Chapter 18b: Assessment of the shark stocks in the Bering Sea

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EXECUTIVE SUMMARY

Summary of Major Changes

Changes to the input data

1. Total catch for BSAI sharks from 2003-2008 updated due to changes to Catch Accounting System.
2. Total catch for BSAI sharks is updated to include 2009 (as of Oct 7, 2009)
3. Biomass estimates from the 2009 EBS shelf survey updated.

Changes in assessment methodology

There are no changes in the assessment methodology; however, due to changes to the Catch Accounting System, the estimated catches of sharks from 2003-2008 have changed. The new catch estimates are generally greater than those in previous assessments (Appendix B). The changes are reflected in the estimates of ABC and OFL. In last year's assessment we presented the 1997-2007 timeline for estimation of the ABC OFL OFL. Here we present an expanded timeline (1997-2008) as well. At the September 2009 Plan Team meeting, the joint plan teams discussed what would constitute a "reasonable time period" and recommended a 12-year period. The expanded timeline does not change the Tier 6 ABC and OFL values significantly. The standard time series for the Tier 6 calculations is 1978-1995, providing up to 17 years of data. The proposed 1997-2008 timeline would include 12 years of data.

Summary of Results

There is no evidence to suggest that overfishing is occurring for any shark species in the BSAI. We recommend that sharks be managed as Tier 6 species with the ABC and OFL based on the average catch between 1997 - 2008. This results in an ABC of 423 t and an OFL of 564 t for the shark complex combined. There are currently no directed commercial fisheries for shark species in federally or state managed waters of the BSAI, and most incidentally captured sharks are not retained. Incidental catches of shark species in the BSAI fisheries have been very small compared to catches of target species. Sharks have only been reported to species in the catch since 1997 and have made up from 1% to 5% of Other Species catch from 1997 – 2008. Pacific sleeper shark make up 60% of the total shark catch in the BSAI, followed by Other/unidentified sharks at 20%, salmon shark at 9% and spiny dogfish at 2%.

ABC and OFL Calculations and Tier 6 recommendations for 2010-2011

BSAI Tier 6 Calculations (mt) ABC=0.75*Average Catch, OFL=Average Catch

Species	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidentified shark	**Total shark complex**
Tier	6	6	6	6	**6**
M	0.097	0.097	0.18	0.097	
1997-2007 Average catch	8	416	48	126	598
ABC	6	312	36	95	449
OFL	8	416	48	126	598
1997-2008 Average catch	9	391	47	116	**564**
ABC	7	294	35	87	**423**
OFL	9	391	47	116	**564**

Responses to SSC Comments

Responses to SSC comments specific to this assessment
From the December 2008 SSC minutes:

The SSC accepts the updated base period as the scientifically best alternative to the standard Tier 6 base period of 1978-1995, but recommends to stock assessment authors that the terminal year be fixed at 2007 to avoid a shifting baseline.

We present both the 1997-2007 and 1997-2008 timelines for consideration. After discussion with the plan team and other "Other Species" assessment authors, a 12 year time period was recommended as a "reasonable time period", and recommended the 1997-2008 as the baseline with no future changes to the timeline.

The SSC notes that reasonable estimates of biomass and natural mortality exist for spiny dogfish, but due to unique life history characteristics of this species including low fecundity and extremely late age at maturity, Tier 5 management may not be appropriate.

We concur.

The SSC also notes that while reliable estimates of relative population numbers (RPNs) exist for Pacific sleeper sharks, reliable estimates of natural mortality do not exist due to the difficulty in ageing this species.

We concur. We are computing RPNs for the NMFS longline survey for all shark species and for the IPHC longline survey to present in the 2010 stock assessment.

The SSC encourages the development of length or age based models for spiny dogfish in the near future that account for these life history characteristics.

We are working with existing surveys to collect length and ages to incorporate into future assessments of spiny dogfish.

INTRODUCTION

Alaska Fisheries Science Center (AFSC) bottom trawl and longline surveys and fishery observer catch records provide information on sharks that occur in the Bering Sea and Aleutian Islands (BSAI) (Table 1, Figure 1). The three shark species most likely to be encountered in BSAI fisheries and surveys are two members of the family Squalidae, the Pacific sleeper shark (*Somniosus pacificus*) and the piked or spiny dogfish (*Squalus acanthias*), and the salmon shark (*Lamna ditropis*). A history of the management measures taken for the other species group and shark complex is summarized in Table 2.

General Distribution

Spiny Dogfish

Spiny dogfish are demersal, occupying shelf and upper slope waters from the Bering Sea to the Baja Peninsula in the North Pacific, and worldwide in non-tropical waters. They are considered more common off the U.S. west coast and British Columbia (BC) than in the Gulf of Alaska or Bering Sea and Aleutian Islands (Hart 1973, Ketchen 1986, Mecklenburg et al. 2002). This species may once have been the most abundant living shark. However, it is commercially fished worldwide and has been heavily depleted in many locations. Directed fisheries for spiny dogfish are often selective on larger individuals (mature females), resulting in significant impacts on recruitment (Hart 1973, Sosebee 1998).

Spiny dogfish are captured periodically in National Marine Fisheries Service (NMFS) bottom trawl surveys of the Aleutian Islands, but biomass estimates are very low (0 - 62 mt, Table 3, Figure 2). Spiny dogfish are captured less frequently in NMFS bottom trawl surveys of the Bering Sea shelf and Bering Sea slope, and biomass estimates are also very low (0 - 389 mt, Table 4 andTable **5**, Figure 3 andFigure **4**).

Pacific Sleeper Shark

Pacific sleeper sharks (*Somniosus spp.*) range as far north as the arctic circle in the Chukchi Sea (Benz et al. 2004), west off the Asian coast and the western Bering Sea (Orlov and Moiseev 1999), and south along the Alaskan and Pacific coast and possibly as far south as the coast of South America (de Astarloa et al. 1999). However, Yano et al. (2004) reviewed the systematics of Pacific sleeper sharks and suggested that Pacific sleepers in the southern hemisphere and the southern Atlantic were misidentified as Pacific sleeper and are actually *Somniosus antarcticus*, a species of the same subgenera. Pacific sleeper sharks have been documented at a wide range of depths, from surface waters (Hulbert et al. 2006) to 5,700 ft (seen on a planted grey whale carcass off Santa Barbara, CA, www.nurp.noaa.gov/Spotlight/Whales.htm). Pacific sleeper sharks are found in relatively shallow waters at higher latitudes and in deeper habitats in temperate waters (Yano et al. 2007).

Pacific sleeper shark biomass from NMFS bottom trawl surveys appears to be distributed primarily on the eastern Bering Sea slope (biomass estimates range between 2,000 and 25,000 t; **Table 3**, Figure 3). Pacific sleeper sharks are captured consistently in NMFS bottom trawl surveys of the eastern Bering Sea shelf and the Aleutian Islands, but biomass estimates are relatively low (<5,600 t, Table 4 andTable **5**, Figure 2 andFigure 3).

Salmon Shark

Salmon sharks range in the North Pacific from Japan through the Bering Sea and Gulf of Alaska to southern California and Baja, Mexico. They are considered common in coastal littoral and epipelagic waters, both inshore and offshore. Salmon sharks are rarely encountered in commercial fisheries or bottom trawl surveys in the BSAI (Table 2 -,**Table 5** Figure 2 -Figure **4**).

In other areas, salmon sharks have been considered a nuisance because they eat salmon and damage fishing gear (Macy et al. 1978, Compagno 1984). They have been investigated as potential target species in the Gulf of Alaska; however they are currently only targeted by sport fishermen in the state fishery (Paust and Smith 1989).

Management Units

There have been no directed fisheries for sharks in the Bering Sea or Aleutian Islands (BSAI), but some incidental catch of sharks results from directed fisheries for commercial species. Sharks are currently managed in aggregate as part of the "Other Species" complex in the BSAI Fishery Management Plan (FMP) (Gaichas et al. 1999, Gaichas 2003). The Other Species complex includes sharks, skates, sculpins, and octopus. Other Species are considered ecologically important and may have future economic potential. An aggregate annual quota limits Other Species catch under an interim management policy for the BSAI. Because data for these species are sparse, acceptable biological catch (ABC) and overfishing levels (OFL) are usually based on Tier 5 and Tier 6 criteria (Table 2). Total allowable catch (TAC) for the Other Species complex is constrained by the BSAI optimum yield (OY) cap of 2 million metric tons. Sharks have only been reported to species in the catch since 1997 and have made up from 1% to 5% of Other Species catch from 1997 – 2006 (Table 6).

Evidence of Stock Structure

Spiny Dogfish
Information on the spiny dogfish in the BSAI is limited, thus we assume biological characteristics from GOA studies. Previous studies have shown complex population structure for spiny dogfish populations in other areas. Tagging studies show separate migratory populations that mix seasonally on feeding grounds in the United Kingdom. British Columbia and Washington State have both local and migratory populations that mix at a very small rate (Compagno 1984, McFarlane and King 2003). The migratory populations of spiny dogfish may undertake large-scale migrations, ranging from British Columbia to Japan or Mexico (McFarlane and King 2003). Spiny dogfish tend to segregate by sex and by size, meaning that large males and large females are generally separate, and large sub-adults and small mature adults of both sexes tend to mix. The observed age structure in the GOA ranges from 8-50 years, and all areas of the GOA have generally the same age structure (Tribuzio and Kruse in press).

Pacific Sleeper Shark
Little is known about Pacific sleeper shark migratory behavior or their life history. Tagging studies in Alaska have shown that at least some Pacific sleeper sharks reside in the Gulf of Alaska and Prince William Sound throughout the year, where they exhibit relatively limited geographic movement (< 100 km; Hulbert et al. 2006). Pacific sleeper sharks commonly migrate vertically throughout the water column (Orlov and Moiseev 1999, Hulbert et al. 2006), but did not migrate far from initial tagging locations in the Gulf of Alaska (Hulbert et al. 2006). Median distance traveled for conventionally tagged sharks was 29.2 km, and median time at liberty was 1,729 days (Courtney and Hulbert 2007). Median vertical movement rate calculated from 4,781 hours of recorded depth data from one shark was 6 km/day (Hulbert et al. 2006). Similarly, sharks with acoustic tags in Southeast Alaska were tracked at depths greater than 500 m and made vertical migrations off the bottom (Courtney and Hulbert 2007). Another tracked shark also made horizontal movements of 6 km/day (Courtney and Hulbert 2007).

Salmon Shark

Salmon sharks differ by length-at-maturity, age-at-maturity, growth rates, weight-at-length, and sex ratios between the western North Pacific Ocean (WNP) and the eastern North Pacific Ocean (ENP) separated by longitude 180^{o} (Goldman and Musick 2006). In the WNP, a salmon shark pupping and nursery ground may exist just north of the transitional domain in oceanic waters, a band of high productivity at the southern boundary of the sub-arctic domain (~40-45˚N) of the North Pacific Ocean. According to Nakano and Nagasawa (1996), juveniles (70-110 cm PCL, slightly larger than term embryos) were caught in waters with SST's of 14^{o}-16^{o}C, with adults occurring in colder waters further north. Another pupping and nursery area may exist in the ENP and appears to range from southeast Alaska to northern Baja California, Mexico in near coastal waters (Goldman and Musick 2006, 2008).

Life History Information

Sharks are long-lived species with slow growth to maturity, a large maximum, size and low fecundity. Therefore, the productivity of shark populations is very low relative to most commercially exploited teleosts (Holden 1974 and 1977, Compagno 1990, Hoenig and Gruber 1990). Shark reproductive strategies in general are characterized by long gestation periods (6 months - 2 years), with small numbers of large, well-developed offspring (Pratt and Casey 1990). Because of these life history characteristics, large-scale directed fisheries for sharks have collapsed, even where management was attempted (Anderson 1990, Hoff and Musick 1990, Castro et al. 1999). This year, staff at AFSC calculated vulnerability scores for 41 BSAI species (O. Ormseth). Sharks were 3 of the 5 most vulnerable species, with salmon shark least vulnerable at 1.96 (lower scores are less vulnerable), spiny dogfish at 2.10 and Pacific sleeper shark at 2.24, the most vulnerable of all GOA species calculated.

<u>Spiny Dogfish</u>
Eastern North Pacific spiny dogfish grow to a relatively large maximum size of 160 cm (Compagno 1984). In 2006, through a special project with AFSC's Fishery Monitoring and Analysis program, fishery observers measured spiny dogfish lengths throughout the EBS, AI, and the GOA. Sample sizes were not substantial enough to break length frequencies out by area, but for all areas combined male lengths averaged 80.2 cm and ranged from 48-110 cm (N = 524, Figure 5). The average female length was larger than the male (average = 82.4, range 9-128, N = 601). Female modal lengths occurred at a smaller size (74 cm) than males (82 cm), however, the length frequency extended to larger sizes than males. Although females peaked earlier, there were a greater proportion of females 94 - 128 cm long than males. In comparison, size frequencies for dogfish sampled during a UAF study in the GOA showed similar average sizes, but distributions were different. Male length averaged 80.3 cm TL_{ext} (measured from the tip of the snout to the tip of the upper caudal lobe with the tail depressed to align with the horizontal axis of the body) with a mode at 85 cm, and ranged from 53-99 cm (N=623). The average female length was 87.6 cm, ranged from 50-123 cm, but was fairly uniformly distributed between 65-100 cm, with no apparent peak in length frequency (N=1351). While females had a larger size range than males, both sexes had similar frequencies for sizes <75 cm.

Historic estimates of spiny dogfish age-at-50%-maturity for the ENP range from 20 to 34 years. Ages-at-50%-maturity for BC spiny dogfish is reported at 35 years for females, and 19 years for males (Saunders and McFarlane 1993). Ages from the spines of oxytetracycline-injected animals provided validation of an age-length relationship (Beamish and McFarlane 1985, McFarlane and Beamish 1987). The ages of ENP spiny dogfish have further been validated by bomb radiocarbon (Campana et al. 2006). The same study suggested that longevity in the ENP is between 80 and 100 years and that several earlier published ages-at-maturity (and therefore longevity) were low due to agers rejecting difficult-to-read spines and spine annuli that were grouped very close together. Age-at-maturity is similar in the GOA, 34 years for females and 19 years for males (Tribuzio, unpublished data). Growth rates for this species are among the slowest of all shark species, κ=0.03 for females and 0.06 for males (Tribuzio and Kruse, in press).

The mode of reproduction for spiny dogfish is aplacental viviparity where embryos are retained within the uterus throughout gestation, but there is no physical attachment (such as a placenta) between the mother and offspring. In this case, spiny dogfish embryos are nourished solely by their yolk sac. Gestation is 18-24 months. The majority of biological knowledge of spiny dogfish is based on field research conducted in the North Atlantic and European stock assessments, and in controlled laboratory experiments (Tsang and Callard 1987, da Silva and Ross 1993, Polat and Guemes 1995, Rago et al. 1998, Koob and Callard 1999, Jones and Ugland 2001, Soldat 2002, Stenberg 2002). Little research has been conducted in the North Pacific outside of British Columbia. Ketchen (1972) reported timing of parturition in BC to be October through December and in the Sea of Japan parturition occurred between February and April (Kaganovskaia 1937, Yamamoto and Kibezaki 1950, Anon 1956,). Washington State spiny dogfish have a long pupping season, which peaks in October and November (Tribuzio 2004). In the GOA, pupping may occur during winter months, based on the size of embryos observed during summer and fall sampling (Tribuzio, pers. obs.). Pupping is believed to occur in estuaries and bays or mid-water over depths of about 165-370 m (Ketchen 1986). Small juveniles and young of the year tend to inhabit the water column near the surface or areas not fished commercially. Therefore juveniles are not available to commercial fisheries until they grow or migrate to fished areas (Beamish et al. 1982, Tribuzio and Kruse, in review). The average litter size is 6.9 pups for spiny dogfish in Puget Sound, WA (Tribuzio 2004), 6.2 in BC (Ketchen 1972) and 9.7 in the GOA (Tribuzio and Kruse, in review). The number of pups per female also increases with the size of the female, with estimates ranging from 0.20 – 0.25 more pups for every centimeter in length after the onset of maturity (Ketchen 1972, Tribuzio 2004, Tribuzio and Kruse, in review).

