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U.S. DEPARTMENT OF COMMERCE
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by
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ABSTRACT

The Alaska Fisheries Science Center conducted the second annual National Marine Fisheries Service (NMFS) longline survey to study the abundance and biological condition of sablefish (Anoplopoma fimbria) and other groundfish along the upper continental slope of the Gulf of Alaska during the summer of 1988. This survey replicated the 1987 survey, with some modifications to the sampling gear and a change in the bait from Pacific herring (Clupea pallasi) to Atlantic squid (Illex spp.). Sampled stations were the same as those used during the Japan-U.S. cooperative longline survey which has been conducted in the Gulf of Alaska from 1979 to 1988. In addition, 11 stations were sampled in gullies. The most notable change in abundance during the second NMFS survey was the decrease in sablefish and the increase in giant grenadiers (Albatrossia pectoralis) in the western Gulf of Alaska. Sablefish relative abundance was the highest of any species, followed by grenadiers. Sablefish abundance indices were highest in the 401-600 m depth interval and grenadiers were most abundant in 801-1,000 m. Those two species accounted for 83.1% of the total relative population number (RPN) and 93.9% of the relative population weight (RPW). Rockfish (Sebastes aleutianus and S. borealis), Pacific cod (Gadus macrocephalus), and arrowtooth flounder (Atheresthes stomias) together comprised 10.8% and 5.5% of the total RPN and total RPW.

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INTRODUCTION

Since 1979, annual longline surveys of sablefish (Anoplopoma fimbria) and other groundfish species have been conducted cooperatively by Japan and the United States. Initially the survey sampled the upper continental slope of the Gulf of Alaska, but it was later expanded to similar depths in-the Aleutian Islands region (1980) and in the eastern Bering Sea (1982). This research was conducted by Japanese and U.S. scientists using Japanese commercial fishing vessels chartered by the Fisheries Agency of Japan. The resultant data were analysed annually to estimate the relative abundance of sablefish and other groundfish (Sasaki 1987, Sigler 1987, Wakabayashi and Teshima 1987, Mito 1987, Sasaki and Teshima 1987).

In 1987 the National Marine Fisheries Service's (NMFS), Alaska Fisheries Science Center (AFSC), initiated a similar research program in the Gulf of Alaska using a chartered U.S. longline vessel. The second annual (1988) NMFS longline survey used the same station pattern, similar sampling gear, and was conducted during the same season as the Japan-U.S. cooperative longline survey in 1988. In addition, the NMFS longline survey sampled 11 stations in gullies adjacent to the upper continental slope (Figs. la and lb).

Three objectives guided the 1988 NMFS longline survey. The first objective was to determine the relative abundance and size composition of commercially important groundfish species found on the upper continental slope of the Gulf of Alaska, including

sablefish, shortspine thornyhead (Sebastolobus alascanus), rougheye rockfish (Sebastes aleutianus) and shortraker rockfish (Sebastes borealis). The second objective was to determine the relative abundance and size composition of other species caught during the survey, such as Pacific cod (Gadus macrocephalus), grenadiers (Macrouridae), arrowtooth flounder (Atheresthes stomias), and other incidental species. The third objective was to sample gullies on the continental shelf to compare catch rates and size compositions from these deepwater shelf regions with the adjacent slope.

The 1988 NMFS longline survey was conducted-jointly by two components of the AFSC: the Resource Assessment and Conservation Engineering Division in Seattle, Washington, and the Auke Bay Laboratory in Juneau, Alaska.

MATERIALS AND METHODS

Vessel and Gear

Survey operations were conducted aboard the chartered 35 m longline vessel Prowler. A description of the vessel, equipment, and crew complement appear in Sigler and Zenger (1989). A generalized diagram of longline gear is shown in Figure 2.

The total length of groundline set each day was 16 km (8.6 nmi). It was composed of 160 sections of longline gear, called skates, tied together; each skate was 100 m (55 fathoms) long and contained 45 circle hooks (7,200 hooks total). The Mustad No. 13/0 circle hooks were attached to 38 cm (15 in)

gangions that were secured to beckets tied into the groundline at 2 m (6.5 ft) intervals. Five meters (16 ft) of groundline were left bare on the ends of each skate. Gangion, becket, and groundline materials were medium lay No. 60 braided nylon, medium lay No. 60 thread braided nylon (newer skates contained beckets of medium lay No. 72 braided nylon), and medium lay 9.5 mm (3/8 in) Goldline, respectively. Each end of the groundline was attached sequentially to 366 m (200 fm) of Goldline, a 27 kg (60 lb) anchor, 92 m (50 fm) Goldline, a 16 kg (35 lb) piece of chain (to dampen the effects of wave surge on the buoyline), 92 m of 9.5 mm polypropylene line, a buoyline made of 183-1,281 m (l00-700 fm) Goldline, and at the surface, a buoy array and flag. The groundline was weighted with 3.2 kg (7 lb) lead balls attached with snaps to the end of each skate. Hooks were baited by hand with chopped squid at a rate of about 5.5 kg (12 lb) per 100 hooks.

The standard Japanese survey gear was modified for the U.S. survey to more closely match methods used in the U.S. commercial fishery and to adapt to/differences between the Japanese and U.S. commercial fishing vessels. The circle hooks used in the NMFS longline survey replaced the "tara" (J-shaped) hooks that were used in the cooperative longline survey. The U.S. survey gear was set in two equal parts laid end to end because the Prowler did not have a second line hauler to retrieve intermediate buoylines. On the Japanese vessel used in the cooperative survey, 160 skates were set in a continuous groundline with

buoylines, buoy arrays, and flags at each end and two buoylines and buoy arrays in between.

The 1988 NMFS longline survey incorporated four changes based on the experience gained from the first NMFS survey. First, Atlantic squid (Illex spp.) was used for bait instead of Pacific herring (Clupea pallasi); second, the gangions were changed from No. 48 stiff lay braided nylon to No. 60 medium lay braided nylon; third, 3.2 kg lead balls were snapped on at the end of each skate of gear instead of a combination of lead balls and clusters of seine weights; and fourth, Mustad 13/0 circle hooks replaced Eagle Claw No. 7 circle hooks.

Survey Area and Operations

The upper continental slope from the Islands of Four Mountains (lat. 52°45'N, long. 170°W) eastward to Dixon Entrance (lat. 54°30'N, long. 133°00'W) was sampled at a rate of one station per day (Fig. la) in 1987 and 1988. These correspond to station numbers 62-108 of the Japan-U.S. cooperative longline survey (Yoshimura and Sasaki 1987). In addition, three stations (nos. 54-56) were sampled in Shumagin Gully, four (nos. 48-51) in Shelikof Trough, one (no. 57) off Kodiak Island, one (no. 59) in. Amatuli Gully, one (no. 60) in Spencer Gully, and one (no. 52) in Ommany Trench (Figs. la and lb).

The survey was conducted from 6 July to 17 September 1988 and was divided into three legs of 23-24 days each. Leg 1 began at the Islands of Four Mountains and sampled eastward to the

Shelikof Trough; leg 2 continued the survey eastward to near the W-grounds; and leg 3 completed the sample pattern southward to Dixon Entrance (Fig. lb).

The longline gear was set from shallow to deep depths and was retrieved in the same order, except on infrequent occasions when the groundline parted or wind and sea conditions dictated that it be pulled from the opposite direction. Setting and retrieval began at about 0630 and 0930 hours ADT, respectively, and retrieval was completed at about 1900 hours. Soak time ranged from 3 to 10 hours.

Data Collection

Fish species and hook condition were recorded as the sampling gear was retrieved. Hook condition was classified as baited, bare, or ineffective (missing, broken, or tangled). Time and depth in meters were recorded when the first, last, and every fifth skate came aboard and also when depth strata changed, where strata l-8 were 0-100 m, 101-200 m, 201-300 m, 301-400 m, 401-600 m, 601-800 m, 801-1,000 m, and l,00l-1,200 m, respectively.

The lengths of sablefish, Pacific cod, grenadiers, arrowtooth flounder, rockfish (Sebastes spp.), and thornyheads (Sebastolobus spp.) were measured. Two species, sablefish and Pacific cod, were sorted by depth stratum before sex and length were determined. Subsamples of sablefish and Pacific cod were measured when catches were large; otherwise all fish were measured. Pacific halibut were not measured but were counted and

released at the rail.

Analytical Methods

Catches were stratified based on the recorded depth of every fifth skate or the interpolated depth of the intervening four skates. The number of fish caught per skate for each station was adjusted for ineffective (e.g., lost or broken) hooks by the following formula:

$$N_c = \frac{N}{45 - M} * 45 ,$$

where Nc is the adjusted number of fish caught per skate by species, N is the unadjusted number, M is the number of ineffective hooks, and 45 is the number of hooks per skate. The number of fish caught per skate was not adjusted for bait loss. The average number of fish caught per skate or catch-per-unit-effort (CPUE) was calculated by species from the adjusted data for each stratum of a station. The data for a given skate were excluded in the CPUE computation when the number of ineffective hooks was greater than five for that skate.

Relative population number (RPN, an index of abundance in numbers) for each species or species group were computed from CPUE by stratum (Sasaki 1985, Gulland 1969, Quinn et al. 1982). The RPN values were determined for each stratum between 201 and 1,000 m and for the five International North Pacific Fisheries Commission (INPFC) Gulf of Alaska statistical areas (Fig. la).

For depths less than 201 m or greater than 1,000 m, RPN was not computed because those depths were sampled intermittently. The CPUE for each stratum of a station was multiplied by the area (km*) of the stratum (Table 1) and the resultant values were averaged within the INPFC area to obtain an RPN for each stratum. These RPN values were summed across strata to derive a total RPN for each INPFC area and then summed across all INPFC areas to calculate a grand total RPN for the Gulf of Alaska.

The abundance indices apply only to the portion of the species' population resident on the upper continental slope. We believe that the ranges of adult populations of sablefish, rougheye and shortraker rockfish, and shortspine thornyhead are largely encompassed by the survey area. Other populations such as Pacific cod, Pacific halibut, rockfish species other than rougheye and shortraker rockfish, grenadiers, and arrowtooth flounder, are distributed over broader regions than those surveyed and thus are only partially represented in abundance estimates.

The depth intervals and areas used to calculate RPN for this survey differ from those used to calculate RPN for the Japan-U.S. cooperative surveys. Estimates from the cooperative surveys (Sasaki 1987, Sigler 1987) included gullies and parts of the continental shelf, even though only a small fraction of those regions was surveyed. Thus, the cooperative survey RPN was apparently overestimated at l00-1,000 m (Sigler 1987).

Length frequencies were computed to examine the size compositions of each species. Relative population number adjusted length frequencies (RPN-LF) by stratum and INPFC area were computed for the 201-1,000 m depth intervals by the following method. For each stratum within a station, RPN was allocated to each centimeter increment of the length frequency based on the relative number (RPN) of fish caught at that increment. The resultant RPN-LF by station and stratum was averaged within the INPFC area to calculate an RPN-LF by stratum and INPFC area. For sablefish and Pacific cod at depths of 101-200 m, a catch-per-skate-weighted length frequency (CPUE-LF) was computed for each INPFC area by the same procedure used to compute RPN-LF. A CPUE-LF was calculated instead of an RPN-LF because RPN was not estimated for those depths.

Relative population weights (RPW, an index of biomass) were computed to assess relative biomasses of sablefish, Pacific cod, grenadiers, arrowtooth flounder, rougheye and shortraker rockfish, and shortspine thornyheads. For each species, the appropriate length-weight equation (Table 2) was applied to RPN-LF by stratum and INPFC area to compute corresponding RPW-weighted length frequencies. These weighted length frequencies were summed across lengths to calculate an RPW for each stratum within an INPFC area. These RPWs were summed across strata to calculate an RPW for each INPFC area and then across INPFC areas to calculate a total RPW for the Gulf of Alaska.

Sebastes spp. were tallied as "rockfish" as they came aboard and were identified to species when their lengths were measured. As a result, the computation of RPN-LF and RPW for rougheye and shortraker rockfish follows a modified procedure. We assume all rockfish at depths greater than 201 m are rougheye and shortraker rockfish because those two species comprised nearly all (88%) of the rockfish caught during the survey and were all caught below 201 m. Weighted length frequencies (RPN-LF) were calculated for rougheye and shortraker rockfish for each station by allocating the station's rockfish RPN to each centimeter increment of the station's length frequency distribution based on the relative numbers of each species caught at that increment. The resultant RPN-LF by station were averaged within each INPFC area to calculate an RPN-LF by INPFC area. An RPW then was calculated for each species as described above.

The bootstrap method (Efron 1982, Efron and Tibshirani 1986) was used to compute RPN confidence intervals. The method is similar to that used by Sigler and Fujioka (1988). For our application, stations were randomly sampled with replacement within each INPFC area. A value denoted $RPN_{i,k}$ where i = INPFC area and k = species was computed from the CPUE of the sampled stations by the method of RPN calculation described above. The $RPN_{i,k}$ were summed across area to compute RPNk*, the total for the Gulf of Alaska. Sampling with replacement and the computation of the RPN_k* were repeated 1,000 times producing a bootstrap distribution of 1,000 RPNk*.

Efron and Tibshirani (1986) outlined methods for setting an approximate confidence interval from a bootstrap distribution for a statistic of interest, here RPNk*. They considered the use of the simplest method, the percentile method, to be correct if the bootstrap distribution of the statistic of interest was described by a normal distribution. Normality of the bootstrap distribution was tested using the D'Agostino D Test (D'Agostino and Stephens 1986) and in most cases the null hypothesis of normality was accepted, thus justifying the use of the percentile method. In the remaining cases where the null hypothesis of normality was rejected, the bias-corrected percentile method recommended by Efron and Tibshirani (1986) was applied.

RELATIVE ABUNDANCE AND BIOLOGICAL CONDITION

Sablefish

Longline survey catches indicated that sablefish was the most abundant species of the groundfish population along the upper continental slope both in numbers and weight; the RPN and RPW for sablefish were 58.5% and 61.4% of their respective totals for the Gulf of Alaska (Tables 3 and 4). By INPFC area, the percentage of sablefish was the highest of any species, although grenadiers closely followed sablefish in terms of RPW in the Shumagin and Chirikof INPFC areas (Table 4). Sablefish ranked first in all depth strata except depths 801-1,000 m, where the percentage (RPN and RPW) of grenadiers was slightly higher (Tables 5 and 6).

The RPN and RPW for sablefish were largest in the Kodiak INPFC area and smallest in the Southeastern INPFC area (Fig. 3a, Tables 7 and 8). By stratum, the sablefish RPN and RPW were highest for the intermediate depths, 401-600 m and 601-800 m, and lowest for the remaining three strata 201-300 m, 301-400 m, and 801-1,000 m (Fig. 3b, Tables 5 and 6).

The percentages of the overall RPN and RPW attributable to sablefish were markedly lower in 1988 compared with 1987; in 1987 these percentages were 72.0% and 80.0%, respectively (Sigler and Zenger 1989). In comparison, catch rates of grenadiers increased in 1988 (24.6%, expressed as a percentage of the RPN for the Gulf of Alaska, Table 3) compared with 1987 (8.53%). The decreased sablefish proportion may be due to decreased sablefish abundance, increased grenadier abundance, or an untested bait effect. The INPFC area with the highest RPN and RPW for sablefish changed from the Shumagin INPFC area in 1987 to the Kodiak INPFC area in 1988.

Most of the male sablefish (72.6%) were medium sized, ranging from 57 to 66 cm fork length (FL) and most of the female sablefish (78.4%) were larger than 66 cm FL (Table 9, Fig. 4). More males (5.5%) were smaller (less than 57 cm FL) than females (1.9%). The percentage of small males and females has declined since 1987, when they were 10.9% and 4.1%, respectively (Sigler and Zenger 1989). For both sexes combined, the percentage of large fish generally increased with depth, whereas the percentage of medium-sized fish generally decreased with depth (Fig. 5).

The length compositions of fish sampled in the 101-200 m depth range from previous Japan-U.S. cooperative longline surveys were used to document the relatively strong 1977 and 1980 year classes; modes at lengths less than 62 cm FL often were associated with these two relatively strong year classes (Sigler and Fujioka 1988). Length compositions from the NMFS longline survey for 1987 and 1988 demonstrated similar length modes in the Shumagin, Yakutat, and Southeastern INPFC areas, suggesting the presence of a year class which was stronger than the adjacent year classes and whose members were growing in length (Fig. 6). Other reports have suggested that the 1984 year class may be strong (Sigler 1987, McDevitt 1987, Sigler 1988, Sigler and Zenger 1989), however the modal lengths from the NMFS longline survey generally were greater than expected for 3-year-old fish in 1987 and 4-year-old fish in 1988 (McFarlane and Beamish 1983), and thus, we are uncertain if they represent the 1984 year class. Alternatively, the progression of modes may be due to changes in the distribution of fish rather than the growth of fish remaining in a particular INPFC area.

Compared with the adjacent regions of the upper continental slope, sablefish catch rates were higher for Shelikof Trough, Albatross Bank, Amatuli Gully, and Spencer Gully and lower for Shumagin Gully during 1988 (Table 10). These differences were not significant however ($P > 0.10$, t-test, Snedecor and Cochran 1967).

Length frequency distributions for Shelikof Trough and the adjacent upper slope region were not statistically different (Fig. 7), whereas length frequencies from the other gullies and Albatross Bank and their respective adjacent upper slope regions were significantly different ($P < 0.05$, Kolmogorov-Smirnov goodness of fit test, Zar 1984). Large sablefish (> 66 cm FL) were much less abundant in Shumagin Gully compared with the adjacent continental slope. The principal length frequency mode for Spencer Gully was smaller than that of the adjacent upper continental slope (Fig. 7). This suggests that in most cases, the gully and slope populations are different.

