# *Appendix D*

# *Octopus Complex*

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## Executive Summary

Through 2006, octopuses have been managed as part of the "other species" complex, with catch reported only in the aggregate with sharks, squids, and sculpins. Due to increasing market value of skates and octopus, retention of other species complex members is increasing. This appendix to the other species SAFE chapter was prepared to review available information that would be needed if the other species complex were to be split into separate components for future management. All octopus species would continue to be grouped into a species assemblage. At least seven species of octopus are found in the GOA, and the species composition both of the natural community and the commercial harvest is unknown at this time. Octopuses are taken as incidental catch in trawl, longline, and pot fisheries throughout the GOA; the highest catch rates are from Pacific cod pot fisheries in the central and western GOA (statistical areas 610 and 630).

The current data are not sufficient for any model-based assessment. The GOA trawl surveys produce estimates of biomass for octopus, but these estimates are highly variable and may not reflect the same species and sizes of octopus caught by industry. As an example of how this species complex might be managed under catch quotas, we have estimated Tier 6 and Tier 5 catch limits from available data. The long-term average estimated incidental catch rate (including discards) for 1997-2005 is 189 mt. A strict Tier 6 approach could result in an overly conservative OFL limit that would affect cod fisheries. If the most recent 10-year average of bottom trawl survey biomass of 1,765 tons and a conservative estimate of M=0.53 are used, Tier 5 OFL and ABC levels would be 935 and 701 tons, respectively. We feel that a standard Tier 6 approach based on the average incidental catch would result in an overly conservative limit, because these data are from a period in which there was very little market or directed effort for octopus**. We propose instead an alternative approach under Tier 6 that treats the existing data as a "probable safe catch rate", and uses the maximum incidental catch to set the ABC. This approach would result in an ABC of 298 mt and an OFL of 398 mt. This approach would prohibit octopus catch from increasing markedly over existing levels, without unnecessarily constraining fisheries that take octopus as bycatch.**

| **Method** | **ABC** | **OFL** |
|---|---|---|
| Tier 5 | 701 | 935 |
| Tier 6 (avg) | 141 | 189 |
| **Tier 6 (max)** | **298** | **398** |

Because of the lack of information at this time, we recommend that directed fishing for octopus be discouraged in federal waters of the GOA and that incidental catch be limited by conservative

catch limits. As better catch accounting and biological data for these species are collected, possible future assessment methods can be investigated.

## Summary of Major Changes

**The primary change from the 2005 octopus SAFE is the proposal of a new approach for setting catch limits based on the maximum incidental catch**. This approach is described in detail in the "Projections and Harvest Alternatives" section. Otherwise, there have been only minor changes since this document was reviewed by the SSC in February 2006. There was no NMFS bottom trawl survey of the GOA in 2006. Catch data for 2003-2006 from the Alaska region have been revised, and the resulting average catch rate is slightly higher than previously reported. Catch data for the first half of 2006 (winter season fisheries) have been included, but these figures are expected to increase during the fall cod fisheries. A time series of trawl survey catch data from the ADF&G survey shows similar patterns to NMFS survey and industry CPUE time series. Incidental catch data from the IPHC longline survey indicates that the Sanak subregion had the highest incidental catch rate in the GOA. The most important addition is data from a NPGOP special project conducted on fishing vessels and in the one Kodiak processor that purchases octopus. These data indicate that octopus harvested for market in the GOA were all over 3.5 Kg, with an average weight of 11.6 Kg. This weight range suggests that most octopus in Jan-Mar plant deliveries were giant Pacific octopus *E. dofleini*. A few observations from sablefish pot fisheries in May and June included smaller specimens that may include other species; these octopus were not retained for market. Two-thirds of the octopus delivered to plants during Jan – April were males, and all deliveries came from cod pot boats.

Octopus remains difficult to place within the existing tier system for setting regulatory catch limits. In February 2006, the SSC concurred with the SAFE authors that the size difference between trawl and pot-caught octopus makes biomass data based on the trawl survey questionable for this species group. The best available estimates of octopus catch rates do not cover the time period specified for Tier 6 evaluation, and represent only incidental catch rates rather than targeted fishing. A modification of tier 6 has been suggested that would allow continued incidental catch at existing rates but prevent substantial increases in harvest. Since there will be no need to set ABC and OFL for octopus in 2007, this report remains a discussion of possible future management approaches, without specific recommendations for setting catch levels.

## Introduction

### *Description and General Distribution*

Octopuses are marine molluscs in the class Cephalopoda. The cephalopods, whose name literally means head foot, have their appendages attached to the head and include octopuses, squids, and nautiluses. The octopuses (order Octopoda) have only eight appendages or arms and unlike other cephalopods, the octopus lack shells, pens, and tentacles. There are two groups of Octopoda, the cirrate and the incirrate. The cirrate have fins and cirri and are by far less common than the incirrate which contain the more traditional forms of octopus. Octopuses are found in every ocean in the world and range in size from less than 20 cm (total length) to over 3 m (total length); the latter is a record held by *Enteroctopus dofleini* (Wülker, 1910). *Enteroctopus dofleini* is one of at least seven species of octopus (Table 1) found in the GOA. Members of these seven species come from five genera and can be found from less than 10 m to greater than 1500 m. All but one, *Japetella diaphana*, are benthic octopuses. The state of knowledge of octopuses in the GOA, including the true species composition, is very limited.

In the GOA octopuses are found from subtidal waters to deep areas near the outer slope (Figure 1). The highest diversity is along the shelf break region of the Gulf of Alaska, although, unlike the Bering Sea, there is a high abundance of octopuses on the shelf. While octopuses were observed throughout the GOA, they are more commonly observed in the Central and Western GOA (stat areas 610-630) than in the Eastern GOA. The greatest number of observations are clustered around the Shumagin Islands and Kodiak Island. These spatial patterns are influenced by the distribution of fishing effort. AFSC Survey data also show the presence of octopus throughout the GOA but also indicate highest biomass in areas 610 and 630. Octopuses were caught at all depths ranging from shallow inshore areas (mostly pot catches) to trawl and longline catches on the continental slope at depths to nearly 1000 meters. The majority of octopus caught with pots in the GOA came from 40-60 fathoms (70-110 meters); catches from longline vessels tended to be in deeper waters of 200-400 fathoms ( 360-730 meters). Octopuses are also common in the eastern Bering Sea and throughout the Aleutian Island chain.

**Life History and Stock Structure**

In general, octopus life spans are either 1-2 years or 3-5 years however the specifics of the seven of the eight species in the Bering Sea are not known. *Enteroctopus dofleini* has been studied extensively and its life history will be reviewed here; generalities on the life histories of the other six species will be inferred from what is known about other members of the genus.

*Enteroctopus dofleini* are sexually mature after approximately three years. In Japan, females weigh between 10 – 15 kg at maturity while males are 7 – 17 kg (Kanamaru and Yamashita, 1967). *Enteroctopus dofleini* move to deeper waters to mate during July – October, they move to shallower waters to spawn during October – January. There is a two-month lag time between mating and spawning. This time may be necessary for the females to consume extra food to last the seven months required for hatching of the eggs, during which time the female guards and cleans the eggs but does not feed. *Enteroctopus dofleini* is a terminal spawner, females die after the eggs hatch while males die shortly after mating. While females may have 60,000 -100,000 eggs in their ovaries only an average of 50,000 eggs are laid (Kanamaru, 1964). Hatchlings are approximately 3.5 mm. Mottet (1975) estimated survival to 6 mm at 4% while survival to 10 mm was estimated to be 1%; mortality at the 1 – 2 year stage is also estimated to be high (Hartwick, 1983). Since the highest mortality occurs during the larval stage it stands to reason that ocean conditions would have the largest impact on the number of *E. dofleini* in the Gulf of Alaska and large fluctuations in numbers of *E. dofleini* should be expected.

*Octopus californicus* is a medium-sized octopus, maximum total length of approximately 40 cm. Very little is known about this species of octopus. It is collected between 100-1000 m. It is believed to spawn 100-500 eggs. Hatchlings are likely benthic; hatchling size is unknown. The female likely broods the eggs and dies after hatching.

*Octopus sp. A* is a small-sized species, maximum total length < 10 cm. This species has only recently been identified in the GOA and its full taxonomy has not been determined. *Octopus sp. A* is likely a terminal spawner with a life-span of 12-18 months. The eggs of *Octopus sp. A* are likely much larger than those of *O. rubescens*, as benthic larvae are often bigger; they could take up to six months or more to hatch. Females have 80-90 eggs.

*Benthoctopus leioderma* is a medium-sized species, maximum total length ~ 60 cm. Its life span is unknown. It occurs from 250 – 1400 m and is found throughout the shelf break region. It is a common octopus and often occurs in the same areas where *E. dofleini* are found. The eggs are brooded by the female but mating and spawning times are unknown. They are thought to spawn under rock ledges and crevices. The hatchlings are benthic.

*Opisthoteuthis californiana* is a cirrate octopus, it has fins and cirri (on the arms). It is common in the Gulf of Alaska but would not be confused with *E. dofleini*. It is found from 300 – 1100 m and likely common over the abyssal plain. Other details of its life history remain unknown.

*Japetella diaphana* is a small pelagic octopus. Little is known about members of this family. This is not a common octopus in the Gulf of Alaska and would not be confused with *E. dofleini*.

*Vampyroteuthis infernalis* is a cirrate octopus. It is not common in the Gulf of Alaska and is easily distinguishable from other species of octopus by its black coloration. Nothing is known of its reproduction or early life history.

In summary, there are at least seven species of octopus present in the GOA, and the species composition both of natural communities and commercial harvest is unknown. At depths less than 200 meters *E. dofleini* appears to be the have the highest biomass, but the abundances of *Octopus sp. A* and *B. leioderma* are also very high. The greatest difference in species composition between the BSAI and the GOA is the presence of *O. californicus* and the small *Octopus sp. A*.

