Status of the Pacific Mackerel Resource and Fishery in 1998

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Executive Summary

Based on the projected Pacific mackerel biomass estimate of 132,500 tons for July 1, 1998, the commercial fishery quota for the 1998/99 fishing season was recommended and set at 33,700 short tons. The 1998 biomass was estimated using output from a stock assessment computer model called ADEPT and certain assumptions about fishing mortality during the first half of 1998. Several important changes were made to improve our assessment during 1998. The assessment model was changed from a quarterly to an annual one and now covers sixty-nine years of fishery data. New indices of relative abundance were added to the analysis to account for changes in mackerel biomass off central and northern California. The July 1, 1998, biomass estimate is slightly higher than last year's CDFG estimate of 101,000 tons for 1997. This year's results indicate there were more fish in the older year classes than previously estimated.

The Pacific Mackerel Fishery

Background

Pacific mackerel (*Scomber japonicus*) is a trans-boundary stock supporting commercial fisheries in the U.S. and Mexico. Both fisheries have declined in recent years. The principal cause of reduced Pacific mackerel catches has been low biomass and lack of fish on the traditional fishing grounds in southern California waters. Also, cannery closures since 1993 may have reduced demand for Pacific mackerel, possibly leading to lower landings.

During recent years, we suspect the stock has more fully occupied the northernmost portions of its range in response to a warm oceanographic regime in the northeast Pacific Ocean, and Pacific mackerel have been found as far north as British Columbia, Canada (Ware and Hargreaves 1993; Hargreaves and Hungar 1995). During summer months, Pacific mackerel have become frequent bycatch in commercial whiting and salmon fisheries off the Pacific northwest. In addition, they are taken by recreational anglers on commercial passenger fishing vessels.

The 1997 California Fishery

Landings of mackerel in both the U.S. and Mexico increased significantly in the latter half of 1997, countering a mid-1990's trend of reduced catches attributed to low biomass and lack of abundance on the traditional fishing grounds located in waters off southern California and Ensenada. Annual California landings in 1997 totaled 22,243 tons, nearly double the 11,338 tons caught in 1996 (Table 1; Figure 1). The surge in landings is attributable to an increase in effort by the wetfish fleet prompted by the lack of a late fall and winter market squid fishery. In Ensenada, 1997 annual landings totaled 13,753 tons, up from 6,176 tons in 1996.

The Pacific mackerel fishing season is defined as the 12-month period from July 1 through June 30 of the following calendar year. Consequently, quotas and landings are tabulated on a July-June basis. Based on an estimated biomass of 52,000 tons on July 1, 1996, a 9,600 ton quota was set for the 1996/97 fishery, the lowest allocation in two decades.

On March 12, 1997, the season quota was filled and the Pacific mackerel directed fishery was closed for the first time since 1985, although regulations allowed incidental landings of mackerel mixed with those of other wetfish species. Following the closure, bycatch tolerance was limited to 35% mackerel by weight, resulting in approximately 800 tons of incidental mackerel landings between March 12 and the close of the 1996/97 season on June 30, 1997. Landings for the season totaled 10,788 tons, surpassing the 1995/96 season total of 8,394 tons, which ranked lowest since the commercial fishery reopened in 1977.

The 1997/98 fishery opened on July 1, 1997, with a quota allocation of 24,300 tons based on an estimated biomass of 101,000 tons (Figure 2). Landings through the summer months were consistently higher than recent years, followed by monthly totals surpassing the 5,000 ton mark in both October and November (Figure 3). Southern California vessel operators reported generally good availability on the traditional fishing grounds, with many landings occurring at the east end of Catalina Island and waters adjacent the coastline from San Pedro to Newport Beach (Figure 4). Fleet operators reported that SONAR equipment was the most successful method of locating mackerel in 1997. Spotter pilots were less effective in finding fish for the fleet in 1997 than in previous years, as schools had a tendency to aggregate somewhat deeper in the water column and were also less visible due to lower levels of bioluminescence. This may be due, in part, to an increase in the mixed layer depth typically associated with El Niño conditions.

Abnormally warm water temperatures driven by an El Niño condition prompted a decline in market squid availability in southern California waters during the winter of 1997/98. This caused the wetfish fleet to focus increased effort toward Pacific mackerel and Pacific sardine which would normally be directed toward squid. As of April, 1998, 22,243 tons of mackerel had been landed against the quota, and it is anticipated the fishery will catch the remaining portion of the quota prior to the end of the season on June 30 (Figure 2).

Nearly eighty-five percent of California landings during 1997 were made by the southern California wetfish fleet, while the remainder was landed in the Monterey area (Figure 4). Although no directed commercial fishery exists for Pacific mackerel north of Monterey, it is suspected the stock has more fully occupied the northernmost portions of its range during recent years in response to a warm oceanographic regime in the northeast Pacific Ocean, and schools have been found as far north as British Columbia, Canada. Bycatch of Pacific mackerel has been notable in the Oregon and Washington whiting fisheries throughout the 1990's, and there is increasing interest in developing directed mackerel fisheries in those states.

The ex-vessel value of the 1997 Pacific mackerel fishery was approximately $2.99 million paid to fishermen for their catch, at a mean price of $135 per ton. Throughout the year, the price paid ranged from $60 to $150 per ton, but higher quality fish in the fall months generated higher prices. Approximately 4,150 tons were exported (18.6 percent of the statewide total landed in 1997), earning approximately $3.3 million in revenue for California processors involved in the sale of mackerel. Australia ranked highest among export nations, followed by Japan and Uruguay. Mean export price was approximately $800 per ton.

Population Estimates

Assessment Model

We used a modified virtual population analysis (VPA) stock assessment model ('ADEPT', Jacobson 1993), based on Gavaris' (1988) procedure, to estimate biomass of Pacific mackerel that employs both fishery-dependent and -independent data to estimate abundance. Biomass estimates are adjusted or "tuned" by the model to match the fishery-independent indices of relative abundance. ADEPT has been used by CDFG to assess Pacific mackerel during the past four years (Jacobson et. al. 1994, Barnes and Hanan 1995, Barnes et. al. 1997, Yaremko et al. 1998). A conventional VPA back-calculates age-structured biomass estimates utilizing catch-at-age data, weight-at-age data, natural mortality estimates, and fishing mortality estimates for the most recent year (terminal F). ADEPT improves upon a conventional VPA by choosing terminal F and other parameters to obtain the best statistical fit (lowest log-scale sums of squares) between VPA output and survey indices of relative abundance, including spotter pilot sightings, CalCOFI larval data from southern California, recreational fishery catch-per-unit-effort, power plant impingement rates, and triennial trawl survey data. The crux of the estimate lies in the model's ability to estimate terminal age-specific fishing mortality rates based upon the survey indices, essentially using them to adjust the conventional VPA output.

We used the ADEPT model to calculate biomass estimates through the end of 1997 (calendar year), and then projected an estimate of biomass for July 1, 1998, based upon: 1) number of Pacific mackerel estimated to comprise each year class at the end of 1997; 2) assumptions for natural (M=0.5) and fishing mortality through the first half of 1998; and 3) estimates of age-specific growth.

Key Changes to the 1997 Assessment

Several important changes were made to improve our assessment during 1998. Last year, the span of years was extended back in time to incorporate all available data (Prager and MacCall, 1988) so that abundance estimates made by ADEPT covered the fishery back to 1929. An additional year of fishery-dependent and fishery data was added to the following analysis, which now covers a span of sixty-nine years from 1929 to 1997. Most significantly, we pooled quarterly landings and catch-at-age data into annual time increments to smooth problems with inter-quarter variation in age composition and fishing mortality estimates.

Substantial changes and additions were made to some indices of abundance. Historical commercial passenger fishing vessel (CPFV) data recently recovered into digital format were used to recalculate a recreational catch rate index for southern California, and allowed us to extend the survey time series back to 1936. In addition, we created a northern California CPFV index (1957 to 1997), based on the same database, to account for changes in mackerel biomass north of Pt. Conception. We added an index based on southern California power plant impingement data to measure changes in recruitment since the mid-1980s. We also added an index based on mackerel coincidentally caught during triennial NMFS hake trawl surveys off central and northern California.

As in past assessments, component likelihoods for each survey were weighted equally to a value of 1.0. ADEPT also has the ability to weight influence of annual survey observations using the coefficient of variation (CV), although this feature has not been used in past assessments. This year, we calculated CVs for each survey and re-scaled the CVs to the median value. Re-scaling CVs of each survey to a value of 1.0 had the effect of maintaining equal weighting among surveys while down-weighting annual observations within surveys in poorly-sampled or highly-variable years.

Input Data

Catch

Due to inconsistencies in fishing mortality patterns when catch data were stratified by quarterly increments, 1998 catch-at-age data was tabulated on an annual basis. Prager and MacCall (1988) compiled landings data for years 1929 to 1977, which we combined with CDFG landings information for years 1978 through 1997. Most data prior to 1978 were taken from Prager and MacCall (1988), although those data were supplemented with official landings data from historical CDFG sources.

As no age composition or weight-at-age data were available for periods of very low catch during 1969-1974, we substituted mean values from preceding years. The ADEPT algorithm adjusts catch in numbers of fish proportionally by age so the sum (numbers x weight) for all ages equals total tons landed. Tons landed from all fishery segments since 1978 were included (*e.g.*, California recreational; Ensenada commercial; northern California commercial; and southern California commercial). Mexican landings prior to 1984 were unknown, but thought to be minor and not included in our analysis. Also, recreational catches prior to 1978 were not included in our analysis. Although Pacific mackerel is known to be a large component of whiting bycatch in the Pacific northwest, recorded landings are very small (annual totals of less than 500 tons). However, there is increasing interest in developing fisheries for Pacific mackerel in both Oregon and Washington.

Random stratified port sampling was conducted by CDFG during nearly all years in the time series, with the exception of those noted above. For most years, including 1997, age composition of the catch in Monterey and Ensenada was assumed to reflect that of southern California, since insufficient or no age composition data was available from those areas.

In 1997, Pacific mackerel mean weight-at-age (Table 2, Figure 5) when tabulated on an annual basis did not change significantly from previous years. Age composition of the catch (Figure 6), however, was significantly older than recent years since 1993. Over 40 percent of fish sampled (by number) were age three or older, compared with approximately 12 percent in 1996. Tabulating catch and weight-at-age data by year rather than by quarter had the effect of reducing inconsistencies resulting from small sample-size that may have been present in some quarters when landings were low, particularly in the older age classes where the number of fish sampled may be extremely low in some years.

Aerial Spotter Observations

Pilots employed by the wetfish fleet to locate Pacific mackerel schools report data for each flight on standardized logbooks and provide them under contract to National Marine Fisheries Service (NMFS), Department of Commerce. Raw logbook data were compiled and analyzed based on a delta log-normal model (Lo et. al, 1992) to produce an annual (calendar year) spotter index of relative abundance for 1963 to 1997 (Figure 7). Initial examination of modeled index values revealed unreasonable fit between observed and predicted values over the period of rapid biomass increase in the late 1970's. This led us to believe that the selectivity pattern previously chosen for this index, assumed identical to that of the fishery, was inappropriate. We altered the selectivity pattern such that all age groups were fully selected based on the assumption that spotter pilots will record all fish schools sighted (including age 0 fish), not only those reported to the wetfish fleet. This change improved overall fit to the data. An exponent of 0.93 gave the best fit to the spotter data.

CalCOFI (Southern California) Larvae Index

California Cooperative Oceanic Fisheries Investigations (CalCOFI) research program was founded in the early 1950's to study the California Current and 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.

CalCOFI conducted quarterly plankton surveys in the Southern California Bight using both bongo (CALBOBL) and CALVET plankton nets; bongo nets captured Pacific mackerel larvae which were used in our assessment. We assumed a nonlinear relationship between proportion positive (larvae caught) bongo tows and size of adult spawning stock. The modeled relationship used numbers-at-age and maturity ogives given in Dickerson et al. (1992) to estimate larval abundance (in terms of proportion positive). We compiled CalCOFI data for years from 1951 to 1997, and calculated an annual index of proportion positive net tows for the Southern California Bight (Figure 8). Data from all years were used, but December or January data were excluded as there were no positive tows in those months. The data grid included standard CalCOFI lines 66 to 110. Last year the index excluded data beyond standard station 80 and included an inshore/offshore stratification, but this year we modeled station directly and the grid was extended out to standard station 115. Standard stations were binned by 5 inside of station 60 and then by 10 outside of station 60. The generalized additive model (GAM) for proportion positive was fit by logistic regression to year, month, standard line, and standard station, and was significant in all terms. An exponent of 0.41 gave the best fit to the CalCOFI data.

Sport Fish Catch-Per-Unit-Effort

Fish and Game Code has required Commercial Passenger Fishing Vessel (CPFV) skippers to provide records of catch and effort data to CDFG since 1936. Pacific mackerel is consistently among the top five species reported on CPFV logs both in southern California and statewide. Last year, a crude index of adult mackerel abundance was generated using aggregate values of southern California mackerel catch divided by number of anglers for all southern California CPFV trips based on annual summary reports from 1957 to 1996.

This year, we utilized a new database containing historical CPFV logbook records summarized by month and Fish and Game block areas (10 nautical mile squares) spanning a 62-year period. Two indices of abundance were developed from this database to better estimate mackerel abundance both inside and beyond the range of the commercial fishery. A southern California CPFV index was generated using records from south of Pt. Arguello to the Mexican border (block numbers 651-899). Blocks within this range were stratified into three latitudinal groups ('bigblock' areas for 600, 700, and 800 block series) representing catch areas west of Santa Barbara, Los Angeles, and San Diego. Raw catch-per-unit-effort (CPUE) was calculated as number of mackerel per 1,000 angler-hours. A generalized-additive model (GAM) was used to standardize the natural logarithms of CPUE for year, month, and area effects.

Pacific mackerel are found north of Pt. Arguello during warm ocean periods. This is reflected in commercial and sport catch statistics (Figure 9). This year, we developed an additional CPFV index for northern California mackerel using newly available logbook data for 1957 to 1997. The index included selected regions north of Pt. Arguello (block numbers<651), with areas stratified into 'bigblock' strata of 200, 300, 500, and 600 series latitudinal groups. The 100 and 400 series strata had low catch rates across the entire time series and were excluded from the analysis.

A comparison of commercial and recreational length composition data suggests that CPFV catch is mostly composed of fish older than those caught in the commercial fishery. We used length data from the RecFIN database to estimate selectivity patterns for southern and northern California CPFV fisheries. For the southern California fishery, age 1 fish were 70% selected and ages 2+ were fully selected, thus the southern CPUE index was primarily used to tune the data for age 2+ fish. Northern California CPFV's catch older mackerel, with age 2 fish assumed 59% selected and age 3+ fish fully selected, so the index primarily tunes for age 3+ fish. Northern and southern selectivity patterns were applied to their respective fisheries through the entire time series.

The southern California CPUE time series demonstrates a low and gradually declining trend in relative abundance from 1936 to 1976, with a dramatic increase from 1977 to 1980. Relative abundance steadily declined from 1981 to 1997, which is consistent with other information (Figure 10). The model output closely fits the southern CPFV data, although the relationship is non-linear, suggesting saturation. An index exponent of 0.40 gave the best fit because changes in biomass were greater than changes in CPUE.

The northern California CPUE time series showed very low abundance from 1957 to 1978, with a strong increase between 1978 and 1981, a second and higher peak in 1984, and a drop in abundance from 1984 to 1989 (Figure 11). Increases in relative abundance occurred during El Niño events of 1959, 1984, 1992, and 1997. The model output closely fits the data, but the relationship was non-linear in nature since catch rates increased more rapidly than biomass. An exponent of 0.62 gave the best fit to the northern California data.

Power Plant Impingement Data

We used Southern California Edison (SCE) impingement data as an 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 of the entrained fish are new recruits. Catch rates derived from these data have shown a slight downward trend between 1986 and 1995 (Figure 12). We were unable to update this index to include the past two years, but plan to do so in future assessments. Future improvements to this index will include GAM analyses to account for possible season and station (location) effects.

Triennial Trawl Survey

Since 1977, the Resource Assessment and Conservation Engineering (RACE) Division at the Alaska Fisheries Science Center has conducted bottom trawl surveys of west coast groundfish resources on a triennial basis. Although Pacific mackerel are not a target species in this survey design, bycatch has been significant since 1989, particularly in areas of the Pacific northwest. Survey area in 1989, 1992, and 1995 was defined by a northern boundary of 49°40' N (Vancouver Island, Canada) and a southern boundary of 34°30' N (Point Conception, CA). Data available from this survey prior to 1989 were not fitted to the model due to very low numbers of incidental mackerel taken (Figure 13).

The survey is composed of trawls conducted at three depth ranges; the shallowest being 55-183 m. Relative abundance estimates for Pacific mackerel were used only in the shallowest depth strata, as nearly all mackerel collected were from tows in that strata. Over the entire survey area, Pacific mackerel ranked sixth in catch per unit effort in the shallow depth strata. Highest densities were found in the Columbia River area and waters off Eureka.

The triennial survey selectivity pattern was determined from length composition data collected from the three surveys used in this analysis. Although data were sparse, fish appeared to be fully selected at age one, with length ranging between 230 and 430 mm, and a mean length of 333 mm.

Relative abundance estimates provided by the triennial survey may survey a portion of the mackerel population that is not encountered in other indices, as these fish were collected largely in waters north of the range of the southern California and Monterey fisheries, and were captured using bottom trawl gear rather than purse seine. These fish also would not be vulnerable to detection by spotter pilots.

Terminal Fishing Mortality

Accuracy of ADEPT biomass estimates is contingent upon the model's ability to estimate fishing mortality upon each age group during the final year ('terminal F'). Input data are typically insufficient to allow the model algorithm to directly estimate selectivities in the terminal year, because abundance indices are not age specific (Figure 14). In past assessments, terminal F has been estimated by averaging fishing selectivities over the previous five to six years. This was problematic in 1997 due to the notable shift in fishery age composition to older year classes, presumably from availability of larger fish and prevalent El Niño conditions in the Southern California Bight. As an alternative method, we estimated terminal selectivities by calculating mean values for years having similar proportional catch at age (1929, 1938, 1953, 1983, 1987, 1990, 1991, and 1993; Figure 6) and years having strong El Niño conditions (1958, 1959, 1983, 1984). An average of the two patterns was calculated and applied as fixed values in the model for the final year (Figure 15). We ran the model through a number of iterations until it converged. The chosen selectivity pattern shows fishing pressure being exerted on the oldest age groups (4 and older).

Recruitment

It is difficult for ADEPT to estimate year class abundance in the most recent years since those year classes have yet to undergo significant fishing mortality. Estimation of 1997 year class strength was especially problematic due to the shift in 1997 fishery selectivity to older year classes. Output from the final model run showed an unreasonably low recruitment estimate for 1997 of 69 million fish, a value well below any recent or historical value (Figures 16 and 17).

To derive an estimate of 1997 year class abundance, we chose six different methods to provide more realistic range of recruitment values based on our knowledge of recent and historical spawning biomass. These values were used to calculate an average recruitment for the six methods. Recruitment estimates included: 1) long-term (1929-1996) median of 396 million fish; 2) long-term mean of 690 million; 3) recent (1989-1996) mean of 556 million; 4) averaged ratio of age 0 to age 1 abundance (recent years) applied to 1997 age 1 abundance giving a value of 501 million; 5) 1996 recruitment estimate of 530 million; and 6) predicted recruitment of 758 million based on a stock-recruitment function. Using these six estimates, we calculated a mean recruitment of 572 million fish. This value was applied in our projection of the 1998 biomass.

Current and Projected Biomass

We estimate the July 1, 1997, Pacific mackerel biomass to have been 139,000 tons (Table 3, Figure 18). This estimate is higher than last year's CDFG projection of 101,000 tons for 1997, probably because initial projections for abundance of the 1994 and older year classes were too low. The most notable change for the historical biomass time series was the dramatic reduction in biomass estimates for the 1980 to 1984 period which were probably unreasonably high in the 1997 assessment (Table 3, Figure 18). The 1982 peak biomass decreased from 2.2 million (Yaremko et al. 1998) to 1.3 million short tons in the current assessment. Historical biomass estimates changed as a result of changing the VPA from quarterly to annual time steps. The remainder of the time series, prior to 1980 and post-1985, corresponds well with the 1997 estimate (Figure 18).

Our current 1982 peak biomass estimate of 1.3 million short tons is still relatively high compared to MacCall et al.'s (1985) estimate of 510,000 short tons. Biomass estimates for the late 1970's and early 1980's will always be imprecise due to the inability of the VPA algorithm to accurately estimate biomass during periods of low cumulative fishing mortality (the total fishing mortality incurred by each year class throughout the time series; Figure 14). However, the current estimate is likely an improvement over that of MacCall et al. (1985) due to more complete data for that period. The current estimates agree well with information on relative abundance available from our fishery-independent indices.

Our biomass estimate for 1997 and projection for July 1, 1998, was dependent upon estimates of age-specific fishing mortalities (terminal F) during 1997 and assumed fishing mortalities for the first half of 1998 (Table 4). We assumed that age-specific fishing mortality during 1997 was equal to average values for years having similar age composition or environmental conditions (see *Terminal Fishing Mortality* section) and that instantaneous natural mortality (0.5) remained unchanged. Given the numbers of fish in each year class at the beginning of 1997, we used our 1997 mortality assumptions to calculate number of fish alive at the end of 1997. We then applied assumed fishing mortality for the first half of 1998 to calculate number of fish (age 1+) remaining on July 1, 1998. Mean weight-at-age data for 1992-1997 were used to convert numbers of fish to biomass for each age and were summed over ages to get total biomass. Fishing mortality for the first half of 1998 (11,285 tons) was estimated by summing Ensenada landings for the first half of 1997 (4,662 tons), US Commercial quota remaining as of January 1, 1998 (6,123 tons), and US Recreational catch (500 tons). Using Baranov's catch equation to calculate age-specific mortality and catch, and we adjusted total F for the first half of 1998 until total catch matched the assumed value of 11,285 tons. Based on this, we project the total biomass of Pacific mackerel will be 132,500 tons at the beginning of the 1998/99 fishing season, July 1, 1998 (Table 4).

1998/99 Season Quota

Commercial landings of Pacific mackerel in California are quota-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. If total biomass is less than 20,000 tons no directed landings are allowed, and if total biomass is greater than 150,000 tons no limitation on total catch is imposed. Because the 1997/98 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 132,500 tons for July 1, 1998, the commercial fishery quota for the 1998/99 fishing season was recommended and set at 33,700 short tons. This is thirty-nine percent higher than last season's quota of 24,300 tons; however, the 1997/98 quota is low compared to the magnitude of the fishery during the 12-year period of 1980-1991.

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Literature Cited

Barnes, J.T. and D.H. Hanan. 1995. Status of the Pacific mackerel resource and fishery, 1994 and 1995. California Department of Fish and Game, Mar. Res. Div. Admin. Rpt. 95-4. 20p.

Barnes, J.T., M. Yaremko and T. Bishop. 1997. Status of the Pacific mackerel resource during 1996 and management recommendations for the fishery. California Department of Fish and Game, Mar. Res. Div. Admin. Rpt. 97-2. 24p.

Dickerson, T.L., B.J. Macewicz and J.R. Hunter. 1992. Spawning frequency and batch fecundity of chub mackerel, *Scomber japonicus*, during 1995. Calif. Coop. Oceanic Fish. Invest. Rep. 33:130-140.

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

Hargreaves, N.B. and R.M. Hungar. 1995. Robertson creek chinook assessment and forecast for 1994 and 1995. Part B: early marine mortality. PSARC Report S95-03. 55 p.

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.

Lo, N.C.H., L.J. Jacobson and J. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

MacCall, A.D., R.A. Klingbeil, and R.D. Methot. 1985. Recent increased abundance and potential productivity of Pacific mackerel (*Scomber japonicus*). Calif. Coop. Oceanic Fish. Invest. Rep. 26:119-129.

Prager, M.H. and A.D. MacCall. 1988. Revised estimates of historical spawning biomass of the Pacific mackerel, *Scomber japonicus*. Calif. Coop. Oceanic Fish. Invest. Rep. 29:91-101.

Ware, D.M. and N.B. Hargreaves. 1993. Occurrence of Pacific (chub) mackerel off the B.C. coast in 1993. PICES Press 2(1):12-13.

Yaremko, M, J. T. Barnes, and L. D. Jacobson. 1998. Status of the Pacific mackerel resource during 1997 and management recommendations for the fishery. California Department of Fish and Game, Marine Region Admin. Rpt. 98-3. 25 p.

Table 1. Pacific mackerel commercial landings (short tons), 1929-1997.

YEAR	CALIFORNIA	ENSENADA	TOTAL	YEAR	CALIFORNIA	ENSENADA	TOTAL
1929	28979	0	28979	1964	21442	0	21442
1930	8264	0	8264	1965	11973	0	11973
1931	7126	0	7126	1966	2315	0	2315
1932	6235	0	6235	1967	583	0	583
1933	34798	0	34798	1968	1567	0	1567
1934	56908	0	56908	1969	1179	0	1179
1935	73194	0	73194	1970	311	0	311
1936	50258	0	50258	1971	78	0	78
1937	30460	0	30460	1972	54	0	54
1938	39913	0	39913	1973	28	0	28
1939	40443	0	40443	1974	67	0	67
1940	60235	0	60235	1975	144	0	144
1941	39073	0	39073	1976	328	0	328
1942	26269	0	26269	1977	10163	0	10163
1943	37597	0	37597	1978	23722	0	23722
1944	41818	0	41818	1979	39488	0	39488
1945	26851	0	26851	1980	42095	0	42095
1946	26931	0	26931	1981	46793	0	46793
1947	23232	0	23232	1982	38602	0	38602
1948	19687	0	19687	1983	39081	149	39230
1949	24879	0	24879	1984	50234	141	50375
1950	16321	0	16321	1985	44659	2845	47504
1951	16733	0	16733	1986	51320	5381	56701
1952	11264	0	11264	1987	45429	2294	47723
1953	2073	0	2073	1988	48492	5382	53874
1954	13760	0	13760	1989	42590	14752	57342
1955	18444	0	18444	1990	43927	39415	83342
1956	35602	0	35602	1991	35453	19230	54683
1957	27594	0	27594	1992	21714	26828	48542
1958	10885	0	10885	1993	13977	8531	22508
1959	16377	0	16377	1994	11070	14678	25748
1960	19817	0	19817	1995	9554	5313	14867
1961	21514	0	21514	1996	11339	6175	17514
1962	21949	0	21949	1997	22117	13753	35870
1963	25343	0	25343				

Table 2. Pacific mackerel mean weight-at-age, 1929-1997 (1929-1977 data based on Prager and MacCall, 1988).

