A PROGRESS REPORT ON THE STATUS OF CANARY ROCKFISH (SEBASTES PINNIGER) IN THE INPFC VANCOUVER, COLUMBIA AND EUREKA AREAS IN 1984

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INTRODUCTION

This report summarizes progress made to date on the assessment of canary rockfish (Sebastes pinniger) stocks in the INPFC Vancouver, Columbia and Eureka Areas (Figure 1). Canary rockfish are an important constituent of the rockfishes inhabiting the continental shelf off northern California to southern Washington, especially. Vancouver Area landings have declined in recent years with a recent increase in 1983 where landings reached 1,558 mt (Table 1). Most of the increase (695 mt) came from Canadian trawl landings in PMFC Area 3D while landings in the U.S. section of the Vancouver Area have remained stable. Landings of canary rockfish have increased substantially since 1979, and 1983 landings from the Columbia Area were twice the twenty year average (Table 2). Average domestic trawl catch in the Eureka Area from 1977-1983 was 384 mt (Table 3).

The Fishery Management Plan, approved by the Pacific Fishery Management Council in February, 1981, stated that acceptable biological catch (ABC) of canary rockfish should not exceed 1,300 mt in the Columbia Area and 4,000 mt in the Vancouver Area. The Groundfish Management Team (Team) set assessment of canary rockfish as a high priority item since landings have substantially exceeded the recommended ABC in the Columbia Area. Both ABC estimates were based on trawl survey data. In late 1982, the Team recommended and the Council approved an 800 mt ABC for the U.S.-Vancouver Area, based on the highest catch of record instead.

Several technical problems have made traditional analysis such as production modelling (Pella and Tomlinson, 1969) and virtual population

analysis (VPA) (Gulland, 1965) difficult to perform satisfactorily. In the case of the former approach, insufficient effort information is available and the variability inherent in data that are available is large enough to render catch per effort models useless (Johnson, 1982). In the case of the latter techniques, uncertainties in validity of new aging techniques, the large number of age classes, the large number of incompletely recruited ages, high variability of catch at age data and lack of samples complicate VPA as an assessment means. Newer techniques such as stock reduction analysis (SRA) (Kimura and Tagart, 1982) hold some promise and may be useful for canary rockfish when an appropriate version of the model is developed. We have chosen a simpler approach based on a subjective evaluation of age and length data as well as catch history and recent rockfish survey results, instead of relying on the more formal albeit published techniques to assess canary rockfish.

LIFE HISTORY FEATURES

Canary rockfish occur from Baja California to southeast Alaska (Hart 1973). The species has been recorded to depths of 200 fms (Alverson et al. 1964) but most often occurs shallower, on the continental shelf (Fraidenburg et al., 1977).

Centers of abundance seem primarily limited to the INPFC Eureka and Columbia Areas, especially south of the Columbia River with lesser amounts in the Monterey and Vancouver Areas. Recruitment of canary rockfish seems to occur in the inshore recreational fishery first, where juveniles as well as some adults can be found. Mean length of canary rockfish in the 1979 recreational fishery off Cannon Beach, Oregon was 39 cm although fish as large as 57 cm were caught. Eighty-three percent of the fish sampled were less than 42 cm in length. Mean length in the commercial trawl fishery ranges from 44 to 50 cm.

Canary rockfish grow at moderate rates until fully recruited to the fishery and very slowly thereafter. Von Bertalanffy growth completion rates in samples taken from the commercial fishery average about 0.202 for males and females combined (Table 4). Recent use of higher magnification, sectioning (Boehlert, 1982) and break and burn techniques for age determination reveal ages greater than 50 years. Ninety-seven percent of the ages assigned in 1980-1982 by Oregon Department of Fish and Wildlife biologists using the newer techniques were less than 36 years of age, however. Archibald et al. (1981) reported total instantaneous mortality rates (Z) of 0.01 to 0.24 for this species in British Columbia waters.

Sexual maturity seems to be coupled with the exploitation pattern; fish that are at the age of full recruitment (about 15 years old) are near 100% maturity. Canary rockfish are ovoviviparous and mate in October-December

(Barss, et al., 1982). Canary rockfish are a highly fecund species. Gunderson et al. (1977) reported fecundity at 50% maturity and L^{∞} to be .82 to 1.30 million oocytes respectively. Males fertilize the females' eggs internally through copulation. Parturition takes place January through February.

Weight-length relationships are somewhat variable ($r^2 = 0.82$) in the Columbia Area (Table 5). For example, Tagart (1982) reported r^2 values for yellowtail rockfish (S. flavidus) which ranged from 0.87 to 0.96. Changes in condition factor due to reproduction probably contribute significantly to the variability in weight of canary rockfish. Once this species matures it adds very little in length or weight as it grows older (Table 6).

Males comprise most of the catch in numbers, averaging 60% from 1977 through 1982. Females seem to achieve a larger asymptotic size and live shorter lives than the males.

METHODS AND MATERIALS

Catch

Before the advent of rockfish species composition sampling in 1963 the catch of canary rockfish was unknown. All species except Pacific ocean perch (Sebastes alutus) were reported in a "other rockfish" category. Since 1963, market sampling of landed catch has been used to identify major species of the genus Sebastes.

We relied extensively on reports produced by Barss and Niska (1978) and Tagart and Kimura (1982) to estimate the removals of canary rockfish by both domestic and foreign trawlers. Domestic catch was based on these reports from 1963-1977 in the INPFC Columbia Area and from 1967-1976 in the INPFC Vancouver Area. The average proportion of canary rockfish in "other rockfish" from

1967-1971 was used to estimate canary rockfish taken by U.S. and Canadian trawlers from the Vancouver Area during the period 1963-1966 using the PMFC data series reported "other rockfish" landings. U.S. shrimp trawl catches of canary rockfish were estimated by applying the percentage of canary rockfish observed in species composition samples obtained by ODFW in 1982, to "other rockfish" catch by shrimp trawlers reported in the PMFC data series.

Domestic trawl landings in the INPFC Eureka Area were available from 1977-1983 from Agency TSC Reports and from Larry Quirollo (personal communication). Pacific Fishery Information Network (PACFIN) data were available for the first half of 1984 for all three INPFC areas.

Foreign removals were based on several additional data sources. Where possible, reported catches of canary rockfish by foreign and joint venture trawlers were used (French et al., 1981 and Tagart pers. comm., 1983). Estimates of all nation removals of "other rockfish" and Pacific ocean perch (Sebastes alutus) from Fraidenburg et al. (1977), Forrester et al. (1978), Gunderson et al. (1977) and Murai et al. (1981) were used as sources upon which foreign removals of canary rockfish were based. The percentage of canary rockfish in all rockfish excluding Pacific ocean perch in domestic catches was applied to reported foreign "other rockfish" catch in those years where it was not combined with Pacific ocean perch. In years 1967-1972 "other rockfish" reported by the U.S.S.R. included Pacific ocean perch and a different procedure was used. The percentages of canary rockfish in all rockfish excluding and including Pacific ocean perch in domestic landings were applied to estimated foreign removals including and excluding Pacific ocean perch as estimated by Gunderson et al. (1977). The two estimates of canary rockfish catches resulting from this procedure were averaged and used as the best estimate of foreign removals.

Age and Length Composition

Age composition data are sparse. Vancouver Area catch samples were collected by the Washington Department of Fisheries (WDF) in 1975 and 1977-1980 and by ODFW in 1982-1983. In the Columbia Area, Oregon data used in this analysis were available only for 1974 and the period 1977-1984. Washington data are available only for the years 1976 and 1978-1980. Eureka Area data from Oregon sampling were available for 1983 and 1984. Ages of otoliths collected in 1980 and previous years were determined by counting hyaline bands (annuli) on the surface of the otolith using a 10 power binocular microscope. All 10 power readings were done by WDF. Beginning in 1980, and continuing through 1982 ODFW began reading canary rockfish otoliths at 60 power and also began breaking and burning the otoliths to reveal the banding on the interior of the otoliths. Ages assigned in 1980-1984 by ODFW were obtained using a combination of 60 power surface or break and burn readings.

Length frequency data were more complete spanning 1968-1980 (WDF) and 1982-1983 (ODFW) in the Vancouver Area and 1971-1984 in the Columbia Area (excluding missing data in 1973 and 1975). Eureka Area data are available from 1983-84 Oregon sampling. Age data developed from the newer aging techniques were examined in more detail by PMFC Area in an attempt to determine effects of fishing (if any) or strong recruitment to the grounds on age composition.

Mortality

Because of the potential under-aging bias in age composition from otoliths obtained during 1974-1979, estimates of total instantaneous mortality rate (Z) were made only for the Columbia Area from age data obtained in 1980-1984. Estimates of Z were determined by regressions of the log of catch at age data for canary rockfish including ages ranging from 15 to 35 years.

Survey Data

Bottom trawl survey biomass estimates by INPFC Area were available for 1977 (Gunderson and Sample, 1980), 1980 (Dark et al., 1983) and 1983 (Mark Wilkins, pers. comm.). Biomass estimates were made using the area swept method (Gunderson, 1980) over a range of 55 to 457 meters.

Acceptable Biological Catch

Since reliable quantitative assessments of canary rockfish are not yet available, a subjective method was developed which incorporated the catch history as a measure of the production potential, and any relevant biological data which would reflect signs of stress due to high fishing mortality. The objective was to adjust estimates of sustainable yield (ABC) in an adaptive manner to aim the fishery in the right direction. Some indicators of biological stress which might be related to high fishing mortality include a decreasing trend in average length and/or average age coupled with higher catches, an increase in the proportion of catch at age younger than the age of full recruitment, and a decrease in the proportion of sexually mature fish in landings.

We recommend that the following guidelines be applied to the catch history, to arrive at an ABC:

(1) On stocks with a history of moderate exploitation where catches are stable and no consistent signs of biological stress are present allow for an annual catch up to 130% of the average catch. The new ABC would be held constant for 3-5 years while evaluation of the resource is conducted with assessments aimed determining the direction of future catches (e.g. increase or decrease ABC). Actual ABC's would range between 100 and 130% of average catch depending on how mature the fishery is.

(2) If catches have undergone a recent (5-7 years) substantial increase (doubling or tripling) over the long term average and no consistent signs of stress are present, use a range between the long term average before the increase and the peak catch to set ABC. The actual ABC would depend on any information that indicated the degree of exploitation. If no additional information is available, the mean of the range would be used to set ABC. Assessments should be conducted annually with recommendations at the end of each year on the direction harvest should go. A shorter period is required for assessment since the risk of recruitment failures may be greater;

(3) If catches have peaked or are high and signs of stress (especially juvenescence) are beginning to appear, reduce the most current annual catch by 10 to 30% and continue yearly assessments to determine the severity of stress. The ABC then would range between 70 to 90% of the most recent annual catch depending on the severity of stress. Longer term modelling on appropriate MSY values and rebuilding scenarios should be conducted as necessary.

RESULTS

Catch

Vancouver Area

U.S. trawl catches have made up the largest portion of canary rockfish caught by U.S. and Canadian trawlers in 20 years of fishing (Table 1). Canadian trawlers have taken a larger proportion while U.S. trawlers have taken less in recent years due to exclusion of U.S. trawlers north of the U.S.-Canada boundary line. About 42.5% of the total production by both

countries has come from U.S. waters. Shrimp trawl-caught canary rockfish has increased in recent years following a pattern similar to that seen in the Columbia Area.

