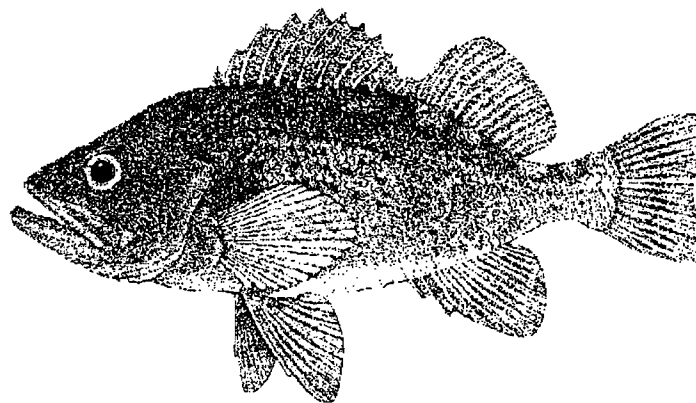


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ROCKFISH ASSESSMENT IN PRINCE WILLIAM SOUND, ALASKA



By
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ABSTRACT

I provide a general description of rockfish (genera *Sebastes* and *Sebastolobus*) life histories, including examples of natural mortality and longevity. Size, age, and growth data from rockfish caught in commercial fisheries and surveys of the Inside District of the Prince William Sound Management Area are used as examples of rockfish in species assemblages from this area. Pelagic shelf rockfish, which comprised 10% of commercial landings and were taken primarily by jig gear, are represented by black rockfish *Sebastes melanops*. Demersal shelf rockfish, which comprised 21% of commercial harvests and were taken primarily by jig and longline gears, are represented by yelloweye rockfish *S. ruberrimus* and quillback rockfish *S. maliger*. Rougheye rockfish *S. aleutianus*, shortraker rockfish *S. borealis*, and shortspine thornyhead *Sebastolobus alascanus* represented slope rockfish, which comprised 69% of commercial harvests. Although representing the largest component of the harvests, most slope rockfish are taken as bycatch incidental to longline fisheries targeting Pacific halibut and sablefish and a bottom trawl fishery for pandalid shrimp. The amount and type of biological data available for individual species was quite variable as a result of opportunistic sampling. In general, rockfish ages among species extended from < 10 to >130 years. Typical habitat distributions of species assemblages, and efficiencies of different gears within various habitats, are suggested as causal factors for differences in rockfish catches between commercial and recreational harvests and between different gears fished within the management area. Rockfish characteristics of late maturity, extended longevity, and low natural mortality require a conservative approach to fisheries management. The Prince William Sound Rockfish Management Plan was adopted in 1992 as a mechanism to address increasing rockfish harvests in the absence of fishery information and management guidelines. As additional information becomes available, changes to the management plan may be appropriate. Considerations for future management strategies are discussed.

KEY WORDS: Rockfish, *Sebastes*, *Sebastolobus*, life history Prince William Sound

INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) has management responsibility for groundfish resources in the territorial seas (0-3 miles from shore) off the coast of Alaska. Effort and harvest in these fisheries has increased in the last decade as traditional fisheries, such as salmon and crab, have experienced biological or economic declines (Bechtol 1995; Trowbridge 1996). Due to lack of extensive groundfish research or management programs in territorial waters of the Central Region, the ADF&G, with some exceptions, has adopted the same inseason management actions announced by the National Marine Fisheries Service (NMFS) for adjacent federal waters of the Exclusive Economic Zone (EEZ). Specifically, federal openings and closures have been simultaneously implemented in nearshore state waters. However, given area-specific stock characteristics, federal management strategies may be inappropriate for some species, notably nearshore rockfish inhabiting territorial seas. To address concerns about rapid increases in annual commercial harvests of Central Region rockfish resources, the Alaska Board of Fisheries adopted a rockfish management plan for the Prince William Sound Management Area (PWS) in 1992 (Bechtol 1992). Plan components, listed under 5 AAC 28.265, included guideline harvest levels (GHL), trip limits, and a provision to implement bycatch-only retention for rockfish.

To ensure long-term, sustainable yield, stock management needs to be appropriate for both the resource and the fisheries harvesting the resource. This report summarizes information on nearshore rockfish, with an emphasis on assessment data compiled by the ADF&G Division of Commercial Fisheries program within PWS. Specifically, this report describes:

- (1) a generalized review of rockfish life history;
- (2) rockfish habitat within the management area; and
- (3) size and age data on commercially important rockfish sampled from PWS.

GENERAL BIOLOGY AND DISTRIBUTION

Rockfish include fishes of the genera *Sebastes* and *Sebastolobus* (Eschmeyer et al. 1984; Kramer and O'Connell 1995). In some areas of the Pacific coast, rockfish management is based on species assemblages (Phillips 1994) defined by characteristic habitats and the prevalence of co-occurring species (Table 1; Figure 1). These habitats to some extent determine which fisheries harvest particular assemblages.

Pelagic shelf rockfish, defined in regulation 5 AAC 39.975(37), (e.g., black rockfish) are typically associated with nearshore, rocky reef areas in territorial seas and are harvested primarily in directed fisheries, often with mechanical and hand jigs. In some waters of the EEZ, pelagic shelf species, such as dusky rockfish, exhibit a midwater, schooling behavior and can be taken by trawl gear (Clausen and Heifetz 1998).

Demersal shelf rockfish, defined in regulation 5 AAC 39.975(34) (e.g., yelloweye and quillback rockfishes) are also typically associated with rocky, reef areas, but tend to be bottom-dwelling and occur at greater depths than pelagic shelf species (O'Connell and Carlile 1993). Demersal shelf species are distributed beyond territorial seas, and harvests occur in both directed and incidental fisheries (O'Connell et al. 1998). Demersal shelf rockfish may be taken in trawls, but are more commonly harvested with jig fisheries targeting rockfish or lingcod (*Ophiodon elongatus*), or longline fisheries targeting rockfish, Pacific halibut (*Hippoglossus stenolepis*), or Pacific cod (*Gadus macrocephalis*).

Slope rockfish (e.g., rougheye and shortraker rockfishes) are defined in regulation 5 AAC 39.975(38) as any species of *Sebastes* not specified as either demersal shelf rockfish or pelagic shelf rockfish. As adults, slope rockfish are typically found near the bottom in waters deeper than 200 m, such as waters found along the break of the continental shelf (Heifetz et al. 1998) or in the bottoms of deep coastal fiords. Slope rockfish are generally captured incidental to longline fisheries targeting halibut and sablefish (*Anoplopoma fimbria*), or bottom trawl fisheries targeting shrimp, particularly sidestripe shrimp (*Pandalopsis dispar*).

Thornyhead rockfish are defined in regulation 5 AAC 39.975(39) as any species of the genus *Sebastolobus*, although only shortspine thornyhead occur in the Cook Inlet Management Area. Adult shortspine thornyhead are found near the bottom in waters deeper than 200 m, such as waters found along the break of the continental shelf (Ianelli and Ito 1998) or in deep basins. In the territorial seas, shortspine thornyhead are captured incidentally by fisheries directed at other species, sablefish or shrimp, and are typically taken by longline or bottom trawl gears.

Rockfish have unusual reproductive patterns. Most marine fishes produce free-floating eggs that are externally fertilized and undergo embryonic development within the water column. After hatching, the fish generally feed off a yolk-sac during which time pigmentation and free-feeding mechanisms develop. Less than 20% of the eggs of most marine fish survive the yolk-sac stage (Hempel 1979). In contrast, rockfish internally fertilize between 10 thousand and 1 million eggs that develop and hatch inside the ovary. An estimated 75% of these eggs survive to be extruded as planktonic, free-feeding larvae (Boehlert, et al. 1987). Larval release (parturition) for most rockfishes occurs during the first six months of the year, although specific timing varies substantially within and between species (Wyllie Echeverria 1987). The period of larval release is poorly documented for rockfish species in PWS. In southeast Alaska, the duration of larval release varies from 1-9 months (Table 2; O'Connell 1987). The release period for a given species tends to be later and have a shorter duration in more northern latitudes (Kendall and Lenarz 1987). The occurrence of ripe male rockfish in southeast Alaska tends to overlap and slightly precede the period of larval release by females (Table 3).

The juvenile rockfish stage, defined as the stage at which the fin ray, gill raker, and lateral line pore counts are the same as in adults, begins at a length of 20-30 mm (1 inch; Matarese et al. 1989). Juvenile distribution and life history patterns are not well documented for most species. Juveniles of some species are either pelagic or associated with drifting objects such as kelp until they begin a benthic existence at about one year of age (Boehlert 1977). Other species do not begin a benthic existence until their second year of life (Carlson and Haight 1976). Nearshore movement may

precede juvenile settlement for some species (Anderson 1983). After settlement, juvenile rockfish resemble and may associate with adults.

Rockfish, in general, grow slower, live longer, and reach sexual maturity at an older age than many other marine fishes (Figure 2; Archibald et al. 1981). Growth is asymptotic with low annual growth rates for rockfish older than about 10 years. Although maximum rockfish size and age varies among species, slow growth and greater longevity is generally coupled with a low natural mortality and a relatively late onset of sexual maturity (Figure 2; Table 4). Species-specific age of sexual maturity for rockfish can range from 4 to over 20 years, and longevity may exceed 120 years in some species (O'Connell and Funk 1986). Pelagic shelf rockfish tend to reach sexual maturity earlier and have shorter lives than demersal shelf or slope rockfishes (Table 4; Figure 3). Low natural mortality, great longevity, and late sexual maturity are factors that indicate annual harvest rates should be kept low to ensure sustainability of this resource.

Individual adult rockfish may also show strong site fidelity and reside within a very limited area, although homing and distribution characteristics may vary among species. ADF&G SCUBA surveys conducted along the outer Kenai Peninsula in 1983 and 1984 observed black rockfish at the same location at which they were tagged 2-3 years previously (unpublished data). In southeast Alaska, yellowtail rockfish returned to a home reef after being tagged and moved 22.5 km (13 miles) from the reef (Carlson and Haight 1972).

Another consideration in managing rockfish species is susceptibility to gear and mortality when caught. *Sebastes* species have a physoclastic air bladder and tend to embolize when brought to the surface from deeper than approximately 18 m (60 ft). Survival is thought to be low for fish that embolize prior to being released, although mortality may depend on the depth from which the fish is captured and the speed at which the fish is retrieved. In some instances, efforts have been made to deflate the embolized swim bladder through use of a hypodermic needle and to push the stomach back into place with a rod (Collins et al. 1999). However, these methods are largely unevaluated for long-term survival. A study of this method for blue rockfish (*S. mystinus*) indicated long-term survival to be low, particularly for fish requiring stomach replacement (Gotshall 1964). It is likely that embolism causes internal injuries in addition to an inverted swim bladder, and it is unlikely that swimbladder deflation would be effective for fish retrieved from great depths.

PRINCE WILLIAM SOUND ROCKFISH MANAGEMENT

Area and Habitat

The Prince William Sound Management Area (PWS) consists of all waters of Alaska from 140° 00' W long., outside of Yakutat Bay, to the longitude of Cape Fairfield (148° 50' 15" W. long.). PWS includes two districts: the Inside District and the Outside District (Figure 4).

The Inside District includes all waters enclosed by lines from Point Whittard to Point Barrow, from Cape Hinchinbrook to Zerkof Point, and from Cape Clear to Cape Puget (Figure 5). Habitat in this district is quite varied with a mixture of bottom types. High-relief, rocky outcroppings are common around islands and along the sides of the glacial fjords that define the northern and western extent of the district. Many of the larger bays and open basins have mud bottoms. Water in the fjords may exhibit glacial clouding. Depths are typically deeper than 100 fathoms (183 m) with approximately 25% of the habitat deeper than 200 fathoms (366 m). In addition to tidal fluctuations, marine currents in the Inside District generally flow counterclockwise. In general, the deep habitat of the Inside District supports populations of slope rockfish, with demersal shelf rockfishes associated with shallower, rocky habitat, especially in the southwest portion of the Inside District. Pelagic shelf species are also found in the southwest area.

The Outside District, comprised of the Gulf of Alaska waters 0-3 miles from shore, is divided into three sections: Western, Eastern, and West Yakutat. These areas are separated at Cape Suckling (143° 53' W. long.) and 147° W. long. (Figure 4). At the January 2000 meeting of the Alaska Board of Fisheries, the West Yakutat Section was removed from PWS and redefined as a portion of the Eastern Gulf of Alaska Management Area. This change will be implemented during the 2000 calendar year. Habitat in the Outside District generally defines the upper extent of the continental slope; substrate tends to be mud or sand interspersed with hard bottom or high-relief rocky outcroppings. Depths are typically shallower than 100 fathoms (183 m), although some offshore trenches extend shoreward with water deeper than 100 fathoms. Marine currents typically flow westward in this area. Nearshore waters on the eastern portion of the Outside District may exhibit glacial silting. The lack of protection from storms in this area inhibits fishing opportunities for small vessels.

