FINAL

RECOVERY PLAN FOR THE SEI WHALE

(*Balaenoptera borealis*)

Office of Protected Resources
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

December 2011

FINAL

RECOVERY PLAN FOR THE SEI WHALE

(*Balaenoptera borealis*)

Prepared by:

Office of Protected Resources
National Marine Fisheries Service

Approved: ______________________________
Eric C. Schwaab
Assistant Administrator for Fisheries
National Oceanic and Atmospheric Administration

Date: ______________________

PREFACE

Congress passed the Endangered Species Act of 1973 (16 USC 1531 *et. seq.*) (ESA) to provide a means to conserve the ecosystems upon which endangered and threatened species depend, to provide a program for the conservation of such endangered and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions that conserve such species. The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service share responsibility for the administration of the Act. NMFS is responsible for most marine mammals including the sei whale (*Balaenoptera borealis*). This Recovery Plan was prepared at the request of the Assistant Administrator for Fisheries to promote the conservation of sei whales.

The goals and objectives of the Plan can be achieved only if a long-term commitment is made to support the actions recommended herein. Achievement of these goals and objectives will require the continued cooperation of the governments of the United States and other nations. Within the United States, the shared resources and cooperative involvement of federal, state, and local governments, industry, academia, nongovernmental organizations, and individuals will be required throughout the recovery period.

ACKNOWLEDGMENTS

The National Marine Fisheries Service gratefully acknowledges the contributions of Randall R. Reeves and Gregory K. Silber in developing the original Draft Recovery Plan for the Sei Whale. Subsequent revisions were made by Shannon Bettridge, Larissa Plants, and Gregory K. Silber.

Special thanks goes to the following for their technical assistance, editing, and review: Jay Barlow, Phil Clapham, Monica DeAngelis, Peter Duley, David Gouveia, Amanda Johnson, David Morin, Richard Pace, Allison Rosner, Barbara Taylor, Sofie Van Parijs, and Gordon Waring. Robin Baird, Mari Smultea, and Thomas Jefferson provided comments on a draft of this plan.

DISCLAIMER

Recovery plans delineate such reasonable actions as may be necessary, based upon the best available scientific and commercial data available, for the conservation and survival of listed species. Plans are published by NMFS, sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in the plan formulation, other than NMFS. They represent the official position of NMFS only after they have been signed by the Assistant Administrator. Recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, or the completion of recovery actions.

LITERATURE CITATION SHOULD READ AS FOLLOWS:

National Marine Fisheries Service. 2011. Final Recovery Plan for the Sei Whale (*Balaenoptera borealis*). National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. 108 pp.

ADDITIONAL COPIES MAY BE OBTAINED FROM:

National Marine Fisheries Service
Office of Protected Resources
1315 East-West Highway, 13th Floor
Silver Spring, Maryland 20910
301-427-8402 or 301-427-8403

Recovery plans can also be downloaded from the NMFS website:
http://www.nmfs.noaa.gov/pr/recovery/plans.htm

Cover photograph of sei whale by Peter Duley, Permit 775-1875, Courtesy of NMFS, Northeast Fisheries Science Center.

LIST OF TERMS AND ACRONYMS

The following is a list of acronyms, abbreviations, and terms used throughout the recovery plan.

CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CI	confidence interval
CV	coefficient of variance
dB	decibels
Delisting	removal from the list of Endangered and Threatened Wildlife and Plants
DPS	distinct population segment
Downlisting	considered for reclassification from endangered to threatened under the ESA
DOS	U.S. Department of State
ESA	Endangered Species Act
FR	Federal Register
Hz	hertz
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
kHz	kilohertz
LFA	low frequency active (for sonar)
m	meters
MARU	marine acoustic recording unit
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service
nmi	nautical miles
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
SURTASS	Surveillance Towed Array Sensor System

This Page Intentionally Left Blank

EXECUTIVE SUMMARY

Current Species Status: Sei whales, *Balaenoptera borealis,* are widely distributed in the world's oceans. The sei whale has been listed as "endangered" under the Endangered Species Act (ESA) since its passage in 1973. Most populations of sei whales were reduced, some of them considerably, by extensive commercial whaling in the 1950s through the early 1970s. They were hunted by modern whalers primarily after the preferred larger or more easily taken baleen whale species had been seriously depleted, including the right (*Eubalaena* spp.), humpback (*Megaptera novaeangliae*), gray (*Eschrichtius robustus*), blue (*Balaenoptera musculus*), and fin (*Balaenoptera physalus)* whales. International protection for sei whales only began in the 1970s, but the taking of sei whales has continued at relatively low levels by Icelandic and Japanese operations. Of the commercially exploited "great whales," the sei whale is one of the least studied, and the current status of most sei whale stocks is poorly known.

Sei whales have a global distribution and occur in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. Currently, the population structure of sei whales has not been adequately defined. Populations are often divided on an ocean basin level. This Recovery Plan is organized, for convenience, by ocean basin and discussed in three sections, those sei whales in the Atlantic Ocean, those in the Pacific Ocean and its adjoining seas and gulfs, and those in the Southern Hemisphere. There is a need for improved understanding of the genetic differences among and between populations to determine stock structure—a prerequisite for assessing abundance and trends, but such information is not available for this Recovery Plan.

Habitat Requirements and Limiting Factors: Stocks in the North Atlantic and North Pacific Ocean have been legally protected from whaling since the International Whaling Commission (IWC) moratorium on commercial whaling was passed in 1986, and this protection continues. Although the main direct threat to sei whales was addressed by the IWC whaling moratorium on commercial whaling, several potential threats remain. These include collisions with vessels, entanglement in active or derelict fishing gear, reduced or displaced prey abundance due to climate change, the possibility that illegal whaling or resumed legal whaling will cause removals at biologically unsustainable rates, and the effects of increasing anthropogenic ocean noise.

Recovery Strategy: Because the current population status of sei whales is unknown, the primary purpose of this Recovery Plan is to provide a research strategy to obtain data necessary to estimate population abundance, trends, and structure and to identify factors that may be limiting sei whale recovery. These data will also provide greater understanding of natural and anthropogenic threats to the species.

Traditional marine mammal survey approaches (such as line transect surveys, photographic identification) have not yielded sufficient data to determine population structure, abundance, or trends. Because of the rarity with which these data are obtained during routine marine mammal research cruises, sufficient data to demonstrate recovery would demand an enormous amount of resources and ship time and would likely take many decades to realize. While traditional marine mammal survey approaches have not yielded sufficient data on sei whales, passive acoustic techniques are highly cost-effective, are less limited by poor weather conditions and thus are able to make observations more consistently, and pose fewer risks to human observers. As a result, this recovery plan incorporates an adaptive management strategy that divides recovery actions into three tiers. Tier I involves: 1) continued international regulation of whaling (*i.e.*, a moratorium on commercial sei whaling); 2) determining population size, trends, and structure using opportunistic data collection in conjunction with passive acoustic monitoring, if determined to be feasible; and 3) continued stranding response and associated data collection. After ten years of conducting Tier I actions, NMFS expects to evaluate this approach to determine if the approach is providing sufficient data to assess recovery (or if more efficient data collection methods become available). If the Tier I method proves to be sufficient, *i.e.*, is providing appropriate information to estimate population abundance, trends, and structure, and to more clearly identify factors that may be limiting sei whale recovery, NMFS will continue Tier I data collection activities. If Tier I data collection methods are insufficient, NMFS will consider Tier II actions, building upon research conducted during Tier I. If after a few years of acoustic data collection it is clear that the acoustic work is not effective, NMFS will reassess its strategy and move to Tier II if resources are available.

Tier II adds more extensive directed abundance and distribution survey research and actions that are dependent upon acquiring comprehensive information (*e.g.*, assessment of threats currently ranked as unknown). Some Tier I and II actions can occur simultaneously if possible (they are not mutually exclusive). Tier III recovery actions depend upon data collected in Tiers I and/or II. When sufficient data are obtained, Tier III recovery activities will be undertaken as feasible, and can be undertaken before all Tier I and II actions are complete. Costs have been estimated for Tier I recovery actions only.

Estimated Cost of Tier I Recovery Actions for First Ten Fiscal Years (estimates are in thousands of dollars):

ACTION ITEMS LISTED AS:	ACTION 1	ACTION 2	ACTION 3	ACTION 4	ACTION 5	TOTAL
PRIORITY 1	$0	$0	$0	$0	$0	$0
PRIORITY 2	$0	$9,772	$920	$300	$0	$10,992
PRIORITY 3	$0	$0	$0	$0	$1,000	$1,000
TOTAL COST (in thousands)	**$0**	**$9,772**	**$920**	**$300**	**$1,000**	**$11,992**

Recovery Goals and Criteria: The goal of this recovery plan is to promote the recovery of sei whales to the point at which they can be downlisted from Endangered to Threatened status, and ultimately to remove them from the list of Endangered and Threatened Wildlife and Plants, under the provisions of the ESA. The intermediate goal is to reclassify the species from endangered to threatened.

The recovery criteria presented in this Recovery Plan were based on the *Report of the Workshop on Developing Recovery Criteria for Large Whales Species* (Angliss *et al.* 2002). The sei whale is currently listed as a single species on a global scale.

Downlisting Criteria:

Sei whales will be considered for reclassifying from endangered to threatened when all of the following are met:

> 1. Given current and projected threats and environmental conditions, the sei whale population in each ocean basin in which it occurs (North Atlantic, North Pacific and Southern Hemisphere) satisfies the risk analysis standard for threatened status (has no more than a 1% chance of extinction in 100 years) *and* the global population has at least 1,500 mature, reproductive individuals (consisting of at least 250 mature females and at least 250 mature males in each ocean basin). Mature is defined as the number of individuals known, estimated, or inferred to be capable of reproduction. Any factors or circumstances that are thought to substantially contribute to a real risk of extinction that cannot be incorporated into a Population Viability Analysis will be carefully considered before downlisting takes place.
>
> And
>
> 2. None of the known threats to sei whales are known to limit the continued growth of populations. Specifically, the factors in 4(a)(l) of the ESA are being or have been addressed: A) the present or threatened destruction, modification or curtailment of a species' habitat or range; B) overutilization for commercial, recreational or educational purposes; D) the inadequacy of existing regulatory mechanisms; and E) other natural or manmade factors (there are no criteria for Factor C, disease or predation).

It is important to emphasize that sei whales will be considered for downlisting only when <u>all</u> criteria are met globally—minimum abundance level is met, risk analysis standard for threatened status (has no more than a 1% chance of extinction in 100 years) has been satisfied, and all known threats have been addressed.

Delisting Criteria:

Sei whales will be considered for removal from the list of Endangered and Threatened Wildlife and Plants under the provisions of the ESA when all of the following are met:

> 1. Given current and projected threats and environmental conditions, the total sei whale abundance in each ocean basin in which it occurs (North Atlantic, North Pacific and Southern Hemisphere) satisfies the risk analysis standard for unlisted status (has less than a 10% probability of becoming endangered (has more than a 1% chance of extinction in 100 years) in 20 years). Any factors or circumstances that are thought to substantially contribute to a real risk of extinction that cannot be incorporated into a Population Viability Analysis will be carefully considered before delisting takes place.
>
> And

2. None of the known threats to sei whales are known to limit the continued growth of populations. Specifically, the factors in 4(a)(l) of the ESA have been addressed, namely: A) the present or threatened destruction, modification or curtailment of a species' habitat or range; B) overutilization for commercial, recreational or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; and E) other natural or manmade factors.

ANTICIPATED DATE OF RECOVERY: The time and cost to recovery is not predictable with the current information and global listing of sei whales. The difficulty in gathering data on sei whales and uncertainty about the success of passive acoustic monitoring in fulfilling data needs make it impossible to give a timeframe to recovery. While we are comfortable estimating costs for the first 10 years of plan implementation for Tier I actions ($11.87M), any projections beyond this date are likely to be imprecise and unrealistic until we can determine the success of passive acoustic monitoring of sei whales to obtain data. The anticipated date for removal from the endangered species list also cannot be determined because of the uncertainty in the success of passive acoustic monitoring of sei whales. The effectiveness of many management activities is not known on a global level. Currently it is impossible to predict when such measures will bring the species to a point at which the protections provided by the ESA are no longer warranted, or even determine whether the species has recovered enough to be downlisted or delisted. In the future, as more information is obtained it should be possible to make more informative projections about the time to recovery, and its expense.

ESTIMATED COST OF TIER I RECOVERY ACTIONS (FIRST 10 FISCAL YEARS): $11.872 MILLION

TABLE OF CONTENTS

I. BACKGROUND

A. Brief Overview

B. Species Description, Taxonomy, and Population Structure

Species Description

The sei whale, *Balaenoptera borealis* (Lesson 1828), is a cosmopolitan species of the world's temperate to subpolar marine waters (Gambell 1985b; Horwood 1987). It is generally considered monomorphic, although little effort has been applied to intraspecies comparisons. The difficulty of distinguishing sei whales at sea from their close relatives, Bryde's (*Balaenoptera edeni/brydei),* Omura's *(Balaenoptera omurai),* and fin (*Balaenoptera physalus)* whales, has created confusion about distributional limits and frequency of occurrence, especially in waters where Bryde's whales are most common.

Mead (1977) cited the very fine bristles of the sei whale's baleen (about 0.1 mm in diameter at the base) as the most reliable feature for distinguishing it from all other *Balaenoptera* species. He also noted that the sei whale could be distinguished from all the other species, except the smaller minke whale (*Balaenoptera acutorostrata*), by the relative shortness of its ventral grooves, which extend back only to a point about midway between the flippers and the umbilicus. The best diagnostic feature for clearly identifying sei and Bryde's whales, apart from the differences in their baleen, is the presence of lateral ridges on the dorsal surface of the Bryde's whale's head. However, this feature alone cannot be used to distinguish sei whales from Bryde's whales, as sei and fin whales sometimes have lateral ridges, but they are reduced in fin whales (Jefferson *et al.* 2008). Large sei whales can be mistaken for fin whales unless the latter's asymmetrical head coloration is clearly seen—the right lower jaw being white and the left gray. Thus, these relatively small morphological differences among the balaenopterid species complicate accurate identification at sea.

Sei whales are essentially gray. Their skin is often marked by pits or wounds, which after healing become ovoid white scars. These are probably caused mainly by ectoparasitic copepods (*Penella* spp.) (Andrews 1916; Ivashin and Golubovsky 1978), lampreys (Pike 1951; Rice 1977), and "cookie-cutter" sharks (*Isistius brasiliensis*) (Shevchenko 1977).

Sei whales in the Southern Ocean can attain lengths of up to 18 m and weigh up to 28,000 kg (Lockyer 1977b). Those in the Northern Hemisphere are smaller than those in the Southern Ocean. The largest specimens taken off Iceland were slightly longer than 16 m (Martin 1983). Females are considerably larger than males.

The dorsal fin is usually prominent and curves backward, set about two-thirds of the way back from the tip of the snout; there are additional features of the dorsal fin that are unique to this species (Jefferson *et al.* 2008). Sei whales, unlike fin whales, tend not to roll high out of the water as they dive. In sei whales, the blowholes and dorsal fin are often exposed above the water surface simultaneously, but in fin whales this is rarely the case (Jefferson *et al.* 2008). Sei whales almost never raise their flukes out of the water, and they rarely breach. Dorsal fin shape, pigmentation pattern, and scarring have been used to a limited extent in photo-identification studies of sei whales (Schilling *et al.* 1992).

Hearing and Vocalizations
Marine mammal hearing has been reviewed by several authors, notably Popper (1980a; 1980b), Schusterman (1981), Ridgway (1983), Watkins and Wartzok (1985), Moore and Schusterman (1987), Au (1993), Richardson *et al.* (1995), Wartzok and Ketten (1999), and Southall *et al.* (2007). Auditory thresholds at various frequencies can be directly determined either by behavioral tests with trained captive animals or by electrophysiological tests on captive or beached animals or indirectly predicted via inner ear morphology, taxonomy, behavior, or vocalizations. Hearing abilities have been studied in some toothed whales, hair seals, and eared seals. Most of the available data on underwater hearing deal with frequencies of 1 kilohertz (kHz) or greater, and many relate to frequencies above 20 kHz (up to 180 kHz). Recently, Southall *et al.* (2007) suggested that marine mammals be divided into five basic functional hearing groups: high-frequency cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhychids), mid-frequency cetaceans ("dolphins," toothed whales, beaked whales, and bottlenose whales), low-frequency cetaceans (mysticetes), pinnipeds in water, and pinnipeds in air.

There is no direct information about the hearing abilities of baleen whales. It is generally assumed that most animals hear well in the frequency ranges similar to those used for their vocalizations. Also, estimation of hearing ability based on inner ear morphology has been completed on two mysticete species: humpback whales (*Megaptera novaeangliae*) (700 hertz [Hz] to 10 kHz; Houser *et al.* 2001); and North Atlantic right whales (10 Hz to 22 kHz; Parks *et al.* 2007b). Preliminary anatomical data indicate minke whales may be able to hear slightly above 22 kHz (Ketten and Mountain 2009). The anatomy of the baleen whale inner ear seems to be well-adapted for detection of low-frequency sounds (Ketten 1991; 1992; 1994). Baleen whale calls are also predominantly at low frequencies, mainly below 1 kHz (Richardson *et al.* 1995), and their hearing is presumed good at corresponding frequencies. Southall *et al.* (2007) estimated the hearing range of low-frequency cetaceans to extend from approximately 7 Hz to 22 kHz. Additional data support this approximate hearing range for mysticetes. For example, Watkins (1986) reported a variety of mysticete species responding to sounds up to 28 kHz; Au *et al.* (2006) reported humpback whales songs having harmonics that extend beyond 24 kHz; and an abstract from Frankel (2005) and paper by Lucifredi and Stein (2007) reported gray whales potentially responding to sounds beyond 22 kHz. Thus, the auditory system of baleen whales is almost certainly more sensitive to low-frequency sounds than that of the small- or moderate-sized toothed whales. However, auditory sensitivity in at least some large whale species extends up to higher frequencies than the maximum frequency of the calls, and relative auditory sensitivity at different low-moderate frequencies is unknown.

Although sei whale vocalizations have been recorded since at least the 1970s, these sounds have only recently been linked to the species. A number of researchers described characteristics of sei whale vocalizations from various locations and populations, including off the Antarctic Peninsula (McDonald *et al.* 2005; Gedamke and Robinson 2010), near Nova Scotia (Thompson *et al.* 1979; Knowlton *et al.* 1991), off the Hawaiian Islands (Rankin *et al.* 2007), and waters off New England (Baumgartner and Fratantoni 2008; Baumgartner *et al.* 2008). Generally, calls are 1.0 to 1.5 s in duration and tend to down-sweep from 100–40 Hz. McDonald *et al.* (2005) reported calls that ranged from 200–600Hz with an average frequency around 430 Hz. It is reasonable to assume that sei whale hearing includes, and likely extends beyond, the frequencies described for these vocalizations.

Taxonomy
The sei whale was described as *Balaena rostraia*, *Balaena borealis*, *Balaenoptera laticeps*, and *Eulama physalus*, among others, before alternative *Balaenoptera borealis* was formalized (Allen 1916). Sei whales are rorquals (family Balaenopteridae), baleen whales that include the humpback, blue (*Balaenoptera musculus)*, Bryde's, fin, Omura's, and minke whales. Rorquals take their name from the Norwegian word *røyrkval*, meaning "furrow whale", because family members have a series of longitudinal pleats or grooves below the mouth that continue along the body's underside. Balaenopteridae diverged from the other families of suborder Mysticeti, also called the whalebone whales or great whales, as long ago as the middle Miocene (*i.e.*, roughly 10–20 million years ago).

Two subspecies have been identified (although not yet confirmed with empirical evidence): the northern sei whale (*Balaenoptera borealis borealis*) and southern sei whale (*Balaenoptera borealis schleglii*) (Rice 1998) although definitive conclusions regarding this classification cannot be made. Perrin *et al.* (2009), for example, noted that evidence for sei whale subspecies is weak. In any case, the ranges of these populations are not known to overlap (Rice 1998).

Population Structure
The population structure of sei whales is not known. Population structure is assumed to be is discrete by ocean basin, except for sei whales in the Southern Ocean, which may form a ubiquitous population or several discrete ones.

From a U.S. perspective, sei whales are managed under three constructs, all with different objectives and, therefore, different terminology for population structure: the Marine Mammal Protection Act (MMPA), the IWC, and the ESA. The goal of the MMPA is to protect marine mammal species by maintaining marine mammal population "stocks" as functioning elements of their ecosystem; the IWC manages whales with a goal of maintaining healthy stocks while authorizing hunts to meet aboriginal needs (and potentially commercial catches), scientific research and related purposes; and the ESA seeks to avoid extinction and recover threatened and endangered species to a point at which they no longer need ESA protections. Sei whale population estimates are reported in MMPA mandated Stock Assessment reports, so while sei whales are listed globally under the ESA, the best available population estimates are referenced by stock.

Both the MMPA and the IWC use the term "stocks" to refer to units to conserve.
In this document we use the term "stocks" in the context of MMPA or IWC stocks and use the more generic term "populations" when referring to subunits of the same species in other contexts. The stock concept has been the subject of much discussion among biologists and natural resource managers. A recent working definition of "stock" under the MMPA is a "demographically isolated biological population" (Wade and Angliss 1997) where internal dynamics (births and deaths) are far more important than external dynamics (immigration and emigration) to maintaining the population. The IWC uses a two definitions of stock: biological stocks, based on genetic separation, and management stocks, referring to population units defined in functional terms (Donovan 1991). Although considerable effort has been expended to

tighten the definition of stocks, current IWC practice continues to define on a case-by-case basis and only on stocks in need of current management.

The IWC only recognizes one stock of sei whales in the North Pacific (Donovan 1991), but some evidence suggests the existence of multiple populations (Masaki 1977; Mizroch *et al.* 1984b; Horwood 1987). Based on a “conservative management approach,” NMFS recognizes four MMPA sei whale stocks: the Eastern North Pacific, Hawaiian, Nova Scotian, and Western North Atlantic (Waring *et al.* 2010). To date there has been no effort to define subspecies or Distinct Population Segments (DPSs) for sei whales under the ESA. For a more detailed discussion on population structure, see the Life History sections in this Recovery Plan for the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere.

C. Zoogeography

Sei whales are highly mobile, and there is no indication that any population remains in a particular area year-round, *i.e.*, is resident, but studies are lacking to make definitive conclusions regarding possible residency. Poleward summer feeding migrations occur, and sei whales generally winter in warm temperate or subtropical waters (Horwood 1987; Jefferson *et al.* 2008) . The species is cosmopolitan (Figure 1), but with a generally anti-tropical distribution centered in the temperate zones. The larger body size found in Southern Hemisphere sei whales has been regarded by some authorities as differing from the smaller Northern Hemisphere sei whales at the subspecies level (Rice 1998). On a global scale, the populations in the North Atlantic, North Pacific, and Southern Hemisphere are almost certainly separate, and they may be further subdivided into smaller geographical stocks.

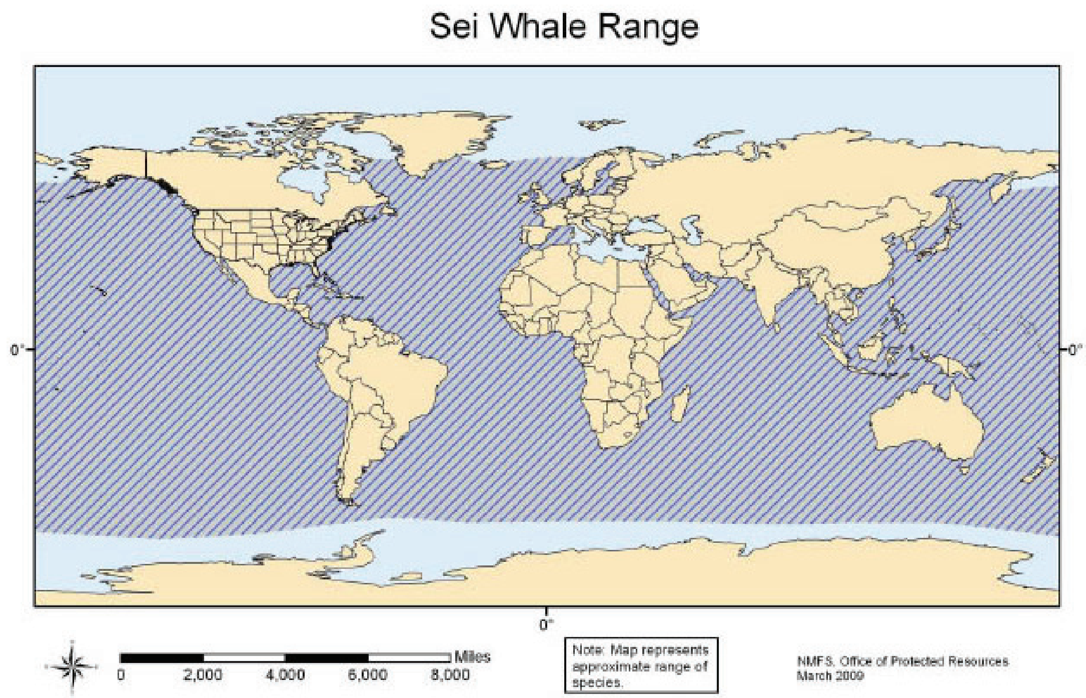

Figure 1. Sei whale global range.

D. Life History – North Atlantic Ocean

D.1 Population Structure

Stock divisions traditionally used by the IWC are based on little empirical evidence (Donovan 1991). The fact that sei whales seem to occur in two main centers of abundance off eastern Canada was used as the primary basis for recognizing two stocks in the northwestern Atlantic, one from the southeastern coast of Newfoundland northward (Labrador Sea stock) and the other south from Newfoundland (Nova Scotia stock) (Mitchell and Chapman 1977). Meager evidence from tag-recapture studies is consistent with this two-stock hypothesis (Mitchell and Chapman 1977), although recent studies demonstrated that sei whales satellite-tagged near the Azores traveled to the western North Atlantic (Olsen *et al.* 2009; Prieto *et al.* 2010). A third stock, the Iceland–Denmark Strait stock, was designated in the central North Atlantic essentially to reflect Iceland's shore-based whaling grounds (Donovan 1991). Results of Icelandic sighting surveys, however, have been interpreted as suggesting that the sei whales in Denmark Strait (Irminger Sea) arrive late in the season from the southwest and thus might belong to the "Labrador Sea stock" (Sigurjónsson 1989; Sigurjónsson *et al.* 1991). A preliminary study of genetic variation in sei whales from Icelandic waters indicated that they were more homogeneous than fin whales around Iceland (Danielsdottir *et al.* 1991).

Some evidence supports the idea that the "Nova Scotia stock" extends along the U.S. coast to at least North Carolina. Photographic matches showed a connection between sei whales in the southern Gulf of Maine and those on the Scotian Shelf (Schilling *et al.* 1992).

The unpredictability, or irregularity, of the sei whale's occurrence in particular feeding areas has frequently been noted (*e.g.*, Ingebrigtsen 1929; Jonsgård and Darling 1977; Martin 1983; Horwood 1987; Schilling *et al.* 1992). Influxes of sei whales on the whaling grounds in the eastern North Atlantic were sometimes referred to as "invasions" (Andrews 1916). Kapel (1985b) reported a correlation between the occasional appearance of sei whales and the incursions of relatively warm waters of the Irminger Current off West Greenland. He concluded, provisionally, that sei whales off West Greenland likely belong to the Iceland–Denmark Strait stock rather than to the Labrador Sea stock. Limited evidence from tag returns indicates that individual sei whales return to the Icelandic whaling grounds in successive (and later) years (Sigurjónsson 1983; Anonymous 1984; 1985; 1986; 1987).

