Chapter 18b: Assessment of the shark stocks in the Gulf of Alaska

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EXECUTIVE SUMMARY

Summary of Major Changes

<u>Changes to the input data</u>

1. Total catch for GOA sharks from 2003-2008 updated due to changes to Catch Accounting System. See Appendix B for details.
2. Total catch for GOA sharks is updated to include 2009 (as of Oct 7, 2009)
3. Biomass estimates from the 2009 GOA bottom trawl survey are incorporated.
4. Preliminary estimates of bycatch in unobserved IFQ Halibut fisheries are examined in Appendix A. These catches are not included in the ABC calculations.

<u>Changes in assessment methodology</u>

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 and 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 appreciably. 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 over fishing is occurring for any shark species in the GOA. 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 916 t and an OFL of 1,222 t for the shark complex combined. There are currently no directed commercial fisheries for shark species in federally or state managed waters of the GOA, 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 GOA fisheries have been very small compared to catch rates of target species. Sharks have only been reported to species in the catch since 1997 and have made up from 11% to 65% of Other Species catch from 1997 – 2008. Spiny dogfish make up 57% of the shark catch, followed by Pacific sleeper shark at 24%, Other/unidentified sharks at 14% and salmon sharks at 5%.

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

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

Species	Spiny dogfish (t)	Pacific sleeper shark (t)	Salmon shark (t)	Other/Unidentified shark (t)	**Total shark Complex (t)**
Tier	6	6	6	6	6
M	0.097	0.097	0.18	0.097	0.097
1997-2007 Average catch	703	316	69	188	1,276
ABC	528	237	52	141	957
OFL	703	316	69	188	1,276
1997-2008 Average catch	689	295	64	173	**1,222**
ABC	517	221	48	130	**916**
OFL	689	295	64	173	**1,222**

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 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 and the IPHC longline survey for all shark species 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) survey and fishery observer catch records provide information on shark species known or suspected to occur in the Gulf of Alaska (GOA) (Table 1, Figure 1). The three shark species most likely to be encountered in GOA fisheries and surveys are the Pacific sleeper shark (*Somniosus pacificus)*, the piked or spiny dogfish (*Squalus acanthias)*, and the salmon shark (*Lamna ditropis*).

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 GOA 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).

Pacific Sleeper Shark

Pacific sleeper sharks 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 (Orlav 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 sleeper sharks and suggested that sleeper sharks in the southern hemisphere and the southern Atlantic were misidentified as Pacific sleeper sharks 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 1,750 m (seen on a planted grey whale carcass off Santa Barbara, CA, www.nurp.noaa.gov/Spotlight/Whales.htm). Sleeper sharks are found in relatively shallow waters at higher latitudes and in deeper habitats in temperate waters (Yano et al. 2007).

Salmon Shark

Salmon sharks range in the North Pacific from Japan through the Bering Sea and GOA to southern California and Baja, Mexico. They are considered common in coastal littoral and epipelagic waters, both inshore and offshore. Salmon sharks have been considered a nuisance because they consume salmon and they damage fishing gear (Macy et al. 1978, Compagno 1984). Salmon sharks have been investigated as potential target species in the GOA; however, they are currently only targeted by sport fishermen in the state fishery (Paust and Smith 1989). Salmon sharks tend to be more pelagic and surface oriented than the other shark species in the GOA, about 72% of their time is spent in waters less than 50 m deep (Weng et al. 2005). While some salmon sharks migrate south during the winter months, others remain in the GOA throughout the year (Weng et al. 2005, Hulbert et al. 2006).

Management Units

There are no directed fisheries for sharks in the GOA, but some incidental catch of sharks results from directed fisheries for other commercial species. Sharks are currently managed in aggregate as part of the “Other Species” complex in the GOA Fishery Management Plan (FMP) (Gaichas et al. 1999, 2003). The Other Species complex includes sculpins, sharks, squid, and octopus. Skates were separated from the GOA Other Species complex in 2003 (Gaichas et al. 2003). Other Species are considered ecologically important and may have future economic potential. The total allowable catch (TAC) for the GOA Other Species complex is currently set at 4,500 t (Table 2). Acceptable Biological Catch (ABC) and Overfishing Limits (OFL) are set Gulf wide as an aggregate of the Other Species complex. Sharks catches have only been identified to the species level since 1997 and have made up from 11% to 64% of Other Species catch from 1997–2009 (Table 3).

Evidence of Stock Structure

Spiny Dogfish

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; 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 sleeper shark migratory behavior, or their life history. However, tagging studies in Alaska have shown that at least some Pacific sleeper sharks reside in the GOA and Prince William Sound throughout the year, where they exhibit relatively limited geographic movement (< 100 km) (Hulbert et al. 2006). Sleeper sharks commonly migrate vertically throughout the water column (Orlav and Moiseev 1999, Hulbert et al. 2006), but did not migrate far from initial tagging locations in the GOA (Hulbert et al 2006). Median distance traveled for numerically 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, sonically tagged sharks in Southeast Alaska were acoustically tracked at depths greater than 500 m and made vertical migrations off the bottom (Courtney and Hulbert 2007). In addition, one sonically tagged 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 (WNP) and the eastern North Pacific (ENP) separated by the longitude of 180°W (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 in 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 sea surface temperatures of 14°-16°C; adults occurred 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 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, 1977, Compagno 1990, Hoenig and Gruber 1990). Shark reproductive strategies in general are characterized by long gestational periods (6 months - 2 years), with small broods 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 21 GOA species (O. Ormseth). Sharks were 3 of the 4 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.

Spiny Dogfish

Eastern North Pacific (ENP) spiny dogfish grow to a relatively large maximum size of 160 cm (Compagno 1984). In 2006, through a special project with the NMFS observer program, spiny dogfish lengths were measured throughout the eastern Bering Sea (EBS), Aleutian Islands (AI), and the GOA. Sample sizes were not sufficient for determining length frequencies by area, but for all areas combined, male lengths averaged 80.2 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) and ranged from 48-110 cm (N = 524, Figure 2). Females averaged 82.4 cm and ranged from 9-128 cm (N = 601). The highest proportion of females at a given length occurred at 74 cm; the highest proportion of males was observed at 82 cm. Although the distribution of female lengths peaked at a smaller size than the peak in males, there were a greater proportion of females 94-128 cm long. In comparison, average dogfish lengths observed during a University of Alaska (UAF) study in the GOA were similar to those reported by NMFS observers, but length distributions were different. Male lengths averaged 80.3 cm TL_{ext} and ranged from 53-99 cm (N=623) while the greatest proportion of individuals were 85 cm. 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 length frequencies among fish <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 are 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 biased low due to agers rejecting difficult to read spines and spine annuli that were grouped very close together. Age-at-maturity is similar to BC 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. Embryos are retained within the uterus throughout gestation, but there is no physical attachment (such as a placenta) between the mother and offspring. During gestation, which is 18-24 months, spiny dogfish embryos are nourished solely by their yolk sac. The majority of biological knowledge of spiny dogfish is based on field biology conducted in 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 BC. 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 in areas not fished commercially and are therefore not available to commercial fisheries until they grow or migrate to fished areas (Beamish et al. 1982, Tribuzio and Kruse b 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 Shark

Sleeper sharks (*Somniosus* spp.) can attain large sizes and most likely posess a slow-growth rate and are long-lived (Fisk et al. 2002). A Greenland shark (*Somniosus microcephalus*), the North Atlantic cogener 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 maximum lengths of *Somniosus* sp. captured in mid-water trawls in the Southern Ocean off the outer shelf and upper continental slope of subantarctic islands are 390 cm TL (total length with the tail in the natural position) +- 107 cm (range 150-500 cm, n=36, Cherel and Duhamel 2004). Large *Somniosus* sharks observed in photographs from deep water have been estimated at lengths up to 700 cm (Compagno 1984). The maximum lengths of captured Pacific sleeper sharks are 440 cm for females and 400 cm for males (Mecklenburg et al. 2002). Pacific sleeper sharks 150-250 cm in length are most common in Alaska (Sigler et al. 2006). Pacific sleeper sharks as large as 430 cm have been caught in the northwestern Pacific Ocean, where the species exhibits sexual dimorphism, 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) (Orlav 1999). The cartilage in sleeper sharks does not calcify to the degree of many other shark species, therefore aging is difficult and methods of age validation are under investigation.

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 sleeper sharks have been documented in the literature. The reproductive mode of 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 (<10 mm) were present as well as 372 large vascularized eggs (24-50 mm) (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 (Orlav 1999). Two recently born 74 cm sharks have been caught off the coast of California at depths of 1300 and 390 m; 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 sharks, 65-75 cm long, have been sampled 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 mature and newly born sharks, and the absence of dates in the literature, the spawning and pupping season is unknown for sleeper sharks.

Measurement techniques for determining the length of Pacific sleeper sharks are varied. In NMFS bottom trawl surveys, 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 2, 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).

Salmon Shark

Like other lamnid sharks, salmon sharks are active and highly mobile, maintaining body temperatures as high as 21.2 ^{o}C above ambient water temperatures and appear to maintain 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 greater than 260 cm PCL (300 cm TL) 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 when 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 2.2:1 (Nagasawa 1998), but this is from a very limited sample size. In the eastern Pacific, one record of 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

Commercial

There are currently no directed commercial fisheries for shark species in federal or state managed waters of the GOA and most incidentally caught sharks are not retained. However, a small amount of spiny dogfish landings in Kodiak were reported in 2004, 2005 and 2007 (~ 1 mt each year, J. Gasper, AKRO, pers. comm.). There is an ADF&G Commissioner's Permit fishery for spiny dogfish in lower Cook Inlet; however only one application has been received to date and the permit was not issued.

Spiny dogfish are also allowed as retained incidental catch in some ADF&G managed fisheries with some landings reported in Yakutat for 2005-2008. The landings were highest in 2005 (about 11,363 kg landed) and decreased in 2008 to 138 kg landed. There were no recorded landings of dogfish in Yakutat in 2009.

Recreational (provided by Scott Meyer, ADF&G)
Spiny dogfish, salmon shark, and Pacific sleeper shark are caught in the recreational fisheries of Southeast and Southcentral Alaska. Sleeper sharks are uncommon in the recreational catch and rarely retained. The State of Alaska manages recreational shark fishing in state and federal waters, but most of the harvest occurs in state waters. The shark fishery is managed under a statewide plan with a daily bag limit of one shark of any species and an annual limit of two sharks (5 AAC 75.012).

There are three sources of information on sport harvest: (1) the ADF&G statewide harvest survey (SWHS) provides estimates of catch (including released fish) and harvest (fish kept) of all shark species combined, (2) the mandatory charter logbook provides estimates of statewide charter harvest of salmon sharks, and (3) onsite harvest monitoring provides estimates of species, age, length, and sex composition in Southcentral Alaska. ADF&G also maintains a tagging database that includes only external numbered tags deployed by ADF&G, NMFS, and other permitted researchers.

The SWHS estimates of shark harvest are available for portions of the state since the late 1990s, but estimates for more recent years include the entire state. Estimated annual harvest of all shark species combined averaged 308 fish in Southeast Alaska (range 149-576) and 795 fish in Southcentral Alaska (range 502-1,007) from 2003-2007. The precision of the Southeast Alaska estimates is quite low; CVs are on the order of 50%. Whereas, CVs for Southeast Alaska were 20% 2007. Estimated annual catch, including released fish, averaged about 18,000 sharks in Southeast and 36,000 sharks in Southcentral Alaska from 2003 to 2007. The discrepancy between catch and harvest illustrates that the vast majority of sharks are caught incidentally and released.

