic region as they mature). More tagging data and/or higher resolution nuclear DNA research could help explore these hypotheses and better determine mixing rates.

ICES/ICCAT (2009) determined for management purposes that Porbeagles consist of four separate stocks – the NW Atlantic, NE Atlantic, SW Atlantic, and SE Atlantic. An Indo-Pacific stock may also be present, but these stock boundaries remain unclear. However, fishery management units are not the equivalent to DPSs unless they also meet the criteria for identifying a DPS. The NW Atlantic stock includes Porbeagles from the waters on and adjacent to the continental shelf of North America, and the NE Atlantic stock includes Porbeagles from the waters in and adjacent to the Barents Sea, south to northwest Africa (ICES/ICCAT 2009). ICES/ICCAT (2009) also divides Porbeagles in the South Atlantic into two separate stocks - the SW and SE Atlantic. Despite these stock delineations, the available genetics data indicate, as described above, that only the North and South Atlantic are genetically differentiated, but the populations within the two hemispheres are not significantly differentiated (Pade et al. 2006, Testerman et al. 2007, Kitamura & Matsunaga 2010).

DISTRIBUTION AND ABUNDANCE

Porbeagles are found in the North Atlantic Ocean in pelagic and coastal waters in and adjacent to the NE coast of the United States, Newfoundland Banks, Iceland, Barents, Baltic, and North Seas, the coast of Western Europe down to the NW African coast, and the Mediterranean Sea. In the southern hemisphere, they are distributed in a circumglobal band of temperate waters in the southern Atlantic, southern Indian, and southern Pacific Oceans. The Porbeagle prefers colder water, and it appears that they do not occur in equatorial waters (Figure 1).

Description of Population Abundance and Trends

Northwest Atlantic

The number of Porbeagles in the NW Atlantic population was estimated between 188,000 to 195,000 in 2005 (DFO 2005). A recent Canadian assessment (Campana et al. 2012, 2012

Canadian assessment) used a forward-projecting age and sex based model starting from an assumed unfished NW Atlantic population with estimates from 1961 and projecting forward by adding recruitment and removing catches. The 2012 Canadian assessment updated landings, catch data, and some research results for the NW Atlantic stock through 2011. This assessment estimated the total 2009 population to be between 196,911 to 206,956 individuals, with the estimated number of mature females ranging from 11,339 to 14,207 individuals. These estimates indicate that there were more Porbeagles in the NW Atlantic in 2009 compared to 2005. We are able to directly compare these population estimates because they use the same models and data sources, with updated information. Based on model estimates, the 2005 population was estimated to be 12-24% of what it had been in 1961 (Gibson and Campana 2005). Estimates of 1961 population levels are assumed to be indicative of virgin or unexploited levels, as this was before the period of major fishing exploitation for this species.

The 2012 Canadian assessment estimates, which reflect data through 2011, indicate that the NW Atlantic population is approximately 22-27% what it was in 1961. The 2012 Canadian assessment estimates the number of mature females in 2009 at 12-16% of the 1961 levels, and 104-120% of the 2005 levels (Campana et al. 2012). Estimates of mature females or the spawning stock biomass are typically used as a good indicator of stock health, and all four models from the 2012 Canadian assessment indicate that the number of mature females for the NW Atlantic stock is increasing (Campana et al. 2012). The 2012 Canadian assessment estimated total biomass in 2009 to be around 10,000 metric tons (mt) (22,046,228 pounds (lb)) which is 20-24% of the 1961 estimates (Campana et al. 2012). The 2012 Canadian assessment also indicates that biomass in 2009 was 4-22% higher than biomass estimates for 2001 (Campana et al. 2012, Campana et al. 2010b). These estimates clearly suggest that biomass has increased since 2001, and that biomass was greater in 2009 compared to 2005, indicating continued population growth.

Since most of the removals reported to ICCAT/ICES are reported in weight, population metrics are expressed in biomass rather than abundance (number of individuals). An increase in biomass is generally indicative of an increase in the total number of individuals in the stock. The increase in biomass since 2001 noted above, also noted in the ICES/ICCAT (2009) stock assessment (see below), likely indicates increased recruitment to the adult stock and continued growth of individual fish in the stock, which is supported by conclusions of the 2012 Canadian stock assessment indicating an increased number of reproductive females and of the population as a whole.

The ICES/ICCAT (2009) stock assessment working group ran a Bayesian Surplus Production (BSP) model for the NW Atlantic stock, which was considered in addition to the forward projecting age- and sex-based model from Campana et al. (2010), and used catch-weighted catch per unit effort (CPUE) indices to estimate biomass. Each model is based on differing assumptions as to how the data should be interpreted and weighed, and therefore, each model results in a differing estimate. The BSP model was a way for the stock assessment to confirm the results from the Canadian age-structured model.

The catch-weighted BSP model estimated biomass in 2005 to be 66 percent of the 1961 biomass, compared to the 10-24% estimate for 2005 from the age-structured model (2010 Canadian assessment), and 20-24% from the 2012 Canadian assessment (comparing 2009 estimates with 1961) results presented above (Campana et al. 2012, ICES/ICCAT 2009, Campana et al. 2010b). CPUE data in the BSP model were either weighted by the relative proportion of total catch corresponding to the fleet represented by each CPUE series in each year, or weighted equally. With equal weighting, the BSP model estimated 2005 biomass at 37% of 1961 biomass, which was more similar to the age-structured model (ICES/ICCAT 2009). Furthermore, results of the BSP model applied to data through 2009 were similar to those of the Canadian age-structured stock assessment that used only Canadian data, noting that the model indicated a low current fishing mortality rate (the rate at which fish are removed from the stock) relative to fishing at the maximum sustainable yield (F_{MSY}), indicating that the stock was increasing (ICES/ICCAT 2009). The BSP model predicted that the NW Atlantic stock could recover to the biomass at MSY (B_{MSY}) in approximately 20 years with no fishing when using only the Canadian assessment data up to 2005 (ICES/ICCAT 2009).

Significantly, all four model variations from the 2012 Canadian assessment showed mean increases in biomass since 2001, which confirms the increasing biomass estimated in the stock assessment (ICES/ICCAT 2009). The ranges in population estimates for general population numbers, mature females and biomass mentioned above reflect the varying results from the four different model runs using differing assumptions in the Canadian assessment. Model 1 was determined to be the "most plausible" of the four model variations, based on the maximum likelihood estimates (i.e., examining the parameters of a model and determining how well the model reflects the data in the assumed estimate). Model 1 shows increases in both the numbers of mature females as well as the general population numbers since 2001, which likely reflects the positive effects of management measures put into place for this species around that time (Campana et al. 2012). Canadian directed landings of Porbeagle have been less than 250 mt since 2002.

All models from the 2012 Canadian assessment also show an increase in general population numbers since 2001, except Model 2. This model variation (Model 2) implies that there were fewer fish in 2009 than 2001, but the maximum likelihood points for this model indicate that it is the "least plausible" model, and therefore, is not likely an indicator of the true trend in the population (Campana et al. 2010b, Campana et al. 2012). Looking at the period between 2005 and 2009, all four variations of the model from this assessment show increases in the mature female stock numbers, and three of the four model variations showed increases in the general population numbers. The exception was Model 2, which showed a slight decrease (approximately 2% or 4,000 fish) in the general population numbers from 2005 to 2009. However, as mentioned above, Model 2 was determined to be the "least plausible" of all the model variations (Campana et al. 2012). Furthermore, Campana et al. (2010), and the 2012 Canadian assessment (Campana et al. 2012), estimated the total 2009 population at 196,911 to 206,956 individuals, with a biomass estimated at 4-22% higher than the 2001 population. Based on the results of the four Canadian model runs, which all show increases in biomass since 2001, and taking into account the most plausible scenarios, as determined by the authors of the

Canadian assessments, which all show increases in female spawning numbers as well as general population numbers, the only reasonable conclusion is that biomass, as well as the general population have increased since 2001 (Campana et al. 2010b, Campana et al. 2012).

The ICES/ICCAT (2009) working group looked at all the different models, data, and fits to the data, and determined, through a thorough assessment, that there is clearly an increasing trend in B/B_{MSY} (biomass over biomass at maximum sustainable yield) and a decreasing trend in F/F_{MSY} (fishing mortality over fishing mortality at maximum sustainable yield) in recent years, indicating that the stock is recovering (see Figure 17 of ICES/ICCAT, 2009). Based on the results of all the modeling efforts, the working group concluded in 2009 that the NW Atlantic stock biomass is depleted below B_{MSY}, but recent fishing mortality is below F_{MSY}, and recent biomass and abundance appears to be stable or increasing. These conclusions have also been supported by other and more recent assessments mentioned above (Campana et al. 2012, Campana et al. 2010b, ICES/ICCAT 2009, SCRS 2014).

The NW Atlantic stock is considered to be overfished ($B< ½ B_{MSY}$), but overfishing is not occurring ($F<F_{MSY}$) (SCRS 2014). While the NW Atlantic stock consists of fewer individuals compared to 1961 estimates, the population is still large, estimated around 200,000 fish. When a population is at very low numbers of individuals, chance factors outside of directed fishing or other anticipated threats can pose a major risk to the species; however, Campana et al. (2012) reports the large population size of the Porbeagle should make it such that random factors would not pose a threat to the species, and that they are expected to recover even with modest fishing mortality. At mortality rates less than 4% of the vulnerable biomass, recovery was estimated to be achievable between 5-100 years (Campana et al. 2012). The vulnerable biomass is the portion of the entire population that is biologically available to the fishery to catch, meaning the amount of the population that is of a size that could be caught in fishing gear used for the fishery, not the amount that they are allowed to fish/catch in a given year. The 2012 Canadian assessment estimated the vulnerable biomass in 2009 to be between 4,406 and 5,093mt (9,713,568 and 11,228,143 lbs) (see Table 13 from Campana et al. 2012).

The ICCAT stock assessment (2009) takes into consideration all data and models available at that time (including the Campana et al. (2010) assessment which was prepared and available for the 2009 assessment, despite being published in 2010), and supersedes any singular model interpretation as it encompasses all data and models, and represents the most thorough assessment of the stocks. Furthermore, all information related to this stock since the 2009 assessment validates the conclusions in the ICCAT (2009) stock assessment. The stock assessment concluded that the NW Atlantic stock is increasing; therefore, the only reasonable conclusion is that this stock is increasing.

Northeast Atlantic

According to ICES/ICCAT (2009), the NE Atlantic Porbeagle stock has the longest history of commercial exploitation with the highest catches occurring between the 1930s and 1950s. The lack of CPUE data derived during the peak of the fishery makes it difficult to estimate current status relative to virgin biomass. The ICCAT working group ran a range of model scenarios, the majority of which predicted that this stock was overfished (B_{2009}<B/ ½ B_{MSY}) and that overfishing was not occurring, i.e., recent fishing mortality rates (F) were either near or below sustainable levels (F_{MSY}) (ICES/ICCAT 2009). The working group concluded that current management efforts were likely to result in the stock remaining stable and indicated that the stock would recover within 15-34 years under no fishing mortality (ICES/ICCAT 2009). Under the 2009 European Union (EU) total allowable catch (TAC) of 436 mt (961,215 lb), projections indicated that the stock would slowly increase but not rebuild in 50 years. Since 2010, the TAC has been at zero (SCRS 2014); therefore, it is reasonable to assume that under current EU fishing levels (zero TAC) the stock will progressively increase. Thus, although the NE Atlantic stock is considered to be overfished, but overfishing is not occurring, no fishing is currently permitted, and the zero TAC management measures will continue to help this stock rebuild (SCRS 2014).