Pacific Sleeper Sharks

Measurement techniques for determining the length of Pacific sleeper sharks are varied. In NMFS bottom trawl surveys, Pacific sleeper shark lengths have been recorded as pre-caudal length (PCL; tip of snout to the dorsal insertion of the caudal peduncle), fork length (FL; tip of snout to fork in tail), and total length (TL; tip of snout to tip of tail in a natural position). In NMFS longline research Pacific sleeper shark lengths have been reported in PCL (Sigler et al. 2006). In the GOA, Pacific sleeper shark length frequency distributions show peaks between 150 and 210 cm TL (Figure 5, bottom panel), with observations between 120-340 cm TL for the bottom trawl survey (1987-2007, n = 86, 76 hauls, 72% female) and 120-280 cm TL for longline research (n = 198, 24 hauls, 60% female, Courtney unpublished data, Sigler et al. 2006).

Pacific sleeper sharks are most likely slow growing and long lived (Fisk et al. 2002). A Greenland shark (*Somniosus microcephalus*), the North Atlantic congener of the Pacific sleeper shark, was sampled in 1999 and was determined to be alive during the 1950's-1970's because it had high levels of DDT, which was used as an insecticide during this period (Fisk et al. 2002). The cartilage in Pacific sleeper sharks does not calcify to the degree of many other shark species, therefore aging is difficult and methods are under investigation. Pacific sleeper sharks can attain large size. The maximum lengths of captured and measured Pacific sleeper sharks are 440 cm for females and 400 cm for males (Mecklenburg et al. 2002). Larger individuals have been reported to reach up to 700 cm or more in length, estimated from photographs taken in deep water (Compagno 1984). The maximum lengths of *Somniosus* (sp.) captured and measured from mid-water trawls in the Southern Ocean off the outer shelf and upper continental slope of subantarctic islands are 390 cm +- 1.07 (1.50 – 5.00, n=36) (Cherel and Duhamel 2004). In the Gulf of Alaska, Pacific sleeper sharks of 150-250 cm have been measured (e.g. Sigler et al. 2006) and Pacific sleeper sharks as large as 420 m have been measured in the Northwestern Pacific (Orlov 1999). This species exhibits sexual dimorphism in the northwest Pacific Ocean, with females being shorter and heavier (avg. length = 138.9 cm, avg. weight = 28.4 kg) than males (avg. length = 140 cm, avg. weight = 23.7 kg) (Orlov 1999).

Published observations suggest that mature female Pacific sleeper sharks are in excess of 365 cm TL (total length), mature male Pacific sleeper sharks are in excess 397 cm TL, and that size at birth is approximately 40 cm TL (Gotshall and Jow 1965, Yano et al. 2007). However, only five mature female Pacific sleeper sharks have been documented in the literature. The reproductive mode of Pacific sleeper sharks is thought to be aplacental viviparity. Three mature females 370-430 cm long were opportunistically sampled off the coast of California. In one of these specimens several thousand small eggs (<10mm) were present as well as 372 large vascularized eggs (24-50mm; Ebert et al. 1987). Another mature Pacific sleeper shark 370 cm long was caught off Trinidad California (Gotshall and Jow 1965). The ovaries contained 300 large unfertilized eggs and many small undeveloped ova. Diameters of the large eggs ranged from 45 to 58 mm. Additionally, a single mature female was found off the Kuril Islands, northeast of Hokkaido, Japan, that measured 423 cm long (Orlov 1999). Two recently-born 74 cm sharks have been caught off the coast of California at 1300 and 390 m depth; one still had an umbilical scar (Ebert et al. 1987). Unfortunately, the date of capture was not reported. A newly born shark of 41.8 cm was also caught at 35 m depth off Hiraiso, Ibaraki, Japan (Yano et al. 2007). Additionally, three small Pacific sleeper sharks, 65-75 cm long, have been caught in the Northwest Pacific, but the date of sampling was not reported (Orlov and Moiseev 1999). In 2005, an 85 cm (pre-caudal length) female was caught during the annual sablefish survey near Yakutat Bay (Tribuzio, unpublished data). Because of a lack of observations on mature and newly born sharks, and the absence of dates in the literature, the spawning and pupping season is unknown for Pacific sleeper sharks.

Salmon Shark

Like other sharks of the family Lamnidae, salmon sharks are active and highly mobile, maintaining body temperatures as high as 21.2 ^{o}C above ambient water temperatures and apparently maintaining a constant body core temperature regardless of ambient temperatures (Goldman 2002, Goldman et al. 2004). Adult salmon sharks typically range in size from 180-210 cm PCL (where TL = 1.1529•PCL + 15.186, from Goldman 2002, Goldman and Musick 2006) in the eastern North Pacific (no conversions are given in the literature for salmon sharks in the western North Pacific) and can weigh upwards of 220 kg. Lengths of 260 cm PCL (300 cm TL) and greater and weights exceeding 450 kg are rumored but unsubstantiated (Goldman and Musick 2008). Length-at-maturity in the WNP has been estimated to occur at approximately 140 cm pre-caudal length (PCL) for males and 170-180 cm PCL for females (Tanaka 1980). These lengths correspond to ages of approximately 5 years and 8-10 years, respectively. Length-at-maturity in the ENP has been estimated to occur between 125-145 cm PCL (age three to five) for males and between 160-180 cm PCL (age six to nine) for females (Goldman 2002, Goldman and Musick 2006). Tanaka (1980, see also Nagasawa 1998) states that maximum age from vertebral analysis for WNP salmon shark is at least 25 years for males and 17 years for females, and that the von Bertalanffy growth coefficients (κ) for males and females are 0.17 and 0.14, respectively. Goldman (2002) and Goldman and Musick (2006) gave maximum ages for ENP salmon shark (also from vertebral analysis) of 17 years for males and 30 years for females (Goldman, unpublished data), with growth coefficients of 0.23 and 0.17 for males and females, respectively. Longevity estimates are similar (20-30 years) for the ENP and WNP. Salmon sharks in the ENP and WNP attain the same maximum length (approximately 215 cm PCL for females and about 190 cm PCL for males). However, males past approximately 140 cm PCL and females past approximately 110 cm PCL in the ENP are of a greater weight-at-length than their same-sex counterparts in the WNP (Goldman 2002, Goldman and Musick 2006).

The reproductive mode of salmon sharks is aplacental viviparity and includes an oophagous stage in which embryos feed on eggs produced by the ovary (Tanaka 1986 cited in Nagasawa 1998). Litter size in the western Pacific is four to five pups, and litters have been reported to be male dominated in a 2.2:1 ratio (Nagasawa 1998), but this is from a very limited sample size. In the eastern Pacific, a pregnant female salmon shark caught near Kodiak Island had four pups: two males and two females (Gallucci et al. 2008). Gestation times throughout the North Pacific appear to be nine months, with mating occurring during the late summer and early fall and parturition occurring in the spring (Tanaka 1986, Nagasawa 1998, Goldman 2002, Goldman and Human 2004, Goldman and Musick 2006). Size at parturition is between 60-65 cm PCL in both the ENP and WNP (Tanaka 1980, Goldman 2002, Goldman and Musick 2006).

FISHERY

Directed Fishery

There are currently no directed commercial fisheries for shark species in federally- or state- managed waters of the BSAI, and most sharks captured incidentally are not retained.
However, in the GOA a small amount of spiny dogfish landings in Kodiak have been reported in 2004, 2005 and 2007 (~ 1 mt each year, J. Gasper, AKRO, pers. comm.). There is a Commissioners Permit fishery for spiny dogfish in lower Cook Inlet, but only one application has been received to date and the permit was not issued.

Some retention of incidentally caught spiny dogfish is allowed in ADF&G managed fisheries, with some landings reported in the GOA off Yakutat during 2005 - 2008. The landings were highest in 2005 (about 11,363 kg landed) and decreased in 2008 (138 kg landed). Salmon sharks are targeted by sport fishermen in Alaska state waters.

Bycatch, Discards, and Historical Catches

Historical catches of sharks in the BSAI are composed entirely of incidental catch, and nearly all incidental shark catch is discarded. Mortality rates of discarded catch are unknown, but are conservatively estimated in this report as 100%. Aggregate incidental catches of the Other Species management category from federally prosecuted fisheries for Alaskan groundfish in the BSAI are tracked in-season by the NMFS AKRO (**Table 6**). Other Species reported catches have been relatively small each year since 1977 in the GOA (e.g., in 2001 Other Species catches of 25,482 tons made up 1.5% of the 1,652,802 ton total BSAI catch). Discard rates for sharks are presented in Table 7. Most sharks are discarded, however, “Other/unidentified sharks” have been retained as much as 66% over the entire year (87 mt in 2009). The majority of the retained shark catch is used for fishmeal (AKFIN, queried by Terry Hiatt, Oct 21, 2009).

DATA

Data regarding sharks were obtained from the following sources:

Source	Data	Years
AKRO Catch Accounting System	Nontarget catch	2003 – 2009
Improved Pseudo Blend (AFSC)	Nontarget catch	1997 – 2002
NMFS Bottom Trawl Surveys –Eastern Bering Sea Shelf (Annual)	Biomass Index	1979 – 2009
NMFS Bottom Trawl Surveys –Eastern Bering Sea Slope (Historical)	Biomass Index	1979 – 1991
NMFS Bottom Trawl Surveys –Eastern Bering Sea Slope	Biomass Index	2002, 2004, 2008
NMFS Bottom Trawl Surveys –Aleutian Islands (Biannual)	Biomass Index	1980 – 2006

Incidental Catch

This report summarizes incidental shark catches by species as two data time series: 1997 – 2002 and 2003 – 2009 (Table 6). Sharks have been reported by species by the NMFS AKRO Catch Accounting System (CAS) since 2003. Shark catches by species from 1997 – 2002 were estimated by staff at the AFSC using a pseudo-blend method (Gaichas 2001, 2002). In the pseudo-blend method, target fisheries were assigned to each vessel / gear / management area / week combination based upon retained catch of allocated species, according to the same algorithm used by the NMFS AKRO. Observed catches of other species (as well as forage fishes and nonspecified species) were then summed for each year by target fishery, gear type, and management area. The ratio of observed Other Species group catch to observed target species catch was multiplied by the NMFS AKRO blend-estimated target species catch within that area, gear, and target fishery (Table 6). This method more closely matched the NMFS AKRO blend catch estimation system than the previous pseudo-blend estimation method (Gaichas et al. 1999) and is therefore considered more accurate. In making these catch estimates, we are assuming that Other Species catch aboard observed vessels is representative of Other Species catch aboard unobserved vessels throughout the BSAI. Observer coverage is fairly complete in the BSAI, but because observer assignment to vessels is not random, there is a possibility that this assumption is incorrect.

Based on the pseudo-blend estimates from 1997 – 2002 Gaichas (2001, 2002) and the NMFS AKRO estimates from 2003 – 2009, BSAI shark catch composed from 1% to 5% of Other Species total catch (Table 6). Pacific sleeper sharks composed 69% of total shark catch, unidentified sharks 20%, salmon sharks 9%, and spiny dogfish 2% (Table 6).

From 1997 to 2009 in the BSAI, spiny dogfish were caught primarily in the Pacific cod fishery (85%, Table 8), while Pacific sleeper sharks were caught primarily in the pollock fishery (49%, Table 9). Pacific sleeper sharks were also caught in the Pacific cod fishery (40%). Salmon sharks were rarely encountered, but 89% of the salmon shark catch occurred in the pollock fisheries (Table 10). Other sharks and unidentified sharks occurred primarily in the pollock fisheries (48%, Table 11).

Survey Biomass Estimates

Biomass estimates are available for shark species from NMFS AFSC bottom trawl surveys conducted in the Aleutian Islands (AI, 1979 – 2004,Table 3 andTable **12**), the eastern Bering Sea (EBS) shelf (1979 – 2008, Table 4 andTable **12**), and during two different time periods on the EBS slope (1979-1991 and 2002-2009; Table 5 andTable **12**). Where available, individual species biomass trends were evaluated for the three most commonly encountered shark species (spiny dogfish, Pacific sleeper shark, and salmon shark). Sharks may not be well sampled by bottom trawl surveys, as evidenced by the high uncertainty in many of the biomass estimates. The efficiency of bottom trawl gear also varies by species, and trends in these biomass estimates should be considered, at best, a relative index of abundance for shark species until more formal analyses of survey efficiencies by species can be conducted. In particular, pelagic shark species such as salmon sharks are encountered by the trawl gear not while it is in contact with the bottom, but rather on the way down or on the way up. Biomass estimates are based, in part, on the amount of time the net spends in contact with the bottom. Consequently, bottom trawl survey biomass estimates for pelagic species are unreliable. Spiny dogfish are patchily distributed, and their distribution may vary seasonally, both geographically and within the water column. This can result in highly uncertain biomass estimates. Pacific sleeper sharks are large animals and may be able to avoid the bottom trawl gear. In addition, biomass estimates for Pacific sleeper sharks are often based on a very small number of individual hauls within a given survey and a very small number of individual sharks within a haul. Consequently, these biomass estimates can be highly uncertain. The biomass estimates presented here should be considered at best a relative index of abundance for shark species until more formal analyses of survey efficiencies by species can be conducted.

Analysis of the EBS shelf biomass time series is subject to the following caveats. The EBS shelf survey started as a crab survey in the 1960s. The survey was standardized in 1982 to its current gear type, fixed stations, and survey time period (June 1 – August 4). Prior to 1982, the set of survey stations varied greatly, and prior to 1979, the set of survey stations was very small. Consequently, surveys from 1982 to the present may be useful for identifying trends in relative abundance of commonly encountered species, while surveys between 1979 and 1982 should only be used for identifying the relative distribution of species (Gary Walters, pers. comm.).

Shark catches from the EBS shelf bottom trawl surveys are very rare, and there does not appear to be any biomass trend for shark species (Table 4 andTable **12**, Figure 3). Survey catches of Pacific sleeper sharks and spiny dogfish are so rare in the EBS shelf survey that relative abundance trends are probably unreliable (as evidenced by the high uncertainty in the biomass estimates). Salmon sharks were only captured in one haul during the entire time series of the EBS shelf survey.

Analysis of the EBS slope survey biomass time series is subject the following caveats. The slope survey was standardized in 2002 to its current gear type, survey strata, and survey design. Because the survey stratification changed in 2002, biomass estimates are not comparable between the historical EBS slope survey (1979 – 1991) and the new slope survey biomass (2002 and 2004). In addition, prior to 2002, the survey utilized a mix of commercial and research vessels with various gear configurations. Consequently, surveys from 2002, 2004, and 2008 may be useful for estimating relative abundance of commonly encountered species, while surveys between 1979 and 1991 should only be used for identifying the relative distribution of species (Gary Walters, pers. comm.).

Shark catches from the historical EBS slope bottom trawl surveys (1979 – 1991) show an increasing biomass trend for Pacific sleeper sharks but come from very few survey years (Table 5 andTable **12**, Figure 4). Historical survey catches of Pacific sleeper sharks and spiny dogfish are rare and abundance trends are unreliable for these species (as evidenced by the high uncertainty in the biomass estimates). Salmon sharks were not captured in the historical EBS slope survey (1979 – 1991).