Shortraker and Rougheye Rockfish

Rockfish was the third most abundant species group in number and the fourth most abundant by weight (Tables 3 and 4). Their RPN and RPW were highest at depths 201-400 m and in the Shumagin, Yakutat, and Southeastern INPFC areas (Fig. 8). Shortraker rockfish RPW was almost twice as high as that of rougheye rockfish (Table 4). Shortraker rockfish RPW was greater than rougheye rockfish abundance in the Shumagin, Kodiak, and Yakutat INPFC areas. The difference was especially large in the Yakutat INPFC area.

Rougheye rockfish RPW was almost twice as high as shortraker rockfish RPW in 1987, whereas shortraker rockfish dominated by weight in 1988. The change from 1987 to 1988 is primarily due to decreased catches of rougheye rockfish in the Southeastern INPFC

area and increased catches of shortraker rockfish in the Shumagin, Chirikof, Kodiak, and Yakutat INPFC areas (Fig. 9). In 1987, the RPN and RPW for rockfish were highest in the Yakutat and Southeastern INPFC areas (Sigler and Zenger 1989), whereas in 1988, they were highest in the Shumagin, Yakutat, and Southeastern INPFC areas.

Shortraker rockfish were generally larger than rougheye rockfish (Figs. 10a and b), which helps to explain the striking differences in their relative biomasses. For both species, sizes were distributed over a relatively wide range. Shortraker and rougheye rockfish lengths ranged from 35 to 80 cm FL and from 30 to 60 cm FL, respectively.

Thornyheads

Thornyheads were a relatively minor component of the survey catches, comprising 2.8% of the Gulf-wide RPN for all species, (Table 3) and 0.5% of the RPW (Table 4). Shortspine thornyheads accounted for almost all of the thornyhead catch. The RPN and RPW were highest in the Shumagin INPFC area and lowest in the Southeastern INPFC area (Tables 3 and 4 and Fig. 11). The thornyhead RPN was similar over the entire range of depths sampled during the survey except in the deepest stratum, 801-1,000 m, where the RPN was somewhat lower (Fig. 11). Fish in the 30-40 cm FL category dominated the thornyhead population in all INPFC areas (Fig. 10c).

Thornyheads comprised 4.3% (Sigler and Zenger 1989) of the Gulf-wide RPN in 1987 and 2.8% in 1988.

Pacific Cod

This survey did not adequately sample Pacific cod stocks in the Gulf of Alaska. During the summer, Pacific cod are common on the continental shelf in relatively shallow water, whereas sampling occurred mostly on the upper continental slope or in gullies at depths greater than 200 m. However, catch per unit effort and size composition provide indices of abundance and information on the biological condition of the stock.

Pacific cod ranked fourth in number and third by weight (Tables 3 and 4). Pacific cod RPN and RPW were highest in the Shumagin INPFC area, about four times as large as in the Chirikof, Kodiak, and Yakutat INPFC areas (Fig. 12a). Catches of cod were restricted mostly to depths less than 300 m (Fig. 12b). The 1988 RPN increased slightly and the RPW remained the same compared with the 1987 survey. The principal difference was that the apparent center of cod abundance shifted more toward the Shumagin INPFC area.

Male and female cod had similar size compositions (Figs. 13 and 14). A distinct mode at 55 cm, corresponding to age 3+ (Niggol 1982), indicated that the 1985 year class had recruited to the adult population, and that it appeared to be slightly smaller than the 1984 year class that recruited during the previous year (Sigler and Zenger 1989).

Miscellaneous Species

Grenadiers were the second most abundant fish caught in the survey in terms of both RPN and RPW (Tables 3 and 4). Grenadier RPN was highest in the Chirikof and Shumagin INPFC areas, low in the Yakutat INPFC area, very low in the Southeastern and Yakutat INPFC areas, and increased with depth without exception (Fig. 15). The most common grenadier species was the giant grenadier, (Albatrossia pectoralis). Another species, Pacific grenadier (Coryphaenoides acrolepis), was caught less frequently. A mode was present at 30 cm anal vent length (length from tip of snout to vent) in the Shumagin, Chirikof, and Kodiak INPFC areas and at 18 cm and 26 cm in the Yakutat INPFC area (Fig. 16).

The grenadier RPN for the Gulf of Alaska increased by four times from 1987 to 1988. This group comprised 8.5% of the Gulf-wide RPN for all species in 1987, (Sigler and Zenger 1989) and 24.6% in 1988 (Table 5). Gross fluctuations in the apparent abundance of grenadiers have been observed previously in the Japan-U.S. cooperative longline survey (Sasaki 1987).

Arrow-tooth flounder was the fifth most abundant species in terms of RPN and fourth in terms of RPW (Tables 3 and 4) and was the most abundant flatfish in the Gulf of Alaska. Both RPN and RPW were highest in the Shumagin INPFC area and lowest in the Southeastern INPFC area. Fish from 50 to 65 cm FL dominated the arrow-tooth population in the Yakutat, Kodiak and Southeastern INPFC areas (Fig. 17). Modes were present at 62 cm FL in the Shumagin INPFC area, 56 and 71 cm FL in Chirikof and Kodiak INPFC

areas, and 60 cm FL in the Yakutat and Southeastern INPFC areas (Fig. 18).

Arrowtooth flounder comprised, 3.3% of the Gulf-wide RPN for all species, a slight decrease from 4.6% in 1987. Their depth distribution did not change from that of 1987, whereas their length frequency distributions shifted; the major mode was at 70 cm FL in 1987 and 60 cm FL in 1988.

Pacific halibut were the seventh most abundant species caught during the survey. This group comprised 1.8% of the Gulf-wide RPN for all species (Table 3). RPWs were not estimated for Pacific halibut. Pacific halibut were released rather than hauled aboard to minimize handling and injury and as a result no size measurements were taken. The PPNs for Pacific halibut were similar in the Shumaginin Kodiak, Yakutat, and Southeastern INPFC areas (Fig. 19) and was much lower in the Chirikof INPFC area. The RPN was greatest at depths 201-300 m (Fig. 19) for all INPFC areas; at this depth, Pacific halibut was the fourth most abundant species caught. The proportion of Pacific halibut compared with sablefish expressed in percent was highest at depths of 201-300 m, and it decreased with depth: 1.5% at 201-300 m, 0.4% at 301-400 m, and it was not present at depths greater than 400 m.

The proportion of Pacific halibut caught was similar in 1987 and 1988. The percentage of the Gulf-wide RPN attributable to Pacific halibut decreased only slightly: from 2.0% in 1987 (Sigler and Zenger 1989) to 1.8% in 1988 (Table 3).

Skates (Order Rajiformes) were a relatively minor component of the total catch (Table 3) and were not identified to species. In 1988, skate abundance was similar to that observed in 1987. Skates comprised 0.4% of the Gulf-wide RPN for all species (Table 5) compared with 0.3% in 1987 (Sigler and Zenger 1989). Length was not recorded for skates, thus no RPW was calculated. Their abundance was highest in the Shumagin INPFC area and at 201-300 m in depth.

Forty-two other species or species groups were captured during the survey. Twenty-nine of these actively took the baited hooks (Table 11). The remaining 13 were incidentally snagged on the bottom or in the water column and include jellyfishes, sea anemones, tubeworms, sponges, sea cucumbers, Alaska false jingles, skate egg cases, sea pens, sea squirts, scallops, coral, and fucus.

CITATIONS

D'Agostino, R. B., and M. A. Stephens (eds.). 1986. Goodness-of-fit techniques. Marcel Dekker, Inc. New York. ,560 p.

Efron, B. 1982. The jackknife, the bootstrap and other resampling plans. CBMS-NSF Regional Conference Series in Applied Mathematics 38, Soc. Ind. Appl. Math., 92 p. Arrowsmith Ltd., Bristol, England.

Efron, B., and R. Tibshirani. 1986. Bootstrap methods for, standard errors, confidence intervals, and other measures of statistical accuracy. Stat. Sci. 1:54-77.

Gulland, J. A. 1969. Manual of methods for fish stock assessment. Part 1. Fish population analysis. St. Paul's Press Ltd., Malta, Italy, 154 p.

McDevitt, S. A. 1987. Sablefish. In R. G. Bakkala, and J. W. Balsiger (eds.). Condition of groundfish resources of the eastern Bering Sea and Aleutian Islands Region in 1986, p* 97-116. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-117.

McFarlane, G. A., and R. J. Beamish. 1983. Biology of adult sablefish (Anoplopoma fimbria) in waters off western Canada.' Proc. Int. Sablefish Symposium. March 29-31, 1983. Anchorage, Alaska.

Mito, K-i. 1987. Stock assessment of rockfishes and thornyheads in the eastern Bering Sea and Aleutian Islands Region in 1987. Unpubl. manuscr., 10 p. Far Seas Fish. Lab., Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan.

Niggol, K. 1982. Data on fish species from Bering Sea and Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-29, 125 p.

Quinn, T. J., II., S.,H. Hoag, and G. M. Southward. '1982. Comparison of two methods of combining catch-per-unit-effort data from geographic regions. Can. J. Fish. Aquat. Sci. 39:837-846.

Sasaki, T. 1985. Studies on the sablefish resources in the north Pacific Ocean. Bull. 22, Far Seas Fish. Res. Lab. 1000 Orido, Shimizu, 424, Japan, 108 p.

Sasaki, T. 1987. Stock assessment of sablefish in the Bering Sea, Aleutian Islands Region, and the Gulf of Alaska in 1987. Unpubl. manuscr., 33 p. (Document submitted to the annual meeting of the International North Pacific Fisheries Commission, Vancouver, November 1987.) FarSeas Fish. Lab.,

Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan.

Sasaki, T. and K. Teshima. 1987. Data report of abundance indices of flatfishes, rockfishes, shortspine thornyhead and grenadiers based on the results from Japan-U.S. joint longline surveys, 1979-1986. Unpubl. manuscr., 26 p. Far Seas Fish. Res. Lab., Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan.

Sigler, M. F. 1987. Preliminary assessment of the Gulf of Alaska sablefish population based on the Japan-U.S. cooperative longline survey, 1986. NWAFC Processed Rep. 87-14, 28 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, AK 99801.

Sigler, M. F. 1988. Assessment of Gulf of Alaska sablefish based on the Japan-U.S. cooperative longline survey, 1987. In T. K. Wilderbuer (ed.), Condition of groundfish resources of the Gulf of Alaska in 1988, p. 243-273. U.S. Dep. Commer . , NOAA Tech. Memo. NMFS F/NWC-165.

Sigler, M. F., and J. T. Fujioka. 1988. Evaluation of variability in sablefish, Anoplopoma fimbria, abundance indices in the Gulf of Alaska using the bootstrap method. Fish. Bull., U.S. 86:445-452.

Sigler, M. F., and H. H. Zenger, Jr. 1989. Assessment of Gulf of Alaska sablefish and other groundfish based on the domestic longline survey-, 1987. U.S. Dep. Commer., NOAA Tech Memo. NMFS F/NWC-169,. 54 p.

Snedecor, G. W., and W. G. Cochran. 1967. Statistical methods, 6th edition. Iowa State Univ. Press; Ames, 593 p.

Wakabayashi, K., and K. Teshima. 1987. Stock assessment of rockfishes and thornyheads in the Gulf of Alaska in 1987. Unpubl. Manuscr., 10 p. Far Seas Fish. Res. Lab., Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan.

Yoshimura, T., and T. Sasaki. 1987. Preliminary report on Japan-U.S. joint longline survey by Fukuyoshi Maru No. 8 in 1986. Unpubl. manuscr., 21 p. (Document submitted to the annual meeting of the International North Pacific Fisheries Commission, Vancouver, November 1987). Far Seas Fish. Res. Lab., Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan.

Zar, J. H. 1984. Biostatistical analysis, second edition. Prentice-Hall, Inc. Englewood Cliffs, NJ. 718 p.

Table 1.--Area (km*) of the upper continental slope of the Gulf of Alaska by International North Pacific Fisheries Commission (INPFC) statistical area and depth.

	INPFC Statistical Area				
Depth (m)	Shumagin	Chirikof	Kodiak	Yakutat	Southeastern
201-300	2,737	1,533	1,626	1,494	891
301-400	1,264	817	1,480	1,494	891
401-600	2,269	1,766	2,255	1,666	822
601-800	1,629	1,955	1,923	1,470	1,006
801-1,000	1,248	2,012	2,296	1,489	1,165
201-1,000	9,147	8,083	9,580	7,613	4,775

Sources : Shumagin, Chirikof, and Kodiak INPFC areas and Yakutat INPFC area from long. 147" to long. 144": E. Brown, Alaska Fisheries Science Center, RACE Division, 7600 Sand Point Way NE., BIN C15700, Seattle, WA 98115, Pers. commun., 1985. Yakutat INPFC area from long. 144" to long. 135" and Southeastern INPFC area: R. Haight, Alaeka Fisheries Science Center, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, AK 99801-8626, Pere. commun., 1986.

Table 2.--Length-weight parameters used to calculate relative population weight with the relationship, $W = aL^b$. Length is expressed in centimeters and weight is expressed in kilograms.

Species	a	b
Sablefish	2.99×10^{-6}	3.30
Pacific cod	3.06×10^{-6}	3.21
Giant grenadiers	7.20×10^{-4}	2.54
Arrowtooth flounder	3.46×10^{-6}	3.16
Rougheye rockfish	6.41×10^{-6}	3.17
Shortraker rockfish	1.31×10^{-6}	3.42
Shortspine thornyhead	5.49×10^{-6}	3.14

Sources: Sablefish from Sasaki (1985). Giant grenadiers from Sasaki, Far Seas Fisheries Research Laboratory, 1000 Orido, Shimizu 424, Japan. Pers. commun., 1987. The length-weight relationship for giant grenadiers was applied to both species of grenadiers. Remaining species from E. Brown, Alaska Fisheries Science Center, RACE Division, 7600 Sand Point Way NE., BIN C15700, Seattle, WA 98115. Pers. commun., 1987.

Table 3.--Relative population number (RPN) eummed by International North Pacific Fisheries Commieeion (INPFC) statistical area and expressed as percentage of the total Gulf of Alaska RPN. SF = sablefish, PC = Pacific cod, GR = grenadiers, HB = Pacific halibut, ATF = arrowtooth flounder, RF = rockfish, TH = thornyheads, SK = skateB, OS = other species. NMFS longline survey, 1988.

INPFC Area	SF	PC	GR	HB	ATF	RF	TH	SK	OS
Shumagin	11.7	2.0	8.0	0.5	1.0	1.0	1.2	0.1	0.2
Chirikof	12.3	0.4	8.8	0.2	0.7	0.3	0.5	0.0	0.2
Kodiak	15.3	0.5	5.2	0.4	0.9	0.7	0.5	0.0	0.4
Yakutat	10.8	0.5	2.2	0.4	0.6	1.2	0.4	0.1	0.2
South-eastern	8.4	0.1	0.4	0.4	0.2	0.8	0.2	0.0	0.2
Gulf of Alaska	58.5	3.5	24.6	1.8	3.3	4.0	2.8	0.3	1.2

Table 4.--Relative population weight (RPW) summed by International North Pacific Fisheries Commission (INPFC) statistical area and expressed as a percentage of the total Gulf of Alaska RPW. SF = sablefish, PC = Pacific cod, GR = grenadiers, ATF = arrowtooth flounder, RNF= rougheye rockfish, SRF =shortraker rockfieh, TH = thornyheade. NMFS longline survey, 1988.

INPFC Area	SF	PC	GR	ATF	RRF	SRF	TH
Shumagin	12.0	1.2	10.2	0.4	0.1	0.2	0.2
Chirikof	12.8	0.2	12.6	0.4	0.1	0.1	0.1
Kodiak	15.4	0.2	6.9	0.4	0.1	0.2	0.1
Yakutat	11.6	0.3	2.3	0.3	0.2	0.6	0.1
South-eastern	9.6	0.1	0.5	0.1	0.3	0.1	0.0
Gulf of Alaska	61.4	2.0	32.5	1.6	0.7	1.2	0.5

Table 5.--Relative population number (RPN) summed by depth stratum and expressed as a percentage of the RPN for the Gulf of Alaska. SF = sablefish, PC = Pacific cod, GR = grenadiers, HB = Pacific halibut, ATF = arrowtooth flounder, RF = rockfish, TH = thorny-heads, SK = skates, OS = other species. NMFS longline survey, 1988.

Depth (m)	SF	PC	GR	HB	ATF	RF	TH	SK	OS
201-300	9.1	3.4	0.1	1.6	2.2	0.8	0.6	0.2	0.5
301-400	6.8	0.1	1.6	0.3	0.9	2.5	0.6	0.1	0.1
401-600	17.2	0.0	5.5	0.0	0.1	0.5	0.7	0.0	0.1
601-800	15.3	0.0	7.2	0.0	0.0	0.0	0.6	0.0	0.0
801-1,000	10.1	0.0	10.3	0.0	0.0	0.1	0.3	0.0	0.4

Table 6.--Relative population weight *(RPW)* summed by depth stratum and expressed as a percentage of the RPW for the Gulf of Alaska. SF = eablefieh, PC = Pacific cod, GR = grenadiers, ATF = arrow-tooth flounder, RRF = rougheye rockfish, SRF = shortraker rock-fieh, TH = thornyheade. NMFS longline Burvey, 1988.

Depth (m)	SF	PC	GR	ATF	RRF	SRF	TH
201-300	8.7	2.0	0.1	1.1	0.1	0.3	0.1
301-400	6.3	0.0	1.9	0.4	0.5	0.8	0.1
401-600	18.0	0.0	7.1	0.1	0.1	0.1	0.1
601-800	16.9	0.0	9.9	0.0	0.0	0.0	0.1
801-1,000	11.5	0.0	13.6	0.0	0.0	0.0	0.1

Table 7.--Relative population number by species, International North Pacific Fisheries Commission (INPFC) statistical area and depth stratum. SF = sablefish, PC = Pacific cod, GR = grenadiers, HB = Pacific halibut, ATF = arrowtooth flounder, RF = rockfish, TH = thornyheade, SK = skates, OS = other species. Listed below each total RPN are the lower (L) and upper (0) 95% confidence intervals. NMFS longline survey, 198B.