D.2 Distribution and Habitat Use

The range of sei whales in the North Atlantic extends from southern Europe/northwestern Africa to Norway in the east, and from the southeastern United States (or occasionally the Gulf of Mexico and Caribbean Sea; Mead 1977) to West Greenland in the west (Gambell 1977; Gambell 1985b; Horwood 1987). They undertake seasonal north/south movements, wintering at relatively low latitudes and summering at relatively higher latitudes. Generally speaking, sei whales do not tend to move to as high latitudes as do some of the other balaenopterid species, and they also tend not to enter semi-enclosed water bodies, such as the Gulf of Mexico, the Gulf of St. Lawrence, Hudson Bay, the North Sea, and the Mediterranean Sea. Throughout their range, sei whales occur predominantly in deep water; they are most common over the continental slope (*e.g.*, Mitchell 1975a; Cetacean and Turtle Assessment Program 1982; Martin 1983; Olsen *et al.*

2009), shelf breaks (Committee on the Status of Endangered Wildlife in Canada 2003), and deep ocean basins situated between banks (*e.g.*, Sutcliffe and Brodie 1977). Over 40 sei whales were observed in a multi-species assemblage over and near Hydrographer Canyon off Cape Cod, Massachusetts, in April 1980 (Kenney and Winn 1987) suggesting an affinity for submarine canyon areas. Based on satellite tag data, Olsen *et al.* (2009) found that one sei whale traveled 1,500 km in less than two weeks from the Azores Islands to the Labrador Sea and was associated with gyre-driven and other currents. They also determined that this whale's movements were associated with oceanic fronts, sea surface temperatures, and specific bathymetric features (in this case, the Charlie Gibbs Fracture Zone).

Along the U.S. Atlantic seaboard, in spring and early summer sei whales are frequently observed in areas with North Atlantic right whales in the Great South Channel and southern Gulf of Maine (NMFS Northeast Fisheries Science Center unpublished data). Weinrich *et al.* (1986) reported seeing groups of up to 10 sei whales in the inshore waters of the southern Gulf of Main on 30 of 67 days during the summer of 1986. Sei whales were previously believed to only occasionally occupy the inshore waters of the Gulf of Maine in response to increases in copepod prey density (Payne *et al.* 1990; Schilling *et al.* 1992); however, Baumgartner *et al.* (2011) report sei whale observations during springtime in the Great South Channel from 2004 to 2010, suggesting that sei whales are reasonably common in the area.

The southernmost confirmed records in the western North Atlantic Ocean are strandings along the northern Gulf of Mexico and in the Greater Antilles (Mead 1977). Sightings and catch records suggest that sei whales move north along the shelf edge to arrive in the areas of Georges Bank, Northeast Channel, and Browns Bank by mid- to late June (Mitchell and Chapman 1977). They occur off southern Newfoundland in August and September, and there is a southbound "run" west and south along the Scotian Shelf from mid-September to mid-November (Mitchell and Chapman 1977). Sei whales occur in the Labrador Sea as early as the first week of June and may move farther northward to waters southwest of Greenland later in the summer (Mitchell and Chapman 1977; Anonymous 1995).

On Icelandic whaling grounds in Denmark Strait, sei whales were usually absent until mid-July, and remained in the Strait through mid-September (Martin 1983). Their migratory routes are poorly known; no tag recoveries in the northeastern Atlantic have been reported. However, Martin (1983) inferred from the literature that sei whales wintered as far south as West Africa and followed the continental slope northward in spring. Judging by catch composition and timing, large females lead the northward migration and reach Denmark Strait earlier and more reliably than do other age/sex classes (Martin 1983). In some years, males and younger females apparently remain at lower latitudes throughout the summer.

Major changes have been noted in sei whale distribution and movements over the last few decades in the North Atlantic. Sei whales were said to have been scarce in the 1960s and early 1970s off northern Norway, where large numbers were taken at the end of the nineteenth century (Jonsgård 1974). They were "plentiful" off western Norway during and after the Second World War but then were rarely observed there during the 1960s. Jonsgård (1974) stated that although the sei whale "is known for its irregular appearance, it cannot be denied that its disappearance [off Norway] may be due to overexploitation." A possible alternative explanation is that a "drastic reduction" of copepod stocks in the northeastern Atlantic during the late 1960s caused a change in sei whale distribution (Cattanach *et al.* 1993).

Studies in various ocean basins indicate that sei whales are associated with ocean fronts and eddies (Nasu 1966; Nemoto and Kawamura 1977; Skov *et al.* 2008; Bost *et al.* 2009). These are oceanographic features that likely concentrate prey and, in turn, are dependent on prevailing currents. Sei whales may also use currents in large scale movements or migrations (Olsen *et al.* 2009).

D.3 Feeding and Prey Selection

Sei whales in the North Atlantic reportedly feed primarily on calanoid copepods, with a secondary preference for euphausiids (Hjort and Ruud 1929; Mitchell 1975b; Mitchell *et al.* 1986; Christensen *et al.* 1992). Their preference for zooplankton and micronekton has been shown not only by stomach content analyses, but also by direct observations of feeding behavior (Watkins and Schevill 1979), by inference (sei whale occurrence and prey (copepod) densities; Olsen *et al.* 2009), and examination of feces collected near sei whales in the southern Gulf of Maine (Weinrich *et al.* 1986; Schilling *et al.* 1992). Baumgartner and Franantoni (2008) described a linkage between sei whale vocalizations as related to surface feeding and the diel water column migrations of calanoid copepods in the southwest Gulf of Maine.

D.4 Competition

Because it feeds at more than one trophic level (Nemoto and Kawamura 1977), the sei whale may compete for food resources with a variety of other species, including humans. The predominant copepod prey suggests a likely important interactive role with other major copepod consumers such as clupeid fishes, sand lance (family Ammodytidae), fry and juveniles of larger fishes, basking sharks (*Cetorhinus maximus*), and right whales. Schilling *et al.* (1992), suggested the occurrence of inter-specific competition given the relationship between sei whale presence and a collapse of sand lance populations on Stellwagen Bank in 1986. Mitchell (1975b) suggested that the decline of Northern right whales caused by whaling allowed sei whale populations to increase, in turn impeding the recovery of the right whale. Mitchell *et al.* (1986) found that sei and right whales were closely sympatric on the Scotian Shelf, especially in Roseway Basin between Browns and Baccaro Banks.

Clapham and Brownell (1996) concluded that there was no convincing evidence that interspecific competition among baleen whales is affecting population recovery rates. They argued that "... the probable resource partitioning mediated by food preferences or by the biomechanics of body size, the lack of territoriality, and the absence of observations of agonistic interactions, all suggest that such competition is unlikely."

D.5 Reproduction

Whereas information reported here for sei whale reproduction is based on data from various ocean basins, it is likely that they generally hold true for this species globally (however, see section E.5). The sei whale gestation period has been estimated as 10¾ months (Lockyer and Martin 1983), 11¼ months (Lockyer 1977b), or one year (Risting 1928), depending on which model of fetal growth is selected. In the North Atlantic, most births take place in November/December and conceptions in December/January (Lockyer and Martin 1983). Sei whale calves are probably nursed for six to nine months (Lockyer and Martin 1983), so weaning occurs on the feeding grounds in summer or autumn. The average calving interval is probably at least two years (Jonsgård and Darling 1977; Lockyer and Martin 1983). The mean age of sexual maturity is thought to be 8–10 years in both sexes (Lockyer and Martin 1983). Best and Lockyer (2002) calculated an average age of sexual maturity of 8.2 years and 8.6 years for (Southern Hemisphere) females and males, respectively, (with a first onset occurring in some individuals in the third year) based on an examination of over 1,000 sei whales captured off the coast of South Africa.

D.6 Natural Mortality

Two independent approaches to natural mortality rate estimates applied to data from the Southern Ocean gave values on the order of 0.060–0.065 for the natural mortality rates of mature animals of both sexes (Lockyer 1977a), and Rice (1974) provided estimates of 0.088–0.103 for both sexes of North Pacific sei whales. A mortality rate of 0.075 has also been cited (Mizroch *et al.* 1984b). No estimates of natural mortality rates are available for the North Atlantic, and little is known about causes of natural mortality. Predation by killer whales and sharks, particularly on young or sick individuals, may occur, but such events have not been reported in the North Atlantic (see, for example, Ford and Reeves 2008).

D.7 Abundance and Trends

No estimates of pre-exploitation population size are available and the total number of sei whales in the North Atlantic Ocean is not known (Waring *et al.* 2009). There are insufficient data to determine population trends for this species (Waring *et al.* 2009).

A shipboard sighting survey in 1989 produced an estimate of about 10,300 sei whales (CV 0.27) sei whales in Icelandic and Faroese waters (Cattanach *et al.* 1993). Mitchell and Chapman (1977) estimated that during the late 1960s there were about 1,400–2,200 (based on tag-recapture studies) or at least 870 (shipboard strip survey) sei whales in the putative Nova Scotia stock and at least 965 (strip survey) in the putative Labrador Sea stock. A very imprecise estimate of about 250 sei whales in spring in continental shelf and shelf-edge waters between North Carolina and Nova Scotia was made in the late 1970s/early 1980s (Cetacean and Turtle Assessment Program 1982); the aforementioned sighting of 40+ sei whales at Hydrographer Canyon in 1980 was outside the CETAP study area and thus did not contribute to the estimate (Kenney and Winn 1987). The whales included in this estimate would presumably belong to the putative Nova Scotia stock. In addition, the CETAP estimate was not adjusted to account for animals that were submerged while the survey aircraft passed overhead.

Five abundance estimates are available for portions of the sei whale habitat in the North Atlantic Ocean: from Nova Scotia during the 1970's, in the U.S. Atlantic waters in 1979–1981, and in the U.S. and Canadian Atlantic in 2002, 2004, and 2006 (Waring *et al.*, 2009). The August 2004 abundance estimate (n=386, no CV) is considered the best available for the Nova Scotia sei whale stock. However, this estimate must be considered low and limited given the known range of the sei whale in the entire western North Atlantic, and the uncertainties regarding population structure and whale movements between areas surveyed and those that were not. An abundance estimate of 71 (CV=1.01) sei whales was obtained from an aerial survey conducted in August 2002 which covered 7,465 km in waters over 1000 m deep on the southern edge of Georges Bank to Maine (Palka 2006). Sei whale sighting information from surveys conducted in summer 2004 in waters north of Maryland (38ºN) yielded an abundance estimate of 386 (CV=0.85) (Palka 2006). Also, an abundance estimate of 207 (CV=0.62) sei whales was obtained from an aerial survey conducted in August 2006 which covered 10,676 km of trackline in the region on the southern edge of Georges Bank to the upper Bay of Fundy and to the entrance of the Gulf of St. Lawrence (Waring *et al.* 2009).

In another location, MacLeod *et al.* (2005) reported that an estimated 1,011 (CI=497–2058) sei whales occur in waters off Scotland, based on vessel-based surveys in that region.

E. Life History – North Pacific Ocean

E.1 Population Structure

Masaki's (1977) evaluation of tag recoveries, catch distributions, sightings, and baleen morphology led him to propose three North Pacific stocks, divided by longitudes 175° W and 155° W. Tag recoveries in the eastern North Pacific demonstrate movement between waters off central California and Vancouver Island (Rice 1977). Also, sei whales taken off California carried a different species of *Penella* (an ectoparasite) than those taken off Japan (Rice 1977). Carretta *et al.* (2010), citing the paucity of data on population structure, considered the sei whales east of 180° W a separate stock — the eastern North Pacific stock.

Wada and Numachi (1991) concluded that a single sei whale population existed in the North Pacific based on genetic studies (the study included samples from 632 sei whales collected in 1974 and 1975 east of 160°E). Using higher genetic resolution than that used by Wada and Numachi (1991), but a smaller geographic sampling area (489 whales sampled between 2002 to 2007 in the area between 143°E and 170°E ; and 301 archived whale data collected in 1972 and 1973 from 165°E to 139°W), Kanda *et al.* (2006) observed a small degree of heterogeneity in a sample of 89 whales, and came to a similar conclusion regarding a single population. These authors, however, also indicated a number of caveats that should accompany their conclusions—a relatively small sampling in time and area among them.

E.2 Distribution and Habitat Use

As noted above and generally speaking, sei whales are more likely restricted to more temperate waters than are some (but, not all) other rorqual species. In the North Pacific Ocean, the sei whale has been reported to occur mainly south of the Aleutian Islands (Nasu 1974; Leatherwood *et al.* 1982) although Japanese sighting records presented by Masaki (1977) reported concentrations in the northern and western Bering Sea from July through September. These data have never been confirmed and must be considered doubtful because no other authority has ever reported them in the areas indicated. Horwood's (1987) synoptic evaluation of the Japanese sighting data led him to conclude that sei whales "rarely penetrate deep into the Bering Sea." They occur, however, all across the temperate North Pacific north of 40°N latitude. In the south, they range from Baja California, Mexico, to Japan and Korea in the west (Andrews 1916;

Horwood 1987), and have been documented in the Hawaiian Islands (Smultea *et al.* 2010).

Sei whales were present off central California during the 1960s, mainly in late summer and early fall (Rice 1974). They were also described as abundant off the west coast of Vancouver Island, British Columbia, from June through August (Pike and Macaskie 1969). Gregr *et al.* (2000) reported that sei whales likely moved through British Columbian waters primarily in June through August northward to feeding areas off Alaska or in the open ocean. Their offshore distribution along the continental slope (Gregr and Trites 2001) probably explains, at least in part, the infrequency of observations in shelf waters between northern California and Washington. Clapham *et al.* (1997) suggested that a catch of 25 sei whales in 1926 at Trinidad, California, could have represented a "sudden influx" that year, similar to those described for the North Atlantic (see above). An alternative explanation would be that the whalers switched to sei whales as humpback whales became scarce in the local whaling areas (Clapham *et al.* 1997). Pregnant females are believed to lead the migration to and from northern feeding grounds (Mizroch *et al.* 1984b), and the migration along the Canadian coast is believed to occur in stages based both on gender and age (Gregr *et al.* 2000) .

As noted above, studies in both the North Pacific and North Atlantic Oceans show that sei whales are strongly associated with ocean fronts and eddies (Nasu 1966; Nemoto and Kawamura 1977; Skov *et al.* 2008). A similar affinity for oceanic fronts was observed among sei whales in Antarctic waters (Bost *et al.* 2009). These are oceanographic features that likely concentrate prey—and may be exploited by feeding sei whales—that, in turn, are dependent on prevailing currents. These whales may also use currents in large scale movements or migrations (Olsen *et al.* 2009).

The sei whale's tendency not to enter semi-enclosed marginal seas or gulfs, noted above for the North Atlantic, also applies in the North Pacific. They are much rarer than Bryde's whales in the Gulf of California, Mexico (Tershy *et al.* 1990) although they do occur there occasionally, usually in association with other rorqual species (Gendron and Rosales 1996). Few enter the Sea of Japan in spite of the very high primary production in portions of this sea (Nemoto and Kawamura 1977).

E.3 Feeding and Prey Selection

Sei whales are considered to feed at somewhat higher trophic levels in the North Pacific than in the Southern Ocean (Nemoto and Kawamura 1977). In addition to calanoid copepods and euphausiids, sei whales in the North Pacific reportedly prey on "almost every gregarious organism occurring with large biomass," including pelagic squid and fish the size of adult mackerel (Nemoto and Kawamura 1977; Kawamura 1982). Some fish species in their diet are commercially important. For example, off central California, sei whales fed during the 1960s mainly on anchovies from June through August and on krill (*Euphausia pacifica*) during September and October (Rice 1977; Clapham *et al.* 1997). Analysis of 1,453 sei whale stomachs from whales caught in a commercial hunt based in British Columbia in 1963 through 1967, Flinn *et al.* (2002) found that copepods were the dominant prey type. Euphausiids and a number of fish species (including saury, whiting, lamprey, and herring) were also present. Utilization of some prey varied between years (*i.e.*, a drop in presence of copepods and an increase in various fish species occurred in 1966 and 1967), and varied throughout the sampling period (May through

September), particularly in the frequency of copepods and saury (Flinn *et al.* 2002). In an analogous study that examined the content of 489 sei whale stomachs from 2000 to 2007 taken from waters east and northeast of Japan and west of 170°E, Tamura *et al.* (2009) found that these whales fed on 12 prey species, including three copepod, three euphasiid, five fish (including varieties of anchovy, saury, and mackerel), and one squid species. These authors also concluded that sei whales are opportunistic feeders with flexible diets; principal prey items differed between years and by area (tending to prey principally on copepods in the northern part of the North Pacific and fishes and squids elsewhere).

E.4 Competition

In the North Pacific Ocean, the trophic interactions of sei whales with other large marine vertebrates are complicated because of the diversity of prey taken by sei whales in this ocean basin (Kawamura 1980; 1982). Rice (1977) suggested that the euryphagous character of sei whales in the eastern North Pacific should allow them to take advantage of declines in populations of other mysticete whales by increasing and occupying vacated niches. It could also mean that they are more likely than their North Atlantic counterparts to be affected by, and to affect, commercial fisheries for finfish and squid.

E.5 Reproduction

The information reported in section D.5 for sei whale reproduction is likely to generally hold true for this species globally. However, Rice's (1977) sample of sei whales killed off central California yielded estimates of reproductive parameters that differ somewhat from those reported above, for North Atlantic sei whales. He estimated the gestation period as 12.7 months and the average calving interval as three years. The calving season was judged to last from September to March and lactation to continue for at least nine months. Rice also found the mean age at sexual maturity to be 10 years.

E.6 Natural Mortality

Rice (1977) estimated the total annual mortality rate for adult females at 0.088 and adult males at 0.103. Rice (1977) also reported that 7% of the 284 sei whales killed off central California from 1959 to 1970 were afflicted with an unknown disease causing their baleen to be shed and replaced by "an abnormal papilloma-like growth." Although these whales were not emaciated and had fish in their stomachs, Rice speculated that the disease could have caused "significant mortality" in the population.

Rice (1977) also found sei whales taken off California to be heavily infected with endo-parasitic helminths, some of which are pathogenic.

Predation by killer whales and sharks, particularly on young or sick individuals occurs, but observations of such predation are few (see, for example, Ford and Reeves 2008). From examinations of whales taken off Japan, Andrews (1916) concluded that sei whales were attacked by killer whales less often than were blue whales on the same grounds.

E.7 Abundance and Trends

Application of various models to whaling catch and effort data suggests that the total population of adult sei whales in the North Pacific declined from about 42,000 to 8,600 individuals between 1963 and 1974 (Tillman 1977). Because 500 to 600 sei whales per year were killed off Japan from 1910 to the late 1950s, the stock size presumably was already, by 1963, below its carrying capacity (Tillman 1977). The catch per unit effort for sei whales in California shore whaling declined by 75% between 1960 and 1970 (Rice 1977), which is consistent with the idea that the overall population was substantially reduced.

Ship surveys of coastal waters off California and Baja California in 1979/1980 and 1991 provided no meaningful estimates of sei whale abundance, in part because of the failure to consistently distinguish sei from Bryde's whales (Barlow 1994). Even if it were assumed, however, that all whales logged as "unidentified sei or Bryde's whale" were sei whales, the estimated abundance from these surveys would be very low (several tens to several hundreds). Comparably small abundance numbers were obtained from summer and fall surveys conducted in 1991–2008 within 550 km (300 nautical miles (nmi)) of the coasts of California, Oregon, and Washington (Barlow *et al.* 1997).

F. Life History – Southern Hemisphere

F.1 Population Structure

In the Southern Hemisphere, the IWC has divided the Southern Ocean into six baleen whale feeding areas—designated at 60° S latitude and longitude as: 60°–120° W (Area I), 0°–60° W (Area II), 0°–70° E (Area III), 70°–130° E (Area IV), 130°–170° W (Area V), and 170°–120°W (Area VI). There is little information on the population structure of sei whales in Antarctic waters, although some degree of separation among IWC Areas I–VI has been noted, although sei whale movements appear to be dynamic and individuals have been observed to have moved between stock designation areas (Donovan 1991).

F.2 Distribution and Habitat Use

Sei whales occur throughout the Southern Ocean during the austral summer, generally between 40°–50° S (Gambell 1985a), feeding in these locations from December to April. During the austral winter, sei whales occur off Brazil and the western and eastern coasts of southern Africa and Australia. However, sei whales generally do not occur north of 30º S in the Southern Hemisphere (Reeves *et al.* 1999). Confirmed sighting records exist for Papua New Guinea and New Caledonia, with unconfirmed sightings in the Cook Islands (Secretariat of the Pacific Regional Environment Programme 2007). Recent sightings have been reported in the Golfo San Jorge, Argentina and near the Falkland Islands (Iniguez *et al.* 2010); and a sei whale stranded in New Caledonia (ca. 21° S) in May 1962 (Borsa 2006).

The species occurs between the subtropical convergence and the Antarctic convergence during the austral summer (Rice 1977). Only large individuals have been found outside the Antarctic convergence (Lockyer 1977a; Iniguez *et al.* 2010). Best and Lockyer (2002) reported that off the west coast of south Africa, sei whales occurred primarily off the continental shelf break; with males tending to occur closer to shore than did females.

Studies in the North Pacific indicate that sei whales are strongly associated with ocean fronts and eddies (Nasu 1966; Nemoto and Kawamura 1977; Skov *et al.* 2008), and a similar affiliation with oceanic currents was observed among sei whales in Antarctic waters (Bost *et al.* 2009).

F.3 Feeding and Prey Selection

There are fewer data on prey selection for sei whales in the Southern Hemisphere than for the Northern Hemisphere. Nonetheless, Southern Hemisphere sei whales exhibit feeding patterns and prey type selection that are similar to their Northern Hemisphere counterparts. In particular, sei whales feed primarily on copepods, but may also take small shoaling fish and swarms of planktonic crustaceans (Bonner 1986; Iniguez *et al.* 2010). In certain Southern Hemisphere locations, relatively large feeding aggregations have been observed (Reeves *et al.* 2002).

F.4 Competition

There are no specific data on inter-specific competition regarding sei whales and other species in the Southern Hemisphere. However, the sei whale may compete for food resources with a variety of other species, because it feeds at several different trophic levels (Mitchell 1975b; Nemoto and Kawamura 1977). Given its primary prey is copepods, the species may interact ecologically with other major copepod consumers such as clupeid fishes, sand lance, fry and juveniles of larger fishes, basking sharks, and right whales. However, Clapham and Brownell (1996) concluded that there was no convincing evidence that inter-specific competition among baleen whales is affecting population recovery rates.

F.5 Reproduction

See summary in Section D.5.

F.6 Natural Mortality

Two independent approaches to natural mortality rate estimates applied to data from the Southern Ocean gave values on the order of 0.06–0.065 for the natural mortality rates of mature animals of both sexes (Lockyer 1977a). Predation by killer whales and sharks, particularly on young or sick individuals occurs, but observations of such predations are few (see, for example, Ford and Reeves 2008). Sei whales tend to engage in a flight responses to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). In a review of killer whale attacks on mysticete whales (Ford and Reeves 2008), only two incidents of sei whale attacks are noted. Both occurred in waters off Tierra del Fuego, Argentina (one in 1990 and one in 2004) and in both cases the sei whale was driven ashore by the killer whales (Goodall *et al.* 2007).

Endoparasitic helminths (worms) are commonly found in sei whales and can result in pathogenic effects when infestations occur in the liver and kidneys (Rice 1977). However, there is no evidence that this or any other parasite or disease leading to large-scale mortality, although detailed investigations on pathogens and disease are lacking.

F.7 Abundance and Trends

Braham (1991) provided an estimate of 65,000 (no CV) individuals in the Southern Hemisphere pre-exploitation sei whale population; and Mizroch *et al.* (1984b) estimated 63,100 sei whales (no CV) occurred in these waters prior to exploitation. In the Southern Hemisphere, more recent population estimates range between 9,800 and 12,000 (no CV) sei whales (Mizroch *et al.* 1984b; Perry *et al.* 1999). The IWC reported an estimate of 9,718 sei whales (no CV) based on results of surveys between 1978 and 1988 (International Whaling Commission 1996).

G. Threats

A threat is defined as any factor that could represent an impediment to recovery. In this recovery plan all threats, natural and human-related, are considered. The threats were ranked as high, medium, low, and unknown (further research is needed to determine whether it falls into high, medium, or low). Relative Impact to Recovery, which is defined in the last column in the threats table (Table 1) and at the end of each subsection, is a combination of the severity (magnitude, scope, and relative frequency with which the threat is expected to occur) and uncertainty of information for each. There are different types of uncertainty relating to threats. For example, there may be uncertainty about the extent to which something affects sei whales (*e.g.*, ship strikes); whether a factor affects sei whales negatively or positively (*e.g.*, climate change); or how a factor affects sei whales (*e.g.*, anthropogenic noise). Therefore, how severity and uncertainty interact (to produce Relative Impact to Recovery ranking) is unique by situation and may result in combining the above identified categories (*e.g.*, "unknown, but potentially low"). Threats to sei whales are summarized in Table 1.

G.1 Fishery Interactions – UNKNOWN BUT POTENTIALLY LOW

Sei whales, because of their offshore distribution and relative scarcity in U.S. Atlantic and Pacific waters, likely have a relatively low incidence of entrapment and entanglement in fishing gear. This distribution away from human population centers may also diminish the level of detection of entangled sei whales, although in a number of geographic locations fisheries interaction reporting programs are being run or developed. Data on entanglement and entrapment in non-U.S. waters can be largely anecdotal and are not reported systematically because observer coverage is not 100 percent of all fisheries.

Carretta *et al.* (2010) indicated that the offshore drift gillnet fishery is the only fishery likely to take North Pacific sei whales, based on the reasoning that other large whale species have been taken in this fishery in the past. However, there have been no sei whale deaths or serious injuries reported in the fishery. In addition, takes of large whales in this fishery had been much reduced by the early-2000s and there were no documented large whale takes from 2002–2006. With regard to North Atlantic sei whale stock(s), Waring *et al.* (2009) provided only one documented record of a sei whale death resulting from fishery interactions—it took place in September 2006 in Jeffreys Ledge (the gear type was not determined).

Heyning and Lewis (1990) made a crude estimate of about 73 rorquals killed per year in the southern California offshore drift gillnet fishery during the 1980s. Some of these may have been sei whales. Some balaenopterids may also be taken in the drift gillnet fisheries for sharks and swordfish along the Pacific coast of Baja California, Mexico (Barlow *et al.* 1997). Heyning and Lewis (1990) suggested that most whales killed by offshore fishing gear do not drift far enough to strand on beaches or to be detected floating in the nearshore corridor where most whale-watching and other types of boat traffic occur. Thus, the small amount of documentation should not be interpreted to mean that entanglement in fishing gear is an insignificant cause of mortality. Observer coverage in the Pacific offshore fisheries has been too low for any confident assessment of species-specific entanglement rates (Barlow *et al.* 1997). Like other large whale species, sei whales may break through or carry away fishing gear. Whales carrying gear may die later, become debilitated or seriously injured, or have normal functions impaired, but with no evidence of the incident recorded.

The threat of fishing gear entanglement occurs at a low severity level, but with the medium level of uncertainty, the relative impact to recovery of sei whales of this threat is ranked as unknown (Table 1).

