# 14. Gulf of Alaska Thornyheads

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# Executive Summary

## Summary of Major Changes

*Changes in the input data:*

1. Total catch weight for GOA thornyheads is updated with 2004 and partial 2005 data.
2. Trawl survey biomass information for GOA thornyheads is updated with 2005 data.
3. Relative population numbers and weights for GOA thornyheads from ABL longline surveys are updated with 2004 and 2005 data.
4. Information on the position of thornyheads within the GOA ecosystem and the potential ecosystem effects of the thornyhead fishery are included.

*Changes in assessment methodology:*

Assessment methodology changed significantly in 2003 with the transition from an age structured modeling approach (Tier 3) to a biomass based approach (Tier 5). There are no changes in assessment methodology this year. We continue to assess GOA thornyheads using Tier 5 criteria, using the assessment methodology introduced in 2003. In their December 2003 minutes, the SSC supported moving Thornyhead species to Tier 5 given the lack of age information to support age structured modeling. We will continue to assess Thornyheads using the Tier 5 approach until age composition data become available.

*Changes in assessment results:*

Thornyhead biomass remained generally stable in the 2005 GOA trawl survey compared with the 2003 trawl survey. Using the same method (but different survey biomass estimates) to calculate ABC and OFL under Tier 5 results in slightly changed recommendations from 2003. The average of the two most recent complete GOA trawl survey biomass estimates (2003 and 2005), 98,158 t, was multiplied by M=0.03 times 0.75 for an **ABC recommendation of 2,209 t** and times 1 for an **OFL recommendation of 2,945 t**. This compares with values estimated in 2003 based on the 1999 and 2003 survey estimates which gave an average biomass of 86,200 metric tons, and ABC of 1,940 t, and an OFL of 2,586 t.

*Responses to SSC Comments*

<u>SSC comments specific to the GOA thornyheads assessment:</u>
There were no specific SSC comments on the GOA thornyheads assessment in 2004.

<u>SSC comments on assessments in general:</u>
From the December, 2004 SSC minutes: *In its review of the SAFE chapter, the SSC noted that there is variation in the information presented. Several years ago, the SSC developed a list of items that should be included in the document. The SSC requests that stock assessment authors exert more effort to address each item contained in the list. Items contained in the list are considered critical to the SSC's ability to formulate advice to the Council. The SSC will review the contents of this list at its February meeting.*

This year, an Ecosystem Considerations section for GOA thornyheads was added to the assessment. All other sections were substantially revised to better conform with SAFE guidelines.

# Introduction

*Description, Scientific Names, and General Distribution*

Thornyheads (*Sebastolobus* species) are bony (Teleost) fish belonging to the order Scorpaeniformes and the family Scorpanenidae, which contains the rockfishes. Scorpaeniform fishes are characterized by the presence of a suborbital stay, a bony extension across the cheek. Some other members of this diverse order found in Alaska include the sculpins (Cottidae), poachers (Agonidae), snailfishes (Liparidae), sablefishes (Anoplopmatidae), and greenlings (Hexagrammidae). The family Scorpanenidae is characterized morphologically within the order by venomous dorsal, anal, and pelvic spines, numerous spines in general, and internal fertilization of eggs. While they are considered rockfish themselves, thornyheads are distinguished from the "true" rockfish in the genus Sebastes primarily by reproductive biology; all Sebastes rockfish are live-bearing (viviparous) fish, but thornyheads are oviparous, releasing fertilized eggs in floating gelatinous masses. Thornyheads also have more dorsal spines (15-17) than other Scorpaenids, and lack a swim bladder (Eshmeyer et al 1983, Nelson 1994). There are three species in the genus *Sebastolobus,* including the shortspine thornyhead *Sebastolobus alascanus*, the longspine thornyhead *Sebastolobus altivelis*, and the broadfin thornyhead *Sebastolobus macrochir* (Eshmeyer et al 1983, Love et al 2002).

Thornyheads are distributed in deep water habitats throughout the north Pacific, although juveniles can be found in shallower habitats. The range of the shortspine thornyhead (*Sebastolobus alascanus*) extends from 17 to 1,524 m depth and along the Pacific rim from the Seas of Okhotsk and Japan in the western north Pacific, throughout the Aleutian Islands, Bering Sea slope and Gulf of Alaska, and south to Baja California in the eastern north Pacific (Love et al 2005). Shortspine thornyheads are considered most abundant from the Northern Kuril Islands to southern California. They are concentrated between 150 and 450 m depth in cooler northern waters, and are generally found in deeper habitats up to 1000m in the warmer waters of this range (Love et al 2002). The longspine thornyhead (*S. altivelis*) is found only in the eastern north Pacific, where it ranges from the Shumagin Islands in the Gulf of Alaska and south to Baja California. Longspine thornyheads are generally found in deeper habitats ranging from 201-1,756 m (Love et al 2005). They are most commonly found below 500 m throughout their range. Off the California coast, longspine thornyheads are a dominant species in the 500-1000 m depth range, which is also a zone of minimal oxygen (Love et al 2002). The broadfin thornyhead (*S. macrochir*) is found almost entirely in the western north Pacific, ranging from the Seas of Okhotsk and Japan, but also ranges into the Aleutian Islands and eastern Bering Sea. The depth range of the broadfin thornyhead, 100-1,504 m, is similar to that of the shortspine thornyhead. The broadfin thornyhead is relatively uncommon in the eastern north Pacific, and some researchers believe that historical records of this species from the Bering Sea may have been misidentified shortspine thornyheads. The broadfin thornyhead has had multiple common names, including broadbanded thornyhead, broadhanded thornyhead, and bighand thornyhead, all referring to *S. macrochir* (Love et al 2005). In this assessment, we follow the standard set in the AFS list of North American fish names which established "broadfin thornyhead" as the common name for *S. macrochir*.

*Management Units and Stock Structure*

The Gulf of Alaska "Thornyheads" management unit is currently a species complex which includes shortspine thornyhead (*Sebastolobus alascanus*) and two congeneric thornyhead species, the longspine thornyhead (*Sebastolobus altivelis*) and the broadfin thornyhead, *S. macrochir.* The broadfin thornyhead is currently believed to be extremely unlikely to stray into the Gulf of Alaska, and is very uncommon even in the Aleutian Islands and eastern Bering Sea. Therefore, it would be reasonable for management to exclude the broadfin thornyhead (*S. macrochir*) from consideration within the Gulf of Alaska thornyhead species complex. Longspine thornyheads (*S. altivelis*) do occur in the Gulf of Alaska, but are much less common than the shortspine thornyheads and are found much deeper. Because longspine thornheads are infrequently encountered in the Gulf of Alaska (GOA) trawl surveys and fisheries, this assessment has historically focused exclusively on the shortspine thornyhead. This year, we provide information on longspine thornyheads from GOA trawl surveys and fishery sampling to help determine whether they should be explicitly considered along with shortspine thornyheads as an assemblage in future assessments. The rest of this document will refer to either shortspine or longspine thornyheads explicitly, and will ignore broadfin thornyheads because they do not occur in the Gulf of Alaska.

The population structure of shortspine thornyheads is not well defined anywhere throughout their north Pacific range. Genetic analyses have suggested that there is "considerable mixing of shortspine thornyheads along much of the Pacific coast" (Love et al 2002, p. 116). All shortspine thornyheads in the Gulf of Alaska have been managed as a single stock since 1980 (Ianelli and Ito 1994, 1995, 1998, Ianelli et al 1997), and separate management has been applied to shortspine thornyheads on the U.S. west coast (e.g., Hamel 2005). Bering Sea and Aleutian Islands shortspine thornyheads are effectively managed as a separate stock from Gulf of Alaska thornyheads. In the BSAI FMP, all thornyhead species are managed within the "Other rockfish" species complex (Reuter and Spencer 2004).

Shortspine thornyheads are abundant throughout the Gulf of Alaska and are commonly taken by bottom trawls and longline gear. In the past, this species was seldom the target of a directed fishery. Today thornyheads are one of the most valuable of the rockfish species, with most of the domestic harvest exported to Japan. Despite their high value, they are still managed using a "bycatch only" fishery status in the Gulf of Alaska because they are nearly always taken in fisheries directed at sablefish (*Anoplopma fimbria*) and other rockfish (*Sebastes* spp). The incidental catch of shortspine thornyheads in these fisheries has been sufficient to capture the full thornyhead quota established in recent years, so directed fishing on shortspine thornyheads exclusively is not permitted. Although the thornyhead fishery is conducted operationally as a "bycatch" fishery, the high value and desirability of shortspine thornyheads means they are still considered a "target" species for the purposes of management.

Population structure of longspine thornyheads has not been studied in Alaska. Longspine thornyheads are not the target of a directed fishery in the Gulf of Alaska, but are the target of directed fisheries off the U.S. west coast where they are managed separately from shortspine thornyheads (e.g., Fay 2005). They have not been explicitly managed in the Gulf of Alaska to date.

*Life History*

Like all rockfish, thornyheads are generally longer lived than most other commercially exploited groundfish, and are further distinguished by reproductive habits such as internal fertilization of eggs (as discussed above). Unlike rockfish in the genus *Sebastes* which retain fertilized eggs internally and release hatched, fully developed larvae, thornyheads spawn a bi-lobed mass of fertilized eggs which floats in the water column (Love et al 2002). Shortspine thornyhead spawning takes place in the late spring, between April and July in the Gulf of Alaska (and earlier along the U.S. west coast, between December and May). It is unknown when longspine thornyheads spawn in the Alaskan portion of their range, although they are reported to spawn between January and April on the U.S. West coast (Pearson and Gunderson, 2003). Fecundity at length has been estimated by Miller (1985) and Cooper et al (2005) for shortspine thornyheads in Alaska (and Cooper et al 2005 found no significant difference in fecundity at length between Alaskan and West Coast shortspine thornyheads). It appeared that fecundity at length in the more recent study was somewhat lower than that found in Miller (1985), but it was unclear whether the difference was attributable to different methodology or to a decrease in stock fecundity over time. Longspine thornyhead fecundity at length was estimated by Wakefield (1990) and Cooper et al (2005) for the West Coast stocks; it is unknown whether this information is applicable to Alaskan longspine thornyheads.

Once the pelagic egg masses hatch, larval and juvenile thornyheads spend far more time in a pelagic life stage than the young of rockfish in the genus *Sebastes* (Love et al 2002). Shortspine thornyhead juveniles spend 14-15 months in a pelagic phase, and longspine thornyhead juveniles are pelagic even longer, with up to 20 months passing before they settle into benthic habitat. While shortspine thornyhead juveniles tend to settle into relatively shallow benthic habitats between 100 and 600 m and then migrate deeper as they grow, longspine thornyhead juveniles settle out into adult longspine habitat depths of 600 to 1,200 m. Once in benthic habitats, both shortspine and longspine thornyheads associate with muddy substrates, sometimes near rocks or gravel, and distribute themselves evenly across this habitat, appearing to prefer minimal interactions with individuals of the same species. They have very sedentary habits and are most often observed resting on the bottom in small depressions, especially longspine thornyheads which occupy a zone of minimal oxygen at their preferred depths (Love et al 2002).

Both shortspine and longspine thornyheads are long-lived, relatively slow-growing fishes, but shortspines appear to have the greater longevity. Shortspine thornyheads may live 80-100 years (see below for further details) and the larger-growing females reach sizes up to 80 cm fork length (Love et al 2002). Longspine thronyheads are generally smaller, reaching maximum sizes less than 40 cm and maximum ages of at least 45 years (Love et al 2002). Size at maturity varies by species as well. The size-at-maturity schedule estimated in Ianelli and Ito (1995) for shortspine thornyheads off the coast of Oregon suggests that female shortspine thornyheads appear to be 50% mature at about 22 cm. More recent data analyzed in Pearson and Gunderson (2003) confirmed this, estimating length at maturity for Alaska shortspine thornyheads at 21.5 cm (although length at maturity for west coast fish was revised downward to about 18 cm). Male shortspine thornyheads mature at a smaller size that females off Alaska (Love et al 2002). Longspine thornyheads reach maturity between 13 and 15 cm off the U.S. west coast; it is unknown whether this information applies in the Alaskan portion of the longspine thornyheads range.

Despite a general knowledge of the life history of thornyheads throughout their range, precise information on age, growth, and natural mortality remains elusive for shortspine thornyheads in Alaska, and is unknown for longspine thornyheads. Miller (1985) estimated shortspine thornyhead natural mortality by the Ricker (1975) procedure to be 0.07. The oldest shortspine thornyhead she found was 62 years old. On the U.S. continental west coast, at least one large individual was estimated to have a maximum age of about 150 years (Jacobson 1990). Another study of west coast shortspine thornyheads found a 115 year old individual using conventional ageing methods (Kline 1996). These maximum ages would suggest natural mortality rates ranging from 0.027 to 0.036 if we apply the relationship developed by Hoenig (1983). Recent radiometric analyses suggest that the maximum age is between 50-100 years (Kastelle et al 2000, Cailliet et al 2001), but these are high-variance estimates due to sample pooling and other methodological issues. A recent analysis of reproductive information for Alaska and west coast populations also indicates that shortspine thornyheads are very long-lived (Pearson and Gunderson, 2003). The longevity estimate was based on an empirically derived relationship between gonadosomatic index (GSI) and natural mortality (Gunderson 1997), and suggested much lower natural mortality rates (0.013-0.016) and therefore much higher maximum ages (250-350 years) than had ever been previously reported using any direct ageing method. In past assessments, we attempted to estimate shortspine thornyhead growth within a size-based model using a range of assumptions from Miller (1985), Kline (1996), Kastelle et al (2000), and Pearson and Gunderson (2003). These explorations did not result in a definitive growth relationship for GOA shortspine thornyheads. Improved otolith ageing techniques are in development at AFSC to address this problem.

