STATE OF WASHINGTON August 2017

Periodic Status Review for Blue, Fin, Sei, North Pacific Right, and Sperm Whales

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The Washington Department of Fish and Wildlife maintains a list of endangered, threatened, and sensitive species (Washington Administrative Codes 220-610-010 and 220-200-100). In 1990, the Washington Wildlife Commission adopted listing procedures developed by a group of citizens, interest groups, and state and federal agencies (Washington Administrative Code 220-610-110). These procedures include how species listings will be initiated, criteria for listing and delisting, a requirement for public review, the development of recovery or management plans, and the periodic review of listed species.

The Washington Department of Fish and Wildlife is directed to conduct reviews of each endangered, threatened, or sensitive wildlife species at least every five years after the date of its listing by the Washington Fish and Wildlife Commission. These periodic reviews include an update on the species status to determine whether the species warrants its current listing or deserves reclassification. The agency notifies the general public and specific parties interested in the periodic status review, at least one year prior to the end of the five-year period, so that they may submit new scientific data to be included in the review. The agency notifies the public of its recommendation at least 30 days prior to presenting the findings to the Fish and Wildlife Commission. In addition, if the agency determines that new information suggests that the classification of a species be changed from its present state, the Department prepares documents to determine the environmental consequences of adopting the recommendations pursuant to requirements of the State Environmental Policy Act.

This periodic status review for the blue whale, fin whale, sei whale, North Pacific right whale, and the sperm whale was reviewed by species experts and was available for a 90-day public comment period from May 19 to August 17, 2017. All comments received were considered during the preparation of the final periodic status review. The Department intends to present the results of this periodic status review to the Fish and Wildlife Commission for action at an upcoming meeting.

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EXECUTIVE SUMMARY

Blue, fin, sei, North Pacific right, and sperm whales have been listed as state endangered species in Washington since 1981. Populations of all five species, including those in the North Pacific Ocean, greatly declined in the 1800s and 1900s from being severely overharvested by whalers. Current abundance remains strongly influenced by past levels of whaling harvest. Information on the biology, stock status, and trend of these species is summarized below.

- **Blue whale** – This large baleen whale forages primarily on krill along continental shelf slopes and deeper oceanic waters. Animals off Washington belong to the Eastern North Pacific stock, which mostly migrates between northern summer feeding locations and wintering areas off western Mexico and Central America. Current stock size is about 1,600 whales and remains below the estimated historical stock size of 2,200 individuals. Stock trend is possibly stable. Blue whales are now regularly present off the outer Washington coast.

- **Fin whale** – Another large baleen whale, this species occurs mainly along or beyond continental shelf breaks, where it feeds on krill, forage fish, and other prey. Fin whales off Washington belong to the California/Oregon/Washington stock, which is at least partially migratory. The stock currently holds about 9,000 animals and is experiencing strong growth. Historical stock size is unknown. Fin whales are now regularly present off the outer coast of Washington. Rare sightings in the Salish Sea in 2015 and 2016 are the first in recent decades.

- **Sei whale** – This medium-sized baleen whale forages on copepods and other prey mainly in deep oceanic waters. Most individuals are migratory between higher latitudes in the summer and lower latitudes in the winter. Animals off Washington belong to the Eastern North Pacific stock, which currently numbers about 500 whales. Trend and historical stock size are unknown. Although there have been no recent confirmed detections of sei whales in Washington, the species likely remains a rare visitor to the state's outermost waters.

- **North Pacific right whale** – A large baleen whale, this species feeds primarily on copepods in shelf, shelf edge, and deeper oceanic waters, and is migratory between northern summering areas and southern wintering areas. Animals along the western North American coast belong to the Eastern North Pacific stock. Once abundant, this stock now contains about 30 whales and is near extirpation, with no sign of recovery. Stock members are very rare visitors south of Alaska, with just a handful of records off the outer coast of Washington since the early 1900s.

- **Sperm whale** – The largest of the toothed whales, sperm whales are deep diving predators of mainly squid. Deep oceanic waters are inhabited, although males sometimes venture onto continental shelves. Animals off Washington belong to the California/Oregon/Washington stock, which currently numbers about 2,100 whales. Although historical stock size is unknown, it was probably larger than current size. Stock trend is possibly stable. Sperm whales are regularly present off the outer Washington coast.

The stocks of all five species face potentially significant and increasing threats from one or more factors, with those of greatest concern being ship strikes, entanglement in fishing gear and marine debris, human-generated marine sound, climate change, and in the case of North Pacific right whales, issues related to small population size. With these considerations in mind and because all five species are federally listed as endangered, it is recommended that blue, fin, sei, North Pacific right, and sperm whales remain listed as state endangered species in Washington.

INTRODUCTION

This periodic status review summarizes the biology, population status, threats, and recent management actions directed at four species of baleen whales and one species of toothed whale that occur in the marine waters of Washington. These species are the blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), sei whale (*B. borealis*), North Pacific right whale (*Eubalaena japonica*), and sperm whale (*Physeter macrocephalus*). This review also assesses whether these species should retain their current endangered status under state law or be reclassified to another status. The Washington Department of Fish and Wildlife (WDFW) has not previously published status reports for these whales.

SPECIES BACKGROUND AND NATURAL HISTORY

Blue whale. This species is the world's largest animal, with individuals measuring 24–32.6 m (79–107 ft) in length and weighing between 69,000 and 145,000 kg (76 and 160 tons) (Shirihai and Jarrett 2006, Deméré 2014). Females are somewhat larger than males, and animals in the Southern Hemisphere are larger than those in the Northern Hemisphere. Blue whales have a long and slender head and body, a broadly flattened and tapering head, a very small dorsal fin, and mottled gray or bluish-gray body coloration (Figure 1; Shirihai and Jarrett 2006).

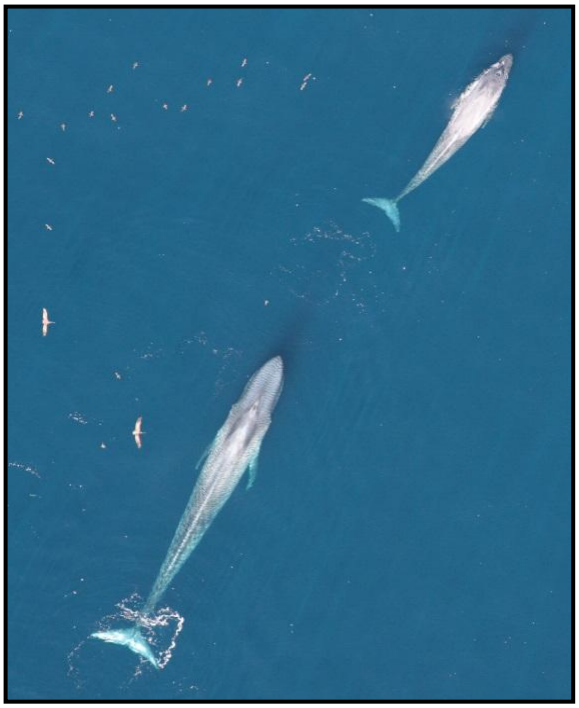

Figure 1. Blue whale mother and calf (photo by J. Gilpatrick and M. Lynn, NOAA).

Blue whales are a member of the rorqual family Balaenopteridae (i.e., baleen whales with expandable throat pleats) and are found in oceans worldwide, excluding most of the Arctic Ocean. Five subspecies are recognized, with *B. m. musculus* present in the North Pacific and North Atlantic (Committee of Taxonomy 2017). Two populations, or stocks, exist in the North Pacific and are known as the Eastern North Pacific and Central North Pacific stocks (Monnahan et al. 2014, Carretta et al. 2017). The Eastern North Pacific stock, which occurs off Washington, ranges from the Gulf of Alaska to the eastern tropical Pacific (Stafford et al. 1999). The species generally occurs farther offshore than most other whales, but also makes regular use of continental shelf waters. All records from Washington (excluding two ship strike records) are from off the outer coast (Appendix A; Scheffer and Slipp 1948).

Blue whales feed primarily on krill (euphausiids), with *Euphausia pacifica*, *Thysanoessa spinifera,* and *Nyctiphanes simplex* among the most targeted species along the west coast of North America (Yochem and Leatherwood 1985, Schoenherr 1991, Fiedler et al. 1998). Less significant prey include copepods, pelagic red crabs, and possibly fish. Blue whales feed by engulfing large volumes of water

and prey in their mouths, which are then filtered against the baleen plates. Foraging occurs within the upper 350 m of water, and is usually shallower at night when krill ascend toward the sea surface (Friedlaender et al. 2015, Mate et al. 2015). Foraging dives typically last under 15 minutes and involve lunging and rolling motions (Goldbogen et al. 2011, 2012, 2015, Mate et al. 2015). An average of 1–4 feeding lunges are made per dive (Goldbogen et al. 2011, Friedlaender et al. 2015, Mate et al. 2015). Foraging animals often aggregate along continental shelf edges where upwelling produces concentrations of krill (Schoenherr 1991, Fiedler et al. 1998, Gregr and Trites 2001, Deméré 2014). Feeding occurs throughout the year, but predominates from spring to early winter.

In general, the species migrates between feeding grounds in higher latitude regions in the summer and fall and lower latitudes during winter and spring. Most of the Eastern North Pacific stock spends the winter off Baja California, in the Gulf of California, and off Costa Rica and Nicaragua (Mate et al. 1999, 2015, Stafford et al. 1999, Bailey et al. 2009). Animals then travel northward to spend the summer and fall at highly productive feeding areas near cold water upwellings, especially off California, but with some ranging as far north as the Gulf of Alaska (Gregr 2000, Burtenshaw et al. 2004, Stafford et al. 2009, Calambokidis et al. 2009, 2015, Irvine et al. 2014, Campbell et al. 2015, Mate et al. 2015). Some portions of this stock's range appear to remain occupied during most or all of the year (e.g., Stafford et al. 2009, Busquets-Vass et al. 2017). Acoustic detections indicate that blue whales can occur off Washington during all months (Appendix A).

Blue whales do not form close-knit groups and usually live alone or with 1–2 other individuals (Deméré 2014, Lomac-MacNair and Smultea 2016). However, as many as 50 may gather when foraging in areas with abundant food.

Mating takes place during the winter and probably involves males competing for females (Sears et al. 2013). Females give birth to a single calf every 2–4 years, with births happening from fall to mid-winter in the Northern Hemisphere (COSEWIC 2002, Sears et al. 2013, Deméré 2014). Mexico and Central America are regular calving and nursing areas for the Eastern North Pacific stock, but other locations may exist as well (Sears et al. 2013). Both sexes reach sexual maturity at 8–10 or more years of age at body lengths of 21–24 m for females and 20–23 m for males (Sears et al. 2013, Deméré 2014). Life span probably averages about 65 years with a maximum of 80 years (Deméré 2014).

Fin whale. This is the second largest species of whale, reaching lengths of 22–27 m (72–89 ft) and weights of 60,000–90,000 kg (66–99 tons) (Deméré 2014). Animals in the Southern Hemisphere are larger than those in the Northern Hemisphere, and females are 5–10% larger than males. Fin whales have a long sleek head and body and a noticeable dorsal fin. Body coloration is dark gray on the back and flanks and white beneath, with several pale gray V-shaped markings on the back behind the head (Figure 2; Shirihai and Jarrett 2006).

Figure 2. Fin whale (photo by Aqqa Rosing-Asvid, Flickr Creative Commons).

The head features an asymmetrical color pattern that is mostly dark gray except for a whitish lower right jaw.

Fin whales belong to the family Balaenopteridae and are found in oceans worldwide, excluding most of the Arctic Ocean and tropical regions between 20°N and 20°S (Mizroch et al. 2009, Edwards et al. 2015). Three subspecies are recognized, with *B. p. physalus* present across most of the North Pacific, including the west coast of North America, and in the North Atlantic (Committee of Taxonomy 2017; but see Archer et al. 2013). In the North Pacific, two major population groupings, one in the east and one in the west, have been distinguished (Nishiwaki 1966, Mizroch et al. 2009). Fin whales in U.S. Pacific waters are currently managed as three stocks, which are the California/Oregon/Washington, Northeast Pacific, and Hawaii stocks (Carretta et al. 2017, Muto et al. 2017). Records from Washington originate predominantly from off the outer coast, with a few non-ship-strike records also coming from the Salish Sea (Appendix A; Scammon 1874, Scheffer and Slipp 1948).