Porbeagles also occur in the Mediterranean Sea (Figure 1), where they have been historically harvested as incidental catches in various fisheries (Compagno 2002, Storai et al. 2005, Ferretti et al. 2008, Scacco et al. 2012, CITES 2013). Ferretti et al. (2008) examined a variety of historical data sources from the region, and estimated that lamnid sharks (including Porbeagle and Shortfin Mako Sharks, *Isurus oxyrinchus*) had experienced declines of 83-99% from historical levels. They were unable to distinguish between the two species in their data sources, so there is no way to know what proportion of these estimated declines can be attributed to only Porbeagle. These authors also acknowledged that these species appeared to have low occurrence and catch rates even at the earliest stages of their time series (Ferretti et al. 2008). This observation is confirmed by Storai et al. (2005) who were only able to document 33 verified records of Porbeagles from around Italy from 1871-2004, and Scacco et al. (2012) who documented two specimens in the Adriatic Sea in 2010-2011. Other limited data sources analyzed show low historical occurrences of Porbeagle throughout the Mediterranean Sea (CITES 2013). The estimates of Ferretti et al. (2008) were based on small overall sample sizes (0-10 lamnid sharks per year over 24 and 56-year time series) and used methods that have been previously criticized as producing overly pessimistic population trends (Burgess et al. 2005). The available information from the Mediterranean Sea suggests that Porbeagle abundance has possibly declined, but the species was already historically uncommon in the region. There is also no information suggesting the Mediterranean population is isolated from the larger NE Atlantic stock, and given the species' highly migratory nature it is likely to mix with adjacent regions.

Southern Hemisphere

The 2009 ICES/ICCAT working group concluded that the data for the southern hemisphere Porbeagle stock was too limited to provide a robust indication on the status of this stock, and the updated SCRS(2014) report came to the same conclusion (SCRS 2014, ICES/ICCAT 2009). They noted available data indicated a decline in CPUE in the Uruguayan fleet (ICES/ICCAT 2009). They conducted a similar modeling effort and noted that depletion levels may be below MSY and fishing mortality rates above those producing MSY; however, they also indicated that catch and other data were generally too limited to allow definition of sustainable harvest levels.

The working group noted, however, that available catch rate patterns (patterns in CPUE) suggest this stock has stabilized since the early 1990s, since catch rates of Porbeagles during that time period were stable (ICES/ICCAT 2009). SCRS (2014) subsequently determined that the SW Atlantic stock was overfished, but that overfishing was probably not occurring.

Information and data for Porbeagle in the SE Atlantic were too limited to assess their status as to overfished/overfishing; however, the working group noted that available catch rate patterns suggested that this stock has stabilized since the early 1990s (ICES/ICCAT 2009). The recent SCRS (2014) report also noted they were unable to determine stock status for the SE stock due to limited data and that landings were likely underestimated for this stock.

Though information on the southern hemisphere populations of Porbeagle has been limited, the 2009 ICES/ICCAT stock assessment determined that the stock had likely stabilized since the early 1990s. Recent studies have been able to look more fully at the distribution and abundance trends for the southern hemisphere Porbeagle. Pons & Domingo (2010) examined CPUE of Porbeagles in the Uruguayan pelagic longline fleet, and found declines during the 1990s, but the trend has been stable or slightly increasing since 2000. Semba et al. (2013) analyzed the distribution and abundance trends of Porbeagles in the southern hemisphere using standardized CPUE from the Southern Bluefin Tuna (SBT) longline fishery from 1994-2011 and a driftnet survey from 1982-1990. This study found no decreasing trend in abundance of Porbeagles in the southern hemisphere, and also concluded that they were found in a widely continuous distribution and abundance from the South Pacific and southeastern Indian Oceans and the southwestern Indian Ocean and the southeastern Atlantic Ocean (Semba et al. 2013). Due to a lack of fishing effort within the Indian Ocean, this study was unable to confirm presence within the Southern Indian ocean, though it was noted that genetic analysis suggests that there is no genetic separation between the two areas indicating that this distribution is likely continuous through the Indian Ocean (Semba et al. 2013).

In Australia, prior to 1997, Porbeagles were caught for many years by Japanese longline vessels operating in the Australian EEZ (Bruce et al. 2014). Based on observer records, from 1991-1996, an estimated 24,213 Porbeagles were caught off Tasmania. However, since 1997, Japanese vessels have been excluded from fishing in Australian waters, and domestic Australian fishing effort has been greatly reduced in the regions where most Porbeagles were caught (Bruce et al. 2014). Although no abundance trend data are available, Porbeagle catches in Australia have significantly declined in recent years due this reduction in fishing effort, as well as prohibitions on fisheries targeting Porbeagle and Shortfin Mako Sharks (Bruce et al. 2014).

Porbeagles are also taken as incidental catches in New Zealand's Southern Bluefin Tuna (SBT) longline fishery. Reported Porbeagle landings peaked in 1999 at 301 mt, but have declined to 55-81 mt since 2005 (WCPFC 2014). Francis et al. (2014) and WCPFC (2014) reviewed stock status indicators for Porbeagle in New Zealand waters in recent years, and found no signs of declining trends in abundance. The CPUE indices examined were stable or increasing, and the frequency of zero catches in the fishery declined, both of which suggest increases in relative abundance since at least 2005.

Kitamura & Matsunaga (2010) analyzed mitochondrial DNA from samples in the North and South Atlantic which showed high diversity, indicative of a large population. When a population has been severely reduced, a “population bottleneck” can occur as a result of inbreeding and resulting genetic homogenization (meaning that individuals are more similar to each other genetically which could reduce the resiliency of the population). The low diversity and “population bottlenecks” that would be evident with severely depleted populations is not evident in the genetic data for this species; in fact, the data indicate the opposite. Additionally, Porbeagles are the third most dominant species in the sub-Antarctic region of the South Pacific, and they are common in the pelagic ocean throughout the southern hemisphere (Semba et al. 2013). The majority of pregnant females were recorded off the Cape of Good Hope, as well as one record each from both the eastern Indian Ocean and the Tasman Sea (Semba et al. 2013). Additionally, Semba et al. (2013) noted that pregnant females were not limited to coastal areas, finding a wide distribution in pelagic areas as well. This study also found that the SBT fishery occurs primarily on the edge of Porbeagle habitat and that the majority of southern hemisphere Porbeagle presence is located outside of where the SBT fishery operates, determining that the adult abundance in the southern hemisphere is not likely to be significantly impacted by this fishing effort (Semba et al. 2013).

Summary of Abundance and Trends

The abundance and trends information for Porbeagle indicates that the species is widely distributed throughout the North Atlantic Ocean and adjacent waters and are found in a continuous distribution in the southern hemisphere with common occurrence in the pelagic ocean throughout the southern hemisphere. Porbeagles have experienced a decline from the population levels in the 1960s due to overharvest during that period; however, current information and analyses indicate that the populations are stable or increasing and on a trajectory to recovery under current fisheries management measures. The NW, NE, and SW Atlantic stocks are all considered to be overfished, but overfishing is not occurring. Furthermore, genetic data available for this species have shown a significantly high diversity indicative of large populations. By contrast, severely depleted populations generally exhibit low genetic diversity and “population bottlenecks.”

As is often the case with marine species, the data are limited with respect to absolute population sizes for the Porbeagle stocks. However, the most reliable evidence indicates that North Atlantic Porbeagles are now slowly rebuilding from historical overexploitation and on a trajectory toward recovery within 100 years or less (ICCAT 2009, Campana et al. 2010b, Campana et al. 2012). Overall, trends throughout the North Atlantic portion of the species’ range suggest that the population is reduced as compared to historical estimates, but no longer declining. The NW Atlantic stock alone is estimated to number approximately 200,000 according to Canadian estimates and is increasing in abundance and biomass. We further find evidence suggesting that population abundance and trends of Porbeagles throughout the southern hemisphere are stable or increasing, with high genetic diversity and an extensive distribution.

ANALYSIS OF THE ESA SECTION 4(A)(1) FACTORS

The ESA requires NMFS to determine whether a species is endangered or threatened because of any of the factors specified in section 4(a)(1) of the ESA. The following provides information on each of these five factors as they relate to the current status of the Porbeagle.

Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

The ESA requires an evaluation of any present or threatened destruction, modification, or curtailment of habitat or range. Due to global climate change, the distribution of prey resources and competitors for these resources may change, which could limit the potential for Porbeagles to recover; however, there is no information indicating that this factor is negatively impacting the species. The best available information indicates that Porbeagles are adapted to a fairly wide temperature range (2 to 23 °C) with the ability to thermoregulate (Skomal et al. 2009, Campana et al. 2010a), are highly mobile opportunistic feeders and thus, changes in temperature in the range of those projected under various climate scenarios are unlikely have a significant impact on the species. Furthermore, there is no information indicating that there has been any change in the distribution of Porbeagles as a result of climate change or any other cause, or that they would be unable to adapt to potential changes in distributions of prey species.

Fabry et al. (2008) indicates that increases in carbon dioxide (CO_2) have the potential to affect pH levels in marine organisms. However, the authors state that active animals have a higher capacity for buffering pH changes, and that the tolerance of CO_2 by marine fish appears to be very high. Porbeagles are an active, highly mobile species; therefore, it is reasonable to expect they have the ability to tolerate changes in CO_2 and buffer pH changes (Compagno 2001, Fabry et al. 2008).

The National Shark Research Consortium (NSRC) conducted studies from 2002-2007 that focused on essential fish habitat (EFH) and the effects of environmental pollutants on the reproduction, growth, and maturation of sharks along the eastern U.S. coast. NSRC submitted a five-year technical report to NOAA/NMFS which found that although coastal and estuarine U.S. Atlantic sharks were exposed to polychlorinated bi-phenyls (PCB), the concentrations of PCB congeners showed that the more harmful, highly toxic congeners only accounted for 0.7 to 4 percent of the total PCB load, indicating that effects from these contaminants did not pose a significant threat (NSRC 2007). In addition, they determined that it was unlikely that infertility rates were associated with exposure to contaminants like organochlorine pesticides and PCBs (NSRC 2007). Recent information on contaminants in the NE stock of Porbeagle also found that contaminants were generally low or undetectable in the individuals studied, and suggested that compared with information on contaminants in other shark species, the findings for contaminants in Porbeagles were significantly lower (Bendall et al. 2014). The best available information does not indicate that the fitness of Porbeagles may be negatively impacted by mercury or other bioaccumulated contaminants to any significant degree.

In U.S. waters, EFH has been designated for Porbeagles (Figure 5; NMFS 2009). The potential impacts of any Federal activities (e.g., fishery regulations, energy development, dredging, etc.) on this EFH is required to be evaluated. To date, no activities potentially affecting Porbeagle EFH have been identified as having negative impacts.