Estimated foreign removals peaked in 1968 and again in 1974 (Table 2). Estimated foreign removals may have contributed to 52% of the total catch from 1967 to 1976.

Columbia Area

Prior to 1963 landed catch of "other rockfish" by Oregon trawlers averaged 2,444 mt from 1942 to 1962, peaking in 1945 when 7,917 mt of rockfish were landed (Anonymous, 1971). Although the landings of canary rock-fish were unknown from 1945 through 1962, one of the founders of the Oregon trawl fishery stated that a large part of the rockfish landed by the domestic fleet were canary rockfish (Mr. Gordon White, pers. comm., 1980).

Since 1963 and through 1977 the U.S. annual trawl catch of canary rock-fish from the Columbia area was relatively stable averaging 577 mt (Table 2). Catches during this period especially were limited by market factors. In 1978 the catch increased to 1,372 mt, more than double the average catch of the previous 15 years. Record landings continued, peaking at 3,151 mt in 1982. Much of the increase was due to improved market condition but was also attributed to the expansion of traditional grounds by use of roller trawls. Estimated catch in 1981 was 1,669 mt, a reduction from previous years, an anomaly which we partially attribute to a shift in effort in the midwater trawl fishery for widow rockfish (Sebastes entomelas). This fishery, which was at its peak in 1981-82 developed new markets for rockfish, especially widow rockfish, at a lower price, which probably actually diminished demand for canary rockfish which was landed at a higher ex-vessel price. Now that the widow rockfish fishery has declined, demand for other rockfish species is likely to increase effort on canary rockfish.

Shrimp trawl landings of canary rockfish have increased in recent years along with fish trawl landings. Shrimpers facing reductions in abundance and price of shrimp have sought to supplement their income by developing markets for incidentally-caught groundfish.

Foreign removals of canary rockfish may have contributed to a significant proportion of the harvest, especially from 1963-1973. Joint venture operations seem to be contributing very little to the catch in recent years.

Eureka Area

Only U.S. trawl landings were available from 1977-1983 at the time of writing. No accounting has yet been made of foreign and shrimp trawl removals of canary rockfish during this period. Domestic landings averaged 384 mt and peaked in 1982 at 901 mt (Table 3). It is likely that the lower production is due in part to the smaller size of the Eureka Area and smaller continental shelf area in optimal depth ranges (50-100 fms) inhabited by canary rockfish, compared to other INPFC areas.

Age and Length Composition

Vancouver Area

All age data from the Vancouver area were compiled from low power surface readings from 1975-1980. Average age ranged from 7.5 years to 15.8 years in 1975 and 1978 respectively (Figure 2). The 1962 and 1967 yearclasses seemed to be strong in this area as well. The age distributions seemed quite variable and may reflect inadequate sampling in some years (Table 7). More recent age data from Oregon samples from Area 3B developed from high power-break and burn methods reveal a wider range of ages (Figure 3). The 1967 yearclass was strong in 1982 but very weak in 1983. The 1973 yearclass appeared to be quite strong. These inconsistencies reflect the paucity of sample data in 1982-83, however. Average age was 18.9 and 15.9 years in 1982 and 1983, respectively.

Length frequency data were available for a longer time series, and average lengths seemed stable with the exception of average length in 1975. Average lengths ranged from 42.2 to 50.3 cm with most being 49 to 50 cm (Figure 4). Average lengths in 1982 and 1983 samples from Area 3B were 51.5 and 49.3 cm respectively. No consistent trends in the proportion of fish less than the effective length of recruitment were observed from 1968-1980 (Table 8).

Columbia Area

Fish sampled from commercial landings ranged in age from 5 to 54 years with most fish between 10 and 35 years old (Table 9 and Figure 5). Recruitment seems to be somewhat variable. The 1962 yearclass and more recently the 1967 and 1968 yearclasses seem to be strong contributors to the catch. Mean age for otoliths aged at low power varied from 10.0 years in 1976 to 15.8 years in 1979. Mean age for otoliths aged at high power and break and burn techniques ranged from 16.2 years in 1983 to 18.3 years in 1984.

Examination of the age frequency data by PMFC Area by six-month period from 1980 through the first six-months of 1984 revealed a high degree of variability in assigned ages (Figure 6). The 1973 and 1974 yearclasses seemed fairly strong in samples from Area 3A and 2B-2C. The most consistent yearclass in Area 2B-2C seemed to be the 1973 yearclass. The 1974 yearclass was most consistent in Area 3A, although the 1973 yearclass was strong in the first half of 1983.

Average length ranged from 43.9 cm to 50.2 cm in 1976 and 1978 respectively (Figure 7). The presence of small fish and absence of larger ones in 1976 was attributed to inadequate sampling. The only samples taken were from small trips made in shallow water. Aside from 1976, average length has been fairly stable. As in the Vancouver area, no consistent trends were observed in the proportion of smaller fish (Table 10).

Eureka Area

In 1982, the 1972 yearclass seemed to be strong with little indication of carryover into 1983 (Figure 8). The 1974 yearclass appeared to dominate in 1983. Average age was 20.6 and 18.4 years in 1982 and 1983 and average length was 49.9 and 49.1 respectively, in the Eureka Area.

It is suspected that the high number of age groups, relatively small sample size per age class and aging errors may contribute a great deal to the variability in age frequencies. There seems to be an increasing percentage of fish less than 11 years of age in recent times as well as an increase in the percentage at an advanced age. The former phenomena appears to be shifting back in 1984 in the Columbia Area. We suspect that the changes in proportion of younger and older fish may be due to strong yearclasses passing through the fishery and increased accuracy in assigning ages of the most recent samples.

Mortality

Estimates of Z based on the descending limb method ranged from 0.109 to 0.132 (Table 11). These estimates may underestimate true instantaneous rate of mortality and could be reflective only of mortality rates prior to recent increases in exploitation. Effort information was poor due to the refusal of some of the more productive vessel operators to keep logbooks. Poor effort data and probable changes in catchabilities due to gear improvements make it difficult to estimate Z using other methods.

Estimates of M are somewhat subjective, but in view of the longevity of canary rockfish, a low rate is plausible. Archibald et al. felt that the values of Z may be influenced by extensions of the catch curve resulting from a possible decrease in mortality for older fish prior to the onset of mortality associated with senescence. Ages as great as 76 years were seen in Canadian data which seem to have contributed to this extension effect.

Exploitation in the Columbia Area has probably been higher than in Canadian waters and fewer older fish were seen. As mentioned earlier, most of the fish seen in the commercial catch were less than 35 years of age.

For the above reasons, we chose M=0.1 as our best estimate for an instantaneous rate of natural mortality for fish between the ages of 15 and 35. If Archibald et al. are correct, then natural mortality rates of fish beyond the age of full recruitment to age 35 may be higher than for fish beyond age 35. M=0.1, therefore, represents a compromise between the value of M = 0.2 reported in the Groundfish Plan and Z = 0.02 - 0.08 reported by the Canadians.

Survey Results

Canary rockfish biomass estimates ranged from 2,698 to 19,940 mt in the Vancouver Area and from 2,918 to 6,342 mt in the Columbia Area. Both areas demonstrated similar trends in abundance (Table 12), declining from 1977 to 1980 and increasing in 1983. The Eureka Area estimates ranged from 366 to 1,258 mt and a trend reverse to that in the Vancouver and Columbia Areas was observed. The most recent estimates seem to be lower than what would realistically support a fishery under recent levels of catch. The survey data may be useful as an index of abundance; however, the large variances associated with the estimates tend to limit their utility.

Acceptable Biological Catch

Vancouver Area

Option 1 was selected for use in calculating ABC's on the basis of the data examined to date. Catches have peaked and declined somewhat to a fairly stable level (with the exception of 1983 catch in the Canadian portion of the Vancouver Area) and no alarming trends have yet been seen in average age or length. The 1983 PMFC Area 3B samples indicate a lower average size of fish

compared to previous years but the average was based on a sample size of 100 fish. No clear trend has been established by previous data. Recently received length frequency data from samples taken in 1980-1984 will be analyzed for trends in the percentage of young fish and average length.

The 1977-1983 U.S. portion of the INPFC Vancouver landed catch averaged 499 mt and landed catch exceeded current ABC of 800 mt only in 1978 when the catch reached 901 mt. Recent catches have been near or below the long term average so an ABC of at least 110% of the mean catch through 1977-1983 would be recommended while assessment work is completed. Applying this recommendation at 110 and 130% of the 1977-1983 average landed catch (U.S. portion) for each year since 1983 would result in a range of 1985 ABC's of 604 to 843 mt.

Columbia Area

Option 2 was selected as appropriate for the Columbia Area. Catches have undergone a recent increase which has doubled the long term mean catch. Although there were signs of a higher proportion of younger fish in the catch, there has been no alarming trend in average age or length and in 1984 average length and age increased over previous years. Landed catch prior to recent increases averaged 946 mt (1963-1977) while catches peaked at 3,309 mt. Unde option 2 these values represent the lower and upper bounds of ABC. We recommend the mean of these limits as the ABC for 1985 or 2,127 mt until assessments are completed in 1985. Note that the recommended ABC falls within the Pacific Coast Groundfish Plan guidelines for a maximum adjustment in ABC using 1983 as a base year. Using the Plan's procedure a 1985 ABC of 2,197 mt would be allowable (see section 9.3 in the Plan).

Eureka Area

Option 1 was selected for the Eureka Area since catches have been variable and no signs of stress are evident in the limited amount of data we have had to work with. Average landed catch was 384 mt from 1977-1983. The range of ABC's in 1985 applying 110 and 130% to 384 mt for each year since 1983 would be 465 to 649 mt.

DISCUSSION AND RECOMMENDATION

None of the areas examined exhibit significant trends in the percentage of young fish in the catch, average age or average length. The survey information does not provide any real conclusive evidence for stock decline or increase in recent years. Lack of good independent measures of fishing mortality rates, and questionable age data make VPA estimates difficult. Stock reduction analysis (SRA) holds promise but needs refinement. There appears to be no overriding biological reason to limit the harvest to 1,300 mt (the current ABC) in the Columbia Area. Recommended ABC's in the Vancouver and Eureka Areas (800 and 600 mt respectively) may be more appropriate based on the relative area capable of producing fish and catch history.

We recommend the following:

(1) Set 1985 Vancouver, Columbia and Eureka Area ABC's at 800, 2,100, and 600 mt, respectively (ABC's rounded to nearest 100 mt).

(2) Continue to monitor the length and age of Canary rockfish to determine if the presence of young fish in recent years was due to fishing or the passage of strong yearclasses.

(3) Examine 1983 survey catch at age data and compare with commercial data to determine effects of strong recruitment and to detect presence of strong yearclasses not yet recruited to the fishery.

(4) Complete model development by 1985 and design a sampling program to estimate required parameters for stock assessment.

LITERATURE CITED

Alverson, D.L., A.T. Pruter and L.L. Ronholt, 1964. A study of demersal fishes and fisheries of the northeastern Pacific Ocean. Ocean Inst. of Fish., Univ. of British Columbia, Vancouver, B.C., 190 pp.

Anonymous, 1971. Report of the Technical Subcommittee of the International Trawl Fishery Committee, appointed by the Second Conference on Coordination of Fisheries Regulations Between Canada and the United States. Twelfth Annual Meeting, June 16-18, 1971. Vancouver, B.C., 24p.

