"The potential for a sustained, manageable Armhook squid (*Berryteuthis magister*) fishery in Southeast Alaska"

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Abstract

The first Armhook squid (Berryteuthis magister) fishery permit in Alaska was issued this year, 2011. Market squid commercial fishery implementation has been sporadic in the past. Since then, the presence of squid fisheries in Alaska has been sporadic. The recently implemented squid fishery in Ketchikan is largely unmanaged and without further research we won't understand how squid will react to a consistent harvest.

Information required to implement an adequate management plan is missing in many cases. In order to put a decent plan into place, we would need more information about squid distribution, size, and behavior. Information regarding how squid population would react to environmental changes, such as rising ocean temperature and ocean acidification is needed. One possible way we could learn more about the distribution of squid is the use of acoustic assessment of squid stock. Using this method, sonar would be used to great effect to locate and document specific squid species.

Currently, atmospheric CO2 content is rising at ~0.5% per year, and pH content of the world ocean is falling. It is projected to fall between 0.3 and 0.4 pH units by the end of the century. It has been suggested that this will likely result in a rise in squid populations in Alaska (Fabry et al, 2007).

Introduction

In 2011, the first commercial permit in Southeast Alaska for the Armhook squid (*Berryteuthis magister*) (figure 1) was issued to fishermen outside of Ketchikan. Several permits have been issued in similar areas for the market squid (*Loligo opalescens*) but there has not been a consistent fishery or catch. Although the squid fishery in Alaska is just emerging it has been a consistent and successful fishery in California for over 100 years, with general increase in landings per vessel over the past 10 years (figure 2). We believe, with additional research and knowledge about squid behavior, that a successful fishery could also be implemented in Alaska. Although California has a productive fishery, there is a wide range of research needed before a large scale Alaskan fishery can be put in place. For example, much remains unknown about their diet, distribution, and overall effects on the Southeast Alaska ecosystem. The rising ocean temperature and ocean acidification

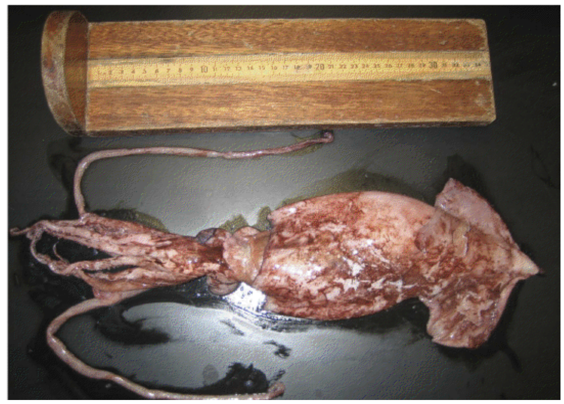

Figure 1. *Berryteuthis magister. (Droby et. al., 2008)*

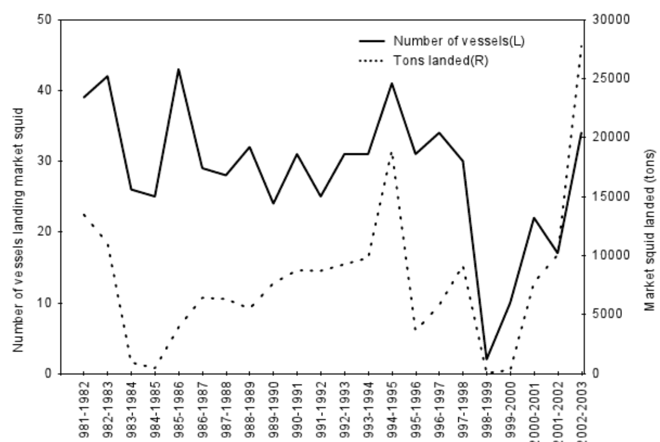

Figure 2. *Number of vessels and market squid landings by season for Northern California. (State of California, Dept. of Fish and Game, 2005)*

could lead to a rising squid population in Alaska. This will happen as squid migrate north in search of cooler waters.

In order to develop a stable fishery in Southeast Alaska, we need to look further into the research that California used to in managing their fishery. Such as, what boats were used? Were divers deployed? And what traps were set? By looking at California's fishery, we can improve our own by learning from their advances and their mistakes.

