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The Resources Agency
DEPARTMENT OF FISH AND GAME

STATUS OF THE PACIFIC MACKEREL RESOURCE AND FISHERY 1994 AND 1995

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MARINE RESOURCES DIVISION

Administrative Report No. 95-4

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INTRODUCTION

The California fishery for Pacific mackerel, *Scomber japonicus*, has declined precipitously since 1990, and statewide landings during 1994 totaled only 11,070 short tons. The principal cause of the low catches has been low biomass and poor availability on the traditional fishing grounds in southern California waters.

Several sources of information are available on the status of the Pacific mackerel stock. Landing statistics were available since 1978 for both the U.S. and Mexican fisheries, and both fisheries show similar declines during recent years. Other fishery-independent data from aerial observations and plankton surveys (mackerel larvae samples) also show declines in abundance compared to the early 1980's.

We used a tuned virtual population analysis (VPA) model called ADEPT to estimate Pacific mackerel abundance. The model finds the best statistical fit between fishery-based age-structured biomass estimates and other data from the aerial observations and the plankton surveys. A model-derived biomass estimate for July 1, 1994 was 71,000 tons. Based on the estimated number of fish in each year class at the end of 1994, and using certain assumptions concerning expected fishing mortality during the first half of 1995, we project that the Pacific mackerel biomass will be 56,000 tons at the beginning of the 1995/96 fishing season, on July 1, 1995.

The Fish and Game Code specifies that when the biomass is between 20,000 and 150,000 tons, the season's quota shall be 30 percent of the biomass in excess of 20,000 tons. Using that formula and our projection for July 1, 1995, the commercial fishery quota for the 1995/96 fishing season is 10,800 tons.

THE PACIFIC MACKEREL FISHERY

Background

The Pacific mackerel resource is a trans-boundary stock supporting commercial fisheries in the U.S. and Mexico. Combined total landings from both nations reached a record high of 82,000 tons in 1990, but have declined precipitously since that year (figure 1). Combined landings reached a low of 23,000 tons during 1993, and improved only slightly to 25,000 tons during 1994. Prior to 1990 the fishery was dominated by the U.S. fleet, however both nations currently take about an equal share of the catch. During 1994, the U.S. fishery landed 45% of the total harvest (11,070 tons) while the Enseñada, Mexico fleet caught the remaining 55% (13,700 tons).

California-based round-haul vessels (commonly referred to as the wetfish fleet) account for nearly all the commercial fishing effort for Pacific mackerel in U.S. waters. The wetfish fleet also harvests several other schooling species (e.g., Pacific sardine,*Sardinops sajax*; jack mackerel, *Trachurus symmetricus*; market squid, *Loligo opalescens*; Pacific bonito, *Sarda chiliensis*; Pacific herring, *Clupea pallasii*; and occasionally bluefin tuna, *Thunnus thynnus*; and northern anchovy, *Engraulis mordax*). Under provisions of the California State Fish and Game Code, fishing quotas for Pacific mackerel and sardines are established by the Department of Fish and Game (Department). Northern anchovy are managed by the Pacific Fisheries Management Council (PFMC) under a fisheries management plan (FMP) adopted for the species in 1978.

Historically, Pacific mackerel landings have been concentrated in southern California, with most of the vessels operating out of San Pedro/Terminal Island and a few others out of Port Hueneme and/or Santa Barbara. A smaller fleet in Monterey catches a minor percentage of the state's total annual landings.

In California, the fishing season for Pacific mackerel is defined as the 12-month period from July 1 of one calendar year through June 30 of the following calendar year. Mackerel are fished during every month, as long as total landings remain below the harvest quota. A season quota is established for the commercial fishery when the stock's total biomass is determined by the Department to be greater than 20,000 tons but less than 150,000 tons. If the biomass is less than 20,000 tons, a moratorium on any directed catch is in effect and if the biomass is greater than 150,000 tons, there is no limitation on the total catch.

The 1994 California Commercial Fishery

California landings of Pacific mackerel have trended downward since 1988, and for the 1994 calendar year, totaled only 11,070 tons (figure 1).

Pacific mackerel availability was poor on traditional southern California fishing grounds during the entire 1993/94 fishing season. Total landings for the 1993/94 fishing season were 11,890 tons, well below the season quota of 25,500 tons.

Poor mackerel availability continued during the last half of 1994, when the fishery was operating with a 1994/95 season quota of 16,200 tons. Landings during July through December were only 4,375 tons, about 1,000 tons less than the same period for 1993, and 78% less than the average for 1988-1992.

Prices paid to fishermen for Pacific mackerel have declined since the early 1980's, and are currently near an all time low. During the 1993/94 season, fishermen received an average price of $116 per ton, with the ex-vessel value of the industry totalling $1.4 million.

The 1994 California Recreational Fishery

Pacific mackerel have historically been important sport fish in southern California, but

total recreational landings are minor compared to the commercial fishery. The recreational catch averages about 600-900 tons per year, and was estimated to be 1,000 tons during 1994.

POPULATION ESTIMATES

Background

The stock assessment model that we used to estimate the biomass of the Pacific mackerel stock (called ADEPT, Jacobson 1993) is an implementation of Gavaris's (1988) algorithm for tuning virtual population analyses (VPA). ADEPT was also used by the Department for last year's stock assessment (Jacobson et. al., 1994). ADEPT's tuning process finds the best statistical fit (lowest log-scale sums of squares) between age-structured biomass estimates (VPA output) and other abundance information from two independent indices of stock abundance (aerial observations and larval density). Our current assessment derives biomass estimates through the last quarter of the 1994 calendar year. In addition, we project an estimate of the biomass as of July 1, 1995, based upon: 1) number of Pacific mackerel estimated to comprise each year class during the last quarter of 1994; 2) assumptions for natural and fishing mortality through the first two quarters of 1995; and 3) estimates of age-specific growth.

