STATUS OF THE PACIFIC MACKEREL RESOURCE DURING 1996 AND MANAGEMENT RECOMMENDATIONS FOR THE FISHERY

by **J. Thomas Barnes, Marci Yaremko** *and* **Traci Bishop**

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Executive Summary

The California fishery for Pacific mackerel (*Scomber japonicus*) has declined precipitously since 1990. Statewide landings during 1995 continued the downward trend, and totaled only 9,185 short tons. During the last few years, the principal cause of reduced catches has been low biomass and poor availability on the traditional fishing grounds in southern California waters. Cannery closures since 1993 may have also affected demand.

Several sources of information are available on the status of the Pacific mackerel stock, all of which suggest a decline in stock biomass compared to the late 1970's and 1980's. Landing statistics, available since 1978 for both the U.S. and Mexican fisheries, show reduced catches during recent years. Catch rates for the southern California Commercial Passenger Fishing Vessel (CPFV) fleet have also shown declining trends since the 1970's. Other fishery-independent data from spotter pilot aerial observations and California Cooperative Oceanic Fisheries Investigations (CalCOFI) ichthyoplankton surveys indicate lower abundance compared to the early 1980's.

We used a tuned virtual population analysis (VPA) model called ADEPT to estimate Pacific mackerel biomass. The model finds the best statistical fit between fishery-based, age-structured biomass estimates and other data from aerial observations, plankton surveys, CPFV catch data, and a spawner-recruit relation.

Based on the estimated number of fish in each year class during the last quarter of 1995 (including the 1995 year class), and using certain assumptions for expected fishing mortality during the first half of 1996, we project that the Pacific mackerel biomass will be 52,000 tons at the beginning of the 1996/97 fishing season, on July 1, 1996. There is a large degree of uncertainty in our 1996 biomass estimate because the 1995 year class (fish of age one) comprises most of the biomass.

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 total biomass in excess of 20,000 tons. Using that formula and our projection for July 1, 1996, we recommend a commercial fishery quota of 9,600 tons for the 1996/97 fishing season.

THE PACIFIC MACKEREL FISHERY

Background

Pacific mackerel is a trans-boundary stock supporting commercial fisheries in the U.S. and Mexico, and have been found as far north as British Columbia in recent years. Combined total landings from the U.S. and Mexico reached a record high of 82,000 tons in 1990, but have declined precipitously since that year (figure 1). Combined landings were 14,867 tons during the 1995 calendar year, the lowest since the late 1970's, when a moratorium was lifted following collapse of the fishery in the mid-1960's. Prior to 1990, the fishery was dominated by the U.S. fleet, however both nations currently take nearly equal shares of the catch. During 1995, the U.S. fishery landed 64% of the combined harvest (9,554 tons) while the Mexican fishery landed the remaining 36% (5,313 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 including Pacific sardine (*Sardinops sagax*), jack mackerel (*Trachurus symmetricus*), market squid (*Loligo opalescens*), bonito (*Sarda chiliensis*), Pacific herring (*Clupea pallasi*), and occasionally bluefin tuna (*Thunnus thynnus*) and northern anchovy (*Engraulis mordax*). Under provisions of the California Fish and Game Code, fishing quotas for Pacific mackerel and sardine are established by the Department of Fish and Game (CDFG). Northern anchovy are managed by the Pacific Fishery Management Council (PFMC) under authority of a fisheries management plan (FMP) adopted in 1978. The Department of Commerce may drop the anchovy FMP, in which case management authority for anchovy is expected to revert to the state.

Historically, Pacific mackerel landings have been concentrated in southern California, with most vessels operating out of San Pedro/Terminal Island and a few others out of Ventura County. A smaller fleet in Monterey has historically caught a minor percentage of the state's total annual landings.

California Fish and Game Code sets the Pacific mackerel fishing season as a 12-month period from July 1 through June 30 of the following calendar year. Mackerel are fished during every month, until the annual harvest quota is filled. A season quota is established for commercial fishing when total biomass, determined by CDFG, is greater than 20,000 tons but less than 150,000 tons. If total biomass is less than 20,000 tons no directed catch is allowed, and if total biomass is greater than 150,000 tons no limitation on total catch is imposed.

The 1995 California Commercial Fishery

Annual Pacific mackerel landings in California have been on a downward trend since 1988, totaling only 9,554 tons for the 1995 calendar year (figure 1). This was the lowest level of landings since the commercial fishery reopened in 1976.

The 1994/95 fishing season landings were 10,331 tons, well below the season quota of 16,200 tons. The 1994/95 season quota was set 50% lower than 1993/94 because of decreasing biomass estimates (Barnes and Hanan, 1995). In addition to poor Pacific mackerel availability, low landings during recent fishing seasons are also due to diversion of wetfish fleet fishing effort from mackerel to the more lucrative winter squid and summer tuna fisheries.

CDFG set the 1995/96 Pacific mackerel commercial fishing quota at 10,800 tons, 33% lower than the previous season based on projections of further biomass decline.

Landings at the end of the season totaled 7,956 tons. Despite sharp decreases in allowable take, the 1995/96 fishing season marked the fourth in a row that the quota was not filled.

Ex–vessel price for Pacific mackerel has declined since the early 1980's to near the all time low. During 1995, price ranged from $80/ton to $180/ton and averaged $119/ton. As a result, 1995 statewide ex–vessel value was $1.2 million; approximately 15% less than the 1994 statewide ex–vessel value.

1995 California Recreational Fishery

Pacific mackerel have historically been an important component of sport fish landings in southern California, but total recreational landings are minor compared to commercial landings. The recreational catch averages about 600-900 tons per year, and was estimated to be 865 tons during 1995. Recreational landings decreased slightly (15%) in 1995 compared to 1994 landings.

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 used by CDFG for the mackerel stock assessment during the past two years (Jacobson et. al., 1994; Barnes and Hanan, 1995). ADEPT finds the best statistical fit (lowest log-scale sums of squares) between age-structured biomass estimates (VPA output) and other abundance information from indices of stock abundance; i.e., output is tuned to the abundance information. We used the ADEPT model to calculate biomass estimates through the last quarter of the 1995 calendar year, and to project an estimate of biomass for July 1, 1996, based upon: 1) number of Pacific mackerel estimated to comprise each year class during quarter four of 1995; 2) assumptions for natural (M=0.5) and fishing mortality through quarters one and two of 1996; and 3) estimates of age-specific growth.

The Pacific Mackerel Assessment Team

A newly formed Pacific Mackerel Assessment Team (PMAT) met on April 15, 1996, at Southwest Fisheries Science Center in La Jolla. PMAT was comprised of researchers from NMFS and CDFG, each of whom had previously worked on Pacific mackerel. Travel complications and scheduling conflicts prevented an invited Mexican scientist from participating. PMAT was formed to develop recommendations for improving data and assumptions used for CDFG stock assessment. An important PMAT recommendation for Pacific mackerel was to obtain Mexican fishery age composition data. No suitable data existed from the 1995 Ensenada fishery, but efforts are underway to attain this information for future stock assessments.

We included several improvements to this year's assessment as a result of PMAT suggestions: 1) a sportfishing CPUE time series (calculated from the Department's CPFV logbook program) as a new model tuning index of abundance for older mackerel; 2) spawner-recruit constraints (Ricker curve) in an attempt to improve model recruitment estimates for 1994 and 1995 year classes; 3) an age-specific selectivity pattern for quarter four 1995, that reduced fishery vulnerabilities of each successively older age, from age 1 through age 5+; 4) vulnerability of age 0 fish was fixed lower than that for age 1; and 5) the abundance of year class 1995 was constrained to fall within ranges for spawning success (recruits/spawner) observed since 1978. Under these constraints, the 1995 year class had the highest spawning success since 1978.

Input Data

Catch

Landings data were compiled on a quarterly basis for the years 1978 through 1995. Data from all fishery segments were included (e.g., southern California recreational; Ensenada commercial; northern California commercial; and southern California commercial).

For many years, CDFG has conducted random stratified port sampling from southern California wetfish landings. These samples provided data on fish length (figure 2), weight (figure 3), maturity and age composition of commercial landings (figures 4 and 5). Ages were assigned to individual specimens by examining and counting otolith annuli. We assume that size and age compositions for all landings did not differ from those determined for southern California commercial catches.

Increased mackerel landings from Ensenada in recent years require additional data from that fishery. Age composition data from U.S. landings was assumed to mirror age composition for Mexican catch because both fisheries utilized the same stock. However, there was not sufficient evidence to support or refute this assumption.

A small amount of length-frequency data was available for the Ensenada mackerel fishery in Instituto Nacional de la Pesca's Boletin Informativo Mensual #40, 41, 42, and 44, although samples were obtained in only four months of 1995. Age composition was estimated from length data by deriving age from our San Pedro fishery length-at-age data.

Our calculated age composition for Ensenada landings differ dramatically among months, and from those of the corresponding U.S. fishery during the same months of 1995 (figures 5 and 6). Additionally, Ensenada sample sizes for each of these months are very small, and likely represent a single load of fish sampled. Because inconsistencies could not be reconciled, we excluded Ensenada length/age data from this assessment. Efforts are currently underway to attain better length and age composition data from Ensenada for both mackerel and Pacific sardine.

Aerial Observations

Aircraft were often used by the southern California based wetfish fishery to assist in 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 via contract to National Marine Fisheries Service, Department of Commerce (NMFS). Raw logbook data were compiled and analyzed based on a delta log-normal model (Lo et al, 1992) to produce an annual spotter index of relative abundance for 1978-1995 (figure 7). We used the spotter index from 1985 through 1995 in our stock assessment. Data from earlier years were not used, which improved the fit between observed and predicted values (Jacobson et. al., 1994). Spotter data was compiled using calendar year instead of fishing year for assessment to attain the best estimate of 1995 abundance.