YEAR	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5+
1929	0.1981	0.3680	0.6550	0.8870	1.1520	1.3550
1930	0.1981	0.3060	0.6640	0.9310	1.1270	1.3300
1931	0.1981	0.2520	0.6090	0.8800	1.1610	1.3370
1932	0.1981	0.1780	0.6110	0.8360	1.1210	1.3320
1933	0.1981	0.1820	0.4420	0.6600	1.0870	1.2890
1934	0.1981	0.3130	0.4360	0.5130	0.9500	1.1860
1935	0.1981	0.4090	0.4790	0.5530	0.8360	1.0410
1936	0.1981	0.4250	0.6260	0.7450	0.8670	0.9980
1937	0.1981	0.3890	0.7000	0.9450	1.0160	1.1070
1938	0.1981	0.3830	0.6830	0.9880	1.1720	1.2840
1939	0.1981	0.3710	0.6950	0.9860	1.2060	1.3890
1940	0.1981	0.4290	0.5750	0.7950	0.9840	1.2800
1941	0.1981	0.4820	0.6850	0.8830	1.1130	1.3220
1942	0.1981	0.3810	0.7030	0.9000	1.1430	1.4650
1943	0.1981	0.4790	0.6170	0.9440	1.1320	1.3840
1944	0.1981	0.4610	0.7390	0.9030	1.1820	1.4220
1945	0.1981	0.3690	0.7280	0.9650	1.1810	1.4400
1946	0.1981	0.4110	0.6540	0.9660	1.2040	1.4230
1947	0.1981	0.5100	0.7960	1.0480	1.2110	1.4500
1948	0.1981	0.3510	0.7410	1.0600	1.2750	1.4840
1949	0.1981	0.3270	0.5770	0.8640	1.2620	1.4800
1950	0.1981	0.4620	0.5640	0.8040	1.0590	1.4370
1951	0.1981	0.3530	0.6920	0.8460	1.0510	1.3110
1952	0.1981	0.6110	0.7850	1.0580	1.2130	1.4420
1953	0.1981	0.4380	0.7900	0.9590	1.2190	1.4710
1954	0.1981	0.3420	0.7400	1.0750	1.2270	1.4840
1955	0.1981	0.3500	0.5560	0.8890	1.1590	1.4970
1956	0.1981	0.3980	0.6520	0.8990	1.0920	1.4030
1957	0.1981	0.4530	0.6620	0.9310	1.1340	1.3420
1958	0.1981	0.4130	0.6970	0.8440	1.0930	1.2940
1959	0.1981	0.4140	0.7350	0.9680	1.1360	1.4090
1960	0.1981	0.3640	0.6900	1.0440	1.2850	1.5210
1961	0.1981	0.3890	0.6680	1.0170	1.2360	1.4550
1962	0.1981	0.5080	0.7510	1.0390	1.2360	1.4800
1963	0.1981	0.6420	0.8730	1.0930	1.2910	1.5600
1964	0.1981	0.5760	0.8270	1.1190	1.3120	1.6160
1965	0.1981	0.4020	0.7450	1.0080	1.2540	1.2890
1966	0.1981	0.3710	0.7170	1.0700	1.2920	1.7150
1967	0.1981	0.4130	0.6050	1.0040	1.2660	1.5830
1968	0.1981	0.4270	0.7120	1.0510	1.2400	1.5240
1969	0.1981	0.5570	0.8010	1.0440	1.3710	1.6140
1970	0.1981	0.4011	0.7423	1.2505	1.2500	1.5240
1971	0.1981	0.4011	0.7423	1.2505	1.4243	1.7648
1972	0.1981	0.4011	0.7423	1.2505	1.4243	1.7648
1973	0.1981	0.4011	0.7423	1.2505	1.4243	1.7648
1974	0.1981	0.4011	0.7423	1.2505	1.4243	1.7648
1975	0.1981	0.4650	0.7423	1.2505	1.4243	1.7648
1976	0.1981	0.4650	0.7410	1.2505	1.4243	1.7648
1977	0.1981	0.4150	0.9400	1.8400	1.4243	1.7648
1978	0.2333	0.4850	0.8950	1.3282	1.5602	1.5257
1979	0.1981	0.3225	0.9125	1.2150	1.7400	2.0846
1980	0.2383	0.4175	0.7700	1.0300	1.4000	2.0237
1981	0.2533	0.3800	0.6825	0.9800	1.0300	1.5669
1982	0.2033	0.3307	0.6100	0.8625	1.6300	1.3899
1983	0.1733	0.3400	0.5875	0.7750	0.9425	1.0935
1984	0.1933	0.4387	0.6225	0.7900	1.0050	1.2406
1985	0.1981	0.4457	0.6910	0.9000	0.9825	1.3395
1986	0.2733	0.4582	0.7850	1.0150	1.1125	1.2078
1987	0.2433	0.4950	0.7725	0.9975	1.2225	1.4650
1988	0.1983	0.4900	0.8000	1.1000	1.3325	1.6149
1989	0.2083	0.3225	0.6650	1.0177	1.4355	1.6948
1990	0.1700	0.4850	0.6900	1.0475	1.3000	1.6067
1991	0.1583	0.4175	0.7850	0.9700	1.2350	1.6259
1992	0.1933	0.4075	0.5050	0.9175	1.0825	1.4141
1993	0.1833	0.3383	0.5397	0.8598	1.1948	1.4172
1994	0.2133	0.2998	0.5421	0.8838	1.1095	1.4609
1995	0.2100	0.3086	0.4445	0.7644	0.9735	1.4304
1996	0.2476	0.2698	0.5349	0.8931	1.1674	1.3445
1997	0.3406	0.3468	0.5553	0.8760	1.1437	1.4710

Table 3. Estimates of Pacific mackerel Age 1+ biomass (short tons) and recruitment (Age 0, 1x10^6) estimated using the ADEPT model.

YEAR	Age 1+ Biomass (Short tons)	Recruits (millions)	YEAR	Age 1+ Biomass (Short tons)	Recruits (millions)
1929	171,888	1,022	1964	29,988	12
1930	246,171	1,397	1965	5,220	12
1931	327,557	1,565	1966	2,873	7
1932	404,375	1,113	1967	2,274	7
1933	388,825	378	1968	1,785	4
1934	321,815	164	1969	930	2
1935	213,990	185	1970	498	3
1936	142,027	397	1971	661	5
1937	127,095	319	1972	1,169	9
1938	116,543	548	1973	2,249	18
1939	128,936	360	1974	4,356	45
1940	100,278	308	1975	10,553	28
1941	94,703	631	1976	13,503	640
1942	125,070	230	1977	90,179	419
1943	115,563	205	1978	156,247	3,894
1944	91,483	211	1979	498,429	548
1945	70,316	65	1980	654,641	2,444
1946	44,121	53	1981	753,699	6,142
1947	21,938	535	1982	1,295,342	1,290
1948	58,213	285	1983	1,155,112	575
1949	61,531	32	1984	994,118	833
1950	43,372	13	1985	850,560	1,145
1951	22,751	8	1986	762,003	892
1952	7,983	169	1987	702,915	460
1953	24,662	400	1988	579,311	1,288
1954	58,325	168	1989	499,168	484
1955	53,553	288	1990	408,492	652
1956	59,716	58	1991	338,019	342
1957	31,475	85	1992	222,959	392
1958	20,767	274	1993	188,809	358
1959	42,043	234	1994	161,088	310
1960	47,702	377	1995	131,969	488
1961	72,105	204	1996	136,740	409
1962	86,142	35	1997	138,556	572*
1963	62,213	21	1998**	132,500	------

* assumed recruitment (see *Recruitment* section)

**July 1998 projection (see Table 4)

Table 4. Projected Pacific mackerel biomass for beginning of 1998/99 season.

Annual F in '98= 0.27615 <-adjusted to match predicted and assumed catch sem. 1 98
Annual M= 0.5

Age	#Fish (10^6) Jan 1997	F Mort 1997	F Mort 1998	#Fish (10^6) July 1998	Wt@Age (Lbs/Fish)	Projected Biomass, July '98 (Lbs x10^6)
0	572	0.001				
1	315	0.130	0.077	259.624	0.313	81.174
2	185	0.166	0.099	124.424	0.523	65.111
3	64	0.248	0.147	68.780	0.855	58.836
4	29	0.465	0.276	20.553	1.118	22.974
5	71	0.465	0.276	25.855	1.425	36.838

Projected Biomass (Short Tons)= 132,500

Assumed Catch (tons) for sem. 1 '98

Mex Comm	US Comm	US Rec
4662	6123	500

11285 <-Total sem. 1 '98 catch (tons)

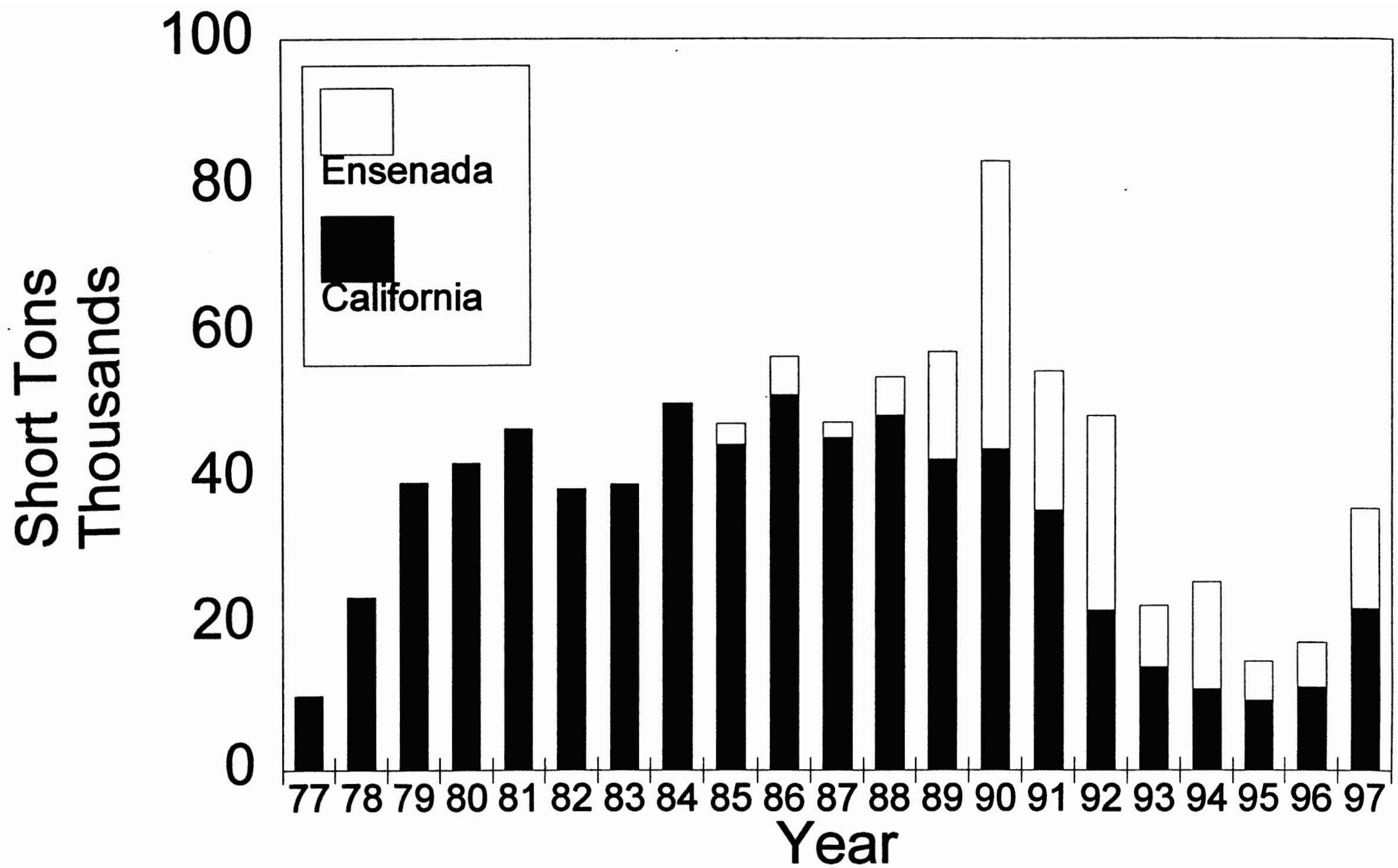

Figure 1. Annual Pacific mackerel landings by directed fisheries in California and Ensenada, 1977 through 1997. Projected values were substituted for the remainder of 1997.

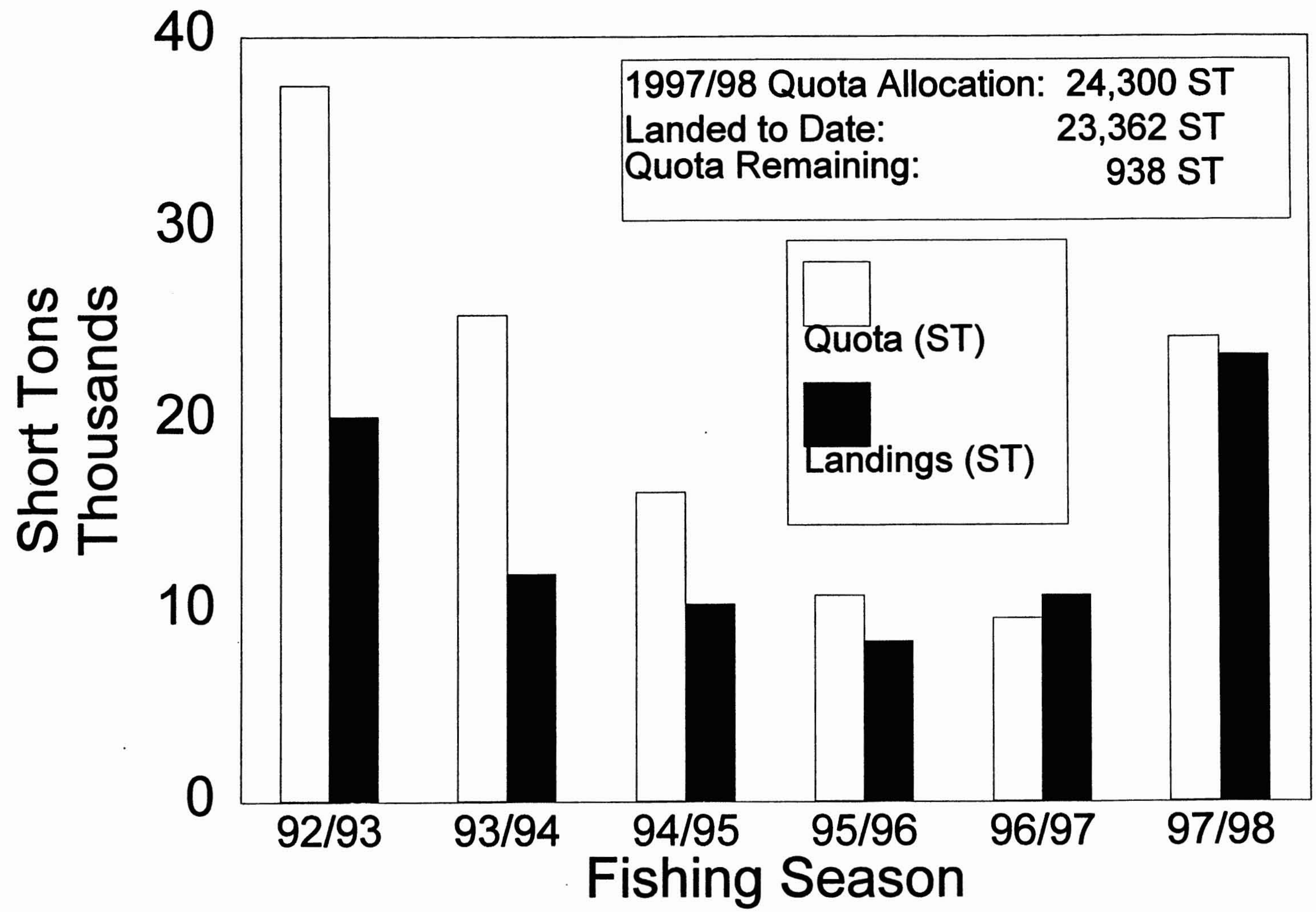

Figure 2. California commercial Pacific mackerel landings relative to quota for 1992/93 to 1997/98 fishing seasons.

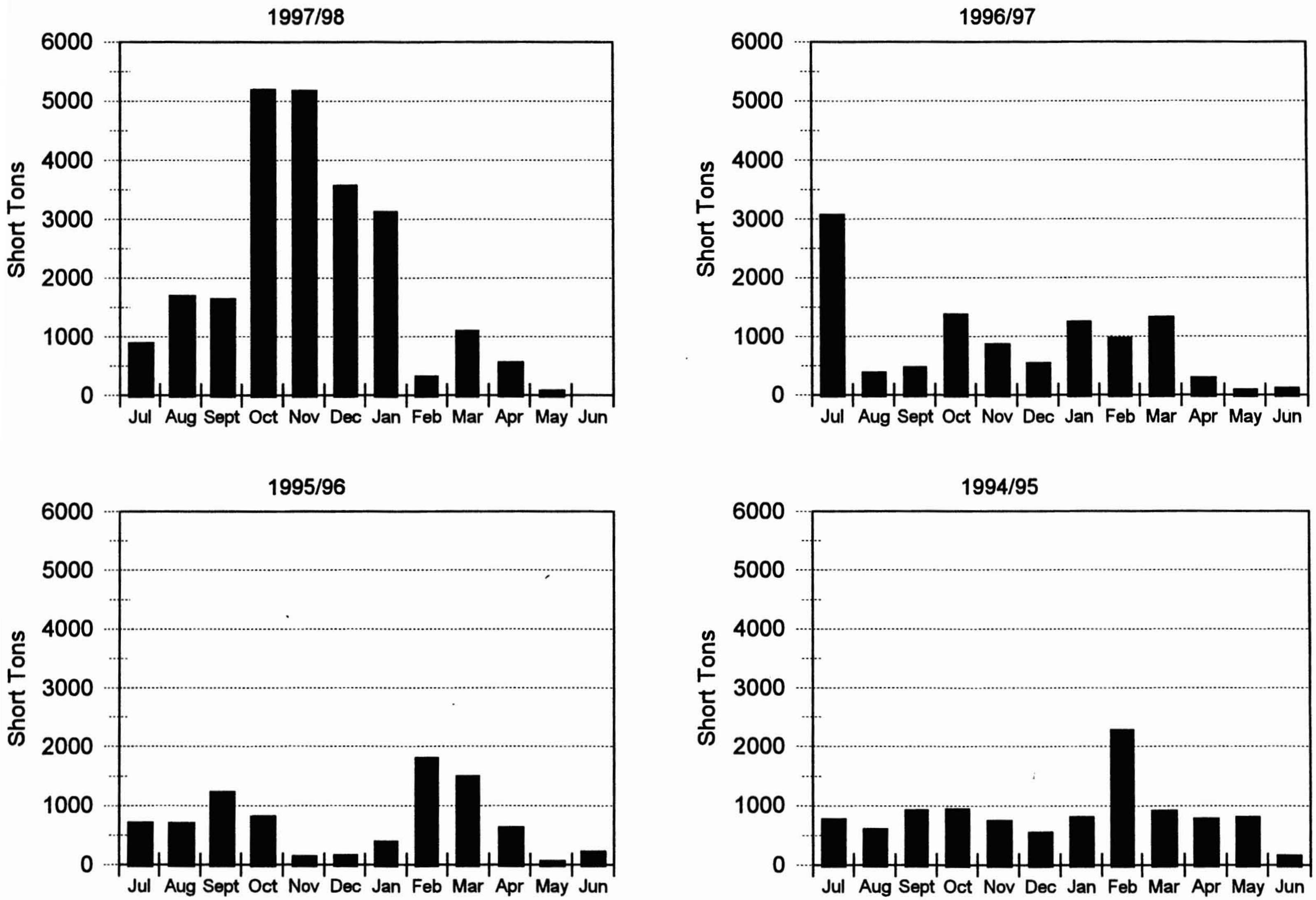

Figure 3. Monthly mackerel landings.

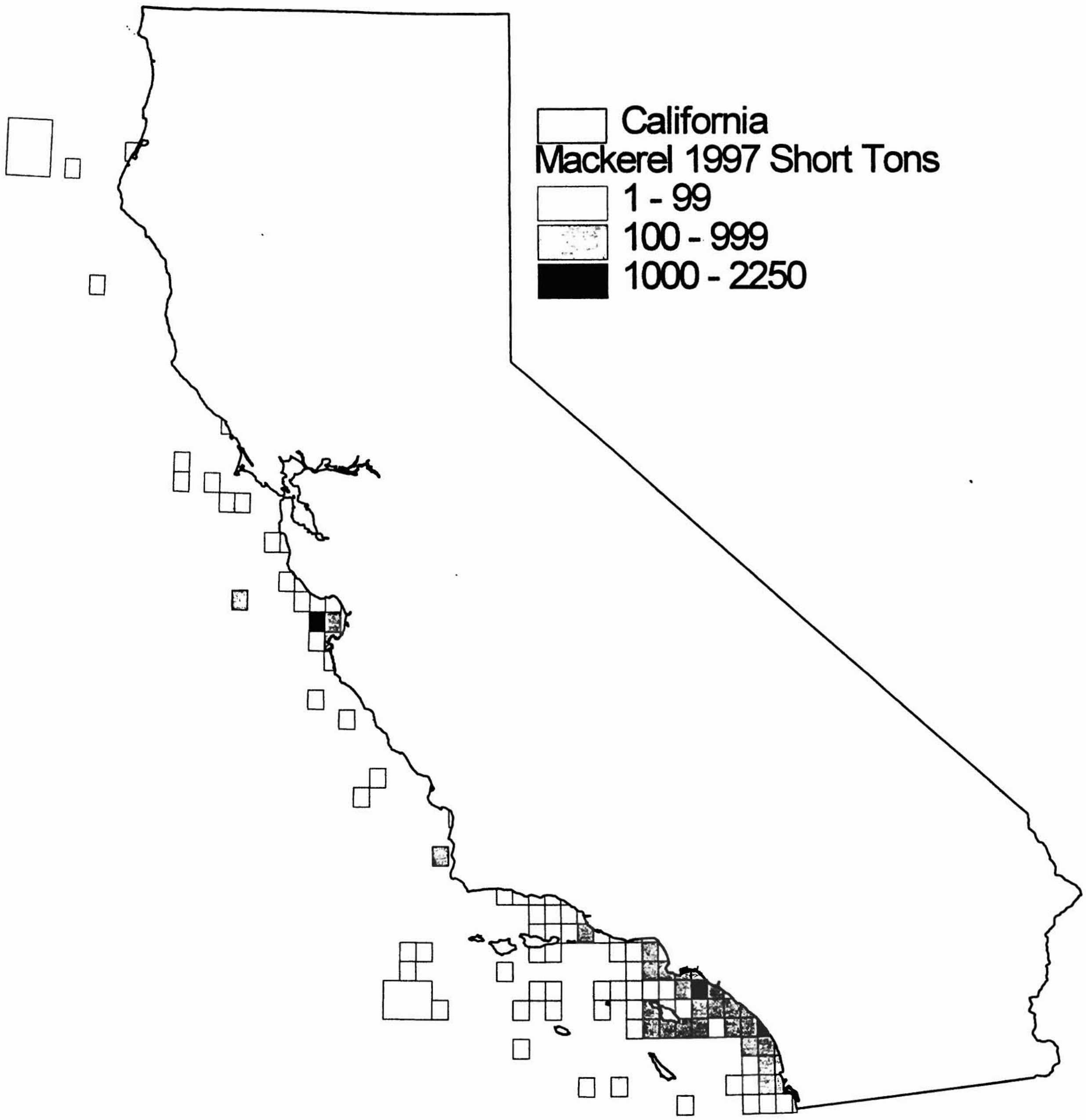

Figure 4. Commercial catch areas for Pacific mackerel in 1997.