Diet is comprised of krill (euphausiids; e.g., *Euphausia pacifica*, *Thysanoessa* spp., and *Nyctiphanes simplex* in the eastern North Pacific), large copepods, small schooling fish (e.g., herring, capelin, pollock, and anchovies), and occasionally small squid (Flinn et al. 2002, Ladrón de Guevara P. et al. 2008, Mizroch et al. 2009, Sigler et al. 2012, Deméré 2014, Friedlaender et al. 2015, Witteveen and Wynne 2016). Fasting or minimal feeding takes place in the winter. Like other rorquals, fin whales feed by lunging into schools of prey with their mouths open, using the throat pleats to gulp large volumes of food and water, and then filtering the food from the water with their baleen (Goldbogen et al. 2007). Foraging dives usually last 3–10 minutes and can vary from shallow depths to more than 470 m deep (Panigada et al. 1999, Friedlaender et al. 2015). Foraging occurs at locations with high prey productivity, mainly along or beyond continental shelf breaks, but sometimes over shelves as well (Schorr et al. 2013, Ford 2014).

Most populations of fin whales were formerly believed to migrate annually between higher latitude summer feeding grounds and lower latitude wintering grounds, but recent analyses reveal a more complex and variable pattern of movements that remains poorly understood (Mizroch et al. 2009, Oleson et al. 2014, Edwards et al. 2015, Geijer et al. 2016). In the North Pacific, fin whales summer from latitudes of roughly 30°N to 70°N (Mizroch et al. 2009). However, some whales remain present in much of this range year-round to as far north as the Gulf of Alaska and the Commander Islands (e.g., Stafford et al. 2009, Campbell et al. 2015) and do not travel to southern wintering grounds, the locations of which have yet to be discovered. Additionally, several genetically distinct non-migratory populations have been identified in the North Pacific, including one in the Gulf of California (Mizroch et al. 2009).

Fin whales in the northeastern Pacific, including those in the California/Oregon/Washington stock, are at least partially migratory, based on records of wintering animals marked off Baja California and southern California being relocated during the summer off central California, Oregon, British Columbia, and Alaska (Rice 1974, Mizroch et al. 2009) and on telemetry records of individuals tagged off Washington (Schorr et al. 2013). Whaling records that revealed increases in abundance off Washington (May, June, and September; Scheffer and Slipp 1948) and British Columbia (June to September; Gregr et al. 2000) are consistent with some annual migration along this portion of the North American west coast. Acoustic detections indicate that fin whales are present off Washington for most of the year (Appendix A).

Fin whales are generally solitary or occur in groups of 2–7 individuals (Deméré 2014). Larger aggregations regularly gather at concentrated food sources, but members demonstrate no social bonds.

Mating and calving take place during winter, with a single calf born at 2-year intervals. Pregnancy rates have been demonstrated to decline under conditions of reduced prey abundance (Williams et al. 2013). The locations of calving grounds remain largely undocumented. Historically, individuals did not reach sexual maturity until 10–12 years of age, but age of sexual maturity declined to 6–7 years in females and about 5 years in males when populations fell below carrying capacity due to whaling (Ohsumi 1986, NMFS 2010a, Deméré 2014). Fin whales may live 80–90 years (Aguilar 2002).

Sei whale. Sometimes described as the most graceful of whales (Haldane 1909), sei whales are a medium-sized rorqual that attains lengths of 17–20 m (56–66 feet) and weights of 22,000–38,000 kg (24–42 tons) (Deméré 2014). Females are somewhat larger than males and animals in the Southern Hemisphere are larger than those in the Northern Hemisphere. The species features a long streamlined head and body, a relatively tall and distinctively erect dorsal fin, and coloration that is dark bluish-gray to black above and whitish below (Figure 3; Shirihai and Jarrett 2006).

Figure 3. Sei whale mother and calf (photo by Christin Khan, NOAA).

Sei whales are members of the family Balaenopteridae and are broadly distributed across the Pacific, Atlantic, and Indian oceans. Temperate waters are favored, with colder polar seas generally avoided. Two subspecies are recognized, with *B. b. borealis* present in the Northern Hemisphere (Committee of Taxonomy 2017). Two stocks referred to as the Eastern North Pacific and Hawaii stocks are managed in U.S. Pacific waters (Carretta et al. 2017). The Eastern North Pacific stock, which occurs off Washington, ranges from the west coast of North America westward to a longitude of 180°. Contrary to Osborne et al. (1988), all Washington records are from off the outer coast except for one ship-strike record (Appendix A; Scheffer and Slipp 1948). Sei whales are more pelagic than most other large whales and are mostly found in deep oceanic waters. They regularly occur along continental shelf slopes and edges, but infrequently venture over shelf waters (Gregr and Trites 2001, Deméré 2014).

The biology of sei whales is less known than for most other rorquals (Prieto et al. 2012). Diet is diverse, with copepods considered the primary food, but krill, amphipods, decapods, small schooling fish, and squid are also taken, sometimes in large amounts depending on season and location (Horwood 1987, Flinn et al. 2002, Deméré 2014). Prey are filtered through the species' extremely fine baleen. Sei whales regularly exhibit skim-feeding behavior to capture low density prey at or near

the surface, which is unique among the rorquals, but more typical lunge feeding is also practiced (Baumgartner and Fratantoni 2008). The species generally feeds at shallower depths (i.e., within the upper 100–150 m) than other rorquals. Foraging occurs when prey rise to near-surface waters and therefore is most common from dusk to dawn (e.g., Baumgartner and Fratantoni 2008). Most feeding occurs in summer (Horwood 1987). Sei whales often forage along or near oceanographic fronts and over areas of high topographic relief (e.g., seamounts), where conditions enhance prey abundance (Skov et al. 2008, Watanabe et al. 2012, Murase et al. 2014).

Most sei whales undertake annual migrations between summer feeding grounds at higher latitudes and wintering grounds at lower latitudes, although some animals may be sedentary year-round in temperate areas (Horwood 1987, Deméré 2014). Feeding ground locations can vary substantially among years depending on changing ocean conditions and resulting prey abundance. Migrating individuals are segregated by age, sex, and reproductive condition, with mature females being the first to depart the wintering grounds (Horwood 1987, Gregr et al. 2000). In the Eastern North Pacific stock, migration past Vancouver Island, British Columbia, mostly occurs from May to August (Pike and MacAskie 1969, Masaki 1977, Gregr et al. 2000) and past central California mainly in late summer and early fall (Rice 1974). Two individuals tagged off California were later caught off Washington and Vancouver Island (Rice 1974). The locations of this stock's summering and wintering grounds have not been identified.

Sei whales are usually seen alone or in groups of 2–6 animals (Schilling et al. 1992, Deméré 2014). Aside from mother-calf pairs, social bonds are apparently briefly maintained. Loose aggregations of as many as 100 individuals sometimes gather at feeding sites.

Mating and calving occur in winter, with one calf born every 2–3 years (Horwood 1987). Most births happen from about October to January (Rice 1977). Age and size of sexual maturity have declined since the 1920s to 1930s, probably due to changes in ocean carrying capacity caused by whaling (Lockyer 1984). Both sexes formerly did not reach sexual maturity until 11 years of age, but now become sexually mature at about 8 years of age (Lockyer 1984, Horwood 1987). Life span is about 60 years.

North Pacific right whale. A large baleen whale, adults grow to lengths of 15.0–18.5 m (49–61 ft) and weights in excess of 80,000 kg (88 tons) (Shirihai and Jarrett 2006, Ivashchenko and Clapham 2012, Deméré 2014). Females are larger than males. Compared to rorqual whales, right whales have a much more rotund body shape, lack an expandable pleated throat, and have much taller baleen plates. North Pacific right whales have a large head, narrow rostrum, highly arched mouthline, broad pectoral fins, smooth back without a dorsal fin, and a large well-notched tail. Coloration is typically blackish overall (Figure 5), although some

Figure 4. North Pacific right whale (photo by Robert Pitman, NOAA).

individuals have an irregular white belly patch that occasionally extends onto the flanks. Small gray-white or black patches of roughened skin known as callosities are present on the head.

North Pacific right whales are members of the right whale family Balaenidae. The species was formerly treated as conspecific with the North Atlantic right whale (*E. glacialis*), but recent studies have confirmed the two as separate (Rosenbaum et al. 2000, Gaines et al. 2005, Churchill et al. 2011). No subspecies of North Pacific right whales are distinguished (Committee of Taxonomy 2017). The species is restricted to the North Pacific Ocean between 20°N and 60°N latitude, with most historical records distributed either north of 45°N and east of 175°W or north of 35°N and west of 170°E (Scarff 1986, 1991, Clapham et al. 2004, Josephson et al. 2008a, Gregr 2011). At present, most remaining occurrences are from the Sea of Okhotsk, east of the Kuril Islands and Kamchatka, and the southeastern Bering Sea (Sekiguchi et al. 2014, Ovsyanikova et al. 2015, Muto et al. 2017). In the eastern North Pacific, rare detections continue to be made in the Gulf of Alaska and even more rarely from British Columbia to Baja California and in Hawaii (Gendron et al. 1999, Salden and Mickelsen 1999, Mellinger et al. 2004, Wade et al. 2011a, Širović et al. 2015, Ford et al. 2016, Muto et al. 2017). Two stocks are currently recognized and are known as the Eastern North Pacific stock, which includes animals that venture to Washington, and the Western North Pacific stock (Muto et al. 2017). Despite the remarks in Osborne et al. (1988) and Calambokidis and Baird (1994), all Washington records appear to be from off the outer coast (Appendix A; Scheffer and Slipp 1948).

Diet is comprised mainly of calanoid copepods (especially *Calanus*, *Neocalanus*, and *Metridia*), with small euphausiids and amphipods also consumed (Omura 1969, Gregr and Coyle 2009, Baumgartner et al. 2013). The species' slow swimming speed precludes the capture of small fish and large krill. Prey are captured by skim feeding as the whales move with open mouths for 4–6 minutes through patches of prey, which are filtered through the whales' baleen. Feeding occurs from spring to fall, and varies in depth from the surface to at least 175 m (Kenney 2002, Wade et al. 2011a). Dives last 10–20 minutes (Kenney 2002). The species forages in shelf, shelf slope, and deeper oceanic waters with high prey abundance (Shelden et al. 2005, Gregr and Coyle 2009, Gregr 2011, Zerbini et al. 2015).

North Pacific right whales generally migrated between northern summering grounds and southern wintering grounds (Scarff 1991, Brownell et al. 2001, Clapham et al. 2004). However, animals were found across a broad latitudinal range during both seasons, suggesting a staggered migration pattern (Scarff 1991). The specific locations of wintering and calving areas for both stocks remain unconfirmed (NMFS 2013). The few historical records from along the west coast of North America indicate that the eastern stock might winter in mid-ocean waters (Scarff 1991).

This species is generally solitary or occurs in pairs, although larger groupings sometimes form at feeding and breeding sites (Jefferson et al. 2008). Individuals are regularly observed near other species of large whales (e.g., humpback whales [*Megaptera novaeangliae*]) when foraging (e.g., Wade et al. 2011a, Ford et al. 2016).

Little demographic information exists. Mating and calving occur from about November to March (Cummings 1985, Deméré 2014). Females give birth to one calf probably every 3–5 years. Age of sexual maturity is about 10 years and life span likely exceeds 70 years (Jefferson et al. 2008).

Sperm whale. This is the largest species of toothed whale. Adult males measure 15.2–19.2 m (50–63 ft) long and 45,000–70,000 kg (50–77 tons) in weight and are substantially larger than adult females, which reach 10.4–12.5 m (34–41 ft) long and 15,000–24,000 kg (16.5–26 tons) in weight (Mesnick 2014). Sperm whales have massive rectangular heads that comprise about one-third of the total body length in males. The head is often marked with pale scarring and has a comparatively small, narrow lower jaw with conical teeth. Other traits include a small triangular dorsal fin, a ridge of smaller "knuckles" along the upper tail stock, broad triangular tail flukes, dark brownish-gray to black body coloration except for a whitish mouth and genital region, and a wrinkled appearance to the skin (Figure 5; Shirihai and Jarrett 2006).

Figure 5. Sperm whale mother and calf (photo from Wikimedia Commons).

Sperm whales are the only member of the family Physeteridae and no subspecies are recognized (Committee of Taxonomy 2017). The species is widely distributed in all oceans except ice-bound portions of the Arctic Ocean, with females and immatures usually occurring at lower latitudes than adult males (primarily south of 50°N in the Northern Hemisphere; Mesnick 2014). Older studies distinguished two or three discrete populations in the North Pacific (see Mizroch and Rice 2013), and animals in U.S. Pacific waters are currently managed as three stocks known as the California/Oregon/Washington, North Pacific, and Hawaii stocks (Carretta et al. 2017, Muto et al. 2017). However, these population assignments are not biologically supported based on the broad movements of sperm whales within the North Pacific (Mizroch and Rice 2013, Straley et al. 2014). In addition, recent genetic analyses indicate low levels or an absence of population structure within the Pacific (Mesnick et al. 2011, Alexander et al. 2016). Sperm whales chiefly inhabit deep oceanic waters, approaching land mainly where shelf edges and submarine canyons exist near coasts, although males regularly venture into shallower waters in some locations (Whitehead 2003, Ford 2014). All Washington records are from off the outer coast (Appendix A; Scheffer and Slipp 1948).

