



Brief Species Description: Basking sharks (*Cetorhinus maximus* Gunnerus 1765) reach lengths of 33 ft (10 m) and are the second largest shark species (Compagno 2001). Like the even larger whale sharks, they are filter-feeders and forage near the base of the food-web. The obvious external features that distinguish basking sharks from whale sharks are their large gill slits that nearly encircle the head, a pointed snout, and mottled dark gray to brown coloration (Ebert 2003). While this species has been reported globally from tropical to arctic waters, they are most commonly observed in coastal temperate waters where flow patterns set up convergence zones that concentrate forage (Sims and Quayle 1998, Sims 1999, Ebert 2003). Here, they are commonly observed foraging at the surface, similar to other large filter feeders. Their prey consists largely of zooplankton, especially copepods.

KEY INFORMATION

Area(s) of Concern

Eastern North Pacific

Year Identified as "Species of Concern"
2010

Factors for Decline

- Interaction with vessels and fisheries
- Low reproductive rates, and hence a low intrinsic rate of recovery.

•Conservation Designations

IUCN: Endangered, North Pacific population

CITES: Appendix II. Vulnerable globally and endangered in North Pacific.

Canada: Endangered in the North Pacific; protected under Species at Risk Act.

USA: Prohibited species in the Pacific under the Highly Migratory Species Fishery Management Plan.

Convention on Migratory Species: Appendix I and II.

Seasonal changes in the distribution of basking sharks are noted globally, with abundance shifting between higher latitudes in the spring and summer, and lower latitudes in the fall and winter months. Recent satellite tagging studies in the Atlantic reveal that basking sharks are capable of basin-scale migrations (Skomal *et al.* 2004, Gore *et al.* 2008, Skomal *et al.* 2009). While in the tropics they tend to remain in cooler waters below the mixed layer, which may explain the lower number of observations from these regions.

In the eastern North Pacific, basking sharks are thought to originate from a single population that shifts north to south seasonally from Canada to central California (Compagno 2001, Ebert 2003, McFarlane *et al.* 2009). The full geographic range of this population and potential links to the central, western or southern Pacific are unknown (Figure 1). Basking sharks are observed across the North Pacific from North America to the Hawaiian Islands, to Japan and China, including Taiwan.

In many regions basking sharks exhibit strong sexual segregation. For example, off the United Kingdom, fisheries data reveal a 40:1 female:male sex ratio (Compagno 2001). In the eastern North Pacific, sex ratios are unknown.



Basking sharks appear to have very low reproductive rates and may be more vulnerable to overfishing than any other shark species (Compagno 1984, 2001). Popping frequency has not been determined, but has been estimated at 18 months to 3 years, with litter sizes of about 1 to 6 pups. While some estimates are available, in reality, most aspects of their reproductive biology and age and growth are unknown or poorly understood (Ebert 2003, Natanson *et al.* 2008).

