STATUS OF THE COASTWIDE CHILIPEPPER (*SEBASTES GOODEI*) FISHERY

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September,1986

1. Introduction

This report updates the 1985 chilipepper (Sebastes goodei) status of stock report, incorporating additional commercial fishery data and revised assessment methodology to estimate stock size and sustainable yield levels. Sampling methodology, life history characteristics, and fishery-independent survey data were described in detail in the 1985 status of stock report and will not be included here.

2. Recent Catch History of Fishery

Chilipepper are landed in commercial quantities in the Eureka, Monterey, and Conception INPFC areas, although the Monterey area has accounted for 82.8% of the six-year (1980-1985) total statewide catch of chilipepper (Table 1). The Pacific Fishery Management Council's Fishery Management Plan established chilipepper Acceptable Biological Catch (ABC) levels for the Monterey and Conception areas at 1,300t and 1,000t, respectively. Minor catches in the Eureka area did not necessitate a separate ABC. Most commercial chilipepper catches are made with bottom trawls, but 100-200t are landed annually by setnet and hook-and-line gears. Statewide trawl landings of chilipepper peaked in 1980 at 2,768t, and have fluctuated moderately since 1977. Mean trawl catches for the Eureka, Monterey, and Conception areas during 1977-1985 were 122t, 1641t, and 256t, respectively.

Historically, chilipepper have been a principal component of the trawl rockfish fishery in both the Monterey and Conception areas. For example, in 1984 and 1985 in the Monterey area, this species comprised 34 and 29 % of the total trawl rockfish catch, respectively. In the Conception area during 1984 and 1985, chilipepper constituted 36 and 37% of the respective trawl rockfish catches. By comparison, less than 3% of the Eureka area trawl rockfish catches were chilipepper during the same period.

3. Review of Previous Assessment

The 1985 status of stock report utilized cohort analysis to derive estimates of fishing mortality (F) and biomass (Murphy 1965). Chilipepper were treated as a unit stock for the 1985 and 1986 reports. Cohort analysis was conducted assuming a constant starting F for the age 10 ageclass, as the linkage of two equally-fished ageclasses proved infeasible to build a fishing mortality-at-age matrix. Starting F values for younger ageclasses were generated by assuming that in 1982 (the starting year for calculations) the ratio of F for the age in question to F of age 10 fish was the same as in previous years. Cohort analysis was conducted using two trial F values, 0.05 and 0.25, as upper and lower limits of F. The resultant total biomass estimates ranged from 20,113t at high F to 72,648t at low F. The brief time series of catch-at-age data (1978-1982) and overestimation of the effect of El Nino on the 1983 harvest rate hampered the analysis. In fact, 1983 chilipepper catches did not decline as drastically as previously thought in the Monterey area during El Nino (Table 1).

4. 1986 Assessment Methodology

For the 1986 assessment the cohort analysis procedures employed in the previous report were re-examined with the addition of another year of catch-at-age data. The results of this suggested that ageclass linkage was still inappropriate, as was the assumption of constant F for age 10 chilipepper used in the previous analysis. For this report , the catch-at-age model (lognormal process error model) developed by Deriso et al. (1985) was successfully used to estimate fishing mortality rates, population abundance, and biomass.

As in the 1985 analysis, efforts were concentrated on female chilipepper, for they constitute over 78% of the catch and have a higher rate of exploitation than male chilipepper. The light exploitation of male fish would not produce meaningful results in catch-at-age analyses.

Deriso et al.'s catch-at-age analysis model is based on a nonlinear least squares approach, using the following equation (equation 11 in their paper): min $\widetilde{SSQ}$(catch) + SSQ(effort) + SSQ(spawn) where $\widetilde{SSQ}(catch) = \sum_{t,a}[\log \tilde{C}(t,a) - \log C'(t,a)]^2$. $\tilde{C}(t,a)$ is defined as predicted catch in numbers of fish of reference age a in year t. The actual observed catch is C′(t, a). A principal assumption of the model is that fishing mortality (F) is separable into a product of an age-specific selectivity coefficient, s(a), and a full-recruitment fishing mortality, f(t): F(t,a) = s(a)f(t), where s(a) = 1 for at least one age. This separability reduces the number of fishing mortality parameters to be estimated from A x T unknowns (A = number of ages, T = number of years of data) to less than A + T unknowns (T fishing mortality rates and fewer than A age-specific selectivity coefficients). Initial parameters included estimates of fecundity, weight-at-age, catch-at-age for the years 1978-1983, natural mortality (M), and effort. Fecundity values were obtained from Wyllie-Echeverria (ms.); and weight-at-age values were used from Phillips (1964). The Cooperative California-NMFS Groundfish Survey supplied catch-at-age estimates. A natural mortality rate of 0.20 was used, following consideration of such parameters as the von Bertalanffy k factor of 0.18, maximum age of 29 years, the proportion of very old individuals in the population, as well as M values for other rockfishes. In addition, the regression tech nique described by Hoenig (1983) confirmed that an M of 0.20 is more appropriate than an M of 0.25 used previously. The effort values used were adjusted catch data.