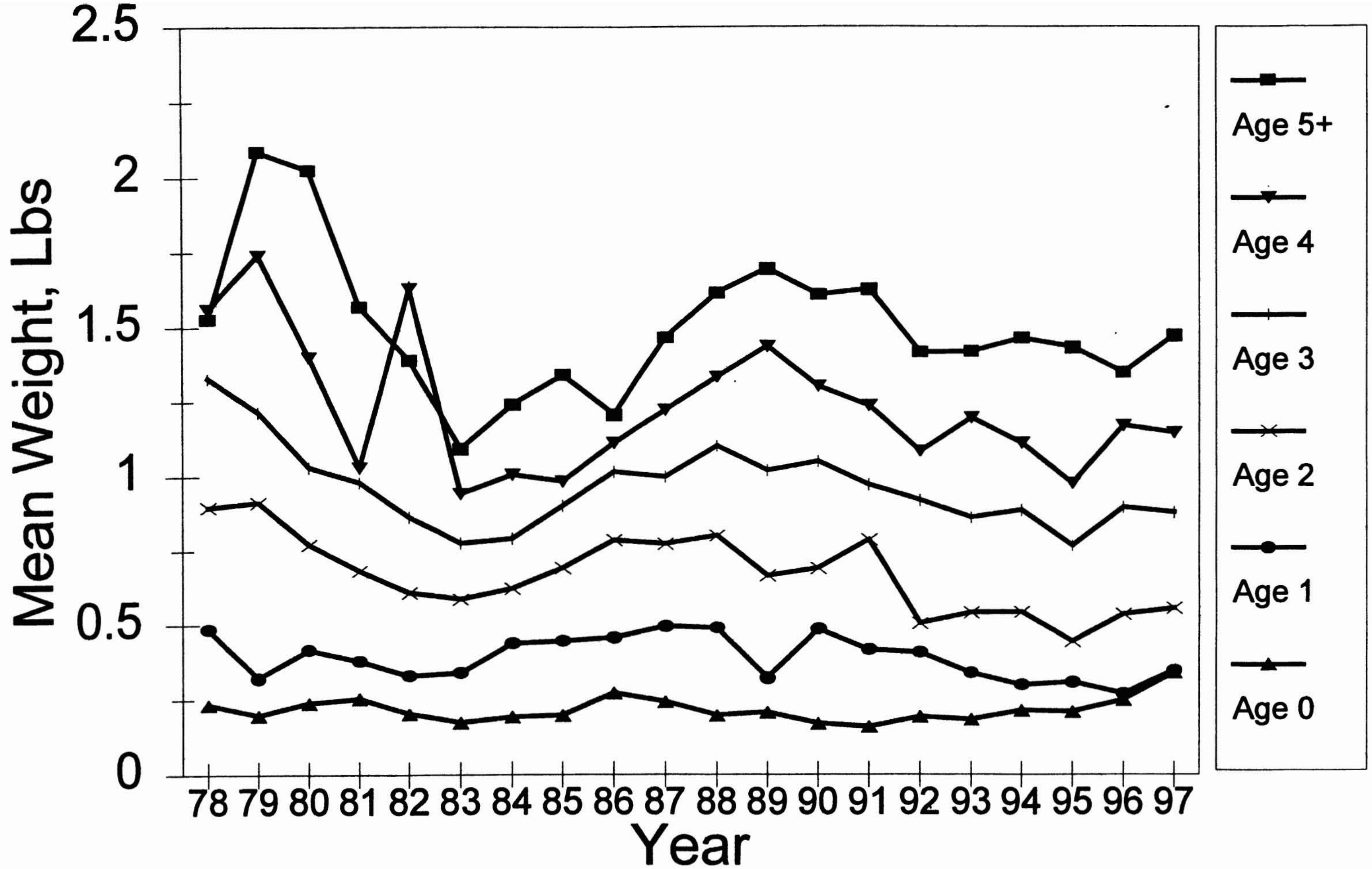

Figure 5. Pacific mackerel weight-at-age for the 1978-1997 California fishery.

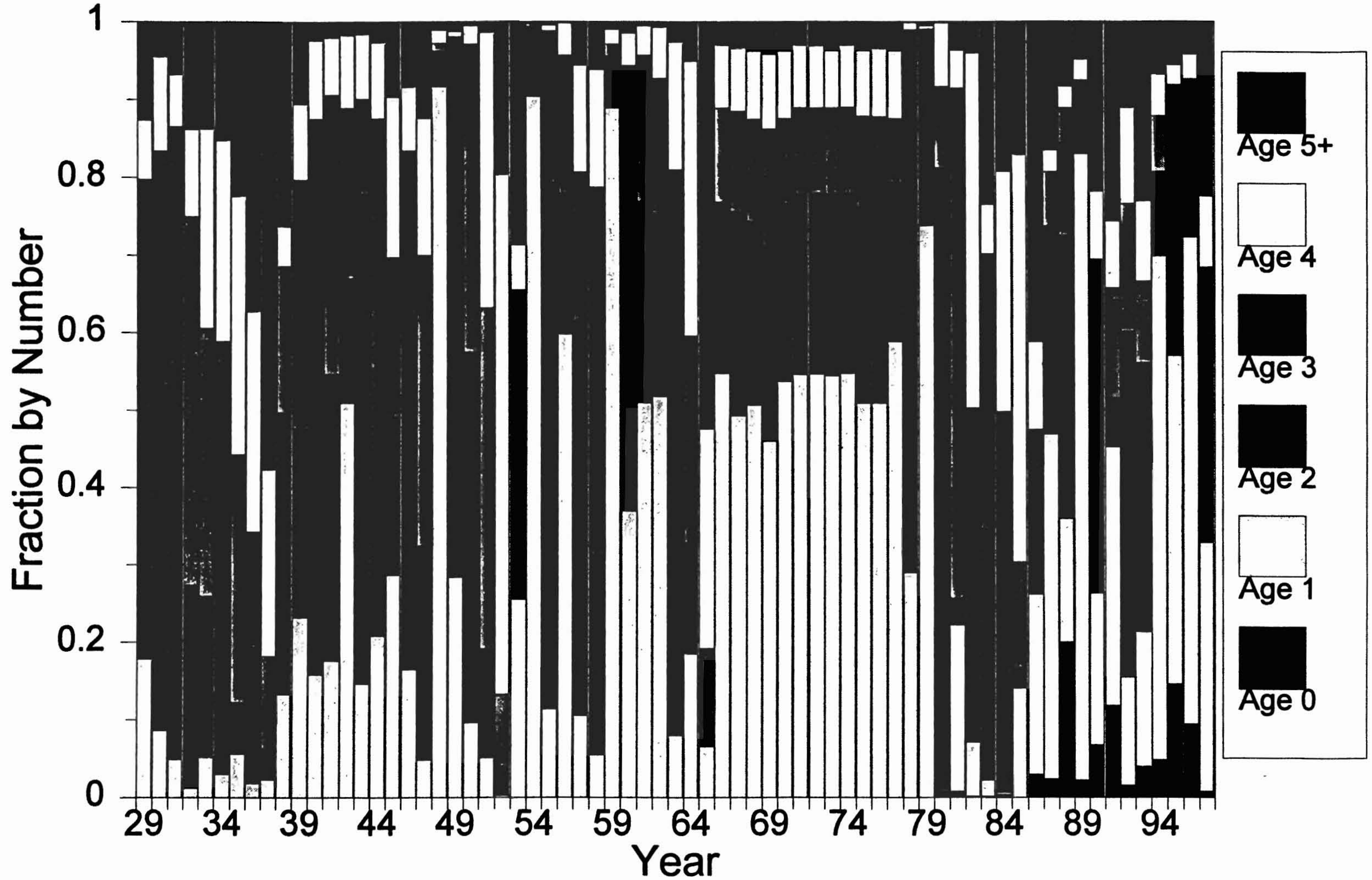

Figure 6. Pacific mackerel proportional catch-at-age for the 1929-1997 California commercial fishery.

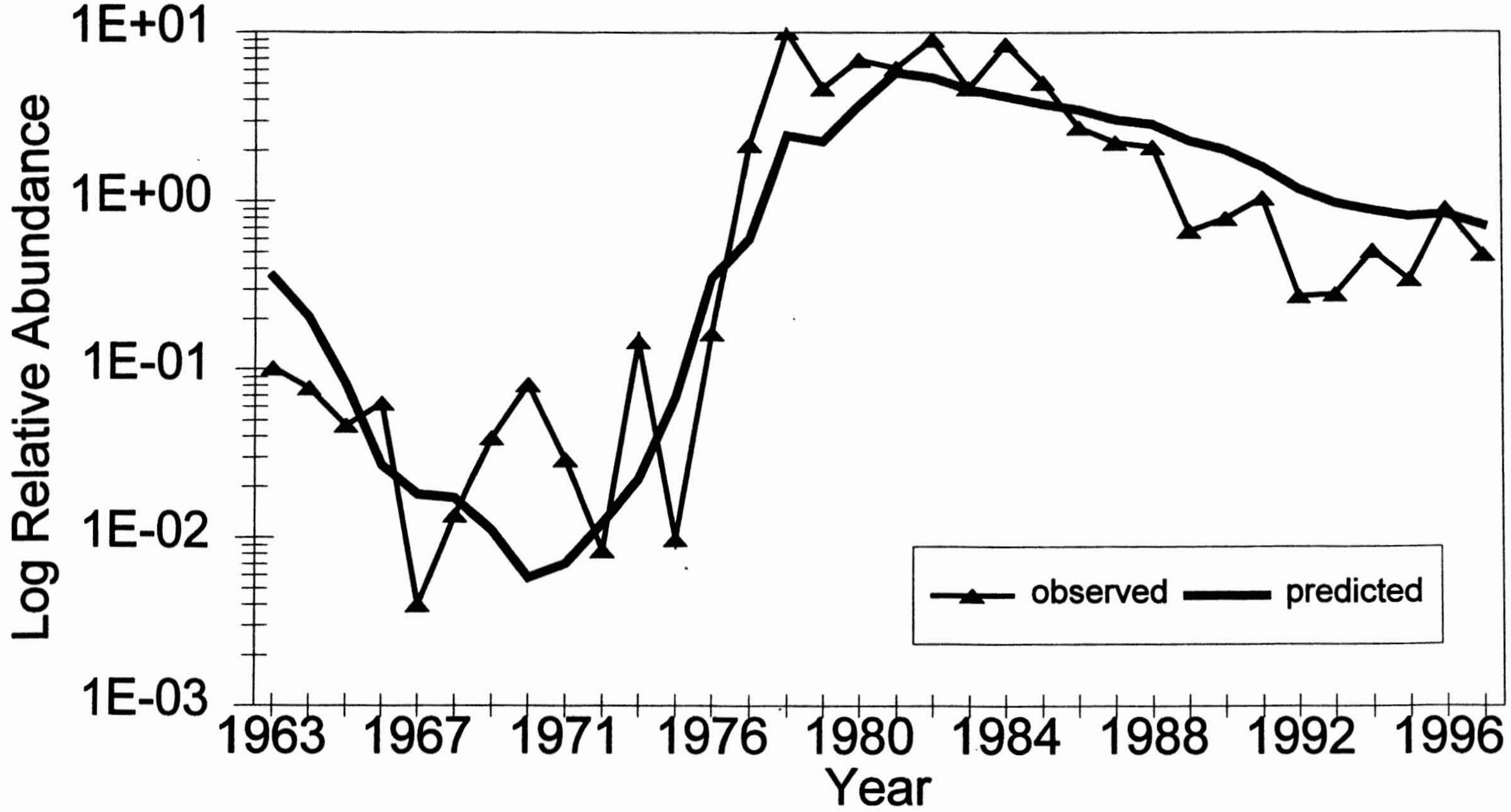

Figure 7. Relative abundance of Pacific mackerel based on aerial spotter pilot sightings, 1963-1997.

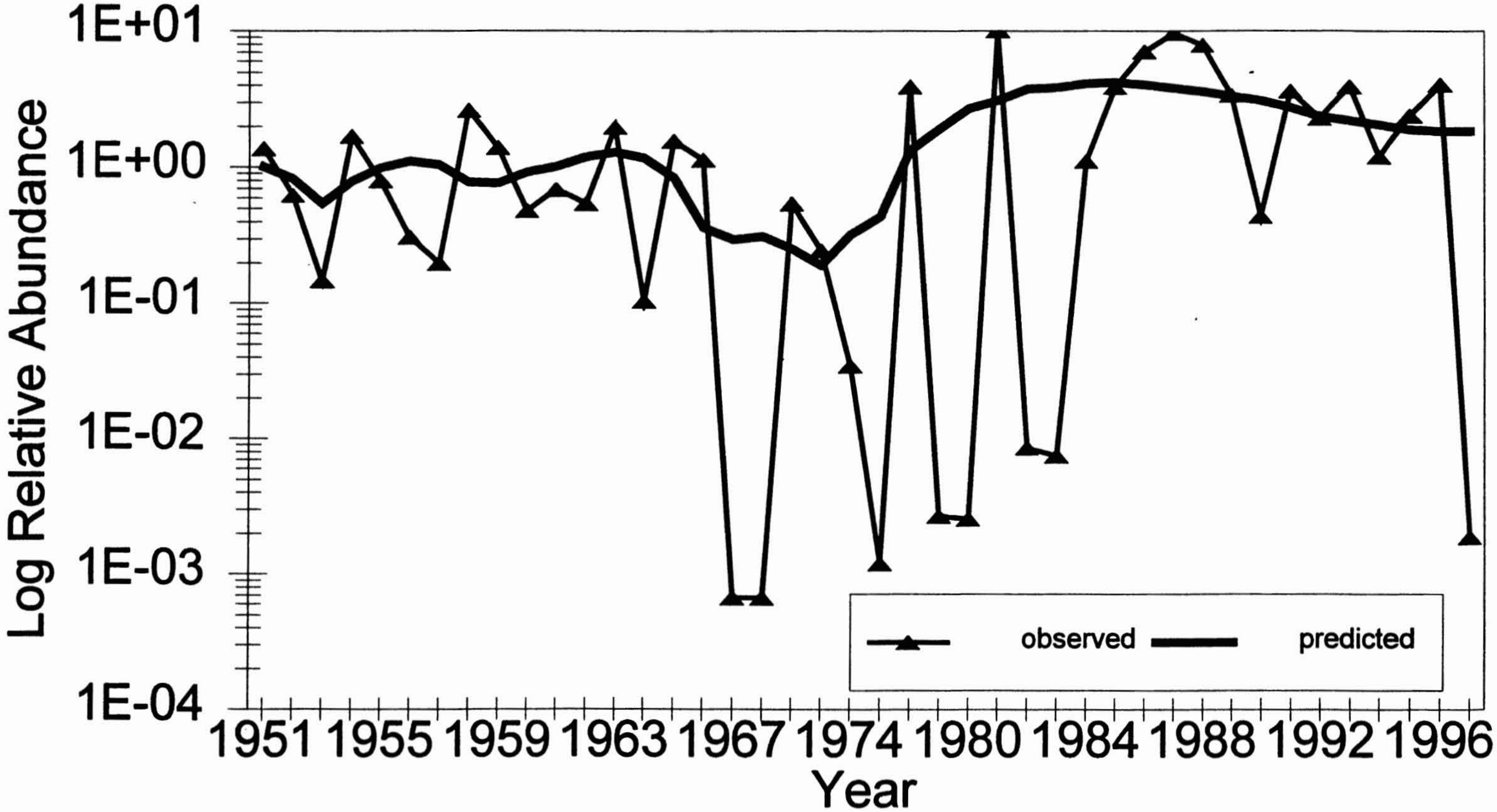

Figure 8. Relative abundance of Pacific mackerel larvae off southern California based on CalCOFI bongo tows, 1951-1997. Proportion positive data were standardized using a generalized additive model.

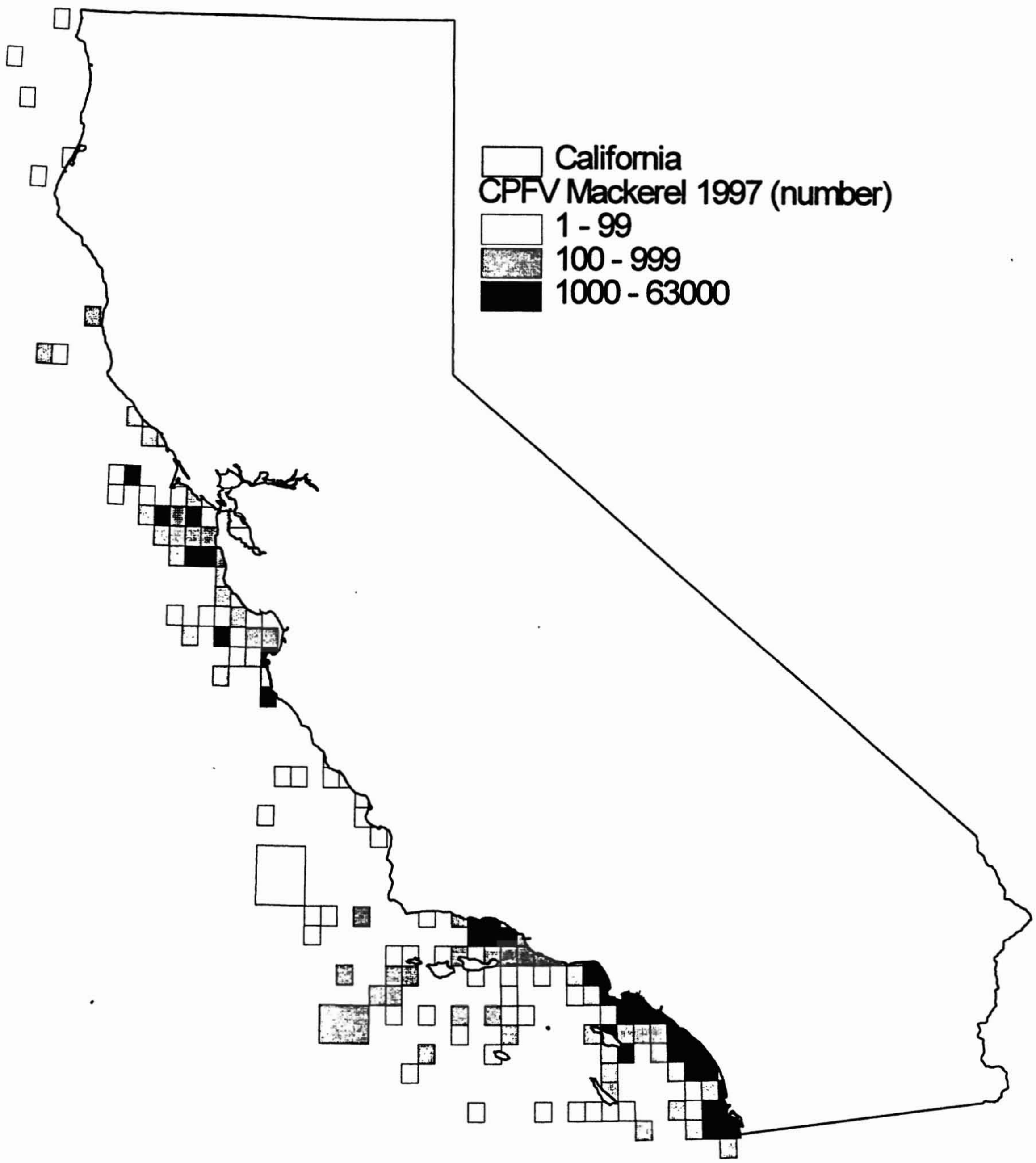

Figure 9. CPFV catch areas for Pacific mackerel in 1997.

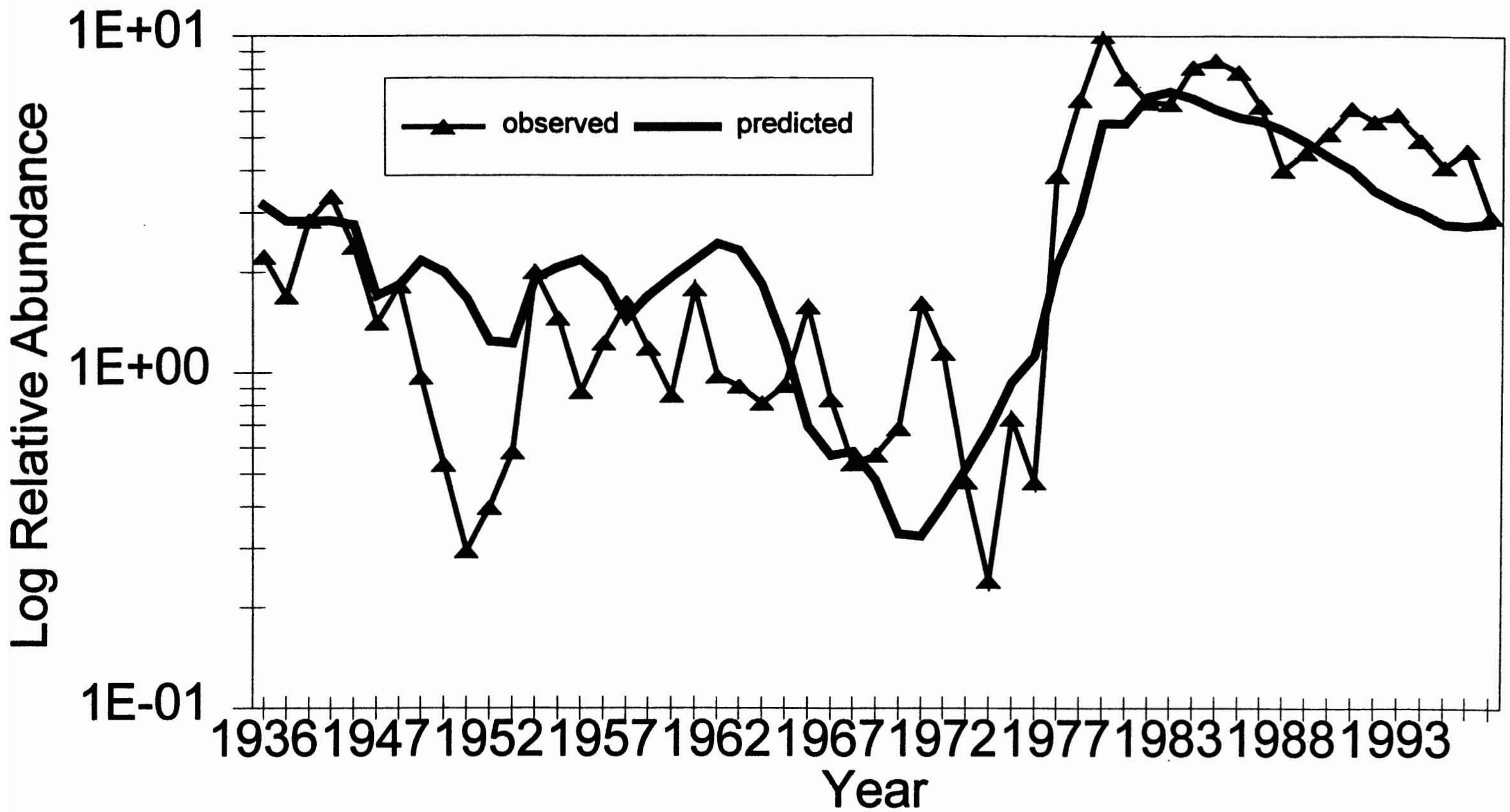

Figure 10. Relative abundance of Pacific mackerel off southern California based on catch-per-unit-effort by recreational anglers fishing from commercial passenger fishing vessels, 1936-1997.

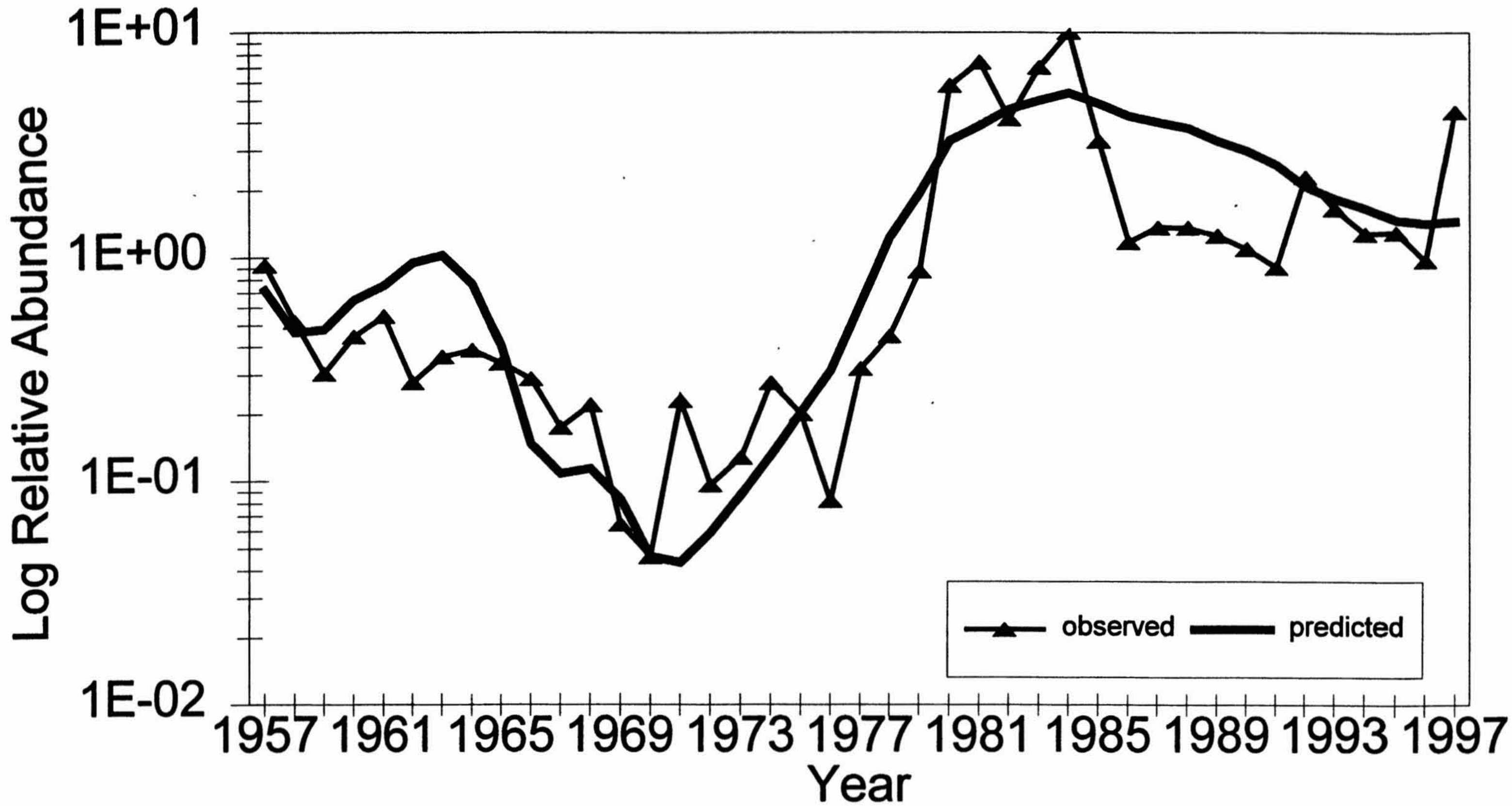

Figure 11. Relative abundance of Pacific mackerel off northern California based on catch-per-unit-effort by recreational anglers fishing from commercial passenger fishing vessels, 1957-1997.

