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RECOVERY POTENTIAL ASSESSMENT FOR BASKING SHARK IN CANADIAN PACIFIC WATERS

Figure 1. Basking shark (Courtesy of T.Campbell).

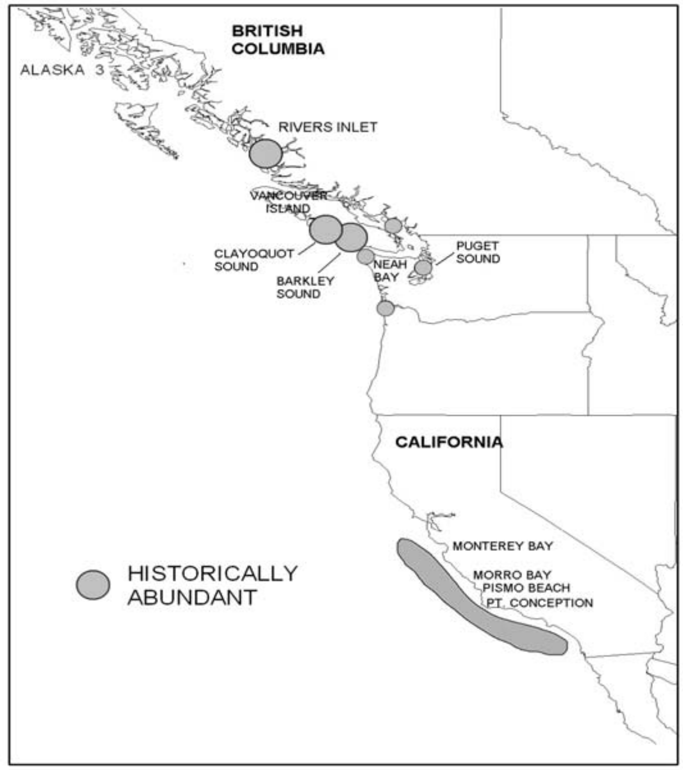

Figure 2. Historic ranges of basking shark in the Northeast Pacific (From McFarlane et al. 2009).

Context :

Basking sharks (Cetorhinus maximus) are a large planktivorous shark that ranges across the north-east Pacific and Atlantic Oceans. They were assessed by COSEWIC in 2007 as Endangered. To support decision-making, information is required on the species' biology, population trends and targets, habitat requirements, threats to the survival or recovery and allowable harm. This Recovery Potential Assessment (RPA) was developed based on a peer-review by the Pacific Scientific Advice Review Committee (PSARC).

SUMMARY

- The Pacific population of basking sharks is designated by COSEWIC as endangered.
- Basking sharks are large planktivorous sharks that range across the north-east Pacific.
- They are very slow growing, slow to mature, and have low fecundity.
- The historic north-east Pacific population is estimated at 1000-2600 animals.
- Since 1996 there have been 12 sightings of basking sharks in Pacific Canadian waters.
- It is estimated that 200 years are needed before population numbers will return to their unexploited status but only if human induced mortality is zero. If human induced mortality exceeds 11-18 sharks per year the population could be extinct within approximately 30 years.
- A short-term goal for the basking shark is to promote the population's recovery such that it can be downlisted from its current COSEWIC endangered status. An interim goal is to see positive population growth to the number of observations recorded for the 1945-1970 period. A long-term goal is to promote the sustained viability of a naturally-reproducing population.

INTRODUCTION

The basking shark (*Cetorhinus maximus* Gunnerus, 1765) is the sole member of the family Cetorhinidae belonging to the order Lamniformes. The basking shark is readily distinguished from other sharks by its large size (maximum reported 12.2 m), elongated gill slits, pointed snout, large mouth with minute hooked teeth, caudal peduncle with strong lateral keels, and crescent shaped caudal fin (Figure 1). Colour is typically blackish to grey-brown, grey or blue-grey above and below on the body and fins. The under-surface is sometimes lighter, and it often has irregular white blotches on the underside of the head and abdomen. Internal gill openings have prominent gill rakers.