Management Approach

Management of rockfish harvests in PWS has continued to evolve. The Prince William Sound Rockfish Management Plan (state regulation 5 AAC 28.265) was adopted by the Alaska Board of Fisheries in 1992 to address increasing commercial rockfish harvests amid an absence of fishery management guidelines (Bechtol 1992). The plan included three main components: (1) vessel trip limits; (2) a bycatch allowance for low-level retention of incidentally caught rockfish once the directed fishery closed; and (3) a guideline harvest level (GHL). The vessel trip limit was intended to slow the pace of the fishery and improve fishery manageability. The trip limit of 3,000 lb in 5 days was recommended by the fishing industry under an assumption that a slow-paced fishery could harvest 1,000 lb per day for the 3-day fishing trip that was common for the nearshore fleet in southcentral Alaska. Provisions for retention of incidentally caught rockfish (bycatch) recognized that rockfish caught incidentally in other fisheries, such as halibut or Pacific cod, embolize and suffer 100% mortality. Establishment of a bycatch allowance discouraged directed fishing on rockfish, but reduced waste of rockfish incidentally caught and killed in non-rockfish fisheries. The bycatch allowance of 20% was a standard used by the Commercial Fishery Entry Commission and was believed to be adequate to provide for retention of incidentally caught rockfish. Harvest guidelines are usually based on some measure of species abundance and biology to ensure sustainability. For most groundfish, abundance is calculated from area-swept estimates that

extrapolate trawl survey catch rates over available habitat (Gunderson 1993). However, the high-relief substrate preferred by rockfish precludes trawling, particularly in areas inhabited by pelagic and demersal shelf rockfishes (Phillips 1994). One assessment approach applied in Southeast Alaska involves line transects with submersibles (O'Connell and Carlile 1994). This method, although effective in many high-relief habitats, is extremely expensive and also depends upon an appropriate measure of available habitat. Another approach involves setting annual the GHL relative to average harvests sustained over a previous time period. This method is often used when stock assessment data is lacking, and is similar to the Tier 6 approach applied by the North Pacific Fishery Management Council in setting harvest guidelines for some groundfish fisheries in the Gulf of Alaska and Bering Sea (DiCosimo 1997). For PWS, the GHL of 150,000 lb (78 mt) was calculated as the average commercial rockfish harvest from the Inside District as a time when PWS was only defined to include the Inside District (Bechtol 1992). To accommodate uncertainty in fisheries that were continuing to develop, this GHL was treated as a "trigger" to close the directed rockfish fishery and implement a bycatch only fishery.

In 1996, the management area was modified to include the West Yakutat Section of the PWS Outer District (Figure 4; Berceli et al. 1999). Also in 1996, the Board of Fisheries amended the management plan to define the 150,000-lb GHL as a harvest cap instead of a bycatch trigger. In January 1997, the management area was again modified to include Outside District waters east to 140° W. long. As was described above, the West Yakutat Section was removed from PWS in 2000.

Rockfish Harvests

Annual commercial rockfish harvests from PWS since 1987 ranged from 108,806 lb in 1993 to 506,435 lb in 1990, and averaged 197,939 lb (Table 5). Continued harvest reductions since 1995 resulted from increasingly restrictive inseason management strategies to prevent the annual GHL from being exceeded (Berceli et al. 1999). Recreational harvests during 1991-1998 ranged from 37,800 lb in 1991 to 101,800 lb in 1997, and averaged 78,088 lb (Table 5; Meyer 1999). Historically, slope rockfish comprised 54% of the commercial rockfish harvests from PWS whereas pelagic rockfish comprised 67% of the recreational harvests.

Annual rockfish harvests in the Inside District during 1987-1998 ranged from 81,352 lb in 1993 to 489,118 lb in 1990 and averaged 151,742 lb (Table 6). Slope species, predominantly rougheye and shortraker rockfishes, comprised 69% of commercial rockfish harvests in the Inside District during 1987-1999 (Berceli et al. 1999).

During 1987-1998, annual rockfish harvests in the Outside District ranged from 2,289 lb in 1987 to 158,451 lb in 1995 and averaged 46,197 lb (Table 7). Pelagic shelf rockfish, predominately black rockfish, comprised 85% of the commercial catch reported from the Outside District (Berceli et al. 1999).

DATA COLLECTION AND ANALYSIS

Species size and age composition data in this report were obtained by sampling commercial rockfish landed at the ports of Cordova, Seward, and Whittier. Landings were sampled from both directed rockfish fisheries and from incidental harvests associated with fisheries for Pacific cod, sablefish, lingcod, and halibut. Rockfish were also sampled from ADF&G multi-species trawl surveys (Bechtol 1999) and ADF&G longline surveys (Bechtol and Vansant 1998). All rockfish sampled were classified to species, measured for total length, and identified for sex. For a portion of these samples, sagittal otoliths were removed, cleaned, and stored for later age determination.

Rockfish data for samples collected during 1991-1999 were pooled by species across years and gear types. For each species, mean, minimum, and maximum total length and age were determined. Size and age composition data were then summarized by species, year, and gear type for species considered to be representative of the three rockfish assemblages. Black rockfish and yelloweye rockfish were selected as representative species for pelagic shelf and demersal shelf assemblages, respectively. Roughey rockfish, shortraker rockfish, and shortspine thornyhead were used to represent the slope rockfish assemblage. Selection of these species was based primarily on the availability of adequate sample sizes for data analysis. Mean size-at-age relationships were calculated for roughey rockfish and shortraker rockfish using a von Bertalanffy growth equation (Ricker 1975).

RESULTS

Pelagic Shelf Rockfish

Commercial harvests of pelagic shelf rockfish averaged 15,602 lb annually, comprised 10% of commercial rockfish landings from the Inside District of PWS during 1987-1998 (Table 6). Black rockfish was one of the most commonly harvested pelagic shelf rockfish species in PWS (Berceli et al. 1999). Black rockfish tend to be associated with shallow, rocky reefs and are most commonly caught near the islands west of Montague Strait (Figures 1 and 4). They are most often caught on jig gear, but are also harvested with longline gear placed across reefs. Lengths of black rockfish sampled from commercial jig harvests in 1995 ranged from 44-60 cm and averaged 51.0 cm (n=134; Table 7; Figure 6). The most abundant size class was 51-cm fish.

The seven dusky rockfish sampled during 1991-1999 ranged from 22-49 cm and averaged 37.7 cm. Sampled fish ranged in age from 7-20 years with a mean age of 11.8 years (n=6; Table 7).

Demersal Shelf Rockfish

Commercial harvests of demersal shelf rockfish from the Inside District of PWS during 1987-1998 averaged 31,162 lb and comprised 21% of all commercial rockfish landings from this area (Table 6). Yelloweye rockfish were the most commonly harvested demersal shelf species in PWS (Berceli et al. 1999). Yelloweye rockfish tend to be associated with deep, rocky substrate and are most often caught by jig and longline gears. Yelloweye rockfish lengths ranged from 32-91 cm and averaged 50.9 cm among all samples (n=650; Table 7). The most abundant size class of fish sampled from the 1998 longline landings was 54 cm (n=602; Figure 7). Ages of 10 yelloweye rockfish ranged from 16-37 years, with a mean age of 23.9 years (Table 7).

Lengths of quillback rockfish sampled during 1991-1999 ranged from 30-45 cm, with a mean length of 37.5 cm (n=100; Table 7). The most abundant size class of fish sampled from the 1998 longline landings was 38 cm (n=96; Figure 8).

Slope Rockfish

Commercial harvests of slope rockfish from the Inside District of PWS during 1987-1998 averaged 104,978 lb and comprised 69% of all commercial rockfish landings from this area (Table 6). The most commonly harvested slope species, roughey rockfish and shortraker rockfish, are often caught as bycatch by longline fisheries targeting halibut and sablefish and by a trawl fishery targeting sidestripe shrimp (Berceli et al. 1999). Roughey rockfish are also the most abundant rockfish caught in ADF&G trawl and longline surveys (Bechtol and Vansant 1998; Bechtol 1999). Shortraker rockfish are also caught in ADF&G trawl and longline surveys, although their distribution tends to be deeper than roughey rockfish (Bechtol and Vansant 1998).

During 1991-1999, lengths of sampled roughey rockfish ranged from 8-92 cm, with a mean length of 36.5 cm (n=8,839; Table 7). Trawl-caught samples indicated a major length mode progressing from 32 cm in 1991 to 42 cm in 1997 (Figure 9). A second mode at 11-14 cm during 1991-1993 became the most abundant size class at 36 cm in 1999. The predominant length mode of roughey rockfish samples caught by longline generally increased in 1992-1994 and 1998, years when longline sample sizes exceeded 100 fish (Figure 10). Although the smaller sample size obtained in most years for longline catches compared to trawl catches may have affected the longline catch size distribution, the predominant length mode was often slightly larger for longline catches, likely indicating gear selectivity differences. For example, fish smaller than 30 cm were caught on longline gear only in 1994 when 854 lengths were obtained from longline catches. In 1994, the predominant length mode of 41 cm for longline samples was similar to the mode of 39-40 cm for trawl samples. Roughey rockfish age ranged from 2-112 years, with a mean age of 13.4 years (n=3,888; Table 7). For both trawl and longline samples, the most abundant age class increased from age 11 in 1992 to age 13 in 1994 (Figure 11). Although individual size-at-age of roughey rockfish was quite variable, fish grew rapidly during their first 20 years and began to asymptote at an age of around 40-60 years; mean L_{∞} was around 70 cm (Figure 12).

Lengths of shortraker rockfish sampled during 1992-1999, ranged from 19-100 cm, with a mean length of 66.3 cm (n=1,235; Table 7). The predominant length mode of longline-caught samples ranged from 65-75 cm in all years, and the predominant length mode was 48-cm fish sampled from trawl catches in 1999 (n=47). Length distributions within years and gears were multimodal with a wide variety of lengths represented (Figure 13). Shortraker rockfish ages, obtained from longline catches in 1994 and 1996, ranged from 14-139 years, with a mean age of 57.5 years (n=197; Table 7). Age distributions were widely distributed and multimodal (Figure 14). Few samples of shortraker rockfish were available to examine size-at-age younger than about 20 years. Mean growth began to asymptote at an age of around 40-60 years; mean L_{∞} was around 75 cm (Figure 15).

Redstripe rockfish are caught by a variety of gears at moderate depths (Bechtol and Vansant 1998). During 1991-1999, length of redstripe rockfish ranged from 13-73 cm, with a mean length of 35.1 cm (n=302; Table 7). Ages of sampled redstripe rockfish ranged from 3-28 years, with a mean age of 8.8 years (n=12; Table 7).

For other slope rockfish species sampled from PWS (Table 7), lengths ranged from 17-56 cm for redbanded rockfish (n=26), 35-54 cm for silvergray rockfish (n=55), and 19-39 cm for sharpchin rockfish (n=5).

Shortspine thornyhead rockfish are also caught in ADF&G trawl and longline surveys, with a distribution that is typically deeper than roughey rockfish (Bechtol and Vansant 1998). During 1996-1999, length of shortspine thornyhead sampled from longline catches ranged from 12-87 cm, with a mean length of 59.9 cm (n=288; Table 7). Although less than 100 fish were sampled within years, the predominant length mode ranged from 59-63 cm in all years (Figure 16). Ages of shortspine thornyhead ranged from 5-89 years, with a mean age of 39.5 years (n=50; Table 7).

DISCUSSION

Commercial rockfish harvests from the Inside District of PWS substantially exceeded harvest from the Outside District in all years except 1994 and 1995 (Tables 5 and 6). Commercial harvests have generally declined in recent years in response to more intensive management strategies. In contrast, recreational harvests have generally increased, although there is substantial uncertainty around estimated recreational harvests (Berceli et al. 1999; Meyer 1999). Although market conditions and alternative fishing opportunities affected effort and landings, species availability due to habitat and gear fished in the primary fisheries probably played the primary role in determining the composition of landings. The deep water throughout much of PWS supports populations of slope rockfish that are largely harvested incidentally to other commercial fisheries such as longline fisheries for Pacific halibut and sablefish and bottom trawl fishery for sidestripe shrimp. The commercial longline fisheries targeting Pacific cod incidentally caught a mixture of slope and demersal shelf species. Efforts to commercially target rockfish in PWS have been limited and primarily involved jig gear targeting both black and yelloweye rockfishes and longline gear targeting yelloweye rockfish.

Rockfish have slow growth, extended longevity, late sexual maturity, and low natural mortality relative to other marine species. These characteristics vary somewhat among species, but tend to be more consistent within species assemblage. Mean sizes of several commercially important rockfishes were generally similar, but slightly larger, in PWS compared to the Cook Inlet Management Area for samples pooled among years and gears (Table 7; Bechtol 1998). For example, within the pelagic shelf assemblage, mean length of black rockfish was 51.0 cm in PWS compared to 48.0 cm in Cook Inlet. Within the demersal shelf assemblage, mean length of yelloweye rockfish was 50.9 cm in PWS compared to 49.7 cm in Cook Inlet. Within the slope assemblage, rougheye rockfish mean length was 36.5 cm compared to 32.1 cm in Cook Inlet.