To propose that there could be a consistent fishery in Southeast Alaska, we have to analyze California's increase and Japan's decrease in fishery income. When comparing Japan's fishery and California's the differences are substantial. Japan used their resources to the point where their fishery collapsed, whereas California has succeeded in maintaining a sustainable fishery.

Squid biology

Armhook squid can live up to 4 years. spending most of their life in a juvenile phase, maturing late in life, spawning once and then dying. Male armhook squid grow slower, but reach maturation earlier than their female counter parts

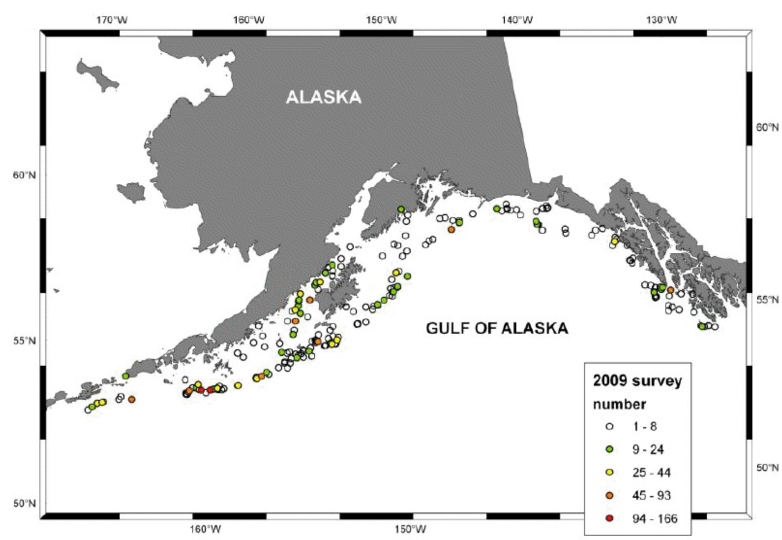

Figure 3. *Distribution of Squid caught in during 2009 bycatch survey. (Ormseth and Spital, 2010)*

(Ormseth and Spital, 2010)

Armhook squid can be found from southern Japan, throughout the Bering Sea, Aleutian Islands, Gulf of Alaska and extend south to the U.S. West coast as far as southern Oregon. (Roper et al. 1984). The distribution of squid bycatch in AK from pelagic and benthic fisheries mostly occur along the shelf break and in deeper waters and on the south end of Kodiak Island (figure 3). There are many species of marine life in these areas which rely on squid as prey as well as a wide variety of species consumed by the squid themselves.

The primary predators of squid in the Gulf of Alaska are salmon, accounting for about half of squid mortality. Another 14% can be attributed to marine mammals such as sperm whales. Combined, the primary groundfish predators of squid (sablefish, pollock, and grenadiers) account for another 10%. A detailed view of squid mortality sources can be seen in figure 4 (Ormseth and Spital, 2010).

