INVESTIGATION OF BYCATCH OF SHARKS IN THE BERING SEA AND THEIR ECOLOGY

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INTRODUCTION

Commercial fisheries in the North Pacific Ocean and Bering Sea often interact with non-targeted species, especially long lived, slow growing, low fecund species such as sharks. This project investigates the demography and trophic ecology of salmon sharks and Pacific sleeper sharks caught as bycatch in Bering Sea pollock fisheries. Salmon sharks and Pacific sleeper sharks are caught as bycatch at levels between 200 and 1,400 metric tons annually. It is not known if the shark population in Bering Sea can sustain these levels of removal. Very little is known about the life history of these sharks in the Bering Sea or about their role in the ecosystem as top level predators. Current information from the Gulf of Alaska sharks suggests that segments of the salmon shark population migrate in and out of Gulf waters while Pacific sleeper shark have a relatively small home range. This data suggests that bycatch may not be consistent among life history stage, sexes, or species. Therefore, archived data regarding shark population structure and commercial Bycatch will be collected as part of this project. In addition, data was collected in 2007 aboard commercial pollock at-sea processors to estimate demographic, reproductive, and diet variables. The pollock industry, in particular At-Sea Processors, has provided considerable support to adequately assess the potential impacts of shark bycatch so that informed mitigation efforts can be implemented and consequences evaluated. The outcome of this study will be an integrated understanding of ecosystem function and likely consequences of the removal of observed levels of shark biomass in the Bering Sea.

The underlying hypothesis of this study is that bycatch is an ecosystem level phenomenon that can be controlled, if not eliminated, and that there may be consequences associated with large scale perturbations of the ecosystem, such as bycatch. Nevertheless, it remains to be determined whether these perturbations are indeed significant. Of the several North Pacific elasmobranch species (sharks and skates), this research focuses on salmon sharks (*Lamna ditropis*) and Pacific sleeper sharks (*Somniosus pacificus*), two of the largest fish species in the North Pacific Ocean.

Vessels associated with the At Sea Processors in Seattle, Washington have noted a potential increase in shark bycatch during pollock and sablefish Bering Sea fisheries (personal communication; Dr. Edward Richardson of At Sea Processors). Shark biomass estimates from the National Marine Fisheries Service (NMFS) bottom trawl survey and bycatch estimates from the NMFS observer database have also increased through the early 2000's (Figures 1-3; Courtney et al. 2005). Although data are limited, bottom trawl data collected by the NMFS indicates that total shark biomass (dominated by salmon, Pacific sleeper and dogfish sharks) increased in the 1990's to a peak in 2002 of 6,000 and 25,000 mt on the eastern Bering Sea shelf and slope, respectively (Figure 1; Courtney et al. 2005).