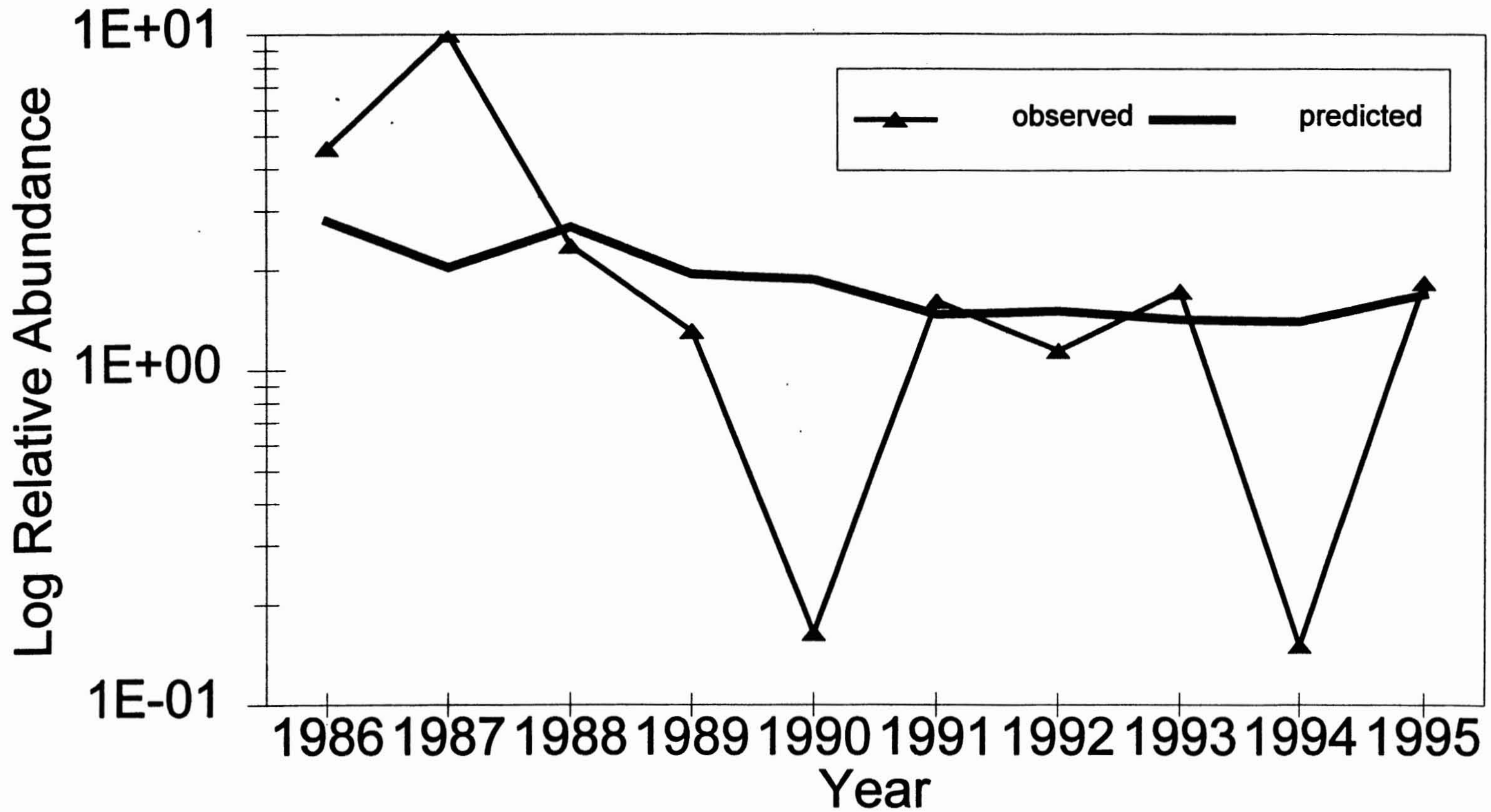

Figure 12. Relative abundance of Pacific mackerel juveniles off southern California based on Southern California Edison impingement data, 1986-1995.

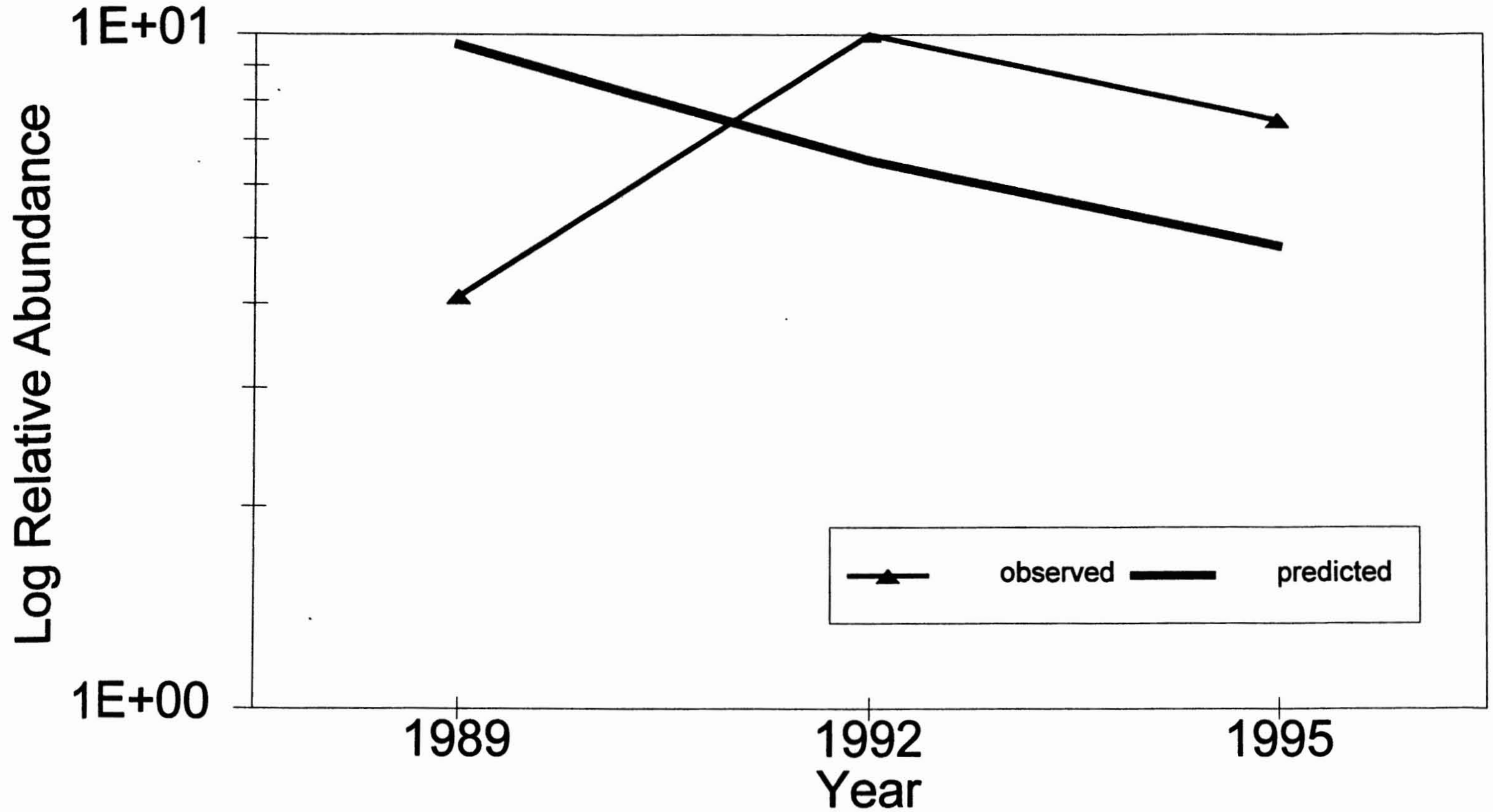

Figure 13. Relative abundance of Pacific mackerel off central California based on triennial trawl surveys conducted by the National Marine Fisheries Service, 1989-1995.

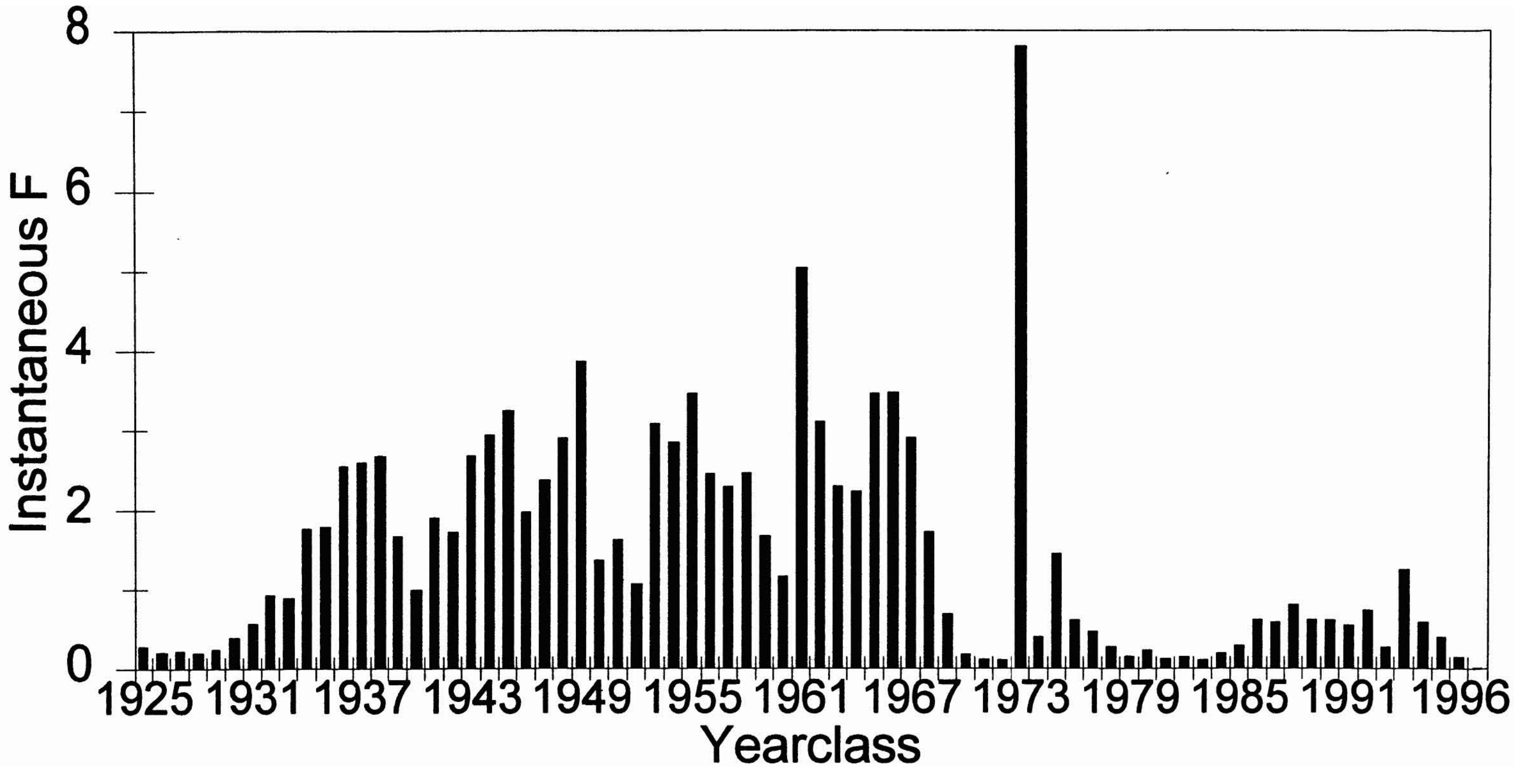

Figure 14. Cumulative fishing mortality of Pacific mackerel by yearclass.

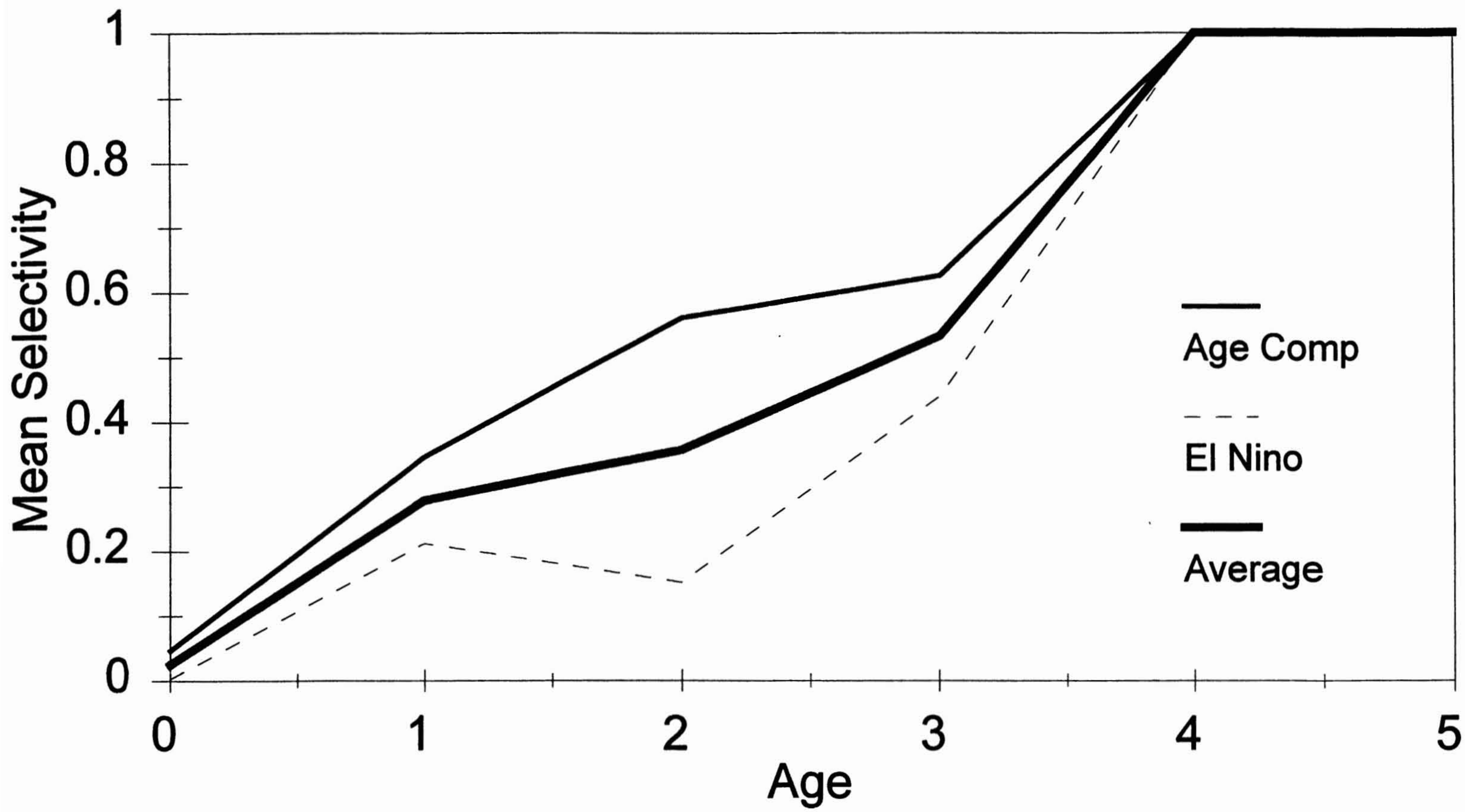

Figure 15. Age-specific terminal fishery selectivities applied in Pacific mackerel biomass assessment model ADEPT. Average values were applied as fixed values in the final year.

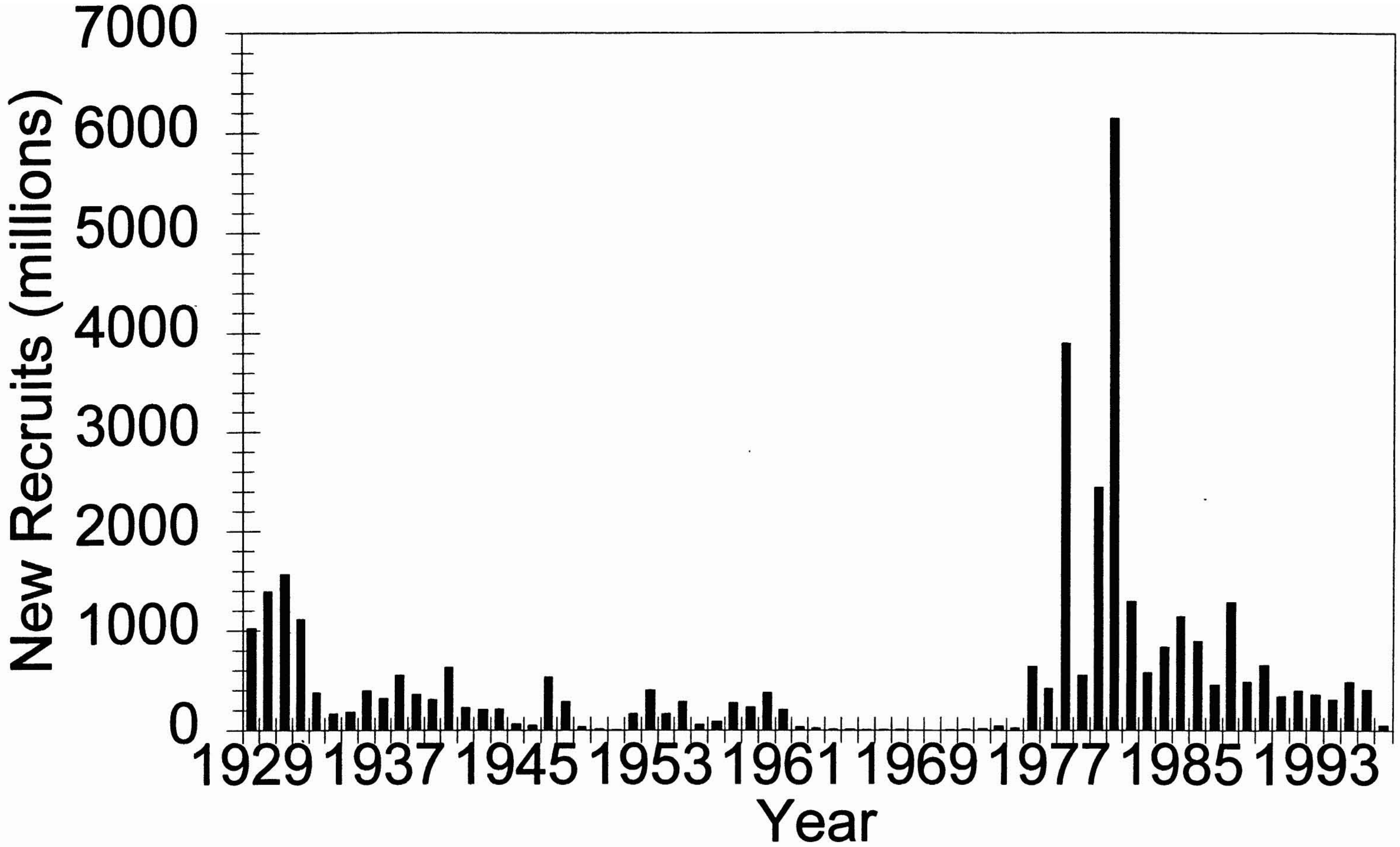

Figure 16. Year class abundance of Pacific mackerel, July 1.

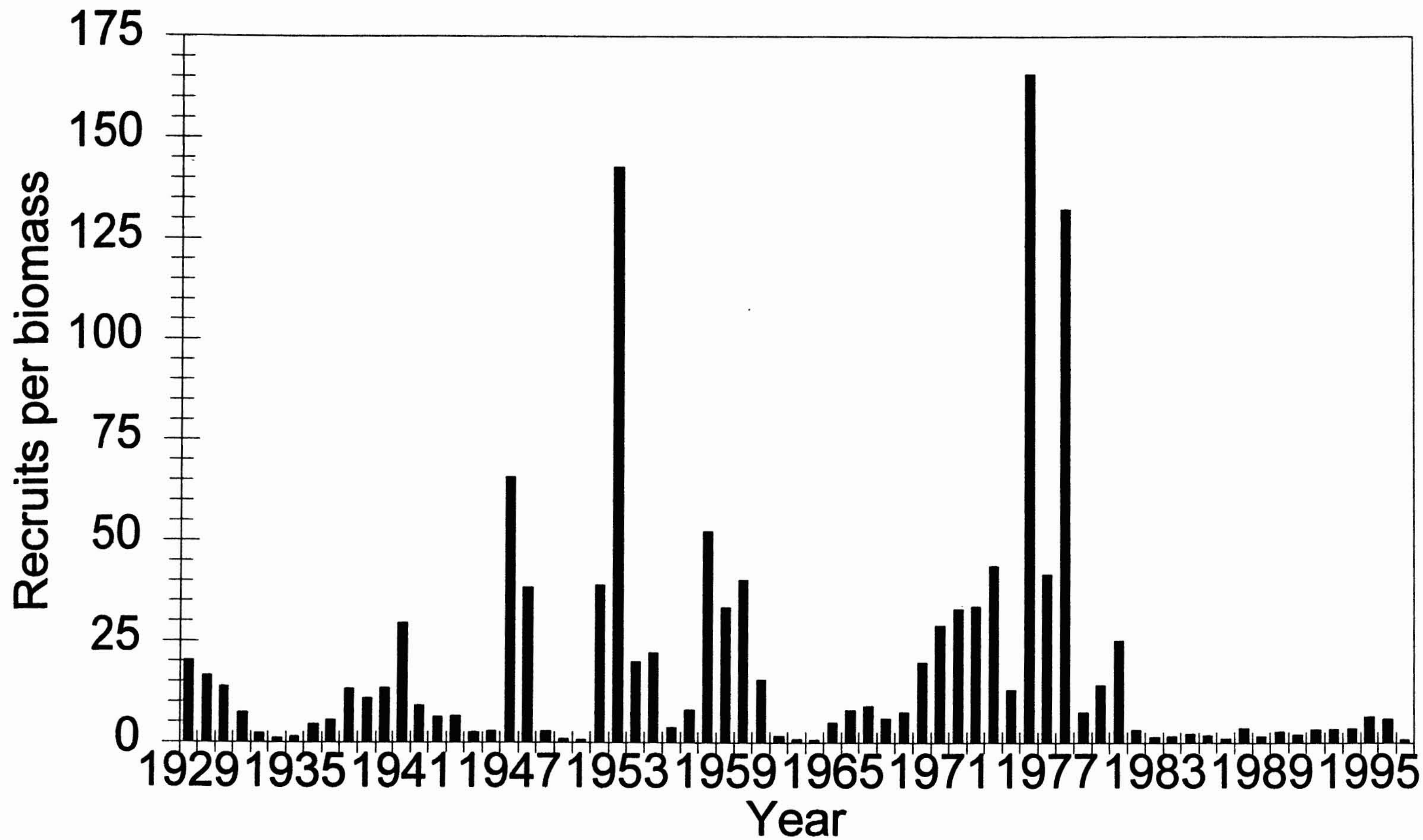

Figure 17. Pacific mackerel recruits per spawning biomass, 1929-1997.