Basking sharks have been recorded in surface waters ranging from 8 to 24ºC; with the majority of the observations from 8 to 14ºC waters. Recent tagging has largely disproved the longstanding theory that basking sharks 'hibernate' in deep water over the winter (Sims et al. 2003). Very little is known regarding the dispersal and migratory patterns of individual basking sharks. Seasonal migrations are suspected to occur from deep to shallow water or from lower to higher latitudes. This inference is based on observations of seasonal changes in abundance on both the Atlantic and Pacific coasts of North America. In the northeast Pacific, more basking sharks were observed in spring and summer off British Columbia and Washington, and more were counted off California in autumn and winter. It has been inferred from these observations that there is a single northeast Pacific population that migrates seasonally (Compagno 2001).

The presence of basking sharks on the ocean surface in areas of high zooplankton concentrations, combined with the anatomical adaptation of specialized gill rakers, suggests that they are primarily planktivores. Stomach content analyses confirm that zooplankton is the preferred prey, but these analyses are based primarily on basking sharks that were active at the surface when they were captured in commercial fisheries. Other information indicates that a wide range of prey sources, aside from zooplankton, may also be utilized.

Basking sharks are known for their tendency to appear seasonally, in large aggregations, in particular localities, and where they are observed intermittently over several months before disappearing again. In British Columbia, anecdotal and newspaper accounts also indicate that several bays and small inlets were noteworthy for the regular occurrence of high densities of basking sharks. These aggregations may reflect some unknown breeding or foraging behaviour.

This recovery potential assessment (RPA) was based on a science peer by the Pacific Scientific Advice Review Committee (PSARC) and based on DFO guidelines for developing an RPA (DFO 2007a). A more detailed account of the assessment and source material for the review is provided by McFarlane et al. (2009).

ASSESSMENT

PHASE I: assessment of status

Range and historical abundance

Basking sharks in British Columbia and California may belong to a single seasonally migrating population. This hypothesis is based on observations that the seasonal disappearance of basking sharks from California waters between May and July coincided with the appearance of basking sharks in relative abundance in British Columbian waters. Further evidence for this relationship is found in the coincidental disappearance after 1993 of the small congregations of basking sharks that were seen only in Clayoquot Sound in British Columbia and in Monterey Bay in California in the early 1990s (COSEWIC 2007). The likelihood that the basking sharks frequenting coastal inlets of British Columbia and the northeast Pacific Ocean in summer are from the same population of animals occupying central California in the fall and winter underlies the importance of considering all of the basking sharks occurring along the coast of North America as a single population.

It is important to note that basking sharks have only been enumerated while visible at the surface. However, the percentage of time spent at the surface is unknown and is likely influenced by prey distribution, weather conditions, and reproductive behaviours. Basking sharks have been known to spend more time at the surface in shallow, inner continental shelf areas than in deep, well stratified waters. This is thought to be due to associated differences in migratory behaviour of zooplankton prey. Therefore, abundance estimates based on daytime surface sightings may under or overestimate shark abundance by at least 10-fold (Sims et al. 2005). Furthermore, those making the sightings are also influenced by weather and sea conditions, and this may bias the interpretation of seasonality of abundance.

Any decline in abundance of basking sharks has been obscured by the unpredictability in the occurrence and numbers of basking sharks visiting the coastal areas in which they are seen. Early accounts from central California mention basking sharks returning every twenty years or so, and the sudden appearance of large numbers inspired the establishment of fisheries in the early 1920s and again in the late 1940s. Whether the high degree of annual variation in basking shark abundance in the northwest coast of North America is related to climate driven changes in sea surface temperature as is suspected for basking sharks off southwest Britain, is unknown (Cotton et al. 2005).