Anonymous, 1982. Final fishery management and suplemental environmental impact statement for the Washington, Oregon and California groundfish fishery. Pac. Fish. Man. Coun., Portland, Oregon.

Anonymous, 1982. ABC calculations for widow and yellowtail rockfish. Pac. Fish. Man. Coun., Portland, Oregon.

Archibald, C.P., W. Shaw and B.M. Leaman, 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-1979. Car. Tech. Rep. Fish. Aquat. Sci. 1048:iv + 57p.

Chilton, D.E. and R.J. Beamish, 1982. Age determination methods for fishes studied by the groundfish program at the Pacific Biological Station. Car. Spec. Pub. of Fish and Aquatic Sci. No. 60.

Dark, T.A., M.E. Wilkins, and K. Edwards. 1983. Bottom trawl survey of canary rockfish (Sebastes pinniger), yellowtail rockfish (S. flavidus), bocaccio (S. paucispinis), and chilipepper (S. goodei) off Washington-California, 1980. NOAA Tech. Mem. NMFS F/NWC-48. 40p.

Fraidenburg, M.E., J.E. Smith, W.H. Barss and T. Jow, 1977. Minimum estimates of the all nation removals, north American trawl species composition and CPUE for "other rockfish" in the northeastern Pacific ocean. Wash. Dept. of Fish. Tech. Rept. No. 34:31 pp.

Gulland, J.A., 1965. Estimation of mortality rates, Annex to Artic Fisheries Working Group Report, Int. Counc. Expl. Sea, Ann. Meeting 1965 (Mimeo).

Gulland, J.A., 1971. The fish resources of the ocean. Fishing News (Books) Ltd. Surrey, England. 255 p.

Gunderson, D.R., and T.M. Sample. 1980. Distribution and abundance of rockfish off Washington, Oregon and California during 1977. Mar. Fish. Rev. 42(3-4):2-16.

Hart, J.L., 1973. Pacific fishes of Canada. Fish. Res. Bd. Cn. Bull. No. 80:740 pp.

Johnson, S.L., W.H. Barss and R.L. Demory, 1982. Rockfish assessment studies on Heceta Bank, Oregon, 1980-81. Ore. Dept. Fish and Wildl. Sub. Proj. Annual Rept. NMFS Proj. No. 1-151-R-2, 22 p.

Kimura, D.K. and J.V. Tagart. 1982. Stock reduction analysis, another solution to the catch equations. Can. J. Fish. Aquat. Sci. 39:1467-1472.

Pella, J.J., and P.K. Tomlinson. 1969. A generalized stock production model. Bull. Inter-Am. Trop. Tuna Comm., 13:419-496.

Robson, D.S., and D.G. Chapman. 1961. Catch curves and mortality rates. Trans. Am. Fish. Soc. 90:181-189.

Schaefer, M.B. 1954. Some aspects of the dynamics of populations important to the management of commercial marine fisheries. Inter-Amer. Trop. Tuna Comm. Bull. 1(2), 26-56.

Tagart, J.V. 1982. Status of the yellowtain rockfish (Sebastes flavidus) fishery. Wash. Dept. of Fish. Tech. Rept., 65 pp.

Table 1 . Minimum estimated catch (mt) of canary rockfish (Sebastes pinniger) by United States and foreign trawlers in the INPFC Vancouver area.

	U.S.		Canadian	Foreign	All Nation
Year	Trawl	Shrimp Trawl	Trawl	Trawl	Total
1963	932				932
1964	723				723
1965	824				824
1966	983				983
1967	770		15	3474	4259
1968	1176		32	1660	2868
1969	1192	1	44	582	1819
1970	1161	1	67	398	1627
1971	1078		90	426	1594
1972	379		14	196	589
1973	575		37	647	1259
1974	800	11	76	2970	3857
1975	1083	10	44	33	1170
1976	815	21	152	211	1199
1977	1060	19	196		1275
1978	1582	37	69		1688
1979	743	84	133		960
1980	529	62	126		717
1981	410	60	65		535
1982	504	22	316		842
1983	647	65	846		1558
1984 (proj.)	170	NA	NA		170
Ave 63-83	856				1489
Ave 77-83	782				1082
Ave 77-83	(US portion)				499 mt

Table 2 . Minimum estimated catch (mt) of canary rockfish (Sebastes pinniger) by United States and foreign trawlers in the INPFC Columbia area.

	U.S.		Foreign	All Nation
Year	Trawl	Shrimp Trawl	Trawl	Total
1963	573			573
1964	772			772
1965	703			703
1966	785			785
1967	127	31	409	567
1968	551	30	950	1531
1969	620	35	242	897
1970	484	40	310	834
1971	585	21	302	908
1972	613	57	309	979
1973	784	89	1905	2778
1974	556	89	22	667
1975	365	59	225	649
1976	464	100	34	598
1977	671	137	7	815
1978	1372	120	31	1523
1979	2341	239	38	2618
1980	2613	270	31	2914
1981	1669	202	3	1874
1982	3151	158		3309
1983	2819	111		2930
1984(proj.)	1662	NA	NA	2283
Ave 63-83	1077			1392
Ave 77-83	2091			2283

Table 3. Minimum estimated catch (mt) of canary rockfish (Sebastes pinniger) by United States and foreign trawlers in the INPFC Eureka area.

	U.S.		Foreign	All Nation
Year	Trawl	Shrimp Trawl	Trawl	Total
1977	107			107
1978	437			437
1979	291			291
1980	80			80
1981	325			325
1982	901			901
1983	544			544
1984	66			66
Ave 77-83	384			384

Table 4. Estimated vonBertalanffy growth parameters for canary rockfish *(S. pinniger)* from market samples collected from 1980-1982. Standard errors of estimate in parenthesis.

INPFC Area	Sex	L_∞ (mm)	K	To	N
Vancouver	Male				
	Female				
Columbia	Male	512.9 (1.43)	0.162 (0.008)	-2.634 (0.496)	1311
	Female	573.2 (3.37)	0.153 (0.010)	-1.221 (0.580)	907
	Combined	527.8 (1.64)	0.202 (0.010)	-0.0765(0.416)	2218

Table 5. Estimated length-weight parameters for canary rockfish (*S. pinniger*) from market samples collected from 1977-1981[a/].

INPFC Area	Sex	a	b	n	r^2
Vancouver					
Columbia	Male	2.15X10-4	2.596	1294	0.808
	Female	1.41X10-4	2.665	776	0.824
	Combined	1.31X10-4	2.677	2214[b/]	0.835

a/ $W = al^b$ using an ordinary regression where W = weight in grams and 1 = fork length in mm.

b/ includes additional sample data obtained from WDF in 1980.

Table 6. Estimated average weight and length at age for canary rockfish (*S. pinniger*) aged 6-35, in the INPFC Columbia area.

	Males		Females		Combined[1/]	
	Weight	Length	Weight	Length	Weight	Length
Age	kg	cm	kg	cm	kg	cm
6	1.124	38.7	1.077	38.3	1.020	37.3
7	1.272	40.6	1.292	41.0	1.268	40.1
8	1.407	42.2	1.494	43.3	1.475	42.4
9	1.522	43.5	1.685	45.3	1.648	44.3
10	1.633	44.7	1.859	47.0	1.791	45.8
11	1.730	45.7	2.021	48.5	1.911	47.1
12	1.810	46.5	2.158	49.7	2.011	48.2
13	1.881	47.2	2.287	50.8	2.094	49.0
14	1.944	47.8	2.397	51.7	2.164	49.7
15	2.008	48.4	2.497	52.5	2.222	50.2
16	2.051	48.8	2.586	53.2	2.270	50.7
17	2.095	49.2	2.665	53.8	2.310	51.1
18	2.128	49.5	2.732	54.3	2.344	51.4
19	2.162	49.8	2.785	54.7	2.372	51.6
20	2.185	50.0	2.840	55.1	2.395	51.8
21	2.208	50.2	2.882	55.4	2.415	52.0
22	2.230	50.4	2.923	55.7	2.431	52.2
23	2.242	50.5	2.951	55.9	2.445	52.3
24	2.253	50.6	2.980	56.1	2.456	52.4
25	2.265	50.7	3.008	56.3	2.465	52.4
26	2.277	50.8	3.022	56.4	2.473	52.5
27	2.288	50.9	3.051	56.6	2.480	52.6
28	2.288	50.9	3.065	56.7	2.485	52.6
29	2.300	51.0	3.080	56.8	2.490	52.6
30	2.300	51.0	3.080	56.8	2.494	52.7
31	2.312	51.1	3.094	56.9	2.497	52.7
32	2.312	51.1	3.109	57.0	2.499	52.7
33	2.312	51.1	3.109	57.0	2.502	52.7
34	2.323	51.2	3.123	57.0	2.503	52.7
35	2.323	51.2	3.123	57.1	2.505	52.7

1/ Represents an average weighted to sex from data collected during 1980-1982.

Table 7. Sample numbers (sample size) of canary rockfish (S. pinniger) age structures used in assigning ages shown in Figures 5-7.

Number of samples taken and (number of observations)

YEAR	3B	3A	2B-2C	2A
1984		2(160)	4(400)	
1983 Jul-Dec		6(600)	6(598)	2(198)
1983 Jan-Jun	1(100)	7(686)	7(642)	
1982 Jul-Dec	1(31)		1(60)+8(617)	1(100)
1982 Jan-Jun			6(257)+2(195)	1(99)
1981 Jul-Dec			5(414)	
1981 Jan-Jul			3(219)	
1980 Jul-Dec			9(381)	
1980 Jan-Jun			3(138)	

Table 8. Proportion of catch less than or equal to length of recruitment (lr) of canary rockfish (S.pinniger) in the INPFC Vancouver area.

Year	C'l/Cl	lr (cm)		
	46	47	48	49
1968	.1960	.2470	.3340	.4321
1969	.2052	.2878	.3978	.4903
1970	.2381	.2946	.3544	.4250
1971	.1789	.2431	.3067	.4116
1972	.0914	.1482	.2684	.3742
1973	.1709	.2550	.3764	.5174
1975	.5818	.6052	.6408	.6658
1977	.0890	.1576	.2338	.3086
1978	.1182	.2050	.2695	.3418
1979	.1858	.2526	.3248	.4239
1980	.1371	.1876	.2589	.3279

Table 9. Estimated annual landings (number of fish) of canary rockfish (S.pinniger) from INPFC Columbia area, 1980-1983 and 1984 landings (first 6 mo.). All ages assigned using 60 power surface or break and burn technique.