Input Data

Landings data were compiled on a quarterly basis for the years 1978 through 1994. Data from all fishery segments were included (e.g., southern California recreational; Enseñada commercial; northern California commercial; and southern California commercial).

For many decades, the Department has conducted random stratified port sampling for southern California wetfish landings. These samples provide data on fish sizes (figure 2), and age composition of commercial landings (figure 3). Ages were assigned to individual specimens by

examining otoliths for annuli. We assume that the size and age composition for all landings was the same as that determined for the southern California commercial fishery.

Aircraft were often used by the southern California based wetfish fishery to assist vessels in the location and capture of fish schools. Pilots employed for this activity routinely recorded information on species encountered, school size, and total area searched. Spotter pilot data were reported for each flight on standardized logbooks and provided under contract to National Marine Fisheries Service, Department of Commerce (NMFS). Raw logbook data were compiled and analyzed by N.C.H. Lo (NMFS, La Jolla) to produce an annual spotter index of relative abundance for 1978-1994 (figure 4). We used the spotter index from 1985 through 1993 in our stock assessment. Data from earlier years were not used, which improved the fit between observed and predicted values (Jacobson et. al., 1994).

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) research program was founded in the early 1950's to study the California Current, and the organisms that live in it. The principal CalCOFI members over the past five decades have included Scripps Institution of Oceanography, NMFS Southwest Fisheries Science Center, and the Department of Fish and Game.

Quarterly plankton surveys of the Southern California Bight were conducted under CalCOFI auspices, using both bongo and CALVET plankton nets. Pacific mackerel larvae were captured in the CalCOFI bongo net samples. We assumed that a relationship between larval density and size of adult spawning stock existed. We compiled CalCOFI data for the second and third quarters of each year from 1978-1994, and calculated an annual index of average larval density for the area encompassed by the Bight (figure 4). Larval density data from 1986 through 1994 were used in our stock assessment; data from earlier years were excluded to improve the fit between observed and predicted values.

Results

Based upon the ADEPT model output, the July 1, 1994, Pacific mackerel biomass was estimated to be 71,000 tons. This estimate was nearly unchanged from the Department's 1994 forecast of 74,000 tons on which the initial 1994/95 fishing season quota was established. Using the estimated abundance of each year class at the end of 1994, we project the total biomass of Pacific mackerel will be 56,000 tons at the beginning of the 1995/96 fishing season, July 1, 1995. This estimate is consistent with the long term decline in abundance that has continued almost without interruption since 1982 (figure 5).

Our biomass prediction for July 1, 1995, was closely linked to estimates of age-specific fishing mortalities (terminal F) during the last quarter of 1994. Data were insufficient to allow the model algorithm to directly estimate terminal F's, so we iteratively fit linear regressions to clear trends in age-specific fishing mortalities for 1986-1993 (figure 6). The fitted regressions were used to project terminal F for ages 0, 1, 2, and 4. Terminal F for ages 3 and 5 were interpolated to obtain more consistent estimates for those ages (figure 7). This approach provided an acceptable fit to survey data because the model's simplex algorithm could not improve upon the sums of squares associated with our terminal F's.

For our projection, we assumed that age specific fishing mortality during the first and second quarters of 1995 will be equal to the average values for 1993 and 1994, and that instantaneous natural mortality remained unchanged at 0.5. Given the numbers of fish in each year class during the last quarter of 1994, we used our mortality assumptions to calculate the number that would remain alive as of July 1, 1995. Historical mean weight at age data were used to convert numbers of fish to biomass for each age, which were summed over all ages to obtain total biomass (Table 1). Potential recruitment from the 1995 year class was not included in the 1995 forecast.

Estimates of age-specific abundance suggest that the numbers of age 3 and older fish are

currently at the lowest levels in many years, and that recruitment has been below average since 1989. Three of the four most recent year classes are the weakest ones to appear since the stock recovered from depressed levels in the late 1970's (figure 8). Despite poor abundance for the 1993 and 1994 year classes, they compose about 70% of the current biomass, because of the lack of older fish in the population.

A warm water oceanic regime has dominated the California Current region for about 15 years, and may have caused a northern emigration of Pacific mackerel, particularly the older ones. Bycatch of large (old) mackerel in the Washington/Oregon/California whiting mid-water trawl fishery has been notable in recent years, although the catches have remained small (less than 500 tons) compared to the directed fishery in California. The apparent emigration may have been compounded during 1993, because of another strong El Niño influence on sea-surface temperatures. Such emigration would exacerbate availability problems to the southern California wetfish fleet. Our model-derived estimates of age specific fishing availability support this hypothesis, with reduced availability for each successive age beyond age 2 (figure 7). Reduced fishing availability for older ages should help offset potential bias in model output associated with northern emigration of those age classes.

SEASON QUOTAS

Commercial landings of Pacific mackerel are limited according to a harvest formula given in Section 8412 of the Fish and Game Code. The formula specifies that when the biomass is between 20,000 and 150,000 tons, the season's quota shall be 30 percent of the biomass in excess of 20,000 tons. Because the 1995/96 biomass estimate is above 20,000 tons but below 150,000 tons, a quota will be in effect. Also, a minor revision must be made to the quota for the 1994/95 season, using the updated biomass estimate for July 1, 1994.

Based on our revised biomass estimate for July 1, 1994, the 1994/95 season quota is

adjusted downward to 15,300 tons. This revision is not expected to have any impact on the remainder of the 1994/95 fishery because landings have been low and total landings will probably not approach the quota.

Based on our projected biomass estimate of 56,000 tons for July 1, 1995, the commercial fishery quota for the 1995/96 fishing season is 10,800 tons. This is the lowest estimate of biomass and most restrictive quota since the late 1970's. The 1995/96 quota is similar in magnitude to recent fishery landings, therefore it could be filled sometime before the end of the 1995/96 fishing season. The July 1, 1995, biomass estimate will be reevaluated during the first quarter of the 1996 calendar year, and if warranted, the 1995/96 quota will be adjusted at that time.