Shark catches from recent EBS slope bottom trawl surveys (2002, 2004 and 2008) show a substantial biomass of Pacific sleeper sharks on the EBS slope in 2002 but not in 2004 and 2008 (Table 5 andTable **12**, Figure 4). Until the 2000 EBS slope pilot survey, it was thought that bottom trawl surveys did not adequately sample large shark species such as Pacific sleeper sharks. However, Pacific sleeper sharks accounted for the third highest CPUE of the 2000 EBS pilot slope survey (Gaichas 2002). This recent information suggests that Pacific sleeper sharks can be sampled by bottom trawls and that a difference in the location and timing of EBS trawl surveys may result in differing biomass estimates for sharks in the EBS. Changes in distribution of particular species may also account for biomass fluctuations. Salmon sharks have not been captured in the new EBS slope survey (2002, 2004, and 2008 Table 5). Spiny dogfish have only been recorded in one haul in the last three new EBS slope surveys (Table 5).

Shark catches in the AI bottom trawl surveys have been relatively rare, and there do not appear to be any biomass trends for shark species (Table 3 andTable **12**, Figure 2). As with the EBS shelf survey, spiny dogfish and Pacific sleeper shark catches are so rare in the AI survey that relative abundance trends are probably unreliable (as evidenced by the high uncertainty in the biomass estimates). Salmon sharks were only captured in one haul during the entire time series of the AI survey.

NMFS bottom trawl and longline and IPHC longline research survey catches of sharks from the EBS and AI are listed in Table 13.

Other Data Sources

Catch from unobserved fisheries is a concern. Work is underway to estimate the bycatch of sharks in unobserved IFQ Pacific halibut fisheries. In Appendix A we examine a modification of the previously used CPUE ratio method (Gaichas et al. 2005, Courtney et al. 2006).

Weight-at-length and average length and weight values for all three species are presented in Table 14. Length-at-age models have been published for salmon sharks (Goldman and Musick, 2006) in the GOA, and for spiny dogfish in the GOA (Tribuzio and Kruse, in press). Growth models have been published for this species for many areas around the globe though. Because of the difficulty with aging Pacific sleeper sharks, growth models are not available for this species. Growth model parameters for the von Bertalanffy growth models are presented in Table 14. While sharks are slow growing compared to teleosts fish, the spiny dogfish has the slowest growth rate of any modeled shark species.

ANALYTIC APPROACH, MODEL EVALUATION, AND RESULTS

Model Structure

The available data do not support population modeling for sharks in the BSAI, so many of the standard sections of text usually required for NPFMC SAFE reports are not relevant. We discuss estimates of M and results of demographic modeling and present ABC and OFL calculation methods. Sharks in the BSAI are managed under Tier 6, where harvest specifications based on average historical catch. Demographic models, which are not used to estimate biomass, have been evaluated for spiny dogfish (Tribuzio and Kruse, in review) and salmon sharks (Goldman 2002, Courtney et al. 2006). Age- and stage-based Leslie matrix type models were used for spiny dogfish to compare the applicability of each type for a long lived species and life tables were used for salmon sharks to validate the compensation model of Au and Smith (1997). All models estimated intrinsic rebound potential (r), sustainable fishing mortality (F), and, for the spiny dogfish models, risk contours with different fishing scenarios.

Parameters Estimated Independently

Parameters estimated independently are identified for the major shark species in the Gulf of Alaska or North Pacific where data are lacking (**Table 15**, estimates are not available for BSAI stocks and thus GOA values are used as a proxy). Data gaps are identified where data are not available (NA). An estimate of the natural mortality rate (M = 0.097) is derived for spiny dogfish in the Gulf of Alaska (Tribuzio and Kruse, in review). The value of M (0.097) for the Gulf of Alaska is similar to the previously published estimate of M from British Columbia spiny dogfish of 0.094 (Wood et al. 1979). A range of natural mortality estimates is derived for salmon shark in the central Gulf of Alaska (Goldman, 2002). A natural mortality estimate is not available for Pacific sleeper sharks. Maximum reported age for central Gulf of Alaska salmon shark is 30 years (Goldman and Musick 2006). Maximum age of spiny dogfish in the eastern North Pacific is between 80 and 100 years (Beamish and McFarlane 1985, McFarlane and Beamish 1987). Age at first recruitment to a commercial fishery is 5 years old for central Gulf of Alaska salmon sharks (Goldman, 2002). Maximum age and age of first recruitment are not available for spiny dogfish or Pacific sleeper shark, however, Tribuzio and Kruse (in press) report the youngest encountered dogfish in fishery dependent sampling was 8 years old. Ages are not currently available for Pacific sleeper shark as this species is very difficult to age.

Parameters Estimated Conditionally

Demographic analyses have been performed for both GOA spiny dogfish (Tribuzio and Kruse, in review) and ENP salmon sharks (Goldman 2002) to estimate the rebound potential and sustainable fishing levels. Assuming an unfished population, the spiny dogfish population is increasing at a rate of 3.4% (1.2-6%, 95% confidence intervals) and salmon shark are increasing at a rate of 1.2% (-1.5-4.1%, 95% confidence intervals). Sustainable fishing levels for spiny dogfish were at $F<0.03$ and for salmon shark $F<0.05$. In both models, fishing mortality was uniform across all selected age classes. These models do not take into account bycatch mortality from unobserved fisheries. Because of the assumptions of the model (i.e. closed populations, uniform F across all ages), results should be considered as a "best case" scenario. Assuming a true unfished population is not realistic, because the actual fishing mortality is >0, however, the actual level of fishing mortality is unknown. Bycatch in unobserved Pacific halibut fisheries has been modeled, but not for state fisheries such as the salmon gill net fisheries, which may have at times very high spiny dogfish mortality. Salmon sharks are rare in commercial fisheries and the sport fishery is small, therefore the actual level of fishing mortality may be closer to zero.

ABC and OFL Calculations

In 1998 the SSC recommended Tier 5 procedures for specification of Other Species ABC (ABC = 0.75*M*biomass). At the time, this shift in methodology would have indicated nearly a 4-fold increase in maximum allowable ABC. The SSC was uncomfortable with such a large increment and implemented a 10-year stair-step process to gradually increase the ABC from the Tier 6 values to the Tier 5 values. In 2006, the SSC decided that Tier 5 is not appropriate for sharks at this time and we continue with Tier 6 estimates of ABC and OFL until reliable estimates of biomass are available.

Last year (2008 recommendations for 2009), the SSC calculated the Other Species specifications as sums of Tier 5 calculations for skates and sculpins and Tier 6 calculations for sharks and octopus, and recommended a total of the ABCs and OFLs for the Other Species complex.

The Tier 6 option is provided for consideration in the BSAI. Tier 6 criteria require a reliable catch history from 1978 – 1995, which do not exist for the shark species in the BSAI prior to 1997, however catch has been estimated from 1995-2009. For this reason, Courtney et al. (2006) provided a Tier 6 calculation using 1997 – 2005 as the base period for the catch history as an alternative to the 1978 – 1995 period typically specified for Tier 6. Last year the SSC recommended placement of sharks in Tier 6 with this alternative base period, fixing the final year at 2007. We recommend using the Tier 6 methodology to estimate ABC and OFL for sharks. We also present the ABC and OFL using 1997-2008 time series. The base timeline was discussed at the Joint Plan Teams meeting in September 2009 and it was recommended that 1997-2008 be used as the base timeline for the Tier 6 "Other Species" which did not have reliable data prior to 1997.

Available data do not support Tier 5 criteria for establishing ABC and OFL for sharks in the BSAI. Typical Tier 5 criteria for establishing ABC and OFL require reliable point estimates for biomass and natural mortality. Natural mortality estimates do not exist for Pacific sleeper sharks which make up the 69% of shark biomass in the BSAI (Table 6). Natural mortality has recently been estimated for spiny dogfish in the Gulf of Alaska (M = 0.097, Tribuzio and Kruse, in review), and is included here as a conservative estimate of natural mortality for sharks in the BSAI. However, natural mortality estimates from spiny dogfish in the Gulf of Alaska may not be a reliable point estimate for the shark complex in the BSAI, which is dominated by Pacific sleeper sharks in the BSAI.

Tier 6

Tier 6 for BSAI shark ABC and OFL are presented both for individual species and for sharks as a complex. The Tier 6 option for sharks as a complex is recommended for ABC and OFL. Incidental shark catches for the years 1997 – 2002 were obtained from the pseudo-blend method (Gaichas 2001 and 2002, Table 6). Incidental shark catches for the years 2003 - 2009 were provided by the NMFS AKRO CAS (Table 6). Because of the large size of most commercial fishing vessels in the BSAI, NMFS Observer coverage of incidental shark catch in BSAI commercial fisheries is fairly complete.

Tier 6 calculations by species and total of all species (t) and recommendations for 2010-2011.

BSAI Tier 6 Calculations (mt)

Species	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidentified shark	**Total shark complex**
1997-2007 Average catch	8	416	48	126	598
ABC	6	312	36	95	449
OFL	8	416	48	126	598
1997-2008 Average catch	9	391	47	116	**564**
ABC	7	294	35	87	**423**
OFL	9	391	47	116	**564**

ECOSYSTEM CONSIDERATIONS

Ecosystem Effects on Stock, and Fishery Effects on Ecosystem

Understanding shark species population dynamics is fundamental to describing ecosystem structure and function in the Bering Sea. Shark species are top level predators as well as scavengers and likely play an important ecological role. Studies designed to determine the ecological roles of spiny dogfish, Pacific sleeper sharks, and salmon sharks are ongoing and will be critical to determine the affect of fluctuations in shark populations on community structure in the BSAI.

Spiny dogfish

Previous studies have shown spiny dogfish to be opportunistic feeders (Alverson and Stansby 1963), not wholly dependent on one food source. Small dogfish are limited to consuming smaller fish and invertebrates, while the larger animals will eat a wide variety of foods (Bonham 1954). Diet changes are consistent with the changes of the species assemblages in the area by season (Laptikhovsky et al. 2001). Spiny dogfish in the northwest Atlantic can eat twice as much in summer as in winter (Jones and Geen 1977). Spiny dogfish have also been shown to prey heavily on out-migrating salmon smolts (Beamish et al. 1992). In the GOA, preliminary diet studies further suggest that spiny dogfish are highly generalized, opportunistic feeders (Tribuzio, unpublished data).

Pacific sleeper shark

Pacific sleeper sharks were once thought to be sluggish and benthic because their stomachs commonly contain offal, cephalopods, and bottom dwelling fish such as flounder (*Pleuronectidae*) (e.g., Yang and Page 1999). The more current hypothesis is that these sharks make vertical oscillations throughout the water column searching for prey as well as scavenging. Evidence for this behavior was documented in a tagging study in the Gulf of Alaska (Hulbert et al. 2006). Also, a diet analysis documented prey from different depths in the stomachs of a single shark, such as giant grenadier (*Albatrossia pectoralis*) and pink salmon (*Oncorhynchus gorbuscha*), indicating that they make depth oscillations in search of food (Orlov and Moiseev 1999). Other diet studies that have found that Pacific sleeper sharks prey on fast moving fish such as salmon (*O. spp.)* and tuna (*Thunnus spp*.), and marine mammals such as harbor seals (*Phoca vitulina*), that live near the surface (e.g., Bright 1959; Ebert et al. 1987; Crovetto et al. 1992; Sigler et al. 2006), suggesting that these sharks may not be as sluggish and benthic oriented as once thought. Although Pacific sleeper sharks share the same areas as pupping Stellar sea lions (*Eumetopias jubatus*) in the Gulf of Alaska, they were not found to prey on newborn sea lions but did have tissues from other marine mammals in their stomachs (Sigler et al. 2006). Taggart et al. (2005) found that Pacific sleeper sharks in Glacier Bay were only caught in traps at locations where harbor seals were at their highest concentrations. However, they did not find any seal tissue in their stomachs and concluded that Pacific sleeper sharks may either be a predator of the seals or might be attracted to the same food sources as the seals, such as walleye pollock (*Theragra chalcogramma*), cephalopods, flounder, or capelin (*Mallotus villosus*).

Analyses of mercury and other elemental concentrations in the tissues of Pacific sleeper sharks show that they are at a lower trophic level than ringed seals (*Pusa hispida*) and were at a similar level as flathead sole (*Hippoglossoides elassodon*) (McMeans et al. 2007). Another study used stable isotopes to determine the trophic level of Greenland sharks and found that larger sharks were at a higher trophic level than smaller sharks because larger sharks were more likely to feed on marine mammals (Fisk et al. 2002).

Salmon Shark

Salmon sharks are opportunistic feeders, sharing the highest trophic level of the food web in subarctic Pacific waters with marine mammals and seabirds (Brodeur 1988, Nagasawa 1998, Goldman and Human 2004). They feed on a wide variety of prey, including salmon (*Oncorhynchus* sp.), rockfishes (family Sebastes), sablefish (*Anoplopoma fimbria*), lancetfish (family Alepisaurus), daggertooth (family Anotopterus), lumpfishes (family Cyclopteridae), sculpins (family Cottidae), Atka mackerel (*Pleurogrammus*), mackerel (family Scomber), pollock and tomcod (family Gadidae), herring (family Clupeidae), spiny dogfish, tanner crab (family Chionoecetes), squid, and shrimp (Sano 1960 and 1962, Farquhar 1963, Hart 1973, Urquhart 1981, Compagno 1984 and 2001, Nagasawa 1998). Incidental catch in the central Pacific has been significantly reduced since the elimination of the drift gillnet fishery, and the population appears to have rebounded to its former levels (Yatsu et al. 1993, H. Nakano pers. comm.). Additionally, recent demographic analyses support the contention that salmon shark populations in the eastern and western North Pacific are stable at this time (Goldman 2002). Seasonal foraging movements and migratory patterns of salmon sharks in the northeast Pacific Ocean have been described in Hulbert et al. (2005) and Weng et al. (2005).