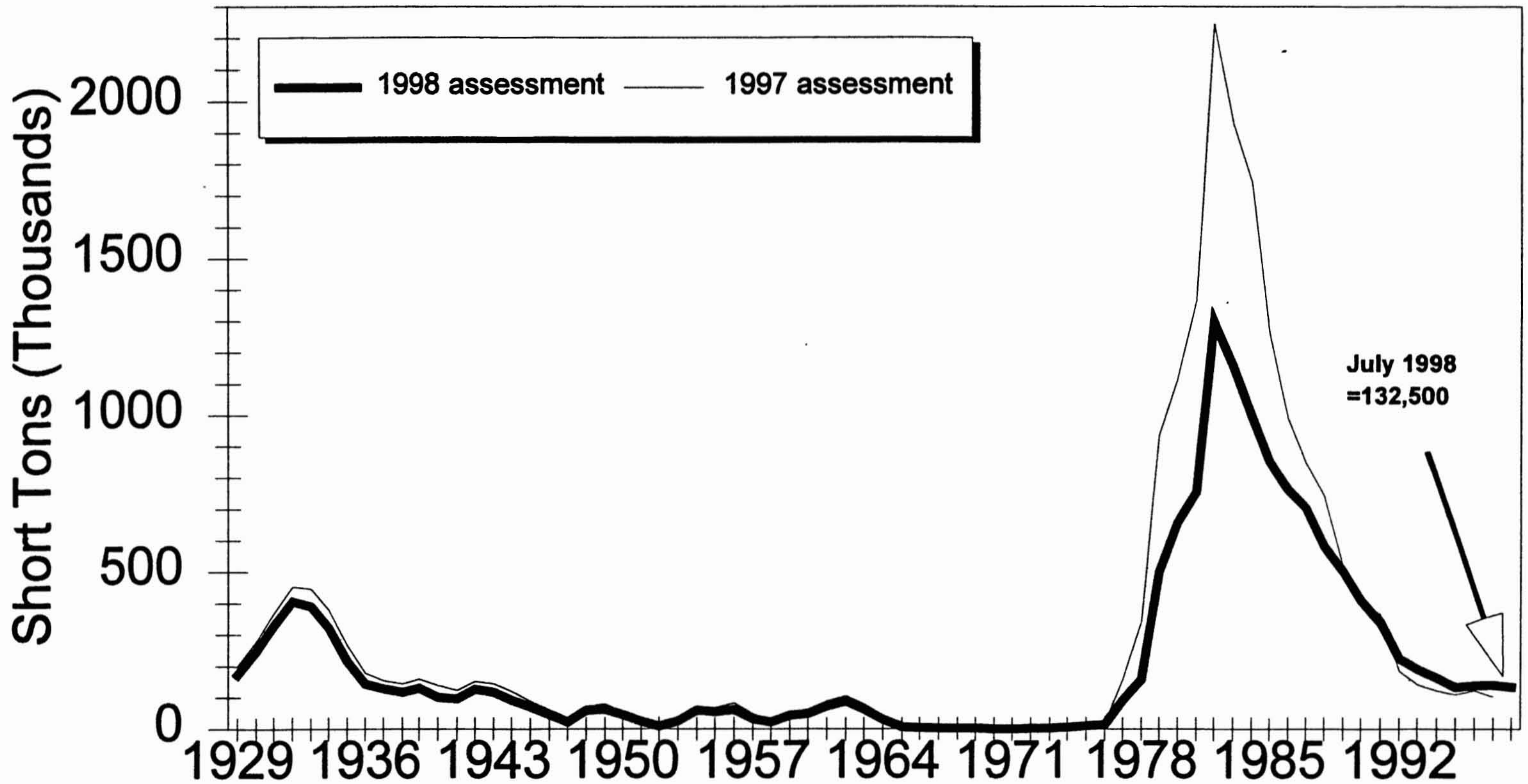

Figure 18. Pacific mackerel age 1+ biomass, 1929-1997, with projected value for July 1, 1998.

Appendix A

Final ADEPT model run input/output (select portions) for 1998/99 Pacific mackerel assessment.

```
================================================================================

 ---------------smpl: simplex/newton parameter estimation program---------------

 -------------USER SPECIFIED OUTPUT FROM MODEL FOR FINAL PARAMETERS-------------

 run definition parameters:
 first year in analysis
1929
 last year in analysis
1997
 first age in analysis
0
 last age in analysis
5
 last age a plus group?
 T
 seasons in each year
1
 skip any of the oldest cohorts?
 F
 additional terminal f's specified?
 F
 annual natural mortality rate
5.00E-01
 use murphy's algorithm to calculate f for oldest true age and plus group?
 T
 check data and issue warnings in first call to VPA?
 T
 detailed output?
 T
 number surveys used in analysis
12
 weight in composite likelihood for survey  1
1.00E+00
 weight in composite likelihood for survey  2
1.00E+00
 weight in composite likelihood for survey  3
1.00E+00
 weight in composite likelihood for survey  4
0.00E+00
 weight in composite likelihood for survey  5
1.00E+00
 weight in composite likelihood for survey  6
0.00E+00
 weight in composite likelihood for survey  7
0.00E+00
 weight in composite likelihood for survey  8
1.00E+00
 weight in composite likelihood for survey  9
1.00E+00
 weight in composite likelihood for survey 10
0.00E+00
 weight in composite likelihood for survey 11
0.00E+00
 weight in composite likelihood for survey 12
0.00E+00
 pointer to first survey q parameter
10
 pointer to first survey availability parameter
34
 any additional abundance/biomass summaries?
 T
 number of additional summaries
3
 season for summary  1
1
 elapsed time in season for summary  1
0.00E+00
 lower bound for summary  1
1
 upper bound for summary  1
5
 season for summary  2
1
 elapsed time in season for summary  2
5.00E-01
 lower bound for summary  2
1
 upper bound for summary  2
5
 season for summary  3
1
 elapsed time in season for summary  3
5.00E-01
 lower bound for summary  3
0
 upper bound for summary  3
0
 adjust catch@age data to match aggregate catch by year/season?
 T
```

```
Calculate egg production or spawning biomass?
T
Season for egg production/spawing?
1
Elapsed time at egg production/spawning?
5.00E-01
Ogive value (units per biomass) for age 0?
0
Ogive value (units per biomass) for age 1?
0.07
Ogive value (units per biomass) for age 2?
0.24
Ogive value (units per biomass) for age 3?
0.47
Ogive value (units per biomass) for age 4?
0.73
Ogive value (units per biomass) for age 5?
1
read environmental/auxiliary data?
T

------------------------------------------------------------------------------------------
raw catch and weight age data (catches adjusted before use in analysis)
1929      1         0          0.00E+00  1.98E-01
1929      1         1          5.10E+01  3.68E-01
1929      1         2          9.21E+01  6.55E-01
1929      1         3          8.54E+01  8.87E-01
1929      1         4          2.14E+01  1.15E+00
1929      1         5          3.63E+01  1.36E+00
1930      1         0          0.00E+00  1.98E-01
1930      1         1          5.44E+00  3.06E-01
1930      1         2          2.80E+01  6.64E-01
1930      1         3          1.89E+01  9.31E-01
1930      1         4          7.48E+00  1.13E+00
1930      1         5          2.88E+00  1.33E+00
1931      1         0          0.00E+00  1.98E-01
1931      1         1          3.77E+00  2.52E-01
1931      1         2          3.93E+01  6.09E-01
1931      1         3          2.44E+01  8.80E-01
1931      1         4          5.15E+00  1.16E+00
1931      1         5          5.24E+00  1.34E+00
1932      1         0          0.00E+00  1.98E-01
1932      1         1          5.76E-01  1.78E-01
1932      1         2          1.29E+01  6.11E-01
1932      1         3          2.34E+01  8.36E-01
1932      1         4          5.57E+00  1.12E+00
1932      1         5          6.80E+00  1.33E+00
1933      1         0          0.00E+00  1.98E-01
1933      1         1          1.66E+01  1.82E-01
1933      1         2          6.85E+01  4.42E-01
1933      1         3          1.15E+02  6.60E-01
1933      1         4          8.42E+01  1.09E+00
1933      1         5          4.51E+01  1.29E+00
1934      1         0          0.00E+00  1.98E-01
1934      1         1          1.50E+01  3.13E-01
1934      1         2          1.63E+02  4.36E-01
1934      1         3          1.09E+02  5.13E-01
1934      1         4          1.25E+02  9.50E-01
1934      1         5          7.44E+01  1.19E+00
1935      1         0          0.00E+00  1.98E-01
1935      1         1          3.39E+01  4.09E-01
1935      1         2          3.97E+01  4.79E-01
1935      1         3          1.92E+02  5.53E-01
1935      1         4          1.99E+02  8.36E-01
1935      1         5          1.34E+02  1.04E+00
1936      1         0          0.00E+00  1.98E-01
1936      1         1          7.58E+00  4.25E-01
1936      1         2          6.88E+01  6.26E-01
1936      1         3          5.87E+01  7.45E-01
1936      1         4          1.11E+02  8.67E-01
1936      1         5          1.47E+02  9.98E-01
1937      1         0          0.00E+00  1.98E-01
1937      1         1          5.66E+00  3.89E-01
1937      1         2          9.94E+00  7.00E-01
1937      1         3          3.08E+01  9.45E-01
1937      1         4          6.10E+01  1.02E+00
1937      1         5          1.47E+02  1.11E+00
1938      1         0          0.00E+00  1.98E-01
1938      1         1          4.90E+01  3.83E-01
1938      1         2          1.35E+02  6.83E-01
1938      1         3          7.00E+01  9.88E-01
1938      1         4          1.83E+01  1.17E+00
1938      1         5          9.77E+01  1.28E+00
1939      1         0          0.00E+00  1.98E-01
1939      1         1          1.21E+02  3.71E-01
1939      1         2          1.28E+02  6.95E-01
1939      1         3          1.69E+02  9.86E-01
1939      1         4          5.08E+01  1.21E+00
1939      1         5          5.50E+01  1.39E+00
1940      1         0          0.00E+00  1.98E-01
1940      1         1          9.62E+01  4.29E-01
1940      1         2          3.21E+02  5.75E-01
1940      1         3          1.17E+02  7.95E-01
1940      1         4          6.27E+01  9.84E-01
1940      1         5          1.43E+01  1.28E+00
1941      1         0          0.00E+00  1.98E-01
1941      1         1          6.04E+01  4.82E-01
1941      1         2          1.28E+02  6.85E-01
```

1941	1	3	1.24E+02	8.83E-01
1941	1	4	2.47E+01	1.11E+00
1941	1	5	7.33E+00	1.32E+00
1942	1	0	0.00E+00	1.98E-01
1942	1	1	1.43E+02	3.81E-01
1942	1	2	4.48E+01	7.03E-01
1942	1	3	6.18E+01	9.00E-01
1942	1	4	2.57E+01	1.14E+00
1942	1	5	5.27E+00	1.47E+00
1943	1	0	0.00E+00	1.98E-01
1943	1	1	6.15E+01	4.79E-01
1943	1	2	2.67E+02	6.17E-01
1943	1	3	5.01E+01	9.44E-01
1943	1	4	3.52E+01	1.13E+00
1943	1	5	7.29E+00	1.38E+00
1944	1	0	0.00E+00	1.98E-01
1944	1	1	7.84E+01	4.61E-01
1944	1	2	9.02E+01	7.39E-01
1944	1	3	1.61E+02	9.03E-01
1944	1	4	3.65E+01	1.18E+00
1944	1	5	9.76E+00	1.42E+00
1945	1	0	0.00E+00	1.98E-01
1945	1	1	6.78E+01	3.69E-01
1945	1	2	4.89E+01	7.28E-01
1945	1	3	4.86E+01	9.65E-01
1945	1	4	4.89E+01	1.18E+00
1945	1	5	2.27E+01	1.44E+00
1946	1	0	0.00E+00	1.98E-01
1946	1	1	4.64E+01	4.11E-01
1946	1	2	1.28E+02	6.54E-01
1946	1	3	5.90E+01	9.66E-01
1946	1	4	2.32E+01	1.20E+00
1946	1	5	2.38E+01	1.42E+00
1947	1	0	0.00E+00	1.98E-01
1947	1	1	7.47E+00	5.10E-01
1947	1	2	4.33E+01	7.96E-01
1947	1	3	5.93E+01	1.05E+00
1947	1	4	2.76E+01	1.21E+00
1947	1	5	1.94E+01	1.45E+00
1948	1	0	0.00E+00	1.98E-01
1948	1	1	3.09E+02	3.51E-01
1948	1	2	1.55E+01	7.41E-01
1948	1	3	3.70E+00	1.06E+00
1948	1	4	5.40E+00	1.28E+00
1948	1	5	3.52E+00	1.48E+00
1949	1	0	0.00E+00	1.98E-01
1949	1	1	1.08E+02	3.27E-01
1949	1	2	2.44E+02	5.77E-01
1949	1	3	2.12E+01	8.64E-01
1949	1	4	3.40E+00	1.26E+00
1949	1	5	4.41E+00	1.48E+00
1950	1	0	0.00E+00	1.98E-01
1950	1	1	2.03E+01	4.62E-01
1950	1	2	1.01E+02	5.64E-01
1950	1	3	8.32E+01	8.04E-01
1950	1	4	4.93E+00	1.06E+00
1950	1	5	1.11E+00	1.44E+00
1951	1	0	0.00E+00	1.98E-01
1951	1	1	7.68E+00	3.53E-01
1951	1	2	2.15E+01	6.92E-01
1951	1	3	6.73E+01	8.46E-01
1951	1	4	5.40E+01	1.05E+00
1951	1	5	1.99E+00	1.31E+00
1952	1	0	0.00E+00	1.98E-01
1952	1	1	2.40E-01	6.11E-01
1952	1	2	2.71E+00	7.85E-01
1952	1	3	6.69E+00	1.06E+00
1952	1	4	4.93E+01	1.21E+00
1952	1	5	1.45E+01	1.44E+00
1953	1	0	0.00E+00	1.98E-01
1953	1	1	4.41E+00	4.38E-01
1953	1	2	3.10E+00	7.90E-01
1953	1	3	3.80E+00	9.59E-01
1953	1	4	1.05E+00	1.22E+00
1953	1	5	4.95E+00	1.47E+00
1954	1	0	0.00E+00	1.98E-01
1954	1	1	2.60E+02	3.42E-01
1954	1	2	2.53E+01	7.40E-01
1954	1	3	1.35E+00	1.08E+00
1954	1	4	4.60E-01	1.23E+00
1954	1	5	2.52E-01	1.48E+00
1955	1	0	0.00E+00	1.98E-01
1955	1	1	2.79E+01	3.50E-01
1955	1	2	1.66E+02	5.56E-01
1955	1	3	4.72E+01	8.89E-01
1955	1	4	1.60E+00	1.16E+00
1955	1	5	1.11E+00	1.50E+00
1956	1	0	0.00E+00	1.98E-01
1956	1	1	3.02E+02	3.98E-01
1956	1	2	9.14E+01	6.52E-01
1956	1	3	8.94E+01	8.99E-01
1956	1	4	2.22E+01	1.09E+00
1956	1	5	3.80E-01	1.40E+00
1957	1	0	0.00E+00	1.98E-01
1957	1	1	2.91E+01	4.53E-01
1957	1	2	1.42E+02	6.62E-01
1957	1	3	5.29E+01	9.31E-01
1957	1	4	3.81E+01	1.13E+00

1957	1	5	1.55E+01	1.34E+00
1958	1	0	0.00E+00	1.98E-01
1958	1	1	5.71E+00	4.13E-01
1958	1	2	2.65E+01	6.97E-01
1958	1	3	4.86E+01	8.44E-01
1958	1	4	1.56E+01	1.09E+00
1958	1	5	6.33E+00	1.29E+00
1959	1	0	0.00E+00	1.98E-01
1959	1	1	2.49E+02	4.14E-01
1959	1	2	1.85E+01	7.35E-01
1959	1	3	4.60E+00	9.68E-01
1959	1	4	5.63E+00	1.14E+00
1959	1	5	2.45E+00	1.41E+00
1960	1	0	0.00E+00	1.98E-01
1960	1	1	8.82E+01	3.64E-01
1960	1	2	9.92E+01	6.90E-01
1960	1	3	3.83E+01	1.04E+00
1960	1	4	1.00E+01	1.29E+00
1960	1	5	3.36E+00	1.52E+00
1961	1	0	0.00E+00	1.98E-01
1961	1	1	1.42E+02	3.89E-01
1961	1	2	7.26E+01	6.68E-01
1961	1	3	5.17E+01	1.02E+00
1961	1	4	1.09E+01	1.24E+00
1961	1	5	1.52E+00	1.46E+00
1962	1	0	0.00E+00	1.98E-01
1962	1	1	1.27E+02	5.08E-01
1962	1	2	5.87E+01	7.51E-01
1962	1	3	4.23E+01	1.04E+00
1962	1	4	1.63E+01	1.24E+00
1962	1	5	1.85E+00	1.48E+00
1963	1	0	0.00E+00	1.98E-01
1963	1	1	1.62E+01	6.42E-01
1963	1	2	9.38E+01	8.73E-01
1963	1	3	5.45E+01	1.09E+00
1963	1	4	3.33E+01	1.29E+00
1963	1	5	5.09E+00	1.56E+00
1964	1	0	0.00E+00	1.98E-01
1964	1	1	2.95E+01	5.76E-01
1964	1	2	2.28E+01	8.27E-01
1964	1	3	4.30E+01	1.12E+00
1964	1	4	5.70E+01	1.31E+00
1964	1	5	7.97E+00	1.62E+00
1965	1	0	0.00E+00	1.98E-01
1965	1	1	5.28E+00	4.02E-01
1965	1	2	3.20E+00	7.45E-01
1965	1	3	7.11E+00	1.01E+00
1965	1	4	2.31E+01	1.25E+00
1965	1	5	4.28E+01	1.29E+00
1966	1	0	0.00E+00	1.98E-01
1966	1	1	1.56E+01	3.71E-01
1966	1	2	6.37E+00	7.17E-01
1966	1	3	3.40E+00	1.07E+00
1966	1	4	2.29E+00	1.29E+00
1966	1	5	9.04E-01	1.72E+00
1967	1	0	0.00E+00	1.98E-01
1967	1	1	3.54E+00	4.13E-01
1967	1	2	1.90E+00	6.05E-01
1967	1	3	9.12E-01	1.00E+00
1967	1	4	5.88E-01	1.27E+00
1967	1	5	2.48E-01	1.58E+00
1968	1	0	0.00E+00	1.98E-01
1968	1	1	9.20E+00	4.27E-01
1968	1	2	4.34E+00	7.12E-01
1968	1	3	2.34E+00	1.05E+00
1968	1	4	1.62E+00	1.24E+00
1968	1	5	6.88E-01	1.52E+00
1969	1	0	0.00E+00	1.98E-01
1969	1	1	5.30E+00	5.57E-01
1969	1	2	2.90E+00	8.01E-01
1969	1	3	1.78E+00	1.04E+00
1969	1	4	1.10E+00	1.37E+00
1969	1	5	4.88E-01	1.61E+00
1970	1	0	0.00E+00	1.98E-01
1970	1	1	1.94E+00	4.01E-01
1970	1	2	8.28E-01	7.42E-01
1970	1	3	3.92E-01	1.25E+00
1970	1	4	3.20E-01	1.25E+00
1970	1	5	1.36E-01	1.52E+00
1971	1	0	0.00E+00	1.98E-01
1971	1	1	4.88E-01	4.01E-01
1971	1	2	2.08E-01	7.42E-01
1971	1	3	1.00E-01	1.25E+00
1971	1	4	7.20E-02	1.42E+00
1971	1	5	2.80E-02	1.76E+00
1972	1	0	0.00E+00	1.98E-01
1972	1	1	3.36E-01	4.01E-01
1972	1	2	1.44E-01	7.42E-01
1972	1	3	6.80E-02	1.25E+00
1972	1	4	4.80E-02	1.42E+00
1972	1	5	2.00E-02	1.76E+00
1973	1	0	0.00E+00	1.98E-01
1973	1	1	1.76E-01	4.01E-01
1973	1	2	7.60E-02	7.42E-01
1973	1	3	3.60E-02	1.25E+00
1973	1	4	2.40E-02	1.42E+00
1973	1	5	1.20E-02	1.76E+00
1974	1	0	0.00E+00	1.98E-01

1974	1	1	4.20E-01	4.01E-01
1974	1	2	1.80E-01	7.42E-01
1974	1	3	8.40E-02	1.25E+00
1974	1	4	6.00E-02	1.42E+00
1974	1	5	2.40E-02	1.76E+00
1975	1	0	0.00E+00	1.98E-01
1975	1	1	7.76E-01	4.65E-01
1975	1	2	3.84E-01	7.42E-01
1975	1	3	1.80E-01	1.25E+00
1975	1	4	1.28E-01	1.42E+00
1975	1	5	5.60E-02	1.76E+00
1976	1	0	0.00E+00	1.98E-01
1976	1	1	1.77E+00	4.65E-01
1976	1	2	8.72E-01	7.41E-01
1976	1	3	4.12E-01	1.25E+00
1976	1	4	2.96E-01	1.42E+00
1976	1	5	1.24E-01	1.76E+00
1977	1	0	0.00E+00	1.98E+01
1977	1	1	3.61E+01	4.15E-01
1977	1	2	1.25E+01	9.40E-01
1977	1	3	5.11E+00	1.84E+00
1977	1	4	5.36E+00	1.42E+00
1977	1	5	2.26E+00	1.76E+00
1978	1	0	2.30E-02	2.33E-01
1978	1	1	1.72E+01	4.85E-01
1978	1	2	4.08E+01	8.95E-01
1978	1	3	6.80E-01	1.33E+00
1978	1	4	5.55E-01	1.56E+00
1978	1	5	1.00E-04	1.53E+00
1979	1	0	0.00E+00	1.98E-01
1979	1	1	1.17E+02	3.23E-01
1979	1	2	1.70E+01	9.13E-01
1979	1	3	2.31E+01	1.22E+00
1979	1	4	5.00E-01	1.74E+00
1979	1	5	9.18E-01	2.08E+00
1980	1	0	9.62E-01	2.38E-01
1980	1	1	3.10E-01	4.18E-01
1980	1	2	9.99E+01	7.70E-01
1980	1	3	1.27E+01	1.03E+00
1980	1	4	1.02E+01	1.40E+00
1980	1	5	2.83E-01	2.02E+00
1981	1	0	8.69E-01	2.53E-01
1981	1	1	2.66E+01	3.80E-01
1981	1	2	4.10E+00	6.83E-01
1981	1	3	8.12E+01	9.80E-01
1981	1	4	6.24E+00	1.03E+00
1981	1	5	4.48E+00	1.57E+00
1982	1	0	2.41E-01	2.03E-01
1982	1	1	6.56E+00	3.31E-01
1982	1	2	3.34E+01	6.10E-01
1982	1	3	7.25E+00	8.63E-01
1982	1	4	4.35E+01	1.63E+00
1982	1	5	3.74E+00	1.39E+00
1983	1	0	2.76E-01	1.73E-01
1983	1	1	1.85E+00	3.40E-01
1983	1	2	3.13E+01	5.88E-01
1983	1	3	3.42E+01	7.75E-01
1983	1	4	6.00E+00	9.43E-01
1983	1	5	2.27E+01	1.09E+00
1984	1	0	4.94E-01	1.93E-01
1984	1	1	1.73E-01	4.39E-01
1984	1	2	4.70E+00	6.23E-01
1984	1	3	4.76E+01	7.90E-01
1984	1	4	3.28E+01	1.01E+00
1984	1	5	2.05E+01	1.24E+00
1985	1	0	0.00E+00	1.98E-01
1985	1	1	1.40E+01	4.46E-01
1985	1	2	2.72E+00	6.91E-01
1985	1	3	1.35E+01	9.00E-01
1985	1	4	5.22E+01	9.83E-01
1985	1	5	1.71E+01	1.34E+00
1986	1	0	3.71E+00	2.73E-01
1986	1	1	2.75E+01	4.58E-01
1986	1	2	1.98E+01	7.85E-01
1986	1	3	5.31E+00	1.02E+00
1986	1	4	1.36E+01	1.11E+00
1986	1	5	4.92E+01	1.21E+00
1987	1	0	2.94E+00	2.43E-01
1987	1	1	5.72E+01	4.95E-01
1987	1	2	3.43E+01	7.73E-01
1987	1	3	9.03E+00	9.98E-01
1987	1	4	3.70E+00	1.22E+00
1987	1	5	2.12E+01	1.47E+00
1988	1	0	2.89E+01	1.98E-01
1988	1	1	2.34E+01	4.90E-01
1988	1	2	5.33E+01	8.00E-01
1988	1	3	2.38E+01	1.10E+00
1988	1	4	4.10E+00	1.33E+00
1988	1	5	1.21E+01	1.61E+00
1989	1	0	5.18E+00	2.08E-01
1989	1	1	2.00E+02	3.23E-01
1989	1	2	9.79E+00	6.65E-01
1989	1	3	1.33E+01	1.02E+00
1989	1	4	6.76E+00	1.44E+00
1989	1	5	1.22E+01	1.69E+00
1990	1	0	1.29E+01	1.70E-01
1990	1	1	3.74E+01	4.85E-01
1990	1	2	6.82E+01	6.90E-01

1990	1	3	1.38E+01	1.05E+00
1990	1	4	1.72E+01	1.30E+00
1990	1	5	4.16E+01	1.61E+00
1991	1	0	1.42E+01	1.58E-01
1991	1	1	4.07E+01	4.18E-01
1991	1	2	7.42E+00	7.85E-01
1991	1	3	1.75E+01	9.70E-01
1991	1	4	1.04E+01	1.24E+00
1991	1	5	3.10E+01	1.63E+00
1992	1	0	2.20E+00	1.93E-01
1992	1	1	1.82E+01	4.08E-01
1992	1	2	5.81E+01	5.05E-01
1992	1	3	2.19E+01	9.18E-01
1992	1	4	1.62E+01	1.08E+00
1992	1	5	1.44E+01	1.41E+00
1993	1	0	2.05E+00	1.83E-01
1993	1	1	9.20E+00	3.38E-01
1993	1	2	1.85E+01	5.40E-01
1993	1	3	5.44E+00	8.60E-01
1993	1	4	5.60E+00	1.19E+00
1993	1	5	1.22E+01	1.42E+00
1994	1	0	5.57E+00	2.13E-01
1994	1	1	7.72E+01	3.00E-01
1994	1	2	1.28E+01	5.42E-01
1994	1	3	8.66E+00	8.84E-01
1994	1	4	6.29E+00	1.11E+00
1994	1	5	7.97E+00	1.46E+00
1995	1	0	1.13E+01	2.10E-01
1995	1	1	3.34E+01	3.09E-01
1995	1	2	2.25E+01	4.45E-01
1995	1	3	5.09E+00	7.64E-01
1995	1	4	1.93E+00	9.73E-01
1995	1	5	4.41E+00	1.43E+00
1996	1	0	7.88E+00	2.48E-01
1996	1	1	5.32E+01	2.70E-01
1996	1	2	1.24E+01	5.35E-01
1996	1	3	4.70E+00	8.93E-01
1996	1	4	2.83E+00	1.17E+00
1996	1	5	3.54E+00	1.34E+00
1997	1	0	6.25E-01	3.41E-01
1997	1	1	3.01E+01	3.47E-01
1997	1	2	2.23E+01	5.55E-01
1997	1	3	1.11E+01	8.76E-01
1997	1	4	8.48E+00	1.14E+00
1997	1	5	2.11E+01	1.47E+00