PFMC FISHERY MANAGEMENT PLAN

The Pacific Fishery Management Council tentatively adopted the coastal pelagic species fishery management plan (FMP) at its March 1995 meeting. After review for any potential problems, the FMP will be considered for final adoption at the June 1995 meeting. The FMP will then be submitted to the Secretary of Commerce and NMFS for implementation. The proposed FMP would manage northern anchovy, Pacific sardine, Pacific mackerel, and jack mackerel with a limited entry program established as a small and a large boat license program based on landing capacity. Landings of the four coastal pelagic species would be regulated by an optimum yield formula based on total fish biomass and subject to strict overfishing safeguards.

ACKNOWLEDGEMENTS

We thank our colleagues at the NMFS Southwest Fisheries Science Center in La Jolla for

the assistance that they provided. In particular, insight and technical advice given by Larry Jacobson was invaluable. Also, at our request, Geoff Moser made a special effort to process the 1994 CalCOFI bongo samples for mackerel larvae, and Richard Charter used those results to update the CalCOFI database. N.C.H. Lo updated the aerial spotter index, and provided us with the results. Marci Yaremko provided editorial assistance.

LITERATURE CITED

Gavaris, S. 1988. An adaptive framework for the estimation of population size. Can. Atl. Fish. Sci. Adv. Comm. (CAFSAC) Res. Doc. 88/29: 12p.

Jacobson, L.D. 1993. ADEPT: Software for VPA analysis using Gavaris's procedure. National Marine Fisheries Service, Southwest Fisheries Science Center. Admin. Rep. LJ-93-02: 71p.

Jacobson, L.D., E. Konno, and J.P. Pertierra. 1994. Status of Pacific mackerel and trends in abundance during 1978-1993 (with data tables). National Marine Fisheries Service, Southwest Fisheries Science Center. Admin. Rep. LJ-94-08: 33p.

Figure 1

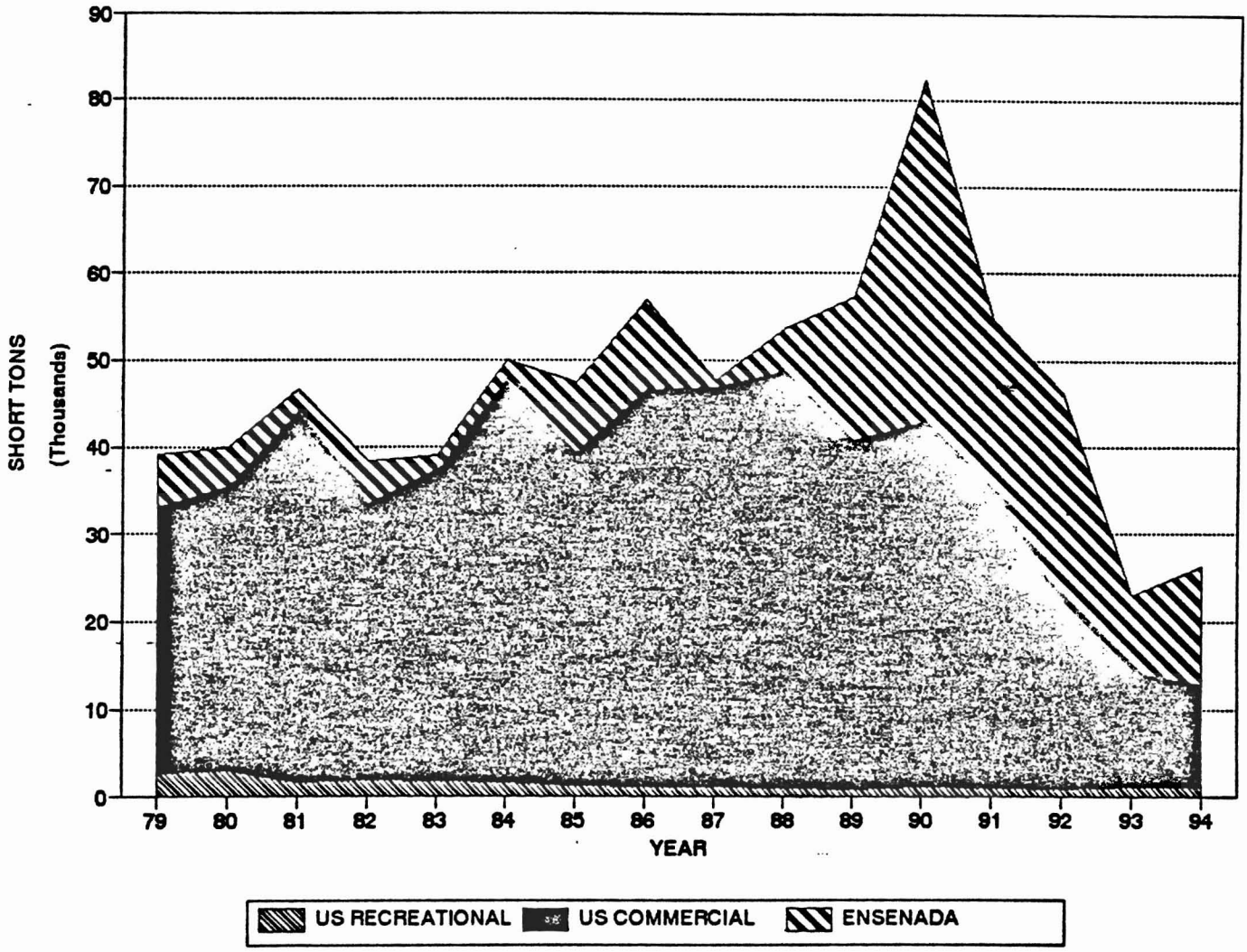
PACIFIC MACKEREL LANDINGS
SHORT TONS
(Thousands)
90
80
70
60
50
40
30
20
10
0
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
YEAR
US RECREATIONAL
US COMMERCIAL
ENSENADA