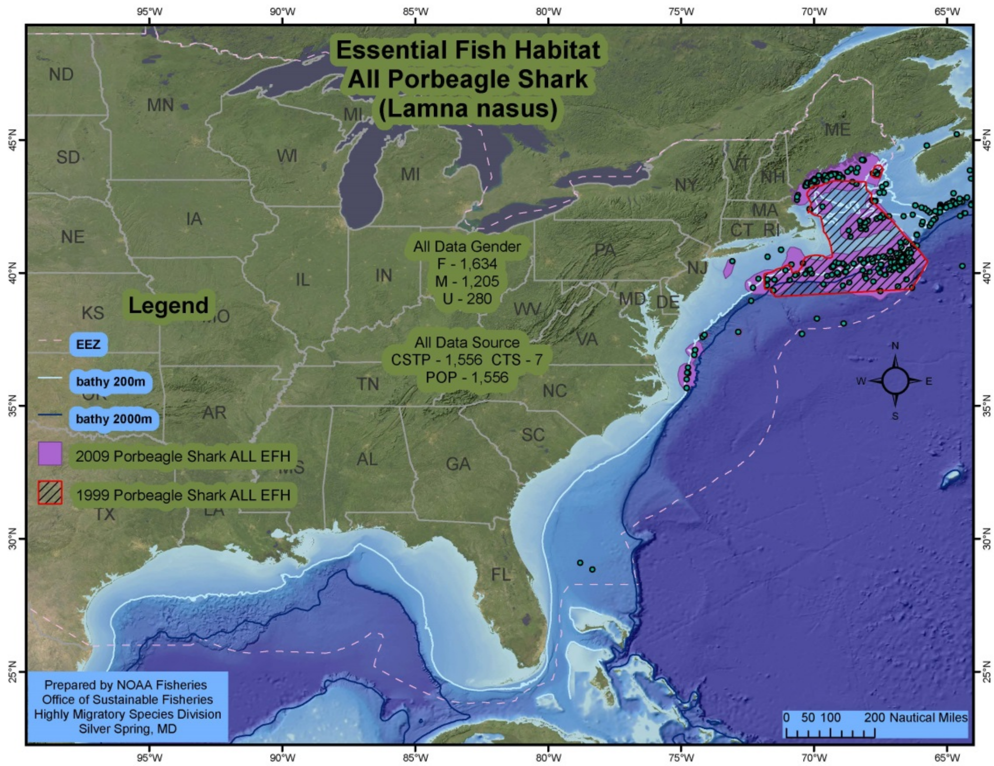

Figure 5. Essential Fish Habitat (light purple area) for the Porbeagle within the US EEZ (Source: NMFS 2009).

<u>Conclusion</u>

There is no evidence of significant present or threatened destruction, modification, or curtailment of the Porbeagle's habitat or range. Porbeagles are a highly mobile species capable of thermoregulation and are highly opportunistic feeders. The best available information suggests that contaminants are even less of a threat to Porbeagles than to other shark species, and that these factors are not significantly impacting Porbeagles. Furthermore, there is no information to indicate that the range of Porbeagles has been contracted or curtailed.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The ESA contains no guidance on how to assess overutilization, nor does it outline levels of population decline relative to an endangered or threatened status. For the purposes of this status review, population dynamic characteristics, such as current population size, abundance trends by regions, recruitment and depensation, and the effects of trade on the population were considered for evaluating the status of the species.

A detailed description of the Porbeagle's population trends and current status is summarized above in the DISTRIBUTION AND ABUNDANCE section. Throughout much of the 20th century, Porbeagles were heavily exploited (Figures 6 and 7), resulting in well-documented population declines (DFO 2005, ICCAT 2009). Porbeagles have primarily been harvested incidentally in various longline fisheries targeting other species (tunas, swordfish, other sharks). However, directed fisheries did occur in Canada, France, Norway, Faroe Islands, and Uruguay (Figure 7). Worldwide catch peaked in the mid-1960s at over 9,500 mt (Figure 6). For much of this time, shark fisheries around the world were completely unregulated, allowing unconstrained harvests. However, in recent years significant improvements have been made in conservation and managing shark fisheries, halting the declines of a number of species (e.g., Barker & Schluessel 2005, Carlson et al. 2012, Ward-Paige et al. 2012).

Declines in Porbeagle catches in recent years (Figures 6 and 7) are largely attributable to greater regulatory control over their harvests, especially in nations that had directed Porbeagle fisheries (DFO 2005, ICCAT 2009). All current stock assessments for Porbeagles determined that stocks were "overfished," but "overfishing" was not occurring for the NW, NE and SW Atlantic stocks, and that information was too limited to determine overfished/overfishing status for the SE Atlantic stock, but that it has been stable and not declining, since the 1990s (ICES/ICCAT 2009, SCRS 2014). This means that while Porbeagle stocks have declined due to fishing pressure, declines have generally been halted and stocks appear to be increasing in response to improved management.

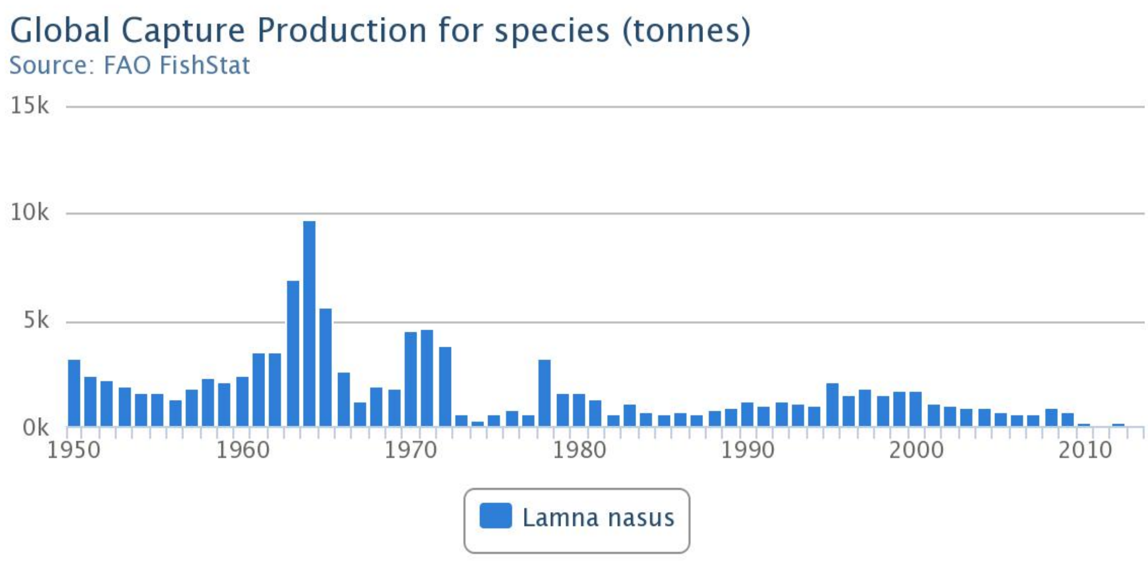

Figure 6. FAO estimated global catches of Porbeagles, 1950-2013 (Source: www.fao.org; accessed September 18, 2015).

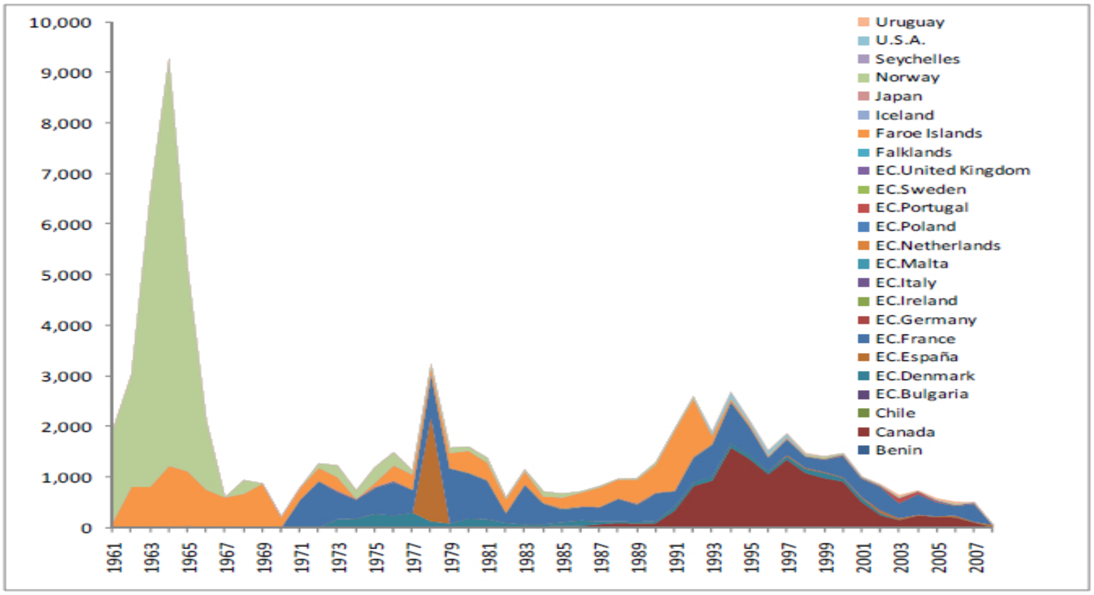

Figure 7. Porbeagle catch (mt) by country, 1961-2008 (Source: ICCAT 2009).

U.S. fisheries have significantly curtailed Porbeagle harvests in recent years. In 2008, NMFS implemented Amendment 2 to the 2006 Consolidated Highly Migratory Species (HMS) Fishery Management Plan (FMP) (June 24, 2008, 73 FR 35778; corrected on July 15, 2008; 73 FR 40658), which, among other things, set a TAC for Porbeagles in the NW Atlantic at 11.3 mt dressed weight (dw) (24,912 lbs dw), and a commercial quota of 1.7 mt dw (3,747 lbs dw). The TAC is the total amount of a species that is allowed to be caught by all resource users over a particular period of time (e.g., year/fishing season). The commercial quota is the amount of the TAC that can be landed by fishermen issued a Federal limited access shark permit. All commercial fishing for a species ceases when the commercial quota is reached. NMFS establishes the annual quotas and opening dates for all shark management groups based on any over- and/or underharvests from previous fishing seasons in an annual specifications rule.

In 2010 and 2011, NMFS reduced the commercial quota slightly due to overharvest from previous fishing seasons. The commercial quota was reduced to 1.5 mt dw (3,307 lbs dw) in 2010 (75 FR 250; January 5, 2010) and to 1.6 mt dw (3,479 lb dw) in 2011 (75 FR 76302; December 8, 2010). In 2012, the commercial quota was reduced to 0.7 mt dw (1,585 lb dw) due to overharvest of the quota. The commercial fishery was closed in 2013 due to overharvests in the previous years. In 2014, the commercial landings of Porbeagle exceeded the quota by 227% with a reported 2.9 mt dw (6,414 lb dw) total reported landed. Because of this overharvest, which exceeded the commercial quota, NMFS closed fishing for the commercial Porbeagle quota through the end of 2015 (79 FR 75068; December 17, 2014). Given the strict quota in place for Porbeagles, the reported overharvest in 2014 of 1.7 mt dw (3,594 lb dw) could represent approximately 27 fish, if the catch consisted of large adults (~130 lbs each). Given that the NW Atlantic population is estimated to have around 200,000 fish, it is unlikely that this overharvest (approximately 27 fish) represents a significant threat to the species. Although Porbeagles in the NW Atlantic are overfished and biomass has been depleted, biomass is currently increasing and overfishing is no longer occurring (ICES/ICCAT 2009, NMFS/HMS 2009, NMFS/HMS 2012, SCRS 2014).

Likewise, the available data show that Canadian fisheries are not likely to pose a significant threat to the species. According to CITES (2010), Canadian catch data indicate that commercial Porbeagle landings have progressively decreased from a peak in 1995 of 1,400 mt (3,086,471 lb) to 92 mt (202,825 lb) in 2007, corresponding with decreasing TAC levels (Campana et al. 2012). The TAC for Porbeagle in Canada was decreased from 250 mt (551,155 lb) to 185 mt (407,855 lb) in 2005; of this amount, 125 mt (275,577 lb) was the quota for the directed commercial shark fishery in the Maritimes Region; 10mt (22,046 lb) was the quota for the directed commercial fishery in the Gulf and Quebec Regions combined; and the remaining 50 mt (110,231 lb) quota was reserved to account for bycatch of Porbeagle in other fisheries (DFO 2009). Mating grounds for the species have also been closed in Canada to directed fisheries since 2000. The Annual Report of Canada to ICCAT reported that in 2012 there were no landings of Porbeagles in a directed fishery; and total landings as bycatch of Porbeagle in 2012 was 33.3 mt (73,413 lb) (ICCAT 2014). Canadian directed fisheries for Porbeagles have been closed since 2013 (ICCAT 2014). CITES (2010) states that population projections indicate that the population will recover if harvest rates are kept under 4 percent the vulnerable biomass (approximately, 185 mt (407,855 lb) of the estimated 2005 biomass, as cited in DFO (2005)). Canadian landings have been below the TAC since 2007, and Campana et al. (2012) indicates that the NW Atlantic stock is increasing. Thus, reduced commercial landings in both the U.S. and Canada appear to be having a positive impact on the stock, and the stock is expected to continue to recover under the management measures in place in both countries.