### Management Units

Through 2006, octopuses have been managed as part of the “other species” complex in the GOA. Prior to 2003 catch of other species (squid, octopus, sharks, skates, and sculpins) was reported only in the aggregate. Separate catch reporting for different components of the other species complex has been initiated, but octopus are still reported as an aggregate catch for all species. Catch of other species through 2005 has been limited by a Total Allowable Catch (TAC) set at 5% of the total catch of all species. In 2006, the NPFMC is expected to set the other species TAC at or below the 5% level Increasing market value and a small directed fishery for skates in 2003-2004 caused this group to be broken out of the GOA other species complex and managed under a separate TAC. The Gulf of Alaska Plan Team and NPFMC are reviewing procedures and options for future management of other species catch, including octopus.

Draft revisions to guidelines for National Standard One instruct managers to identify core species and species assemblages. Species assemblages should include species that share similar regions and life history characteristics. In anticipation of this change, we prepared this appendix to the other species chapter to provide insight to managers on the implications of this change. All octopuses would continue to be grouped into a species assemblage, as octopus are difficult to identify to species. Octopus are recorded by fisheries observers as either “octopus unidentified” or “pelagic octopus unidentified”, and routine species identification of octopus by observers is not anticipated (although special projects may be pursued). *E. dofleini* is the key species in the assemblage and is the best known. It is important to note, however, that the eight species in the assemblage do not necessarily share common patterns of distribution, growth, and life history. A directed federal fishery for octopus is not recommended at this time, because data are insufficient for management. Instead, we recommend conservative management of octopus through catch limits, MRAs, or bycatch-only status.

# Fishery

### *Directed Fishery*

There is no federally-managed directed fishery for octopus in the GOA. One processor in Kodiak purchases incidentally-caught octopus, primarily for halibut bait. A new processor in Dutch Harbor purchases octopus for human consumption at high ex-vessel prices (in the range of $0.90/lb; J. Nordeen, Harbor Crown Seafoods, personal communication). Recent increases in market value have increased retention of incidentally-caught octopus in the GOA (based on observer data). Because of the relatively large number of small boats in the GOA commercial fleet and recent changes to crab fishing seasons, there may be some interest in directed fishing for octopus in the GOA.

The State of Alaska allows directed fishing for octopus in state waters under a commissioner's permit. A small directed fishery in state waters of the BSAI existed from 1988-1995; catches from this fishery were reportedly less than 8 mt per year (Fritz, 1997). Between 1995 and 2003, all reported state harvests of octopus in the BSAI were incidental to other fisheries, primarily Pacific cod (ADF&G 2004). In 2004, commissioner's permits were given for directed harvest of Bering Sea octopus on an experimental basis (Karla Bush, ADF&G, personal communication). Nineteen vessels registered for this fishery, and 13 vessels made landings of 4,977 octopus totaling 84.6 mt. The majority of this catch was from larger pot boats during the fall season cod fishery (Sept.-Nov.). Average weight of sampled octopus from this harvest was 14.1 kg. The sampled catch was 68% males. Only one vessel registered for octopus in 2005. Two vessels registered in 2006, but have not reported any octopus catch. ADF&G is currently developing policy on implementation of new and developing fisheries, which include octopus (ADF&G 2004).

### *Incidental Catch*

Octopus are caught incidentally throughout the GOA in both state and federally-managed bottom trawl, longline, and pot fisheries. From 1997-2002 total incidental catch of octopus in federal waters, was generally between 100 and 200 mt (Table 3). In 2002 the estimated catch of octopus was 298 tons. Catches in 2003-2006 (through Aug 10, 2006) are based on actual catch reporting data, and are similar to estimated catches from the earlier period. The highest estimated chatch was in 2004, consistent with survey data. The majority of incidental catch of octopus comes from Pacific cod fisheries, primarily pot fisheries (Table 3). Some catch is also taken in trawl fisheries for cod and other species. The overwhelming majority of catch in federal waters occurred in the central and western GOA in statistical reporting areas 610, 620 and 630. The species of octopus taken is not known, although size distributions suggest that the majority of the catch from pots is *E. dofleini* (see below).

Mortality of discarded octopus is expected to vary with gear type and octopus size. Mortality of small individuals and deep water animals in trawl catch is probably high. Larger individuals may also have high trawl mortality if either towing or deck sorting times are long. Octopus caught with longline and pot gear are more likely to be handled and returned to the water quickly. Octopuses have no swim bladder and can survive out of water for brief periods. Large octopus caught in pots are typically very active and are expected to have a high survival rate. Octopus survival from longlines is probably high unless the individual is hooked through the mantle or head. Observers report that octopus in longline hauls are often simply holding on to hooked bait or fish catch and are not hooked directly.

### Catch History

Since there has been only a limited market for octopus and no directed fishery in federal waters, there are no data available for documenting catch history. Historical rates of incidental catch do not necessarily reflect future fishing patterns where octopus are part of retained market catch. Estimates of incidental catch based on observer data (Table 3) suggest substantial year-to-year variation in abundance, which would result in large annual fluctuations in harvest. This large interannaul variability is consistent with anecdotal reports (Paust 1989) and with life-history patterns for *E. dofleini*.

### Fisheries in Other Countries

Worldwide, fisheries for *Octopus vulgaris* and other octopus species are widespread in waters off southeast Asia, Japan, India, Europe, West Africa, and along the carribean coasts of South, Central, and North America (Rooper et al.1984). World catches of *O.vulgaris* peaked at more than 100,000 tons per year in the late 1960's and are currently in the range of 30,00 tons (www.fao.org). Octopus are harvested with commercial bottom trawl and trap gear; with hooks, lures and longlines; and with spears or by hand. Primary markets are Japan, Spain, and Italy, and prices in 2004-2005 were near record highs (www.globefish.org). Declines in octopus abundance due to overfishing have been suggested in waters off western Africa, off Thailand, and in Japans inland sea. Morocco has recently set catch quotas for octopus as well as season and size limits (www.globefish.org). Caddy and Rodhouse (1998) suggest that cephalopod fisheries (both octopus and squid) are increasing in many areas of the world as a result of declining availability of groundfish.

Fisheries for *E. dofelini* occur in northern Japan, where specialized ceramic and wooden pots are used, and off the coast of British Columbia, where octopus are harvested by divers and as bycatch in trap and trawl fisheries (Osako and Murata 1983, Hartwick et al 1984). A small harvest occurs in Oregon as incidental catch in the Dungeness crab pot and groundfish trawl fisheries. In Japan, the primary management tool is restriction of octopus fishing seasons based on known seasonal migration and spawning patterns. In British Columbia, effort restriction (limited licenses) is used along with seasonal and area regulation.

Descriptions of octopus management in the scientific literature tend to be older (before 1995) and somewhat obscure; formal stock assessments of octopus are rare. Cephalopods in general (both octopus and squid) are difficult to assess using standard groundfish models because of their short life span and terminal spawning. Caddy (1979, 1983) discusses assessment methods for cephalopods by separating the life cycle into three stages; 1) immigration to the fishery, including recruitment; 2) a period of relatively constant availability to the fishery; and 3) emigration from the fishery, including spawning. Assuming that data permit separation of the population into these three stages, management based on estimation of natural mortality (equivalent to Tier 5) can be used for the middle stage. He also emphasizes the need for data on reproduction, seasonal migration, and spawner-recruit mechanisms. General production models have been used to estimate catch limits for *O. vulgaris* off the African coast and for several squid fisheries (Hatanaka 1979, Sato and Hatanaka 1983, Caddy 1983). These models are most appropriate for species with low natural mortality rates, high productivity, and low recruitment variability (Punt 1995). Caddy (2004) also suggests the use of surplus production models to protect minimum spawning biomass, if sufficient data are available. Perry et al. (1999) describe a framework for management of new and developing invertebrate fisheries; GOA and BSAI octopus fisheries are clearly in phase 0 of this scheme, where existing information is being collected and reviewed.

## Data

### *AFSC Survey Data*

Catches of octopus are recorded during the semi-annual NMFS bottom trawl survey of the Gulf of Alaska. In older survey data (prior to 2003), octopus were often recorded as *Octopus* sp. and not identified to species; other species may also have been sometimes misidentified as *E. dofleini*. Since 2003, increased effort has been put into cephalopod identification and species composition data are considered more reliable; species composition from the 2005 survey is shown in Table 4. These catches are our only source of species-specific information within the species group. Based on available data, the species with the highest biomass in shelf waters is *E. dolfleni*. The size distribution by weight of individual octopus collected by the bottom trawl surveys from 1999 through 2005 is shown in Figure 2. Survey-caught octopus ranged in weight from less than 0.1 kg up to 18 kg; 50% of all individuals were <0.5 kg. Larger octopus may be under-represented in trawl data because of increased ability to avoid the trawl.

Survey catches of octopus occur throughout the GOA but are more frequent in the central and western GOA, and estimated biomass of octopus is higher in these regions. The survey catches octopuses at all depths from 25 to over 900 meters; the most frequent depth of survey catch is in the 100-300 meter range.