G.2 Anthropogenic Noise – UNKNOWN

Humans routinely introduce sound intentionally and unintentionally into the marine environment for underwater communication, navigation, research, and construction. The impact of noise exposure on marine mammals can range from those causing little or no impact to those being potentially severe, depending on noise source level and various other factors. Animal responses to noise may vary with certain factors, including the type and characteristics of the noise source, distance between the source and the receptor, characteristics of the animal (*e.g.*, hearing sensitivity, behavioral context, age, sex, and previous experience with sound source) and time of the day or season (Richardson *et al.* 1995; National Research Council 2003; Wartzok *et al.* 2004; National Research Council 2005; Southall *et al.* 2007). Noise may be intermittent or continuous, steady (non-impulsive) or impulsive, and may be generated by stationary or transient sources. As one of the potential stressors to marine mammal populations, noise may seriously disrupt marine mammal communication, navigational ability, and social patterns. Many marine mammals use sound to communicate, navigate, locate prey, and/or sense their environment. Both anthropogenic and natural sounds may interfere with these functions.

The effects of anthropogenic noise are often difficult to ascertain and research on this topic is ongoing. The possible impacts of the various sources of anthropogenic noise, described below, have not been well studied on sei whales, if at all, although some conclusions from some studies on baleen whales might be generalized for sei whales. The severity of this threat is unknown and there is a high degree of uncertainty associated with the evidence described below. Thus, the relative impact of anthropogenic noise to the recovery of sei whales due to anthropogenic noise is ranked as unknown (Table 1).

Types of Noise: Ambient and Discrete Sources

Ambient or background noise levels are an important consideration in assessing acoustic impacts. Natural (*e.g.*, wind, biologics) and anthropogenic sources contribute significantly to ambient noise levels as a whole (*i.e.*, composite of all sources together) (Wenz 1962). These sound sources can occur locally or contribute from afar, like distant shipping activities (Curtis *et al.* 1999; Andrew *et al.* 2002; McDonald *et al.* 2006; McDonald *et al.* 2008). The ambient noise level of an environment can be quite complicated and vary by location (*e.g.*, involving deep versus shallow water), from day to day, within a day, and/or from season to season. For example, the amount of noise from shipping can be correlated to amount of traffic (*e.g.*, major shipping lanes are louder than areas outside shipping lanes; Hatch *et al.* 2008). Furthermore, soniferous fish species have a seasonal or diel pattern to their vocalizations (*e.g.*, Rountree *et al.* 2006; Sirovic *et al.* 2009). In addition to describing the ambient acoustic environment, sound can be described as discrete sources (*e.g.*, individual seismic vessel, individual tactical sonar, individual ships). More information on sound produced by discrete sources is provided later in this section.

Hearing Damage or Impairment
As mentioned previously, there are no direct measurements of the hearing abilities of most baleen whales. Baleen whale calls are predominantly at low frequencies, mainly below 1 kHz (see section on Hearing and Vocalizations), and it stands to reason that if a species vocalizes in certain frequency ranges, its hearing acuity is good in at least those same ranges. Direct changes in hearing ability from noise exposure have only been measured in a laboratory on a limited number of species (odontocete or pinniped species only) and for only a handful of individuals within those species (see Southall *et al.* 2007 for a review).

The potential effects of continuous or impulse noise sources on sei whales are of particular concern. Intense sound transmissions in the marine environment (*i.e.*, explosives) may impact whales by causing damage to body tissue or gross damage to ears, causing a permanent threshold shift or a temporary threshold shift, if the animal is in close range of a strong sound source or exposed for a long period.

Behavioral Response
Behavioral reactions to noise can vary not only across species and individuals but also for a given individual, depending on previous experience with a sound source, hearing sensitivity, sex, age, reproductive status, geographic location, season, health, social behavior, or context. Severity of responses can also vary depending on characteristics associated with the sound source (*e.g.*, its frequency, whether it is moving or stationary) or the potential of source and individuals co-occurring temporally and spatially (*e.g.*, how close to shore, region where animals may be unable to avoid exposure, propagation characteristics of the area either enhancing or reducing exposure) (Richardson *et al.* 1995; NRC 2003; NRC 2005). As one of the potential stressors to marine mammal populations, noise and acoustic influences could disrupt communication, navigational ability, food finding, and social patterns.

Most observations of behavioral responses of marine mammals to anthropogenic sounds have been limited to short-term behavioral responses, which included the cessation of feeding, resting, or social interactions. Relationships between specific sound sources, or anthropogenic sound in general, and the responses of marine mammals to those sources are still subject to scientific investigation, but no clear patterns have emerged (see Southall *et al.* 2007 for a review). Marine mammals may adapt by altering vocalizations, but acute changes or slight modifications of normal vocalizing behavior or other behavior for an extended period, could have detrimental efficiency and energetic consequences (related, for example, to locating food sources, or locating potential mates). Sensitization (increased behavioral or physiological responsiveness over time) to noise could also exacerbate other effects, and habituation (decreased behavioral responsiveness over time) to chronic noise could result in animals remaining close to noise sources. Sound transmissions could also displace animals from areas for a short or long time period. Noise may also reduce the availability of prey, or increase vulnerability to other hazards, such as fishing gear, predation, etc. (Richardson *et al.* 1995).

It is important to recognize the difficulty of measuring behavioral responses in free-ranging whales. The cumulative effects of habitat degradation are difficult to define and almost impossible to evaluate. Additionally, there is a lack of information on how short-term behavioral responses to noise translate into long-term or population-level effects (National Research Council 2003; Wartzok *et al.* 2004; National Research Council 2005). Responses of sei whales to anthropogenic sounds may depend on the age and sex of animals being exposed, as well as other factors. The behavioral context (*e.g.*, feeding, socializing, or resting) in which whales are exposed is also likely a strong factor in eliciting reactions to a sound stimulus. There is evidence that many individuals respond to certain sound sources, provided the received level is high enough to evoke a response, while other individuals do not. Like other marine mammals, behavioral responses of sei whales to anthropogenic sounds may be highly variable and may not result in the death or injury of individual whales or result in reductions in the fitness of individuals involved. For more specific information on potential impacts of noise associated with military activities, oil and gas exploration, and research, see sections below.

Masking

Masking, or "Auditory Interference," is the obscuring of sounds of interest by interfering sounds and occurs when noise interferes with a marine animal's ability to hear a sound of interest or have its own calls heard. Marine mammals use acoustic signals for a variety of purposes, which differ among species, but include communication between individuals, navigation, foraging, reproduction, and acquisition of information about their environment (Erbe and Farmer 2000; Tyack and Clark 2000). Masking generally occurs when the interfering noise is louder than, and of a similar frequency to, the auditory signal received or produced by the animal. Masking these acoustic signals can disturb the behavior of individual animals, groups of animals, or entire populations.

The size of this "zone of masking" of a marine mammal is highly variable, and depends on many factors that affect the received levels of the background noise and the sound signal (Richardson *et al.* 1995; Foote *et al.* 2004). Masking is influenced by the amount of time that the noise is present, as well as the spectral characteristics of the noise source (*i.e.*, overlap in time, space, and frequency characteristics between noise and receiver). There are still many uncertainties regarding how masking affects marine mammals. For example, it is not known how loud acoustic signals must be for animals to recognize or respond to another animal's vocalizations (National Research Council 2003). It is also unknown if animals listen/respond to all the sounds they can hear or if they can be selective about what they will listen to. Richardson *et al.* (1995) argued that the maximum radius of influence of an industrial noise (including broadband low frequency sound transmission) on a marine mammal is the distance from the source to the point at which the noise can barely be heard. This range is determined by the hearing sensitivity of the animal and/or the background noise level present. Masking by anthropogenic sources is likely to affect some species' ability to detect communication calls and natural sounds (*i.e.*, surf noise, prey noise, etc.; Richardson *et al.* 1995).

Animals may alter their behavior in response to masking. These behavior changes may include producing more calls, longer calls, or shifting the frequency of the calls. For example, two studies indicate that North Atlantic right whales (Parks *et al.* 2007a; Parks *et al.* 2009) and blue whales (Di Iorio and Clark 2010) alter their vocalizations (call parameters or timing of calls) in response to background noise levels. Nonetheless, uncertainties remain regarding how masking affects marine mammals, including sei whales. The potential impacts that masking may have on individual survival, energetic costs associated with, and behavioral changes in response to masking are poorly understood.

G.2.1 Ship Noise – UNKNOWN

Sound emitted from large vessels is the principal source of noise in the ocean today, primarily due to the properties of sound from cargo vessels. Ship propulsion and electricity generation engines, engine gearing, compressors, bilge and ballast pumps, as well as hydrodynamic flow surrounding a ship's hull and any hull protrusions and vessel speed contribute to a large vessels' noise emission into the marine environment. Prop-driven vessels also generate noise through cavitations, which accounts for approximately 85% or more of the noise emitted by a large vessel (Richardson *et al.* 1995; National Research Council 2005). Large vessels tend to generate sounds that are louder and at lower frequencies than small vessels (Polefka 2004).

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans (Simmonds and Hutchinson 1996). Ross (1976) estimated that between 1950 and 1975, shipping caused a rise in ambient noise levels of 10 decibels (dB) (this scale is logarithmic, so a 6 dB increase is a doubling) worldwide. He predicted that this would increase by another 5 dB by the beginning of the 21st century. The National Research Council (2003) estimated that the background ocean noise level at 100 Hz has been increasing by about 1.5 dB per decade since the advent of propeller-driven ships, while others have estimated that the increase in background ocean noise is as much as 3 dB per decade in the Pacific Ocean (Andrew *et al.* 2002; McDonald *et al.* 2006; McDonald *et al.* 2008). Clark *et al.* (2009) recently attempted to quantify the effects of masking on mysticetes, (*i.e.*, fin, North Atlantic right, and humpback whales) exposed to noise from ships and reported that, among other things, whale call rates diminished in the presence of passing vessels. At this time, the severity of the threat of ship noise specifically to sei whales is unknown, and uncertainty of the threat is high. Therefore, the relative impact to recovery of sei whales due to this threat is ranked as unknown (Table 1).

G.2.2 Oil and Gas Exploration and Development – UNKNOWN

A number of activities associated with oil and gas exploration and development result in the introduction of sound into the underwater environment. Loud sound sources from seismic surveys to locate undersea oil reserves may adversely affect marine mammals. Oil and gas exploration, including seismic surveys (airguns), typically operate with marine mammal observers as part of required mitigation measures detailed in incidental take permits issued for the activity. Baleen whales are known to detect the low-frequency sound pulses emitted by airguns and have been observed, in some cases, reacting to seismic vessels (McCauley *et al*. 2000; Stone 2003). All these systems require a vessel platform (or several vessels), which themselves may impact whales. In addition, a variety of devices and technologies are used that introduce energy into the water for purposes of geophysical research, bottom profiling, and depth determination. They are often characterized as high-resolution or low-resolution systems. However, there have been no reported seismic-related or industry ship-related mortalities or injuries to sei whales and other large whale species in areas where marine mammal observers and oil and gas exploration and development operations are present.

During various exploration-related activities, underwater noise is introduced by supply vessels and low-flying aircraft, construction work, and dredging. The transmission of aircraft sound to cetaceans or other marine mammals while they are in the water is influenced by the animal's depth, the aircraft's altitude, aspect, and strength of the noise coming from the aircraft. Generally, the greater the altitude of the aircraft, the lower the sound level received underwater (Richardson *et al*. 1995).

Drilling for oil and gas generally produces low-frequency sounds with strong tonal components—including their occurrence in frequency ranges in which large baleen whales communicate. There are few data on the noise from conventional drilling platforms. Recorded noise from an early study of one drilling platform and three combined drilling production platforms found that noise was so weak it was almost undetectable alongside the platform at Beaufort scale sea states of three or above. The strongest tones were at low frequencies, near 5 Hz (Richardson *et al*. 1995).

For the aforementioned reasons, the severity of this threat is unknown and the uncertainty of this threat is high. Therefore, because of uncertainties associated with the extent and severity of the effects of these activities, the relative impact to recovery of sei whales due to this threat is ranked as unknown (Table 1).

Offshore Energy Development – Low

Anthropogenic noise associated with construction (*e.g.,* pile driving, blasting, or explosives) has the potential to affect sei whales. In-water construction activities such as pile driving can produce sound levels sufficient to disturb marine mammals under certain conditions. The majority of the sound energy associated with pile driving is in the low frequency range (<1,000 Hz) (Illingworth and Rodkin Inc. 2001; Reyff 2003). Several techniques have been adopted to reduce the sound pressure levels to minimize impacts to marine mammals. Because sei whales would only be affected when close to shore, it is assumed that effects would be low in the life cycle of the whale. However, if coastal development occurred in seasonal areas or migration routes where animals concentrate, individuals in the area could be compromised. Scheduling in-water construction activities to avoid those times when whales may be present would likely minimize the disturbance.

In recent years, many Liquefied Natural Gas (LNG) and offshore wind energy projects have been proposed worldwide. The noise generated from construction and operation activities could affect marine mammals located within the vicinity of the project site. In addition, any increase in vessel traffic resulting from construction or operation of an offshore energy facility could negatively impact marine mammals in or moving through the area. While these activities may affect sei whales, in general sei whales occur farther offshore and would not come in contact with wind energy and LNG projects that would need to be located closer to shore to facilitate energy distribution. For more information on vessel impacts, see section G.3.

Based on this information, the threat occurs at a low severity and there is a medium level of uncertainty. Thus, the relative impact to recovery of sei whales due to noise associated with offshore energy development is ranked as low (Table 1).

G.2.3 Military Sonar and Explosives – UNKNOWN

No evidence is available to assess whether military activities in the North Atlantic or North Pacific Oceans have had an impact on sei whale populations. However, the large scale and diverse nature of military activities in this ocean basin mean that there is always potential for disturbing, injuring, or killing these and other whales.

Military training activities by the U.S. Navy and the navies of other countries regularly occur in the Atlantic and adjoining areas (including the Gulf of Mexico, Mediterranean Sea), Indian, and Pacific Oceans. These activities include anti-submarine warfare, surface warfare, anti-surface, mine warfare exercises, missile exercises, sinking exercises, and aerial combat exercises. In addition to these training activities, the U.S. Navy conducts ship shock trials, which involve detonations of high explosive charges.

As part of its suite of training activities, the U.S. Navy employs low-, mid-, and high- active sonar systems. The primary low-frequency active sonar system is the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar system, which produces loud signals in the 100–500 Hz frequency range, and has operated in the western and central Pacific Ocean. The U.S. Navy employs several mid-frequency sonar systems that range from large systems mounted on the hulls of ships (*e.g.*, sonar devices referred to as AN/SQS-53 and -56), to smaller systems that are deployed from helicopters and fixed-wing aircraft, sonobuoys, and torpedoes. These sonar systems can produce loud sounds at frequencies of between 1 and 10 kHz and higher (Evans and England 2001; U.S. Department of the Navy 2008).

The effect of active sonar on sei whales has not been studied and remains uncertain; however, active sonar associated with naval training activities might adversely affect sei whales in several ways. First, low-frequency sonar transmissions that overlap with the frequency ranges of sei whale vocalizations might mask communication between whales which could affect the social ecology and social interactions of sei whale groups. Second, overlap between sei whale hearing and low- and mid-frequency sonar transmissions might result in noise-induced losses of hearing sensitivity or behavioral disturbance as sei whales avoid or evade sonar transmissions. Studies of the effects of SURTASS LFA sonar on mysticetes, specifically foraging blue and fin whales in California, migrating gray whales off California, and singing humpback whales in Hawaii, did not detect biologically significant responses (*e.g.,* detected effects were primarily short-term, with variance between individuals and with context) (U.S. Department of the Navy 2007).

Underwater detonations associated with military training activities range from large explosives such as those associated with sinking exercises or ship shock trials, to missile exercises, gunnery exercises, mine warfare, disposal of unexploded ordnance, and grenades. Detonations produce shock waves and sound fields of varying size. Whales that occur close to a large detonation might be killed or seriously injured; more distant whales might suffer lesser injury (*i.e.,* tympanic membrane rupture, or slight to extensive lung injury); while whales that are still farther away might experience physiological stress responses or behavioral disturbance whose severity depends on their distance from the detonation.

Various measures have been developed to prevent sei whales from being exposed to active sonar transmissions or underwater detonations during testing or exercises, although these measures would not necessarily be employed during combat use. For example, the SURTASS LFA sonar system employs a high-frequency active sonar that allows the U.S. Navy to detect large and most small cetaceans and, if marine mammals are detected, the U.S. Navy is required to shut down sonar transmissions until whales have moved away from the sonar source. As another example, the suite of monitoring protocols the U.S. Navy developed during the ship shock trial on the U.S.S. Winston Churchill were effective at preventing sei whales, other cetaceans, and sea turtles from being exposed to the shock wave associated with those detonations (Clarke and Norman 2005). Other measures are being developed and tested to reduce the probability of exposing sei whales and other cetaceans to active sonar transmissions and shock waves of underwater detonations.

The relatively large spatial scale, frequency, duration, and diverse nature of these training activities in areas in which sei whales occur suggests that these activities have the potential to adversely affect sei whales. However, the severity of the effect of military sonar and detonations on sei whales and the effectiveness of measures that avoid any adverse effects remains largely unknown and the uncertainty of our knowledge is high. Therefore, the relative impact to recovery of sei whales due to this threat is ranked as unknown (Table 1).

G.3 Vessel Interactions

G.3.1 Ship Strikes – UNKNOWN BUT POTENTIALLY LOW

In a database of nearly 300 vessel strike records worldwide between 1975 and 2002, Jensen and Silber (2004) reported two sei whale vessel strikes in the North Atlantic (one each off Massachusetts and Maryland); none having occurred in North Pacific waters; and one record of a ship struck sei whale in 1994 in Hauraki Gulf, New Zealand. A total of three sei whale deaths were attributed to collisions with vessels between 2003 and 2008 in the waters off of the U.S. eastern seaboard (one each off Maine, Maryland, and Virginia) (Nelson *et al.* 2007; Glass *et al.* 2009; Waring *et al.* 2009). One was reported in NMFS stock assessment reports for the waters of the North Pacific Ocean (off Washington) in 2003 (Carretta *et al.* 2010). A global database of large whale ship strikes being administered by the IWC contains a single known sei whale ship strike, having occurred near Dakar, Senegal in March 1998 (R. Leaper, pers. comm.).

It is unclear why records of sei whale ship strikes are disproportionately low as compared to fin whales (Jensen and Silber 2004) which are close taxonomic relatives to sei whales. Sei whale distribution (often occurring at or beyond shelf breaks) and low abundance in areas where vessel traffic is concentrated, and because its distribution renders struck individuals less likely to be detected, may account for a low number of recorded ship strikes.

The possible impacts of ship strikes on recovery of sei whale populations are not well understood. Because many ship strikes go unreported or undetected for various reasons and the offshore distribution of sei whales may make collisions with them less detectable than with other species, the estimates of serious injury or mortality should be considered minimum estimates, thus there is a high level of uncertainty associated with the evidence presented above. The threat occurs at a low severity, but with the high level of uncertainty, the relative impact to recovery of sei whales due to ship strikes is ranked as unknown but potentially low (Table 1).

G.3.2 Disturbance from Whale Watching and Other Vessels – LOW

There are no known directed whale-watch activities that focus on sei whales. Sei whales are observed from whale-watching vessels in eastern North America only occasionally (Edds *et al.* 1984) or in years when exceptional foraging conditions arise (Weinrich *et al.* 1986; Schilling *et al.* 1992). Disturbance of sei whales in the Pacific Ocean is more likely to come from the abundant industrial, military, and fishing vessel traffic off the Mexican, U.S., and Canadian coasts than from the deliberate approaches of whale-watching vessels. In this regard and as noted earlier, low-frequency sounds used by sei whales (McDonald *et al.* 2005; Baumgartner *et al.* 2008; Gedamke and Robinson 2010) for communication and social coordination could be masked or interrupted by noise from vessels or other sources.

In consideration of studies of all large whale species, several investigators reported behavioral responses to close approaches by vessels suggesting that individual whales might experience a stress response (Watkins 1981; Baker *et al.* 1983; Malme *et al.* 1983; Bauer 1986; Bauer and Herman 1986; Baker and Herman 1987; Richardson *et al.* 1995; Jahoda *et al.* 2003). Others suggest that there is mounting evidence that wild animals respond to human disturbance in the same way that they respond to predators (Harrington and Veitch 1992; Lima 1998; Gill *et al.* 2001; Gill and Sutherland 2001; Frid and Dill 2002; Beale and Monaghan 2004; Romero 2004). These responses have been associated with the abandonment of sites (Bartholomew 1949; Allen 1991; Sutherland and Crockford 1993), reduced reproductive success (Giese 1996; Müllner *et al.* 2004), and the death of individual animals (from expending energy and thus compromising their survival) (Feare 1976; Daan *et al.* 1996). However, there is no evidence indicating that these effects are detrimental at the population level.

The potential for injury or disturbance to cetaceans from close proximity of military ships is also a potential threat. NMFS conducted an assessment in its Biological Opinion on Rim of the Pacific exercises, focusing on ship traffic and mid-frequency sonar, and concluded that fin whales in the action area were likely to respond to ship traffic associated with the maneuvers (National Marine Fisheries Service 2008). To the extent sei whales might be exposed to vessel activity associated with these and other military activities, they, too may be adversely affected.

Based on this information, the threat occurs at a low severity and there is a medium level of uncertainty. Thus, the relative impact to recovery of sei whales due to disturbance from vessels and tourism is ranked as low (Table 1).

G.4 Contaminants and Pollutants – LOW

Based on studies of contaminants in baleen whales, including sei whales, pollutants do not appear to be a major threat to sei whales in most areas where sei whales are found. O'Shea and Brownell (1994) indicated that concentrations of organochlorine and metal contaminants in tissues of baleen whales were low, and lower than other marine mammal species. They further stated that there was no firm evidence that levels of organochlorines, organotins, or heavy metals in baleen whales generally were high enough to cause toxic or other damaging effects. In a study of organochlorine exposure and bioaccumulation in another baleen whale, the North Atlantic right whale (*Eubalaena glacialis),* Weisbrod *et al.* (2000) noted that biopsy concentrations were an order of magnitude lower than the blubber burdens of seals and odontocetes. They concluded that there was no evidence to indicate that right whales bioaccumulate hazardous concentrations of organochlorines, and further noted that these were consistent with similar studies of baleen whales (Weisbrod *et al.* 2000). In a review of organochlorine and metal pollutants in marine mammals from Central and South America, Borrell and Aguilar (1999) noted that organochlorine levels in marine mammals (based on studies of franciscana dolphins, *Pontoporia blainvillei*, from Argentina and pantropical spotted dolphins, *Stenella attenuata*, from the eastern tropical Pacific) suggested low levels of exposure compared to other regions of the world. Indeed, although data were extremely scarce, concentrations of organochlorines in the tropical and equatorial fringe of the Northern Hemisphere and throughout the Southern Hemisphere were low or low in marine mammals, and organochlorine concentrations in marine mammals off South America, South Africa and Australia were invariably low (Aguilar *et al.* 2002). The lowest organochlorine concentrations in cetacean species studies were found in the polar regions of both hemispheres. However, due to the systematic long-term transfer of airborne pollutants toward higher latitudes, it is expected that the Arctic and, to a lesser extent, the Antarctic will become major sinks for organochlorines in the future, warranting long-term monitoring of polar regions (Aguilar *et al.* 2002).

The highest concentrations of organochlorines found in cetaceans, including sei whales, are in the Mediterranean Sea. High concentrations of organochlorines in cetaceans also occur, although to a lesser extent, along the Pacific coast of the U.S. and generally in other mid-latitudes in the Northern Hemisphere (Aguilar *et al.* 2002).

Sei whales in some locations are known to accumulate DDT, DDE, and PCBs (Henry and Best 1983; Borrell and Aguilar 1987; Borrell 1993). Males tend to carry larger burdens than females, as gestation and lactation transfer these toxins from mother to offspring, thereby lowering levels in mothers. However, there is no evidence that these or other contaminants are a threat to sei whale populations, or any mysticete species, for that matter.

The sei whale's strong preference for copepods and euphausiids (*i.e.*, low trophic level organisms), at least in the North Atlantic, may make it less susceptible to the bioaccumulation of organochlorine and metal contaminants than, for example, fin, humpback, and minke whales, all of which seem to feed more regularly on fish and euphausiids (O'Shea and Brownell Jr. 1994). Because sei whales off California often feed on pelagic fish as well as invertebrates (Rice 1977), they might accumulate contaminants to a greater degree than do sei whales in the North Atlantic. There is no evidence that levels of organochlorines, organotins, or heavy metals in baleen whales generally (including sei whales) are high enough to cause toxic or other damaging effects (O'Shea and Brownell Jr. 1994). It should be emphasized, however, that very little is known about the possible long-term and trans-generational effects of exposure to pollutants, or about the possible compounding effects of exposure to two or more pollutants, in virtually any marine mammal species.

Oil Spills
Oil spills that occur while sei whales are present could result in skin contact with the oil, baleen fouling, ingestion of oil, respiratory distress from hydrocarbon vapors, contaminated food sources, and displacement from feeding areas (Geraci 1990). Actual impacts would depend on the extent and duration of contact, and the characteristics (*e.g.*, the age) of the oil. Most likely, the effects of oil would include irritation to the respiratory membranes and absorption of hydrocarbons into the bloodstream (Geraci 1990). If a marine mammal was present in the immediate area of fresh oil, it is possible that it could inhale enough vapors to affect its health. Inhalation of petroleum vapors can cause pneumonia in humans and animals, due to large amounts of foreign material (vapors) entering the lungs (Lipscomb *et al.* 1994). Long term ingestion of pollutants, including oil residues, could affect reproductive success, but data are lacking to determine how oil may fit into this scheme for sei whales.

In general, the threat from contaminants and pollutants occurs at a low severity and there is a medium level of uncertainty. Thus, the relative impact to recovery of sei whales due to contaminants and pollution is ranked as low (Table 1). However, this ranking may need to be elevated if future data indicate that reproductive rates are indeed impacted by exposed to contaminants or pollution. For instance, we may obtain new information based on the 2010 Gulf of Mexico oil spill that leads us to reevaluate threats from contaminants in general. Given the limited geographic scope of this spill relative to sei whale distribution, we maintain the low ranking of this threat even in light of this specific event.

G.5 Disease – LOW

Disease presumably plays a role in natural mortality of sei whales, but there are no studies indicating diseases would be expected to threaten this species. Crassicaudiosis was reported in the urinary tract of fin whales (Lambertsen 1986), a species closely related to sei whales. There are no data on, or reports of, diseases in sei whales. However, given the potential but unknown effect of disease on immune suppression, the uncertainty in this determination is considered to be medium and the severity is low. Thus, the relative impact to recovery of sei whales due to disease is considered low.

G.6 Injury from Marine Debris – LOW

Harmful marine debris consists of plastic garbage and other materials washed or blown from land into the sea, fishing gear lost or abandoned by recreational and commercial fishers, and solid non-biodegradable floating materials (such as plastics) disposed of by ships at sea. Examples of plastic and other materials posing potential risks are: bags, bottles, strapping bands, sheeting, synthetic ropes, synthetic fishing nets, floats, fiberglass, piping, insulation, paints, and adhesives. Plastics and other debris may be consumed incidental to normal feeding, and some marine species may actually confuse plastic bags, rubber, or balloons with prey and ingest them. The debris may cause a physical blockage in the digestive system, leading to internal injuries or other types of significant complications.