Rockfish characteristics of late maturity, extended longevity, and low natural mortality require a conservative approach to fisheries management (Leaman and Beamish 1984). Because fisheries management actually involves regulating patterns of human use, to ensure sustainability of rockfishes requires lower exploitation rates than are used for most other marine fishes. However, an estimate of population abundance is typically needed to determine exploitation rates. Determination of population abundance in many rockfish species has continued to be problematic because of rockfishes life histories, habitats, and behaviors (Walters and Collie 1989).

The Prince William Sound Rockfish Management Plan was adopted in 1992 as a mechanism to address increasing rockfish harvests in the absence of fishery information and management guidelines (Bechtol 1992). Although much of the data presented in this report represents information collected after the management plan was adopted, information on stock structure and recruitment mechanisms is still lacking. ADF&G will continue to monitor PWS rockfish resources through by port sampling and fisheries-independent longline and multi-species trawl surveys (Bechtol and Vansant 1998; Bechtol 1999). Port sampling efforts have improved in recent years, in large part due to increased funding from the Alaska Fisheries Information Network (Robert Piorkowski, Alaska Department of Fish and Game, Juneau, personal communication), and the utility of fishery-independent survey continues to develop. Modifications to the management plan may be appropriate as our understanding of rockfish population dynamics improves, or in response to changes in human use patterns. Based on the available data, it is likely that rougheye rockfish will be the first species with sufficient data for population modeling.

In the absence of species-specific population abundance and productivity data, it remains especially important to evaluate developing harvest patterns in light of historical patterns and available biological data. Management measures need to incorporate data on gear selectivity, as well as rockfish life history characteristics, when developing measures to protect the rockfish species or species assemblage(s) of concern. For example, the species composition of commercial jig and recreational fisheries targeting rockfish in PWS is substantially different than longline fisheries targeting sablefish. Thus, closures of most longline fisheries would offer little protection to pelagic shelf species and only limited protection to demersal shelf species. Because rockfish experience high mortality when caught, release of unwanted bycatch is also not an effective means to decrease fishing mortality. In addition, requiring all incidentally caught rockfish to be discarded inhibits long-term management efforts because at-sea discards are poorly documented. Thus, geographical or temporal closures of directed rockfish fishing to prevent excessive targeting of rockfish should be balanced with providing a bycatch allowance that is appropriate for incidental catch in non-rockfish

fisheries. This bycatch allowance needs to be sustainable at the rockfish population level, and should be adequate to discourage at-sea discards that represent a waste of the rockfish resource and an underreporting of fishing mortality.

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Table 1. Some species and assemblage names applied in Central Region rockfish management.

<u>ADF&G Species Code</u>	<u>Common Name</u>	<u>Scientific Name</u>
<u>Pelagic Shelf Rockfish</u>		
142	Black Rockfish	<i>Sebastes melanops</i>
154	Dusky Rockfish	<i>Sebastes ciliatus</i>
155	Yellowtail Rockfish	<i>Sebastes flavidus</i>
<u>Demersal Shelf Rockfish</u>		
138	Copper Rockfish	<i>Sebastes caurinus</i>
145	Yelloweye Rockfish	<i>Sebastes ruberrimus</i>
146	Canary Rockfish	<i>Sebastes pinniger</i>
147	Quillback Rockfish	<i>Sebastes maliger</i>
148	Tiger Rockfish	<i>Sebastes nigrocinctus</i>
149	China Rockfish	<i>Sebastes nebulosus</i>
150	Rosethorn Rockfish	<i>Sebastes helvomaculatus</i>
<u>Slope Rockfish</u>		
136	Northern Rockfish	<i>Sebastes polyspinis</i>
137	Bocaccio Rockfish	<i>Sebastes paucispinis</i>
141	Pacific Ocean Perch	<i>Sebastes alutus</i>
151	Rougheye Rockfish	<i>Sebastes aleutianus</i>
152	Shortraker Rockfish	<i>Sebastes borealis</i>
153	Redbanded Rockfish	<i>Sebastes babcocki</i>
157	Silvergray Rockfish	<i>Sebastes brevispinis</i>
158	Redstripe Rockfish	<i>Sebastes proriger</i>
159	Darkblotched Rockfish	<i>Sebastes crameri</i>
166	Sharpchin Rockfish	<i>Sebastes zacentrus</i>
182	Splitnose Rockfish	<i>Sebastes diploproa</i>
176	Harlequin Rockfish	<i>Sebastes variegatus</i>
<u>Thornyhead Rockfish</u>		
143	Shortspine Thornyhead	<i>Sebastolobus alascanus</i>

Table 2. Months of parturition for some female rockfish occurring in the northern Pacific Ocean.

Common Name	<u>Month of Documented Spawning Condition</u>											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<u>Pelagic Shelf Rockfish</u>												
Black Rockfish	*		?	?								
Dusky Rockfish			*	*	*	*						
Yellowtail Rockfish	*		?	?								
<u>Demersal Shelf Rockfish</u>												
Copper Rockfish			*	*	*	?	*					
Yelloweye Rockfish	*		*	*	*	*	*	*	*			
Canary Rockfish	*		*									
Quillback Rockfish			*	*	*	*	*					
Tiger Rockfish	*		*	*	*	*						
China Rockfish			*	*	*	*	*					
Rosethorn Rockfish	*		*	*	*	*	*	*	*			
<u>Slope Rockfish</u>												
Northern Rockfish												
Bocaccio Rockfish	*		?	?								
Pacific Ocean Perch				*	*							
Rougheye Rockfish				*								
Shortraker Rockfish				*								
Redbanded Rockfish				*	*							
Silvergray Rockfish					*	*	*					
Redstripe Rockfish					*	*						
Darkblotched Rockfish					*	?						
Sharpchin Rockfish						*	?					
Splitnose Rockfish							*					
Harlequin Rockfish												
<u>Thornyhead Rockfish</u>												
Shortspine Thornyhead												

Sources: O'Connell 1987; Wyllie Echeverria 1987.

Table 3. Month in which some male rockfish that occur in the northern Pacific Ocean have been observed in a ripe spawning condition.

Common Name	<u>Month of Documented Spawning Condition</u>											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<u>Pelagic Shelf Rockfish</u>												
Black Rockfish		*						*	*	*	*	*
Dusky Rockfish												
Yellowtail Rockfish	*	*	*						*			
Widow Rockfish												
Blue Rockfish	*		*									
<u>Demersal Shelf Rockfish</u>												
Copper Rockfish		*	*	*	*							
Yelloweye Rockfish	*	*	*	*	*						*	*
Canary Rockfish	*	*	*	*	*			*	*	*	*	*
Quillback Rockfish	*	*	*	*	*		*					
Tiger Rockfish	*	*	*		*						*	
China Rockfish			*			*						
Rosethorn Rockfish		*	*	*	*	*	*		*			
<u>Slope Rockfish</u>												
Northern Rockfish												
Bocaccio Rockfish		*	*									
Pacific Ocean Perch												
Rougheye Rockfish												
Shortraker Rockfish										*		
Redbanded Rockfish	*	*							*	*		
Silvergray Rockfish	*	*	*	*								
Redstripe Rockfish					*							
Darkblotched Rockfish												
Sharpchin Rockfish												
Splitnose Rockfish												
Harlequin Rockfish												
<u>Thornyhead Rockfish</u>												
Shortspine Thornyhead												

All listings from O'Connell 1987.

Table 4. Biological parameters for some rockfishes found in Gulf of Alaska fisheries.

Common Name	Maturity			Inst. Natural Mortality	Source
	Length at 50% (cm)	Age at 50%	Maximum Age		
<u>Pelagic Shelf Rockfish</u>					
Black Rockfish	38-42	6-8	51	0.12-0.26	14, 18
Dusky Rockfish	43	13	67	0.09	5, 14
Yellowtail Rockfish	35-36 ^c	6-7 ^c	42-53	0.06-0.14	14, 15, 16
<u>Demersal Shelf Rockfish</u>					
Copper Rockfish	32-34 ^c	4-6 ^c	50		14, 16
Yelloweye Rockfish	45-50	21-23	114	0.02	3, 4, 17
Canary Rockfish	40-44 ^c	7-9 ^c	23-58	0.03-0.17	14, 15, 16
Quillback Rockfish	22-26 ^c	4-6 ^c	74		14, 16
Tiger Rockfish			84		14,
China Rockfish	27 ^c	4 ^c	56		14, 16
Rosethorn Rockfish	22-23 ^c	7-8 ^c	71		14
					16
<u>Slope Rockfish</u>					
Northern Rockfish	36	13	49	0.06	8, 9
Bocaccio Rockfish	42-48 ^c	3-4 ^c			16
Pacific Ocean Perch	36	10	79-98	0.02-0.08	8, 10
Rougheye Rockfish	45-47		95-140	0.01-0.04	11, 12, 19
Shortraker Rockfish	47		139	0.03-0.04	13, 19, 20
Redbanded Rockfish	31-34 ^c	4 ^c			16
Silvergray Rockfish	44-46	14	80	0.01-0.07	15, 19
Redstripe Rockfish	29-30	8	41	0.09-0.10	15, 19
Darkblotched Rockfish	27 ^c	4 ^c	48	0.07	15, 16
Sharpchin Rockfish	27	10	46	0.05-0.07	8, 15, 20
Splitnose Rockfish	19-22 ^c	7-9 ^c			16
Harlequin Rockfish	23-24		43		19
<u>Thornyhead Rockfish</u>					
Shortspine Thornyhead		11	62 (50-100)	0.07-0.08	1,2

^c – indicates data from California stocks

1 - Ianelli et al. 1998

2 - Miller 1985

3 - O'Connell et al 1998

4 - O'Connell and Funk 1986

5 - Clausen and Heifetz 1998

6 - Meyer 1992

7 - Urban and Phillips 1994

8 - Heifetz and Ianelli 1991

9 - Clausen and Heifetz 1991

10 - Heifetz et al. 1994

11 - Nelson and Quinn 1987

12 - Nelson 1986

13 - McDermott 1994

14 - Meyer personal communication

15 - Archibald et al. 1981

16 - Wyllie Echeverria 1987

17 - O'Connell and Funk 1987

18 - Wallace and Tagart 1994

19 - Haldorson and Love 1991

20 - This report.

Table 5. Commercial rockfish harvest and effort from the Inside and Outside Districts, including black rockfish from adjacent federal waters, during 1987-1999, and recreational rockfish harvests during 1991-1998, Prince William Sound.

Year ^a	Commercial Harvest and Effort							Total
	Inside District			Outside District			Total	Recreational
	Vessels	Landings	Harvest (lb)	Vessels	Landings	Harvest (lb)	Harvest (lb)	Harvest ^b (lb)
1987	60	134	119,052	4	4	2,289	121,341	
1988	64	175	112,019	12	18	87,006	199,025	
1989	35	99	93,428	6	7	25,122	118,550	
1990	93	401	489,118	10	11	17,317	506,435	
1991	88	244	154,636	7	8	2,780	157,416	37,800
1992	105	278	177,814	18	26	13,987	191,801	80,600
1993	67	185	81,352	20	33	27,454	108,806	70,500
1994	65	163	97,608	34	55	103,334	200,942	80,900
1995	122	221	153,556	39	68	158,451	312,007	86,500
1996	85	198	105,804	35	64	77,511	183,315	67,900
1997	89	240	137,186	26	37	29,356	166,542	101,800
1998	79	187	99,379	19	38	9,761	109,140	98,700
1999	79	188	57,615	23	44	11,491	69,106	
Average ^c	79	210	151,742	19	31	46,197	197,939	78,088
Percent of Commercial Total			77%				23%	

^a Preliminary data through October 15, 1999 (Berceli et al. 1999).

^b There is substantial uncertainty around recreational harvest estimates (Meyer 1999).

^c Average through 1998.

Table 6. Commercial rockfish harvest by species assemblage and district from Prince William Sound, 1987 - 1999.