Biomass estimates for the octopus species complex based on bottom trawl surveys are shown in Table 5. These estimates show moderately strong year-to-year variability, but less so than in the BSAI surveys. Survey biomass estimates range from 994 t in 1999 and 2001 to 3,767 t in 2003. The 2005 survey estimate was back down to 1,109t, indicating that 2003 was a year of unusually high abundance. The average biomass of surveys within the last ten years is 1,765 t. Because of poor efficiency of the bottom trawl for benthic octopus, the true biomass of octopus in the GOA is probably higher than the survey estimates (see discussion below). The estimate of octopus biomass from the Ecopath food-web model for the GOA is on the order of 200,000 t (Aydin et. al, *in review*)

### *Federal Groundfish Observer Program Data*

Groundfish observers record octopus in commercial catches as either “octopus unidentified” or “pelagic octopus unidentified”. Observer records do, however, provide a substantial record of catch of the octopus species complex. Figure 1 shows the spatial distribution of observed octopus catch in the GOA. The majority of GOA octopus caught by pot gear come from depths of 40-60 fathoms (70-110 meters); catches from longline vessels tended to be in deeper waters of 200-400 fathoms (360-730 meters). **Unlike the BSAI, the depth range of octopus catches in the GOA is similar between industry and survey data.** The size distribution of octopus caught by different gears is very different (Figure 3); commercial cod pot gear clearly selects for larger individuals. Over 88% of octopus with individual weights from observed pot hauls weighed more than 5 Kg. Based on size alone, these larger individuals are probably *E. dofleini*. Commercial trawls and longlines show size distributions more similar to that of the survey, with a wide range in sizes and a large fraction of octopus weighing less than 2 Kg. These smaller octopuses may be juvenile *E. dofleini* or may be any of several species, especially Octopus sp. A.

Incidental catch rates from observed hauls in frequently-fished areas may provide a time-series index of octopus abundance that includes years not covered by the trawl survey. Figure 4 shows time series of octopus catch rates from pot gear in federal stat areas 610 (Shumagin), 602 (Chirikof), and 630 (Kodiak). These series indicate occasional years of very high abundance; the peak abundance years are not consistent between the three areas. For example, the CPUE data indicate that 2002-2004 were all high abundance years in the Shumagin and Kodiak regions, but that abundance declined after a 2001 peak in the Chirikof region. Isolated years of high catch rates appear in 1990 in the Kodiak region and in 1996 in the Chirikof region). Incidental catch rates in most years (averaged over stat area and year) were on the order of 50-150 lbs/100pots. The earlier data in these series may be less reliable than more recent data due to limited observer coverage.

### *Observer Program Special Project Data*

A special project has been initiated with the North Pacific Observer Program to collect individual weight and sex data on octopuses in the GOA and the Bering Sea. So far, data from the winter-season fisheries in 2006 have been collected. These data include sampling at the one plant in Kodiak that purchases octopus, Alaska Pacific Seafoods. All of the octopus data collected at this plant in January – March 2006 came from pot boats targeting Pacific cod. The size frequency of octopus in these deliveries is shown in Figure 5. All of the delivered octopus were over 3.5 kg gutted weight, with an average weight of 11.6 kg.

The majority of octopus sampled at sea during this period were also from cod pot boats. In the pot fishery the ratio of males to females was skewed towards males; males were, on average, four times more abundant than females. This was not the case for the other three gear types included in the sample (longline, bottom and pelagic trawls). Without further spatial and temporal information it would be difficult to explain the discrepancy in sex rations in the different fisheries. A few observations from sablefish pot fisheries in May and June included noticeable smaller specimens; these octopus were not retained for market.

### *AFG&G Survey Time Series*

The Alaska Department of Fish and Game provided a time series of octopus catch data from their bottom trawl survey state waters from 1990-2004. As with the NMFS trawl survey, octopus are not frequently caught by the ADF&G trawl, but octopus biomass for the surveyed areas was estimated (Figure 6, Table 6). The ADF&G survey does not record weights of individual octopus or identify octopus to species, so there is no size or species composition data associated with these catch estimates. The areas with the greatest average estimated biomass of octopus were the northeast and north mainland sections of Kodiak Island, each with an average estimated biomass over 60 tons. Octopus were present in nearly all survey years in these areas. Within the surveyed areas along the south side of the Alaskan peninsula, catches of octopus were present every year at Pavlof Bay, with an average estimated biomass of 39 tons for the time series. Both Pavlof Bay and west Nagai had estimated biomass over 250 tons in 2003, consistent with the high biomass estimate seen in NMFS trawl data and commercial CPUE data for that year. Catches of octopus in the Chignik region were generally slight. A combined biomass for all ADF&G trawl areas is plotted in Figure 6, along with NMFS trawl survey biomass estimates. In general, these data support the characterization of octopus as a “breakout” species, with occasional years of high abundance. The time series does not show any evidence of declining biomass for this species group, in fact the high biomass estimates in 2003 and 2004 suggest an overall increasing trend from 1990-2004

### *IPHC Longline Survey Data*

Researchers at the International Pacific Halibut Commission also searched their database for records of octopus catch during the annual IPHC longline survey. Extracted data (Table 7) record numbers of octopus caught either in a full sampling of all skates in a set (surveys before 1997), or in a subsample of the first 20 hooks per skate (surveys from 1997-2005). Subregions with the most consistent octopus catches were the Sanak and Shumagin regions south of the Alaska Peninsula and the Albatross region off the east side of Kodiak Island. Weight of bycatch, including octopus, is not always collected on this survey, so that no biomass estimates are feasible from these data.

## Analytic Approach, Model Evaluation, and Results

The available data do not support population modeling for either individual species of octopus in the GOA or for the multi-species complex. As better catch and life-history data become available, it may become feasible to manage the key species *E. dofleini* through methods such as general production models, estimation of reproductive potential, seasonal or area regulation, or size limits. Parameters for Tier 5 catch limits can be estimated (poorly) from available data and are discussed below.

### *Parameters Estimated Independently – Biomass*

Estimates of octopus biomass based on the semi-annual GOA trawl surveys (Table 5) represent total weight for all species of octopus, and are formed using the sample procedures used for estimating groundfish biomass (National Research Council 1998, Wakabayashi et al 1985). The positive aspect of these estimates is that they are founded on fishery-independent data collected by proper design-based sampling. The standardized methods and procedures used for the surveys make these estimates the most reliable biomass data available. The survey methodology has been carefully reviewed and approved in the estimation of biomass for other federally-managed species. There are, however, some serious drawbacks to use of the trawl survey biomass estimates for octopus.

Older trawl survey data, as with industry or observer data, are commonly reported as octopus sp., without full species identification. In surveys prior to 2003, most octopus collected were not identified to species. In more recent years, a greater fraction of collected octopus are identified to species, but some misidentification may still occur. Efforts to improve species identification and collect biological data from octopus are being made, but the survey does not at this time provide species-specific information that could be used in a stock assessment model.

There is strong reason to question whether a trawl is the most suitable gear for sampling octopus. The bottom trawl net used for the GOA survey has roller gear on the footrope to reduce snagging on rocks and obstacles and may allow benthic organisms, including octopus, to escape under the net. Given the tendency of octopus to spend daylight hours near dens in rocks and crevices, it is entirely likely that the actual capture efficiency for benthic octopus is poor (D. Somerton, personal communication, 7/22/05). Trawl sampling is not conducted in areas with extremely rough bottom and/or large vertical relief, exactly the type of habitat where den spaces for octopus would be most abundant (Hartwick and Barringa 1989). The survey also does not sample in inshore areas and waters shallower than 30m, which may contain sizable octopus populations (Scheel 2002). The estimates of biomass in Table 5 are based on a gear selectivity coefficient of one, which is probably not realistic for octopus. For this reason, these are probably conservative underestimates of octopus biomass in the regions covered by the survey. The large numbers of survey tows with no octopus also tend to increase the sampling variability of the survey estimates.

More importantly, there is a considerable difference in size selectivity between survey trawl gear and industry pot gear that catches most of the octopus harvested. The average weight for individual octopus in survey catches is 2.0 kg; over 50% of survey-collected individuals weigh less than 0.5 kg. Larger individuals are strong swimmers and may preferentially escape trawl capture. In contrast, the average weight of individuals from commercial pot gear was over 20 kg (Figure 4). Pot gear is probably selective for larger, more aggressive individuals that respond to bait, and smaller octopus can easily escape commercial pots while they are being retrieved. Unlike the BSAI, the depth range of octopus catches in the GOA is similar between industry and survey data, although pot fisheries tend to be concentrated in shallower shelf waters**.** There is also a seasonal difference between summer trawl surveys and the fall and winter cod seasons, when most octopus are harvested. In general, it may be possible to use trawl survey data as an index of interannual variation in abundance, but the relationship between the summer biomass of individuals vulnerable to trawls and the fall or winter biomass available to pot fisheries will be difficult to establish.

If future management of the octopus complex is to be based on biomass estimates, then species-specific methods of biomass estimation should be explored. Octopus are readily caught with commercial or research pots. An index survey of regional biomass in selected areas of the Kodiak and Shumagin regions would be appropriate and is highly feasible. It may also be feasible to estimate regional octopus biomass using mark-recapture studies or depletion methods (Caddy 1983, Perry et al 1999). If the species composition of commercial harvest can be verified, then it may be appropriate to use species-specific and/or depth-based biomass estimates.

### *Parameters Estimated Independently – Mortality*

It is important to note than not all species of octopus in the GOA have similar fecundity and life history characteristics. This analysis is based on *E. dofleini*, which probably make up the majority of the harvest. Since *E. dofleini* are terminal spawners, care must be taken to estimate mortality for the intermediate stage of the population that is available to the fishery but not yet spawning (Caddy 1979, 1983). If detailed, regular catch data within a given season were available, the natural mortality could be estimated from catch data (Caddy 1983). When this method was used by Hatanaka (1979) for the west African *O. vulgaris* fishery, the estimated mortality rates were in the range of 0.50-0.75. Mortality may also be estimated from tagging studies; Osako and Murata (1983) use this method to estimate a total mortality of 0.43 for the squid *Todarodes pacificus*. Empirical methods based on the natural life span (Hoenig 1983, Richter and Efanov 1976) or von Bertalanffy growth coefficient (Charnov and Berrigan 1991) have also been used. While these equations have been widely used for finfish, their use for cephalopods is less well established. Perry et al. (1999) and Caddy (1996) discuss their use for invertebrate fisheries.