	Species								
Depth (m)	SF	PC	GR	HB	ATF	RF	TH	SK	OS
				Shumagin INPFC Area					
201-300	20,783	14,027	87	3,239	4,975	2,551	2,390	783	584
301-400	10,922	58	6,151	301	1,806	3,470	1,428	142	244
401-600	29,692	0	17,589	7	376	706	1,645	34	197
601-800	15,719	0	19,877	0	7	10	1,541	45	30
801-1,000	7,045	0	13,853	0	0	498	1,412	0	30
Total	84,161	14,085	57,558	3,547	7,165	7,234	8,416	1,003	1,085
				Chirikof INPFC Area					
201-300	20,883	3,024	0	978	3,718	194	504	55	722
301-400	10,649	0	2,884	119	983	1,957	504	80	84
401-600	25,830	0	12,358	11	160	76	1,137	9	301
601-800	26,086	0	18,977	0	66	0	1,416	11	35
801-1,000	5,185	0	29,544	0	0	0	0	0	503
Total	88,632	3,024	63,763	1,108	4,927	2,227	3,560	155	1,645
				Kodiak INPFC Area					
201-300	13,694	3,489	0	2,174	4,443	796	407	210	220
301-400	11,162	28	2,024	664	1,753	3,732	823	107	88
401-600	30,596	87	7,692	12	160	234	1,156	10	33
601-800	26,860	0	8,707	0	4	0	990	0	96
801-1,000	28,279	0	18,906	0	0	0	431	0	2,403
Total	110,591	3,604	37,328	2,850	6,360	4,763	3,807	328	2,840

Table 7.--Continued.

Depth (m)	Species								
	SF	PC	GR	HB	ATF	RF	TH	SK	OS
Yakutat INPFC Area									
201-300	7,039	3,177	314	2,352	2,253	1,613	658	342	816
301-400	9,100	183	284	454	1,520	5,416	1,029	120	281
401-600	24,855	83	1,894	16	236	1,470	555	33	31
601-800	23,747	0	3,663	0	6	125	401	0	19
801-1,000	13,482	0	9,861	0	0	79	393	0	21
Total	78,223	3,443	16,016	2,822	4,014	8,702	3,036	494	1,168
Southeastern INPFC Area									
201-300	3,114	978	0	2,745	637	403	346	117	1,127
301-400	7,133	95	6	384	448	3,811	238	51	373
401-600	13,052	0	123	11	86	1,310	438	17	18
601-800	18,242	0	491	2	19	109	253	17	27
801-1,000	19,210	0	2,301	0	0	174	254	5	33
Total	60,752	1,073	2,922	3,142	1,188	5,807	1,529	208	1,578
Gulf of Alaska									
201-300	65,513	24,695	401	11,488	16,026	5,557	4,304	1,507	3,469
301-400	48,966	364	11,349	1,923	6,510	18,386	4,022	500	1,069
401-600	124,026	169	39,656	57	1,018	3,796	4,931	103	579
601-800	110,653	0	51,714	2	101	243	4,600	73	207
800-1,000	73,202	0	74,465	0	0	751	2,491	5	2,990
Total	422,359	25,228	177,586	13,470	23,655	28,733	20,348	2,188	8,315
L	391,768	17,172	131,731	10,666	19,061	22,543	16,668	-- *	4,742
U	449,516	34,194	195,773	16,561	29,235	34,702	24,626	-- *	15,151

Total RPN for all species combined is 721,882.

* A bootstrap confidence interval could not be calculated because the bootstrap distribution was multimodal.

Table 8.--Relative population weight (RPW) by species, International North Pacific Fisheries Commission (INPFC) statistical area, and depth stratum. SF = sablefish, PC = Pacific cod, GR = grenadiers, ATF = arrowtooth flounder, RRF = rougheye rockfish, SRF = shortraker rockfish, TH = thornyheade. NMFS longline survey, 1988.

Depth (m)	SF	PC	GR	ATF	RRF	SRF	TH
Shumagin INPFC Area							
201-300	58,765	27,235	373	7,102	719	1,924	1,332
301-400	33,477	229	20,614	2,592	2,081	2,296	849
401-600	103,138	0	65,479	535	234	550	955
601-800	57,697	0	88,651	10	7	7	774
801-1,000	25,585	0	61,765	0	158	294	744
Total	278,662	27,464	236,881	10,239	3,198	5,070	4,655
Chirikof INPFC Area							
201-300	63,560	5,662	0	6,300	158	115	279
301-400	34,848	0	13,877	1,704	1,007	2,344	276
401-600	86,365	0	59,266	278	20	115	603
601-800	89,923	0	87,792	132	0	0	807
801-1,000	20,942	0	130,723	0	0	0	0
Total	295,637	5,662	291,658	8,414	1,186	2,574	1,965
Kodiak INPFC Area							
201-300	43,981	5,709	0	7,091	479	771	189
301-400	34,401	7	8,781	2,683	2,175	3,755	408
401-600	95,341	0	32,630	273	75	388	556
601-800	91,176	0	38,053	6	0	0	500
801-1,000	92,747	0	81,169	0	0	0	200
Total	357,646	5,716	160,633	10,053	2,729	4,914	1,853
Yakutat INPFC Area							
201-300	24,858	6,113	998	3,502	592	2,817	370
301-400	18,247	82	952	2,385	2,390	8,056	535
401-600	85,983	0	6,565	380	727	2,005	291
601-800	85,137	0	12,387	9	43	189	217
801-1,000	53,111	0	31,791	0	30	114	214
Total	267,336	6,195	52,694	6,276	3,782	13,181	1,627

Table 8.--Continued.

Depth (m)	SF	PC	GR	ATF	RRF	SRF	TH
			Southeastern INPFC Area				
201-300	10,634	2,047	0	1,005	359	273	175
301-400	24,968	139	24	730	3,782	1,644	133
401-600	45,231	0	481	132	1,488	382	338
601-800	67,327	0	1,839	29	114	37	176
801-1,000	73,397	0	8,458	0	173	77	171
Total	221,556	2,186	10,802	1,896	5,917	2,414	993
			Gulf of Alaska				
201-300	201,797	46,767	1,371	24,999	2,307	5,901	2,344
301-400	145,941	456	44,248	10,095	11,435	18,096	2,202
401-600	416,058	0	164,421	1,598	2,545	3,439	2,743
601-800	391,260	0	228,723	186	164	233	2,474
801-1,000	265,781	0	313,905	0	361	486	1,328
Total	1,420,837	47,223	752,667	36,878	16,812	28,154	11,092

Total RPW for all species combined is 2,313,663.

Table 9.--Sablefish commercial size composition percentage for RPN-weighted length frequencies by Internhtional North Pacific Fisheries Commieeion (INPFC) etatietical area, depth stratum, and sex. NMFS longline survey, 1988.

Fork length (cm)	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	Gulf of Alaska
			201-300 m, males			
<57 cm	14.1	3.7	3.1	7.5	8.5	6.5
57-66 cm	76.5	44.1	81.2	56.6	66.7	60.8
>66 cm	9.4	52.2	15.8	36.0	24.8	32.7
			201-300 m, females			
<57 cm	4.2	1.2	2.7	4.0	3.0	2.7
57-66 cm	54.6	29.6	23.6	15.2	20.1	34.1
>66 cm	41.2	69.2	73.7	80.8	77.0	63.2
			301-400 m, males			
<57 cm	7.3	2.4	5.0	5.2	3.6	4.8
57-66 cm	76.8	77.7	79.7	70.2	76.5	76.9
>66 cm	15.9	19.9	15.3	24.6	19.9	18.2
			301-400 m, females			
<57 cm	2.8	0.5	3.0	2.0	1.5	2.0
57-66 cm	37.0	29.7	20.1	18.0	16.8	25.8
>66 cm	60.1	69.8	77.0	80.0	81.8	72.3
			401-600 m, males			
<57 cm	4.4	3.6	8.7	7.6	3.5	6.0
57-66 cm	72.3	78.5	79.9	75.7	83.0	77.5
>66 cm	23.3	17.9	11.4	16.7	13.5	16.5
			401-600 m, females			
<57 cm	0.5	1.0	4.7	3.9	1.2	2.3
57-66 cm	19.7	21.1	20.2	13.9	14.7	18.4
>66 cm	79.8	77.9	75.1	82.2	84.2	79.3
			601-800 m, males			
<57 cm	5.1	4.5	6.6	7.7	4.9	5.8
57-66 cm	69.6	76.8	77.3	76.3	73.7	75.4
>66 cm	25.3	18.8	16.0	16.0	21.4	18.8

Table 9.--Continued.

Length	Shumagin	Chirikof	Kodiak	Yakutat	South-east	Gulf of Alaska
			601-800 m, females			
<57 cm	0.3	1.3	2.4	3.4	1.5	1.9
57-66 cm	15.4	20.0	18.0	11.8	12.6	15.8
>66 cm	84.2	78.7	79.6	84.8	85.9	82.3
			801-1,000 m, males			
<57 cm	1.9	0.0	2.6	4.0	2.4	2.5
57-66 cm	92.5	0.0	70.8	72.5	67.8	67.0
>66 cm	5.6	100.0	26.6	23.5	29.7	30.5
			801-1,000 m, females			
<57 cm	4.4	0.0	0.0	0.6	0.2	0.7
57-66 cm	8.0	0.0	12.0	10.7	8.6	9.5
>66 cm	87.6	100.0	88.0	88.7	91.2	89.8
			201-1,000 m, males			
<57 cm	7.1	3.7	6.2	7.0	3.8	5.5
57-66 cm	74.4	63.9	78.1	73.5	74.1	72.6
>66 cm	18.5	32.4	15.7	19.6	22.1	21.9
			201-1,000 m, females			
<57 cm	2.1	1.0	2.4	2.9	1.1	1.9
57-66 cm	28.8	23.1	17.8	13.0	12.6	19.7
>66 cm	69.1	75.9	79.8	84.1	86.3	78.4

Table 10.--Sablefish catch rates (sablefish per 100 hooks) for gullies and adjacent upper continental slope regions. NMFS longline survey, 1988.

Region	Depth (m)	Mean catch rate	Standard deviation	Station numbers
Shumagin Gully	201-300	31.5	--	54
Adjacent slope	201-300	43.8	6.4	11-13
Shelikof Trough	201-300	24.1	3.1	48-51
Chirikof slope	201-300	20.1	4.3	14-17
Albatross Bank	201-400	10.5	--	57
Adjacent slope	201-400	9.7	--	19-20
Amatuli Gully	201-300	31.7	--	26,59
Adjacent slope	201-300	18.5	2.0	23-25,27-28
Spencer Gully	401-600	45.7	--	60
Adjacent slope	401-600	40.6	3.0	37-39

Table 11.--Species captured infreqently during the 1988 NMFS longline survey of the Gulf of Alaska.

Common Name	Number of Occurrences	Scientific Name
Spiny dogfish	404	*Squalus acanthias*
Yellow Irish lord	112	*Hemilepidotus jordani*
Lingcod	91	*Ophiodon elongatus*
Walleye pollock	75	*Theragra chalcogramma*
Unidentified starfish	72	Aeteroidea
Dover sole	77	*Microstomus pacificus*
Unidentified sculpins	43	Cottidae
Flathead sole	36	*Hippoglossoides elassodon*
Weathervane scallop	23	*Patinopecten caurinus*
True tanner crab	22	*Chionoecetes tanneri*
Pacific flatnoee	18	*Antimora* microlepis
Unidentified brittlestare	17	Ophiuroidea
Unidentified snails	17	Gaetropoda
Rock sole	12	*Lepidopsetta bilineata*
Giant wrymouth	9	Delolepis gigantea
Unidentified basketetars	8	*Gorgonocephal* us spp.
Octopus	7	*octopus* spp.
Pacific sleeper shark	6	*Somniosus pacificus*
Searcher	5	*Bathymaster signatus*
Spinyhead sculpin	5	*Dasycottus setiger*
Spotted ratfish	4	*Hydrolagus colliei*
Coho salmon	3	*Oncorhynchus kisutch*
Blue shark	2	*Prionace* glauca
Broad snow crab	2	*Chionoecetes bairdi*
Chum salmon	1	*Oncorhynchus keta*
Darkfin eculpin	1	*Halacocottus zonurus*
Unidentified greenling	1	Hexagrammidae
Pacific pomfret	1	Brama *japonica*

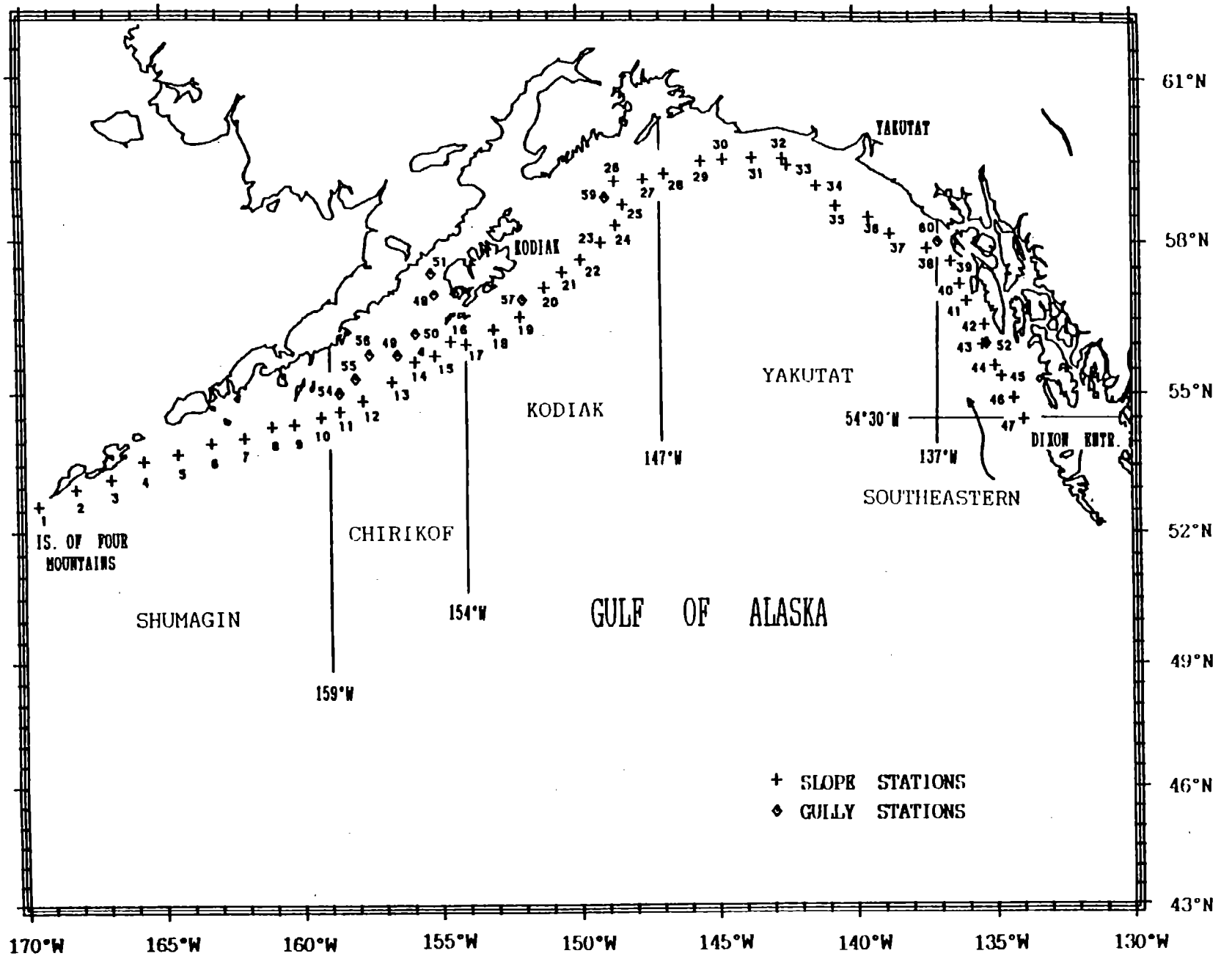


Figure la.--Station locations for the 1988 NMFS longline survey of the Gulf of Alaeka and boundaries of International North Pacific Fisheries Commission statistical areas.