Observational studies cannot fully evaluate the potential for entanglement in ghost gear because entangled whales may die at sea and thus not be seen or reported. And, documentation of stomach obstruction caused by marine debris have not been documented in sei whales, but there

are documented cases of ingestion of marine debris in both odontocete and mysticete species including, but not limited to, sperm, pygmy sperm (*Kogia breviceps*), and minke whales (*Balaenoptera acutorostrata*) (Viale *et al.* 1991; Tarpley and Marwitz 1993). However, it is not believed to be a major threat to sei whales and the severity of this threat is ranked low. Given the unknown effect of entanglement and ingestion of marine debris on sei whales, the uncertainty in this determination is considered to be medium. Thus, the relative impact to recovery of sei whales due to injury from marine debris is ranked as low
(Table 1).

G.7 Research – LOW

Small group sizes, offshore distributions, and fast swimming speeds make this species less than ideal for directed scientific studies. As a result, there is little directed research on sei whales, although some tagging studies (*e.g.*, Baumgartner and Fratantoni 2008; Baumgartner *et al.* 2008; Olsen *et al.* 2009) have been conducted recently in the North Atlantic Ocean. There is no appreciable threat from this source, and thus the threat is regarded as low.

The effects of research that does not involve the direct study of sei whales are addressed in other subsections of the threats section of this Recovery Plan, such as vessel interactions, anthropogenic noise, contaminants and pollutants, oil and gas exploration, and military sonar and explosives.

Directed research activities could result in disturbance to sei whales, but are closely monitored and evaluated in an attempt to minimize any impacts of research necessary for the recovery of sei whales. Specifically, ESA and MMPA permits are required for research affecting sei whales. The threat occurs at a low severity and a medium level of uncertainty, as the potential (although unlikely) does exist for unobserved mortality to occur following the completion, or in the course, of research activities. Thus, the relative impact to recovery of sei whales due to this threat is ranked as low (Table 1).

G.8 Predation and Natural Mortality – LOW

While there are records of killer whale attacks on sei whales and some shark species likely take individual sei whales, there is no evidence that this is a threat to the population. Thus, the relative impact to recovery from predation and natural mortality is ranked as low, based on low severity and medium uncertainty (Table 1).

G.9 Directed Hunting – MEDIUM

Direct hunts, although rare today, was the main cause of initial depletion of sei whales and other large whales. Initially because of their apparent elusiveness (Ingebrigtsen 1929; Sigurjónsson 1988), and later because of their comparatively small yield of oil and meat, sei whales were generally not hunted while sufficient stocks of right, blue, fin, and humpback whales were available. The introduction of steam power in the second half of that century made it possible for vessels to overtake the large, fast-swimming rorquals, including sei whales, and the use of harpoon-gun technology resulted in a high loss rate (Schmitt *et al.* 1980; Reeves and Barto 1986). The eventual introduction of deck-mounted harpoon cannons made it possible to kill and secure blue, fin, and sei whales on an industrial scale (Tonnessen and Christophersen 1982; Tonnessen and Johnsen 1982).

The IWC's moratorium on the commercial hunting of whales has been in force for more than two decades, and it has almost certainly had a positive effect on the species' recovery. There is currently no commercial whaling for sei whales by IWC member nations party to the moratorium. Iceland has consistently expressed a strong interest in resuming its whaling industry targeting fin, sei, and minke whales (Sigurjónsson 1989). Iceland and Norway[1] do not adhere to the IWC's moratorium on commercial whaling because both countries filed objections or reservations to that moratorium. Japan maintains a program of killing sei whales in its scientific whaling program and up to 100 individuals have been taken each year through 2009 (see below).

It should be noted that there has been no IWC assessment of North Pacific sei whales for a number of years, and therefore the Japanese Special Permit scientific whaling continues to be conducted in the absence of reliable and agreed estimates on abundance and trend of this population. Among other things, as discussed in section E.1, it is likely that there is more than one stock of sei whales in the North Pacific, and Japan's whaling may have a disproportionate effect on the trend in stocks. The most recent comprehensive IWC review was in 1975. During that review, an assessment concluded that there had been a severe decline in the population (as noted in section E.7, from 42,000 in 1963 to 8,600 in 1974). The decline was attributed to the intensive exploitation of sei whales in the North Pacific (Tillman 1977).

Although historical whaling activities were responsible for the depletion of sei and other great whale species worldwide, they are now hunted only by Japan and in relatively small numbers (see below) under its scientific whaling program, and therefore, the current overall threat of overutilization by directed hunts is low. However, if the IWC's moratorium on commercial whaling were ended, hunting could again become a threat to sei whales, so hunting is addressed in this plan. Based on this information, this threat is medium and there is a medium level of uncertainty. Thus, the relative impact to recovery of sei whales due to hunting is ranked as medium (Table 1).

G.9.1 North Atlantic

Sei whales were hunted in large numbers in waters off Norway and Scotland from the very beginning of modern whaling in the late nineteenth and early twentieth centuries (Thompson 1919; Brown 1976; Jonsgård and Darling 1977). In a single year (1885), more than 700 sei whales were killed off Finnmark, Norway (Andrews 1916). According to Ingebrigtsen (1929), sei whale meat was a popular food in Norway, and the value of the meat made the hunting of this species remunerative in the early part of the twentieth century.

[1] In 1982, the IWC adopted a moratorium on the commercial whaling of all whale species, effective from 1986. Norway objected to the moratorium, but nevertheless introduced a temporary ban on minke whaling pending more reliable information on the state of stocks. The Norwegian government unilaterally decided to resume whaling in 1993. Norway's legal right to hunt minke whales is not disputed, as Norway objected to the moratorium when it was adopted by the IWC. Iceland conducts commercial whaling under a reservation to the moratorium.

Small numbers of sei whales were taken off Spain and Portugal and in the Strait of Gibraltar beginning in the 1920s (at least sometimes misidentified as fin whales in the catch statistics; Aguilar and Lens 1981; Aguilar and Sanpera 1982; Sanpera and Aguilar 1992) and by Norwegian and Danish whalers off West Greenland from the 1920s to 1950s (Kapel 1985a). In Iceland, a total of 2,574 sei whales were taken from the Hvalfjördur whaling station between 1948 and 1985 (Sigurjónsson 1988). From the late 1960s or early 1970s, the sei whale was second only to the fin whale as a preferred target of Icelandic whalers. The demand for high-quality meat took precedence over that for sperm whale oil.

A total of 825 sei whales were taken on the Scotian Shelf by whalers operating out of Blandford, Nova Scotia, between 1966 and 1972, and an additional 16 were taken during the same period at Newfoundland shore stations, where the species had also been taken occasionally in earlier whaling episodes (Mitchell 1974; Mitchell and Chapman 1977).

No commercial whaling of sei whales is known to have occurred in the western North Atlantic since 1972, when the Canadian east coast whaling stations closed, or in the central North Atlantic since 1986, the last year of commercial operations by the whaling station at Iceland. Between 1986 an 1988, Icelandic whalers took 70 sei whales under an IWC special research permit; but none have been taken under this program since that time. “Aboriginal subsistence” whaling in Greenland for fin whales, which continues under an IWC quota, could result very occasionally in the killing of a sei whale (Kapel 1985a). A total of three sei whales have been taken under this program from 1986 to present (International Whaling Commission 2010).

Well-documented pirate whaling in the northeastern Atlantic occurred as recently as 1979 (Best 1992; Sanpera and Aguilar 1992), and attempted illegal trade in baleen whale meat has been documented several times during the 1990s (Baker and Palumbi 1994). Since the mid-1970s, there has been some demand in world markets (most of it centered in Japan) for baleen whale meat (Aguilar and Sanpera 1982).

G.9.2 North Pacific

Several hundred sei whales were taken each year by whalers based at shore stations in Japan and Korea between 1910 and the start of World War II (Committee for Whaling Statistics 1942). The species was taken less regularly and in much smaller numbers by pelagic whalers elsewhere in the North Pacific during this period (Committee for Whaling Statistics 1942). Small numbers of sei whales were taken sporadically at shore stations in British Columbia from the early 1900s until the 1950s, when their importance began to increase (Pike and Macaskie 1969). More than 2,000 were killed in British Columbian waters between 1962 and 1967, when the last whaling station in western Canada closed (Pike and Macaskie 1969). Small numbers were taken by shore whalers in Washington (Scheffer and Slipp 1948) and California (Clapham *et al.* 1997) in the early twentieth century, and California shore whalers took 386 from 1957 to 1971 (Rice 1977). Heavy exploitation by pelagic whalers began in the early 1960s, with total catches throughout the North Pacific averaging 3,643 per year from 1963 to 1974 (total 43,719; annual range 1,280–6,053; Tillman 1977). The total reported kill of sei whales in the North Pacific by commercial whalers was 61,500 between 1947 and 1987 (Barlow *et al.* 1997).

Although Japan has taken relatively large numbers of sperm, Bryde's, and minke whales between 1985 and 1988 under the auspices of scientific research, no sei whales were killed. However, between 1988 and 2009, Japan, once again under opposition from many IWC member nations, took 592 sei whales in the northwestern Pacific Ocean (International Whaling Commission 2010). In recent years sei whales were a target species for Japanese North Pacific Special Permit whaling. No sei whales were taken under this program through 2000; but between 2001 and 2003, 91 were taken. Under the conditions of the special permit, 100 sei whales were killed in each year between 2004 and 2008 (International Whaling Commission 2010).

Baker *et al.* (2004) found that meat purchased in markets in Japan in 1998 and 2004 included six cetacean species, including sei whales (32 of 82 market purchased products were tested; and represented at least 20 individual sei whales). The 2003/2004 sei whale sample, which included 14 females and 2 males, represented individuals from both the North Atlantic Ocean and southern hemisphere populations. Therefore, it cannot be assumed that sei whales have been fully protected from commercial whaling since 1986.Southern Hemisphere
Between 1910 and 1975, a total of 152,233 sei whales were killed in commercial whaling activities in the Southern Hemisphere (Horwood 1987). Whaling in the Southern Hemisphere originally targeted humpback whales, but by 1913 this species became rare and operations turned to other species (*e.g.*, fin and blue whales) (Mizroch *et al.* 1984a). As these populations were depleted in the course of several decades, sei whales were targeted. The catch of sei whales increased rapidly in the late 1950s and early 1960s (Mizroch *et al.* 1984b), peaking at over 20,000 individuals taken in 1964. By 1976 the number caught dropped to below 2,000 and commercial whaling for the species ceased in 1977 (Perry *et al.* 1999).

G.10 Competition for Resources – LOW

In a review of the evidence for interspecific competition in baleen whales, Clapham and Brownell (1996) conclude that it was not possible to establish that inter-specific competition comprises an important factor in the population dynamics of large whales. The foraging areas of right and sei whales in the western North Atlantic Ocean overlap. Both whale species feed preferentially on copepods (Mitchell 1975a), and the species may interact ecologically with other copepod feeders. Thus, competitive interactions are possible; however, there is no basis for assuming that competition for food among baleen whales, *per se*, is a factor affecting their population trend and abundance.

Sei whales are largely planktivorous, feeding primarily on euphausiids and copepods, but they are known to take piscine prey (Flinn *et al.* 2002), thus fishery-caused reductions in prey resources could have an influence on sei whale abundance. However, competition with commercial fisheries is expected to be low. If competition were to occur, the effect on sei whales' foraging efficiency resulting from disruption of large prey aggregations due to commercial fishing is not well known. Commercial removal of prey species may have a limited effect on sei whales, particularly if a large biomass remains unharvested and accessible. The species-specific duration and degree of prey disruption due to commercial harvest are also unknown. The severity of this threat was ranked as low and the uncertainty was ranked as medium, thus the relative impact to recovery of sei whales due to this threat is ranked as low.

G.11 Loss of Prey Base Due to Climate and Ecosystem Change – UNKNOWN BUT POTENTIALLY HIGH

Climate change has received considerable attention in recent years, with growing concerns about global warming and the recognition of natural climatic oscillations on varying time scales, such as long term shifts like the Pacific Decadal Oscillation or short term shifts, like El Niño or La Niña. Evidence suggests that the productivity in the North Pacific (Mackas *et al.* 1989; Quinn and Niebauer 1995) and other oceans could be affected by changes in the environment. Increases in global temperatures are expected to have profound impacts on arctic and sub-arctic ecosystems, and these impacts are projected to accelerate during this century (Arctic Climate Impact Assessment 2004; Anisimov *et al.* 2007). The potential impacts of climate and oceanographic change on sei whales will likely affect habitat availability and food availability. Sei whale migration, feeding, and breeding locations may be influenced by factors such as ocean currents and water temperature. Any changes in these factors could render currently used habitat areas unsuitable, and new use of previously unutilized or previously not existing habitats may be a necessity for displaced individuals. Changes to climate and oceanographic processes may also lead to decreased productivity in different patterns of prey distribution and availability. Such changes could affect sei whales that are dependent on those affected prey. Recent work has found that copepod distribution has showed signs of shifting in the North Atlantic due to climate changes (Hays *et al.* 2005).

The feeding range of sei whales is wide and consequently, it is likely that the sei whale may be more resilient to climate change, should it affect prey, than a species with a narrower range. The threat severity posed by environmental variability to sei whale recovery was ranked as medium due to the oceanographic and atmospheric conditions that have changed over the last several decades and the uncertainty was ranked as high, due to the unknown potential impacts of climate and ecosystem change on sei whale recovery and regime shifts on sei whale prey; thus the relative impact to recovery was ranked as unknown but potentially high (Table 1).

The following table provides a visual synopsis of the text regarding threats to sei whales, the sources of these threats, and populations that are affected (where information is available). For each threat, the table describes the severity, including the magnitude, scope and relative frequency with which the threat is expected to occur; the uncertainty of information or effects; and the relative impact to recovery, which is a combination of the severity and uncertainty of each threat. The rankings were developed relative to each other, and put into one of four categories: high, medium, low and unknown (further research is needed to determine whether it falls into high, medium, or low). Ranking assignments were determined by an expert panel with contributions from reviewers.

Table 1. Sei whale threats analysis table.

Reference	Threat	Source	Severity	Uncertainty	Relative Impact to Recovery
			(Unknown, Unknown but Potentially High, Unknown but Potentially Low, Low, Med, High)		
G.1	Injury or mortality from gear entanglement	Drift gillnet fishery, *e.g.*	Low	Medium	Unknown but potentially low
G.2	Anthropogenic Noise				
G.2.1	Ship Noise	Ships	Unknown	High	Unknown
G.2.2	Oil and Gas Activities	Seismic surveys, noise from operation of oil exploration, *e.g.*	Unknown	High	Unknown
G.2.3	Offshore Energy Development	Pile driving, *e.g.*	Low	Medium	Low
G.2.4	Military Sonar and Explosives	Vessel interactions, ship shock trials, low and mid-frequency sonar	Unknown	High	Unknown

Reference	Threat	Source	Severity	Uncertainty	Relative Impact to Recovery
G.3	Vessel interactions				
G.3.1	Ship strikes	Areas of high vessel traffic and/or high speed vessel traffic	Low	High	Unknown but potentially low
G.3.2	Disturbance from Whale Watching and Other Vessels	Whale watching, military vessels, *e.g.*	Low	Medium	Low
G.4	Contaminants and Pollutants	Organochlorines, organotins, heavy metals, *e.g.*	Low	Medium	Low
G.5	Disease	Parasites, other vectors	Low	Medium	Low
G.6	Injury from Marine Debris	Plastic garbage from land, lost/abandoned fishing gear, *e.g.*	Low	Medium	Low
G.7	Disturbance due to Research	Genetic, photographic and acoustic studies, *e.g.*	Low	Medium	Low
G.8	Predation and Natural Mortality	Killer whales, sharks	Low	Medium	Low
G.9	Directed Hunts	Possible Greenlandic aboriginal hunting, Japanese whaling in North Pacific, possible pirate whaling	Medium	Medium	Medium

Reference	Threat	Source	Severity	Uncertainty	Relative Impact to Recovery
G.10	Competition for Resources	Competition with human fisheries	Low	Medium	Low
G.11	Loss of Prey Base due to Climate and Ecosystem Change or Shifts in habitat	Climate and Ecosystem Change	Medium	High	Unknown but potentially high

H. Conservation Measures

The sei whale is protected in the U.S. under both the ESA (listed as endangered) and the MMPA. It is listed as endangered by the World Conservation Union (known as the IUCN) (Baillie and Groombridge 1996) and is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (known as CITES). The CITES classification is intended to ensure that no commercial trade in the products of sei whales occurs across international borders.

Sei whales did not have meaningful protection at the international level until 1970, when catch quotas for the North Pacific began to be set on a species basis (rather than on the basis of total production, with six sei whales considered equivalent to one "blue whale unit"). Prior to that time, the kill was limited only to the extent that whalers hunted selectively for the larger species with greater return on effort (Allen 1980). The sei whale was given complete protection from commercial whaling in the North Pacific in 1976, and quotas on sei whales were introduced in the North Atlantic in 1977. With the moratorium on commercial whaling taking effect in the Northern Hemisphere in 1986, all legal commercial whaling for sei whales stopped.

This Page Intentionally Left Blank

II. RECOVERY STRATEGY

Because the current status of sei whales is unknown, the primary purpose of this Recovery Plan is to provide a research strategy to obtain data necessary to estimate population abundance, trends, and structure, and to identify factors that may be limiting sei whale recovery. Once the population and its threats are more fully understood, this plan may be updated to include possible actions to minimize potential threats. With better understanding, the agency can better determine whether the listing status is appropriate.

A. Key Facts

Little is known about the current status of sei whales. The difficulty of distinguishing sei whales at sea from Bryde's and fin whales has created confusion about their distribution and frequency of occurrence. Sei whales are highly mobile, and there is no information to assess whether they may or may not utilize any particular area year-round. Throughout their range, sei whales occur predominantly in deep water, and sightings are sporadic and usually involve lone individuals or small groups. Therefore, traditional marine mammal survey approaches (such as line transect surveys, photographic identification) have not yielded sufficient data to determine population structure, abundance, or trends. In addition, sei whale occurrence can be unpredictable from year to year, so ideally all areas where the species may occur would need to be covered in one year to avoid the potential of double counting segments of the population. Because of the rarity with which these data are obtained during routine marine mammal research cruises, sufficient data to demonstrate recovery would demand an enormous amount of resources and ship time and would likely take many decades to realize. While traditional marine mammal survey approaches have not yielded sufficient data on sei whales, passive acoustic monitoring data collection methods are showing promise as cost-effective and flexible means of collecting population abundance and trends data on large whales (Baumgartner and Fratantoni 2008).

When the ESA was enacted in 1973, sei whales were included in the List of Endangered and Threatened Wildlife and Plants as endangered because of the threat of commercial whaling. Most populations of sei whales were reduced, some of them considerably, by extensive commercial whaling in the 1950s through the early 1970s. This original direct threat to sei whales was addressed by the IWC's whaling moratorium, and an important element in the strategy to protect sei whale populations is to continue the effective international regulation of whaling. The relative impact to recovery of hunting is currently considered "medium".

Because of the cessation of legal commercial whaling for sei whales, there are now no known "high" level threats to sei whales. The following threats to sei whale populations are considered to have low relative impact to recovery: disturbance from whale watching and other vessels, contaminants and pollutants, disease, marine debris, research activities, predation and natural mortality, and competition for resources. Other potential threats, whose relative impact to recovery is unknown, include fishery interactions, disturbance from anthropogenic noise, collisions with vessels, and loss of prey base due to climate change (see Table 1). More research is needed to ascertain whether these potential threats are impeding sei whale recovery.

B. Recovery Approach

Since the main threat to sei whales (whaling) is being addressed and given the paucity of population data for the species, the primary component of this recovery program is data collection. The collection of additional data will facilitate estimating population size, monitoring trends in abundance, and determining population structure. These data will also provide greater understanding of natural and anthropogenic threats to the species.

This recovery plan incorporates an adaptive strategy that divides recovery actions into three tiers. Tier I includes: 1) continued international regulation of whaling; 2) determine population size, trends, and structure using opportunistic data collection in conjunction with passive acoustic monitoring, if determined to be feasible; and 3) continued stranding response and associated data collection. After ten years of conducting Tier I actions, NMFS expects to evaluate this approach to determine if the approach is providing sufficient data on abundance and distribution (or if more efficient data collection methods become available). If the Tier I method proves to be sufficient, *i.e.*, is providing appropriate information to estimate population abundance, trends, and structure, and to more clearly identify factors that may be limiting sei whale recovery, NMFS will continue Tier I data collection activities. If Tier I data collection methods are insufficient, NMFS will consider Tier II actions, building upon research conducted during Tier I. If after a few years of acoustic data collection it is clear that the acoustic work is not effective, NMFS will reassess its strategy and move to tier II if resources are available.

Tier II adds more extensive directed abundance and distribution survey research and actions that are dependent upon acquiring comprehensive information (*e.g.*, assessment of threats currently ranked as unknown). Some Tier I and II actions can occur simultaneously if possible (they are not mutually exclusive). Some Tier III recovery actions depend upon data collected in Tiers I and/or II. When sufficient data are obtained, Tier III recovery activities will be undertaken as feasible, and can be undertaken before all Tier I and II actions are complete. Costs have been estimated for Tier I recovery actions only.

III. RECOVERY GOALS, OBJECTIVES, AND CRITERIA

A. Goals

The goal of this Recovery Plan is to promote recovery of sei whales to levels at which it becomes appropriate to "downlist" them from endangered to threatened status, and ultimately to "de-list", or remove them from the list of Endangered and Threatened Wildlife and Plants, under the provisions of the ESA. The Act defines an "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." A "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."

B. Objectives and Criteria

The two main objectives for sei whales are to 1) achieve sufficient and viable populations in all ocean basins, and 2) ensure significant threats are addressed. A prerequisite to achieving these objectives is obtaining sufficient data to determine whether they have been met. Likewise, recovery criteria take two forms: 1) those that reflect the status of the species itself and 2) those that indicate effective management or elimination of threats. The former criterion may explicitly state a certain risk of extinction as a threshold for downlisting or delisting and uses models based on at least abundance and trends in abundance to assess whether this threshold has been reached. Since sei whales are currently globally listed, all ocean basins where sei whales occur would need to meet these criteria.

Guidance on appropriate levels of risk for down-listing and de-listing decisions was developed in a workshop for large cetaceans (Angliss *et al.* 2002). This guidance was employed in the North Atlantic Right Whale Recovery Plan criteria (National Marine Fisheries Service 2005) and is also appropriate here. The following framework was suggested:

- A large cetacean species shall no longer be considered endangered when, given current and projected conditions, the probability of quasi-extinction is less than 1% in 100 years;
- A large cetacean species shall no longer be considered threatened when, given current and projected conditions, the probability of becoming endangered is less than 10% in a period of time no shorter than 10 years and no longer than 25 years (in the case of the sei whale the period of 25 years is considered necessary given imprecise abundance estimates); and
- Recurrence of threats that brought the species to the point that warranted listing and current threats to the species have been addressed.

B.1 Downlisting Objectives and Criteria

Sei whales will be considered for reclassifying from endangered to threatened when all of the following are met (Table 2).

Objective 1: Achieve sufficient and viable populations in all ocean basins

Criterion: Given current and projected threats and environmental conditions, the sei whale population in each ocean basin in which it occurs (North Atlantic, North Pacific and Southern Hemisphere) satisfies the risk analysis standard for threatened status (has no more than a 1% chance of extinction in 100 years) *and* the global population has at least 1,500 mature, reproductive individuals (consisting of at least 250 mature females and at least 250 mature males in each ocean basin). Mature is defined as the number of individuals known, estimated, or inferred to be capable of reproduction. Any factors or circumstances that are thought to substantially contribute to a real risk of extinction that cannot be incorporated into a Population Viability Analysis will be carefully considered before downlisting takes place.

The International Union for the Conservation of Nature and Natural Resources (IUCN) maintains a "Redlist" to classify species and populations worldwide according to their extinction risk. The IUCN system was designed to provide an objective method for classifying a wide variety of species with varying amounts and kinds of data available. The IUCN Redlist criteria are used to classify species into four different risk categories: Critically Endangered, Endangered, Vulnerable, and Least Concern. The IUCN Redlist uses five criteria: A. magnitude of population reduction, B. geographic range, C. abundance and trends in abundance, D. abundance alone (population size numbers fewer than 50 mature individuals), and E. quantitative estimate of the probability of extinction. For criteria D, the IUCN Redlist uses a tiered approach, expressing increasing levels of risk. These levels are <1,000 mature individuals for Vulnerable, <250 mature individuals for Endangered, and <50 mature individuals for Critically Endangered.

The IUCN categories do not equate directly to the ESA categories of Endangered and Threatened. However, the three IUCN population levels are based on standards in the conservation literature that can be used to provide a relative measure of risk. Relative to the IUCN criteria, in each ocean basin the downlisting criteria for abundance alone contained in this plan are more protective, in that they are higher, than the IUCN "Endangered" threshold (<250 mature to be Endangered), but less protective than the IUCN "Vulnerable" threshold (<1,000 mature). However, at a global scale, this is more protective than the IUCN "Vulnerable" category, as <1,000 mature is less than the total of 1,500 mature across 3 ocean basins.

Objective 2: Ensure significant threats are addressed

Criteria: Factors that may limit population growth, *i.e.*, those that are identified in the threats analysis under relative impact to recovery as high or medium or unknown, have been identified and are being or have been addressed to the extent that they allow for continued growth of populations. Specifically, the factors in 4(a)(l) of the ESA are being or have been addressed as follows:

Factor A: The present or threatened destruction, modification, or curtailment of a species' habitat or range.

- Effects of reduced prey abundance due to climate change continue to be investigated and action is being taken to address the issue, as necessary.

- Effects of anthropogenic noise continue to be investigated and actions taken to minimize potential effects, as necessary.

Factor B: Overutilization for commercial, recreational, or educational purposes.

- Management measures are in place that ensure that any hunting (commercial, subsistence, and scientific) is at a sustainable level.

Factor C: Disease or Predation.

There are no criteria for this factor because there are no data to indicate that disease or predation are more than low threats.

Factor D: The inadequacy of existing regulatory mechanisms.

Hunting is addressed under Factor B.

Factor E: Other natural or manmade factors affecting its continued existence.

- Ship collisions continue to be investigated and actions taken to minimize potential effects, as necessary.

- Entanglement with gear associated with the offshore gillnet fishery continues to be investigated and actions taken to minimize potential effects, as necessary.

It is important to emphasize that sei whales will be considered for downlisting only when all criteria are met globally—minimum abundance level is met, risk analysis standard for threatened status (has no more than a 1% chance of extinction in 100 years) has been satisfied, and all known threats have been addressed (see Table 2).

B.2 Delisting Objectives and Criteria

Sei whales will be considered for removal from the list of Endangered and Threatened Wildlife and Plants under the provisions of the ESA when all of the following are met:

Objective 1: Achieve sufficient and viable populations in all ocean basins

Criterion: Given current and projected threats and environmental conditions, the sei whale population in each ocean basin in which it occurs (North Atlantic, North Pacific, and Southern Hemisphere) satisfies the risk analysis standard for unlisted status (has less than a 10% probability of becoming endangered (has more than a 1% chance of extinction in 100 years) in 20 years). Any factors or circumstances that are thought to substantially contribute to a real risk of extinction that cannot be incorporated into a Population Viability Analysis will be carefully considered before delisting takes place.