## Fishery

*Directed fishery, Bycatch and Discards*

As an element of the deepwater community of demersal fishes, thornyheads have probably been caught in the northeastern Pacific Ocean since the late l9th century, when commercial trawling by U.S. and Canadian fishermen began. In the mid-l960s Soviet fleets arrived in the eastern Gulf of Alaska (Chitwood 1969), where they were soon joined by vessels from Japan and the Republic of Korea. This represented the first directed exploitation of Gulf of Alaska rockfish resources, primarily Pacific Ocean perch (*Sebastes alutus*), and likely resulted in the first substantial catches of thornyheads as well. Rockfish catch peaked in 1965 with nearly 350,000 metric tons removed (Ito 1982). However, records of catch and bycatch from this fishery were not detailed enough to determine precisely what thornyhead catch in these early fisheries might have been. Furthermore, we are unable to distinguish shortspine and longspine thornyheads in the historical catch records discussed below, although we believe the overwhelming majority of the catch would be shortspine thornyheads because of their dominance in the areas and depths where fisheries have occurred to date.

For this assessment, thornyhead retained and discarded catch by gear type (Table 14.1) has been derived from a variety of sources. The earliest available records of thornyhead catch begin in 1967, as published in French et al. (1977). Active data collection began as part of the U.S. Foreign Fisheries Observer Program in l977, when the thornyhead catch in the Gulf of Alaska was estimated at 1,397 t. Beginning in 1980, the Observer program generated annual estimates of the foreign catch of thornyheads by International North Pacific Fisheries Commission (INPFC) statistical area. Beginning in 1983, the observer program also estimated the catches of thornyheads in joint venture fisheries where U.S. catcher vessels delivered catch to foreign processor vessels. Beginning in l984, thornyheads were identified as a separate entity in the U.S. domestic catch statistics. Data from 1981 to 1989 are based on reported landings extracted from the Pacific Fishery Information Network (PacFIN) database and the NMFS Observer Program. Before this period, estimates are based on the following reports: French et al. (1977), and Wall et al. (1978-81). Catches in more recent years (1990-2002) are based on “blended” fishery observer and industry sources using an algorithm developed by the NMFS Alaska Regional Office (AKRO). Catches from 2003 to the present were provided by NMFS Regional Office Catch Accounting System (CAS), an improved form of the “blend” used previously. Estimates of discards for the years 1990 through the present are provided by the NMFS AKRO as well. Thornyhead discards before 1990 are unknown. We assumed that the reported catches before 1990 included both retained and discarded catch. The only other known catch of thornyheads occurs as a result of scientific surveys in the Gulf of Alaska. Survey research catches of all thornyhead species (Table 14.2) are a very small component of overall removals, and has been 100% shortspine thornyheads in all years except 1999, 2003, and 2005 when it was 98-99% shortspine thornyheads and 1-2% longspine thornyheads (see survey section below).

Catch trends for GOA thornyheads since 1967 appear to result mainly from management actions rather than from thornyhead stock fluctuations. Thornyhead catches averaged 1,300 tons between 1973 and 1981 in the GOA, a similar magnitude to current catches (Table 14.1). The greatest foreign-reported harvest activities for thornyheads in the Gulf of Alaska occurred during the period 1979-83. The catches of thornyheads in the GOA declined markedly in 1984 and 1985, due primarily to restrictions on foreign fisheries imposed by U.S. management policies. In 1985, the U.S. catch surpassed the foreign catch for the first time. U.S. catches of thornyheads continued to increase, reaching a peak in 1989 with a total removal of 2,616 t. Catches have since averaged about 1,300 t for the period 1990 though 2004. Recent catches from 1995 to the present have averaged around 1,200 tons, while catches from the early 1990s averaged 1,500 tons.

Since 1995, thornyhead total catch has been less than the Allowable Biological Catch (ABC) and Total Allowable Catch (TAC) established by management (Table 14.3). Management decisions since 2000 have tended to favor relatively low TACs for GOA thornyheads due to uncertainty in assessment model results which suggested that higher quotas would be sustainable. The assessment model uncertainty resulted from inadequate age and growth information and low levels of biological sampling from the fisheries, which have not yet been fully corrected, so in 2003 we suspended use of the assessment model until data quality improves. The Tier 5 biomass based approach to calculating ABC and OFL for GOA thornyheads which was initiated in 2003 results in similar recommendations as the more conservative assessment model predictions previously preferred by management. Even with this relative conservatism in recent thornyhead management, fisheries do not appear to be constrained by small TACs for thornyheads.

Given the relatively low catches of thornyheads relative to recent TACs, it seems clear that thornyhead catch is limited more by constraints in the target fisheries in which it occurs: sablefish, rockfish, and to a lesser extent flatfish fisheries. By weight, the directed fishery for rockfish harvested the most thornyheads in 2003, followed by sablefish and combined flatfish fisheries (Figure 14.1, left hand panel). However, fisheries directed at sablefish harvested the largest amount of thornyheads in 2004, followed by rockfish and the combined flatfish fisheries (Figure 14.1, right hand panel). In 2003 and 2004, thornyhead discard continued to be a low proportion of total catch, approximately 10-11% by weight. Discard in 2003 was more characteristic of past years in that thornyhead discard from the flatfish fisheries was higher while relatively fewer discards were incurred from the sablefish and rockfish fisheries (Figure 14.2, left hand panel). In 2004, most thornyhead discards came from the rockfish fishery, followed by the sablefish and flatfish fisheries (Figure 14.2, right hand panel). The distribution of thornyhead catches ranges broadly throughout the Gulf of Alaska and is consistent within recent years for the different gear types (Figures 14.3 and 14.4). Length sampling from trawl and longline fisheries for 1990-2005 is shown in Figures 14.5 and 14.6; in general, longline fisheries capture larger thornyheads than trawl fisheries, perhaps because they operate in deeper waters.

## Survey Data

*Longline surveys*

Longline surveys were conducted jointly by the United States and Japan in the Gulf of Alaska each year from 1979 to 1994 to ascertain the abundance level and length composition of important groundfish species in the depths from 101 to 1,000 m. Since 1987, a U.S. longline survey has also been conducted using similar methodology to the cooperative survey. The U.S. longline survey covered a complete standard area in the Gulf of Alaska beginning in 1990. For selected target species in the longline survey, the catch rate, the area, and the size composition of samples from each depth stratum were used to determine the relative population number (RPN) and weight (RPW) for each depth stratum. The RPNs and RPWs for the various depth strata (201-1,000 m for thornyheads) were summed to obtain GOA totals (Table 14.4). Note that these represent only relative abundance and are not generally comparable with the trawl survey estimates of abundance. Length sampling from longline surveys for 1990-2005 is shown in Figure 14.7.

The use of the longline survey to estimate relative abundance of thornyheads may be questionable because of a possible interaction with sablefish abundance. For example, Sigler and Zenger (1994) found that thornyhead catch increased in areas where sablefish abundance decreased. They suggested that the increase in thornyhead catch rates between 1988 and 1989 (their data) might be partly due to the decline in sablefish abundance. They reasoned that availability of baited hooks to thornyheads may have increased. Further research is needed on the effect of hook competition between slow, low metabolism species such as shortspine thornyheads and faster, more actively feeding sablefish.

The NMFS Auke Bay Lab began tagging shortspine thornyheads from the longline survey in 1997 and has continued to tag them on an opportunistic basis in each year since then. From 1997-2004, some 4,354 shortspine thornyheads have been tagged and released in the GOA during the sablefish longline survey.

About 50 recaptures have been reported (roughly 1%) over this period. The longest time at liberty was over 6 years and the average time at liberty among all recaptures is 2.4 yrs. All but three recaptures were found within 200 nautical miles and 80% of the recaptures were found within 50 nm of where they were released. For all recaptures the biggest difference in growth was 2 cm. However, length data were unavailable for more than 65% of the recaptured thornyheads. This work is part of an ongoing project to learn more about movement and growth rates of this deep-water species.

*Trawl surveys*

The most recent NMFS trawl survey for the Gulf of Alaska was conducted during the summer of 2005 (Table 14.5). This survey employed standard NMFS Poly-Nor'eastern bottom trawl gear and provide biomass estimates using an "area-swept" methodology described in Wakabayashi et al. (1985). The 1984, 1987 1999 2003, and 2005 surveys extended into deeper water (>500 m) and covered the range of primary habitat for the shortspine thornyhead stock. The 2001 survey and surveys during the early 1990s did not extend to the deeper zones where concentrations of larger shortspine and all longspine thornyheads are known to exist. This gives survey biomass estimates a disjointed appearance (Figure 14.8, upper panel). A comparison of survey biomass estimates by depth strata suggests that different portions of the shorspine thornyhead population are sampled depending on survey depth coverage (Figure 14.8, lower panel). In addition, the 2001 survey did not extend into the eastern Gulf, where a significant portion of shortspine thornyhead biomass has been found in past surveys (Fig. 14.8, lower panel). It is evident from trawl survey results that a significant portion of the biomass of shortspine thornyheads exists beyond depths of 500 m, and that all of the biomass of longspine thornyheads exists beyond depths of 500m (Figure 14.9). Therefore, in assessing the relative abundance of GOA thornyheads, it is important to consider only surveys covering the full depth and geographic range of the species, which in recent years limits us to only the 1999, 2003, and 2005 surveys. The spatial distribution of shortspine thornyhead catch per unit effort in these recent complete trawl surveys appears relatively similar (Figure 14.10) Length sampling from trawl surveys for 1990-2005 is shown in Figure 14.11.

## Analytic Approach, Model Evaluation, and Results

At present, the available data do not support population modeling for any species of thornyheads in the GOA, so none of these stock assessment sections are relevant for this Tier 5 assessment, except for one:

*Parameters estimated independently: M*

In past years, we examined multiple assumptions about natural mortality from Miller (1985), Kline (1996), Kastelle et al (2000), and Pearson and Gunderson (2003) within an age-structured model for shortspine thornyheads. These natural mortality estimates, along with several others, are summarized in Table 14-6. We concluded that the age and length data available for this species in Alaska were inadequate to resolve the uncertainties related to these parameters within a modeling context. Considering the uncertainty inherent even in applying the Tier 5 method to thornyhead species in the GOA, we elected to use one of the more conservative estimates of M derived from these methods (M=0.03, Table 14-6). Assuming M=0.03 implies a longevity in the range of 125 years, which is bracketed by estimates derived from Jacobson (1990) and Kline (1996). This natural mortality rate is lower than the M=0.05 applied to shortspine thornyheads on the U.S. West Coast and in the BSAI Other rockfish assessment (Hamel 2005, Reuter and Spencer 2004). Applying this comparatively low estimate of M=0.03 for use in the GOA was suggested by the GOA Plan Team and the NPFMC SSC, and is considered conservative because it will result in the low estimates of ABC and OFL under Tier 5 which still allow for historical levels of catch to be taken in the fishery. Until we find better information on shortspine thornyhead productivity, age, and growth in the GOA, this is the best interim measure balancing shortspine thornyhead conservation and allowing for historical levels of incidental catch in target groundfish fisheries.

*Assemblage analysis and recommendations*

It seems clear that broadfin thornyheads, *Sebastolobus macrochir*, do not range into the Gulf of Alaska and should therefore not be considered within the GOA thornyheads assemblage. Furthermore, it is clear that the GOA thornyheads assemblage is overwhelmingly dominated in biomass and catch by the shortspine thornyhead, *S. alascanus*, so the historical single species focus of this assessment on shortspines seems appropriate. Therefore, we continue to make harvest recommendations specific to shortspine thornyheads in the Gulf of Alaska (see below).

At present, we do not attempt to estimate natural mortality or apply Tier 5 assessment methods to longspine thornyheads (*S. altivelis*) in the Gulf of Alaska. Our fishery sampling indicates that this species is extremely rarely encountered in fisheries (likely because most fisheries operate at depths shallower than 500 m in the GOA), and surveys suggest that it is uncommon relative to shortspine thornyheads in Alaska even in its preferred depths from 500 to 1,000 m. The center of longspine thornyhead abundance appears to be off the U.S. West Coast, not in Alaska. Furthermore, the TAC established based on the biomass and natural mortality of shortspine thornyheads has not been fully exploited since 1994, suggesting that fishing pressure on thornyheads in general is relatively light. Therefore, additional management measures specific to longspine thornyheads in the Gulf of Alaska are not recommended at this time. In the future, if fisheries shift to deeper depths along the continental slope, and/or the catch of shortspine thornyheads increases dramatically, specific management measures for longspine thornyheads should be considered.

# Projections and Harvest Alternatives

## Acceptable Biological Catch

A Tier 5 estimate of ABC can be calculated based on the average of trawl survey biomass of shortspine thornyheads in 2003 and 2005 (the most recent complete surveys) and using an M of 0.03.

The average of the 2003 survey biomass estimate of 101,576 t and the 2005 survey biomass estimate of 97,740 t is calculated as (101,576 t + 94,740 t)/2 =98,158 t.

The Tier 5 estimate of shortspine thornyhead ABC is estimated as biomass times M times 0.75, or 98,158 t * 0.03 * 0.75 = 2,209 t.

## Overfishing Level

The Tier 5 estimate of shortspine thornyhead OFL is estimated as biomass times M, or 98,158 t * 0.03 = 2,945 t.

*Other considerations: Apportionment of ABC*

Based on the 2005 survey biomass distribution, we computed the following apportionment of shortspine thornyheads ABC broken out by management areas. We recommend the most recent survey biomass for the apportionment for two reasons; first, the GOA Plan Team and NPFMC SSC have approved of using the most recent survey biomass estimate for ABC apportionment since the 2003 assessment. Second, this seems the most reasonable survey distribution to use considering the apportionment will be applied in both 2006 and 2007.

| GOA Area (NPFMC Area) | 2005 Biomass | Percent of Total Biomass | Area ABC Apportionment |
|---|---|---|---|
| Western (610) | 22,005 | 23% | 513 |
| Central (620 and 630) | 42,419 | 45% | 989 |
| Eastern (640 and 650) | 30,316 | 32% | 707 |
| Gulfwide Total | 94,740 | 100% | 2,209 |

# Ecosystem Considerations

This section focuses on shortspine thornyheads exclusively, because they overwhelmingly dominate the thornyhead biomass in the Gulf of Alaska. Shortspine thornyheads occupy different positions within the GOA food web depending upon life stage; adults are generally more piscivorous and are also available to fisheries (Figure 14-12, upper panel) whereas juveniles prey more on invertebrates and are therefore at a lower trophic level (Figure 14-12, lower panel). These food webs were derived from mass balance ecosystem models assembling information on the food habits, biomass, productivity and consumption for all major living components in each system (Aydin et al in review).