If we apply Hoenig's (1983) equation to *E. dofleini*, which have a maximum age of five years, we get an estimated M = 0.86. Rikhter and Efanov's (1976) equation gives a mortality value of 0.53 based on an age of maturity of 3 years for *E. dofleini*. The utility of maturity/ mortality relationship for cephalopods needs further investigation, but these estimates represent the best available data at this time. The Rikhter and Evanov estimate of **M=0.53** represents the most conservative estimate of octopus mortality, based on information currently available. If future management of octopus is to be based on Tier 5 methods, a direct estimate of octopus mortality in the GOA, based on either experimental fishing or tagging studies, is desirable.

## Projections and Harvest Alternatives

If GOA octopus were separated from the other species complex, it would be feasible to better monitor and control catches, especially given their rising market value. Separate catch accounting, both of retained catch and discards, is necessary to achieve this strategy. None of the existing groundfish Tier strategies is well suited to available information for octopus. Regulatory limits under three different strategies are presented below, but all three are problematic.

It would be possible to set catch limits for the octopus complex under Tier 6 based on historical rates of incidental catch estimated from observer data (Table 3). **The long-term average estimated incidental catch rate (including discards) for 1997-2005 is 189 mt.** Note, however, that this period of catch data does not coincide with the period specified for Tier 6 estimates. We also feel that these data would result in an overly conservative limit, because they represent catch rates during a period in which there was very little market or directed effort for octopus. These data do not necessarily reflect fishing patterns with octopus as a market species. Under existing regulations, if octopus catch reached OFL, then it would be placed on prohibited status and fisheries with significant octopus bycatch (i.e. Pacific cod pot fishing) would be restricted. Because survival of discarded octopus from pot boats is probably high, it is not clear that prohibited species status provides substantially more protection than the discard-only status triggered at TAC. While a conservative TAC is advisable for octopus due to the lack of knowledge, this group would not necessarily benefit from the additional restrictions of a conservative OFL.

**We suggest a new approach for management of octopus under Tier 6.** Examination of trends in both survey biomass data and selected fishery CPUE data suggest that fishing patterns in 1997-2005 did not adversely affect octopus; the trend in survey biomass during this period is strongly increasing (Figure 6). **We propose that the estimated incidental catch data be considered a "probable safe" level of fishing and that the maximum incidental catch over this period be used to set the ABC for the octopus complex. The OFL would then be set so that this ABC would represent 75% of the OFL. This approach allows continued fishing under historical patterns where octopus was not a target species, but will restrict catch rates for the complex from substantially increasing, thus achieving the management goal of preventing a rapidly expanding directed octopus fishery.** The higher OFL provides a margin of error so that fisheries that take octopus as bycatch would not be constrained unless catch rates increases well past current levels. **Using this approach, the ABC for octopus would be 298 mt and the OFL would be 398 mt.** This OFL is roughly double the average incidental catch rate, but still less than half the Tier 5 estimate.

It would also be possible to manage the complex under Tier 5, using trawl survey biomass estimates and estimates of mortality for *E. dofleini*. Trawl survey estimates of biomass for the species complex represent the best available data at this time. There are serious concerns, however, about both the suitability of trawl gear for accurately sampling octopus biomass and the extent to which the survey catch represents the population subject to commercial harvest. The trawl survey probably underestimates octopus biomass because it does not sample octopus well and does not include rocky and nearshore areas where octopus abundance may be highest. Of greatest concern is the almost complete lack of overlap in size distributions between the trawl survey and industry pot catch. The majority of octopus caught in bottom trawls weigh less than 2 kg. The pot fishery, which takes the majority of octopus incidental catch, rarely retains octopus under 2 kg and has an average individual weight of over 20 kg. While some of this discrepancy may be due to seasonal movements and growth, it is not certain that the survey is sampling the same species and sizes of octopus that are vulnerable to harvest. **If the most recent 10-year average (1996 – 2005) of survey biomass of 1,765 tons and the conservative M estimate of 0.53 are used, the standard Tier 5 OFL and ABC for GOA octopus would be 935 and 701 tons, respectively.**

**If future management of the octopus complex under Tier 5 is envisioned, then dedicated field experiments are needed to obtain both a more realistic estimate of octopus biomass available to the fishery and a more accurate estimate of natural mortality rates.**

**Another option is to prohibit directed fishing for octopus in federal waters by placing the complex on bycatch-only status, and managing octopus catch through a maximum retainable allowance (MRA) of the catch of target species.** It is not clear that it is necessary at this time to explicitly prohibit directed fishing. The majority of octopus incidental catch in the GOA comes from the cod pot fisheries (both state and federal). Average catch rates for cod pot operations, estimated from observer data, are on the order of 50-150 lbs per 100 pots. Cod pot boats typically work between 100 and 200 pots per day and have high fuel and crew costs. Even at $1.00 a pound, these catch rates are unlikely to support a directed fishery in federal waters. Commercial octopus fisheries in Japan are conducted as inshore, small-boat fisheries, using large numbers of smaller, unbaited "habitat" pots (Mottett 1974, Osako and Murata 1983). The State of Alaska has conducted studies of directed octopus fishing using habitat pots (Paust 1988, Wilson and Gorham 1982) and is currently investigating appropriate gear for a directed octopus fishery (K. Bush, ADF&G, personal communication). **We anticipate that octopus harvest in federal waters of the GOA will continue to be largely an issue of incidental catch in existing groundfish fisheries. We do expect the high market value of octopus to increase percent retention of octopus for market, especially in cod pot fisheries.**

## Author Recommendation

Octopus should be managed very conservatively due to the poor state of knowledge of the species, life history, distribution, and abundance in the GOA. Further research is needed in several areas before octopus could even begin to be managed by the methods used for commercial groundfish species. It is unclear at this time how best to fit octopus into the existing Tier system. The authors feel that a standard Tier 6 approach using the average incidental catch rate would be overly conservative, especially in creating a low OFL that could adversely impact Pacific cod fisheries without providing substantially improved protection to octopus. Tier 5 estimates (using either method) are based on survey biomass estimates, which are very poor but are probably lower than actual biomass. **We recommend a modified Tier 6 approach, which uses the maximum incidental catch over 1997-2005 to set ABC, and sets OFL at the usual margin above ABC. This approach would result in an ABC of 298 tons and an OFL of 398 tons. This approach will allow continued incidental catch at current levels without unduly impacting fisheries, but will prevent the total harvest of octopus from substantially increasing.** Because of the overall lack of biological data and the large uncertainty in both abundance and mortality estimates, we strongly recommend conservative management for this complex. We do not recommend a directed fishery for octopus in federal waters at this time, because data are insufficient for adequate management.

## Ecosystem Considerations

Very little is known about the role of octopus in North Pacific ecosystems. In Japan, *Enteroctopus dofleini* prey upon crustaceans, fish, bivalves, and other octopuses (Mottet 1974). Food habit data and ecosystem modeling of the GOA (Livingston et al. 2003, Aydin et al, in review) indicate that octopus diets in the GOA are dominated by epifauna such as snails and crabs and infauna such as mollusks. The Ecopath model (Figure 7) indicates that octopus in the GOA are preyed upon primarily by grenadiers, Pacific cod, halibut, and sablefish. **Unlike in the Bering Sea, Steller sea lions and other marine mammals are not significant predators of octopus in the GOA. Model estimates show octopus are less than 0.5% in the diet of both juvenile and adult Steller sea lions (Figure 8).** At least 20% of the estimated overall mortality of octopus in the GOA cannot be explained by the model.

Analysis of scat data (Sinclair and Zeppelin 2002) shows unidentified cephalopods are a frequent item in Steller sea lion diets in both the Bering Sea and Aleutian Islands, but much less so in the western GOA. This analysis does not distinguish between octopus and squids. The frequency of cephalopods in sea lion scats averaged 8.8% overall, and was highest (11.5-18.2%) in the Aleutian Islands and lowest (<1 – 2.5%) in the western GOA. Proximate composition analyses from Prince William Sound in the GOA (Iverson et al 2002) show that squid had among the highest high fat contents (5 to 13%), but that the octopus was among the lowest (1%).

Little is known about habitat use and requirements of octopus in Alaska. Hartwick and Barriga (1989) reported increased trap catch rates in offshore areas during winter months. Octopus require secure dens in rocky bottom or boulders to brood young until hatching, which may be disrupted by fishing effort. Activity is believed to be primarily at night, with octopus staying close to their dens during daylight hours. Hartwick and Barriga (1989) suggest that natural den sites may be more abundant in shallow waters but may become limiting in offshore areas. In inshore areas of Prince William Sound, Scheel (2002), noted highest abundance of octopus in areas of sandy bottom with scattered boulders or in areas adjacent to kelp beds.

## Data Gaps and Research Priorities

The first data gap that must be filled for separate management of an octopus species assemblage in the GOA is separate catch accounting, both of retained and discarded octopus catch. Dropoff of larger octopus from longlines before hooks are brought aboard is reportedly common, and needs to be treated consistently in catch reporting and accounting. Estimates of the percentage of catch retained, and of octopus retained as a percentage of target catch, are also important for future management of octopus as a bycatch complex. Communication with the State of Alaska regarding directed fisheries in state waters, gear development, and octopus biology is important.

Identification of octopus to species is difficult even for trained biologists, and we do not expect that either industry or observers will be able to accurately determine species on a routine basis. A volume on cephalopod taxonomy in Alaska is in development and is expected to be published within a few years (Jorgensen, in prep). Efforts to improve octopus identification during AFSC trawl surveys will continue, but because of seasonal differences between the survey and most fisheries, questions of species composition of octopus incidental catch may still be difficult to resolve. Octopus species could be identified from tissue samples by genetic analysis, if funding for sample collection and lab analysis were available. Special projects and collections in octopus identification and biology will be pursued as funding permits. One simple addition to observer data collection would be to collect individual weights of all octopus by sex; the sex of octopus is readily observed by external characters on the third right arm. This information may lead to better understanding of seasonal and sex-specific migration patterns in Alaska.

