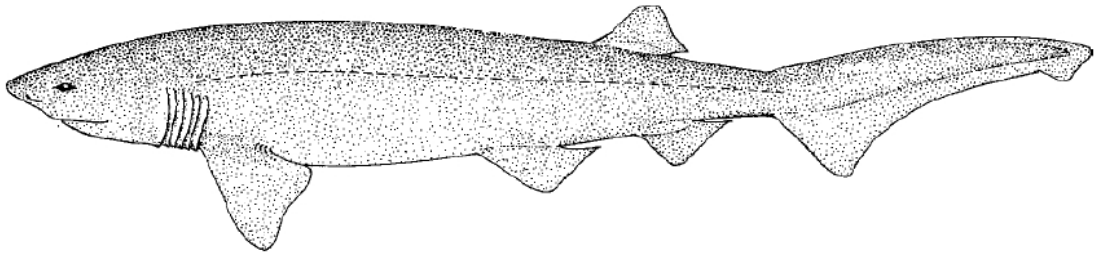
COSEWIC
Assessment and Status Report

on the

bluntnose sixgill shark
Hexanchus griseus

in Canada



SPECIAL CONCERN
2007

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Production note:

COSEWIC would like to acknowledge Scott Wallace, Gordon McFarlane and Jacquelynne King for writing the status report on bluntnose sixgill shark, *Hexanchus griseus*, in Canada, prepared under contract with Environment Canada. The report was overseen and edited by Paul Bentzen, Co-chair, COSEWIC Marine Fishes Species Specialist Subcommittee and Jamie Gibson, member, Marine Fishes Species Specialist Subcommittee.

For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment Canada
Ottawa, ON
K1A 0H3

Tel.: 819-953-3215
Fax: 819-994-3684
E-mail: COSEWIC/COSEPAC@ec.gc.ca
http://www.cosewic.gc.ca

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Cover illustration:
Bluntnose sixgill shark — Source: Compagno 1984.

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COSEWIC
Assessment Summary

Assessment Summary – April 2007

Common name
Bluntnose Sixgill Shark

Scientific name
Hexanchus griseus

Status
Special Concern

Reason for designation
This large (maximum reported length 4.8 m), heavy-bodied shark is a benthic species that is widely distributed over continental and insular shelves in temperate and tropical seas throughout the world. In Canadian Pacific waters, it is found in inlets and along the continental shelf and slope typically at depths greater than 91 m (range 0-2500 m). In the absence of information about population structure, it is treated as a single population for assessment purposes. The present population size and abundance trends are not known. The only available abundance index, encounter rates with immature sharks at a shallow site in the Strait of Georgia, has decreased significantly (>90%) in the last five years. This index is not likely representative of the overall abundance trend because only immature sharks are encountered and the site is shallow relative to the preferred depth range. The principal known threat to the species is fishing. This shark has been the focus of at least three directed fisheries in Canadian waters, most recently in the late 1980s and early 1990s. It continues to be caught as bycatch, but survival of released sharks is unknown. Sharks observed by divers sometimes show scars from entanglement in fishing gear. Because of its late age of maturity (18-35 yr for females), it is likely susceptible to overfishing even at low levels of mortality. Little is known about the abundance and movement patterns of this species elsewhere in the world, so the potential for a rescue effect is unknown.

Occurrence
Pacific Ocean

Status history
Designated Special Concern in April 2007. Assessment based on a new status report.

COSEWIC
Executive Summary

bluntnose sixgill shark
Hexanchus griseus

Species information

The bluntnose sixgill shark (*Hexanchus griseus*) is one of four species belonging to the family Hexanchidae sometimes referred to as cow sharks. The name, *sixgill*, refers to the presence of six gill slits whereas most other shark species have only five. The population structure of bluntnose sixgill sharks in Canada's Pacific waters is unknown. For the purposes of this report, bluntnose sixgill sharks are considered as one designatable unit throughout Canadian waters.

Distribution

Bluntnose sixgill sharks are widely distributed throughout temperate and tropical seas around the world. Bluntnose sixgill sharks are likely well distributed throughout much of Canada's Pacific waters including inlets, continental shelf and slope and the Strait of Georgia. There are two records from Atlantic Canadian waters.

Habitat

The bluntnose sixgill shark is considered to be primarily a deepwater benthic species found in waters below 91 m, but is known to occur from the surface to depths of 2500 m. The species is primarily found over the outer continental and insular shelves as well as upper slopes associated with areas of upwelling and high biological productivity. Young bluntnose sixgill sharks are thought to remain in shallower waters of the continental shelf and uppermost slope until they reach adolescence, at which time they move further down the slope and into deeper water.

Biology

Mating and courtship is believed to take place in deepwater. Bluntnose sixgill sharks are ovoviviparous, meaning the young hatch within the female's body before being released. Females have a two-year reproductive cycle with an estimated 12-24 month gestation. The number of pups carried by females is known from only three credible accounts ranging from 47-70 pups and 61-73 cm in size. Age and growth information is constrained by difficulty in age determination and the lack of large mature specimens. This species is sexually dimorphic with females growing larger than males.

Length at maturity has been reported for females to be 421-482 cm. For males length at maturity is 310 cm. Mature animals are rarely found with only one mature female recorded from northeast Pacific waters. Age of maturity is widely reported at 11-14 years for males and 18-35 years for females as is an estimated longevity of up to 80 years, but these values have not been confirmed through valid aging studies. Maximum reported length is 482 cm. The generation time for bluntnose sixgill shark is not known nor have there been estimates of natural mortality. Predators of adult bluntnose sixgill sharks have not been recorded. The bluntnose sixgill shark is a generalist feeder primarily foraging nocturnally on a wide variety of prey items. Overall, movement patterns include a migration of mature individuals to shallower nursing areas to give birth. Juveniles appear to utilize shallower coastal waters and have extended residency in relatively small areas. Migratory behaviour on a seasonal and/or latitudinal basis has not been recorded.

Interactions with fisheries

The bluntnose sixgill shark has been the focus of at least three known directed fisheries in Canadian waters. The first occurred in the early 1920s with a focus on skins used to make shark leathers. The second took place between 1937 and 1946 with a focus on the shark livers for vitamin A. The third commercial fishery for bluntnose sixgill sharks commenced under an experimental basis in the late 1980s to early 1990s but was terminated due to conservation concerns. Present-day bycatch of bluntnose sixgill sharks in British Columbia is poorly known. Recent observer data indicates that this species is caught regularly by fisheries pursuing halibut and spiny dogfish.

Population sizes and trends

There are presently no reliable indicators for understanding bluntnose sixgill shark status in Canadian waters. The long-term effective population size for sixgill shark in the northeast Pacific was estimated based on genetic techniques to be about 8000, but this estimate has wide uncertainty and cannot be used to estimate current abundance. Encounter rates with immature bluntnose sixgill sharks at a shallow site in the Strait of Georgia have decreased significantly (>90%) over the last five years based on video surveillance and anecdotal diving records.

Limiting factors and threats

Fishing presents the only known proximate threat to bluntnose sixgill shark populations in Canada. Intensive fishing for this species took place in the late 1930s to mid-1940s but at present the catch is composed of non-utilized bycatch. The overall impact that present-day fishing has on the population depends on the size of the population, the fishing mortality, and the demographics of the bycatch itself (age, size and sex), all of which are largely unknown.

Special significance of the species

The bluntnose sixgill shark is the largest predatory shark regularly encountered in Canada's Pacific waters. In Canada's Pacific waters immature bluntnose sixgill sharks regularly make forays into shallow waters in some locales allowing the opportunity for SCUBA divers to observe them.

Existing protection

The IUCN has assessed the bluntnose sixgill shark as lower risk/near threatened (LR/nt) (Shark Specialist Group 2000). In Canada this species receives no formal protection.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

bluntnose sixgill shark

Hexanchus griseus

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2007

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SPECIES INFORMATION

Name and classification

The bluntnose sixgill shark (*Hexanchus griseus*) is one of four species belonging to the family Hexanchidae sometimes referred to as cow sharks. There are two other sixgill shark species in the genus *Hexanchus*; *H. nakamurai* and *H. vitulus*, neither of which is found in Canada's Pacific waters. The bluntnose sixgill shark is also commonly referred to as sixgill shark, six-gill shark, mud shark, cow shark, shovelnosed shark, grey shark, and gray shark (Froese and Pauly 2005). Early historical documents in Canada refer often refer to this species as *mud shark*. In French they are called *requin griset*.

Morphological description

The bluntnose sixgill shark is an easily recognizable shark with several characteristics not often found in other shark species (Mecklenburg *et al*. 2002). The name, *sixgill*, refers to the presence of six gill slits whereas most other shark species have only five (Figure 1). A second obvious characteristic is the presence of only a single dorsal fin compared to two in all other shark species normally found on Canada's Pacific coast. Their colour is a dark brown or grey to black dorsally with the colour becoming lighter towards their underside. Their head is broad and depressed with a blunt snout. Their eyes are conspicuously bright green and moderately large (Ebert 2003). The upper and lower teeth of the bluntnose sixgill shark are strikingly different, with the lower teeth being quite large, low and wide with several cusplets (8-12) and the upper teeth being smaller and singularly pointed (Mecklenburg *et al*. 2002). The single dorsal fin is located far back on the body and positioned above and in between the pelvic and anal fins on the ventral side. Like many benthic sharks, the caudal fin of the bluntnose sixgill shark has a small lower lobe.

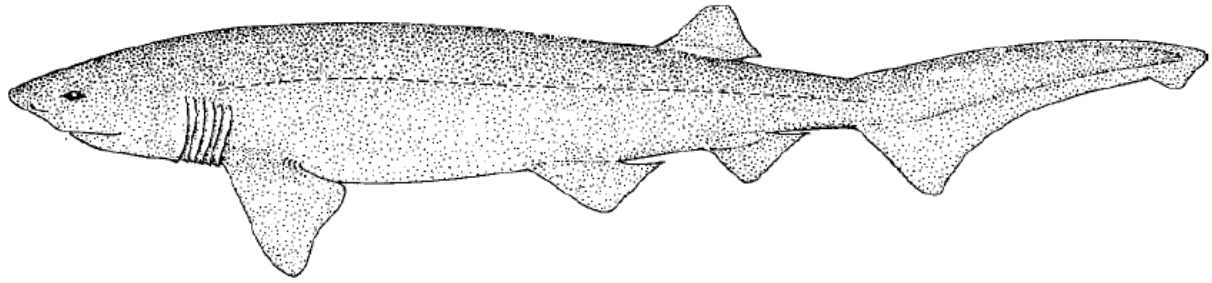

Figure 1. Diagram of the bluntnose sixgill shark. Source: Compagno 1984.

