

STATUS OF BOCACCIO OFF CALIFORNIA IN 2002

by

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## EXECUTIVE SUMMARY

**SPECIES/AREA:** Bocaccio rockfish (*Sebastes paucispinis*) occurring in waters off the state of California. For management purposes, the stock may be considered to reside in U.S. waters south of Cape Mendocino. This stock assessment treats the resource in Southern and Central California as a combined unit (see unresolved problems below).

YEAR	1951	1961	1971	1976	1981	1986	1991	1996	1999	2000	2001	2002
BIOMASS (MT, 2+)	58,754	36,856	108,159	81,031	56,986	26,981	14,112	6,874	4,373	3,738	3,364	2,914
CATCH (MT)	5,119	5,079	5,478	11,825	5,742	3,172	1,757	599	213	233	215	
EXPLOITATION RATE	0.087	0.138	0.051	0.146	0.101	0.118	0.125	0.087	0.049	0.062	0.064	

**CATCHES:** Catches have been in severe decline for the last two decades, reflecting both a long-term decline in abundance and progressive restrictions on harvest of bocaccio. Values of catches in recent years are imprecise, for example because of undocumented discarding. In the base model of this assessment, recreational catches may have been slightly overestimated and commercial catches underestimated. Some alternative values were explored. All interpretations of total catch indicate that the 100 MT OY established by the PFMC for 2000 and 2001 has been exceeded.

**DATA AND ASSESSMENT:** The last assessment was conducted in 1999. Like the previous assessment, this assessment uses a length-based stock synthesis model. Whereas the previous assessment extended back to 1969, this assessment extends back to 1951. Data included catches from seven fisheries segments reflecting four gears and two areas (trawl, setnet, hook&line, and recreational; the latter three segments were divided into Southern and Central California areas), length compositions from eight sources (all seven fisheries segments, and the Triennial Survey), three indexes of abundance in Central California (trawl logbook CPUE, recreational CPUE, and the Triennial Survey), two indexes of abundance in Southern California (CalCOFI index of spawning abundance and recreational CPUE), and two indexes of recruitment (Central California Juvenile Rockfish Survey, and Southern California Power Plant Impingement Index).

**UNRESOLVED PROBLEMS AND MAJOR UNCERTAINTIES:** The relationship between stock segments in Southern and Central California is unclear, and the status and productivity in those two areas may differ. Results of area-specific models indicates that Southern California is relatively less depleted (ca. 10% of unfished abundance), and may have greater capacity for rebuilding. Central California, which appears to be more severely depleted, has a higher unfished biomass, but a lower productivity rate, suggesting a tendency to large natural fluctuations in abundance, with consequent difficulty in rebuilding the stock. Even in the combined model, the historical variability in recruitment produces a very imprecise estimate of unfished abundance (see reference points below), with similar imprecision in the rebuilding target.

**REFERENCE POINTS:** Population reproductive potential is measured as spawning output (units of billion eggs). Unfished abundance cannot be estimated reliably from the stock and recruitment due to lack of curvature in the relationship. An imprecise estimate of unfished

spawning output of 14857 (CV=31%) was obtained by multiplying the average recruitment (1953 to 1998) by SPR(F=0). The PFMC proxy of 50% SPR is supported by the average recruitment success (recruits/spawning output), which indicates that a 49% SPR is sustainable (however, the CV is 51%).

**STOCK BIOMASS:** Estimated spawning output in 2002 is 720 billion eggs, or 4.8% of the estimated unfished level. The estimated 2002 total biomass (age 2+) is 2958 MT.

**RECRUITMENT:** The last significant recruitment appeared as age 1 fish in 1989. The following decade was remarkable for consistent recruitment failure. Although the 1999 year class is the strongest in several years, it now appears to be weak relative to the range of possibilities considered in the 1999 assessment.