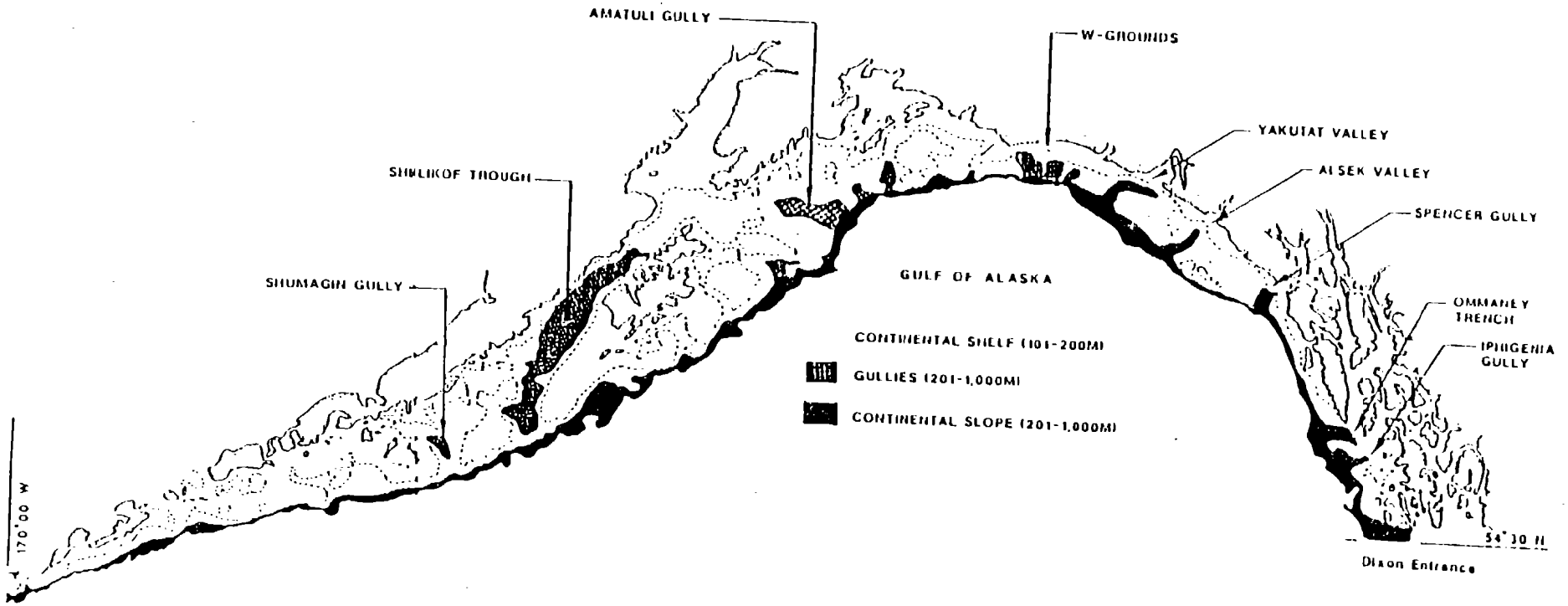


Figure 1b.--Distribution of continental shelf (101-200 m), continental slope (201-1,000 m), and gully areas in the Gulf of Alaska.

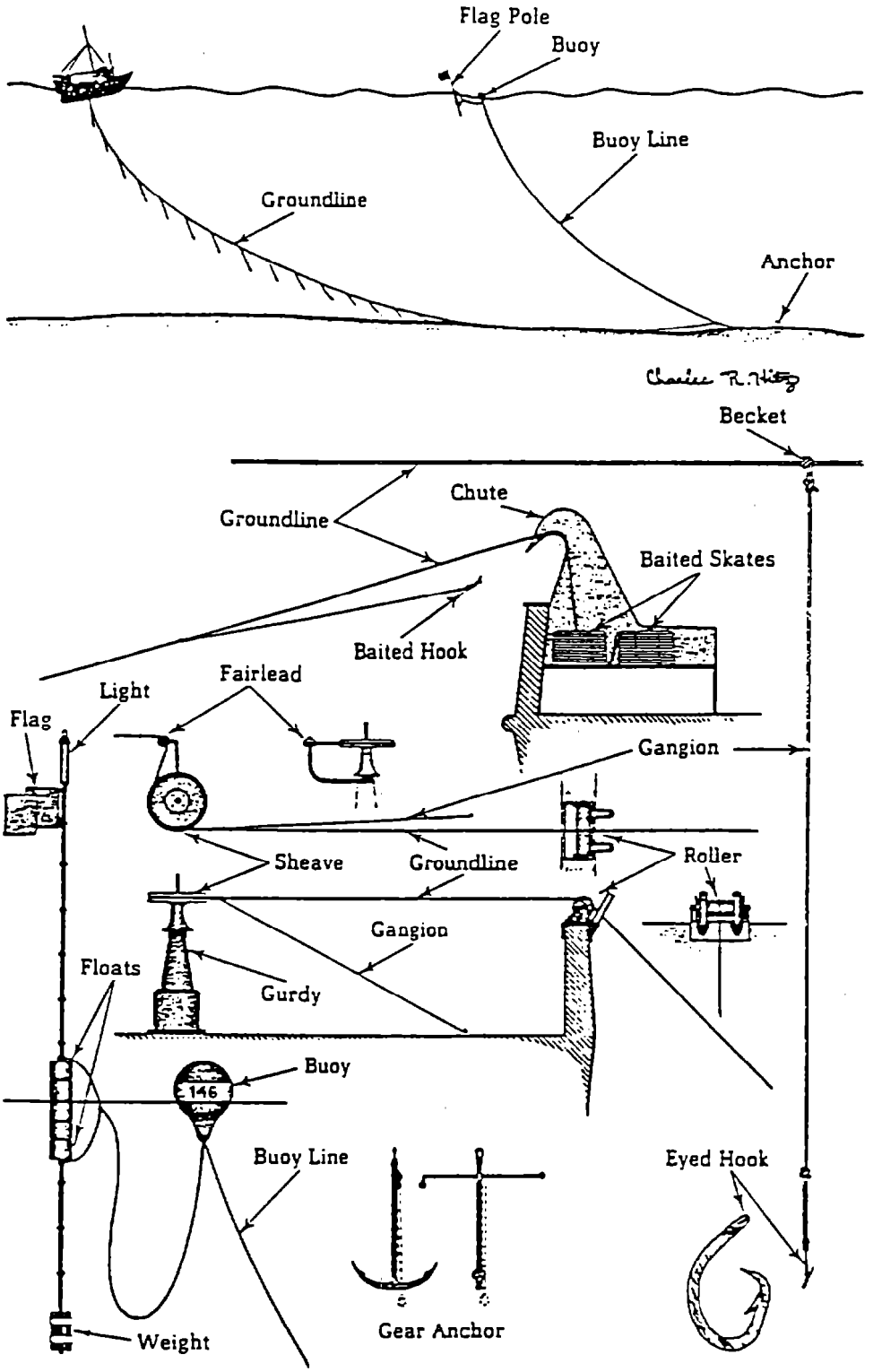


Figure 2 .--Generalized description of longline fishing gear and longline hauling equipment. Adapted from drawings by Charles R. Hitz, Alaska Fisheries Science Center, Resource Asseesment and Conservation Engineering Division, 7600 sand Point Way NE, BIN C15700, Seattle, WA 98115.

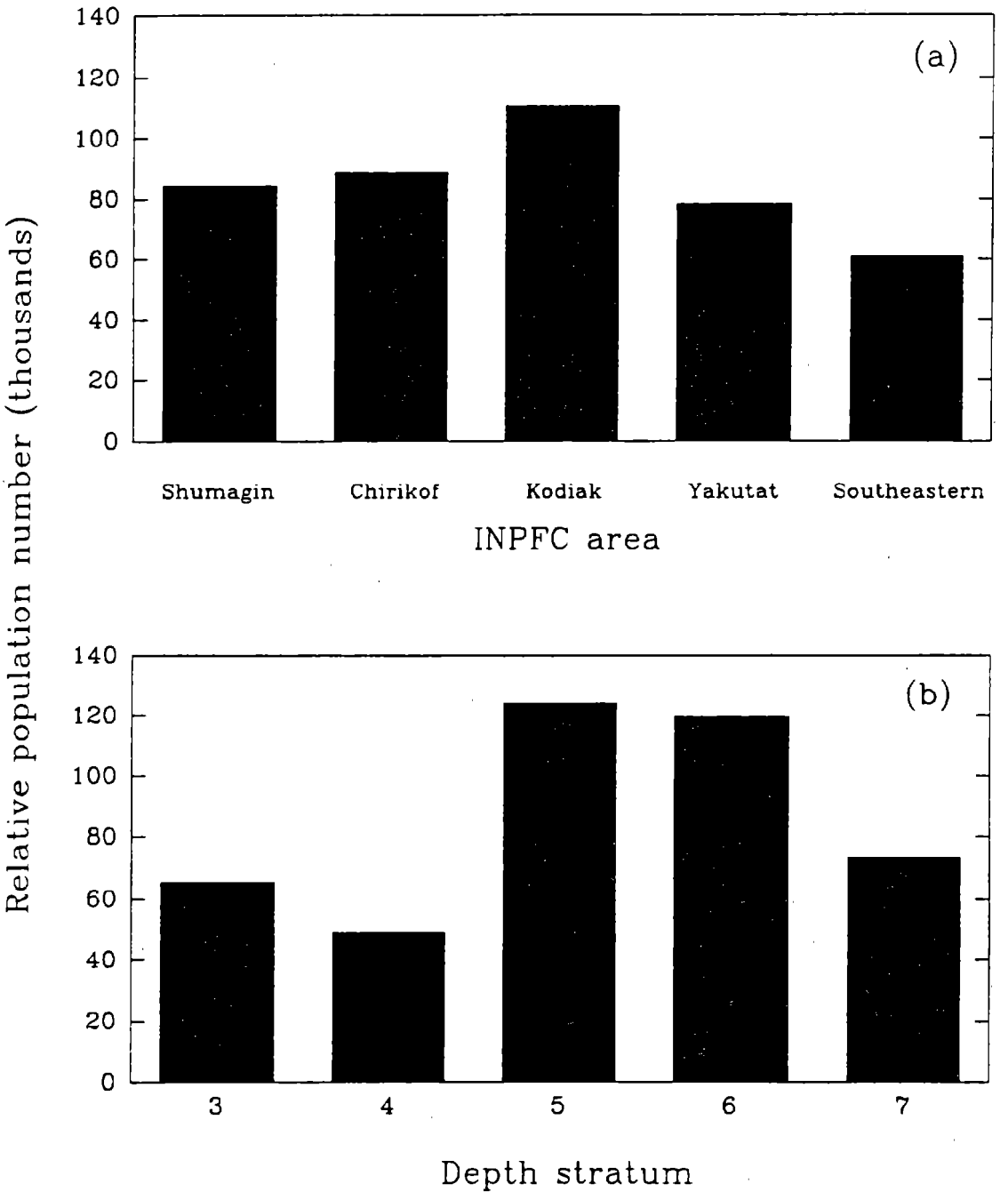


Figure 3.--Sablefish relative population numbers for the upper continental slope of the Gulf of Alaska by: (a) International North Pacific Fisheries Commission (INPFC) statistical area and (b) depth stratum. Stratum codes: 3 = 201-300 m, 4 = 301-400 m, 5 = 401-600 m, 6 = 601-800 m, 7 = 801- 1,000 m. National Marine Fisheries Service longline survey, 1988.

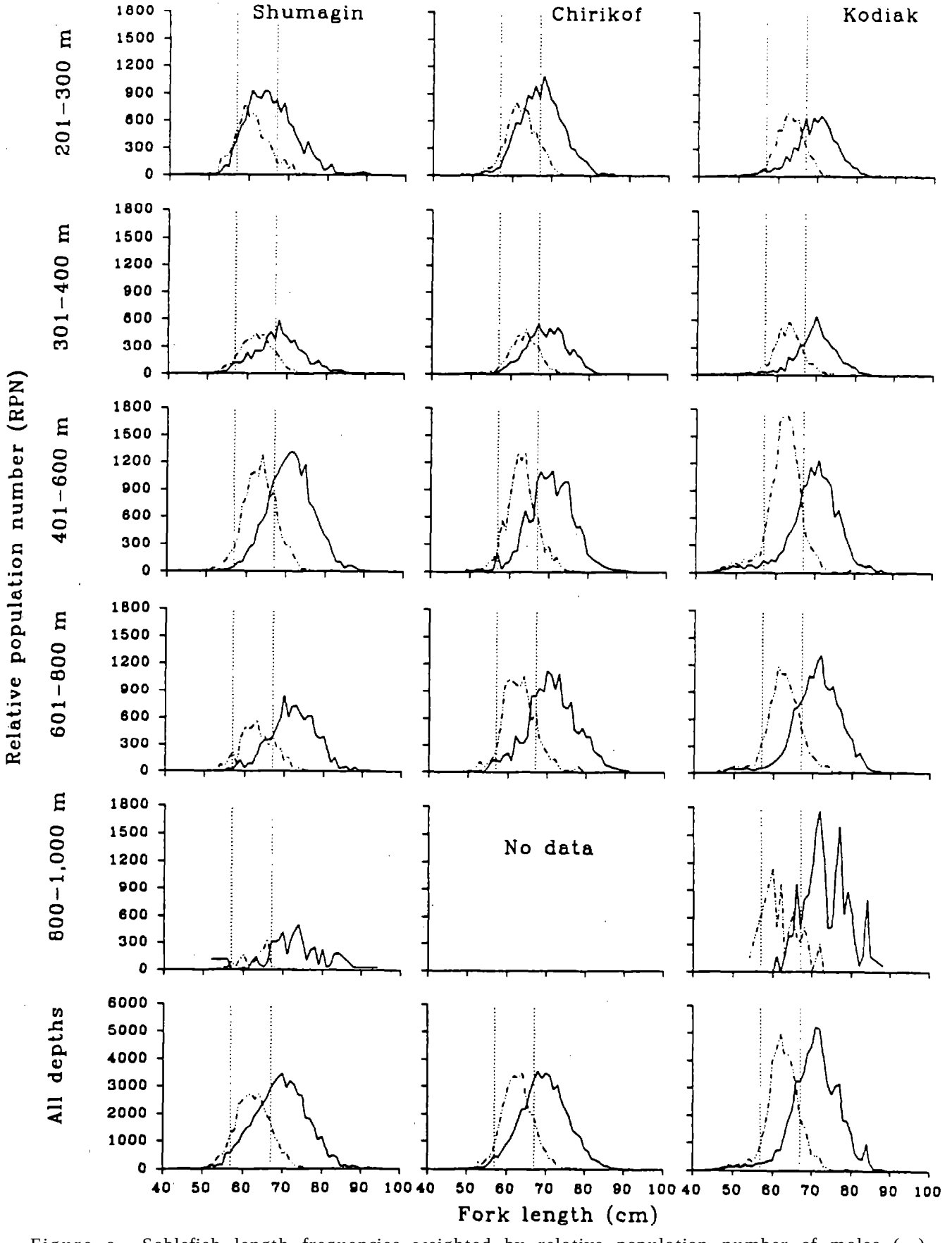


Figure a.-- Sablefish length frequencies weighted by relative population number of males (-) and females (-). for the upper continental slope of the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area and depth stratum, Vertical dotted lines delineate small, medium, and large commercial sizes. National Marine Fisheries Service longline survey, 1988.

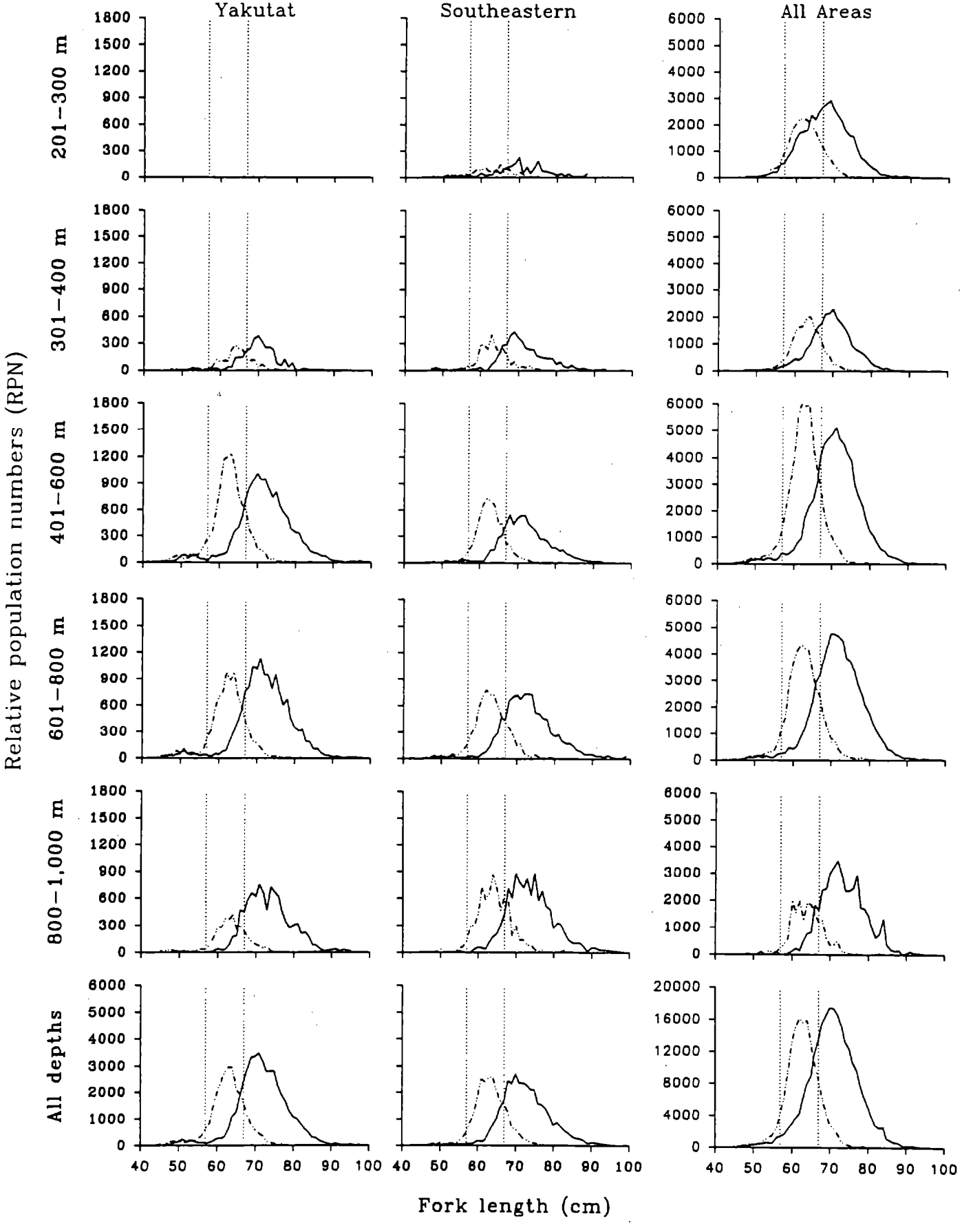


Figure 4. --Continued.