Genetic description

The population structure of bluntnose sixgill sharks has not been adequately studied anywhere in its global range. The small amount of research that does exist is primarily from the northeast Pacific. In Canada, a single tagging study (n=214) was undertaken along the west coast of Vancouver Island in 1994 but no information on population structure was ascertained from this small study (McFarlane, pers. comm. 2006). A combined tagging and genetic study has been ongoing in Puget Sound since 2001 (Larson *et al*. 2005). As of January 2006, a total of 45 sharks have been tagged with a visible stainless-steel dart tag (Larson and Christiansen 2003; Christiansen pers. comm. 2006). Sixteen of the tagged sharks have been resighted at the observation area with one shark having been resighted four times over a period at large of nearly 700 days. Preliminary genetic results from over 200 samples suggest that the long term effective population size is at least 7900 individuals (Larson *et al*. 2005), but it is not possible to infer current levels of population abundance from the genetic estimate. Overall, the population structure is not known.

Designatable units

The population structure of bluntnose sixgill sharks in Canada's Pacific waters is unknown. There are no known obstacles to migration or dispersal, and therefore for the purposes of this report, bluntnose sixgill sharks are considered to be one designatable unit throughout Canadian waters.

DISTRIBUTION

Global range

Bluntnose sixgill sharks are widely distributed throughout temperate and tropical seas around the world. In the north Pacific they can be found from Japan, south of the Aleutian Islands, to California and Mexico as well as the Hawaiian Islands (Figure 2) (Compagno 1984; Mecklenburg *et al*. 2002). In the south Pacific they are reported from Australia and New Zealand. In the western Atlantic Ocean, their range is considered to be from North Carolina to Florida and from the northern Gulf of Mexico to northern Argentina including Nicaragua, Costa Rica, and Cuba; however, two immature individuals were captured off Nova Scotia in 1989 and 1990 (Proc. N.S. Inst. Sci. 1989). In the eastern Atlantic, this shark is found from Iceland and Norway south to Namibia, including the Mediterranean Sea. Its range in the Indian Ocean includes waters off Madagascar and Mozambique.

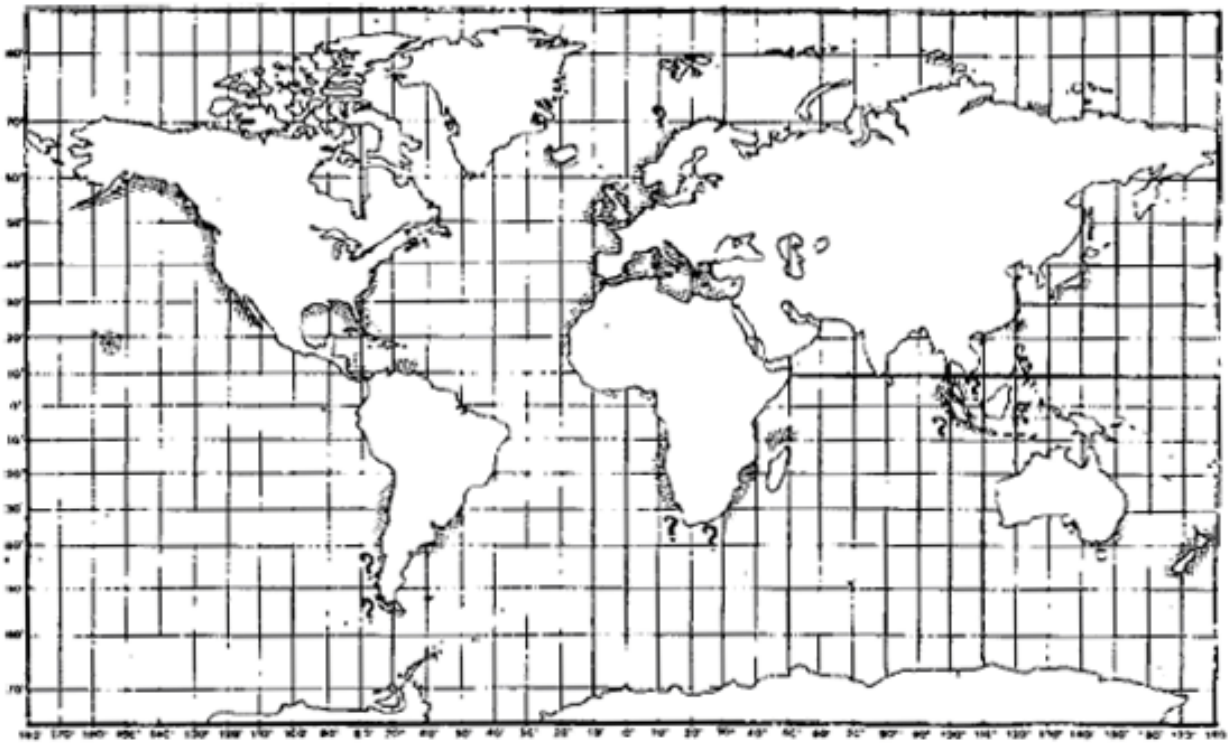

Figure 2. Global distribution of bluntnose sixgill sharks. Source: Compagno 1984.

Canadian range

Bluntnose sixgill sharks are likely well distributed throughout much of Canada's Pacific waters including inlets, continental shelf and slope, and the Strait of Georgia (Figure 3). Recorded observations available in databases are limited to recent commercial catch records (1996-2005) and research surveys and therefore do not provide a full understanding of their Canadian range (Figure 3). The trawl fleet captures this species over a wide range of depths (20-1000 m) (Figure 4). The hook and line fleet has encountered this species between 20 and 440 m with most observations less than 200 m (Figure 5). They are reported in the literature to exist to at least 2500 m (Ebert 2003). In the absence of better information, for this report the extent of occurrence is considered to be all Canadian waters between 20-2000 m, which represents an area of 133,139 km^2 (Figure 6). A record of two immature individuals from Nova Scotia in 1989 and 1990 indicates that this species also occurs in Atlantic Canadian waters, although it is likely very rare there or present only as a vagrant (Proc. N.S. Inst. Sci. 1989).

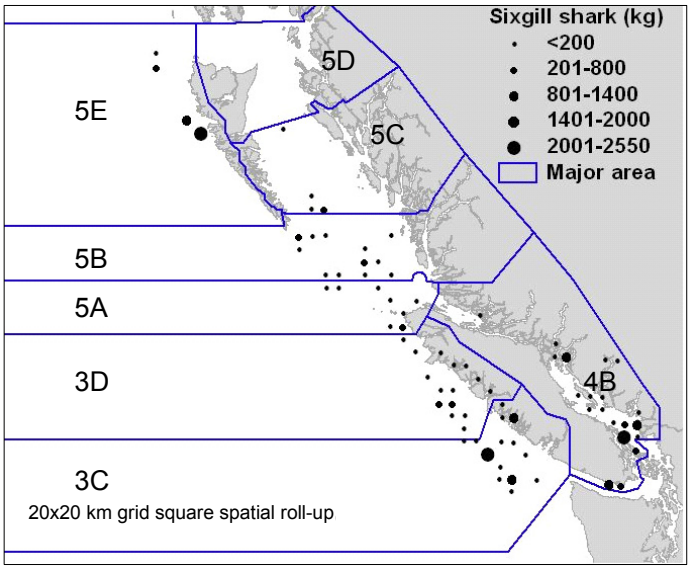

Figure 3. Canadian range of bluntnose sixgill shark based on observations in the commercial hook and line and trawl fisheries between 1996 and 2005. Note that records up inlets appear to be on land. Source: PacHarv database.

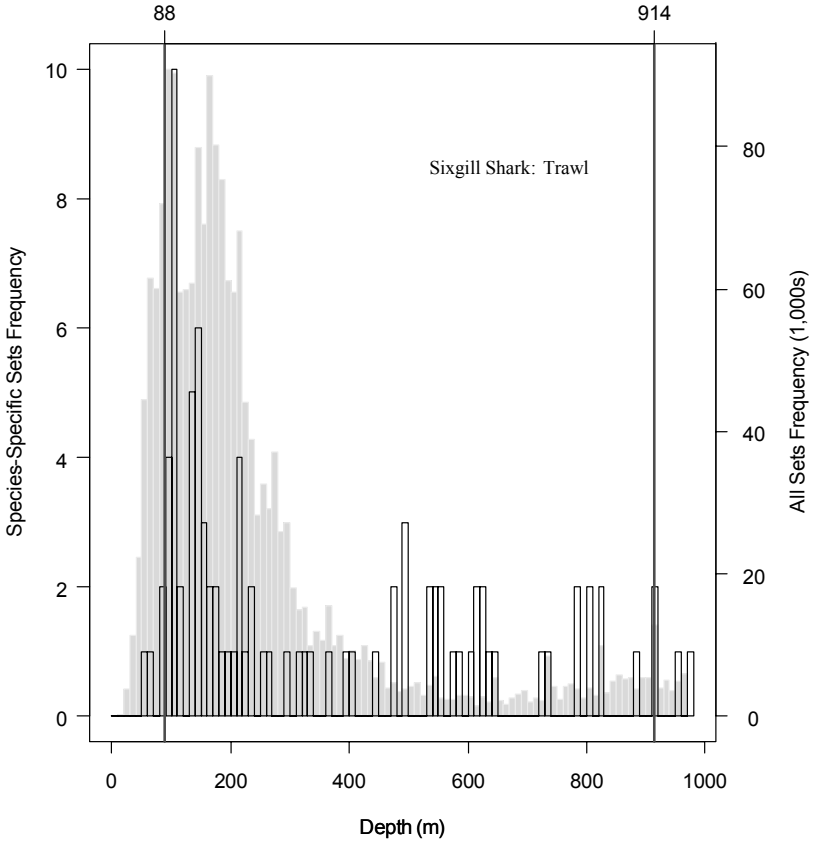

Figure 4. Depth distribution of commercial trawl tows coastwide between 1996-2005 with records of bluntnose sixgill shark (clear bars) compared with the total trawl effort by depth (solid grey bars). Records between the vertical lines represent the depth interval accounting for 95% of the sightings. Source: PacHarvTrawl database.