Figure 2

SECOND SEMESTER WEIGHT AT AGE
BY YEAR, 1978-1994

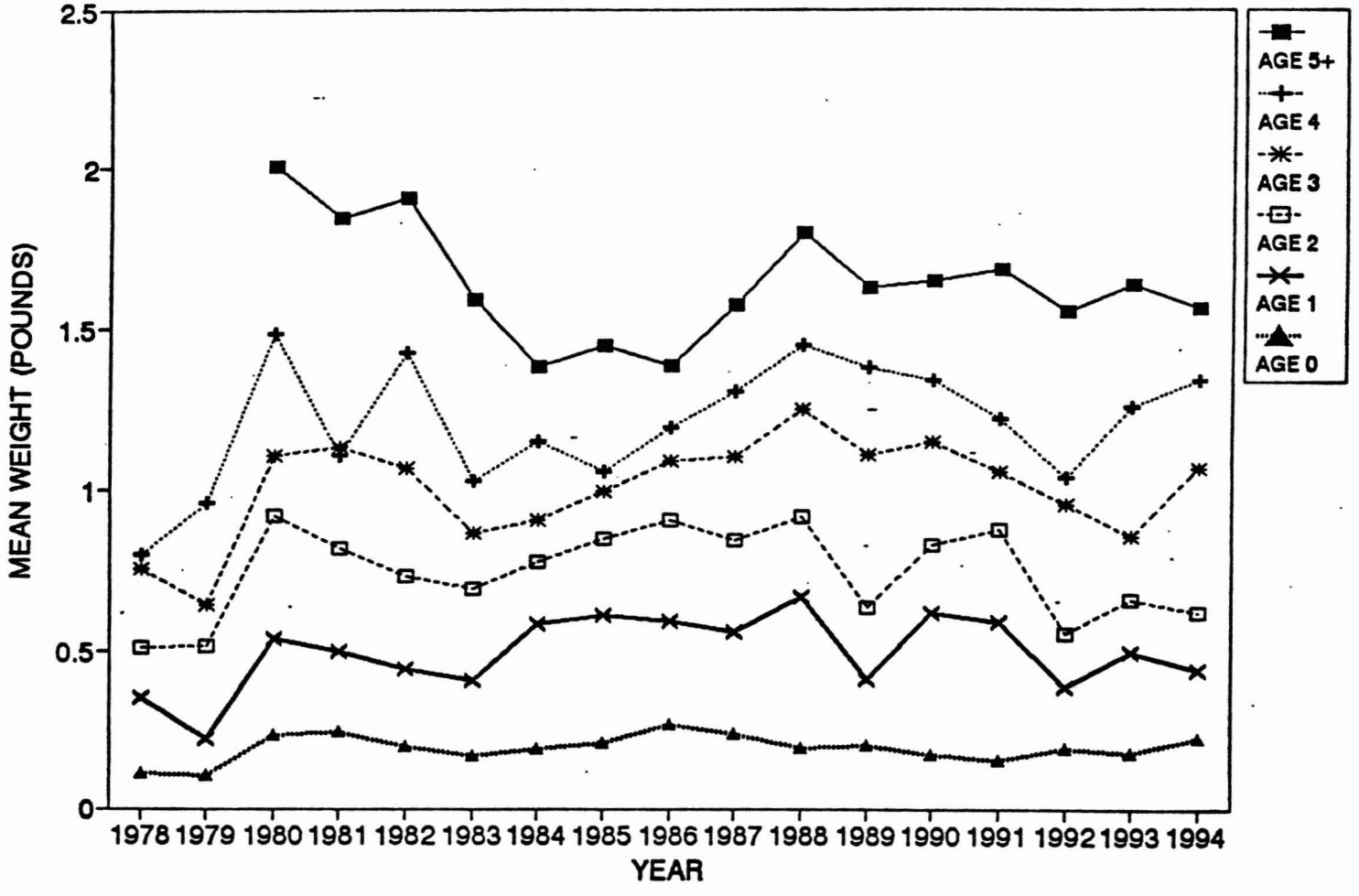

Figure 3

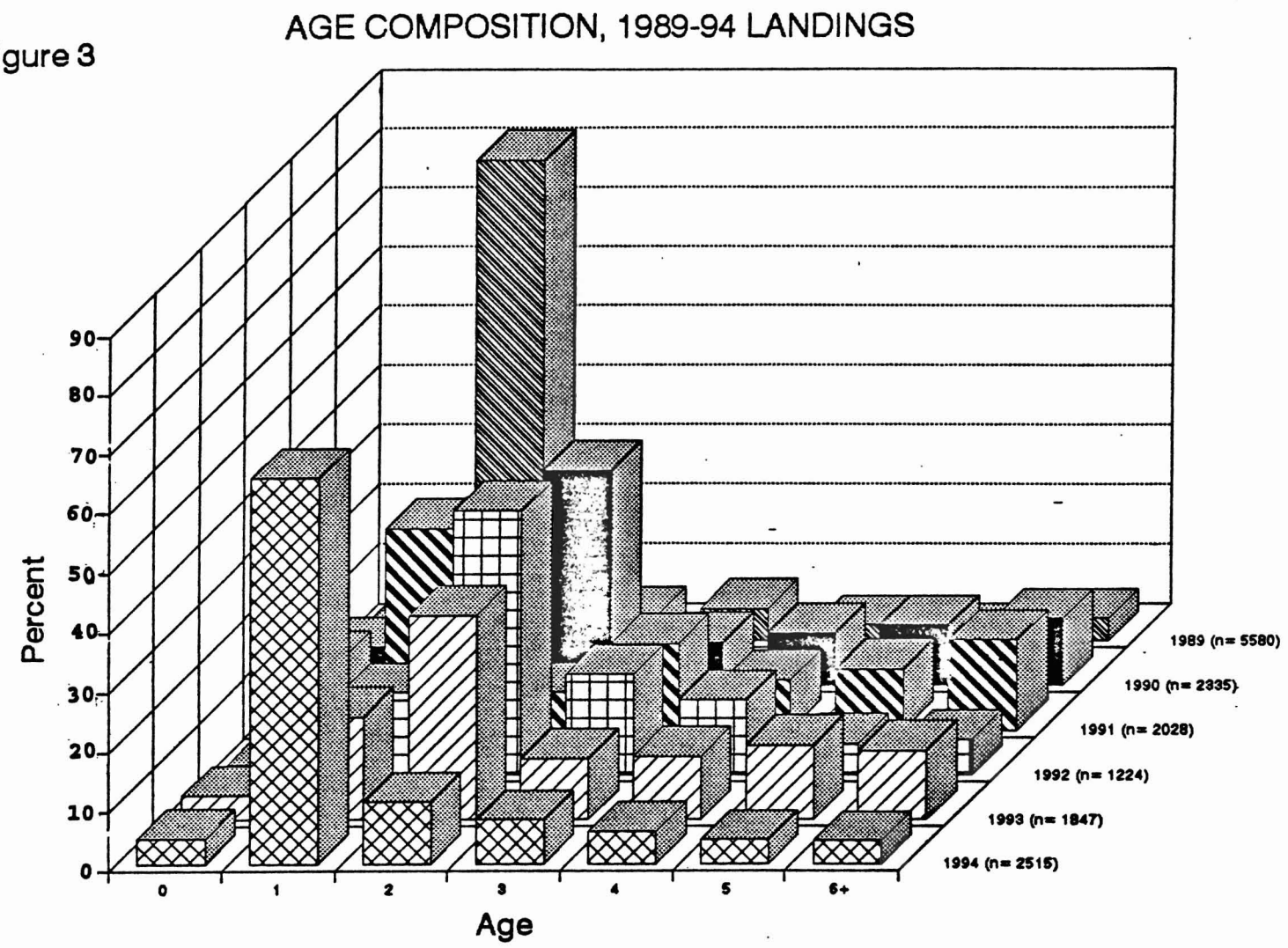
AGE COMPOSITION, 1989-94 LANDINGS
Percent
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6+
Age
1989 (n= 5580)
1990 (n= 2335)
1991 (n= 2028)
1992 (n= 1224)
1993 (n= 1847)
1994 (n= 2515)