Objective 2: Ensure significant threats are addressed

Criteria: Factors that may limit population growth (those that are identified in the threats analysis as high or medium or unknown) have been identified and are being or have been addressed to the extent that they allow for continued growth of populations. Specifically, the factors in 4(a)(l) of the ESA are being or have been addressed as follows:

Factor A: The present or threatened destruction, modification, or curtailment of a species' habitat or range.

- Effects of reduced prey abundance due to climate change have continued to be investigated and any necessary actions being taken to address the issue are shown to be effective or this is no longer believed to be a threat.

- Effects of anthropogenic noise have continued to be investigated and any necessary actions being taken to address the issue are shown to be effective or this is no longer believed to be a threat.

Factor B: Overutilization for commercial, recreational, or educational purposes.

- Management measures are in place that ensure that any hunting (commercial, subsistence, and scientific) is at a sustainable level.

Factor C: Disease or Predation.

There are no criteria for this factor because there are no data to indicate that disease or predation are more than low threats.

Factor D: The inadequacy of existing regulatory mechanisms.

Hunting is addressed under Factor B.

Factor E: Other natural or manmade factors affecting its continued existence.

- Ship collisions continue to be investigated and actions being taken to address the issue are shown to be effective or this is no longer believed to be a threat.

o

- Entanglement with gear associated with the offshore gillnet fishery continues to be investigated and actions being taken to address the issue are shown to be effective or this is no longer believed to be a threat.

Table 2. Criteria for considering reclassification (from endangered to threatened or from threatened to not listed) for sei whales.

	Minimum population		**PVA**		**Threats**
Downlisted	≥1,500 mature, reproducing individuals, including 250 females and 250 males in ***each*** ocean basin	***AND***	<1% Probability of extinction in 100 years	***AND***	Are being or have been addressed
Delisted	(Not specified, but implicitly must be ≥1,500)	***AND***	<10% Probability of becoming endangered in 20 years	***AND***	Have been addressed

This Page Intentionally Left Blank

IV. RECOVERY PROGRAM

A. Recovery Action Outline

Items in this outline are not in order of priority. Priorities are identified in the Implementation Schedule below.

TIER I
After ten years of conducting Tier I actions, NMFS expects to evaluate this approach to determine if the approach is providing sufficient data (or if more efficient data collection methods become available). If the Tier I method proves to be sufficient, NMFS will continue Tier I data collection activities.

1.0 Coordinate State, Federal, and International Actions to Maintain International Regulation of Whaling for Sei Whales.

2.0 Develop and Apply Methods to Collect Sei Whale Data.

2.1 *Investigate the feasibility of using passive survey methods to estimate the relative and/or absolute abundance of sei whales.*

2.2 *If feasible, conduct passive acoustic studies to collect data on sei whale populations in U.S. waters.*

2.2.1 Collect sei whale acoustic data using archival bottom mounted recorders.

2.2.1.1 Collect sei whale acoustic data using archival bottom mounted recorders in the Northwest Atlantic Ocean.

2.2.1.2 Collect sei whale acoustic data using archival bottom mounted recorders in the Eastern North Pacific Ocean.

2.2.1.3 Collect sei whale acoustic data using archival bottom mounted recorders in the Central North Pacific Ocean.

2.2.2 Collect sei whale acoustic data using sonobuoys, in U.S. waters.

2.2.2.1 Collect sei whale acoustic data using sonobuoys in the Northwest Atlantic Ocean.

2.2.2.2 Collect sei whale acoustic data using sonobuoys in the Eastern North Pacific Ocean.

2.2.2.3 Collect sei whale acoustic data using sonobuoys in the Central North Pacific Ocean.

2.2.3 Opportunistically collect sei whale acoustic data using acoustic tags, if feasible, in U.S. waters.

2.2.3.1 Opportunistically collect sei whale acoustic data using acoustic tags in the Northwest Atlantic Ocean.

2.2.3.2 Opportunistically collect sei whale acoustic data using acoustic tags in the Eastern North Pacific Ocean.

2.2.3.3 Opportunistically collect sei whale acoustic data using acoustic tags in the Central North Pacific Ocean.

2.2.4 Collect sei whale acoustic data using autonomous gliders in U.S. waters.

2.2.4.1 Collect sei whale acoustic data using autonomous gliders in the Northwest Atlantic Ocean.

2.2.4.2 Collect sei whale acoustic data using autonomous gliders in the Eastern North Pacific Ocean.

2.2.4.3 Collect sei whale acoustic data using autonomous gliders in the Central North Pacific Ocean.

2.3 *Continue opportunistic data collection to estimate abundance and monitor trends.*

2.3.1 Continue opportunistic data collection to estimate abundance and monitor trends in the Atlantic Ocean.

2.3.2 Continue opportunistic data collection to estimate abundance and monitor trends in the Pacific Ocean.

2.4 *If actions 2.2 and 2.3 prove successful at providing sufficient data, extend passive acoustic and opportunistic data collection to international waters.*

3.0 Support existing studies to investigate population discreteness and population structure of sei whales using genetic analyses.

3.1 *Opportunistically collect biopsy samples in the Atlantic and Pacific Oceans.*

3.2 *Collaborate with foreign agencies and researchers to obtain genetic samples.*

3.3 *Perform genetic analyses on preserved samples.*

3.4 *If feasible, locate and consolidate existing sei whale photo-identification catalogs.*

4.0 Continue to Collect Data on "Unknown" Threats to Sei Whales.

4.1 *Opportunistically collect data on the impacts of climate change on sei whales.*

4.2 *Opportunistically collect data on injury and mortality caused by fisheries and fishing equipment.*

4.3 *Opportunistically collect data on mortality and serious injury from vessel collisions.*

4.4 *Opportunistically collect data on the effects of anthropogenic noise on the distribution, behavior, and productivity of sei whales.*

5.0 Maximize Efforts to Acquire Scientific Information from Dead, Stranded, and Entangled Sei Whales.

5.1 *Continue to respond to strandings of dead sei whales in U.S. waters.*

5.1.1 Continue and improve programs to maximize data collected from the necropsy of sei whale carcasses.

5.1.2 Maintain and review, and, if needed, improve the system for reporting dead, stranded, or entangled sei whales.

5.1.3 Improve, or, as necessary, develop and implement protocols for securing and retrieving stranded (on land) or floating (at sea) sei whale carcasses.

5.2 *Review, analyze, and summarize data on stranded sei whales on an annual basis.*

5.3 *Establish reliable sources of funding for rescue, necropsy, tissue collection, and analysis efforts.*

TIER II

If Tier I data collection methods are insufficient, NMFS will consider Tier II actions, building upon research conducted during Tier I.

6.0 Estimate Population Size and Monitor Trends in Abundance.

6.1 *Determine the best means to maximize (shipboard and aerial) survey efforts to assess sei whale status and trends.*

6.2 *Conduct surveys to estimate abundance and monitor trends in sei whale populations worldwide.*

6.2.1 Estimate abundance and monitor trends in the Atlantic Ocean.

6.2.2 Estimate abundance and monitor trends in the Pacific Ocean.

6.2.3 Estimate abundance and monitor trends in the Southern Hemisphere.

6.3 *Develop an intensive and geographically broad scale program to obtain biopsies of sei whales for mark-recapture abundance estimation.*

7.0 Initiate New Studies to Determine Population Discreteness and Population Structure of Sei Whales.

7.1 *Initiate new studies to investigate population discreteness and population structure of sei whales using genetic analyses, including directed surveys to collect biopsy samples of sei whales in the Atlantic and Pacific Oceans.*

7.2 *Assess daily and seasonal movements and inter-area exchange, using telemetry and photo-identification.*

7.2.1 Conduct telemetry and photo-identification studies of sei whales in the Atlantic Ocean.

7.2.2 Conduct telemetry and photo-identification studies of sei whales in the Pacific Ocean.

7.2.3 Conduct telemetry and photo-identification studies of sei whales in the Southern Hemisphere.

TIER III

Tier III recovery actions depend upon data collected in Tiers I and/or II. When sufficient data are obtained, Tier III recovery activities will be undertaken as feasible.

8.0 Conduct Risk Analyses.

8.1 *Conduct risk analyses for the North Atlantic Ocean.*

8.2 *Conduct risk analyses for the North Pacific Ocean.*

8.3 *Conduct risk analyses for the Southern Hemisphere.*

9.0 Identify, Characterize, Protect, and Monitor Habitat Important to Sei Whale Populations in U.S. Waters and Elsewhere.

9.1 *Characterize sei whale habitat.*

9.2 *Monitor important habitat features and sei whale use patterns to assess potentially detrimental shifts in these features that might reflect disturbance or degradation of habitat.*

9.3 *Promote actions to protect important habitat in U.S. waters.*

9.4 *Promote actions to define, identify, and protect important habitat in foreign or international waters.*

9.5 *Improve knowledge of sei whale feeding ecology.*

10.0 Investigate Human-Caused Threats, and, Should they be Determined to be Medium or High, Reduce Frequency and Severity.

10.1 *Investigate and, if medium or high ranked threat, reduce injury and mortality caused by fisheries and fishing equipment and reduce depredation.*

10.1.1 Conduct a systematic review of data on sei whale interactions with fishing operations.

10.1.2 Review photographic databases for evidence of injuries to sei whales caused by encounters with fishing gear to better characterize and understand fishing gear interactions.

10.1.3 Investigate the development of a system to non-lethally deter sei whales from fishing gear.

10.1.4 Conduct studies of gear modifications that reduce the likelihood of entanglement, mitigate the effects of entanglements, and enhance the possibility of disentanglement. Determine whether measures to reduce entanglements are effective.

10.1.5 Develop and implement schemes to reduce the rate at which gear is lost, and improve the reporting of lost gear.

10.1.6 Continue to review, evaluate, and act upon reports from fishermen and fishery observers of fishery interactions with sei whales.

10.2 *Investigate and, if medium or high ranked threat, reduce injury and mortality caused by anthropogenic noises.*

10.3 *Investigate and, if medium or high ranked threat, reduce mortality and serious injury from vessel collisions.*

10.3.1 Identify areas where concentrations of sei whales coincide with significant levels of maritime traffic.

10.3.2 Identify specific areas where recorded ship strikes of sei whales have occurred and conduct studies to identify ecosystem-based traits that could support an assemblage of predictive tools.

10.3.3 Conduct analyses of shipping routes and important sei whale habitat areas to determine the risk of ship collisions with sei whales.

10.3.4 Work with mariners, the shipping industry, and appropriate state, federal, and international agencies to develop and implement regionally-based measures to reduce the threat of ship strikes. Assess the effectiveness of ship strike measures and adjust, as necessary.

10.3.5 Explore possible mechanisms to encourage vessels that have struck a whale to report the incident.

10.3.6 Review photographic databases for evidence of injuries to sei whales caused by ships to better characterize and understand vessel collisions.

10.4 *Investigate the impacts of climate change on sei whales and seek strategies to reduce any impacts found to be detrimental to sei whales and their habitat.*

10.4.1 Conduct studies and perform analyses to assess the effects of climate change on the distribution, behavior, and productivity of sei whales.

10.4.2 Seek strategies to reduce any detrimental impacts of climate change on sei whales and their prey and habitats.

11.0 Develop Post-Delisting Monitoring Plan.

B. Recovery Action Narrative

As noted elsewhere in this Plan, sei whales generally do not occur in coastal waters (and thus, are difficult and expensive to study), and little is known about the species' population structure and its specific patterns of distribution. Sei whales are rarely seen at sea; therefore, a number of customary approaches to addressing these uncertainties are not practicable in the short term for this species. Nonetheless, the Plan identifies techniques and study approaches that might be used to address uncertainties in ideal situations even though some are not feasible at this time. If possible, analyses should be directed at examining trends over time, and attempts should be made to correlate observed changes in whale populations with physical, biological, or human-induced changes in the environment.

TIER I

After ten years of conducting Tier I actions, NMFS expects to evaluate this approach to determine if the approach is providing sufficient data (or if more efficient data collection methods become available). If the Tier I method proves to be sufficient, NMFS will continue Tier I data collection activities.

1.0 Coordinate State, Federal, and International Actions to Maintain International Regulation of Whaling for Sei Whales.

A coordinated approach to the tasks described in this Recovery Plan would greatly facilitate their completion. The establishment of a team charged with coordinating state and federal implementation efforts, and with pursuing international cooperative efforts, is highly desirable. Liaison efforts between the team and the lead agency would be the responsibility of the designated individual from the latter body.

Cooperate with the IWC (and other relevant international bodies or agreements) to ensure that any whaling of sei whales is conducted on a sustainable basis and that all whaling activity is conducted within the purview of the IWC. The international regulation of whaling is vital to the recovery of whale populations. This is particularly true for sei whales because of their wide distribution and far-ranging movements. In no location is there sufficient information on sei whale population size, trends, and structure to justify the resumption of exploitation.

2.0 Develop and Apply Methods to Collect Sei Whale Data.

2.1 *Investigate the feasibility of using passive survey methods to estimate the relative and/or absolute abundance of sei whales.*

Sei whales primarily occur in pelagic open-ocean areas where marine mammal surveys are rare or absent. The cost of surveys for abundance or trends in those areas will be very high due to the logistical challenges. Passive acoustic methods have potential utility in reducing the costs of monitoring relative abundance and estimating minimum abundance for sei whales. Like other *balaenopterid* whales, sei whales make low-frequency vocalizations that are audible over long distances in the ocean. The breeding calls of many species (believed to be made only by males) can be used to identify species and, in some cases, populations. Researchers are working to develop methods to estimate whale abundance using passive acoustic monitoring stations. However, additional studies are needed (*e.g.*, detectability and detectability at distances, and the ability to discern sei whale vocalizations from those of other large whale species) to evaluate the feasibility of acoustic surveys for sei whales. Where passive acoustic data collections exist, analyze to identify and, if possible enumerate, sei whale occurrence.

2.2 *If feasible, conduct passive acoustic studies to collect data on sei whale populations in U.S. Waters.*

Detection of underwater calls of a number of cetacean species has been used in studies of cetacean occurrence and distribution. Large whale species tend to vocalize rather often, depending on behavioral, social, and other contexts, and the technique has proven effective in determining presence (but not absence) of large whales. With arrays of three or more detection elements (to enable “triangulation”) information on distribution and, in some cases abundance, can be determined. Bottom-mounted recording element systems have been used to detect baleen whales with considerable success. Particularly when considered relative to vessel- or aircraft-based observer surveys, passive acoustic techniques are highly cost-effective, are less limited by poor weather conditions and thus are able to make observations more consistently, and pose fewer risks to human observers. Therefore, and particularly with regard to their cost-effectiveness attributes, passive acoustic studies should be used, if feasible, in attempts to determine sei whale occurrence, distribution, abundance, trends in abundance, and possibly response to some threats (*e.g.*, anthropogenic underwater noise). It is possible that sei whale calls exhibit dialects or regionally specific call types and therefore, this technique may also help provide some information on stock structure.

2.2.1 Collect sei whale acoustic data using archival bottom mounted recorders.

2.2.1.1 Collect sei whale acoustic data using archival bottom mounted recorders in the Northwest Atlantic Ocean.

For the past decade, the NMFS Northeast Southeast Fisheries Science Center’s have collaborated with the Woods Hole Oceanographic Institution and Cornell University to develop methods for application of passive acoustics to remotely identify and enumerate marine species in the Northwest Atlantic Ocean. Initial development of bottom mounted autonomous marine acoustic recording units (MARUs) in the late 1990s have evolved to the point where there are now semi permanent arrays of MARUs in the Massachusetts/Cape Cod Bay area and along the Southeast US coast, which continuously record and archive marine sounds in the 10Hz to 10kHz range. MARUs are deployed/retrieved quarterly. MARUs are superior data collection platforms to vessel and aircraft when only presence of whales is of concern because:

- They appear to detect (and locate) many more animals than simultaneous visual surveys.
- They are largely unaffected by viewing conditions (*e.g.*, darkness, fog and sea state) and can provide a method for detecting the presence of animals year-around.
- They are safer than aerial surveys, and on an area-specific basis may be more cost efficient.
- They can provide data on a host of species simultaneously and when coupled with other sensors, can provide information about habitat (*e.g.*, oceanographic conditions, prey distribution).

The major drawback of the current technology is the limited listening range of the units, which necessitates very dense deployments (thus increasing the cost). Recorders have detected sei whale calls in the Atlantic Ocean; however, sei whale calls are similar to certain fin whale calls and little work has been done in attempts to differentiate sei whale vocalizations from those of Bryde's whales, making species differentiation difficult. In addition, little or nothing is known about sei whale call rates and whether these rates differ by gender, age, location, behavior or other factors. Therefore, technological refinement is necessary before any large-scale sei whale passive acoustic study is initiated.

2.2.1.2 Collect sei whale acoustic data using archival bottom mounted recorders in the Eastern North Pacific Ocean.

Should arrays of bottom-mounted recorders be deployed in the Pacific Ocean, certain considerations must be made for oceanographic conditions. Given the difficulty accessing likely sites, it is unrealistic to deploy and retrieve recorders quarterly. More realistically, recorders would be deployed and retrieved annually. To maximize cost efficiency, deploy and retrieve arrays in conjunction with other scheduled research cruises, adding one day to ship time to the trip for passive acoustic work. This assumes subsequent research cruises will return to the passive acoustic recording site. When deployed for 12-month periods, the recorders must be programmed to record on a cycle (rather than 24 hours per day) to conserve/account for battery life.

2.2.1.3 Collect sei whale acoustic data using archival bottom mounted recorders in the Central North Pacific Ocean.

2.2.2 Collect sei whale acoustic data using sonobuoys, in U.S. waters.

For decades, the U.S. Navy has used "sonobuoy" to record the sound of submarines. Sonobuoys can be deployed either from an aircraft or a surface ship and includes a single underwater hydrophone and a radio transmitter to send the recorded signals back to the aircraft or ship via

VHF radio to operators onboard the vessel. Thus, remote or difficult to access locations can be sampled. By deploying multiple sonobuoys in a pattern, researchers can determine the location of the "target". Sonobuoys provide real-time, full bandwidth acoustic data to researchers on board ships. The buoys are capable of transmitting data for a few hours before sinking. The short life span of the device prohibits long-term monitoring of ocean sounds; however the technology provides a relatively low-cost method for recording underwater acoustic behavior of marine mammals. Sonobuoys have been used recently in ocean exploration to record marine mammal calls and listen for earthquake activity

Similar to action 2.2.1, the application of this technology to sei whale research is limited by the ability to clearly distinguish sei whale calls from other ocean sounds, and refinement of this technology (in its capacity to reliably detect sei whales) is necessary before sonobuoy passive acoustic studies can provide information on sei whale distribution and abundance. Hence, this recovery action is dependent upon successful completion of action 2.1.

2.2.2.1 Collect sei whale acoustic data using sonobuoys in the Northwest Atlantic Ocean.

2.2.2.2 Collect sei whale acoustic data using sonobuoys in the Eastern North Pacific Ocean.

2.2.2.3 Collect sei whale acoustic data using sonobuoys in the Central North Pacific Ocean.

Sonobuoys are currently being used on marine mammal research cruises by the Pacific Islands Fisheries Science Center to collect acoustic data. The units are deployed systematically (2–3 units per day) as well as opportunistically when marine mammal species of interest are sighted.

2.2.3 Opportunistically collect sei whale acoustic data using acoustic tags, if feasible, in U.S. waters.

Should researchers encounter sei whales while conducting marine mammal research cruises, opportunistically deploy acoustic tags if possible. Multi-sensor, synchronous motion, acoustic recording tags can provide fine scaled data on the underwater behavior of whales. The results allow virtual visualization of the underwater activities of a tagged animal, concurrent with the sounds the animal makes and is exposed to. It should be noted that given the rarity of encounters with sei whales, it is highly unlikely that this action would be feasible.

2.2.3.1 Opportunistically collect sei whale acoustic data using acoustic tags in the Northwest Atlantic Ocean.

2.2.3.2 Opportunistically collect sei whale acoustic data using acoustic tags in the Eastern North Pacific Ocean.

2.2.3.3 Opportunistically collect sei whale acoustic data using acoustic tags in the Central North Pacific Ocean.

2.2.4 Collect sei whale acoustic data using autonomous gliders in U.S. waters.

The distribution and habitat of marine mammals, including sei whales, can be studied along predetermined transect lines using autonomous gliders equipped with instrumentation to: 1) record low and mid-frequency marine mammal vocalizations, 2) detect, classify, and remotely report vocalizations of interest, and 3) measure high-frequency acoustic backscatter, chlorophyll fluorescence and oceanographic conditions. The passive acoustic data can be used to document the distribution of acoustically active marine mammals, including sei whales, and accompanying environmental measurements will be used to characterize the oceanographic conditions in relation to acoustic activity.

Autonomous gliders allow researchers to collect data in areas they are not able to access or in seasons they cannot survey with other means. Onboard detectors for baleen whales currently exist for gliders. Current longevity for gliders is six weeks, thus costs are for multiple 6-week surveys.

2.2.4.1 Collect sei whale acoustic data using autonomous gliders in the Northwest Atlantic Ocean.

2.2.4.2 Collect sei whale acoustic data using autonomous gliders in the Eastern North Pacific Ocean.

2.2.4.3 Collect sei whale acoustic data using autonomous gliders in the Central North Pacific Ocean.

2.3 *Continue opportunistic data collection to estimate abundance and monitor trends.*

Researchers equipped to collect data on other whale species within U.S. waters should be encouraged to collect data on sei whales (including sightings data and satellite tagging, as feasible), on an opportunistic basis. Costs in the implementation table include equipment deployed (such as tags) and analysis of any samples collected.

2.3.1 Continue opportunistic data collection to estimate abundance and monitor trends in the Atlantic Ocean.

2.3.2 Continue opportunistic data collection to estimate abundance and monitor trends in the Pacific Ocean.

2.4 *If actions 2.2 and 2.3 prove successful at providing sufficient data, extend passive acoustic and opportunistic data collection to international waters.*

3.0 Support existing studies to investigate population discreteness and population structure of sei whales using genetic analyses.

Existing knowledge of the population structure and taxonomy of sei whales is insufficient, and a more comprehensive understanding is essential for developing strategies to promote recovery and for classifying the populations according to their recovery status.

3.1 *Opportunistically collect biopsy samples in the Atlantic and Pacific Oceans.*

Researchers equipped to sample other whale species (*e.g.*, right and humpback whales) within U.S. waters, particularly in more remote areas where sei whale samples have not previously been obtained, should be encouraged to take advantage of opportunities to obtain samples from sei whales. Costs in the implementation table include equipment deployed and analysis of any samples collected.

3. 2 *Collaborate with foreign agencies and researchers to obtain genetic samples.*

Collaborative efforts with foreign (particularly Canadian, Mexican, Greenlandic, and Icelandic) agencies and researchers will probably be necessary to obtain sufficient samples over wide enough areas for conclusive analyses. Standard sampling protocols and analytical procedures should be used. Costs in the implementation table include equipment deployed and analysis of any samples collected.

3.3 *Perform genetic analyses on preserved samples.*

The genetics work should be complemented by a thorough review of existing data from whaling and other sources. This might include investigation of geographical variation in morphology and meristics of sei whales. New methods examining stable isotopes and fatty acids have also proven effective auxiliary data in cases where there is population mixing (*i.e.*, genetically distinct groupings mix spatially usually on the feeding grounds). Any such methods that can assist in resolving population structure should be encouraged. Costs in the implementation table include analysis.

3.4 *If feasible, locate and consolidate existing sei whale photo-identification catalogs.*

Efforts should be made to locate and consolidate photo-identification data that may exist in various laboratories or individual researcher collection. A central repository for sei whale photographs, and a system for curating and analyzing them, should be established. These data should be used to assess possible human impacts and to help determine population sizes. The scientific importance of such catalogs has been demonstrated with numerous species, and the possibilities for obtaining insights relevant to effectively managing the species will increase as more information is obtained.

It should be noted, however, that mark-recapture models for abundance estimation, using photo-identification as the marking and recapture method, will be difficult to apply to sei whales because variation in natural markings in sei whales is not nearly as great (or as obvious) as in some other species (*e.g.*, humpback and right whales), and matching is therefore difficult and sometimes equivocal. From the standpoint of mark-recapture statistics, this creates the problem of potential false positives (two individuals wrongly identified as one animal), which is a much more serious source of bias than false negatives (an individual observed repeatedly but not matched) (Gunnlaugsson and Sigurjonsson 1990).

4.0 Continue to Collect Data on "Unknown" Threats to Sei Whales.

Data quantifying the effects of climate change as well as the volume and type of ship traffic, fisheries, and noise in areas known to be important to sei whales would provide a useful perspective on the potential seriousness of these threats.

4.1 *Opportunistically collect data on the impacts of climate change on sei whales.*

Improved knowledge of the effects of climate change on sei whale feeding ecology and habitat use would be informative for evaluating or predicting shifts in prey abundance or distribution caused by climatic fluctuations. Investigating the degree of overlap between distributions of different species, the environmental factors influencing their distributions, and the effect of spatial scale on the significance of different environmental predictors should be supported to improve knowledge on the potential effects of climate change on sei whales. Although the natural absorption of carbon dioxide by the world's oceans helps mitigate the climatic effects of anthropogenic emissions of carbon dioxide, it is believed that the resulting decrease in pH will have negative consequences. While the full ecological consequences of these changes are not known, organisms, such as sei whales, may suffer adverse effects, either directly as reproductive or physiological effects or indirectly through negative impacts on their food resources. As possible, and in conjunction with ongoing climate change research, collect data to quantify the threat of climate change on sei whales.

4.2 *Opportunistically collect data on injury and mortality caused by fisheries and fishing equipment.*

The extent and impacts of fishing gear interactions on recovery of sei whale populations are not well understood. As possible, and in conjunction with ongoing fisheries research, collect data to quantify the threat of fishing gear interactions on sei whales. Costs in the implementation table include analysis of any data collected.

4.3 *Opportunistically collect data on mortality and serious injury from vessel collisions.*

The possible impacts of ship strikes on recovery of sei whale populations are not well understood. Many ship strikes go unreported or undetected and the offshore distribution of sei whales may make ship strikes less detectable than for other species, thus the estimates of serious injury or mortality should be considered minimum estimates. As possible, and in conjunction with ongoing marine mammal vessel collision research, collect data to quantify the threat of vessel collisions on sei whales. Costs in the implementation table include analysis of any data collected. Additionally, maintain records of confirmed ship strikes, and continue to work with the IWC on development of an international ship strike database.

4.4 *Opportunistically collect data on the effects of anthropogenic noise on the distribution, behavior, and productivity of sei whales.*

Sei whales are among the cetaceans likely to be sensitive to disturbance by loud or unfamiliar noise. Their deep-ocean distribution and far-ranging movements put them in potential conflict with a wide array of human activities, including mineral exploration and exploitation (*e.g.*, seismic surveys), military maneuvers, and research using acoustic methods. It is therefore important to understand the effects of anthropogenic noise on these animals. As possible, and in conjunction with ongoing anthropogenic noise research, collect data to quantify the threat of anthropogenic noise on sei whales. Costs in the implementation table include analysis of any data collected.

5.0 Maximize Efforts to Acquire Scientific Information from Dead, Stranded, and Entangled Sei Whales.

Assessment of the causes and frequency of mortality (either natural or human-caused) is important to understanding population dynamics and the threats that may impede the recovery of sei whale populations. However, discovery of a carcass under circumstances allowing it to be examined in a timely and rigorous manner is a relatively rare event. Accordingly, efforts to detect and investigate sei whale deaths should be as efficient as possible. Costs in the implementation table include necropsy and stranding response for sei whales in the Atlantic and Pacific U.S. Exclusive Economic Zone.