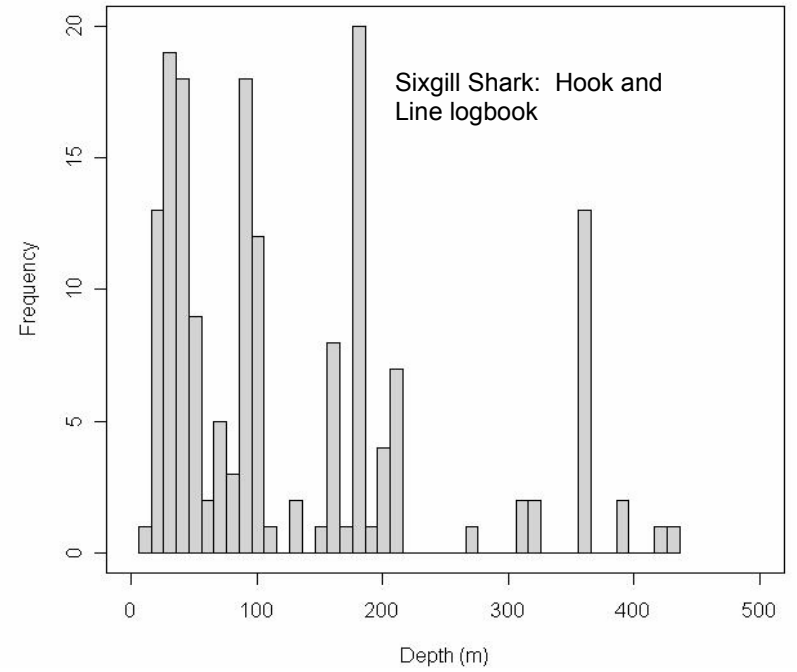

Figure 5. Depth distribution of commercial hook and line sets capturing bluntnose sixgill shark along the coast of British Columbia between 1996 and 2004. Source PacHarvHL database.

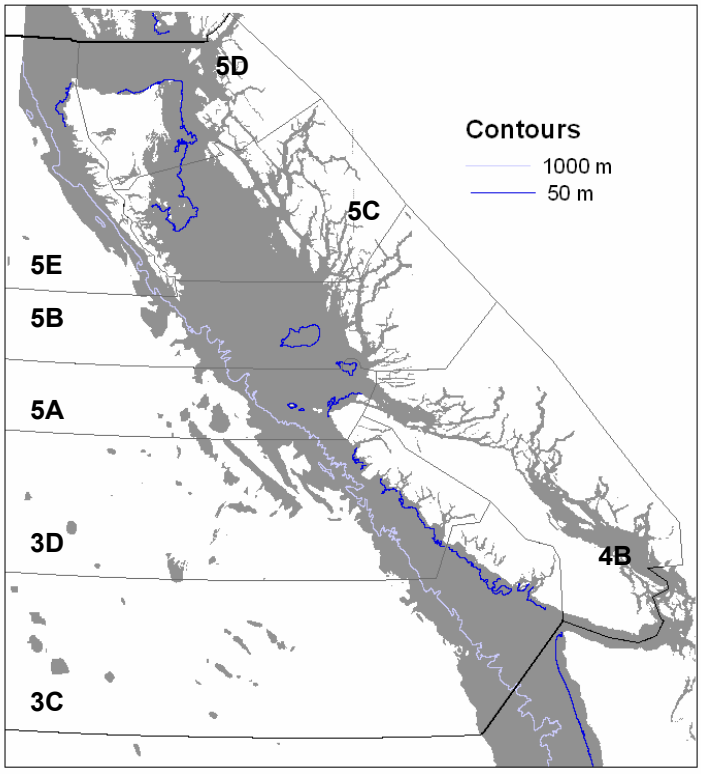

Figure 6. Probable distribution of bluntnose sixgill shark in Canada's Pacific waters (grey shaded area) based on preferred depth range (20-2000 m).

HABITAT

Habitat requirements

The bluntnose sixgill shark is considered to be primarily a deepwater benthic species found in waters below 91 m, but is known to occur from the surface to depths of 2500 m (Ebert 2003). The species is primarily found over the outer continental and insular shelves as well as upper slopes associated with areas of upwelling and high biological productivity (Ebert 2003). Young bluntnose sixgill sharks are thought to remain in shallower waters of the continental shelf and uppermost slope until they reach adolescence, at which time they move further down the slope and into deeper water (Ebert 2003). Newborn pups and juveniles may often stray close to shore and occasionally occur in bays and harbours (Ebert 2003). Adult males typically remain in deeper water, where mating and courtship take place. In British Columbia, a single tagging study (n=214) in inlets along the west coast of Vancouver Island found primarily juveniles of both sexes with no mature females and a mean length for both sexes of 205 cm (Figures 7 and 8). A video surveillance study in the Strait of Georgia has also observed only immature animals with a mean length of 240 cm (n=35) (Dunbrack pers. comm. 2006).

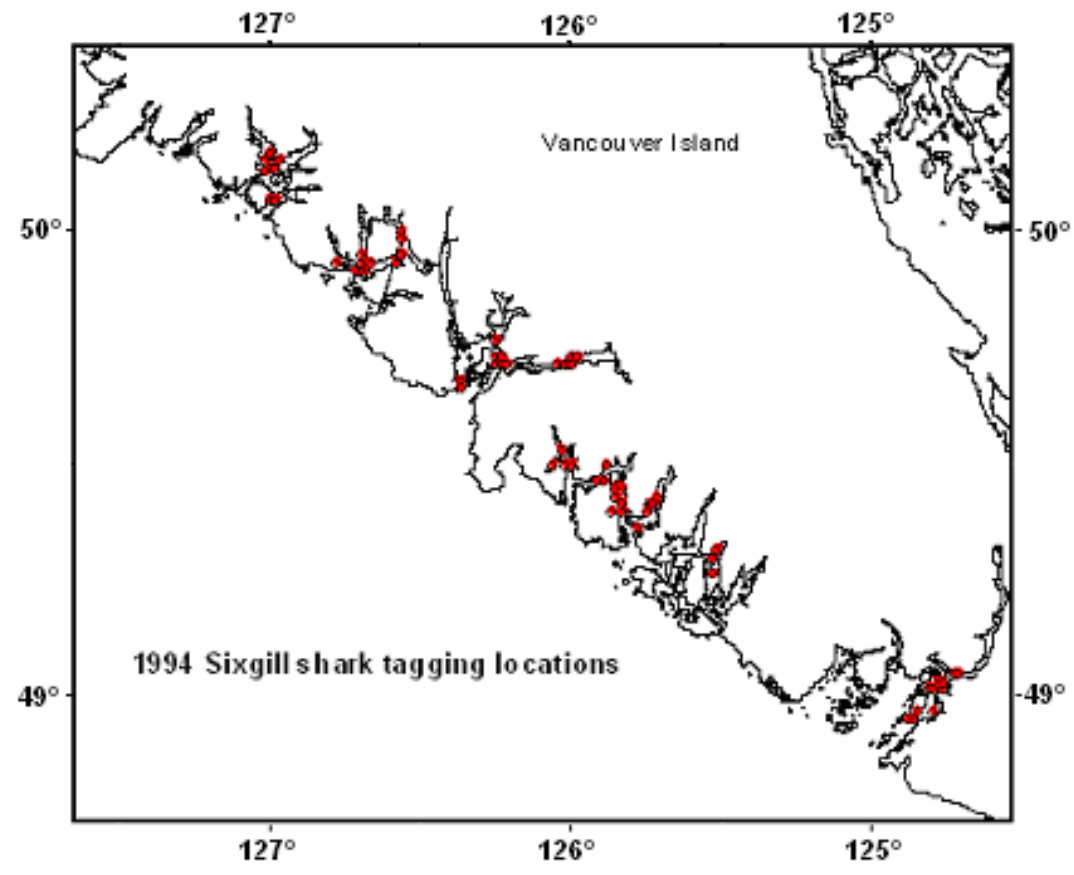

Figure 7. Tagging locations (red circles) of bluntnose sixgill shark along the west coast of Vancouver Island during a 1994 tagging survey.

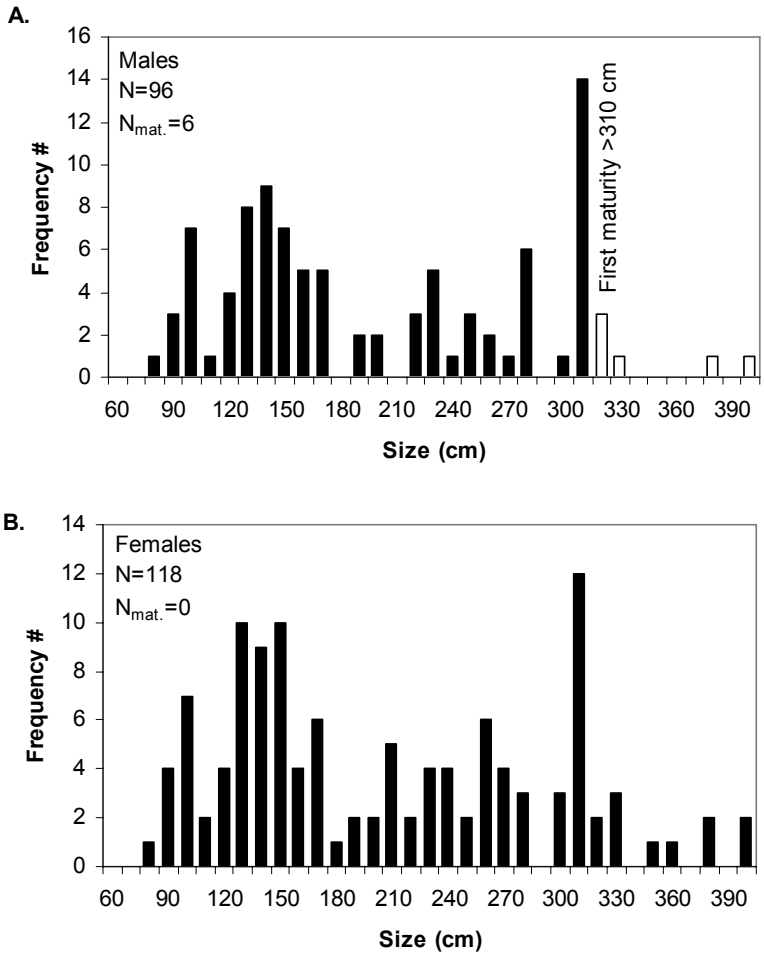

Figure 8. Length frequency distribution of male (top panel) and female (bottom panel) bluntnose sixgill sharks caught on a research survey along the west coast of Vancouver Island in 1994. Source: DFO Unpublished data.