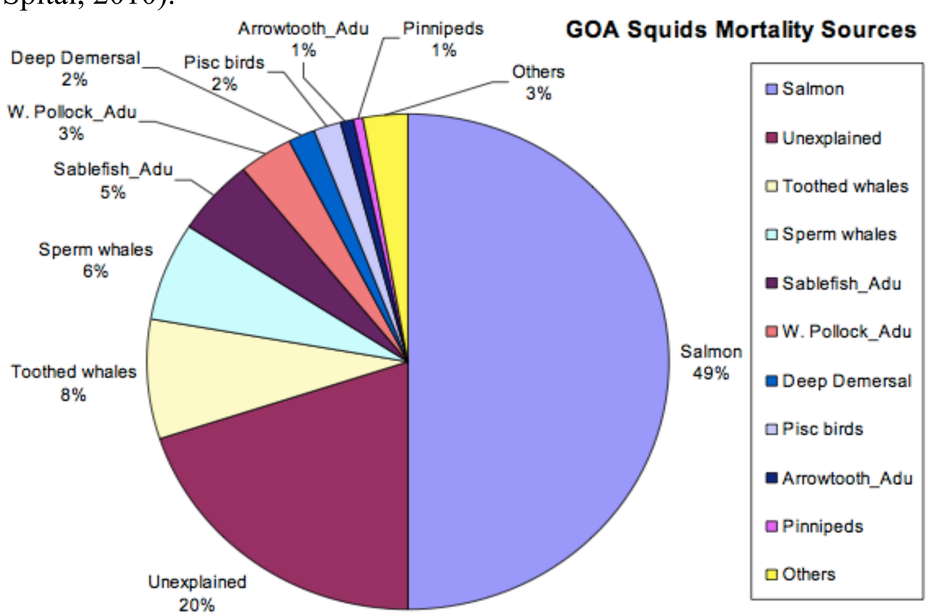

Figure 4. *Squid mortality sources and their relative percentages in the Gulf of Alaska. (Ormseth and Spital, 2008)*

The diet of squid in the Gulf of Alaska is dominated by pelagic zooplankton, such as euphausiids and copepods (figure 5). Based on this assessment, squid can be estimated at consuming one to five million metric tons of zooplankton annually. Fish are also thought to account for a small portion of their diet. As much as one million metric tons are consumed annually. Armhook squid eat larger prey such as this by ripping them apart with their beak while shoving it into their mouths with their 8 arms. Their beak, which is used for feeding is very sharp and tough, made out of chitin, the same material as human fingernails. Indigestible beaks have been found in the stomachs of captured whales.

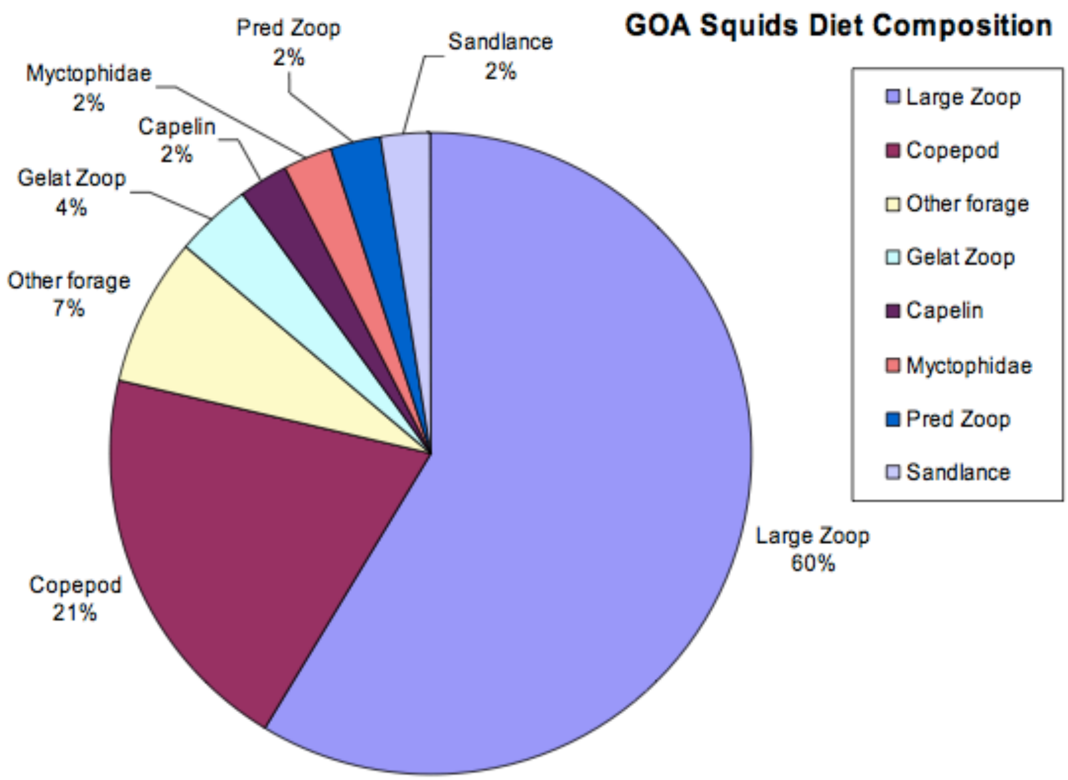

Figure 5. *Squid diet composition and their relative percentages in the Gulf of Alaska. (Ormseth and Spital, 2008)*