The NE Atlantic stock is depleted, but was projected to remain stable under the older TAC of 436 mt (961,215 lb). The ICES/ICCAT (2009) assessment determined that further reductions in fishing mortality would allow the population to rebuild (ICES/ICCAT 2009). The TAC of 436 mt (961,215 lb) referred to in ICES/ICCAT (2009) is no longer applicable as 2010 regulations set the EU TAC at zero in domestic waters and prohibit EU vessels from fishing for, retaining on board ships, trans-shipping (e.g., transferring from one ship to another), and landing Porbeagles in international waters (EU, 2010). The elimination of directed and bycatch fisheries for Porbeagles are expected to allow the population to rebuild.

While ICES/ICCAT (2009) determined that the data for southern hemisphere stocks was too limited to adequately assess their overfished/overfishing status at the time of the assessment, data on catch rate patterns indicated the stock had stabilized since the early 1990s. Data suggest a potential decline in CPUE reported for the Uruguayan fishing fleet, though the assessment notes that this “may or may not be indicative of stock abundance and could be the result of environmental changes, changes in fishing strategies or other changes (ICES/ICCAT 2009, Pons & Domingo 2010).” However, CPUE has been stable or slightly increasing since 2000 (Pons & Domingo 2010), and in 2013, Uruguay prohibited retention of Porbeagles (ICCAT 2014).

Porbeagles have historically been harvested as incidental catches in Argentinian and Chilean longline and trawl fisheries. From 2003-2006, Argentina's Porbeagle catches ranged from 18-70 mt, but Argentina currently requires all live sharks greater than 1.5 m to be released (CITES 2013). Landings in Chilean fisheries are mostly unreported, but Hernandez et al. (2008) estimated that Porbeagles comprise less than 2% of harvests based upon analysis of shark fin markets.

Recent studies have been able to look more fully at abundance trends for the southern hemisphere Porbeagle and found no declining trend (Pons & Domingo 2010, Semba et al. 2013, Francis et al. 2014, WCPFC 2014). Semba et al. (2013) analyzed the distribution and abundance trends of porbeagle in the southern hemisphere using standardized CPUE from the SBT longline fishery from 1994-2011 and a driftnet survey from 1982-1990 and found the abundance trend of porbeagle in the southern hemisphere to be stable. The authors also concluded that Porbeagles were found to have an extensive distribution in the southern hemisphere (Semba et al. 2013). They also determined that juvenile abundance has not changed greatly during the time period (1982-2011), and that Porbeagle occurrence in the pelagic ocean was widespread and common throughout the southern hemisphere (Semba et al. 2013). This study also found that the SBT fishery occurs primarily on the edge of Porbeagle habitat and that the majority of southern hemisphere Porbeagle presence is located outside of where the SBT fishery operates. The authors conclude that adult abundance in the southern hemisphere is not likely to be impacted by fishing (Semba et al. 2013). This study also asserts that there is only small overlap between the main areas of porbeagle presence and the SBT and eastern Pacific purse-seine fisheries (Semba et al. 2013). Catches of Porbeagles in Australia and New Zealand have declined significantly in recent years due to reductions in fishing effort and regulations protecting Porbeagles, and relative abundance appears to be stable or increasing (Bruce et al. 2014, Francis et al. 2014, WCPFC 2014). Therefore, southern hemisphere fisheries do not currently appear to be a threat to the species.

Recreational fishery harvests of Porbeagles do not appear to be a significant threat to the species. Catch of porbeagle in recreational fisheries is considered to be extremely low in Canada and the U.S. (CITES 2009). Recreational harvests of Porbeagles in New Zealand are also considered to be negligible (WCPFC 2014). The Annual Report of Canada notes that the recreational fishery for sharks in Canada is catch-and-release, with any retention allowed only through federally authorized shark derbies, and these are reported in Canada's National Report (Andrushchenko et al./Canada 2014). Recreational fisheries for sharks in the U.S. are limited to rod, reel, and handline gear (50 CFR Part 635), and similar requirements exist in Canada. According to the 2013 HMS SAFE Report, only 112 Porbeagles have been observed in the rod and reel fishery from 2000-2012 and, out of that total, only 10 were kept and 102 were released. Overall, recreational catch of this species is minimal (NMFS, 2013a).

Amendment 2 to the 2006 Consolidated HMS FMP summarizes estimated recreational catch in Tables 3.24 and 3.26; however, there are differences between the estimates depending on the data source analyzed (NMFS 2008). Table 3.24 is a compilation of recreational fisheries data from the Marine Recreational Fisheries Statistics Survey (MRFSS), showing projected MRFSS survey estimates, while table 3.26 shows raw, unexpanded numbers of fish from the large pelagic survey (LPS). Offshore fishing trips targeting pelagic sharks typically make up a small proportion of all recreational fishing trips. Generalized angler surveys, such as the MRFSS, aimed at estimating catch and effort for all species do not produce precise estimates for many shark species given the low overall fishing effort. In addition to low precision due to low effort and catch, estimates for sharks derived from MRFSS may suffer from biases associated with sampling under-coverage of shark tournaments, since MRFSS interviews are not conducted at tournament sites. Instead, NMFS relies on specialized surveys to achieve the desired level of statistical precision. The NMFS LPS was specifically designed to collect information on recreational fishing directed at highly migratory species (e.g., tunas, billfishes, swordfish, and sharks). Also, unlike the MRFSS, LPS dockside interviews are conducted at HMS tournaments. This specialization has allowed the higher levels of sampling needed to provide more precise landings estimates of pelagic sharks such as Shortfin Mako, Common Thresher, and Blue sharks from Maine through Virginia. However, for shark species less commonly encountered by recreational anglers, including Porbeagles, even a specialized survey such as the LPS cannot produce precise landings estimates. The available information shows that only two Porbeagles were landed and only 20 were reported as caught (which were reportedly released alive) during 18,626 LPS dockside interviews conducted from 2005 through 2009. That information, combined with the minimal number of Porbeagles that have been observed in the rod and reel fishery from 2000-2012, suggests that recreational fisheries from Virginia through Maine are not a significant threat to the species.

Although controls on directed Porbeagle fisheries have been significantly improved in recent years (ICCAT 2014), bycatch in other non-directed fisheries could be an ongoing source of fishing mortality (Simpson and Miri 2013). The ICES/ICCAT (2009) assessment concludes that, although catches of Porbeagles on the high seas did occur, they occurred at low levels; indicating that bycatch and directed catch on the high seas is minor and does not pose a significant threat to the species (ICES/ICCAT 2009). Furthermore, bycatch of Porbeagle within some major ICES and NAFO longline fisheries was reported to be very rare, and bycatch of Porbeagle in the North and South Atlantic swordfish (*Xiphias gladius*) longline fisheries was very low (ICES/ICCAT 2009). A joint note by the Northeast Atlantic Fisheries Commission (NEAFC) and ICCAT (ICCAT Circular #3732/2013, NEAFC/ICCAT 2013) gave an overview of their management measures and summarizes measures prohibiting fisheries for Porbeagles in the NEAFC regulatory area (i.e. the high seas). The note reports that from 2012 to 2014 all directed fishing of Porbeagle in the NEAFC area by vessels flying their flags was prohibited and that any Porbeagle caught incidentally would be promptly released unharmed (NEAFC/ICCAT 2013).

In Canada and the U.S., Porbeagle incidental catches (retained) and bycatch (discarded) also occasionally occur in continental shelf associated trawl, gillnet, and bottom longline fisheries for various groundfish species (e.g., cod, flounders, hake, monkfish, redfish, and skates) (Simpson and Miri 2013, NAFO, unpublished data: www.nafo.int). Observer coverage and reporting requirements have improved in recent years to help estimate bycatch in these fisheries. Estimated Porbeagle bycatch in Canada's NAFO Division 3LNOP (Newfoundland/Grand Banks region) averaged 19 mt per year from 2006-2010 (Simpson and Miri 2013). Total reported catches of Porbeagle from NAFO fisheries averaged 43.2 mt per year from 2010 to 2014 (NAFO, unpublished data). These catches are incorporated into assessment and management of the NW Atlantic stock (DFO 2009).

In addition to landings, it is important to understand at-vessel (or hooking) and post-release mortality rates, especially where Porbeagles are being discarded/released. If these mortality rates are high, live release or zero-possession policies may not actually be effective at reducing fishing mortality. Analyses assessing vulnerability to longline bycatch mortality looked at mean survival, age at maturity and fecundity and ranked Porbeagle among the least vulnerable of the 13 species assessed (i.e., Porbeagles were ranked 9 out of 13, with 13 being the least vulnerable; Gallagher et al., 2014). Gallagher et al. (2014) reports that Porbeagles have a high survival rate (82.7%) in tuna longline fisheries, with an overall mortality rate of 21.4% for all longline fisheries analyzed, though the species ranks lower in productivity compared with the other species analyzed. These results are corroborated by Marshall et al. (2012), who cited unpublished data on at-vessel mortality rates of 24% (i.e., 76% survival) for Porbeagles in the NW Atlantic longline fishery. Porbeagles were also found to have intermediate hematological stress indicators compared to other species, suggesting some level of tolerance to capture stress (Marshall et al. 2012). The magnitude of bycatch and at-vessel mortality rates (mean = 16.5%) in US HMS fisheries also appears to be low (Tables 1 and 2).

Table 1. Reported effort in pelagic longline sets and Porbeagle interactions, 2008-2013 (Source: NMFS Fishery Logbook System).

Year	Total Number of Sets	Sets with Porbeagle Interactions	Percentage of Sets w/Porbeagle Interactions
2008	8,838	41	0.5%
2009	9,346	38	0.4%
2010	7,513	76	1.0%
2011	8,163	71	0.9%
2012	10,543	12	0.1%
2013	8,299	43	0.5%
TOTAL	52,702	281	0.5%

Table 2. Reported porbeagle landings, discards, and discard mortality rates in U.S. Highly Migratory Species fisheries, 2008-2014 (Source: NMFS HMS Logbooks)

Year	Sum of Porbeagle Kept	Sum of Porbeagle Discarded Alive	Sum of Porbeagle Discarded Dead	Minimum Estimated Discard Mortality Rate
2008	4	144	13	8.3%
2009	4	80	15	15.8%
2010	5	518	85	14.1%
2011	28	133	40	23.1%
2012	3	28	2	6.7%
2013	0	122	52	29.9%
2014	0	127	21	14.2%
TOTAL	44	1,152	228	16.5%

While at-vessel mortality rates in longline gears averaged 20% in multiple studies (Table 2, Marshall et al. 2012, Griggs and Baird 2013, Gallagher et al. 2014), some other studies found rates ranging 30-40% (Francis et al. 2004, Coelho et al. 2012, Campana et al. 2015). Campana et al. (2015) reported a mean at-vessel mortality rate of 43.8% in the Canadian pelagic longline fishery, and additional post-release mortality rates (determined from PSATs deployed on 33 Porbeagles) of 10-75% (mean = 27%), depending on the condition of the shark. Combining their observed at-vessel and post-release mortality rates for Porbeagle resulted in a mean total mortality rate of 59% (95% CI: 46-72%) (Campana et al. 2015). Applying the 27% mean post-release mortality rate from Campana et al. (2015) to the other published at-vessel mortality rates (mean = 20%) suggests average total mortality rates of ~47%. Collectively, these results suggest there is a great deal variability in at-vessel and post-release mortality rates of Porbeagles which are dependent on numerous factors including fishing practices (e.g., soak time, handling), water temperature, shark size or sex, degree of injury, etc. (e.g., Campana et al. 2015). However, it is apparent that once a Porbeagle is hooked on longline gear, it will likely have moderate to high risk of mortality regardless of whether or not it is released. Best practices in handling and release of live sharks could help minimize these mortality rates.