There is a modest directed sport fishery for salmon sharks involving a few charter boats, most of which operate in Prince William Sound. Onsite sampling indicates that a small fraction of the directed salmon shark harvest is taken by unguided anglers. Logbook data for salmon sharks have not been rigorously edited or summarized, but indicate annual statewide harvests ranging from about 140-280 fish per year. About 25-65% of the harvest in recent years has come from Prince William Sound. The directed salmon shark fishery appeared to increase in the late 1990s in response to media attention, but appeared to wane in 2007 and 2008. Female salmon sharks sampled from the Southcentral Alaska sport harvest from 1997 to 2007 averaged 227 cm total length (n=300), and 145 kg predicted round weight. Males averaged 220 cm in length (n=50) and 131 kg predicted round weight. The smaller sample size for males reflects their lower frequency in the catch. Ages of fish harvested from 1997 to 2000 ranged from 5-17 years. ADF&G is currently working on age estimation for a backlog of salmon shark vertebrae collected since 2001.

Spiny dogfish make up the vast majority of the recreational shark catch and harvest but are rarely targeted. Instead, most of the catch is incidental to the halibut fishery. Catch rates can be quite high at certain times of the year, particularly in Cook Inlet, southwestern Prince William Sound, and near Yakutat. Anecdotal reports indicate that many spiny dogfish are handled poorly when released. Discard mortality is unknown but probably substantial. The numbers of spiny dogfish observed seem low in relation to harvest estimates from the mail survey, suggesting that anglers are reporting some spiny dogfish that are not retained as harvest. These fish may be released dead or cut up for bait. Only 62 spiny dogfish were sampled from the Southcentral Alaska sport harvest from 1998 through 2007. The mean total length of these fish was 92 cm and mean round weight was 3.75 kg.

ADF&G has provided tissue samples from salmon sharks and spiny dogfish to the Alaska Department of Environmental Conservation for analysis of methylmercury. These species had substantially higher methylmercury levels than all other species tested (Verbrugge 2007). It is unknown to what degree these results are influencing angler demand.

Bycatch, Discards, and Historical Catches

Historical catches of sharks in the GOA are composed entirely of incidental catch, and nearly all 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 GOA are tracked in-season by the NMFS Alaska Regional Office (AKRO) (Table 3). Other Species reported catches have been relatively small each year since 1977 in the GOA (e.g., in 2001 the Other Species catch of 4,801 tons made up 2.6% of the 182,011 ton total GOA catch).

DATA

Data regarding sharks were obtained from the following sources:

Source	Data	Years
AKRO Catch Accounting System	Non-target catch	2003–2009
(AFSC) Improved Pseudo Blend	Non-target catch	1997–2002
(AFSC) Pseudo Blend	Non-target catch	1990–1998
ADF&G	Target catch	2003-2008
NMFS Bottom Trawl Surveys – GOA	Biomass Index	1984–2009
NMFS Sablefish Longline Survey	Survey catch numbers	1989-2009
IPHC Longline Survey	Survey catch numbers	1998-2008
NMFS Sablefish Longline Survey	RPNs	1989-2003

Incidental Catch

This report summarizes incidental commercial catches by species as three data time series: 1990–1998, 1997–2002, and 2003–2009 (Table 3). Discard rates for sharks are presented in Table 4. Most sharks are discarded (>90%), however, "Other/unidentified sharks" have been retained as much as 6% (~1 mt in 2009). Prior to 2003, shark catches, by species, were estimated by staff at the AFSC by two different methods: one for the years 1997–2002 and the other for years 1990–1998.

For the years 1990–1998, the pseudo-blend method of Gaichas et al. (1999) was used to estimate catches of sharks by species. Using data reported by fishery observers, the method uses the following procedure: each year's observed catch by species group was summed within statistical area, gear type, and target fishery. The ratio of observed Other Species group catch to observed target species catch was multiplied by the AKRO blend-estimated target species catch within that area, gear, and target fishery. Other Species annual total catches estimated in this manner were generally lower than AKRO reported catches of Other Species due to both targeting assignment discrepancies and gear strata with no observer coverage (i.e., jig gear fisheries, Gaichas et al. 1999). Direct application of this method to estimate Other Species catches using foreign and joint venture observer data is not possible due to differences in database structure. Consequently, incidental catches for sharks by species are not available prior to the beginning of the domestic observer program in 1990. Using the pseudo-blend estimates from 1990–1998 in the GOA, spiny dogfish composed 49% of total shark catch, Pacific sleeper sharks 19%, salmon sharks 12%, and unidentified sharks 18%, and Blue, sixgill, and brown cat sharks were rarely identified in catches (Table 3).

For the years 1997–2002, Gaichas (2001, 2002) used a new pseudo-blend method to estimate species group catches, and catches by species for sharks within the Other Species complex in the GOA. In the new pseudo-blend method, target fisheries were assigned to each vessel, gear, management area, and week combination based upon retained catch of allocated species according to the same algorithm used by the AKRO. Observed catches of other species (as well as forage and non-specified 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 AKRO blend-estimated target species catch within that area, gear, and target fishery (Table 3). This method more closely matched the AKRO blend catch estimation system and is therefore considered more accurate and an improvement over the previous pseudo-blend method.

There is a two year overlap (1997-1998) between the two catch estimation methodologies. For these two years, the catches estimated from the earlier method (Gaichas et al. 1999) were considerably lower than catches estimated by the later method (Gaichas 2001, 2002). Therefore, these two data series are not directly comparable; however, the earlier time series is still valuable as an indicator of trends. All stock assessment computations will use only the time series calculated with the new pseudo-blend method that began in 1997.

From 1997–2009, shark catches composed from 11% to 65% of the estimated Other Species total catches. Spiny dogfish composed 57% of total shark catch, Pacific sleeper sharks 24%, unidentified sharks 14%, and salmon sharks 5% (Table 3). Blue sharks, sixgill sharks, and brown cat sharks were rarely identified in catches and were included with unidentified sharks. The majority of caught sharks are discarded (Table 4) and those that are retained are nearly all used for fishmeal (T. Hiatt, pers. comm.)

Based on the 1997–2009 GOA catch estimates, spiny dogfish were caught primarily in the flatfish (35%) and Pacific cod (23%) fisheries (Table 5). Pacific sleeper sharks were caught primarily in the Pacific cod (38%) and pollock (34%) fisheries (Table 6), and salmon sharks were caught primarily in the pollock (68%) and halibut (11%) fisheries (Table 7). Incidental catches of other and unidentified shark species were rare in the GOA except for a large catch in 1998 taken in the sablefish fishery (Table 8).

The majority of vessels fishing in the GOA are smaller vessels subject to 30% observer coverage, although some target fisheries (i.e. rockfish) are conducted by larger vessels with 100% observer coverage. 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 GOA. These catch estimates do not include unobserved fisheries such as the halibut IFQ fishery or ADF&G managed fisheries such as the salmon setnet fisheries, both of which are thought to have high levels of shark bycatch. See Appendix A for discussion on estimating bycatch from the IFQ halibut fisheries.

Catch from unobserved fisheries is a concern. Work is underway to estimate the bycatch of sharks in unobserved IFQ halibut fisheries. In Appendix A we present preliminary estimates of catch in the unobserved portion of the halibut IFQ fisheries based the CPUE ratio method of Gaichas et al. 2005 and Courtney et al. 2006.

Survey Biomass Estimates

NMFS AFSC bottom trawl survey biomass estimates are available for shark species in the GOA (1984-2009, Table 9). Where available, individual species biomass trends were evaluated for the three most commonly encountered shark species (spiny dogfish, Pacific sleeper shark, and salmon shark, Figure 3). 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.

Analyses of GOA biomass trends are subject to several caveats regarding the consistency of the survey time series. Surveys in 1984, 1987, and 1999 included deeper strata than the 1990-1996 surveys; therefore the biomass estimates for deeper-dwelling species are not comparable across years. The 2001 survey did not include all areas of the Eastern GOA and consequently, the 2001 survey may not be comparable with the other surveys for species such as spiny dogfish which appear to be relatively abundant in the Eastern GOA.

Data from the 1984-2007 GOA bottom trawl surveys indicate an increasing biomass trend for the shark species group as a result of increases in spiny dogfish and sleeper shark biomass between 1990 and 2007 (Table 9, Figure 3). Salmon shark biomass has been stable or decreasing according to this survey, but salmon sharks are pelagic and unlikely to be sampled efficiently by bottom trawls. Both salmon shark and Pacific sleeper shark biomass estimates are also based on a very small number of individual hauls in a given survey (Table 9). No salmon sharks were encountered in either the 1999, 2001 or 2009 survey. The 2009 survey biomass estimate for spiny dogfish was the lowest since 1987 and had the lowest CV of any previous biomass estimate. Spiny dogfish were captured in a relatively large number of hauls each year. However, spiny dogfish distributions in the GOA water column are not well known and may affect biomass estimation. In particular, if spiny dogfish are caught off the bottom, then biomass estimates may be unreliable. The total NMFS survey catch of all sharks (excluding the longline surveys) is listed in Table 10.

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).

Relative population numbers (RPNs) have been estimated from the GOA longline survey for the years 1982-2003 (Figure 4, Courtney et al. 2006). This index shows the RPN for Pacific sleeper shark increasing from 1994-2001, then declining through the remainder of the time series. The spiny dogfish index is more variable and shows peaks in 1993 and 1998, otherwise the index was relatively low. Analysis of data from the years 2004-2009 is underway using the methods in Courtney and Sigler, 2007. Further, similar methods are being used to calculate RPNs from the IPHC survey data. Results will be presented in next years SAFE.

The Alaska Department of Fish and Game has conducted annual longline surveys in and around Prince William Sound from 1997-2006. Not all stations were surveyed each year, and thus trends in catches are difficult to detect. However, spiny dogfish catch was low with sporadic large catches (up to 52 dogfish per 100 hooks, Figure 5 and Figure 6), with the greatest dogfish catches in 1998 in the central and eastern part of Prince William Sound and in 2006 near the western entrance to Prince William Sound. Sleeper shark catch was low in all years, relative to spiny dogfish (maximum of 2 sleeper sharks per 100 hooks, Figure 7 and Figure 8), and the greatest catches were in 1999 in western Prince William Sound.

Weight-at-length and average length and weight values for all three species are presented in Table 11. Length-at-age models for the GOA have been published for salmon sharks (Goldman and Musick 2006), and are under review for spiny dogfish (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. Length-at-age models have been estimated for both spiny dogfish and salmon shark (Tribuzio and Kruse in press, Goldman and Musick 2006, respectively). Parameters of the von Bertalanffy growth model are presented in Table 11. While sharks are slow-growing compared to teleost fish, the spiny dogfish has the slowest growth rate of any modeled shark species.

ANALYTIC APPROACH, MODEL EVALUATION, AND RESULTS

Model Structure

Sharks in the GOA are managed under Tier 6 (harvest specirfications based on average historical catch), so no modeling is performed. However, demographic modeling has been performed for dogfish and salmon sharks. Demographic models 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, equivalent to population growth $\lambda = e^r$), 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 12). 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 comparable 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 would be 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 appears to be 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 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 recruited 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 a "best-case" scenario. The assumption that shark populations are unfished is not realistic because the actual fishing mortality is >0. However, the actual level of fishing mortality is unknown. Bycatch in unobserved halibut fisheries has been modeled, but not for state fisheries such as the salmon gillnet fisheries, which may have very high spiny dogfish mortality in some years. 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

Two Tier 6 options are provided for consideration in the GOA. Tier 6 criteria require a reliable catch history from 1978-1995, which do not exist for sharks in the GOA prior to 1997. In 2008 the SSC recommended placement of sharks in Tier 6 with the 1997-2007 time period, fixing the final year at 2007. We also present the ABC and OFL using 1997-2008 time series (Figure 9, bottom panel). The Plan Team (September 2009) recommended fixing the time period at 12 years (1997-2008) after discussion of what would constitute a "reasonable time period". The preliminary estimates of catch in unobserved halibut IFQ fisheries presented in Appendix A are not included in the ABC calculations because the best method for estimating these catches has not been determined. The levels of these catches are very sensitive to the estimation method used and other methods not yet explored in Appendix A may be more appropriate.