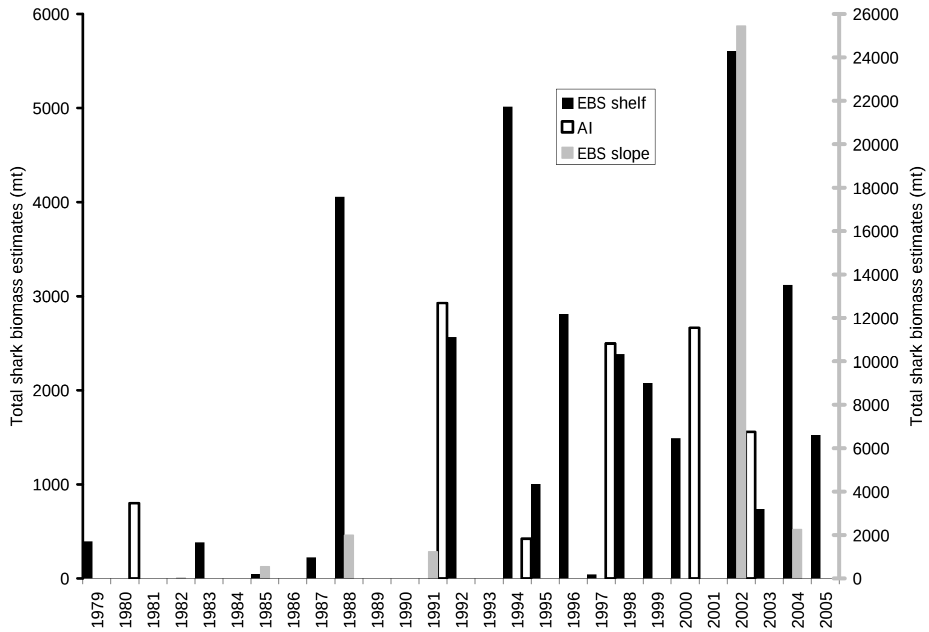


Figure 1. Total shark biomass (mt) estimated for the Eastern Bering Sea slope, Eastern Bering Sea shelf, and the Aleutian Islands based on NMFS bottom trawl surveys. Data are from Table 12 in Courtney et al. 2005. Data were not collected in all years so zeros do not reflect no sharks. Grey bars (EBS slope) correspond to the right y-axis.

Estimated bycatch rates of sharks in the Bering Sea from a combination of observer and NMFS catch data increased from a total of 400 mt in 1997 to 1400 mt in 2002 (Figure 2; Courtney et al. 2005). Pacific sleeper shark bycatch dominated the total with a peak of 800 mt followed by salmon sharks with a total of 50 mt, both in 2002 (Figure 2; Courtney et al. 2005). Between 1997 and 2002, both species of shark were caught incidental to fisheries in 11 of 17 Bering Sea and Aleutian Island statistical and reporting areas. Further, 77% of Pacific sleeper shark and 74% of salmon shark bycatch was focused in 2 areas in particular (517 and 521, Boldt et al. 2003). The majority (87%) of the salmon shark bycatch occurred during the pollock trawls in 1997-2001 while the Pacific sleeper shark bycatch occurred during the Pacific cod longline (30%), pollock trawl (26%), and turbot longline (17%) fisheries (Courtney et al. 2005).

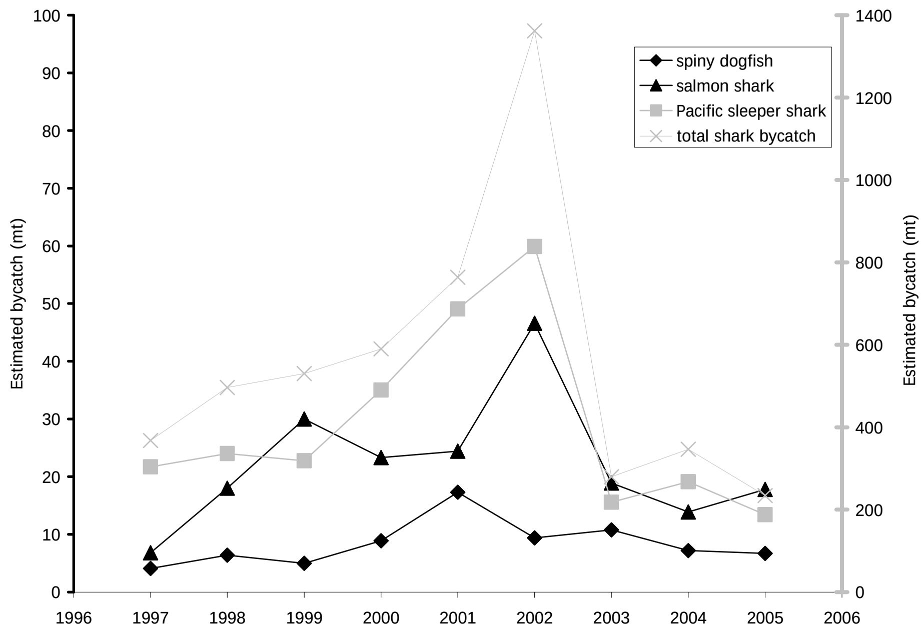


Figure 2. Estimated shark bycatch (mt) in the Eastern Bering Sea and the Aleutian Islands based on NMFS observed fishery catches. Data are from Table 3 in Courtney et al. 2005. Note that biomass was estimated differently in 1997-2002 than from 2003-2005.