Estimates of past abundances was made possible by examining a variety of historical records including scientific sources, newspapers, government records pertaining to the 1945-1970 eradication program, commercial harvest, and sport fishing. From 1900 to 1970, basking sharks were regularly found in numerous locations along British Columbia's coast. Within three generations (66-99 years), basking sharks had all but disappeared from areas where they were once abundant. Throughout this period (1900 – 1970), basking sharks were subjected to a commercial harvest, a directed eradication program, incidental catch, and sport harpooning. It has been estimated that the total number of basking sharks killed in Canadian waters (1945-1970) by eradication is 413, other patrol/eradication methods (200-300), entanglement (400-1500), and sport kills (50-400) (COSEWIC 2007). Thus, these eradications totalled from 1000 to 2600 animals. At a mortality rate of 40 animals per year (1000 kills in 25 years) and using estimates of annual productivity, it would take 25 years for an initial population of 750 to be diminished to zero. Note that there is no reliable information on trends in abundance to corroborate this inference.

Current abundance

The current abundance of basking sharks in Canada's Pacific waters is unknown. At present, basking sharks appear infrequently in Pacific waters, with only six confirmed sightings since 1996[1] and only ten since 1973 (not including Clayoquot Sound). Four of these sightings are from trawl observer records and the basking sharks were likely killed (COSEWIC 2007). Thus, there is no reliable way to estimate the current population size, but the current population is assumed to be very small.

Darling and Keogh (1994) provide a comprehensive list of reliable sightings in Clayoquot Sound. They list 97 sightings in 1992 (27 individual sharks were identified), 54 basking shark observations from a commercial pilot's flight log (1973-1992, observations in all but 5 years), and six other observations (1988-1991). All observations were from channels and inlets. However, since 1994 there have been no confirmed sightings from Clayoquot Sound (COSEWIC 2007).

In addition to Barkley Sound, Clayoquot Sound, and Rivers Inlet in British Columbia, the only other areas known for basking shark aggregations in the northeast Pacific Ocean are central and southern California. Areas reported to once support abundant populations in the Pacific northeast are shown in Figure 2.

Life history parameters

The life cycle and reproduction of basking sharks are poorly understood. Pairing for reproduction is thought to occur in early summer based on observed courtship behaviour and scarring. The gestation period has been estimated at 2.6 to 3.5 years. Time between successive litters may be two to three years. Longevity is presumed to be approximately 50 years and age at maturity is estimated at 12 to 16 years in males and 16 to 20 years in females. At birth, basking sharks are between 1.5-1.7 m in length; large enough to escape predation by most marine species. Length at maturity is estimated at 4.6 to 6.1 m for males based on clasper development; females are presumed to mature at a larger size than males as in many other shark species.

Estimates of annual productivity measured as the intrinsic rate of population growth range from 0.013 to 0.023 per year. This suggests that the potential for recovery is lower for basking shark than for other Pacific sharks (Smith et al. 1998). The generation time is estimated to range from 22 to 33 years.

[1] Since the time of writing of the initial Research Document (McFarlane et al. 2009) two confirmed sightings have been reported in 2008, and an additional four probable sightings in the 2000-2007 period.

Habitat requirements and habitat use patterns

No specific locations have been identified for reproduction, pupping or rearing, although some other shark species are known to mate in northern areas and pup in southern areas. Feeding has been associated with oceanographic fronts which vary both temporally and spatially. There are areas that were once regularly visited by large numbers of basking sharks (e.g. Barkley Sound, Clayoquot Sound, and Rivers Inlet); however, a recovered stock may not return to these areas. Characteristics that might attract particular life stages such as high seasonal food availability or the occurrence of particular behaviours that might indicate reproductive behaviour have not been identified in these areas.

Residences

SARA s. 2(1) defines Residence as “a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating.” Currently the policy for designation and protection of residences under SARA is still being developed. The concept of residence as defined above does not explicitly apply to basking shark, which is an open ocean highly migratory fish.

Recovery goal

A short-term goal is to promote the population’s recovery such that it can be downlisted from its current COSEWIC endangered status. An interim goal is to see positive population growth, perhaps reaching the number of observations (average annual kills) recorded for the 1945-1970 period (i.e. 40 per year). A long-term goal is to promote the sustained viability of a naturally-reproducing population.