	Year of Catch				
Age	1980	1981	1982	1983	1984
5	0	0	1243	3590	0
6	7440	1345	4973	10803	1581
7	14881	4035	16164	38303	5567
8	49601	26900	45244	91667	14635
9	27282	48420	86183	124889	27779
10	24801	52455	103022	133517	35705
11	57042	37660	82833	85347	38212
12	104165	64559	116125	74324	24871
13	101684	75319	128085	76794	22320
14	79363	69940	121868	90306	27584
15	81844	34969	101686	66650	25928
16	71923	33625	66964	39130	25778
17	81844	26900	46014	36392	11953
18	54562	49765	38358	41588	11513
19	79363	49765	56730	36647	5699
20	64482	36315	70213	48303	10289
21	52082	33625	65721	40179	17045
22	49601	36315	46775	42132	18545
23	49601	25554	35297	37226	14032
24	42161	20175	35779	28664	11565
25	24801	13450	35872	18143	10614
26	27282	14794	18845	14959	9659
27	22321	8070	20664	16160	8856
28	14881	9415	16358	10293	5003
29	12401	5379	12053	22592	977
30	24801	9415	16739	11078	5735
31	9920	14794	11478	12754	4770
32	9920	2690	8991	10647	5003
33	7440	10760	9566	6106	3827
34	7440	5379	13584	9401	6270
35	9920	10760	8323	4471	1788
36	7440	5379	8323	6804	810
37	0	2690	9279	5078	2771
38	4961	1345	1243	3359	7093
39	2480	1345	6216	4785	3618
40	0	1345	2487	5551	5738
41	0	0	8323	3598	3228
42	0	2690	2487	3180	2546
43	0	1345	4017	2625	3948
44	0	0	0	1454	1386
45	2480	2690	1531	472	977
45+	4960	0	9279	12061	3721
Total	1287169	851380	1494936	1332022	448940

Table 10.Proportion of catch less than or equal to length of recruitment (lr) of canary rockfish (S.pinniger) in the INPFC Columbia area.

Year	C'l/Cl	lr (cm) 46	47	48	49
1971		.2765	.3855	.5055	.6275
1972		.1576	.2663	.4100	.5489
1974		.1039	.1800	.2874	.4035
1976		.6218	.6824	.7057	.7612
1977		.1919	.2647	.3751	.4587
1978		.1158	.1679	.2307	.3176
1979		.1034	.1722	.2645	.3714
1980		.1075	.1647	.2301	.3384
1981		.1339	.1829	.2853	.3847
1982		.1621	.2184	.3103	.4166
1983		.1907	.2482	.3159	.4046
1984	(First 6 mo.)	.1599	.2091	.2659	.3913

Table 41. Estimates of instantaneous total mortality (Z) for canary rockfish (S. pinniger) in the INPFC Columbia area during 1980-1983 and first 6 mo. of 1984. Catch at ages 15-35 were used to estimate Z by regression of $\log_e$ of the catch at age.

	Year					
	1980	1981	1982	1983	1984	Average
Z	.132	.109	.118	.112	.097	.115

Table 12. Biomass estimates of canary rockfish in the INPFC Vancouver (U.S.) Columbia and Eureka areas from rockfish surveys 1977,1980 and 1983.

Year	Depth	INPFC Area					
		Vancouver		Columbia		Eureka	
	m	mt	.90 CI	mt	.90 CI	mt	.90 CI
1977	91-457	19,940	0 53,530	6,290	3,080 9,510	490	0 1,280
1980	55-183	2,698	0 6,954	2,918	1,163 4,676	1,258	0 3,287
1983	55-366	4,636	1,298 7,974	6,342	2,473 10,211	366	208 538

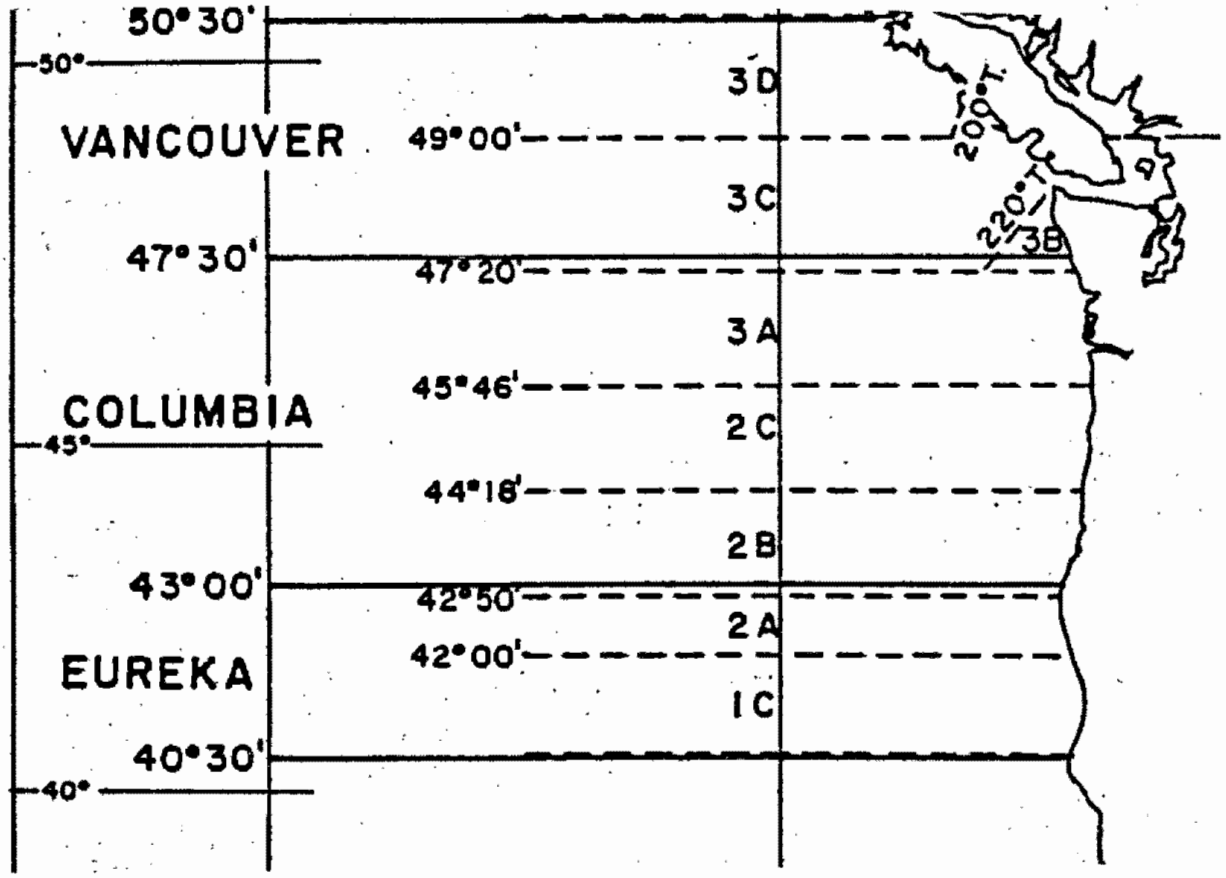


Figure 1. PMFC and INPFC statistical areas off British Columbia, Washington, Oregon and California.

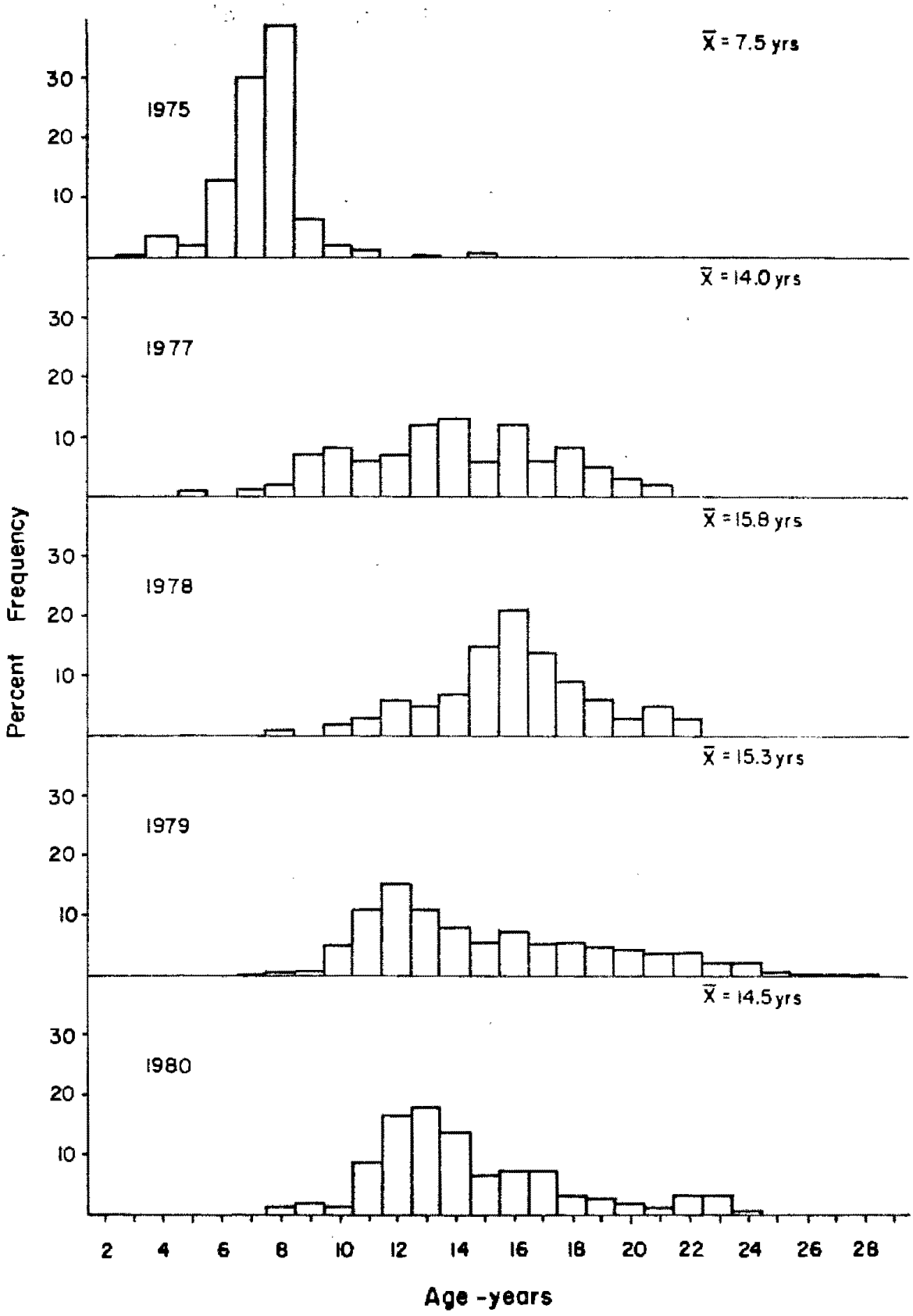


Figure 2. Age composition of canary rockfish (*S. pinniger*) in the INPFC Vancouver area. Low power (10x) surface readings used in 1975-1980. Continued on next page.