Generally, as the total shark biomass in the Bering Sea increases, the bycatch rate also increases (Figure 3; Courtney et al. 2005) suggesting that understanding the trophic relationships, migration patterns, and life history characteristics of these species is important to understanding ***when*** they will interact with commercial fisheries in the Bering Sea. To determine ***what*** the relative impact of these bycatch trends is will require a quantitative assessment of what life history stage of shark is being caught and the relative importance of each shark to the Bering Sea Ecosystem, none of which has been collected in the Bering Sea.

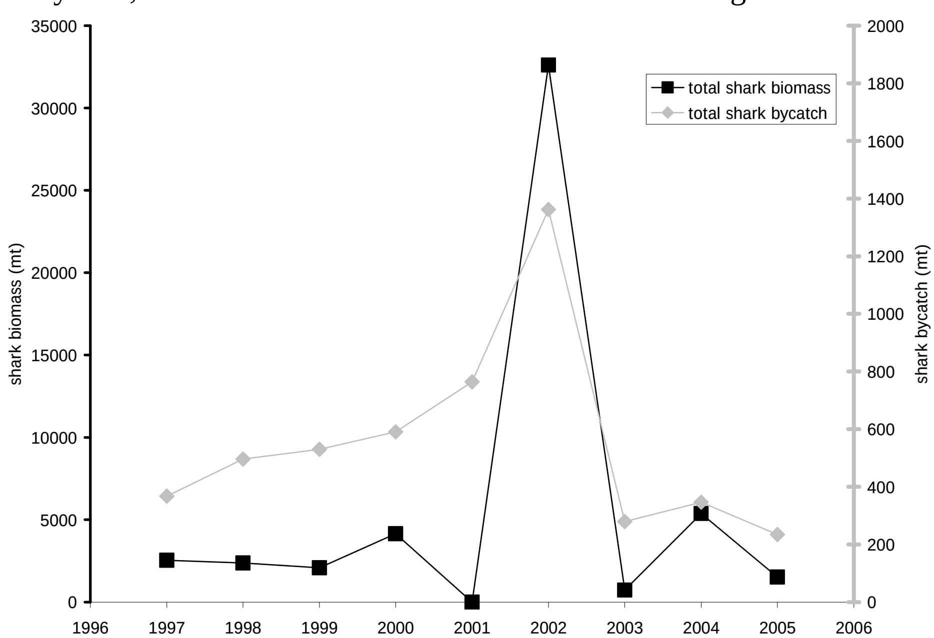


Figure 3. Total shark biomass (mt) estimated for the Eastern Bering Sea slope, Eastern Bering Sea shelf, and the Aleutian Islands based on NMFS bottom trawl surveys. Data are from Tables 3 and 12 in Courtney et al. 2005. Bycatch data were estimated differently in 1997-2002 and in 2003-2005. Bottom trawl data were not collected in all years from all regions of the Bering Sea and Aleutian Islands so this represents only an index of biomass.

When the prospect of estimating abundance for either salmon shark or sleeper shark is considered it is important to consider the migration of salmon shark both between the Gulf of Alaska and the Bering Sea, it is also important to note that reproductively mature female salmon sharks migrate as far south as Southern California (Hulbert et al. 2004), over 2000 km, for pupping.

OBJECTIVES/HYPOTHESES

The goal of this study is to investigate bycatch and assess the trophic status of Pacific sleeper and salmon sharks in Bering Sea commercial fisheries. The underlying hypothesis is that bycatch is an ecosystem level phenomenon that can be controlled, if not eliminated, and that there may be consequences associated with large scale perturbations of the ecosystem, such as bycatch. It remains to be determined whether these perturbations are significant.

The objectives include:

- Characterization of the shark bycatch from multiple sources including but not limited to commercial fishing groups, NMFS, observer database, and the IPHC survey. This will include an analysis of appropriate methods for estimating bycatch in shark data limited databases.
- Characterization of the shark bycatch onboard the at-sea processors fishing pollock in 2007-2009.
- Collection of demographic parameters (vital rates including reproduction and survival) to support mathematical population projections.
- Identification of the diet composition of shark bycatch to support estimation of the trophic level of sharks based on species, size, and sex.
- Discuss the implication and impacts for the amount of bycatch that would result from changes in the spatial and temporal fishing patterns by the pollock at-sea processors in the Bering Sea.