			Inside District				
Year ^a	<u>Pelagic Shelf</u>		<u>Demersal Shelf</u>		<u>Slope</u>		Total Pounds
	Pounds	% of year	Pounds	% of total	Pounds	% of total	
1987	48	0%	63,419	53%	55,585	47%	119,052
1988	1,425	1%	24,201	22%	86,393	77%	112,019
1989	9,752	10%	4,293	5%	79,383	85%	93,428
1990	20,583	4%	24,254	5%	444,281	91%	489,118
1991	25,381	16%	31,616	20%	97,639	63%	154,636
1992	50,016	28%	35,313	20%	92,485	52%	177,814
1993	3,070	4%	12,140	15%	66,142	81%	81,352
1994	17,770	18%	22,280	23%	57,558	59%	97,608
1995	28,098	18%	29,848	19%	95,610	62%	153,556
1996	12,402	12%	38,714	37%	54,688	52%	105,804
1997	17,842	13%	34,767	25%	84,577	62%	137,186
1998	890	1%	53,097	53%	45,392	46%	99,379
1999	1,770	3%	34,230	59%	21,615	38%	57,615
Average ^b	15,602	10%	31,162	21%	104,978	69%	151,742
			Outside District				
Year ^a	<u>Pelagic Shelf</u>		<u>Demersal Shelf</u>		<u>Slope</u>		Total Pounds
	Pounds	% of year	Pounds	% of total	Pounds	% of total	
1987	372	16%		0%	1,917	84%	2,289
1988	84,269	97%	2,715	3%	22	0%	87,006
1989	11,844	47%	13,278	53%		0%	25,122
1990	6,304	36%		0%	11,013	64%	17,317
1991	1,624	58%	52	2%	1,104	40%	2,780
1992	2,863	20%	7,505	54%	3,619	26%	13,987
1993	24,557	89%	2,069	8%	828	3%	27,454
1994	99,036	96%	921	1%	3,377	3%	103,334
1995	157,063	99%	533	0%	855	1%	158,451
1996	60,314	78%	14,950	19%	2,247	3%	77,511
1997	20,180	69%	6,635	23%	2,541	9%	29,356
1998	4,012	41%	3,906	40%	1,843	19%	9,761
1999	1,451	13%	9,002	78%	1,038	9%	11,491
Average ^b	39,370	85%	4,380	10%	2,447	5%	46,197

^a includes preliminary data through October 15, 1999 (Berceli et al. 1999).

^b average through 1998

Table 7. Size and age data for rockfish sampled from commercial fishery landings and surveys in Prince William Sound, 1991-1999.

Species	Length (cm) ^{a/}				Age (years) ^{a/}			
	Minimum	Maximum	Average	Sample n	Minimum	Maximum	Average	Sample n
<u>Pelagic Shelf Rockfish</u>								
Black Rockfish	44	60	51.0	136	11	11	11.0	1
Dusky Rockfish	22	49	37.7	7	7	20	11.8	6
<u>Demersal Shelf Rockfish</u>								
Yelloweye Rockfish	32	91	50.9	650	16	37	23.9	10
Quillback Rockfish	30	45	37.5	100	16	32	20.5	4
Tiger Rockfish	34	34	34.0	1				
China Rockfish	40	42	41.0	2				
<u>Slope Rockfish</u>								
Pacific Ocean Perch	40	55	44.8	4				
Rougeye Rockfish	8	92	36.5	8,839	2	112	13.4	3,888
Shortraker Rockfish	19	100	66.3	1,235	14	139	57.5	197
Redbanded Rockfish	17	56	46.1	26	7	48	27.3	6
Silvergray Rockfish	35	54	42.8	55	10	13	11.3	3
Redstripe Rockfish	13	73	35.1	302	3	28	8.8	12
Sharpchin Rockfish	19	39	26.0	5	5	7	6.0	2
<u>Thornyhead Rockfish</u>								
Shortspine Thornyhead	12	87	59.9	288	5	89	39.5	50

^{a/} Data pooled among gear types and years.

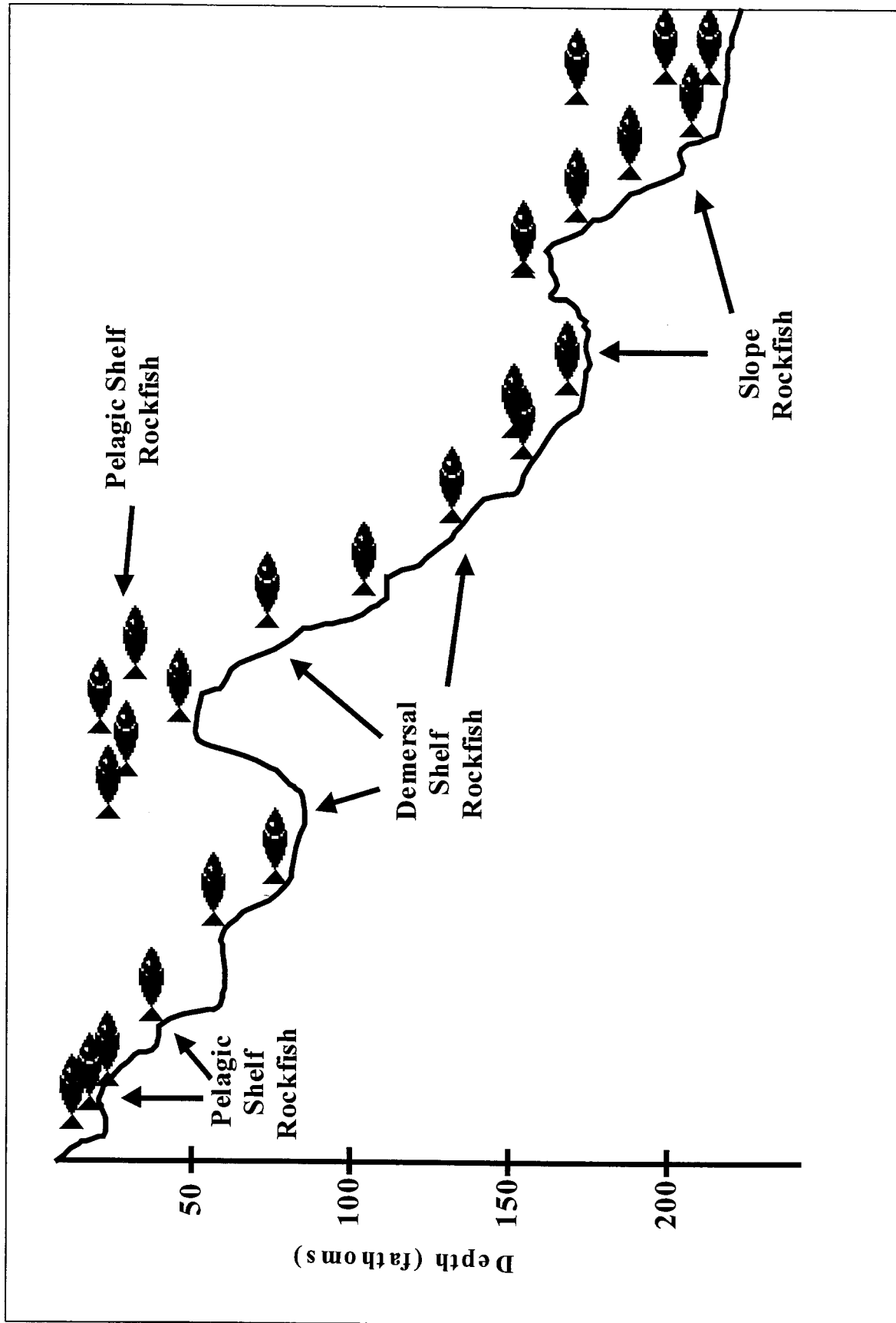


Figure 1. Typical habitat distribution of rockfish species assemblages.

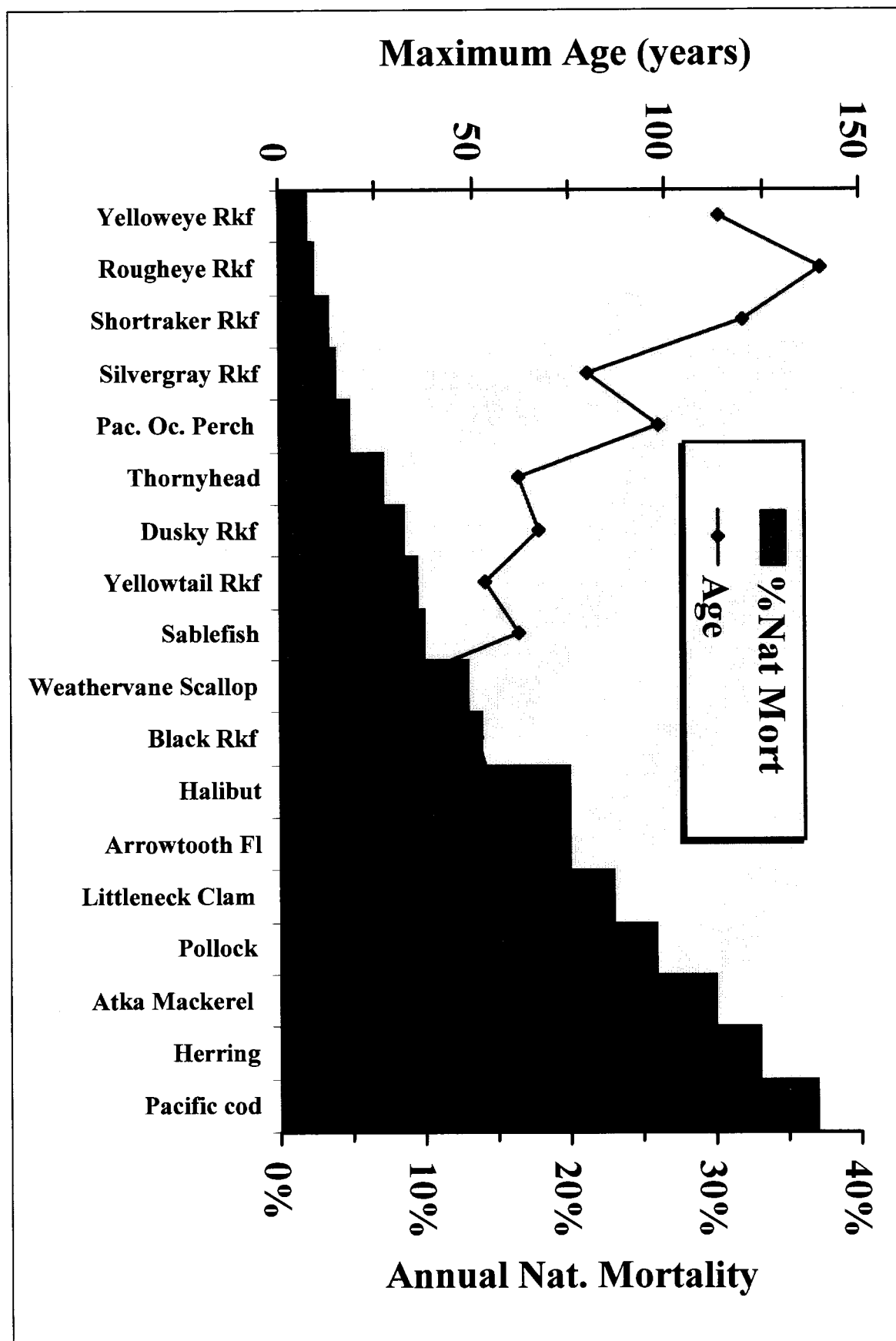


Figure 2. Comparisons of natural mortality rates to longevity for a variety of marine species.

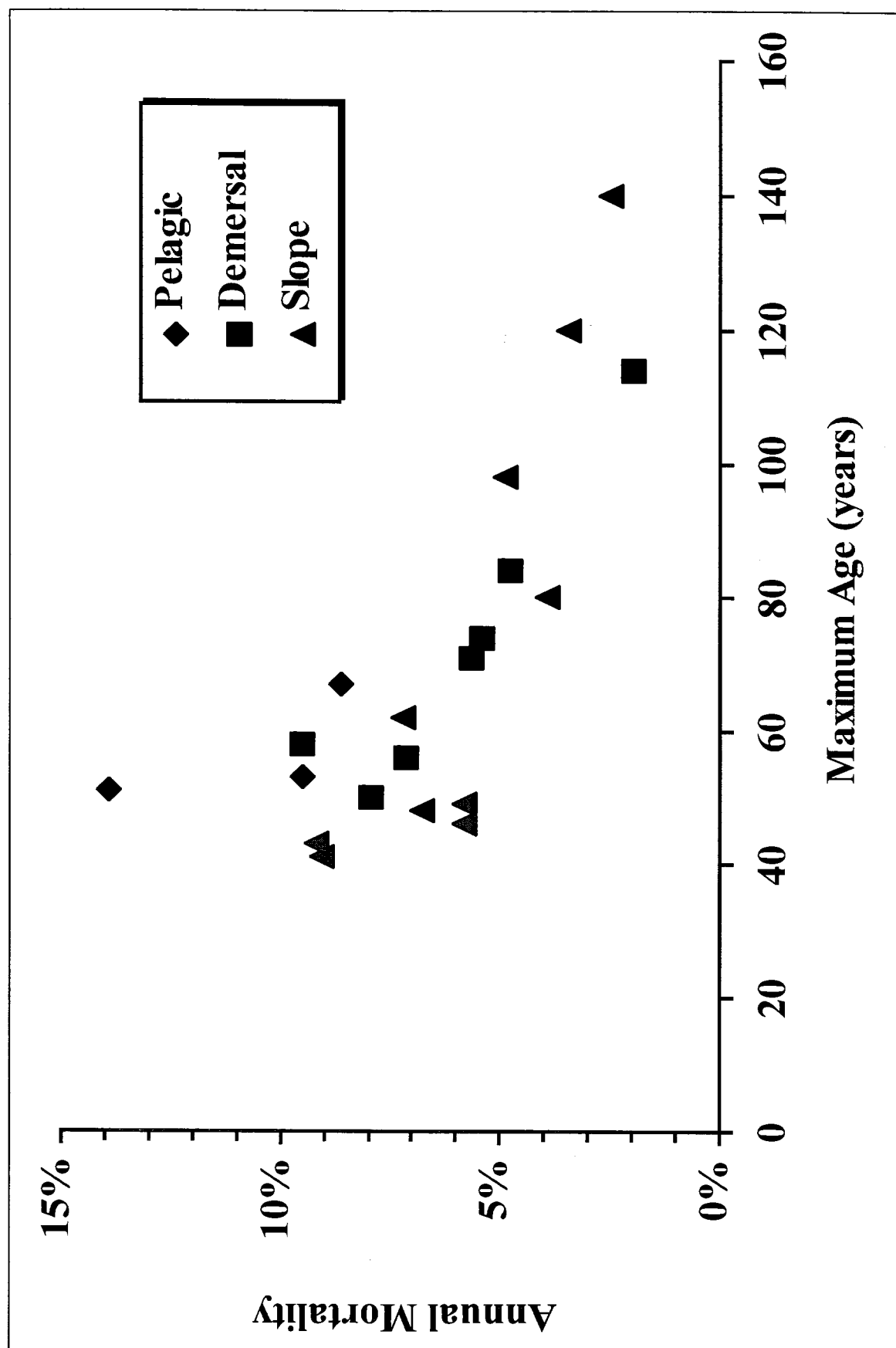


Figure 3. Distribution of rockfish longevity and natural mortality by species assemblage.