The model incorporates a weighting term, lambda, which adjusts the degree of influence of auxiliary information, such as effort estimates in this case. Lambda may vary from 0.0 (no influence) to 1,000.0 (F is directly proportional to effort). The catch-at-age model was run with values of 0.5 (used by the International Pacific Halibut Commission) and 10.0.

An age-structured deterministic population model program (GENMOD), developed by Hightower (NMFS-Tiburon), was utilized to estimate maximum sustainable yield (MSY) and equilibrium yields at upper and lower fishing mortality estimates produced by the Deriso et al. model. The GENMOD model incorporates the standard catch equation and a Beverton-Holt stock-recruitment relationship. Catchability estimates for use in GENMOD were determined by averaging F by ageclass over years, then scaling the average values by the maximum value so that catchability ranged from zero to one. Natural mortality (M) and catchability were set to zero for pre-recruits (ages 1 and 2). Recruitment was first determined as the average of age 3 fish for 1978-1983, from the catch-at-age analyses using the Deriso et al model, at 6.2×10^6 and 11.5×10^6

age 3 fish. F-at-age by year matrices were obtained as a product of annual F values for fully recruited fish multiplied by the selectivity values for each ageclass.

Using the above parameter estimates in a constant recruitment Beverton-Holt model [R(0.5)/R(1.0) = 1] where beta=0 and alpha = 1/mean recruitment, I obtained a first estimate of spawning biomass (S1). This estimate was then used to solve for alpha and beta assuming that recruitment is reduced by 10% when spawning stock is 50% of the unfished level [R(0.5)/R(1.0) = 0.9]. This assumption seems to be consistent with chilipepper fecundity data. These estimates of alpha and beta were used in a second iteration to obtain final estimates.

5.Results

The Deriso et al. catch-at-age model was run with lambda = 0.5 and 10.0. Resultant fishing mortality-at-age matrices indicate that F peaked in 1980, the year of exceptional landings in the Monterey area (Tables 2 and 3). The average F for fully recruited age 11 female chilipepper was 0.103 for the lambda = 0.5 run and 0.232 for the lambda = 10.0 run. The higher lambda value resulted in increased agreement between F for fully recruited fish and the fishing effort data. The F values are essentially lower and upper bounds of F, but the higher value seems to be the more appropriate value. As can be seen in Tables 2 and 3, no directional trend in F by year is apparent. In addition, these F values suggest moderate exploitation of the stock.

Total average biomass of female chilipepper to age 12 varied from 39,217t at lambda = 0.5 to 20,773t at lambda = 10.0 (Tables 4 and 5). Biomass varied by 15% over the 1978-1983 period. This stability was also detected in the NMFS synoptic rockfish surveys of 1977, 1980, and 1983 (Gunderson and Sample 1980; Dark et al. 1983; Weinberg et al. 1984). However, total numerical abundance has declined 29-35% from its peak in 1979 (Table 4). This decline in numerical abundance is due to the passage of the strong 1973 and 1975 cohorts through the fishery, followed by several years of average recruitment.

Use of the results from the Deriso et al. catch-at-age model in the GENMOD production model allowed the estimation of equilibrium yields and stock biomass at recent F levels. At a mean F for fully recruited female fish of 0.103, the resulting equilibrium yield would be 2,170t (Table 5). At the higher mean F for fully recruited fish of 0.232, the equilibrium yield would be 1,700t (Table 6). MSY levels from the GENMOD runs were estimated to be 3,540t and 2,020t, respectively. Equilibrium stock size at the current levels of fishing mortality (F = 0.232 and 0.103 for age ll fish) ranged from 22,240t to 48,000t.

Because it was infeasible to employ male chilipepper data in the above estimation procedure, yield and biomass estimates were expanded by the ratio of female catch to total catch to produce estimates for both sexes. The expanded values are presented in Table 7. The mean of the two equilibrium yield estimates is 2,480t and the mean MSY estimate is 3,563t.