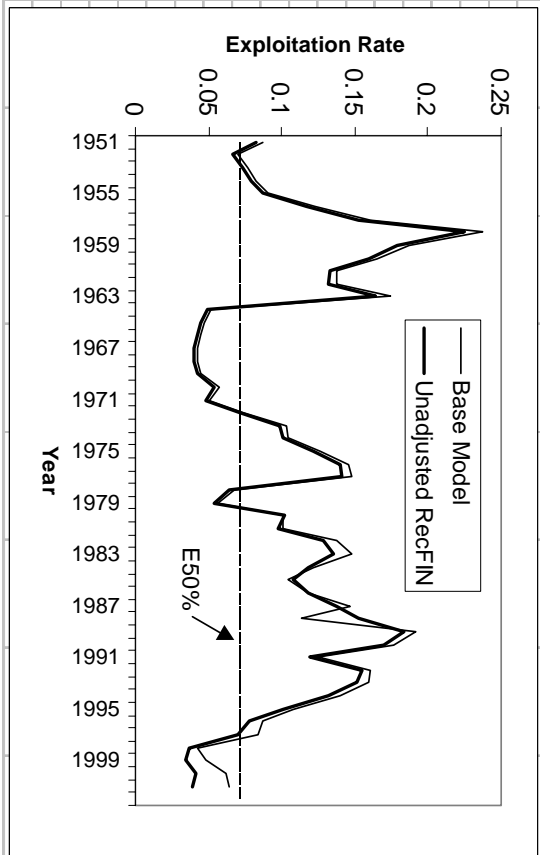
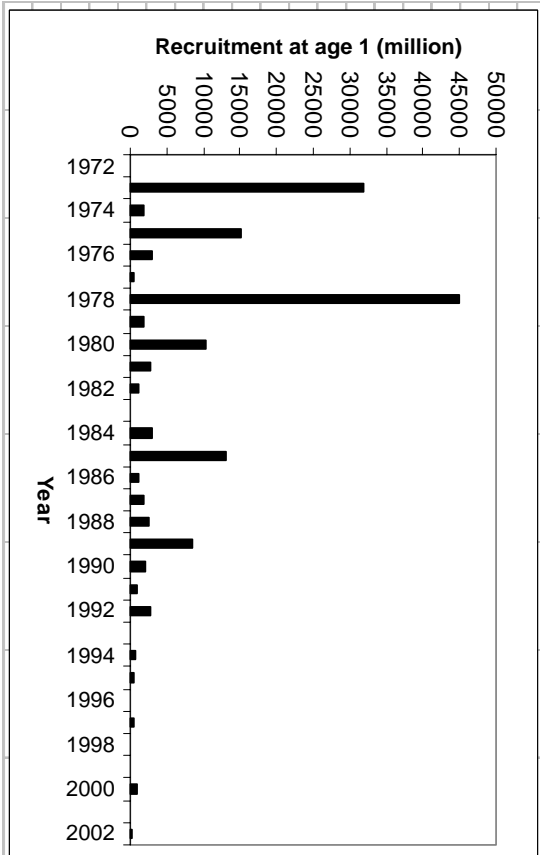
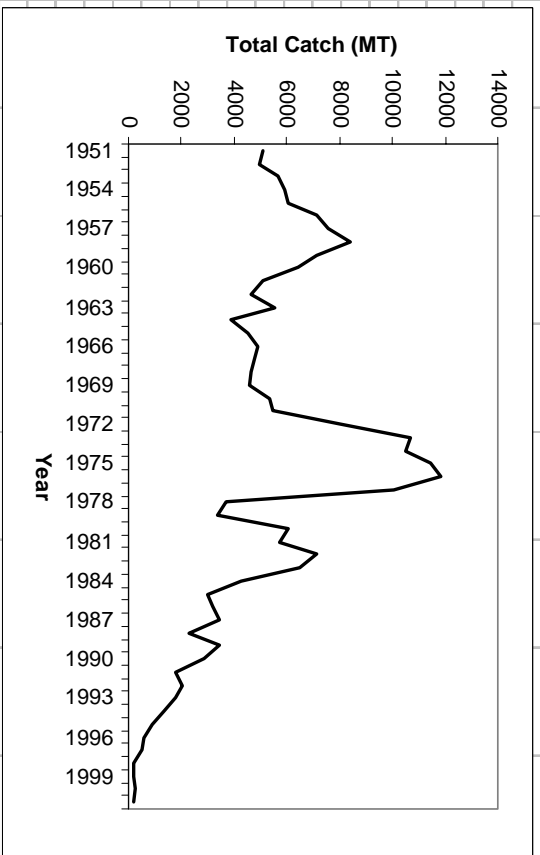
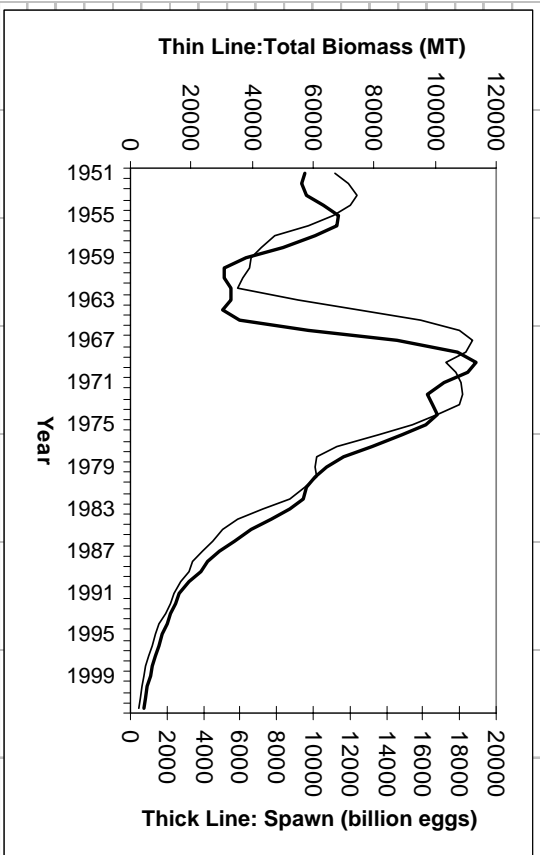
**EXPLOITATION STATUS:** Estimated exploitation rate (catch/total biomass age 2+) in 2001 depends on the values of catch taken by recreational and commercial fisheries (see CATCHES above). Exploitation rate in the base model was 6.4%, which is slightly below the 50% SPR level of 0.0717 used as a proxy MSY rate by the PFMC. If catches have been overestimated, the exploitation rate would be correspondingly lower.