Feeding is believed to occur year-round. Diet consists mainly of numerous species of large to small pelagic squid, with usually much smaller quantities of sharks, rays, other fish, and octopus also eaten (Rice 1989, Whitehead 2003). Males typically eat more fish than females, and in some northern areas, males may feed primarily on fish. Squid dominate the diet along the west coast of North America, although ragfish (*Icosteus* spp.) and rockfish (*Sebastes* spp.) are also consumed in significant amounts (Scheffer and Slipp 1948, Fiscus et al. 1989, Flinn et al. 2002, Harvey et al. 2014). Foraging sperm whales are known for making deep and prolonged dives that commonly reach depths of 200–1,200 m, but can possibly extend to >3,000 m deep (Whitehead 2003, Watwood et al. 2006, Aoki et al. 2007, Davis et al. 2007, Teloni et al. 2008). Dives usually last <45 minutes, but sometimes continue >90 minutes. Multiple prey are caught per dive using echolocation (Mesnick 2014, Fais et al. 2016). Surface time between dives averages 5–12 minutes.

Sperm whales are believed to be nomadic, with both sexes moving widely across the North Pacific (Mizroch and Rice 2013). Males appear to travel farther than females, although maximum travel distances in both sexes occasionally exceed 4,000 km (Whitehead et al. 2008, Mizroch and Rice 2013). Movements are probably frequently linked to changes in squid abundance (Whitehead 2003). Areas of sperm whale concentrations in the North Pacific correspond with oceanographic frontal areas where high nutrient levels exist (Mizroch and Rice 2013). Migration to lower latitudes also occurs, with mature males periodically doing so to breed and females doing so to find warmer waters during winter. Three satellite-tagged males moved from Southeast Alaska to Mexico following a route that took them along or near the continental shelf slope off Washington (Straley et al. 2014). Acoustic detections indicate that sperm whales can occur off Washington during all months (Appendix A).

Sperm whales are the most social of the great whales and form several types of social groupings. Related females and their offspring (including immature males up to 4–21 years old) live in stable matrilineal-based units averaging about 10 animals, which regularly join with unrelated units to form larger temporary groups of 20–40 whales (Whitehead 2003, Gero et al. 2014, 2015, Mesnick 2014). Members of matrilineal units share in the care of younger calves. Upon departing their birth unit, males form loose bachelor groups typically containing 10–25 animals. Adult males become less social as they grow older, usually becoming solitary, but sometimes temporarily associating with a few other large males.

Sexual maturity is achieved at 7–13 years of age in females and 18–21 years of age in males, but both sexes continue to grow until reaching physical maturity at about 25–45 years in females and 35–60 years in males (Rice 1989). Maximum life span is estimated at 77 years (Mesnick 2014). In the North Pacific, mating probably occurs in April and May and calving from June to October (Ohsumi 1965, Gregr et al. 2000). Only larger, older males are able to compete for breeding females. Adult males travel between groups of females, spending only a few hours with each group as they search for receptive females (Jaquet and Gendron 2009). Females give birth to single calves at 4–6-year intervals (Rice 1989). The species is characterized by a low maximum potential rate of increase, possibly as low as 1% annually (Whitehead 2002).

POPULATION STATUS AND TRENDS

In the following species accounts, reported stock sizes do not represent closed population estimates for any species (Barlow 2016). Surveys by the National Marine Fisheries Service (NMFS) overlap with the summer-fall migration period when both migrating and resident whales are present. Thus, survey results are subject to year-to-year variation caused by changes in environmental conditions that can affect movement patterns, prey availability, and other influences. Kracker and Menza (2015) summarized the different types of surveys conducted for large whales and other marine mammals in Washington from 2002 to 2014.

Blue whale. The pre-whaling global population of this species was several hundred thousand animals, most of which occurred in the Southern Hemisphere (Branch et al. 2004). Total numbers declined to fewer than 10,000 whales by the 1970s due to massive harvest (Gambell 1976, 1979) and are currently estimated at 10,000–25,000 animals (Reilly et al. 2008).

Monnahan et al. (2015) estimated the pre-whaling size of the Eastern North Pacific stock to be 2,210 (95% credible interval = 1,823–3,721) whales and that numbers never fell below 460 individuals during the whaling era. Despite some variation in population estimates, the best current estimate of the stock's size is 1,647 whales (CV = 0.07) based on photographic mark-recapture analyses from 2008 to 2011 (Calambokidis and Barlow 2013, Carretta et al. 2017). There is no verified change in population size since the early 1990s (Carretta et al. 2017). In contrast, Monnahan et al. (2014) have suggested that this stock grew at 2% annually from 1993 to 2008 and is near carrying capacity, and has therefore recovered. Although the highest concentrations of animals in this stock are found off California, there has been a partial distributional shift resulting in increased abundance off Oregon, Washington, British Columbia, and Alaska in recent years, possibly due to decadal changes in oceanographic conditions (Calambokidis et al. 2009, Barlow 2010, 2016).

Blue whale abundance off Washington has not been well described. The Makah were familiar with the species and may have rarely hunted it (Swan 1870:19). The large number of blue whale harvest records from Alaska and British Columbia (Gregr et al. 2000, Gregr and Trites 2001, Rankin et al. 2006, Monnahan et al. 2014) suggests that the species was formerly a common passage migrant off Washington. Based on the few whales captured by vessels from the Bay City whaling station (see Table 2 in Overexploitation), it is likely that the species was mainly distributed well offshore (Scheffer and Slipp 1948).

Acoustic and telemetry studies since the mid-1990s indicate that blue whales are regularly present in modest numbers off Washington (Appendix A). Vocalizations typically peak from September to February (Appendix A), but this pattern does not necessarily reflect seasonal presence in state waters (Stafford et al. 2009). Sightings off Washington are rare, with just a few made since the late 1950s, and the species is infrequently observed during visual surveys (Appendix A, B). One noteworthy sighting involved six whales seen on 8 December 2011, four of which were previously recorded off California (Appendix A). The only strandings of blue whales in the state since at least 1980 were two animals killed by ship strikes that were likely carried into Washington (Appendix A; NMFS, unpubl. data).

Fin whale. Evans (1987) estimated the pre-whaling population size of this species at about 548,000 animals. Commercial harvests began in the 1870s, then intensified during the 20th century and were highest in the Southern Hemisphere (Rocha et al. 2014). In the North Pacific, abundance declined from a pre-whaling estimate of 42,000–45,000 animals to 13,600–18,700 animals by 1973, with 8,500–11,000 of these in the eastern North Pacific (Ohsumi and Wada 1974). Harvest in this region peaked from 1951 to 1972 (Danner at al. 2006, Mizroch et al. 2009, Rocha et al. 2014). Recent estimates of the worldwide and North Pacific populations are lacking, but global numbers have probably increased since whaling ended and may now exceed 100,000 animals (see Reilly et al. 2013, Thomas et al. 2016).

Size of the California/Oregon/Washington stock before and immediately after the whaling era is unreported. However, many fin whales were killed by shore-based whalers along the U.S. west coast during the 1900s (nearly 2,700 whales; Mizroch et al. 2009 [supplementary tables]). Harvest was even higher off British Columbia (>7,600 whales) and may have included some animals belonging to this stock. The stock has shown strong growth in recent decades (especially in the Oregon-Washington zone) and held an estimated 9,029 whales (CV = 0.12) in 2014 (Nadeem et al. 2016 [supplemental tables]). Numbers increased roughly five-fold from 1991 to 2014, with the average

annual rate of increase estimated at 7.5% (95% prediction interval = 5.1–9.8%) during this period (Moore and Barlow 2011, Nadeem et al. 2016). Fin whales are now the second-most common large whale along the U.S. west coast after migrating gray whales (*Eschrichtius robustus*; see Barlow 2016). Strong recovery in British Columbia has also been noted in recent years (Ford 2014).

Fin whale abundance in Washington has not been well detailed. Fin whales were occasionally caught by tribes along the outer northwest Washington coast (Collins 1892:243, Scheffer and Slipp 1948) and their bones represent a small fraction of the whale bones recovered at archaeological sites in the area (Huelsbeck 1988, 1994). The species was considered common off the outer coast in the 1800s and early 1900s (Scammon 1874, Scheffer and Slipp 1948) and was the second-most harvested whale by Bay City whalers (see Table 2 in Overexploitation). However, fin whale numbers became depleted as whaling progressed through the 1960s. Most visual surveys from 1989 to 2007 failed to sight the species (Appendix B). Nevertheless, detections (mostly acoustic) have regularly occurred off Washington since the 1990s (Appendix A) and the species is now recorded throughout most of each year. Vocalizations typically peak from September to April (Appendix A), but this pattern may not accurately reflect seasonal presence (Stafford et al. 2009) and contrasts with the seasonality of past harvest records that showed most captures in May, June, and September (Scheffer and Slipp 1948). The increased numbers of records since the 1990s are likely due to expanded survey efforts, partial recovery of the stock, and immigration of animals into the stock's range (Stafford et al. 2009, Moore and Barlow 2011). Guide and Grays Canyons are two areas of concentrated sightings off Washington (Calambokidis et al. 2015).

Fin whales may have once been occasional or regular visitors to the Salish Sea (Scammon 1874, Scheffer and Slipp 1948, Calambokidis and Baird 1994), but there are few early accounts to confirm this. Scheffer and Slipp (1948) documented only two verified or potential records in Washington's inner marine waters from 1915 to the late 1940s, suggesting presence was rare during this period, and there were apparently no further reports (excluding ship strikes) into the 1980s (Everitt et al. 1980, Osborne et al. 1988). Several sightings have since been made, including two or three separate individuals seen in 2015 and 2016 (Appendix A), but the species remains rare in these waters.

Twelve stranding records of fin whales exist for Washington since 1986, with all but one occurring after 2001 (see Table 3 in Ship strikes; Appendix A). Vessel strikes were implicated in ten of these instances. Many of these collisions may have occurred outside of Washington, thus they are not reliable indicators of presence in the state (Douglas et al. 2008).

Sei whale. The global population of sei whales declined from an estimated 250,000 animals before whaling to perhaps 32,000 animals by the 1970s to 1980s (Evans 1987, Thomas et al. 2016). Most harvest didn't begin until the late 1800s, with catch peaking from 1960 to 1970 (Horwood 2002). Pre-whaling numbers in the North Pacific ranged from 42,000 to 62,000 animals, but fell to an estimated 8,600 whales by the time whaling ceased (Ohsumi and Wada 1974, Tillman 1977). Current abundance in this region is estimated at about 29,600 animals (CV = 0.242; 95% CI = 18,576–47,267; IWC 2016). Japan's research whaling program has taken 90–100 sei whales annually in the western North Pacific since 2004 (Thomas et al. 2016). An assessment of the North Pacific population by the International Whaling Commission (IWC) is pending to determine the sustainability of this continued harvest (IWC 2016).

The original size of the Eastern North Pacific stock is unknown, but large numbers were harvested off Vancouver Island and elsewhere in British Columbia from 1908 to 1967, with more than half caught between 1962 and 1966 (see Table 2 in Overexploitation; Pike and MacAskie 1969, Gregr et al. 2000, Gregr and Trites 2001). The rarity of sightings along the U.S. and Canadian west coasts since the 1970s (COSEWIC 2003, Ford 2014, Barlow 2016, Carretta et al. 2017) indicates that the stock remains depleted (IWC 2016), but the species is difficult to survey because of its distribution farther offshore. The best estimate of abundance for California, Oregon, and Washington waters out to 556 km (300 nautical mi) is 519 whales (CV = 0.40) based on survey results averaged for 2008 and 2014 (Barlow 2016; Carretta et al. 2017). Despite a recent increase in numbers seen during surveys (Barlow 2016), stock trend is best treated as unknown (Carretta et al. 2017).

Sei whale abundance off Washington has not been well described. The many catch records from British Columbia suggest that the species was probably once moderately common off Washington, although most animals likely occurred well offshore. However, many fewer animals were caught by Bay City whalers than off British Columbia during 1911–1925 (see Table 2 in Overexploitation; Pike and MacAskie 1969), suggesting lower abundance off Washington. Japanese whalers also took some sei whales off Washington, all west of 130°W, between 1952 and 1972 (Masaki 1977). Masaki (1977) reported fairly high sighting rates of this species between 45°–50°N and from the coasts of Washington and Vancouver Island west to 140°W from 1965 to 1972. American researchers have not detected the species with certainty within 556 km of the Washington coast during a number of visual and acoustic surveys extending back to late 1950s (Appendix B), confirming the species' recent rarity in Washington waters. A number of sightings, however, were made far to the west of Washington (west of 135°W) from 2010 to 2014 (IWC 2016:447), indicating the potential for sei whales to visit state waters. The only stranding of this species in Washington since 1980 was an animal killed by a ship strike in 2003 and likely carried into the state (Appendix A; NMFS, unpubl. data).