Examination of the age composition of commercial chilipepper landings for the 1978-1983 period revealed several noteworthy points (Figures 1-6). First, several large cohorts, particularly the 1973 and 1975 cohorts, contributed significantly to the fishery during this period. Second, the 1979 cohort is above average in strength when compared with recent recruitment of other cohorts at age 4. Finally, there is no apparent trend toward juvenation as a result of intense exploitation.

Juvenile rockfish surveys have been conducted by the NMFS in central California waters since 1983. Juvenile chilipepper have been collected in the spring of every year except 1983 (an El Nino year). Because chilipepper release larvae earlier than most rockfishes, these surveys may be inadequate indicators of chilipepper yearclass strength (W. Lenarz, pers. comm.). Given these limitations, the NMFS surveys do suggest good chilipepper recruitment in 1984 and 1985. Based on fishery and recruitment data, I do not expect a significant decrease in stock size in the near future, barring an increase in fishing effort.

6. Recommendations

Considerable evidence exists of a single unit stock of chilipepper in the Eureka, Monterey, and Conception (at least to Point Conception) areas. Based on this evidence, a highly mobile trawl fleet, and enforcement considerations, it is recommended that a single coastwide ABC be established to replace the separate ABC's presently in effect for the Monterey and Conception areas. The coastwide ABC could be set at the midpoint of the two MSY estimates, 3,500t. With the pattern of good recent recruitment and absence of apparent biological stress, no other changes in current management regulations are recommended.

LITERATURE CITED

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

Deriso,R.B., T.J. Quinn II, and P.R. Neal. 1985. Catch-age analysis with auxiliary information. Can. J. Aquat. Sci. 42: 815-824.

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.

Henry, F.D. 1985. A progress report on the status of chilipepper (*Sebastes goodei*) off California. (submitted to the Pacific Fishery Management Council, Portland, Oregon. October, 1985.) California Department of Fish and Game, 411 Burgess Drive, Menlo Park, CA 94025.

Hoenig, J. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull., U.S. 81:898-902.

Murphy, G. 1965. A solution to the catch equation. J. Fish. Res. Bd. Can. 22:191-202.

Phillips, J.B. 1964. Life history studies on ten species of rockfish (*genus Sebastodes*). Calif. Dep. Fish Game, Fish Bull. 126, 70p.

Weinberg, K.L., M.E. Wilkins, and T.A. Dark. 1984. The 1983 Pacific west coast trawl survey of groundfish resources: estimates of distribution, abundance, age and length composition. NOAA Tech. Mem. NMFS-F/NWC-70.

Wyllie-Echeverria, T. ms. Maturity and seasonality of reproduction of 34 species of rockfish (Sebastes) from central and northern California.

TABLE 1. Estimated commercial trawl catch of chilipepper by INPFC Area and year (metric tons).

YEAR	EUREKA	INPFC AREA MONTEREY	CONCEPTION	TOTAL
1977	78	1454	N.A.	N.A.
1978	209	1035	N.A.	N.A.
1979	178	1810	N.A.	N.A.
1980	25	2404	339	2768
1981	26	1611	401	2038
1982	224	1276	269	1769
1983	180	1652	160	1992
1984	92	1953	229	2274
1985	86	1575	141	1802
1977-85 MEAN	122	1641	**256	**2107

**1980-85 MEAN

TABLE 2. Fishing mortality-at-age matrix for female chilipepper with lambda = 0.5.

F-AT-AGE MATRIX FOR FEMALE CHILIPEPPER
Lambda=0.50
M=0.20

AGE	SELECTIVITY	1978	1979	1980	1981	1982	1983	AVE	SCALED
3	0.026	0.002	0.003	0.004	0.002	0.002	0.002	0.005	0.049
4	0.079	0.006	0.010	0.012	0.008	0.006	0.007	0.008	0.078
5	0.170	0.014	0.022	0.025	0.016	0.013	0.015	0.018	0.175
6	0.295	0.024	0.039	0.043	0.028	0.023	0.026	0.030	0.291
7	0.358	0.029	0.047	0.053	0.034	0.028	0.031	0.037	0.359
8	0.583	0.047	0.076	0.086	0.055	0.045	0.051	0.060	0.582
9	0.697	0.056	0.091	0.102	0.066	0.054	0.061	0.072	0.699
10	0.741	0.059	0.097	0.109	0.070	0.057	0.065	0.076	0.738
11	1.000	0.080	0.131	0.147	0.095	0.077	0.088	0.103	1.000
12	0.915	0.073	0.120	0.135	0.087	0.070	0.081	0.094	0.913

TABLE 3. Fishing mortality-at-age matrix for female chilipepper with lambda = 10.0.