Larval Density

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. Principal CalCOFI members over the past five decades have included Scripps Institution of Oceanography, NMFS Southwest Fisheries Science Center, and CDFG.

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 quarters two and three of each year from 1978-1994, and calculated an annual index of average larval density for the area encompassed by the Bight. Larval density data from 1986 through 1995 were used in our stock assessment; data from earlier years were excluded to improve the fit between observed and predicted values. Despite excluding the data from earlier years, predicted larval density values from the model poorly fit observed CalCOFI data, possibly because the standard CalCOFI grid is on the northern fringe of the Pacific mackerel spawning grounds. Therefore, in accordance with PMAT recommendations, we greatly down-weighted the CalCOFI index in our stock assessment (lambda = 0.001).

Sportfish Catch-Per-Unit-Effort

CDFG has conducted a program to obtain logbook data from the Commercial Passenger Fishing Vessel (CPFV, otherwise known as partyboats) fleet since 1936. Included in the logbook data are information on total fishing effort and number caught, by species (Kevin Hill, CDFG La Jolla, pers. comm.). A comparison of commercial and recreational length composition data (figure 8) suggests that CPFV catch is composed mostly of older fish; therefore CPUE data from this source may be used as a tuning index for ages 2+ prior to 1993. In more recent years, the recreational fishery took even larger fish, ages 3+. The CPUE time series show a declining trend, consistent with other information on the resource (figure 7). The model output closely fits the CPFV data, although the relationship is non-linear; CPFV catch rates do not change in direct proportion to changes in biomass. At biomass levels encountered in recent years, catch rates change more slowly than biomass. At lower levels of biomass, CPFV catch rates should decline more rapidly.

Powerplant Impingement Data

We investigated Southern California Edison (SCE) impingement data as a potential index of recruitment for our model. SCE routinely collects samples of fish that become entrained in the cooling water intakes at ten power generating stations along the southern California coast (Kevin Herbinson, SCE, Rosemead, CA. pers. comm.). Length frequency data suggest that most fish in their samples are new recruits. Catch rates derived from these data inexplicably increased since 1990 (figure 9). Although these data suggest increased presence of young mackerel in recent years, they were not used in our analysis at this time because of difficulty in reconciling these data with other information on the stock. Additional work with these data, including general linear model (GLM) analyses to account for possible season and plant (facility) effects, may allow use in future assessments.

Recruitment

Since the model algorithm was not able to adequately estimate the number of fish in the 1995 year class, we fixed that value based on analyses of model output, and assumptions about expected productivity of the stock.

Our estimate of abundance for the 1995 year class was closely linked to estimates of age-specific fishing mortalities (terminal F) and associated selectivities during quarter four of 1995. Data were insufficient to allow the model algorithm to directly estimate terminal selectivities, partly because cumulative fishing mortalities for the two youngest year classes were quite low (figure 10). VPA calculations tend to give poor results when cumulative fishing mortality is less than about 2.0 for each year class. We investigated two scenarios to derive estimates of age specific selectivities for the last quarter of 1995 from outside the model algorithm. Both scenarios used model output for our calculations. First, we iteratively fit linear regressions to clear trends in logtransformed, age-specific fishing mortalities for 1990-1994. Fitted regressions were used to project terminal F for all ages, and projected terminal F's were then used to obtain age specific selectivities. As our second alternative, we used mean fourth-quarter age specific selectivities for 1990-1994 as estimates for quarter four of 1995. Three iterations were required to finalize the results. Since neither approach was deemed better than the other overall, terminal selectivities that we adopted were the mean of the two scenarios, for ages 1-5. Terminal selectivity for age 0 was set at the lowest value that conformed with the spawning success constraint, as described above (figure 11). 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 selectivities.

Resulting estimate for 1995 year class recruitment (463 x10^6 fish) is less than mean recruitment since 1978 (715 x10^6 fish), but it is the best since 1988 (figure 12) despite the extremely low spawning biomass in 1995. Given our estimates of recruits and spawning biomass for 1995, spawning success was much better than average (11.9 recruits/spawner), second only to the record high observed in 1978 (90.2 recruits/spawner) (figure 13). Assuming that a spawner-recruit relation is valid for Pacific mackerel, our estimate of 1995 year class abundance is near the expected upper limit, based on recent population dynamics of the stock.

RESULTS

Based upon this assessment's ADEPT model output, the July 1, 1995 Pacific mackerel biomass is now estimated to have been 28,000 tons. This estimate is significantly lower than last year's CDFG projection of 56,000 tons for 1995, because our initial projections for the abundance of the 1994 year class were too high. Updating this assessment and accounting for anticipated success of the 1995 year class, we project the total biomass of Pacific mackerel will be 52,000 tons at the beginning of the 1996/97 fishing season, July 1, 1996. This estimate is consistent with the lower levels of abundance that have occurred since 1992 (figures 12 and 14), although higher than our current estimate for 1995.

Our biomass estimate for July 1, 1996, was closely linked to estimates of age-specific fishing mortalities (terminal F) during the last quarter of 1995, as described above. We assumed that age specific fishing mortality during the first and second quarters of 1996 will be equal to the average values for 1990-1995, and that instantaneous natural mortality remained unchanged at 0.5. Given the numbers of fish in each year class during the last quarter of 1995, we used our mortality assumptions to calculate the number that would remain alive as of July 1, 1996. Weight at age data for 1995 were used to convert numbers of fish to biomass for each age, which were summed over all ages to obtain total biomass (Table 1).

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 year classes. A latitudinal cline in mean size is apparent in the California sportfish catch, lending support to the hypothesis that the older fish tend to move farther north (figure 15). By-catch of presumed large (old) mackerel in the Oregon whiting fishery has been notable in recent years, although 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. Estimates of age specific fishing availability used in our assessment are consistent with this hypothesis, with reduced availability for each successive age beyond age 1 (figure 11). 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 1996/97 biomass estimate is above 20,000 tons but below 150,000 tons, a quota will be in effect.

Based on our projected biomass estimate of 52,000 tons for July 1, 1996, the recommended commercial fishery quota for the 1996/97 fishing season is 9,600 tons. Following last season's quota of 10,800 tons, this is the lowest estimate of biomass and most restrictive quota since the late 1970's. The recommended 1996/97 quota is similar in magnitude to recent fishery landings, therefore it could be filled sometime before the end of the 1996/97 fishing season.

PFMC FISHERY MANAGEMENT PLAN

During 1995, the Pacific Fishery Management Council (PFMC) voted to adopt the draft coastal pelagic species fishery management plan (FMP). Following that decision, the PFMC submitted the FMP to the Department of Commerce for implementation. However, the Department of Commerce chose to reject the plan. Therefore, the draft FMP was not adopted by the PFMC despite their earlier vote to the contrary, and management of the Pacific mackerel fishery remains the responsibility of the state.

ACKNOWLEDGMENTS

We thank our colleagues at the NMFS Southwest Fisheries Science Center (SWFSC) in La Jolla. In particular, the insight, technical advice and programming given by Larry Jacobson (NMFS) was invaluable. Also, at our request, Geoff Moser (NMFS) made a special effort to process the 1995 CalCOFI bongo samples for mackerel larvae. Kevin Hill (CDFG, La Jolla) compiled data for the new CPFV catch rate index, and provided information on the CPFV fishery. Richard Parrish, of the Pacific Fisheries Environmental Group (PFEG) in Monterey gave direction and guidance to our work and provided review that greatly improved it, especially concerning population dynamics. Kevin Herbinson (Southern California Edison) provided powerplant impingement data. Port sample data were provided by the CDFG Long Beach Monitoring and Management Unit, pursuant to National Oceanic and Atmospheric Administration Award No. NA66FI0220-01.

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TABLE 1

PROJECTED PACIFIC MACKEREL BIOMASS FOR BEGINNING OF 1996/97 SEASON

YEAR CLASS (YC)	F MORT 4TH QTR 1995	F MORT 1ST QTR 1996	F MORT 2ND QTR 1996	F MORT 10/95-7/96	M MORT (M=.5/YR) 10/95-7/96	TOTAL MO (Z=M+F) 10/95-7/96	# FISH/YC (10^6) 10/1/95	# FISH/YC (10^6) 7/1/96	WT/AGE (LBS/FISH) 7/1/96	LBS/YC (10^6) 7/1/96
1995	0.0286	0.1510	0.0250	0.2046	0.375	0.5796	463	259.3367	0.3190	82.7284
1994	0.0763	0.1750	0.1190	0.3703	0.375	0.7453	48	22.7804	0.3990	9.0894
1993	0.0425	0.1090	0.1250	0.2765	0.375	0.6515	10	5.2126	0.6700	3.4925
1992	0.0240	0.0510	0.0860	0.1610	0.375	0.5360	5	2.9254	0.9960	2.9137
1991	0.0174	0.0310	0.0860	0.1344	0.375	0.5094	0	0.0000	1.3900	0.0000
<1991	0.0191	0.0290	0.0732	0.1213	0.375	0.4963	6	3.6527	1.3900	5.0772