North Pacific right whale. This species was nearly eliminated by whaling and may now be the most endangered large whale in the world. Total population size before harvesting began is unknown, although early whalers found it abundant (Scarff 1991). Numbers were rapidly depleted in the 1840s by intense whaling pressure in both the eastern and western North Pacific (Scarff 1991, 2001, Josephson et al. 2008b). Much lower harvests continued thereafter, culminating in the illegal Soviet taking of 765 individuals primarily in the 1960s that devastated the small, but probably recovering stocks at that time (Brownell et al. 2001, Ivashchenko and Clapham 2012, Thomas et al. 2016). Total harvests during the 19th and 20th centuries likely exceeded 26,500 animals (Scarff 2001).

The Eastern North Pacific stock now numbers only about 30 whales (Marques et al. 2011, Wade et al. 2011b) and is at high risk of extirpation (Brownell et al. 2001, LeDuc et al. 2012), whereas the western stock holds an estimated 400 animals (Thomas et al. 2016). Population trend of the eastern stock is unknown, but there are no indications of recovery (Muto et al. 2017). Two factors contributing to the poor prognosis for this stock are the very few observations of females with calves in recent years and a sex ratio skewed about 2:1 toward males (Wade et al. 2011b, LeDuc et al. 2012).

The historical status of North Pacific right whales off Washington is unclear, but evidence suggests the species was once a regular, but perhaps rare, visitor before the whaling era. Tribes inhabiting the

state's northwest coast were familiar with this whale (Swan 1870, Scheffer and Slipp 1948) and its bones have been recovered in small numbers from Native American archaeological sites in the area (Huelsbeck 1988, 1994). Scammon's (1874) statement that North Pacific right whales were once found "occasionally in large numbers" off Oregon was disputed by Scarff (1986), who cited a lack of supporting evidence from other sources. Josephson et al.'s (2008a) re-evaluation of whaling data compiled in the early 1850s has subsequently revealed an absence of historical captures and sightings by whalers off Washington and nearby areas out to at least 135°W.

Detections are now exceptionally rare along the west coast of North America south of Alaska, with very few records since the early 1900s (Brownell et al. 2001, Ford et al. 2016). Only four confirmed records exist for Washington during this period, the most recent being an acoustic detection near the Quinault Canyon in June 2013 (Appendix A). Several hypothetical records also exist and one or two sightings have been made just outside of Washington's border with British Columbia, including one at Swiftsure Bank in October 2013 (Appendix A). Nearly all of the cetacean surveys in Washington since the 1970s have failed to detect the species (Appendix B). There are no known strandings for the state (Norman et al. 2004; NMFS, unpubl. data).

Sperm whale. Global population size before whaling has been estimated at 1.1 million (95% CI = 672,000–1,512,000) individuals, with numbers declining to roughly 360,000 by 1999 (Whitehead 2002, 2003). Although sperm whaling began in the early 1700s, annual harvests remained relatively low through the end of World War II, then spiked sharply from the 1950s to 1970s, when most of the overall harvest occurred (Whitehead 2002, Smith et al. 2008, Mesnick 2014). The current worldwide population is estimated at 300,000 to 450,000 animals, but trend is unknown (Taylor et al. 2008, Mesnick 2014).

Pre-whaling abundance in the North Pacific is not known, but this species comprised more than half of the region's whale harvest during the 20th century (Rocha 2014). This level of catch, including the capture of many adult females, seriously depleted sperm whale numbers throughout the North Pacific (Ivashchenko et al. 2014). Current abundance in the North Pacific is estimated at roughly 80,000 whales (Ford 2014).

Estimates are lacking of the historical size of the California/Oregon/Washington stock. Large harvests of sperm whales took place along the U.S. west coast, between Hawaii and the U.S. west coast, and off British Columbia between 1908 and 1971 (see Table 2 in Overexploitation; Pike and MacAskie 1969, Ohsumi 1980, Gregr et al. 2000, Gregr and Trites 2001) and undoubtedly depleted the stock. Stock size was last estimated at 2,106 whales (CV = 0.58) based on data from 1991 to 2008, with trend perhaps being stable (Moore and Barlow 2014, Carretta et al. 2017).

Sperm whale abundance off Washington has not been well detailed. Swan (1870:19) remarked that the species was "very rarely" observed by the Makah and only modest numbers were caught by Bay City whalers from 1911 to 1925 (see Table 2 in Overexploitation), both of which suggest a limited presence of sperm whales over Washington's continental shelf during the 1800s and early 1900s. Occurrence was much greater in the deeper oceanic waters west of Washington based on the extensive captures made by Soviet whalers from 1948 to 1979, which mainly took place west of 130°W, but with some harvest also happening between 126°W and 130°W (Mizroch and Rice 2013, Ivashchenko et al. 2014). The large numbers of sperm whales caught off British Columbia further suggest that the species was probably once common off Washington as well.

Small to moderate numbers of sperm whales have been detected during acoustic surveys along and near the continental shelf slope off Washington since 2004 (Appendix A). Calling activity is variable between years, but shows a pattern of increased occurrence from January to May and a peak in June (Appendix A). Because sperm whales call year-round, this seasonal pattern in vocalizations likely reflects actual presence in state waters (K. M. Stafford, pers. comm.). There have been relatively few sightings of sperm whales off Washington since the 1980s and a number of visual surveys have failed to record the species (Appendix A, B). However, most of the surveys sampled shallower shelf and slope waters where sperm whales are less likely to occur. Twelve strandings, all of single animals, have been documented since 1980 (see Table 2 in Ship strikes), including five males, three females, and four of unknown sex. A mass stranding of 41 sperm whales occurred 250 km south of Washington near Florence, Oregon, in June 1979 (Rice et al. 1986).

FACTORS AFFECTING CONTINUED EXISTENCE

Adequacy of existing regulatory mechanisms. Stocks of blue, fin, sei, North Pacific right, and sperm whales along western North America have benefited from the protections afforded under a variety of national, international, and state laws. All are protected under the U.S. federal Marine Mammal Protection Act (MMPA), which prevents the taking (defined as harassing, hunting, capturing, killing, or attempting to harass, hunt, capture, or kill) and importation of these animals and products derived from them. The MMPA allows some incidental take during commercial fishing operations and some other circumstances. Under the MMPA, these stocks are considered "depleted" (Table 1) and are designated as "strategic stocks."

All five species were federally listed as endangered in 1970 under the Endangered Species Conservation Act of 1969, which preceded the Endangered Species Act of 1973 (ESA; Table 1). Federal endangered status includes prohibitions on take of listed species similar to those under the

Table 1. Conservation status of blue, fin, sei, North Pacific right, and sperm whales under seven listing arrangements.

	Conservation status[1,2]						
Species	WA	ESA	MMPA	COSEWIC	SARA	BC	IUCN
Blue whale	E	E	Depleted	E[3]	E[3]	Red List	E
Fin whale	E	E	Depleted	T[3]	T[3]	Red List	E
Sei whale	E	E	Depleted	E[3]	E[3]	Red List	E
North Pacific right whale	E	E	Depleted	E	E	Red List	CE[4]
Sperm whale	E	E	Depleted	Not at risk	No status	Blue List	V

[1] Listing system abbreviations: WA, Washington Administrative Code (WAC 220-610-010); ESA, U.S. Endangered Species Act; MMPA, U.S. Marine Mammal Protection Act; COSEWIC, Canada's Committee on Status of Endangered Wildlife in Canada; SARA, Canada's Species at Risk Act; BC, British Columbia's Wildlife Act; IUCN, International Union for the Conservation of Nature.
[2] Status abbreviations: CE, critically endangered; E, endangered; T, threatened; V, vulnerable.
[3] Pacific Ocean population.
[4] Eastern North Pacific population.

MMPA. NMFS has designated critical habitat for only one of the five species, North Pacific right whales, with two areas of Alaskan waters established in 2008.

National marine sanctuary regulations (15 CFR 922 Subpart O, 152(a)), which apply to the Olympic Coast National Marine Sanctuary off the outer northwest coast of Washington, contain prohibitions on the taking and possessing of any marine mammal in the sanctuary, except as authorized by the MMPA and ESA, or allowed through tribal treaty rights.

Under Washington state law (WAC 220-610-010), all five species were listed as endangered in 1981 (Table 1). This prohibits the hunting, possession, malicious harassment, and killing of these species (RCW 77.15.120). Only blue and sperm whales are considered priority species under WDFW's Priority Habitats and Species (PHS) program, but specific management recommendations for them have not been developed under this program.

Canada's federal Species at Risk Act (SARA) classifies North Pacific right whales and Pacific populations of blue and sei whales as endangered and the Pacific population of fin whales as threatened (Table 1). Under this regulation, the killing, harassment, and possession of these species are prohibited. Sperm whales have not been classified. Critical habitat has not been established under SARA for any of these species.

The IWC has maintained its current international moratorium on commercial whaling of large whales since 1986, although several countries continue to conduct relatively small-scale harvests through objections or reservations to the moratorium or through research programs (see Overharvesting). All five whale species are also listed on Appendix I of the Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES), which bans international commercial trade in specimens of these species.

Overexploitation. Populations of most large whales were decimated worldwide by large-scale commercial whaling during the 19th and 20th centuries. Despite the end of nearly all hunting by 1980, many populations remain well below their pre-whaling abundance, showing only partial recovery or no recovery at all (Clapham et al. 1999, Roman and Palumbi 2003, Thomas et al. 2016). Whaling efforts focused initially on sperm whales and right whales, then expanded to gray whales, humpback whales, and bowhead whales (*Balaena mysticetus*), and finally to other rorquals and again sperm whales in response to depletion of populations, improvements in technology, and changing market demand for different whale products (Smith et al. 2012). Despite legal protections instituted for various species or populations between 1935 and 1986, some illegal whaling continued (e.g., Ivashchenko et al. 2012) and further impacted the recovery potential of populations. Massive numbers of whales were killed during the whaling era, with nearly 3 million animals caught during just the 20th century, when whaling reached its peak (Rocha et al. 2014). The impacts of this past harvest continue to the present for many species or individual populations through reduced abundance or reproduction (Thomas et al. 2016).

Intensive harvest of whales pushed a number of whale populations in the eastern North Pacific to the verge of extirpation. Most of the early harvest was centered in California and Alaska, with less focus on Washington and neighboring areas (Scheffer and Slipp 1948). Modern shore-based whaling began in the eastern North Pacific in 1905 and quickly expanded to include a whaling station operated by the American Pacific Whaling Company at Bay City, Washington, from 1911 to

1925 (Figure 6), and six stations in British Columbia, with the last closing in 1967 (Scheffer and Slipp 1948, Crowell 1983, Gregr et al. 2000). More than 27,500 whales were processed at these stations (Table 2). Catcher vessels from the Bay City facility operated mostly within 220 km of Grays Harbor, thus covering the coasts of Washington and northern Oregon, but sometimes ventured as far as southern Oregon and Vancouver Island (Scheffer and Slipp 1948, Crowell 1983). Historical catch records and other materials from this operation and the Canadian stations are held at the Special Collections library, University of Washington, Seattle.

Figure 6. Processing a sperm whale at the Bay City whaling station at Bay City, Washington, circa 1920. Used with permission from the Jones Photo Historical Collection, Anderson & Middleton Company.

Several nations (Japan, Norway, and Iceland) have resumed limited commercial and research whaling operations, and small amounts of aboriginal whaling also continue (IWC 2017). These harvests are not considered a threat for most stocks (Clapham et al. 1999, Thomas et al. 2016) and are not known to affect those discussed in this report.

Table 2. Numbers of whales processed historically at shore whaling stations in Bay City, Washington, and in British Columbia.

	Numbers of whales	
Species	Washington[a] (1911-1925)	British Columbia[b] (1908-1967)
Humpback whale	1,933	5,638
Fin whale	602	7,605
Sperm whale	120	6,158
Sei whale	21	4,002
Blue whale	13	1,398
Beaked whale spp.	8	41
North Pacific right whale	0	8
Total	2,698	24,850

[a] Scheffer and Slipp (1948) [b] Gregr et al. (2000)

Ship strikes. Blue whales and perhaps other species show only limited avoidance responses to closely approaching ships (McKenna et al. 2015). Thus, whales swimming or resting near the ocean surface can be vulnerable to injury or death from collisions with ships, especially in areas of frequent vessel traffic such as the U.S. west coast. Ship strikes have become more common in recent decades due to increases in shipping traffic, ship speeds, and whale abundance (Laist et al. 2001). Documented collisions and resulting mortalities undoubtedly represent just a small fraction of those that actually happen (Jensen and Silber 2004, Williams et al. 2011a). For some small whale populations, ship strikes may be frequent enough to slow or prevent recovery (Kraus et al. 2005, Redfern et al. 2013).