PHASE II: scope for management to facilitate recovery

Probability of achieving recovery targets

Given the lack of knowledge of current abundance, migratory behaviour and range, and the impacts of past and present human activities, there is great uncertainty in population abundance projections in Pacific Canada.

Three different recovery targets were assessed: 1) 1000 breeding pairs, 2) 30% of number of individuals pre-exploitation, 3) 30% of the initial biomass pre-exploitation. Pre-exploitation is assumed to be before 1920.

If a breeding population currently exists in the northeast Pacific Ocean and if no further human - induced mortality occurs then 1) it will take hundreds of years for the population to recover to 1000 breeding pairs; 2) 200 years are needed before population numbers will return to their unexploited states; and 3) recovery to 30% of the original biomass could happen within 45 years if complete protection is afforded. The likelihood of a rescue effect from US waters is considered low because abundance in US waters is also depleted.

Sources of harm

Basking sharks are particularly vulnerable to human-induced mortality because of their late age of maturity, low fecundity, long gestation period, long periods between gestations, low productivity, sex segregated populations, use of habitat that supports commercial fisheries, lack of fear of vessels, and current small population size. Like whale sharks, *Rhincodon typus*, basking sharks return regularly to the same seasonal feeding locations. This tendency for high site fidelity makes the species particularly vulnerable to localised depletion. There is considerable doubt whether even moderate exploitation pressure on basking sharks can be sustained (Compagno 2001), and the ramifications for further erosion of already low genetic diversity worldwide is considerable (Hoelzel et al. 2006).

Human-induced mortality in Pacific Canadian waters is primarily from interactions with fishing gears. Records indicate that basking sharks are readily caught in gillnets but are also caught by trawl (bottom, midwater, and shrimp), and easily become entangled in longlines, prawn traps, cod traps, and even herring seines (Wallace and Gisborne 2006). Between 1942 and 1969, several hundred gillnetters annually fished in the areas of Barkley Sound and Rivers Inlet. It is suspected that several hundred sharks (400-1500) may have been killed from entanglement (COSEWIC 2007).

Harassment, sometimes to the point where it is lethal, has also been mentioned in historic anecdotes and this behaviour may reappear if basking sharks return in numbers to Canada's Pacific coast.

Tourism is not a critical issue for basking sharks at this time but, as has become apparent in the whale watching industry, if basking sharks do increase off the coast of British Columbia, then protocols to minimize disturbance and prevent harassment of the animals may need to be implemented.

Altercations between boat propellers and basking sharks may be common. The habit of the animals of feeding slowly at the surface in shallow water increases the likelihood of this occurring.

The effects of very loud sounds on shark behaviour are not well documented but some recent evidence suggests that they could potentially disrupt normal behaviours such as feeding, mating, and migration. The apparent attraction of basking sharks to boat propellers, possibly to the sound they generate, may contribute to boat-shark interactions that have led to considerable scarring on the fins and snouts of sharks (Darling and Koegh 1994).

Concerns about potential contamination and bioaccumulation of organic pollutants and heavy metals in marine organisms, particularly long-lived cetaceans, also extend to basking sharks. Basking sharks that feed low in the food chain are unlikely to bioaccumulate contaminants at as high a level as are animals such as killer whales that feed from higher trophic levels. However, indirect impacts of pollution on the planktonic food items of basking sharks could cause local depletion of prey species resulting in a shift in habitat use due to food scarcity.

Likelihood that the current quantity and quality of habitat is sufficient

Habitat quality and quantity for the species is not likely to have changed from historical levels. Given the very low numbers and previous wide distribution of individuals, available habitat does not appear to be limiting survival or recovery. Longer-term trends in climate may influence prey availability but recent theoretical work suggests that basking sharks can achieve a net energy gain under moderate concentrations of prey. Fluctuations in abundance or avoidance of historic seasonal areas of surface feeding may be associated with fluctuations in zooplankton abundance as found for basking sharks off west Ireland, or changes in sea surface temperature driven by global weather patterns as observed off southwest Britain between 1988 and 2001 (Cotton *et al*. 2005).