Under-reporting of Porbeagle catches has been noted as a concern in a number reports and assessments (e.g., ICES/ICCAT 2009, CITES 2013, Simpson and Miri 2013). In particular, incidental catches are known to occur in high seas fisheries of a number of nations that have not regularly monitored or reported their harvests (e.g., China, Japan, Taiwan, Korea, Chile, Senegal, Suriname). However, ICES/ICCAT (2009) estimated catches from non-reporting fisheries and determined that in the North Atlantic these amounted to small quantities, and data were available from all major fishing nations. Non-reporting in southern hemisphere fisheries has been more problematic and uncertain (ICES/ICCAT 2009). However, there remains little evidence that unreported catches of Porbeagles are of a magnitude that would significantly alter the results of stock assessments in the southern hemisphere (Semba et al. 2013, Francis et al. 2014).

Conclusion

The available information indicates that Porbeagle population trends are stable or increasing throughout the species' range, and that protections for the species are increasing as well. The Porbeagle is currently one of the most widely protected sharks in the world, with a variety of domestic, regional, and international protections (see detail below). Historic overfishing led to declines in porbeagle populations, but those declines have halted and porbeagle stocks are stable or increasing, and are no longer responding negatively to recent and current levels of fishing mortality. Overfishing is not occurring for the NW, NE, and SW Atlantic stocks and there is minimal overlap between major longline fisheries for SBT in the SE Atlantic and Porbeagle presence. The capture of Porbeagles in Canadian, U.S., and New Zealand recreational fisheries is minimal and there is no information indicating that Porbeagles may be negatively impacted by these interactions. At-vessel and post-release mortality rates of Porbeagles in longline gears are moderate to high, but the elimination of most directed fisheries and overall reductions in catches are still likely reducing overall fishing mortality on their stocks. Therefore, overutilization no longer appears to be a threat to the species' survival anywhere in its range. However, consistent and improved fisheries management efforts will be necessary to continue to rebuild overfished stocks and prevent future declines.

Disease or Predation

The ESA requires an evaluation of disease and predation factors as they affect Porbeagles. Porbeagles are an apex predator, and other than unlikely, rare predation by white sharks (*Carcharodon carcharias*) and orcas (*Orcinus orca*), humans are likely to be the only significant predator for this species (CITES 2007). Studies have shown some incidence of cancer in sharks, although actual rates of cancer in sharks have not been determined, and there is no direct evidence of cancer occurring in Porbeagle (National Geographic 2003). There is no information indicating that predation or disease may be negatively impacting Porbeagles.

Conclusion

Available information on disease and predation on Porbeagles is limited; however, the best available information indicates that it is not likely that these factors may pose a significant threat to the species.

Evaluation of the Inadequacy of Existing Regulatory Mechanisms

The ESA requires an evaluation of existing regulatory mechanisms to determine whether they may be inadequate to address threats to the global Porbeagle population. Existing regulatory mechanisms may include Federal, state, and international regulations. Below is a description and evaluation of current domestic and international management measures that affect the Porbeagle.

Porbeagles are currently one of the most widely-protected shark species in the world, with a variety of international and domestic management measures in place throughout their range (CITES 2013). Porbeagles are currently managed by DFO in Canada, NMFS in the United

States, the EU in Europe, with NEAFC, ICES, and ICCAT working collaboratively to perform stock assessments and make recommendations for management actions specific to Porbeagles. Porbeagles are managed throughout the western and central Pacific Ocean by the Western and Central Pacific Fisheries Commission (WCPFC), a regional convention that coordinates fisheries management with states within the region. In the southern hemisphere, there are Porbeagle fishery regulations in Australia, New Zealand, Argentina, and Uruguay, and under the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). Prohibitions on shark finning have recently been implemented in numerous nations, providing improved protections for all shark species. Porbeagles are also listed under several international conventions, including the UN Convention on the Law of the Sea (UNCLOS), the Barcelona Convention Protocol, the Bern Convention on the Conservation of European Wildlife and Habitats, the Convention for the Protection of the Marine Environment of the North-east Atlantic (OSPAR), the Bonn Convention on the Conservation of Migratory Species (CMS), and CITES. These are described in more detail below.

Porbeagles in U.S. waters are managed under the Magnuson-Stevens Fishery Conservation and Management Act (MSA). States generally have authority within state waters. Porbeagles and other "highly migratory species (HMS)," including other sharks, tunas, billfishes, and swordfish, are managed by NMFS (as delegated by the Secretary of Commerce) under the 2006 Consolidated HMS Fishery Management Plan (FMP) and its amendments. The 2006 Consolidated HMS FMP and its amendments regulate fishing for HMS in Federal waters through measures such as quotas, permit requirements, retention limits, time/area closures, designating prohibited species, observer coverage, and fishermen and dealer reporting. The FMP also requires that all sharks be landed with all fins naturally attached. Porbeagles are an authorized species, meaning that they are a managed species and cannot be legally landed commercially without a permit, and the Federal commercial fishery for Porbeagles is regulated by a base commercial quota and TAC that is adjusted yearly. NMFS' regulatory mechanisms are designed to prevent overfishing for Porbeagles and allow biomass to increase. Recent and current NMFS management of Porbeagles is detailed above under **Overutilization for Commercial, Recreational, Scientific or Education Purposes**.

ICES/ICCAT (2009) notes that management efforts and regulations that benefit Porbeagles are also increasing in Canada and other international waters. Canada has implemented closures of Porbeagle mating grounds to targeted fisheries, and also lowered the TAC to 185 mt (407,855 lb) from a MSY of 250 mt (551,155 lb). In Canada, the Porbeagle fishery is managed under the Atlantic Integrated FMP Pelagics which is a Canadian FMP designed to govern the exploitation of shark species and focuses primarily on Porbeagle stock recovery measures (ICES/ICCAT 2009, DFO 2007). In 2007, Canada's DFO published a national plan for the conservation and management of sharks and their long-term sustainable use. This document outlined Canada's monitoring and management measures for sharks, and includes 100% At-Sea observer program coverage for Porbeagles with 5% coverage for foreign vessels and domestic vessels in Canadian fisheries waters, as well as dockside monitoring programs (DFO 2007). ICES/ICCAT (2009) considered Canada's harvest regime of Porbeagles in Canada's Exclusive Economic Zone (EEZ) to be conservative, and population growth is being seen as a result of reduced exploitation

(Camapana et al. 2012). In 2013, to further accelerate rebuilding of the stock, Canada suspended their directed fishery for Porbeagles, and will not resume this directed fishery until a stock assessment indicates that the stock has sufficiently recovered (Canada/ICCAT 2014, Doc.No. PA4-810).

A working paper from the 19th Special Meeting of ICCAT (CPC/ICCAT, 2014; Doc. No. COC-314/2014) included responses by ICCAT Contracting Parties and Cooperating Non-Contracting Parties (CPC) summarizing how members have reported on their implementation of ICCAT shark measures (CPC/ICCAT 2014, Doc. No. COC-314/2014). In this report, of the countries that specifically address Porbeagles, Belize states that they do not conduct any scientific research for Porbeagle or catch them in the convention area; the EU reports that Porbeagle are a prohibited species, meaning that there is no permitted harvest of Porbeagles; Gabon asserts that the tuna longline vessels have been withdrawn in order to reduce bycatch of sharks; Japan reports that none of their tuna longline vessels are targeting Porbeagles and any caught as bycatch are either retained with all parts onboard for inspection or released alive; South Africa states that they do not fish for Porbeagles; Turkey states that Porbeagle are a prohibited species from catch, retaining, landing, transporting, storing, selling, displaying or offering for sale; the UK reports that all catches are reported as per the regulations and that Porbeagle were not reported in 2013 and are rarely caught; and the U.S. declared that catch limits were in place, that they fulfill the requirements of ICCAT's shark recommendations, and will continue to submit catch and effort data to ICCAT (CPC/ICCAT 2014, Doc. No. COC-314/2014). Several other CPCs reported that they either do not fish for or catch sharks or are otherwise in compliance with the ICCAT's shark conservation management recommendations, but do not mention Porbeagles directly.

Recently, in November 2015, ICCAT adopted additional protections for Porbeagles caught in ICCAT fisheries. These include a requirement that all vessels promptly release unharmed Porbeagles when brought alive alongside the vessel, improved reporting of alive and dead discards, and encouragement of additional research and monitoring on Porbeagles to improve future stock assessments.

The joint NEAFC and ICCAT note (NEAFC/ICCAT 2013, ICCAT Circular #3732/2013) mentioned previously summarizes measures prohibiting fisheries for Porbeagles in the NEAFC regulatory area (i.e., the high seas). At the 2011 NEAFC annual meeting, a measure for the conservation and management of Porbeagles in the NEAFC regulatory area from 2012 to 2014 was adopted, with recommendations that prohibited all directed fishing of Porbeagle in the NEAFC area by vessels flying their flags; any Porbeagles that were caught incidentally would be promptly released unharmed; all data on Porbeagles would be submitted to ICES by all CPCs; and all CPCs were encouraged to take conservation measures in their own national fisheries jurisdiction that would have a similar effect (NEAFC/ICCAT 2013, ICCAT Circular #3732/2013). Although catch on the high seas is minimal, as discussed previously, these measures will help ensure protections for Porbeagles on the high seas.

Restrictive harvest quotas for Porbeagles are also now in place in New Zealand and Australia, and catches have been greatly reduced in recent years (Bruce et al. 2014, Francis et al. 2014). Since 2006, CCAMLR has implemented a moratorium on all directed shark fishing in the Antarctic region, and the live release of incidental shark catches has been encouraged. In Argentina, where Porbeagles were historically landed incidental to other fisheries, fishing vessels are currently required to release all live sharks greater than 1.5 m in length (CITES 2013). Additionally, since 2013, Uruguay has prohibited retention of Porbeagles in its fisheries (ICCAT 2014).

Porbeagles have been listed under Annex I of UNCLOS, which establishes conservation measures for highly migratory fish stocks on the high seas, and encourages cooperation between nations on shark fisheries management. Listing under the Barcelona Convention (Annex II), Bern Convention (Appendix III), and the OSPAR Convention (Annex V) are intended to protect Porbeagles and their habitats in the Mediterranean Sea and NE Atlantic. The Convention on the Conservation of Migratory Species (CMS) Migratory Shark Memorandum of Understanding and Appendix II of CMS aims to enhance conservation of migratory sharks, and require range states to coordinate management efforts for highly migratory trans-boundary stocks. Additional protections were also put into place for Porbeagles internationally in September 2014, when they were included under CITES Appendix II, which will result in close monitoring and regulation of trade of this species. This will provide further reporting and monitoring of Porbeagle catches, and require international trade to be non-detrimental to the survival of their stocks. Progress in the implementation of management measures by party states under these conventions has been variable, but Porbeagles have clearly been prioritized for regulatory protections at the international level, and worldwide catches are currently being constrained.