Habitat trends

There are no known habitat trends of the bluntnose sixgill shark in British Columbia waters.

Habitat protection/ownership

No habitat has been specifically protected for the purpose of conserving bluntnose sixgill sharks. There are several Rockfish Conservation Areas which restrict most fishing activities; however, the use of these areas by bluntnose sixgill sharks is unknown. In the past there have been various proposals to protect areas with known high concentrations and dive tourism values but to date none have been successfully implemented (Harvey-Clark 1995).

BIOLOGY

Current knowledge regarding life history parameters of Pacific elasmobranchs has been summarized in an online life history matrix assembled by the Pacific Shark Research Centre at Moss Landing Marine Laboratories (http://psrc.mlml.calstate.edu/lht.php). The matrix includes up-to-date information on taxonomy, geographic range, age and growth, longevity, reproduction, demography, trophic interactions, habitat utilization, genetics, recruitment, mortality, and behavior of 102 species. This matrix was drawn upon as an authoritative summary of the current state of bluntnose sixgill shark knowledge in the northeast Pacific.

Life cycle and reproduction

Mating and courtship is believed to take place in deepwater (Ebert 2003). Although courtship and mating have not been observed, it is believed that the male grabs the female near the gills, pectoral fins and flanks as evidenced by the seasonal appearance of scars on the females (Florida Museum of Natural History 2006). Bluntnose sixgill sharks are ovoviviparous, meaning the young hatch within the female's body before being released. Females have a two-year reproductive cycle with an estimated 12- to 24-month gestation (Ebert 1990). The number of pups carried by females is known from only three credible accounts of litter size of 47, 51 and 70 pups and 61 to 73 cm in size (Ebert 2002; Ebert 2003). An unverified report of a single specimen with 108 pups exists from a fisherman in France at the turn of the 20th century (Bigelow and Schroeder 1948). The bluntnose sixgill shark is one of the most fecund species of elasmobranch.

Age and growth information is constrained by difficulty in age determination and the lack of large mature specimens (Ebert 1986; McFarlane *et al*. 2002). McFarlane *et al*. (2002) estimate that immature bluntnose sixgill shark grow at approximately 25 cm per year. In the same study length-at-age of immature females (N=8) is reported from 130 cm at 4 years to 340 cm at age 10. This species is sexually dimorphic with females growing larger than males. Length at maturity has been reported for females at between 450-482 cm (Springer and Waller 1969), 421 cm (Ebert 1986) and 420 cm (Ebert 2002). A female 405 cm long carrying five pups was found washed up on shore in the Strait of Georgia (Comox, BC) in 2001 (King pers. comm. 2006). For males length at maturity is known primarily from South African waters at 310 cm (Ebert 2002). Mature animals are rarely found with only one mature female recorded from northeast Pacific waters (Ebert 1986). A single tagging study undertaken along the west coast of Vancouver Island in 1994 captured no mature females (N=118) while 20% of the male population were near or at the length of first maturity (N=96) (Figure 8).

Age at maturity is unknown due to the lack of mature specimens. Age of maturity and longevity is widely reported on a variety of websites at 11-14 years for males and 18-35 years for females and an estimated longevity of up to 80 years, but these values have not been confirmed through valid aging studies or published in the primary literature (Florida Museum of Natural History 2006). Maximum reported length is a minimum of 482 cm; however, lengths above 500 cm should not be unexpected (Compagno 1984; Ebert 2002). Claims of specimens over 800 cm are considered false.

A length-weight relationship for female bluntnose sixgill sharks from California waters was found to be: W_{kg}= -37.5 + ($6.64x10^{-2}$)(TL_{cm})+($-3.11x10^{-5}$)(TL_{cm}^2)+($1X10^{-8}$)(TL_{cm}^3) (Ebert 1986). A recent study using juveniles captured in Puget Sound found the allometric length weight relationship to be W_{kg} = ($7.80X10^{-7}$) * $TL_{cm}^{3.38}$ (Gallucci *et al*. 2005).

The generation time for bluntnose sixgill shark is not known nor have there been estimates of natural mortality.

Herbivory/predation

Predators of adult bluntnose sixgill sharks have not been recorded. Their deepwater existence and large size likely limits their potential to be preyed upon. Their large litter size suggests that natural mortality on young bluntnose sixgill sharks is likely quite high. Other elasmobranchs are thought to consume the juveniles; however, there is only a single record from a prickly shark (*Echinorhinus cooke*) (Varoujean 1972).

Dispersal/migration

Knowledge on dispersal and migration of bluntnose sixgill shark in the northeast Pacific is limited to localized studies. The only study in British Columbia waters involved the tagging of ~214 individuals in 1994. There was only one recovery from this program, a 170 cm female released near Tofino and recaptured by a fisherman in 2000 also near Tofino estimated to be 275-300 cm (McFarlane pers. comm. 2006).

The Seattle Aquarium has conducted a small research project in Puget Sound involving *in situ* tagging and video observation of bluntnose sixgill sharks from a single station (Larson and Christiansen 2003; Larson *et al*. 2005). Since 2001, 45 sharks have been tagged with a visible Floy VM69 stainless-steel dart tag of which 16 have been resighted at least once, with one individual being seen on four separate observation periods while at large for 699 days (Christiansen pers. comm. 2006). In 2005 seven sharks were tagged with radio transmitters. Preliminary findings of both the visible and radio tagging program suggest that movement is limited with at least some of the sharks remaining nearby the tagging location (Christiansen pers. comm. 2006). In general the sharks appear to be more abundant from July through to September.

The Washington Department of Fish and Wildlife are also involved with a four-year tagging program in Puget Sound (2003-2006) (Bargmann pers. comm. 2006). Approximately 200 sharks have been captured to date of which all have been juveniles (Gallucci *et al*. 2005). Captured animals have been tagged with conventional tags and an additional 20 juvenile sharks had radio transmitters placed on them in 2005. Early unpublished information suggests that the juvenile animals have a restrictive home range (Bargmann pers. comm. 2006). Survey effort in deeper Puget Sound waters to capture mature individuals has been unsuccessful.

A third ongoing study at the Flora Islets (49°30.9′N, 124°34.5′W) in the Strait of Georgia, British Columbia takes place from a single observation area where bluntnose

sixgill sharks become seasonally abundant (Dunbrack and Zielinski 2003). Using video surveillance technology Dunbrack and Zielinski (2003) found that sharks at their study site were present only from May 28 to October 16 with a peak between mid-June and mid-July. All of the observed sharks have been immature animals (Dunbrack pers. comm. 2006). Dunbrack suspects that the Strait of Georgia and other near-shore areas along the British Columbia coast are primarily nursery areas and that mature animals are primarily found offshore in deeper waters (Dunbrack pers. comm. 2006). However, a mature female (length = 405 cm; carrying 5 pups) was found beached near the Comox area in the Strait of Georgia in 2001 indicating that some bluntnose sixgill sharks in the Strait of Georgia may be mature (King pers comm. 2006). Dunbrack's proposed general movement pattern is consistent with that proposed by Ebert (2003) for other areas. Based on scarring patterns, Dunbrack (pers. comm. 2006) has observed some residency over a period of a week. Typically the animals are present for a few days at which time they are replaced by new animals.

There have been no long-term tracking studies on bluntnose sixgill shark. Overall, movement patterns include a migration of mature individuals to shallower nursing areas to give birth. Juveniles appear to utilize shallower coastal waters and have extended residency in relatively small areas. Migratory behaviour on a seasonal and/or latitudinal basis has not been recorded. In the Strait of Georgia and Puget Sound, the sharks become more abundant in shallow waters during summer months.

Interspecific interactions

The bluntnose sixgill shark is a generalist feeder primarily foraging nocturnally on a wide variety of prey items including cephalopods, crustaceans, several species of bony fish (e.g. hake, herring, flounders, cod, mackerels, and rockfish), sharks and rays and on the carrion of marine mammals including porpoises, dolphins, and sea lions (Compagno 1984; Ebert 1986; Ebert 1994; Ebert 2003). A study on the west coast of Vancouver Island examined stomach contents of 56 juvenile bluntnose sixgill sharks. Of these 48 were empty, seven contained salmon, and one contained squid (Benson *et al*. 2001).

Adaptability

The bluntnose sixgill shark is one of widest ranging shark species in the world (Compagno 1984; Ebert 1986). Their body form closely resembles fossil forms dating back 200 million years (Florida Museum of Natural History 2006). This species can likely adapt to natural fluctuations in the environment such as changes in prey type and availability. It is unknown how well the bluntnose sixgill shark is able to adapt to human-caused changes to the environment or changes to population structure due to fishing mortality.

INTERACTIONS WITH FISHERIES

The bluntnose sixgill shark has been the focus of at least three known directed fisheries in Canadian waters. The first occurred in the early 1920s around the waters of Mayne Island in the southern Strait of Georgia with a focus on 'mudshark' skins used to make shark leathers (see Appendix 1). The success of this venture in terms of sharks caught and duration is unknown. Newspaper articles from the time report an experimental fishery capturing 357 sharks over a 24-day period (Times, May 4 1922, p. 13).

The second directed fishery for these sharks took place between 1937 and 1946 throughout British Columbia. The fishery primarily targeted the livers of the sharks, which were processed for vitamin A. Fishing was conducted in depths between 20 and 100 m using longlines with between 300 and 500 hooks (Sunderland 1937). Landing statistics for this species did not appear in government records until 1942 when it was recorded under the heading '*mudshark livers landed'*. Between 1942 and 1946, 276 t of bluntnose sixgill shark liver was marketed in British Columbia (Table 1).