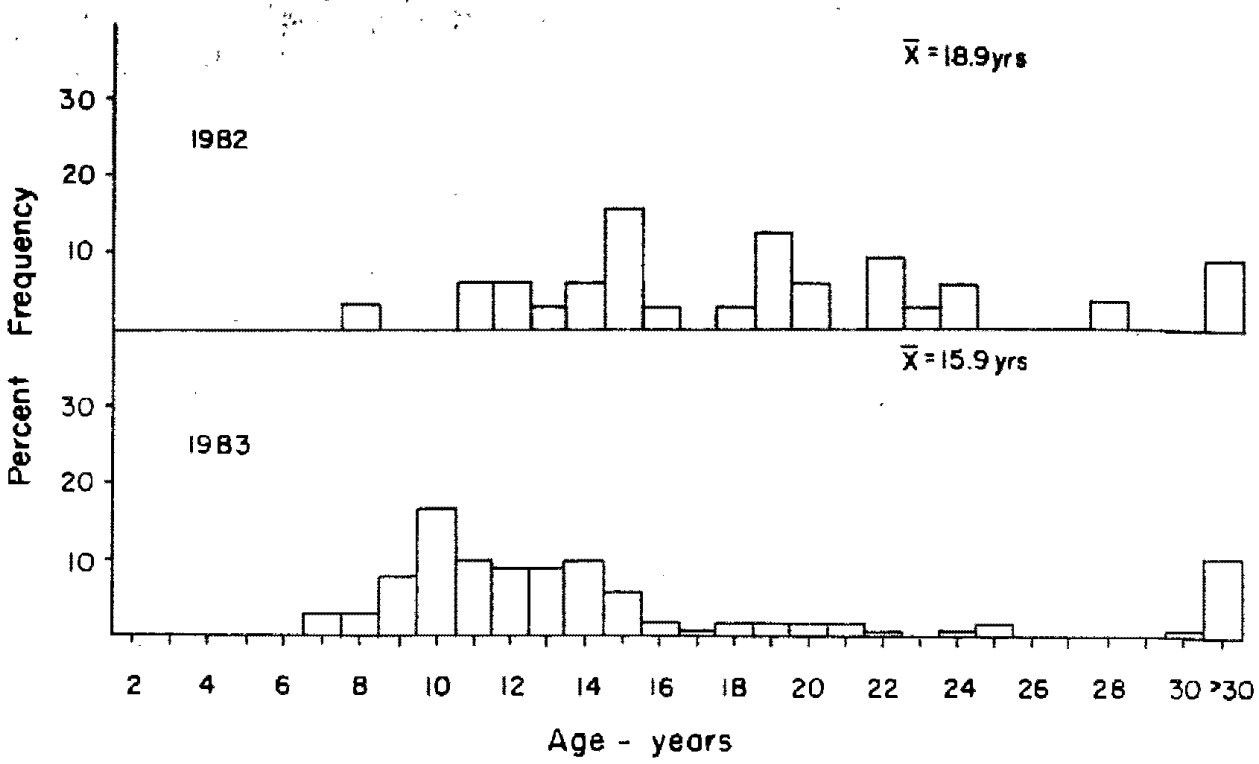
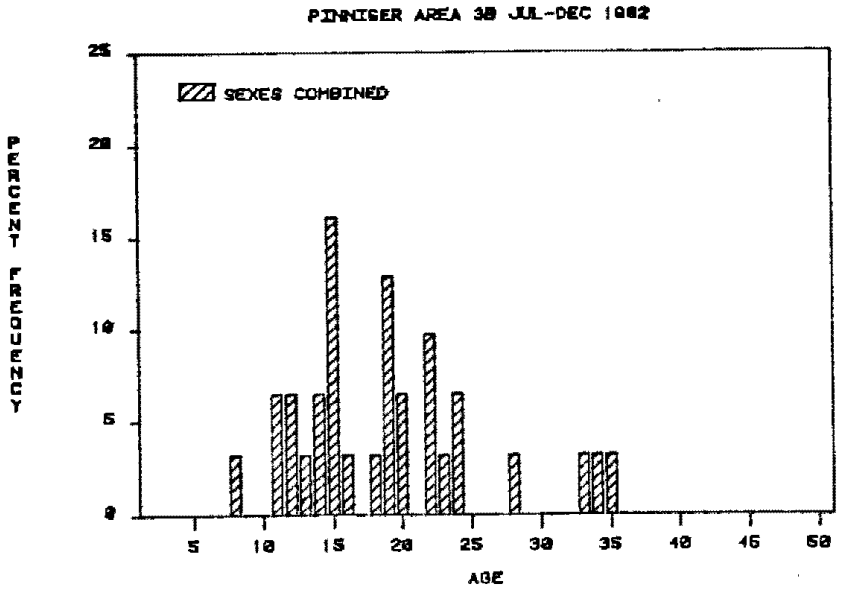


Figure 2.(cont.) Age composition of canary rockfish (*S. pinniger*) in the INPFC Vancouver area. High power (60x) break and burn readings used in 1982-1983.



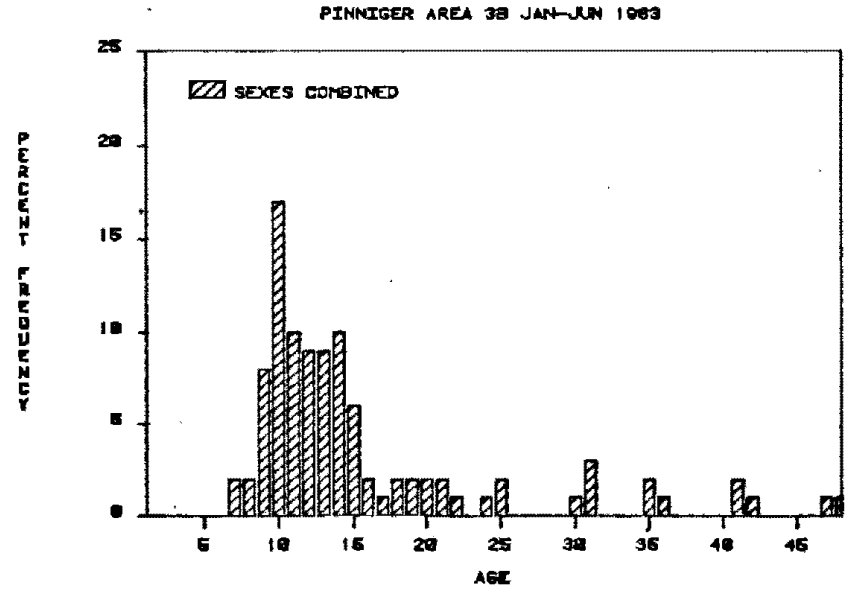


Figure 3. Age composition of canary rockfish (*S. pinniger*) in PMFC area 3B (INPFC Vancouver area), 1982-1983. High power (60X) break and burn readings used to assign ages.

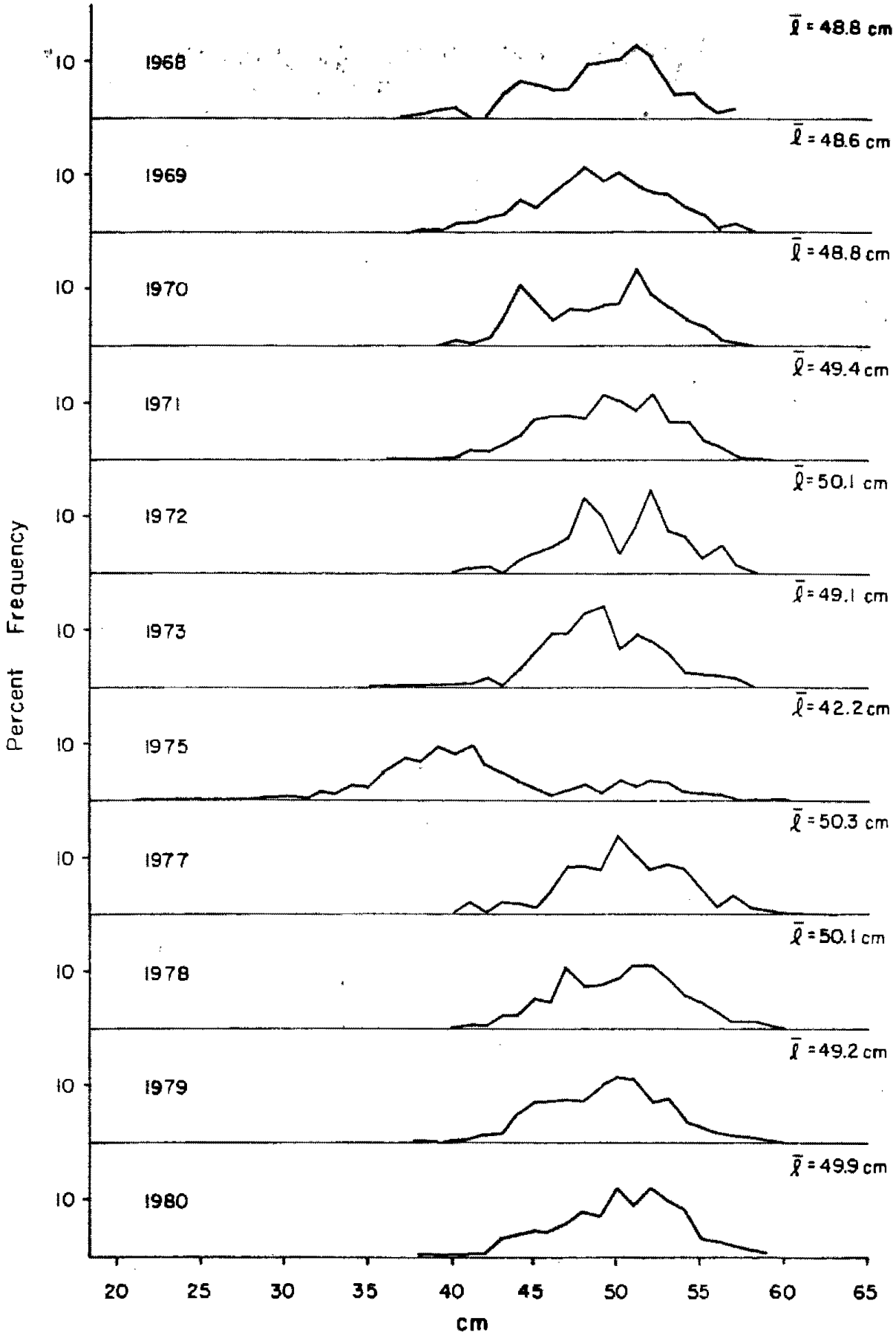


Figure 4. Length composition of canary rockfish (*S. pinniger*) in the INPFC Vancouver area. Continued next page.

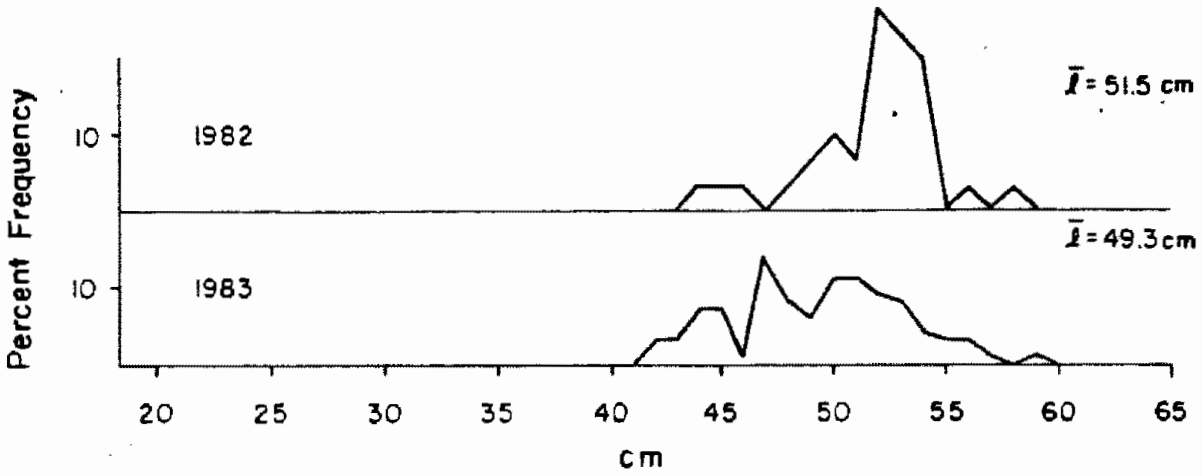


Figure 4.(cont.) Length composition of canary rockfish (*S. pinniger*) in the INPFC Vancouver area.