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survey data:
number of surveys in data file
12
name of survey
'FISHSPOTTER '
number observations this survey
34

1963	1	0.00E+00	1.01E-01	5.87E-01
1964	1	0.00E+00	7.72E-02	8.02E-01
1965	1	0.00E+00	4.62E-02	9.44E-01
1966	1	0.00E+00	6.25E-02	1.06E+00
1967	1	0.00E+00	3.96E-03	1.86E+00
1968	1	0.00E+00	1.35E-02	1.49E+00
1969	1	0.00E+00	3.89E-02	1.80E+00
1970	1	0.00E+00	8.09E-02	1.82E+00
1971	1	0.00E+00	2.89E-02	1.65E+00
1972	1	0.00E+00	8.31E-03	1.73E+00
1973	1	0.00E+00	1.46E-01	1.92E+00
1975	1	0.00E+00	9.72E-03	1.94E+00
1976	1	0.00E+00	1.63E-01	1.28E+00
1977	1	0.00E+00	2.15E+00	7.60E-01
1978	1	0.00E+00	1.00E+01	6.23E-01
1979	1	0.00E+00	4.63E+00	6.71E-01
1980	1	0.00E+00	6.86E+00	6.55E-01
1981	1	0.00E+00	6.12E+00	6.25E-01
1982	1	0.00E+00	9.01E+00	6.35E-01
1983	1	0.00E+00	4.64E+00	7.12E-01
1984	1	0.00E+00	8.47E+00	7.46E-01
1985	1	0.00E+00	5.05E+00	7.13E-01
1986	1	0.00E+00	2.72E+00	7.59E-01
1987	1	0.00E+00	2.22E+00	7.29E-01
1988	1	0.00E+00	2.08E+00	8.38E-01
1989	1	0.00E+00	6.63E-01	1.06E+00
1990	1	0.00E+00	7.86E-01	8.12E-01
1991	1	0.00E+00	1.04E+00	8.05E-01
1992	1	0.00E+00	2.71E-01	1.39E+00
1993	1	0.00E+00	2.80E-01	1.35E+00
1994	1	0.00E+00	5.05E-01	1.13E+00
1995	1	0.00E+00	3.41E-01	1.47E+00
1996	1	0.00E+00	8.93E-01	1.54E+00
1997	1	0.00E+00	4.80E-01	1.73E+00

name of survey
'SCALCPFV' '
number observations this survey
55

1936	1	0.00E+00	2.21E+00	1.81E+00
1937	1	0.00E+00	1.68E+00	1.57E+00
1938	1	0.00E+00	2.82E+00	1.64E+00
1939	1	0.00E+00	3.34E+00	1.56E+00
1940	1	0.00E+00	2.36E+00	1.52E+00
1947	1	0.00E+00	1.41E+00	1.16E+00

1948	1	0.00E+00	1.81E+00	1.07E+00
1949	1	0.00E+00	9.68E-01	1.08E+00
1950	1	0.00E+00	5.30E-01	1.07E+00
1951	1	0.00E+00	2.94E-01	1.09E+00
1952	1	0.00E+00	3.95E-01	1.12E+00
1953	1	0.00E+00	5.78E-01	1.16E+00
1954	1	0.00E+00	1.99E+00	1.01E+00
1955	1	0.00E+00	1.45E+00	9.78E-01
1956	1	0.00E+00	8.74E-01	1.05E+00
1957	1	0.00E+00	1.22E+00	1.01E+00
1958	1	0.00E+00	1.61E+00	1.01E+00
1959	1	0.00E+00	1.18E+00	1.04E+00
1960	1	0.00E+00	8.55E-01	1.07E+00
1961	1	0.00E+00	1.77E+00	9.78E-01
1962	1	0.00E+00	9.75E-01	1.03E+00
1963	1	0.00E+00	9.09E-01	1.01E+00
1964	1	0.00E+00	8.08E-01	9.81E-01
1965	1	0.00E+00	9.14E-01	1.03E+00
1966	1	0.00E+00	1.56E+00	9.24E-01
1967	1	0.00E+00	8.28E-01	9.99E-01
1968	1	0.00E+00	5.34E-01	9.88E-01
1969	1	0.00E+00	5.66E-01	1.00E+00
1970	1	0.00E+00	6.81E-01	1.03E+00
1971	1	0.00E+00	1.60E+00	1.00E+00
1972	1	0.00E+00	1.14E+00	9.99E-01
1973	1	0.00E+00	4.71E-01	1.05E+00
1974	1	0.00E+00	2.38E-01	1.16E+00
1975	1	0.00E+00	7.27E-01	1.05E+00
1976	1	0.00E+00	4.70E-01	1.00E+00
1977	1	0.00E+00	3.84E+00	8.46E-01
1978	1	0.00E+00	6.48E+00	7.81E-01
1980	1	0.00E+00	1.00E+01	7.16E-01
1981	1	0.00E+00	7.49E+00	7.14E-01
1982	1	0.00E+00	6.35E+00	7.18E-01
1983	1	0.00E+00	6.28E+00	7.38E-01
1984	1	0.00E+00	8.06E+00	7.48E-01
1985	1	0.00E+00	8.44E+00	7.62E-01
1986	1	0.00E+00	7.80E+00	7.72E-01
1987	1	0.00E+00	6.17E+00	7.94E-01
1988	1	0.00E+00	4.00E+00	7.93E-01
1989	1	0.00E+00	4.52E+00	8.35E-01
1990	1	0.00E+00	5.13E+00	7.93E-01
1991	1	0.00E+00	6.11E+00	7.96E-01
1992	1	0.00E+00	5.58E+00	8.08E-01
1993	1	0.00E+00	5.84E+00	8.04E-01
1994	1	0.00E+00	4.91E+00	8.12E-01
1995	1	0.00E+00	4.09E+00	7.80E-01
1996	1	0.00E+00	4.58E+00	7.64E-01
1997	1	0.00E+00	2.90E+00	7.80E-01

name of survey
'NCALCPFV '
number observations this survey
41

1957	1	0.00E+00	9.18E-01	7.47E-01
1958	1	0.00E+00	5.16E-01	9.50E-01
1959	1	0.00E+00	3.02E-01	9.89E-01
1960	1	0.00E+00	4.41E-01	1.21E+00
1961	1	0.00E+00	5.45E-01	9.48E-01
1962	1	0.00E+00	2.75E-01	1.04E+00
1963	1	0.00E+00	3.59E-01	1.12E+00
1964	1	0.00E+00	3.85E-01	1.10E+00
1965	1	0.00E+00	3.35E-01	1.21E+00
1966	1	0.00E+00	2.86E-01	1.65E+00
1967	1	0.00E+00	1.74E-01	1.80E+00
1968	1	0.00E+00	2.18E-01	3.00E+01
1969	1	0.00E+00	6.37E-02	1.75E+00
1970	1	0.00E+00	4.58E-02	1.27E+00
1971	1	0.00E+00	2.28E-01	1.77E+00
1972	1	0.00E+00	9.57E-02	4.18E+00
1973	1	0.00E+00	1.26E-01	1.25E+00
1974	1	0.00E+00	2.75E-01	2.59E+00
1975	1	0.00E+00	1.99E-01	3.00E+01
1976	1	0.00E+00	8.13E-02	2.82E+00
1977	1	0.00E+00	3.17E-01	2.70E+01
1978	1	0.00E+00	4.46E-01	1.08E+00
1979	1	0.00E+00	8.64E-01	1.38E+00
1980	1	0.00E+00	5.79E+00	4.30E-01
1981	1	0.00E+00	7.38E+00	3.09E-01
1982	1	0.00E+00	4.12E+00	4.31E-01
1983	1	0.00E+00	6.99E+00	3.28E-01
1984	1	0.00E+00	1.00E+01	3.93E-01
1985	1	0.00E+00	3.29E+00	5.42E-01
1986	1	0.00E+00	1.16E+00	6.10E-01
1987	1	0.00E+00	1.35E+00	8.48E-01
1988	1	0.00E+00	1.35E+00	8.50E-01
1989	1	0.00E+00	1.24E+00	7.86E-01
1990	1	0.00E+00	1.09E+00	7.30E-01
1991	1	0.00E+00	8.95E-01	1.04E+00
1992	1	0.00E+00	2.28E+00	6.98E-01
1993	1	0.00E+00	1.63E+00	1.00E+00
1994	1	0.00E+00	1.27E+00	8.49E-01
1995	1	0.00E+00	1.29E+00	1.19E+00
1996	1	0.00E+00	9.66E-01	1.68E+00
1997	1	0.00E+00	4.42E+00	6.39E-01