Because octopuses are semelparous, a better understanding of reproductive seasons and habits is needed to determine the best strategies for protecting reproductive output. *Enteroctopus dofleini* in Japan and off the US west coast reportedly undergo seasonal movements, but the timing and extent of migrations in Alaska is unknown. The distribution of octopus biomass and extent of movement between federal and state waters is unknown and could become important if a directed state fishery develops. Tagging studies to determine seasonal and reproductive movements of octopus in Alaska would add greatly to our ability to appropriately manage commercial harvest. If feasible, it would be desirable to avoid harvest of adult females following mating and during egg development. Larger females, in particular, may have the highest reproductive output (Hartwick 1983).

Factors determining year-to year patterns in octopus abundance are poorly understood. Octopus abundance is probably controlled primarily by survival at the larval stage; substantial year-to-year variations in abundance due to climate and oceanographic factors are expected. The high variability in trawl survey estimates of octopus biomass makes it difficult to depend on these estimates for time-series trends; trends in CPUE from observed cod fisheries may be useful. If the interest in octopus fishing continues to increase, an index survey of octopus in the Kodiak and Shumagin areas would probably be the best tool for tracking trends in octopus abundance. Based on recent field studies, an index survey using research pot gear is highly feasible.

## Summary

Octopus are found throughout the GOA, but are more commonly observed in the central and western GOA (stat areas 610-630) than in the eastern GOA. At least seven species of octopus are found in the GOA. The most abundant species in shelf surveys is the Giant Pacific octopus *Enteroctopus dofleini;* size composition of octopus delivered to processing plants in Jan-April 2006 suggests that this species made up the majority of retained catch from cod pot fisheries,. Other species of octopus may be included in other fisheries. Octopus are taken as incidental catch in bottom trawl, longline, and pot fisheries throughout the GOA, with the largest catches from pot gear in areas 610 and 630. Recent development of markets and a high ex-vessel price has spurred increased interest in fishing for and retention of octopus in BSAI fisheries, and may lead to increased interest in the GOA.

Octopus are short-lived and fast-growing, and their potential productivity is high. It is probable that the GOA can support increased commercial harvest of octopus, since the historical catch rate is only a fraction of the estimated mortality. Both survey biomass estimates and industry catch per unit effort data show stable long-term catch levels with occasional years of markedly increased abundance. The difficulty with octopus as a commercial species is that data for determining appropriate management levels and strategies are almost nonexistent. The GOA trawl survey provides an estimate of biomass for the octopus complex, but these estimates may not reflect the same species and sizes of octopus caught by industry. Information on life history patterns and mortality is limited for *E. dofleini* and not available at all for other species. Because of the lack of information at this time, we strongly recommend that directed fishing for octopus be discouraged in federal waters of the GOA and that incidental catch be controlled either by catch limits or MRAs. Improved catch accounting, species identification of harvested octopus, and better understanding of seasonal movement and reproductive patterns are all needed to provide responsible management strategies.

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Table 1. Species of Octopodae found in the Gulf of Alaska.

| Rank | Scientific Name | Common Name | General Distribution | Age at Maturity | Size at Maturity |
|---|---|---|---|---|---|
| Class | Cephalopoda | | | | |
| Order | Vampyromorpha | | | | |
| Genus | *Vampyroteuthis* | | | | |
| | ***Vampyroteuthis infernalis*** | | GOA; > 300 m | unknown | unknown |
| Order | Octopoda | | | | |
| Group | Cirrata | | | | |
| Family | Opisthoteuthidae | | | | |
| Genus | *Opisthoteuthis* | | | | |
| Species | ***Opisthoteuthis californiana*** | flapjack devilfish | GOA; > 300 m | unknown | unknown |
| Group | Incirrata | | | | |
| | Bolitaenidae | | | | |
| | *Japetella* | | | | |
| | ***Japetella diaphana*** | pelagic octopus | Pelagic; over the shelf break | unknown | < 300 g |
| Family | Octopodidae | | | | |
| Genus | *Benthoctopus* | | | | |
| Species | ***Benthoctopus leioderma*** | smoothskin octopus | GOA; > 250 m | unknown | < 500 g |
| Genus | *Enteroctopus* | | | | |
| Species | ***Enteroctopus dofleini*** | giant octopus | all GOA; 10 - 1400 m | 3 - 5 yr | >10 kg |
| Genus | *Octopus* | | | | |
| Species | ***Octopus californicus*** | | E. GOA; 100 - 1000 m | unknown | 1 -2 kg |
| | ***Octopus* sp. A** | | GOA shelf , 10 - 300 m | unknown | < 250 g |

Table 2 History of federally-managed other species complex (skates, sharks, squid, octopi, and sculpins) in the GOA. Skates were removed from the complex in 2004.

| Year | ABC | TAC | Other species catch* |
|---|---|---|---|
| 1977 | N/A | | 4,725 |
| 1978 | N/A | | 6,299 |
| 1979 | N/A | | 4,545 |
| 1980 | N/A | | 6,445 |
| 1981 | N/A | | 8,280 |
| 1982 | N/A | | 2,643 |
| 1983 | N/A | | 2,918 |
| 1984 | N/A | | 1,969 |
| 1985 | N/A | | 2,356 |
| 1986 | N/A | | 408 |
| 1987 | N/A | | 182 |
| 1988 | N/A | | 129 |
| 1989 | N/A | | 1,560 |
| 1990 | N/A | | 6,289 |
| 1991 | N/A | | 5,700 |
| 1992 | N/A | 13,432 | 12,313 |
| 1993 | N/A | 14,602 | 6,867 |
| 1994 | N/A | 14,505 | 2,721 |
| 1995 | N/A | 13,308 | 3,421 |
| 1996 | N/A | 12,390 | 4,480 |
| 1997 | N/A | 13,470 | 5,439 |
| 1998 | N/A | 15,570 | 3,748 |
| 1999 | N/A | 14,600 | 3,858 |
| 2000 | N/A | 14,215 | 5,649 |
| 2001 | N/A | 13,619 | 4,801 |
| 2002 | N/A | 11,330 | 3,748 |
| 2003 | N/A | 11,260 | 6,371 |
| 2004 | N/A | 12,942 | 1,704 |
| **2005 | N/A | 13,871 | 2,253 |

Sources: TAC from AKRO website
Other species catch estimated by AKRO Blend & Catch Accounting System
**2005 catches estimated as of November 19, 2005

Table 3 Estimated catch (t) of all octopus species combined by target fishery, gear, and area. 1997-2002 estimated from blend data. 2003-2006 data from AK region catch accounting. *Data for 2006 are as of August 2006.

| **Target Fishery** | **Gear** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006*** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pacific cod | hook n line | 0.84 | 25.10 | 16.82 | 16.39 | 6.43 | 6.98 | 2.97 | 13.29 | 1.21 | 0.89 |
| | trawl | 25.09 | 0.72 | 4.40 | 0.06 | 2.71 | 6.95 | 0.48 | 5.56 | 0.29 | 0.56 |
| | pot | 167.91 | 73.84 | 141.99 | 137.09 | 62.97 | 251.51 | 185.24 | 247.38 | 139.16 | 97.25 |
| Pacific cod | Total | 193.85 | 99.66 | 163.21 | 153.54 | 72.10 | 265.44 | 188.85 | 266.45 | 140.68 | 98.70 |
| Pollock | | 0.74 | 3.51 | 0.03 | - | 0.18 | 0.04 | - | 0.00 | 0.06 | 2.74 |
| Flatfish | | 1.35 | 4.34 | 2.43 | 0.69 | 0.84 | 17.16 | 15.97 | 2.48 | 8.42 | 8.76 |
| Rockfish | | 2.26 | 0.76 | 0.47 | 0.18 | 0.04 | 0.66 | 0.65 | 0.43 | 0.19 | 0.59 |
| Sablefish | | 22.41 | 0.27 | 0.18 | 0.52 | 2.01 | 0.99 | 0.06 | 16.44 | 1.65 | 0.10 |
| Unknown Target | | | | | | | | 2.77 | 0.09 | 0.22 | 0.14 |
| Total | | 232.19 | 112.00 | 166.33 | 156.12 | 87.59 | 298.14 | 208.30 | 285.88 | 151.22 | 111.04 |

| **Stat Area** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006*** |
|---|---|---|---|---|---|---|---|---|---|---|
| 610 | 40.56 | 18.99 | 19.55 | 37.72 | 24.95 | 207.95 | 144.54 | 202.01 | 57.92 | 25.38 |
| 620 | 82.46 | 24.86 | 15.42 | 13.28 | 24.60 | 30.58 | 13.50 | 8.58 | 3.08 | 6.79 |
| 630 | 99.37 | 68.14 | 129.66 | 104.97 | 37.97 | 59.46 | 47.99 | 74.86 | 90.19 | 78.84 |
| 640 | 0.43 | 0.01 | 0.08 | 0.01 | 0.04 | 0.12 | 0.32 | 0.07 | 0.00 | 0.02 |
| 649 | 7.87 | 0.00 | 1.61 | 0.00 | | 0.00 | | | | |
| 650 | 0.08 | 0.00 | 0.00 | 0.15 | 0.03 | 0.02 | 1.95 | 0.36 | 0.04 | 0.01 |
| 659 | 1.41 | 0.00 | | | | | | | | |
| Total | 232.19 | 112.00 | 166.33 | 156.12 | 87.59 | 298.14 | 208.30 | 285.88 | 151.22 | 111.04 |

**Average estimated catch 1997 - 2005 = 188.6 tons**

Table 4 Species Composition of octopus from AFSC Gulf of Alaska bottom trawl survey.

| | Year | | | |
|---|---|---|---|---|
| **Species** | **1999** | **2001** | **2003** | **2005** |
| *Benthoctopus leioderma* | 6 | 4 | 7 | 8 |
| *Japatella diaphana* | | | 2 | 2 |
| *Enteroctopus dofleini* | 5 | 7 | 32 | 9 |
| *Octopus californicus* | | | | 4 |
| *Octopus rubescens* | | | 1 | |
| *Octopodidae* | 33 | 22 | 36 | 38 |
| *Opisthoteuthis californiana* | 18 | | 1 | 14 |
| *Vampyroteuthis infernalis* | 6 | | 3 | |

