Shark abundance increases in the Gulf of Alaska

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Bruce Wright and Lee Hulbert started the Alaska Shark Assessment Program in 1998, as part of the Alaska Predator Ecosystem Experiment (APEX) Project. They were interested in the ecological implications of increasing shark abundance in their study area. Several sources of information identified the increasing role of sharks in the northeast Pacific. Mr. Wright is now the Chief of the Office of Oil Spill Damage Assessment and Restoration, and the Chairman of the Jay Hammond Bald Eagle Research Institute. He graduated from San Diego State University in 1977 with a M.S. degree in ecology. Mr. Hulbert is the principal investigator of the Alaska Shark Assessment Project and is co-principal investigator of the APEX Forage Fish Assessment project. He graduated from the Humboldt State University in 1991 with a B.S. in fisheries biology.

Dogfish bycatch has presented a formidable problem for IPHC statistical analyses of halibut abundance in recent years (Dan Randolf 1999 pers. comm.). The increasing trend of dogfish abundance is supported by data from Paul Anderson with the National Marine Fisheries Service (NMFS) lab in Kodiak who conducts standardized small mesh trawl surveys in the Kodiak Island region (Fig. 2). The downturn in this trend in 1999 corresponds to a virtual absence of eulachon (Thaleichthys pacificus) in the Copper River, although fishermen in the Yakutat area continued to have problems with dogfish swamping salmon gillnets.

Another shark species that has increased in abundance in recent years is the Pacific sleeper shark (Figs. 3 and 4). Sleeper sharks are one of the few sharks found in polar waters year-round. They are a large demersal species generally inhabiting deep water, although they occasionally come to the surface at high latitudes. NMFS and IPHC researchers in Alaska have caught specimens in the six meter range although they average 1.8-2.4 meters in length in PWS sablefish surveys. Sleeper sharks are opportunistic predators whose diet consists primarily of groundfish, squid, and salmon. They are also known to prey on marine mammals, including harbor seals and southern right whale dolphins.
Sleeper sharks are suspected of attacking halibut that has been caught on fishing gear (Fig. 5). Alaska Department of Fish and Game sablefish survey data also indicate an increasing trend in sleeper shark abundance since the survey began in 1996. While finding empirical data for relative trends in sleeper shark and dogfish bycatch in Alaska is difficult, it is particularly hard for salmon sharks. Salmon sharks are rarely caught in commercial gear and information on trends in abundance is largely anecdotal. However, salmon sharks appear to be the predominant large predatory pelagic fish in the coastal GOA (Fig. 6). A member of the family Lamnidae, they are the Pacific congener of the porbeagle shark in the Atlantic and are closely related to white and mako sharks. Throughout the 1990s, salmon shark abundance in the northern GOA increased dramatically. The vast majority of salmon sharks aggregating in surface waters of the GOA are adult females. They have been reported to reach 3m in length, although normal size range appears to be between 1.8 and 2.4m. Salmon sharks maintain an elevated body temperature and studies have shown that they may have the highest body temperature of any shark, as much as 13.6°C above ambient water temperatures. Because of this, they likely possess a relatively high metabolic rate and daily ration. Their diet consists primarily of salmon, squid, and groundfish.

As part of the Alaska Predator Ecosystem Experiment (APEX) project (See PICES Press July 1999, pages 35-36), the NMFS Auke Bay Laboratory conducted a pilot salmon shark study in 1999, the first sampling effort ever directed at salmon sharks in the eastern Pacific. We collected non-lethal stomach contents, tissue samples for fatty acids, stable isotope, and population genetics analyses. The sharks were tagged with Floy tags, and three were released with “pop-up” archival satellite tags. Although large surface aggregations of salmon sharks have become common during summer months in PWS in recent years, data collected from the satellite tags, hydroacoustics, and underwater video indicate that the majority of the sharks present are below the surface at any given time. The pop-up archival satellite tag data from late July to late September indicates that the sharks spend the majority of their time between 10 and 50 meters depth. The sharks did not have clear diel patterns of depth preference. The hydroacoustics, and underwater video data support this finding.

What caused the increase in abundance of sharks in coastal GOA?

An ocean climate regime shift occurred in the winter of 1976/77. One of the major findings from the evaluation of historic data is that there has been a dramatic shift in the biotic communities in the GOA in the past two decades. A biota dominated by crustaceans and capelin in the early 1970s and before, shifted to a biota dominated by gadids and flatfish by the late 1980s (See PICES Press July 1999 pages 35-36). This shift coincides with a shift in temperatures (sea surface (cont. on page 22)
Model experiments and comparisons

The MODEL Task Team plans to vary three factors: the model, the geographical location and corresponding sets of biological parameters, and physical forcing scenarios. The model comparison protocols will be used as a basis of comparison.

Recommendations for future work

- Perform a sensitivity/stability analysis on NEMURO.
- Test the sensitivity of production of small and large zooplankton, P/B ratio, and ecological efficiency to inclusion of the microbial food web.
- Develop a way to measure when a change in model output is “significant”. The metric should consider time, space, and some absolute values of parameters.
- Future work should be coordinated by the MODEL Task Team Co-Chairmen, and participants encouraged to present their results at the next Annual Meeting of PICES. Cooperation and coordination with other CCCC Task Teams are very important.
- Issues related to model management need to be addressed to control the increasing number of different versions of model, including process equations, parameter files, physical forcing data files, and post processing programs. We propose to examine the ICES/GLOBEC experience to obtain guidance as to how best to proceed.
- Develop a NEMURO/Stella Box Model using the Stella software package.
- Make progress on making an executable version of the prototype model available on the WWW.
- Develop a means of staying in contact to continue unfinished work.
- Develop a project home page.

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temperature, air temperature, and ocean temperature at 250 meters depth) from cooler to warmer. Forage species began a rapid decline between 1977 and 1980 and high trophic level groundfish increased 250% in biomass by the 1990s. By the late 1980s the GOA saw dramatic declines in abundance indices of sea lions, fur seals, and harbor seals.

The forage base responds quickly to changes in climate regimes and is further impacted by predation as groundfish biomass increases. It may be that shark succession in trophic community structure is a natural response to the regime shift, but delayed due to low intrinsic rates of population increase. Has enough time elapsed following the trophic regime shift to justify an explanation of the trend to an increase in shark numbers? Little is known of salmon shark and sleeper shark life history parameters and dogfish age at maturity appears to vary greatly with region and environmental stressors. Considering low intrinsic rates of population increase for sharks in general, it may seem unlikely that the trend follows an increase in numbers. However, changes in reproductive potential due to favorable conditions is a factor that should not be ruled out. Until demographic parameters of these sharks in the GOA are described, the answer is highly speculative. Other reasons for the increase in shark abundance in the northeast Pacific may be the due to increased salmon production, both hatchery and wild salmon, reduced mortality from high seas gillnetting, or a shift in the shark populations in reaction to changes in water temperatures.

In conclusion, we believe that a combinations of factors has resulted in the increased shark abundance in the northeast Pacific and they are now one of the predominant apex predators in the region. The cause and consequences of this trend are unclear. Monitoring shark population trends through better shark bycatch data records and directed surveys, combined with research describing the sharks’ spatial and temporal movements, diet, and demographics, will contribute greatly to the understanding of the role of sharks as indicators of, and their affects on, trophic community structure in the GOA.