Tier 6

Tier 6 for GOA shark ABC and OFL are presented both for individual species and for sharks as a complex. Incidental shark catches for the years 2003-2009 were provided by the NMFS AKRO (Table 3). The time series of incidental catch for sharks for the years 1997-2005 is considered the best available information on catch of shark species in the GOA and is used here to provide an approximate Tier 6 option for GOA shark ABC and OFL. Catches of other shark species in the GOA are rare and consequently catch estimation for other shark species is unreliable. We also present an expanded time series (1997-2007) for consideration for estimation of the average catch.

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

GOA Tier 6 Calculations (t)

Species	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidentified shark	Total shark complex
1997-2007 Average catch	703	316	69	188	1,276
ABC	528	237	52	141	957
OFL	703	316	69	188	1,276
1997-2008 Average catch	689	295	64	173	**1,222**
ABC	517	221	48	130	**916**
OFL	689	295	64	173	**1,222**

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

Ecosystem effects on *GOA Sharks (cont'd)*			
Indicator	Observation	Interpretation	Evaluation
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 over fishing is occurring for any shark species in the GOA. There are currently no directed commercial fisheries for shark species in federal or state managed waters of the GOA, 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 GOA fisheries have been very small compared to catch rates of target species. 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 spiny dogfish and Pacific sleeper sharks in the GOA. In the GOA, average catch of spiny dogfish from 1997-2005 (422 tons) represented about 1% of the available spiny dogfish biomass from GOA bottom trawl surveys 1996-2009 (average of 66,772 tons, Table 9). The 2001 survey did not include all areas of the eastern GOA and consequently, the 2001 survey may not be comparable with the other surveys for species such as spiny dogfish which appear to be relatively abundant in the eastern GOA. Average catch of Pacific sleeper sharks from 1997-2005 (313 tons) represented less than 1% of the available Pacific sleeper shark biomass from GOA bottom trawl surveys 1996-2005 (average of 37,822 tons, Table 9). Average catch of salmon sharks from 1997-2005 (63 tons) was relatively small. GOA bottom trawl survey biomass estimates for salmon sharks are unreliable because trawl gear is an inefficient sampling technique for salmon sharks and salmon sharks were only caught in four hauls from 1996-2005 (Table 9).

2010 and 2011 recommendations	Spiny Dogfish	Pacific Sleeper Shark	Salmon Shark	Other/Unid Sharks	Total Sharks
Tier	6	6	6	6	6
M	0.097	0.097	0.18	0.097	0.097
Biomass (2009)	274,880	39,6688	0		67,568
Avg Catch (1997-2008)	689	295	64	173	**1,222**
ABC	517	221	48	130	**916**
OFL	689	295	64	173	**1,222**

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Table 1. Shark species in the Gulf of Alaska (GOA) including life history and biological characteristics. Missing information is denoted by "?". Lengths presented as total length (TL) except as precaudal length (PCL) when noted in table.

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]	?	? yrs, 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 unpublished data; [20]G. A. McFarlane pers. comm.

Table 2. Time series of Other Species TAC, Other Species and shark catch, and ABC for sharks. Note that the decrease in TAC in 2008 was a regulatory change and not based on biological trends.

Year	TAC	Other Sp. Catch	Est. Shark Catch	ABC	Management Method
1992	13,432	12,313	517	N/A	Other Species TAC (included Atka)
1993	14,602	6,867	1,027	N/A	Other Species TAC (included Atka)
1994	14,505	2,721	360	N/A	Other Species TAC
1995	13,308	3,421	308	N/A	Other Species TAC
1996	12,390	4,480	484	N/A	Other Species TAC
1997	13,470	5,439	1,041	N/A	Other Species TAC
1998	15,570	3,748	2,390	N/A	Other Species TAC
1999	14,600	3,858	1,036	N/A	Other Species TAC
2000	14,215	5,649	1,117	N/A	Other Species TAC
2001	13,619	4,801	853	N/A	Other Species TAC
2002	11,330	4,040	427	N/A	Other Species TAC
2003	11,260	6,262	751	N/A	Other Species TAC
2004	12,592	3,580	2,333	N/A	Other Species TAC*
2005	13,871	2,512	1,101	N/A	Other Species TAC
2006	13,856	3,882	1,603	N/A	Other Species TAC
2007	12,229	3,026	1,388	1,792	Other Species TAC
2008	4,500	2,984	619	1,792	Other Species TAC
2009	4,500	2,085	365	777	Other Species TAC

*Skates were removed from the GOA Other Species category in 2004.
Sources: TAC and Other Species catch from AKRO. Estimated shark catches from 1992-1996 from Gaichas et al. 1999, catches from 1997-2002 from Gaichas et al. 2003 and catches from 2003-2009 from AKRO Catch Accounting System (CAS, Updated Oct 7, 2009).

Table 3. NMFS estimated catch (tons) of sharks (by species) and Other Species (in aggregate) in the Gulf of Alaska. 1990-1998 catch estimated by pseudo-blend estimation procedure (Gaichas et al. 1999). 1997-2002 catch estimated with NMFS new pseudo-blend estimation procedure (Gaichas, 2002). Years 2003-2009 from NMFS AKRO as of October 7, 2009. Breaks in the table represent different catch estimation periods.

Year	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/ Unident shark	Total sharks	Total other species	% of Other Species Catch
1990	171	20	53	30	274	6289	4%
1991	141	49	42	108	340	5700	6%
1992	321	38	142	17	517	12313	4%
1993	383	215	89	340	1027	6867	15%
1994	160	120	25	56	360	2721	13%
1995	141	63	55	49	308	3421	9%
1996	337	66	28	53	484	4480	11%
1997	233	118	25	59	436	5,439	8%
1998	298	161	79	132	669	3,748	18%
-	-	-	-	-	-	-	-
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	362	298	37	54	751	6,262	12%
2004	1,966	286	41	40	2,333	3,580	65%
2005	485	486	60	70	1,101	2,512	44%
2006	1,232	254	34	83	1,603	3,882	41%
2007	849	297	135	107	1,388	3,026	46%
2008	534	66	7	12	619	2,984	21%
2009	291	47	4	22	365	2,085	17%
Average 1997-2008	689.34	294.78	64.19	173.33	1,221.56	4,148.42	
Maximum 1997-2008	1,966	608	135	1,380	2,390	6,262	
Total 1997-2009	8,563	3,585	775	2,102	15,023	51,866	
% of Total Sharks	57%	24%	5%	14%	100%		
% of Other Species	17%	7%	1%	4%	29%		

Table 4. Estimated discard rates of sharks (by species) caught in the Gulf of Alaska. Source: AKFIN database, queried by Terry Hiatt.

Year	Spiny dogfish	Pacific sleeper shark	Salmon shark	Other/Unidentified shark
2005	98%	99%	98%	69%
2006	97%	99%	97%	78%
2007	96%	100%	100%	90%
2008	93%	98%	94%	59%
2009	92%	99%	99%	6%
Average	96%	99%	99%	74%

Table 5. Estimated catch (tons) of spiny dogfish in the Gulf of Alaska by fishery. 1990-1996 catch estimated by pseudo-blend estimation procedure (Gaichas et al. 1999). 1997-2001 catch estimated with NMFS new pseudo-blend estimation procedure (Gaichas 2002). Years 2003-2009 from NMFS AKRO using the improved pseudo-blend estimation procedure (as of Oct. 7, 2009). Catch by target fishery not estimated for 2002. Spiny dogfish do not occur in the Atka Mackerel fishery. Bycatch in the halibut fisheries has been estimated by NMFS AKRO since 2003, but it is based only on landed sharks and does not include discarded catch (See Appendix A for details on preliminary estimation of bycatch in this unobserved fishery).

Fishery	Pollock	Pacific Cod Total	Flatfish Total	Rockfish Total	Halibut	Sablefish Total	Grand Total	Year % of Total 97-09
1990	57.6	36.0	13.5	1.8		59.0	170.9	
1991	29.3	52.6	16.2	16.4		26.2	141.2	
1992	84.4	50.5	116.0	22.4		40.7	320.6	
1993	137	10.1	138.5	2.4		95.3	383.4	
1994	22	16.9	83.4	2.5		35.4	160.2	
1995	2.8	28.1	24.1	18.4		50.7	140.6	
1996	2.9	15.3	182.6	19.8		79.5	336.9	
1997	2.8	57.6	137.2	326.2		133.7	657.5	8%
1998	4.9	727.2	69.0	3.1		59.6	864.9	10%
1999	8.6	160.2	56.6	4.8		83.4	313.6	4%
2000	18.7	29.4	66.3	146.6		136.6	397.6	5%
2001	11.6	172.8	162.5	25.1		122.1	494.0	6%
2002	-	-	-	-	-	-	-	
2003	6.685	43.6	166.0	35.5	7.3	20.0	279.1	3%
2004	9.173	19.6	1776.9	2.3	14.8	142.6	1965.3	24%
2005	15.826	27.9	50.1	2.8	18.0	369.9	484.6	6%
2006	49.959	113.2	122.9	2.0	770.1	153.2	1211.3	15%
2007	47.524	250.4	151.4	6.2	226.7	166.7	848.9	10%
2008	59.824	290.2	85.9	4.8	0.5	92.7	533.9	6%
2009	14.136	50.3	61.6	1.4	93.8	69.4	290.6	3%
Total 97-09	249.7	1,942.5	2,906.3	560.7	1,131.2	1,549.9	8341.3	
Fishery % of Total	3%	23%	35%	7%	14%	19%		

Table 6. Estimated catch (tons) of Pacific sleeper sharks in the Gulf of Alaska by fishery. 1990-1996 catch estimated by pseudo-blend estimation procedure (Gaichas et al. 1999). 1997-2001 catch estimated with NMFS new pseudo-blend estimation procedure (Gaichas 2002). Years 2003-2009 from NMFS AKRO using the improved pseudo-blend estimation procedure. Catch by target fishery not estimated for 2002. Bycatch in the halibut fisheries has been estimated by NMFS AKRO since 2003, but it is based only on landed sharks and does not include discarded catch (See Appendix A for details on preliminary estimation of bycatch in this unobserved fishery).