Table 5 Biomass estimates for octopus (all species) from GOA bottom trawl surveys.

| Survey Year | Survey Hauls | Hauls with Octopus | | Estimated Biomass (t) |
|---|---|---|---|---|
| 1984 | 929 | 89 | 9.6% | 1,498 |
| 1987 | 783 | 35 | 4.5% | 2,221 |
| 1990 | 708 | 34 | 4.8% | 1,029 |
| 1993 | 775 | 43 | 5.5% | 1,335 |
| 1996 | 807 | 34 | 4.2% | 1,960 |
| 1999 | 764 | 47 | 6.2% | 994 |
| 2001 | 489 | 29 | 5.9% | 994 |
| 2003 | 809 | 70 | 8.7% | 3,767 |
| 2005 | 839 | 55 | 6.6% | 1,109 |
| | | Average all | | 1,656 |
| | | Average last 10 yrs | | 1,765 |
| | **Tier 5** | **OFL = 0.53*10yr** | | **935.28** |
| | **Tier 5** | **ABC = 0.75*OFL** | | **701.46** |

Table 6. Estimated biomass of octopus (all species), in metric tons, from 1990 – 2004 ADF&G bottom trawl survey of inshore areas.

| | YEAR | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | AVG. |
| **KODIAK AREA** | | | | | | | | | | | | | | | | |
| NORTHEAST | 44 | 79 | 87 | 95 | 15 | 16 | 122 | 15 | 58 | 89 | 42 | 69 | 119 | 82 | 104 | 69.07 |
| EASTSIDE | 0 | 22 | 0 | 7 | 4 | 13 | 0 | 30 | 54 | 73 | 2 | 10 | 51 | 0 | 0 | 17.73 |
| SOUTHEAST | 0 | 0 | 0 | 51 | 0 | 5 | 54 | 0 | 45 | 10 | 0 | 14 | 2 | 12 | 0 | 12.87 |
| SOUTHWEST | 0 | 0 | 2 | 0 | 0 | 65 | 3 | 1 | 0 | 0 | 3 | 5 | 6 | 31 | 0 | 7.73 |
| WESTSIDE | 20 | 0 | 39 | 101 | 13 | 2 | 23 | 29 | 49 | 42 | 13 | 37 | 43 | 34 | 36 | 32.07 |
| NORTH MAINLAND | 2 | 0 | 0 | 293 | 64 | 0 | 1 | 36 | 1 | 180 | 3 | 0 | 195 | 98 | 66 | 62.60 |
| **CHIGNIK AREA** | | | | | | | | | | | | | | | | |
| IVANOF BAY | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 31 | 0 | 0 | 11 | 3.73 |
| MITROFANIA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 60 | 0 | 0 | 4.53 |
| CHIGNIK BAY | 2 | 0 | 0 | 9 | 0 | 0 | 0 | 1 | 10 | 8 | 12 | 0 | 24 | 40 | 8 | 7.60 |
| KUJULIK BAY | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 10 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1.33 |
| **SOUTH AK PENINSULA** | | | | | | | | | | | | | | | | |
| SANAK ISLAND | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 75 | 0 | 0 | 0 | 5.36 |
| MORZHOVOI BAY | 21 | 0 | 11 | 10 | 16 | | 0 | 15 | 6 | 0 | 31 | 0 | 0 | 12 | 37 | 11.36 |
| COLD BAY/ BELKOFSKI | 57 | 0 | 92 | 88 | 16 | | 18 | 26 | 18 | 20 | 21 | 7 | 1 | 69 | 58 | 35.07 |
| PAVLOF BAY/ VOLCANO | 20 | 0 | 40 | 51 | 74 | | 4 | 14 | 0 | 13 | 11 | 0 | 23 | 247 | 46 | 38.79 |
| BEAVER/ BALBOA/UNGA | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 42 | 0 | 1 | 74 | 129 | 143 | 27.79 |
| STEPOVAK BAY | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| WEST NAGAI | 0 | 0 | 52 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 5 | 123 | 309 | 207 | 49.71 |
| KODIAK TOTAL | 66 | 100 | 127 | 548 | 97 | 101 | 204 | 111 | 207 | 394 | 63 | 136 | 416 | 257 | 206 | 202.20 |
| CHIGNIK TOTAL | 2 | 0 | 0 | 9 | 0 | 14 | 7 | 20 | 14 | 8 | 12 | 31 | 84 | 40 | 19 | 17.33 |
| SOUTH PENINSULA TOTAL | 97 | 0 | 193 | 149 | 106 | | 22 | 55 | 24 | 75 | 63 | 87 | 222 | 766 | 490 | 167.79 |
| TOTAL | 165 | 100 | 320 | 706 | 203 | 115 | 233 | 186 | 245 | 477 | 138 | 254 | 722 | 1063 | 715 | 376.13 |

Table 7. Incidental catch of octopus (number of animals) in longline surveys conducted by the International Pacific Halibut Commission. Surveys in 1993-1996 include sampling of all hooks; surveys from 1997 on include sampling of 20 hooks per skate.

| IPHC Region | SubArea | Year 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3A | Albatross | | | | | | 2 | | | 3 | 4 | 1 | | 2 | 12 |
| | Kodiak | 3 | 2 | 2 | 2 | | | | | | | | | | 9 |
| | Portlock | | | | | | | | | 2 | 3 | 2 | | 2 | 9 |
| | PWS | | | | | | | | | | 1 | | | | 1 |
| | Seward | | | | | | | | | 12 | | | | | 12 |
| | Shelikof | | | | | | 2 | 1 | | | 2 | | | | 5 |
| | Yakutat | | | | 2 | | | | | | | | | | 2 |
| 3B | Chignik | | | | | | | | 1 | | | | | | 1 |
| | Chirikof | | | | 1 | | | | | | | | | | 1 |
| | Kodiak | | 1 | | | | | | | | | | | | 1 |
| | Sanak | | | | | 1 | 2 | 2 | 1 | 3 | 2 | 5 | 3 | 1 | 20 |
| | Semidi | | | | | | | | | 1 | 1 | 1 | | | 3 |
| | Shumagin | | | | 2 | | 1 | 1 | 1 | | 4 | 3 | | 1 | 13 |
| | Trinity | | | | | | | 1 | | | | 1 | | | 2 |
| Total by Year | | 12 | 3 | 11 | 11 | 7 | 23 | 21 | 7 | 38 | 39 | 38 | 25 | 40 | 275 |

Figure 1. Distribution of octopus (all species) in the Gulf of Alaska, based on octopus recorded in observed hauls.

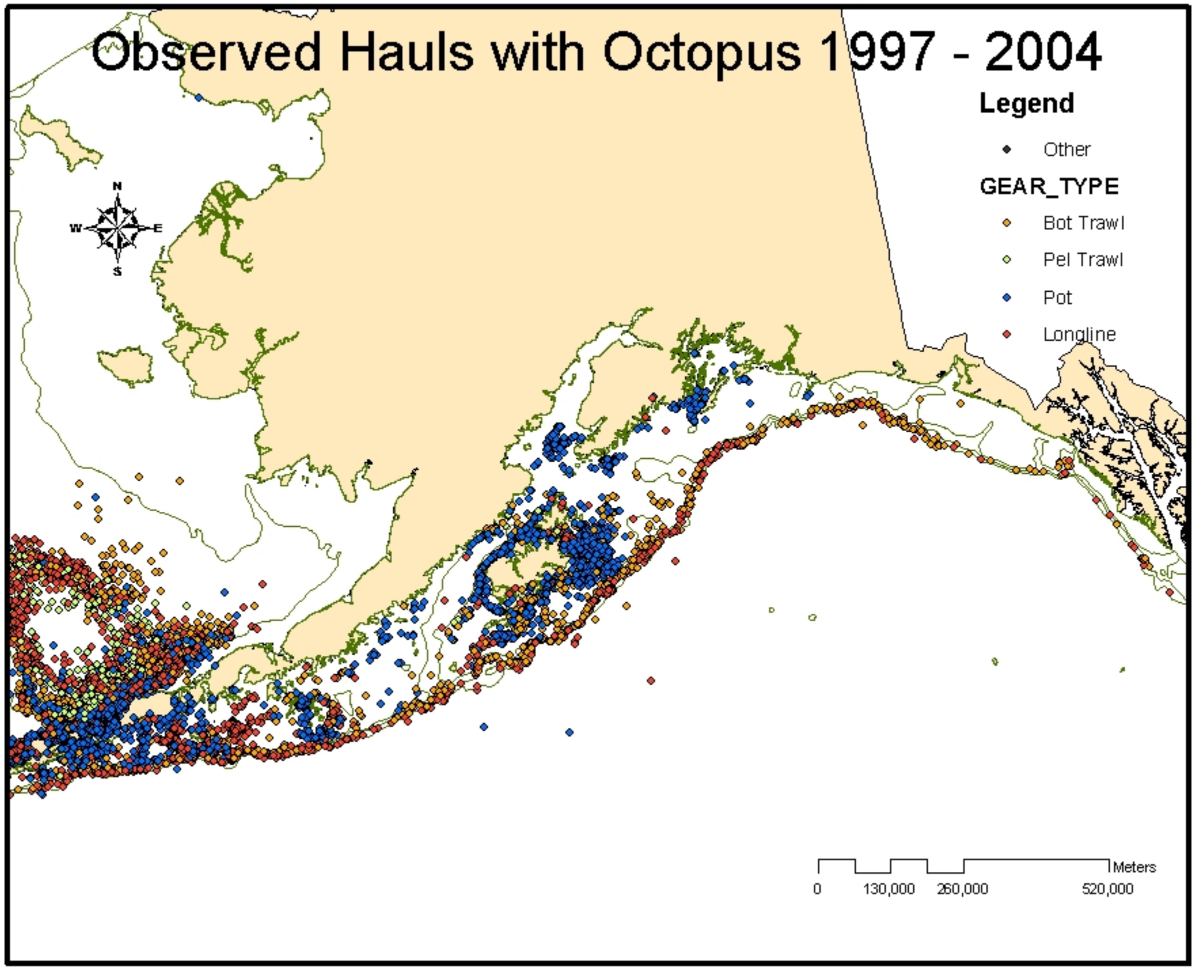


Figure 2 Size frequency of individual octopus (all species) from AFSC bottom trawl surveys in the GOA 1999-2005.