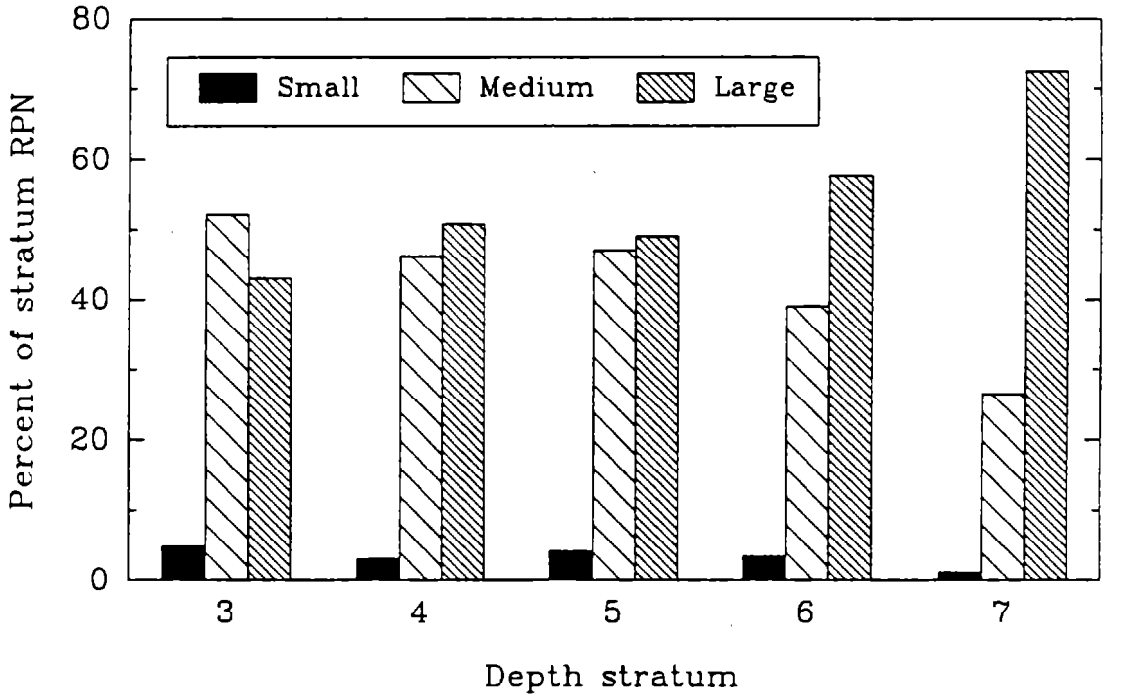


Figure 5.--Percent of sablefish relative population number (RPN) by commercial size category for depth intervals 3-7. Small-sized sablefish are less than 57 cm fork length (FL); medium sablefish are 57-66 cm FL; and large sablefish are greater than 66 cm FL. Stratum codes: 3=201-300 m, 4=301-400 m, 5=40l-600 m, 6=601-800 m, and 7=801-1,000 m. National Marine Fisheries Service longline survey, 1988.

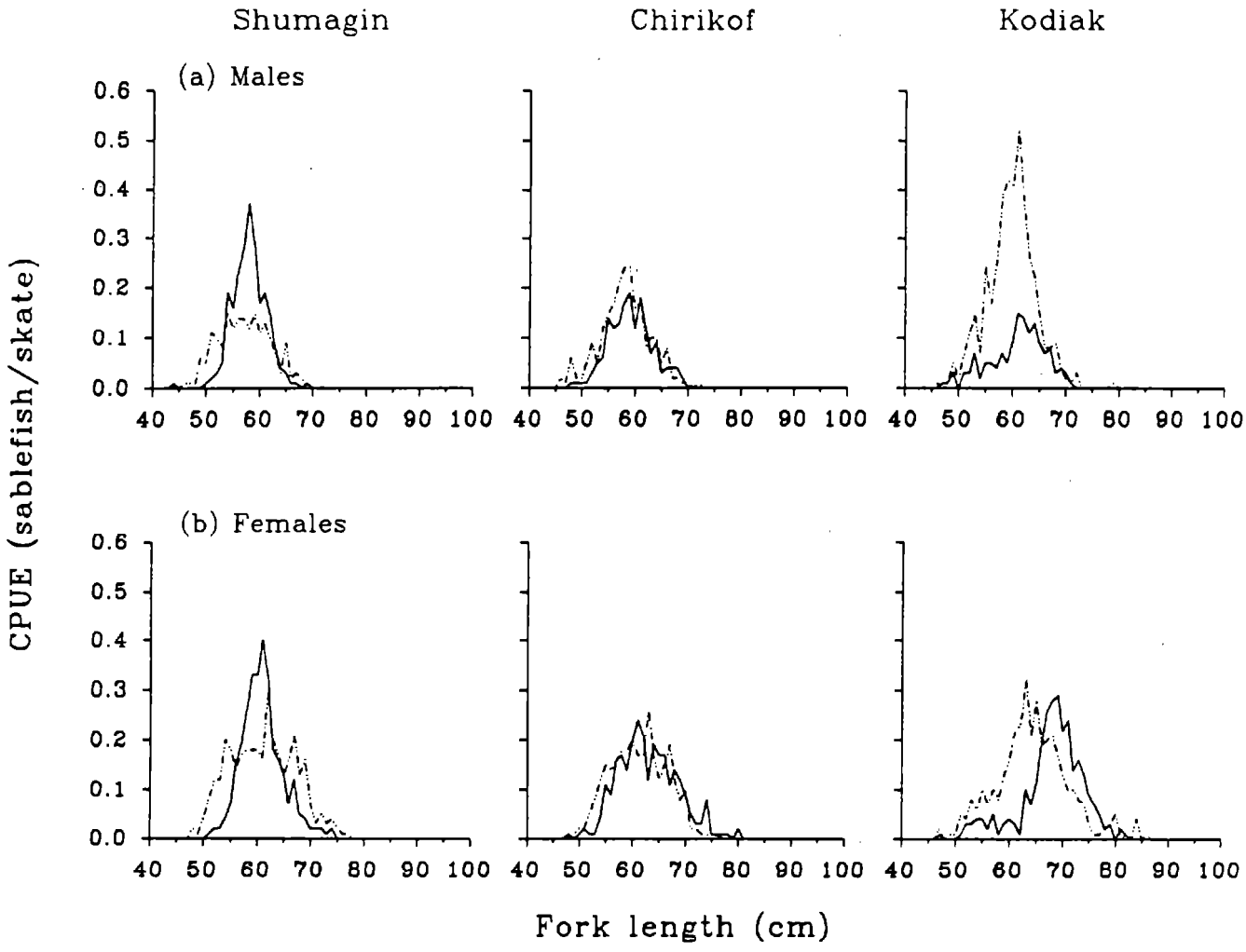


Figure 6.--Length frequencies of: (a) male sablefish and (b) female sablefish, weighted by catch per unit effort (CPUE), for the 101-200 m depth interval on the outer continental shelf of the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area. National Marine Fisheries Service longline surveys, 1987 (-) and 1988 (-).

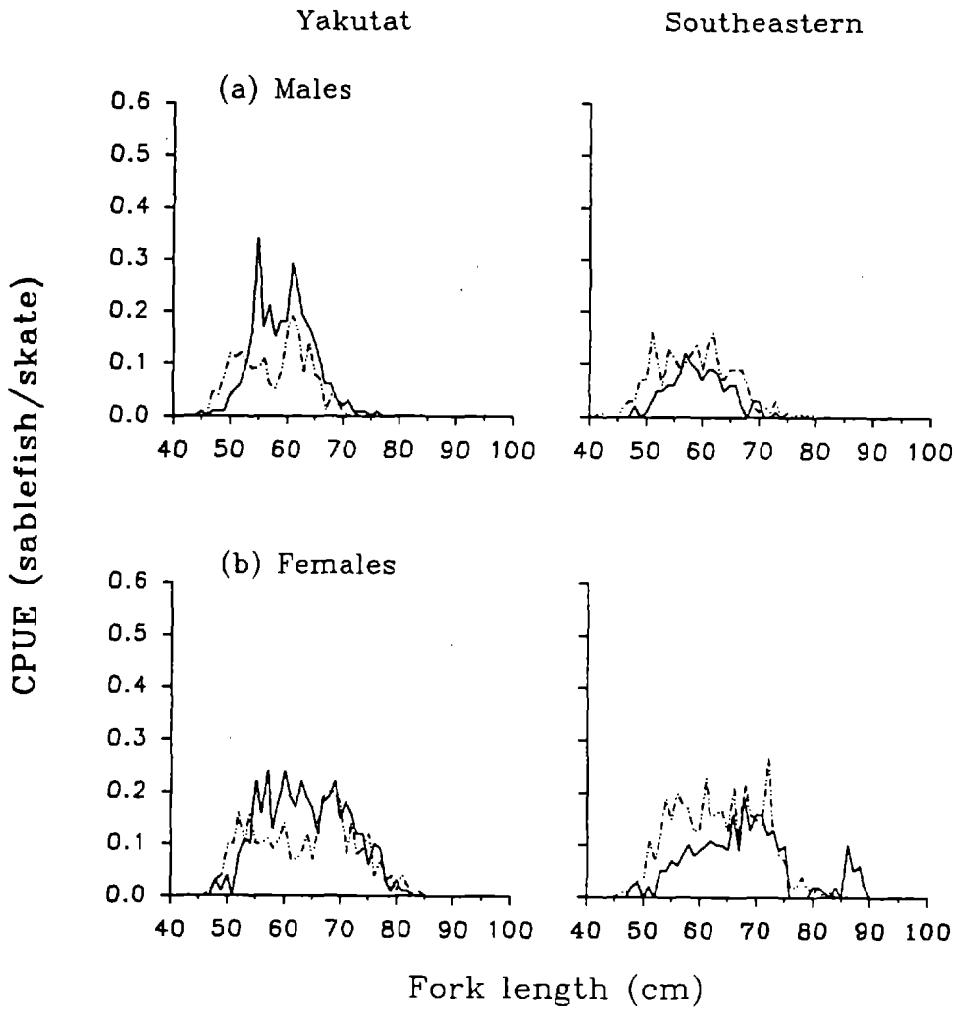


Figure 6.--Continued.

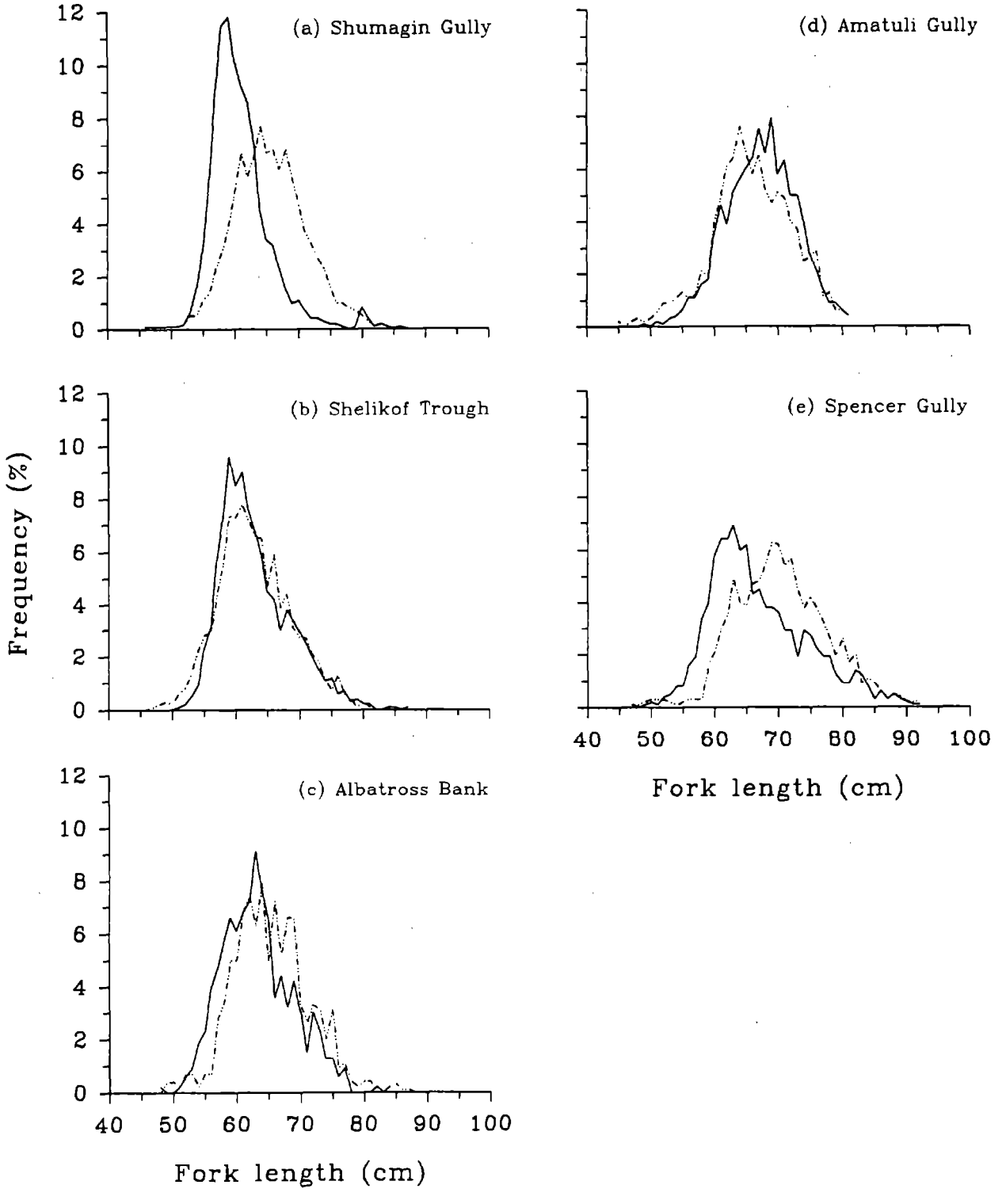


Figure 7.--Sablefish length frequencies from: (a) Shumagin Gully, 201-300 m, (b) Shelikof Trough, 201-300 m, (c) Albatross Bank, 201-400 m, (d) Amatuli Gully, 20 l-300 m, and (e) Spencer Gully, 401-600 m (--); and equivalent adjacent upper continental slope depths (-..). National Marine Fisheries Service longline survey, 1988.

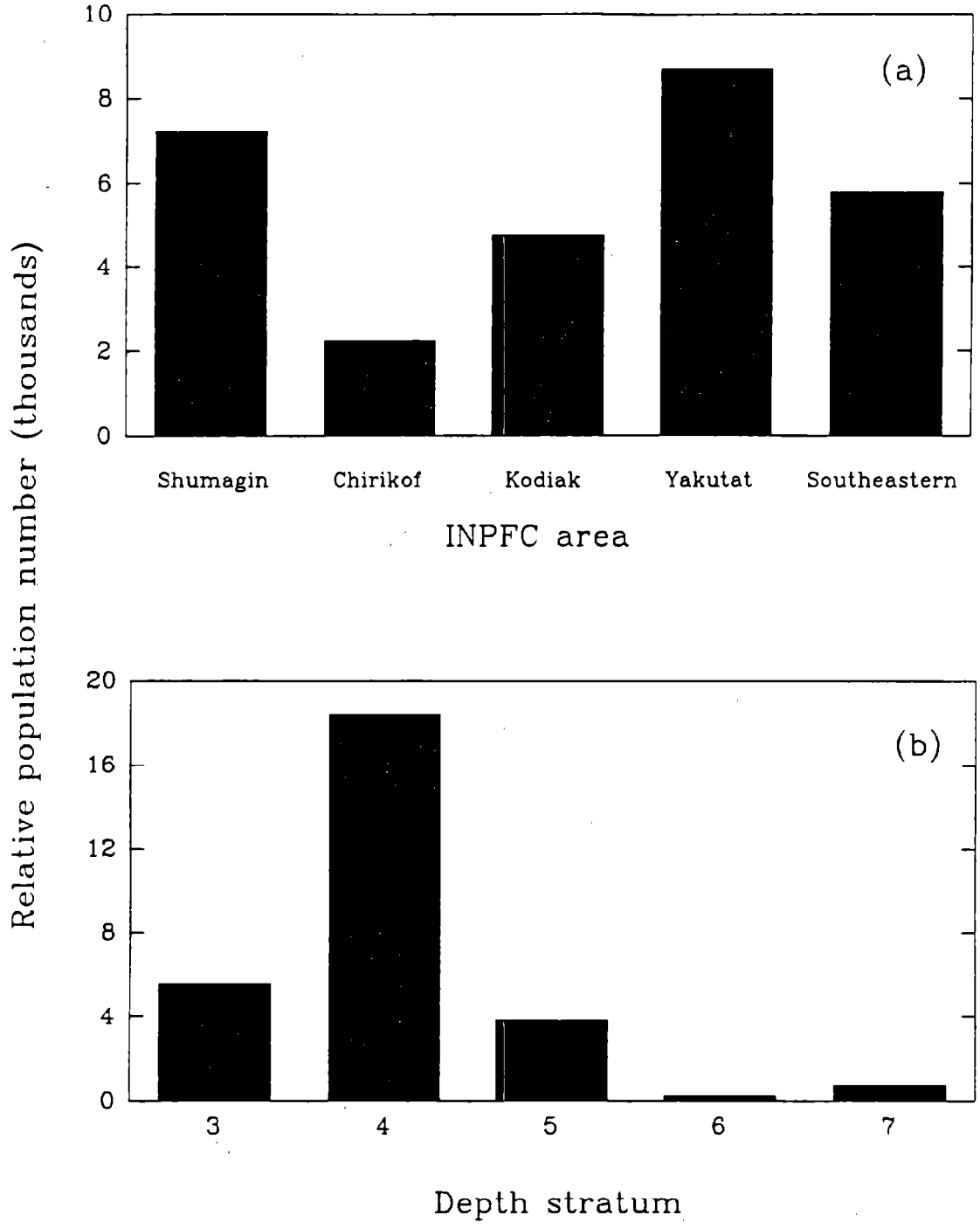


Figure 8. --Combined rougheye and shortraker rockfish relative population numbers for the upper continental slope of the Gulf of Alaska by: (a) International North Pacific Fisheries Commission (INPFC) statistical area, and (b) depth stratum. Depth stratum codes: 3=201-300 m, 4=301-400 m, 5=401-600 m. 6=601-800 m, and 7=801- 1,000 m. National Marine Fisheries Service longline survey, 1988.