North Pacific Basking Shark SOC Range

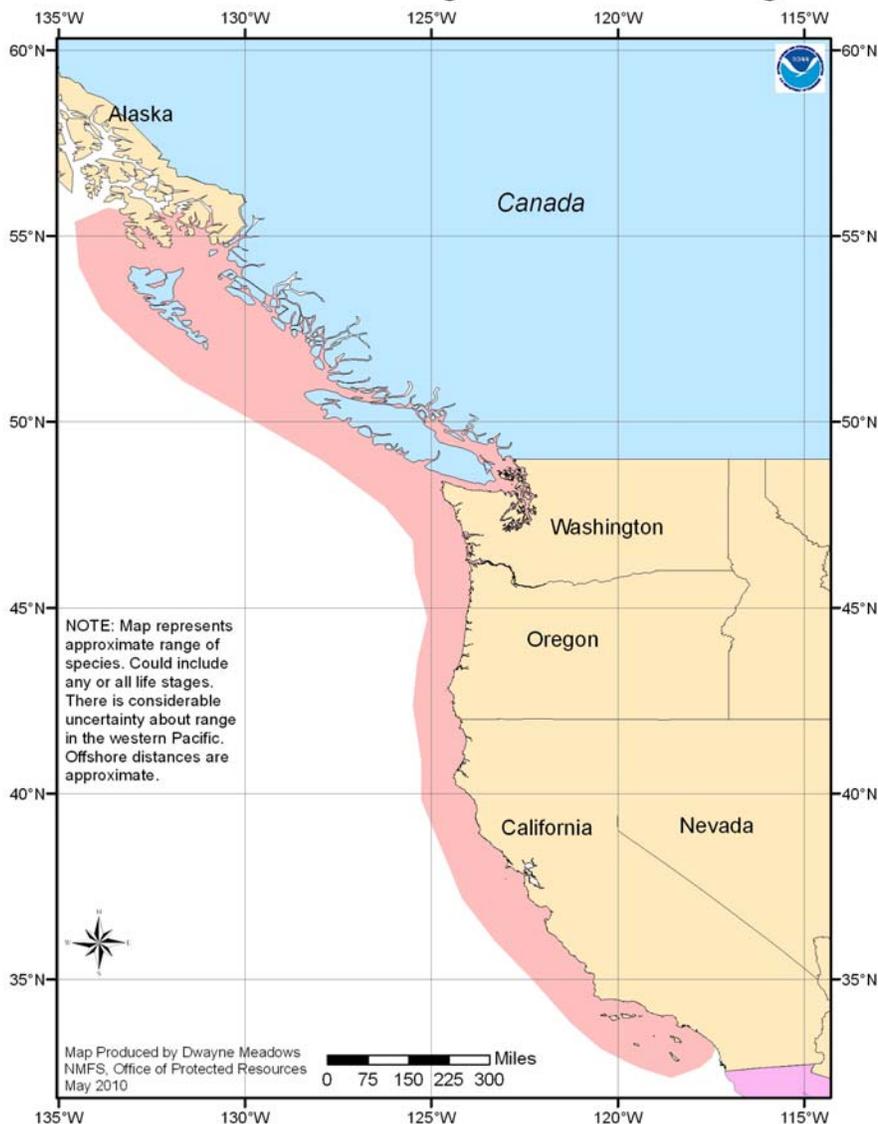


Figure 1. Geographic range of the North Pacific basking shark Species of Concern.

Rationale for “Species of Concern” Listing:

There are three primary reasons for concern about the long-term viability of basking shark populations in the eastern North Pacific. First, observations and fisheries data collected for basking sharks off



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both Canada and California suggest dramatic declines from the early and mid 1900's, when animals were targeted by fisheries in both locations (Figure 2).

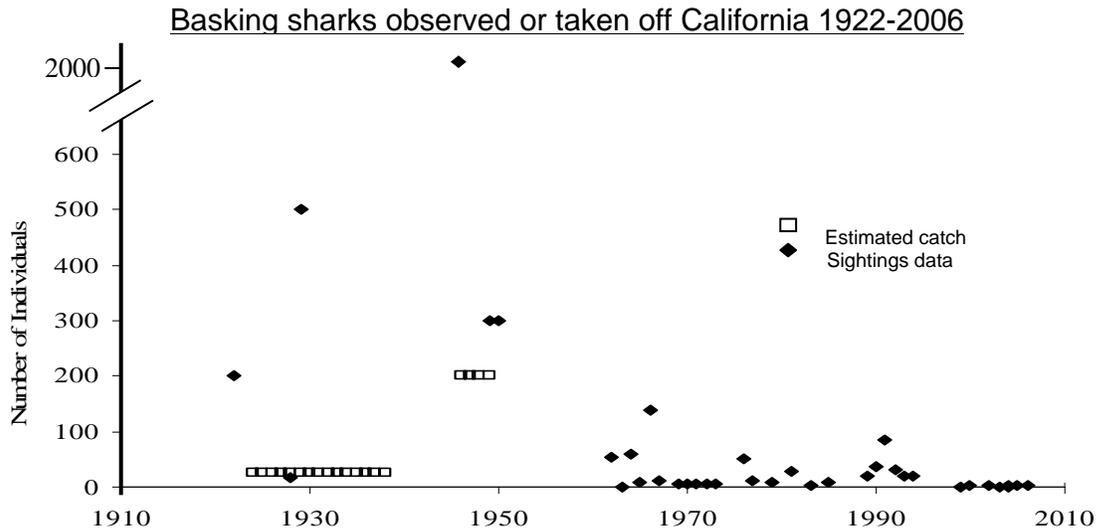


Figure 2. Basking sharks both taken and observed off California from 1922-2006. Sightings data were compiled from a range of sources; e.g., newspaper reports, scientific papers, individual observations from researchers, boat captains and spotter pilots. For a complete list see McFarlane *et al.* 2009. For the sightings data, the maximum value for a given year is shown. When a range of values was reported the mid-point of the range was used. When 100s or 1,000s were reported, 200 and 2,000 were used, respectively. Note that much of the sightings data is anecdotal and the fisheries data do not reflect effort.