Fishery	Pollock	Pacific Cod Total	Flatfish Total	Rockfish Total	Atka Mackerel	Halibut	Sablefish Total	Grand Total	Year % of Total 97-09
1990	2.9	9.9	0.4	4.3	0		2.2	19.7	
1991	27.2	2.8	3.1	0	0		16.2	49.4	
1992	1.1	27.4	2.7	0	0		6.4	37.6	
1993	156.5	21.8	1	0	0		35.5	214.8	
1994	79.6	16.6	0.8	1.3	0		21.2	119.5	
1995	16.9	13.7	20.7	0.1	0		11.6	63	
1996	14.5	11.9	12.1	0	0.2		26.4	65.9	
1997	22.3	59.3	46	0.9	0		7.5	135.9	4%
1998	32.4	19.6	10.1	0.2	0		11.3	74	2%
1999	34.1	505.8	6	3	0		8.7	557.7	17%
2000	178.4	376.8	35.9	0.3	0		16.7	608.2	18%
2001	145.9	65.8	6.3	0.7	0		30.3	249	7%
2002	-	-	-	-	-		-	-	
2003	73.422	56.3	93.0	0.3	0.0	60.177	13.1	296.2	9%
2004	170.297	25.6	73.7	0.8	0.0	8.885	6.7	285.9	9%
2005	198.756	133.8	129.6	0.2	0.0	2.205	20.2	484.7	14%
2006	154.471	13.5	60.4	0.4	0.0	0.836	24.1	253.7	8%
2007	58.802	9.1	222.7	0.0	0.0	3.867	2.7	297.2	9%
2008	46.873	13.2	2.0	1.1	0.0	0	2.4	65.6	2%
2009	28.686	4.2	14.0	0.3	0.0	0	0.2	47.4	1%
Total 97-09	1,144.4	1,283.0	699.7	8.1	0.0	76.0	143.9	3,355.6	
Fishery % of Total	34%	38%	21%	0%	0%	2%	4%		

Table 7. Estimated catch (tons) of salmon sharks in the Gulf of Alaska by fishery. 1990-1996 catch estimated by pseudo-blend estimation procedure (Gaichas et al. 1999). 1997-2001 catch estimated with NMFS new pseudo-blend estimation procedure (Gaichas 2002). Years 2003-2009 from NMFS AKRO using the improved pseudo-blend estimation procedure. Catch by target fishery not estimated for 2002. Bycatch in the halibut fisheries has been estimated by NMFS AKRO since 2003, but it is based only on landed sharks and does not include discarded catch (See Appendix A for details on preliminary estimation of bycatch in this unobserved fishery).

Fishery	Pollock	Pacific Cod Total	Flatfish Total	Rockfish Total	Atka Mackerel	Halibut	Sablefish Total	Grand Total	Year % of Total 97-09
1990	45.3	3.2	0.2	0.7	0.0		2.1	52.7	
1991	36.2	0.0	0.0	0.0	0.0		5.3	41.6	
1992	123.1	16.5	0.2	0.0	0.0		2.1	141.9	
1993	86.7	0.0	2.5	0.0	0.0		0.0	89.2	
1994	24.2	0.0	0.0	0.0	0.0		0.0	24.5	
1995	25.9	21.6	3.2	0.2	0.0		3.1	54.9	
1996	26.9	0.0	0.0	0.0	0.1		0.2	27.8	
1997	19.8	0.1	0.0	0.0	0.0		0.0	123.8	15%
1998	69.7	0.0	0.8	0.4	0.0		0.0	71.0	9%
1999	111.8	0.7	0.7	0.0	0.0		18.4	131.6	16%
2000	32.7	0.0	3.7	0.8	0.0		0.6	37.8	5%
2001	29.5	0.0	1.5	1.8	0.0		0.0	32.8	4%
2002		-	-	-	-		-	-	
2003	36.5	0.0	0.3	0.0	0.0	0	0.1	36.9	5%
2004	33.1	1.7	5.4	0.1	0.0	0	0.4	40.8	5%
2005	43.3	0.8	15.7	0.5	0.0	0	0.0	60.3	8%
2006	31.4	0.6	1.6	0.6	0.0	0	0.0	34.3	4%
2007	125.1	0.0	9.0	0.5	0.0	88	0.0	222.6	28%
2008	6.2	0.0	0.1	0.7	0.0	0	0.0	7.1	1%
2009	4.0	0.0	0.0	0.4	0.0	0	0.0	4.3	1%
Total 97-09	543.1	4.0	38.9	5.8	0.0	88.0	19.5	803.3	
Fishery % of Total	68%	0%	5%	1%	0%	11%	2%		

Table 8. Estimated catch (tons) of unidentified/other sharks in the Gulf of Alaska by fishery. 1990-1996 catch estimated by pseudo-blend estimation procedure (Gaichas et al. 1999). 1997-2001 catch estimated with NMFS new pseudo-blend estimation procedure (Gaichas 2002). Years 2003-2009 from NMFS AKRO using the improved pseudo-blend estimation procedure. Catch by target fishery not estimated for 2002. Bycatch in the halibut fisheries has been estimated by NMFS AKRO since 2003, but it is based only on landed sharks and does not include discarded catch (See Appendix A for details on preliminary estimation of bycatch in this unobserved fishery).

Fishery	Pollock	Pacific Cod Total	Flatfish Total	Rockfish Total	Atka Mackerel	Halibut	Sablefish Total	Grand Total	Year % of Total 97-09
1990	4.1	21.3	0.8	1.4	0.0		2.9	30.5	
1991	17.8	36.7	35.5	4.4	0.0		13.7	108.1	
1992	3.3	8.4	3.5	0.1	0.0		1.5	17.2	
1993	138.3	38.1	3.7	0.0	0.0		159.3	339.6	
1994	41.6	2.3	3.0	0.0	0.0		8.9	55.8	
1995	4.0	3.4	10.6	9.7	0.0		14.3	49.3	
1996	14.2	3.1	17.8	1.9	0.1		16.0	53.4	
1997	8.9	13.4	9.0	47.5	0.0		43.9	123.4	6%
1998	24.2	10.2	17.9	2.3	0.0		1325.2	1379.8	66%
1999	6.1	12.3	8.1	0.1	0.0		6.4	33.0	2%
2000	12.3	3.5	34.0	4.8	0.0		18.7	73.6	4%
2001	35.0	1.4	1.5	1.4	0.0		37.7	77.0	4%
2002		-	-	-	-		-	-	
2003	7.6	6.4	18.2	0.2	0.0	17.5	4.2	54.1	3%
2004	11.1	2.7	18.8	0.2	0.0	2.8	4.5	40.1	2%
2005	35.2	1.2	21.5	0.2	0.0	0.2	11.6	69.8	3%
2006	40.9	11.9	24.4	1.6	0.0	0.0	4.5	83.3	4%
2007	13.7	38.9	49.6	0.4	0.0	0.0	4.7	107.3	5%
2008	4.3	2.4	2.4	0.0	0.0	0.0	2.9	12.1	1%
2009	10.4	2.5	9.4	0.0	0.0	0.0	0.0	22.2	1%
Total 97-09	209.7	106.7	214.8	58.8	0.0	20.5	1,464.3	2,075.8	
Fishery % of Total	10%	5%	10%	3%	0%	1%	71%		

Table 9. Gulf of Alaska AFSC trawl survey estimates of individual shark species total biomass (tons) with Coefficient of Variation (CV), and number of hauls with catches of sharks. Data updated October, 2009 (RACEBASE). Analysis of GOA biomass trends are subject to the following caveats regarding the consistency of the survey time series. Survey efficiency in the GOA may have increased for a variety of reasons between 1984 and 1990, but should be stable after 1990 (Gaichas et al. 1999). Surveys in 1984, 1987, and 1999 included deeper strata than the 1990-1996 surveys; therefore the biomass estimates for deeper-dwelling species are not comparable across years. The 2001 survey did not include all areas of the Eastern GOA and consequently, the 2001 survey may not be comparable with the other surveys for species such as spiny dogfish which appear to be relatively abundant in the Eastern GOA. Source: Gaichas et al. (1999), RACEBASE.

		Spiny Dogfish			Sleeper Shark			Salmon Shark			
Year	Survey Hauls	Haul w/ catch	Biomass Est.	CV	Hauls w/catch	Biomass Est.	CV	Hauls w/catch	Biomass Est.	CV	Total Shark Biomass
1984	929	125	10,143.0	0.206	1	163.2	1	5	7,848.8	0.522	18,155.0
1987	783	122	10,106.8	0.269	8	1,319.2	0.434	15	12,622.5	0.562	24,048.5
1990	708	114	18,947.6	0.378	3	1,651.4	0.66	13	12,462.0	0.297	33,061.0
1993	775	166	33,645.1	0.204	13	8,656.8	0.5	9	7,728.6	0.356	50,030.5
1996	807	99	28,477.9	0.736	11	21,100.9	0.358	1	3,302.0	1	52,880.8
1999	764	168	31,742.9	0.138	13	19,362.0	0.399	0	NA	NA	51,104.9
2001	489	75	31,774.3	0.45	15	37,694.7	0.362	0	NA	NA	69,469.0
2003	809	204	98,743.8	0.219	28	52,115.6	0.247	2	3,612.8	0.707	154,472.2
2005	839	156	47,926.1	0.17	26	57,022.0	0.263	1	2,455.3	1	107,403.4
2007	820	164	161,965.1	0.35	15	39,634.8	0.39	2	12,339.7	0.75	213,939.6
2009	884	182	27,879.9	0.120	8	39,687.7	0.446	0	NA	NA	67,567.6

Table 10. Research survey catch (tons) of sharks between 1977 and 2007 in the Gulf of Alaska (GOA). The GOA LL and IPHC LL survey catches are provided in numbers, weight (t) is estimated based on average weight of the individual fish species and the number of each species caught, which may change as data improves.

Year	GOA Trawl surveys (t)	GOA LL Survey (#s)	GOA LL Survey (t)	IPHC LL Survey (#s)	IPHC LL Survey (t)
1977	0.14				
1978	1.44				
1979	1				
1980	0.86				
1981	2.23				
1982	0.36				
1983	1.03				
1984	3.12				
1985	0.96				
1986	1.38				
1987	3.55				
1988	0.27				
1989	0.87	751	4.88		
1990	3.52	583	4.75		
1991	0.15	2,039	8.95		
1992	0.12	3,881	13.57		
1993	5.03	2,557	15.38		
1994	0.43	2,323	15.32		
1995	0.57	3,882	17.25		
1996	3.48	2,206	15.95		
1997	0.52	2,822	12.40		
1998	0.58	7,701	30.76	42,361	390.45
1999	NA	1,185	11.77	21,705	336.20
2000	NA	1,212	15.98	29,257	426.83
2001	0.45	1,726	23.56	34,227	361.80
2002	NA	1,576	23.78	22,028	324.52
2003	7.36	2,372	19.91	68,940	613.42
2004	NA	1,964	12.03	48,850	447.15
2005	7.13	3,775	14.14	44,082	369.70
2006	NA	6,593	19.32	41,355	314.79
2007	14.06	3,552	11.47	34,023	241.40
2008	0.73	3,606	12.11	24,655	187.25
2009		4,709	12.77		

Sources: Gaichas et al. (1999, Table 3) Sandra Lowe and Darin Jones (pers comm., Oct 2009) for 2001–2009 trawl surveys and C. Rodgveller (pers comm., Oct 2009) for 1989-2009 GOA longline survey. IPHC data provided by Claude Dykstra.

Table 11. Life history parameters. 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, with L_∞ either being the PCL or the TL_{ext} (total length in cm 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). 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 12. Natural mortality (*M*) parameter estimates for shark species in the Gulf of Alaska (GOA). Source: GOA spiny dogfish (Tribuzio and Kruse in review); eastern North Pacific (ENP) spiny dogfish (Wood et al. 1979); salmon shark (Goldman 2002).