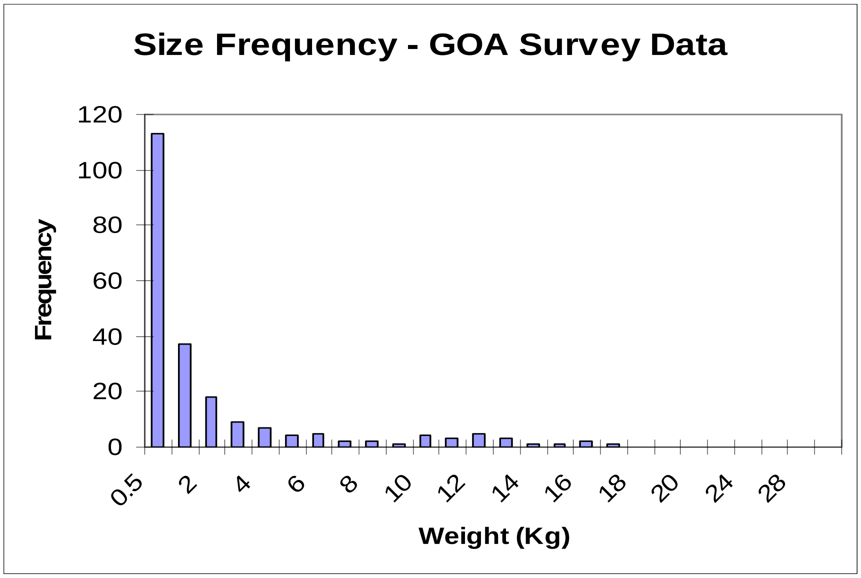



Figure 3 Size frequency of individual octopus (all species) from observed commercial hauls in the GOA 1987-2005, by gear type: a) bottom and pelagic trawls, b) longline, and c) pots.

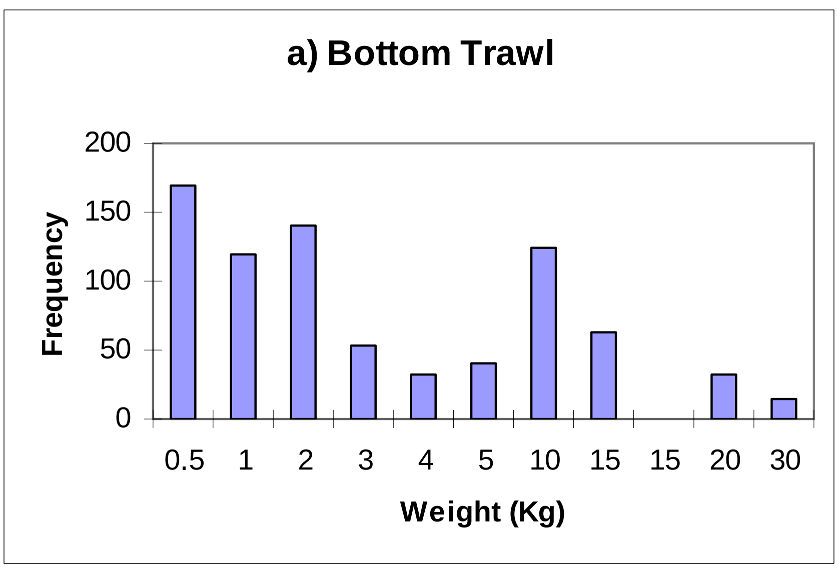
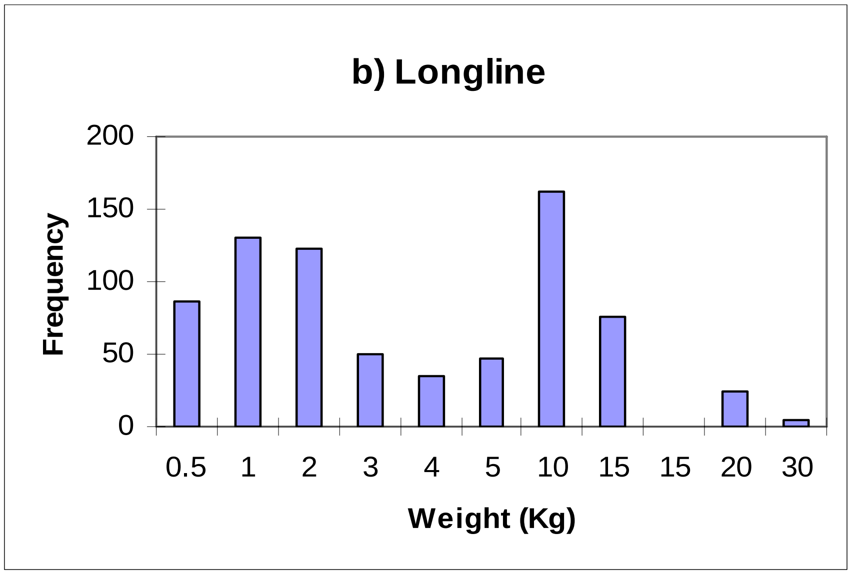


Figure 3 Continued.



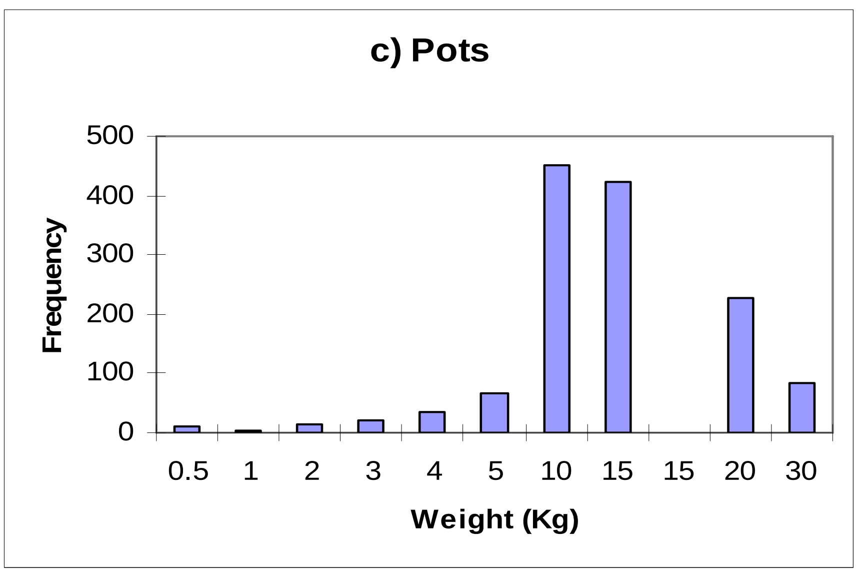



Figure 4 Time series of average octopus catch rates for observed hauls in selected statistical reporting areas of the GOA: annual averages for pot gear only.

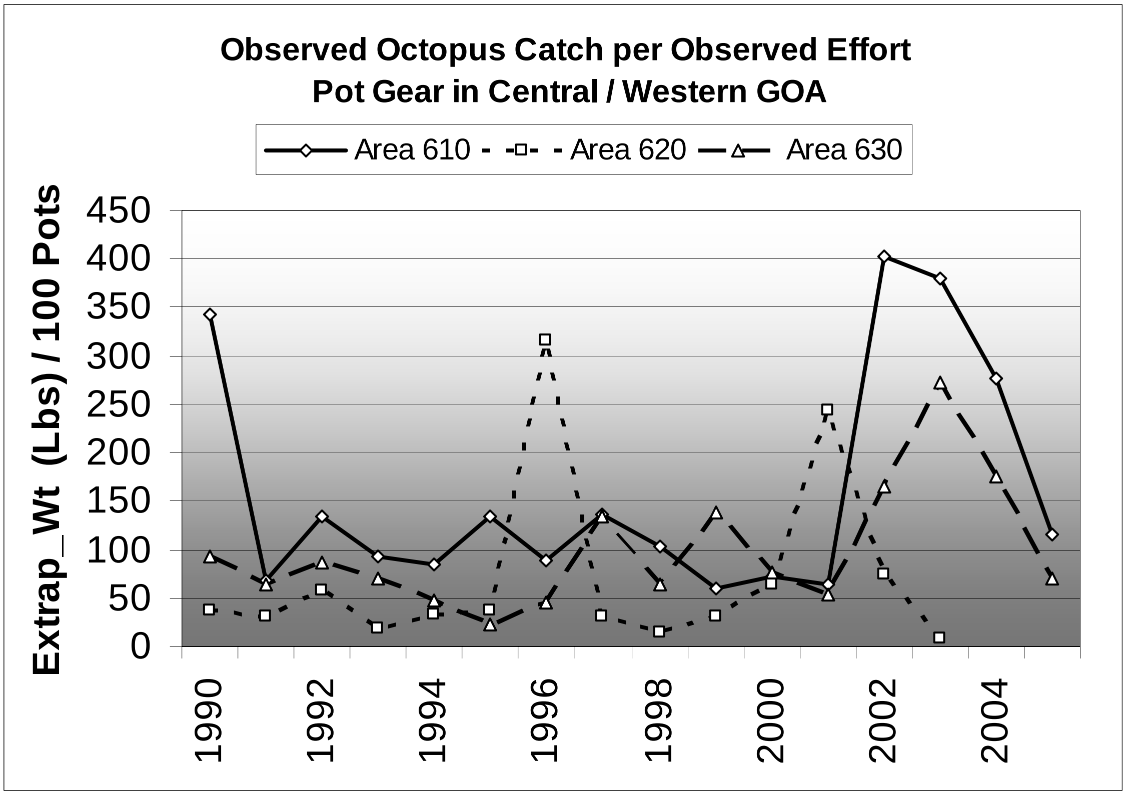



Figure 5. Size frequency (gutted weight in Kg) by sex for plant-delivered octopus from the observer program special project, January - March 2006.