F-AT-AGE MATRIX FOR FEMALE CHILIPEPPER
Lambda=10.0
M=0.20

AGE	SELECTIVITY	1978	1979	1980	1981	1982	1983	AVE	SCALED
3	0.022	0.004	0.006	0.007	0.005	0.004	0.004	0.005	0.021
4	0.065	0.011	0.018	0.021	0.015	0.012	0.013	0.015	0.063
5	0.138	0.024	0.038	0.045	0.031	0.027	0.027	0.032	0.134
6	0.239	0.042	0.066	0.078	0.054	0.046	0.048	0.056	0.234
7	0.292	0.051	0.080	0.095	0.066	0.056	0.058	0.068	0.285
8	0.488	0.085	0.134	0.159	0.111	0.094	0.097	0.113	0.473
9	0.606	0.105	0.167	0.197	0.138	0.116	0.121	0.141	0.590
10	0.680	0.118	0.187	0.221	0.154	0.131	0.135	0.158	0.661
11	1.000	0.174	0.275	0.325	0.227	0.192	0.199	0.232	0.971
12	1.032	0.180	0.284	0.335	0.234	0.198	0.205	0.239	1.000

TABLE 4. Female chilipepper numerical abundance and biomass estimates derived from the Deriso et al. catch-at-age model.

	LAMBDA=0.5		LAMBDA=10.0	
YEAR	NUMERICAL ABUNDANCE	TOTAL BIOMASS(kg)	NUMERICAL ABUNDANCE	TOTAL BIOMASS(kg)
1978	60,688,761	34,694,067	34,133,581	19,311,917
1979	64,273,198	39,925,108	35,690,573	22,009,121
1980	56,741,611	40,939,076	30,909,922	22,106,947
1981	46,687,548	39,411,938	24,742,784	20,624,619
1982	52,630,326	40,154,366	27,145,223	20,500,565
1983	45,836,428	40,174,971	23,296,572	20,083,538
MEAN	54,476,312	39,216,588	29,319,776	20,772,785

Model form: Bev-Holt

Effort	Yield	Spawners	N[1]	Stock biomass
0.000	0.00	57.7	12.0	64.8
0.100	2.17	41.3	11.5	48.0
0.200	3.00	32.8	11.1	39.1
0.300	3.35	27.5	10.7	33.5
0.400	3.50	23.7	10.4	29.6
0.500	3.54	20.9	10.1	26.6
0.600	3.53	18.8	9.8	24.2
0.700	3.49	17.0	9.5	22.2
0.800	3.43	15.5	9.3	20.6
0.900	3.36	14.2	9.0	19.1
1.000	3.28	13.1	8.8	17.9
1.100	3.20	12.2	8.5	16.8
1.200	3.11	11.3	8.3	15.8
1.300	3.03	10.6	8.1	14.9
1.400	2.95	9.9	7.9	14.0
1.500	2.86	9.3	7.7	13.3
1.600	2.78	8.7	7.5	12.6
1.700	2.69	8.2	7.3	12.0
1.800	2.61	7.7	7.1	11.4
1.900	2.53	7.2	6.9	10.8
2.000	2.45	6.8	6.7	10.3

Maximum yield (3.54), at f= 0.500.

TABLE 5. Estimated yields and stock size from the GENMOD production model using results from the lambda = 0.5 catch-at-age analysis.

Model form: Bev-Holt

Effort	Yield	Spawners	N[1]	Stock biomass
0.000	0.00	32.5	6.8	36.5
0.100	1.16	24.0	6.5	27.8
0.200	1.63	19.6	6.3	23.2
0.300	1.85	16.7	6.1	20.2
0.400	1.95	14.7	6.0	18.1
0.500	2.00	13.2	5.8	16.5
0.600	2.02	12.0	5.7	15.2
0.700	2.02	11.0	5.6	14.1
0.800	2.00	10.2	5.4	13.2
0.900	1.98	9.4	5.3	12.4
1.000	1.95	8.8	5.2	11.7
1.100	1.92	8.3	5.1	11.1
1.200	1.89	7.8	5.0	10.5
1.300	1.86	7.3	4.9	10.0
1.400	1.82	6.9	4.8	9.5
1.500	1.79	6.6	4.7	9.1
1.600	1.75	6.2	4.6	8.7
1.700	1.71	5.9	4.5	8.3
1.800	1.68	5.6	4.4	8.0
1.900	1.64	5.4	4.3	7.7
2.000	1.61	5.1	4.2	7.4

Maximum yield (2.02), at f= 0.600.