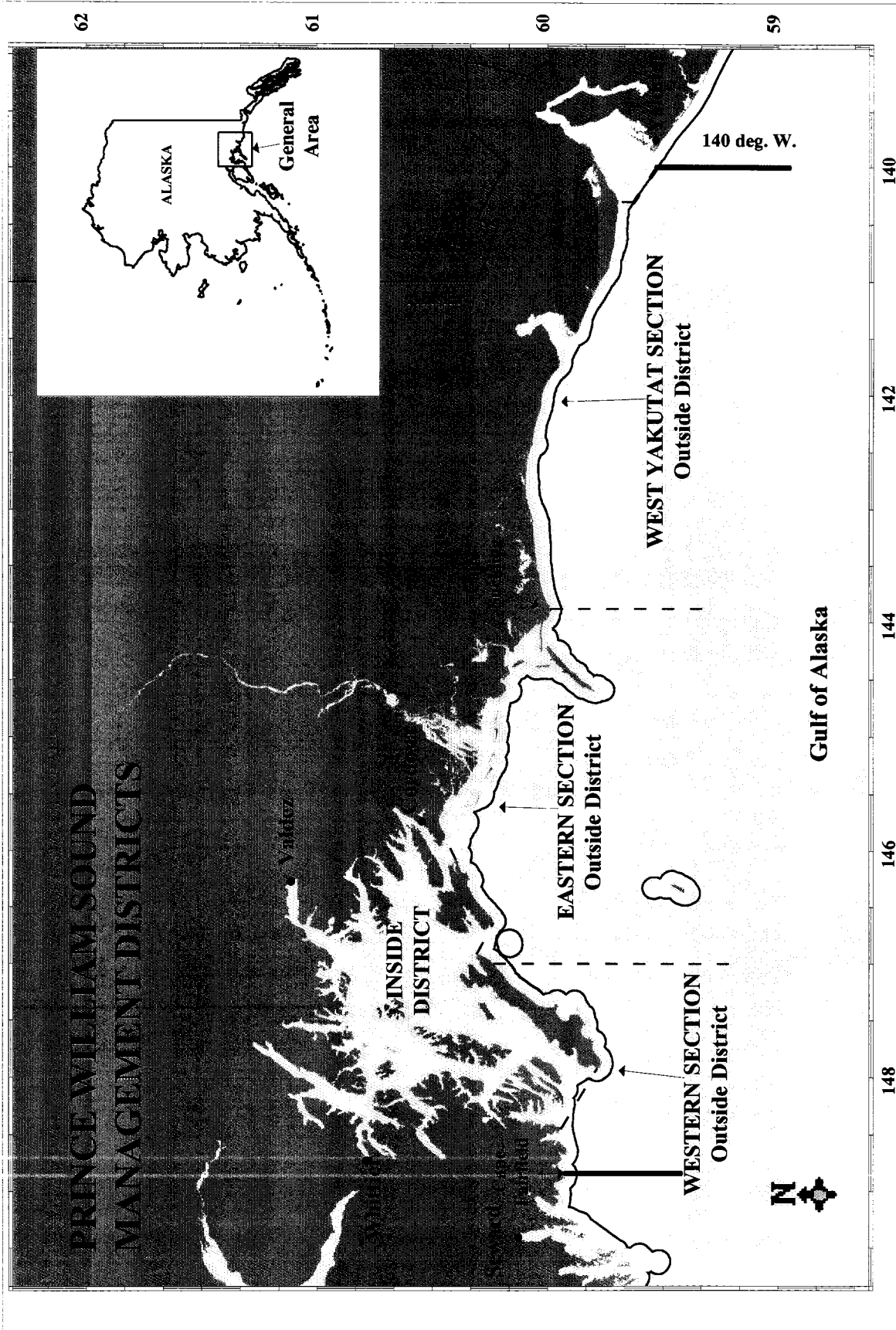


Figure 4. Groundfish fishing districts of the Prince William Sound Management Area.

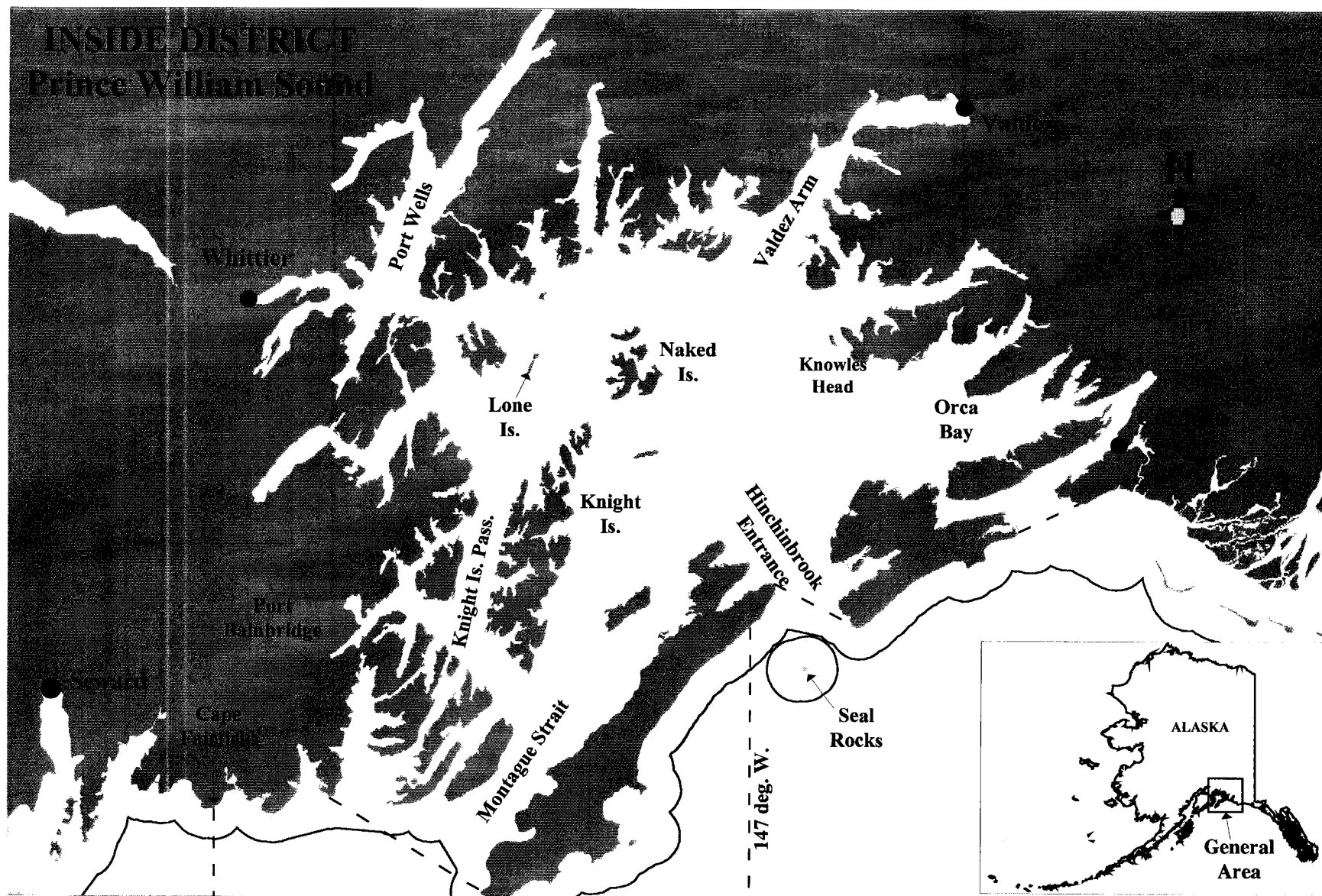


Figure 5. Areas of note within the Inside District of Prince William Sound.

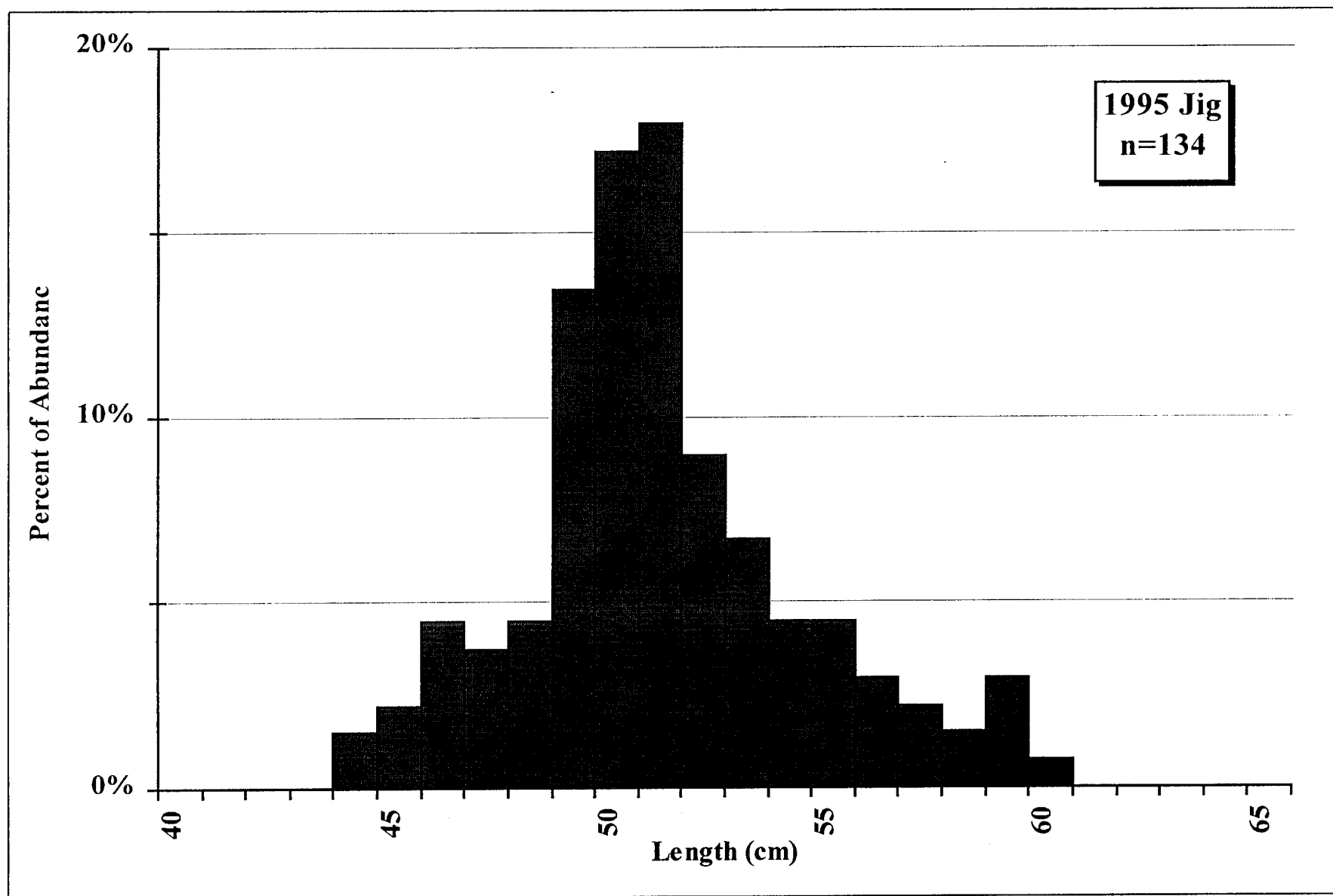


Figure 6. Length composition of black rockfish sampled from jig catches in Prince William Sound, 1995.