TOTAL BIOMASS (7/1/96)	
POUNDS (10^6)	103.301
SHORT TONS	52,000

Figure 1

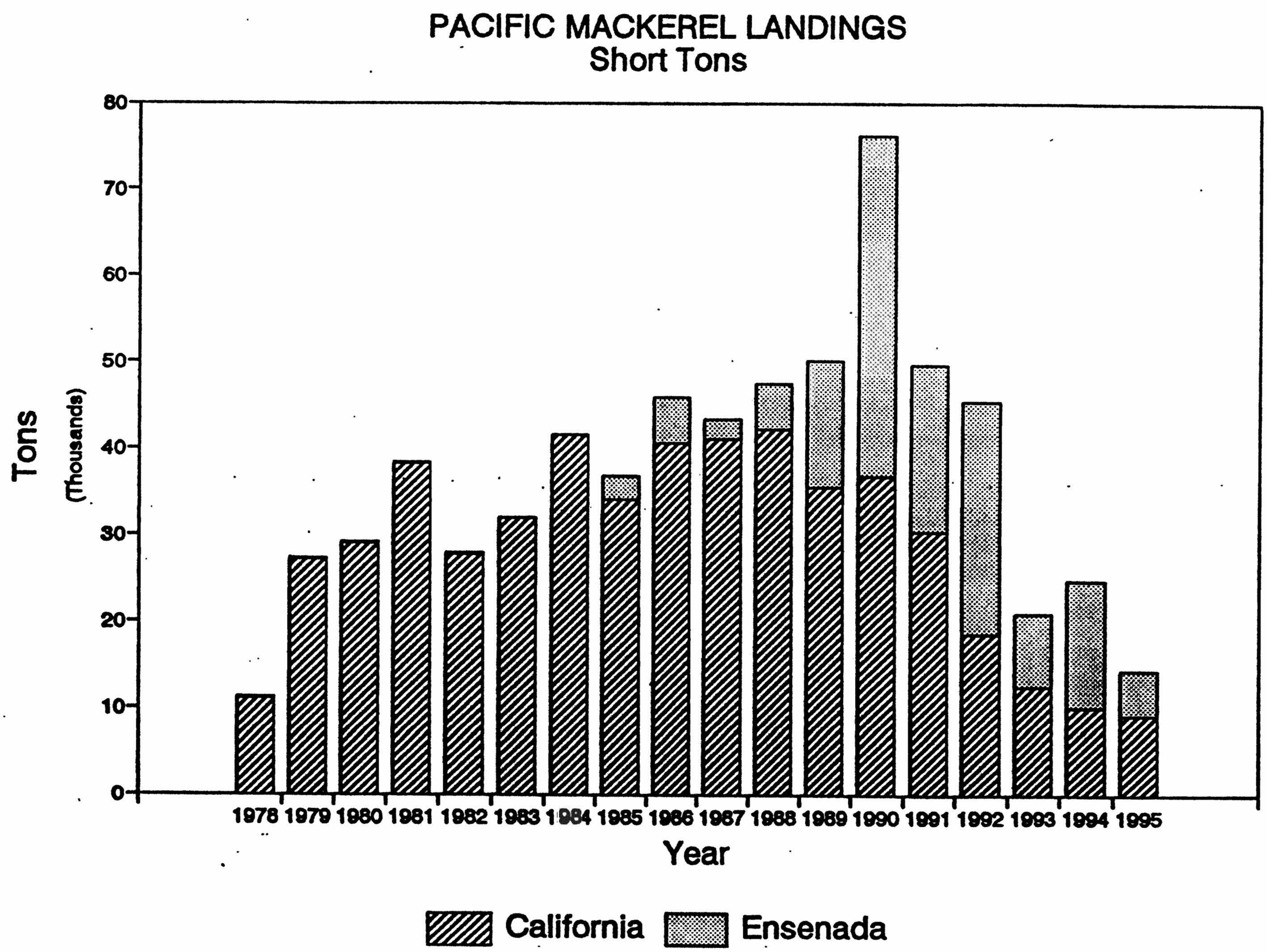

PACIFIC MACKEREL LANDINGS
Short Tons
Tons
(Thousands)
0
10
20
30
40
50
60
70
80
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Year
California
Ensenada

Figure 2

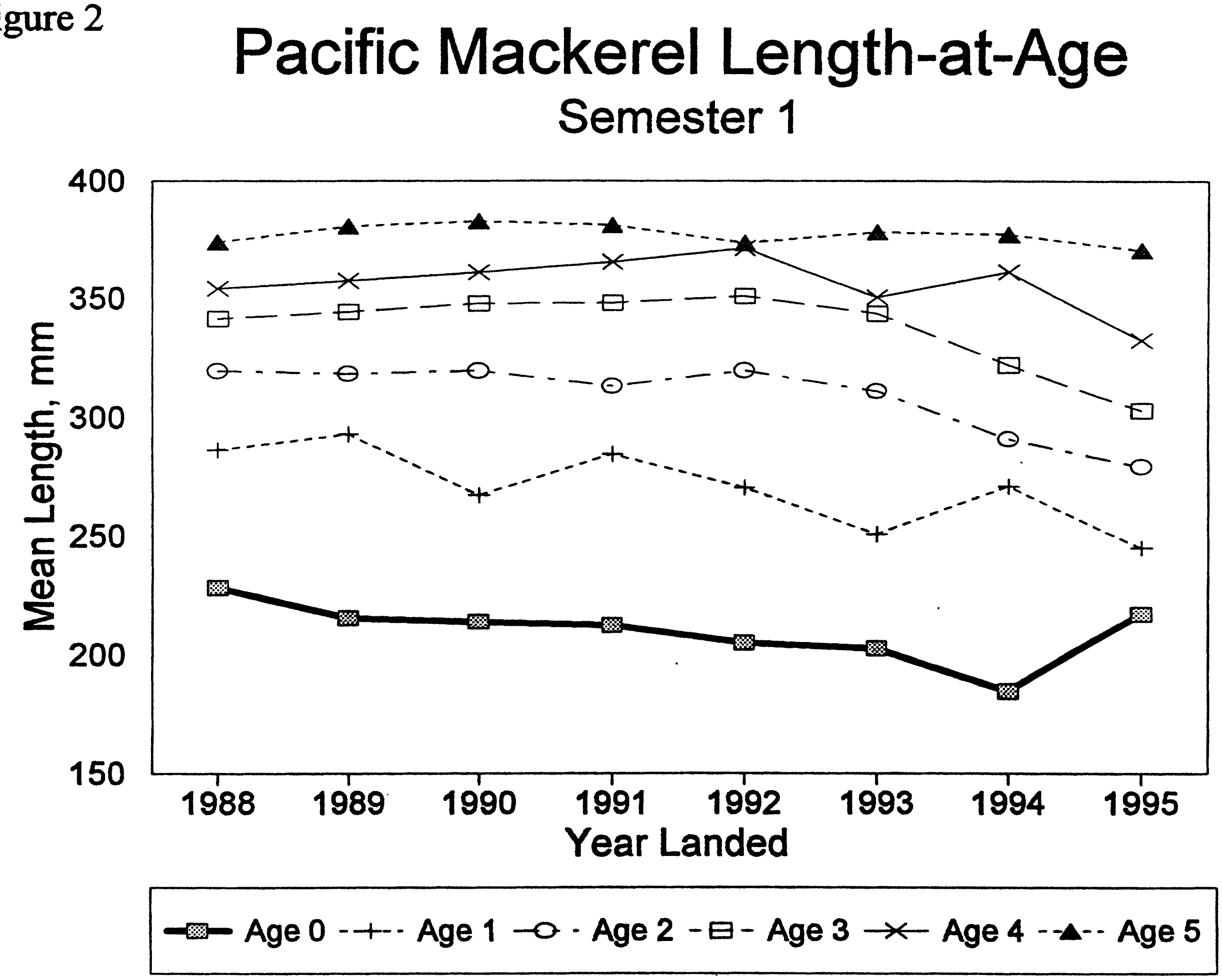

Pacific Mackerel Length-at-Age
Semester 1
Mean Length, mm
400
350
300
250
200
150
1988
1989
1990
1991
1992
1993
1994
1995
Year Landed
Age 0
Age 1
Age 2
Age 3
Age 4
Age 5