Ecosystem effects on *GOA Sharks*			
Indicator	Observation	Interpretation	Evaluation
Prey availability or abundance trends			
Zooplankton	Stomach contents, ichthyoplankton surveys, changes mean wt-at-age	Stable, data limited	Unknown
Non-pandalid shrimp and other benthic organism	Trends are not currently measured directly, only short time series of food habits data exist for potential retrospective measurement	Composes the main portion of spiny dogfish diet	Unknown
Sandlance, capelin, other forage fish	Trends are not currently measured directly, only short time series of food habits data exist for potential retrospective measurement	Unknown	Unknown
Salmon	Populations are stable or slightly decreasing in some areas	Small portion of spiny dogfish diet, maybe a large portion of salmon shark diet	No concern
Flatfish	Increasing to steady populations currently at high biomass levels	Adequate forage available	No concern
Pollock	High population levels in early 1980's, declined to stable low level at present	Primarily a component of salmon shark diets	No concern
Other Groundfish	Stable to low populations	Varied in diets of sharks	No concern
Predator population trends			
Marine mammals	Fur seals declining, Steller sea lions increasing slightly	No likely a predator on sharks	No concern
Birds	Stable, some increasing some decreasing	Affects young-of-year mortality	No concern
Fish (Pollock, Pacific cod, halibut)	Stable to increasing	Possible increases to juvenile spiny dogfish mortality	
Sharks	Stable to increasing	Larger species may prey on spiny dogfish	Currently, no concern
Changes in habitat quality			
Temperature regime	Warm and cold regimes	May shift distribution, species tolerate wide range of temps	No concern
Benthic ranging from inshore waters to shelf break and down slope	Sharks can be highly mobile, and benthic habitats have not been monitored historically, species may be able to move to preferred habitat, no critical habitat defined for GOA	Habitat changes may shift distribution	No concern

***GOA Sharks* effects on ecosystem**			
Indicator	Observation	Interpretation	Evaluation
Fishery contribution to bycatch			
Not Targeted	None	No concern	No concern
Fishery concentration in space and time	None	No concern	No concern
Fishery effects on amount of large size target fish	If targeted, could reduce avg size of females, reduce recruitment, reduce fecundity, skewed sex ratio (observed in areas targeting species)	No concern at this time	No concern at this time
Fishery contribution to discards and offal production	None	No concern	No concern
Fishery effects on age-at-maturity and fecundity	Age at maturity and fecundity decrease in areas that have targeted species	No concern at this time	No concern at this time

Data Gaps and Research Priorities

Data limitations are severe for shark species in the GOA and effective management of sharks is extremely difficult with the current limited information. Gaps include inadequate catch estimation, unreliable biomass estimates, lack of size frequency collections, and a lack of life history information including age and maturity, especially for Pacific sleeper sharks. Regardless of future management decisions for the structure for the Other Species management category, it is essential to continue to improve shark fishery and survey sampling with the collection of biological data from sharks. Future shark research priorities will focus on the following areas:

1. Expand collection of length data and begin collecting age samples from NMFS and IPHC surveys in the GOA
2. Improve species identification by observers
3. Collect length data from sharks caught in observed hauls/samples on observed commercial vessels
4. Estimate bycatch from unobserved fisheries (see Appendix A for halibut IFQ fishery)
5. Define the stock structure and migration patterns (i.e. tagging studies, genetics)
6. Determine or clarify existing estimates of life history parameters for use in models

SUMMARY

There is no evidence to suggest that overfishing is occurring for any shark species in the BSAI. There are currently no directed commercial fisheries for shark species in federally or state managed waters of the BSAI, and most incidentally captured sharks are not retained. Spiny dogfish are allowed as retained incidental catch in some ADF&G managed fisheries, and salmon sharks are targeted by some sport fishermen in Alaska state waters. Incidental catches of shark species in the BSAI fisheries have been very small compared to catches of target species. Sharks have only been reported to species in the catch since 1997 and have made up from 1% to 5% of Other Species catch from 1997 – 2005. Preliminary comparisons of incidental catch rates with available biomass by species suggest that current levels of incidental catches are low relative to available biomass for Pacific sleeper sharks in the BSAI (Courtney et al. 2006). In the BSAI, average catch of Pacific sleeper sharks from 1997 – 2005 (445 metric tons) represented 2.5% of the available Pacific sleeper shark biomass from BSAI bottom trawl surveys 1996 – 2005 (total of average Pacific sleeper shark biomass from EBS shelf, EBS slope and AI surveys for the years 1996 – 2005 is 17,647 metric tons; Table 2 - Table 4). Spiny dogfish and salmon sharks were rarely encountered in commercial fisheries or bottom trawl surveys in the BSAI.

2010 and 2011 recommendations	Spiny Dogfish	Pacific Sleeper Shark	Salmon Shark	Other/unid Shark
Tier	6	6	6	6
M	0.097	0.097	0.18	0.097
Avg catch (1997-2008)	9	391	47	116
ABC	7	294	35	87
OFL	9	391	47	116

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Table 1. Biological characteristics and depth ranges for shark species in the eastern Bering Sea, and Aleutian Islands (BSAI). Missing information is denoted by "?".

Scientific Name	Common Name	Max. Obs. Length (TL, cm)	Max. Obs. Age	Age, Length, 50% Maturity	Feeding Mode	Fecundity	Depth Range (m)
Apristurus brunneus	brown cat shark	68[1]	?	?	Benthic[3]	?	1,306[2]
Carcharodon carcharias	White shark	792[4]	36[7]	15 yrs, 5 m[7]	Predator[6]	7-14[5]	1,280[3]
Cetorhinus maximus	basking shark	1,520[1]	?	5 yrs, 5m[8]	Plankton[6]	?	?
Hexanchus griseus	sixgill shark	482[9]	?	4m[1]	Predator[6]	22-108[1]	2,500[10]
Lamna ditropis	salmon shark	305[1]	20[11]	6-9 yrs, 165 cm PCL[11]	Predator[6]	3-5[7]	668[12]
Prionace glauca	blue shark	400[16]	15[13]	5 yrs[5], 221 cm[14]	Predator[6]	15-30 (up to 130)[15]	150[16]
Somniosus pacificus	Pacific sleeper shark	700[1]	?	?	Benth/Scav[17]	Up to 300[1]	2,700[18]
Squalus acanthias	Spiny dogfish	125[19]	107[20]	34 yrs, 80 cm[19]	Pred/Scav/Bent[19]	7-14[19]	300[3]

[1]Compagno, 1984; [2]Eschmeyer et al., 1983; [3]Mecklenburg et al. 2002; [4]Scott and Scott, 1988; [5]Smith et al. 1998; [6]Cortes, 1999; [7]Gilmore, 1993; [8]Mooney-Seus and Stone, 1997; [9]Castro, 1983; [10]Last and Stevens, 1994; [11]Goldman and Musick 2006, [12]Hulbert et al. 2005; [13]Stevens, 1975; [14] ICES 1997; [15] White et al. 2006; [16]Smith, 1997; [17]Yang and Page, 1999; [18]www.nurp.noaa.gov; [19]Tribuzio ongoing studies; [20]G. A. McFarlane, pers. comm.

Table 2. Time series of Other Species TAC, Other Species and shark catch, ABC for sharks and the management method for 1997-2009.

Year	Other spp. TAC	Est. other spp. catch	Est. shark catch	ABC	Management method
1997	25,800	25,176	368	N/A	Other Species TAC
1998	28,800	25,531	497	N/A	Other Species TAC
1999	32,860	20,562	530	N/A	Other Species TAC
2000	31,360	26,108	590	N/A	Other Species TAC
2001	26,500	27,178	764	N/A	Other Species TAC
2002	30,825	26,296	1,362	N/A	Other Species TAC
2003	32,309	25,373	520	N/A	Other Species TAC
2004	27,205	29,637	515	N/A	Other Species TAC
2005	29,000	29,505	417	N/A	Other Species TAC
2006	29,000	26,797	689	N/A	Other Species TAC
2007	37,355	26,667	331	463	Other Species TAC
2008	50,000	21,340	185	463	Other Species TAC
2009	50,000	24,291	132	447	Other Species TAC

Data Sources: TAC and Other Species catch came from AKRO catch statistics website. 1977- 2002 Gaichas (2002); 2003 - 2009 NMFS AKRO BLEND database, Juneau, AK 99801, as of Oct. 7, 2009.

Table 3. Aleutian Islands AFSC trawl survey estimates of individual shark species total biomass (metric tons) with CV, and number of hauls. Source: Personal communication, Mark Wilkins, Oct. 2008.

		Spiny Dogfish			Pacific sleeper Shark			Salmon Shark		
Year	Survey Hauls	Hauls w/catch	Biomass Est.	CV	Hauls w/catch	Biomass Est.	CV	Hauls w/catch	Biomass Est.	CV
1980	129	0			0			0		
1983	372	3	2.3	0.61	3	253.50	0.65	0		
1986	443	6	13.8	0.51	12	1994.90	0.36	0		
1991	331	0			3	2926.50	0.69	0		
1994	381	9	47.00	0.37	3	373.50	0.64	0		
1997	397	2	11.4	0.71	10	2485.70	0.29	0		
2000	419	3	25.00	0.62	3	2638.30	0.57	0		
2002	417	0			4	536.20	0.55	1	893.00	1.00
2004	420	0			2	1016.90	0.96	0		
2006	358	6	61.8	0.49	1	76.40	1.00	0		

Table 4. Eastern Bering Sea shelf AFSC trawl survey estimates of individual shark species total biomass (metric tons) with cv and number of hauls (Bob Lauth, pers. comm., October, 2009).

		Spiny Dogfish			Pacific sleeper Shark			Salmon Shark		
Year	Survey Hauls	Hauls w/catch	Biomass Est.	CV	Hauls w/catch	Biomass Est.	CV	Hauls w/catch	Biomass Est.	CV
1979	452	4	389	0.56	0			0		
1980	342	0			0			0		
1981	290	0			0			0		
1982	329	0			0			0		
1983	354	2	379	0.83	0			0		
1984	355	0			0			0		
1985	353	1	47	0.99	0			0		
1986	354	0			0			0		
1987	342	3	223	0.60	0			0		
1988	353	1	249	1.0	0			1	3,808	1.0
1989	353	0			0			0		
1990	352	0			0			0		
1991	351	0			0			0		
1992	336	0			2	2,564	0.72	0		
1993	355	0			0			0		
1994	355	0			2	5,012	0.82	0		
1995	356	0			1	1,005	1.00	0		
1996	355	0			2	2,804	0.82	0		
1997	356	1	37	1	0			0		
1998	355	1	254	1	1	2,124	1.00	0		
1999	353	0			2	2,079	0.71	0		
2000	352	0			1	1,487	1.00	0		
2001	355	0			0			0		
2002	355	0			3	5,602	0.65	0		
2003	356	0			1	734	1.00	0		
2004	355	1	28	1.00	2	3,093	0.71	0		
2005	353	0			2	1,532	0.75	0		
2006	356	0			2	2,944	0.78	0		
2007	356	0			0			0		
2008	375	0			0			0		
2009	376	1	72	1	0			0		

Table 5. Eastern Bering Sea slope AFSC trawl survey estimates of individual shark species total biomass (metric tons) with cv, and number of hauls (Jerry Hoff, pers. comm., October, 2008).

		Spiny Dogfish			Pacific sleeper Shark			Salmon Shark		
Year	Survey Hauls	Hauls w/catch	Biomass Est.	CV	Hauls w/catch	Biomass Est.	CV	Hauls w/catch	Biomass Est.	CV
1979	105	0			0			0		
1981	205	1	1	0.83	0			0		
1982	299	3	8	0.73	1	12	1.02	0		
1985	325	3	2	0.66	19	543	0.1	0		
1988	131	0			10	1,993	0.39	0		
1991	85	0			6	1,235	0.44	0		
New Slope Survey										
2002	141	0			15	25,445	0.87	0		
2004	231	0			24	2,260	0.34	0		
2008	207	1	14	1	28	2,037	0.27	0		

Table 6. Estimated incidental catch (mt) of sharks in the eastern Bering Sea and Aleutian Islands (BSAI) by species as of October 7, 2009. 1997 – 2002 from the NMFS pseudo-blend catch estimation procedure (Gaichas 2001, 2002), 2003 – 2009 from NMFS AKRO blend-estimated annual catches.

Year	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidentified shark	Total sharks	Total other species	Shark % of other species
1998	6	336	18	136	497	25,531	2%
1999	5	319	30	176	530	20,562	3%
2000	9	490	23	68	590	26,108	2%
2001	17	687	24	35	764	27,178	3%
2002	9	839	47	468	1,362	26,296	5%
2003	11	280	196	33	520	26,938	2%
2004	9	420	26	60	515	30,364	2%
2005	11	333	47	26	417	30,678	1%
2006	7	313	63	305	689	28,299	2%
2007	3	256	44	28	331	27,833	1%
2008	17	120	42	7	185	31,137	1%
2009	6	45	76	6	132	24,291	1%
Total est. catch	113	4,742	643	1,401	6,901	350,390	
species % of total sharks	2%	69%	9%	20%			
Avg. 1997 – 2008	9	391	47	116	564	27,175	

Sources:
1997 – 2002; Gaichas (2002, Table 15-5).
2003 – 2009; NMFS AKRO as of October 7, 2009.

Table 7. Estimated discard rates of sharks (by species) in the BSAI. Source: AKFIN database, queried by Terry Hiatt.

Year	**Spiny dogfish**	**Pacific sleeper shark**	**Salmon shark**	**Other/Unidentified shark**
		Aleutian Islands		
2005	100%	100%	100%	100%
2006	100%	100%	100%	100%
2007	99%	100%	100%	100%
2008	100%	100%	100%	100%
2009	100%	100%	100%	100%
Average	100%	100%	100%	100%
		Bering Sea		
2005	99%	96%	97%	74%
2006	98%	95%	98%	97%
2007	98%	93%	99%	47%
2008	100%	94%	97%	37%
2009	97%	95%	100%	34%
Average	99%	95%	98%	89%

Table 8. Estimated catches (mt) of spiny dogfish in the eastern Bering Sea and Aleutian Islands (BSAI) by target fishery. Years 1997-2001 from the pseudo-blend catch estimation procedure (Gaichas 2002), 2004-2009 are from NMFS AKRO blend-estimated annual catches.

Year	Atka Mackerel	Flatfish	Pacific Cod	Pollock	Rockfish	Sablefish	Turbot	Halibut	Total
1997	0	0	4.1	0	0	0	0		4.1
1998	0.2	0.4	5.6	0.1	0	0	0		6.3
1999	0	0	4.9	0	0	0	0		4.9
2000	0	0.2	8.6	0	0	0	0		8.8
2001	2.8	1.6	12.7	0.1	0	0.1	0		17.3
2002									
2003	0.1	0	11.0	0	0	0	0	0.1	11.3
2004	0	0.2	8.3	0	0	0.1	0	0	8.6
2005	0	0.1	11.2	0	0	0	0	0	11.4
2006	0.1	0.1	6.6	0.2	0	0.1	0	0	7.0
2007	0	0.3	2.5	0.2	0	0.1	0	0	3.0
2008	0.1	0.2	10.2	0.2	0.2	0	0	5.9	16.7
2009	0	0.1	4.8	0.4	0	0.2	0	0	5.5
Total	3.3	3.2	90.5	1.2	0.1	0.6	0.1	5.9	104.9
Avg. % of Total	3%	3%	86%	1%	0%	1%	0%	6%	

Table 9. Estimated catches (mt) of Pacific sleeper sharks in the eastern Bering Sea and Aleutian Islands (BSAI) by target fishery. Years 1997-2001 from the pseudo-blend catch estimation procedure (Gaichas 2002), 2004-2009 are from NMFS AKRO CAS.

Year	Atka Mackerel	Flatfish Total	Pacific Cod Total	Pollock Total	Rockfish Total	Sablefish Total	Turbot Total	Halibut	Total
1997	0.1	0	0	6.7	0	0	0		6.8
1998	0	0.1	0.8	16.2	0	0	0.8		17.9
1999	0.2	2.5	1.2	24.7	0	0	1.5		30.1
2000	0	0	3.8	19.5	0	0	0		23.3
2001	0.4	0.4	1.2	22.5	0	0	0		24.5
2002									
2003	0.5	33.5	121.1	74.4	0.5	19.3	9.7	18.4	277.4
2004	2.0	37.3	229.8	144.0	0.7	2.3	2.6	1.1	419.9
2005	0	6.3	191.2	127.6	0.1	3.8	2.7	0.1	331.8
2006	0	9.5	122.9	178.0	0.1	1.0	1.3	0.1	312.9
2007	1.9	8.5	44.3	180.2	14.5	2.4	0.5	0	251.5
2008	0.1	5.9	12.4	98.1	1.2	1.2	0.4	0	119.2
2009	0.6	8.5	12.0	22.4	0.2	1.2	0.1	0	45.0
Total	4.9	112.4	740.7	914.3	17.4	31.3	19.5	19.8	1,860.2
Avg. % of Total	0%	6%	40%	49%	1%	2%	1%	1%	

Table 10. Estimated catches (mt) of salmon sharks in the eastern Bering Sea and Aleutian Islands (BSAI) by target fishery. Years 1997-2001 from the pseudo-blend catch estimation procedure (Gaichas 2002), 2004-2009 are from NMFS AKRO CAS.