Off California, basking sharks were targeted in fisheries where they were used for both fishmeal and oil. Where schools in the 100s and 1,000s used to occur, no more than 3 individuals have been observed at any one time since 1993 (Phillips 1948, Squire 1967, 1990, McFarlane *et al.* 2009). In Canada, sharks were targeted primarily in an eradication program due to their negative interactions with salmon fisheries. A “razor billed shark slasher” was used to kill an estimated 1,000 to 2,600 sharks from 1900 to 1970. In the bays and inlets off the coast of British Columbia, thousands of animals were reported in the early 1900's (summarized in McFarlane *et al.* 2009). In the last 13 years, since 1996, only 6 animals have been documented (McFarlane *et al.* 2009).

A second reason for concern is that despite decades with no directed fishing pressure, the eastern North Pacific population has apparently not rebounded. This raises concerns about their intrinsic recovery rate as well as the impacts of even low levels of mortality. When compared to nine other sharks species, the basking shark was ranked lowest in terms of rebound potential (Smith *et al.*, 2008). While not targeted in the United States or Canada since the 1950's and 1970's, respectively, basking sharks are still impacted by human activities. They are struck by vessels and caught incidentally in a range of fishing gear including longlines, nets, and the lines from prawn traps (CITES 2002, McFarlane *et al.* 2009). From 1996 through 2006, four basking sharks were caught by the Canadian bottom trawl fleet. From 1981 through 2008, 96 basking sharks are reported in the logbook and observer records obtained from a range of net-based fisheries operating off the U.S. West Coast



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(Larese and Coan 2008, NMFS unpublished data). Although it isn't clear if the populations are linked, basking sharks have also been caught in the high seas drift gillnet fishery in the central North Pacific (Bonfil 1994) and targeted in fisheries in the western North Pacific (Martin and Harvey-Clark 2004). Basking shark fins are still found in Asian markets where they are sold to make shark fin soup (Magnussen *et al.* 2007). Many of these fins are not accounted for in CITES export permits that are required under Appendix II (Magnussen *et al.* 2007). With the cost of one fin reaching \$57,000, the incentive for taking basking sharks is high.

While the data are imprecise because of their anecdotal and incomplete nature and unsystematic collection, there a number of lines of evidence that suggest the population trends are real. First, these declines are similar to those documented in other locations where fisheries existed (ICES 2005, McFarlane *et al.* 2009; Figure 3). While declines have been observed globally, there have been no reports of dramatic population shifts to explain these declines, although an offshore shift may be hard to document. While data collection has not been systematic, there is no reason to believe that a reduction in survey efforts explains the reduced sightings. In fact, activity on and above the water

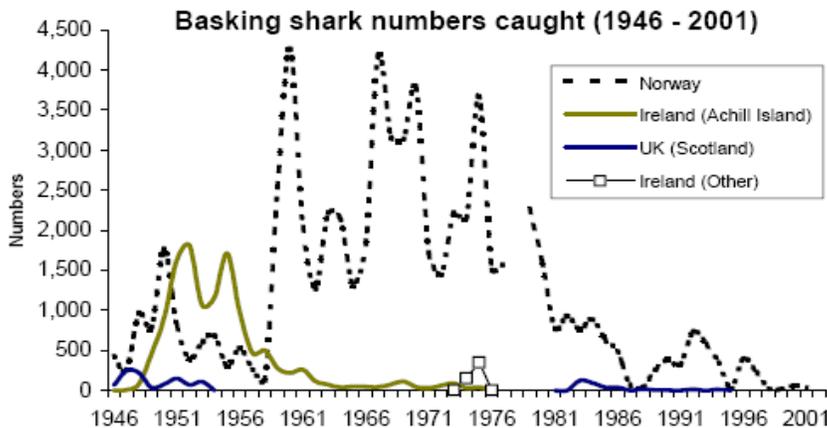


Figure 3. Capture data for basking sharks in the Northeast Atlantic Ocean since the end of WWII (ICES 2005).