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

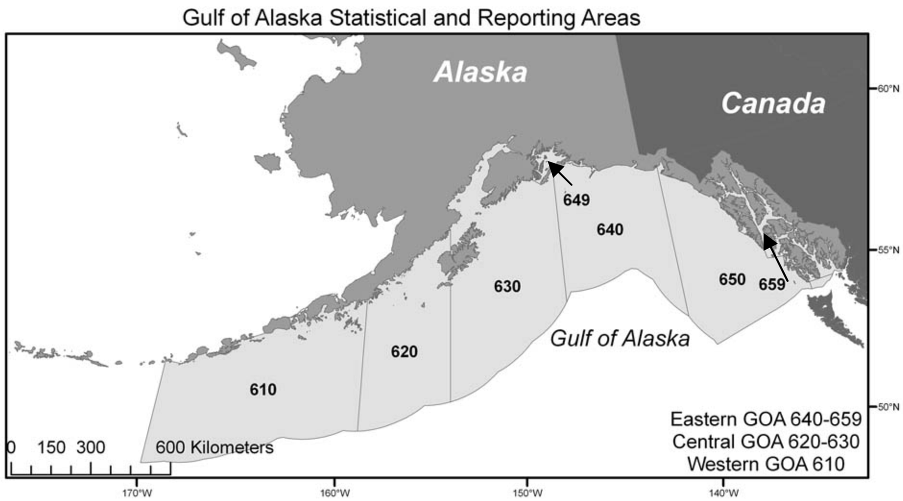

Figure 1. The statistical areas for NMFS observer data in the Gulf of Alaska.

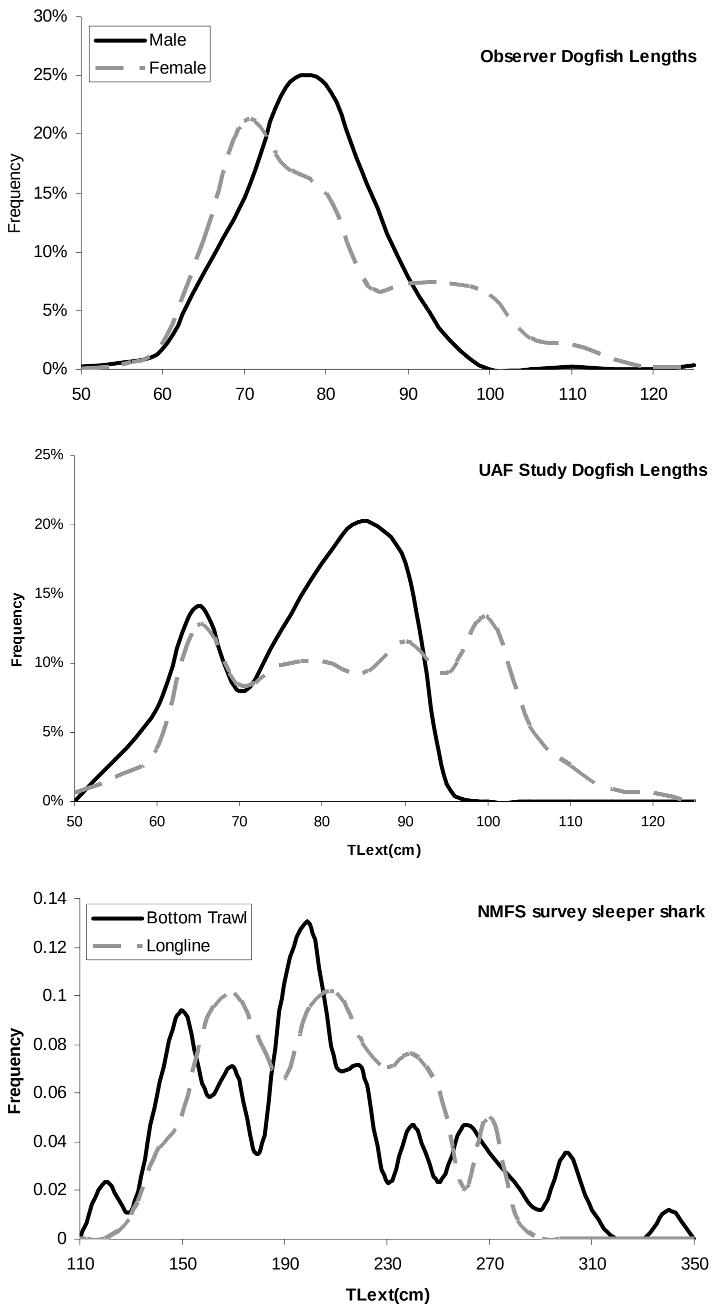

Figure 2. Observed length frequencies for: (top) spiny dogfish from a special project with the NMFS observer program; (center) spiny dogfish from University of Alaska Fairbanks study; (bottom) Pacific sleeper shark from NMFS bottom trawl and longline surveys.

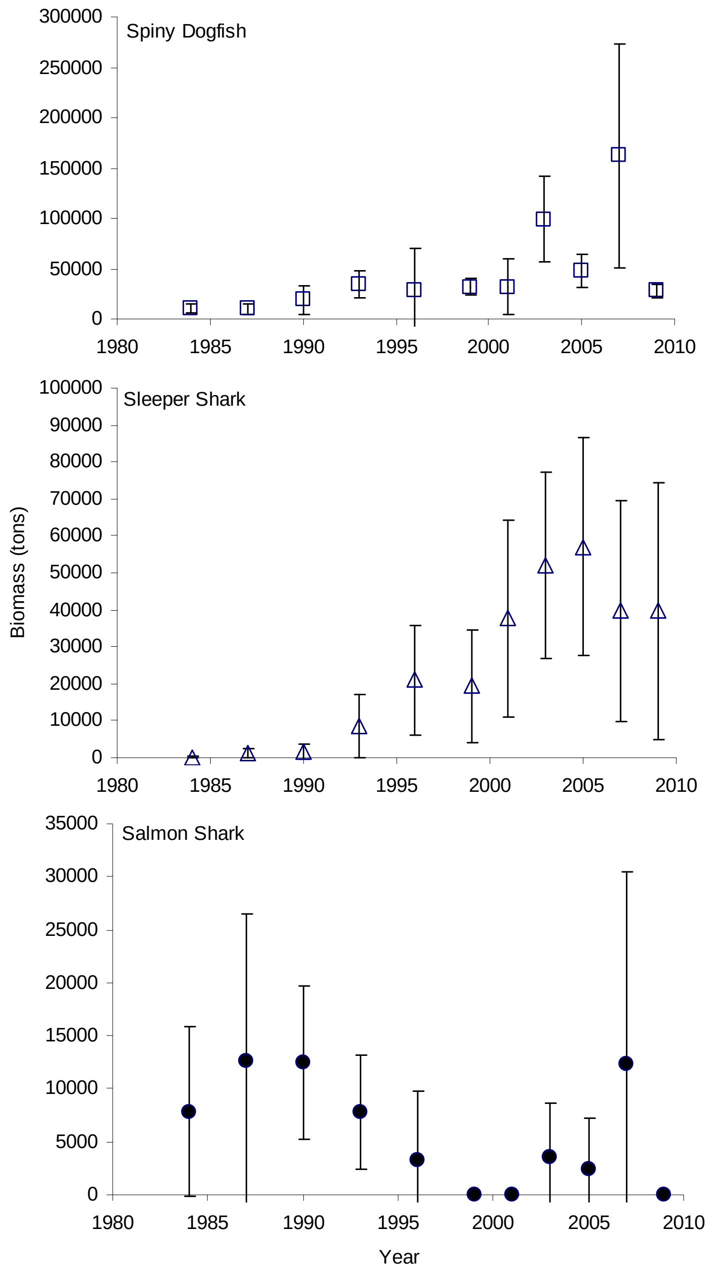

Figure 3. Trends in Gulf of Alaska (GOA) AFSC bottom trawl survey estimates of individual shark species total biomass (mt) reported here as an index of relative abundance. Error bars are 95% confidence intervals. Analysis of GOA biomass trends are subject to the following caveats regarding the consistency of the survey time series. Survey efficiency in the GOA may have increased for a variety of reasons between 1984 and 1990, but should be stable after 1990 (Gaichas et al. 1999). Surveys in 1984, 1987, and 1999 included deeper strata than the 1990-1996 surveys; therefore the biomass estimates for deeper-dwelling species are not comparable across years. The 2001 survey did not include all areas of the Eastern GOA and consequently, the 2001 survey may not be comparable with the other surveys for species such as spiny dogfish which appear to be relatively abundant in the Eastern GOA. Source: Gaichas et al. (1999), RACEBASE.

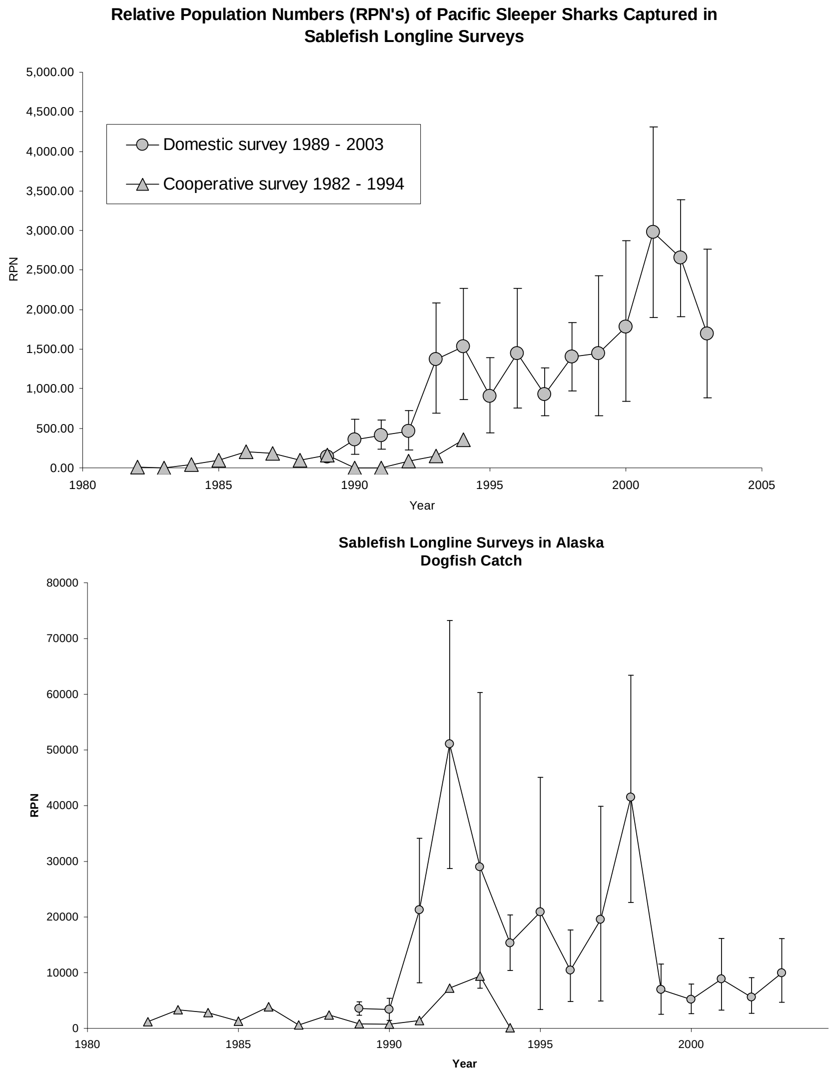

Figure 4. Relative population numbers (RPN's) of Pacific sleeper sharks (top) and spiny dogfish (bottom) captured in the northeast Pacific (Eastern Bering Sea, Aleutian Islands, and Gulf of Alaska) during the years 1982-1994 by the Japan-U.S. cooperative sablefish longline survey, and during the years 1989-2003 by the domestic sablefish longline survey (with 95% bootstrap confidence intervals). From Courtney et al. 2006, Appendix E.