Along the west coast of North America, blue and fin whales are among the species most at risk from ship strikes (Calambokidis 2011, Carretta et al. 2017). North Pacific right whales may also be vulnerable based on the high rates of collisions experienced by the similar North Atlantic right whale (Muto et al. 2017). Calambokidis (2011) reported a major increase in the proportion (to about one-third) of strandings of large whales appearing to involve vessel collisions in the Pacific Northwest from 2001 to 2010. Since 1980 in Washington, 15 of the 27 stranding records for the species covered in this report were linked to ship strikes, with fin whales experiencing by far the highest number (Table 3). Sperm whales appear much less affected, possibly because the species' more oceanic range means fewer individuals encounter ships or because fewer struck animals wash ashore (Douglas et al. 2008). Some of the strikes listed in this report likely took place outside of Washington, with the whales then carried on the ships' bows into state waters (see Douglas et al. 2008). Along Washington's outer coast, major shipping lanes converge from several directions into the mouths of the Strait of Juan de Fuca and Columbia River, and another follows a north-south route leading to California.

Table 3. Numbers of strandings, including those linked to ship strikes, of five whale species in Washington, 1980–2016. Details of individual strandings appear in Appendix A.

	Number of strandings		
Species	Ship-strike related[a]	Others	Total
Blue whale	2	0	2
Fin whale	10	2	12
Sei whale	1	0	1
North Pacific right whale	0	0	0
Sperm whale	2	10	12
Total	15	12	27

[a] Includes confirmed and likely strikes.

Entanglement in fishing gear and marine debris. A poorly understood, but growing concern is the levels of threat that entanglement poses to whale populations (IWC 2010, Williams et al. 2011b, Reeves et al. 2013). Large whales can become entangled in active drifting or stationary fishing gear (such as gillnets and the vertical lines used to mark trap/pot fisheries) or in discarded netting and other marine debris. Death, injury, or eventual starvation may result when entangled animals fail to free themselves of gear or debris. Risk of entanglement varies with species, the amount of overlap with various fisheries, and the type of gear used in those fisheries. More entanglements occur in coastal and continental shelf waters than in waters farther offshore (Saez et al 2013). In some whale populations, half or more of all individuals show scarring from past entanglements (e.g., Neilson et al. 2009).

Along the U.S. west coast, reports of large whale entanglements averaged 10 per year from 1982 to 2012, then increased to 62 reports in 2015 and 71 reports 2016 (NOAA Fisheries 2017). Actual numbers of entanglements are considered much higher than indicated by these reports. Humpback and gray whales, both of which inhabit more coastal waters, are the species most frequently entangled, with far fewer incidents involving blue, fin, sei, and sperm whales (Saez et al 2013, Carretta et al. 2017). Most incidents involve trap/pot gear, especially from commercial Dungeness crab fisheries (Saez et al 2013, NOAA Fisheries 2017). Most entanglements have been documented off California, but this is due in part to the greater observer numbers and longer coastline there than in Washington and Oregon. The vulnerability of the eastern stock of North Pacific right whales to entanglement is unknown, but may be high based on multiple reports for the western stock (Burdin et al. 2004, IWC 2010). The right whale seen at the entrance of the Strait of Juan de Fuca in 2013 showed a severe entanglement scar (Ford et al. 2016).

A total of 38 large whale entanglements have been reported in Washington since 1990, with most happening since 2000 (Table 4). Nearly all have involved gray or humpback whales, and more have occurred in outer coastal waters than in the Salish Sea. Of the five species covered in this report, the only confirmed entanglement in the state involved one stranded fin whale (Table 4). However, for the reasons described above, entanglements of these species are probably more frequent than indicated by these data.

Table 4. Numbers of large whale entanglements documented in Washington by species, location, and time period, 1990–2017 (NMFS, unpublished data).

Species	Total	Location		Time period		
		Outer coast	Salish Sea	1990-1999	2000-2009	2010-2017
Gray whale	27	19	8	7	14	6
Humpback whale	10	7	3	0	2	8
Fin whale	1	1	0	0	1	0
Total	38	27	11	7	17	14

To illustrate some of the entanglement opportunity for whales in Washington, a maximum of 78,000 crab pots are deployed annually off the outer coast at the start of the commercial Dungeness crab fishery in December and January (D. Ayres, pers. comm.). Pot numbers decline as the season progresses, falling to 7,300 pots by the end of the fishery on September 15. An estimated 5–10% of the pots are lost each season, although some are subsequently recovered in a program allowing fishers 45 days after the season closes to keep any pots they find. Crab pots are typically set at depths of <183 m within 45 km of shore. Smaller trap/pot fisheries for sablefish, hagfish, and spot prawn, some of which extend to the shelf slope, also occur along the state's outer coast (Ayres 2014). Thus, these fisheries together partially overlap with the habitats of the five whale species covered in this report.

Disturbance from sound and vessels. Marine mammals in all oceans are exposed to increasing levels of underwater sound from vessels, seismic surveys, sonar, marine construction, and other human-related sources (Nowacek et al. 2007, 2015). Marine ambient noise levels at frequencies below 500 Hz, which overlap with the low-frequency calls of baleen whales, have increased by at least 20 dB (re 1 μPa) since pre-industrial conditions (Hildebrand 2009), including along much of the North American west coast (Andrew et al. 2011, Redfern et al. 2017). Large whales rely on their acoustic sensory system for communicating with other individuals, sometimes at distances of hundreds of kilometers, and in the case of sperm whales, for navigating and capturing prey. Significant levels of anthropogenic sound can therefore interfere with these activities by masking vocalizations (Erbe et al. 2016). Intense sound can also displace animals from occupied areas, produce temporary or permanent hearing damage and physiological stress, and cause changes in surface, foraging, and vocal behavior (e.g., Nowacek et al. 2007, Castellote et al. 2012, Risch et al. 2012, Rolland et al. 2012, DeRuiter et al. 2017). Nevertheless, responses by whales can vary depending on localized circumstances, sometimes with no observable reactions recorded. Where sound-related impacts are severe, reproduction and survival of animals may be affected (Clark et al. 2009). Several studies have described anthropogenic sound-related effects on large whales along the U.S. west coast (e.g., Moore and Clarke 2002, Melcón et al. 2012, Goldbogen et al. 2013, DeRuiter et al. 2017).

The tremendous growth in whale watching in recent decades has brought increasing concern over disturbance caused to cetaceans, which can result from the physical presence and sound of whale-watching vessels (Parsons 2012, Hoyt and Parsons 2014). For large whales along the outer coasts of Washington, British Columbia, and Oregon, viewing pressure is generally limited to areas near a few ports with whale-watching companies and mainly targets migrating gray whales (O'Connor et al. 2009). Thus, the five species covered in this report likely receive little disturbance from whale watching while in Washington.

Climate change. Global climate change is likely to be one of the greatest threats to many species of marine mammals in the coming decades because of its capacity to alter marine ecosystems and food webs through changes in ocean temperatures, currents, stratification, and nutrient cycling, and by causing higher sea levels and increased occurrence of unusual and extreme ocean conditions such as strong El Niño events (e.g., Doney et al. 2012). Climate change effects on oceans will probably occur unevenly, with some areas affected more severely than others. Large whales will most likely be affected by resulting changes in prey abundance and availability, changes in habitats used for specialized activities such as breeding, and through increased exposure to novel diseases (Simmonds and Eliott 2009). Warmer ocean conditions and altered prey distributions may result in some whale species shifting their ranges to higher latitudes, as already documented for fin whales and several other species, which are expanding from the North Pacific into the Arctic Ocean as summer sea ice coverage retreats (Moore 2016). The ability to move long distances means that some whale populations in large ocean basins such as the North Pacific may be fairly resilient to climate change, at least in the short term (MacLeod 2009, Ramp et al. 2015, Thomas et al. 2016). Nevertheless, negative impacts may well accrue in the future as climate change progresses. For North Pacific right whales, sea ice losses from climate change will likely open major shipping routes through the Bering Sea into the Arctic Ocean, thus bringing greater exposure to human-caused marine noise and ship strikes (NMFS 2013). A related concern, increasing ocean acidification, is currently not considered a future threat to marine mammals off western North America (Marshall et al. 2017).

Small subpopulation size and isolation. The very small size and few remaining females place the Eastern North Pacific stock of North Pacific right whales at high risk of extirpation due to an increased likelihood of inbreeding, loss of genetic variability, difficulty in finding mates, and occurrence of chance events such as demographic fluctuations, ship strikes, and entanglements (LeDuc et al. 2012). This threat may not affect the larger stocks of blue, fin, sei, and sperm whales occurring off the U.S. west coast.

Environmental contaminants. Marine mammals are susceptible to a variety of environmental contaminants that bioaccumulate upward through marine food webs. These substances include organochlorines (e.g., polychlorinated biphenyls [PCBs], dioxins, dichloro-diphenyl trichloroethane [DDT] and its derivatives, and various other pesticides and herbicides), polybrominated diphenyl ethers (PBDEs), polycyclic aromatic hydrocarbons (PAHs), trace metals (e.g., mercury, cadmium, copper), and other established or emerging pollutants (O'Shea 1999, O'Hara and O'Shea 2001). High levels of organochlorines and PBDEs in marine mammals can interfere with reproduction, immune and endocrine function, and gene expression, whereas elevated concentrations of metals can variously produce neurotoxic effects and harm organ function (O'Hara and O'Shea 2001, Buckman et al. 2011, Mongillo et al. 2016). Several factors commonly influence the contaminant loads carried by large whales. These include species habitat preferences (nearshore vs. offshore),

trophic level (baleen whales typically carry smaller contaminant loads than toothed whales because of their lower position in food chains), sex (females transfer much of their fat-soluble contaminant burden to their calves during pregnancy and nursing, and thus usually have lower levels than males of the same age), and movement patterns (O'Shea and Brownell 1994, Reijnders et al. 1999).

Few studies have examined contaminant levels in blue, fin, sei, North Pacific right, or sperm whales off western North America (Valdez-Márquez et al. 2004, Niño-Torres et al. 2009, Fossi et al. 2014). However, when combined with results for gray and humpback whales (Krahn et al. 2001, Elfes et al. 2010), most baleen whales in the region appear to possess relatively low contaminant levels that are beneath those associated with health disorders. One exception is the high PAH concentrations of blue whales (Fossi et al. 2014). Sperm whales in the region have been sampled in just one study and found to have higher chemical loads than baleen whales, but substantially lower levels than in Pacific killer whales (*Orcinus orca*), which feed in the highest trophic position (Fossi et al. 2014). North Pacific sperm whales may carry potentially toxic levels of mercury and cadmium, as suggested by studies elsewhere (NMFS 2010b).

Oil spills. At the population level, marine oil spills are generally considered a relatively minor threat for large whales, with few if any harmful impacts reported in the literature. Nevertheless, when exposed to oil, individual whales can experience baleen fouling, ingestion of oil, respiratory distress from inhalation of vapors at the water's surface, and contaminated food sources (Geraci 1990, Takeshita et al. 2017), all of which may produce physiological effects that remain poorly understood. Direct mortality of prey and displacement from feeding areas may also occur. Lingering reproductive and health impacts may result from major spills (Kellar et al. 2017, Smith et al. 2017). The extent of effects depends mainly on the amount and duration of contact that whales have with the oil, and the age and type of oil involved.

As a shipping and oil-refining hub, Washington experienced seven major oil spills ranging from 0.1–2.3 million gallons along the outer coast, the Strait of Juan de Fuca, and the lower Columbia River between 1964 and 1991 (Neel et al. 2007). It is unknown whether any of these harmed large whales. Increased safety measures and prevention programs since the 1990s have helped reduce the number and scale of vessel spills in Washington, where no spills exceeding 100,000 gallons have occurred since 1991 (Etkin and Neel 2001, Neel et al. 2007). However, the sheer volume of shipping traffic (i.e., >6,800 vessel transits in 2016; WSDOE 2017) makes oil spills a persistent threat in the state. Shipping routes for major ports in Seattle, Tacoma, and Vancouver, B.C., as well as several major oil refineries and the third largest naval base in the U.S., all traverse waters used by large whales in Washington. A 2015 risk assessment of oil spills from vessels transiting the Salish Sea and northern outer coast of Washington found that the region remains at risk of a large spill (Van Dorp and Merrick 2017). Spill risk in Washington's marine habitats is expected to increase substantially in the future as tanker traffic from ports in British Columbia and possibly Washington increases due to expanded oil and natural gas production in the interior of North America.