Table 1. Reported landings of 'mudshark' liver in government catch statistics from 1942-1946 and estimated number of sharks based on an average liver size of 72 kg. Source: Canada Fisheries Statistics.

Year	Pounds of liver	Tonnes of liver	Est. # of sharks
1942	124219	56	776
1943	245444	111	1534
1944	140800	64	880
1945	84200	38	526
1946	15100	7	94
Total	609763	276	3810

Non-scientific publications at the time reported that an average size liver was 72 kg (160 pounds) (Anon. 1943). The liver of bluntnose sixgill shark comprises between 10-20% of its round weight (Bailey 1952). If the 72 kg estimate is accurate, then the average size shark would have been ~360-720 kg, which corresponds to an approximate length of 370-450 cm based on the length-weight equation $W_{kg} = (7.80X10^{-7}) * TL_{cm}^{3.38}$ (Gallucci *et al*. 2005). (Note this equation was derived from smaller animals). This estimated length range is high relative to the other known lengths observed in Canada's Pacific waters of ~200 to 250 cm (Dunbrack and Zielinksi 2003; this report see *Habitat* section). The estimated liver weight of 72 kg per shark is likely high unless the fishery was able to consistently target adults or large juveniles.

A rough estimate of the number of sharks captured can be calculated by dividing the total weight of the livers (276 t) by the reported average weight of the liver (72 kg) for a conservative catch of ~3800 animals (Table 1) from 1942-1946. Assuming that the ratio of liver to body weight is correct; between 1380 t and 2760 t of round weight shark

may have been landed during this period. If the liver weight is overestimated, then the number of sharks taken in the fishery (Table 1) would be underestimated.

Similar liver-directed fisheries for bluntnose sixgill sharks were occurring in adjacent Washington State waters during this same time period (Bargmann pers. comm. 2006). The combined long-term effect of these fisheries on the northeast Pacific population has never been investigated. If the population structure observed today in shallow waters was similar during the 1930s and 1940s then the fishery would have caught primarily juvenile animals. The segregation between adults and juveniles may have provided some resilience given the presumed longevity of this species and the relatively brief fishery (ten years). However, if the fishery was capturing both mature and juvenile sharks then the impact to the population and their subsequent recovery would likely have been much greater.

The third commercial fishery for bluntnose sixgill sharks commenced on an experimental basis in the late 1980s to early 1990s but was terminated due to conservation concerns (McFarlane *et al*. 2002). Between 1985 and 2005 a total of 75 t of “cowshark” and “sixgill” was recorded in federal fisheries catch databases with the peak year occurring in 1985 at 14.6 t (Figure 9). The Strait of Georgia and west coast of Vancouver Island account for 75% (55.7 t) of the recorded catch (Figure 10; Appendix 2).

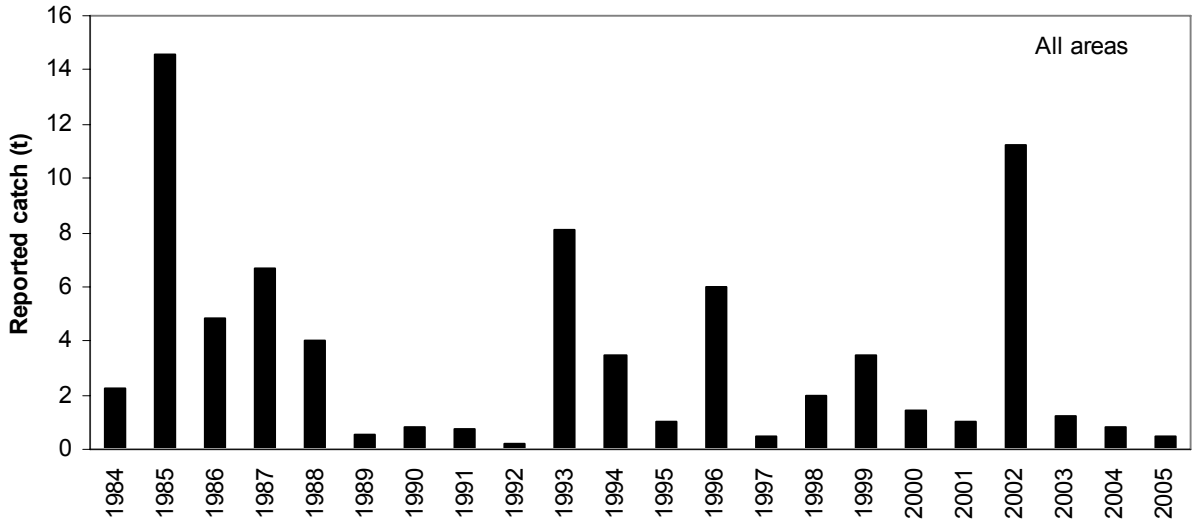

Figure 9. Reported coast-wide catch of bluntnose sixgill sharks from Canada’s Pacific waters from 1984 to 2005. Source: PacHarv database.

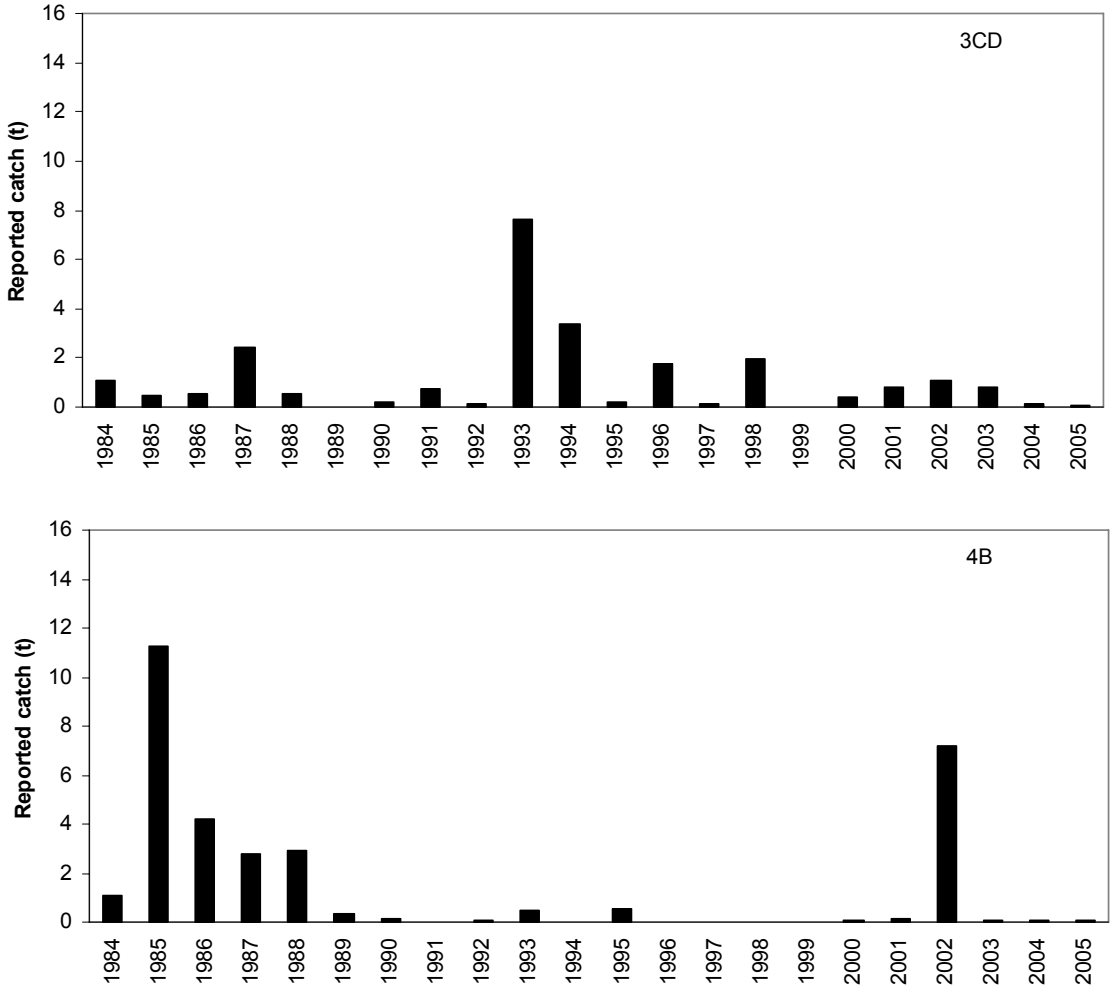

Figure 10. Reported catch of bluntnose sixgill catch in management areas 3CD-West Coast Vancouver Island (top panel) and 4B-Strait of Georgia (bottom panel). Source: PacHarv database.

Throughout the history of commercial fishing on British Columbia's coast, bluntnose sixgill sharks were caught as bycatch primarily by longline and to a lesser degree trawl fisheries, while in the pursuit of other commercial species. Present-day catch (1996-2005) is composed exclusively of bycatch and therefore the recorded amounts are a function of the bycatch reporting systems in place in the various fisheries. The relative spatial distribution of reported catch is shown in Figure 3.

Since 1996 the commercial groundfish trawl has received 100% at-sea observer coverage and therefore catches of bluntnose sixgill sharks reported from this fishery are considered accurate. A total of 10.8 t are reported between 1996 and October 2005 or approximately 1.1 t/yr. The number of sharks this represents is unknown. If we assume an average size of 205 cm (~50 kg) as was found in a tagging study along the west coast, then about 22 bluntnose sixgill sharks a year are being caught by trawl gear.

Catches are greatest from Pacific Marine Fisheries Commission (PMFC) areas 3C/D along the west coast of Vancouver Island, representing about 40% of the total catch (Table 2).

Table 2. Commercial trawl catch (kg) and number of bluntnose sixgill shark in British Columbia waters from 1996 to October 2005 by PMFC management areas. Number of sharks is estimated by assuming an average weight of 50 kg. Source: PacHarvTrawl database.