Figure 4

PACIFIC MACKEREL ABUNDANCE INDICES
BY YEAR, 1978-1994

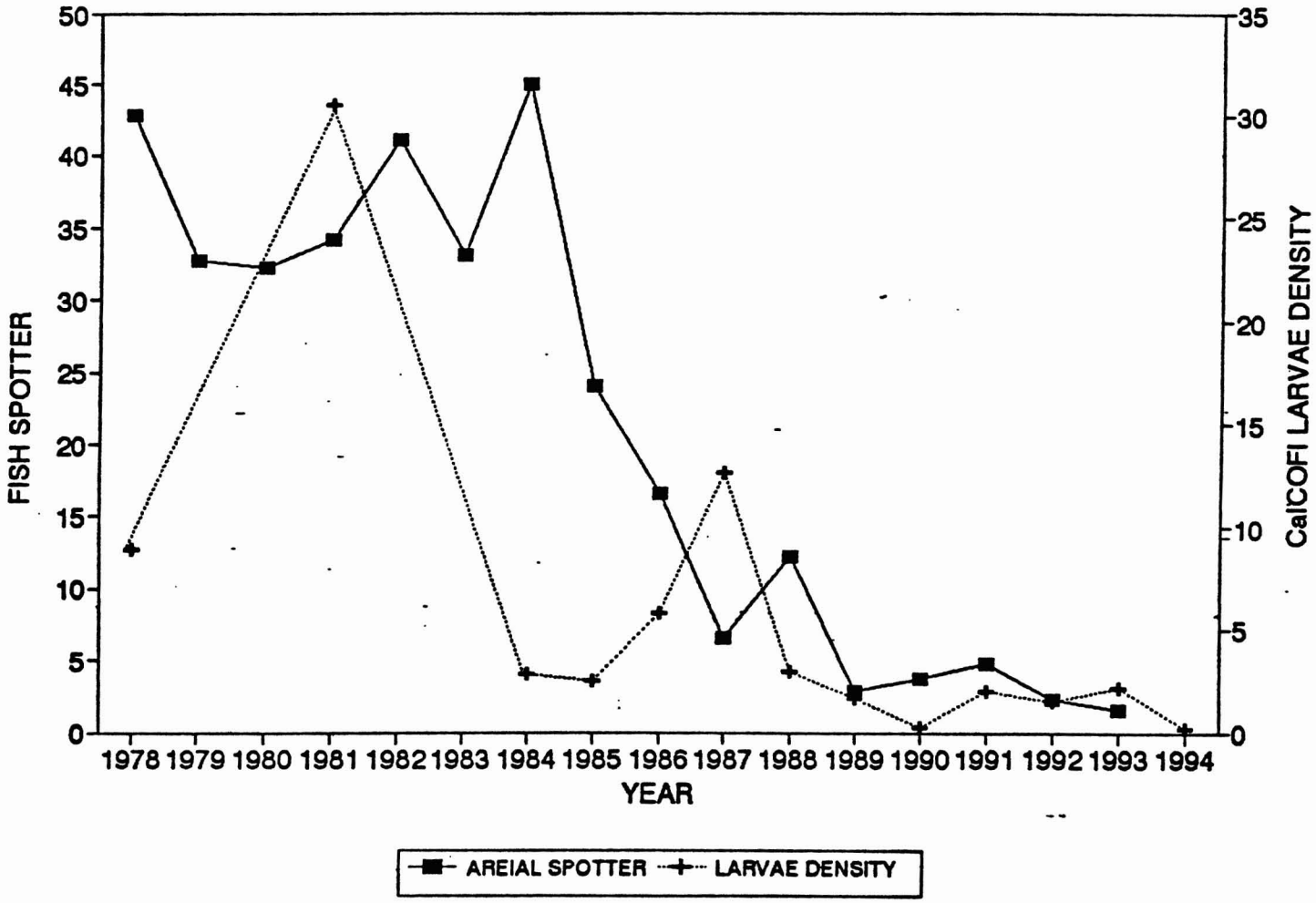

Figure 5

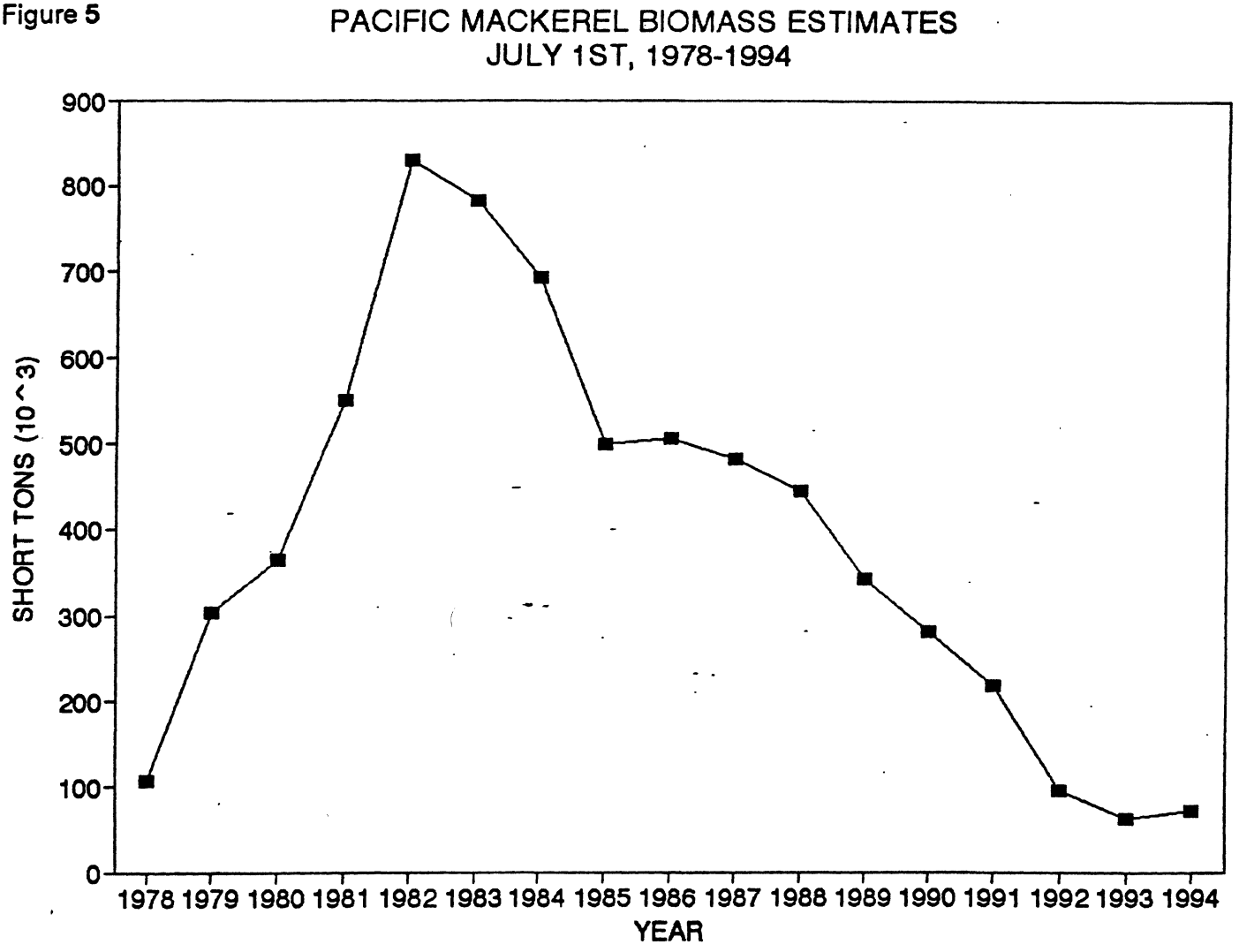
PACIFIC MACKEREL BIOMASS ESTIMATES
JULY 1ST, 1978-1994
SHORT TONS (10^3)
900
800
700
600
500
400
300
200
100
0
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994
YEAR