Harmful algal blooms. Harmful algal blooms, also known as "red tides," result from rapid, temporary increases in local populations of particular dinoflagellates, protists, or other phytoplankton. Two of the most common toxins produced by algal blooms along the west coast of North America are the neurotoxins domoic acid and saxitoxin, both of which can be toxic to marine mammals, especially pinnipeds (Torres de la Riva et al. 2009, Lewitus et al. 2012). Although few known cases of acute algal poisoning have been confirmed among large whales (Fire et al. 2010,

Lewitus et al. 2012), there have been increasing reports of both toxins being detected in whales and blooms coinciding with whale mortalities (Lefebvre et al. 2016, Wilson et al. 2016). Harmful algal blooms are projected to become increasingly common in the future with warming ocean conditions (McKibben et al. 2017) and therefore represent a possible emerging concern for large whales.

Competition with fisheries for prey resources. A potential threat to large whales that remains poorly understood is the extent to which food availability is reduced by commercial harvesting of small schooling fish, squid, and krill. The extent of impacts from these fisheries likely depends on many factors, including size of the fishery, the amount of prey biomass remaining after the harvest, and whether the whales are able to switch to alternative prey or foraging areas. Competition with fisheries is currently not considered an important concern in U.S. waters for the whale species discussed in this report (Reeves et al. 1998, NMFS 2010a, 2010b, 2011a, 2013).

MANAGEMENT ACTIVITIES

Prohibitions on whaling. Declining whale stocks resulted in the enactment of various international restrictions on whaling beginning in the 1930s and continuing after the founding of the IWC in 1946 (Clapham and Baker 2002, Rocha et al. 2014). However, these agreements often failed to curb the unsustainable harvests of species and populations due to poor management, a lack of enforcement, and illegal hunting. In 1986, an international moratorium on commercial whaling was established by the IWC and remains in effect to the present. This measure represents the primary conservation tool for protecting all large whales despite several countries conducting relatively small-scale harvests through objections or reservations to the moratorium or through research programs.

Ship strikes. NMFS, the International Maritime Organization, and others have implemented various measures to reduce the risk of vessel collisions with whales in specific locations. These include the re-routing of shipping lanes, creation of areas to be avoided by ships, mandatory or voluntary speed restrictions for ships, using ship crew as lookouts for whales, and increasing the awareness of ship crews about whale strikes (Calambokidis 2013, Ritter and Panigada 2014). Several of these actions have been undertaken in areas of California and Alaska, but none have yet been implemented in Washington. NMFS has also expanded its efforts to document ship strikes of all large whales in the eastern North Pacific.

Entanglement in fishing gear and marine debris. NMFS has led national efforts to mitigate the problem of whale entanglements through collaboration with stakeholders (NOAA Fisheries 2017). This has included modifications to fishing gear and requirements that most types of gear be marked for ownership. Outreach has been directed at commercial and recreational fishing communities to implement recommended gear changes and other best practices for avoiding entanglements. Outreach has also targeted the broader marine community to encourage the prompt reporting of entangled animals and to improve report quality. This together with expanding the response capabilities of permitted organizations and response teams will result in more rescue attempts to disentangle whales. Continuing research and improved documentation of incidents is also underway to inform future management efforts. In Washington, NMFS has held disentanglement training workshops and cached disentanglement equipment at sites in the state. Cascadia Research and other entities have participated in many of the disentanglement attempts made in the state. Various projects to remove derelict crab pots and lines have also been conducted, including ones by the

Quileute Nation, Quinault Indian Nation, and The Nature Conservancy along sections of the outer coast (e.g., Antonelis 2014; WDFW, no date).

Recovery planning and review of listing status. U.S. federal recovery plans have been published for blue whales (Reeves et al. 1998), fin whales (NMFS 2010a), sei whales (NMFS 2011a), North Pacific right whales (NMFS 2013), and sperm whales (NMFS 2010b). Canada has also completed federal recovery strategies and an action plan for blue, fin, sei, and North Pacific right whales (Gregr et al. 2006, DFO 2011, 2017). WDFW has not prepared state recovery plans for any of these species.

Four of the five U.S. federal recovery plans for these species (excluding blue whales) contain downlisting and delisting objectives based on quantitative and threat-based criteria at the species level. NMFS has conducted recent 5-year reviews of listing status for fin whales (NMFS 2011b), sei whales (NMFS 2012a), North Pacific right whales (NMFS 2012b), and sperm whales (NMFS 2015a) to determine whether these species met the objectives set forth for downlisting and delisting. In all four cases, federal endangered status was maintained, with a lack of sufficient data on one or more criteria preventing any listing changes.

Reduction of marine noise. There is growing recognition that current levels of human-generated noise in oceans require mitigation to reduce impacts on marine fauna. Implementing noise-reduction actions requires government engagement with industry, the military, and other stakeholders. The National Oceanic and Atmospheric Administration has recently completed an ocean noise reduction strategy to help address concerns in U.S. waters (NOAA 2016). Existing mitigation actions can include steps to (1) detect and limit impacts to animals (e.g., closing areas to certain technology, avoiding use during specified seasons or times of day, discontinued use if animals are detected, and gradual powering up of equipment to warn animals away) and (2) reducing sound levels at the source (e.g., applying noise abatement measures). One example of mitigation measures are those agreed upon by the U.S. Navy and NMFS for reducing naval training impacts on marine mammals in the Northwest Training and Testing Offshore Area along the Washington, Oregon, and northern California coasts (see NMFS 2015b, p. 73565–73566). Internationally, efforts are underway to design and implement quieting technologies in shipping, oil and gas exploration, and marine construction (IMO 2014, Hatch et al. 2016).

Monitoring and research. Ongoing visual and passive acoustic surveys performed by NMFS, Fisheries and Oceans Canada, and partner groups (e.g., Cascadia Research Collective, Scripps Institution of Oceanography) have allowed the monitoring of stock size, trend, and distribution of large whales off western North America. The U.S. Navy has funded many recent survey efforts in the U.S. waters of this region. Updated stock assessments are regularly produced from survey results (e.g., Carretta et al. 2017, Muto et al. 2017). NMFS also monitors mortality from entanglement, ship strikes, and other causes. Numerous research projects involving these species have been conducted in recent years or are underway in the region. These include analyses of acoustics, stock structure, life history and ecology, genetics, the extent of different threats, and impacts from past whaling.

Stranding responses. NMFS coordinates responses to strandings of large whales through the West Coast Marine Mammal Stranding Network, which is comprised of cooperating scientific investigators, institutions, organizations, and state and federal agencies. Cascadia Research, WDFW,

and other collaborators sample or necropsy many of these animals to determine cause of death, animal condition and health, and other traits. Stranding data are maintained in a national database.

Oil spill prevention and response. State and federal agencies, industry, and other stakeholders continue their efforts to prevent oil spills from occurring in Washington. In 2010, a rescue tug was permanently deployed at Neah Bay with funding provided by the petroleum and shipping industries under a new state law. Presence of the tug greatly reduces the threat of spills associated with impaired vessels and barges in whale habitat near the entrance of the Strait of Juan de Fuca and along a portion of the outer coast. Establishment of an Area to Be Avoided (ATBA) off the northwestern coast encourages large vessels to stay well offshore during transit (WSDOE 2017). Use of single-hull tanker vessels and barges was completely phased out in the U.S. in January 2015 to reduce the risk of spills. Spill response planning, participation in oil spill drills, and outreach are ongoing. Measures to haze killer whales away from spills (NMFS 2012c) could be extended to large whales on a case-by-case basis (D. Noviello, pers. comm.). Improved regulations have been enacted in both the U.S. and Canada to minimize the risk of accidental spills.

Management of prey resources. Pelagic fisheries for sardines and anchovies off the U.S. west coast are managed by the Pacific Fishery Management Council with a priority for maintaining their ecosystem functions, primarily as a food source for marine mammals, seabirds, salmon, and other predators (PFMC 2011). The Council has banned the commercial harvest of krill along the U.S. west coast since 2006, whereas British Columbia allows a limited harvest of 500 tons per year in its waters. Squid are not commercially harvested off Washington.

CONCLUSIONS AND RECOMMENDATION

Blue, fin, sei, North Pacific right, and sperm whales have not had their Washington listing statuses formally reviewed since they were state listed as endangered in 1981. Current stocks of these whales along the U.S. west coast or in the eastern North Pacific differ in size and trend. Stocks of blue and sperm whales are estimated to number about 1,600 and 2,100 whales, respectively, with possibly stable trends, whereas the fin whale stock holds about 9,000 animals and has strongly increased in recent decades. Sei and North Pacific right whales, both rarely recorded in Washington waters, have current estimated stock sizes of about 500 and 30 animals, respectively, and unknown trends. However, there is no evidence of recovery in the North Pacific right whale population, and its stock is on the verge of extirpation.

All five species were heavily harvested in the eastern North Pacific during the whaling era. Historical stock size of blue whales has been estimated at about 2,200 individuals, thus current abundance remains below past levels of this stock. Historical stock size is unknown for fin whales, making it difficult to judge whether current numbers are approaching historical abundance. Estimates of historical stock sizes are also not available for sei and sperm whales, but current numbers of both species probably remain depleted. North Pacific right whales were once numerous and are clearly far below their pre-whaling stock size.

The stocks of all five species face possibly significant and increasing threats from one or more factors, such as ship strikes, entanglement in fishing gear and marine debris, human-generated marine sound, climate change, and in the case of North Pacific right whales, issues related to small

population size. Recent federal reviews of listing status have been conducted for fin, sei, North Pacific right, and sperm whales, and have maintained federal endangered status for all four species. Blue whales also remain federally listed as endangered. With these considerations in mind, it is recommended that blue, fin, sei, North Pacific right, and sperm whales remain listed as state endangered species in Washington.

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Appendix A. Records of blue whales, fin whales, sei whales, North Pacific right whales, and sperm whales from Washington waters or farther offshore since the 1950s. Records of whales struck by ships and carried into Washington are also included. These records likely do not represent a complete listing of documented records and some records may be duplicated if reported in more than one publication.

Date	Notes and sources
Blue whale	
24 Oct 1980	An 18.3-m long individual found off the bow of a freighter that arrived in Seattle after traveling from Taipei with intermediate stops in California and Port Angeles, Washington (Norris 1980, Laist et al. 2001, Jensen and Silber 2004, Douglas et al. 2008; NMFS, unpubl. data). The whale was believed to have been on the bow for at least five days, thus the strike probably occurred in California. A partial skeleton of the animal is held at the Burke Museum of Natural History, Seattle (UWBM 42004). The NMFS stranding database, which was cited by Norman et al. (2004), lists this whale as a 16.2-m-long female.
11 Jun 1989	A 20-m-long individual found across the bow of a container ship arriving in Tacoma from southern California (Jensen and Silber 2004, Douglas et al. 2008).
18–19 Aug 1990[a]	One or more whales detected acoustically east of the Juan de Fuca Ridge just south of the Washington-Oregon border (McDonald et al. 1995).
4 Aug 1994	Two whales detected acoustically west of Willapa Bay near 46°34'N, 129°00'W (Stafford et al. 1998).
1993–1994	Many acoustic detections off southwestern Washington from roughly 46°15'N to 47°00'N and 126°50'W to 129°20'W (Moore et al. 1999). Calls heard from July to February, peaking from August to January. No calls detected from March to June.
1994–2000	Acoustic data revealed small numbers of whales routinely present off southwestern Washington from September to February (Burtenshaw et al. 2004).
1994–2008	Five of 104 whales satellite-tagged off southern California passed through Washington waters. Animals occurred coastally or farther offshore (Bailey et al. 2009, Irvine et al. 2014, Mate et al. 2015).
Jun 2008 to Jun 2009	Many acoustic detections at a site off Cape Elizabeth, with most activity from Sep to Dec (Širović et al. 2011, Oleson and Hildebrand 2012). No detections from Mar to Jul.
13 Jan 2009	One seen at Grays Harbor Canyon (Oleson and Hildebrand 2012).
2 Aug 2009	One seen west of Westport (Westport Seabirds, unpubl. data).
Jan to Nov 2011	Many acoustic detections at sites in the Quinault Canyon and off Cape Elizabeth, with most activity from Sep to Feb (Širović et al. 2012). No detections from Apr to Aug.
8 Dec 2011	Six seen feeding with humpback and fin whales about 40 km off Westport. Four of the whales were photographed and identified as animals previously seen off California (Cascadia Research 2011, Jeffries 2012).
Dec 2011 to Jul 2012	Many acoustic detections at sites in the Quinault Canyon and off Cape Elizabeth, with most activity from Dec to Apr (Kerosky et al. 2013). No detections in May and July.