	Area and Catch (kg)								
Year	3C	3D	4B	5A	5B	5C	5E	Total (kg)	Est. # sharks
1996		82		252	23			357	7
1997	107	34		84	130			355	7
1998	1816	14	14	11	408		2268	4531	91
1999	308	34		194	38		581	1155	23
2000	14	50	91		91			246	5
2001	794	248	441	68				1551	31
2002	57	136	68		231	544		1036	21
2003	103	576	193	27	291			1190	24
2004		68		23	68	91	45	295	6
2005			65					65	1
Total (kg)	3199	1242	872	659	1280	635	2894	10781	216

Hook and line fisheries, including fisheries for spiny dogfish, lingcod, rockfish, halibut and sablefish have only recently (2001-present) been subject to at-sea observers with typically between 10-15% coverage per fleet (DFO 2003, 2004, 2005a). In addition to at-sea observer data, some fishers have also reported bluntnose sixgill shark catches in their logbooks. From 2001 to 2004 the at-sea observer program has recorded 7.2 t (Table 3) and from 2001 to 2005 fisher logbooks have recorded 4.7 t (Table 4). Since fishers have not been obligated to report catches of bluntnose sixgill shark in their logbooks, the actual catch is not known but would be higher. The halibut fishery and the spiny dogfish fishery (also called Schedule II) capture the largest amounts of bluntnose sixgill sharks (Appendix 3).

Table 3. Observer recorded catch of bluntnose sixgill shark by PMFC management areas from commercial hook and line fisheries in British Columbia. Number of sharks is estimated by assuming an average weight of 50 kg. Source: PacHarvHL database.

	Area and Reported Catch (kg)									Total	
Year	3C	3D	4B	5A	5B	5C	5D	5E	UNK	(kg)	Est. # sharks
2001	18		363					295		676	14
2002		2267	37	562	141		95			3102	62
2003	262	295	1031		182	113	91	286		2260	45
2004	45	816	104						181	1146	23
Total	325	3378	1535	562	323	113	186	581	181	7184	144

Table 4. Fisher logbook data of reported catch (kg) of bluntnose sixgill shark by PMFC management area. Number of sharks is estimated by assuming an average weight of 50 kg. Source: PacHarvHL database.

	Area and Reported Catch (kg)					Total	
Year	3C	3D	4B	5E	UNK	(kg)	Est. # sharks
1986					67	67	1
1989					240	240	5
1990					186	186	4
1992		145				145	3
1996					13	13	0
2001	548		110			658	13
2002			2631	987	329	3947	79
2003	92					92	2
2004	14					14	0
2005			18			18	0
Total	654	145	2759	987	835	5380	108

There is presently no reliable method of expanding observer data in order to derive an actual catch. Expansions of lesser-caught species such as the bluntnose sixgill shark should be viewed with caution; nonetheless, an expansion does provide a basis for understanding true catch. It should also be noted that observer coverage in the hook and line fisheries is not equally distributed by vessel type (i.e., smaller vessels are unable to carry additional people), which causes an additional source of error as smaller vessels tend to fish in more protected and shallower waters. Under the assumption that the observed catch of bluntnose sixgill sharks is directly proportional to the fleet as a whole, actual catch may be closer to 12 t/yr (~240 sharks) between 2001 and 2004 based on assumed observer coverage of 15%.

Another method of estimating the actual total bycatch is to look at the ratio of observed bluntnose sixgill shark as a proportion of the retained target species. For spiny dogfish and Pacific halibut, the observed ratio is 7.0 kg and 1.9 kg per tonne of retained spiny dogfish and Pacific halibut respectively (Appendix 4). From 2001 to 2005, on average approximately 4100 t of spiny dogfish and 5100 t of Pacific halibut were retained annually in British Columbia resulting in a possible estimated catch of 38 t/yr (~760 sharks) of bluntnose sixgill shark (Appendix 4).

Overall the catch of bluntnose sixgill sharks in British Columbia is poorly known. Recent observer data indicates that bluntnose sixgill sharks are caught regularly by fisheries pursuing halibut and spiny dogfish. Beginning in 2006 all hook and line fisheries became subjected to 100% at-sea observer coverage using electronic monitoring (i.e., video surveillance) which will help determine the actual bycatch of bluntnose sixgill shark. At the time of writing this report, these data were not yet available. There may also be sharks that become hooked but are able to break free of the hook before being brought to the surface. Mortality associated with the bycatch of

bluntnose sixgill sharks has not been investigated. According to one spiny dogfish fisherman, the occasional bluntnose sixgill shark is brought up dead if it happens to get wrapped up in the groundline, but usually they are lively at the surface and when released they swim away quite strongly (Edwards pers. comm. 2006).

POPULATION SIZES AND TRENDS

Search effort

In the preparation of this report, the authors approached shark experts and institutions along the west coast of North America. There are no long-term indices of bluntnose sixgill shark abundance or estimates of absolute abundance. Standard fisheries independent surveys using either bottom trawls or setline gear do not capture bluntnose sixgill shark with sufficient regularity to index their populations. We examined the International Pacific Halibut Commission setline survey 1994-2004 (6 records), the National Marine Fisheries Service Triennial bottom trawl survey (1 record from Canadian waters), and several Department of Fisheries and Oceans trawl surveys (1 record). None of these surveys are suitable for indexing trends in abundance or suitable for estimating absolute abundance through expansion.

Abundance

Long-term effective population size has been estimated through genetic techniques to be about 7900 individuals (Larson *et al*. 2005). This estimate was based on examining genetic diversity using seven microsatellite DNA markers from ~200 individual juvenile animals biopsied in Puget Sound (2001-2004). Given the low number of markers, assumptions about mutation rates, and the limited spatial area from which the samples were drawn (central and southern Puget Sound), this estimate is unlikely to be accurate, and in any event may not reflect recent changes in population abundance. Furthermore, the spatial extent of the breeding population is unknown. If suspected dispersal and movement patterns of bluntnose sixgill shark are correct then the breeding population likely resides along the continental shelf of western North America. The extent of latitudinal migration and dispersal is unknown.

Fluctuations and trends

A video surveillance study occurring on a small shallow rocky reef near Flora Islets (49°30.9′N, 124°34.5′W) in the Strait of Georgia described earlier in this report is the only index of abundance available for bluntnose sixgill sharks in Canadian waters (see section on Dispersal and Movement). Unpublished results from this study have shown a consistent and gradual decline in the frequency of sightings from 2001 to 2005 (Figure 11, Dunbrack pers. comm. 2006). It is important to note that individual sharks are typically not identifiable and therefore the index may not record abundance but rather behaviour at the site. The observed change is also corroborated by a similar

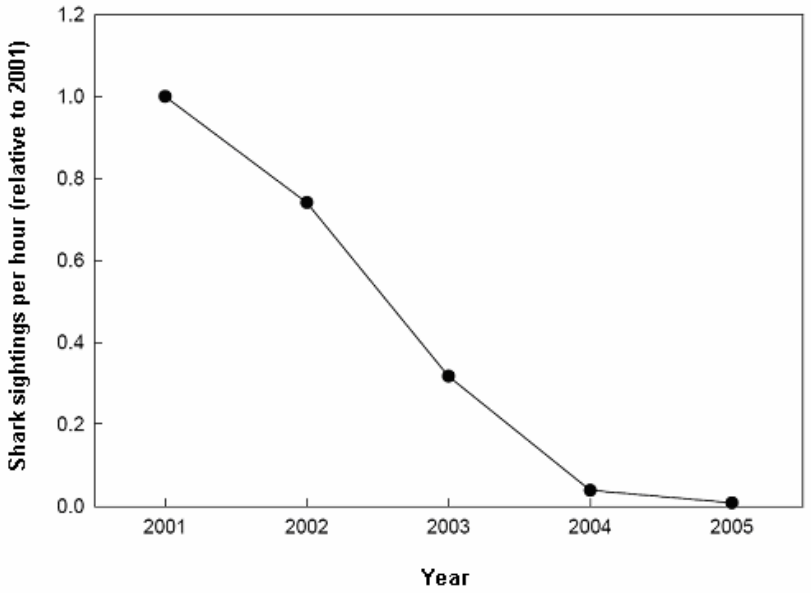

Figure 11. Relative frequency of bluntnose sixgill shark sightings from a permanent video surveillance camera at Flora Islets, Strait of Georgia. Sightings are recorded during daylight hours. Dunbrack pers. comm. (2006) unpublished data.

decline in encounter rates during recreational SCUBA dives from an average of 1.8 sharks/dive in 1999 to 0.1 sharks/dive in 2005 (Heath pers. comm. 2006; Appendix 5). The dive data has not been standardized to account for actual effort (i.e., time in water, number of divers) and therefore is considered to be anecdotal.

The Flora Islet study site is globally unique as there are very few places where bluntnose sixgill sharks can be observed regularly in shallow waters. Because of the atypical nature of this site combined with only a single surveillance point, interpretations made from the observed trend must be viewed with caution. There are no obvious explanations, such as the start of a major fishery, for the decline in the encounter rate. The only fishery in the Strait of Georgia known to capture bluntnose sixgill sharks is the spiny dogfish longline fishery. This fishery has operated in the Strait of Georgia for several decades with various levels of landings (Figure 12). Since 2002 spiny dogfish landings have increased in the entire Strait of Georgia. It is unlikely, even under the assumption that mortality to bluntnose sixgill shark has increased that it would be enough to account for the virtual disappearance of bluntnose sixgill sharks from the Flora Islets site.

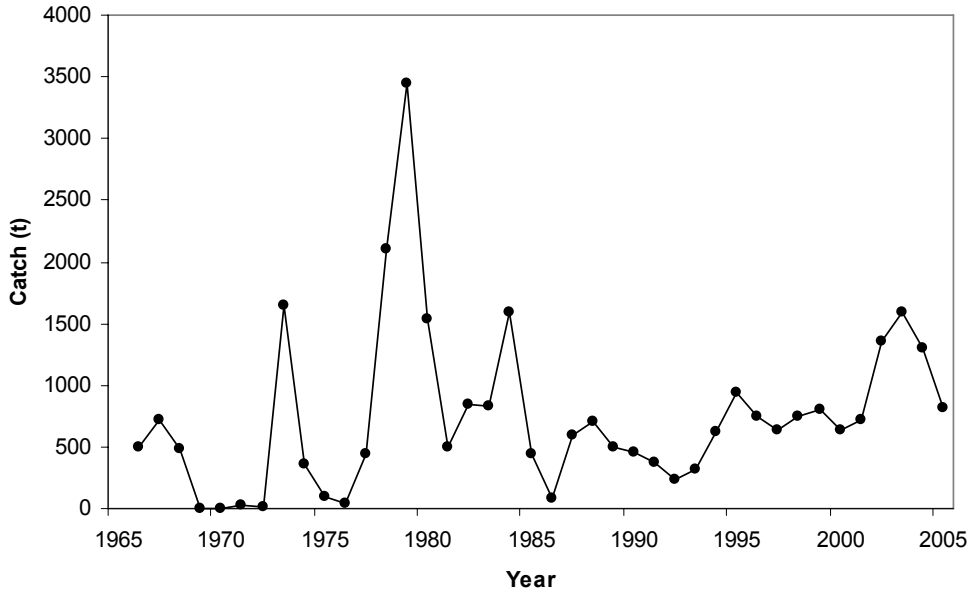

Figure 12. Landings (t) of spiny dogfish by longline gear in PMFC area 4B: Strait of Georgia. Source: PacHarvHL database.