Figure 3

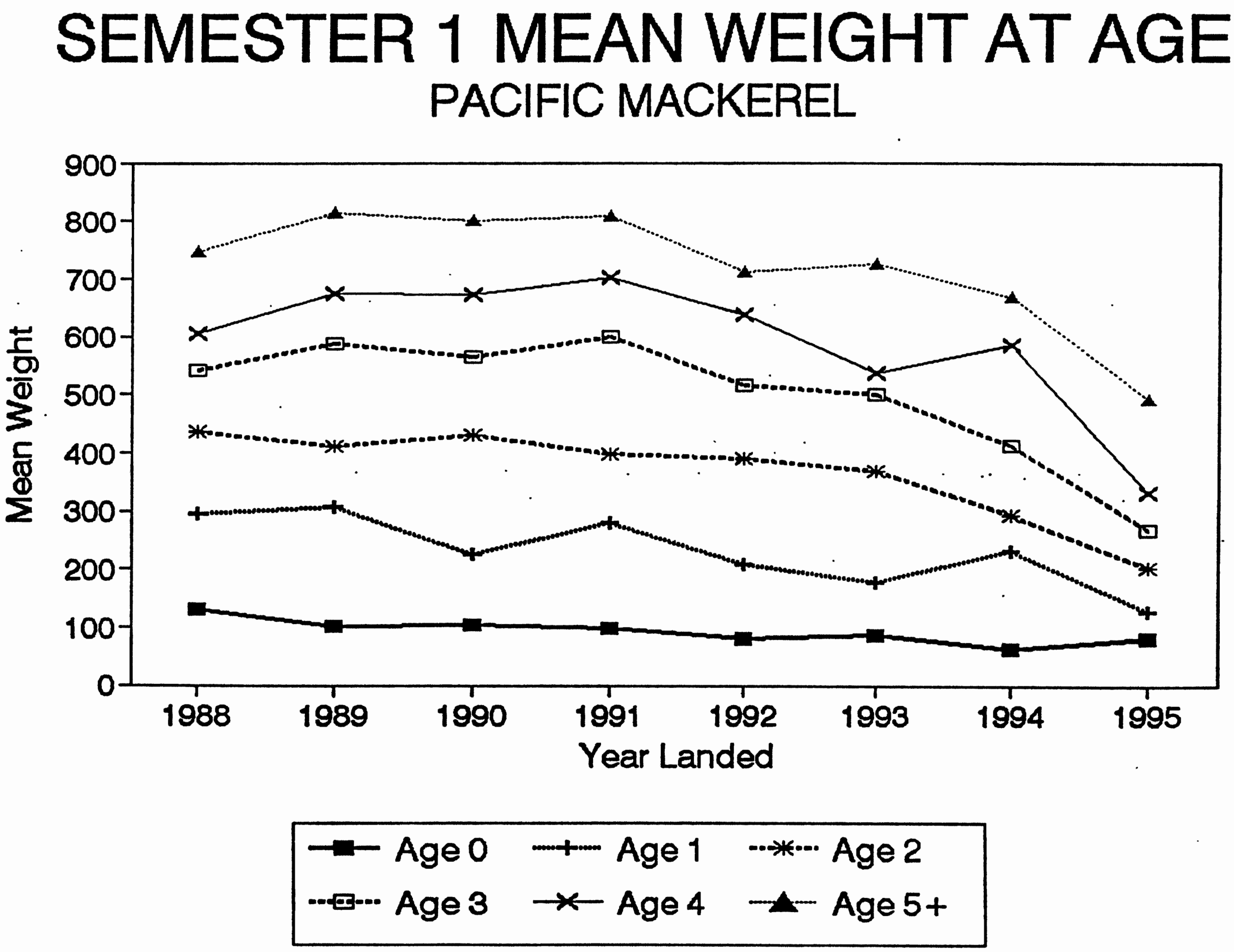
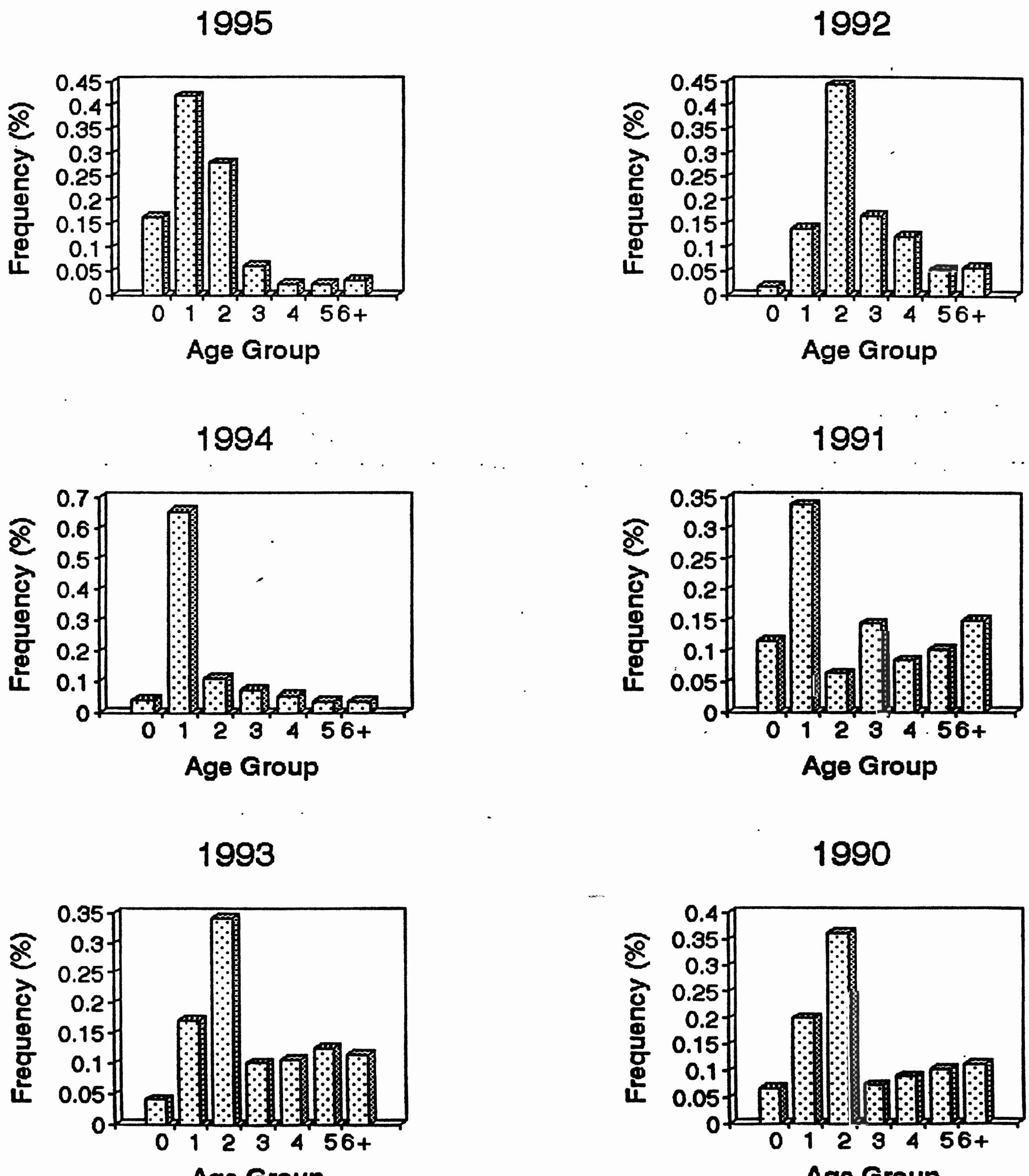

SEMESTER 1 MEAN WEIGHT AT AGE
PACIFIC MACKEREL
Mean Weight
900
800
700
600
500
400
300
200
100
0
1988
1989
1990
1991
1992
1993
1994
1995
Year Landed
Age 0
Age 1
Age 2
Age 3
Age 4
Age 5+

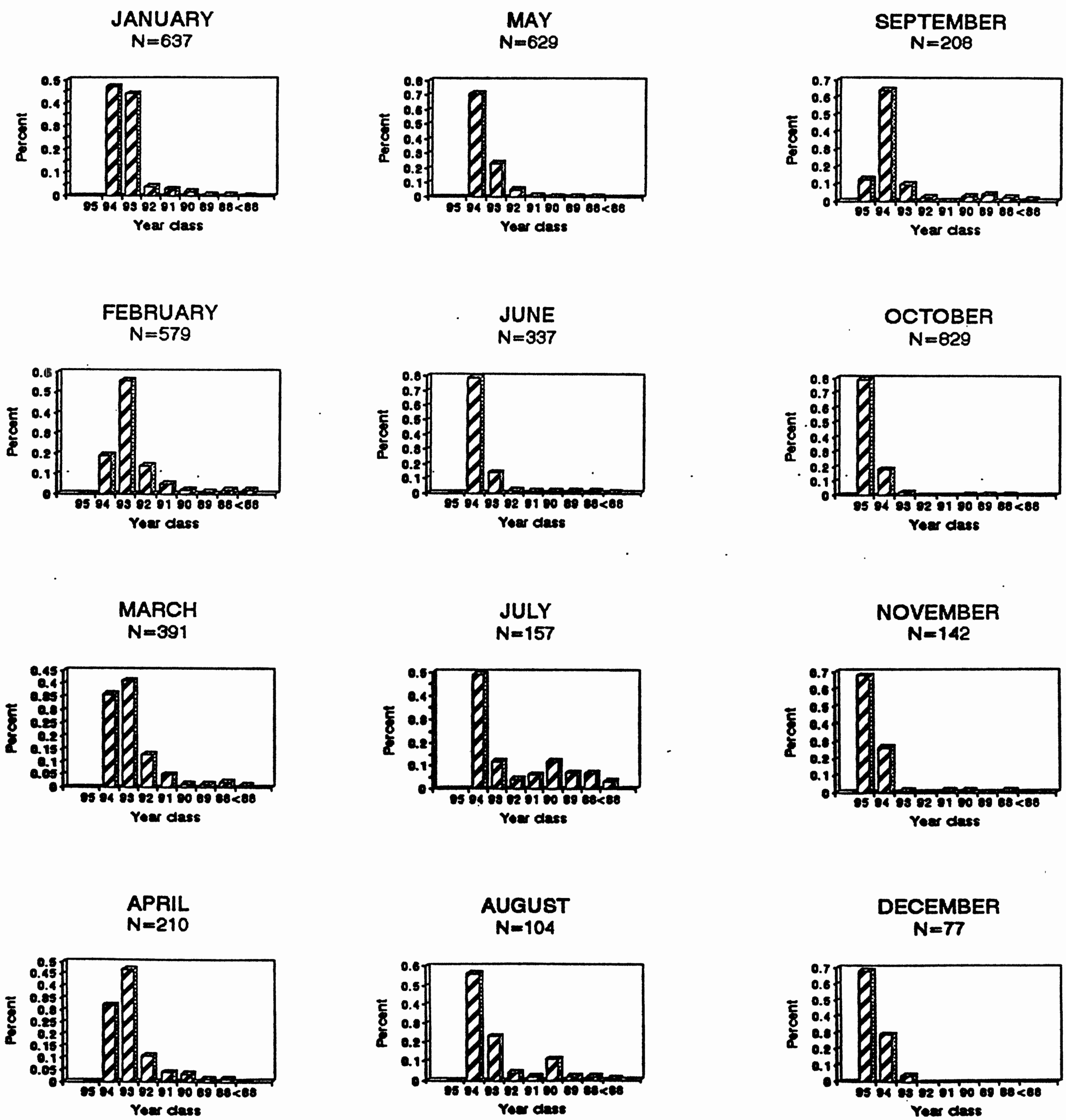
Figure 4

AGE COMPOSITION OF COMMERCIAL CATCH
SAN PEDRO, CA



Pacific Mackerel Age Composition, San Pedro CA 1995
Age Determined from Sagittal Otoliths

Figure 5



Pacific Mackerel Age Composition, Ensenada, Mexico 1995
(Calculated from length frequencies)