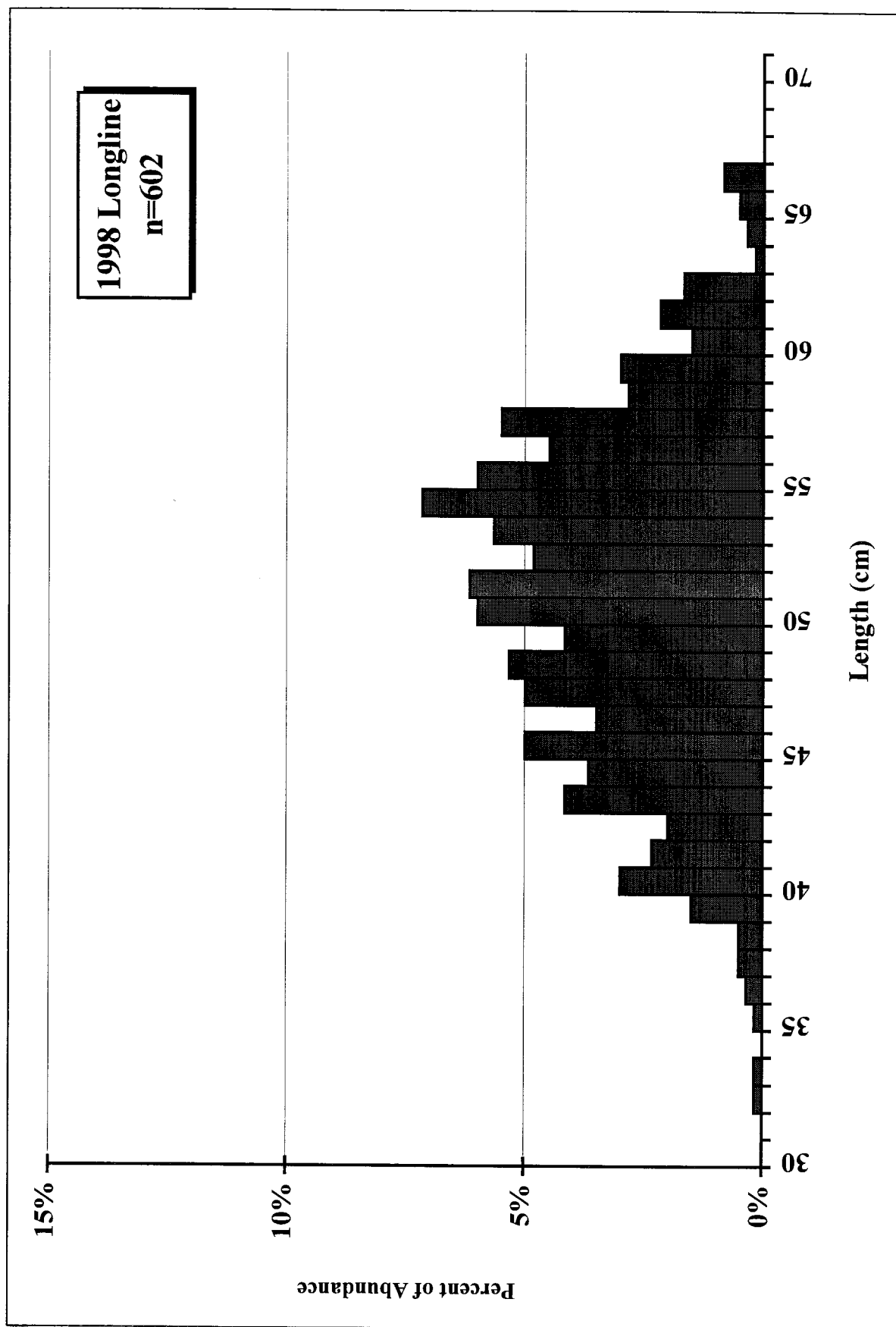


Figure 7. Length composition of yelloweye rockfish sampled from longline catches in Prince William Sound, 1998.

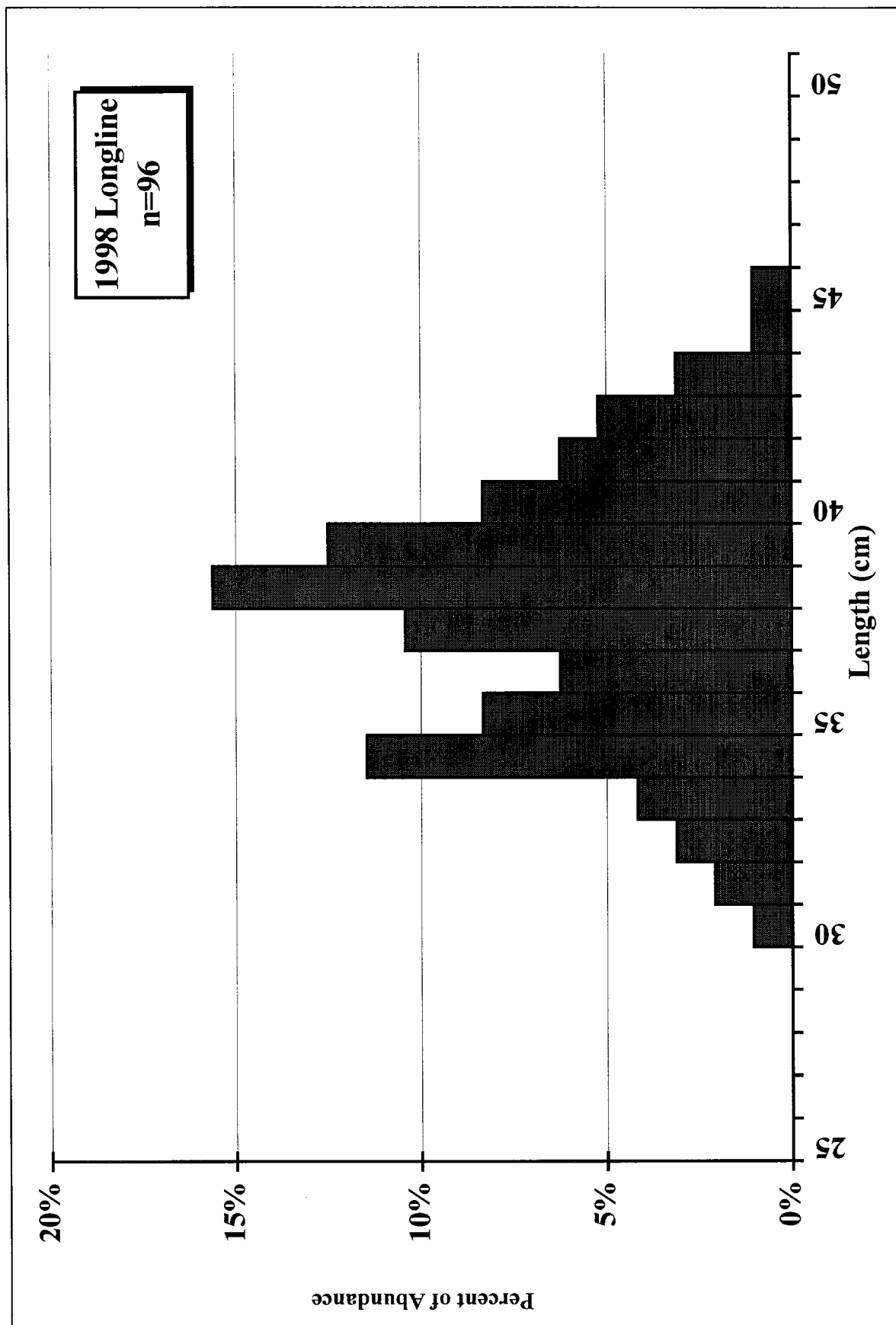


Figure 8. Length composition of quillback rockfish sampled from longline catches in Prince William Sound, 1998.

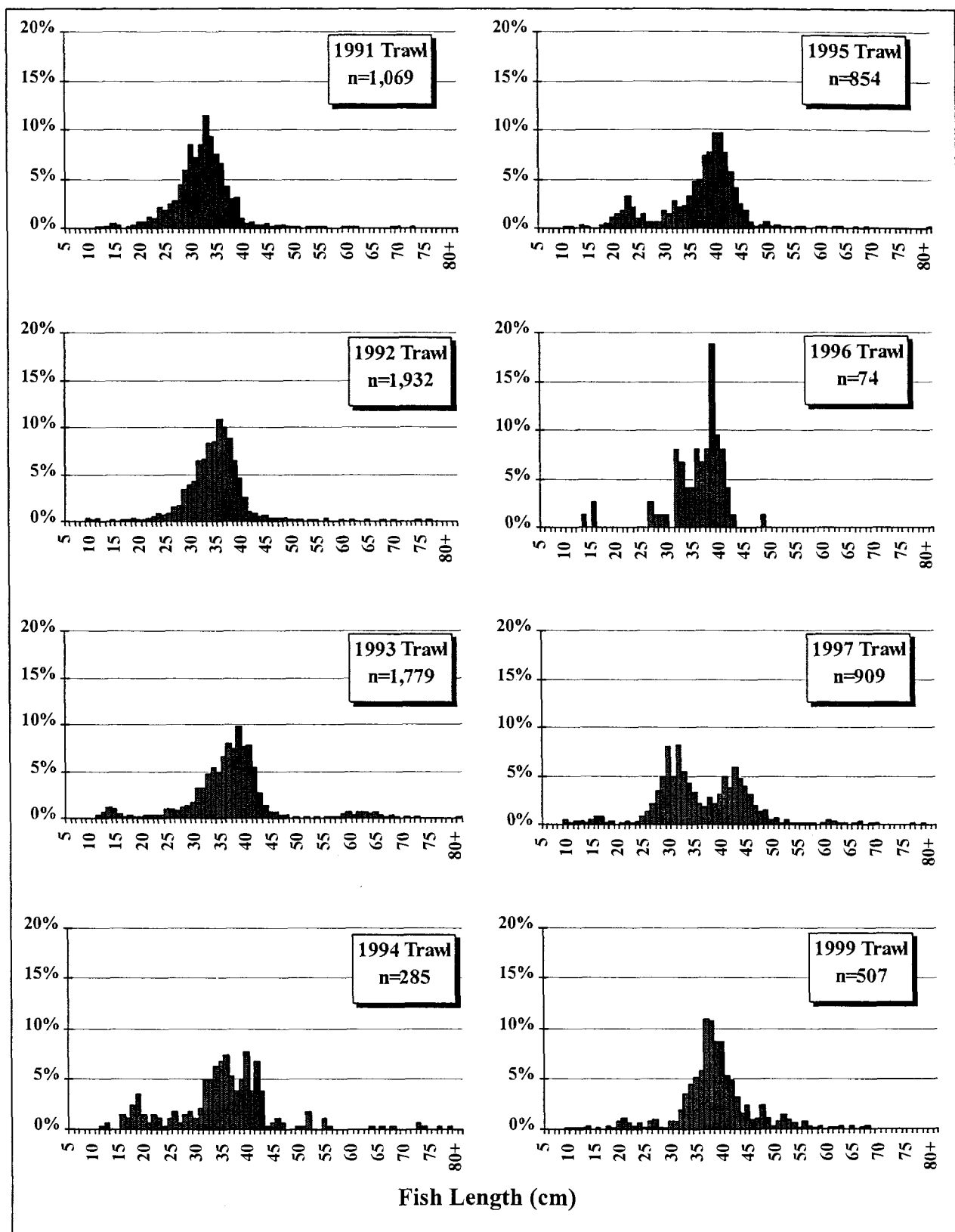


Figure 9. Length composition of roughey rockfish sampled from trawl catches in Prince William Sound, 1991-1999.