One simple way to evaluate ecosystem effects relative to fishing effects is to measure the proportions of overall mortality attributable to each source. In the GOA, mass balance ecosystem modeling based on early 1990's information indicates that adult shortspine thornyheads experience more fishing mortality than predation mortality, while juvenile thornyheads only experience predation mortality (Figure 14-13). Adult and juvenile groups were not modeled separately in the EBS and AI, so the upper panel of Figure 14-13 includes all thornyheads in those two ecosystems. Combining adults and juveniles with different sources of mortality could account for the apparent differences between the GOA and BSAI in the overall dominance of fishing vs predation mortality. However, since shortspine thornyheads are the target of a fishery in the GOA and they are not in the BSAI, it is likely that fishing mortality is a more important component of total mortality for GOA thornyheads than for those populations in the AI and EBS.

In terms of annual tons removed, it is clear that fisheries were annually removing 1,300 tons of thornyheads from the GOA on average during the early 1990's (see Fishery section above). While estimates of predator consumption of thornyheads are more uncertain than catch estimates, the ecosystem models incorporate uncertainty in partitioning estimated consumption of shortspine thornyheads between their major predators in each system. The predators with the highest overall consumption of adult shortspine thornyheads in the GOA are arrowtooth flounder, which consumed between 100 and 300 metric tons of thornyheads annually during the early 1990's in that ecosystem, followed by "toothed whales" (sperm whales), which consume a similar range of thornyheads annually (Figure 14-14, upper panel). Sharks consumed between 50 and 200 tons of shortspine thornyheads annually, and sablefish were estimated to consume less than 75 tons of adult thornyheads. Juvenile shortspine thornyheads are consumed almost exclusively by adult thornyheads, according to these models (Figure 14-14, lower panel). Thornyheads are an uncommon prey in the Gulf of Alaska, as they generally make up far less than 2% of even their primary predators' diets.

Diets of shortpine thornyheads are derived from food habits collections taken in conjunction with GOA trawl surveys. Over 70% of adult shortspine thornyhead diet measured in the early 1990s was shrimp, including both commercial (Pandalid) shrimp and non commercial (NP or Non-Pandalid shrimp) in equal measures (Figure 14-15, upper panel). This preference for shrimp in the adult thornyhead diet combined with consumption rates estimated from stock assessment parameters and biomass estimated from trawl surveys results in an annual consumption estimate ranging from 2,000 to 10,000 tons of shrimp (Figure 14-15, lower panel). Other important prey of shortspine thornyheads include crabs, zooplankton, amphipods, and other benthic invertebrates, and thornyheads are estimated to consume up to an additional 1,000 metric tons of each of these prey annually in the GOA (Figure 14-15). Juvenile thornyheads have diets similar to adults, but they are estimated to consume far less prey overall than adults, as might be expected when a relatively small proportion of the population is in the juvenile stage at any given time (Figure 14-16).

Examining the trophic relationships of shortspine thornyheads suggests that the direct effects of fishing on the population which are evaluated with standard stock assessment techniques are likely to be the major ecosystem factors to monitor for this species, because fishing is the dominant source of mortality for shortspine thornyheads in the Gulf of Alaska, and there are currently no major fisheries affecting their primary prey. However, if fisheries on the major prey of thornyheads—shrimp and to a lesser extent deepwater crabs—were to be re-established in the Gulf of Alaska, any potential indirect effects on thornyheads should be considered. Furthermore, the ecosystem models employed in this analysis are not designed to incorporate habitat relationships or any effects that human activities might have on habitat.

While it is difficult to evaluate the ecosystem effects of a “thornyhead fishery” because no isolated thornyhead fishery exists in the Gulf of Alaska, we can examine the ecosystem effects of the primary target fisheries which catch thornyheads. According to Alverson et al. (1964), groundfish species commonly associated with thornyheads include: arrowtooth flounder (*Atheresthes stomias*), Pacific ocean perch (*Sebastes alutus*), sablefish (*Anoplopoma fimbria*), rex sole (*Glyptocephalus zachirus*), Dover sole (*Microstomus pacificus*), shortraker rockfish (*Sebastes borealis*), rougheye rockfish (*Sebastes aleutianus*), and grenadiers (family Macrouridae). As described above, most thornyhead catch comes from fisheries directed at sablefish, rockfish, and flatfish in the Gulf of Alaska. Besides thornyheads, these fisheries remove a number of other target species as well as nontarget species. Sablefish fisheries in the GOA are prosecuted with longlines, with a small proportion of catch taken by trawl. GOA sablefish fisheries take over half of all estimated nontarget bycatch annually, due to their high rate of grenadier bycatch (Table 14.7). They also catch sharks, skates, and other demersal fishes. GOA rockfish and flatfish fisheries generally have lower bycatch as a percentage of target species catch than sablefish fisheries. These fisheries also have bycatch of grenadiers, skates and sharks, although at a lower rate than sablefish. Flatfish fisheries also take a small amount of sculpin bycatch. When the total bycatch in these fisheries is summed to give the percent of total nontarget species bycatch taken in fisheries which catch thornyheads, it is apparent that these fisheries have their largest potential indirect ecosystem effect through the removal of grenadiers as opposed to any other nontarget species (Table 14.7). Fisheries for Pacific halibut also take thronyheads and other rockfish, as well as skates and sharks, but they are presently unmonitored, so it is difficult to assess the impacts of these fisheries on the ecosystem.

## Data gaps and research priorities

Because fishing mortality appears to be a larger proportion of adult thornyhead mortality in the GOA than predation mortality, highest priority research should continue to focus on direct fishing effects on shortspine thornyhead populations. The most important component of this research is to fully evaluate the age and growth characteristics of GOA thornyheads to re-institute the age structured population dynamics model with adequate information.

## Ecosystem Effects on Stock and Fishery Effects on the Ecosystem: Summary

In the following table, we summarize ecosystem considerations for GOA thornyheads and the groundfish fisheries where they are caught: sablefish, rockfish, and flatfish. The observation column represents the best attempt to summarize the past, present, and foreseeable future trends. The interpretation column provides details on how ecosystem trends might affect the stock (ecosystem effects on the stock) or how the fishery trend affects the ecosystem (fishery effects on the ecosystem). The evaluation column indicates whether the trend is of: *no concern, probably no concern*, *possible concern, definite concern,* or *unknown.*

**Ecosystem effects on GOA Thornyheads** ***(evaluating level of concern for thornyhead populations)***

| Indicator | Observation | Interpretation | Evaluation |
|---|---|---|---|
| *Prey availability or abundance trends* | | | |
| Shrimp<br>Benthic invertebrates<br>Pelagic zooplankton | Trends are not currently measured directly Gulfwide. Shrimp biomass in isolated nearshore habitats may have declined since 1977, but it is unclear if all biomass declined, especially in deeper habitats occupied by thornyheads. Only short time series of food habits data exist for potential retrospective measurement | Unknown | Unknown |
| *Predator population trends* | | | |
| Arrowtooth flounder | Increasing since 1960's, leveling recently | Possibly higher mortality on thornheads, but still small relative to fishing mortality | Probably no concern |
| Toothed whales | Unknown population trend | Predation mortality is small relative to fishing mortality | Probably no concern |
| Sharks | Unknown population trend | Predation mortality is small relative to fishing mortality | Probably no concern |
| Shortspine thornyheads | Adults prey on juveniles, but population biomass is apparently stable | Stable mortality on juvenile thornyheads | No concern |
| Changes in habitat quality | | | |
| Benthic slope habitats | Physical habitat requirements for thornyheads are unknown, and changes in deepwater habitats have not been measured in the Gulf of Alaska. | Unknown | Unknown |

**"Thornyhead fishery" effects on the ecosystem *(evaluating level of concern for ecosystem)***

| Indicator | Observation | Interpretation | Evaluation |
|---|---|---|---|
| *Fishery contribution to bycatch* | | | |
| Sablefish fishery | GOA sablefish removes the highest weight of nontarget species bycatch of any GOA fishery, mostly grenadiers | Possible effects on grenadier populations, deep slope food webs | Possible concern |
| Rockfish fishery | Small bycatch of skates, grenadiers and other non-specified demersal fish | Catch of skates small relative to other fisheries | Probably no concern |
| Non-halibut flatfish fisheries | Small bycatch of skates, sculpins, and grenadiers, moderate bycatch of halibut | Catch of skates moderate relative to other fisheries | Probably no concern |
| Halibut fisheries | Bycatch unmonitored, high estimated bycatch of skates, moderate estimated bycatch of sharks, flatfish and rockfish | Catch of skates estimated high relative to all groundfish fisheries | Possible concern |
| *Fishery concentration in space and time* | Fisheries are widespread throughout the GOA, as are thornyheads | Unlikely impact | No concern |
| *Fishery effects on amount of large size target fish* | Poor length sampling of thornyheads from fisheries makes this difficult to evaluate | Unknown | Unknown |
| *Fishery contribution to discards and offal production* | High discard of grenadiers in sablefish fishery, lower offal production in all | Dead grenadiers affect energy flow? | Unknown |
| *Fishery effects on age-at-maturity and fecundity* | Lower thornyhead fecundity-at-length in 2005 than 1985 study could be methodology or real difference | Requires more investigation | Unknown |

# Summary

| **2006 GOA shortspine thornyheads** | |
|---|---|
| M | 0.03 |
| Tier | 5 |
| Biomass | 98,158 |
| F OFL | 0.03 |
| Max F ABC | 0.0225 |
| Recommened F ABC | 0.0225 |
| OFL | 2,945 |
| Max ABC | 2,209 |
| Recommened ABC | 2,209 |

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# Tables

Table 14-1. Estimated retained catch and discard of GOA thornyheads (tons) by gear type[1], 1967-2005.

| | Trawl gear | | | Longline gear | | | All gears combined | | |
|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Retained** | **Discarded** | **Total** | **Retained** | **Discarded** | **Total** | **Retained** | **Discarded** | **Total** |
| 1967 | 7 | - | 7 | 0 | - | 0 | 7 | - | 7 |
| 1968 | 56 | - | 56 | 6 | - | 6 | 62 | - | 62 |
| 1969 | 94 | - | 94 | 3 | - | 3 | 97 | - | 97 |
| 1970 | 48 | - | 48 | 6 | - | 6 | 53 | - | 53 |
| 1971 | 230 | - | 230 | 11 | - | 11 | 241 | - | 241 |
| 1972 | 202 | - | 202 | 14 | - | 14 | 216 | - | 216 |
| 1973 | 1,550 | - | 1,550 | 15 | - | 15 | 1,565 | - | 1,565 |
| 1974 | 1,529 | - | 1,529 | 8 | - | 8 | 1,537 | - | 1,537 |
| 1975 | 1,215 | - | 1,215 | 15 | - | 15 | 1,229 | - | 1,229 |
| 1976 | 1,189 | - | 1,189 | 124 | - | 124 | 1,313 | - | 1,313 |
| 1977 | 1,163 | - | 1,163 | 234 | - | 234 | 1,397 | - | 1,397 |
| 1978 | 442 | - | 442 | 344 | - | 344 | 786 | - | 786 |
| 1979 | 645 | - | 645 | 454 | - | 454 | 1,098 | - | 1,098 |
| 1980 | 1,158 | - | 1,158 | 327 | - | 327 | 1,485 | - | 1,485 |
| 1981 | 1,139 | - | 1,139 | 201 | - | 201 | 1,340 | - | 1,340 |
| 1982 | 669 | - | 669 | 118 | - | 118 | 787 | - | 787 |
| 1983 | 620 | - | 620 | 109 | - | 109 | 729 | - | 729 |
| 1984 | 177 | - | 177 | 31 | - | 31 | 208 | - | 208 |
| 1985 | 70 | - | 70 | 12 | - | 12 | 82 | - | 82 |
| 1986 | 607 | - | 607 | 107 | - | 107 | 714 | - | 714 |
| 1987 | 1,863 | - | 1,863 | 14 | - | 14 | 1,877 | - | 1,877 |
| 1988 | 2,132 | - | 2,132 | 49 | - | 49 | 2,181 | - | 2,181 |
| 1989 | 2,547 | - | 2,547 | 69 | - | 69 | 2,616 | - | 2,616 |
| 1990 | 1,233 | 38 | 1,271 | 284 | 20 | 304 | 1,518 | 58 | 1,576 |
| 1991 | 1,188 | 60 | 1,248 | 236 | 53 | 289 | 1,424 | 113 | 1,537 |
| 1992 | 1,041 | 129 | 1,169 | 532 | 375 | 907 | 1,573 | 504 | 2,077 |
| 1993 | 489 | 173 | 662 | 401 | 305 | 706 | 890 | 479 | 1,369 |
| 1994 | 488 | 222 | 710 | 305 | 295 | 600 | 793 | 516 | 1,310 |
| 1995 | 471 | 165 | 636 | 392 | 86 | 478 | 863 | 251 | 1,114 |
| 1996 | 435 | 170 | 605 | 424 | 101 | 525 | 860 | 272 | 1,131 |
| 1997 | 567 | 224 | 791 | 398 | 61 | 459 | 964 | 285 | 1,249 |
| 1998 | 470 | 113 | 583 | 508 | 57 | 565 | 978 | 171 | 1,148 |
| 1999 | 597 | 195 | 792 | 445 | 43 | 488 | 1,042 | 240 | 1,282 |
| 2000 | 557 | 92 | 649 | 580 | 78 | 658 | 1,137 | 170 | 1,308 |
| 2001 | 479 | 52 | 532 | 770 | 38 | 808 | 1,249 | 90 | 1,339 |
| 2002 | 500 | 90 | 590 | 501 | 47 | 548 | 1,001 | 137 | 1,138 |
| 2003 | 714 | 97 | 811 | 370 | 38 | 409 | 1,084 | 135 | 1,220 |
| 2004 | 414 | 61 | 476 | 367 | 30 | 397 | 781 | 91 | 872 |
| 2005* | | | | | | | | | 695* |

[1] Prior to 1990, retained catch was assumed to equal retained and discarded catch combined. Catches by gear type from 1981-1986 were estimated by apportioning 85% of the total catch to trawl and and 15% to longline gear. ***Source***: 1967-1980 based on estimates extracted from NMFS observer reports (e.g., Wall et al. l978) 1981-1989 based on PACFIN and NMFS observer data, 1990-2002 based on blended NMFS observer data and weekly processor reports, 2003-2005 from the NMFS Alaska Regional Office catch accounting system.