Year	Atka Mackerel	Flatfish	Pacific Cod	Pollock	Rockfish	Sablefish	Turbot	Halibut	Total
1997	0.1	0	0	6.7	0	0	0		6.8
1998	0	0.1	0.8	16.2	0	0	0.8		17.9
1999	0.2	2.5	1.2	24.7	0	0	1.5		30.1
2000	0	0	3.8	19.5	0	0	0		23.3
2001	0.4	0.4	1.2	22.5	0	0	0		24.5
2002									
2003	0.1	0.5	0.9	194.9	0	0	0	0	196.3
2004	0	0.1	0.1	25.5	0	0	0	0	25.6
2005	18.2	0.7	2.0	25.7	0	0	0	0	46.7
2006	0.2	25.9	1.2	36.1	0	0	0	0	63.3
2007	0.1	0	0	44.4	0	0	0	0	44.5
2008	0	0.8	0	41.7	0	0	0	0	42.5
2009	0.3	1.7	0.1	73.5	0	0	0	0	75.6
Total	19.6	32.6	11.2	531.4	0	0	2.3	0	597.1
Avg. % of Total	3%	5%	2%	89%	0%	0%	0%	0%	

Table 11. Estimated catches (mt) of other and unidentified sharks in the eastern Bering Sea and Aleutian Islands (BSAI) by target fishery. Years 1997-2001 from the pseudo-blend catch estimation procedure (Gaichas 2002), 2004-2009 are from NMFS AKRO CAS.

Year	Atka Mackerel	Flatfish	Pacific Cod	Pollock	Rockfish	Sablefish	Turbot	Halibut	Total
1997	0	0.4	26.8	15.6	2.5	1.2	6.3		52.8
1998	13.1	0	48.4	45.4	0	2.1	26.9		135.9
1999	0	0.2	18.8	10.3	0	1.8	144.9		176
2000	0	1.2	56.1	0.1	0	7.2	3		67.6
2001	0	0	19.6	2.3	0	10.4	2.7		35
2002									
2003	0	0	19.7	11.9	0	0	1.28	0	32.9
2004	0	22.2	20.2	17.6	0	0.04	0	0	60.1
2005	0	0	10.1	16.0	0	0.01	0	0	26.2
2006	0	2.1	3.6	298.0	0	0.07	1.59	0	305.4
2007	0	5.9	2.1	19.8	0	0	0	0	27.8
2008	0	0.3	0.6	5.9	0	0	0	0	6.8
2009	0	0	0.2	5.4	0.21	0.00	0	0	5.9
Total	13.1	32.3	226.3	448.3	2.71	22.8	186.7	0	932.3
Avg. % of Total	1%	3%	24%	48%	0%	2%	20%	0%	

Table 12. Total shark biomass estimates (mt) from AFSC bottom trawl surveys in the eastern Bering Sea (EBS), and Aleutian Islands (AI).

Year	EBS Shelf	EBS Slope	AI
1979	389	0	
1980	0		0
1981	0	1	
1982	0	20	
1983	379		255
1984	0		
1985	47	545	
1986	0		2,009
1987	223		
1988	4,057	1,993	
1989	0		
1990	0		
1991	0	1,235	2,926
1992	2,564		
1993	0		
1994	5,012		420
1995	1,005		
1996	2,804		
1997	37		2,497
1998	2,378		
1999	2,079		
2000	1,487	Pilot survey	2,663
2001	0		
2002	5,602	25,445	1,429
2003	734		
2004	3,121	2,260	1,017
2005	1,523		
2006	2,944		138
2007	0		
2008	0	2,051	
2009	71		

Source: Gaichas et al. (1999, Table 15), Gaichas (2003, Table 16-8). EBS Shelf and Slope updated Oct, 2008 (Pers. Comm., Bob Lauth, Jerry Hoff). AI updated Oct 2008 (Pers. Comm., Mark Wilkins).

Table 13. Research catches of sharks between 1977 and 2009 in the eastern Bering Sea (EBS), and Aleutian Islands (AI). Trawl survey catches are reported in metric tons (mt), longline surveys are reported in numbers (#'s).

Year	EBS (mt)	AI (mt)	NMFS LL (#'s)	IPHC LL (#'s)
1977	0			
1978				
1979	0.03			
1980	0	0.3		
1981	0.07			
1982	0.16	0.02		
1983	0.01	0.26		
1984				
1985	0.59			
1986		2.21		
1987	0.01			
1988	1.06			
1989	0.07			
1990	0			
1991	0.56	0.52		
1992	0.09			
1993				
1994	0.17	0.13		
1995	0.04			
1996	0.1		2	
1997	0.11	0.42	81	
1998	0.09		1	207
1999	0.08		20	152
2000	8.5	0.62	2	723
2001			12	164
2002	5.74	0.23	1	169
2003	0.03		11	368
2004	0.76	0.1	3	251
2005	0		6	237
2006	0	0.07	2	241
2007	0		34	170
2008	0.47		8	208
2009	2.02		2	

Sources: Gaichas et al. (1999, Table 3), Gaichas (2002, Table 15-9), Bob Lauth, Mark Wilkins and Jerry Hoff (Pers. Comm.)

Table 14. Life history parameters for spiny dogfish, Pacific sleeper, and salmon sharks. Top: Length-weight coefficients and average lengths and weights are provided for the formula $W=aL^b$, where W = weight in kilograms and L = PCL (precaudal length in cm). Bottom: Length at age coefficients are from the von Bertalanffy growth model coefficients, where L_∞ is PCL or the TL_{ext} (total length with the upper lobe of the caudal fin depressed to align with the horizontal axis of the body). Sources: NMFS sablefish longline surveys 2004 - 2006, NMFS GOA bottom trawl surveys in 2005; Sigler et al (2006); Goldman and Musick (2006); and Tribuzio and Kruse (in review).

Species	Area	Gear type	Sex	Average size PCL (cm)	Average weight (kg)	a	b	Sample size
Spiny dogfish	GOA	NMFS bottom trawl surveys	M	63.4	2	1.40E-05	2.86	92
Spiny dogfish	GOA	NMFS bottom trawl surveys	F	63.8	2.29	8.03E-06	3.02	140
Spiny dogfish	GOA	Longline surveys	M	64.6	1.99	9.85E-06	2.93	156
Spiny dogfish	GOA	Longline surveys	F	64.7	2.2	3.52E-06	3.2	188
Pacific sleeper shark	Central GOA	Longline surveys	M	166	69.7	2.18E-05	2.93	NA
Pacific sleeper shark	Central GOA	Longline surveys	F	170	74.8	2.18E-05	2.93	NA
Salmon shark	Central GOA	NA	M	171.9	116.7	3.20E-06	3.383	NA
Salmon shark	Central GOA	NA	F	184.7	146.9	8.20E-05	2.759	NA

Species	Sex	L_∞ (cm)	κ	t_0 (years)
Spiny Dogfish	M	93.7 (TL_{ext})	0.06	-5.1
Spiny Dogfish	F	132.0 (TL_{ext})	0.03	-6.4
Pacific Sleeper Shark	M	NA	NA	NA
Pacific Sleeper Shark	F	NA	NA	NA
Salmon Shark	M	182.8 (PCL)	0.23	-2.3
Salmon Shark	F	207.4 (PCL)	0.17	-1.9

Table 15. Natural mortality parameter estimates for each species in the GOA. Sources for GOA spiny dogfish are Tribuzio and Kruse (in review), ENP spiny dogfish (Wood et al. 1979) and Goldman (2002) for salmon shark.

Species	Area	M for Tier calc	Max age	Age of first recruit
Spiny dogfish	GOA	0.097	NA	NA
Spiny dogfish	ENP	0.094	80 – 100	NA
Pacific sleeper shark	NA	NA	NA	NA
Salmon shark	GOA	0.18	30	5

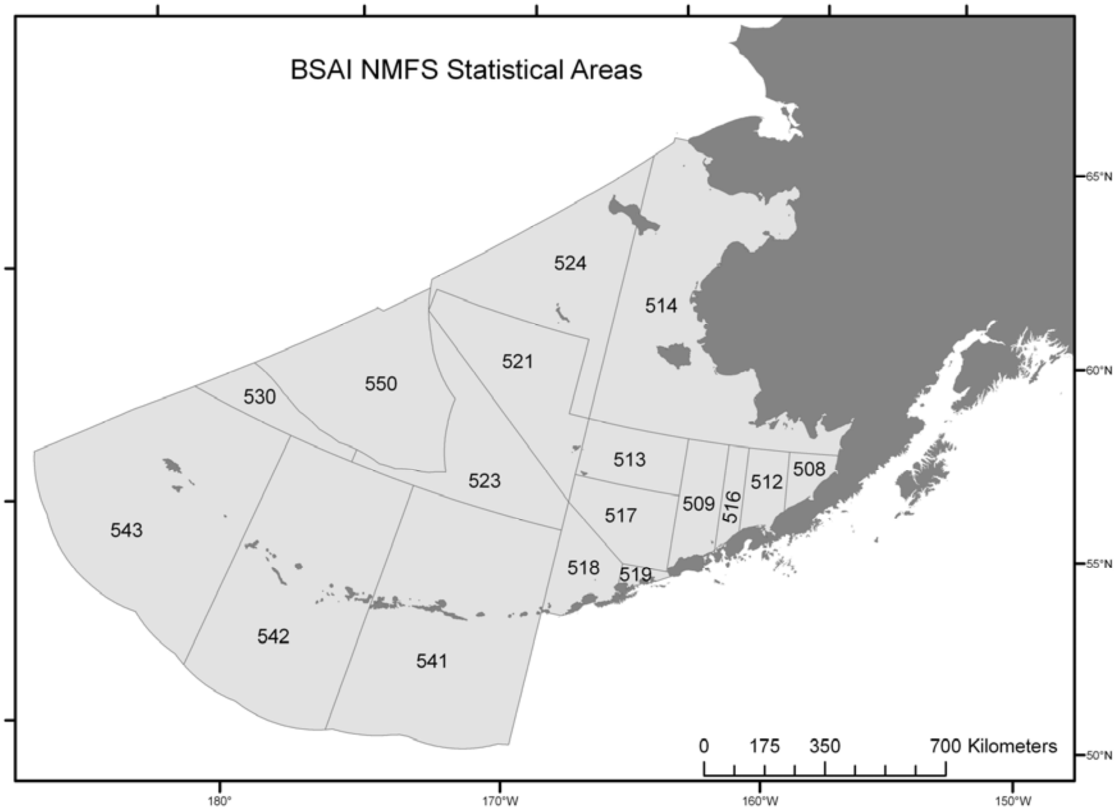

Figure 1. NMFS statistical areas in the Bering Sea and Aleutian Islands.

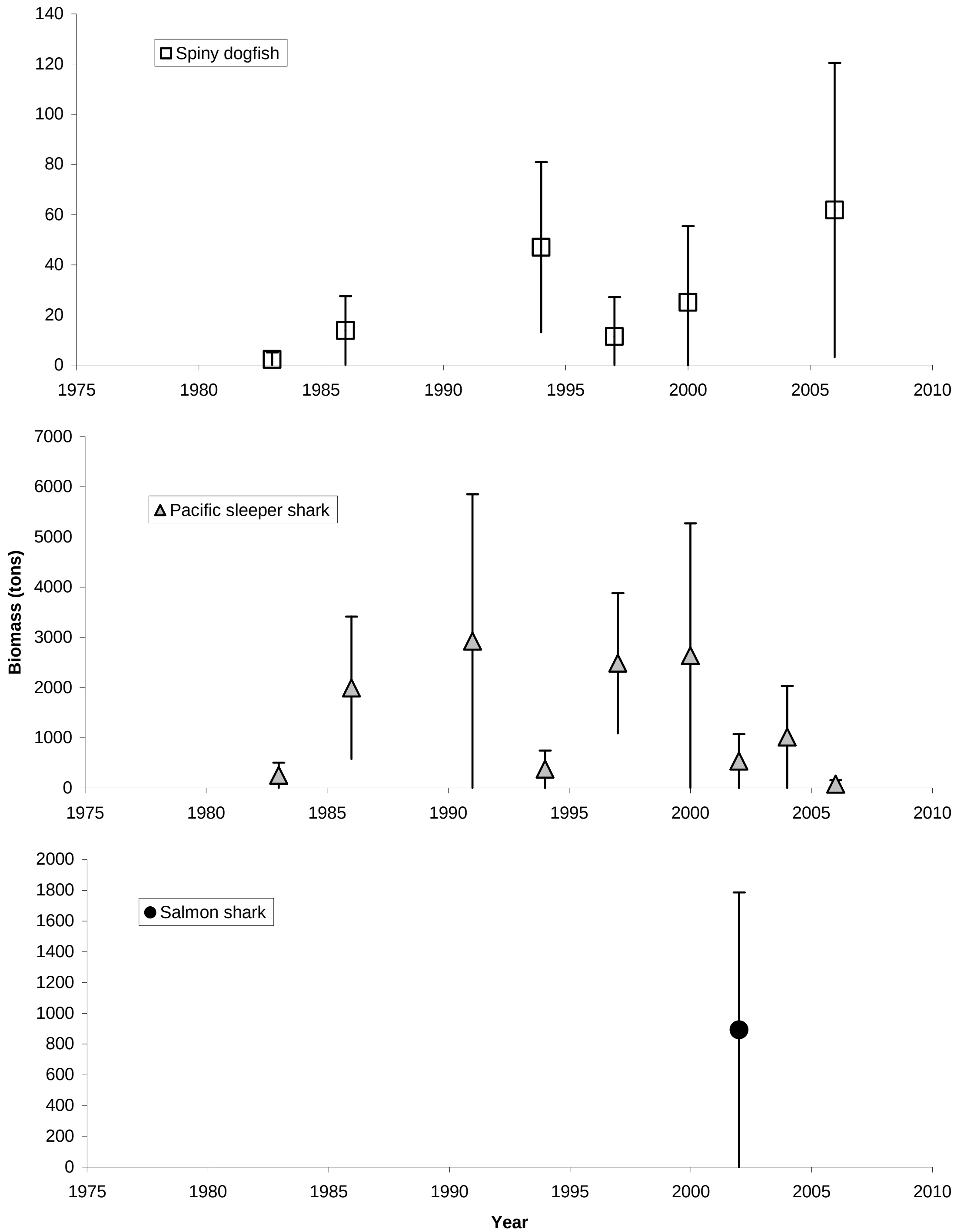

Figure 2. Time series of biomass estimates (mt) for spiny dogfish, Pacific sleeper and salmon sharks in the Aleutian Islands (AI) AFSC bottom trawl surveys, reported here as an index of relative abundance. Error bars are 95% confidence intervals. Analysis of AI survey biomass trends is subject the following time series caveats. Catchability of sharks in the AI trawl survey is unknown.