name of survey
'US.Lar.Dens '
number observations this survey
35

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1951      1          0.00E+00  3.56E+00  9.52E-01
1952      1          0.00E+00  3.40E+00  8.57E-01
1953      1          0.00E+00  3.26E+00  7.94E-01
1954      1          0.00E+00  3.73E+00  8.57E-01
1955      1          0.00E+00  3.50E+00  9.37E-01
1956      1          0.00E+00  3.33E+00  8.89E-01
1957      1          0.00E+00  3.25E+00  9.05E-01
1958      1          0.00E+00  4.08E+00  7.94E-01
1959      1          0.00E+00  3.60E+00  7.62E-01
1960      1          0.00E+00  3.46E+00  8.73E-01
1961      1          0.00E+00  3.53E+00  1.19E+00
1962      1          0.00E+00  3.45E+00  1.27E+00
1963      1          0.00E+00  3.80E+00  1.11E+00
1964      1          0.00E+00  3.32E+00  8.89E-01
1965      1          0.00E+00  3.81E+00  9.05E-01
1966      1          0.00E+00  3.60E+00  7.94E-01
1967      1          0.00E+00  3.00E+00  1.62E+00
1968      1          0.00E+00  3.04E+00  1.56E+00
1969      1          0.00E+00  3.47E+00  9.05E-01
1972      1          0.00E+00  3.34E+00  1.35E+00
1975      1          0.00E+00  2.98E+00  9.68E-01
1978      1          0.00E+00  5.71E+00  8.73E-01
1981      1          0.00E+00  1.00E+01  9.37E-01
1984      1          0.00E+00  3.82E+00  1.00E+00
1985      1          0.00E+00  4.60E+00  1.25E+00
1986      1          0.00E+00  5.71E+00  1.30E+00
1987      1          0.00E+00  4.21E+00  1.22E+00
1988      1          0.00E+00  4.58E+00  1.22E+00
1989      1          0.00E+00  4.09E+00  1.16E+00
1990      1          0.00E+00  3.49E+00  1.22E+00
1991      1          0.00E+00  3.92E+00  1.44E+00
1992      1          0.00E+00  3.66E+00  1.10E+00
1993      1          0.00E+00  4.37E+00  1.22E+00
1994      1          0.00E+00  3.73E+00  1.35E+00
1995      1          0.00E+00  4.32E+00  1.19E+00
 name of survey
 'US.Prop.Pos '
 number observations this survey
42
1951      1          0.00E+00  1.36E+00  9.62E-01
1952      1          0.00E+00  6.17E-01  1.00E+00
1953      1          0.00E+00  1.45E-01  1.43E+00
1954      1          0.00E+00  1.68E+00  8.49E-01
1955      1          0.00E+00  7.90E-01  1.00E+00
1956      1          0.00E+00  3.04E-01  1.25E+00
1957      1          0.00E+00  1.95E-01  1.43E+00
1958      1          0.00E+00  2.60E+00  7.92E-01
1959      1          0.00E+00  1.38E+00  8.49E-01
1960      1          0.00E+00  4.74E-01  1.08E+00
1961      1          0.00E+00  6.77E-01  1.26E+00
1962      1          0.00E+00  5.34E-01  1.45E+00
1963      1          0.00E+00  1.95E+00  9.06E-01
1964      1          0.00E+00  1.02E-01  1.91E+00
1965      1          0.00E+00  1.54E+00  9.43E-01
1966      1          0.00E+00  1.13E+00  8.87E-01
1967      1          0.00E+00  6.59E-04  2.31E+01
1968      1          0.00E+00  6.59E-04  2.26E+01
1969      1          0.00E+00  5.36E-01  1.13E+00
1972      1          0.00E+00  2.42E-01  1.91E+00
1974      1          0.00E+00  3.39E-02  2.34E+01
1975      1          0.00E+00  1.19E-03  7.79E+00
1978      1          0.00E+00  3.88E+00  7.74E-01
1979      1          0.00E+00  2.64E-03  1.20E+01
1980      1          0.00E+00  2.50E-03  1.18E+01
1981      1          0.00E+00  1.00E+01  7.17E-01
1982      1          0.00E+00  8.43E-03  1.82E+01
1983      1          0.00E+00  7.38E-03  1.66E+01
1984      1          0.00E+00  1.10E+00  9.43E-01
1985      1          0.00E+00  3.84E+00  8.87E-01
1986      1          0.00E+00  7.00E+00  8.49E-01
1987      1          0.00E+00  9.59E+00  8.11E-01
1988      1          0.00E+00  7.84E+00  7.92E-01
1989      1          0.00E+00  3.37E+00  8.68E-01
1990      1          0.00E+00  4.31E-01  1.45E+00
1991      1          0.00E+00  3.60E+00  9.25E-01
1992      1          0.00E+00  2.28E+00  8.87E-01
1993      1          0.00E+00  3.87E+00  9.06E-01
1994      1          0.00E+00  1.18E+00  1.08E+00
1995      1          0.00E+00  2.37E+00  9.06E-01
1996      1          0.00E+00  4.01E+00  8.68E-01
1997      1          0.00E+00  1.85E-03  1.04E+01
 name of survey
 'MX.Lar.Dens '
 number observations this survey
24
1951      1          5.00E-01  4.08E+00  1.01E+00
1952      1          5.00E-01  2.91E+00  8.06E-01
1953      1          5.00E-01  4.84E+00  9.35E-01
1954      1          5.00E-01  5.48E+00  9.87E-01
1955      1          5.00E-01  4.39E+00  1.17E+00
1956      1          5.00E-01  3.76E+00  8.97E-01
1957      1          5.00E-01  7.40E+00  8.77E-01
1958      1          5.00E-01  2.96E+00  8.84E-01
1959      1          5.00E-01  3.52E+00  8.32E-01
1960      1          5.00E-01  3.31E+00  8.77E-01
1961      1          5.00E-01  3.53E+00  1.12E+00
1962      1          5.00E-01  1.00E+01  1.21E+00
1963      1          5.00E-01  8.41E+00  1.04E+00
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1964     1        5.00E-01  3.96E+00  1.01E+00
1965     1        5.00E-01  4.11E+00  8.26E-01
1966     1        5.00E-01  4.27E+00  7.87E-01
1967     1        5.00E-01  4.59E+00  1.15E+00
1969     1        5.00E-01  3.16E+00  8.65E-01
1972     1        5.00E-01  2.98E+00  1.12E+00
1975     1        5.00E-01  2.54E+00  1.03E+00
1978     1        5.00E-01  3.94E+00  9.42E-01
1981     1        5.00E-01  8.34E+00  1.26E+00
1984     1        5.00E-01  3.69E+00  1.60E+00
1996     1        5.00E-01  2.87E+00  1.25E+00
 name of survey
 'MX.Prop.Pos '
 number observations this survey
24
1951     1        5.00E-01  3.98E+00  1.01E+00
1952     1        5.00E-01  1.49E+00  8.06E-01
1953     1        5.00E-01  6.83E+00  9.35E-01
1954     1        5.00E-01  7.53E+00  9.87E-01
1955     1        5.00E-01  4.71E+00  1.17E+00
1956     1        5.00E-01  2.58E+00  8.97E-01
1957     1        5.00E-01  8.55E+00  8.77E-01
1958     1        5.00E-01  1.42E+00  8.84E-01
1959     1        5.00E-01  3.39E+00  8.32E-01
1960     1        5.00E-01  3.03E+00  8.77E-01
1961     1        5.00E-01  3.01E+00  1.12E+00
1962     1        5.00E-01  1.00E+01  1.21E+00
1963     1        5.00E-01  8.46E+00  1.04E+00
1964     1        5.00E-01  5.16E+00  1.01E+00
1965     1        5.00E-01  4.66E+00  8.26E-01
1966     1        5.00E-01  5.06E+00  7.87E-01
1967     1        5.00E-01  4.83E+00  1.15E+00
1969     1        5.00E-01  1.47E+00  8.65E-01
1972     1        5.00E-01  7.90E-01  1.12E+00
1975     1        5.00E-01  2.78E-01  1.03E+00
1978     1        5.00E-01  2.87E+00  9.42E-01
1981     1        5.00E-01  9.37E+00  1.26E+00
1984     1        5.00E-01  1.96E+00  1.60E+00
1996     1        5.00E-01  1.97E+00  1.25E+00
 name of survey
 'SoCalEdImpi '
 number observations this survey
10
1986     1        0.00E+00  4.59E+00  4.73E-01
1987     1        0.00E+00  1.00E+01  7.62E-01
1988     1        0.00E+00  2.35E+00  5.35E-01
1989     1        0.00E+00  1.31E+00  5.03E-01
1990     1        0.00E+00  1.63E-01  1.05E+00
1991     1        0.00E+00  1.60E+00  1.00E+00
1992     1        0.00E+00  1.14E+00  9.98E-01
1993     1        0.00E+00  1.71E+00  1.58E+00
1994     1        0.00E+00  1.50E-01  1.80E+01
1995     1        0.00E+00  1.82E+00  3.58E+00
 name of survey
 'TRIENNIAL   '
 number observations this survey
3
1989     1        0.00E+00  4.09E+00  1.00E+00
1992     1        0.00E+00  1.00E+01  1.00E+00
1995     1        0.00E+00  7.46E+00  1.00E+00
 name of survey
 'SCCPFVearly''
 number observations this survey
35
1936     1        0.00E+00  2.21E+00  1.81E+00
1937     1        0.00E+00  1.68E+00  1.57E+00
1938     1        0.00E+00  2.82E+00  1.64E+00
1939     1        0.00E+00  3.34E+00  1.56E+00
1940     1        0.00E+00  2.36E+00  1.52E+00
1947     1        0.00E+00  1.41E+00  1.16E+00
1948     1        0.00E+00  1.81E+00  1.07E+00
1949     1        0.00E+00  9.68E-01  1.08E+00
1950     1        0.00E+00  5.30E-01  1.07E+00
1951     1        0.00E+00  2.94E-01  1.09E+00
1952     1        0.00E+00  3.95E-01  1.12E+00
1953     1        0.00E+00  5.78E-01  1.16E+00
1954     1        0.00E+00  1.99E+00  1.01E+00
1955     1        0.00E+00  1.45E+00  9.78E-01
1956     1        0.00E+00  8.74E-01  1.05E+00
1957     1        0.00E+00  1.22E+00  1.01E+00
1958     1        0.00E+00  1.61E+00  1.01E+00
1959     1        0.00E+00  1.18E+00  1.04E+00
1960     1        0.00E+00  8.55E-01  1.07E+00
1961     1        0.00E+00  1.77E+00  9.78E-01
1962     1        0.00E+00  9.75E-01  1.03E+00
1963     1        0.00E+00  9.09E-01  1.01E+00
1964     1        0.00E+00  8.08E-01  9.81E-01
1965     1        0.00E+00  9.14E-01  1.03E+00
1966     1        0.00E+00  1.56E+00  9.24E-01
1967     1        0.00E+00  8.28E-01  9.99E-01
1968     1        0.00E+00  5.34E-01  9.88E-01
1969     1        0.00E+00  5.66E-01  1.00E+00
1970     1        0.00E+00  6.81E-01  1.03E+00
1971     1        0.00E+00  1.60E+00  1.00E+00
1972     1        0.00E+00  1.14E+00  9.99E-01
1973     1        0.00E+00  4.71E-01  1.05E+00
1974     1        0.00E+00  2.38E-01  1.16E+00
1975     1        0.00E+00  7.27E-01  1.05E+00
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1976        1          0.00E+00  4.70E-01  1.00E+00
 name of survey
 'SCCPFVlate' '
 number observations this survey
20
1977        1          0.00E+00  3.84E+00  8.46E-01
1978        1          0.00E+00  6.48E+00  7.81E-01
1980        1          0.00E+00  1.00E+01  7.16E-01
1981        1          0.00E+00  7.49E+00  7.14E-01
1982        1          0.00E+00  6.35E+00  7.18E-01
1983        1          0.00E+00  6.28E+00  7.38E-01
1984        1          0.00E+00  8.06E+00  7.48E-01
1985        1          0.00E+00  8.44E+00  7.62E-01
1986        1          0.00E+00  7.80E+00  7.72E-01
1987        1          0.00E+00  6.17E+00  7.94E-01
1988        1          0.00E+00  4.00E+00  7.93E-01
1989        1          0.00E+00  4.52E+00  8.35E-01
1990        1          0.00E+00  5.13E+00  7.93E-01
1991        1          0.00E+00  6.11E+00  7.96E-01
1992        1          0.00E+00  5.58E+00  8.08E-01
1993        1          0.00E+00  5.84E+00  8.04E-01
1994        1          0.00E+00  4.91E+00  8.12E-01
1995        1          0.00E+00  4.09E+00  7.80E-01
1996        1          0.00E+00  4.58E+00  7.64E-01
1997        1          0.00E+00  2.90E+00  7.80E-01
```

Approximate standard deviations for surveys calculated
from mean squared residual (used for bootstrapping):

survey name	N obs	stand. dev.
FISHSPOTTER	34	1.05E+00
SCALCPFV'	55	6.37E-01
NCALCPFV	41	7.38E-01
US.Prop.Pos	42	2.93E+00
SoCalEdImpi	10	1.18E+00
TRIENNIAL	3	6.06E-01

Selectivities for FISHSPOTTER

columns ->

row	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Selectivities for SCALCPFV'

columns ->

row	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
0	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003
1	.5001	.5001	.5001	.5001	.5001	.5001	.5001	.5001	.5001	.5001
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

columns ->

row	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003
1	.5001	.3329	.3329	.3329	.3329	.3329	.3329	.3329	.3329
2	1.0000	.6663	.6663	.6663	.6663	.6663	.6663	.6663	.6663
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Selectivities for NCALCPFV

columns ->

row	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	.0137	.0137	.0137	.0137	.0137	.0137	.0137	.0137	.0137
1	.1511	.1511	.1511	.1511	.1511	.1511	.1511	.1511	.1511
2	.5892	.5892	.5892	.5892	.5892	.5892	.5892	.5892	.5892
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Selectivities for US.Prop.Pos

columns ->

row	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0738	.0738	.0738	.0738	.0738	.0738	.0738	.0738	.0738
2	.2459	.2459	.2459	.2459	.2459	.2459	.2459	.2459	.2459
3	.4742	.4742	.4742	.4742	.4742	.4742	.4742	.4742	.4742
4	.7329	.7329	.7329	.7329	.7329	.7329	.7329	.7329	.7329
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Selectivities for SoCalEdImpi

columns ->

row	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	.2019	.2019	.2019	.2019	.2019	.2019	.2019	.2019	.2019
2	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
5	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

Selectivities for TRIENNIAL

columns ->

row	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Age 5 is a plus group and 4 is the last true age.
F for plus group and last true age in last season of each year
computed using Murphy's algorithm.

fishing mortality (seasonal rates) by age and year for season 1
(multiply by 1.000000E+00)

columns ->

row	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0461	.0029	.0011	.0002	.0066	.0220	.1167	.0204	.0054	.0630
2	.1354	.0572	.0252	.0073	.0321	.1425	.0994	.4713	.0348	.2523
3	.1724	.0661	.0635	.0308	.1037	.1128	.3405	.2643	.4188	.5540
4	.2839	.0362	.0226	.0304	.1870	.2785	.4270	.4383	.5031	.7550
5	.2839	.0362	.0226	.0304	.1870	.2785	.4270	.4383	.5031	.7550

columns ->

row	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0688	.1405	.0995	.1146	.1186	.1862	.1527	.3263	.0677	.3145
2	.2357	.6903	.3878	.1354	.3925	.3865	.2331	.6057	1.2636	.2744
3	.5836	1.1074	1.0307	.4676	.2659	.6981	.5320	.6191	1.4857	.4319
4	1.1758	1.7052	1.1854	.8876	.6703	.4881	.6953	.6781	1.6384	.6935
5	1.1758	1.7052	1.1854	.8876	.6703	.4881	.6953	.6781	1.6384	.6935

columns ->

row	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.1613	.2739	.2663	.0120	.0107	.3040	.0703	.5440	.2276	.0278
2	.5109	.2986	.8735	.1958	.2919	.1071	.4646	.4887	.8201	.4779
3	.8850	.4479	.5222	1.3552	.6801	.2799	.4215	.7372	.9094	1.3490
4	1.2272	.7448	1.0976	1.9196	1.3603	.2194	1.0323	.5201	1.5768	1.3772
5	1.2272	.7448	1.0976	1.9196	1.3603	.2194	1.0323	.5201	1.5768	1.3772

columns ->

row	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.4538	.1661	.1662	.2903	.2070	.8370	.2044	.6932	.2254	.8180
2	.1622	.4729	.2798	.1314	.5212	.7461	.2717	.5890	.2272	.7025
3	.1955	.8934	.7269	.3704	.2409	.7221	.8435	.7750	.2128	.7161
4	.7475	1.5531	1.2045	.8072	.8538	.6230	3.5040	1.3078	.4101	1.2233
5	.7475	1.5531	1.2045	.8072	.8538	.6230	3.5040	1.3078	.4101	1.2233

columns ->

row	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.9464	.4646	.0750	.0293	.0078	.0097	.0071	.0263	.0399	.0703
2	1.1485	.5013	.1117	.0387	.0111	.0133	.0148	.0133	.7313	.1987
3	1.2384	.6239	.1407	.0659	.0164	.0206	.0224	.0267	.2458	.2664
4	1.8172	1.3015	.3077	.1274	.0405	.0465	.0537	.0632	7.7554	.1279
5	1.8172	1.3015	.3077	.1274	.0405	.0465	.0537	.0632	7.7554	.1279

columns ->

row	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
0	.0000	.0003	.0001	.0001	.0005	.0006	.0000	.0043	.0060	.0215
1	.0470	.0007	.0158	.0013	.0024	.0005	.0280	.0416	.1050	.0840
2	.1164	.0594	.0179	.0278	.0142	.0100	.0129	.0706	.0832	.1893
3	.2100	.1382	.0947	.0449	.0692	.0361	.0484	.0440	.0519	.1065
4	.4155	.1573	.1415	.0761	.0918	.1180	.0679	.0887	.0486	.0414
5	.4155	.1573	.1415	.0761	.0918	.1180	.0679	.0887	.0486	.0414

columns ->

row	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	.0105	.0191	.0427	.0054	.0063	.0165	.0210	.0201	.0117
1	.2880	.1310	.1123	.0903	.0432	.3906	.1752	.2075	.1296
2	.0634	.2052	.0502	.3029	.1964	.0887	.2572	.1456	.1658
3	.0918	.1626	.1089	.2661	.0642	.1521	.0618	.1245	.2478
4	.0551	.2239	.2643	.1792	.1575	.1123	.0616	.0697	.4646
5	.0551	.2239	.2643	.1792	.1575	.1123	.0616	.0697	.4646

relative vulnerabilities at age by year for season 1

columns ->

row	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.1624	.0434	.0167	.0057	.0352	.0788	.2734	.0433	.0107	.0835
2	.4769	.8646	.3977	.2355	.1719	.5115	.2327	1.0000	.0693	.3342
3	.6071	1.0000	1.0000	1.0000	.5546	.4051	.7976	.5608	.8324	.7338
4	1.0000	.5479	.3569	.9877	1.0000	1.0000	1.0000	.9301	1.0000	1.0000
5	1.0000	.5479	.3569	.9877	1.0000	1.0000	1.0000	.9301	1.0000	1.0000

columns ->

row	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0585	.0824	.0840	.1291	.1769	.2668	.2196	.4811	.0413	.4535
2	.2005	.4048	.3272	.1526	.5855	.5536	.3352	.8932	.7712	.3957
3	.4963	.6494	.8695	.5268	.3967	1.0000	.7652	.9130	.9068	.6228
4	1.0000	1.0000	1.0000	1.0000	1.0000	.6992	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	.6992	1.0000	1.0000	1.0000	1.0000

columns ->

row	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.1314	.3678	.2426	.0062	.0079	1.0000	.0681	.7380	.1444	.0202
2	.4163	.4009	.7958	.1020	.2146	.3523	.4501	.6630	.5201	.3470
3	.7211	.6014	.4757	.7060	.5000	.9209	.4083	1.0000	.5768	.9795
4	1.0000	1.0000	1.0000	1.0000	1.0000	.7218	1.0000	.7056	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	.7218	1.0000	.7056	1.0000	1.0000

columns ->

row	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.6070	.1069	.1380	.3596	.2425	1.0000	.0583	.5301	.5496	.6687
2	.2169	.3045	.2323	.1627	.6105	.8915	.0775	.4504	.5541	.5742
3	.2615	.5753	.6035	.4589	.2822	.8627	.2407	.5926	.5189	.5854
4	1.0000	1.0000	1.0000	1.0000	1.0000	.7443	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	.7443	1.0000	1.0000	1.0000	1.0000

columns ->

row	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.5208	.3569	.2438	.2296	.1934	.2086	.1323	.4164	.0051	.2639
2	.6320	.3852	.3629	.3037	.2752	.2870	.2755	.2103	.0943	.7460
3	.6815	.4794	.4573	.5173	.4053	.4437	.4169	.4223	.0317	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.4802
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.4802

columns ->

row	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
0	.0000	.0020	.0009	.0018	.0053	.0051	.0000	.0482	.0574	.1137
1	.1130	.0047	.1115	.0169	.0263	.0042	.4118	.4687	1.0000	.4437
2	.2801	.3780	.1266	.3660	.1551	.0850	.1898	.7955	.7923	1.0000
3	.5053	.8789	.6693	.5906	.7532	.3058	.7128	.4959	.4941	.5623
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.4624	.2187
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.4624	.2187

columns ->

row	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	.0363	.0852	.1615	.0179	.0319	.0422	.0816	.0967	.0252
1	1.0000	.5851	.4248	.2983	.2198	1.0000	.6813	1.0000	.2789
2	.2203	.9163	.1899	1.0000	1.0000	.2270	1.0000	.7015	.3568
3	.3188	.7259	.4122	.8784	.3270	.3895	.2405	.5999	.5334
4	.1913	1.0000	1.0000	.5916	.8020	.2875	.2394	.3358	1.0000
5	.1913	1.0000	1.0000	.5916	.8020	.2875	.2394	.3358	1.0000

abundance (n fish) by age and year for season 1
(multiply by 1.000000E+00)

columns ->

row	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
0	1312.	1794.	2009.	1429.	485.	211.	237.	510.	409.	703.
1	364.	796.	1088.	1219.	867.	294.	128.	144.	309.	248.
2	233.	211.	481.	659.	739.	522.	175.	69.	85.	186.
3	173.	123.	121.	285.	397.	434.	275.	96.	26.	50.
4	28.	88.	70.	69.	167.	217.	235.	118.	45.	10.
5	47.	34.	71.	84.	90.	129.	159.	156.	107.	56.

columns ->

row	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948
0	462.	395.	810.	296.	263.	270.	84.	68.	687.	366.
1	426.	280.	239.	491.	179.	160.	164.	51.	41.	416.
2	141.	241.	148.	131.	266.	97.	80.	85.	22.	24.
3	88.	68.	73.	61.	70.	109.	40.	39.	28.	4.
4	17.	30.	14.	16.	23.	32.	33.	14.	13.	4.
5	19.	7.	4.	3.	5.	9.	15.	15.	9.	3.

columns ->

row	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
0	41.	17.	11.	216.	514.	215.	369.	74.	109.	352.
1	222.	25.	10.	6.	131.	312.	131.	224.	45.	66.
2	184.	115.	11.	5.	4.	79.	139.	74.	79.	22.
3	11.	67.	52.	3.	2.	2.	43.	53.	27.	21.
4	2.	3.	26.	19.	0.	1.	1.	17.	15.	7.
5	2.	1.	1.	5.	2.	0.	1.	0.	6.	3.

columns ->

row	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
0	300.	484.	262.	45.	27.	15.	16.	9.	8.	5.
1	213.	182.	293.	159.	27.	16.	9.	10.	6.	5.
2	39.	82.	93.	151.	72.	13.	4.	4.	3.	3.
3	8.	20.	31.	43.	80.	26.	4.	2.	1.	1.
4	3.	4.	5.	9.	18.	38.	8.	1.	1.	1.
5	1.	1.	1.	1.	3.	5.	14.	0.	0.	0.

columns ->

row	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
0	3.	4.	6.	12.	23.	57.	36.	822.	538.	5000.
1	3.	2.	2.	4.	7.	14.	35.	22.	498.	326.
2	1.	1.	1.	1.	2.	4.	8.	21.	13.	290.
3	1.	0.	0.	0.	1.	1.	3.	5.	13.	4.
4	0.	0.	0.	0.	0.	0.	1.	2.	3.	6.
5	0.	0.	0.	0.	0.	0.	0.	1.	1.	0.

columns ->

row	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
0	703.	3138.	7887.	1657.	738.	1069.	1470.	1147.	593.	1672.
1	3033.	427.	1903.	4783.	1005.	448.	648.	892.	693.	357.
2	185.	1755.	259.	1136.	2898.	608.	271.	382.	519.	378.
3	144.	100.	1003.	154.	670.	1733.	365.	163.	216.	290.
4	2.	71.	53.	553.	89.	379.	1014.	211.	94.	124.
5	3.	2.	38.	48.	338.	236.	332.	762.	540.	367.

columns ->

row	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	625.	846.	448.	505.	461.	401.	634.	530.	69.
1	993.	375.	503.	260.	305.	278.	240.	376.	315.
2	199.	451.	200.	273.	144.	177.	114.	122.	185.
3	190.	113.	223.	115.	122.	72.	98.	53.	64.
4	158.	105.	58.	121.	54.	70.	37.	56.	29.
5	286.	255.	174.	108.	116.	88.	85.	70.	71.

Egg production/spawning biomass summary by year for season 1
(elapsed time in season .500).

idx	year	egg production or spwn. biom.
1	1929	5.04E+01
2	1930	8.47E+01
3	1931	1.13E+02
4	1932	1.51E+02
5	1933	1.68E+02
6	1934	1.64E+02
7	1935	1.29E+02
8	1936	8.84E+01
9	1937	5.85E+01
10	1938	4.14E+01

11	1939	3.32E+01
12	1940	2.29E+01
13	1941	2.14E+01
14	1942	2.53E+01
15	1943	3.25E+01
16	1944	3.23E+01
17	1945	2.56E+01
18	1946	1.86E+01
19	1947	8.13E+00
20	1948	7.45E+00
21	1949	1.15E+01
22	1950	1.42E+01
23	1951	1.15E+01
24	1952	4.33E+00
25	1953	2.80E+00
26	1954	8.40E+00
27	1955	1.30E+01
28	1956	1.56E+01
29	1957	1.05E+01
30	1958	5.24E+00
31	1959	6.98E+00
32	1960	9.36E+00
33	1961	1.31E+01
34	1962	2.11E+01
35	1963	2.46E+01
36	1964	1.75E+01
37	1965	2.52E+00
38	1966	8.83E-01
39	1967	7.28E-01
40	1968	5.97E-01
41	1969	2.80E-01
42	1970	1.38E-01
43	1971	1.64E-01
44	1972	2.79E-01
45	1973	5.28E-01
46	1974	1.02E+00
47	1975	2.13E+00
48	1976	3.86E+00
49	1977	1.01E+01
50	1978	2.94E+01
51	1979	7.26E+01
52	1980	1.73E+02
53	1981	2.43E+02
54	1982	4.02E+02
55	1983	4.19E+02
56	1984	4.96E+02
57	1985	5.25E+02
58	1986	4.74E+02
59	1987	4.16E+02
60	1988	3.58E+02
61	1989	3.00E+02
62	1990	2.28E+02
63	1991	1.72E+02
64	1992	1.19E+02
65	1993	1.04E+02
66	1994	8.93E+01
67	1995	7.55E+01
68	1996	6.98E+01
69	1997	6.05E+01

Abundance/biomass summary for season 1 (elapsed time = .000).
The first age group in the summary is 1 and the last age group is 5.

idx	year	abundance	biomass
1	1929	7.97E+02	2.36E+02
2	1930	1.25E+03	3.21E+02
3	1931	1.83E+03	4.25E+02
4	1932	2.32E+03	5.23E+02
5	1933	2.26E+03	5.22E+02
6	1934	1.60E+03	4.51E+02
7	1935	9.71E+02	3.25E+02
8	1936	5.83E+02	2.17E+02
9	1937	5.73E+02	1.84E+02
10	1938	5.51E+02	1.78E+02
11	1939	6.92E+02	1.95E+02
12	1940	6.26E+02	1.75E+02
13	1941	4.78E+02	1.51E+02
14	1942	7.03E+02	1.79E+02
15	1943	5.43E+02	1.74E+02
16	1944	4.06E+02	1.47E+02
17	1945	3.32E+02	1.09E+02
18	1946	2.04E+02	7.59E+01
19	1947	1.13E+02	4.83E+01
20	1948	4.50E+02	8.82E+01
21	1949	4.21E+02	9.66E+01
22	1950	2.10E+02	6.69E+01
23	1951	1.00E+02	4.19E+01
24	1952	3.81E+01	2.06E+01
25	1953	1.40E+02	3.33E+01
26	1954	3.93E+02	8.41E+01
27	1955	3.14E+02	8.16E+01
28	1956	3.68E+02	1.02E+02
29	1957	1.73E+02	6.20E+01
30	1958	1.18E+02	3.55E+01
31	1959	2.65E+02	6.53E+01
32	1960	2.90E+02	7.56E+01

33	1961	4.23E+02	1.08E+02
34	1962	3.62E+02	1.26E+02
35	1963	2.00E+02	9.77E+01
36	1964	9.90E+01	5.41E+01
37	1965	3.89E+01	1.93E+01
38	1966	1.75E+01	5.44E+00
39	1967	1.07E+01	3.31E+00
40	1968	1.02E+01	3.48E+00
41	1969	5.56E+00	2.18E+00
42	1970	2.75E+00	8.69E-01
43	1971	3.12E+00	9.01E-01
44	1972	5.42E+00	1.54E+00
45	1973	1.03E+01	2.91E+00
46	1974	2.00E+01	5.64E+00
47	1975	4.68E+01	1.36E+01
48	1976	4.97E+01	1.75E+01
49	1977	5.28E+02	1.24E+02
50	1978	6.27E+02	2.16E+02
51	1979	3.37E+03	6.66E+02
52	1980	2.35E+03	8.68E+02
53	1981	3.25E+03	9.98E+02
54	1982	6.67E+03	1.69E+03
55	1983	5.00E+03	1.51E+03
56	1984	3.40E+03	1.31E+03
57	1985	2.63E+03	1.12E+03
58	1986	2.41E+03	1.01E+03
59	1987	2.06E+03	9.33E+02
60	1988	1.52E+03	7.77E+02
61	1989	1.83E+03	6.78E+02
62	1990	1.30E+03	5.79E+02
63	1991	1.16E+03	4.69E+02
64	1992	8.78E+02	3.17E+02
65	1993	7.41E+02	2.58E+02
66	1994	6.84E+02	2.24E+02
67	1995	5.75E+02	1.79E+02
68	1996	6.78E+02	1.87E+02
69	1997	6.64E+02	2.03E+02

Abundance/biomass summary for season 1 (elapsed time = .500).
The first age group in the summary is 1 and the last age group is 5.

idx	year	abundance	biomass
1	1929	5.88E+02	1.72E+02
2	1930	9.65E+02	2.46E+02
3	1931	1.42E+03	3.28E+02
4	1932	1.80E+03	4.04E+02
5	1933	1.71E+03	3.89E+02
6	1934	1.16E+03	3.22E+02
7	1935	6.52E+02	2.14E+02
8	1936	3.90E+02	1.42E+02
9	1937	4.14E+02	1.27E+02
10	1938	3.80E+02	1.17E+02
11	1939	4.86E+02	1.29E+02
12	1940	3.79E+02	1.00E+02
13	1941	3.14E+02	9.47E+01
14	1942	5.04E+02	1.25E+02
15	1943	3.65E+02	1.16E+02
16	1944	2.60E+02	9.15E+01
17	1945	2.24E+02	7.03E+01
18	1946	1.21E+02	4.41E+01
19	1947	5.83E+01	2.19E+01
20	1948	2.99E+02	5.82E+01
21	1949	2.78E+02	6.15E+01
22	1950	1.37E+02	4.34E+01
23	1951	5.59E+01	2.28E+01
24	1952	1.67E+01	7.98E+00
25	1953	1.07E+02	2.47E+01
26	1954	2.69E+02	5.83E+01
27	1955	2.12E+02	5.36E+01
28	1956	2.17E+02	5.97E+01
29	1957	9.33E+01	3.15E+01
30	1958	7.61E+01	2.08E+01
31	1959	1.69E+02	4.20E+01
32	1960	1.93E+02	4.77E+01
33	1961	2.93E+02	7.21E+01
34	1962	2.50E+02	8.61E+01
35	1963	1.28E+02	6.22E+01
36	1964	5.44E+01	3.00E+01
37	1965	1.41E+01	5.22E+00
38	1966	9.53E+00	2.87E+00
39	1967	7.43E+00	2.27E+00
40	1968	5.32E+00	1.78E+00
41	1969	2.48E+00	9.30E-01
42	1970	1.64E+00	4.98E-01
43	1971	2.32E+00	6.61E-01
44	1972	4.14E+00	1.17E+00
45	1973	8.01E+00	2.25E+00
46	1974	1.55E+01	4.36E+00
47	1975	3.63E+01	1.06E+01
48	1976	3.83E+01	1.35E+01
49	1977	3.96E+02	9.02E+01
50	1978	4.57E+02	1.56E+02
51	1979	2.55E+03	4.98E+02
52	1980	1.78E+03	6.55E+02
53	1981	2.48E+03	7.54E+02
54	1982	5.16E+03	1.30E+03

55	1983	3.84E+03	1.16E+03
56	1984	2.60E+03	9.94E+02
57	1985	2.00E+03	8.51E+02
58	1986	1.82E+03	7.62E+02
59	1987	1.55E+03	7.03E+02
60	1988	1.12E+03	5.79E+02
61	1989	1.30E+03	4.99E+02
62	1990	9.23E+02	4.08E+02
63	1991	8.46E+02	3.38E+02
64	1992	6.19E+02	2.23E+02
65	1993	5.49E+02	1.89E+02
66	1994	4.78E+02	1.61E+02
67	1995	4.16E+02	1.32E+02
68	1996	4.86E+02	1.37E+02
69	1997	4.69E+02	1.39E+02

Abundance/biomass summary for season 1 (elapsed time = .500).
The first age group in the summary is 0 and the last age group is 0.

idx	year	abundance	biomass
1	1929	1.02E+03	1.01E+02
2	1930	1.40E+03	1.38E+02
3	1931	1.56E+03	1.55E+02
4	1932	1.11E+03	1.10E+02
5	1933	3.78E+02	3.74E+01
6	1934	1.64E+02	1.63E+01
7	1935	1.85E+02	1.83E+01
8	1936	3.97E+02	3.93E+01
9	1937	3.19E+02	3.16E+01
10	1938	5.48E+02	5.42E+01
11	1939	3.60E+02	3.57E+01
12	1940	3.08E+02	3.05E+01
13	1941	6.31E+02	6.25E+01
14	1942	2.30E+02	2.28E+01
15	1943	2.05E+02	2.03E+01
16	1944	2.11E+02	2.09E+01
17	1945	6.52E+01	6.46E+00
18	1946	5.33E+01	5.28E+00
19	1947	5.35E+02	5.30E+01
20	1948	2.85E+02	2.83E+01
21	1949	3.18E+01	3.15E+00
22	1950	1.33E+01	1.31E+00
23	1951	8.23E+00	8.15E-01
24	1952	1.69E+02	1.67E+01
25	1953	4.00E+02	3.96E+01
26	1954	1.68E+02	1.66E+01
27	1955	2.88E+02	2.85E+01
28	1956	5.78E+01	5.72E+00
29	1957	8.48E+01	8.40E+00
30	1958	2.74E+02	2.71E+01
31	1959	2.34E+02	2.31E+01
32	1960	3.77E+02	3.73E+01
33	1961	2.04E+02	2.02E+01
34	1962	3.50E+01	3.47E+00
35	1963	2.07E+01	2.05E+00
36	1964	1.16E+01	1.15E+00
37	1965	1.25E+01	1.23E+00
38	1966	7.09E+00	7.02E-01
39	1967	6.55E+00	6.49E-01
40	1968	3.57E+00	3.54E-01
41	1969	2.10E+00	2.08E-01
42	1970	2.75E+00	2.72E-01
43	1971	4.75E+00	4.70E-01
44	1972	9.20E+00	9.12E-01
45	1973	1.77E+01	1.76E+00
46	1974	4.47E+01	4.43E+00
47	1975	2.77E+01	2.75E+00
48	1976	6.40E+02	6.34E+01
49	1977	4.19E+02	4.15E+01
50	1978	3.89E+03	4.54E+02
51	1979	5.48E+02	5.43E+01
52	1980	2.44E+03	2.91E+02
53	1981	6.14E+03	7.78E+02
54	1982	1.29E+03	1.31E+02
55	1983	5.75E+02	4.98E+01
56	1984	8.33E+02	8.05E+01
57	1985	1.15E+03	1.13E+02
58	1986	8.92E+02	1.22E+02
59	1987	4.60E+02	5.60E+01
60	1988	1.29E+03	1.28E+02
61	1989	4.84E+02	5.04E+01
62	1990	6.52E+02	5.55E+01
63	1991	3.42E+02	2.70E+01
64	1992	3.92E+02	3.79E+01
65	1993	3.58E+02	3.28E+01
66	1994	3.10E+02	3.31E+01
67	1995	4.88E+02	5.13E+01
68	1996	4.09E+02	5.06E+01
69	1997	5.31E+01	9.04E+00

Appendix B

Description of the experimental ADEPT model which allows the user to specify any terminal F.

The ADEPT assessment model was modified on an experimental basis to include options for a new "specify any terminal F" (SATF) algorithm that can be used in a VPA algorithm to specify a terminal fishing mortality rate for any cohort in a VPA. The SATF VPA algorithm makes it possible in theory to estimate a terminal fishing mortality rate for any cohort because terminal F values in SATF can be linked to estimable parameters in an optimization program (like ADEPT) that calls the VPA. Of particular interest are terminal fishing mortality rates for cohorts that end up as the last true age in years prior to the terminal year.

This appendix supplements the user's manual for ADEPT (Jacobson 1993) and describes the experimental SATF algorithm as currently designed. SATF was used experimentally (with little success) during 1998 in the Pacific mackerel assessment for 1997, but was not used for the final assessment run. The experimental SATF may be used more extensively in the future as experience accumulates. The extension makes ADEPT more general at the expense of being a bit harder and more complicated to use. Generality is an advantage in most circumstances so the SATF algorithm may be included in any future VPA model developed using ADEPT software.

Terminal fishing mortality rates are key components in a VPA based approach like ADEPT, because they determine (in combination with the catch-at-age data and natural mortality rate) abundance and recruitment estimates for each cohort. Basically, the terminal fishing mortality rate, catch data and natural mortality assumption for the last true age (defined below) determine abundance of the cohort at the last true age. Abundance estimates for younger ages in the same cohort are then calculated based on abundance of the last true age.

Plus groups (defined below) complicate the SATF algorithm because cohorts become linked (interdependent) and calculations are more complex. Approaches for using the SATF algorithm with plus groups are still under development.

The SATF algorithm makes ADEPT more flexible because the user can directly model abundance and recruitment estimates (calculated from terminal fishing mortality rates) for all cohorts in the analysis. The SATF algorithm starts to bridge the gap between fishery population models based on backcasting (VPA) and forward simulation (e.g. Stock Synthesis, Methot 1989) calculations. With SATF, it is possible to estimate recruitments (which depend largely on terminal fishing mortality rates) for all cohorts (as in stock synthesis) while calculating fishery selectivities based on the VPA algorithm. Thus, the model using SATF becomes more flexible (like Stock Synthesis) but without the complexity and difficulty of having to estimate fishery selectivity parameters (like VPA).

The major problem that may limit SATF applicability in models where SATF parameters are estimated is limited data. There are, for example, too few data for Pacific mackerel to reliably estimate age specific terminal fishing mortality rates in the terminal year. Age specific indices of abundance are generally not available on the west coast but would be useful in this regard. It is also possible that constraints (e.g. constraining recruitment estimates to match a spawner-recruit curve) might also be used in estimating SATF terminal fishing mortality rate parameters. SATF may prove to be useful only in estimating a few terminal fishing mortality rates (rather than an entire set) that are difficult to estimate by conventional means.

Definitions

A "plus group" is an age group that includes fish of more than one age (e.g. the 5+ group for Pacific mackerel includes fish five years and older). A "true age" is any age that is not a plus group. If the analysis includes a plus group, then the "last true age" is the age prior to the last. Alternatively, if there is no plus group, the last true age is the last age. For example, in the ADEPT model for Pacific mackerel, the last true age is age 4. If the Pacific mackerel model were run with ages 0-4 only (i.e. the plus group was eliminated by truncating the catch-at-age data at age 4), then the last true age and the last age would both be age 4.

The "terminal year" is the last year in the analysis. In the ADEPT model used for Pacific mackerel, the terminal year was 1997 and years "prior" to the terminal year were 1929-1996.

A "parameter" is a value supplied to the subroutine responsible for VPA calculations, rather than a value calculated internally by the subroutine. In the context of ADEPT, the parameter may be an estimated value that changes every time the VPA subroutine is called or a fixed value that remains constant.

Description of Algorithm

The ADEPT model used in 1998 to estimate Pacific mackerel biomass during 1929-1997 is used to illustrate this description. The model included years 1929-1997 as annual time steps and ages 0 to 5+ (age 4 was the last true age and age 5+ was a plus group). Thus, there were 1997-1929+1=69 years, 5-0+1=6 age groups, 6-1=5 true age groups, and 69-1+5=73 cohorts. The number of cohorts is always equal to the number of years minus 1 plus the number of true age groups.

Based on this example and the definitions above, there are basically two types of cohorts in a VPA analysis: "group 1" including those that end in the terminal year (as age groups that range from the first to the last true age); and 2) "group 2" including those that end up as the last true age in years prior to the terminal year. In example for Pacific mackerel, there were five cohorts in group 1 (the 1997, 1996, 1995, 1994, and 1993 age classes that were ages 0, 1, 2, 3, and 4 in 1997). Similarly, there were 69-1=68 age groups in group 2 (the 1992, 1991, 1990, . . . 1929, 1928, 1927, 1926, and 1925 year classes that were age 4 in years 1996, 1995, 1994, . . ., 1933, 1932, 1931, 1930, and 1929). As described below, the distinction between these groups is important.

Most tuned VPA programs and implementations of ADEPT already have parameters and other arrangements for estimating terminal fishing mortality rates for group 1 cohorts. With SATF, the user can specify terminal fishing mortality rates for group 1 (and group 2) cohorts. Thus, for the terminal year and group 1 cohorts, the SATF algorithm might be redundant. If the SATF algorithm were used for group 1 cohorts in the terminal year, it would probably be necessary (or at least advisable) to turn off (not estimate) other parameters used to specify the same terminal fishing mortality rates for group 1 cohorts. In the current implementation of ADEPT, SATF specifications override specifications for group 1 and 2 cohorts based on other parameters.

The greatest potential utility of the SATF algorithm is in estimating terminal fishing mortality rates for cohorts in group 2. Thus, it has the same purpose as Murphy's algorithm and the average F algorithm also used for this purpose and already implemented in ADEPT. Murphy's algorithm and the average F algorithm are mutually exclusive and cannot be used in the same model run. Murphy's algorithm assumes that fishing mortality rates on the last true age and plus group are the same while the average F algorithm assumes that fishing mortality rates on the last true age, plus group and at least one of the oldest true age groups is the same. Murphy's algorithm is commonly used when fishery selectivities are "domed" or vary amongst the oldest ages. The average F algorithm is often used when fishery selectivities are "flat" and can be assumed to be the same over a wider range of the oldest ages.

SATF and the Average F Algorithm

SATF can be used either *instead of* or *in addition* to the average F algorithm. The average F algorithm calculates the terminal fishing mortality rate F_y on the last true age in year y based on catch-at-age data for years y and later (C_{y+}), and fishing mortality rates on the last true age in year y+1 and later (F_{y+1+}):

$$F_y = G(C_{y+}, F_{y+1+}).$$

In effect, the terminal F value for a cohort is calculated based previously estimates of F for cohorts represented by younger age classes in the same year.

The average F algorithm is recursive because F_y (once computed) is used to estimate F_{y-1} and so on. The SATF algorithm, in contrast, uses log transformed parameters f_y=ln(F_y) that can be substituted for G(C_{y+},F_{y+1+}) at any point in the recursive calculations. Log transformed parameters are used because the log transformation guarantees that F_y will be positive. If a full set of f_y parameters is provided for group 2 cohorts, then the SATF algorithm is used exclusively. If only a subset of f_y parameters for group 2 cohorts are provided, then SATF is used in addition to the average F approach. In the latter case, the time series of terminal F's used in recursive calculations (F_{y+1+}) simply includes values calculated from f_y parameters in addition to values calculated using the recursive algorithm. In calculation of any particular F_y, the program either uses the parameter F_y=exp(f_y) or the recursive relationship F_y=G(C_{y+},F_{y+1+}). The user must specify in a command file which approach to use in the case of each terminal F value.

The average F algorithm can be used either with or without a plus group. If a plus group is present, then its fishing mortality rate is generally assumed equal (or proportional) to the fishing mortality rate for the last true age in the same year.

SATF and Murphy's Algorithm

Murphy's algorithm (often described as "cohort linking") is an algorithm for calculating terminal F values for type 2 cohorts and the plus group (it can be used only in calculations that include a plus group). Murphy's algorithm involves doing an initial single VPA calculation for the last true age and plus group that spans all of the years in the VPA analysis. After the initial VPA calculation for the last true age and plus group is completed, the resulting F_y and abundance values for the last true age are used to initiate a separate VPA calculation for each cohort.

The SATF algorithm cannot be used in connection with Murphy's approach in the current ADEPT implementation. Murphy's approach complicates the SATF algorithm because there are links in computations between cohorts that make it impossible to substitute SATF estimates at will in the backward calculations. This is a topic of ongoing research.

A possible solution to be investigated in the near future involves using a forward simulation approach for the last true age and plus group and a complete set of ft parameters for all of the type 2 cohorts in the analysis. Basically, abundance of the last true age and plus group would be projected forward in time based on standard forward calculations, catch-at-age, and ft parameters, starting with the first year in the VPA. When complete, the Ft=exp(ft) values would be used to initiate standard backward VPA's for each type 2 cohort. This algorithm would require a full set of ft values for type 2 cohorts and would replace (rather than supplement) Murphy's algorithm. The overall effect would, however, be the same as with SATF and the average F algorithm because the terminal fishing mortality rates for type 2 cohorts could be specified individually while retaining the convenient estimates of fishery selectivity from backward VPA calculations on each cohort.

Implementation

The SATF algorithm in ADEPT is controlled by the user based on commands in the run definition file and parameters in the initial parameter file. As described above, SATF cannot be used in the current implementation of ADEPT with Murphy's algorithm. The program will not prompt or expect SATF control information if Murphy's algorithm is used.

There are basically three steps. In step 1, the user tells the program if the SATF algorithm will be used (i.e. if $\exp(f_y)$ will be used instead of $G(C_{y+},F_{y+1+})$ for at least one cohort). In step 2, the user tells the program the number (location) of the first SATF parameter in the parameter file, whether to "reset" the initial SATF parameter values (see below), and which terminal F's should be replaced by values calculated from SATF parameters. In step 3, the user tells the program which terminal F parameters should be estimated during the optimization phase. The distinction between steps 2 and 3 is important because the user may wish to *use* parameters in some cases *without estimating them*. Steps 1-2 are carried out in the run definition file (see below). Step 3 is carried out in the initial parameter file (see below). Initial values for the SATF parameters can be specified in the initial parameter value file or can be reset as described below.

Steps 2 and 3 (see above) are irrelevant and not carried out if the SATF algorithm is not used. Thus, the new enhanced version of ADEPT behaves exactly like the previous version (and the same run definition and parameter files will work) if the user answers "no" in step 1.

As described above, the SATF algorithm is redundant in the mackerel model for fishing mortality rates on group 1 cohorts in the terminal year. In step 1, therefore, the program was instructed not to use SATF parameters for cohorts in group 1. The first group included the 1997 (age 0), 1996 (age 1), 1995 (age 2), 1994 (age 3) and 1993 (age 4) year classes. In future, the program may be modified to eliminate the possibility of using or estimating redundant parameters for group 1 cohorts. As described above, SATF parameters override other specifications if fishing mortality rates for group 1 cohorts are specified redundantly.

It can be difficult to specify initial values for a large number of SATF parameters and a reset option can be requested in the run definition file to ease this burden. If the user requests that SATF parameters be reset, the program will do an initial VPA run and reset the initial values for SATF parameters. This means that initial values for SATF parameters (normally specified in the initial parameter value file as described in Jacobson 1993) are reset to $f_y=\ln(F_y)$ where F_y is from the preliminary VPA. Reset SATF parameters have no effect on the analysis unless the program is instructed to use them in VPA calculations.

The program checks commands from the user to make sure they are logical. For example, the program makes sure that all parameters estimated during the optimization phase are, in fact, being used in the VPA based on commands in the run definition file. It makes sure that at least one SATF parameter is used if the user answers "yes" in step 1 and the run definition file. A very common mistake is to try and estimate f_y parameters that are not being used.

At the end of a model run, ADEPT generates a table in the output file that reminds the user which SATF parameters were used, which were estimated, and lists initial and final values. (see below).

Experience to Date

The SATF algorithm increases the number of parameters in the model substantially. For example, the ADEPT model used for Pacific mackerel in 1998 included 58 parameters without SATF parameters and 131 parameters when SATF parameters were used. The difference (131-58+1=73 parameters) is the same as the number of cohorts. Of course, very few or none of the SATF parameters may be estimated in any particular run so time required to estimate parameters does not increase in proportion to the total number of parameters.

It is probably impossible to estimate all SATF parameters without age specific survey data. In practice, and with aggregate age survey data available for Pacific mackerel, only a few SATF parameters could be estimated. It seemed particularly difficult to estimate SATF parameters for adjacent years.

It is usually important to remember to turn SATF parameters for group 1 cohorts off. Other parameters are usually used to estimate fishing mortality rates in the terminal year. If SATF parameters for group 1 cohorts are turned on in the run definition file, then the other parameters have no effect on goodness of fit and parameter estimation is affected.

Spawner-recruit constraints generally have little effect on biomass and recruitment estimates from VPA models but may be more important and useful when estimating SATF parameters. If sufficient weight is placed on a spawner-recruit constraint, for example, it may be possible in principle to estimate SATF parameters such that recruitments match predictions from the underlying spawner-recruit model exactly. It is important to remember, however, that spawner-recruit constraints do not affect the first k-1 age groups and cohorts (where k is the number of true age groups) because the earliest k-1cohorts do appear as recruits in the catch-at-age data and VPA analysis.

Run Definition File: The following run definition file tells ADEPT to use SATF parameters for the 1948, 1976 and 1978 year classes. Based on the parameter file (see below), SATF parameters for the 1976 and 1978 year classes will be estimated. The parameter for the 1948 year class will, in contrast, be used but not estimated. The name of the file is RUNDEFIN.SATF-DEMO.