TABLE 6. Estimated yields and stock size from the GENMOD production model using results from the lambda = 10.0 catch-at-age analysis.

TABLE 7. Estimated yields and stock size in metric tons at two levels of current fishing mortality for both sexes combined.

	F=0.103	F=0.232	Mean
BIOMASS	61,538	28,512	45,025
YIELD	2,782	2,179	2,480
MSY BIOMASS	34,102	19,487	26,794
MSY	4,538	2,589	3,563

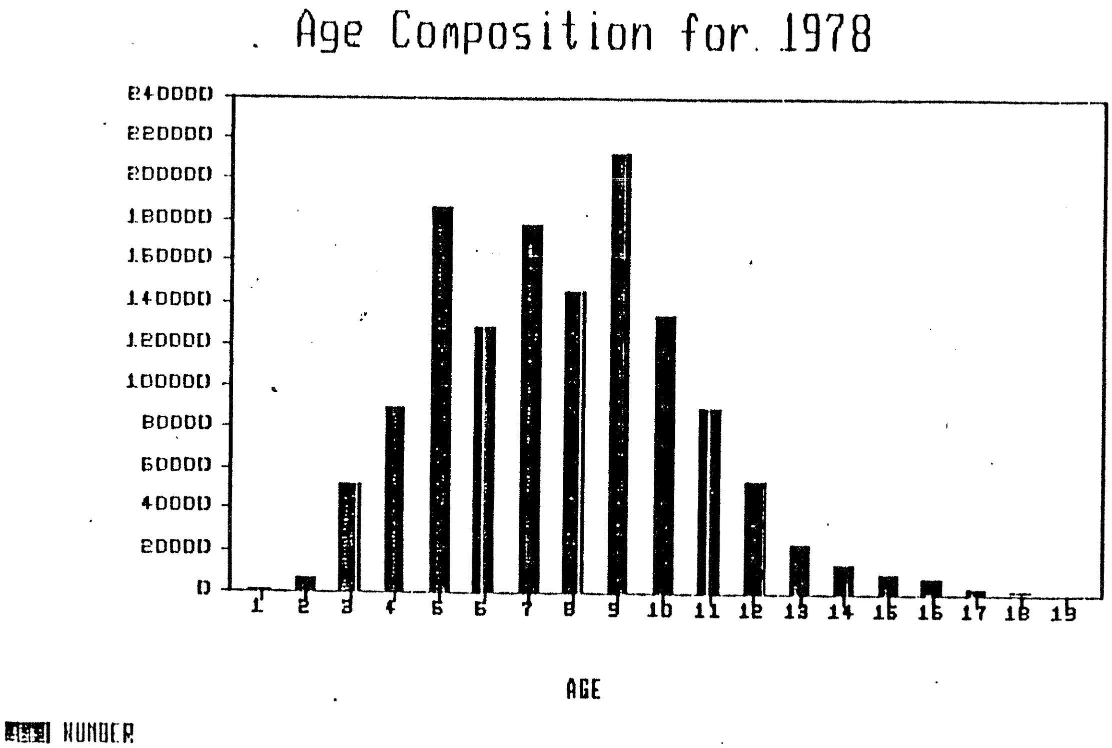

FIGURE 1. Age composition of commercial chilipepper landings for the INPFC Areas of Eureka, Monterey, and Conception in 1978.