Conclusion

The best available information indicates that legal protections for Porbeagles are widespread and increasing, and these regulatory measures are being effective in constraining harvests. We have reviewed: (1) new and existing domestic/territorial/regional management mechanisms; (2) the inclusion of Porbeagles under several international conservation conventions; and (3) the most recent stock assessments, status indicators, and updates which indicate that stocks have stabilized or increased. Based upon this information, the only reasonable conclusion is that existing regulatory mechanisms are adequate, and are allowing Porbeagle stocks to rebuild, as evidenced by the fact that overfishing is not occurring and relative abundance is stable or increasing throughout their range.

Other Natural or Manmade Factors Affecting the Porbeagle's Continued Existence

Though Porbeagles exhibit relatively low productivity as compared with other shark species, multiple studies determined that the stocks were generally stable or increasing on a trajectory toward recovery (refer to the **Overutilization for Commercial, Recreational, Scientific, or Educational Purposes** section above), indicating that their productivity levels are not precluding recovery. Genetic studies indicate that there is no differentiation between the North Atlantic stocks, which indicates that there is some mixing in the North Atlantic; therefore, it is not reasonable to conclude that the threat of isolated populations is a factor for this highly migratory species in the northern hemisphere (Pade et al. 2006, Testerman et al. 2007, Kitamura & Matsunaga 2010). Available information for the southern hemisphere indicates that the distribution of Porbeagles in the South Atlantic is widespread and continuous in a circumglobal band around the southern hemisphere; there is no information indicating that this population may be isolated (ICES/ICCAT 2009, Semba et al. 2013). Considering the highly migratory nature of this species, isolation does not appear to be a factor negatively impacting Porbeagles.

Low productivity is an aspect of a species' life history that has the potential to make the species more vulnerable to specific threats; however, this trait along with all other life history parameters is evaluated and addressed in management and conservation actions. As mentioned previously (refer to the **Reproduction, Growth, and Demography** section above), the species' productivity along with other life history parameters are taken into account throughout the modeling and assessment process. Several Ecological Risk Assessments (ERA) looked at the species' productivity in terms of its vulnerability to certain fisheries. The 2010 ERA for Atlantic pelagic sharks found that Porbeagles ranked among the less vulnerable species in terms of their biological productivity and susceptibility to pelagic longline fisheries (Cortes et al., 2010). Murua et al. (2012) reported on a similar ERA, finding Porbeagle to be ranked eighth (rankings were from 1-16 with lower numbers being more vulnerable) in vulnerability to pelagic longline fisheries in the Indian Ocean. SCRS (2014) reports on an ERA carried out for 20 stocks of pelagic sharks, finding Porbeagle to rank fourth in vulnerability (1 being most vulnerable) to pelagic longline gear.

Although an ERA looking at a specific vulnerability may rank Porbeagles higher than other sharks in some respects, this is not an indicator of a high risk of extinction. Rather, the results of an ERA are used to determine a species' vulnerability to specific fishing gear and are a first step in the assessment process. Thus, results of stock assessments, which incorporate additional and more quantitative sources of information than ERAs, supersede the qualitative outputs from ERAs. Available information does not indicate that there has been any decrease in productivity of Porbeagles.

Global climate change, including warming and acidification of ocean waters within the Porbeagle's range, and resultant potential shifts in ocean productivity and the distributions of prey species, were identified by the petitioners as a potential threat to the survival and recovery of the species. However, the impacts of climate change are unlikely to substantially impact Porbeagle populations. Even where exposure to the direct effects of climate change may be high, Porbeagles would have inherently high adaptive capacity to these effects. Porbeagles are highly mobile and have a broad temperature tolerance, and would be likely to move to more preferable habitats in response to climate change. Additionally, their generalist diet and habitat strategies make them highly likely to successfully adapt to changing environmental conditions. These patterns are supported by the analysis of Chin et al. (2010) who found that continental shelf- and pelagic-associated sharks have low overall vulnerability to climate change.

A recent climate change vulnerability assessment of 82 northeast US fishery species included Porbeagle in its analyses (Hare et al. 2016). This assessment found that Porbeagles in that region, on a scale of *low* to *very high* (as a function of exposure and sensitivity), have *high* vulnerability to climate change. Exposure to warming ocean temperatures and ocean acidification in this region are considered high for most species (Hare et al. 2016). *High* sensitivity was mainly influenced by their low productivity and overfished stock status in the region, while most other sensitivity attributes (e.g., habitat and prey specificity, mobility, early life history requirements, etc.) were considered to be *low* (Hare et al. 2016). Therefore, if poor stock status is removed as a sensitivity factor as the stock continues to rebuild, the overall climate vulnerability ranking would drop to *moderate*. The *high* vulnerability was also estimated to result in a *very high* potential for a distribution shift of the Porbeagle out of the region in response to climate change. However, the overall directional effect (negative, neutral, or positive) of climate change on the species was considered to be *neutral* due to its high mobility and broad temperature tolerances (Hare et al. 2016), meaning that even though the Porbeagle is likely to shift its distribution away from the northeast US, its overall population is likely to persist.

Conclusion

Available information does not indicate that “biological vulnerability” and “isolation” are natural factors affecting the continued existence of Porbeagles. Porbeagles are highly migratory species that undertake extensive migrations. The Porbeagle populations in the North Atlantic are not isolated as evidenced through genetics with dominant haplotypes present in both the NW and NE Atlantic. The southern hemisphere Porbeagle distribution is widespread, spanning around the entire southern hemisphere. The best available information does not indicate that there has been any decrease in Porbeagle productivity and both the northern and southern hemispheres exhibit significant genetic diversity indicative of large populations. Varying ERAs have looked at the vulnerability of Porbeagles to specific fishing gear with varying results. Various ERAs may rank Porbeagles higher than other sharks when looking at certain factors, but an ERA is only one source of information included in assessment considerations. Porbeagle populations are not expected to be negatively affected by global climate change, even where exposure to warming and ocean acidification will be high. Therefore, there are no other natural or manmade factors potentially affecting the continued existence of Porbeagles.

ASSESSMENT OF EXTINCTION RISK FOR THE PORBEAGLE SHARK (*LAMNA NASUS*)

Conducted by the Extinction Risk Analysis (ERA) Team in October 2015

National Marine Fisheries Service
National Oceanic and Atmospheric Administration

INTRODUCTION

The Endangered Species Act (ESA) (Section 3) defines endangered species as “any species which is in danger of extinction throughout all or a significant portion of its range.” Threatened species is defined as “any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” Neither the National Marine Fisheries Service (NMFS) nor the U.S. Fish and Wildlife Service (USFWS) have developed any formal policy guidance about how to interpret the definitions of threatened or endangered species in the ESA. In many previous NMFS status reviews, a team has been convened, often referred to as a “Biological Review Team,” in order to compile the best available information on the species and conduct a risk assessment through evaluation of the demographic risks, threats, and extinction risk facing the species or distinct population segment (DPS). This information is ultimately used by the NMFS Protected Resources office, after consideration of the legal and policy dimensions of the ESA standards and benefits of ongoing conservation efforts, to make a listing determination. For purposes of this risk assessment, an Extinction Risk Analysis (ERA) team, comprised of fishery biologists, managers, and shark experts, was convened to review the best available information in the Status Review document, conduct a DPS analysis, and evaluate the overall risk of extinction facing the Porbeagle now and in the foreseeable future.

Documented global extinctions (i.e., complete biological extinction) of marine fish species are extremely rare compared to other marine, terrestrial, and aquatic taxa (McKinney 1998, Carlton et al. 1999, Dulvy et al. 2003, del Monte-Luna et al. 2007). Acknowledging the difficulties associated with detecting extinction in the ocean (Carlton et al. 1999), most marine fishes are considered to have a level of inherent resistance to global extinction, including broad distributions, moderate to high dispersal and/or mobility, compensatory mechanisms, generalist habitat and feeding strategies, in addition to living within a massive, complex, and comparatively inaccessible environment (Musick 1999, Dulvy et al. 2003, del Monte-Luna et al. 2007). Even amongst biologically vulnerable groups such as elasmobranchs, overfishing, habitat loss, pollution, and other anthropogenic disturbances have not resulted in any documented modern global extinctions (Dulvy et al. 2003, del Monte-Luna et al. 2007). Therefore, as described in previous status reviews on other shark species that have been petitioned, but ultimately not listed under the ESA (e.g., Dusky Shark, Great Hammerhead Shark, White Shark), being overfished is not necessarily equivalent to having a high risk of extinction. However, a number of local extinctions have been documented in elasmobranchs, and there are numerous threats to the persistence and recovery of many depleted populations (Dulvy et al. 2003, 2014). These factors will be considered and discussed as they relate to Porbeagle within this ERA.

DISTINCT POPULATION SEGMENT ANALYSIS

Consideration of the Species Question

In determining whether to list a species, the first issue is whether the petitioned subject is a valid species. The petitioned subject, the Porbeagle, or *Lamna nasus,* is a valid species for listing. The taxonomic breakdown of *L. nasus* is as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Chondrichthyes
Subclass: Elasmobranchii
Order: Lamniformes
Family: Lamnidae
Genus: *Lamna*
Species: *nasus*

Criteria for Identification of Distinct Population Segments

After determining whether the petition identifies a species, the next issue is whether any petitioned populations qualify as DPSs within the species. The joint policy of the USFWS and NMFS provides guidelines for defining DPSs below the taxonomic level of species (61 FR 4722; February 7, 1996). The policy identifies two elements to consider in a decision regarding whether a population qualifies as a DPS: discreteness and significance of the population segment to the species.

<u>Discreteness</u>
A DPS may be considered discrete if it is markedly separate from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors, or if it is delimited by international governmental boundaries. Genetic differences between the population segments being considered may be used to evaluate discreteness.

<u>Significance</u>
If a population segment is considered discrete, its biological and ecological significance must then be evaluated. Significance is evaluated in terms of the importance of the population segment to the overall welfare of the species. Some of the considerations that can be used to determine a discrete population segment's significance to the taxon as a whole include:

1) Persistence of the population segment in an unusual or unique ecological setting;
2) Evidence that loss of the population segment would result in a significant gap in the range of the taxon; and
3) Evidence that the population segment differs markedly from other populations of the species in its genetic characteristics.

Distinct Population Segment Analysis – ERA Team Results

Proposed DPSs by Petitioners

NMFS received a petition from WEG requesting that they list Porbeagle throughout its entire range, or as NW Atlantic, NE Atlantic, and Mediterranean Distinct Population Segments (DPS) under the ESA, as well as designate critical habitat for the species. NMFS also received a petition from the HSUS requesting that they list a NW Atlantic DPS of Porbeagle as endangered in the North Atlantic under the ESA.

Evaluation of DPSs

To be inclusive, NMFS is evaluating whether or not any DPSs exist throughout the Porbeagle's entire global range. As discussed in the status review section on **Population Structure**, tagging and genetics data, as well as fisheries management information, are available with which to make determinations about potential DPSs.

Porbeagles range across the entire North Atlantic and in a continuous band in the southern hemisphere (Figure 1). They are absent from equatorial waters and North Pacific (Figure 1). Recent stock assessments (e.g., ICES/ICCAT 2009) have identified at least four Porbeagle stocks for management purposes: NW and NE Atlantic, and SW and SE Atlantic stocks. An additional Indo-Pacific stock (including Australia, New Zealand, and the greater SW Pacific) may also be present, but potential southern hemisphere stock boundaries are unclear (CITES 2013). The petitioners also requested consideration of a Mediterranean DPS. Based upon this information, NMFS evaluated the potential for up to six DPSs (NW and NE Atlantic, Mediterranean Sea, SW and SE Atlantic, and Indo-Pacific).