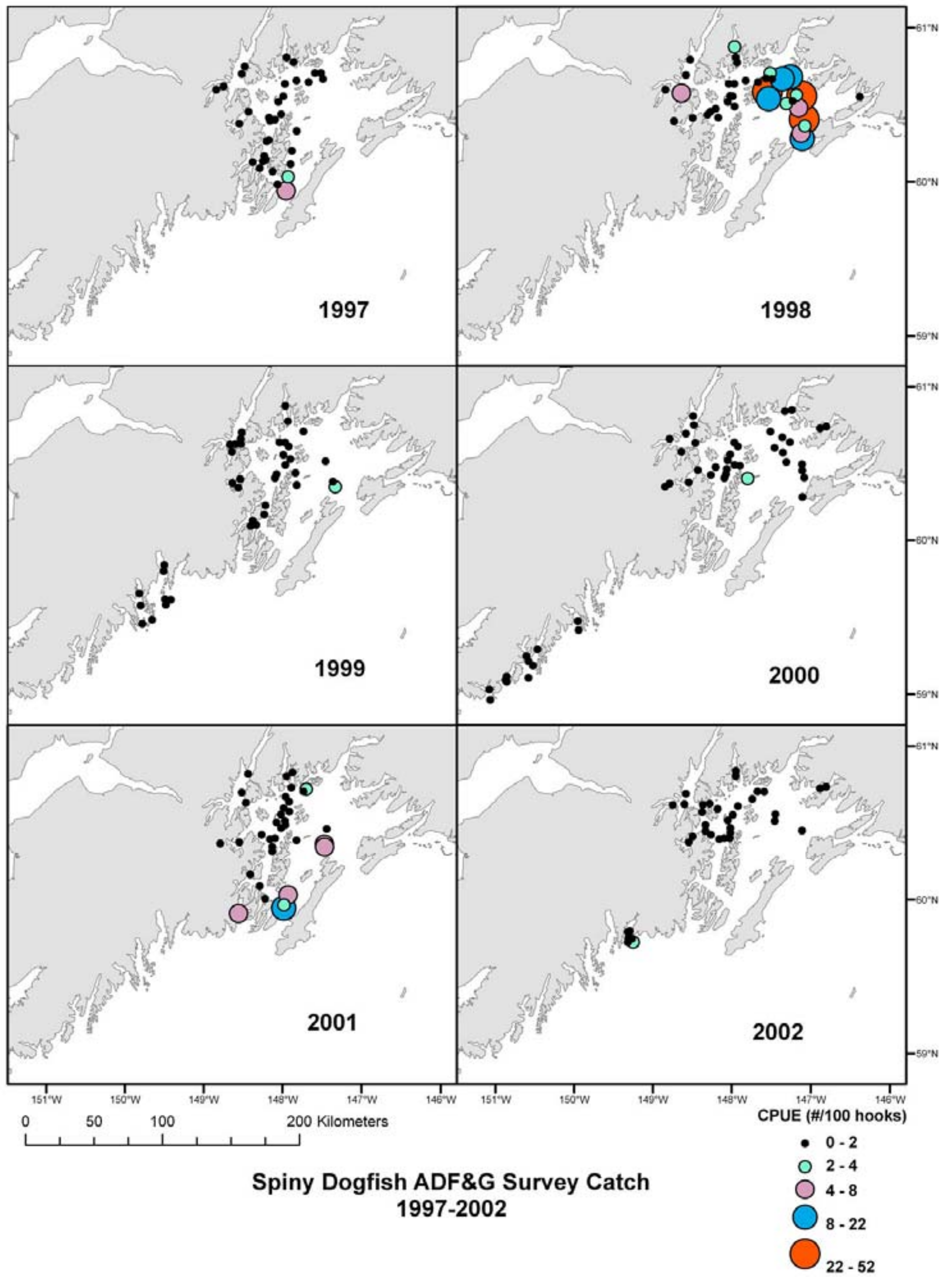

Figure 5. Spiny dogfish catch in the ADF&G longline surveys from 1997-2002.

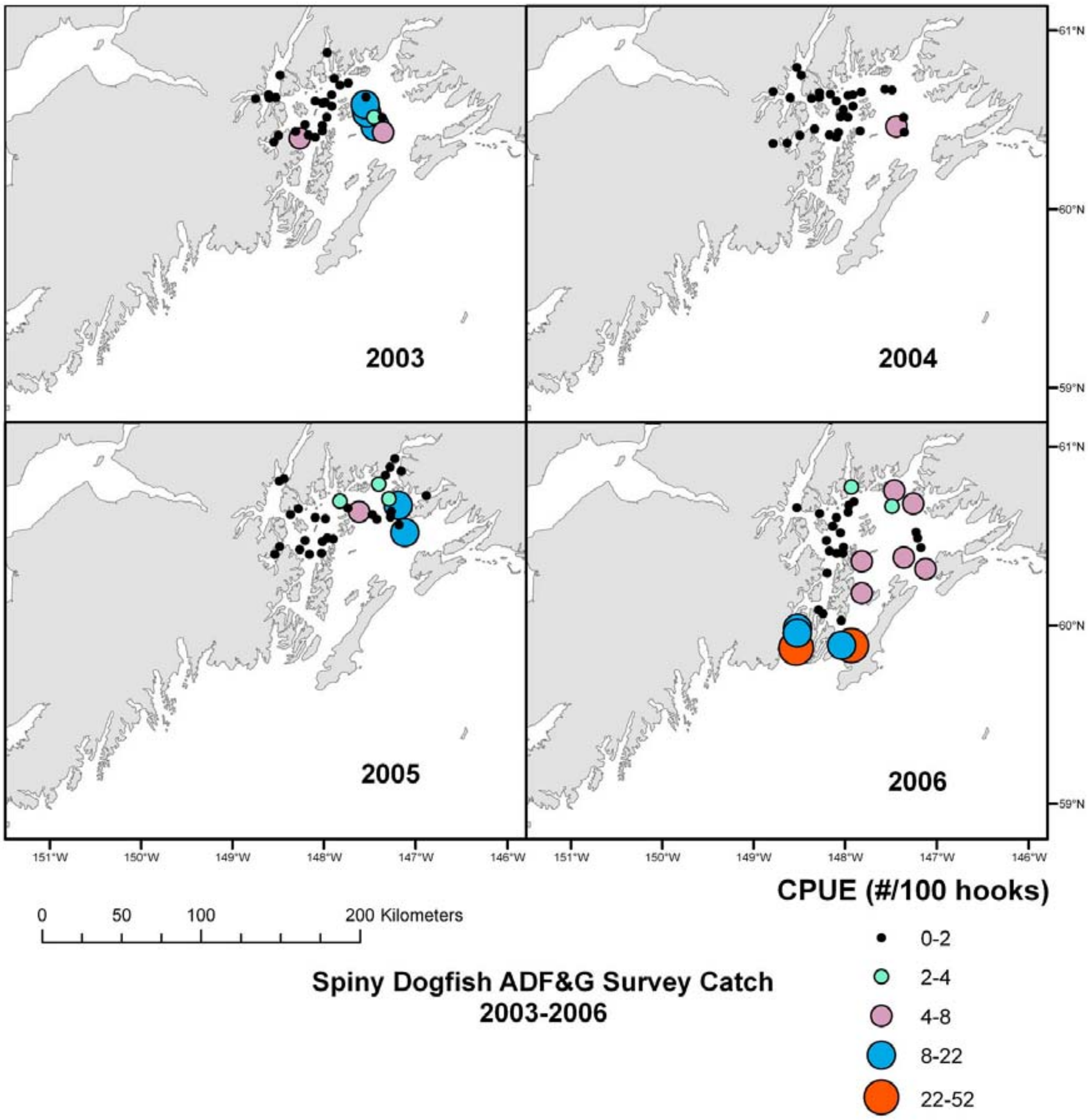

Figure 6. Spiny dogfish catch in the ADF&G longline surveys from 1997-2002.

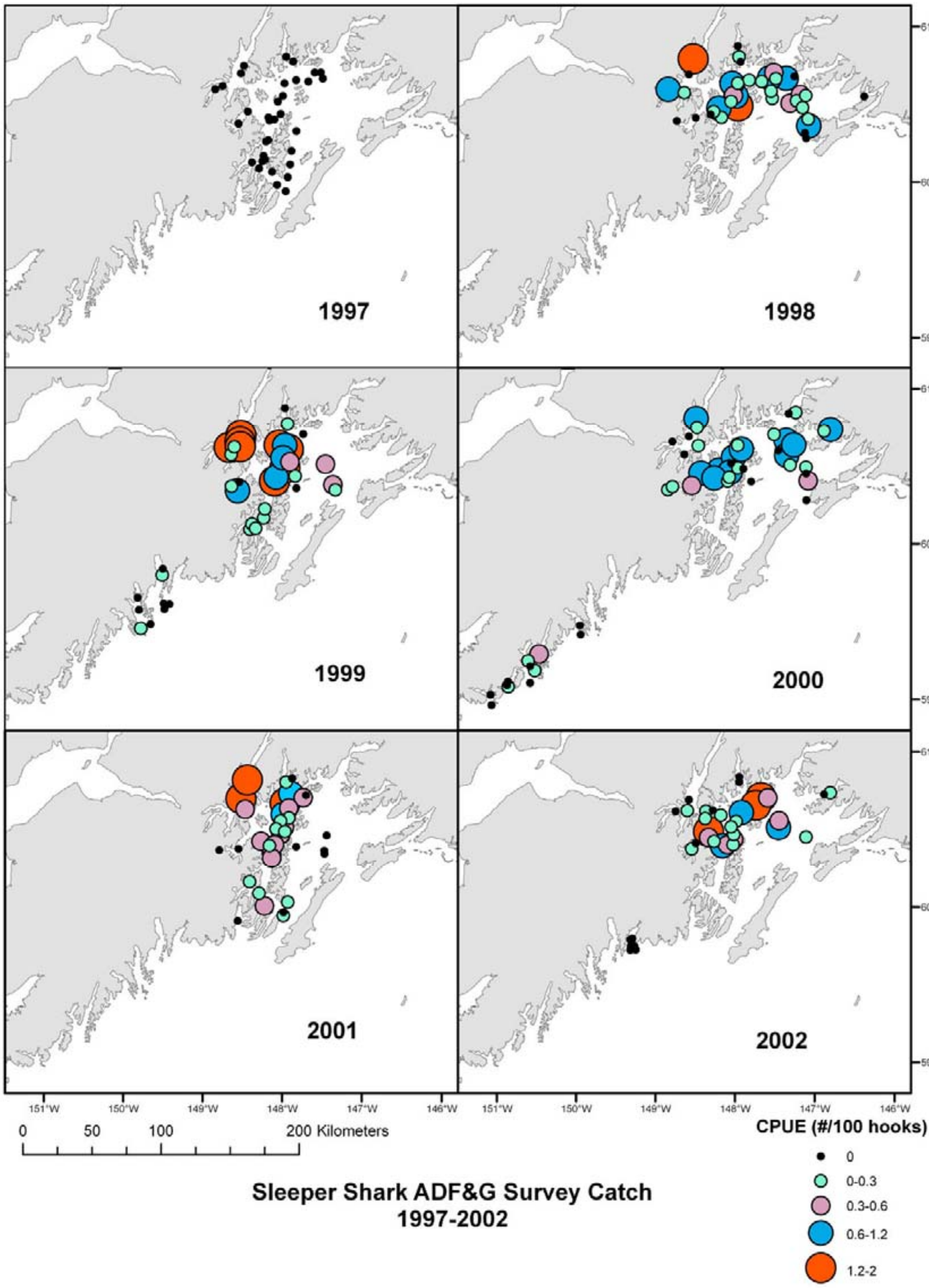

Figure 7. Sleeper shark catch in the ADF&G longline surveys from 1997-2002.