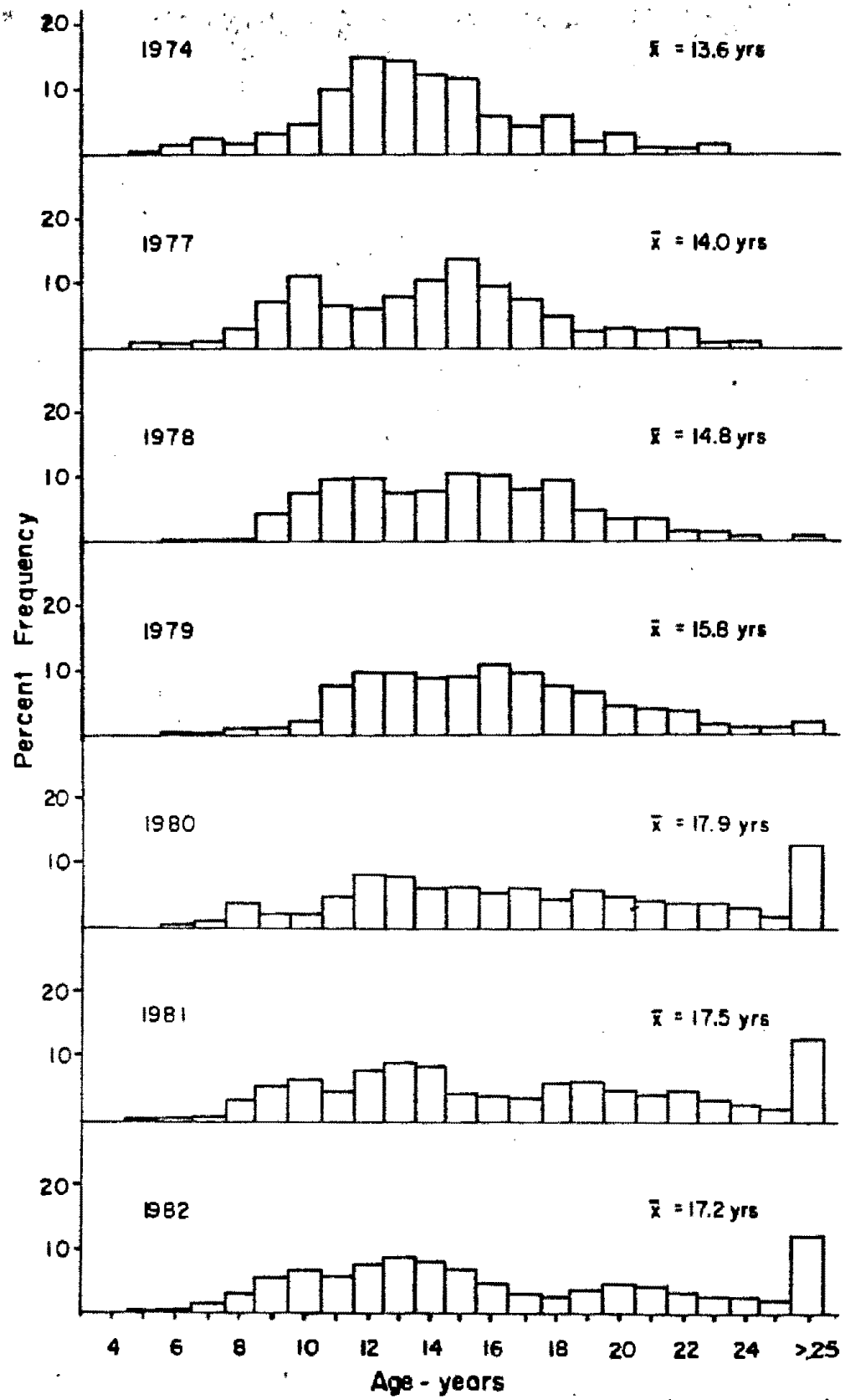


Figure 5. Age composition of canary rockfish (*S. pinniger*) in the INPFC Columbia area. Low power (10x) surface readings used in 1974-1979 and high power (60x) break and burn readings used in 1980-1984. Continued next page.

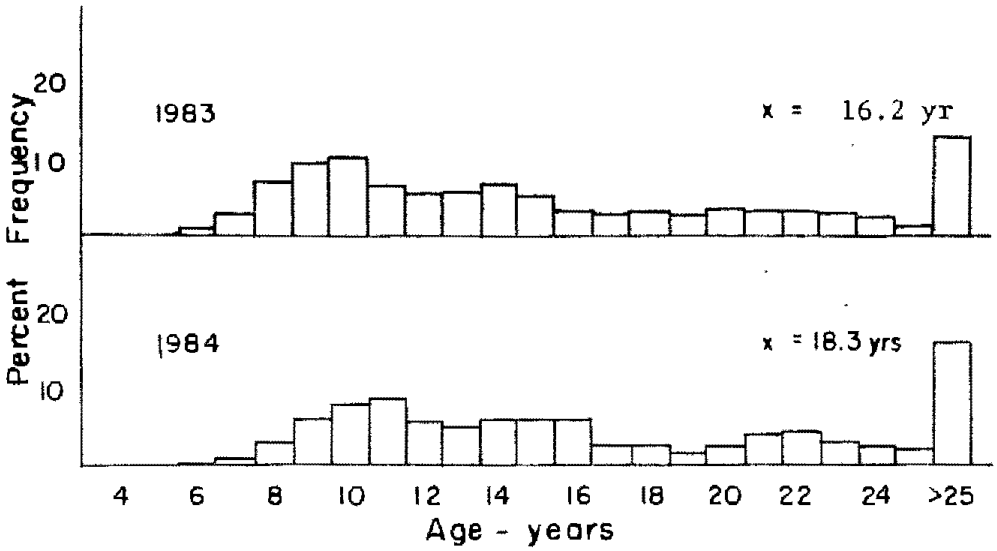


Figure 5.(cont.) Age composition of canary rockfish (*S. pinniger*) in the INPFC Columbia area. Low power (10x) surface readings used in 1974-1979 and high power (60x) break and burn readings used in 1980-1984.

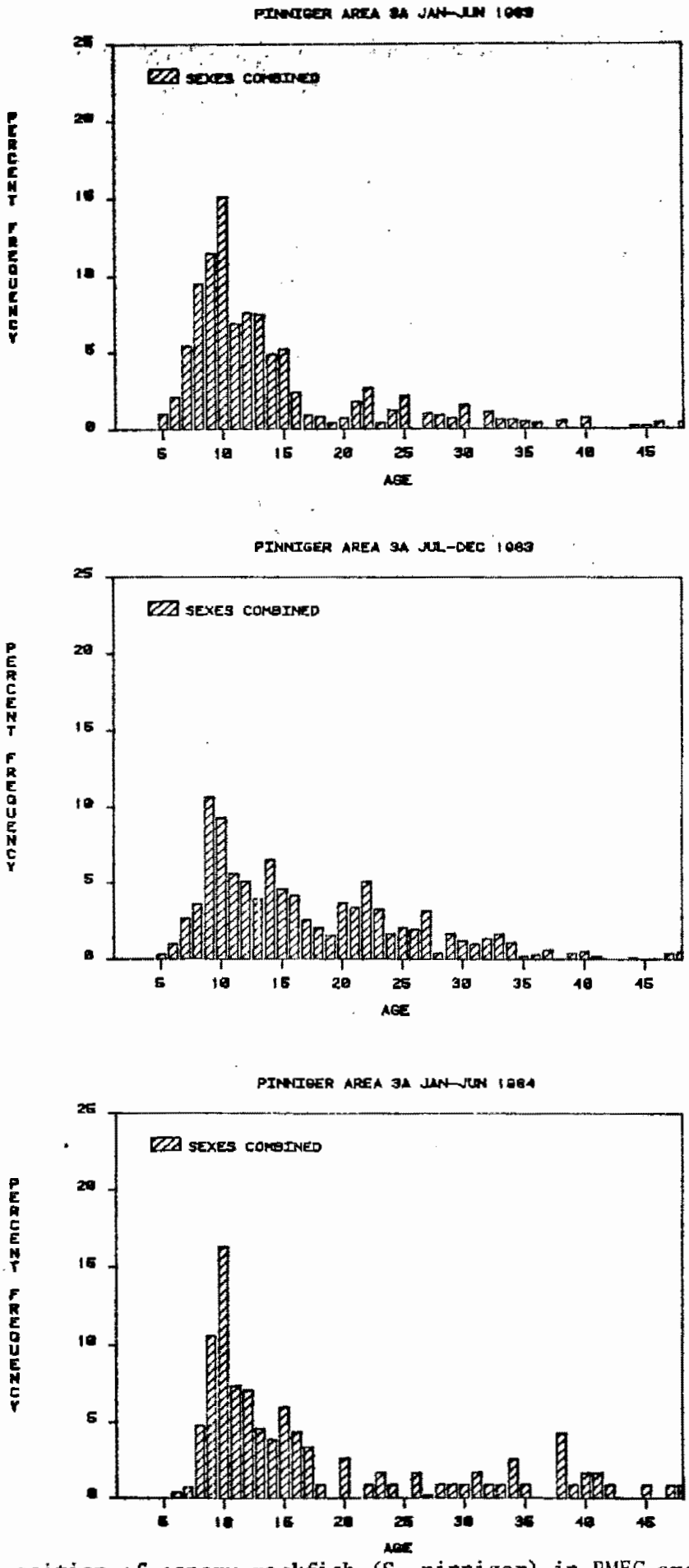
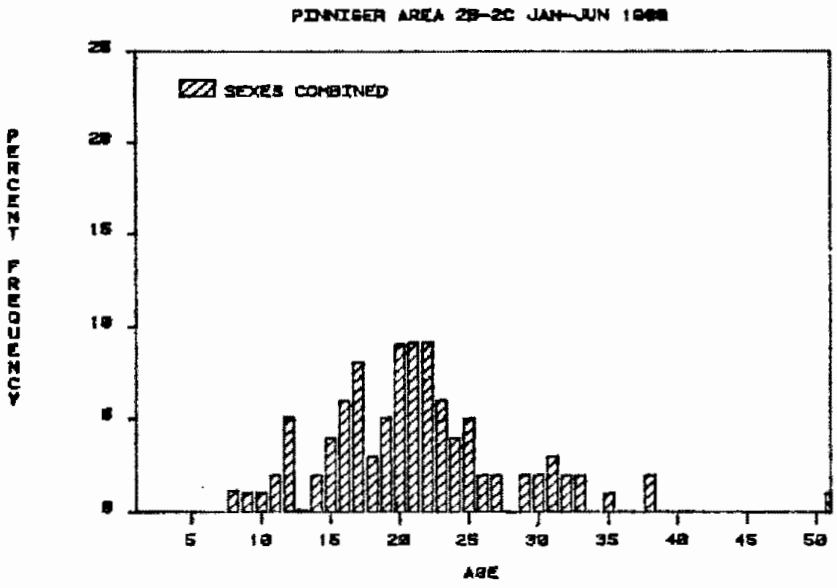


Figure 6. Age composition of canary rockfish (S. pinniger) in PMFC areas 3A, 2B-2C (INPFC Columbia) 1983-1984 and 2B-2C (INPFC Columbia) 1980-1984. High power (60X) break and burn readings used to assign ages.