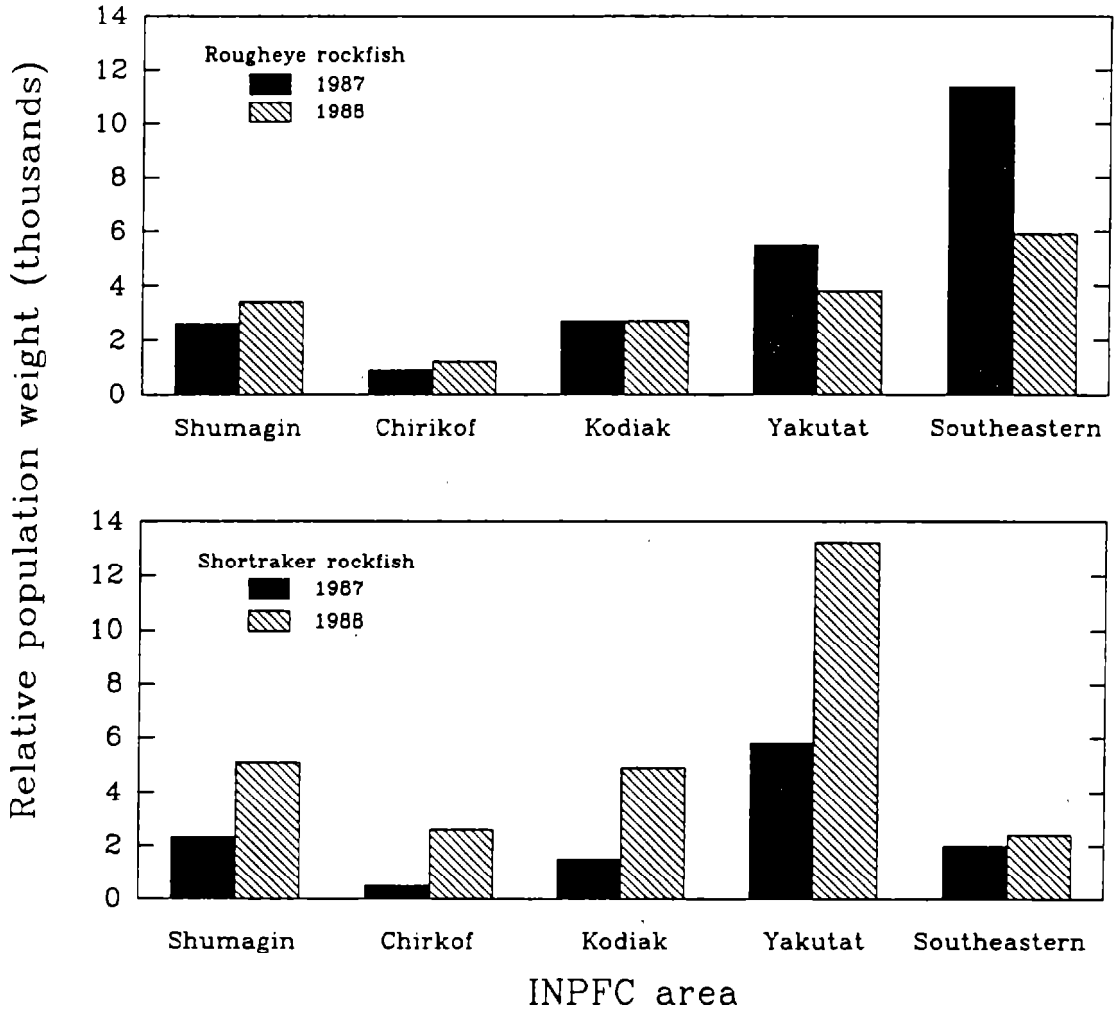


Figure 9.--Rougheye and shortraker rockfish relative biomass (relative population weight, RPW) for the upper continental slope of the Gulf of Alaska by International North Pacific Fisheries Commission (INPFC) statistical area. National Marine Fisheries Service longline surveys, 1987 and 1988.

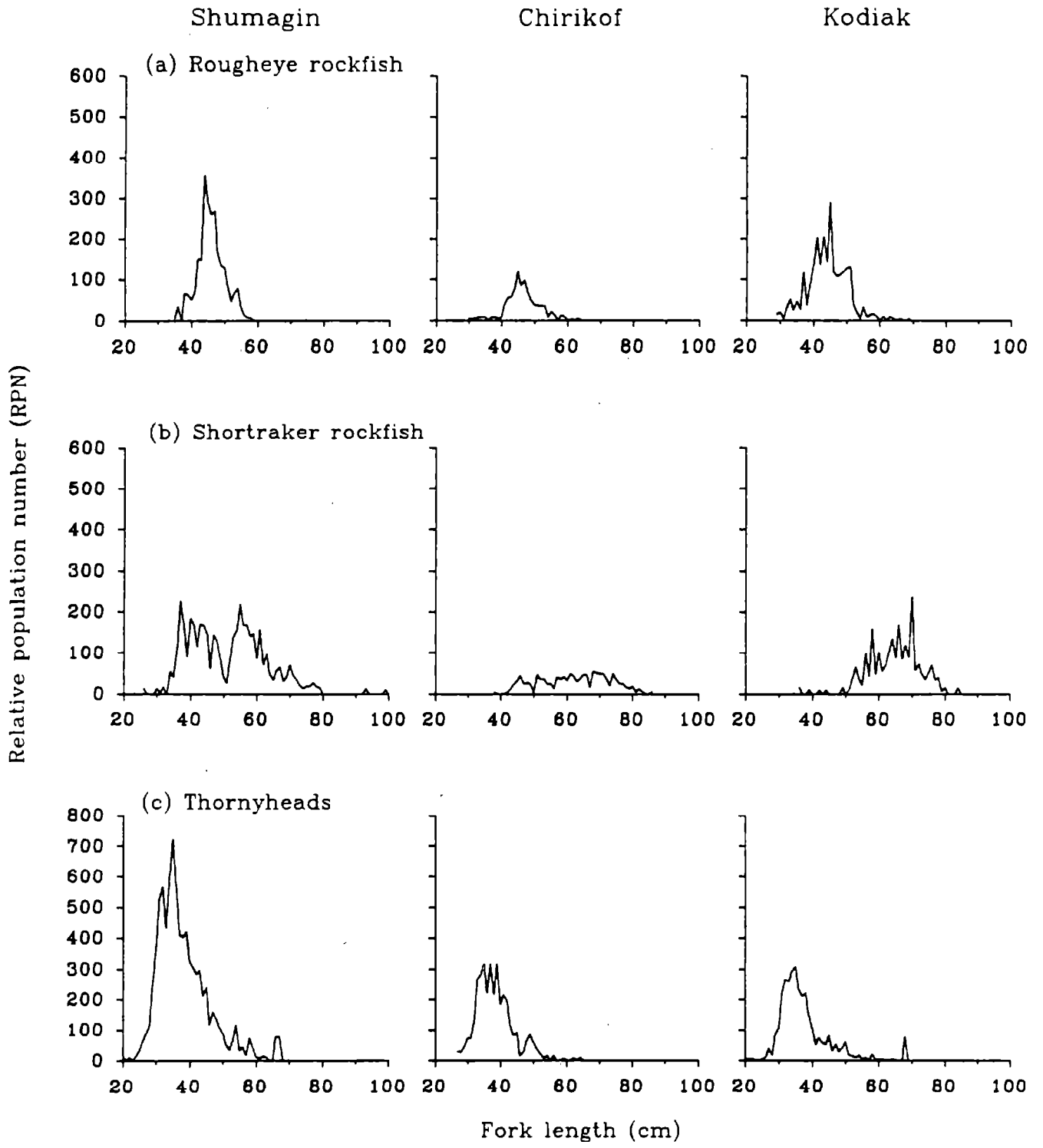
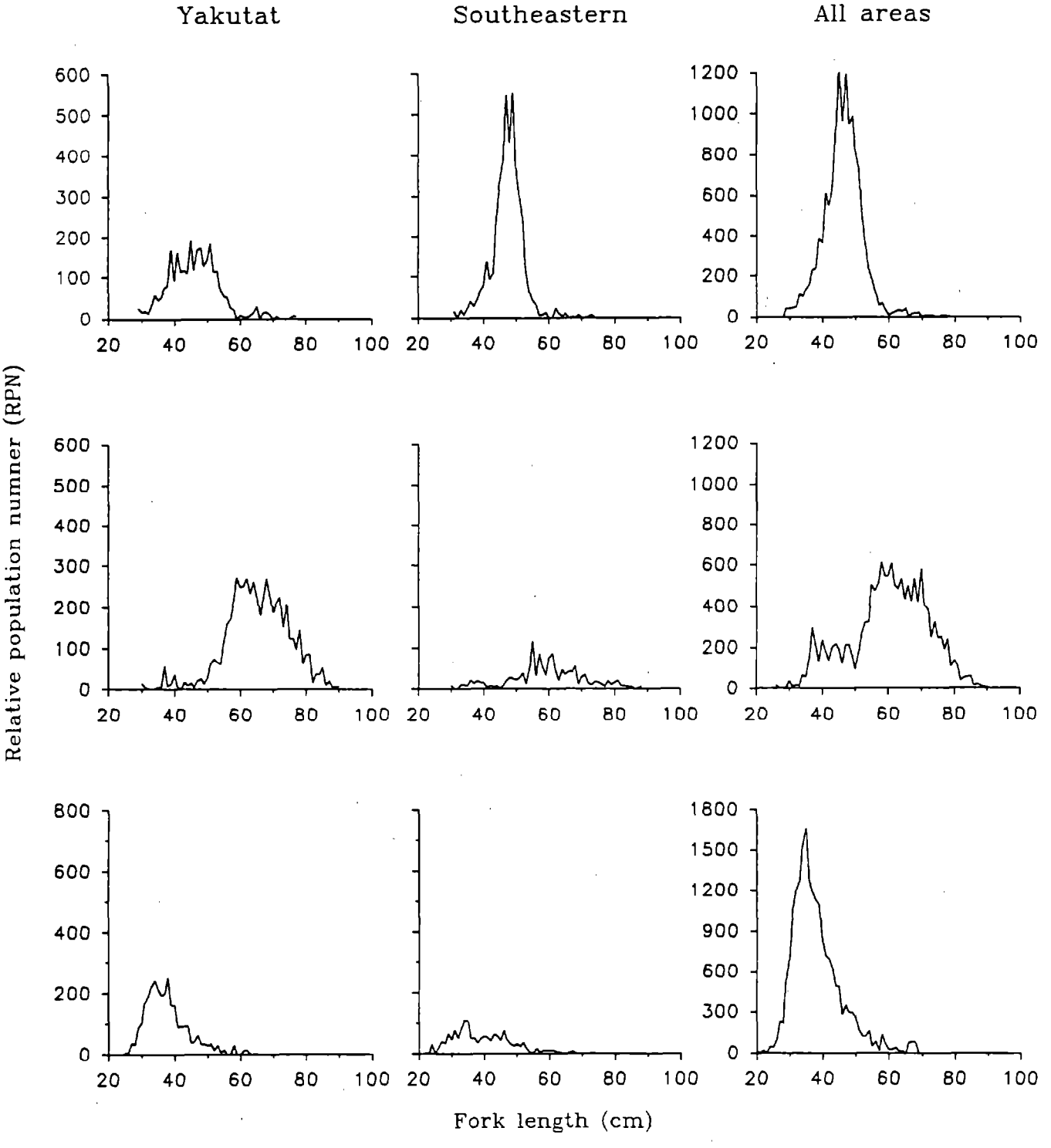


Figure 10.--Length frequencies of: (a) rougheye rockfish, (b) shortraker rockfish, and (c) thornyheads. weighted by relative population number, for the upper continental slope of the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area. National Marine Fisheries Service longline survey, 1988.



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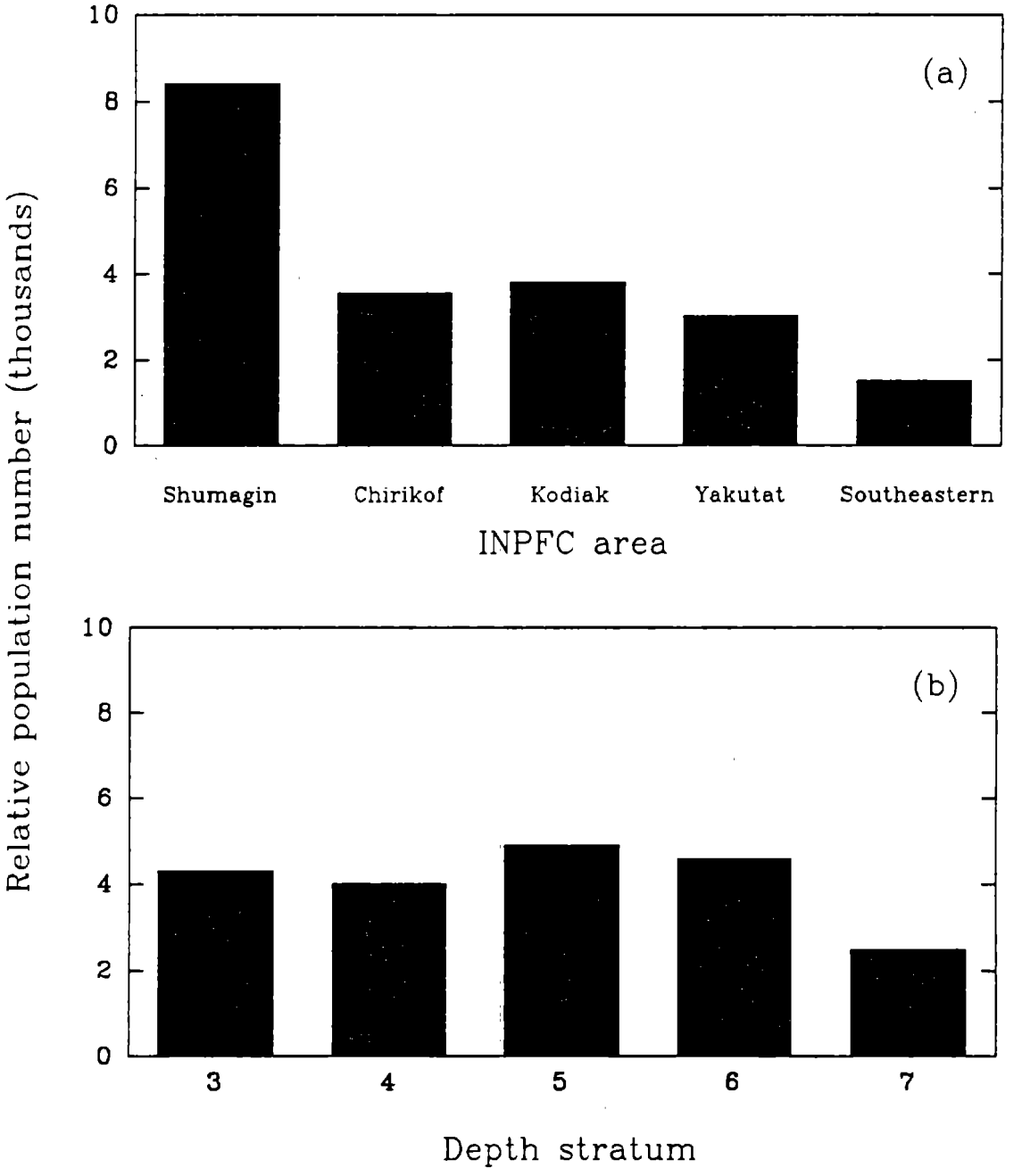


11. - -Thornyhead *(Sebaslolobus* spp.) relative population numbers for the continental slope of the Gulf of Alaska by: (a) International North Pacific Fisheries Commission (INPFC) statistical area and (b) depth -stratum. Stratum codes: 3=201-300 m, 4=301-400 m, 5=401-600 m, 6=601-800 m, 7=801- 1,000 m. National Marine Fisheries Service longline survey, 1988.