The Armhook squid (Berryteuthis anonychus) is most commonly found in subarctic waters in the north pacific, especially off the continental shelf. They feed off of copepods most often. Since we know that's what they are eating, we have to be careful on the increasing numbers of squid because of the direct competition between juvenile salmon for food. Which as a result could damage the amount of salmon we would have in Alaska and their fisheries. We can also include since the copepods are highly seasonal in the spring and all through late summer, that the Armhook squid would have an abundance of prey to feed on. Although coming into the fall and through the winter the copepods start to die off and there is a great amount of decrease in their numbers. We can imagine that the Armhook squid will either move somewhere else for the seasonal decrease or die off as well. Research on the subject of squid migration and foraging behavior is needed in order to know how the Armhook squid is directly affected.

Research needed

The more we look into the possibility of a sustainable Armhook squid fishery, the more research is needed. From basic knowledge regarding their diet and general distribution, to more comprehensive information regarding how they would react to rising ocean temperature and increasing ocean acidification, much is still unknown.

Perhaps the most basic pieces of information needed are the ones regarding basic biology and ecosystem interaction of the squids in question. In order to be confident in knowing how implementing a fishery for these squid, one would need to know what other species would be affected when the population of Armhook squid is reduced in the region of the ocean in question.

One would also need to know what species are being affected, and what their current populations are, as well as what their future populations are likely to be.

The reproduction rate of the Armhook squid still needs to be researched. Before harvesting the Armhook squid knowing how they would react to the impact on their population would need to be known.

Based on what we have observed with other squid species, we can safely assume that the Armhook squid will adapt fairly well to rising ocean temperature and increased ocean CO2 levels. Knowing how their prey species will adapt is still needed. If their prey species is going to be significantly negatively affected one would need to be more conservative in how they interact with the squid population.

We have found that the presence of Armhook squid is most prevalent in subarctic waters in the north Pacific. More specifically than that, however, not much is known, and we have little information about their migratory patterns. Costs in finding this information could be reduced by including input from fishermen happening upon these squid. Estimating populations and distributions of squid using sonar has also been found plausible. This information is needed in implementing a fishery the area.

Acoustic Assessment of squid

Acoustic assessment and the use of sonar technology could be used to estimate squid stock populations. The main instrument used is the echo-sounder, which consists of the transmitter, the transducer, the receiver, and the display. The transducer converts a voltage pulse produced by the transmitter into a pulse of sound. The pulses of sound travel through the water and bounce off objects, returning to the transducer. These echoes are received by transducer and are converted back into electrical pulses. These can then be seen on the display. This data can be converted into a graphical format to easily present the information (figure 6) (Starr and Thorne, 1998).

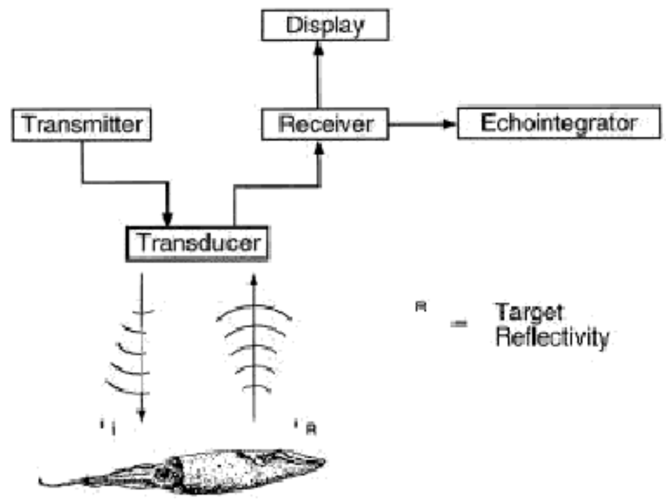

Figure 6. *Diagram depicting how a typical echo sounder sends and receives a signal. (Star and Thorne, 1998)*

A significant amount of information would need to be collected if acoustic assessment is to be put into place. Population densities would need to be collected from many different locations, and at varied distances from the shore. Additionally, because squid migrate vertically in the water column throughout the day, data would have to be collected from varied depths, and at regular intervals throughout the day.