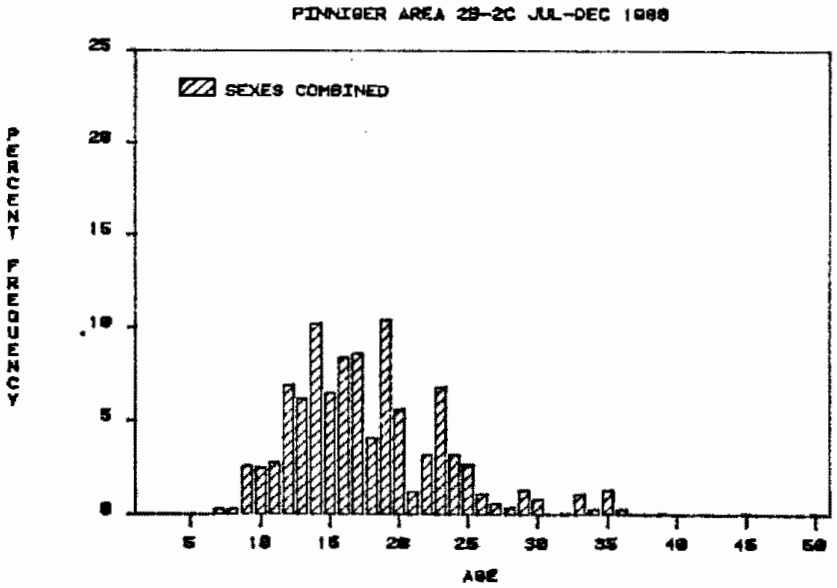
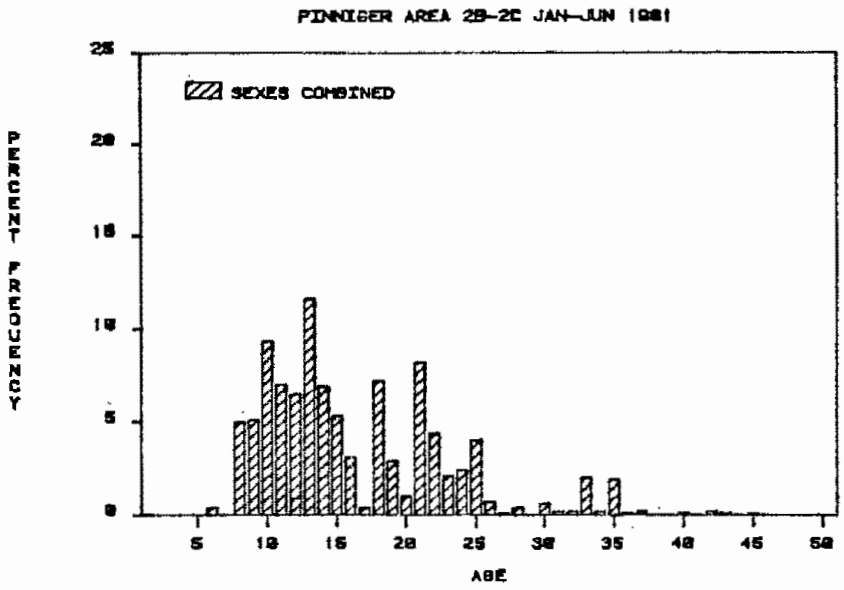
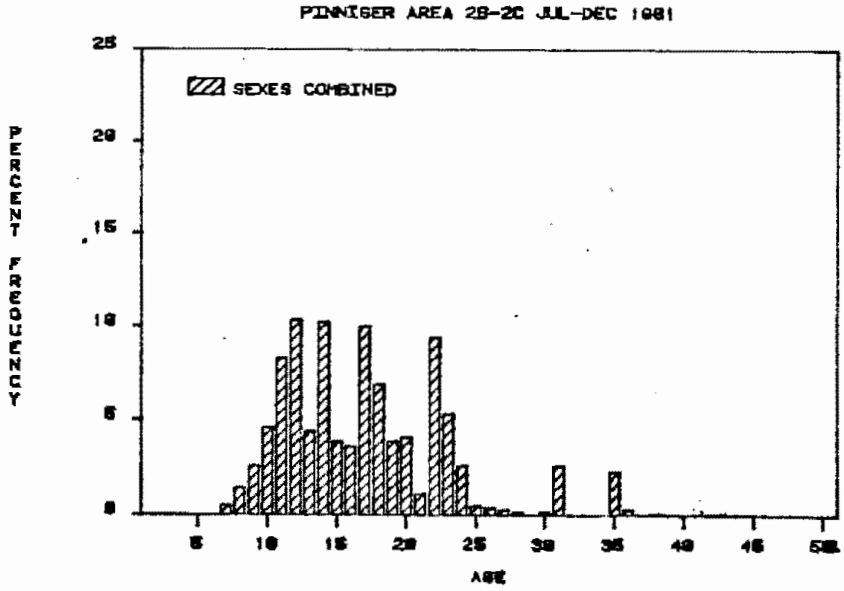


Figure 6. Continued.





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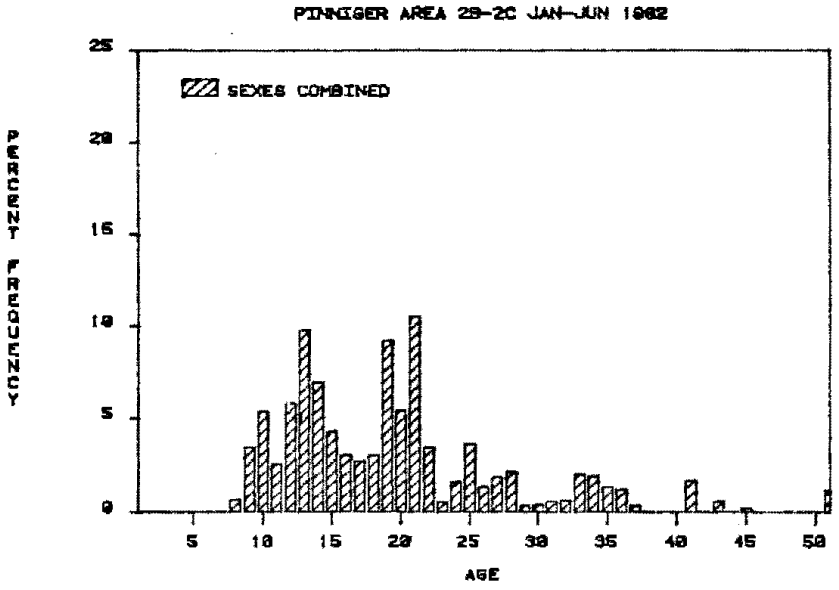


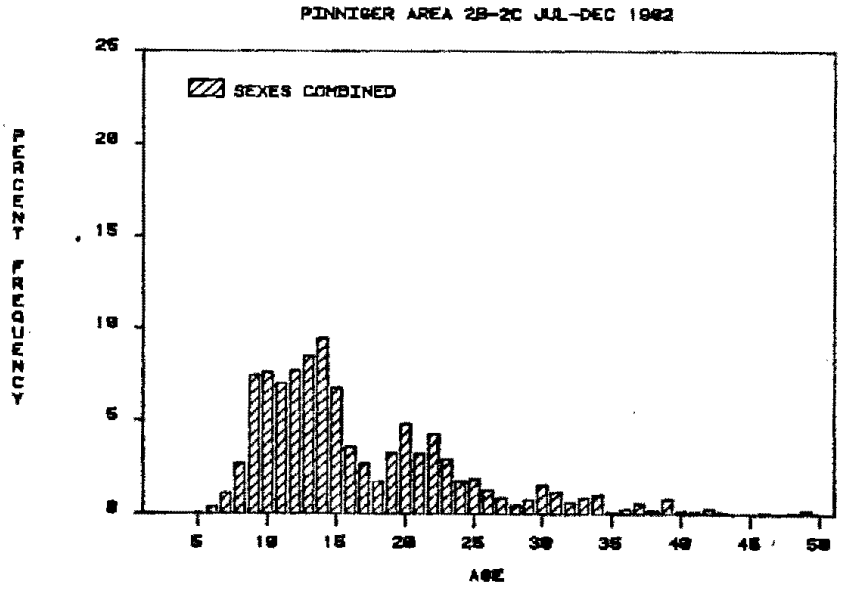
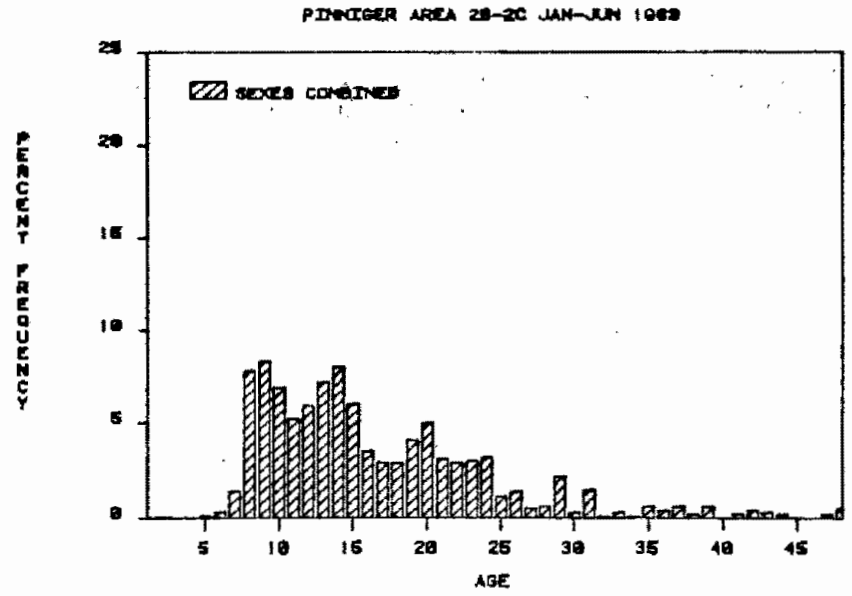
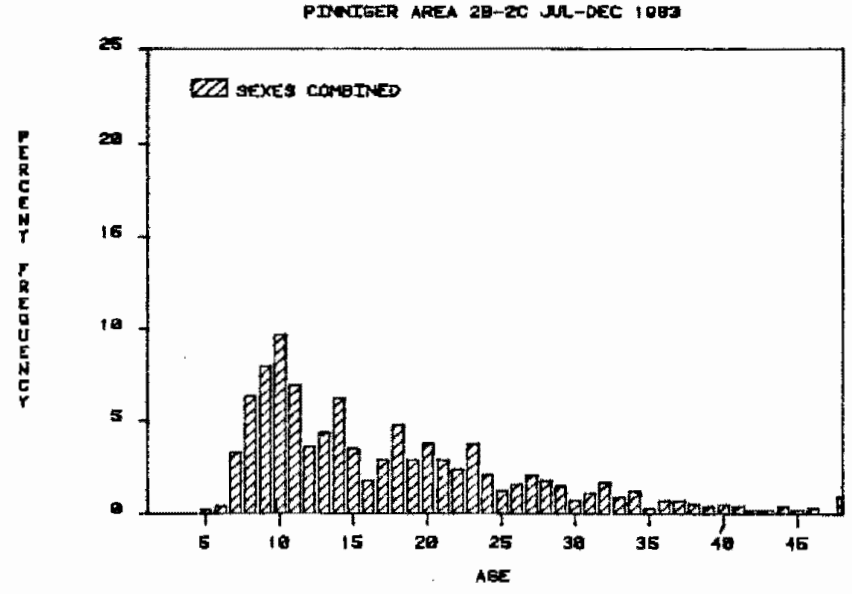