Figure 6

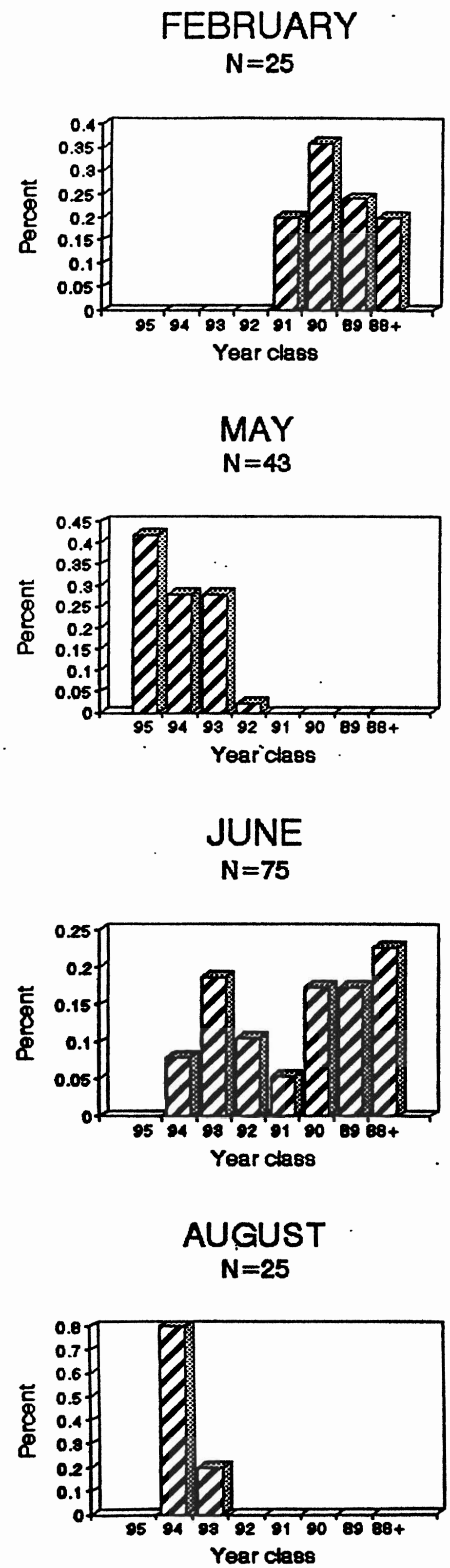


Figure 7

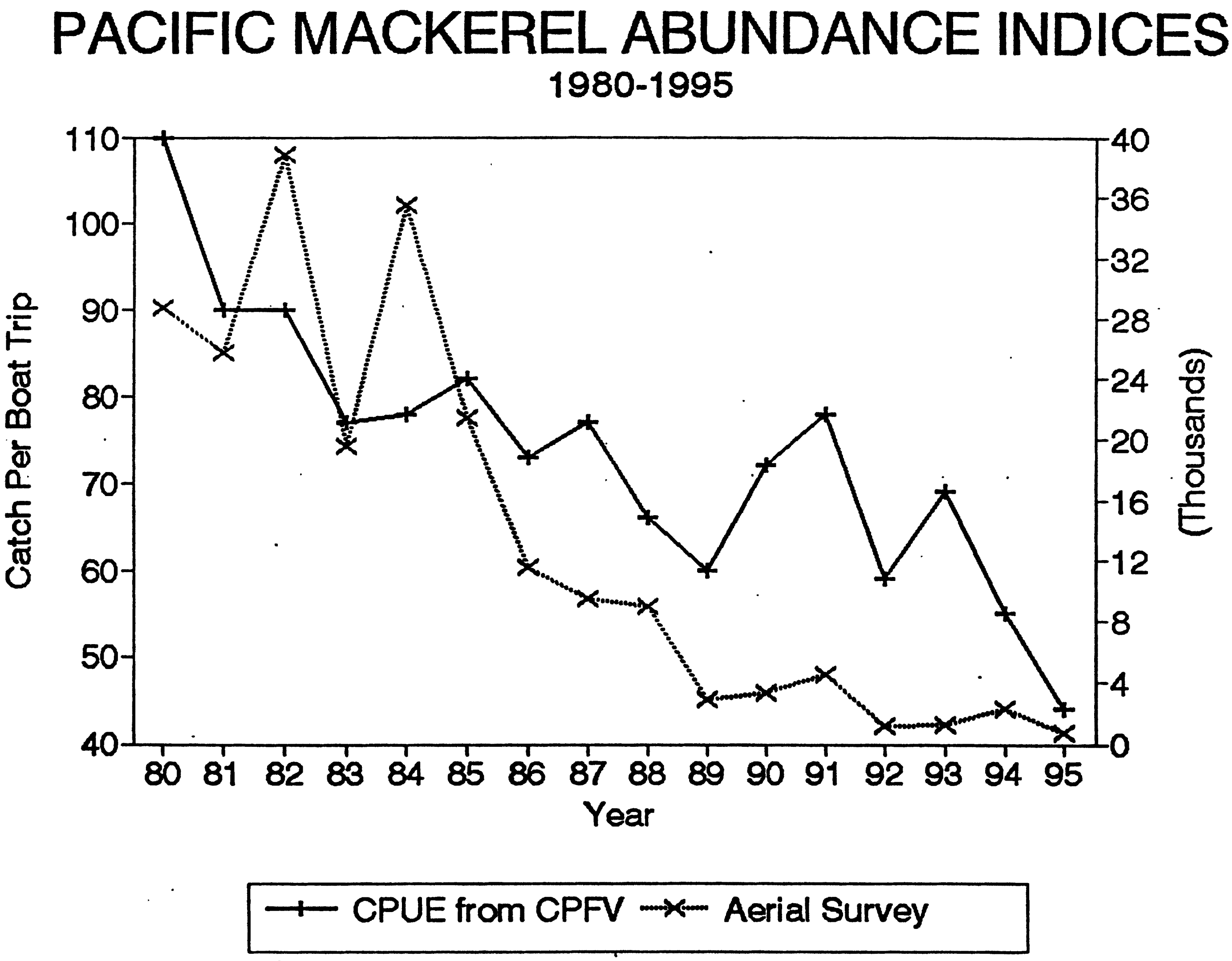

PACIFIC MACKEREL ABUNDANCE INDICES
1980-1995
Catch Per Boat Trip
110
100
90
80
70
60
50
40
40
36
32
28
24
20
16
12
8
4
0
(Thousands)
Relative Abundance
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
Year
CPUE from CPFV
Aerial Survey

Figure 8

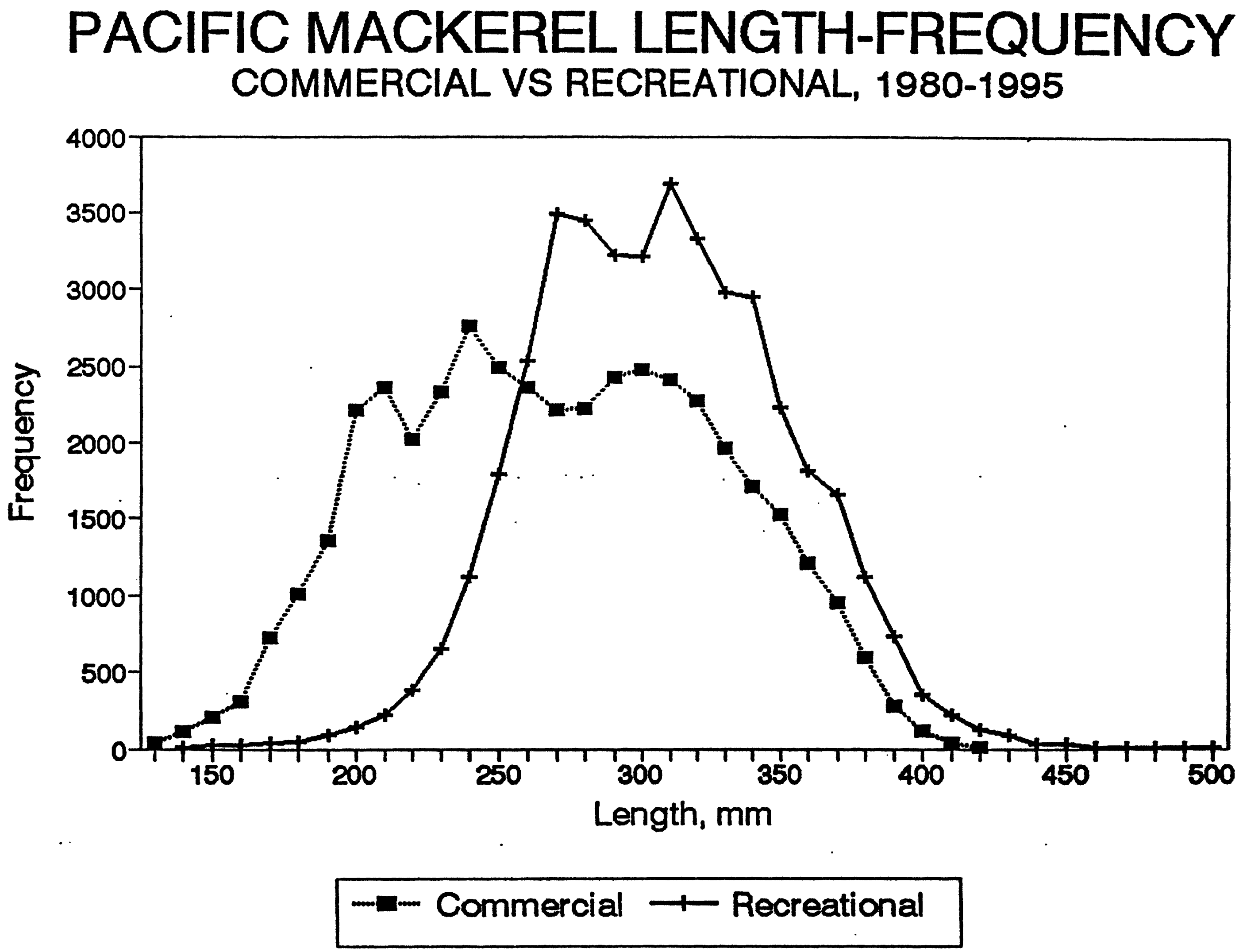

PACIFIC MACKEREL LENGTH-FREQUENCY
COMMERCIAL VS RECREATIONAL, 1980-1995
Frequency
4000
3500
3000
2500
2000
1500
1000
500
0
150
200
250
300
350
400
450
500
Length, mm
Commercial
Recreational