may have increased in the last 50 years. Off Monterey Bay, California, there are currently eight groups actively working in and around the bay: the Monterey Bay Aquarium Research Institute, the Pelagic Shark Research Foundation, Moss Landing Marine Laboratories, the Monterey Bay Aquarium, NOAA Fisheries Protected Resources Division, NOAA National Marine Sanctuary, Stanford University, and the University of California,

Santa Cruz. Three of these groups have actively targeted basking sharks for observation or research. Off Canada, hundreds of basking sharks were observed in predictable nearshore locations. While a range of vessels still visit these locations, few or no basking sharks have recently been observed. Clearly, while more information is needed on population structure, size and range, and the impact of environmental variability, the most parsimonious explanation for the apparent trend is that human-induced population declines have occurred in the eastern North Pacific.

The third reason for concern about basking sharks is the great lack of data, some of which is highlighted above. Most basic demographic and life history parameters are poorly understood or unknown. For example, vertebral ring counts had been used to estimate the age of reproductive maturity for both males and females. However, a recent study by Natanson *et al.* (2008) reveals that



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rings are associated with somatic growth, not time, and cannot be used reliably to infer age. Thus, that critical parameter for population assessments remains uncertain. The limited information that is available on their basic biology tends to be either anecdotal or imprecise due to small sample sizes. As mentioned above, too little information is available on habitat use and population structure to conclusively identify reasons for the apparent reduction in sightings off California and Canada. With the current state of knowledge, it is also challenging to assess population vulnerability and the influence of environmental variability, to identify potential fisheries interactions and other sources of mortality, and to determine how any recovery plan should be structured. Due to the lack of data there are thus uncertainties regarding both biological status and threats to the remaining population. This lack of data further warrants listing basking sharks as a species of concern.

Factors for Decline

The following discussion considers all of the factors that are considered for adding a species to the Species of Concern program (NOAA 2004).

Abundance & Productivity

Historical numbers: Eastern North Pacific regional population estimates are relatively low ranging from a few hundred to a few thousand individuals (Campagno 2001, CITES 2002, Hoelzel *et al.* 2006). Pre-harvest population estimates for the eastern North Pacific are estimated at 3,000 to 5,000 individuals based on sightings and fisheries data (McFarlane *et al.* 2009). Calculations are, however, complicated by the lack of a consistent survey method, inadequate data, and anecdotal descriptions of quantities, such as “some”, “many” and “numerous”. The unexplained, high historic inter-annual variability in the eastern North Pacific also complicates estimates.

Magnitude of decline (extent and rate): In all locations where fisheries have targeted basking sharks, population declines have been rapid, with little sign of recovery after the cessation of fishing activity, even over time periods of 50 years or greater (CITES 2002, McFarlane *et al.* 2009). The same can be said for the population in the eastern North Pacific. Populations off both Canada and California declined coincident with fishing and eradication programs. Based on estimates by the Department of Fisheries and Oceans, Canada (DFO), the current eastern North Pacific population ranges between approximately 300 and 500 animals, or about 10% of pre-harvest levels. Additional information on life history and population structure and range will help to refine estimates, which have large margins of error due to the lack of adequate data.

Distribution

Connectivity: In the eastern North Pacific, it is generally accepted based on the patterns in abundance, that the animals off California and Canada are part of the same population (Ebert 2001, 2003). No additional information on the geographic range of this population is available. Recent data showing large-scale migrations of basking sharks within the Atlantic Ocean (Skomal *et al.* 2004, Gore *et al.* 2008, Skomal *et al.* 2009), a historically high degree of inter-annual variability in numbers of basking sharks observed, and the occurrence of basking sharks across the North Pacific, suggest that the population may extend well beyond United States and Canadian waters.



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Low resilience to environmental variability and catastrophes: Given that the habitats basking sharks depend upon to support long-term survival are not fully known, it is difficult to determine how environmental variability may impact them. Some information is available for nearshore environments where basking sharks are closely tied to conditions that act to concentrate prey in convergence zones (Sims and Quayle 1998, Sims 1999). Any factors that affect productivity or current patterns in coastal areas could influence abundance or habitat quality. In the North Pacific, while it is predicted that upwelling will increase with global climate change, the peak in productivity will shift to later in the year. The shift in timing could negatively impact habitat if migrations and productivity are tightly coupled (Schwing *et al.* 2010). In addition to their links to specific environmental conditions for foraging, low genetic diversity may make basking sharks vulnerable to environmental variability.