PHASE III: Scenarios for mitigation and alternatives to activities

Interactions with fisherman have been few in recent years but the numbers are high considering how few basking sharks have been sighted. From 1996 to 2006, only 10 basking shark sightings could be confirmed in the coastal waters of BC and of these 4 were from observer records of the groundfish trawl fishery. Along the coast of California sightings of 24 individuals have been reported and of these 3 were from observer records of the California drift gill net and set net fisheries (COSEWIC 2007). If the abundance of basking sharks in the coastal waters of the Canadian Pacific increased then the conflicts that were seen from the 1920s to the 1960s might return.

Entanglement and bycatch in fishing gears can be expected, and steps taken to reduce the likelihood of damage and loss to both fishermen and sharks should increase the chances of recovery. In order to achieve zero human-induced mortality due to entanglement or incidental bycatch, revision to fishing gear, fishing areas, and/or fishing plans could be required. A change in fishing plans could include changes in time/area closures, automatic closures based on past distribution of the sharks or closures triggered by some level of potential interaction between sharks and fishing gear. Modification to fishing behaviour could minimize entanglement or incidental bycatch. For example, if a basking shark is sighted at the surface, then setting or hauling fishing gear could be avoided until the shark has left the vicinity. Fishing behaviour modification might be achieved through voluntary participation (i.e. education programs), rather than involuntary participation (i.e. fishing plans). This would alleviate the requirement for such a large scale fishery closure.

Because even moderate exploitation of basking sharks probably cannot be sustained, reliable information on the current level of exploitation is essential for planning effective management and conservation strategies. The imprecise reporting of fishery statistics where several species are lumped together as one category, i.e., “other sharks”, can mask reduction in populations of larger, slower growing species like basking sharks, as well as obscuring changes in community structure. Within the cetacean recovery strategies the observer programs are granted priority. A similar approach could be used for basking sharks where observer programs are expanded to all fisheries with the potential to entangle basking sharks, and species identification and reporting in current observer programs are improved.

Reports of harassment and collisions, and more recent observations of scarring on the dorsal fins of basking shark possibly from boat propellers, indicates a high potential for mortality and injury from contact with boats. A program of public education encouraging responsible boat handling in the vicinity of basking sharks similar to the guidelines and best practices for whale watch operators in BC could be adopted, particularly the minimum approach distance of 100 metres/yards recommended for whales and other marine mammals.

Many of the changes and improvements in fisheries data collection and bycatch management mentioned here have been proposed in the draft National Plan of Action for the Conservation and Management of Sharks of February 9, 2007 (DFO 2007b):

- Improve the reporting of discarded bycatch and the associated mortality rates in domestic fisheries through better data collection and species identification by at-sea fisheries observers and through mandatory reporting of all bycatch for the commercial and recreational fishing industry;
- Continue awareness-raising efforts among commercial and recreational fishers and other resource users about the risks facing certain shark and shark-like species and promote conservation-based release practices to reduce discard mortality;
- Encourage the strengthening of regulations of relevant Regional Fisheries Management Organizations with regard to both the handling and release of shark bycatch species and to improve the identification and reporting of bycatch and associated mortality; and
- Review the current practices of all commercial and recreational fisheries and implement, where feasible, new rules or technologies with the potential to reduce both the bycatch of sharks and associated mortality.

CONCLUSIONS AND ADVICE

Under the assumption that the Pacific population of basking sharks has declined by 90% from 1920 to 2007, catch scenarios predicted by the production model have had a drastic effect on these large, old, slow-growing sharks. It is estimated that some 200 years are needed before population numbers will return to their unexploited states if human induced mortality is zero. Even if they suffered a low level of human induced mortality (which based on 2007 population estimates would equal 1-2 sharks killed per year), these sharks will never return to their unexploited population level. If these animals are afforded complete protection, it will still take centuries for the population to recover to 1000 breeding pairs. Recovery to 30% of the original biomass could happen within 45 years. If human induced mortality is allowed to approach 50% of natural mortality (11-18 sharks per year) the basking shark population could be extinct within approximately 30 years.

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