*The 2005 catch is incomplete, representing catch reported through October 4, 2005.

Table 14-2. Research catches of GOA thornyheads (tons), 1977-2005. (Sources: NMFS trawl survey database; Mike Sigler and Chris Lunsford personal communications.)

| Year | Domestic Longline Survey Catch | Trawl Survey Catch | Co-op Longline Survey Catch | Total research catch |
|---|---|---|---|---|
| 1977 | | 1 | | 1 |
| 1978 | | 1 | | 1 |
| 1979 | | 5 | 3 | 8 |
| 1980 | | 1 | 5 | 6 |
| 1981 | | 10 | 5 | 14 |
| 1982 | | 6 | 4 | 10 |
| 1983 | | 1 | 4 | 5 |
| 1984 | | 24 | 3 | 27 |
| 1985 | | 12 | 4 | 16 |
| 1986 | | 2 | 4 | 5 |
| 1987 | | 17 | 4 | 20 |
| 1988 | 2 | 0 | 5 | 7 |
| 1989 | 3 | 0 | 5 | 8 |
| 1990 | 3 | 4 | 4 | 11 |
| 1991 | 4 | | 3 | 7 |
| 1992 | 5 | | 4 | 9 |
| 1993 | 5 | 5 | 4 | 14 |
| 1994 | 4 | | 5 | 9 |
| 1995 | 5 | | | 5 |
| 1996 | 6 | 6 | | 12 |
| 1997 | 6 | | | 6 |
| 1998 | 6 | 9 | | 15 |
| 1999 | 6 | 23 | | 29 |
| 2000 | 5 | | | 5 |
| 2001 | 7 | 2 | | 9 |
| 2002 | 5 | | | 5 |
| 2003 | 6 | 7 | | 13 |
| 2004 | 5 | | | 5 |
| 2005 | 6 | 9 | | 14 |

Table 14-3. Comparison of recent Allowable Biological Catch (ABC), Total Allowable Catch (TAC), and actual catch for GOA thornyheads (tons). Changes in ABC and TAC allocation over time are indicated, where Gulfwide means TAC was not allocated by area within the GOA, and Split W/C/E means that TAC was allocated proportional to biomass in the Western, Central, and Eastern GOA management areas
.

| Year | ABC | TAC | Total Catch | ABC/TAC Allocation |
|---|---|---|---|---|
| 1992 | 1,798 | 1,798 | 2,077 | Gulfwide |
| 1993 | 1,062 | 1,062 | 1,369 | Gulfwide |
| 1994 | 1,180 | 1,180 | 1,310 | Gulfwide |
| 1995 | 1,900 | 1,900 | 1,114 | Gulfwide |
| 1996 | 1,560 | 1,248 | 1,131 | Gulfwide |
| 1997 | 1,700 | 1,700 | 1,249 | Gulfwide |
| 1998 | 2,000 | 2,000 | 1,148 | Split W/C/E |
| 1999 | 1,990 | 1,990 | 1,282 | Split W/C/E |
| 2000 | 2,360 | 2,360 | 1,308 | Split W/C/E |
| 2001 | 2,310 | 2,310 | 1,339 | Split W/C/E |
| 2002 | 1,990 | 1,990 | 1,138 | Split W/C/E |
| 2003 | 2,000 | 2,000 | 1,220 | Split W/C/E |
| 2004 | 1,940 | 1,940 | 872 | Split W/C/E |
| 2005 | 1,940 | 1,940 | 695* | Split W/C/E |

source: AKRO website catch statistics for each year, final harvest specifications
*2005 catch estimate is reported catch as of October 4, 2005

Table 14-4. Relative population number (RPN) and weight (RPW) for GOA thornyheads from the domestic longline survey 1990-2005 (Chris Lunsford, NMFS Auke Bay Lab, pers. comm.).

| Year | RPN | RPW |
|---|---|---|
| 1990 | 37,531 | 20,667 |
| 1991 | 48,841 | 23,324 |
| 1992 | 63,722 | 32,068 |
| 1993 | 56,788 | 28,448 |
| 1994 | 43,168 | 25,294 |
| 1995 | 52,933 | 26,323 |
| 1996 | 60,135 | 32,217 |
| 1997 | 56,357 | 29,420 |
| 1998 | 56,098 | 31,045 |
| 1999 | 61,950 | 33,810 |
| 2000 | 54,632 | 28,657 |
| 2001 | 82,143 | 43,719 |
| 2002 | 72,016 | 38,004 |
| 2003 | 65,048 | 34,239 |
| 2004 | 48,923 | 24,557 |
| 2005 | 63,530 | 32,013 |

Table 14-5. Biomass estimates (with cv) for GOA thornyheads from the NMFS trawl survey 1984-2005, with comments on survey coverage.

| Species/ Year | Biomass (tons) | CV Biomass | Survey coverage |
|---|---|---|---|
| **Shortspine Thornyhead, Sebastolobus alascanus** | | | |
| 1984 | 57,545 | 0.06 | full GOA, all depths |
| 1987 | 53,358 | 0.10 | full GOA, all depths |
| 1990 | 19,616 | 0.11 | full GOA, <500 m |
| 1993 | 33,014 | 0.08 | full GOA, <500 m |
| 1996 | 51,984 | 0.07 | full GOA, <500 m |
| 1999 | 77,336 | 0.05 | full GOA, all depths |
| 2001 | 28,661 | 0.08 | W/C GOA, <500 m |
| 2003 | 101,576 | 0.08 | full GOA, all depths |
| 2005 | 94,740 | 0.04 | full GOA, all depths |
| **Longspine Thornyhead, Sebastolobus altivelis** | | | |
| 1984 | 0 | | full GOA, all depths |
| 1987 | 48 | 1.00 | full GOA, all depths |
| 1990 | 0 | | full GOA, <500 m |
| 1993 | 0 | | full GOA, <500 m |
| 1996 | 0 | | full GOA, <500 m |
| 1999 | 4,602 | 0.11 | full GOA, all depths |
| 2001 | 0 | | W/C GOA, <500 m |
| 2003 | 1,394 | 0.11 | full GOA, all depths |
| 2005 | 3,526 | 0.14 | full GOA, all depths |

Table 14-6. Range of empirical estimates of natural mortality (M) for GOA shortspine thornyheads. This assessment uses the M from Gaichas and Ianelli 2003, M = 0.03, while other assessments use M = 0.05.

| Estimate | Source |
|---|---|
| 0.013 | Pearson and Gunderson 2003 |
| 0.027 | Kline 1996 |
| 0.036 | Jacobsen 1990 |
| 0.038 | Pearson and Gunderson 2003 |
| 0.07 | Miller 1985 |

Table 14-7. Nontarget species bycatch rates in GOA fisheries catching thornyheads. Bycatch rates are averaged over 1997-2002, and are presented along with average catch of the target species in each fishery. The right hand column represents the sum across fisheries to evaluate the average annual "thornyhead fishery" contribution to total GOA nontarget bycatch, which averaged 20,897 tons between 1997 and 2002. Please note that the relative rate columns do not add to the percent of total nontarget catch column.

| | **Fishery with thornyhead catch** | | | Combined fisheries |
|---|---|---|---|---|
| | **Sablefish** | **Rockfish** | **Flatfish** | percent of annual |
| 6 yr avg catch 97-02 | 13,160 | 21,226 | 30,933 | nontarget catch |
| **Nontarget group** | relative rate | relative rate | relative rate | 20,897 |
| sculpin | 0% | 0% | 1% | 1% |
| skates | 5% | 1% | 2% | 7% |
| shark | 2% | 0% | 0% | 1% |
| salmonshk | 0% | 0% | 0% | 0% |
| dogfish | 1% | 0% | 0% | 1% |
| sleepershk | 0% | 0% | 0% | 0% |
| octopus | 0% | 0% | 0% | 0% |
| squid | 0% | 0% | 0% | 0% |
| smelts | 0% | 0% | 0% | 0% |
| gunnel | 0% | 0% | 0% | 0% |
| sandfish | 0% | 0% | 0% | 0% |
| sticheidae | 0% | 0% | 0% | 0% |
| lanternfish | 0% | 0% | 0% | 0% |
| sandlance | 0% | 0% | 0% | 0% |
| grenadier | 82% | 1% | 1% | 55% |
| otherfish | 11% | 1% | 0% | 9% |
| crabs | 0% | 0% | 0% | 0% |
| starfish | 1% | 0% | 0% | 1% |
| jellyfish | 0% | 0% | 0% | 0% |
| invertunid | 0% | 0% | 0% | 0% |
| seapen/whip | 0% | 0% | 0% | 0% |
| sponge | 0% | 0% | 0% | 0% |
| anemone | 0% | 0% | 0% | 0% |
| tunicate | 0% | 0% | 0% | 0% |
| benthinv | 0% | 0% | 0% | 0% |
| echinoderm | 0% | 0% | 0% | 0% |
| coral | 0% | 0% | 0% | 0% |
| shrimp | 0% | 0% | 0% | 0% |
| birds | 0% | 0% | 0% | 0% |

# Figures

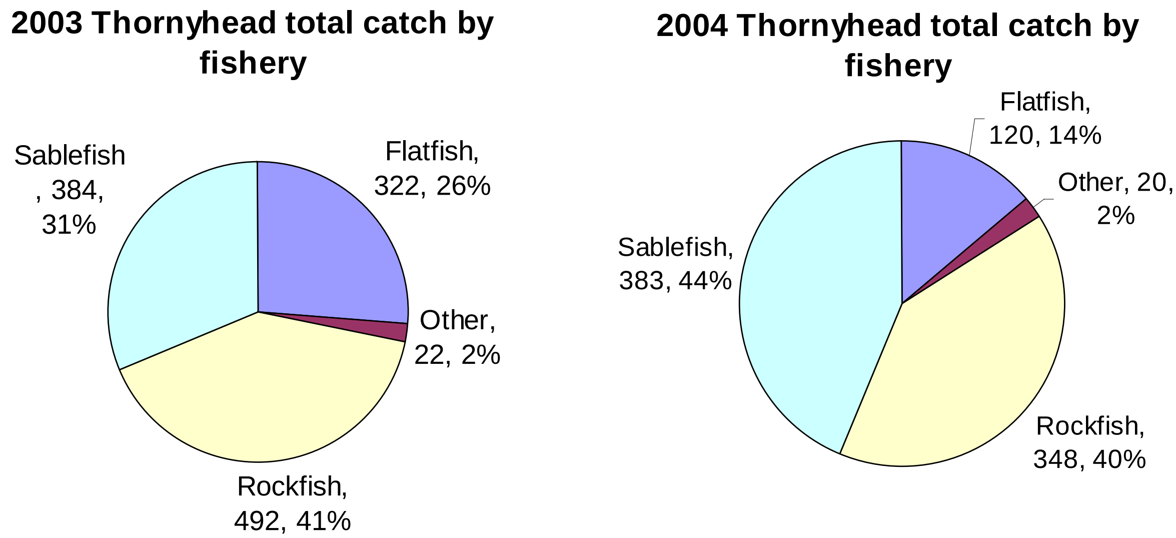


Figure 14.1 Distributions of total catches of GOA thornyheads by target fishery for 2003 and 2004. Fisheries are labeled with target, tons of thornyheads caught, and percentage of total thornyhead catch for the year.

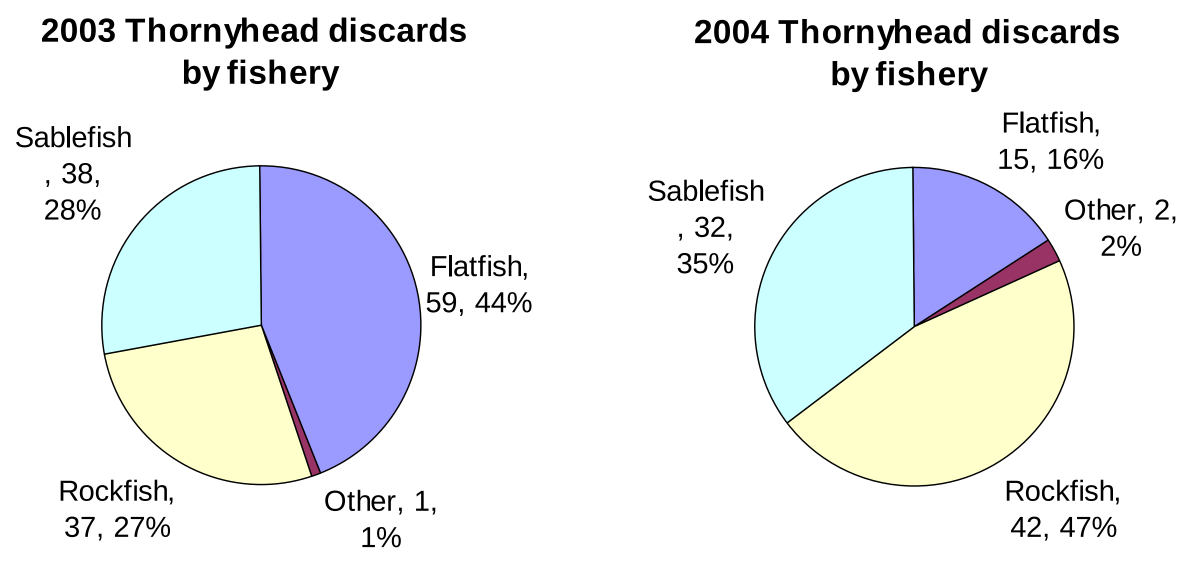


Figure 14.2 Distributions of discarded catches of GOA thornyheads by target fishery for 2003 and 2004. Fisheries are labeled with target, tons of thornyheads discarded, and percentage of total thornyhead discard for the year.