Small range/endemics: The geographic area covered by the population of basking sharks in the eastern North Pacific is not known. Consequently, the range is impossible to assess. The results from tagging studies in the Atlantic Ocean reveal the potential for large-scale movements. Similar studies are needed in the Pacific Ocean. In the Atlantic there is some suggestion of regional site fidelity to nearshore foraging grounds, making these populations particularly susceptible to overfishing (Sims *et al.* 2005, Skomal 2005).

Life-history characteristics

Vulnerable life-history traits: Basking sharks are a more *k*-selected species with very low reproductive rates (Compagno 2001, CITES 2002, Martin and Harvey-Clark 2004, Smith *et al.* 2008). Based on the scarce information that is available, all reproductive traits are very low.

Genetic diversity concerns: Basking sharks are nearly globally distributed but limited information is available on potential population structure within this broad geographic range. A single genetic study revealed no population subdivision and suggests that basking sharks have the lowest genetic diversity yet reported for any shark (Hoelzel *et al.* 2006). The study, however, did not include sharks sampled from the eastern North Pacific. Given the apparent decline in populations, the low genetic diversity is an even greater concern.

Status Reviews/Research Underway:

The Canadian DFO is currently assessing the status of basking sharks in the eastern North Pacific. Limited research is currently being conducted, largely due to the low abundance of basking sharks off Canada and California. The Pelagic Shark Research Foundation in Monterey Bay is making visual observations of basking sharks and tagging individuals with conventional tags when possible. NMFS will be working with researchers at Stanford University, the University of Washington, the Canadian DFO, and the Pacific Shark Research Center (PSRC) at Moss Landing Marine Labs to deploy pop-up satellite tags on basking sharks off Monterey Bay and off the coast of British Columbia. While not the focus of their work, NMFS is documenting sightings of basking sharks during aerial surveys for leatherback sea turtles. Researchers at the PSRC have compiled a comprehensive Life History Data Matrix on basking sharks in the eastern North Pacific and globally.

Data Deficiencies:

There is no aspect of the movements, behaviors, population size or structure, or life history that isn't data deficient for basking sharks in the eastern North Pacific. More is unknown than known. We



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focus here on issues most critical to recovering populations. Key questions relating to life history include age at first reproduction, gestation period, litter size, mating periodicity, nursery ground locations and the dynamics of sexual segregation. From a population perspective, the population dynamics, size, geographic range, and population genetics are not known. For example, it is unknown whether animals observed off Canada and California are a part of the same population as those from the central, western, or southern Pacific Ocean. Limited information is available on the extent of basking shark bycatch in international fisheries that often don't differentiate shark catch to species, if data are collected at all. While some information is available on habitat use in nearshore areas, all data have been collected in the Atlantic Ocean with no comparable studies for the North Pacific Ocean. The lack of information on what types of habitats are important for supporting different life stages of basking sharks makes it hard to assess how environmental variability over long or short-time scales influence abundance and distribution.

Existing Protections and Conservation Actions:

International Union for Conservation of Nature (IUCN) Red List: Endangered in the North Pacific (Fowler 2008)

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES):

Appendix II. While trade is not prohibited under Appendix II, export permits are required and any trade cannot be detrimental to the species' survival.

Convention on the Conservation of Migratory Species (CMS): Appendix I and II. Considered endangered throughout all or part of its range. CMS listing promotes international cooperation by members to support research relating to migratory species; requires members to provide immediate protection for migratory species included in Appendix I; and requires agreements among members covering the conservation and management of migratory species included in Appendix II.

Canada: The Pacific population of basking sharks has been designated as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2007). While this listing has no legal ramifications, in March of 2010 the basking shark was included under the Species at Risk Act (SARA). SARA prohibits the take, harassment and destruction of habitat of basking sharks in Canadian waters.

USA: Prohibited species in the Pacific Ocean in Federal waters (PFMC 2007). Animals incidentally taken cannot be retained and must be released immediately. Essential Fish Habitat has not been designated in the northeast Pacific.

California: Retention of basking sharks in state waters has been banned by the California Department of Fish and Game.

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