METHODS/ANLAYSES

Data Base Collections

Observer bycatch data from catcher-processors has been requested from the NMFS. When these data are available their spatial – temporal information content will be analyzed. Preliminary analyses are seen in the figures above.

Field Data Collection

Two field collection trips were made. The data collected are shown below:

Trip 1: August, 2007

Sleeper Sharks

#	Total Length (cm)	Sex
1	187	Male
2	111	Female
3	213	Male
4	167	Female
5	169	Male
6	215	Male

Salmon Sharks

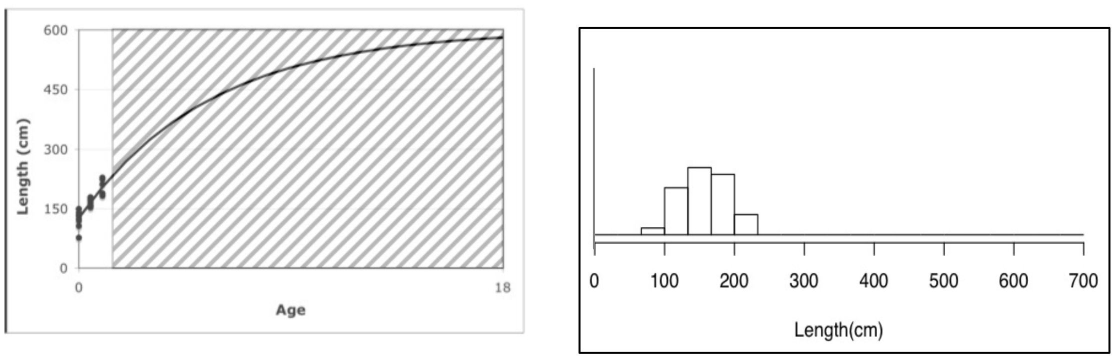
#	Total Length (cm)	Sex
1	212	Male
2	222	Male

Trip 2: October, 2007

Sleeper Sharks

#	Total Length (cm)	Sex
1	117	Male
2	115.5	Male
3	130	Male
4	179	Male
5	166	Female
6	151	Male
7	127	Male
8	128	Female
9	120	Female
10	157.5	Female
11	135.5	Female
12	129	Female
13	174	Female
14	159	Male
15	148	Female
16	128	Male
17	190.5	Male
18	170	Male
19	137	Female
20	153	Male
21	145.5	Male
22	175.5	Male

These length and sample data are summarized in Figure 4 A. and B. These figures clearly illustrate the limited scope that the data cover. For example, the length samples in 4 B. cover a small part of the length structure that is believed standard for a population. The growth schematic in 4 A. is also hypothetical in that it incorporates assumptions based on a number of observations about what a possible age spectrum would look like. Research to test these hypotheses is currently underway. Because of the small sizes of the sleeper sharks caught no reproductive females were found so no reproductive data are available. It is essential that such data be recovered as part of this project. One of the male salmon sharks caught was reproductively mature. Although no mature female salmon shark were caught, reproductive data do exist (Gallucci et al. 2008).



A ***B***

Figure 4: A) Hypothetical growth curve for pacific sleeper shark. Dots represent length of sharks already collected; ages and maximum length are hypothesized based on limited knowledge of the species. The shaded area represents the age classes missing from the database. B) Representative schematic of the catch of sharks similar in length (cm) collected in previous sampling trips.

Laboratory Analysis

The focus on reproductive biology in this study is based upon the need to estimate age of first reproduction and fecundity. As a first step we are actively involved in the estimation of age samples to construct an age-length key. This is being done by the Ageing Laboratory of the NMFS Alaska Fisheries Science Center. Genetic and fatty acid data are also collected.

Trophic Ecology: Stomach contents and stable isotopes are also being collected for laboratory analysis.

Population Demography

No mathematical modeling can be carried out until more demographic data are collected. When these data are collected Leslie matrix models will be used to project the population ahead and retrospectively. The prospect of using stock assessment methodology is also possible when more data are available if bycatch are considered as targeted captures. However, this approach is limited by various conceptual issues such as interpretations of catchability coefficients, etc. as was done by Rice and Gallucci (2008). An alternative is risk analysis which will be carried out is less data intensive (Silva and Gallucci 2007) and thus more practical in such data poor situations as here.

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