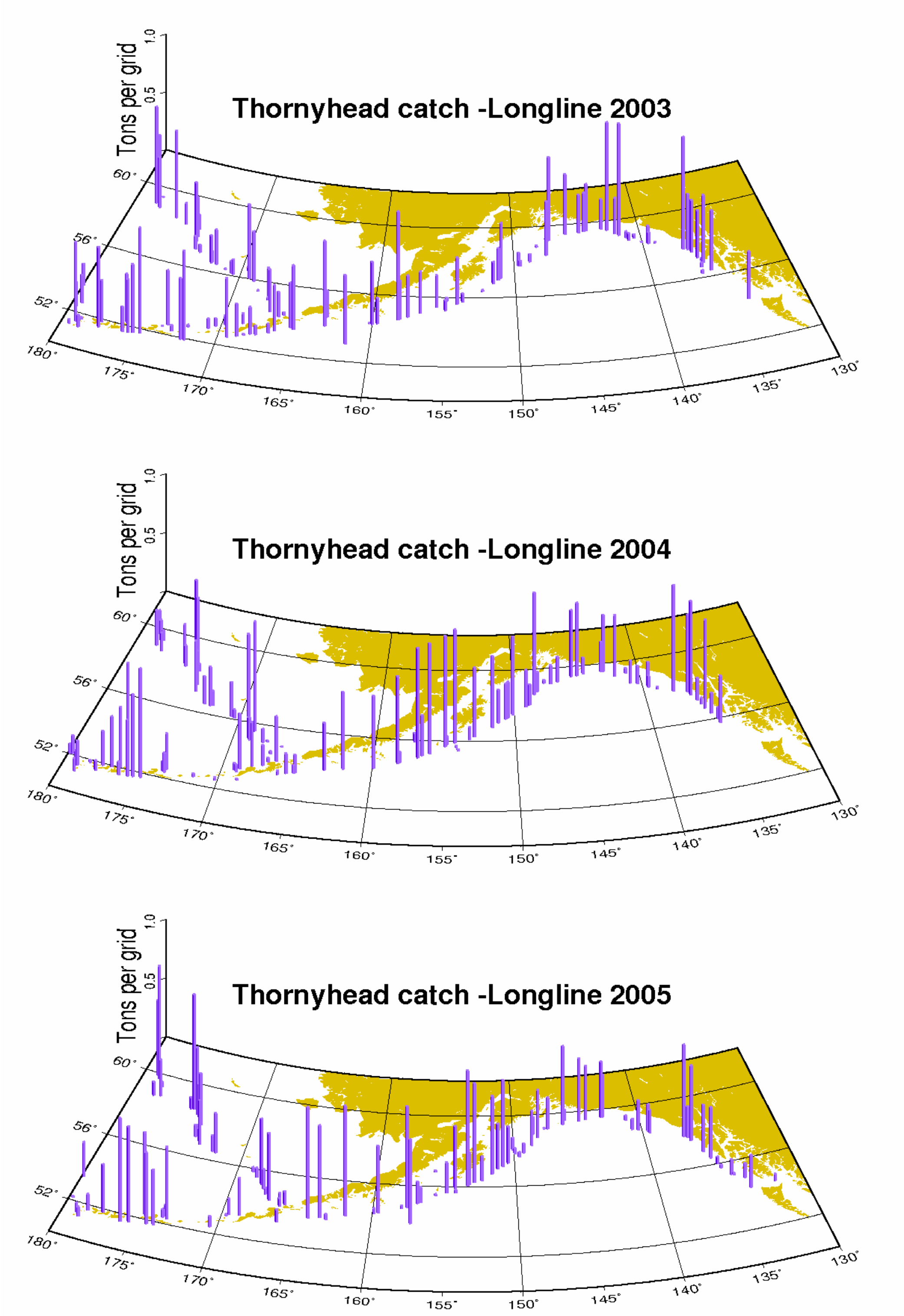


Figure 14.3 Distribution of observed thornyhead catch in longline gear, 2003-2005.

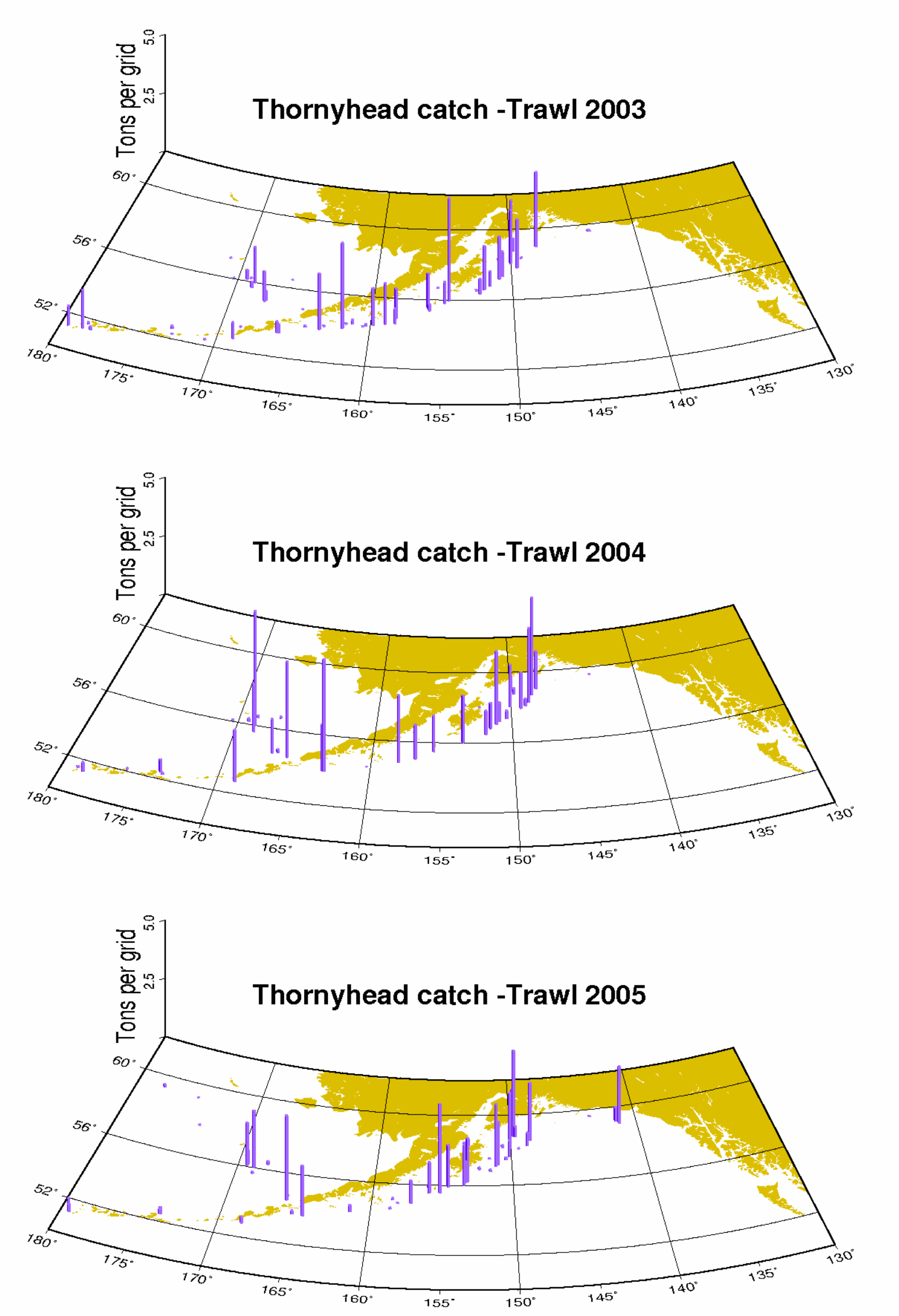


Figure 14.4 Distribution of observed thornyhead catch in trawl gear, 2003-2005.

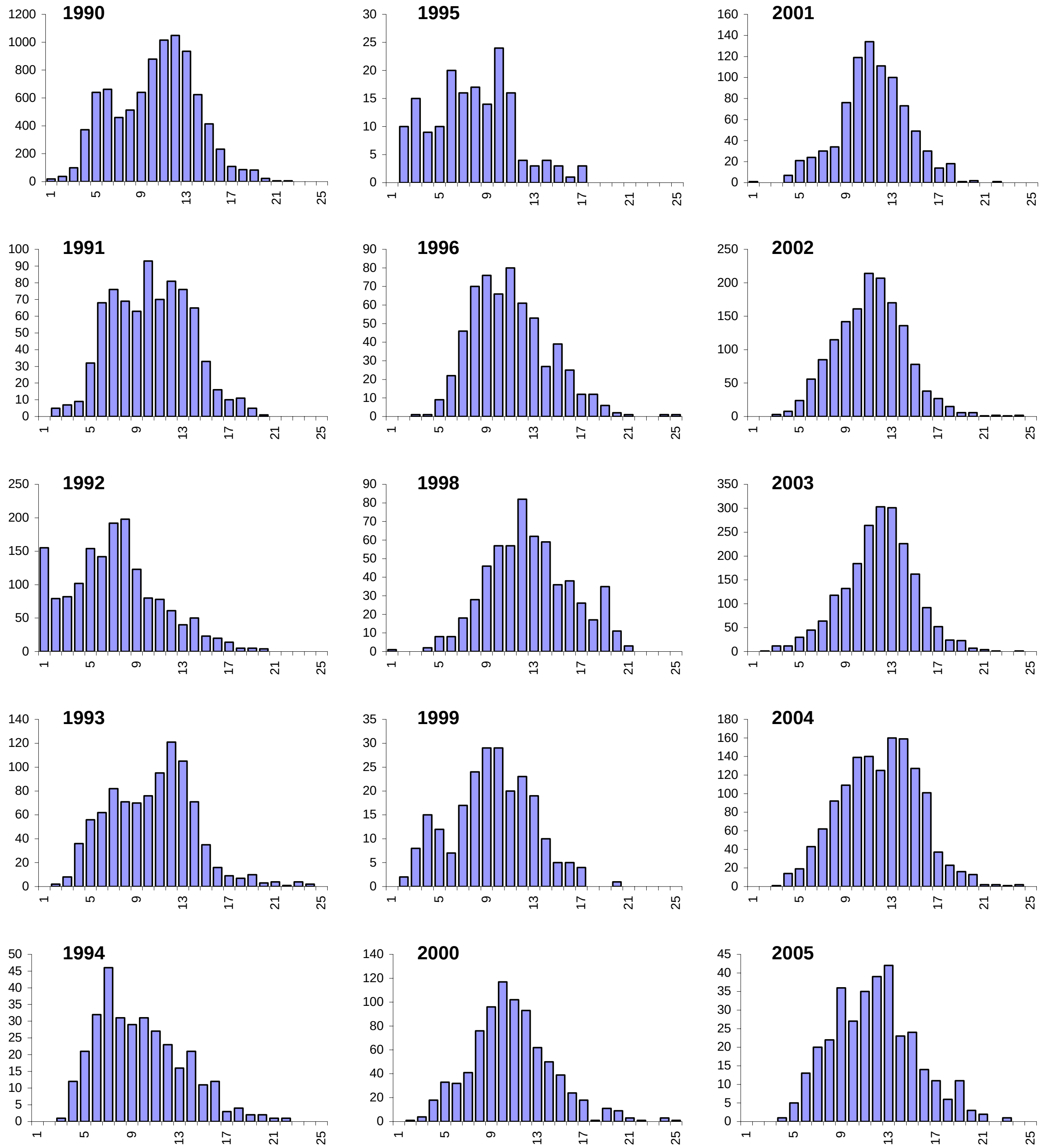


Figure 14-5. Shortspine thornyhead lengths measured in trawl fisheries, 1990-2005. Length bins on x axes are assigned as follows: bin 1, 1-9 cm fish;, bins 2-18, 10 to 47 cm fish (2 cm per bin); bins 19-24, 48 to 67 cm fish (4 cm per bin), and bin 25 spans 68 to 100 cm.