Figure 6

FOURTH QUARTER FISHING MORTALITY BY YEAR AND AGE, 1988-1994

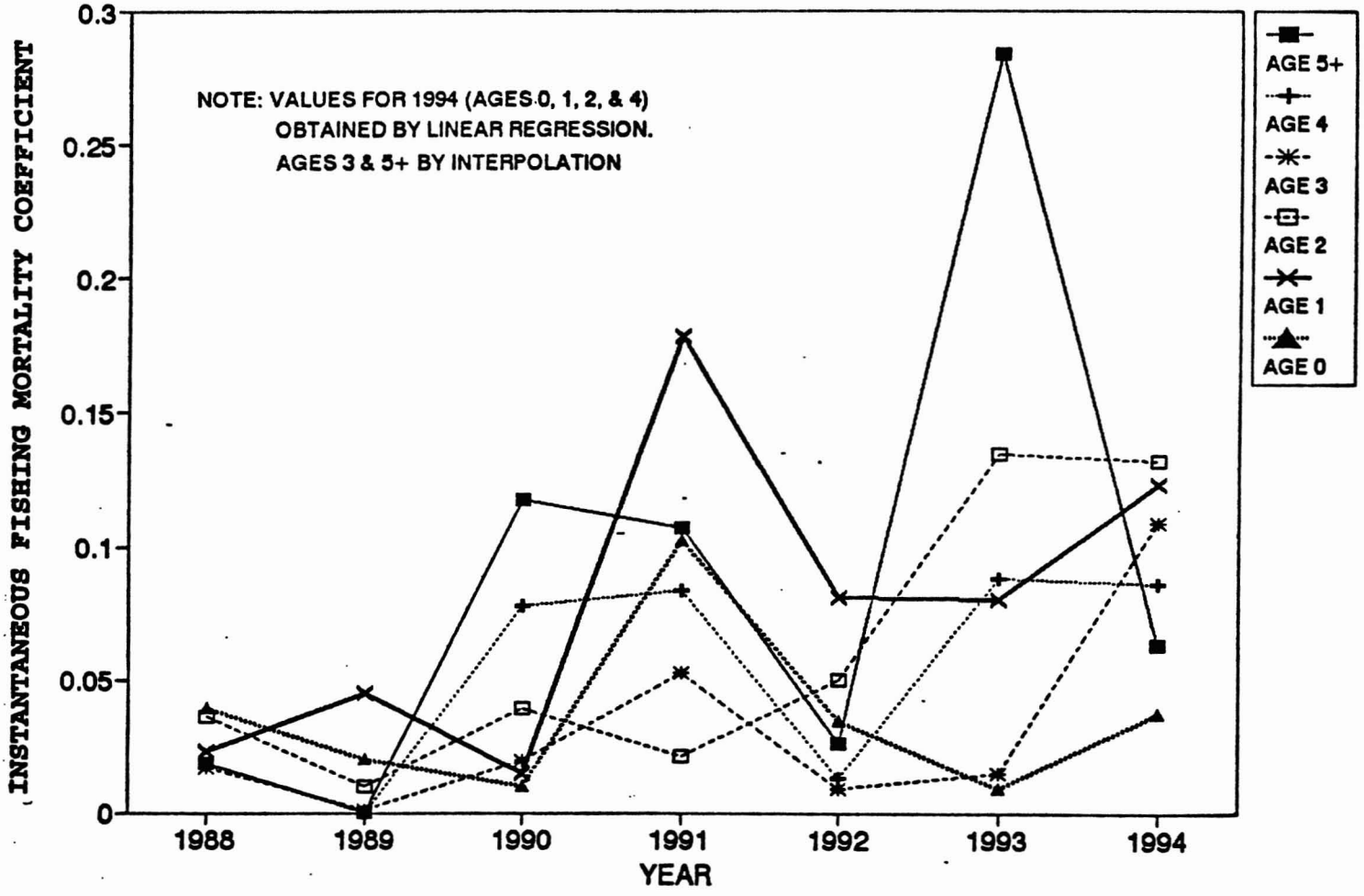

Figure 7

FOURTH QUARTER FISHING MORTALITY
BY AGE, 1994

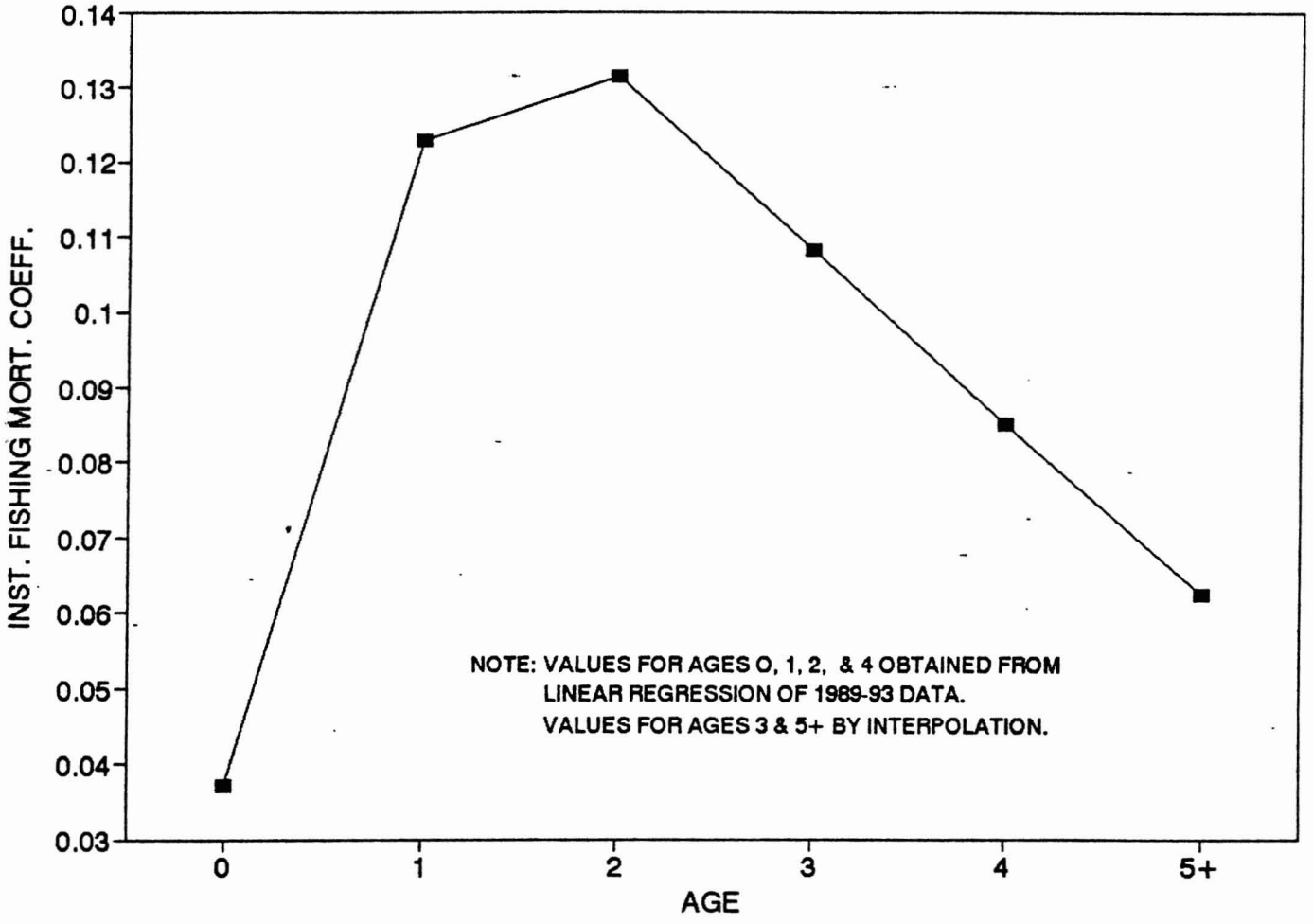

Figure 8

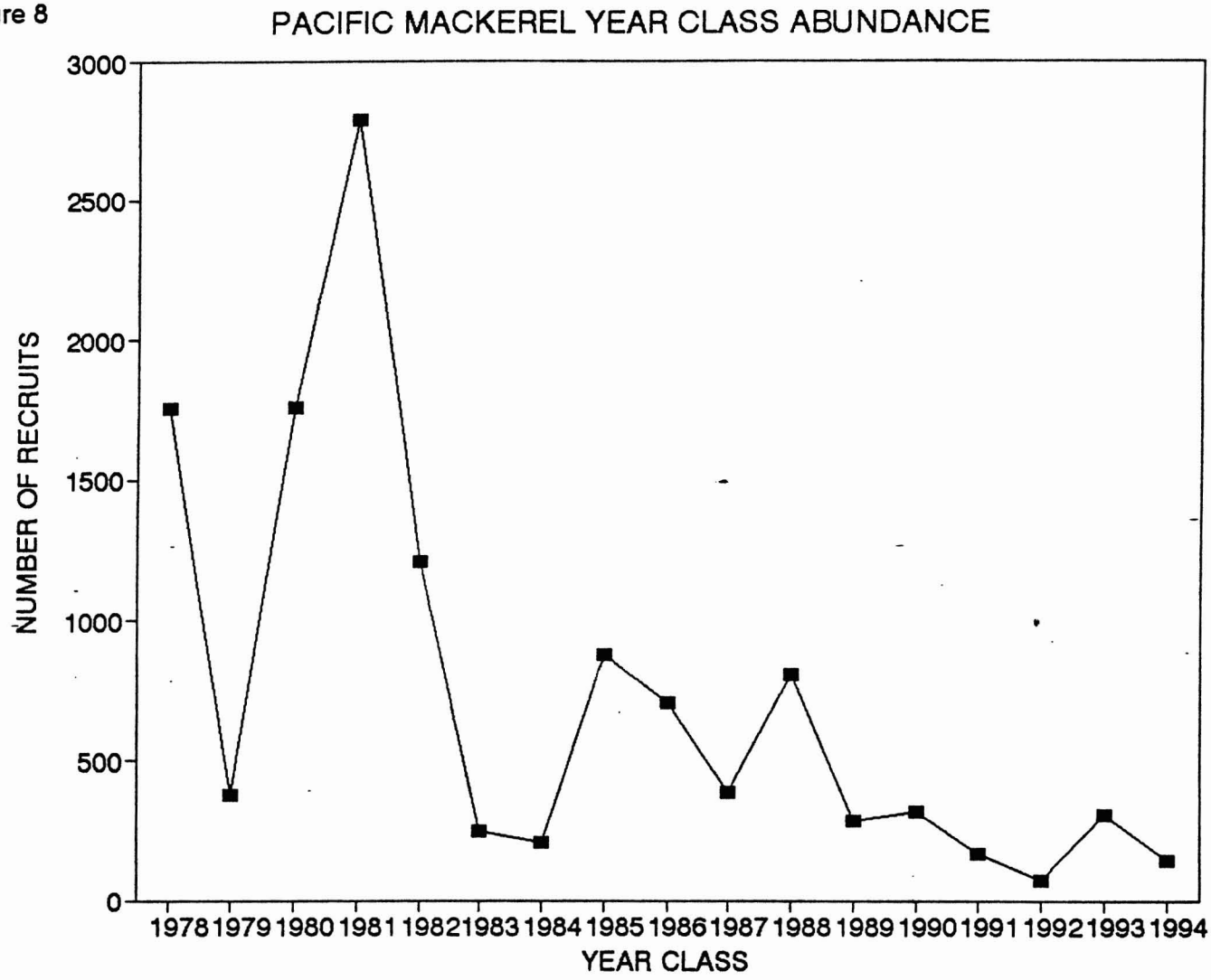
PACIFIC MACKEREL YEAR CLASS ABUNDANCE
NUMBER OF RECRUITS
3000
2500
2000
1500
1000
500
0
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994
YEAR CLASS

TABLE 1

PROJECTED PACIFIC MACKEREL BIOMASS FOR BEGINNING OF 1995/96 SEASON

YEAR CLASS (YC)	F MORT 4TH QTR 1994	F MORT 1ST QTR 1995	F MORT 2ND QTR 1995	F MORT 10/94-7/95	M MORT (M=.5/YR) 10/94-7/95	TOTAL MORT (Z=M+F) 10/94-7/95	# FISH/YC (10^6) 10/1/94	# FISH/YC (10^6) 7/1/95	WT/AGE (LBS/FISH) 7/1/95	LBS/YC (10^6) 7/1/95
1994	0.0228	0.1588	0.0410	0.2225	0.375	0.5975	143	78.6804	0.4680	36.8224
1993	0.1012	0.2167	0.0790	0.3968	0.375	0.7718	138	63.7809	0.7780	49.6215
1992	0.1326	0.1191	0.0846	0.3362	0.375	0.7112	11	5.4016	1.0000	5.4016
1991	0.0614	0.0672	0.0748	0.2034	0.375	0.5784	11	6.1691	1.2600	7.7730
1990	0.0861	0.0415	0.1271	0.2547	0.375	0.6297	9	4.7950	1.3600	6.5212
<1990	0.1734	0.0259	0.0579	0.2571	0.375	0.6321	7	3.7203	1.6600	6.1757

TOTAL BIOMASS (7/1/95)	
POUNDS (10^6)	112.316
SHORT TONS	56,000