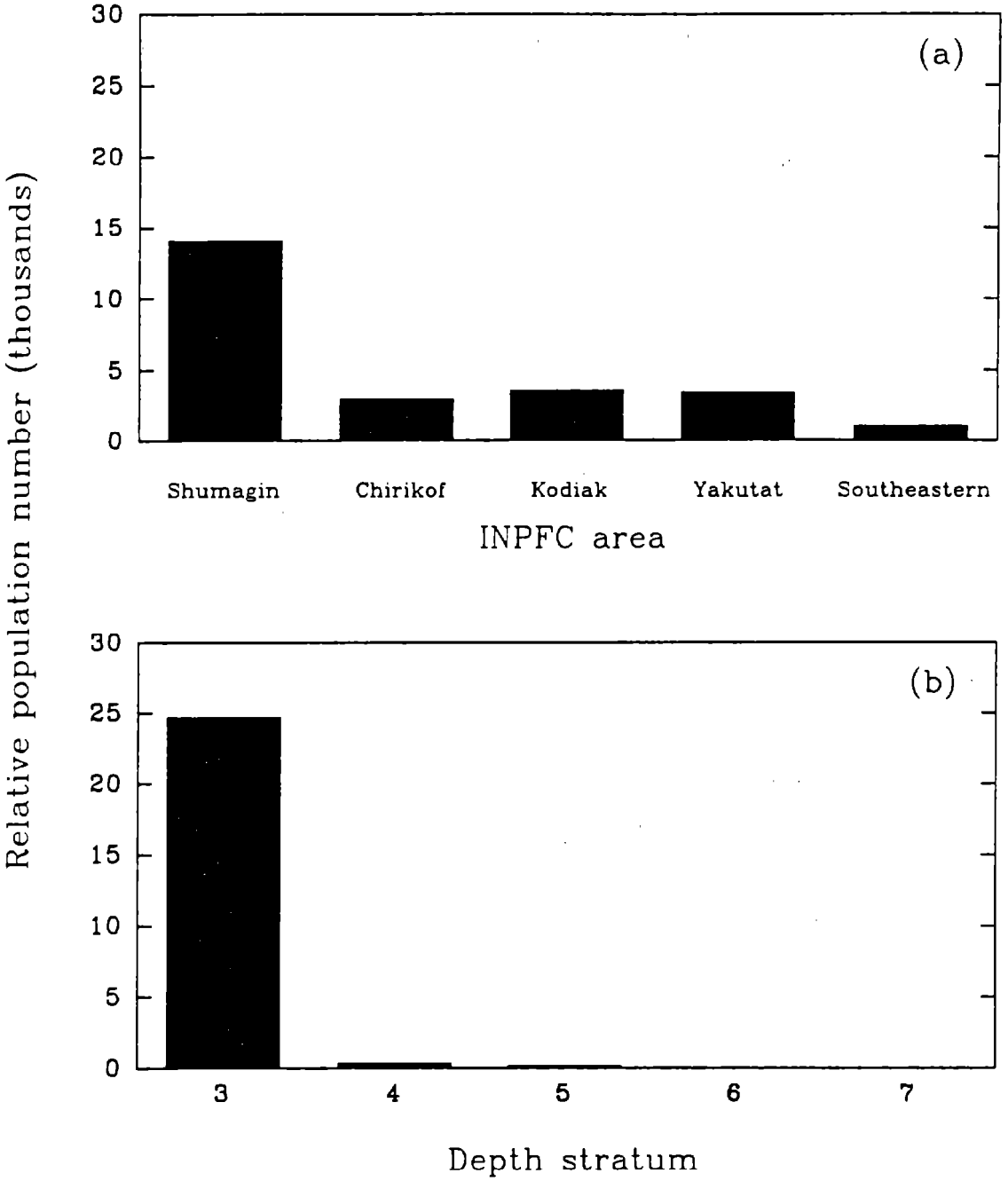


Figure 12.--Pacific cod relative population numbers for the upper continental slope of the Gulf of Alaska by: (a) International North Pacific Fisheries Commission (INPFC) statistical area and (b) depth stratum. Stratum codes: 3=201-300 m, 4=301-400 m, 5=401-600 m, 6=601-800 m, 7=801- 1,000 m. National Marine Fisheries Service longline survey, 1988.

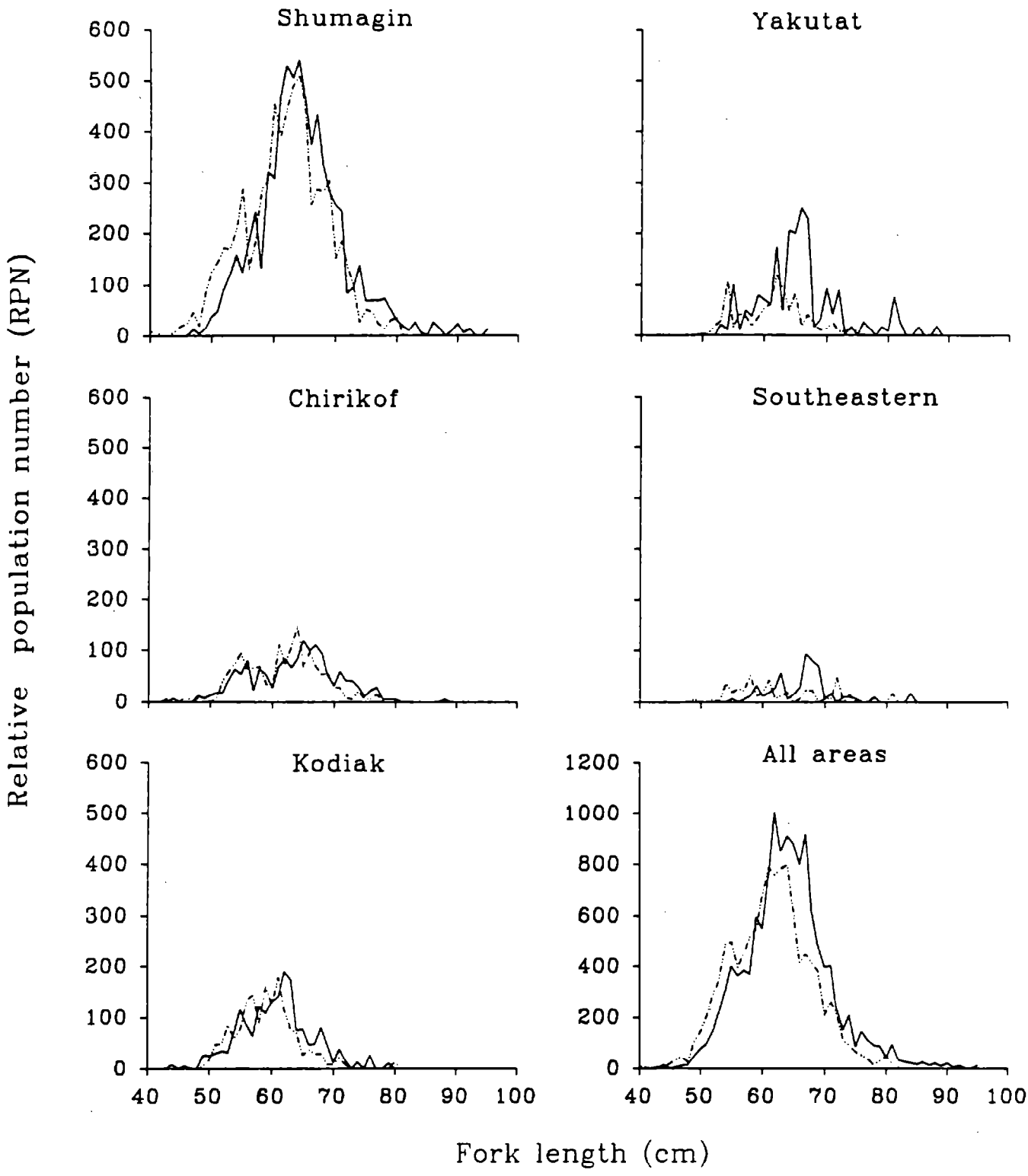


Figure 13.--Pacific cod length frequencies weighted by relative population number of males (-. .) and females (-), for the upper continental slope of the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area. National Marine Fisheries Service longline survey, 1986.

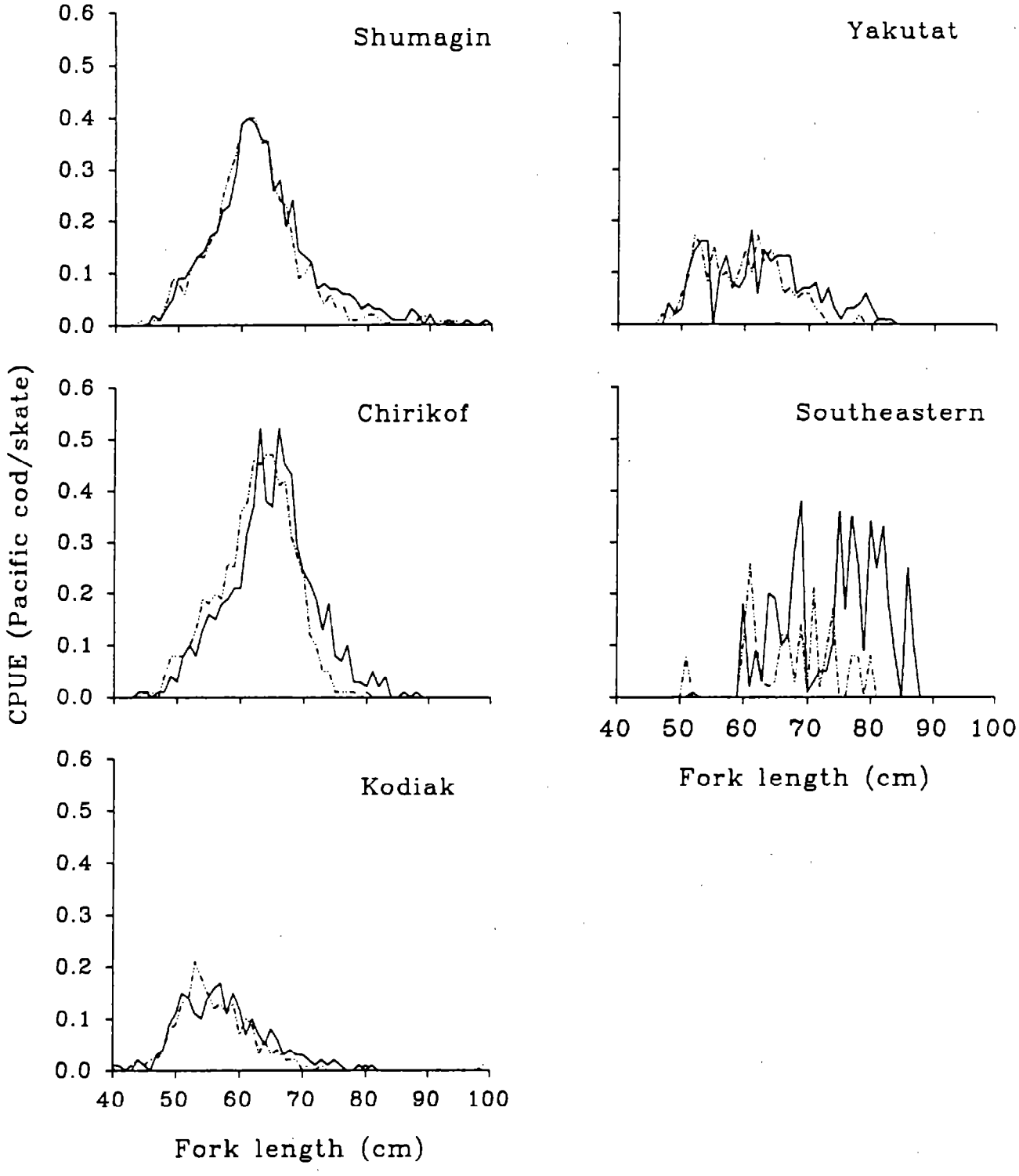


Figure 14.--Pacific cod length frequencies weighted by catch per unit effort (CPUE) of males (-..) and females (-), for the 101-200 m depth stratum in the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area. National Marine Fisheries Service longline survey, 1988.

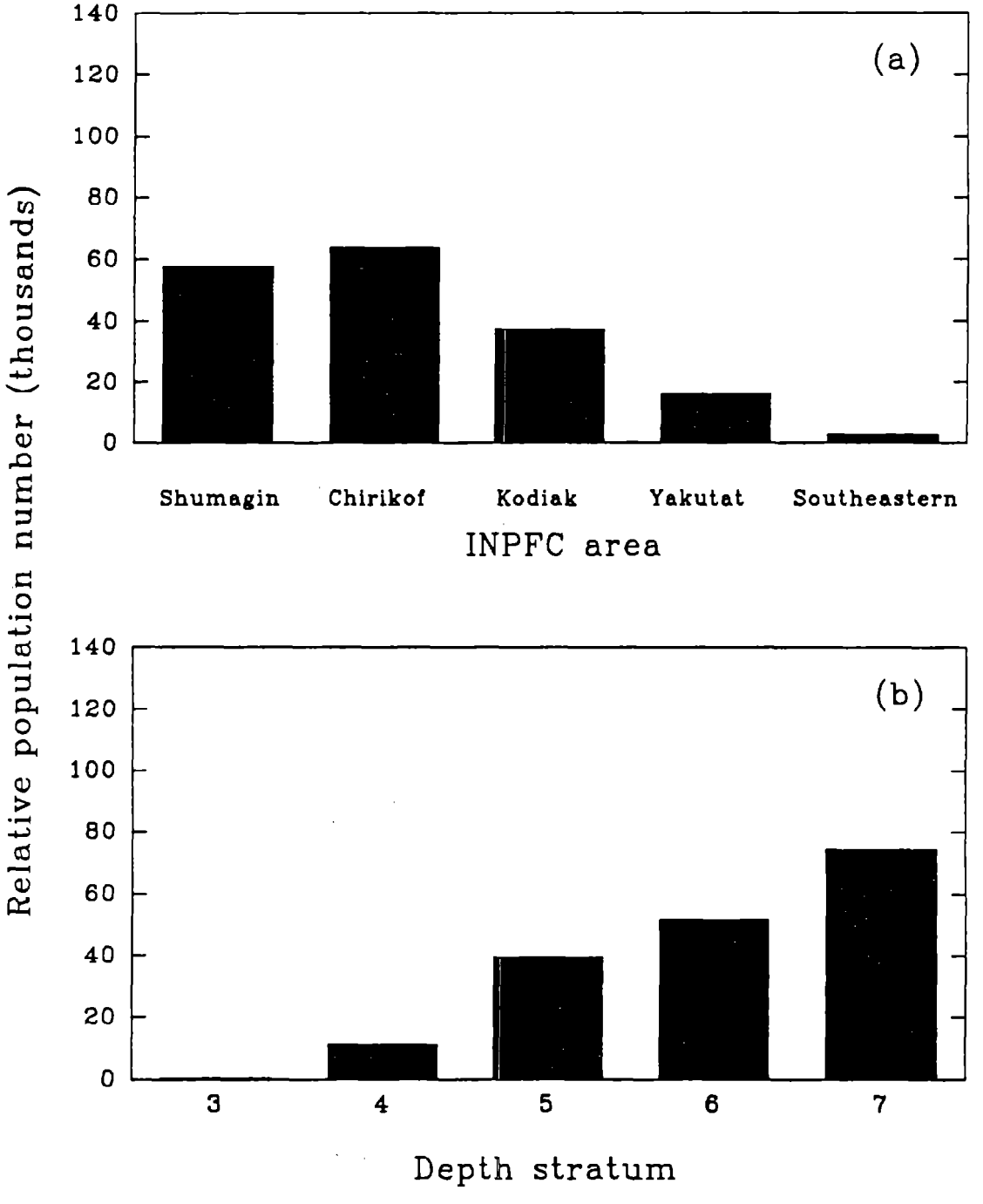


Figure 15.--Grenadier relative population numbers for the upper continental slope of the Gulf of Alaska by: (a) International North Pacific Fisheries Commission (INPFC) statistical area and (b) depth stratum. Stratum codes: 3=201-300 m, 4=301-400 m, 5=401-600 m, 6=601-800 m, 7=601- 1,000 m. National Marine Fisheries Service longline survey, 1988.

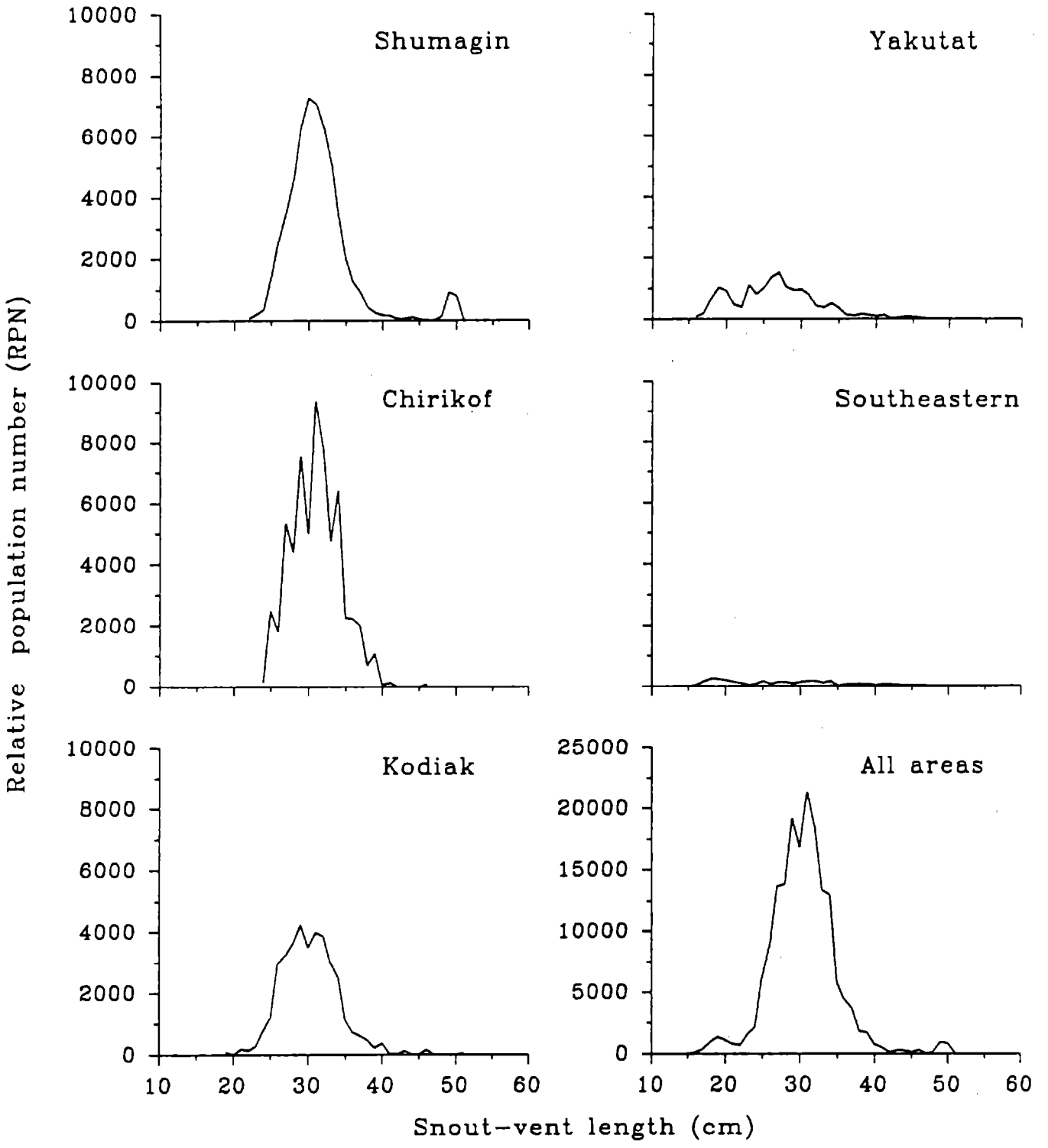


Figure 16.--Giant grenadier length frequencies weighted by relative population number for the upper continental slope of the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area. National Marine Fisheries Service longline survey, 1988.