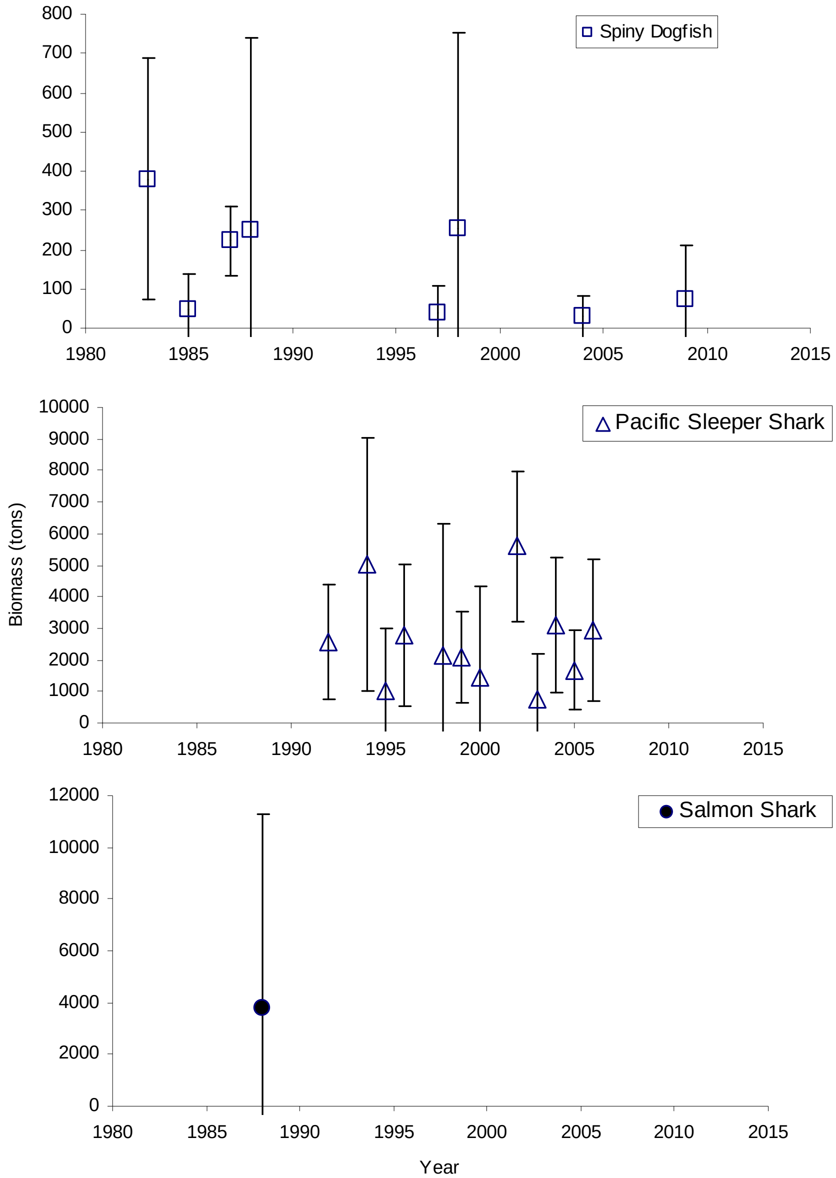

Figure 3. Time series of biomass estimates (mt) in the eastern Bering Sea shelf AFSC bottom trawl surveys of spiny dogfish, Pacific sleeper and salmon sharks, reported here as an index of relative abundance. Error bars are 95% confidence intervals. Analysis of EBS shelf biomass trends is subject to following time series caveats. The EBS shelf survey started as a crab survey in the 1960's. The survey was standardized in 1982 to its current gear type, fixed stations, and survey time period (June 1 – August 4). Prior to 1982, the set of survey stations varied greatly, and prior to 1979 the set of survey stations was very small.

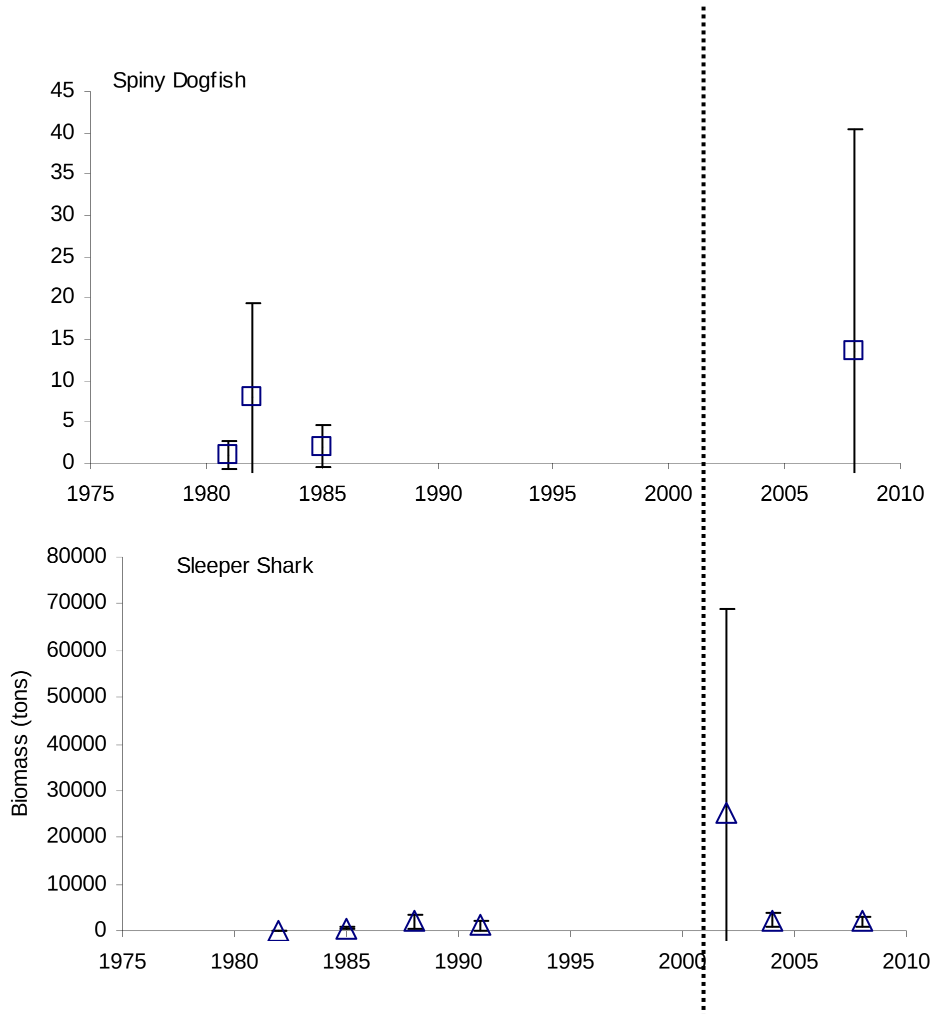

Figure 4. Time series of biomass estimates (mt) in the eastern Bering Sea (EBS) slope AFSC bottom trawl surveys of spiny dogfish and Pacific sleeper sharks (salmon sharks are not encounted on the EBS slope survey), reported here as an index of relative abundance. Error bars are 95% confidence intervals. Dashed line indicates beginning of new EBS slope survey (2002, 2004), which is not comparable to the historical survey (1979 – 1991). Analysis of EBS slope survey biomass trends is subject the following time series caveats. The slope survey was standardized in 2002 to its current gear type, survey strata, and survey design. Because the survey stratification changed in 2002, biomass estimates are not comparable between the historical EBS slope survey (1979 – 1991) and the new slope survey biomass (2002 and 2008). In addition, prior to 2002, the survey utilized a mix of commercial and research vessels with various gear configurations. Salmon shark have not been recorded on this survey.

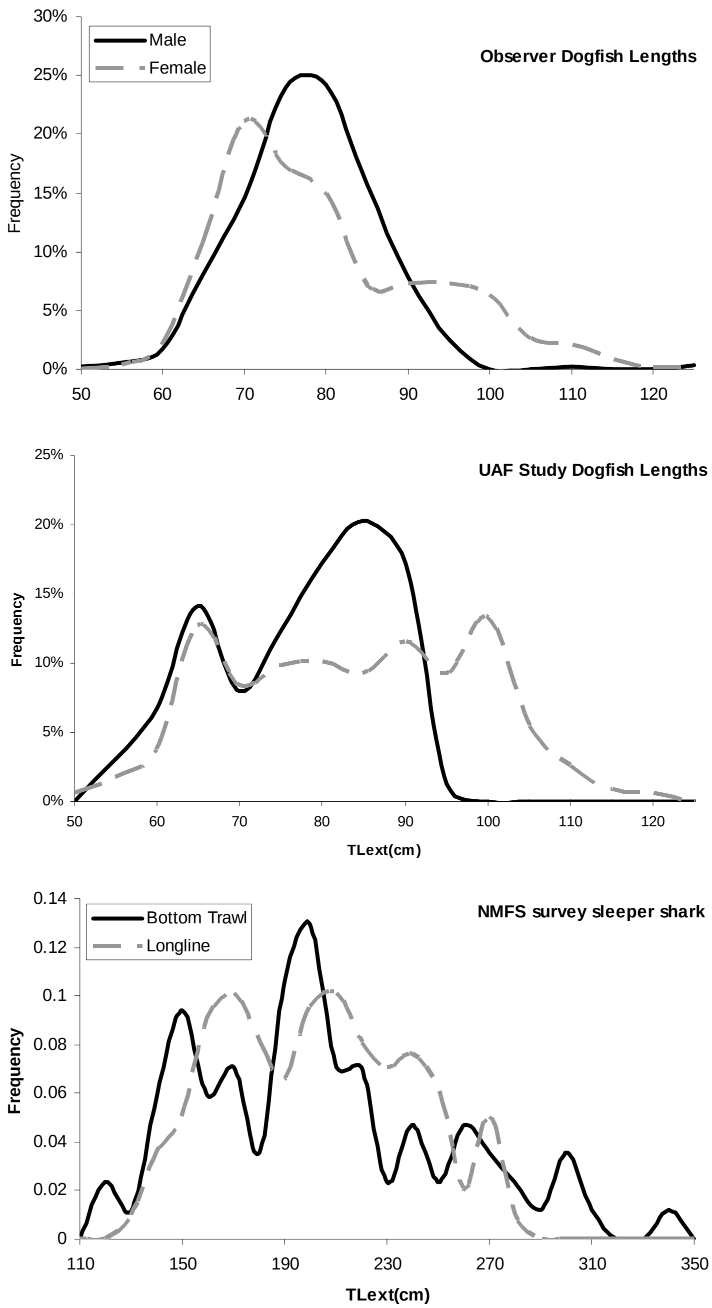

Figure 5. Observed length frequencies for: (top) spiny dogfish collected during a special project with the observer program (in BSAI and GOA); (center) spiny dogfish taken from a separate study conducted by the University of Alaska Fairbanks (GOA); (bottom) Pacific sleeper shark taken during both the bottom trawl and longline surveys (in BSAI and GOA).

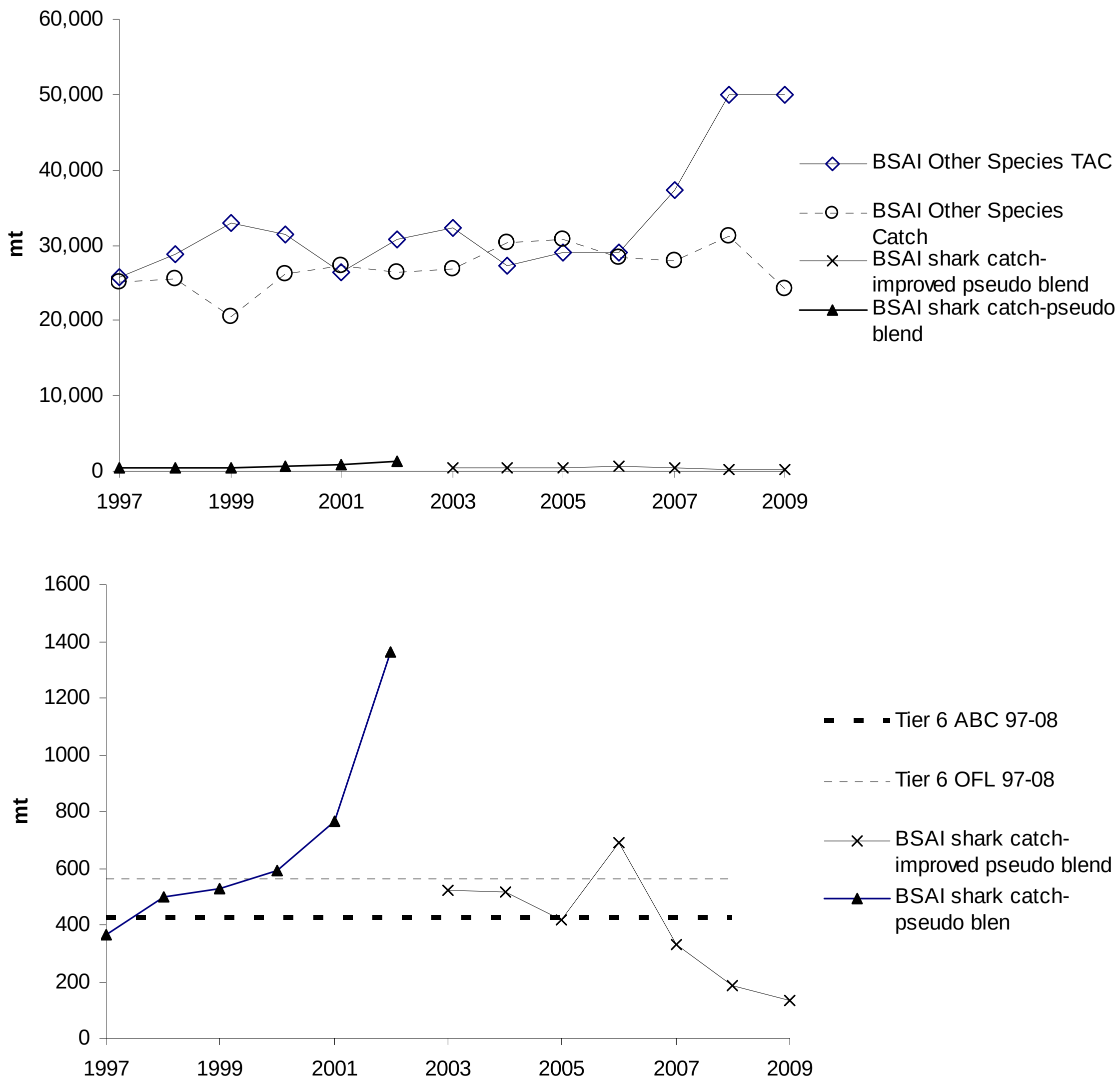

Figure 6. Top: comparison of total BSAI shark catch relative to the total Other Species catch and the Other Species TAC. BSAI total shark catch has been low relative to BSAI other species catch. Bottom: BSAI total shark catch per year plotted relative to 2009 ABC and OFL options for the BSAI shark complex under Tier 6. BSAI shark catch surpasses the Tier 6 ABC in 4 of the past 13 years.

Appendix A: Preliminary estimates of bycatch of sharks in halibut IFQ fisheries

The goal of this report is to examine potential methods for estimating the bycatch of non-target species in the unobserved Pacific halibut longline fishery. Two methods for estimation are examined here, both using the annual International Pacific Halibut Commission (IPHC) survey data as a ratio estimator to extrapolate total catch from commercial harvest or effort. The first method (1) has been used to estimate bycatch of skates (Gaichas et al. 2005) and sharks (Courtney et al. 2006) using survey CPUE and commercial effort to estimate numbers of sharks caught. Method 1 is described in detail below. The second method (2) has been used to estimate bycatch of yelloweye rockfish in Southeast Alaska by the Alaska Department of Fish and Game (Cleo Brylinsky and Allison Sayer, personal communication). Method 2 uses the ratio of the total weight of each bycatch species caught during the IPHC survey to the total weight of Pacific halibut caught during the survey is used to extrapolate the commercial catch of each bycatch species from commercial landings of Pacific halibut. Survey weights for Pacific halibut were only available for 2007-2008 at this time. Because Method 2 could not be analyzed this year, a more thorough analysis of all bycatch estimation methods will be presented in next year's SAFE.

Both methods are subject to the stratified sub-sampling design of the IPHC survey. Non-target species are only counted for the first 20 hooks of each 100 hook skate (20% hook count). Common bycatch species are considered well represented by this stratified design in that extrapolated estimates of total catch are not significantly different from actual total catch, when 100% of the hooks are counted. Estimates of total catch from the 20% hook count for rare or uncommon species are less precise (Menon et al. 2005).