Sep 2012 to Jun 2013	Many acoustic detections in the vicinity of Quinault Canyon (Debich et al. 2014). Detections heard throughout study period, but with most activity from Nov to Jan and lowest from Mar to June.
Jul 2013 to Apr 2014	Many acoustic detections at sites in the Quinault Canyon and off Cape Elizabeth, with most activity from Oct to Feb (Trickey et al. 2015). No detections in Sep, Mar, and Apr.
Aug 2014	At least one individual seen at roughly 48°N, 127°W (Barlow 2016).
Aug 2014 to Feb 2015	One of 22 blue whales satellite-tagged in southern California traveled north into Washington, where it transited state waters twice in the fall, once moving north to Vancouver Island and again going south toward Oregon (Mate et al. 2015). Both routes mainly followed the continental slope edge.
1 Aug 2015	Two individuals seen, with one at 47.02°N, 124.37°W and one at 47.01°N, 124.39°W (Westport Seabirds, unpubl. data).

Fin whale

29 Apr 1958	One seen 77 km west of Cape Flattery at 48°25'N, 125°55'W (Fiscus and Niggol 1965).
6 Apr 1986	A 20.2-m-long female found across the bow of a container ship in Tacoma (Douglas et al. 2008; NMFS, unpubl. data). It was likely struck about 320 km off Cape Flattery after already dying. Jensen and Silber (2004) stated that the ship had arrived from Japan, but mistakenly reported the stranding location as Seattle. A partial skeleton of the animal is held at the Burke Museum of Natural History, Seattle (UWBM 42005).
28–29 Aug 1990[a]	Three whales several kilometers apart and traveling northward were detected acoustically east of the Juan de Fuca Ridge just south of the Washington-Oregon border (McDonald et al. 1995).
21 Jul–1 Aug 1994, Sep 1995	Multiple acoustic detections and several sightings made at different locations off Washington (Moore et al. 1999).
3–5 Sep 2001	Eight sightings of single animals, all from 47°03.00'N to 47°32.18'N and 125°40.66'W to 127°56.78'W (Appler et al. 2004). Locations of three of the sightings are mapped in Barlow and Forney (2007).
20 Apr 2002	One seen in "deep water" off Westport (Westport Seabirds, unpubl. data).
9 Aug 2002	A 17.4-m-long individual found across the bow of a container ship at the Port of Seattle (Jensen and Silber 2004, Douglas et al. 2008; NMFS, unpubl. data).
2 Oct 2002	An 18.4-m-long female found on the bow of a tanker at Cherry Point, Ferndale (Jensen and Silber 2004, Douglas et al. 2008; NMFS, unpubl. data). The ship had traveled from Valdez, Alaska.
4 Nov 2002	A 16.2-m-long male found dead drifting off Waldron, Skipjack, and Sucia Islands (Jensen and Silber 2004, Douglas et al. 2008; NMFS, unpubl. data). It was likely killed by a ship strike.

2003–2006	Many acoustic detections made by recording devices located near the Juan de Fuca Ridge in the vicinity of 47°57'N, 129°06'W (Weirathmueller et al. 2013). Most calls heard in the fall and winter. Soule and Wilcock (2013) reported on a subset of these calls used for tracking local movements.
8 Dec 2005	A pair seen 63 km offshore near the Quinault Canyon at about 47°08'N, 125°03'W (Oleson et al. 2009).
8 Dec 2005	One seen 10 km south of Race Rocks in the Strait of Juan de Fuca in Washington waters (Orca Network, unpubl. data).
14 May 2006	A 16.9-m-long male found floating dead near Lummi Island (Calambokidis 2006, Douglas et al. 2008; NMFS, unpubl. data). It was likely killed by a ship strike.
8 Nov 2006	A 16.4-m-long male found floating dead at the Port of Everett (Douglas et al. 2008; NMFS, unpubl. data). It had been entangled in marine debris (rope) before being struck by a ship. The strike likely happened before the ship entered the Salish Sea (Douglas et al. 2008).
22 Mar 2008	One group of six animals seen at 47°27.94'N, 125°10.93'W (Hanson et al. 2009).
28 May 2008	One or more individuals seen west of Willapa Bay (Orca Network, unpubl. data).
Jun 2008 to Jun 2009	One of the most commonly heard species detected by an acoustic recording device located off Cape Elizabeth, (Širović et al. 2011, Oleson and Hildebrand 2012). Most detections made from Sep to Apr; calls heard on >90% of days from Oct to Feb. No detections in May and Jun.
July–Nov 2008	Three individuals seen at roughly 46°20'N, 127°50'W; 46°40'N, 128°00'W; and 47°20'N, 125°20'W (Barlow 2010).
13 Jan 2009	Three seen together at Grays Harbor Canyon (Oleson and Hildebrand 2012).
7 Aug 2009	A 14.2-m-long juvenile male arrived at the Port of Tacoma across the bow of a container ship (Huggins and Lambourn 2009; NMFS, unpubl. data).
9 Feb 2010	An unmeasured individual stranded at Point Grenville (NMFS, unpubl. data).
6, 9 May 2010	A combined estimated 27 individuals seen off southwestern Washington on these days (Schorr et al. 2010). Four were satellite-tagged at 46.88°N, 125.09°W; 46.81°N, 124.97°W; 46.81°N, 124.99°W; and 46.41°N, 124.92°W (Schorr et al. 2013). Two departed the state within 8 days and moved south to Mexico and California.
28 Jan 2011	A partial carcass stranded at Ocean Shores was later identified as a fin whale through genetic testing (J. Huggins, pers. comm.; NMFS, unpubl. data).
Jan to Nov 2011	Many acoustic detections made by recording devices located in the Quinault Canyon and off Cape Elizabeth (Širović et al. 2012). Most activity was from Sep to Mar, with few detections from late May to late July.
10 Feb 2011	Three individuals satellite-tagged at 46.49°N, 124.90°W; 46.72°N, 124.94°W; and 46.72°N, 124.93°W (Schorr et al. 2013).
6 May 2011	One individual seen near the continental shelf edge west of the mouth of Willapa Bay (Jeffries 2012).
8 Dec 2011	At least one individual seen feeding with humpback and blue whales about 40 km off Westport (Cascadia Research 2011, Jeffries 2012).

Dec 2011 to Jul 2012	Many acoustic detections made by recording devices located in the Quinault Canyon and off Cape Elizabeth (Kerosky et al. 2013). Most activity was from Dec to Apr, with few detections from May to July.
29–31 May 2012	One or more individuals seen over the continental shelf slope west of southern Willapa Bay (Jeffries et al. 2012).
11–22 Jul 2012	One or more individuals seen at each of three locations off Westport, including two sites along the continental shelf slope and one west of the slope (Jeffries et al. 2013a). Another individual was satellite-tagged on 19 Jul at 46.95°N, 124.99°W (Jeffries et al. 2012, 2013a, Schorr et al. 2013). This whale, which was tagged during air-gun array seismic surveys, moved south following the shelf slope to an area off south-central Oregon by mid-Aug.
Sept 2012 to Jun 2013	Many acoustic detections made by recording devices located in the Quinault Canyon (Debich et al. 2014). Activity was highest from Oct to Jun.
15–16 Jan 2013	A group of seven seen over Guide Canyon on 15 Jan (Jeffries et al. 2013b). On 16 Jan, two groups of about five individuals seen over Guide Canyon and one individual seen near Grays Canyon. Some overlap of animals between the two dates was likely.
9 Mar 2013	Three individuals satellite-tagged at 46.54°N, 124.78°W; 46.49°N, 124.85°W; and 46.50°N, 124.78°W (Schorr et al. 2013).
13 Apr 2013	A 20.0-m-long (estimated) individual stranded in Burien after being struck by an unidentified ship (Cascadia Research 2013a; NMFS, unpubl. data). Carcass was severely damaged and was likely carried into the Salish Sea by the ship.
12 Jun 2013	A 20.7-m-long male stranded 3 km north of Ocean City (Cascadia Research 2013b; NMFS, unpubl. data). It was likely killed by a ship strike.
23 Jul 2013	Two seen between 46.50°N, 125.00°W and 46.52°N, 125.04°W (Westport Seabirds, unpubl. data).
Jul 2013 to Apr 2014	Some acoustic detections made by recording devices located in the Quinault Canyon and off Cape Elizabeth (Trickey et al. 2015). Activity was highest in Dec and Jan; no detections made from late Feb to Apr.
Aug 2014	At least one individual seen at each of three locations at roughly 47°N, 126°W; 47°N, 127°W; and 48°N, 127°W (Barlow 2016).
3 Sep to 21 Oct 2015	A juvenile seen multiple times in the eastern Strait of Juan de Fuca, with at least several of these being confirmed sightings (Orca Network, unpubl. data).
23 Jan, 1 Feb 2016	An individual seen off Seattle (Orca Network, unpubl. data). Reliability of these records is unknown.
15 Jul to 7 Aug 2016	An adult seen multiple times, first in the eastern Strait of Juan de Fuca, then later in Puget Sound south to near Olympia (Orca Network, unpubl. data). At least several were confirmed sightings.
23 Jul 2016	One seen at 46.54°N, 124.43°W (Westport Seabirds, unpubl. data).
12 May 2017	A 15.8-m-long juvenile male arrived at the Port of Tacoma across the bow of a vehicle carrier ship (Cascadia Research, unpubl. data). The whale was probably struck near the entrance of the Strait of Juan de Fuca.

Sei whale

17 Apr 1994	One seen in "deep water" off Westport (Westport Seabirds, unpubl. data). Because of potential confusion with fin and common minke (*B. acutorostrata*) whales, this record is probably best treated as hypothetical.
30 Apr 1994	Two seen in "deep water" off Westport (Westport Seabirds, unpubl. data). Because of potential confusion with fin and common minke whales, this record is probably best treated as hypothetical.
20 Apr 2002	Three seen in "deep water" off Westport (Westport Seabirds, unpubl. data). Because of potential confusion with fin and common minke whales, this record is probably best treated as hypothetical.
12 Sep 2003	A dead 13.0-m-long adult male found about 8 km west of Port Angeles (Anonymous 2003, Preston 2003, Douglas et al. 2008; NMFS, unpubl. data). It had been struck by a seafood processing ship coming from Dutch Harbor, Alaska, and was likely carried on the bow for as long as a week before becoming dislodged.

North Pacific right whale

10 Apr 1959	Three seen 53 km west of Grays Harbor at 46°54'N, 124°56'W (Fiscus and Niggol 1965). This record is questionable given the inconsistencies noted for the sightings made nine days later (see below).
19 Apr 1959	Eight seen at two locations, including 21 km southwest of Destruction Island at 47°35'N, 124°46'W and 14 km southwest of Destruction Island at 47°37'N, 124°42'W (Fiscus and Niggol 1965). This record is almost certainly erroneous in at least some of its details and is perhaps best treated as a mixed group comprised of undetermined numbers of humpback, gray, and right whales (Scarff 1986).
1963–1968 (June)	One seen by Soviet whalers at approximately 46°N, 127°W (Ivashchenko and Clapham 2012).
17 Jan 1967	Three seen 28 km west-southwest of Cape Flattery at 48°20'N, 125°06'W (Rice and Fiscus 1968).
20 Mar 1973	Five to seven seen near Cape Flattery at 48°29'N, 124°57'W (Scarff 1986). NMFS staff considered this record as "tentative," meaning that it was probably valid, but not verified (Scarff 1986, Rowlett et al. 1994). However, as discussed in Scarff (1986), the large number of animals noted makes this record highly questionable.
28 Aug 1983[a]	Two seen at Swiftsure Bank at the entrance of the Strait of Juan de Fuca in British Columbia (Reeves and Leatherwood 1985), which is close to the border of Washington and only about 17 km northwest of Tatoosh Island. However, this sighting is considered questionable (Ford 2014).
24 May 1992	One seen over the Quinault Canyon 65 km west of Cape Elizabeth at 47°17.2'N, 125°11.1'W and 6 hr later 48 km west of Destruction Island at 47°38.0'N, 125°07.4'W (Rowlett et al. 1994).
29 Jun 2013	Two acoustic detections made about 2 hr apart by a recording device in the Quinault Canyon (Debich et al. 2014, Širović et al. 2015).

25–26 Oct 2013[a]	One seen at Swiftsure Bank at the entrance of the Strait of Juan de Fuca on the British Columbia side of the international border (Ford et al. 2016). This sighting was just 1 km north of the Washington-British Columbia border and 16.5 km northwest of Tatoosh Island.