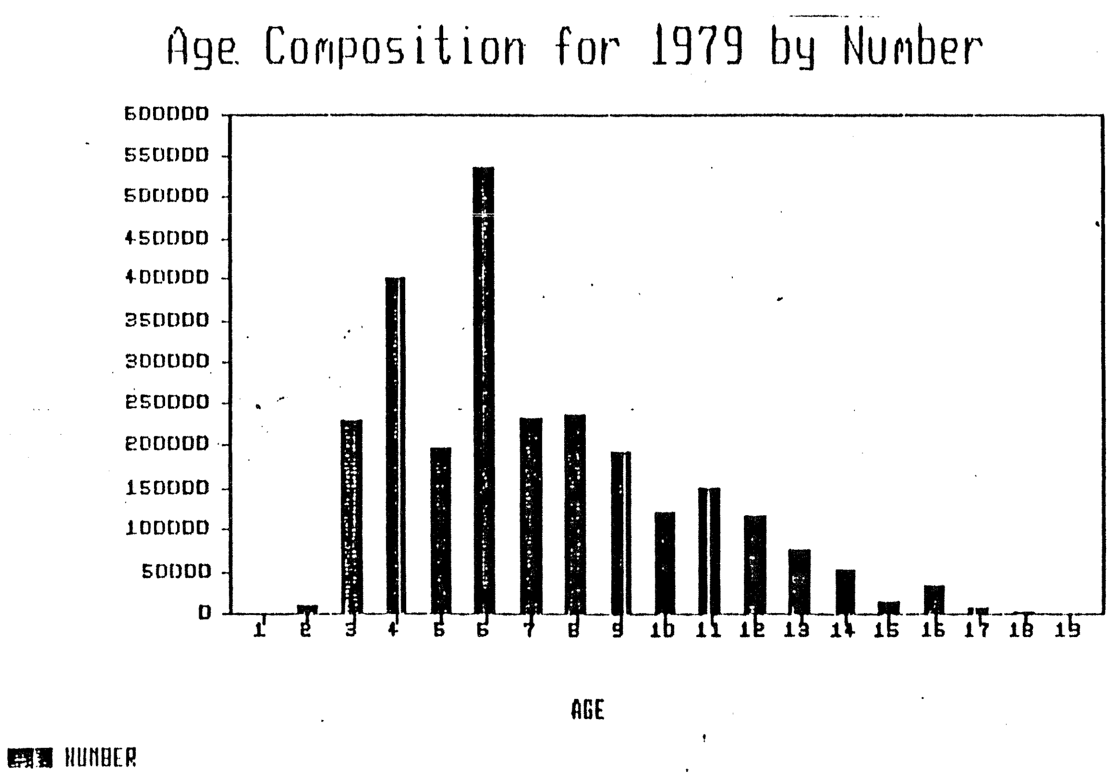

FIGURE 2. Age composition of commercial chilipepper landings for the INPFC Areas of Eureka, Monterey, and Conception in 1979.

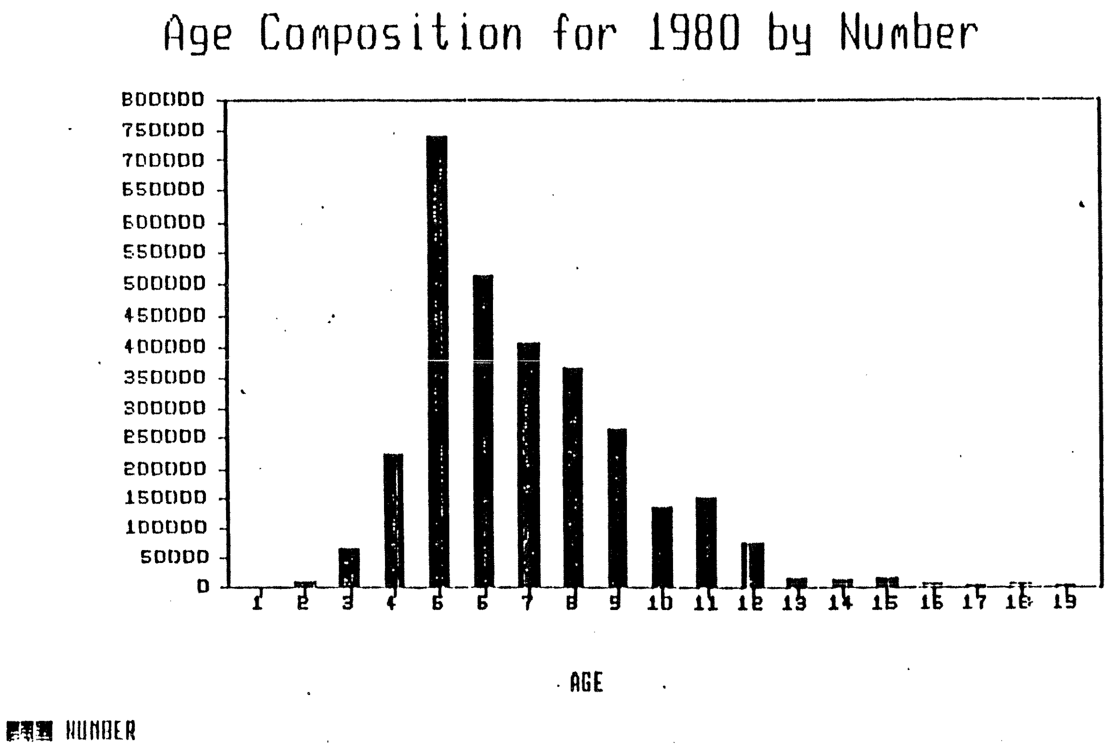

FIGURE 3. Age composition of commercial chilipepper landings for the INPFC Areas of Eureka, Monterey, and Conception in 1980.