Foreseeable problems in implementing this technology relate to its inability to return trustworthy information from near bottom and near surface waters. Use of acoustic assessment may also be limited in shallow waters. The sea surface and bottom are both strong reflectors of acoustic energy, and reading from near the surface would be influenced by wave shape and by movement of the boat carrying the equipment (Starr and Thorne, 1998).

The equipment needed for acoustic assessment of squid populations would extend past the equipment described above. For example, boats would be necessary to carry out usage of this equipment. However, it is possible that costs could be reduced if commercial fishing boats are equipped with this technology, and scientist are allowed to collect data during already scheduled trips.

The usability and convenience of using acoustic assessment is evident, but viability of using sonar to estimate squid populations may still seem questionable. However using this method has shown to be surprisingly accurate. By classifying signal patterns, accuracy in distinguishing between specific species can be increased. Using pattern classifiers, this technology has been proved to be more accurate in identification between cod capelin and mackerel than local fishermen of the Gulf of St. Lawrence. It can also distinguish between specific species of squid. Presumably, the technology could be optimized for similar use with squid. This method also allows for the rapid survey of large areas and process large amounts of information in real time. (Starr and Thorne, 1998)

The essential position of squid within North Pacific pelagic ecosystems, combined with the limited knowledge of the abundance, distribution, and biology of many squid species in the area, make squid a good candidate for management distinct from that applied to other species (Ormseth and Spital, 2010)

Effects of Climate Change

Earth's atmospheric CO2 concentration is rising today at a rate of ~0.5% year-1, and over the last 250 years CO2 levels have risen almost 40%. The world ocean's pH level is projected to fall between 0.3 and 0.4 pH units by the end of the century. It is clear that Earth's rising atmospheric CO2 levels and rising ocean acidification have affected many ecosystems world-wide. Ocean acidification is thought to depress metabolic rates by 31% and activity levels by 45% in the jumbo squid *Dosidicus gigas* (Fabry et al, 2007). However, much is still unknown about the effects of ocean acidification and rising ocean temperatures on the Armhook, or Commander squid *Berryteuthis magister* or the Market squid *Loligo opalescens*. Surprisingly, there is reason to believe that rising ocean temperature could be beneficial to squid in general, because of their fast growth rates, rapid rates of turnover at the population level. This allows them to respond very quickly to environmental changes. However information of this nature on the Armhook and market squid specifically is lacking. In order to formulate a management plan which one could be at all confident in implementing, we would need a significant amount of additional information on the Armhook squid and how they will react to further changes in ocean acidity and temperature. Would the population of these squids increase in Alaska with continued ocean acidification, and if so how would it affect the size and/or well-being of the individual and the ecosystem?

Management Plan

In our fishery, the maximum allowable harvest (MAH) would be 10 tons, or 4,000 individual squid at 5 pounds. Permits would be issued for 2,000 pounds until the MAH was reached. If someone harvested 2,000 pounds, they would be allowed another permit until the MAH was reached. Even if this plan was successful, however, further research and a more detailed management plan would be necessary before a possible increase in harvest levels (Walker, pers. comm. 2011). As with most management plans, it would be reevaluated and adjusted each year as continued research brings new information on the overall impacts and implications of the fishery on Southeast Alaska.

Conclusion

Several attempts have been made to start a squid fishery is Southeast Alaska. While none of them have been successful, personal use catch is becoming more common in that area, and the market value of squid is rising.

There are already squid fisheries present in the western pacific and Russia, and other nations have already fished successfully in Alaskan waters. Squid are also caught as bycatch in large numbers in the Pollock trawl fishery.

As the world ocean's CO_2 levels and temperatures continue to increase, squid may be forced to move to more temperate and/or subarctic waters. This would likely increase the squid population in Alaska. Rising squid populations could change the ecosystem dynamics, this could warrant a more rigorous fishery management plan. Not much is known about the squid population in Southeast Alaska, mainly due to the absence of a major bottom fishery, where most of the information has come from. Therefore, Fish and Game surveys would be focused there, while data from other parts of the state would come more heavily from observations made about fishery bycatch.