Figure 9

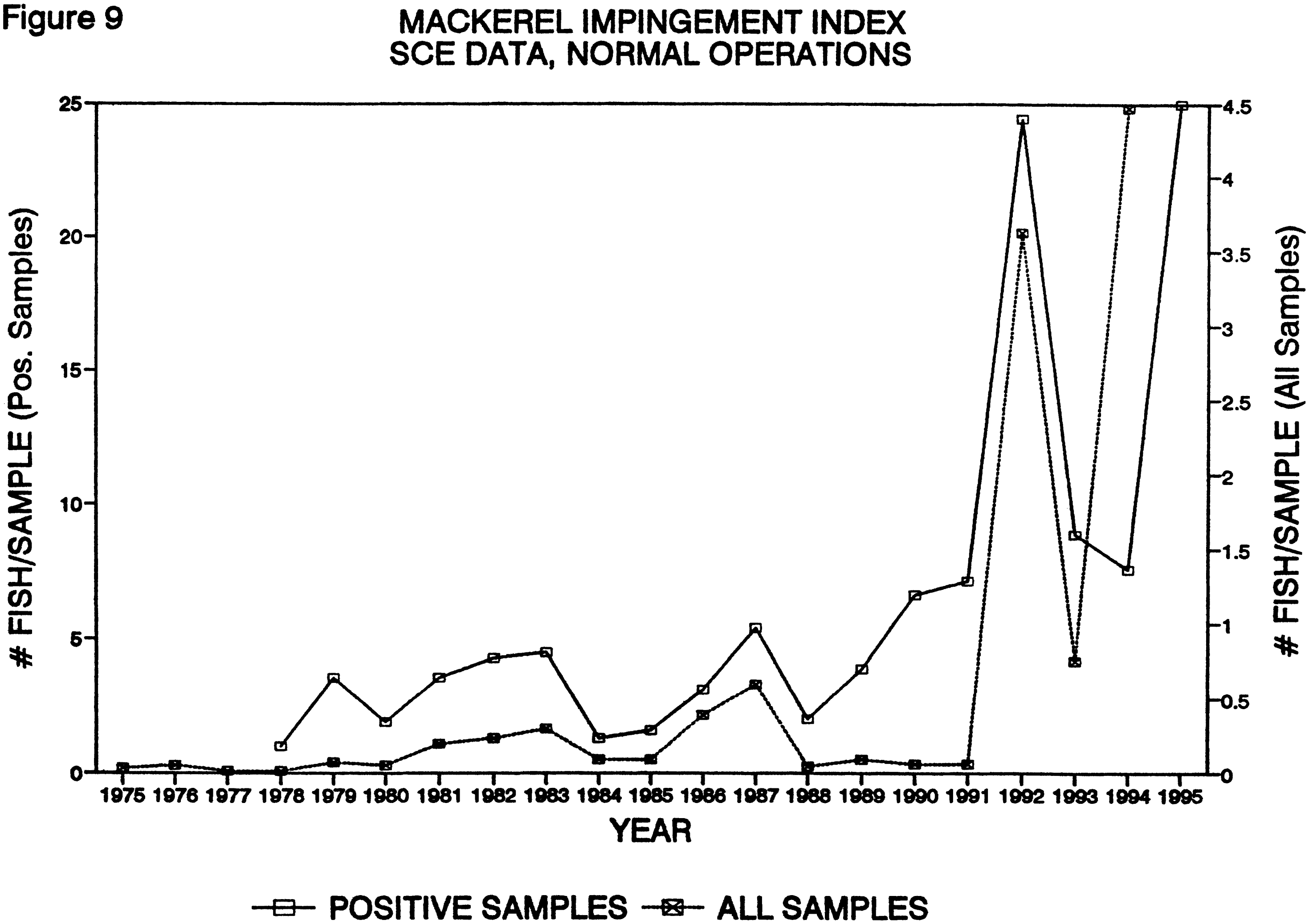

MACKEREL IMPINGEMENT INDEX
SCE DATA, NORMAL OPERATIONS
FISH/SAMPLE (Pos. Samples)
FISH/SAMPLE (All Samples)
25
20
15
10
5
0
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995
YEAR
POSITIVE SAMPLES
ALL SAMPLES

Figure 10

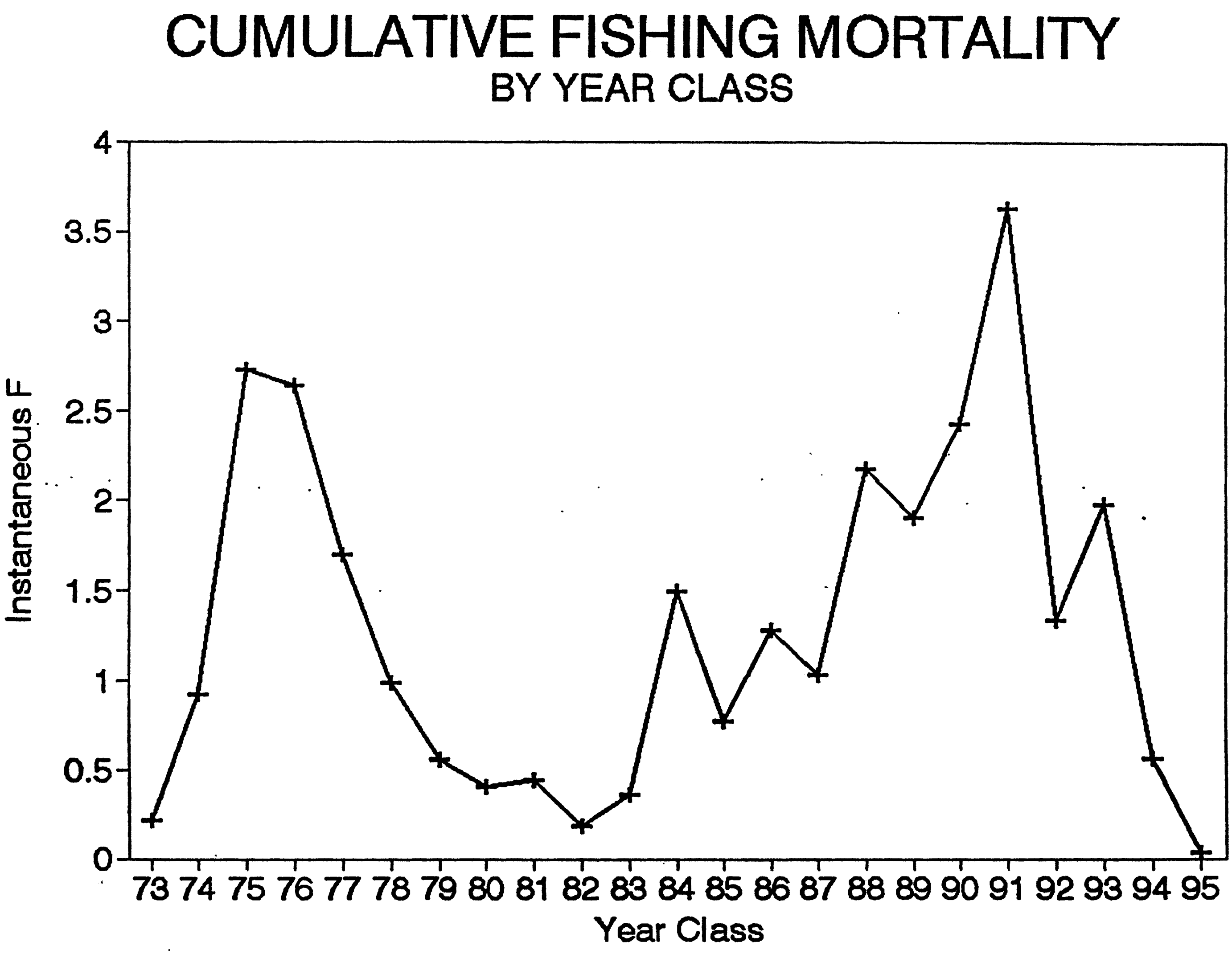

CUMULATIVE FISHING MORTALITY
BY YEAR CLASS
Instantaneous F
4
3.5
3
2.5
2
1.5
1
0.5
0
73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
Year Class