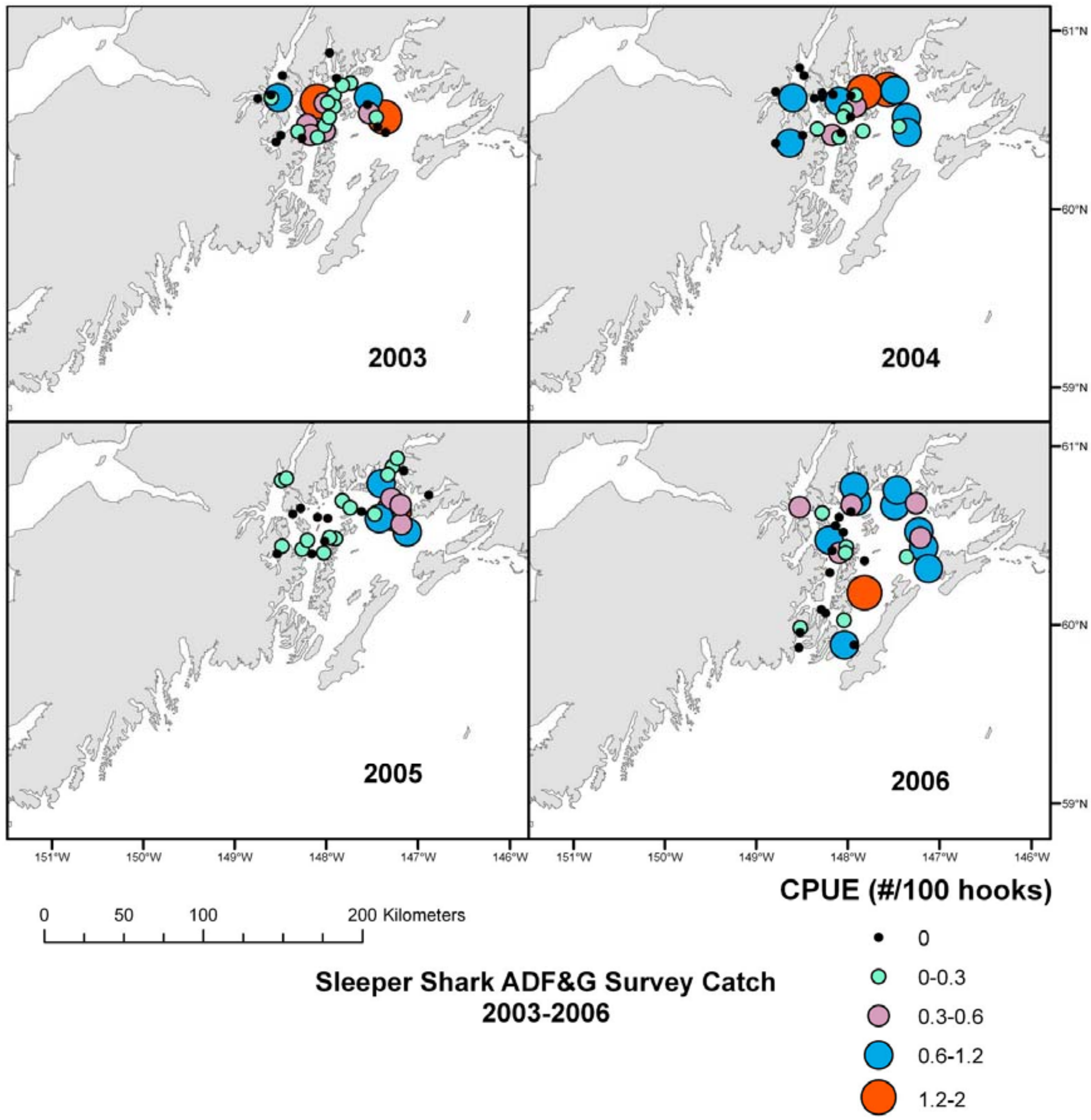

Figure 8. Sleeper shark catch in the ADF&G longline surveys from 1997-2002.

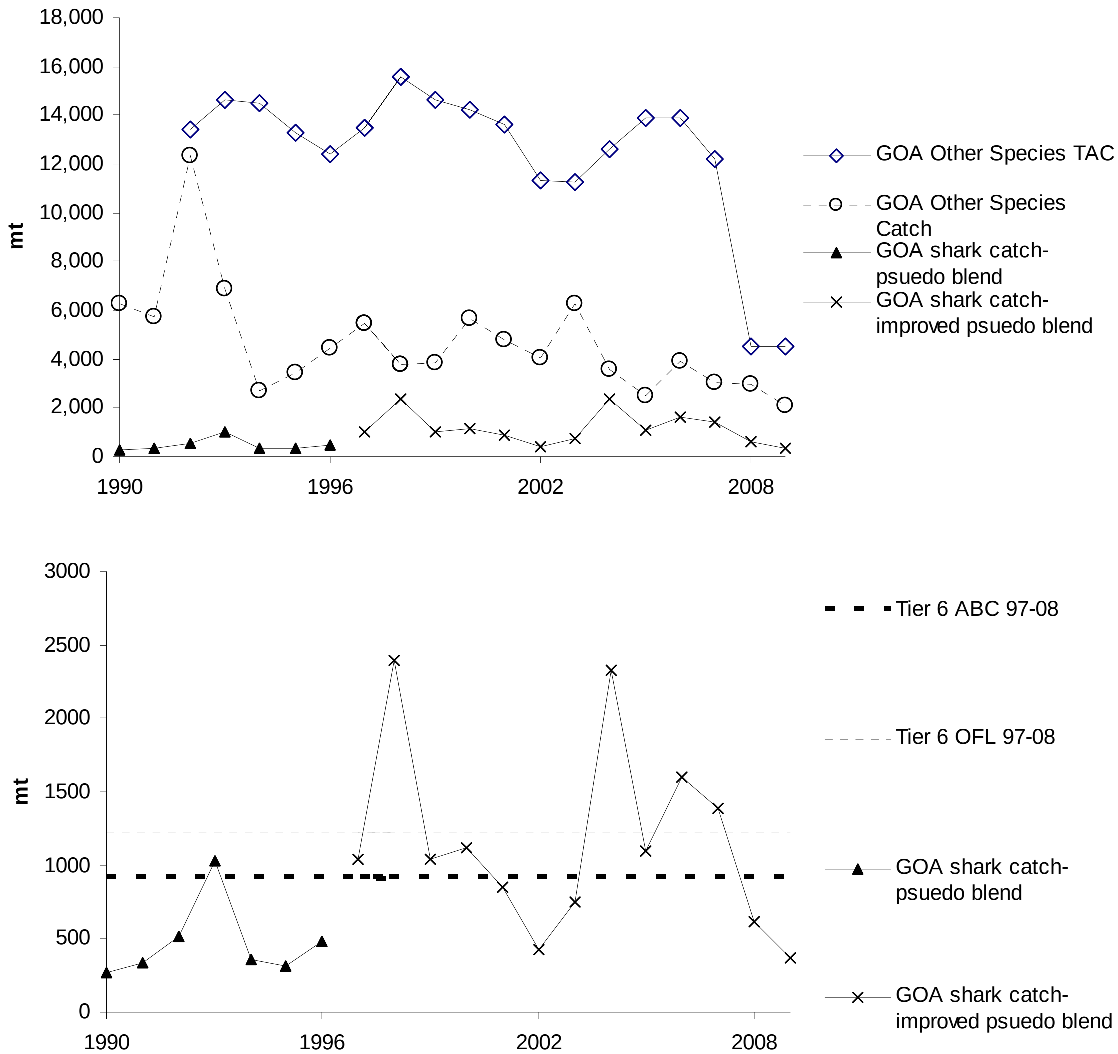

Figure 9. Top: comparison of total GOA shark catch relative to total Other Species catch and Other Species TAC. Bottom: total GOA shark catch per year plotted relative to 2009 ABC and OFL options for the GOA shark complex under Tier 6. Catch data updated as of October 7, 2009.

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.

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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	738.7	60.3	(32.7-88)	187.4	(103.8-271)	7.10%
1999	338.2	33.4	(9.6-57.1)	102.1	(33.3-170.9)	9.81%
2000	467.9	47.5	(16-79.1)	147.8	(53.9-241.7)	7.97%
2001	800.8	79.8	(50.6-109)	236.5	(153.6-319.4)	6.44%
2002	476.1	31.0	(13.7-48.3)	98.7	(45-152.4)	8.85%
2003	1,049.2	133.7	(88.5-178.8)	438.3	(296.3-580.4)	5.81%
2004	734.2	85.2	(43.7-126.7)	274.5	(151.5-397.5)	7.70%
2005	762.2	73.4	(25.9-120.9)	234.5	(83.4-385.6)	7.47%
2006	837.2	62.5	(35-90)	190.5	(110.6-270.3)	7.03%
2007	836.3	66.2	(42.1-90.3)	204.1	(136.3-272)	6.35%

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 (1,000s)	95% CI	Catch weight (t)	95% CI	CV
1998	71.4	17.1	(2.8-31.3)	1,242.0	(207.3-2276.8)	9.69%
1999	74.2	7.8	(3.5-12.2)	569.1	(253.2-884.9)	9.07%
2000	81.8	6.4	(2.1-10.7)	465.9	(156.3-775.6)	9.14%
2001	102.4	17.9	(9.6-26.2)	1,302.4	(696.3-1908.4)	8.95%
2002	97.2	9.3	(2.8-15.9)	680.3	(201.1-1159.5)	8.65%
2003	99.6	19.0	(3-35)	1,383.6	(219.2-2547.9)	9.91%
2004	87.7	24.4	(8-40.8)	1,777.3	(582.7-2971.9)	9.90%
2005	64.9	16.0	(5.1-26.9)	1,164.3	(371.9-1956.8)	12.06%
2006	61.5	13.7	(2.5-25)	1,000.4	(178.9-1822)	12.29%
2007	54.8	12.3	(-1.4-26)	892.3	(-104.2-1888.8)	12.60%

Table AA3. Unfiltered salmon 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	Catch weight (t)	95% CI	CV
1998	0.4	38.5	(-19.9-96.9)	5.6	(-2.9-14)	50.18%
1999	0.1	14.9	(-14.3-44)	2.1	(-2.1-6.3)	100.00%
2000	0.6	37.6	(-27.6-102.7)	5.4	(-4-14.8)	47.02%
2001	0.1	9.2	(-8.8-27.2)	1.3	(-1.3-3.9)	100.00%
2002	0.1	9.6	(-9.2-28.4)	1.4	(-1.3-4.1)	100.00%
2003	0.1	1.7	(-1.6-5)	0.2	(-0.2-0.7)	100.00%
2004	0.0	0.0	(0-0)	0.0	(0-0)	
2005	0.0	0.0	(0-0)	0.0	(0-0)	
2006	0.4	29.8	(-17-76.7)	4.3	(-2.5-11.1)	49.90%
2007	0.1	10.2	(-9.8-30.2)	1.5	(-1.4-4.4)	100.00%

Table AA4. 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	0.2	44.9	(-43.1-132.9)	70.67%
1999	0.9	44.1	(-42.3-130.4)	57.72%
2000	0.0	0.0	(0-0)	
2001	0.7	56.1	(-31.8-144)	44.61%
2002	3.9	294.2	(-127.7-716.1)	37.09%
2003	0.0	0.0	(0-0)	
2004	0.1	27.1	(-26-80.1)	100.00%
2005	0.6	269.6	(-214.3-753.5)	47.03%
2006	0.1	10.0	(-9.6-29.7)	100.00%
2007	0.0	0.0	(0-0)	

Table AA5. Estimated catches (t) of sharks in the IFQ halibut fisheries from the AKRO CAS.