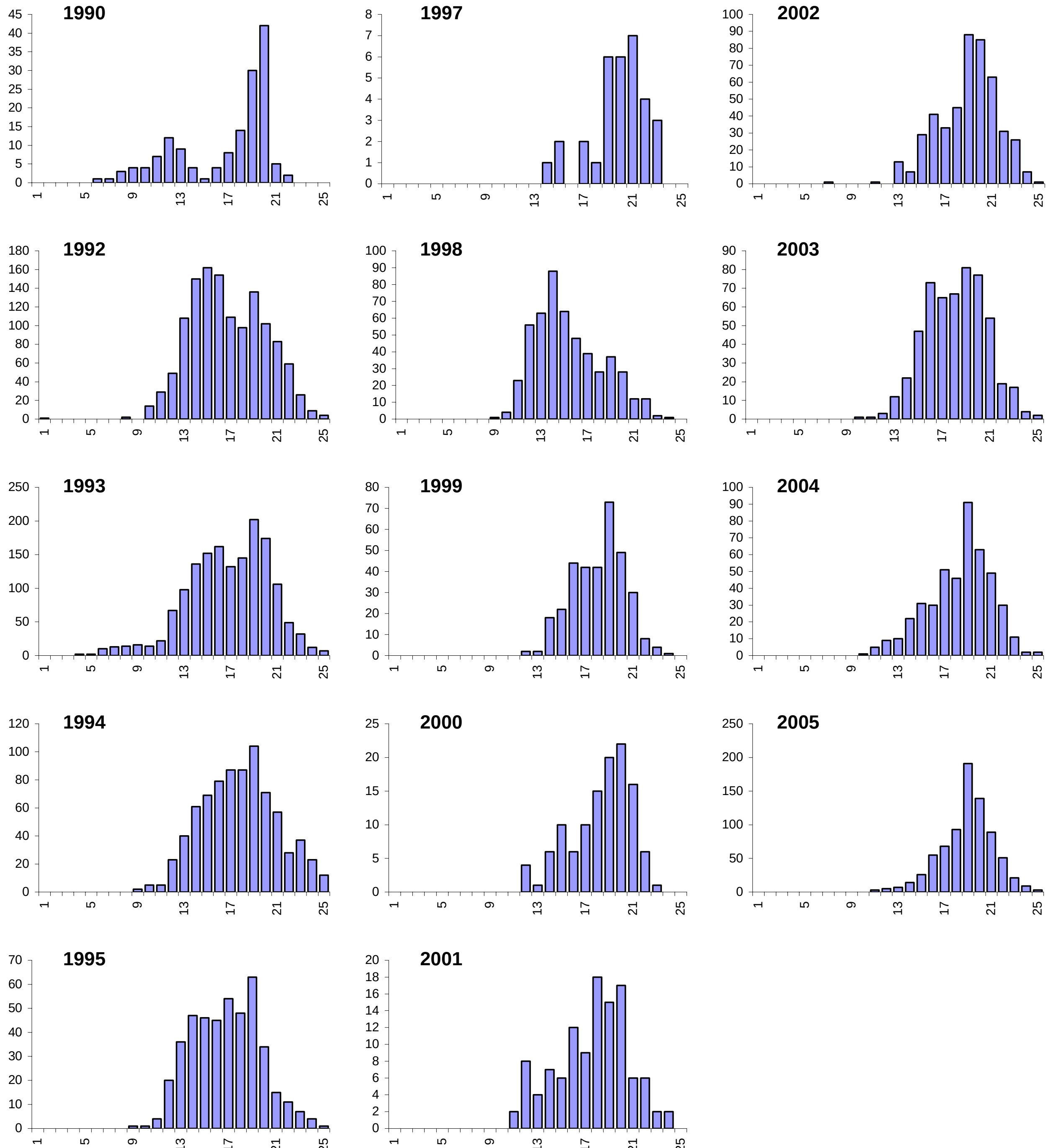


Figure 14-6. Shortspine thornyhead lengths measured in longline fisheries, 1990-2005. Length bins on x axes are assigned as follows: bin 1, 1-9 cm fish;, bins 2-18, 10 to 47 cm fish (2 cm per bin); bins 19-24, 48 to 67 cm fish (4 cm per bin), and bin 25 spans 68 to 100 cm.

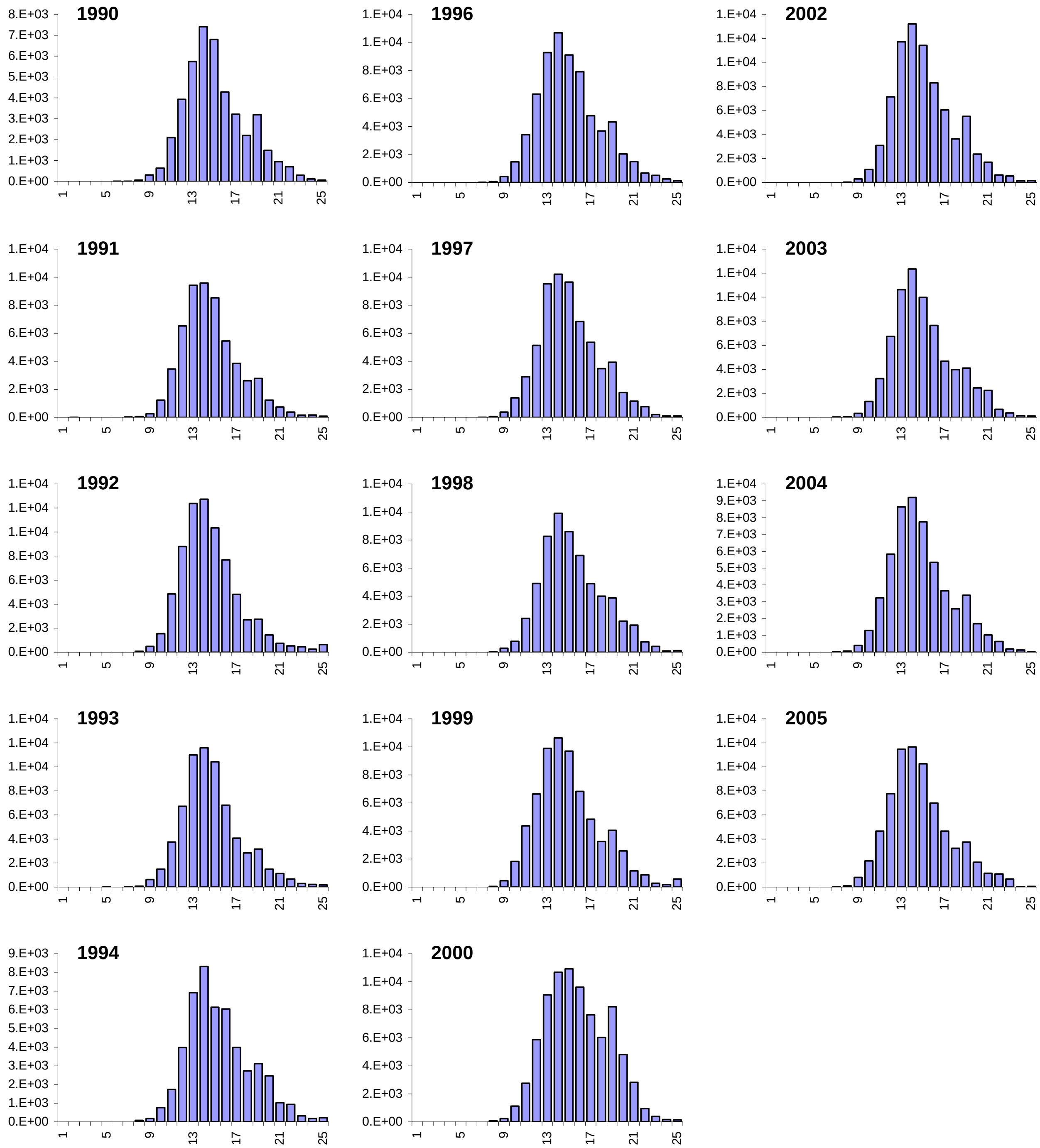


Figure 14.7. Shortspine thornyhead length frequencies from longline surveys, 1990-2005. Length bins on x axes are assigned as follows: bin 1, 1-9 cm fish;, bins 2-18, 10 to 47 cm fish (2 cm per bin); bins 19-24, 48 to 67 cm fish (4 cm per bin), and bin 25 spans 68 to 100 cm.

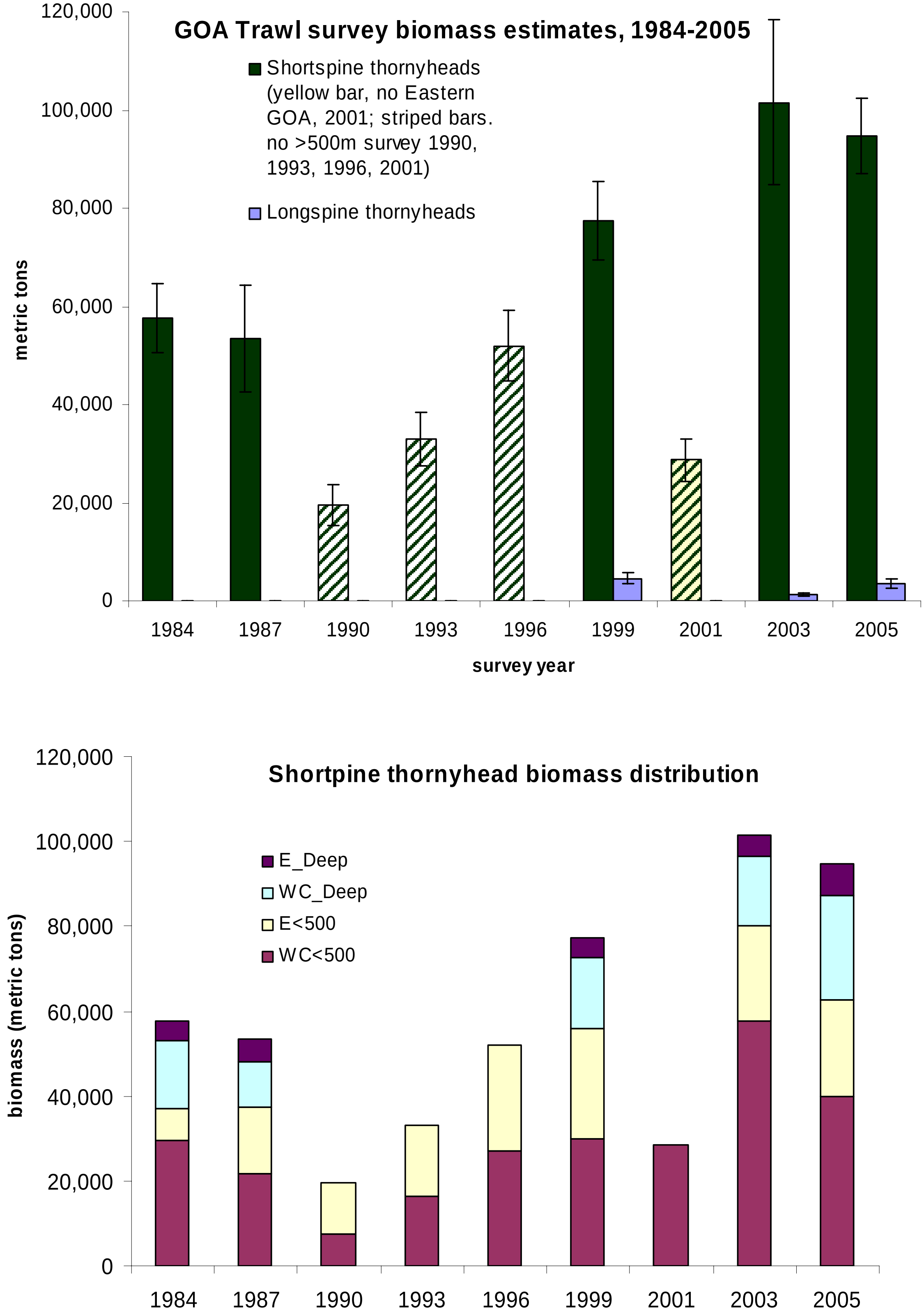


Figure 14.8. Trawl survey biomass estimates for thornyheads (upper) and shortspine thornyheads (lower).

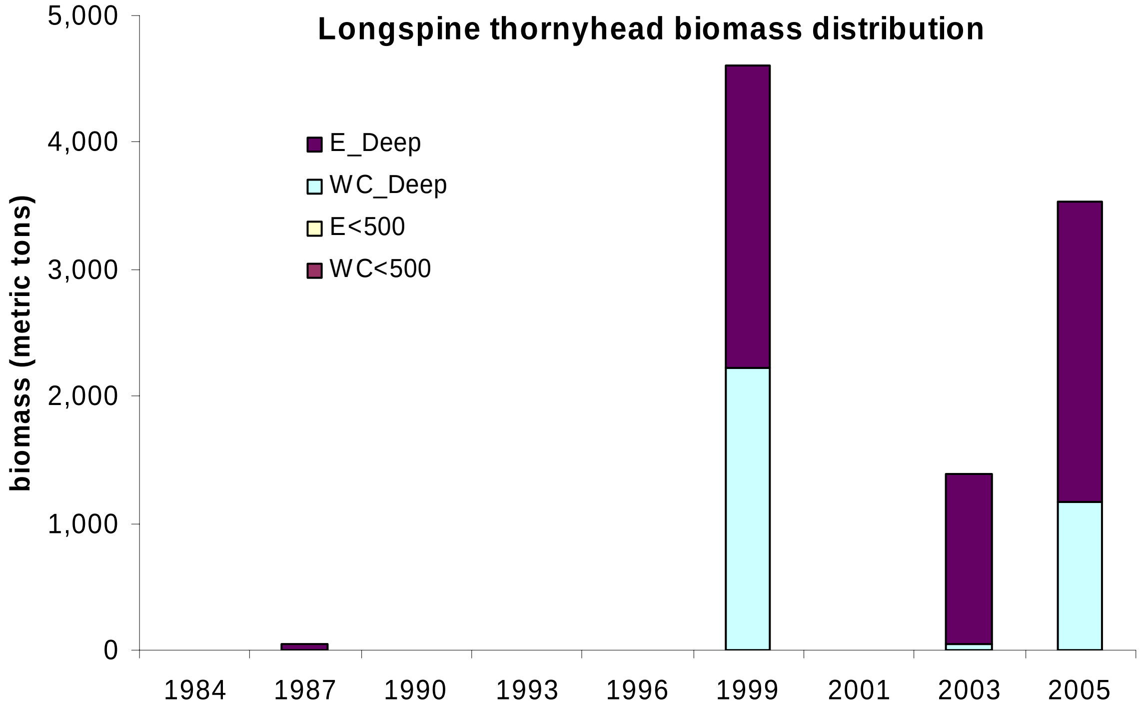


Figure 14.9. Trawl survey biomass estimates for longspine thornyheads, which are only encountered in depths greater than 500m in the GOA, and are more common in the Eastern GOA (areas 640 and 650) than in the Western and Central GOA.