Figure 11

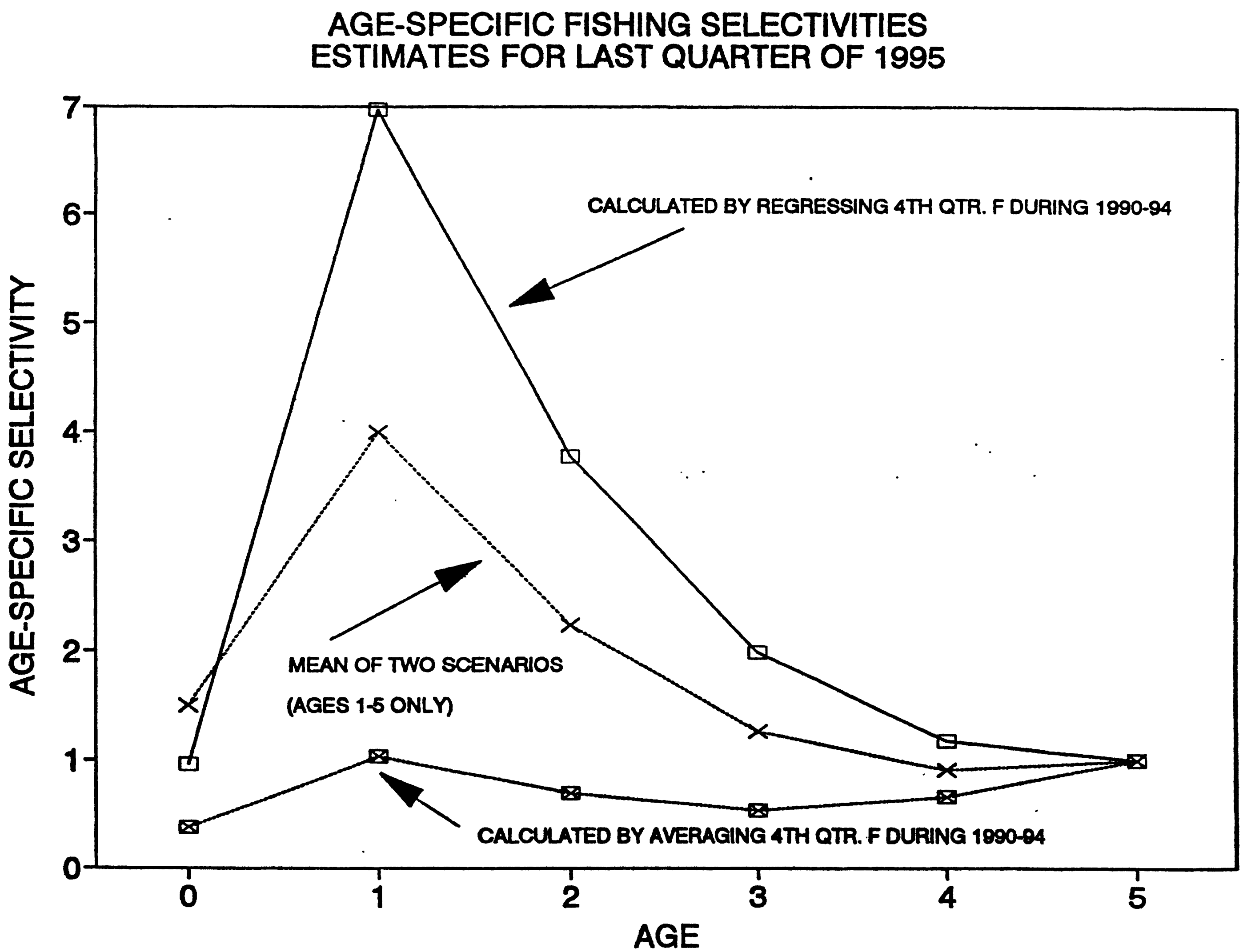

AGE-SPECIFIC FISHING SELECTIVITIES
ESTIMATES FOR LAST QUARTER OF 1995
CALCULATED BY REGRESSING 4TH QTR. F DURING 1990-94
MEAN OF TWO SCENARIOS
(AGES 1-5 ONLY)
CALCULATED BY AVERAGING 4TH QTR. F DURING 1990-94
AGE-SPECIFIC SELECTIVITY
AGE
0
1
2
3
4
5
6
7

Figure 12

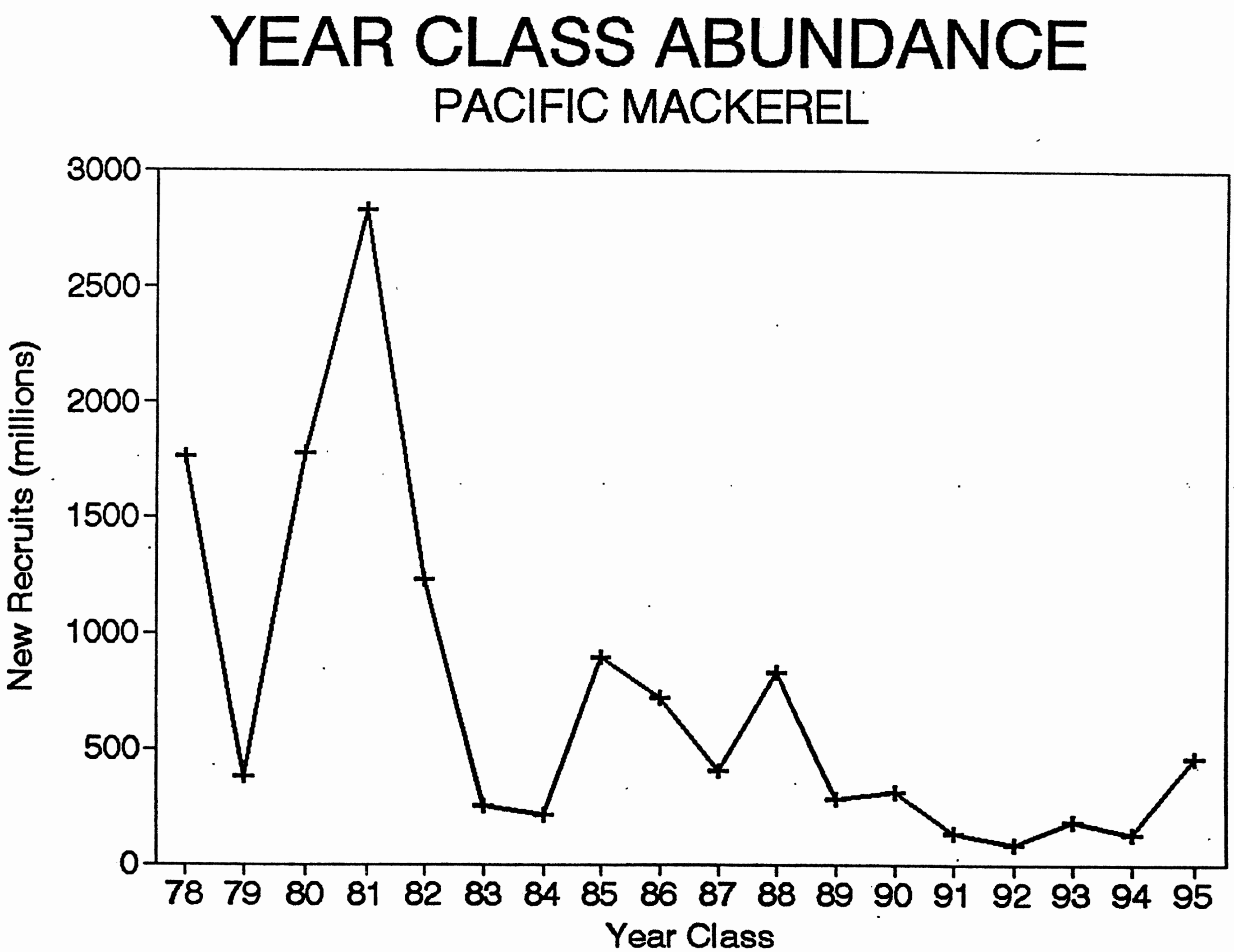

YEAR CLASS ABUNDANCE
PACIFIC MACKEREL
3000
2500
2000
1500
1000
500
0
New Recruits (millions)
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
Year Class