Other plausible explanations include a change in environmental conditions such as water temperature that may influence the depth distribution of the sharks. There has not been reproductive or feeding behaviour of bluntnose sixgill sharks observed at the Flora Islet site. Therefore Dunbrack and Zielinski (2003) suggest that local presence of bluntnose sixgill sharks at the study site might be due to the thermally stable, deep bottom layer of the Strait of Georgia, which is similar to cool continental slope waters (where most bluntnose sixgill shark populations are found). The Navy hydrographic station off Nanoose Bay located in the central Strait of Georgia (~50 km from the study site) has recorded depth-temperature profiles since 1969 (Figure 13). In 2004 the temperature at 10 metres was the second highest annual temperature recorded since 1970 and the bottom layer (395 m) was the warmest on record (DFO 2005b; Figure 13). This warm trend persisted through to 2005 (DFO 2006). It is possible that these observed differences in temperatures extended northwards to the Flora Islet site thereby influencing the video encounter rates of bluntnose sixgill shark at Flora Islet.

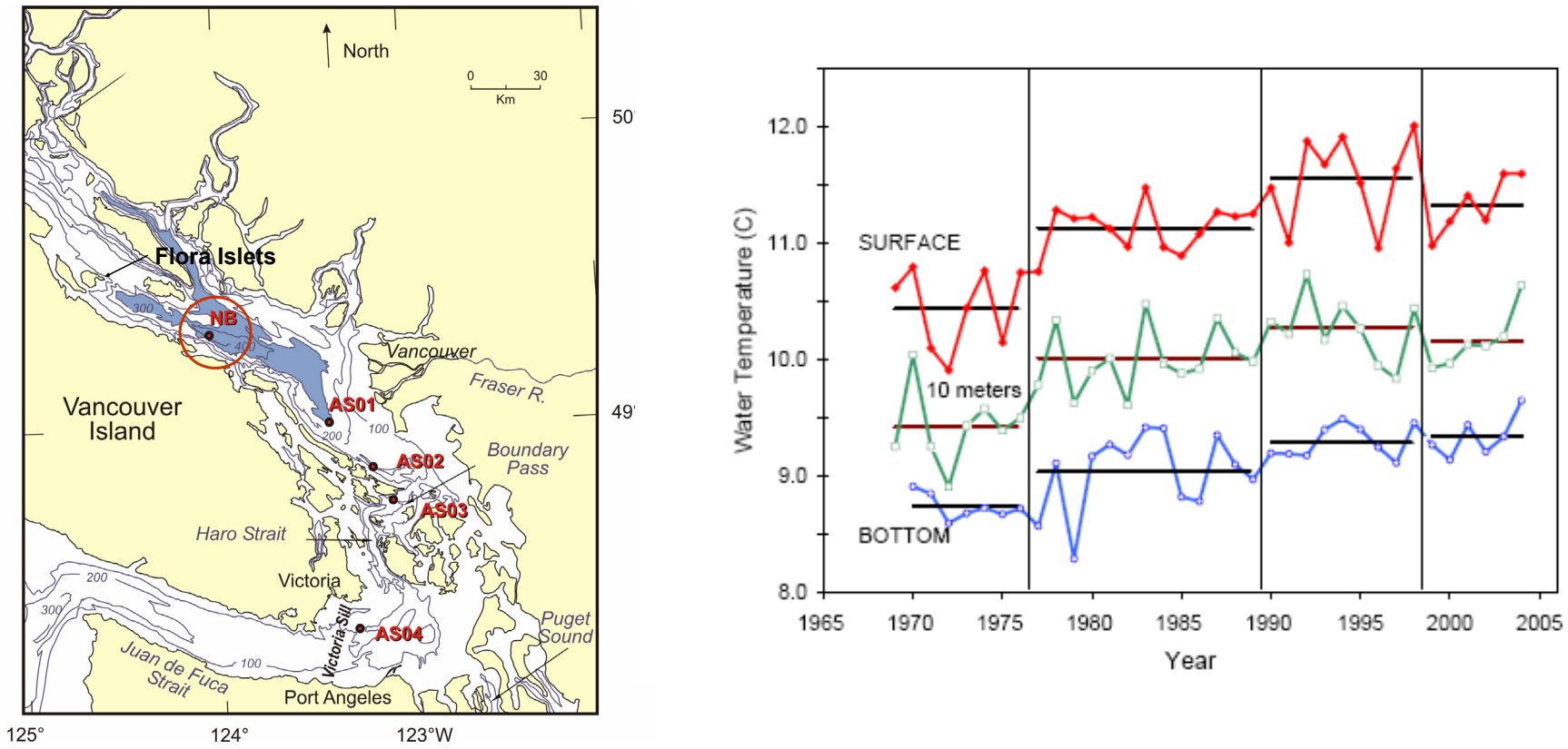

Figure 13. Location of Nanoose Bay (NB) hydrographic station and Flora Islet study site (left panel) and annual mean water temperature profiles (surface, 10m and 395 m) for 1969 to 2003 collected at Nanoose Bay hydrographic station (right panel). Sources: DFO 2002; DFO 2005b.

Summary of trends and current status

There are presently no reliable indicators for understanding bluntnose sixgill shark status in Canadian waters. Intensive fishing for this species took place in the late 1930s to mid-1940s and there was a small experimental fishery in the late 1980s to early 1990s, but otherwise catch of this species has been limited to bycatch. The amount of bycatch is unknown but was estimated in this report to range between 12 and 38 t per year of which an unknown percentage is actually killed. The overall impact that bycatch fishing mortality has on the population depends on the size of the population, which at the present time is largely unknown and the demographic of the bycatch itself (i.e., size, sex). A single abundance estimate based on genetic techniques suggests a long-term effective population size in the northeast Pacific of about 8000 individuals (Larson *et al*. 2005), but the relationship of this value to absolute contemporary abundance is not clear. Encounter rates with immature bluntnose sixgill sharks at a shallow site in the Strait of Georgia have decreased significantly (>90%) over the last five years based on video surveillance and anecdotal diving records (Dunbrack pers. comm. 2006; Heath pers. comm. 2006). Fishing is not likely the cause of this decline. Environmental data, although limited, may offer an explanation for the downward trend.

Rescue effect

At the present time the overall abundance and movement patterns between Canadian and U.S. populations is unknown and therefore the expected rescue effect that the U.S. population may have on the Canadian population is unknown. The abundance of this species in Alaskan waters is unknown, they are rarely caught by commercial fisheries and do not appear in fisheries surveys (Courtney *et al*. 2004).

LIMITING FACTORS AND THREATS

Fishing presents the only known proximate threat to bluntnose sixgill shark populations in Canada. This species is caught regularly by hook and line gear types and to a lesser degree by trawl gear. While the actual catch is not accurately known, two estimates of the catch in hook and line gear, derived from observer data using different methods are 12 t/yr and 38 t/yr for the 2001 to 2004 time period. Captured fish are likely primarily immature animals (see section Interactions with Fisheries). Between 1996 and 2005, catches in the commercial trawl fisheries have averaged about 1.1 t/yr. The degree to which this amount of catch is impacting the population as a whole is unknown. Dunbrack and Zielinski (in press) demonstrated that of 35 sharks observed one third bore scars consistent with fishing gear interaction. None of the seven sharks larger than 280 cm bore scars suggesting that larger animals either do not interact or are more able to break free without damage.

SPECIAL SIGNIFICANCE OF THE SPECIES

The bluntnose sixgill shark is the largest predatory shark regularly encountered in Canada's Pacific waters. Their ecosystem role is largely unknown but they are likely the top predator (trophic level ~4.2) through much of the world's continental shelves (Froese and Pauly 2006). In Canada's Pacific waters immature bluntnose sixgill sharks regularly make forays into shallow waters in select locales allowing the opportunity for SCUBA divers to observe them.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The IUCN has assessed the bluntnose sixgill shark as lower risk/near threatened (LR/nt) (Shark Specialist Group 2000). In Canada this species receives no formal protection. Retention and selling of bluntnose sixgill shark captured by hook and line fisheries, both commercial and recreational, in British Columbia is prohibited. In Puget Sound waters, there has been a permanent closure on the recreational and commercial take of sixgill sharks since 2001. Beginning in April 2006 all commercial hook and line fisheries operating in Canada's Pacific waters became subjected to 100% at-sea monitoring coverage in the form of observers and electronic monitoring (video surveillance). This monitoring will allow for highly reliable catch estimates of non-target species including bluntnose sixgill sharks in the future.

TECHNICAL SUMMARY

Hexanchus griseus
Bluntnose sixgill shark Requin griset
Range of Occurrence in Canada: Pacific Ocean

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* **Based on the area representing the preferred depth interval reported in the literature (20-2000 m).**	133,139 km²
• *Specify trend in EO*	Unknown
• *Are there extreme fluctuations in EO?*	Unlikely
• *Area of occupancy (AO) (km²)* **Not calculated due to insufficient data.**	Unknown
• *Specify trend in AO*	Unknown
• *Are there extreme fluctuations in AO?*	Unlikely
• *Number of known or inferred current locations*	Unknown
• *Specify trend in #*	Unknown
• *Are there extreme fluctuations in number of locations?*	Unknown, unlikely
• *Specify trend in area, extent or quality of habitat*	Unknown
Population Information	
• *Generation time (average age of parents in the population)*	Unknown, no reliable age or mortality estimates.
• *Number of mature individuals*	Unknown
• *Total population trend:*	Unknown
• *% decline over the last/next 10 years or 3 generations.* **Note:** study occurred over a small geographical extent and short time period (5 years).	Largely unknown, single study shows declines>90%.
• *Are there extreme fluctuations in number of mature individuals?*	Unknown, unlikely
• *Is the total population severely fragmented?*	Unknown, unlikely
• *Specify trend in number of populations*	Unknown
• *Are there extreme fluctuations in number of populations?*	Unknown, unlikely
• List populations with number of mature individuals in each:	
Threats (actual or imminent threats to populations or habitats)	
Bycatch of bluntnose sixgill shark during commercial longline fishing operations for halibut and dogfish appear to be the largest threat in Canada's Pacific waters. Commercial bottom trawling also captures small numbers of this species each year. Historical directed fishing (1930s and 1940s) may have also impacted the overall abundance.	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA: The population status in adjacent US jurisdictions is unknown.**	
• *Is immigration known or possible?*	Possible, unknown
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Unknown
• *Is rescue from outside populations likely?*	Unknown
Quantitative Analysis [provide details on calculation, source(s) of data, models, etc]	Quantitative analysis was not undertaken.