Here we are using four species/groups of sharks as example species: spiny dogfish, Pacific sleeper shark, salmon shark, and Other sharks (blue shark, sixgill shark, and "miscellaneous or unidentified" sharks). These species represent four different cases of data availability. Spiny dogfish are commonly caught in the survey through most of the Gulf of Alaska, and become rare in the Aleutian Islands and Bering Sea (Menon 2004). Good estimates of the sex ratio and weight by area and depth stratum exist. Pacific sleeper shark are caught less frequently with increasing catches centered in the western Gulf of Alaska. The 20% hook count data is still considered representative for this species (Menon 2004). Little data exist on the sex ratio and average size of this species, and average size is likely underestimated due to the large size of the species precluding landing and measuring. Salmon shark are rarely caught in the survey, but good data exist on sex ratio and weight, although not at the area and depth stratum resolution. The Other sharks are rarely caught in the survey and little data exist on the proportion of component species, sex ratio or average size of the component species.

The IPHC provided longline survey catch data for the years 1998-2008 in numbers rather than weight. At each station 500 hooks are set. Effective observed hooks were calculated by subtracting bent, broken, missing or otherwise ineffective hooks from the total count of observed hooks. Ineffective stations (those with gear issues, whale predation, pinniped predation and extensive sand flea activity) were removed from the analysis. Catch (in numbers) per 10,000 hooks (CPUE) was estimated for each station of the survey for spiny dogfish, salmon shark, Pacific sleeper shark and Other sharks.

Commercial fishery data was used to estimate the number of effective hooks fished. Data was provided by IPHC for the years 1998-2007, which included logbook data and fishticket data. Commercial data was grouped into larger "grouped statistical areas" to comply with confidentiality rules (Figure 1). Commercial logbook data was reported by weight (landings), effective skates hauled, and number of vessels by depth bin (0-99, 100-199 and 200+ fathoms) within each grouped statistical area. Fishticket data was reported by weight and number of vessels by grouped statistical area. Logbook coverage is not as complete as fishticket landings, but provides a view of how effort is proportioned by depth and was used to proportion the fishticket landings into depth categories. We assumed that fishing gear was universal in that all skates consisted of 100 hooks (Gaichas et al. 2005, Courtney et al. 2006), consistent with the survey, and estimated the number of effective hooks fished from the number of effective skates hauled in each grouped statistical area and depth category.

For Method 1, the average survey CPUE in each grouped statistical area and depth category was multiplied by the number of effective hooks in the fishery to estimate the total number of sharks (by species) caught (Tables 1-3). Numbers were converted to biomass of sharks caught by average weights for spiny dogfish, Pacific sleeper and salmon sharks. For spiny dogfish estimates of average weight by sex and the sex ratio estimates were available by depth (Tribuzio, unpublished data), for Pacific sleeper sharks and salmon sharks an average weight by sex and sex ratio only were available (Sigler et al. 2006, Goldman and Musick 2006).

The Alaska Regional Office (AKRO) reports commercial catch of all groundfish species caught in the Gulf of Alaska (Catch Accounting System, CAS), including any groundfish landed by the unobserved Pacific halibut boats. Currently, sharks in the GOA are not sold for human consumption and landings are low (Table 4). However, landings are not representative of bycatch. To account for any overlap in our bycatch estimates and those in the CAS, the CAS estimate of Pacific halibut fishery bycatch of sharks (Table 5) should be subtracted from our estimates of shark bycatch. However, in instances where a species does not show up in the survey but does show up in the observer data (which CAS is based on) this results in a negative catch. Even though the IFQ Pacific halibut fishery is unobserved, landings may be observed at shoreside processors, and because observer data covers a greater spatial and temporal range than survey data it is expected that rare species may show up in the shoreside sampling and not the survey.

The variability of the survey CPUE is different for common species than from rare species. Common species, such as spiny dogfish and Pacific sleeper shark have low CV's, ~10% (Table 1 and 2). More rare species, such as Other sharks, have a greater CV, generally 50-100% (Table 3), further demonstrating the difficulty in estimating catch for rare species. The estimated catches of common species using Method 1 were all significantly greater than zero, but for all rare species the catches were all not significantly different from zero (Figure 2). A complete hook count on the survey may improve these estimates.

The joint plan teams in September, 2009 recommended filtering the survey data prior to estimating the CPUE to better represent commercial fishing activity. We calculated the catches based on the whole data set (unfiltered) and a subset of the data (filtered). For the filtered data the top third of the IPHC survey stations based on Pacific halibut CPUE were used to estimate average CPUE of sharks. Using this method, the average CPUE, numbers and biomass were lower by roughly an order of magnitude and the CV's and confidence intervals increased (Tables 5-6 and Figure 3). Further, the Other Sharks dropped out of the analysis.

This is a preliminary report of an ongoing data analysis. The goal of this work is to develop a method to estimate bycatch in the unobserved IFQ Pacific halibut fisheries which can be applied to all non-target species, sharks and skates in particular. As data become available, we will examine the weight ratio method used by ADF&G to estimate yelloweye rockfish bycatch. We will also use a Monte Carlo approach to account for uncertainty in the average size and sex ratio estimates, and alternative data filtering approaches to make the survey data more representative of commercial behavior. Further, Method 1 is a modification of that used in Gaichas et al. (2005) in that we depth stratified our survey and commercial data into 100 fathom depth bins, and our statistical area groupings are slightly different from those used in Courtney et al. (2006). Therefore, the results presented here are not directly comparable those previously reported results.

Sources:

Courtney, D., Tribuzio, C., Goldman, K., Rice, J. 2006. Gulf of Alaska Sharks. In: Stock assessment and Fishery Evaluation Report for the groundfish resources of the Gulf of Alaska for 2005. North Pacific Fishery Management Council, 605, W. 4th Ave Ste 306, Anchorage, AK 99501.

Gaichas, S., Sagalkin, N., Gburski, C., Stevenson, D., Swanson, R. 2005. Gulf of Alaska Skates. In: Stock assessment and Fishery Evaluation Report for the groundfish resources of the Gulf of Alaska for 2005. North Pacific Fishery Management Council, 605, W. 4th Ave Ste 306, Anchorage, AK 99501.

Goldman, K.J. and J.A. Musick. 2006. Growth and maturity of salmon sharks in the eastern and western North Pacific, with comments on back-calculation methods. Fish. Bull 104:278-292.

Menon, M. 2004. Spatio-temporal modeling of Pacific sleeper shark (*Somniosus pacificus*) and spiny dogfish (*Squalus acanthias*) bycatch in the northeast Pacific Ocean. MS Thesis. University of Washington, Seattle, WA.

Menon, M., Gallucci, V., Conquest, L. 2005. Sampling design for the estimation of longline bycatch. In: Fisheries assessment and management in data limited situations. Alaska Sea Grant. AK-SG-05-02. pg. 851-870.

Sigler M.F., Hulbert L., Lunsford C., Thompson N., Burek K., Corry-Crowe G., Hirons A. 2006. Diet of Pacific sleeper sharks in the northeast Pacific Ocean. Journal of Fish Biology 69:392-405.

Table AA1. Unfiltered spiny dogfish average CPUE (Avg CPUE; average shark per 10,000 hooks) from IPHC longline surveys, estimated catch in numbers (#'s) in the IFQ fishery from Method 1, and estimated biomass of catch in metric tons (mt) in the fishery. Estimates are based on unfiltered survey data. The coefficient of variation (CV) is provided for the average CPUE and 95% confidence intervals are provided for the average CPUE, estimated # of fish caught, and the estimated catch in the IFQ fishery.

Year	Avg CPUE	Catch (1,000s)	95% CI	Catch weight (t)	95% CI	CV
1998	2.3	22.3	(-15.8-60.5)	0.1	(-0.1-0.2)	27.3%
1999	3.2	58.1	(-46.9-163)	0.2	(-0.1-0.5)	36.8%
2000	0.4	11.7	(-11.3-34.8)	0.04	(-0.04-0.1)	31.0%
2001	2.1	69.7	(-48.7-188.1)	0.2	(-0.1-0.6)	44.4%
2002	0.0	0.0	(0-0)	0	(0-0)	44.4%
2003	0.0	0.0	(0-0)	0	(0-0)	29.7%
2004	1.6	29.6	(-11-70.3)	0.1	(-0.04-0.2)	28.0%
2005	0.4	39.5	(-37.9-116.8)	0.1	(-0.1-0.4)	74.1%
2006	4.3	622.0	(6.7-1237.4)	2.1	(0.1-4.1)	33.0%
2007	4.0	172.1	(-108.6-452.9)	0.6	(-0.3-1.4)	34.1%

Table AA2. Unfiltered Pacific sleeper shark average CPUE (Avg CPUE; average shark per 10,000 hooks) from IPHC longline surveys, estimated catch in numbers (#'s) in the IFQ fishery from Method 1, and estimated biomass of catch in metric tons in the Pacific halibut fishery (mt). Estimates are based on unfiltered survey data. The coefficient of variation (CV) is provided for the average CPUE and 95% confidence intervals are provided for the average CPUE, estimated # of fish caught, and the estimated catch in the IFQ fishery.

Year	Avg CPUE	Catch (100s)	95% CI	Catch weight (t)	95% CI	CV
1998	22.3	2.6	(0.4-4.8)	18.9	(3-34.8)	28.8%
1999	17.5	4.8	(-1.7-11.3)	35.0	(-12.3-82.2)	49.1%
2000	54.0	3.7	(0.9-6.5)	27.0	(6.6-47.3)	18.9%
2001	15.7	5.3	(-3.4-14)	38.7	(-24.6-102)	23.5%
2002	16.9	1.3	(-0.3-2.9)	9.2	(-2.5-20.9)	20.1%
2003	25.9	2.9	(-0.3-6.1)	21.0	(-2.5-44.5)	16.6%
2004	21.2	3.5	(0.3-6.6)	25.2	(2.3-48.1)	19.6%
2005	17.5	5.5	(0-11.1)	40.3	(0.1-80.5)	22.1%
2006	11.7	8.8	(1-16.5)	63.9	(7.6-120.2)	25.8%
2007	13.0	1.8	(-0.5-4)	12.8	(-3.3-28.9)	21.3%

Table AA3. Unfiltered Other shark average CPUE (Avg CPUE; average shark per 10,000 hooks) from IPHC longline surveys, estimated catch in numbers (#'s) in the IFQ fishery from Method 1, and estimated biomass of catch in metric tons in the Pacific halibut fishery (mt). Estimates are based on unfiltered survey data. The coefficient of variation (CV) is provided for the average CPUE and 95% confidence intervals are provided for the average CPUE, estimated # of fish caught, and the estimated catch in the IFQ fishery.

Year	Avg CPUE	Catch (#s)	95% CI	CV
1998	0.0	0.0	(0-0)	
1999	3.2	29.9	(-28.7-88.6)	100.00%
2000	0.0	0.0	(0-0)	
2001	0.0	0.0	(0-0)	
2002	0.0	0.0	(0-0)	
2003	0.0	0.0	(0-0)	
2004	0.0	0.0	(0-0)	
2005	0.8	98.6	(-94.7-291.8)	70.52%
2006	0.0	0.0	(0-0)	
2007	0.0	0.0	(0-0)	

Table AA4. Estimated catches (t) of sharks in the IFQ Pacific halibut fisheries from the AKRO CAS.

Year	Spiny Dogfish	Pacific sleeper Shark	Salmon Shark	Other Shark
2003	0.047	18.399	0	0
2004	0.012	1.134	0	0
2005	0	0.105	0	0
2006	0.012	0.097	0	0
2007	0	0.026	0	0
2008	5.852	0	0	0

Table AA5. Filtered spiny dogfish average CPUE (Avg CPUE; average shark per 10,000 hooks) from IPHC longline surveys, estimated catch in numbers (#'s) in the IFQ fishery from Method 1, and estimated biomass of catch in metric tons in the Pacific halibut fishery (mt). Estimates are based on filtered survey data. The coefficient of variation (CV) is provided for the average CPUE and 95% confidence intervals are provided for the average CPUE, estimated # of fish caught, and the estimated catch in the IFQ fishery.

Year	Avg CPUE	Catch (#s)	95% CI	Catch weight (t)	95% CI	CV
1998	3.2	26.4	(-25.3-78)	0.1	(-0.1-0.3)	100.00%
1999	0.0	0.0		0.0		
2000	0.0	0.0		0.0		
2001	0.0	0.0		0.0		
2002	0.0	0.0		0.0		
2003	0.0	0.0		0.0		
2004	0.0	0.0		0.0		
2005	0.0	0.0		0.0		
2006	0.0	0.0		0.0		
2007	0.0	0.0		0.0		

Table AA6. Filtered Pacific Sleeper shark average CPUE (Avg CPUE; average shark per 10,000 hooks) from IPHC longline surveys, estimated catch in numbers (#'s) in the IFQ fishery from Method 1, and estimated biomass of catch in metric tons in the Pacific halibut fishery (mt). Estimates are based on filtered survey data. The coefficient of variation (CV) is provided for the average CPUE and 95% confidence intervals are provided for the average CPUE, estimated # of fish caught, and the estimated catch in the IFQ fishery.

Year	Avg CPUE	Catch (100s)	95% CI	Catch weight (t)	95% CI	CV
1998	13.4	1.7	(-1.7-5.2)	12.7	(-12.2-37.5)	76.22%
1999	7.7	2.3	(-0.3-5)	17.0	(-2.2-36.2)	68.72%
2000	42.6	38.0	(37-38.9)	276.2	(269.1-283.3)	58.52%
2001	20.6	6.1	(-5.8-18)	44.5	(-42.1-131.1)	50.04%
2002	20.1	1.0	(-0.3-2.3)	7.4	(-2.2-16.9)	72.26%
2003	6.4	0.4	(-0.4-1.3)	3.2	(-3.1-9.5)	100.00%
2004	21.0	6.1	(2.5-9.6)	44.1	(18.4-69.8)	65.47%
2005	0.0	0.0	(0-0)	0.0	(0-0)	
2006	0.0	0.0	(0-0)	0.0	(0-0)	
2007	12.9	6.5	(6.5-6.5)	47.1	(47.1-47.1)	100.00%

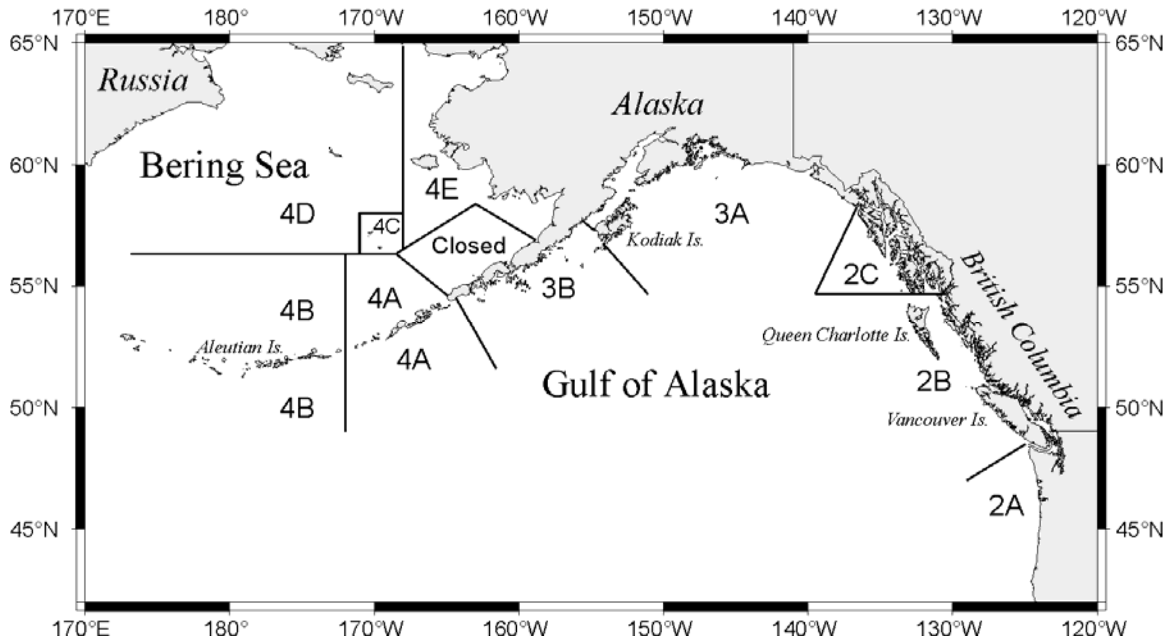

Figure AA1. International Pacific Halibut Commission regulatory areas in the Bering Sea, Aleutian Islands and Gulf of Alaska. Commercial data for this analysis was grouped by regulatory area in the Bering Sea. Source: www.iphc.washington.edu.