Figure 13

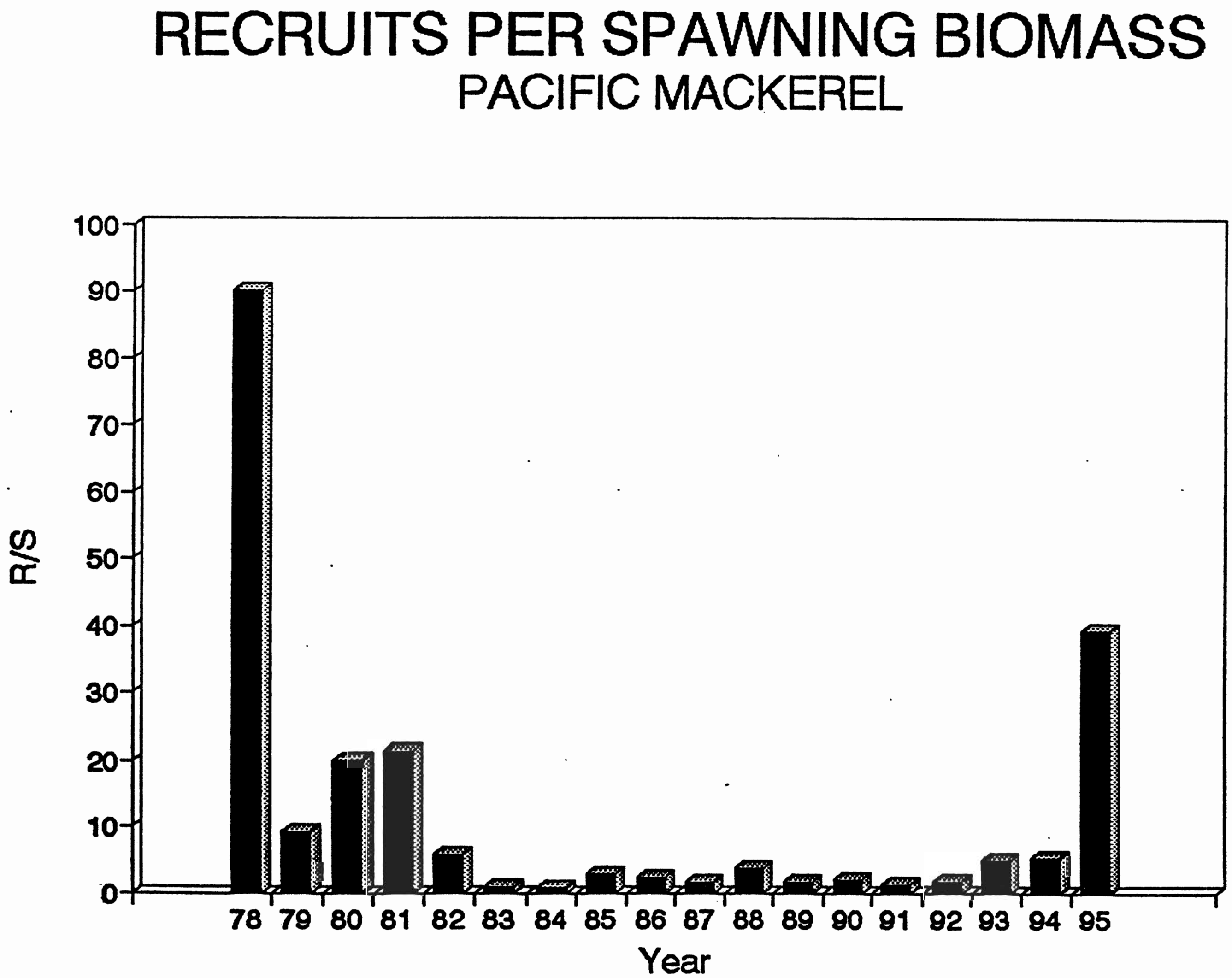

RECRUITS PER SPAWNING BIOMASS
PACIFIC MACKEREL
100
90
80
70
60
50
40
30
20
10
0
R/S
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
Year

Figure 14

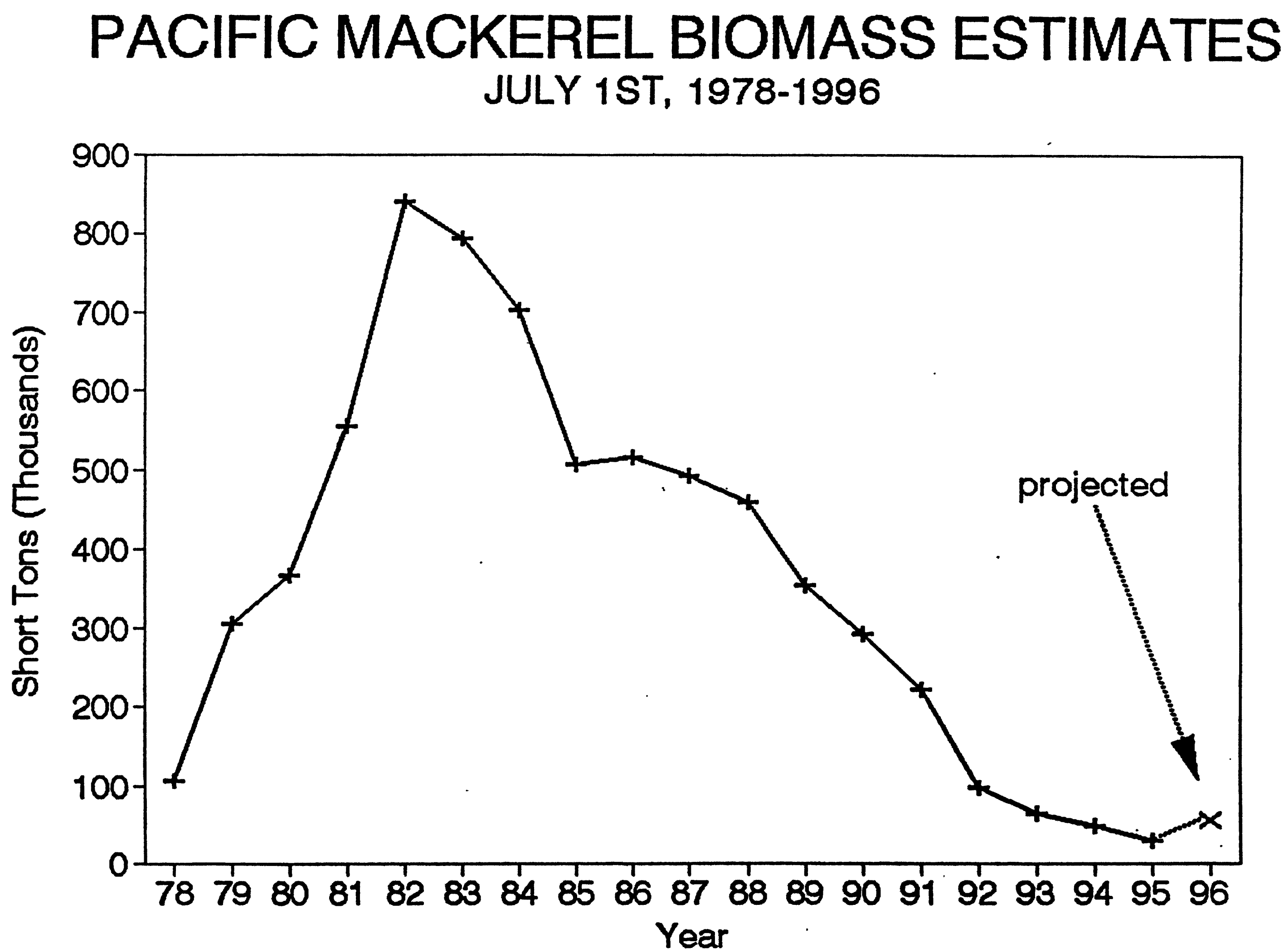
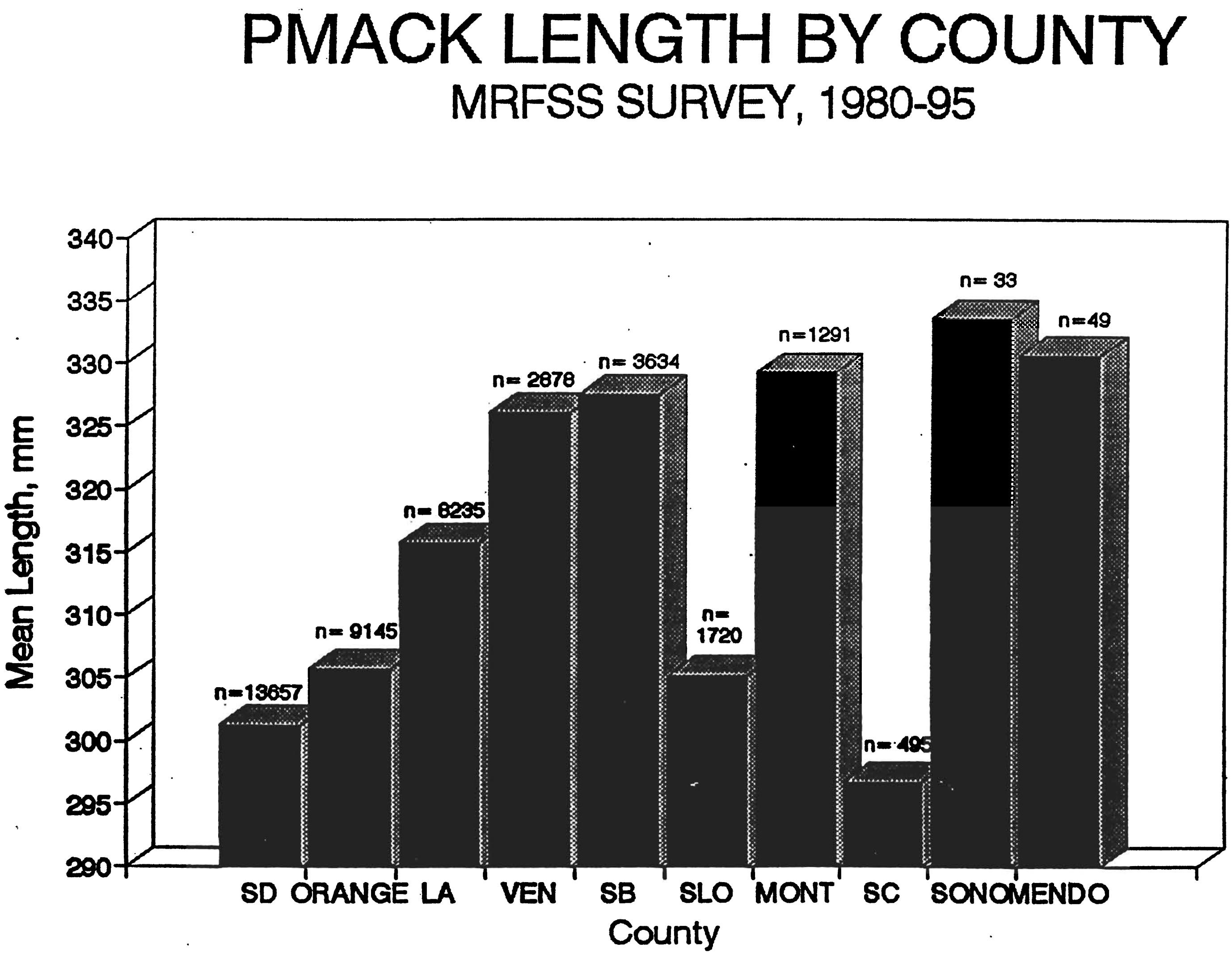

PACIFIC MACKEREL BIOMASS ESTIMATES
JULY 1ST, 1978-1996
Short Tons (Thousands)
0
100
200
300
400
500
600
700
800
900
projected
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96
Year

Figure 15


PMACK LENGTH BY COUNTY
MRFSS SURVEY, 1980-95
Mean Length, mm
340
335
330
325
320
315
310
305
300
295
290
n=13657
n= 9145
n= 8235
n= 2876
n= 3634
n= 1720
n=1291
n= 495
n= 33
n=49
SD
ORANGE
LA
VEN
SB
SLO
MONT
SC
SONO
MENDO
County