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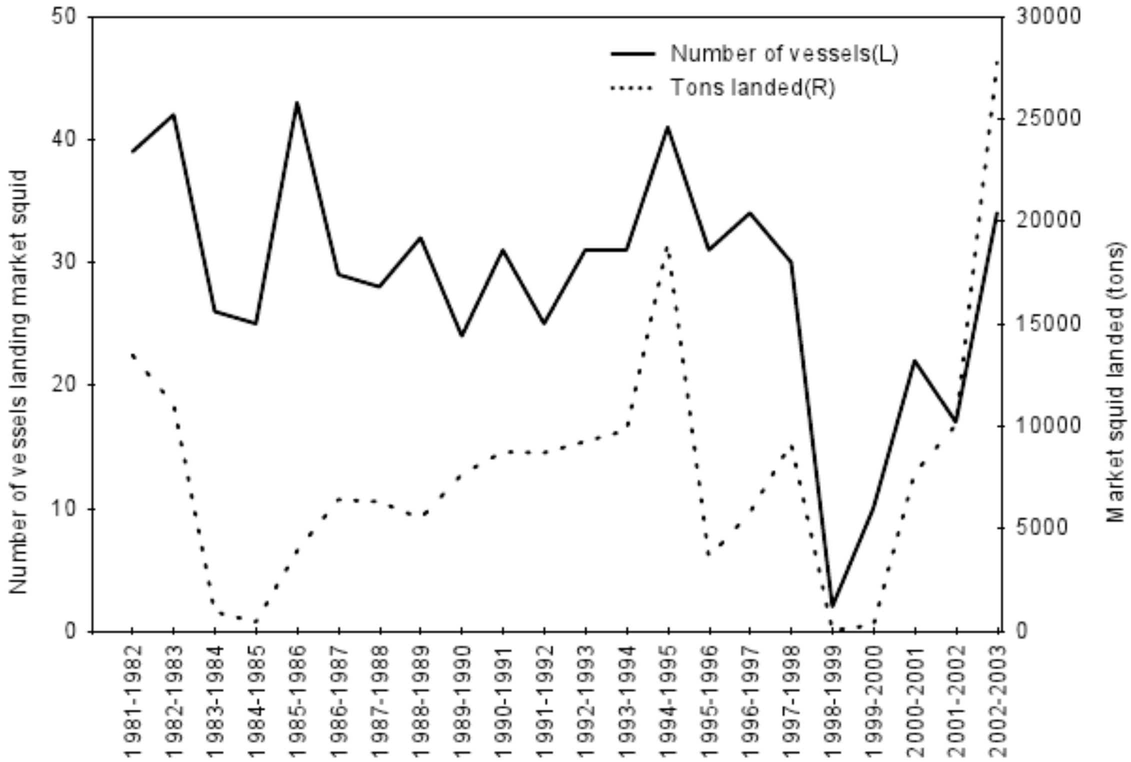
Figures.