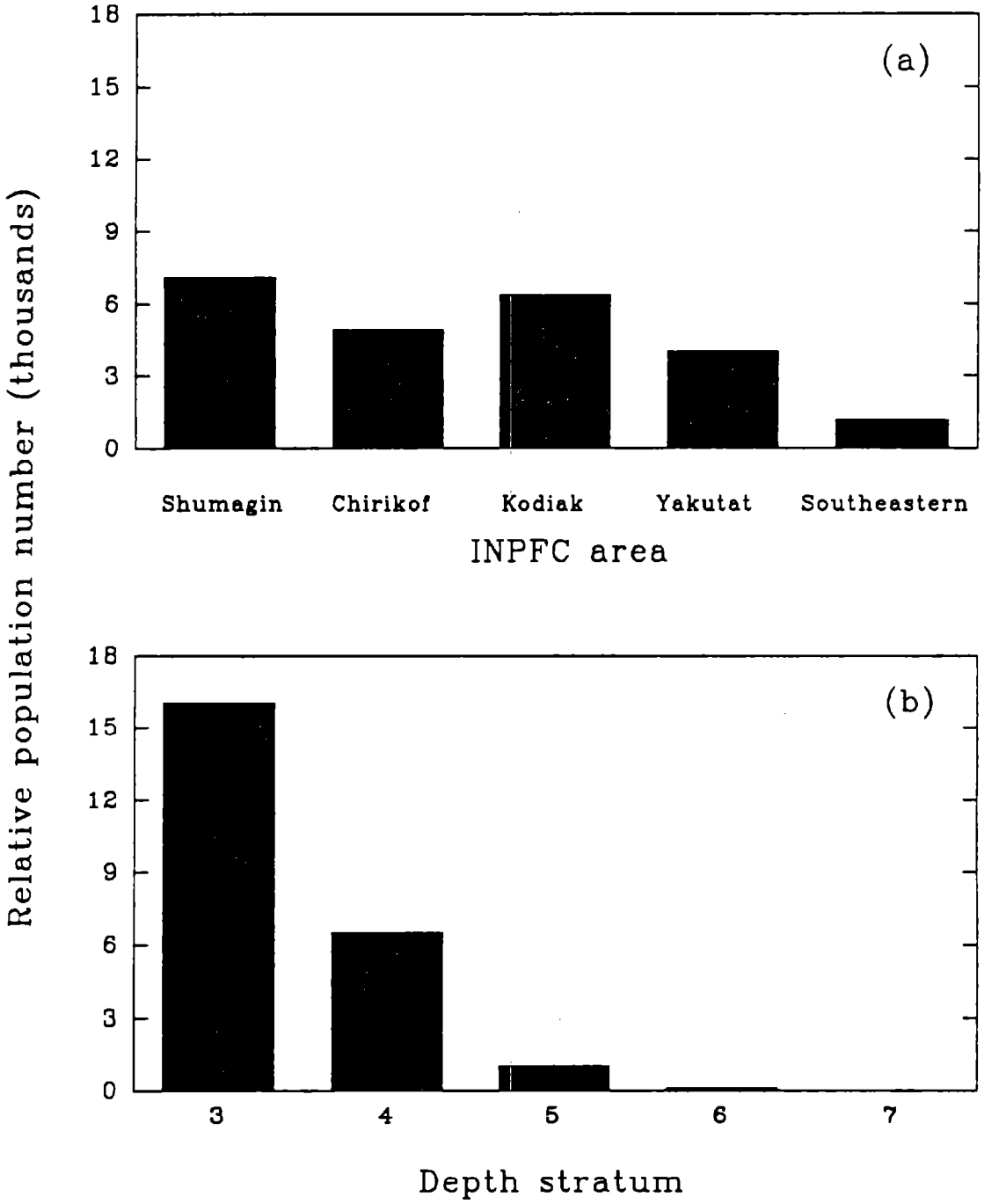


Figure 17.--Relative population numbers of arrowtooth flounder for the upper continental slope of the Gulf of Alaska by: (a) International North Pacific Fisheries Commission (INPFC) statistical area and (b) depth stratum. Stratum codes: 3=201-300 m, 4=301-400 m, 5=401-600 m, 6=601-800 m, and 7=801-1,000 m. National Marine Fisheries Service longline survey, 1988.

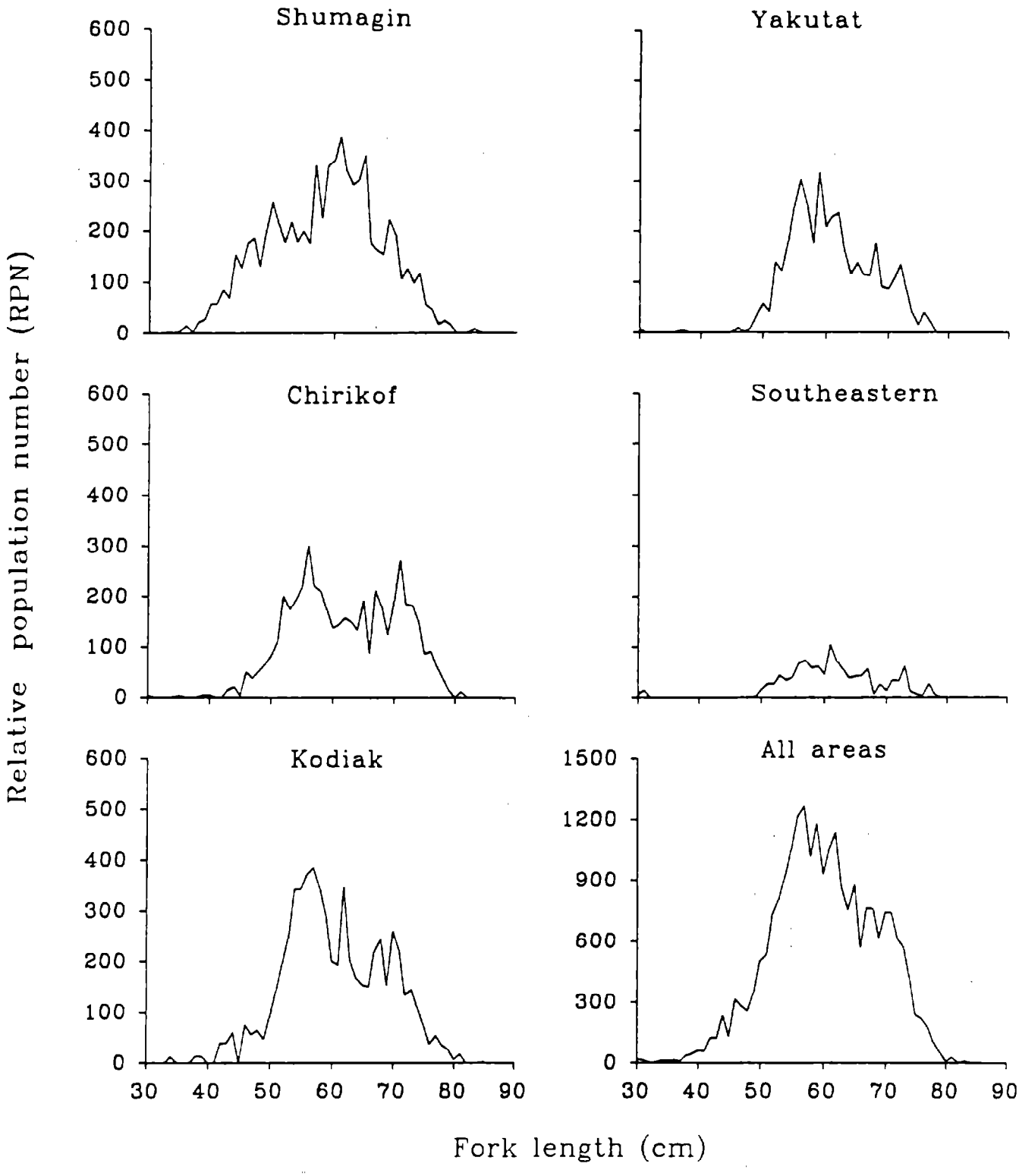
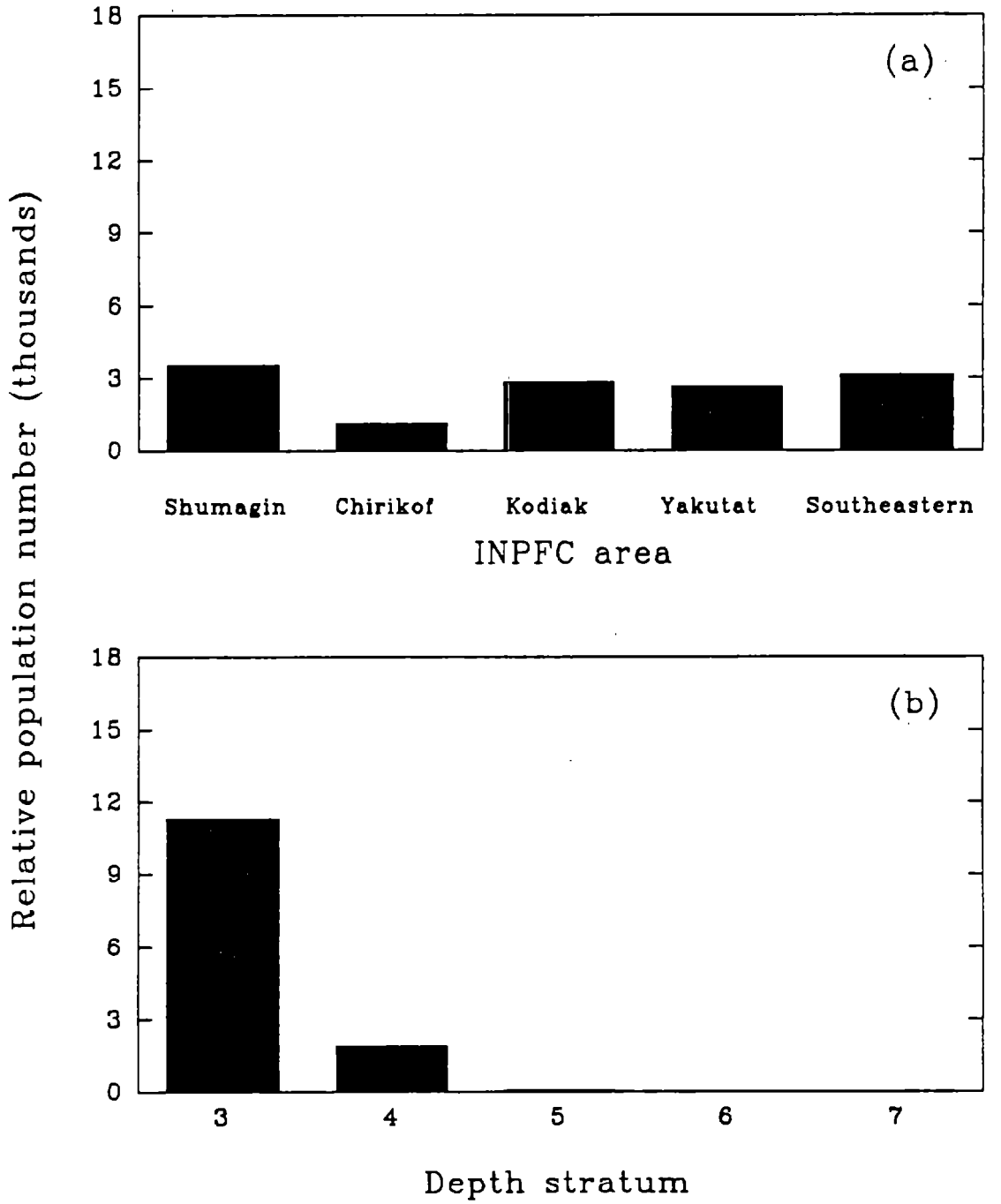


Figure 18.--Arrowtooth flounder length frequencies weighted by relative population numbers, for the upper continental slope of the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area. National Marine Fisheries Service longline survey, 1988.



lg.--Relative population numbers of Pacific halibut for the upper continental slope of the Gulf of Alaska by: (a) International North Pacific Fisheries Commission (INPFC) statistical area and (b) depth stratum. Stratum codes: 3=201-300 m, 4=301-400 m, 5=401-600 m, 6=601-800 m, and 7=801- 1,000 m. National Marine Fisheries Service longline survey, 1988.

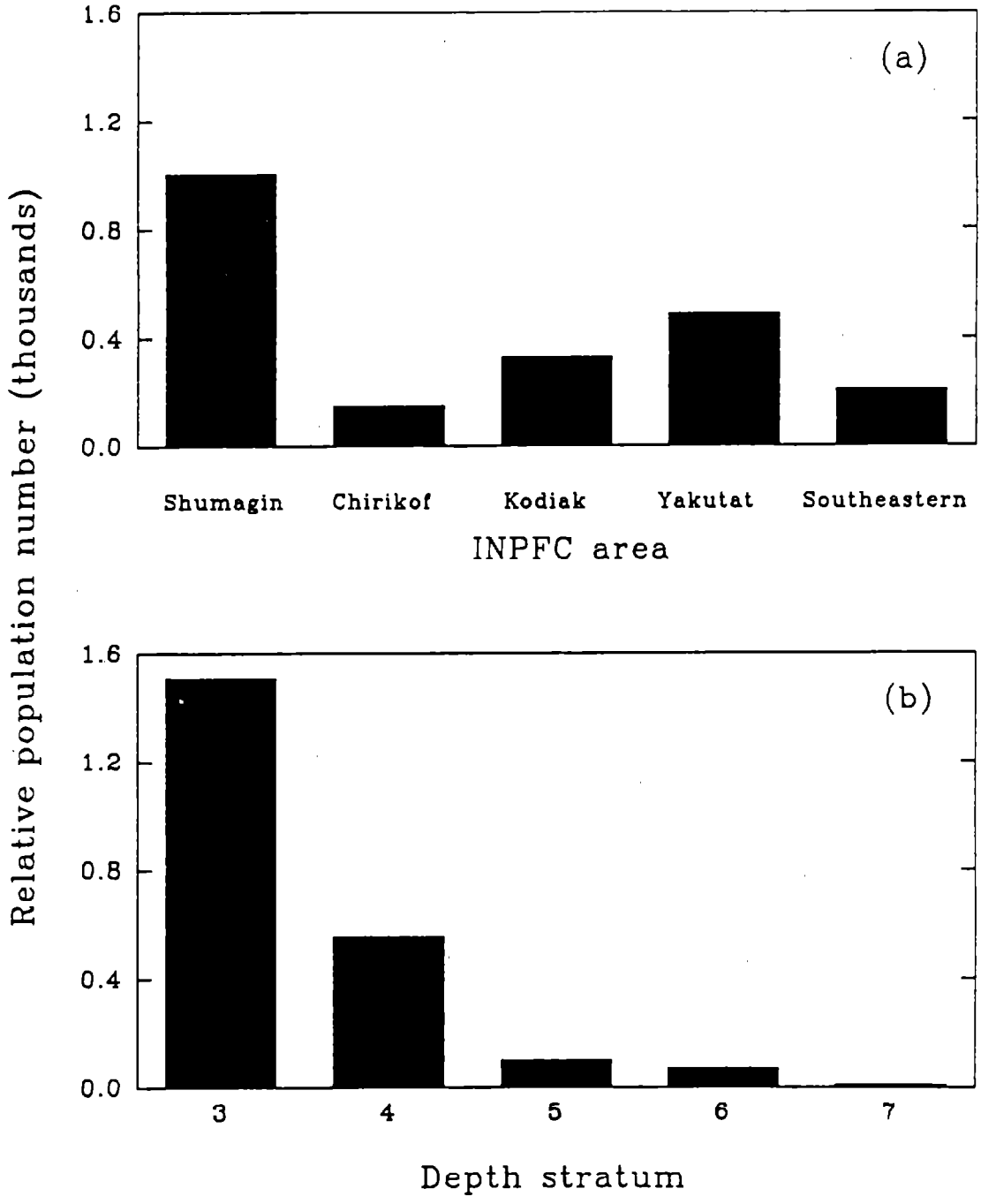


Figure 20.- - Relative population numbers of skates (Rajiidae) for the upper continental slope of the Gulf of Alaska by: (a) International North Pacific Fisheries Commission (INPFC) statistical area and (b) depth stratum. Stratum codes: 3=201-300 m, 4=301-400 m, 5=401-600 m, 6=601-800 m, 7=801-1,000 m. National Marine Fisheries Service longline survey, 1988.

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