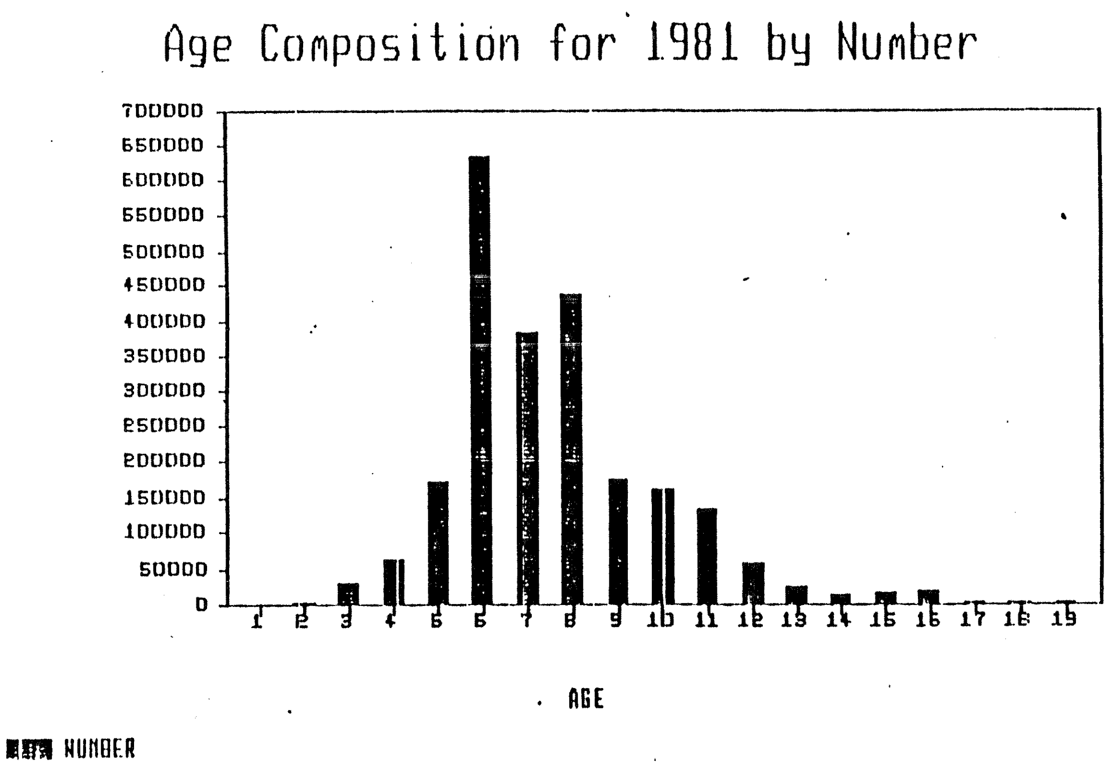

FIGURE 4. Age composition of commercial chilipepper landings for the INPFC Areas of Eureka, Monterey, and Conception in 1981.