As discussed in the **Distribution and Abundance** section of the status review, there is no information indicating Porbeagles in the Mediterranean Sea are isolated from the greater NE Atlantic stock. Additionally, Porbeagles appear to have been historically rare in the Mediterranean Sea (Storai et al. 2005, Ferretti et al. 2008), and they have not been considered as a separate stock for management purposes (ICES/ICCAT 2009). Therefore, there is no rationale to consider Mediterranean Porbeagles as a discrete population, and for the remainder of this analysis they will be considered to compose part of the NE Atlantic stock.

Conventional and satellite tagging data suggest limited, but occasional movements of Porbeagles between the NW and NE Atlantic, as well as long distance movements on the scale of thousands of kilometers into subtropical latitudes (Kohler et al. 2002, Pade et al. 2008, ICCAT 2009, Skomal et al. 2009, Campana et al. 2010a, Saunders et al. 2011, Bendall et al. 2013). The highly-mobile capability of the species indicates that mixing across ocean basins is biologically possible. While mixing rates may be low based upon the available tagging data, population genetics data show a lack of differentiation between the NW and NE Atlantic, indicating that there is gene flow between these stocks (Pade et al. 2006, Testerman et al. 2007). Despite having some separation due to ecological and behavioral factors, as well as being delimited by international boundaries, this lack of genetic differentiation indicates that these two stocks are not discrete.

Similarly in the southern hemisphere, while tagging data are very limited (Francis et al. 2015), genetics data have not revealed any clear differentiation from samples throughout the region (Pade et al. 2006, Testerman et al. 2007, Kitamura & Matsunaga 2010). Porbeagles have a continuous distribution throughout the southern hemisphere (Semba et al. 2013) and potential stock boundaries have been difficult to delineate (CITES 2013). Therefore, there is also no evidence of discrete populations within the southern hemisphere.

No movements of Porbeagles between the northern and southern hemispheres have been documented by tagging (Kohler et al. 2002, Pade et al. 2008, ICCAT 2009, Skomal et al. 2009, Campana et al. 2010a, Saunders et al. 2011, Bendall et al. 2013, Francis et al. 2015). Given the cold-temperate distribution of the Porbeagle, and apparent preferences for waters less than 18 °C, equatorial waters appear to represent a biogeographic barrier (Figure 1). The available population genetics data support the tagging observations, indicating significant structure (no gene flow) between North Atlantic and southern hemisphere samples (Pade et al. 2006, Testerman et al. 2007, ICES/ICCAT 2009, Kitamura & Matsunaga 2010). There appears to be marked separation due to physical, ecological, and behavioral factors, widely separated international boundaries, and strong genetic differentiation between the North Atlantic and southern hemisphere suggesting that these two populations are *discrete*.

The North Atlantic and southern hemisphere populations are also *significant* given that loss of either population segment would result in a significant gap in the range of the taxon, and these population segments appear to differ markedly from each other in genetic characteristics. Therefore, based upon the available information, this ERA will evaluate extinction risk for a North Atlantic DPS and a southern hemisphere DPS of Porbeagle.

EXTINCTION RISK ANALYSIS

Often the ability to measure or document risk factors is limited, and information is not quantitative and very often lacking altogether. Therefore, in assessing risk, it is important to include both qualitative and quantitative information. In previous NMFS status reviews, Biological Review Teams have used a risk matrix method to organize and summarize the professional judgment of a panel of knowledgeable scientists. This approach is described in detail by Wainright and Kope (1999) and has been used in a number of status reviews (see http://www.nmfs.noaa.gov/pr/species/ for links to these reviews). In the risk matrix approach, the condition of the species is summarized according to four demographic risk criteria: abundance, growth rate/productivity, spatial structure/connectivity, and diversity. These viability criteria, outlined in McElhany et al. (2000), reflect concepts that are well-founded in conservation biology and that individually and collectively provide strong indicators of extinction risk. Using these concepts, the ERA team estimated the extinction risk of the porbeagle shark after conducting a demographic risks analysis. Likewise, the ERA team performed a threats assessment for the species by scoring the severity of current threats to the species as well as predicting whether the threat will increase, decrease, or stay the same in the foreseeable future. The summary of the demographic risks and threats obtained by this approach was then considered by the ERA team in determining the species' overall level of extinction risk. Specifics on each analysis are provided below.

Methods

<u>Demographic Risk Analysis</u>

After reviewing all relevant biological and commercial information for the species, including: current abundance of the species in relation to historical abundance and trends in abundance based on indices such as catch statistics; the species growth rate/productivity in relation to other species and its potential effect on survival rates; its spatial and temporal distribution; natural and human-influenced factors that cause variability in survival and abundance; and possible threats to genetic integrity; the ERA team assigned risk scores to each of the four demographic criteria (abundance, growth rate/productivity, spatial structure/connectivity, diversity). Risks for each demographic criterion were ranked on a scale of 1 (no or very low risk) to 5 (very high risk). Below are the definitions that the team used for each ranking:

Ranking	**Definition**
(1) Very Low	It is very unlikely that the particular factor contributes or will contribute significantly to the risk of extinction
(2) Low	It is unlikely that the particular factor contributes or will contribute significantly to the risk of extinction
(3) Medium	It is likely that the particular factor contributes or will contribute significantly to the risk of extinction
(4) High	It is highly likely that the particular factor contributes or will contribute significantly to the risk of extinction
(5) Very High	It is very highly likely (extremely likely) that the particular factor contributes or will contribute significantly to the risk of extinction

The team members were given a template to fill out and asked to rank the risk of the demographic factors. If the demographic factor was ranked as a moderate risk, then the team members were asked to identify those other demographic factors or potential threats that would work in combination with the demographic factor to present a moderate risk to the species (Table 4). After scores were provided, the team discussed the range of perspectives for each of the demographic risks and the supporting data on which it was based, and was given the opportunity to revise scores if desired after the discussion. The scores were then tallied (mode, median, range) and reviewed by the ERA team and considered in making the overall risk determination. Although this process helps to integrate and summarize a large amount of diverse information, there is no simple way to translate the risk matrix scores directly into a determination of overall extinction risk. Other descriptive statistics, such as mean, variance, and standard deviation, were not calculated as the ERA team felt these metrics would add artificial precision to the results.

Table 3. Template for the risk matrix used in ERA team deliberations. The matrix is divided into four sections that correspond to the parameters for assessing population viability (McElhany et al. 2000).

Demographic Risk Analysis Worksheet

RISK CATEGORY SCORE (1-5)

Abundance

Comments:

Other Demographic Factors or Potential Threats:

Growth rate/productivity

Comments:

Other Demographic Factors or Potential Threats:

Spatial structure and connectivity

Comments:

Other Demographic Factors or Potential Threats:

Diversity

Comments:

Other Demographic Factors or Potential Threats:

Threats Assessment

Section 4(a)(1) of the ESA requires the agency to determine whether the species is endangered or threatened because of any of the following factors:

1) destruction or modification of habitat;
2) overutilization for commercial, recreational, scientific, or educational purposes;
3) disease or predation;
4) inadequacy of existing regulatory mechanisms; or
5) other natural or human factors

Similar to the demographics risk analysis, the ERA team members were given a template to fill out and asked to rank the effect that the threat was currently having on the extinction risk of the species. If the threat was identified as having a *low* or *medium* effect on the species' extinction risk, then the ERA team member was asked to identify the other threat(s) or demographic factor(s) that it was interacting with to increase the species' extinction risk by checking the interacting threat/factor box (Table 3). Below are the specific definitions of the threat effect levels:

Ranking	**Definition**
(1) Very Low	It is very unlikely that the particular threat contributes or will contribute to the decline of the species
(2) Low	It is unlikely that the particular threat contributes or will contribute to the decline of the species
(3) Medium	It is likely that the particular threat contributes or will contribute to the decline of the species
(4) High	It is highly likely that the particular threat contributes or will contribute to the decline of the species
(5) Very High	It is very highly likely (extrememly likely) that the particular threat contributes or will contribute to the decline of the species

After scores were provided, the team discussed the range of perspectives for each of the threats, and the supporting data on which it was based, and was given the opportunity to revise scores if desired after the discussion. The scores were then tallied and reviewed by the ERA team and considered in making the overall risk determination.

Table 3. Template for the threats assessment used in ERA team deliberations.

						Interaction with other threats/factors								
						Threats					Demographic			
Threat	**Very Low**	**Low**	**Medium**	**High**	**Very High**	H	O	D/P	I	OT	A	G	SS	D
Habitat destruction, modification or curtailment (H)														
Overutilization (O)														
Disease or predation (D/P)														
Inadequacy of existing regulatory mechanisms (I)														
Other (OT)														

Overall Level of Extinction Risk Analysis

Guided by the results from the demographics risk analysis as well as threats assessment, the ERA team members used their informed professional judgment to make an overall extinction risk determination for the species now and in the foreseeable future. For these analyses, the ERA team defined four levels of extinction risk:

Rank	Definition
Not at Risk	A species is in this category if it exhibits a trajectory indicating that it is not at a low risk of extinction (see description of "Low Risk" below). A species is not at risk of extinction due to projected threats and its likely response to those threats (i.e., long-term stability, increasing trends in abundance/population growth, spatial structure and connectivity, and/or diversity and resilience).
Low Risk	A species is in this category if it exhibits a trajectory indicating that it is more likely not to be at a moderate level of extinction (see description of "Moderate Risk" below). A species may be at low risk of extinction due to projected threats and its likely response to those threats (i.e., stable or increasing trends in abundance/population growth, spatial structure and connectivity, and/or diversity and resilience).
Moderate Risk	A species is in this category if it exhibits a trajectory indicating that it is more likely not to be at a high level of extinction (see description of "High Risk" below). A species may be at moderate risk of extinction due to projected threats and its likely response to those threats (i.e., declining trends in abundance/population growth, spatial structure and connectivity, and/or diversity and resilience).
High Risk	A species is in this category when it is at or near a level of abundance, spatial structure and connectivity, and/or diversity and resilience that place its persistence in question. Demographic risk may be strongly influenced by stochastic or depensatory processes. Similarly, a species may be at high risk of extinction if it faces clear and present threats (e.g., confinement to a small geographic area; imminent destruction, modification, or curtailment of its habitat; or disease epidemic) that are likely to create such imminent demographic risks.

The team adopted the "likelihood point" (FEMAT) method to allow individuals to express uncertainty in determining the overall level of extinction risk facing the species (Table 4). Each team member was provided 10 likelihood points to distribute according to their judgment. The scores were then tallied (mode, median, range), discussed, and summarized for each DPS.

Finally, the ERA team did not make recommendations as to whether either DPS should be listed as threatened or endangered. Rather, the ERA team drew scientific conclusions about the overall risk of extinction faced by the species under present conditions and in the foreseeable future based on an evaluation of the species' demographic risks and assessment of threats.

Table 4. Template for the overall level of extinction risk analysis used in ERA team deliberations. Likelihood points were distributed amongst each of the categories based upon each ERA team member's expert judgment.

	Current Level of Extinction Risk			
DPS	**Not at Risk**	**Low Risk**	**Moderate Risk**	**High Risk**
North Atlantic				
S. Hemisphere				

	Foreseeable Future Level of Extinction Risk			
DPS	**Not at Risk**	**Low Risk**	**Moderate Risk**	**High Risk**
North Atlantic				
S. Hemisphere				

ERA Team's Extinction Risk Results and Conclusion for the Porbeagle Shark

Evaluation of Demographic Risks

<u>Abundance</u>

The ERA team evaluated the available Porbeagle abundance information which is summarized in the **Description of Population Abundance and Trends** section of the status review. For both the North Atlantic and southern hemisphere DPSs of Porbeagles, ERA team members agreed that the available information indicated Porbeagle abundance had declined significantly from historic levels and that stocks are currently considered to be in an overfished condition. However, in all regions where abundance trends and/or indicators are available, declines appear to have been halted. For the North Atlantic DPS and some regions within the southern hemisphere DPS, abundance has been increasing in the most recent years in response to improved fisheries management. Even where significant overfishing had occurred, estimates of population size were in the hundreds of thousands of individuals. Further declines are unlikely due to improved management. The ERA team concluded that a *Low* ranking was warranted for both DPSs, as this factor is unlikely to contribute significantly to the Porbeagle's risk of extinction.