5.1 *Continue to respond effectively to strandings of dead sei whales in U.S. waters.*

5.1.1 Continue and improve programs to maximize data collected from the necropsy of sei whale carcasses.

Each sei whale carcass represents an opportunity for scientific investigation of the cause of death, as well as addressing other questions related to the biology of the species. Delays in attempts to secure or examine a carcass can result in the loss of valuable data, or even of the carcass itself. The Stranding Network coordinator should work with appropriate agencies, organizations, and individuals to ensure that, when a sei whale carcass is reported and secured: (i) a necropsy is performed as rapidly and as thoroughly as possible by qualified individuals to gather information regarding the cause of death; (ii) samples are taken and properly preserved for studies of genetics, toxicology, and pathology; and (iii) funding is available to notify and transport appropriate experts to the site rapidly and to distribute tissue samples to appropriate locations for analysis or storage. In addition, the coordinator should work with stranding networks and the scientific community, to develop and maintain lists of tissue samples requested by qualified individuals and agencies, and ensure that these samples are collected routinely from each carcass and stored in appropriate locations or distributed to appropriate researchers.

5.1.2 Maintain and review, and, if needed, improve the system for reporting dead, stranded, or entangled sei whales.

5.1.3 Improve, or, as necessary, develop and implement protocols for securing and retrieving stranded (on land) or floating (at sea) sei whale carcasses.

The detection and reporting of dead sei whales, whether stranded or floating at sea, need to be encouraged. The Large Whale Recovery Program coordinator and the National Marine Mammal Stranding Network coordinator, should continue working with representatives of local, state, and federal agencies, private organizations, academic institutions, and regional and national stranding networks, to facilitate efficient observer coverage and information exchange. In areas where protocols do not exist, they should be developed. The responsibilities of all relevant agencies, organizations, and individuals should be clearly defined.

Sei whales may die at sea, but not be detected or reported. Mariners, including Navy and Coast Guard personnel, commercial and recreational boaters, and fishermen might observe carcasses at sea, but not recognize the importance of their observation. Mariners should be educated about the importance of reporting carcasses so that as much information as possible can be collected from them.

5.2 *Review, analyze, and summarize data on stranded sei whales on an annual basis.*

Current and complete data on stranding events and the data derived from them is essential to developing protective measures. Summaries should include, but not be limited to, assessments of the cause of death and, where applicable, the types of fishing gear, if fishing operations resulted in the death of the animal.

5.3 *Establish reliable sources of funding for rescue, necropsy, tissue collection, and analysis efforts.*

As noted, collection of information from sei whale carcasses is essential to recovery efforts. Therefore, identifying and committing to predictable sources of funding for completing these tasks is also critical.

TIER II
If Tier I data collection methods are insufficient, NMFS will consider Tier II actions, building upon research conducted during Tier I.

6.0 Estimate Population Size and Monitor Trends in Abundance.

Along with determining population structure, this is among the highest priority actions in this plan. Recovery of sei whale populations can only be assessed if reliable estimates of abundance are available and if trends in abundance can be determined. Although abundance estimates are available for the species in some locations throughout its range, these estimates are generally imprecise and refer to geographic areas rather than to well-founded population units (*i.e.*, populations or stocks).

6.1 *Determine the best means to maximize (shipboard and aerial) survey efforts to assess sei whale status and trends.*

Some information is available on sei whales in the North Atlantic and North Pacific, but very little in the Southern Hemisphere. An assessment of the level and distribution of shipboard and aerial survey efforts required to achieve optimal assessment results for the three ocean basins is essential to ensure that the entire population of sei whales is surveyed and that field work is as efficient and cost-effective as possible. This may be achieved through a workshop or other means.

6.2 *Conduct surveys to estimate abundance and monitor trends in sei whale populations worldwide.*

Should opportunistic data collection efforts not provide sufficient abundance information, systematic surveys should be conducted to assess abundance in areas known, primarily from historic whaling data and large-scale sighting surveys, to have been inhabited regularly by sei whales in the past. The timing of such surveys would be critically important in view of these whales' migratory behavior. Findings from population structure studies will be useful in interpreting survey results. Because of the relatively long generation times of sei whales and the time scales on which environmental factors affecting their distribution may operate, programs to monitor trends in their populations must involve long-term commitments and extended periods of ship-based surveys on large research vessels and/or the development of acoustic monitoring programs. Potential cost savings include combining this objective with other large ship-based research projects in the same area and other objectives listed in this Recovery Plan.

For meaningful estimates, it will be necessary for U.S. scientists to promote and participate in cooperative surveys with scientists from other countries. A primary goal should be to foster international collaboration and cooperation in the study and protection of sei whales worldwide.

6.2.1 Estimate abundance and monitor trends in the Atlantic Ocean.

6.2.2 Estimate abundance and monitor trends in the Pacific Ocean.

6.2.3 Estimate abundance and monitor trends in the Southern Hemisphere.

6.3 *Develop an intensive and geographically broad scale program to obtain biopsies of sei whales for mark-recapture abundance estimation.*

The feasibility of using a genotype-based mark-recapture study to estimate abundance was demonstrated for North Atlantic humpbacks by Palsbøll *et al.* (1997). This approach uses microsatellite DNA to identify individuals unequivocally, without any of the challenges associated with obtaining photos for photo-identification studies. Given the sizes of the sei whale populations involved, a great amount of effort will be required to sample a sufficient number of individuals to generate reasonably precise abundance estimates. In addition, the feasibility of large-scale programs should be investigated, particularly in areas where high recapture rates are anticipated and acceptable levels of precision are possible. Consideration should be given to combining such studies with satellite tagging studies to provide accompanying distributional information.

7.0 Initiate New Studies to Determine Population Discreteness and Population Structure of Sei Whales.

If adequate data collection is feasible, models of sei whale movement (7.2 below) are necessary to understand population structure determined genetically (7.1 below) and to manage the effects of human activities on this species. Two interrelated research initiatives are proposed to assess population structure as described in detail below: the first uses genetic analysis to determine population structure and discreteness and the second uses telemetry and photo-identification to assess movement.

7.1 *Initiate new studies to investigate population discreteness and population structure of sei whales using genetic analyses, including directed surveys to collect biopsy samples of sei whales in the Atlantic and Pacific Oceans.*

Should opportunistic biopsy sampling not provide sufficient genetic samples for analysis, directed surveys will need to be undertaken. All biopsy samples should be preserved in such a way that the accompanying blubber can be used for contaminant analyses.

Although sei whales can occur on the continental shelf in U.S. waters, important questions concerning population discreteness and structure can only be addressed by reference to materials that include samples obtained in areas outside U.S. coastal waters.

7.2 *Assess daily and seasonal movements and inter-area exchange using telemetry and photo-identification.*

Telemetry studies using satellite-linked and VHP radio tags are needed to investigate patterns and ranges of daily, seasonal, and longer-term movements of individual sei whales. Exchange rates between populations might also be addressed to some degree by telemetry studies. Long-term efforts at photo-identification should also be encouraged to continue. It may not be realistic to use photo-identification of sei whales in U.S. waters for mark-recapture population estimation, or even for detailed investigations of social organization and behavior. Sei whales are not found in coastal waters, so large research ships are required to travel to offshore areas to find them. Even if large ships are available, encounters with sei whales are rare and hence photographs are difficult to obtain. However, opportunistic efforts to photo-document sightings could contribute to knowledge of individual animal movements and residency times. Photographs should be supplemented whenever possible by tissue samples (whether sloughed skin or biopsies) for DNA fingerprinting (Amos and Hoelzel 1990).

7.2.1 Conduct telemetry and photo-identification studies of sei whales in the North Atlantic Ocean.

7.2.2 Conduct telemetry and photo-identification studies of sei whales in the North Pacific Ocean.

7.2.3 Conduct telemetry and photo-identification studies of sei whales in the Southern Hemisphere.

TIER III

Tier III recovery actions depend upon data collected in Tiers I and/or II. When sufficient data are obtained, Tier III recovery activities will be undertaken as feasible.

8.0 Conduct Risk Analyses.

Risk analyses incorporate known and projected risks into a population projection. Although currently not possible for this species at this time, ideally, analyses would be based on time series of abundance estimates including uncertainty for a significant portion of each ocean basin and including known population structure. Given the large uncertainties in abundance and population growth rate, such uncertainties should also be directly incorporated into population projections. The output will be the probability of extinction over time for use in the down- and delisting criteria. A workshop may be needed to address how to treat uncertainty in population structure in risk assessment.

8.1 *Conduct risk analyses for the North Atlantic Ocean.*

Conduct simulations to estimate the risk of extinction. Required data are minimum abundance estimates together with estimates on trends in abundance. Data gathering and analyses are prerequisites to risk analysis.

8.2 *Conduct risk analyses for the North Pacific Ocean.*

Conduct simulations to estimate the risk of extinction. Required data are minimum abundance estimates together with estimates on trends in abundance. Data gathering and analyses are prerequisites to risk analysis.

8.3 *Conduct risk analyses for the Southern Hemisphere.*

Conduct simulations to estimate the risk of extinction. Analysis of risks in the Southern Hemisphere would likely take longer than any Northern Hemisphere assessment due to much greater uncertainty within this large region (including whether there are multiple subspecies present) and the potential for no abundance estimates for some areas and consequently great uncertainty about trends. Data gathering and analyses are prerequisites to risk analysis.

9.0 Identify, Characterize, Protect, and Monitor Habitat Important to Sei Whale Populations in U.S. Waters and Elsewhere.

Identifying important sei whale habitat and reducing direct and indirect threats to sei whale habitat is integral to recovery. Important habitat may or may not qualify as critical habitat under the ESA. Information is needed on environmental factors that influence sei whale distribution. In addition, adequate protective measures may be needed to reduce or eliminate human-related impacts to sei whale habitat.

9.1 *Characterize sei whale habitat.*

Areas where sei whales are consistently seen and heard are assumed to be important to their survival. Areas used infrequently or for short periods may also be linked to population rigor. Therefore, it is important to compile or collect relevant physical, chemical, biological, meteorological, fishery, and other data to characterize features of important habitats and potential sources of human-caused destruction and degradation of what are determined to be important areas for sei whales. Habitat characterization also involves, among other things, descriptions of prey types, densities, abundances, and associated oceanographic and hydrographic features. Inter-annual variability in habitat characteristics, and in sei whale habitat use, is an important component of habitat characterization. More research is needed to define rigorously and specifically, the environmental features that make an area important to sei whales. A predictive framework for identifying potentially important sei whale habitat would be a useful management tool. Only with information on the ecological needs of the species will managers be able to provide necessary protections.

9.2 *Monitor important habitat features and sei whale use patterns to assess potentially detrimental shifts in these features that might reflect disturbance or degradation of habitat.*

After baseline data are obtained and analyzed, ongoing studies should be done to determine if shifts are occurring in essential habitat components. Sei whale habitat should be assessed periodically through surveys and GIS analysis. Shifts in distribution or habitat use should be analyzed as potentially resulting from anthropogenic sources of habitat degradation or disturbance. If shifts are detected and are linked to human activities, actions may be taken to modify the activity to reduce or eliminate the cause.

9.3 *Promote actions to protect important habitat in U.S. waters.*

Support efforts to collect and compile data on habitat use patterns for the sei whale population in U.S. waters. Validate those areas where sei whales are thought to occur and determine if those areas are important areas warranting habitat protection.

9.4 *Promote actions to define, identify, and protect important habitat in foreign or international waters.*

Sei whale range is transboundary. Collaborative efforts should be made with foreign governments to protect sei whale habitat within their Exclusive Economic Zone's, and to join multi-national efforts on behalf of marine habitat protection. International efforts to collect and compile data on habitat use patterns for the sei whale population should be supported. Actions that have impacts on sei whale habitat should be mitigated, and the U.S. should support and endorse such efforts. Validation of those areas where sei whales are thought to occur and protection of those areas that are determined as important areas warranting habitat protection should be supported. Due to the very wide-ranging movements of individual sei whales (demonstrated by tag returns) and the species' extensive distribution in both the North Pacific and North Atlantic, international initiatives to reduce pollution and protect resources on the high seas may be key to the long-term conservation of sei whale populations.

9.5 *Improve knowledge of sei whale feeding ecology.*

Studies designed to improve knowledge of sei whale prey preferences, dietary requirements, and energetics will be important to understanding habitat use, impacts of fishery practices on whale populations (*e.g.,* food-web effects of factory-ship trawling for herring), and recovery potential. Consumption of finfish by sei whales suggests that they could interact in important ways with commercial fisheries in many areas, in addition to being affected by shifts in prey abundance and distribution, caused by climatic fluctuations.

10.0 Investigate Human-Caused Threats, and, Should they be Determined to be Medium or High, Reduce Frequency and Severity.

Known or suspected causes of anthropogenic mortality in sei whales include vessel strikes and entanglement in fishing gear or marine debris. Should Tier I data collection be insufficient to characterize these threats to sei whales, more detailed studies should be conducted to determine if the threat should be ranked as medium or high. If ranked as such, measures will need to be developed and implemented to reduce the frequency of these harmful interactions.

10.1 *Investigate and, if medium or high ranked threat, reduce injury and mortality caused by fisheries and fishing equipment and reduce depredation.*

10.1.1 Conduct a systematic review of data on sei whale interactions with fishing operations.

From such a review, it should be possible to make a preliminary evaluation of what types of fisheries and fishing gear pose the greatest risk to sei whales. Data from areas outside U.S. waters could be useful for strengthening inferences and extrapolations.

10.1.2 Review photographic databases for evidence of injuries to sei whales caused by encounters with fishing gear to better characterize and understand fishing gear interactions.

Existing databases, especially those with extensive photographic records, to the extent that they exist, of sei whale observations, should be searched for evidence of encounters with fishing gear. Although it may prove impossible to derive quantitative measures of injury or mortality rates, such a review might at least help to identify areas where the risk is especially high, and the types fishing gear that are particularly troublesome.

10.1.3 Investigate the development of a system to non-lethally deter sei whales from fishing gear.

10.1.4 Conduct studies of gear modifications that reduce the likelihood of entanglement, mitigate the effects of entanglements, and enhance the possibility of disentanglement. Determine whether measures to reduce entanglements are effective.

Current and ongoing research on possible modifications to fishing gear that facilitate an entangled whale to free itself once entangled should be continued. These studies might include assessing the potential use of biodegradable lines, study ways to reduce the number and length of vertical lines in the water column and design breakaway lines for heavy gear.

10.1.5 Develop and implement schemes to reduce the rate at which fishing gear is lost, and improve the reporting of lost gear.

10.1.6 Continue to review, evaluate, and act upon reports from fishermen and fishery observers of fishery interactions with sei whales.

10.2 *Investigate and, if medium or high ranked threat, reduce injury and mortality caused by anthropogenic noises.*

As discussed in section G.2, very little research has addressed questions about the effects of noise on sei whales, and there has been little conclusive evidence in regard to the biological significance of observed effects. Should Tier I actions provide insufficient data, studies will be needed to assess potential adverse effects, if any, of underwater noise (including ship noise) on sei whales, including, but not limited to, disturbance of intraspecific communication, disruption of vital functions mediated by sound, distributional shifts, and stress from chronic or frequent exposure to loud sound. Noise sources studied should include, but not be limited to, industrial and shipping activities, oceanographic experiments, military related activities, and other human activities.

If studies indicate that particular types of underwater noise have adverse effects on sei whales (either by masking their sounds or by damaging their auditory organ systems), or add physiological stress to their lives, implement appropriate regulatory measures on sources of the threat. It is important that the effects of underwater noise on baleen whales become better understood.

10.3 *Investigate and, if medium or high ranked threat, reduce mortality and serious injury from vessel collisions.*

10.3.1 Identify areas where concentrations of sei whales coincide with significant levels of maritime traffic.

If opportunistic data collection from action 4.3 is insufficient to characterize the threat of vessel collisions on sei whales, more detailed studies will be needed to identify areas where high ship traffic densities and sei whale densities overlap to assist with management efforts to reduce the occurrence of ship strikes.

10.3.2 Identify specific areas where recorded ship strikes of sei whales have occurred and conduct studies to identify ecosystem-based traits that could support an assemblage of predictive tools.

This would assist in the determination of when sei whales may be present, why sei whales are present in the area at that time, and whether the presence of ships alters the ecosystem in such a way that sei whales become susceptible to a strike.

10.3.3 Conduct analyses of shipping routes and important sei whale habitat areas to determine the risk of ship collisions with sei whales.

10.3.4 Work with mariners, the shipping industry, and appropriate state, federal, and international agencies to develop and implement regionally-based measures to reduce the threat of ship strikes. Assess the effectiveness of ship strike measures and adjust, as necessary.

The practicality and effectiveness of options to reduce ship strikes should be assessed. Methods and measures developed for other endangered whales (*e.g.*, right whales) should be considered for their possible application to sei whales.

10.3.5 Explore possible mechanisms to encourage vessels that have struck a whale to report the incident.

10.3.6 Review photographic databases for evidence of injuries to sei whales caused by ships to better characterize and understand vessel collisions.

Existing databases, to the extent they exist, especially those with extensive photographic records of sei whale observations, should be searched for evidence of ship strikes. Studies to quantify the volume and type of ship traffic, fisheries, and pollution in areas known to be important to sei whales would provide a useful perspective on the potential seriousness of this threat. Although it may prove impossible to derive quantitative measures of injury or mortality rates, such a review might at least help to identify areas where the risk is especially high, and the types of vessel traffic that are particularly troublesome.

10.4 *Investigate the impacts of climate change on sei whales and seek strategies to reduce any impacts found to be detrimental to sei whales and their habitat.*

10.4.1 Conduct studies and perform analyses to assess the effects of climate change on the distribution, behavior, and productivity of sei whales.

If opportunistic data collection from action 4.1 is insufficient to characterize the threat of climate change on sei whales, conduct more detailed studies.

10.4.2 Seek strategies to reduce any detrimental impacts of climate change on sei whales and their prey and habitats.

Strategies developed through international efforts to mitigate and minimize the effects of climate change should be followed for the benefit of sei whales as well as other ecosystem components.

11.0 Develop Post-Delisting Monitoring Plan.

After populations have been identified, determined to be stable or increasing, and threats controlled, a monitoring plan should be developed to ensure that sei whale populations do not decline in abundance, or become subject to new threats that cause adverse effects. Normally, this monitoring plan will be a scaled-down version of the monitoring conducted prior to delisting, and will continue for a minimum of 1.5 generations, although it may be continued for longer.

V. IMPLEMENTATION SCHEDULE

The implementation schedule that follows is used to estimate costs to direct and monitor implementation and completion of recovery tasks set forth in this Recovery Plan. It is a guide for meeting recovery goals outlined in this Recovery Plan. The Implementation Schedule indicates the action numbers, action descriptions, action priorities, duration of the action, the parties responsible for the actions, and estimated costs. Parties with authority, responsibility, or expressed interest to implement a specific recovery action are identified in the Implementation Schedule.

As described in Part II (the Recovery Strategy), this implementation schedule divides recovery actions into three tiers. After ten years of conducting Tier I actions, NMFS expects to evaluate available data and consider the need for Tier II actions. Tier III actions are dependent upon data collected in Tier I and/or II. Accordingly, costs have been estimated for Tier I recovery actions only.

Priorities in column 3 of the implementation schedule are assigned as follows:

> Priority 1 – An action that must be taken to prevent extinction or to identify those actions necessary to prevent extinction.
>
> Priority 2 – An action that must be taken to prevent a significant decline in population numbers or habitat quality, or to prevent other significant negative trends short of extinction.
>
> Priority 3 – All other actions necessary to provide for full recovery of the species.

This implementation schedule accords priorities to individual tasks to specify their importance in the recovery effort. It should be noted that even the highest-priority tasks within a plan are not given a Priority 1 ranking unless they are actions necessary to prevent extinction or to identify those actions necessary to prevent extinction.

Funding is estimated in accordance with the number of years necessary to complete the task once implementation has begun (for Tier I actions, ongoing costs are calculated out to 10 years). The provision of cost estimates does not mean to imply that appropriate levels of funding will necessarily be available for all sei whale recovery tasks. For each, sub-totals are given as a whole in ***bold italics***. Some costs are listed as discrete (*e.g.*, 5 years) and some are until time to recovery (*i.e.*, "TBD" and "Ongoing").

DISCLAIMER

The Implementation Schedule that follows outlines actions and estimated costs for Tier I actions of the recovery program for the sei whale, as set forth in this Recovery Plan. It is a guide for meeting the recovery goals outlined in this Recovery Plan. This schedule indicates action numbers, action descriptions, action priorities, duration of actions, the parties responsible for actions (either funding or carrying out), and estimated costs.

Parties with authority, responsibility, or expressed interest to implement a specific recovery action are identified in the Implementation Schedule. The listing of a party in the Implementation Schedule does not require the identified party to implement the action(s) or to secure funding for implementing the action(s).

Table 3. Sei Whale Implementation Schedule by Fiscal Year

Action Number	Action Description	Priority	Task Duration (years)	Agencies/ Organizations Potentially Involved	Cost Estimates by FY (thousands of dollars)						
					FY13	FY14	FY15	FY16	FY17	FY18 +	Total/yr. x Task Duration
TIER I ACTIONS											
1.0	***Coordinate State, Federal, and International Actions to Maintain International Regulation of Whaling for Sei Whales.***[2]	2	Ongoing	NMFS, IWC, Department of State (DOS), International Partners	*	*	*	*	*	*	*
TOTAL 1					*	*	*	*	*	*	*
2.0	***Develop and Apply Methods to Collect Sei Whale Data.***										
2.1	Investigate the feasibility of using passive survey methods to estimate the relative and/or absolute abundance of sei whales.	2	1	NMFS	$100	$200	$200	$100	$100		$700
2.2 (costs are split among sub-actions)	If feasible, conduct passive acoustic studies to collect data on sei whale populations in U.S. waters.[3]	2	7	NMFS, International Partners							
2.2.1	Collect sei whale acoustic data using archival bottom mounted recorders.	2	7	NMFS							

[2] Costs for this action are included in the costs for fin whale and sperm whale recovery plans.
[3] Data collected using passive acoustic technology would likely benefit other marine mammal species research.

Action Number	Action Description	Priority	Task Duration (years)	Agencies/ Organizations Potentially Involved	Cost Estimates by FY (thousands of dollars)						
					FY13	FY14	FY15	FY16	FY17	FY18 +	Total/yr. x Task Duration
2.2.1.1	Collect sei whale acoustic data using archival bottom mounted recorders in the Northwest Atlantic Ocean.[4]	2	7	NMFS				$500	$285	$1,425	$2,210
2.2.1.2	Collect sei whale acoustic data using archival bottom mounted recorders in the Eastern North Pacific Ocean.[5]	2	4	NMFS				$540	$312	$624	$1,476
2.2.1.3	Collect sei whale acoustic data using archival bottom mounted recorders in the Central North Pacific Ocean.	2	3	NMFS						$936	$936
2.2.2	Collect sei whale acoustic data using sonobuoys, in U.S. waters.[6]	2	7	NMFS							
2.2.2.1	Collect sei whale acoustic data using sonobuoys in the Northwest Atlantic Ocean.	2	7	NMFS				$80	$80	$400	$560
2.2.2.2	Collect sei whale acoustic data using sonobuoys in the Eastern North Pacific Ocean.	2	7	NMFS				$80	$80	$400	$560

[4] Four sets of six recorders along key areas of coastal Northwest Atlantic waters; $10K per recorder = $24K for 24 units initial cost. Annual maintenance = $24K ($240 per unit, 4 deployments per year). Quarterly retrieval and deployment would require approximately 4 days per site = 64 days at $2.5K per day = $160K. Analysis time (12 months) = $100K.

[5] Four sets of six recorders along key areas of coastal Eastern North Pacific waters; $10K per recorder = $24K for 24 units initial cost. Annual maintenance = $12K ($500 per unit). Annual retrieval and deployment assume tacking on to existing marine mammal research cruises, add $50K per trip for one day of deployment and retrieval per site = $200K. Analysis time (12 months) = $100K. This assumes initial purchase of recorders for use in Eastern North Pacific for four years, transfer equipment to Pacific Islands Science Center for use in Central North Pacific for three years.

[6] 100 sonobuoys per research cruise, at $300 per buoy = $30,000. ½-FTE per cruise for at-sea and lab analysis of data = $50,000. Total = $80,000 per cruise; one cruise per year per region.

Action Number	Action Description	Priority	Task Duration (years)	Agencies/ Organizations Potentially Involved	Cost Estimates by FY (thousands of dollars)						
					FY13	FY14	FY15	FY16	FY17	FY18 +	Total/yr. x Task Duration
2.2.2.3	Collect sei whale acoustic data using sonobuoys in the Central North Pacific Ocean.	2	7	NMFS				$80	$80	$400	$560
2.2.3	Opportunistically collect sei whale acoustic data using acoustic tags in U.S. waters	2	Ongoing	NMFS							
2.2.3.1	Opportunistically collect sei whale acoustic data using acoustic tags in the Northwest Atlantic Ocean.	2	Ongoing	NMFS	$36	$36	$36	$36	$36	$180	$360
2.2.3.2	Opportunistically collect sei whale acoustic data using acoustic tags in the Eastern North Pacific Ocean.	2	Ongoing	NMFS	$10	$10	$10	$10	$10	$50	$100
2.2.3.3	Opportunistically collect sei whale acoustic data using acoustic tags in the Central North Pacific Ocean.	2	Ongoing	NMFS	$10	$10	$10	$10	$10	$50	$100
2.2.4	Collect sei whale acoustic data using autonomous gliders in U.S. waters.	2	6	NMFS							
2.2.4.1	Collect sei whale acoustic data using autonomous gliders in the Northwest Atlantic Ocean.[7]	2	2	NMFS				$700	$102		$802
2.2.4.2	Collect sei whale acoustic data using autonomous gliders in the Eastern North Pacific Ocean.	2	2	NMFS						$204	$204
2.2.4.3	Collect sei whale acoustic data using autonomous gliders in the Central North Pacific Ocean.	2	2	NMFS						$204	$204

[7] Fleet of four gliders at $150K each = $600K for initial purchase. Analysis time (12 months) = $100K annually. Maintenance for gliders is approximated at $2K per year. This assumes initial purchase of gliders for use in Northwest Atlantic Ocean for two years, then transferred to Eastern North Pacific for two years, and then to Pacific Islands Science Center for use in Central North Pacific for two years.