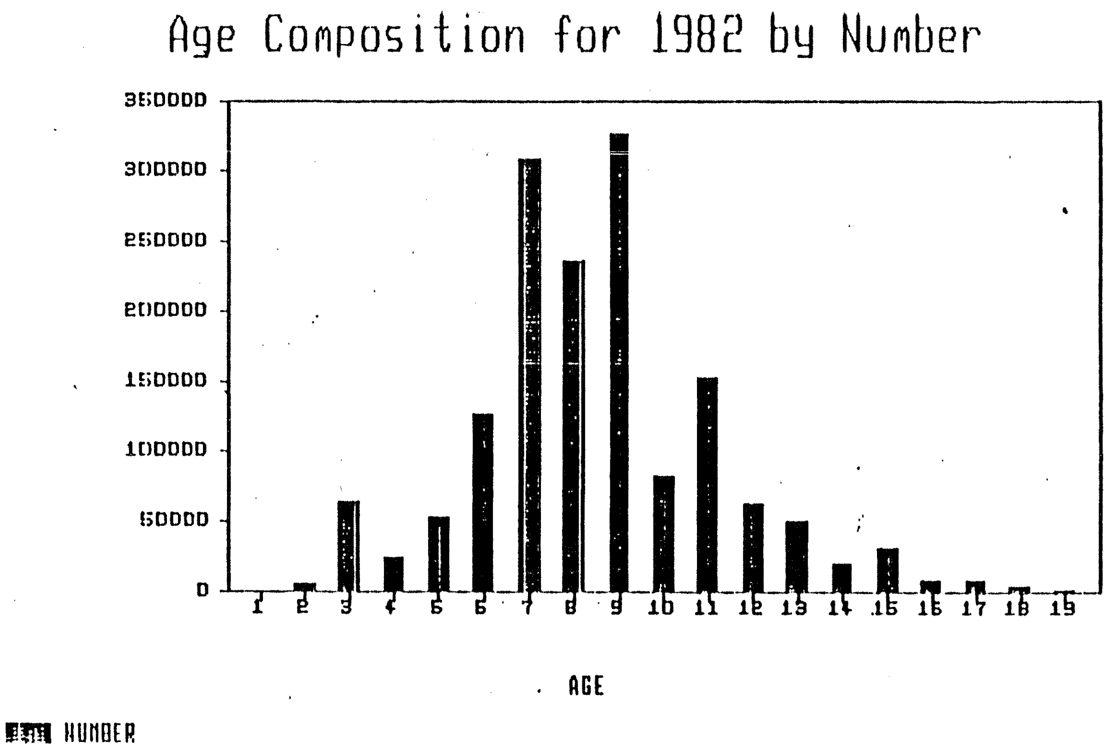

FIGURE 5. Age composition of commercial chilipepper landings for the INPFC Areas of Eureka, Monterey, and Conception in 1982.

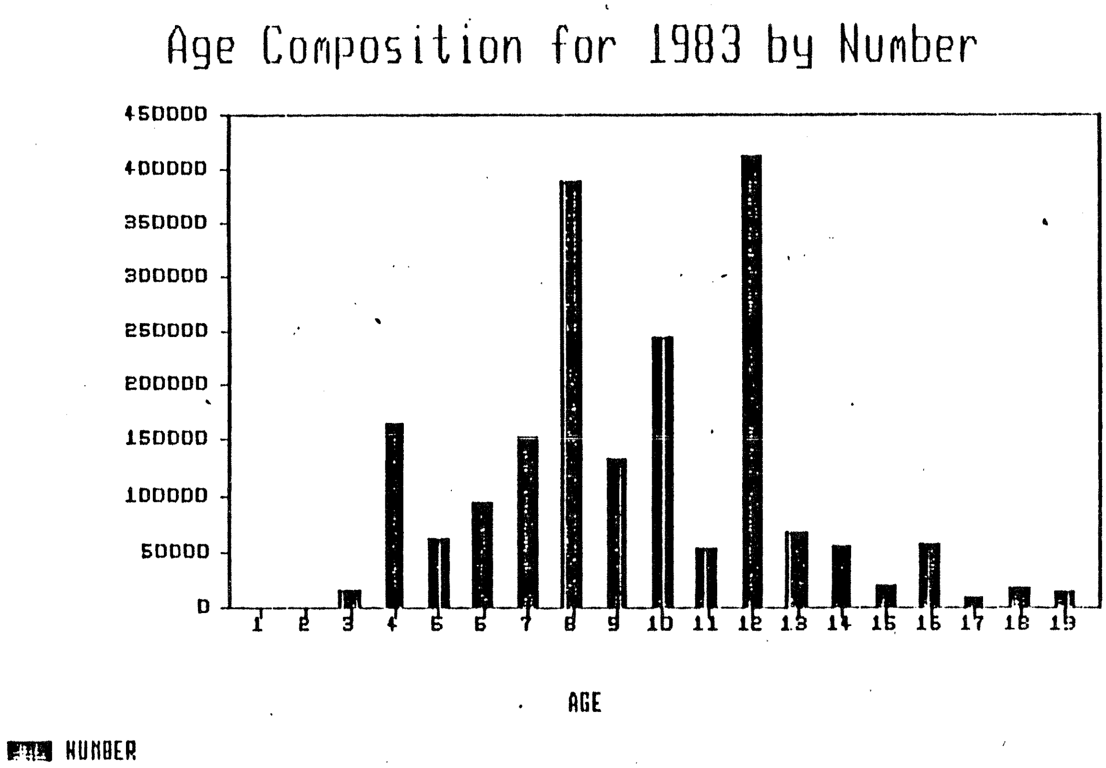

FIGURE 6. Age composition of commercial chilipepper landings for the INPFC Areas of Eureka, Monterey, and Conception in 1983.