Figure 6 . Continued





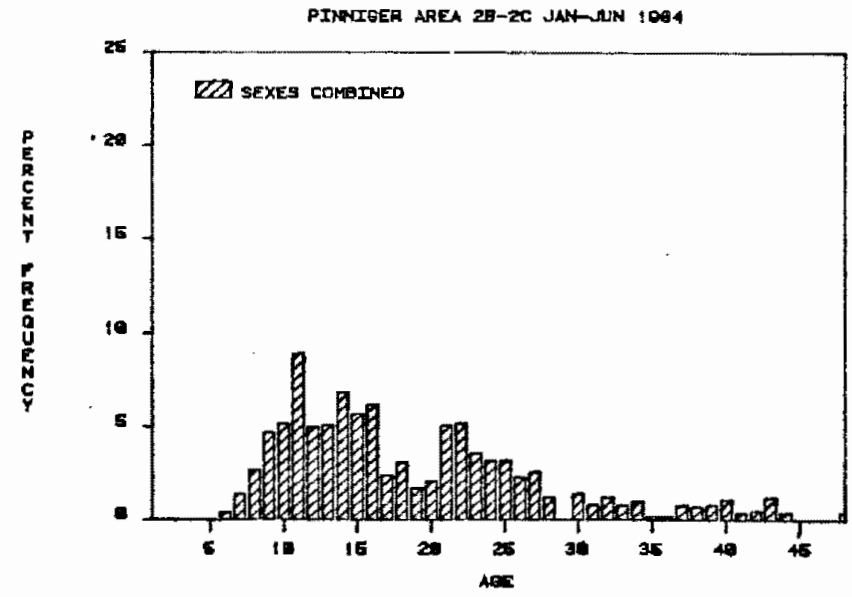


Figure 6. Continued

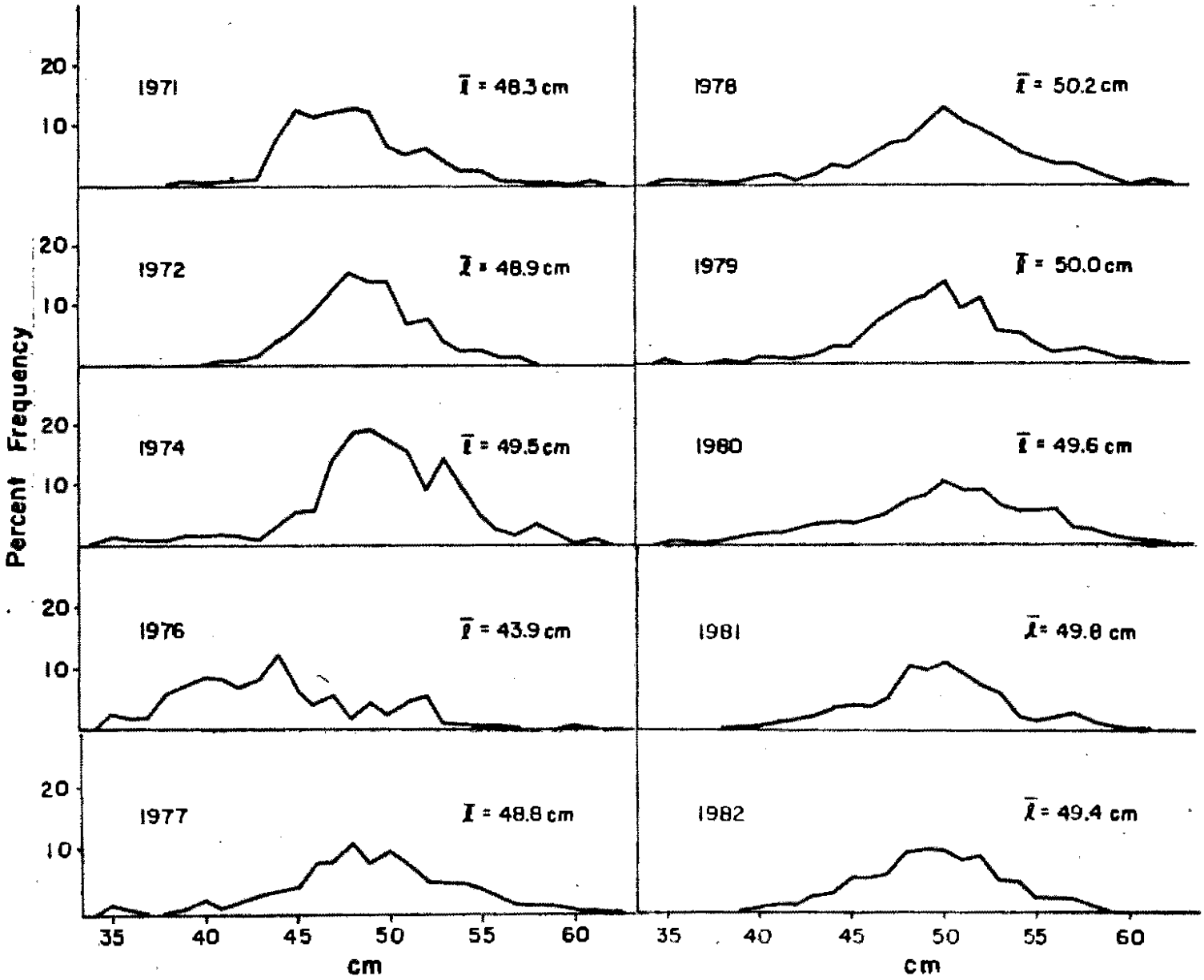


Figure 7. Length composition of canary rockfish (*S. pinniger*) in the INPFC Columbia area.
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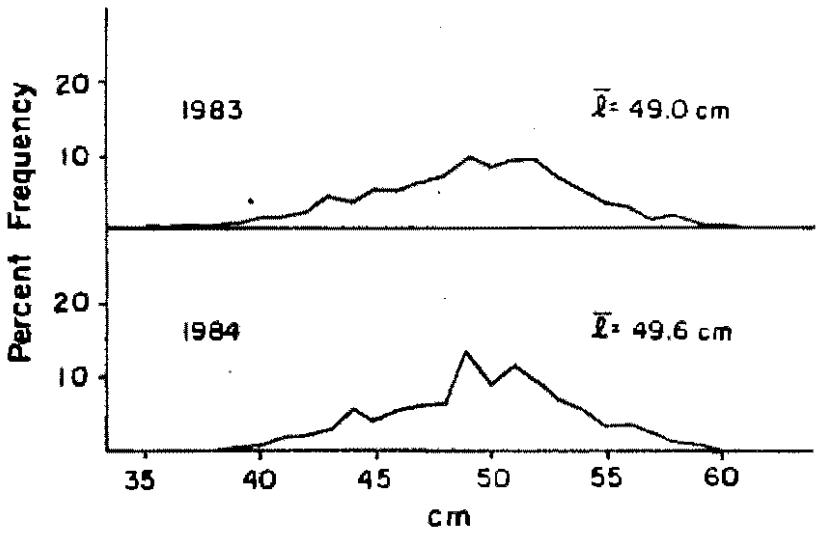

Figure 7.(cont.) Length composition of canary rockfish (*S. pinniger*) in the INPFC Columbia area.

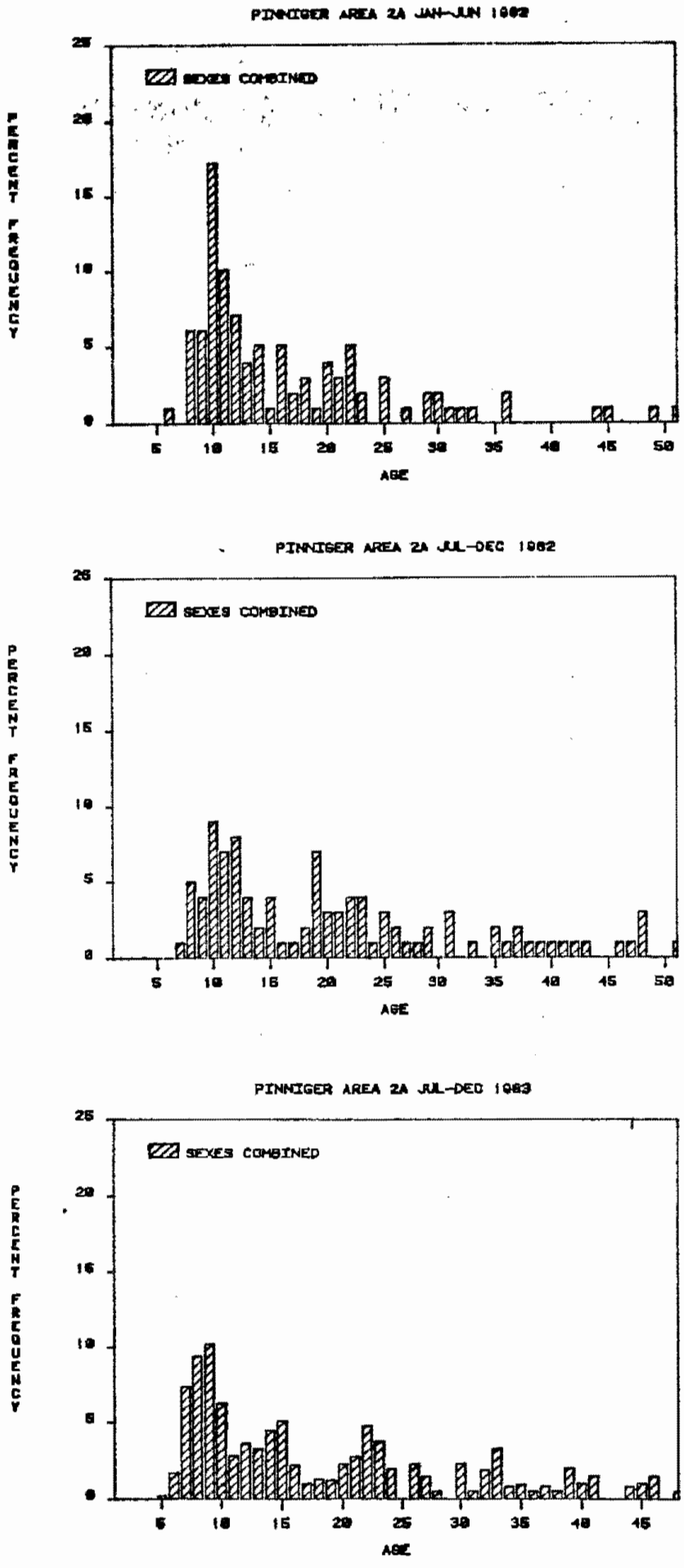

Figure 8. Age composition of canary rockfish (S. pinniger) in PMFC area 2A (INPFC Eureka area) 1982-1983. High power (60X) break and burn readings used to assign ages.