Current Status
COSEWIC: Special Concern 2007 IUCN: lower risk/near threatened (LR/nt)

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code**: NA

Reasons for Designations:

This large (maximum reported length 4.8 m), heavy-bodied shark is a benthic species that is widely distributed over continental and insular shelves in temperate and tropical seas throughout the world. In Canadian Pacific waters, it is found in inlets and along the continental shelf and slope typically at depths greater than 91 m (range 0-2500 m). In the absence of information about population structure, it is treated as a single population for assessment purposes. The present population size and abundance trends are not known. The only available abundance index, encounter rates with immature sharks at a shallow site in the Strait of Georgia, has decreased significantly (>90%) in the last five years. This index is not likely representative of the overall abundance trend because only immature sharks are encountered and the site is shallow relative to the preferred depth range. The principal known threat to the species is fishing. This shark has been the focus of at least three directed fisheries in Canadian waters, most recently in the late 1980s and early 1990s. It continues to be caught as bycatch, but survival of released sharks is unknown. Sharks observed by divers sometimes show scars from entanglement in fishing gear. Because of its late age of maturity (18-35 yr for females), it is likely susceptible to overfishing even at low levels of mortality. Little is known about the abundance and movement patterns of this species elsewhere in the world, so the potential for a rescue effect is unknown.

Applicability of Criteria

Criterion A: (Declining Total Population): Although trends are not known, a decline is suspected because of the past fisheries, present interactions with fisheries and the late age at maturity.

Criterion B: (Small Distribution, and Decline or Fluctuation): Not applicable because both the extent of occurrence and the area of occupancy exceed threshold values for 'Threatened'.

Criterion C: (Small Total Population Size and Decline): Not applicable because population size is unknown.

Criterion D: (Very Small Population or Restricted Distribution): Does not apply because the number of mature individuals likely exceeds 1,000 and area of occupancy is greater than 20 km^2.

Criterion E: (Quantitative Analysis): Not undertaken.

ACKNOWLEDGEMENTS AND AUTHORITIES CONSULTED

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Dr. Scott Wallace is an independent consultant based on Vancouver Island, BC. His interests are best management practices and the sustainability of Pacific fisheries. Dr. Gordon (Sandy) McFarlane is a DFO scientist at the Pacific Biological Station, BC, where he studies the biology and distribution of sharks and skates. Dr. Jacquelynne King is a DFO scientist at the Pacific Biological Station, BC, where she studies age and growth parameters for big and longnose skates, aging methodology for sixgill sharks, and distribution and migration of spiny dogfish.

Appendix 1. References to bluntnose sixgill shark in early non-scientific publications.

Date	Headline	Comments	Source
1920	Shark Fishing About to Start	Processing plant located at Parker Island, near Active Pass. Mostly focused on shark leather products. As common as dogfish. 100 fathoms or greater. Fishing in June. Sharks 12-14 feet in length.	Times, May 14 1920, p. 14.
1921	Shark Industry Being Developed on Coast	500 mud sharks in two months. Between Galiano and Mayne Islands	Times, June 21, 1921 p. 8.
1921	Shark Fishing Industry to be Located on Alberni Canal	Reference to mud sharks producing up to 10 gallons of oil each. Refers to mud sharks being found primarily in the Gulf of Georgia. Best paying part of the fish is the skin.	Port Alberni News, August 31 1921.
1921	Shark Industry to be Developed on Large Scale	Details of an expedition: 21 days in Gulf of Georgia. Averaging 225 pounds each (total 40 t).	Times, August 25, 1921
1922	Sharks to Yield Big Money, Says Industries Head	Details of a single fishing expedition: 24 days of fishing, one set of gear, 357 sharks, 965 gallons of oil, 225 hides. Total selling value $1023.40	Times, May 4 1922, p. 13.
1938	Vitamin Tucked Away Wins Mud Shark Place Among Useful Fish Products	Reports 25-30000 pounds of mud shark liver caught around Prince Rupert.	Fisheries News Bulletin, January 1938, p. 2.
1942	Stuart Island	Mud sharks abundant in Loughboro Inlet	The Fisherman, March 31 1942, p. 4.
1943	Killing Mud Sharks for Livers Nets Tidy Return, Protects Salmon Too		Fisheries News Bulletin, 1943
1943	Mud Shark	Diet: 7-15 sockeye in every stomach caught by fishermen. A total of 500 or so sharks caught in that one season alone. ~160 lbs of liver/shark.	Western Fisheries, June 1943, p. 45.
1943	Mud Sharks Now Valuable for Liver Oil-Big Bottom Feeders Can Move Fast	Similar reference as above: diet of lingcod, sockeye, and hair seal [harbour seal]. Enemy of salmon fishing.	Canadian Fisherman, June 1943, p. 19.
1943	Prices for Dogfish Liver Oil and Mudshark Liver Oil	8-10.4¢/lb depending on vitamin A potency.	Canadian Fisherman, July 1943, p. 25.
1944	Dogfish, Mudshark Liver Settlement	Mud shark liver 19¢/lb	The Fisherman, June 6, 1944, p. 2.
1945	Soupfin, Mud Sharks	Not usually bigger than 10 feet although some “twice” that long are not unknown.	The Fisherman, October 16 1945, p.3.
1971	Sharks Lurking in Georgia Strait	Interview with old fisherman. Describes hot spot area: trench ~ 3 miles off east side of Mayne Island. Little sixgill sharks along the west bank of trench. Big ones down deep.	Province, August 26, 1971, p. 33.

Appendix 2. Reported catch of bluntnose sixgill shark from Canada's Pacific fisheries. Includes trawl (observer data) and hook and line (logbook data). Source: PacHarvTrawl and PacHarvHL databases.

	Area and Reported Catch (t)									
Year	**3C**	**3D**	**4B**	**5A**	**5B**	**5C**	**5D**	**5E**	**UNK**	**Total**
1984		1.1	1.1							2.2
1985	0.2	0.3	11.3	0.1	2.7					14.6
1986	0.1	0.5	4.2	0.0		0.1		0.0		4.9
1987	2.2	0.2	2.8	0.6		0.7	0.2			6.7
1988	0.3	0.2	2.9		0.0	0.4	0.1	0.1		4.0
1989			0.3	0.1		0.1				0.5
1990	0.1	0.1	0.1	0.0		0.2	0.3			0.8
1991	0.5	0.2								0.7
1992	0.0	0.1	0.1	0.0						0.2
1993	2.4	5.2	0.5							8.1
1994	0.4	3.0	0.0		0.1			0.0		3.5
1995	0.1	0.1	0.5	0.1	0.2	0.0	0.0	0.0		1.0
1996	0.0	1.7		0.3	0.0				4.0	6.0
1997	0.1	0.1		0.2	0.2					0.6
1998	1.9	0.1	0.0	0.0						2.0
1999	0.0	0.0		0.2	0.4			2.3	0.6	3.5
2000	0.3	0.1	0.1		0.1			0.6	0.4	1.6
2001	0.8		0.1	0.1					0.1	1.1
2002	0.8	0.2	7.2		0.2	0.5		1.3	0.9	11.1
2003	0.2	0.6	0.1	0.0	0.3					1.2
2004	0.1	0.1	0.0		0.1	0.1			0.5	0.9
2005	0.0	0.0	0.1	0.0		0.0		0.0	0.3	0.4
Total	**10.5**	**13.9**	**31.4**	**1.7**	**4.3**	**2.1**	**0.6**	**4.3**	**6.8**	**75.6**

Appendix 3. Observer recorded catch of bluntnose sixgill shark by fishery type in Canada's Pacific waters from 1999-2004. Source: PacHarvHL database.

Year	Sum of Catch (kg) by Fishery			Grand Total
	Halibut	Schedule II	ZN	
1999	318			318
2000	91			91
2001	313	363		676
2002	313	2551	544	3408
2003	748	1451	68	2267
2004	261	1002		1263
Total	**2044**	**5367**	**612**	**8023**

Appendix 4. Estimated actual catch of bluntnose sixgill shark in commercial spiny dogfish and halibut fisheries based on ratios derived from observer data expanded to dockside monitoring program landings.

	Observer data (kg)			DMP landings (t)	
Year	Sixgill shark	Spiny dogfish	Pacific halibut	Spiny dogfish	Pacific halibut
2001	676	62087	566399	3198	4582
2002	3408	232047	1422023	3823	5298
2003	2267	421785	1521024	4711	5258
2004	1397	394590	650302	4585	5428
Total	7748	1110509	4159747	16317	20566
Ratio (kg sixgill/t retained directed catch)		7.0	1.9		
Average landings/year				4079	5141
Possible actual catch of sixgill (kg)				28460	9576
Estimated Annual Total Catch (kg)					**38037**

Appendix 5. Number of recreational dives and number of sharks observed per year at Flora Islets in the Strait of Georgia, British Columbia. These data are anecdotal. Source: Heath pers. comm. 2006.

Year	# Dives at Flora Islet	# Shark sightings	Notes
1996	2	3	Incomplete records
1997	6	11	Incomplete records
1998	28	45	Incomplete records (complete for the season but did not include zero sightings)
1999	86	158	1st year of complete records
2000	35	37	We did very few scuba dives this year because we had the submersibles here.
2001	74	37	
2002	36	25	
2003	66	28	
2004	52	4	
2005	42	3	