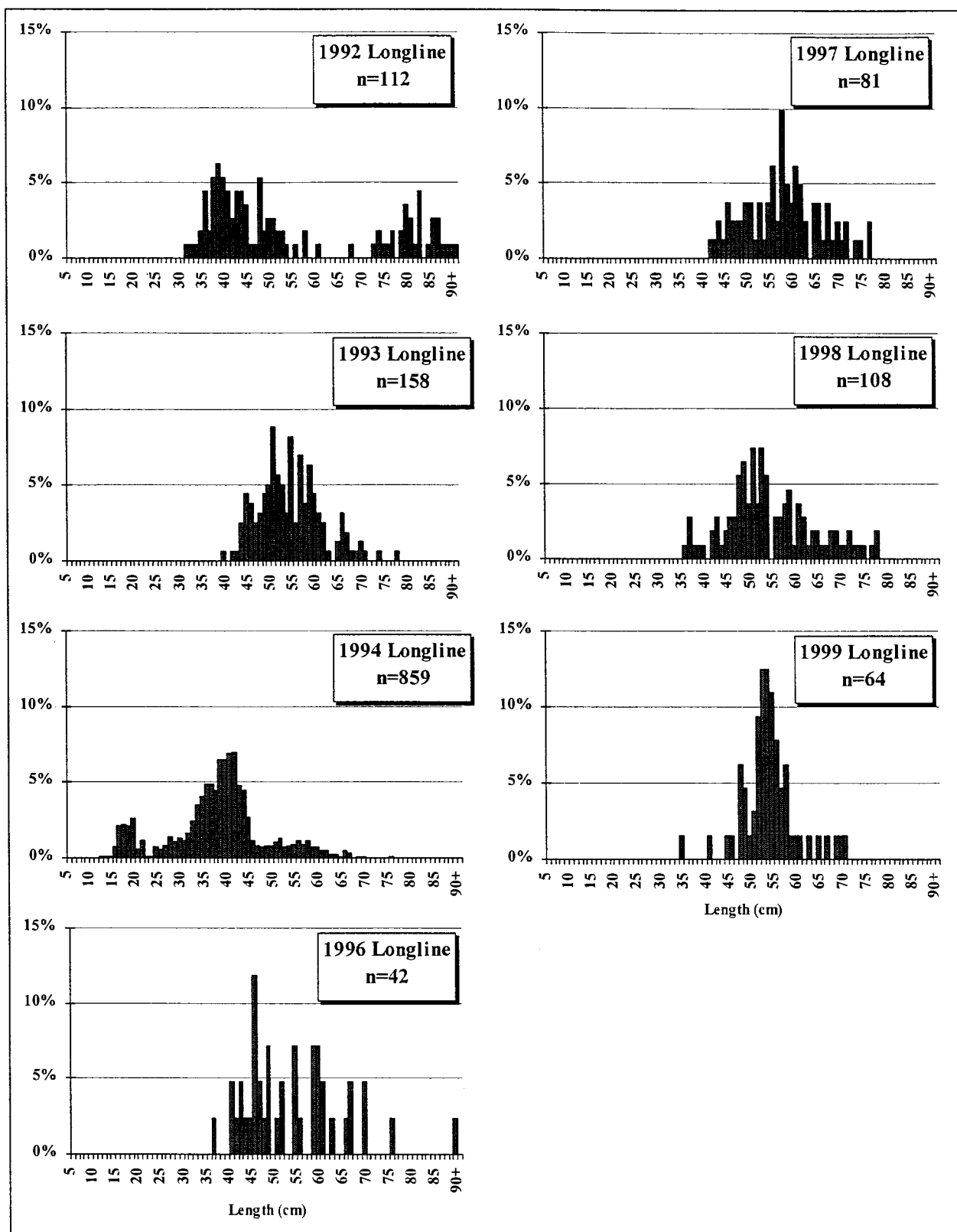


Figure 10. Length composition of rougheye rockfish sampled from longline catches in Prince William Sound, 1992-1999.

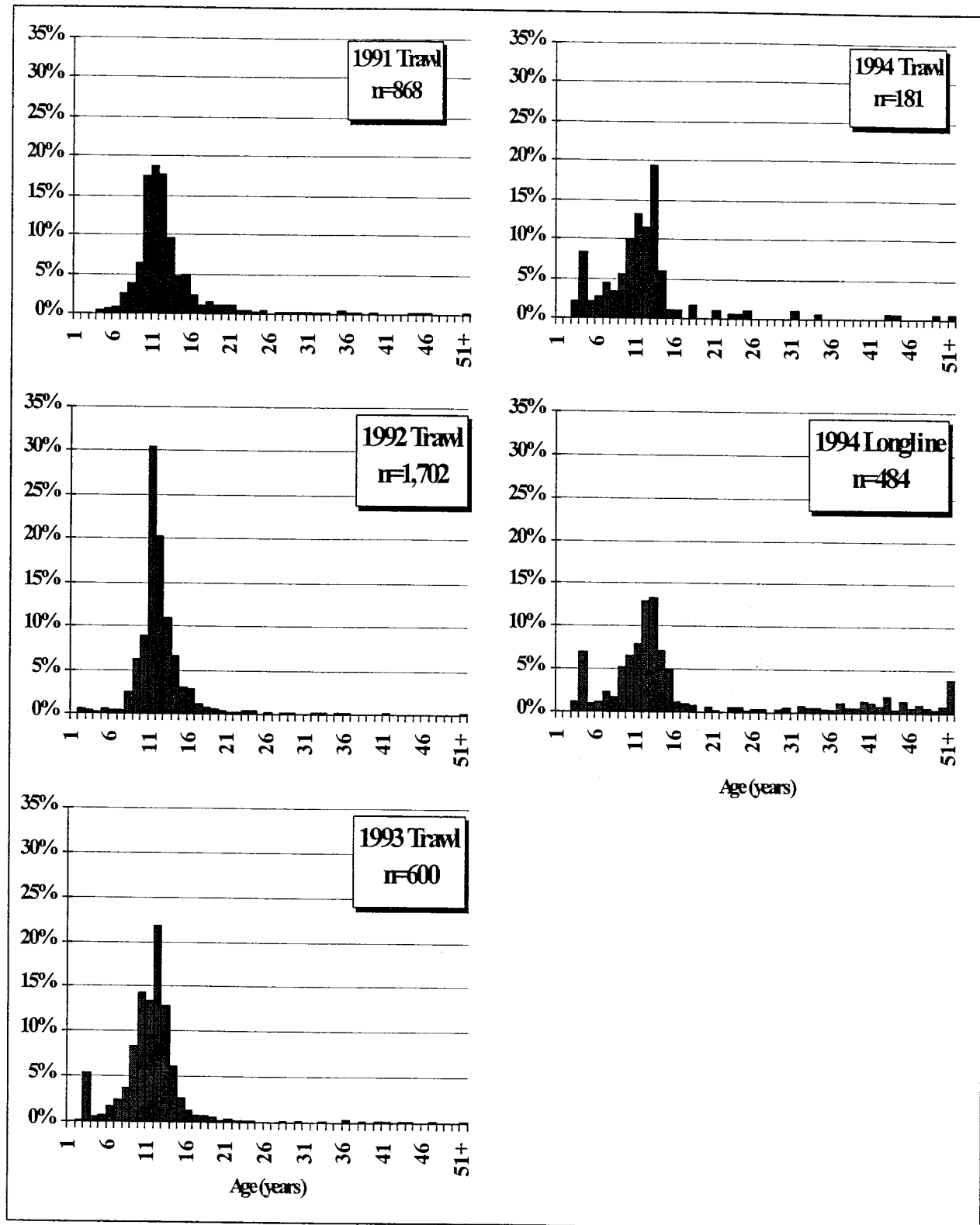


Figure 11. Age composition of roughey rockfish sampled from trawl and longline catches in Prince William Sound, 1991-1999.

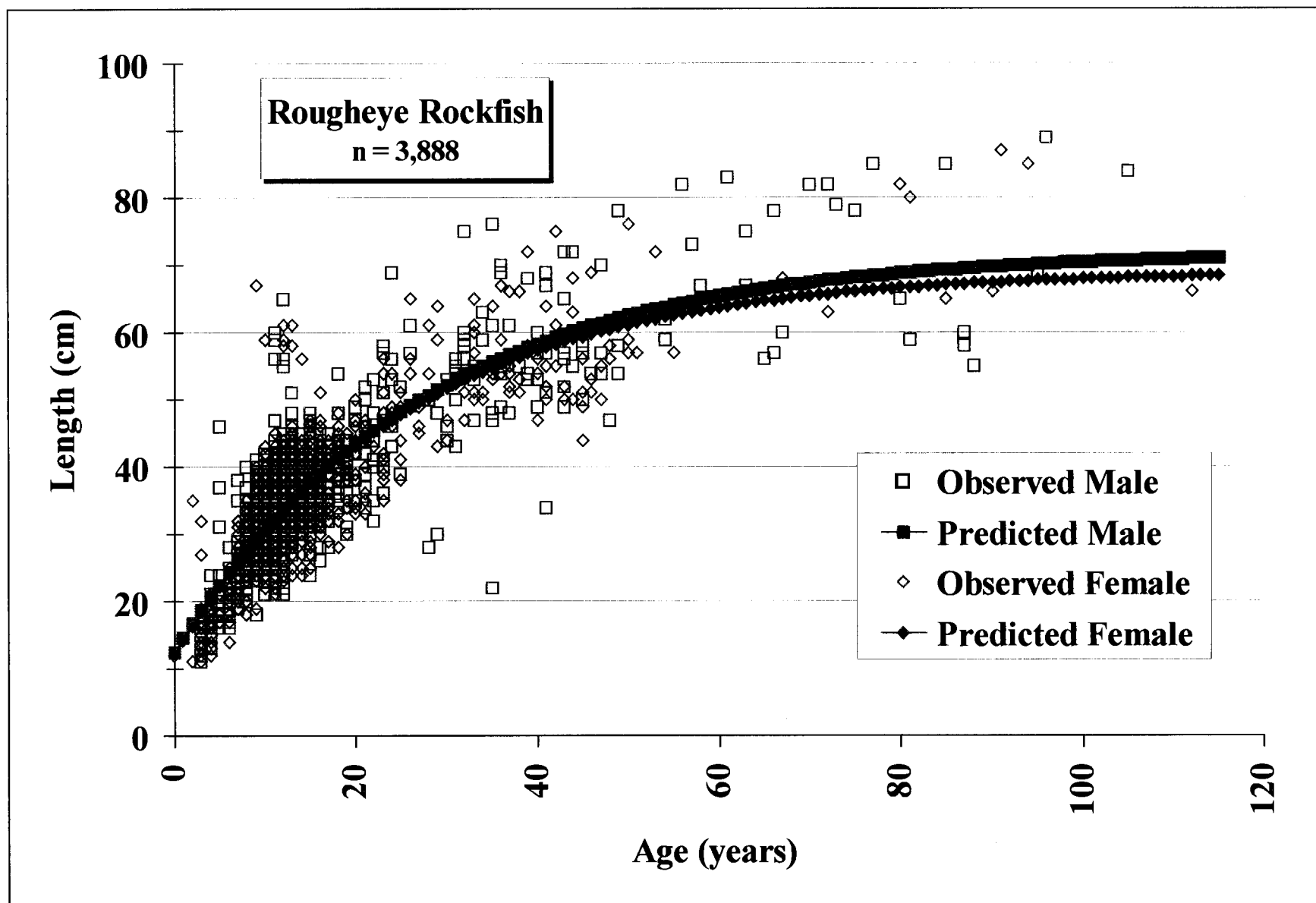


Figure 12. Size-at-age of rougheye rockfish sampled from Prince William Sound, 1991-1999.

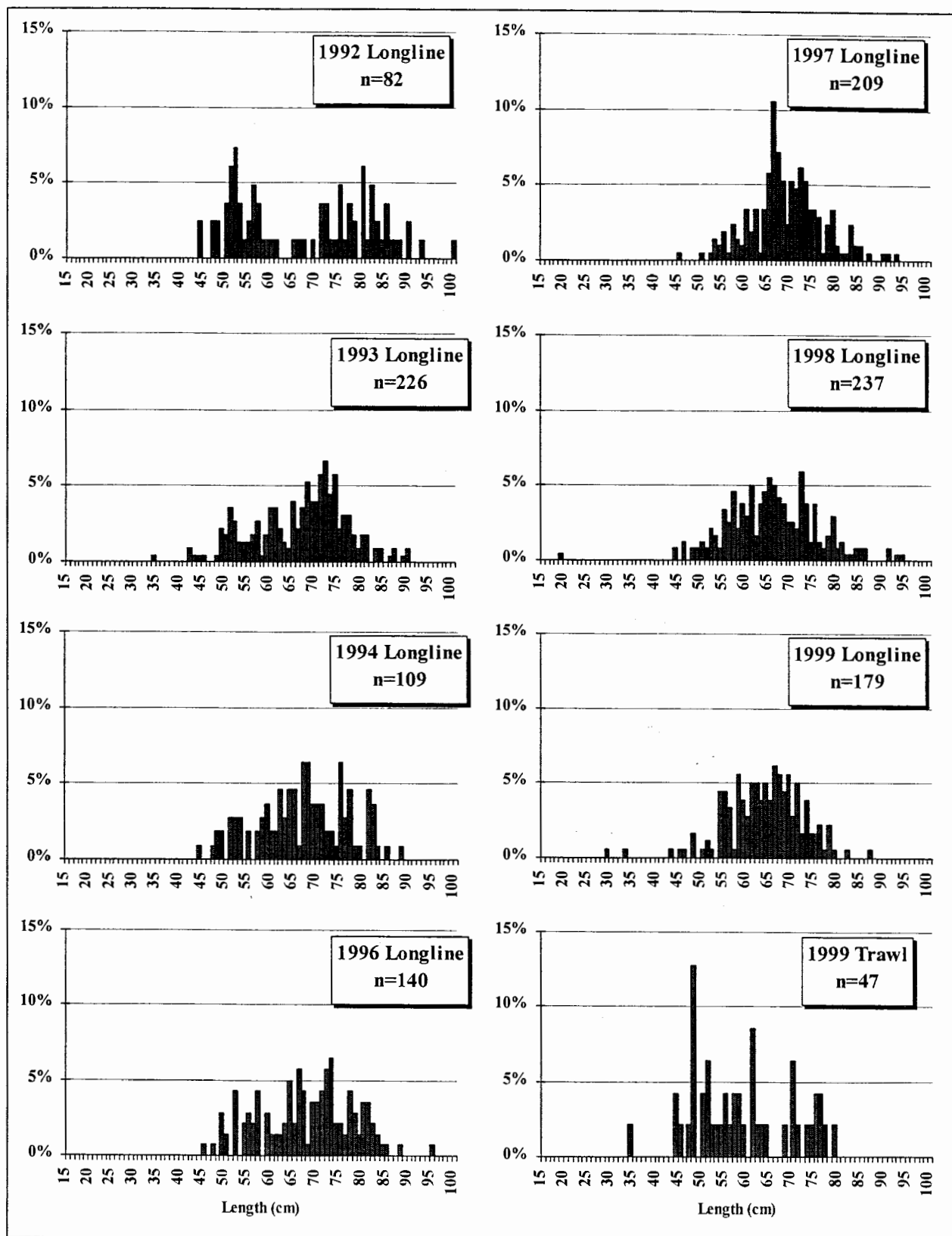


Figure 13. Length composition of shorttraker rockfish sampled from longline and trawl catches in Prince William Sound, 1992-1999.