Action Number	Action Description	Priority	Task Duration (years)	Agencies/ Organizations Potentially Involved	Cost Estimates by FY (thousands of dollars)						
					FY13	FY14	FY15	FY16	FY17	FY18 +	Total/yr. x Task Duration
2.3 (costs are split among sub-actions)	Continue opportunistic data collection to estimate abundance and monitor trends.	2	Ongoing	NMFS, International Partners							
2.3.1	Continue opportunistic data collection to estimate abundance and monitor trends in the Atlantic Ocean.	2	Ongoing	NMFS, International Partners	$50	$50	$50	$50	$50	$250	$500
2.3.2	Continue opportunistic data collection to estimate abundance and monitor trends in the Pacific Ocean.	2	Ongoing	NMFS, International Partners	$50	$50	$50	$50	$50	$250	$500
2.4	If actions 2.2 and 2.3 prove successful at providing sufficient data, extend passive acoustic and opportunistic data collection to international waters.	3	TBD	International Partners	TBD	TBD	TBD	TBD	TBD	TBD	TBD
TOTAL 2					***$256***	***$356***	***$356***	***$2,236***	***$1,195***	***$5,373***	***$9,772***
3.0 (costs are split among sub-actions)	***Support existing studies to investigate population discreteness and population structure of sei whales using genetic analyses.***										
3.1	Opportunistically collect biopsy samples in the Atlantic and Pacific Oceans.	2	Ongoing	NMFS	$50	$50	$50	$50	$50	$250	$500
3.2	Collaborate with foreign agencies and researchers to obtain genetic samples.	2	Ongoing	NMFS, International Partners	$25	$25	$25	$25	$25	$125	$250
3.3	Perform genetic analyses on preserved samples.	2	1	NMFS, International Partners						$50	$50

Action Number	Action Description	Priority	Task Duration (years)	Agencies/ Organizations Potentially Involved	Cost Estimates by FY (thousands of dollars)						
					FY13	FY14	FY15	FY16	FY17	FY18 +	Total/yr. x Task Duration
6.4	If feasible, locate and consolidate existing sei whale photo-identification catalogs.	2	1	NMFS, International Partners			$50	$10	$10	$50	$120
TOTAL 3					***$75***	***$75***	***$125***	***$85***	***$85***	***$475***	***$920***
4.0	***Continue to Collect Data on "Unknown" Threats to Sei Whales***										
4.1	Opportunistically collect data on the impacts of climate change on sei whales.	2	Ongoing	NMFS, International Partners	TBD	TBD	TBD	TBD	TBD	TBD	TBD
4.2	Opportunistically collect data on injury and mortality caused by fisheries and fishing equipment.	2	Ongoing	NMFS, USCG, States	$10	$10	$10	$10	$10	$50	$100
4.3	Opportunistically collect data on mortality and serious injury from vessel collisions.	2	Ongoing	NMFS, USCG, States	$10	$10	$10	$10	$10	$50	$100
4.4	Opportunistically collect data on the effects of anthropogenic noise on the distribution, behavior, and productivity of sei whales.	2	Ongoing	NMFS, Navy, BOEMRE, International Partners	$10	$10	$10	$10	$10	$50	$100
TOTAL 4					***$30***	***$30***	***$30***	***$30***	***$30***	***$150***	***$300***
5.0	***Maximize Efforts to Acquire Scientific Information from Dead, Stranded, and Entangled Sei Whales.***										
5.1	Continue to respond to strandings of dead sei whales in U.S. waters.	3	Ongoing	NMFS, USCG, States	$100	$100	$100	$100	$100	$500	$1,000
5.1.1 (see 5.1 for costs)	Continue and improve programs to maximize data collected from necropsy of sei whale carcasses.	3	Ongoing	NMFS	*	*	*	*	*	*	*

Action Number	Action Description	Priority	Task Duration (years)	Agencies/ Organizations Potentially Involved	Cost Estimates by FY (thousands of dollars)						
					FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18 +**	**Total/yr. x Task Duration**
5.1.2	Maintain and review, and, if needed, improve the system for reporting dead, stranded, or entangled sei whales.	3	Ongoing	NMFS, States	*	*	*	*	*	*	*
5.1.3	Improve, or, as necessary, develop and implement protocols for securing and retrieving stranded (on land) or floating (at sea) sei whale carcasses.	3	1	NMFS, States	*	*	*	*	*	*	*
5.2	Review, analyze, and summarize data on stranded sei whales on an annual basis.	3	Ongoing	NMFS, States	*	*	*	*	*	*	*
5.3	Establish reliable sources of funding for rescue, necropsy, tissue collection, and analysis efforts.	3	Ongoing	NMFS	*	*	*	*	*	*	*
TOTAL 5					***$100***	***$100***	***$100***	***$100***	***$100***	***$500***	***$1,000***
TOTAL TIER I					***$461***	***$561***	***$611***	***$2,451***	***$1,410***	***$6,498***	***$11,992***
TIER II ACTIONS											
6.0	***Estimate Population Size and Monitor Trends in Abundance.***										
6.1	Determine the best means to maximize (shipboard and aerial) survey efforts to assess sei whale status and trends.	2	1	NMFS, International Partners							
6.2	Conduct surveys to estimate abundance and monitor trends in sei whale populations worldwide.	2	TBD	NMFS, International Partners							
6.2.1	Estimate abundance and monitor trends in the Atlantic Ocean.	2	TBD	NMFS, International Partners							

Action Number	Action Description	Priority	Task Duration (years)	Agencies/ Organizations Potentially Involved	Cost Estimates by FY (thousands of dollars)						
					FY13	FY14	FY15	FY16	FY17	FY18 +	Total/yr. x Task Duration
6.2.2	Estimate abundance and monitor trends in the Pacific Ocean.	2	TBD	NMFS, International Partners							
6.2.3	Estimate abundance and monitor trends in the Southern Hemisphere.	2	TBD	NMFS, International Partners							
6.3	Develop an intensive and geographically broad scale program to obtain biopsies of sei whales for mark-recapture abundance estimation.	2	TBD	NMFS, International Partners							
7.0	***Initiate New Studies to Determine Population Discreteness and Population Structure of Sei Whales.***										
7.1	Initiate new studies to investigate population discreteness and population structure of sei whales using genetic analyses, including directed surveys to collect biopsy samples of sei whales in the Atlantic and Pacific Oceans.	2	TBD	NMFS, IWC, International Partners							
7.2	Assess daily and seasonal movements and inter-area exchange using telemetry and photo-identification.	2	TBD	NMFS, International Partners							
7.2.1	Conduct telemetry and photo-identification studies of sei whales in the Atlantic Ocean.	2	TBD	NMFS, International Partners							
7.2.2	Conduct telemetry and photo-identification studies of sei whales in the Pacific Ocean.	2	TBD	NMFS, International Partners							

Action Number	Action Description	Priority	Task Duration (years)	Agencies/ Organizations Potentially Involved	Cost Estimates by FY (thousands of dollars)						
					FY13	FY14	FY15	FY16	FY17	FY18 +	Total/yr. x Task Duration
7.2.3	Conduct telemetry and photo-identification studies of sei whales in the Southern Hemisphere.	2	TBD	NMFS, International Partners							
TIER III ACTIONS											
8.0	***Conduct Risk Analyses.***										
8.1	Conduct risk analyses for the North Atlantic Ocean.	2	2	NMFS, International Partners							
8.2	Conduct risk analyses for the North Pacific Ocean.	2	2	NMFS, International Partners							
8.3	Conduct risk analyses for the Southern Hemisphere.	2	2	NMFS, International Partners							
9.0	***Identify, Characterize, Protect, and Monitor Habitat Important to Sei Whale Populations in U.S. Waters and Elsewhere.***										
9.1	Characterize sei whale habitat.	2	10	NMFS, International Partners							
9.2	Monitor important habitat features and sei whale use patterns to assess potentially detrimental shifts in these features that might reflect disturbance or degradation of habitat.	2	Ongoing	NMFS, International Partners							
9.3	Promote actions to protect important habitat in U.S. waters.	3	Ongoing	NMFS, NOS							
9.4	Promote actions to define, identify, and protect important habitat in foreign or international waters.	3	Ongoing	NMFS, DOS, International Partners							

Action Number	Action Description	Priority	Task Duration (years)	Agencies/ Organizations Potentially Involved	Cost Estimates by FY (thousands of dollars)						
					FY13	FY14	FY15	FY16	FY17	FY18 +	Total/yr. x Task Duration
9.5	Improve knowledge of sei whale feeding ecology.	2	10	NMFS, International Partners							
10.0	***Investigate Human-Caused Threats, and, Should they be Determined to be Medium or High, Reduce Frequency and Severity.***										
10.1	Investigate and, if medium or high ranked threat, reduce injury and mortality caused by fisheries and fishing equipment and reduce depredation.	2	TBD	NMFS, USCG, States							
10.1.1	Conduct a systematic review of data on sei whale interactions with fishing operations.	3	TBD	NMFS, States, International Partners							
10.1.2	Review photographic databases for evidence of injuries to sei whales caused by encounters with fishing gear to better characterize and understand fishing gear interactions.	3	TBD	TBD							
10.1.3	Investigate the development of a system to non-lethally deter sei whales from fishing gear.	2	TBD	NMFS, States, International Partners							
10.1.4	Conduct studies of gear modifications that reduce the likelihood of entanglement, mitigate effects of entanglements, and enhance possibility of disentanglement. Determine whether measures to reduce entanglements are effective.	2	TBD	NMFS, States, International Partners							

Action Number	Action Description	Priority	Task Duration (years)	Agencies/ Organizations Potentially Involved	Cost Estimates by FY (thousands of dollars)						
					FY13	FY14	FY15	FY16	FY17	FY18 +	Total/yr. x Task Duration
10.1.5	Develop and implement schemes to reduce the rate at which gear is lost, and improve the reporting of lost gear.	3	TBD	NMFS, States, International Partners							
10.1.6	Continue to review, evaluate, and act upon reports from fishermen and fishery observers of fishery interactions with sei whales.	2	Ongoing	NMFS, States, USCG							
10.2	Investigate and, if medium or high ranked threat, reduce injury and mortality caused by anthropogenic noises.	2	TBD	NMFS, U.S. Navy, Army Corps of Engineers, BOEMRE, International Partners							
10.3	Investigate and, if medium or high ranked threat, reduce mortality and serious injury from vessel collisions.	2	TBD	NMFS, NOS, USCG, States, International Partners							
10.3.1	Identify areas where concentrations of sei whales coincide with significant levels of maritime traffic.	2	TBD	NMFS, USCG, International Partners							
10.3.2	Identify specific areas where recorded ship strikes of sei whales have occurred and conduct studies to identify ecosystem-based traits that could support an assemblage of predictive tools.	2	TBD	NMFS, NOS, International Partners							
10.3.3	Conduct analyses of shipping routes and important sei whale habitat areas to determine the risk of ship collisions with sei whales.	2	TBD	NMFS, NOS, International Partners							

Action Number	Action Description	Priority	Task Duration (years)	Agencies/ Organizations Potentially Involved	Cost Estimates by FY (thousands of dollars)						
					FY13	FY14	FY15	FY16	FY17	FY18 +	Total/yr. x Task Duration
10.3.4	Work with mariners, the shipping industry, and appropriate state, federal, and international agencies to develop and implement regionally-based measures to reduce the threat of ship strikes. Assess effectiveness of ship strike measures and adjust, as necessary.	2	TBD	NMFS, NOS, USCG, DOS							
10.3.5	Explore possible mechanisms to encourage vessels that have struck a whale to report the incident.	2	Ongoing	NMFS, USCG, International Partners							
10.3.6	Review photographic databases for evidence of injuries to sei whales caused by ships to better characterize and understand vessel collisions.	2	Ongoing	NMFS							
9.6	Investigate the impacts of climate change on sei whales and seek strategies to reduce any impacts found to be detrimental to sei whales and their habitat.	2	TBD	TBD							
9.6.1	Conduct studies and perform analyses to assess the effects of climate change on the distribution, behavior, and productivity of sei whales.	2	TBD	TBD							
9.6.2	Seek strategies to reduce any detrimental impacts of climate change on sei whales and their prey and habitats.	2	TBD	TBD							
11.0	***Develop Post-delisting Monitoring Plan.***	2	TBD	NMFS							

*No cost associated, NMFS staff time

This Page Intentionally Left Blank

VI. LITERATURE CITED

Aguilar, A., A. Borrell, and P. J. H. Reijnders. 2002. Geographical and temporal variation in levels of organochlorine contaminants in marine mammals. Marine Environmental Research 53:425-452.

Aguilar, A., and S. Lens. 1981. Preliminary report on Spanish whaling operations. Report of the International Whaling Commission 31:639-643.

Aguilar, A., and C. Sanpera. 1982. Reanalysis of Spanish sperm, fin and sei whale catch data (1957-1980). Report of the International Whaling Commission 32:465-470.

Allen, G. M. 1916. The whalebone whales of New England. Memoirs of the Boston Society of Natural History 8(2):105-322.

Allen, K. R. 1980. Conservation and management of whales. University of Washington Press, Seattle, WA.

Allen, S. G. 1991. Harbor seal habitat restoration at Strawberry Spit, San Francisco Bay. Point Reyes Bird Observatory Report, PB91-212332/GAR

Amos, B., and A. R. Hoelzel. 1990. DNA fingerprinting cetacean biopsy samples for individual identification. Report of the International Whaling Commission Special Issue 12:79-85.

Andrew, R. K., B. M. Howe, and J. A. Mercer. 2002. Ocean ambient sound: comparing the 1960s with the 1990s for a receiver off the California coast. Acoustics Research Letters Online 3(2):65-70.

Andrews, R. C. 1916. The sei whale (*Balaenoptera borealis* Lesson). Memoirs of the American Museum of Natural History, New Series 1(6):291-388.

Angliss, R. P., G. K. Silber, and R. Merrick. 2002. Report of a workshop on developing recovery criteria for large whale species. NOAA Technical Memorandum, NMFS-OPR-21 32.

Anisimov, O. A., D. G. Vaughan, T. V. Callaghan, C. Furgal, H. Marchant, T. D. Prowse, H. Vilhjálmsson, and J. E. Walsh. 2007. Polar regions (Arctic and Antarctic). Cambridge University Press, Cambridge, UK. 653-685.

Anonymous. 1984. Iceland progress report on cetacean research, June 1982 to May 1983. Report of the International Whaling Commission 199-201.

Anonymous. 1985. Iceland progress report on cetacean research, June 1983 to May 1984. Report of the International Whaling Commission 166-168.

Anonymous. 1986. Iceland progress report on cetacean research, June 1984 to May 1985. Report of the International Whaling Commission 156-157.

Anonymous. 1987. Iceland progress report on cetacean research, June 1985 to May 1986. Report of the International Whaling Commission 169-171.

Anonymous. 1995. Denmark progress report on cetacean research, June 1993 to May 1994. Report of the International Whaling Commission 233-234.

Arctic Climate Impact Assessment. 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press

Au, W. W. L. 1993. The sonar of dolphins. Springer Verlag Inc., New York, NY.

Au, W. W. L., A. A. Pack, M. O. Lammers, L. M. Herman, M. H. Deakos, and K. Andrews. 2006. Acoustic properties of humpback whale songs. Journal of Acoustical Society of America 120:1103-1110.

Baillie, J., and B. Groombridge, editors. 1996. 1996 IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland and Cambridge, UK.

Baker, C. S., M. L. Dalebout, N. Funahashi, M. Yu, D. Steel, and S. Lavery. 2004. Market surveys of whales, dolphins and porpoises in Japan and Korea, 2003-2004, with reference to stock identity of sei whales. Unpublished paper to the IWC Scientific Committee. 8 pp. Sorrento, Italy, July (SC/56/BC3)

Baker, C. S., and L. M. Herman. 1987. Alternative population estimates of humpback whales (*Megaptera novaeangliae*) in Hawaiian waters. Canadian Journal of Zoology 65(11):2818-2821.

Baker, C. S., L. M. Herman, B. G. Bays, and G. B. Bauer. 1983. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1982 season. Report submitted to the National Marine Fisheries Service National Marine Mammal Laboratory, Seattle, WA. 78pp.

Baker, C. S., and S. R. Palumbi. 1994. Which whales are hunted? A molecular genetic approach to monitoring whaling. Science 265(5178):1538-1539.

Barlow, J. 1994. Abundance of large whales in California coastal waters: A comparison of ship surveys in 1979/80 and in 1991. Report of the International Whaling Commission SC/45/O15 44:399-406.

Barlow, J., K. A. Forney, P. S. Hill, J. Robert L. Brownell, J. A. Caretta, D. P. Demaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific Marine Mammal Stock Assessments: 1996 Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, NOAA-TM-NMFS-SWFSC-248 224.

Bartholomew, G. A. 1949. A census of harbor seals in San Francisco Bay (*Phoca vitulina*). Journal of Mammalogy 30(1):34-35.

Bauer, G. 1986. The behavior of humpback whales in Hawaii and modification of behavior induced by human interventions. Ph.D. dissertation:University of Hawaii, Honolulu.

Bauer, G., and L. M. Herman. 1986. Effects of vessel traffic on the behavior of humpback whales in Hawaii. National Marine Fisheries Service, Honolulu, Hawaii. 151.

Baumgartner, M. F., and D. M. Fratantoni. 2008. Diel periodicity in both sei whale vocalization rates and the vertical migration of their copepod prey observed from ocean gliders. Limnology and Oceanography 53(5 Pt 2):2197-2209.

Baumgartner, M. F., N. S. J. Lysiak, C. Schuman, J. Urban-Rich, and F. W. Wenzel. 2011. Diel vertical migration behavior of *Calanus finmarchicus* and its influence on right and sei whale occurrence. Marine Ecology Progress Series 423:167-184.

Baumgartner, M. F., S. M. Van Parijs, F. W. Wenzel, C. J. Tremblay, H. C. Esch, and A. M. Warde. 2008. Low frequency vocalizations attributed to sei whales (*Balaenoptera borealis*). Journal of the Acoustical Society of America 124(2):1339-1349.

Beale, C. M., and P. Monaghan. 2004. Human disturbance: people as predation-free predators? Journal of Applied Ecology 41:335-343.

Best, P. B. 1992. Catches of fin whales in the North Atlantic by the M.V. Sierra (and associated vessels). (*Balaenoptera physalus*). Report of the International Whaling Commission 42:697-700.

Best, P. B., and C. H. Lockyer. 2002. Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s. South African Journal of Marine Science 24:111-133.

Bonner, W. N. 1986. Marine mammals of the Falkland Islands. British Antarctic Survey, Cambridge, UK.
Borrell, A. 1993. PCB and DDTs in Blubber of Cetaceans from the Northeastern North Atlantic. Marine Pollution Bulletin 26(3):146.
Borrell, A., and A. Aguilar. 1987. Variations in DDE percentage correlated with total DDT burden in the blubber of fin and sei whales. Marine Pollution Bulletin 18:70-74.
Borrell, A., and A. Aguilar. 1999. A review of organochlorine and metal pollutants in marine mammals from Central and South America. Journal of Cetacean Research and Management Special Issue 1:195-207.
Borsa, P. 2006. Marine mammal strandings in the New Caldonia region, Southwest Pacific. C.R. Biologies 329:277-288.
Bost, C. A., C. Cotte, F. Bailleul, Y. Cherel, J. B. Charrassin, C. Guinet, D. G. Ainley, and H. Weimerskirch. 2009. The importance of oceanographic fronts to marine birds and mammals of the southern oceans. Journal of Marine Systems 78(3):363-376.
Braham, H. W. 1991. Endangered Whales: A Status Update. National Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, Seattle, Washington. 56.
Brown, S. G. 1976. Modern whaling in Britain and the north-east Atlantic Ocean. Mammal Review 6(1):25-36.
Carretta, J. V., K. A. Forney, M. S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, R. Brownell, J. Robbins, D. K. Mattila, K. Ralls, M. M. Muto, D. Lynch, and L. Carswell. 2010. U.S. Pacific Marine Mammal Stock Assessments: 2008. U.S. Department of Commerce, NOAA 341.
Cattanach, K. L., J. Sigurjonsson, S. T. Buckland, and T. Gunnlaugsson. 1993. Sei whale abundance in the North Atlantic, estimated from NASS-87 and NASS-89 data. (*Balaenoptera borealis*). Report of the International Whaling Commission SC/44/Nab10 43:315-321.
Cetacean and Turtle Assessment Program. 1982. A characterization of marine mammals and turtles in the mid- and north-Atlantic areas of the U.S. Outer Continental Shelf. Cetacean and Turtle Assessment Program, Bureau of Land Management, BLM/YL/TR-82/03, Washington, D.C. 538.
Christensen, I., T. Haug, and N. Øien. 1992. A review of feeding and reproduction in large baleen whales (Mysticeti) and sperm whales (*Physeter macrocephalus*) in Norwegian and adjacent waters. Fauna Norvegica Series A 13:39-48.
Clapham, P. J., and R. L. Brownell. 1996. The potential for interspecific competition in baleen whales. Report of the International Whaling Commission SC/47/SH27 46:361-367.
Clapham, P. J., S. Leatherwood, I. Szczepaniak, and R. L. Brownell. 1997. Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. Marine Mammal Science 13(3):368-394.
Clark, C. W., W. T. Ellison, B. L. Southall, L. Hatch, S. M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Marine Ecology Progress Series 395:201-222.
Clarke, J. T., and S. A. Norman. 2005. Results and evaluation of US Navy shock trial environmental mitigation of marine mammals and sea turtles. Journal of Cetacean Research and Management 7(1):43-50.

Committee for Whaling Statistics. 1942. International whaling statistics, Oslo. 139 pp.
Committee on the Status of Endangered Wildlife in Canada. 2003. COSEWIC assessment and status report on the sei whale *Balaenoptera borealis* (Pacific population, Atlantic population) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Canada. vii + 27.
Curtis, K. R., B. M. Howe, and J. A. Mercer. 1999. Low-frequency ambient sound in the North Pacific: long time series observations. The Journal of the Acoustical Society of America 106(6):3189-3200.
Daan, S., C. Deerenberg, and C. Dijkstra. 1996. Increased daily work precipitates natural death in the kestrel. The Journal of Animal Ecology 65(5):6.
Danielsdottir, A. K., E. J. Duke, P. Joyce, and A. Arnason. 1991. Preliminary studies on genetic variation at enzyme loci in fin whales (*Balaenoptera physalus*) and sei whales (*Balaenoptera borealis*) form the North Atlantic. Report of the International Whaling Commission Special Issue 13:115-124.
Di Iorio, L., and C. W. Clark. 2010. Exposure to seismic survey alters blue whale acoustic communication. Biology Letters 6(1):51-54.
Donovan, G. P. 1991. A review of IWC stock boundaries. Report of the International Whaling Commission Special Issue 13:39-68.
Edds, P. L., T. J. Macintyre, and R. Naveen. 1984. Notes on a sei whale (*Balaenoptera borealis,* Lesson) sighted off Maryland. Cetus 5(2):4-5.
Erbe, C., and D. M. Farmer. 2000. A software model to estimate zones of impact on marine mammals around anthropogenic noise. The Journal of the Acoustical Society of America 108(3):1327-1331.
Evans, D. R., and G. R. England. 2001. Joint Interim Report Bahamas Marine Mammal Stranding Event of 15-16 March 2000. NOAA, National Marine Fisheries Service; Department of the Navy 66.
Feare, C. J. 1976. The breeding of the Sooty Tern Sterna fuscata in the Seychelles and the effects of experimental removal of its eggs. Journal Zoology (London) 197:317-360.
Flinn, R. D., A. W. Trites, E. J. Gregr, and R. I. Perry. 2002. Diets of fin, sei, and sperm whales in British Columbia: An analysis of commercial whaling records, 1963-1967. Marine Mammal Science 18(3):663-679.
Foote, A. D., R. W. Osborne, and A. R. Hoelzel. 2004. Whale-call response to masking boat noise. Nature 428:910.
Ford, J. K. B., and R. R. Reeves. 2008. Fight or flight: antipredator strategies of baleen whales. Mammal Review 38(1):50-86.
Frankel, A. S. 2005. Gray whales hear and respond to a 21-25 kHz high-frequency whale-finding sonar. (*Eschrichtius robustus*). Pages 97 *in* Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.
Frid, A., and L. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6(1):11.
Gambell, R. 1977. A review of population assessments of Antarctic sei whales. (*Balaenoptera borealis*). Report of the International Whaling Commission Special Issue 1:44-49.
Gambell, R. 1985a. Sei whale *Balaenoptera borealis* (Lesson, 1828). Pages 193-240 *in* S. H. Ridgway, and R. Harrison, editors. Handbook of Marine Mammals. Vol. 3: The sirenians and baleen whales. Academic Press, London, United Kingdom.

Gambell, R. 1985b. Sei whale, *Balaenoptera borealis* Lesson, 1828. Handbook of Marine Mammals. Volume 3: the Sirenians and Baleen Whales. Sam H. Ridway and Sir Richard Harrison, eds. p.155-170.

Gedamke, J., and S. M. Robinson. 2010. Acoustic survey for marine mammal occurrence and distribution off East Antarctica (30-80°E) in January-February 2006. Deep Sea Research Part II: Topical Studies in Oceanography 57(9-10):968-981.

Gendron, D., and S. C. Rosales. 1996. Recent sei whale (*Balaenoptera borealis*) sightings in the Gulf of California, Mexico. Aquatic Mammals 22(2):127-130.

Geraci, J. R. 1990. Physiologic and toxic effects on cetaceans. Pages 167-197 *in* J. R. Geraci, and D. J. S. Aubin, editors. Sea Mammals and Oil: Confronting the Risks. Academic Press, San Diego.

Giese, M. 1996. Effects of human activity on adelie penguin *Pygoscelis adeliae* breeding success. Biological Conservation 75(2):157-164.

Gill, J. A., K. Norris, and W. J. Sutherland. 2001. Why behavioural responses may not reflect the population consequences of human disturbance. Biological Conservation 97(2):265-268.

Gill, J. A., and W. J. Sutherland. 2001. Predicting the consequences of human disturbance from behavioral decisions. Pages 51-64 *in* L. M. Gosling, and W. J. Sutherland, editors. Behavior and Conservation. Cambridge University Press, Cambridge.

Glass, A. H., T. V. N. Cole, and M. Garron. 2009. Mortality and serious injury determinations for baleen whale stocks along the United States eastern seaboard and adjacent Canadian Maritimes, 2003-2007 (second edition)

Goodall, N., C. C. Boy, and A. C. M. Schiavini. 2007. Historical and modern records of cetaceans self-stranding to escape killer whale attacks. (*Orcinus orca*). Unpublished paper to the IWC Scientific Committee SC/59/SM17, Anchorage, AK. 11.

Gregr, E. J., L. Nichol, J. K. B. Ford, G. Ellis, and A. W. Trites. 2000. Migration and population structure of northeastern Pacific whales off coastal British Columbia: An analysis of commercial whaling records from 1908-1967. Marine Mammal Science 16(4):699-727.

Gregr, E. J., and A. W. Trites. 2001. Predictions of critical habitat for five whale species in the waters of coastal British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 58(7):1265-1285.

Gunnlaugsson, T., and J. Sigurjonsson. 1990. A note on the problem of false positives in the use of natural marking data for abundance estimation. Report of the International Whaling Commission Special Issue 12:143-145.

Harrington, F. H., and A. M. Veitch. 1992. Calving success of woodland caribou exposed to low-level jet fighter overflights. Arctic 45(3):213-218.

Hatch, L. T., C. W. Clark, S. V. Parijs, R. Merrick, D. Ponirakis, K. Schwehr, M. A. Thompson, and D. Wiley. 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: A case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Journal of the Acoustical Society of America 123(5 Pt. 2):2986-2087.

Hays, G. C., A. J. Richardson, and C. Robinson. 2005. Climate change and marine plankton. Trends in Ecology and Evolution 20(6).

Henry, J., and P. B. Best. 1983. Organochlorine residues in whales landed at Durban, South Africa. Marine Pollution Bulletin 14(6):223-227.