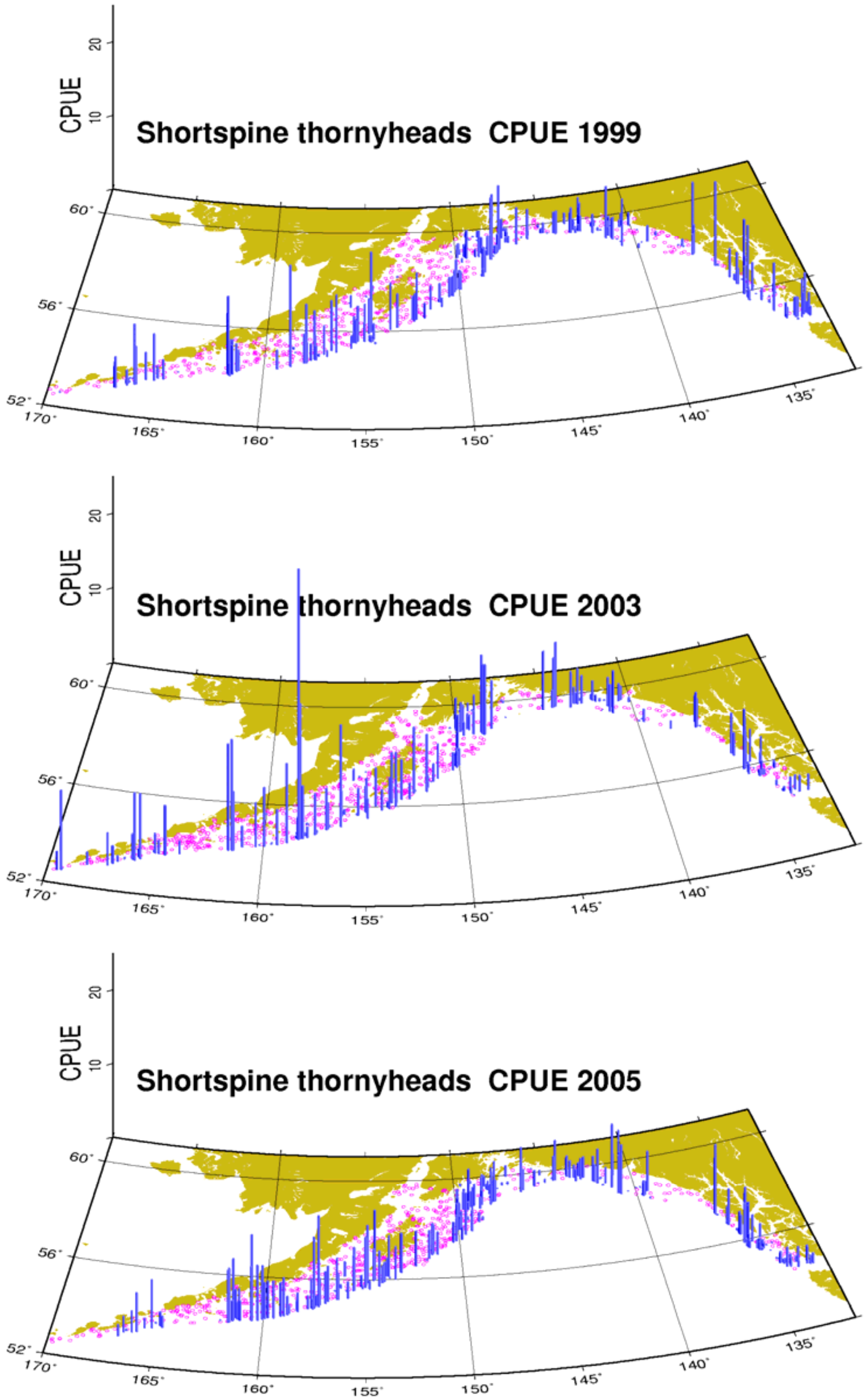


Figure 14.10. Shortspine thornyhead CPUE distributions for the most recent complete GOA trawl surveys in 1999, 2003, and 2005.

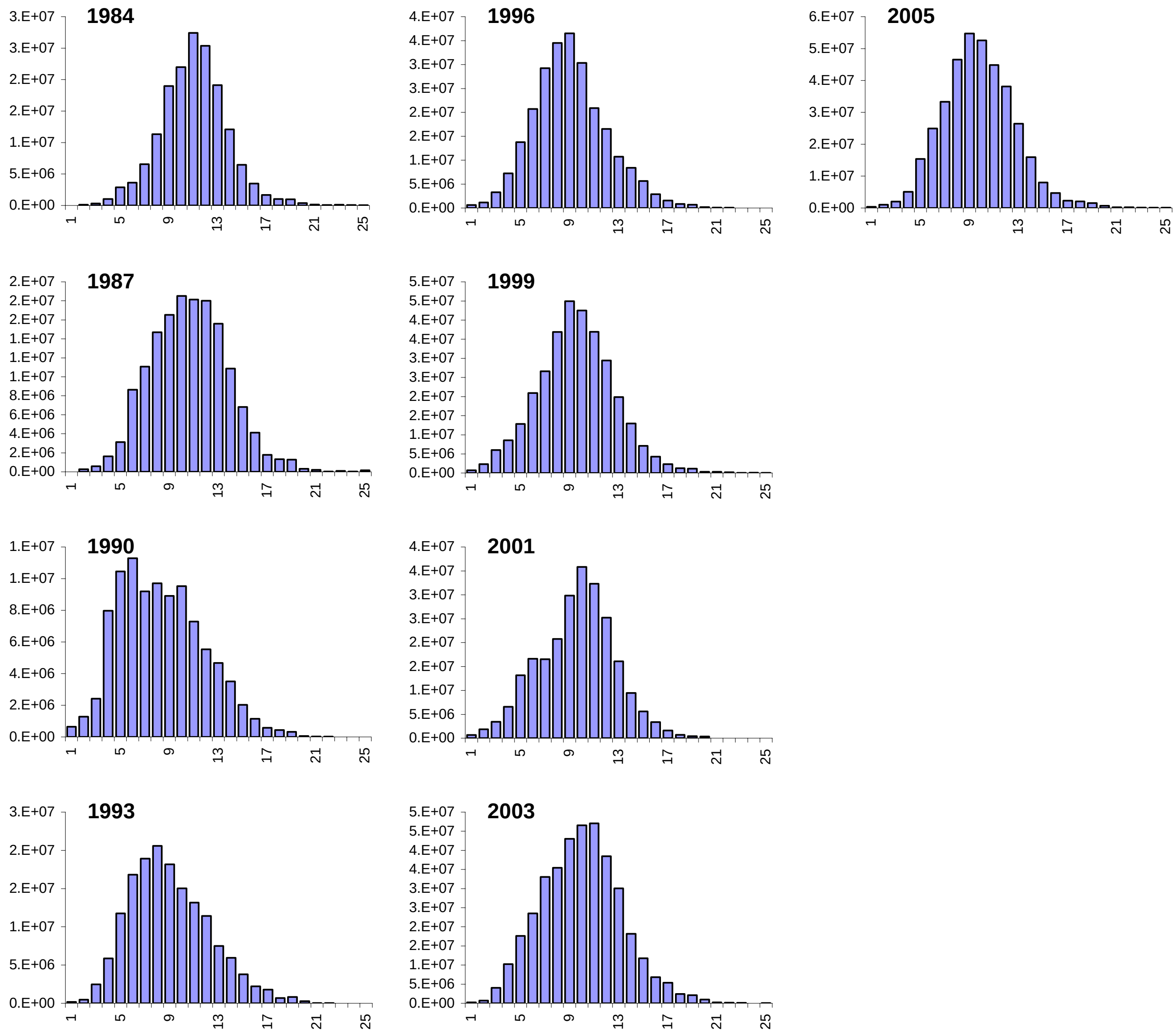


Figure 14.11. Shortspine thornyhead length frequencies from trawl surveys, 1984-2005. Length bins on x axes are assigned as follows: bin 1, 1-9 cm fish;, bins 2-18, 10 to 47 cm fish (2 cm per bin); bins 19-24, 48 to 67 cm fish (4 cm per bin), and bin 25 spans 68 to 100 cm.

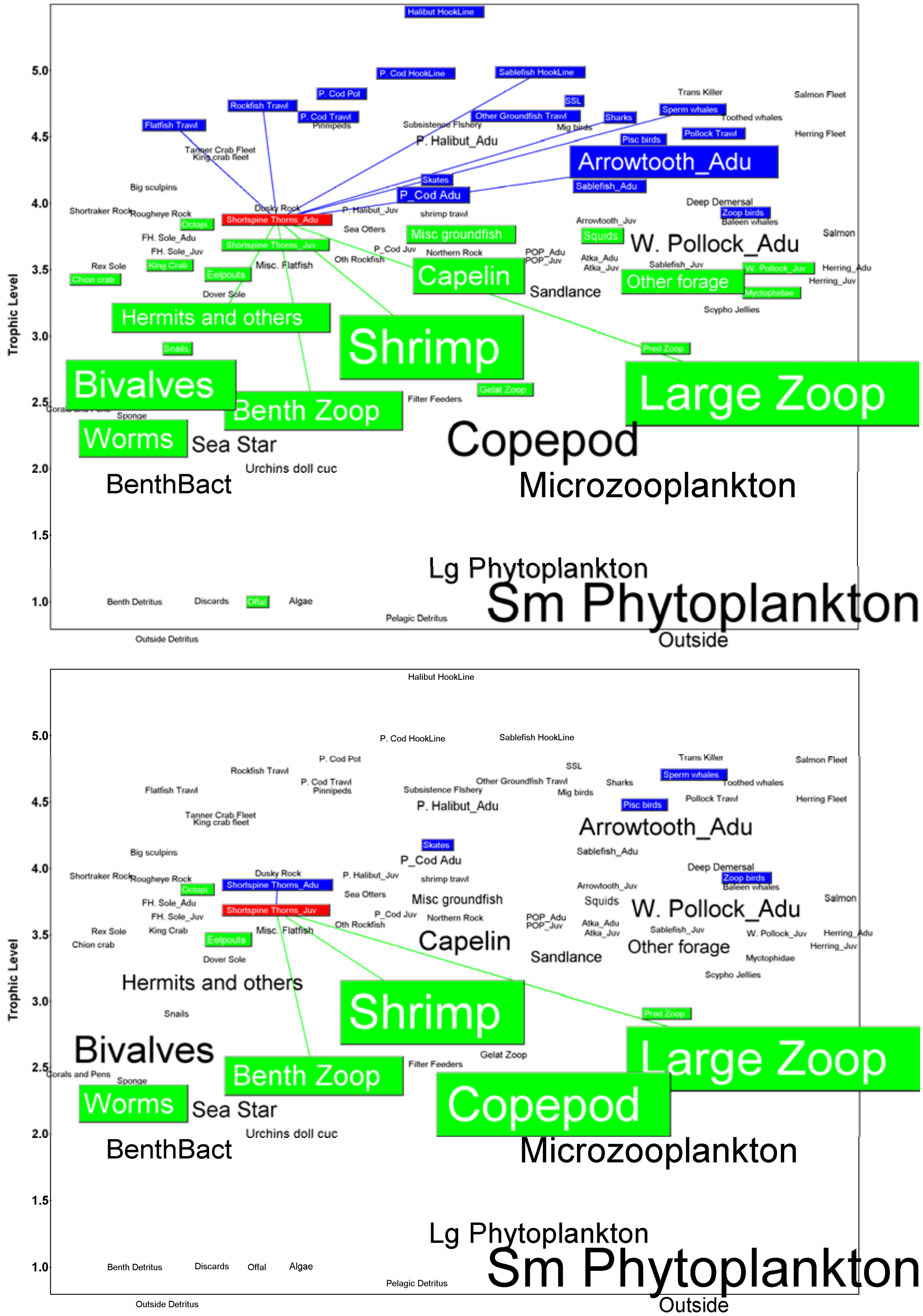


Figure 14.12 Position of shortspine thornyheads within GOA food webs: adults (marked red in upper panel) and juveniles (marked red in lower panel). Groups shaded blue are predators of shortspine thornyheads, and groups shaded green are prey. Similar information for longspine thornyheads is not available.

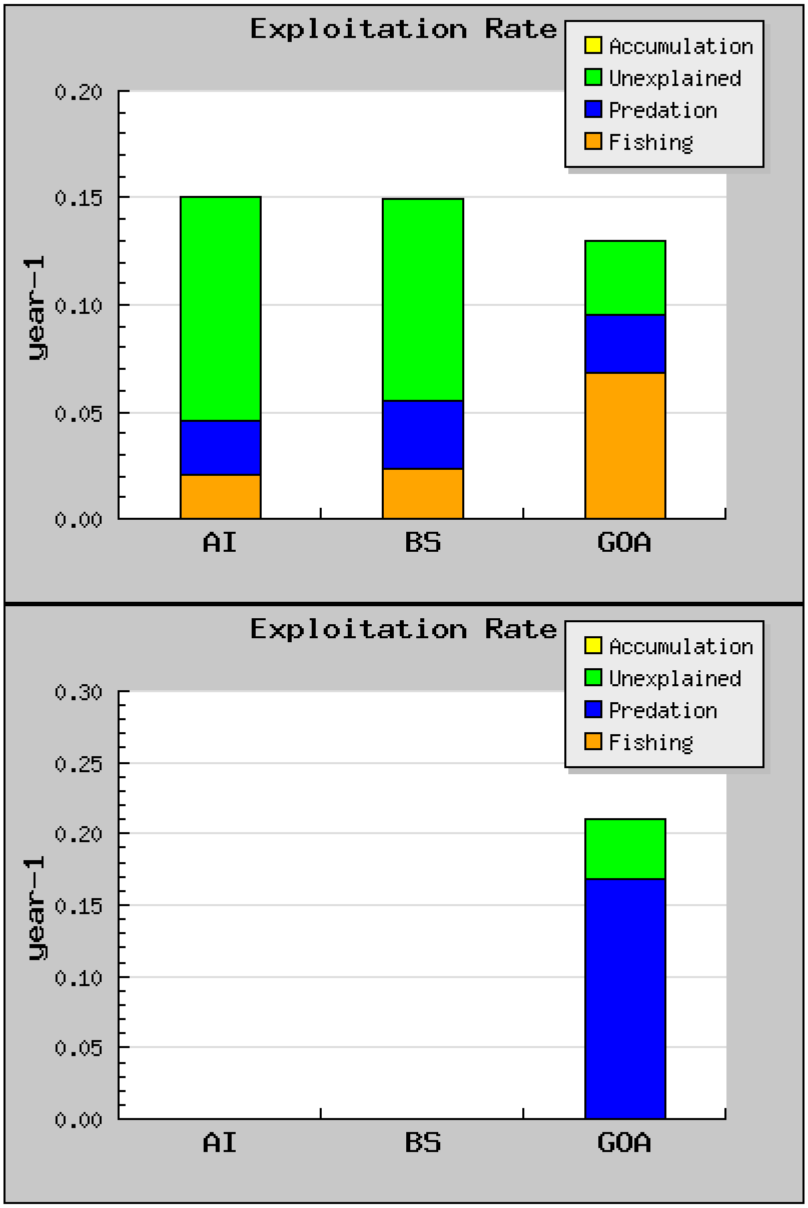


Figure 14.13 Comparison of exploitation rates for shortspine thornyheads across Alaskan ecosystems. Adult shortspine thornyheads (upper panel) have higher predation than fishing mortality in the AI and EBS, but higher fishing mortality in the GOA. Juvenile shortspine thornyheads (lower panel) were only modeled in the GOA, where they do not experience fishing mortality but do experience substantial predation mortality. Because juvenile thornyheads were not explicitly modeled in AI and EBS ecosystem models, juvenile mortality is included along with adult mortality in the top panel for AI and EBS, which exaggerates the differences between predation and fishing mortality between the two systems.