Figure 1. *Berryteuthis magister. (Droby et. al., 2008)*



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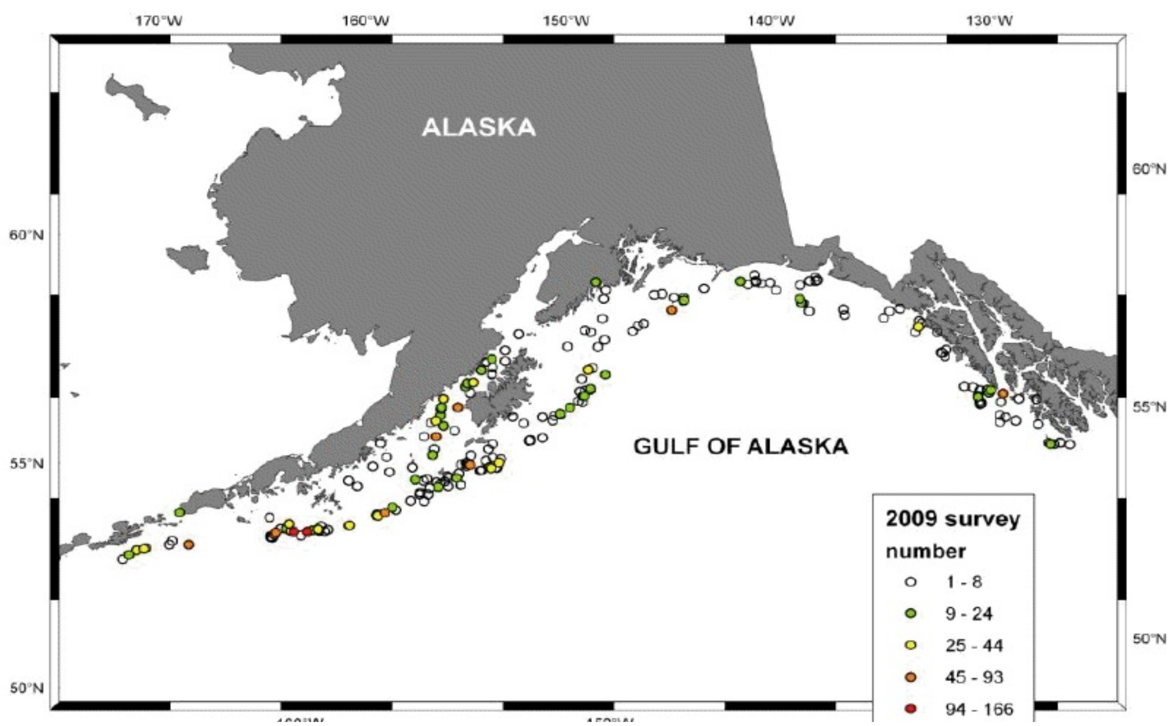

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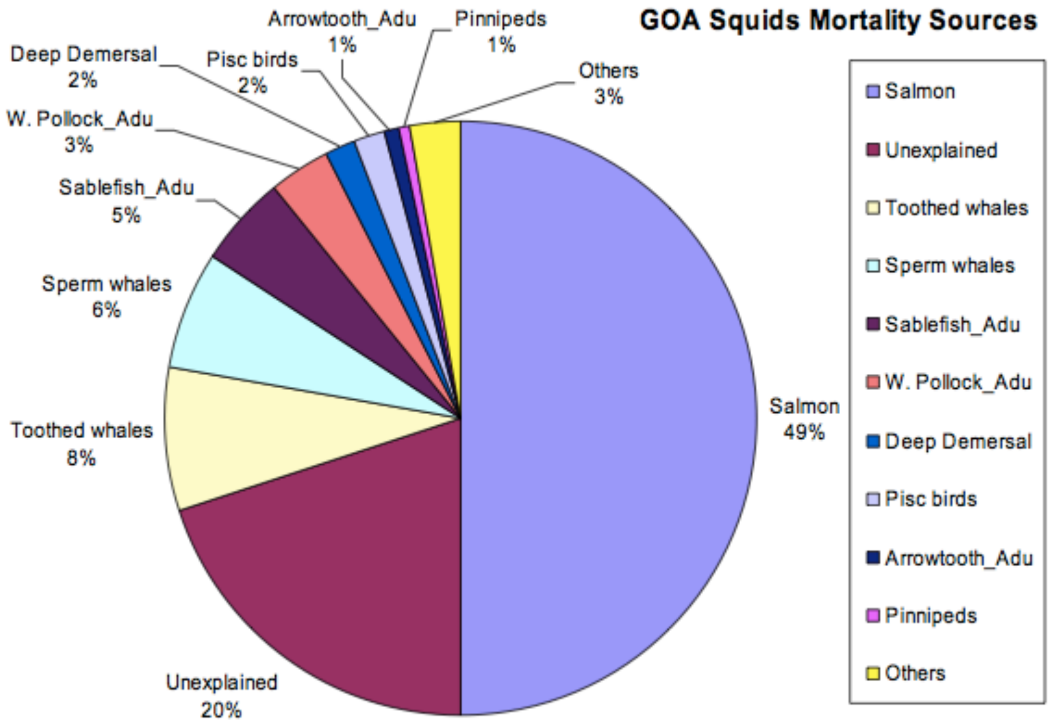