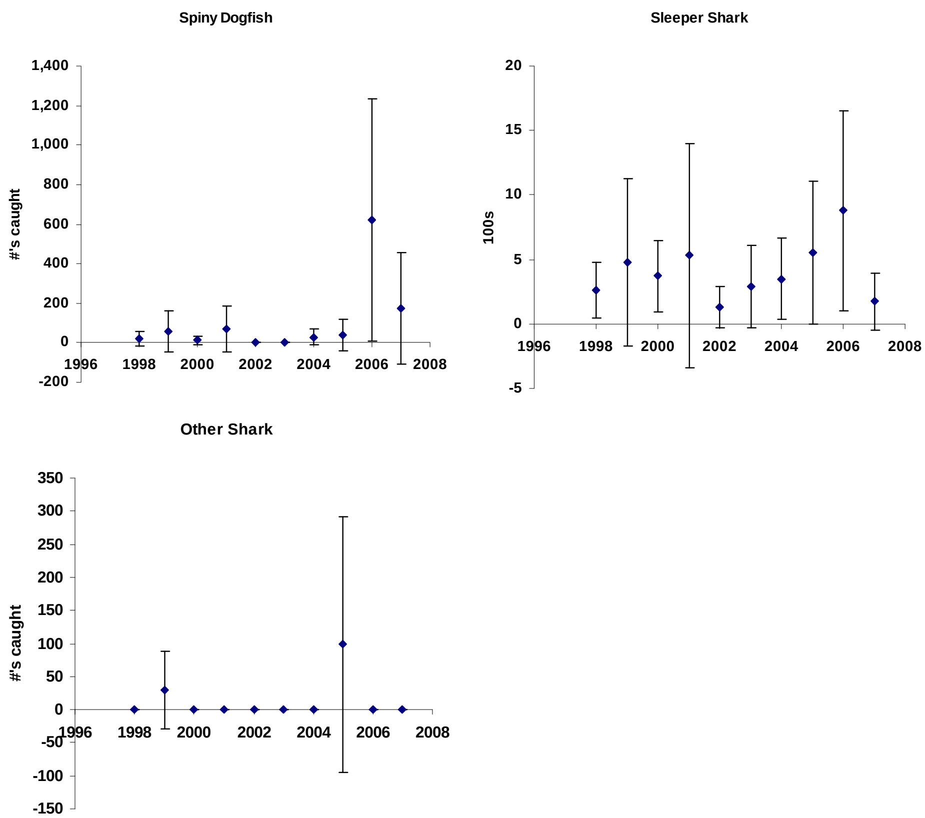

Figure AA2. Estimated catches (in numbers) of sharks in the IFQ Pacific halibut fisheries in the Bering Sea/Aleutian Islands. Error bars are 95% confidence intervals.

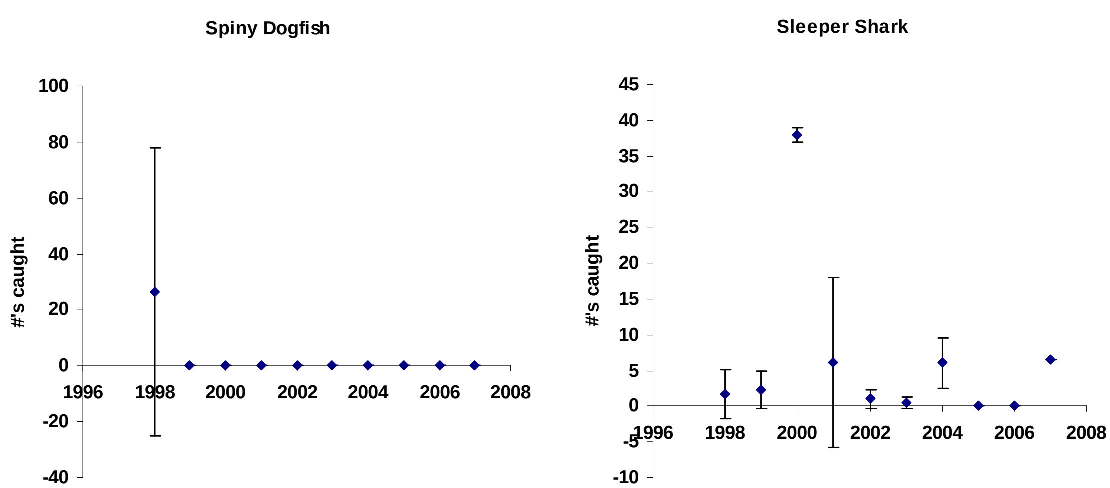

Figure AA3. Estimated catches (in numbers) of sharks in the IFQ Pacific halibut fisheries in the Bering Sea/Aleutian Islands based on filtered survey data. Note that when the data is filtered the estimated catch of other sharks drops to 0. Error bars are 95% confidence intervals.

Appendix B: Changes to the Catch Accounting System for Non-Target Species from 2003-2008

Prior to 2008, the primary catch accounting table did not have individual species codes. Most non-target species, such as sharks, were lumped into a species group code. Individual species data for non-target species was split out in a separate table, which is where the data for the stock assessments was queried from. This non-target estimate table was only run once a year and did not match the catch estimates from the primary catch tables. Staff at the Regional Office were able to determine that the primary table contained the correct catch estimates and the non-target estimate table was incorrect. These errors have been corrected and species are now queried from the primary catch table. There are some notable changes in some of the non-target species; here we look at sharks as an example.

Table 1 contains the catch estimates that had been presented in the 2008 GOA SAFE document, prior to the changes made to the catch accounting system. Table 2 shows what the corrected numbers are for years 2003-2008 and Table 3 shows the percentage of change between the two. The change in the catch of spiny dogfish in 2004 is the most striking, increasing by over 1,000%. Changes were not as dramatic in the BSAI, with 2008 spiny dogfish changing the most at 80% (Tables 4, 5, and 6). This results in increasing the GOA ABC and OFL for spiny dogfish, Pacific sleeper shark and salmon shark by 46%, 4% and 10%, respectively.

Sources:

Gaichas, S.K. 2001. Squid and other species in the Bering Sea and Aleutian Islands. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea and Aleutian Islands for 2002. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Gaichas, S.K. 2002. Squid and other species in the Bering Sea and Aleutian Islands. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea and Aleutian Islands for 2003. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Gaichas, S., L. Fritz, and J. N. Ianelli. 1999. Other species considerations for the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. Appendix D. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99501.

Tribuzio, C. A., C. Rodgveller, J. Heifetz, D. Courtney, and K. J. Goldman. 2008a. Assessment of the shark stocks in the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the ground fish resources of the Gulf of Alaska for 2009. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99501.

Tribuzio, C. A., C. Rodgveller, J. Heifetz, D. Courtney, and K. J. Goldman. 2008b. Assessment of the shark stocks in the Bering Sea. *In* Stock assessment and fishery evaluation report for the ground fish resources of the Gulf of Alaska for 2009. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99501.

Table AB1. (From Table 3, Tribuzio et al. 2008a) NMFS estimated catch (tons) of sharks (by species) in the Gulf of Alaska. 1997-2002 catch estimated with NMFS new pseudo-blend estimation procedure (Gaichas, 2002). 2003-2008 from NMFS AKRO as of October 3, 2008. Breaks in the table represent different catch estimation periods.

Year	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidentified shark	Total sharks	Total other species	% of Other Species Catch
1997	657	136	124	123	1,041	5,439	19%
1998	865	74	71	1,380	2,390	3,748	64%
1999	314	558	132	33	1,036	3,858	27%
2000	398	608	38	74	1,117	5,649	20%
2001	494	249	33	77	853	4,801	18%
2002	117	226	58	26	427	4,040	11%
-	-	-	-	-	-	-	-
2003	369	292	36	62	759	6,335	12%
2004	175	232	22	39	468	1,608	29%
2005	408	440	52	58	959	2,347	41%
2006	816	238	29	83	1,166	3,424	34%
2007	690	294	95	107	1,186	2,800	42%
2008	171	66	1	8	246	2,208	11%
Total 1997-2008	5,473	3,413	691	2,070	11,647	46,257	
Average 1997-2007	482	304	63	187	1,036	4,004	

Table AB2. Updated table with new catch accounting system estimates. NMFS estimated catch (tons) of sharks (by species) in the Gulf of Alaska. 1997-2002 catch estimated with NMFS new pseudo-blend estimation procedure (Gaichas, 2002). Years 2003-2008 from NMFS AKRO as of June 8, 2009. Breaks in the table represent different catch estimation periods.

Year	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidentified shark	Total sharks	Total other species	% of Other Species Catch
1997	657	136	124	123	1,041	5,439	19%
1998	865	74	71	1,380	2,390	3,748	64%
1999	314	558	132	33	1,036	3,858	27%
2000	398	608	38	74	1,117	5,649	20%
2001	494	249	33	77	853	4,801	18%
2002	117	226	58	16.8	418	4,040	10%
-	-	-	-	-	-	-	-
2003	362	298	37	54	751	6,335	12%
2004	1,966	286	41	40	2,333	1,608	145%
2005	485	486	60	70	1,101	2,347	47%
2006	1,232	254	34	83	1,603	3,424	47%
2007	849	297	135	107	1,388	2,800	50%
2008	328	66	3	12	410	2,208	19%
Total 1997-2008	6,230	2,769	440	534	9,973	46,257	
Average 1997-2007	703.4	315.6	69.4	187.1	1,275.5	4,004.5	

Table AB3. Percentage Change in estimated catch of sharks in the GOA due to changes in catch accounting system.

Year	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidentified shark	Total sharks	Total other species	% of Other Species Catch
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0
-	-	-	-	-	-	-	-
2003	-2	2	3	-12	-1	0	-1
2004	1023	23	85	3	398	0	400
2005	19	10	16	20	15	0	14
2006	51	7	18	0	38	0	38
2007	23	1	42	0	17	0	18
2008	92	-1	240	51	66	0	69
Total 1997-2008	14	-19	-36	-74	-14	0	
Average 1997-2007	46	4	10	0	23	0	

Table AB4. (From Table 6 Tribuzio et al. 2008b) Estimated incidental catch (mt) of sharks in the eastern Bering Sea and Aleutian Islands (BSAI) by species as of October 5, 2008. 1997 – 2002 from the NMFS pseudo-blend catch estimation procedure (Gaichas 2001, 2002), 2003 – 2008 from NMFS AKRO blend-estimated annual catches.

Year	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidenti fied shark	Total sharks	Total other species	Shark % of other species
1997	4	304	7	53	368	25,176	1%
1998	6	336	18	136	497	25,531	2%
1999	5	319	30	176	530	20,562	3%
2000	9	490	23	68	590	26,108	2%
2001	17	687	24	35	764	27,178	3%
2002	9	839	47	468	1,362	26,296	5%
2003	11	280	192	33	515	25,373	2%
2004	9	420	25	60	514	29,637	2%
2005	11	328	48	26	414	29,505	1%
2006	7	299	61	305	672	26,798	3%
2007	3	257	44	25	330	26,668	1%
2008	9	119	41	7	176	21,340	1%
Total est. catch	99	4,678	560	1,392	6,732	310,172	
Avgerage 1997-2007	8	414	47	126	596	26,257	

Table AB5. Updated table with new catch accounting system estimates. Estimated incidental catch (mt) of sharks in the eastern Bering Sea and Aleutian Islands (BSAI) by species as of June 8, 2009. 1997 – 2002 from the NMFS pseudo-blend catch estimation procedure (Gaichas 2001, 2002), 2003 – 2008 from NMFS AKRO blend-estimated annual catches.

Year	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidentified shark	Total sharks	Total other species	Shark % of other species
1997	4	304	7	53	368	25,176	1%
1998	6	336	18	136	497	25,531	2%
1999	5	319	30	176	530	20,562	3%
2000	9	490	23	68	590	26,108	2%
2001	17	687	24	35	764	27,178	3%
2002	9	839	47	468	1,362	26,296	5%
2003	11	280	196	33	520	25,373	2%
2004	9	420	26	60	515	29,637	2%
2005	11	333	47	26	418	29,505	1%
2006	7	313	65	305	689	26,798	3%
2007	3	256	45	28	331	26,668	1%
2008	17	120	42	7	185	21,340	1%
Total est. catch	108	4697	572	1,395	6,769	310,172	
Avgerage 1997-2007	8	416	48	126	598	26,258	

Table AB6. Percentage Change in estimated catch of sharks in the BSAI due to changes in catch accounting system.

Year	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidentified shark	Total sharks	Total other species	Shark % of other species
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0
2000	-1	0	1	-1	0	0	0
2001	2	0	2	0	0	0	0
2002	4	0	-1	0	0	0	0
2003	3	0	2	0	1	0	0
2004	-4	0	2	0	0	0	0
2005	4	2	-3	1	1	0	0
2006	0	5	7	0	2	0	0
2007	0	0	1	11	0	0	0
2008	80	1	9	-3	7	0	0
Total est. catch	9	0	2	0	1	0	
Avg. 1997-2007	0	0	2	0	0	0	

Table AB7. Change in ABC and OFL for GOA due to changes in catch accounting system, using the 1997-2007 time series as an example.

GOA Tier 6 Calculations (mt) ABC=0.75*Average Catch, OFL=Average Catch

Species	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidentified shark	**Total shark complex**
From catch accounting system as of October 2008					
Average catch	482	304	63	187	1036
ABC	362	228	47	140	777
OFL	482	304	63	187	1036
From catch accounting system as of June 2009, with changes					
Average catch	703	316	69	187	1,276
ABC	528	237	52	140	957
OFL	703	316	69	187	1,276
Percent Change in ABC and OFL					
Average catch	46	4	10	0	23
ABC	46	4	11	0	23
OFL	46	4	10	0	23

Table AB8. Change in ABC and OFL for BSAI due to changes in catch accounting system, using the 1997-2007 time series as an example.

BSAI Tier 6 Calculations (mt) ABC=0.75*Average Catch, OFL=Average Catch

Species	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidentified shark	**Total shark complex**
From catch accounting system as of October 2008					
Average catch	8.3	414.5	47.2	125.9	**596**
ABC	6.2	310.8	35.4	94.4	**447.0**
OFL	8.3	414.5	47.2	125.9	**596.0**
From catch accounting system as of June 2009, with changes					
Average catch	8.4	416.1	48.0	126.2	598.5
ABC	6.3	312.1	36.0	94.6	448.9
OFL	8.4	416.1	48.0	126.2	598.5
Percent Change in ABC and OFL					
Average catch	0.0	0.0	0.0	0.0	0.0
ABC	0.0	0.0	0.0	0.0	0.0
OFL	0.0	0.0	0.0	0.0	0.0