```
run definition parameters:
 first year in analysis
  1929
 last year in analysis
  1997
 first age in analysis
     0
 last age in analysis
     5
 last age a plus group?
 T
 seasons in each year
     1
 skip any of the oldest cohorts?
 F
 additional terminal f's specified?
 F
 annual natural mortality rate
   5.000000E-01
 use murphy's algorithm to calculate f for oldest true age and plus group?
 F
 first age in estimate of mean f for oldest true age
     3
 check data and issue warnings in first call to VPA?
 T
 detailed output?
 T
 number surveys used in analysis
    12
 weight in composite likelihood for survey  1
  1.000000E-03
 weight in composite likelihood for survey  2
  1.000000E-03
 weight in composite likelihood for survey  3
  1.000000E-03
 weight in composite likelihood for survey  4
  0.000000E+00
```

```
weight in composite likelihood for survey  5
 1.000000E-03
weight in composite likelihood for survey  6
 0.000000E+00
weight in composite likelihood for survey  7
 0.000000E+00
weight in composite likelihood for survey  8
 1.000000E-03
weight in composite likelihood for survey  9
 1.000000E-03
weight in composite likelihood for survey 10
 0.000000E+00
weight in composite likelihood for survey 11
 0.000000E+00
weight in composite likelihood for survey 12
 1.000000E+02
pointer to first survey q parameter
   10
pointer to first survey availability parameter
   34
Use SATF terminal F parameters for any cohort
T
pointer to first SATF parameter
   59
reset SATF parameters on first call
T
Use SATF parameter for cohort age zero in   1997:
F
Use SATF parameter for cohort age zero in   1996:
F
Use SATF parameter for cohort age zero in   1995:
F
Use SATF parameter for cohort age zero in   1994:
F
Use SATF parameter for cohort age zero in   1993:
F
Use SATF parameter for cohort age zero in   1992:
F
Use SATF parameter for cohort age zero in   1991:
F
Use SATF parameter for cohort age zero in   1990:
F
Use SATF parameter for cohort age zero in   1989:
F
Use SATF parameter for cohort age zero in   1988:
F
Use SATF parameter for cohort age zero in   1987:
F
Use SATF parameter for cohort age zero in   1986:
F
Use SATF parameter for cohort age zero in   1985:
F
Use SATF parameter for cohort age zero in   1984:
F
Use SATF parameter for cohort age zero in   1983:
F
Use SATF parameter for cohort age zero in   1982:
F
Use SATF parameter for cohort age zero in   1981:
F
Use SATF parameter for cohort age zero in   1980:
F
Use SATF parameter for cohort age zero in   1979:
F
Use SATF parameter for cohort age zero in   1978:
T
Use SATF parameter for cohort age zero in   1977:
F
Use SATF parameter for cohort age zero in   1976:
T
Use SATF parameter for cohort age zero in   1975:
F
Use SATF parameter for cohort age zero in   1974:
```

F
Use SATF parameter for cohort age zero in 1973:
F
Use SATF parameter for cohort age zero in 1972:
F
Use SATF parameter for cohort age zero in 1971:
F
Use SATF parameter for cohort age zero in 1970:
F
Use SATF parameter for cohort age zero in 1969:
F
Use SATF parameter for cohort age zero in 1968:
F
Use SATF parameter for cohort age zero in 1967:
F
Use SATF parameter for cohort age zero in 1966:
F
Use SATF parameter for cohort age zero in 1965:
F
Use SATF parameter for cohort age zero in 1964:
F
Use SATF parameter for cohort age zero in 1963:
F
Use SATF parameter for cohort age zero in 1962:
F
Use SATF parameter for cohort age zero in 1961:
F
Use SATF parameter for cohort age zero in 1960:
F
Use SATF parameter for cohort age zero in 1959:
F
Use SATF parameter for cohort age zero in 1958:
F
Use SATF parameter for cohort age zero in 1957:
F
Use SATF parameter for cohort age zero in 1956:
F
Use SATF parameter for cohort age zero in 1955:
F
Use SATF parameter for cohort age zero in 1954:
F
Use SATF parameter for cohort age zero in 1953:
F
Use SATF parameter for cohort age zero in 1952:
F
Use SATF parameter for cohort age zero in 1951:
F
Use SATF parameter for cohort age zero in 1950:
F
Use SATF parameter for cohort age zero in 1949:
F
Use SATF parameter for cohort age zero in 1948:
T
Use SATF parameter for cohort age zero in 1947:
F
Use SATF parameter for cohort age zero in 1946:
F
Use SATF parameter for cohort age zero in 1945:
F
Use SATF parameter for cohort age zero in 1944:
F
Use SATF parameter for cohort age zero in 1943:
F
Use SATF parameter for cohort age zero in 1942:
F
Use SATF parameter for cohort age zero in 1941:
F
Use SATF parameter for cohort age zero in 1940:
F
Use SATF parameter for cohort age zero in 1939:
F
Use SATF parameter for cohort age zero in 1938:
F

```
Use SATF parameter for cohort age zero in   1937:
F
Use SATF parameter for cohort age zero in   1936:
F
Use SATF parameter for cohort age zero in   1935:
F
Use SATF parameter for cohort age zero in   1934:
F
Use SATF parameter for cohort age zero in   1933:
F
Use SATF parameter for cohort age zero in   1932:
F
Use SATF parameter for cohort age zero in   1931:
F
Use SATF parameter for cohort age zero in   1930:
F
Use SATF parameter for cohort age zero in   1929:
F
Use SATF parameter for cohort age zero in   1928:
F
Use SATF parameter for cohort age zero in   1927:
F
Use SATF parameter for cohort age zero in   1926:
F
Use SATF parameter for cohort age zero in   1925:
F
any additional abundance/biomass summaries?
T
number of additional summaries
    3
season for summary  1
 1
elapsed time in season for summary  1
  0.000000E+00
lower bound for age in summary  1
 1
upper bound for age in summary  1
 5
season for summary  2
 1
elapsed time in season for summary  2
  5.000000E-01
lower bound for age in summary  2
 1
upper bound for age in summary  2
 5
season for summary  3
 1
elapsed time in season for summary  3
  5.000000E-01
lower bound for age in summary  3
 0
upper bound for age in summary  3
 0
are mean weights and catch/biomass in different units?
T
factor to convert mean weight units to catch/biomass units?
  5.000000E-01
adjust catch@age data to match aggregate catch by year/season?
T
Calculate egg production or spawning biomass?
T
Season for egg production/spawning?
    1
Elapsed time at egg production/spawning?
  5.000000E-01
Ogive value (units per biomass) for age 0?
 .000000
Ogive value (units per biomass) for age 1?
 .070000
Ogive value (units per biomass) for age 2?
 .240000
Ogive value (units per biomass) for age 3?
```

```
 .470000
Ogive value (units per biomass) for age 4?
 .730000
Ogive value (units per biomass) for age 5?
1.000000
read environmental/auxiliary data?
T
```

Initial Parameter File: The following parameter file will estimate terminal F parameters for the 1976 and 1978 year classes. Other F parameters may be used (but not estimated) as specified in the run definition file (see above). The actual initial values for terminal F parameters are irrelevant because they will be reset in the first call to the VPA subroutine (see run definition file above). The name of the file is SATF487678.PAR.

```
best parameter estimates (calls=    10518)
        131    !number parameters
'log full f  ',     6.614059E-01,     1.000000E+00
'SWITCH!!!!!!',    -1.000000E+11,     0.000000E+00
'LogistcSlope',     0.000000E+00,     0.000000E+00
'LogistcIntcp',     0.000000E+00,     0.000000E+00
'log_SelxAge0',    -3.681100E+00,     0.000000E+00
'log_SelxAge1',    -1.276900E+00,     0.000000E+00
'log_SelxAge2',    -1.030600E+00,     0.000000E+00
'log_SelxAge3',    -6.285000E-01,     0.000000E+00
'log_SelxAge4',     0.000000E+00,     0.000000E+00
'LnSpotterQ  ',    -6.369591E+00,     1.000000E+00
'LnSpotterX  ',     1.018966E-02,     1.000000E+00
'LnSCpfvAllQ ',    -1.496530E+00,     1.000000E+00
'LnSCpfvAllX ',    -8.698338E-01,     1.000000E+00
'LnNCpfvQ    ',    -3.307377E+00,     1.000000E+00
'LnNCpfvX    ',    -7.977656E-01,     1.000000E+00
'LnUsLarDenQ ',     4.360000E-02,     0.000000E+00
'LnUsLarDenX ',    -6.930000E-01,     0.000000E+00
'LnUsPPosQ   ',    -1.573782E+00,     1.000000E+00
'LnUsPPosX   ',    -1.574173E+00,     1.000000E+00
'LnMxLarDenQ ',     1.060000E-01,     0.000000E+00
'LnMxLarDenX ',    -6.640000E-01,     0.000000E+00
'LnMxPPosQ   ',     9.960000E-01,     0.000000E+00
'LnMxPPosX   ',    -2.250000E+00,     0.000000E+00
'LnImpingeQ  ',    -3.918530E+00,     1.000000E+00
'LnImpingeX  ',    -6.670000E-01,     0.000000E+00
'LnTriennialQ',     1.784464E+00,     1.000000E+00
'LnTriennialX',    -6.640000E-01,     0.000000E+00
'LnSCpfvEarQ ',    -9.750000E-01,     0.000000E+00
'LnSCpfvEarX ',    -9.180000E-01,     0.000000E+00
'LnSCpfvLatQ ',    -9.750000E-01,     0.000000E+00
'LnSCpfvLatX ',    -9.180000E-01,     0.000000E+00
'RickerInterc',     1.010000E+00,     0.000000E+00
'RickerSlope ',    -5.250000E+00,     0.000000E+00
'SwichCpfvSel',     1.990000E+03,     0.000000E+00
'log_SlCpfvA0',    -8.000000E+00,     0.000000E+00
'log_SlCpfvA1',    -6.930000E-01,     0.000000E+00
'log_SlCpfvA2',     0.000000E+00,     0.000000E+00
'log_SlCpfvA3',     0.000000E+00,     0.000000E+00
'log_SlCpfvA4',     0.000000E+00,     0.000000E+00
'log_SlCpfvA5',     0.000000E+00,     0.000000E+00
'log_SlCpfvB0',    -8.000000E+00,     0.000000E+00
'log_SlCpfvB1',    -1.100000E+00,     0.000000E+00
'log_SlCpfvB2',    -4.060000E-01,     0.000000E+00
'log_SlCpfvB3',     0.000000E+00,     0.000000E+00
'log_SlCpfvB4',     0.000000E+00,     0.000000E+00
'log_SlCpfvB5',     0.000000E+00,     0.000000E+00
'log_N_CpfvB0',    -4.290000E+00,     0.000000E+00
'log_N_CpfvB1',    -1.890000E+00,     0.000000E+00
'log_N_CpfvB2',    -5.290000E-01,     0.000000E+00
'log_N_CpfvB3',     0.000000E+00,     0.000000E+00
'log_N_CpfvB4',     0.000000E+00,     0.000000E+00
'log_N_CpfvB5',     0.000000E+00,     0.000000E+00
'log_SoCalEd0',     0.000000E+00,     0.000000E+00
'log_SoCalEd1',    -1.600000E+00,     0.000000E+00
'log_SoCalEd2',    -1.800000E+01,     0.000000E+00
'log_SoCalEd3',    -1.800000E+01,     0.000000E+00
```

'log_SoCalEd4',	-1.800000E+01,	0.000000E+00
'log_SoCalEd5',	-1.800000E+01,	0.000000E+00
'ln_SATF_yc97',	-6.852446E+00,	0.000000E+00
'ln_SATF_yc96',	-2.280663E+00,	0.000000E+00
'ln_SATF_yc95',	-1.910088E+00,	0.000000E+00
'ln_SATF_yc94',	-2.285061E+00,	0.000000E+00
'ln_SATF_yc93',	-1.976770E+00,	0.000000E+00
'ln_SATF_yc92',	1.439227E-03,	0.000000E+00
'ln_SATF_yc91',	-3.198302E+00,	0.000000E+00
'ln_SATF_yc90',	-2.254832E+00,	0.000000E+00
'ln_SATF_yc89',	-2.279969E+00,	0.000000E+00
'ln_SATF_yc88',	-1.931119E+00,	0.000000E+00
'ln_SATF_yc87',	-1.420433E+00,	0.000000E+00
'ln_SATF_yc86',	-1.664903E+00,	0.000000E+00
'ln_SATF_yc85',	-3.672408E+00,	0.000000E+00
'ln_SATF_yc84',	-3.547970E+00,	0.000000E+00
'ln_SATF_yc83',	-4.343498E+00,	0.000000E+00
'ln_SATF_yc82',	-3.292290E+00,	0.000000E+00
'ln_SATF_yc81',	-3.081339E+00,	0.000000E+00
'ln_SATF_yc80',	-2.271560E+00,	0.000000E+00
'ln_SATF_yc79',	-2.033739E+00,	0.000000E+00
'ln_SATF_yc78',	1.528636E+00,	1.000000E+00
'ln_SATF_yc77',	-1.219304E+00,	0.000000E+00
'ln_SATF_yc76',	5.069730E+01,	1.000000E+00
'ln_SATF_yc75',	-8.047435E-01,	0.000000E+00
'ln_SATF_yc74',	-2.015682E+00,	0.000000E+00
'ln_SATF_yc73',	2.194149E+00,	0.000000E+00
'ln_SATF_yc72',	-2.864057E+00,	0.000000E+00
'ln_SATF_yc71',	-3.185314E+00,	0.000000E+00
'ln_SATF_yc70',	-2.980668E+00,	0.000000E+00
'ln_SATF_yc69',	-3.218363E+00,	0.000000E+00
'ln_SATF_yc68',	-2.572075E+00,	0.000000E+00
'ln_SATF_yc67',	-1.324376E+00,	0.000000E+00
'ln_SATF_yc66',	3.489370E-01,	0.000000E+00
'ln_SATF_yc65',	7.511264E-01,	0.000000E+00
'ln_SATF_yc64',	2.265478E-01,	0.000000E+00
'ln_SATF_yc63',	-9.497458E-01,	0.000000E+00
'ln_SATF_yc62',	3.017970E-01,	0.000000E+00
'ln_SATF_yc61',	1.323811E+00,	0.000000E+00
'ln_SATF_yc60',	-3.330357E-01,	0.000000E+00
'ln_SATF_yc59',	-1.853871E-01,	0.000000E+00
'ln_SATF_yc58',	-1.834261E-01,	0.000000E+00
'ln_SATF_yc57',	2.149205E-01,	0.000000E+00
'ln_SATF_yc56',	5.445216E-01,	0.000000E+00
'ln_SATF_yc55',	-3.395913E-01,	0.000000E+00
'ln_SATF_yc54',	2.895210E-01,	0.000000E+00
'ln_SATF_yc53',	5.260532E-01,	0.000000E+00
'ln_SATF_yc52',	-6.803270E-01,	0.000000E+00
'ln_SATF_yc51',	3.317799E-02,	0.000000E+00
'ln_SATF_yc50',	-1.549418E+00,	0.000000E+00
'ln_SATF_yc49',	3.004892E-01,	0.000000E+00
'ln_SATF_yc48',	-5.455173E-01,	0.000000E+00
'ln_SATF_yc47',	8.740213E-02,	0.000000E+00
'ln_SATF_yc46',	-2.132035E-01,	0.000000E+00
'ln_SATF_yc45',	1.011665E-01,	0.000000E+00
'ln_SATF_yc44',	-4.125120E-01,	0.000000E+00
'ln_SATF_yc43',	5.664117E-01,	0.000000E+00
'ln_SATF_yc42',	-4.321093E-01,	0.000000E+00
'ln_SATF_yc41',	-3.736435E-01,	0.000000E+00
'ln_SATF_yc40',	-6.370272E-01,	0.000000E+00
'ln_SATF_yc39',	-4.407727E-01,	0.000000E+00
'ln_SATF_yc38',	-1.268428E-01,	0.000000E+00
'ln_SATF_yc37',	1.434736E-01,	0.000000E+00
'ln_SATF_yc36',	5.224893E-01,	0.000000E+00
'ln_SATF_yc35',	1.605113E-01,	0.000000E+00
'ln_SATF_yc34',	-3.062493E-01,	0.000000E+00
'ln_SATF_yc33',	-6.425074E-01,	0.000000E+00
'ln_SATF_yc32',	-7.033143E-01,	0.000000E+00
'ln_SATF_yc31',	-7.597531E-01,	0.000000E+00
'ln_SATF_yc30',	-9.640304E-01,	0.000000E+00
'ln_SATF_yc29',	-1.640904E+00,	0.000000E+00
'ln_SATF_yc28',	-3.580507E+00,	0.000000E+00
'ln_SATF_yc27',	-3.942255E+00,	0.000000E+00

```
'ln_SATF_yc26',     -2.516403E+00,      0.000000E+00
'ln_SATF_yc25',     -1.307759E+00,      0.000000E+00
  0     !number of lower bounds specified
  1     !number of upper bounds specified
        1,     7.000000E-01
```

Output File: The output file contains the following table that summarizes which and how terminal F parameters were used.

```
SATF parameters used for some/all cohorts

 -- SATF parameters reset in first call to VPA

ParNo  YC      Age     InLastYear    Use_SATF?     Est_SATF?     SATF_Par  FinalSATF ChkFrmVPA
78     1978    4       1982          T             T             -1.7101      0.1808  0.1808
80     1976    4       1980          T             T             -2.3343      0.0969  0.0969
108    1948    4       1952          T             F             -0.5455      0.5795  0.5795
```