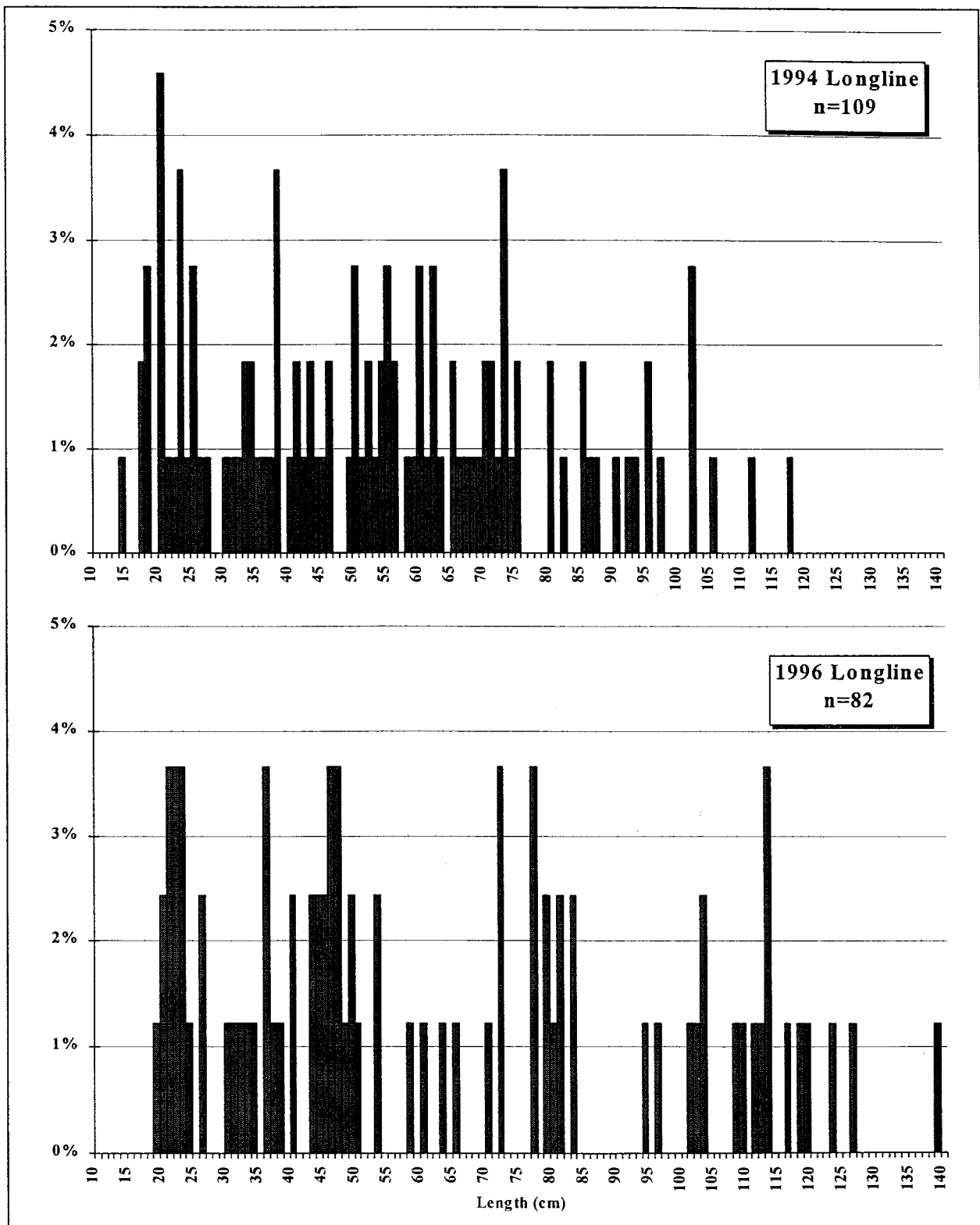


Figure 14. Age composition of shorttraker rockfish sampled from longline catches in Prince William Sound, 1994 and 1996.

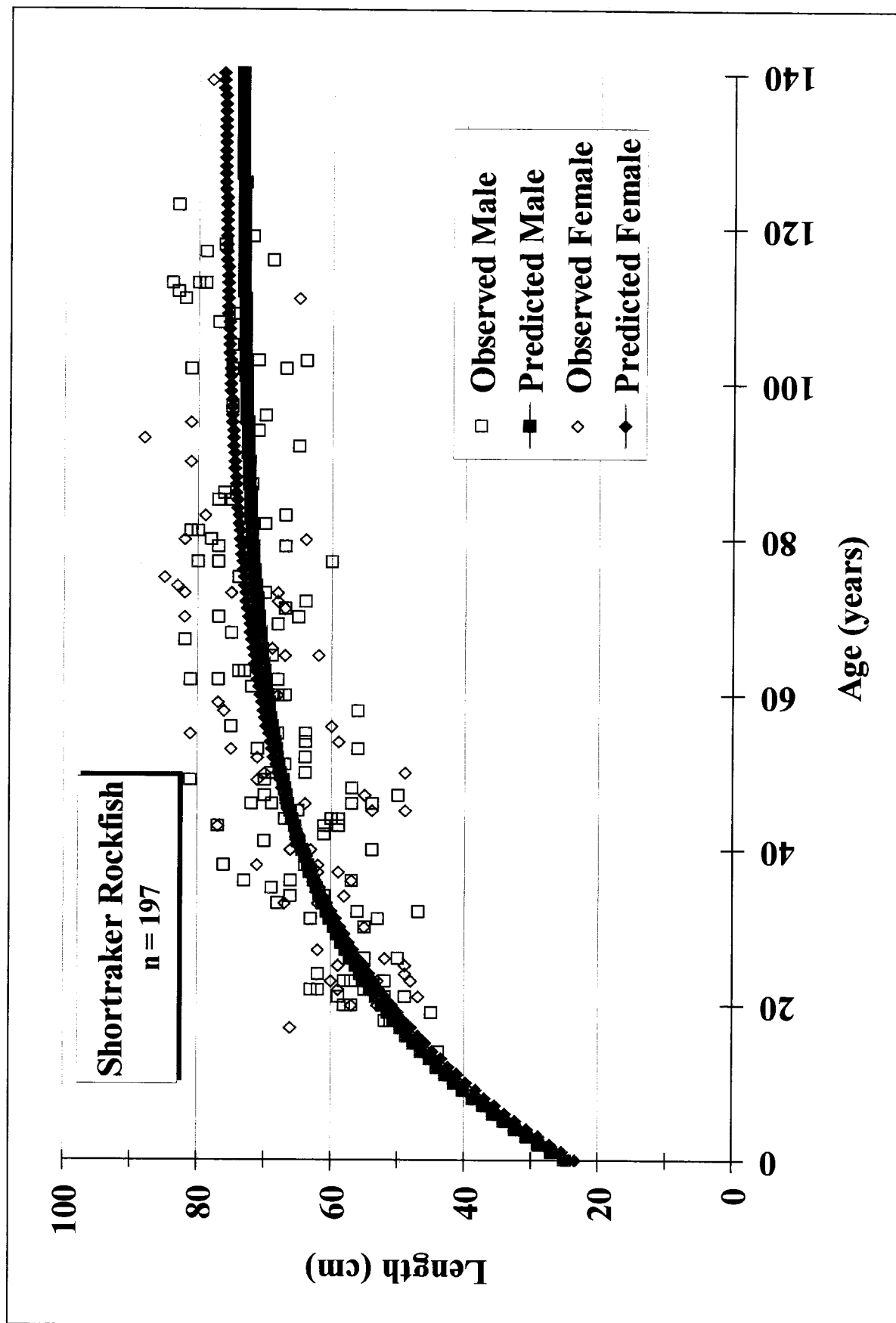


Figure 15. Size-at-age of shortraker rockfish sampled from Prince William Sound, 1994 and 1996.

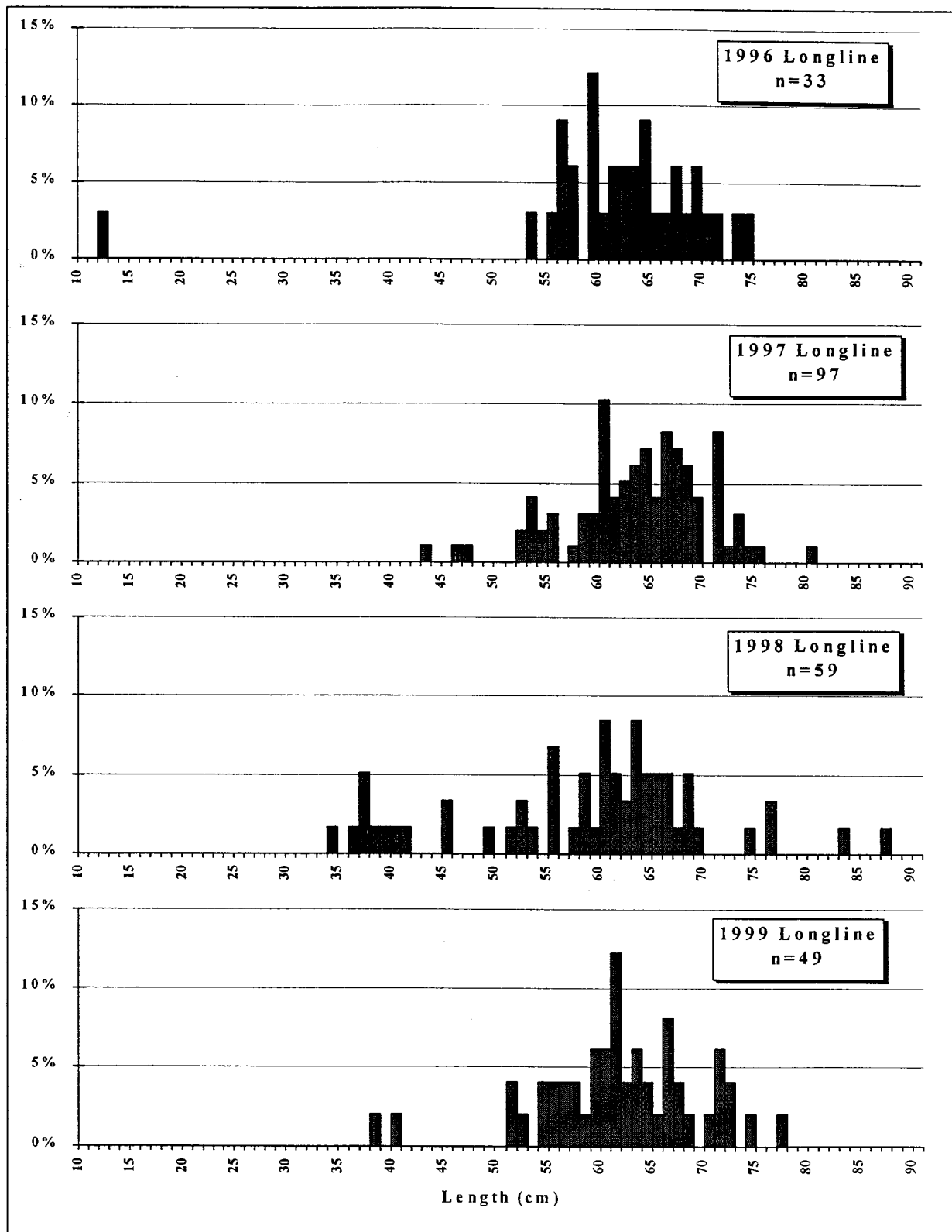


Figure 16. Length composition of shortspine thornyhead sampled from longline catches in Prince William Sound, 1996-1999.

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