Sperm whale

5 Feb 1958	One seen 30 miles west-northwest of James Island at 48°02'N, 125°24'W (Fiscus and Niggol 1965).
22 Apr 1959	One seen 22 miles west of Cape Elizabeth at 47°23'N, 124°51'W (Fiscus and Niggol 1965).
21 Oct 1977	A 15.5-m-long male found stranded at Kalaloch (NMFS, unpubl. data). Teeth and phalanges from the animal are held at the Burke Museum of Natural History, Seattle (UWBM 42013).
4 Jan 1982	A 13.7-m-long female found stranded at Kalaloch (NMFS, unpubl. data).
27 Jul 1982	A 10.8-m-long male found stranded at Ocean Shores (NMFS, unpubl. data).
19 Apr 1986	A 13.1-m-long male found stranded at Seaview (NMFS, unpubl. data).
Apr 1989 to Sep 1990	Four sightings of single individuals made between spring and fall; exact dates not listed (Green et al. 1992). Most were probably large males. Approximate locations were 48°23'N, 125°58'W; 47°25'N, 126°20'W; 47°25'N, 126°23'W; and 46°15'N, 125°00'W (this animal was along the Washington-Oregon border).
28 Nov 1989	An individual of unknown size found stranded at Neah Bay (NMFS, unpubl. data).
10 Jun 1994	A 13.0-m-long male found stranded at Westport (NMFS, unpubl. data).
23–30 July 1994	Eight sightings from about 46°15'N to 46°45'N and 125°15'W to 130°10'W (Moore et al. 1999). Numbers of whales per sighting were not reported.
22 Mar 2000	An 11.7-m-long female found stranded at Ocean Shores (NMFS, unpubl. data).
8 Sep 2002	A 15.3-m-long male found stranded at Twin Harbor Beach near Westport (NMFS, unpubl. data). Carcass showed extensive damage, including superficial propeller marks on its back and head. Douglas et al. (2008) listed the whale as a possible ship strike.
9 Oct 2002	A 5.8-m-long calf found stranded at Ocean Shores (NMFS, unpubl. data).
Jul 2004 to Jun 2008	Many acoustic detections made by recording devices located in the Quinault Canyon and off Cape Elizabeth (Oleson et al. 2009). Calling activity was much reduced at the location along the shelf edge (i.e., off Cape Elizabeth). Most calling activity was from Apr to Aug, with fewer detections from Sep to Mar.
9–13 Jun 2005	One sighting at about 48°N, 126°W (Forney and Bowlby 2005, Forney 2007).
15–23 Mar 2006	Acoustic detections of one or more individuals made from three locations: 46°36.05'N, 124°23.62'W; 47°39.97'N, 124°56.82'W; and 48°14.40'N, 123°39.96'W (Hanson et al. 2008a). On 20 March, one individual sighted at 47°45.34'N, 125°02.12'W.
Aug 2007	One struck by a sablefish longline vessel at idle speed at an offshore location (Carretta et al. 2013). The animal did not appear to be injured.

14 Mar 2008	An 11.3-m-long female found stranded at Washaway Beach near North Cove (NMFS, unpubl. data). Whale appeared to show entanglement scars. Skeletal items and tissue from the animal are held at the Burke Museum of Natural History, Seattle (UWBM 80855).
Jun 2008 to Jun 2009	Some acoustic detections by a recording device located near the shelf edge off Cape Elizabeth (Širović et al. 2011, Oleson and Hildebrand 2012). Calls heard in June of both years and from Aug to Oct and in Dec and Jan; most calling activity in Jun. No detections from Feb to May, Jul, and Nov.
Jul to Nov 2008	One individual seen at about 48°N, 126°W (Barlow 2010).
2008 to Jun 2011	"Frequent" sightings of sperm whales reported by long-line fishing vessel crews working off Washington (Jeffries 2012).
Jun to Oct 2009	Three satellite-tagged individuals traveled along or near Washington's continental shelf slope while en route from Southeast Alaska to Mexico (Straley et al. 2014). Two passed through Washington's waters in Jun-Jul 2009 and one in Oct 2009.
Jan to Nov 2011	Some acoustic detections made by recording devices located in the Quinault Canyon and off Cape Elizabeth (Širović et al. 2012). Detections occurred in all months, especially near Quinault Canyon, with higher activity during Feb, late Apr to Jun, and Sep.
Jun 2011	A group of two individuals sighted at about 47°00'N, 125°30'W (Adams et al. 2014).
21 Jan 2012	An 11.6-m-long subadult found stranded near Long Beach (NMFS, unpubl. data). Its skull was severely fractured, the back appeared to be broken, and there was a hemorrhage at head and right scapula, indicating that it was a ship strike.
Dec 2011 to Jul 2012	Some acoustic detections made by recording devices located in the Quinault Canyon and off Cape Elizabeth (Kerosky et al. 2013). Calling occurred in all months, mostly at relatively low levels except for peaks in Dec-Jan and Jun. Most detections were made near Quinault Canyon.
11–22 Jul 2012	One individual seen over the continental shelf slope west of Westport (Jeffries et al. 2013a).
Sept 2012 to Jun 2013	Some acoustic detections made by a recording device located in the Quinault Canyon (Debich et al. 2014). Calling occurred in all months except Sep and Oct, with peaks from late Jan to early Mar, and in mid-Apr.
10 Dec 2012	An 8.6-m-long subadult found stranded near Cape Alava (NMFS, unpubl. data).
22 Aug 2013	One seen at 46.52°N, 125.00°W (Westport Seabirds, unpubl. data).

[a] Records occurring close to the border of Washington. The whales involved in these may have entered the state's waters.

Appendix B. Species detections of blue, fin, sei, North Pacific, and sperm whales during 31 surveys conducted for cetaceans in Washington between 1958 and 2016.

		Species[1]				
Survey	Survey type[1]	Blue whale	Fin whale	Sei whale	North Pacific right whale	Sperm whale
Fiscus and Niggol 1965	V	-	+	-	?	+
Wahl 1977	V	-	-	-	-	-
Green et al. 1992	V	-	-	-	-	+
Moore et al. 1999	A, V	+	+	-	-	+
Von Saunder and Barlow 1999	V, A	-	-	-	-	-
Shelden et al. 2000	A	-	-	-	-	-
Appler et al. 2004	V, A	-	+	-	-	-
Calambokidis et al. 2004	V	-	-	-	-	-
SWFSC 2006	V	-	-	-	-	-
Calambokidis et al. 2007	V	-	-	-	-	-
Forney 2007	V	-	-	-	-	+
Hanson et al. 2008a	V, A	-	-	-	-	+
Hanson et al. 2008b	V, A	-	-	-	-	-
Calambokidis et al. 2009	V	-	-	-	-	-
Hanson et al. 2009	V, A	-	+	-	-	-
Oleson et al. 2009	A, V	-	+	-	-	+
Barlow 2010	V	-	+	-	-	+
Hanson et al. 2010	V, A	-	-	-	-	-
Širović et al. 2011	A	+	+	-	-	+
Jeffries 2012	V	+	+	-	-	+
Jeffries et al. 2012	V	-	+	-	-	-
Oleson and Hildebrand 2012	A, V	+	+	-	-	+
Širović et al. 2012	A	+	+	-	-	+
Jeffries et al. 2013a	V	-	+	-	-	+
Jeffries et al. 2013b	V	-	+	-	-	-
Kerosky et al. 2013	A	+	+	-	-	+
Adams et al. 2014	V	-	-	-	-	+
Debich et al. 2014	A	+	+	-	+	+
Trickey et al. 2015	A	+	+	-	-	-
Barlow 2016	V	+	+	-	-	-
Westport Seabirds, unpubl. data	V	+	+	?	-	+

[1] Symbols: V, visual methods were used in the survey; A, acoustic methods were used in the survey; +, species recorded during the survey; -, species not recorded during the survey; ?, reported detections of a species that are now considered questionable (see Appendix A for more explanation).

Appendix C. WDFW responses to public comments received during the 90-day public review period for the draft *Periodic Status Review for Blue, Fin, Sei, North Pacific Right, and Sperm Whales in Washington* conducted from May 19 to August 17, 2017. The comments presented here are summaries of the remarks provided by one or more people.

Report Section	Comment and Response
General comments	1. I support the continued listing of blue, fin, sei, North Pacific right, and sperm whales as endangered in Washington.
	Thank you for your comment. WDFW recommends that these five species of whales should remain on the state list of endangered species for the reasons given in the periodic status review.
Blue whale population status	2. In our recently published scientific papers (Monnahan et al. 2014, 2015), we reported that the Eastern North Pacific stock of blue whales has recovered to 97% of its pre-whaling size and is at or near its environmental carrying capacity. The stock is not limited by mortalities from ship strikes.
	The Monnahan et al. (2014, 2015) papers and their information are cited in the periodic status review. Both contain valuable analyses that are important in the overall discussion of blue whale stock recovery off the U.S west coast. However, like all models of the type used in these papers, a number of major assumptions are made that may not be valid all of the time, such as an absence of change in environmental conditions, accurate estimates of whales killed during the whaling era, and an absence of change in other threats. The size of the Eastern North Pacific stock continues to be debated, with the National Marine Fisheries Service using a smaller estimate of stock size (see Carretta et al. 2017) than in the Monnahan et al. (2014, 2015) papers. Based on this, plus the continued federal listing of the species as endangered and the modest numbers recorded in Washington, WDFW is recommending that blue whales continue to be listed as endangered under state law until a more detailed review can be conducted by the National Marine Fisheries Service.
Management activities	3. All commercial fishing and crabbing in Washington should be stopped to provide whales with increased food resources and to reduce the threat of entanglement in gear associated with these fisheries.
	WDFW does not support either of these measures. None of the species covered in this report have been reported to suffer from inadequate prey resources. Entanglement of whales in fishing and crabbing gear is an important concern, but is being addressed through a number of other measures, as described in the Management Activities section.

References Reviewed for the *Periodic Status Review for Blue, Fin, Sei, North Pacific Right, and Sperm Whales in Washington*

Table B presents the 288 references cited in the *Periodic Status Review for Blue, Fin, Sei, North Pacific Right, and Sperm Whales in Washington*. Each reference is categorized for its level of peer review pursuant to section 34.05.271 RCW, which is the codification of Substitute House Bill 2661 that passed the Washington Legislature in 2014. A key to the review categories under section 34.05.271 RCW is provided in Table A.

Individual papers cited cover a number of topics discussed in the report, including information on: 1) the species' taxonomy, distribution, and biology; 2) habitat requirements; 3) population status and trends; 4) conservation status and protections; 5) management activities; and 6) factors affecting the continued existence of the species.

Table A. Key to 34.05.271 RCW Categories:

Category Code	34.05.271(1)(c) RCW
i	(i) Independent peer review: review is overseen by an independent third party.
ii	(ii) Internal peer review: review by staff internal to the department of fish and wildlife.
iii	(iii) External peer review: review by persons that are external to and selected by the department of fish and wildlife.
iv	(iv) Open review: documented open public review process that is not limited to invited organizations or individuals.
v	(v) Legal and policy document: documents related to the legal framework for the significant agency action including but not limited to: (A) federal and state statutes; (B) court and hearings board decisions; (C) federal and state administrative rules and regulations; and (D) policy and regulatory documents adopted by local governments.
vi	(vi) Data from primary research, monitoring activities, or other sources, but that has not been incorporated as part of documents reviewed under the processes described in (c)(i), (ii), (iii), and (iv) of this subsection.
vii	(vii) Records of the best professional judgment of department of fish and wildlife employees or other individuals.
viii	(viii) Other: Sources of information that do not fit into one of the categories identified in this subsection (1)(c).

Table B Reference	34.05.271 RCW Review Category
Adams, J., J. J. Felis, J. W. Mason, and J. Y. Takekawa. 2014. Pacific continental shelf environmental assessment (PaCSEA): aerial seabird and marine mammal surveys off northern California, Oregon, and Washington, 2011−2012. OCS Study BOEM 2014−003, Pacific OCS Region, Bureau of Ocean Energy Management, U.S. Department of the Interior, Camarillo, California.	i

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Archer, F. I., P. A. Morin, B. L. Hancock-Hanser, K. M. Robertson, M. S. Leslie, M. Bérubé, S. Panigada, and B. L. Taylor. 2013. Mitogenomic phylogenetics of fin whales (*Balaenoptera physalus* spp.): genetic evidence for revision of subspecies. PLoS ONE 8(5): e63396.	i
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Barlow, J. 2016. Cetacean abundance in the California Current estimated from ship-based line-transect surveys in 1991-2014. NOAA Fisheries Administrative Report LJ-16-01, Southwest Fisheries Science Center, La Jolla, California.	i
Barlow, J. and K. A. Forney. 2007. Abundance and population density of cetaceans in the California Current ecosystem. Fishery Bulletin 105:509−526.	i
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 53:2197–2209.	i
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