Heyning, J. E., and T. D. Lewis. 1990. Entanglements of baleen whales in fishing gear off southern California. (*Eschrichtius robustus, Balaenoptera acutorostrata, Megaptera novaeangliae*). Report of the International Whaling Commission 40(SC/41/14):427-431.
Hjort, J., and J. T. Ruud. 1929. Whaling and fishing in the North Atlantic. Rapports Et Proces-Verbaux Des Reunions Conseil International Pour L'Exploration de la Mer 56:1-123.
Horwood, J. 1987. The sei whale: Population biology, ecology and management. (*Balaenoptera borealis*). Croom Helm, London.
Houser, D. S., D. A. Helweg, and P. W. B. Moore. 2001. A bandpass filter-bank model of auditory sensitivity in the humpback whale. Aquatic Mammals 27(2):82-91.
Illingworth and Rodkin Inc. 2001. Noise and vibration measurements associated with the pile installation demonstration project for the San Francisco-Oakland Bay Bridge east span, final data report
Ingebrigtsen, A. 1929. Whales caught in the North Atlantic and other seas. Rapports et Procèsverbaux des réunions, Cons. Perm. Int. L'Explor. Mer 56:1-26.
Iniguez, M., J. F. Masello, C. Gribaudo, D. Arcucci, F. Krohling, and J. Belgrano. 2010. On the occurrence of sei whales, *Balaenoptera borealis*, in the south-western Atlantic. Marine Biodiversity Records 3: e68.
International Whaling Commission. 1996. Report of the Scientific Committee. International Whaling Commission 72-77.
International Whaling Commission. 2010. Special Permit Catches since 1985 (Table). International Whaling Commission.
Ivashin, M. V., and Y. P. Golubovsky. 1978. On the cause of appearance of white scars on the body of whales. Report of the International Whaling Commission SC/29/Doc 19 28:199.
Jahoda, M., C. L. Lafortuna, N. Biassoni, C. Almirante, A. Azzellino, S. Panigada, M. Zanardelli, and G. N. Di Sciara. 2003. Mediterranean fin whale's (*Balaenoptera physalus*) response to small vessels and biopsy sampling assessed through passive tracking and timing of respiration. Marine Mammal Science 19(1):96-110.
Jefferson, T. A., M. A. Webber, and R. L. Pitman. 2008. Marine Mammals of the World: A Comprehensive Guide to their Identification. Academic Press, Elsevier. London, U.K.
Jensen, A. S., and G. K. Silber. 2004. Large Whale Ship Strike Database. U.S. Department of Commerce, NMFS-OPR-25 37.
Jonsgård, A. 1974. On whale exploitation in the eastern part of the North Atlantic Ocean. The Whale Problem. W. E. Schevill (ed.). Harvard Univ. Press, Cambridge, Masschusetts. pg. 97-107.
Jonsgård, Å., and K. Darling. 1977. On the biology of the eastern North Atlantic sei whales, *Balaenoptera borealis* Lesson. Reports of the International Whaling Commission Special Issue SC/27/Doc 17 11:123-129.
Kanda, N., M. Goto, and L. A. Pastene. 2006. Genetic characteristics of western North Pacific sei whales, *Balaenoptera borealis*, as revealed by microsatellites. Marine Biotechnology 8(1):86-93.
Kapel, F. O. 1985a. On the occurrence of sei whales (*Balaenoptera borealis*) in West Greenland waters. Report of the International Whaling Commission 35:349-352.
Kapel, F. O. 1985b. On the occurrence of sei whales in West Greenland waters. Report of the International Whaling Commission 35:349-352.

Kawamura, A. 1980. A review of food of balaenopterid whales. Sci. Rep. Whales Res. Inst 32:155-197.

Kawamura, A. 1982. Food habits and prey distributions of three rorqual species in the North Pacific Ocean. Scientific Reports of the Whales Research Institute, Tokyo 34:59-91.

Kenney, R. D., and H. E. Winn. 1987. Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas. Continental Shelf Research 7(2):107-114.

Ketten, D. R. 1991. The marine mammal ear: Specializations for aquatic audition and echolocation. The Biology of Hearing. p.717-754. D. Webster, R. Fay AND A. Popper (eds.). Springer-Verlag Publ.

Ketten, D. R. 1992. The cetacean ear: form, frequency, and evolution. Pages 53-75 *in* J. A. Thomas, R. A. Kastelein, and A. Y. Supin, editors. Marine Mammal Sensory Systems. Plenum Press, New York.

Ketten, D. R. 1994. Functional analyses of whale ears: adaptations for underwater hearing. Proceedings of OCEANS '94. 'Oceans Engineering for Today's Technology and Tomorrow's Preservation' Brest, France.

Ketten, D. R., and D. C. Mountain. 2009. Beaked and baleen whale hearing: Modeling responses to underwater noise. Naval Postgraduate School, NPS-OC-09-005, Monterey, California.

Knowlton, A. R., C. W. Clark, and S. D. Kraus. 1991. Sounds recorded in the presence of sei whales, *Balaenoptera borealis*. Pages 40 *in* Ninth Biennial Conference on the Biology of Marine Mammals, 5-9 December Chicago IL.

Lambertsen, R. H. 1986. Disease of the common fin whale (*Balaenoptera physalus*): Crassicaudiosis of the urinary system. Journal of Mammalogy 67(2):353-366.

Leatherwood, S., R. R. Reeves, W. F. Perrin, and W. E. Evans. 1982. Whales, dolphins and porpoises of the eastern North Pacific and adjacent Arctic waters: A guide to their identification. NOAA Technical Report NMFS CIRCULAR No. 444. 244p.

Lima, S. L. 1998. Stress and decision making under the risk of predation: recent developments from behavioral, reproductive, and ecological perspecitves. Advances in the Study of Behavior 27:215-290.

Lipscomb, T. P., R. K. Harris, A. H. Rebar, B. E. Ballachey, and R. J. Haebler. 1994. Pathology of sea otters. (*Enhydra lutris*). Marine Mammals and the Exxon Valdez. T. R. Loughlin (ed.). Academic Press. p.265-279.

Lockyer, C. 1977a. Mortality rates for mature southern sei whales. (*Balaenoptera borealis*). Report of the International Whaling Commission Special Issue 1:53-57.

Lockyer, C. 1977b. Some estimates of growth in the sei whale, *Balaenoptera borealis*. Report of the International Whaling Commission Special Issue 1:58-62.

Lockyer, C. H., and A. R. Martin. 1983. The sei whale off Western Iceland. II. Age, growth and reproduction. (*Balaenoptera borealis*). Report of the International Whaling Commission 33:465-476.

Lucifredi, I., and P. J. Stein. 2007. Gray whale target strength measurements and the analysis of the backscattered response. Journal of the Acoustical Society of America 121(3):1383-1391.

Mackas, D. L., R. H. Goldblatt, and A. G. Lewis. 1989. Importance of walleye Pollock in the diets of marine mammals in the Gulf of Alaska and Bering Sea and implications for fishery management. Pages Pages 701–726 *in* international symposium on the biology and management of walleye Pollock, November 14-16,1988. Univ. AK Sea Grant Rep. AK-SG-89-01., Anchorage, AK.

MacLeod, C. D., S. M. Bannon, G. J. Pierce, C. Schweder, J. A. Learmonth, J. S. Herman, and R. J. Reid. 2005. Climate change and the cetacean community of north-west Scotland. Biological Conservation 124:477-483.

Malme, C. I., P. R. Miles, C. W. Clark, P. Tyack, and J. E. Bird. 1983. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. Final report for the period of 7 June 1982 - 31 July 1983. Report No. 5366. For U.S. Department of the Interior, Minerals Management Service, Alaska OCS Office, Anchorage, AK 99510. 64pp.

Martin, A. R. 1983. The sei whale off Western Iceland. I. Size, distribution and abundance. (*Balaenoptera borealis*). Report of the International Whaling Commission 33:457-463.

Masaki, Y. 1977. The separation of the stock units of sei whales in the North Pacific. (*Balaenoptera borealis*). Report of the International Whaling Commission Special Issue 1:71-79.

McCauley, R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine Seismic Surveys: Analysis And Propagation of Air-Gun Signals; And Effects of Air-Gun Exposure On Humpback Whales, Sea Turtles, Fishes and Squid Curtin University of Technology, Western Australia. 203.

McDonald, M. A., J. A. Hildebrand, and S. M. Wiggins. 2006. Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. The Journal of the Acoustical Society of America 120(2):711-718.

McDonald, M. A., J. A. Hildebrand, S. M. Wiggins, and D. Ross. 2008. A 50 Year comparison of ambient ocean noise near San Clemente Island: A bathymetrically complex coastal region off Southern California. Journal of the Acoustical Society of America 124(4):1985-1992.

McDonald, M. A., J. A. Hildebrand, S. M. Wiggins, D. Thiele, D. Glasgow, and S. E. Moore. 2005. Sei whale sounds recorded in the Antarctic. Journal of the Acoustical Society of America 118(6):3941-3945.

Mead, J. G. 1977. Records of sei and Bryde's whales from the Atlantic coast of the United States, the Gulf of Mexico, and the Caribbean. Reports of the International Whaling Commission 1:113-116.

Mitchell, E. 1974. Present status of northwest Atlantic fin and other whale stocks. Pages 108-169 *in* The whale problem: A status report. Harvard University Press, Cambridge, Massachusetts.

Mitchell, E. 1975a. Preliminary report on Nova Scotia fishery for sei whales (Balaenoptera borealis). Report of the International Whaling Commission 25:218-225.

Mitchell, E. 1975b. Trophic relationships and competition for food in northwest Atlantic right whales. Proceedings of the Canadian Society of Zoology Annual Meeting 1974:123-133.

Mitchell, E., and D. G. Chapman. 1977. Preliminary assessment of stocks of northwest Atlantic sei whales (*Balaenoptera borealis*). Report of the International Whaling Commission (Special Issue 1):117-120.

Mitchell, E. D., V. M. Kozicki, and R. R. Reeves. 1986. Sightings of right whales, *Eubalaena glacialis*, on the Scotian Shelf, 1966-1972. Report of the International Whaling Commission Special Issue SC/35/RW18 10:83-107.

Mizroch, S. A., D. W. Rice, and J. M. Breiwick. 1984a. The blue whale, *Balaenoptera musculus*. Marine Fisheries Review 46(4):15-19.

Mizroch, S. A., D. W. Rice, and J. M. Breiwick. 1984b. The sei whale, *Balaenoptera borealis*. Marine Fisheries Review 46(4):25-29.
Moore, P. W. B., and R. J. Schusterman. 1987. Audiometric Assessment of Northern Fur Seals, *Callorhinus-Ursinus*. Marine Mammal Science 3(1):31-53.
Müllner, A., K. Eduard Linsenmair, and M. Wikelski. 2004. Exposure to ecotourism reduces survival and affects stress response in hoatzin chicks (*Opisthocomus hoazin*). Biological Conservation 118(4):549-558.
Nasu, K. 1966. Fishery oceanographic study on the baleen whaling grounds. Scientific Reports of the Whales Research Institute Tokyo 20:157-210.
Nasu, K. 1974. Movements of baleen whales in relation to hydrographic conditions in the northern part of the North Pacific Ocean, Bering Sea. Oceanography of the Bering Sea. D. W. Hood and E. J. Kelley, eds. Int. Mar. Sci., University of Alaska, Fairbanks. pp. 345-361.
National Marine Fisheries Service. 2005. Recovery Plan for the North Atlantic Right Whale (*Eubalaena glacialis*). NMFS Office of Protected Resources, editor, Silver Spring, MD.
National Marine Fisheries Service. 2008. Biological Opinion for the 2008 Rim of the Pacific Exercise, several continuing exercises, and Research, Development, Test and Evaluation Activities. NMFS Office of Protected Resources, editor, Silver Spring, MD.
National Research Council. 2003. Ocean Noise and Marine Mammals.National Research Council: Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals.
National Research Council. 2005. Marine mammal populations and ocean noise. Determining when noise causes biologically significant effects. National Academy of Sciences, Washington, DC.
Nelson, M., M. Garron, R. L. Merrick, R. M. Pace III, and T. V. N. Cole. 2007. Mortality and serious injury determinations for baleen whale stocks along the United States eastern seaboard and adjacent Canadian Maritimes, 2001-2005. U.S. Department of Commerce, NOAA, Northeast Fisheries Science Center 26.
Nemoto, T., and A. Kawamura. 1977. Characteristics of food habits and distribution of baleen whales with special reference to the abundance of North Pacific sei and Bryde's whales. Report of the International Whaling Commission (Special Issue 1):80-87.
O'Shea, T., and R. L. Brownell Jr. 1994. Organochlorine and metal contaminants in baleen whales: a review and evaluation of conservation implications. Science of the Total Environment 154(2-3):179-200.
Olsen, E., W. P. Budgell, E. Head, L. Kleivane, L. Nottestad, R. Prieto, M. A. Silva, H. Skov, G. A. Vikingsson, G. Waring, and N. Oien. 2009. First satellite-tracked long-distance movement of a sei whale (*Balaenoptera borealis*) in the North Atlantic. Aquatic Mammals 35(3):313-318.
Palka, D. L. 2006. Summer abundance estimates of cetaceans in US North Atlantic Navy Operating Areas. Northeast Fisheries Science Center 52.
Palsbøll, P. J., J. Allen, M. Bérubé, P. J. Clapham, T. P. Feddersen, R. R. Hudson, H. Jørgensen, S. Katona, A. H. Larsen, F. Larsen, J. Lien, D. K. Mattila, J. Sigurjónsson, R. Sears, T. Smith, R. Sponer, P. Stevick, and N. Øien. 1997. Genetic tagging of humpback whales. Nature 388(6644):767-769.

Parks, S. E., C. W. Clark, and P. L. Tyack. 2007a. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. The Journal of the Acoustical Society of America 122(6):3725-3731.

Parks, S. E., D. R. Ketten, J. T. O'Malley, and J. Arruda. 2007b. Anatomical predictions of hearing in the North Atlantic right whale. Anatomical Record Advances in Integrative Anatomy and Evolutionary Biology 290(6):734-744.

Parks, S. E., I. Urazghildiiev, and C. W. Clark. 2009. Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas. Journal of the Acoustical Society of America 125(2):1230-1239.

Payne, P. M., D. N. Wiley, S. B. Young, S. Pittman, P. J. Clapham, and J. W. Jossi. 1990. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in prey abundance. Fishery Bulletin 88(4):687-696.

Perrin, W. F., J. G. Mead, and J. Robert L. Brownell. 2009. Review of the evidence used in the description of currently recognized cetacean subspecies. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center

Perry, S. L., D. P. Demaster, and G. K. Silber. 1999. The sei whale (*Balaenoptera borealis*). Marine Fisheries Review 61(1):52-58. W. L. Hobart (Ed.). In the Great Whales History and Status of Six Species Listed As Endangered Under the U.S. Endangered Species Act of1973.

Pike, G. C. 1951. Lamprey marks on whales. Journal of the Fisheries Research Board of Canada 8(4):275-280.

Pike, G. C., and I. B. Macaskie. 1969. Marine mammals of British Columbia. Bulletin of the Fisheries Research Board of Canada 171:1-54.

Polefka, S. 2004. Anthropogenic Noise and the Channel Islands National Marine Sanctuary: How Noise Affects Sanctuary Resources and What We Can Do About It. Environmental Defense Center, Santa Barbara, CA. 53.

Popper, A. N. 1980a. Behavioral measures of odontocete hearing. Pages 469-481 *in* R. G. Busnel, and J. F. Fish, editors. Animal Sonar Systems. Plenum Press, New York, NY.

Popper, A. N. 1980b. Sound emission and detection by delphinids. Pages 1-52 *in* L. M. Herman, editor. Cetacean Behavior: Mechanisms and Functions. John Wiley and Sons, New York.

Prieto, R., M. A. Silva, I. Cascão, M. J. Cruz, C. I. B. Oliveira, G. Waring, and J. Gonçalves. 2010. The Importance of Oceanic Fronts in the Labrador Sea to North Atlantic Sei Whales (*Balaenoptera borealis*). Clues from Satellite Telemetry. . Arctic Frontiers Conference, Trømso.

Quinn, T. J., and H. J. Niebauer. 1995. Relation of eastern Bering Sea walleye Pollock (*Theragra chalcogramma*) recruitment to environmental and oceanographic variables. Pages 497-507 *in* R. J. Beamish, editor. Climate change and northern fish populations, volume 121. Canadian Special Publication of Fisheries and Aquatic Sciences.

Rankin, S., J. Barlow, and J. Oswald. 2007. Vocal behavior of cetaceans in the North Pacific Ocean. 3rd International Workshop on the Detection and Classification of Marine Mammals Using Passive Acoustics, p21 Federal Reserve Building Boston MA 24-26, July.

Reeves, R. R., and M. F. Barto. 1986. Whaling in the Bay of Fundy. Whalewatcher 19(4):14-18.

Reeves, R. R., S. Leatherwood, G. S. Stone, and L. G. Eldredge. 1999. Marine mammals in the area served by the South Pacific Regional Environment Programme (SPREP). SPREP, Apia, Samoa.

Reeves, R. R., B. S. Stewart, P. J. Clapham, and J. A. Powell. 2002. Guide to marine mammals of the world. Chanticleer Press, Inc., New York.

Reyff, J. A. 2003. Underwater sound levels associated with construction of the Benicia-Martinez Bridge. Final Report by Illingworth & Rodkin, Inc. under Contract 43A0063 to the California Department of Transportation. 26p.

Rice, D. W. 1974. Whales and whale research in the eastern North Pacific. Pages 170-195 *in* W. E. Schevill, editor. The Whale Problem: A Status Report. Harvard University Press, Cambridge, MA.

Rice, D. W. 1977. Synopsis of biological data on the sei whale and Bryde's whale in the eastern North Pacific. Report of the International Whaling Commission (Special Issue 1):92-97.

Rice, D. W. 1998. Marine mammals of the world: Systematics and distribution. Special Publication Number 4. The Society for Marine Mammology, Lawrence, KS. 231p.

Richardson, W. J., C. R. Greene Jr., C. I. Malme, and D. H. Thomson. 1995. Marine mammals and noise. Academic Press, Inc., San Diego, CA.

Ridgway, S. H. 1983. Dolphin hearing and sound production in health and illness. Hearing and Other Senses: Presentations in Honor of E. G. Wever. R. R. Fay and G. Gourevitch (eds.). p.247-296. the Amphora Press, Box N, Groton, CT 06340. 405pgs.

Risting, S. 1928. Whales and whale fetuses. Rapports Et Proces-Verbaux Des Reunions Conseil International Pour L'Exploration de la Mer 50:1-122.

Romero, L. M. 2004. Physiological stress in ecology: lessons from biomedical research. Trends in Ecology & Evolution 19(5):249-255.

Ross, D. 1976. Mechanics of unterwater noise. Pergamon Press, New York.

Rountree, R. A., R. G. Gilmore, C. A. Goudey, A. D. Hawkins, J. J. Luczkovich, and D. A. Mann. 2006. Listening to fish: Applications of passive acoustics in fisheries science. Fisheries 31(9):433–446.

Sanpera, C., and A. Aguilar. 1992. Modern whaling off the Iberian Peninsula during the 20th century. (Physeter catodon, Balaenoptera physalus, Balaenoptera borealis, Balaenoptera edeni). Report of the International Whaling Commission 42:723-730.

Scheffer, V. B., and J. W. Slipp. 1948. The whales and dolphins of Washington State with a key to the cetaceans of the west coast of North America. American Midland Naturalist 39:257-337.

Schilling, M. R., I. Seipt, M. T. Weinrich, S. E. Frohock, A. E. Kuhlberg, and P. J. Clapham. 1992. Behavior of individually-identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986. Fishery Bulletin 90:749–755.

Schmitt, F. P., C. D. Jong, and F. H. Winter. 1980. Thomas Welcome Roys: America's pioneer of modern whaling. University Press of Virginia, Charlottesville, VA.

Schusterman, R. J. 1981. Behavioral capabilities of seals and sea lions: A review of their hearing, visual, learning, and diving skills. Psychological Record 31:125-143.

Secretariat of the Pacific Regional Environment Programme. 2007. Pacific Islands Regional marine species program 2008-2012. SPREP, Apia, Samoa.

Shevchenko, V. I. 1977. Application of white scars to the study of the location and migrations of sei whale populations in Area III of the Antarctic. (*Balaenoptera borealis*). Report of the International Whaling Commission Special Issue SC/27/Doc 23 1:130-134.

Sigurjónsson, J. 1983. The cruise of the Ljosfari in the Denmark Strait (June-July 1981) and recent marking and sightings off Iceland. Reports of the International Whaling Commission 33:667-682.

Sigurjónsson, J. 1988. Operational factors of the Icelandic large whale fishery. Report of the International Whaling Commission 38:327-333.

Sigurjónsson, J. 1989. To Icelanders, whaling is a godsend. Oceanus 32(1):29-36.

Sigurjónsson, J., G. Vikingsson, and T. Gunnlaugsson. 1991. North Atlantic sei whales: A progress report on a candidate for Comprehensive Assessment. Unpublished paper to the IWC Scientific Committee SC/43/BA8, Reykjavik, Iceland. 5.

Simmonds, M. P., and J. D. Hutchinson. 1996. The conservation of whales and dolphins. John Wiley and Sons, Chichester, U.K.

Sirovic, A., G. R. Cutter, J. L. Butler, and D. A. Demer. 2009. Rockfish sounds and their potential use for population monitoring in the Southern California Bight. ICES Journal of Marine Sciences 66(6):981-990.

Skov, H., T. Gunnlaugsson, W. P. Budgell, J. Horne, L. Nottestad, E. Olsen, H. Soiland, G. Vikingsson, and G. Waring. 2008. Small-scale spatial variability of sperm and sei whales in relation to oceanographic and topographic features along the Mid-Atlantic Ridge. Deep Sea Research Part Ii: Topical studies in Oceanography 55(1-2)254-268.

Smultea, M. A., T. A. Jefferson, and A. M. Zoidis. 2010. Rare Sightings of a Bryde's Whale (Balaenoptera edeni) and Sei Whales (B. borealis) (Cetacea: Balaenopteridae) Northeast of O'ahu, Hawai'i. Pacific Science 64(3):449-457.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene, D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. 2007. Special Issue: Marine Mammal Noise Exposure Criteria Special Issue. Aquatic Mammals 33(4):Iv + 411-521.

Stone, C. J. 2003. The effects of seismic activity on marine mammals in UK waters, 1998-2000. Joint Nature Conservation Committee, JNCC Report No. 323 78.

Sutcliffe, W. H., and P. F. Brodie. 1977. Whale Distributions in Nova Scotia Waters. Bedford Institute of Oceanography, Technical Report No. 722, Dartmoth, Nova Scotia.

Sutherland, W. J., and N. J. Crockford. 1993. Factors affecting the feeding distribution of red breasted geese, Branta ruficollis, wintering in Romania. Biological Conservation 63:61-65.

Tamura, T., K. Konishi, T. Isoda, R. Okamoto, T. Bando, and T. Hakamada. 2009. Some examinations of uncertainties in the prey consumption estimates of common minke, sei and Bryde's whales in the western North Pacific. Unpublished paper to the IWC Scientific Committee, Madeira, Portugal. 24.

Tarpley, R. J., and S. Marwitz. 1993. Plastic debris ingestion by cetaceans along the Texas coast: two case reports. Aquatic Mammals 19(2):93-98.

Tershy, B. R., D. Breese, and C. S. Strong. 1990. Abundance, seasonal distribution and population composition of balaenopterid whales in the Canal de Ballenas, Gulf of California, Mexico. Report of the International Whaling Commission Special Issue 12:369-375.

Thompson, D. W. 1919. On whales landed at the Scottish whaling stations, especially during the years 1908-1914. IV. The bottlenose-whale (Hyperoodon rostratus, auctt.). Scottish Naturalist 85:1-3.

Thompson, T. J., H. E. Winn, and P. J. Perkins. 1979. Mysticete Sounds. . Pages 403-431 *in* H. E. W. a. B. L. Olla, editor. Behavior of Marine Animals, volume 3: Cetaceans. Plenum Press, New York.

Tillman, M. F. 1977. Estimates of population size for the North Pacific sei whale. (Balaenoptera borealis). Report of the International Whaling Commission Special Issue 1(Sc/27/Doc 25):98-106.

Tonnessen, J. N., and A. O. J. T. F. T. N. B. R. I. Christophersen). 1982. The history of modern whaling. University of California Press, Berkeley, CA. 798pp. ISBN 0-520-03973-4.

Tonnessen, J. N., and A. O. Johnsen. 1982. The history of modern whaling. University of California Press, Berkeley, CA. 798pp. ISBN 0-520-03973-4.

Tyack, P. L., and C. W. Clark. 2000. Communication and acoustic behavior of dolphins and whales. Hearing by Whales and Dolphins. p.156-224. W. W. L. Au, A. N. Popper, R. R. Fay (eds.). Springer-Verlag, New York Inc.

U.S. Department of the Navy. 2007. Final Supplemental Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar.

U.S. Department of the Navy. 2008. Draft Environmental Impact Statement/Overseas Environmental Impact Statement: Southern California Range Complex.

Viale, D., N. Verneau, and Y. Tison. 1991. Occlusion gastrique jutale chez un cachalot echoue sur les Iles Lavezzi: macropollution en Mediterranee. Journal de Recherche Oceano-Graphique 16(3-4):100-102.

Wada, S., and K. Numachi. 1991. Allozyme analyses of genetic differentiation among the populations and species of the Balaenoptora. Report of the International Whaling Commission Special Issue 13:125-154.-Genetic Ecology of Whales and Dolphins).

Wade, P. R., and R. P. Angliss. 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. NOAA Technical Memorandum NMFS-OPR-12. 93pgs.

Waring, G. T., E. Josephson, C. P. Fairfield, and K. M.-F. (Eds). 2009. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2008. NOAA Technical Memorandum NMFS-NE-210. 440pp.

Waring, G. T., E. Josephson, K. Maze-Foley, and P. E. Rosel, (Eds). 2010. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2011. NOAA Technical Memorandum NMFS-NE-219. 598pp.

Wartzok, D., and D. R. Ketten. 1999. Marine mammal sensory systems. Biology of Marine Mammals. John E. Reynolds, III and Sentiel A. Rommel (eds.). Smithsonian Institution Press , Washington. p.117-175.

Wartzok, D., A. N. Popper, J. Gordon, and J. Merrill. 2004. Factors affecting the responses of marine mammals to acoustic disturbance. Marine Technology Society Journal 37(4):6-15.

Watkins, W. A. 1981. Activities and underwater sounds of fin whales. Scientific Reports of the Whales Research Institute 33:83-117.

Watkins, W. A. 1986. Whale Reactions to Human Activities in Cape-Cod Waters. Marine Mammal Science 2(4):251-262.

Watkins, W. A., and W. E. Schevill. 1979. Aerial observations of feeding behavior in four baleen whales: *Eubalaena glacialis*, *Balaenoptera borealis*, *Megaptera novaeangliae,* and *Balaenoptera physalus*. Journal of Mammalogy 60(1):155-163.

Watkins, W. A., and D. Wartzok. 1985. Sensory Biophysics of Marine Mammals. Marine Mammal Science 1(3):219-260.

Weinrich, M. T., C. R. Belt, M. R. Schilling, and M. Marcy. 1986. Behavior of sei whales in the southern Gulf of Maine, summer 1986. Whalewatcher 20(4):4-7.

Weisbrod, A. V., D. Shea, M. J. Moore, and J. J. Stegeman. 2000. Organochlorine exposure and bioaccumulation in the endangered northwest Atlantic right whale (*Eubalaena glacialis*) population. Environmental Toxicology and Chemistry 19(3):654.

Wenz, G. M. 1962. Acoustic ambient noise in the ocean: Spectra and sources. Journal of the Acoustical Society of America 34:1936-1956.

PEOPLE PROVIDING PERSONAL COMMUNICATIONS

Russell Leaper, School of Biological Sciences, University of Aberdeen, Tillydrone Avenue, Aberdeen AB24 2TZ, U.K. July 2010.