<u>Growth rate/productivity</u>

The ERA team evaluated the available information on Porbeagle life history traits as they relate to this factor. As summarized in the **Reproduction, Growth, and Demography** section in the status review, Porbeagles have low inherent productivity due to their late age at maturity, low fecundity, slow population growth rates, and long generation times (20 years). This low productivity makes Porbeagle populations vulnerable to overexploitation, and slow to recover from depletion. Due to these inherent biological constraints, the ERA team concluded that a *Moderate* ranking was warranted for both DPSs, as this factor is likely to contribute significantly to the Porbeagle's risk of extinction.

Spatial structure/connectivity

The ERA team evaluated the available information on Porbeagle spatial structure (tagging and genetics information) summarized in the **Population Structure** section of the status review. The Porbeagle has a very broad range, including across the entire North Atlantic Ocean, and in a continuous band around the southern hemisphere. The species is highly mobile, and connectivity across vast expanses of the ocean is apparent from both tagging and genetics data. Despite population declines, there are no indications that the Porbeagle's range has contracted over time, or would be expected to contract in the future. The ERA team concluded that a *Very Low* ranking was warranted for both DPSs, as this factor is very unlikely to contribute significantly to the Porbeagle's risk of extinction.

Diversity

The ERA team evaluated the available information on Porbeagle diversity summarized in the **Population Structure** section of the status review. The available genetics studies indicate that Porbeagle populations have high genetic diversity, and there is reproductive connectivity within each DPS. Significant genetic differentiation within each DPS has not been identified. Therefore, genetic diversity appears to be sufficiently high, and not indicative of isolated or depleted populations. Porbeagles do not appear to be at risk due to substantial changes or loss of variation in life history traits, population demography, morphology, behavior, or genetic characteristics. The ERA team concluded that a *Very Low* ranking was warranted for both DPSs, as this factor is very unlikely to contribute significantly to the Porbeagle's risk of extinction.

Threats Assessment

Habitat Destruction, Modification, or Curtailment

The ERA team evaluated the available information on habitat use and distributions of Porbeagle summarized in the status review. Overall, the Porbeagle is a highly mobile habitat generalist in the marine environment, and not substantially dependent on any particular habitat type. It occurs in coastal and offshore waters, and is not dependent during any life stage on more vulnerable estuarine habitats. Porbeagle habitat use is influenced by temperature and prey distributions, but they have broad temperature tolerances and an opportunistic diet, making them less vulnerable to habitat destruction. They also appear to have comparatively low exposure to potentially harmful pollutants, and there is no information suggesting their individual fitness or populations are threatened by pollution. The ERA team concluded that a *Very Low* ranking was warranted for both DPSs, as it is very unlikely that this threat contributes or will contribute to the decline of the species.

Overutilization

The ERA team evaluated the available information on fishing mortality and abundance trends of Porbeagle summarized in the status review. Overutilization for commercial purposes is considered one of the primary threats to Porbeagle populations. Significant declines have been documented throughout the Porbeagle's range due to fishing pressure. While the most recent information suggests that several stocks are overfished, being overfished is not necessarily equivalent to having a high risk of extinction. Catches have declined in recent years, and overfishing is no longer occurring on any Porbeagle stocks. Populations appear to be stable or slowly increasing. Therefore, there appears to be a low likelihood of further population declines in either Porbeagle DPS. Under current management regimes, Porbeagle populations are projected to continue to recover over the coming decades. Despite the progress that has apparently been made in reducing the overutilization of Porbeagles, the ERA team concluded that a *Medium* ranking was warranted for both DPSs, as it is likely that this threat contributes or will contribute to the decline of the species.

For Porbeagle, the threat of overutilization will tend to be higher when there are also threats due to the inadequacy of regulatory mechanisms (I), and the demographic factor of slow population growth rates (G) (Table 5). The ERA team determined that the threat from the inadequacy of regulatory mechanisms should be considered *Low* for the North Atlantic DPS and *Medium* for the southern hemisphere DPS (Table 5). As described in the status review, regulatory mechanisms protecting Porbeagles are currently widespread and improving throughout their range. The Porbeagle's inherently low productivity (*Moderate* ranking) indicates that recovery from past overutilization will take a long time (decades), but would not significantly increase the overall threat of overutilization from a *Medium* ranking.

Disease or Predation

The ERA team evaluated the available information on disease and predation summarized in the status review. Overall, there is minimal information available with which to evaluate these threats. In general, sharks may be susceptible to diseases, but there is no evidence that disease has ever caused declines in shark populations. Regarding predation, Porbeagles are apex predators with very few potential natural predators. There is no indication that this species would be threatened by excessive predation pressure. Therefore, the ERA team concluded that a *Very Low* ranking was warranted for both DPSs, as it is very unlikely that these threats contribute or will contribute to the decline of the species.

Inadequacy of Existing Regulatory Mechanisms

The ERA team evaluated the available information on fisheries management regulations and abundance trends of Porbeagle summarized in the status review. The inadequacy of regulatory mechanisms to control the harvests of Porbeagles has been considered a significant threat to their populations. However, various domestic, regional, and international regulations have been implemented in recent years designed to reduce catches and rebuild stocks. The Porbeagle is currently among the most highly protected shark species in the world. Notably, directed Porbeagle fisheries have mostly been eliminated around the world, many fisheries require live release of incidentally caught Porbeagles, and restrictions on international trade have been implemented through CITES listings. As noted above, catches have declined in recent years in response to this improved management, and overfishing is no longer occurring.

The ERA team concluded that a *Low* ranking was warranted for the North Atlantic DPS, as it is unlikely that this threat contributes or will contribute to the decline of the species due to significantly improved regulatory mechanisms. The ERA team concluded that a *Medium* ranking was warranted for the southern hemisphere DPS, as it is likely that this threat contributes or will contribute to the decline of the species. In the southern hemisphere there has been less rigorous monitoring, reporting, and enforcement of fisheries management regulations as compared to the North Atlantic, resulting in more uncertainty on the effectiveness of regulations. This suggests that the southern hemisphere DPS may be more vulnerable to this threat than the North Atlantic DPS.

In both DPSs, as described above, threats due to the inadequacy of regulatory mechanisms (I) could interact with the *Medium* threat of overutilization (O) and the demographic factor of slow population growth rates (G) to increase the Porbeagle's risk of extinction (Table 5). However, the threat of overutilization is being reduced through improved regulatory mechanisms throughout their range, as described in the status review. The Porbeagle's inherently low productivity (*Moderate* ranking) indicates that recovery from past overutilization will take a long time (decades), but would not significantly increase the overall threat of the inadequacy of regulatory mechanisms from a *Medium* ranking. These significant, interacting threats to Porbeagle populations are being simultaneously reduced supporting the *Low* (North Atlantic DPS) and *Medium* (southern hemisphere DPS) rankings for this factor.

<u>Other Natural or Manmade Threats</u>

The ERA team evaluated the available information on other potential threats as summarized in the status review. Natural threats focused on the Porbeagle's inherent biological vulnerability which is also reflected in the demographic factors described above. The species has low productivity (G) because of its life history characteristics, and is vulnerable to exploitation and population perturbations. Populations can be quickly depleted and take many years to recover. However, their high mobility, high genetic diversity, and generalist habitat and diet strategy contribute to a comparatively low risk of extinction.

The ERA team also considered the threat of climate change to Porbeagles. Even in regions where Porbeagles may be exposed to substantial increases in water temperature or ocean acidification, their high mobility, broad temperature tolerance, and generalist habitat and diet strategy do not make them particularly sensitive to the effects of climate change. If an area became uninhabitable due to climate change, their population would likely shift out of that area and persist elsewhere. The ERA team concluded that a *Low* ranking was warranted for both DPSs, as it is unlikely that these threats contribute or will contribute to the decline of the species.

These other natural or manmade threats would likely only be increased when interacting with the *Medium* threat of overutilization (O) and the demographic factor of low population growth rates (G) (Table 5). However, since the threat of overutilization is being reduced through improved management and regulatory mechanisms, which take into account the Porbeagle's low productivity, these other threats are expected to remain *Low*.

Table 5. Summary of the ERA team's threats assessment for Porbeagle. The score to the left of the forward slash ("/") is for the North Atlantic DPS, and the score to the right is for the southern hemisphere DPS. Each ERA team member is represented by one point (n=4).

						Interaction with other threats/factors								
						Threats					Demographic			
Threat	**Very Low**	**Low**	**Medium**	**High**	**Very High**	H	O	D/P	I	OT	A	G	SS	D
Habitat destruction, modification or curtailment (H)	4/4	0	0	0	0									
Overutilization (O)	0	0	4/4	0	0				X			X		
Disease or predation (D/P)	4/4	0	0	0	0									
Inadequacy of existing regulatory mechanisms (I)	0	4/0	0/4	0	0		X					X		
Other (OT)	0	4/4	0	0	0		X					X		

Overall Risk Summary

Overall, the ERA team concluded that both the North Atlantic and southern hemisphere DPSs of Porbeagle have a *Low* risk of extinction, currently or in the foreseeable future (defined by the ERA team as two generation times – 40 years). The distributions of likelihood points used in the Overall Extinction Risk Analysis are summarized below (Table 6).

Table 6. Overall level of extinction risk for Porbeagle. Likelihood points were distributed amongst each of the categories based upon each ERA team member's expert judgment.

	Current Level of Extinction Risk			
DPS	**Not at Risk**	**Low Risk**	**Moderate Risk**	**High Risk**
North Atlantic	12.5%	80%	7.5%	0%
S. Hemisphere	2.5%	72.5%	25%	0%

	Foreseeable Future Level of Extinction Risk			
DPS	**Not at Risk**	**Low Risk**	**Moderate Risk**	**High Risk**
North Atlantic	30%	62.5%	7.5%	0%
S. Hemisphere	5%	70%	25%	0%

None of the ERA team members indicated that there was any likelihood of the Porbeagle having a *High* risk of extinction (Table 6). There was some likelihood of a *Moderate* risk of extinction, especially for the southern hemisphere DPS. This was due to more uncertainty in current stock status and projections for the southern hemisphere, and more concern about the adequacy of current and future regulatory mechanisms, including fishery monitoring, reporting, and enforcement in that region. The ERA team indicated that there is a higher likelihood that the North Atlantic DPS is *Not* at risk of extinction than the southern hemisphere DPS. Despite these concerns, the ERA team still agreed that there was a much greater likelihood of southern hemisphere Porbeagle having an overall *Low* risk of extinction. For both DPSs, the ERA team determined that overall extinction risk is likely to be lower in the foreseeable future (40 years) than it is currently, due to improved management and recent indications of population recoveries.

To conclude, the Porbeagle has been subjected to considerable fishing pressure for many decades, and is considered overfished in stock areas throughout its range. However, being overfished does not necessarily equate to the species (or its DPSs) having a high risk of extinction. Improved fisheries management efforts in recent years have reduced fishing mortality rates on Porbeagle stocks, and populations are no longer declining. Recovery is likely to take decades, but demographic risks are mostly low and significant threats have been reduced. Based upon the available information summarized here, the ERA team logically concluded that Porbeagle has a low risk of extinction, assuming the dominant threats to their populations continue to be managed.

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