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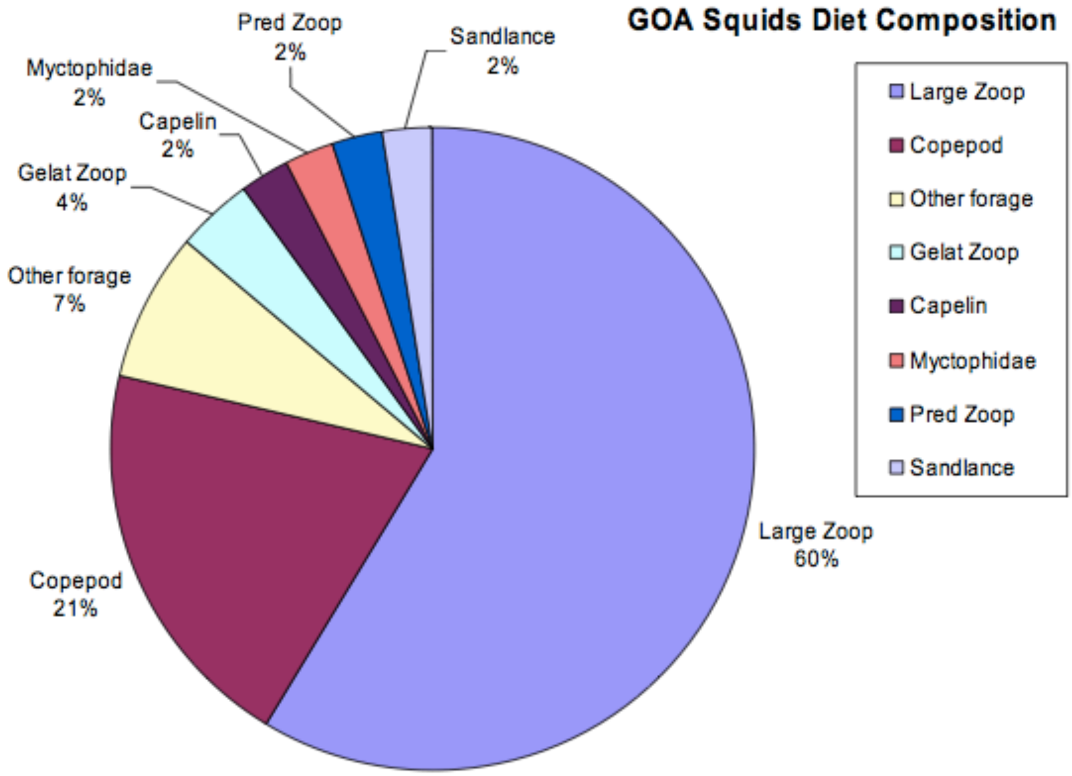

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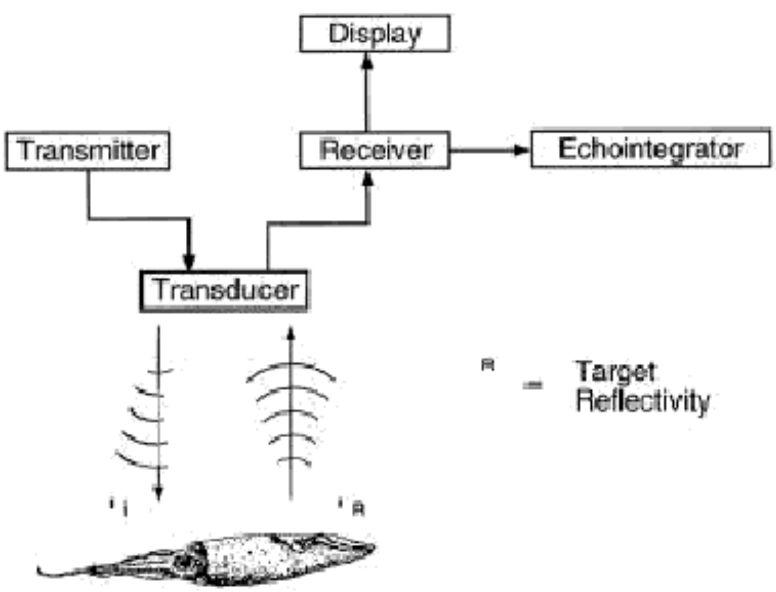

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