Year	Spiny Dogfish	Sleeper Shark	Salmon Shark	Other Shark
2003	7.299	60.177	0	17.495
2004	14.793	8.885	0	2.798
2005	18.037	2.205	0	0.182
2006	770.061	0.836	0	0
2007	226.668	3.867	0.088	0
2008	0.516	0	0	0.032

Table AA6. 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 (1,000s)	95% CI	Catch weight (t)	95% CI	CV
1998	198.9	14.9	(9.6-20.3)	48.7	(30.7-66.7)	13.45%
1999	68.4	10.9	(-0.6-22.3)	37.3	(-2.1-76.6)	21.11%
2000	119.6	9.5	(2.2-16.7)	32.1	(8.9-55.3)	17.82%
2001	248.9	31.8	(18.9-44.7)	104.1	(64.3-144)	13.75%
2002	110.6	9.7	(2.9-16.5)	29.6	(9.2-50)	14.07%
2003	254.6	57.5	(2.8-112.1)	194.5	(7.7-381.2)	13.07%
2004	220.4	37.3	(15.6-59)	124.6	(55.4-193.9)	13.46%
2005	221.6	32.1	(9-55.3)	106.7	(30.7-182.7)	14.77%
2006	204.8	24.0	(7.8-40.1)	72.3	(20.6-123.9)	12.97%
2007	251.5	27.0	(16.9-37)	83.5	(53.3-113.7)	12.37%

Table AA7. 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 (1,000s)	95% CI	Catch weight (t)	95% CI	CV
1998	40.8	2.7	(-0.7-6.1)	196.3	(-49-441.6)	14.03%
1999	69.4	2.9	(1.2-4.7)	213.4	(87.2-339.5)	13.74%
2000	69.0	4.4	(2.4-6.5)	323.2	(171.4-474.9)	14.36%
2001	62.0	3.1	(1.2-4.9)	223.1	(90.7-355.5)	16.00%
2002	75.1	2.8	(1-4.6)	206.7	(75.1-338.3)	13.47%
2003	67.7	4.3	(-0.8-9.4)	313.4	(-57-683.7)	13.31%
2004	48.9	4.5	(1.4-7.5)	324.7	(102.6-546.9)	15.70%
2005	29.3	6.3	(0.8-11.8)	458.6	(57.4-859.8)	21.48%
2006	36.2	4.0	(1.5-6.5)	294.3	(112.6-476)	15.96%
2007	63.6	3.4	(1.2-5.6)	246.7	(85.4-408.1)	18.44%

Table AA8. Filtered salmon 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 (#s)	95% CI	Catch weight (t)	95% CI	CV
1998	0.0	0.0	(0-0)	0.0	(0-0)	
1999	0.0	0.0	(0-0)	0.0	(0-0)	
2000	0.7	44.8	(-43-132.5)	6.5	(-6.2-19.1)	74.44%
2001	0.3	12.1	(-11.6-35.8)	0.0	(0-0)	100.00%
2002	0.3	13.7	(-13.1-40.5)	3.7	(-3.6-11)	100.00%
2003	0.3	0.0	(0-0)	0.0	(0-0)	100.00%
2004	0.0	0.0	(0-0)	0.0	(0-0)	
2005	0.0	0.0	(0-0)	0.0	(0-0)	
2006	0.5	31.0	(-11.5-73.5)	0.0	(0-0)	70.60%
2007	0.0	0.0	(0-0)	4.5	(-1.7-10.6)	

Table AA9. Filtered 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 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	CV
1998	0.2	298.5	(298.5-298.5)	100.00%
1999	1.8	99.0	(-95-293)	75.23%
2000	0.0	0.0	(0-0)	
2001	1.4	67.2	(-24.9-159.4)	49.75%
2002	2.6	107.7	(-34.4-249.8)	68.21%
2003	0.0	0.0	(0-0)	
2004	0.0	0.0	(0-0)	
2005	0.0	0.0	(0-0)	
2006	0.3	15.6	(-14.9-46.1)	100.00%
2007	0.0	0.0	(0-0)	

GOA IPHC statistical areas

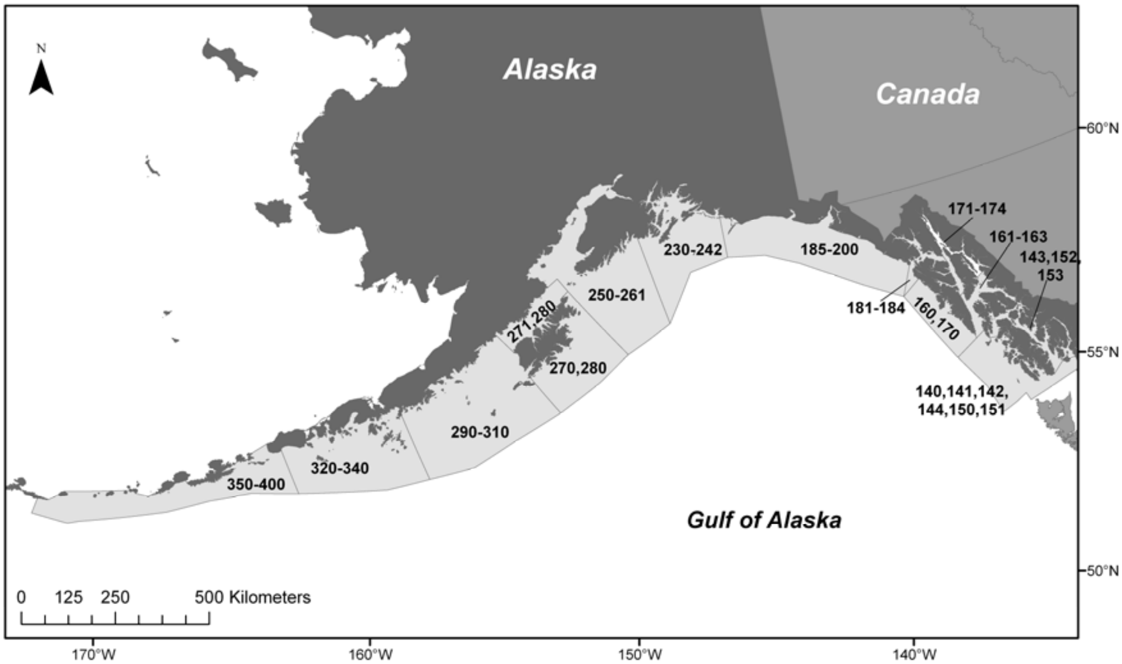

Figure AA1. International Pacific Halibut Commission (IPHC) statistical areas grouped for detailing unobserved fisheries catch records in the Gulf of Alaska. Groupings were based on confidentiality requirements.

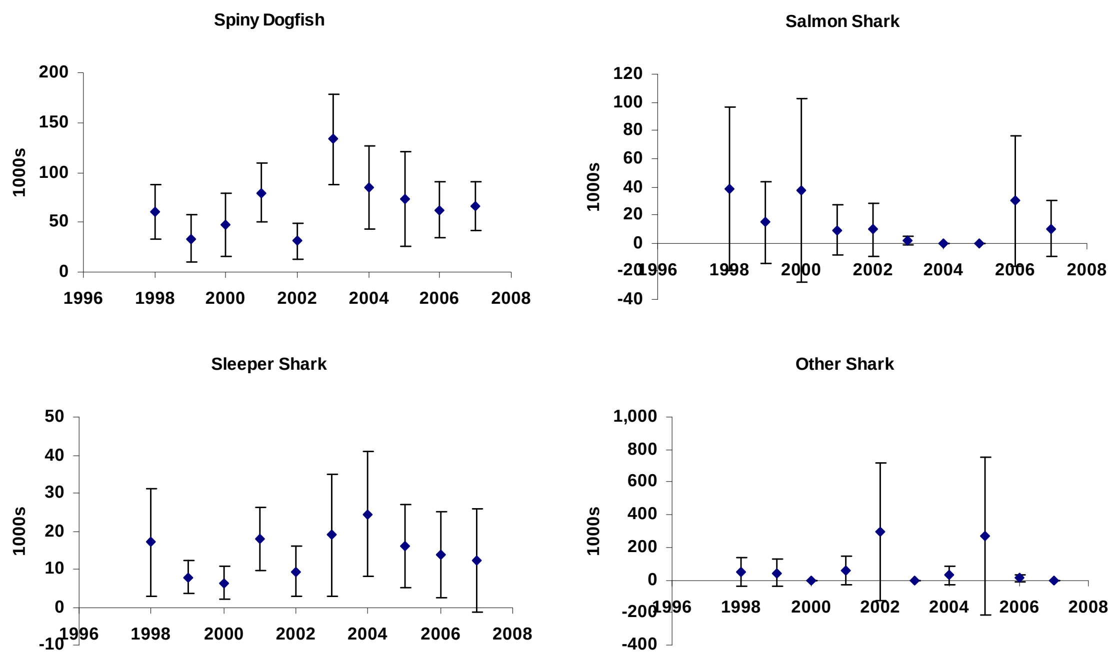

Figure AA2. Estimated catches (in numbers) of sharks in the IFQ halibut fisheries in the Gulf of Alaska. Error bars are 95% confidence intervals.

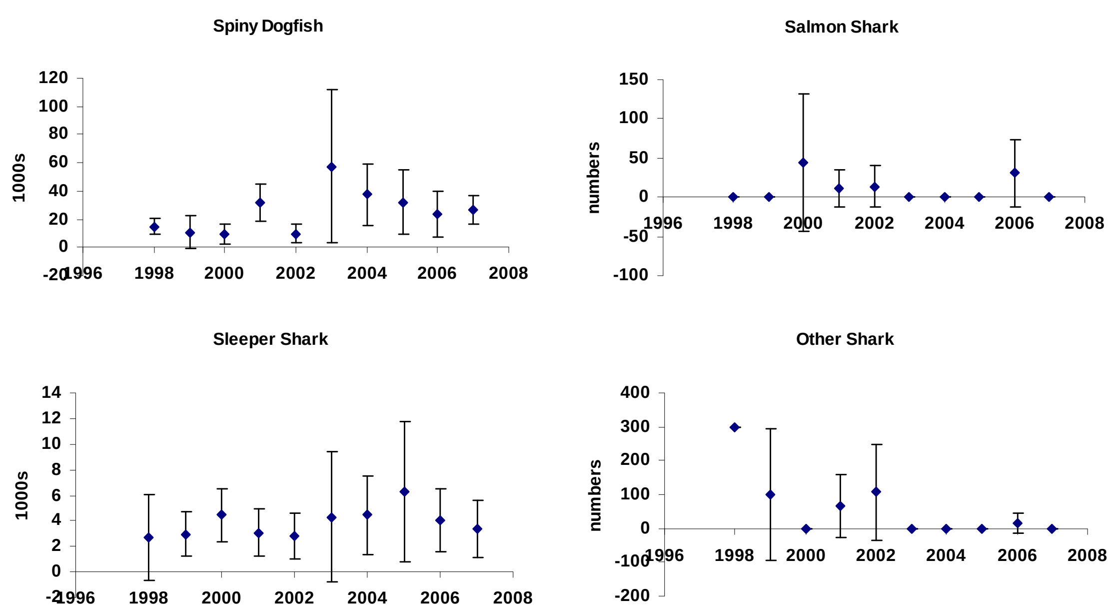

Figure AA2. Estimated catches (in numbers) of sharks in the IFQ halibut fisheries in the Gulf of Alaska based on filtered survey data. Error bars are 95% confidence intervals. Data points without error bars are either zeros or sample size of 1.

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.

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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	534	66	7	12	619	2,208	19%
Total 1997-2008	8,273	3,538	770	2,070	14,650	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/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	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	16	120	45	7	188	21,340	1%
Total est. catch	108.1	4697.2	572.5	1394.6	6770.9	310172	
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