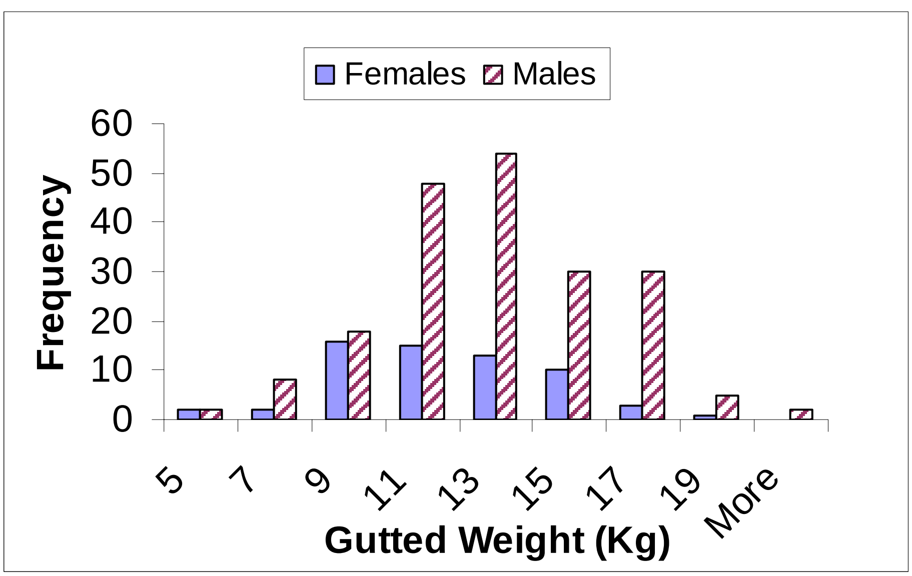


Figure 6. Time series of estimated octopus biomass (all areas combined) from the ADF&G trawl survey compared to biomass estimates from NMFS trawl surveys.

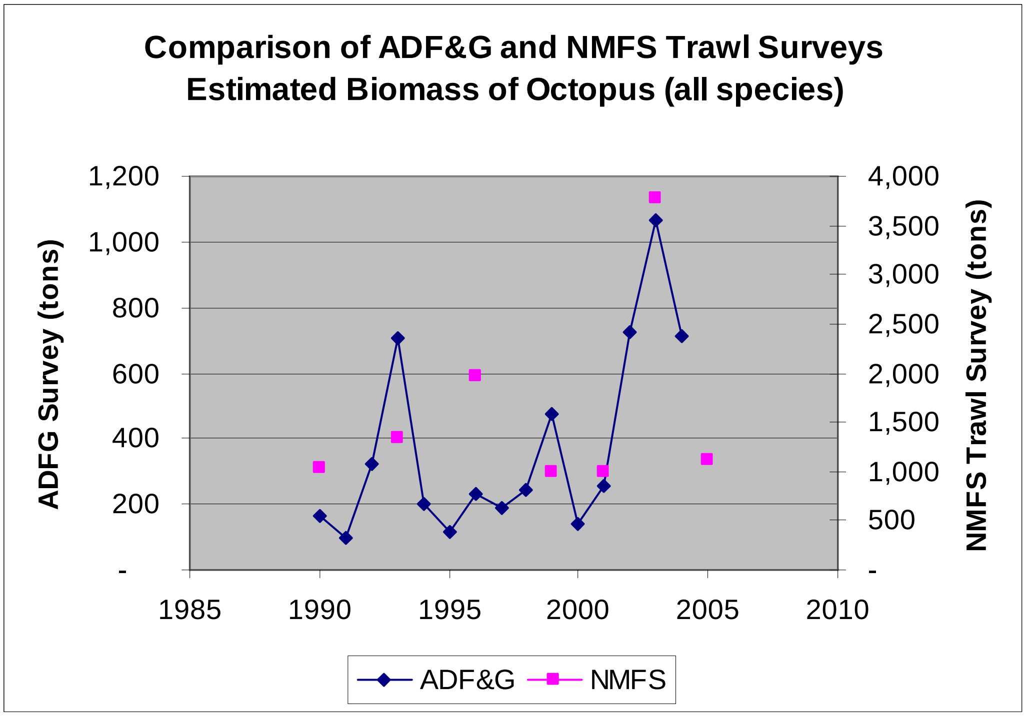



Figure 7. Ecopath model estimates of total consumption of octopus in the GOA.

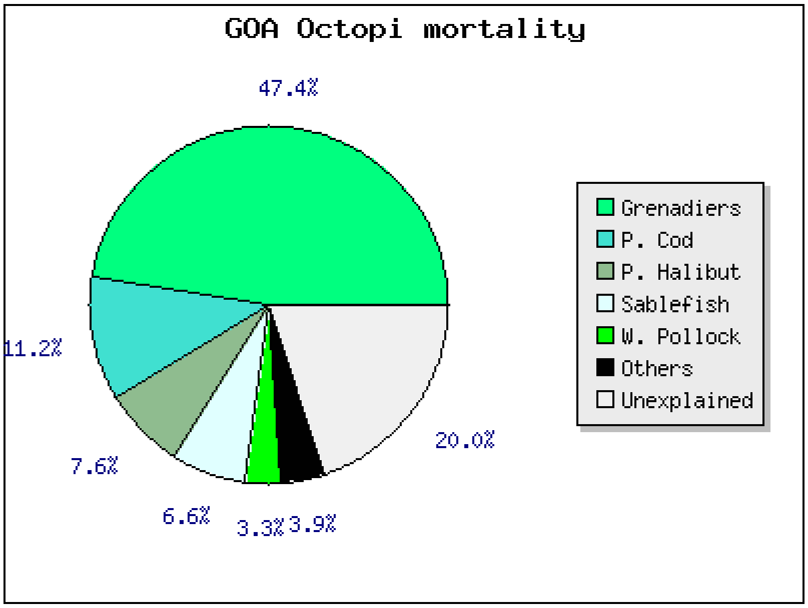
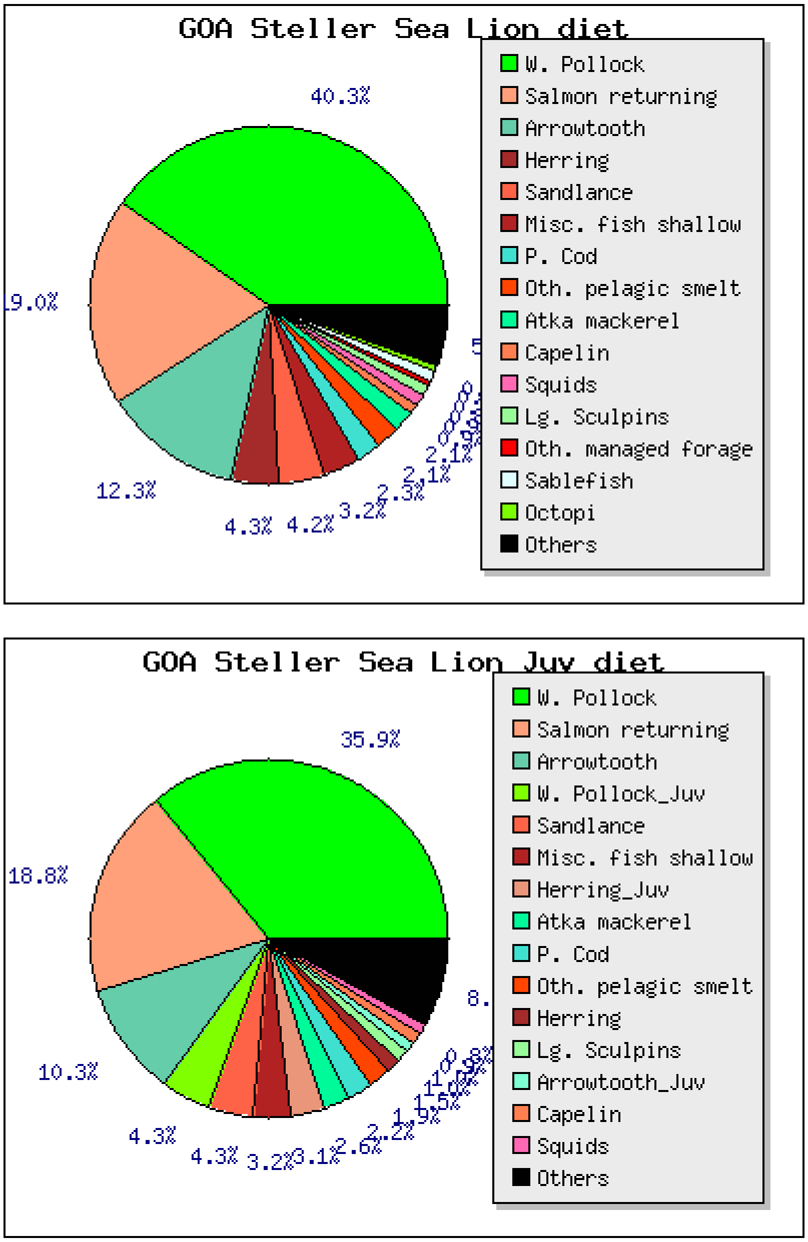


Figure 8. Ecopath model estimates of prey of Steller Sea Lions in the GOA.



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