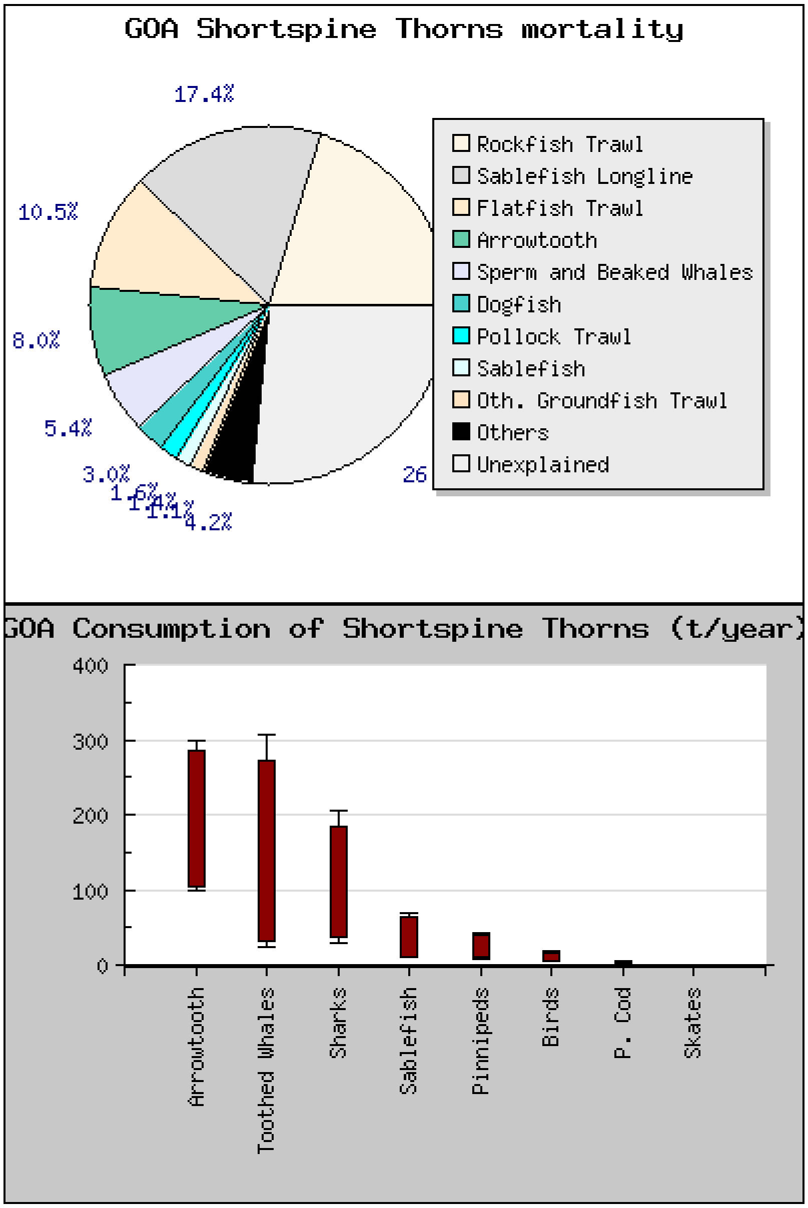


Figure 14-14 Mortality sources (upper panel) and annual consumption in tons (lower panel) by predators of adult shortspine thornyheads in the GOA. Fisheries for rockfish, sablefish, and flatfish account for nearly 50% of total adult shortspine thornyhead mortality, while all predators combined account for about 25% of total mortality.

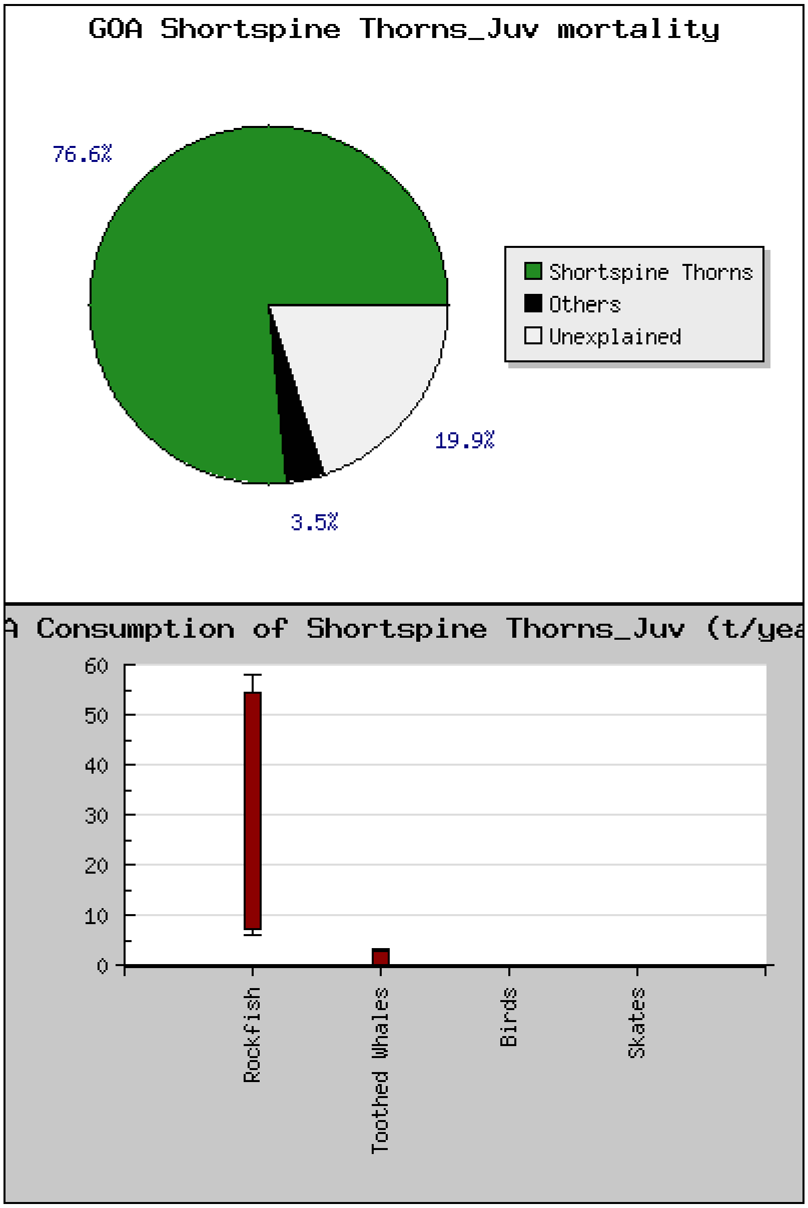


Figure 14.15 Mortality sources (upper panel) and annual consumption in tons (lower panel) by predators of juvenile shortspine thornyheads in the GOA. “Rockfish” in the lower panel refers to adult thornyheads, which account for more than 75% of juvenile thornyhead mortality via cannibalism.

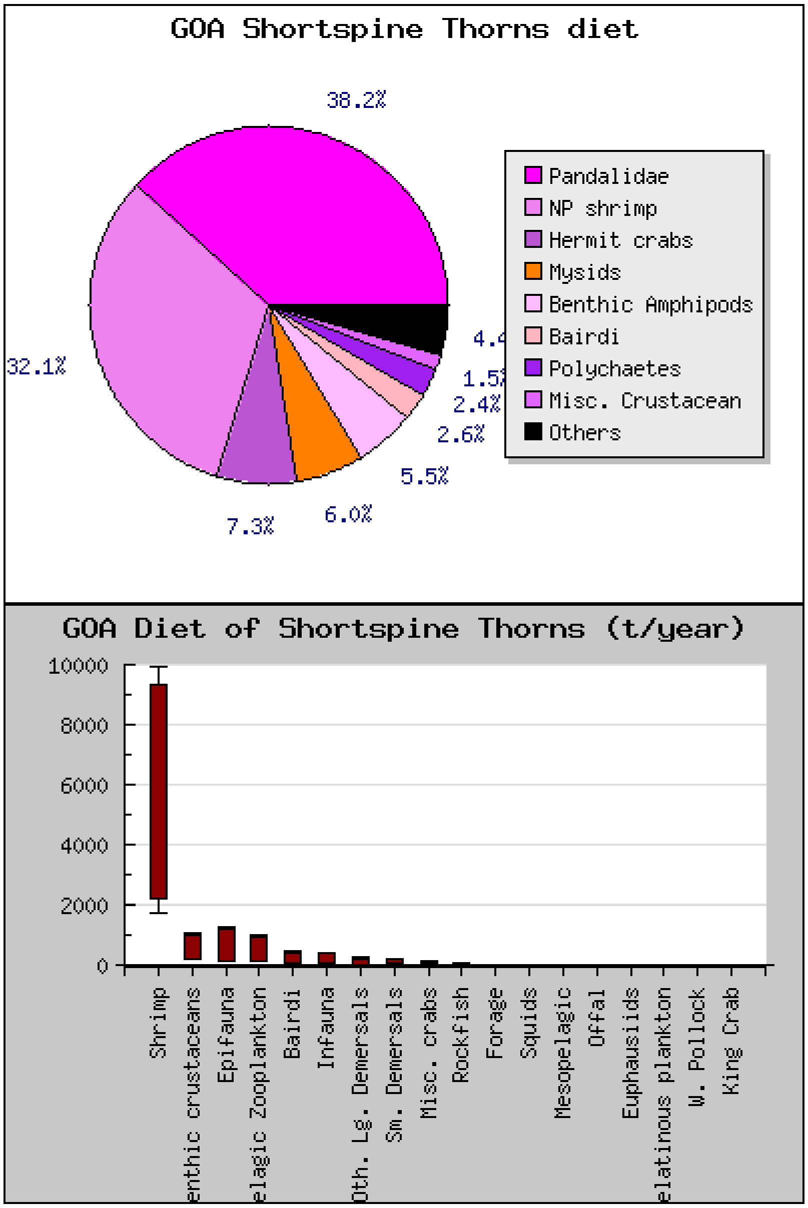


Figure 14.16 Diet composition (upper panel) and annual consumption of prey in tons (lower panel) by adult shortspine thornyheads in the GOA.

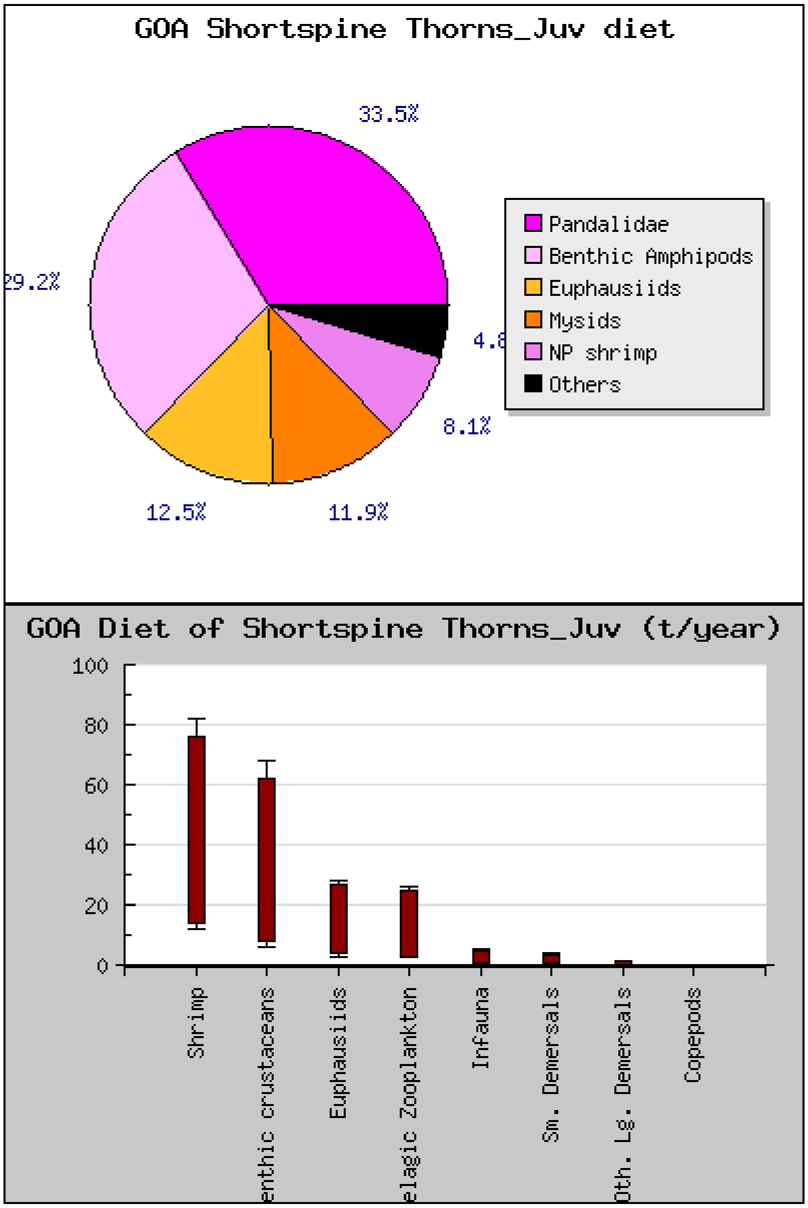


Figure 14.17 Diet composition (upper panel) and annual consumption of prey in tons (lower panel) by juvenile shortspine thornyheads in the GOA.