**MANAGEMENT PERFORMANCE:** In hindsight, the stock has been heavily overfished during the entire period of PFMC management. Stock assessments have identified biomass as being below 25% of the unfished level since 1991, but due to mistaken confidence in the correctness of the F35% proxy, insufficient effort was made to slow the decline in abundance (note that the decline could not have been halted because of weak recruitments). Recent catches have exceeded the 100 MT rebuilding target set for 2000-2002, indicating need for re-evaluation of management measures, especially in view of the drastically reduced catch levels that are now estimated to be required for rebuilding.

**FORECASTS:** Spawning output will continue to decline for several years due to past recruitment failures, with no improvement being likely in the next five to ten years. Stock projections were conducted using stock synthesis and the SSC rebuilding simulation developed by Andre Punt. The projections indicate that the median time to rebuild to 40% of Unfished is approximately 97 years in the absence of fishing. The 1999 assessment was overly optimistic due to erroneous assumptions regarding the strength of the 1999 yearclass. According to this new assessment, the 38-year rebuilding timeframe based on medium yearclass strength scenario of the 1999 assessment is not feasible even if all fishing mortality is eliminated.

**RECOMMENDATIONS:** A revised rebuilding analysis will be prepared. Annual catches of bocaccio must be reduced to a near-zero level. An abbreviated assessment and review in 2003 would address some data problems and help resolve the strength of the 1999 yearclass.

**REFERENCES:** STAR Panel Report.



Long-term patterns of bocaccio abundance, catch, recruitment and exploitation rate.

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## Introduction

Previous stock assessments (Bence and Hightower 1990, Bence and Rogers 1992, Ralston et al. 1996, MacCall et al. 1999) demonstrated that the bocaccio (*Sebastes paucispinis*) resource off California has been declining since 1969, the earliest year for which abundances could be estimated reliably. On the basis of the 1996 assessment by Ralston et al., the stock was declared formally as overfished. A rebuilding plan was implemented beginning in 2000, but formal adoption as a Groundfish Plan Amendment has been delayed. The rebuilding plan and associated Plan Amendment is expected to be revised according to the updated view of the resource developed in this assessment. Also, in January 2001 the National Marine Fisheries Service received a petition to consider listing of bocaccio under the Endangered Species Act. This stock assessment is intended to serve as one of the documents supporting the required Biological Review in response to that petition.

Two aspects of this assessment are of special significance:

*1999 Year Class.* The rebuilding policy adopted by the Pacific Fishery management Council (PFMC) beginning in 2000 was strongly influenced by the assumed strength of the 1999 year class which had been observed in unusual abundance at the San Onofre power plants. This year class is the first significant year class in several years, and became available to the Southern California recreational fishery in 2000 and 2001. However, the 1999 year class still has not made a significant showing in Central California north of Avila/Port San Luis. Determination of the strength of the 1999 year class will help formulate the rebuilding policy.

*Southern California Information.* Previous bocaccio assessments were based mainly on data from Central California (especially the Triennial Survey). This assessment utilizes new information relevant to Southern California. It examines both combined assessment models and individual models for each area, and contributes to an understanding of the relationship between those two segments of the population.

## History of Management

Bocaccio have long been a dominant species in groundfish catches taken off California. In 1962 and 1963, bocaccio comprised over 40% of the rockfish taken by trawling off California, and comprised well over 50% of the rockfish taken by trawl south of San Francisco (Nitsos 1965). There were few restrictions on harvest other than area closures and minimum mesh size requirements prior to federal management of the fishery.

The Pacific Fishery Management Council (PFMC) assumed management responsibility for west coast groundfish when the Groundfish Fisheries Management Plan (FMP) became

effective in September 1982. For all practical purposes, full-time groundfish management by the PFMC began in 1983. The history of bocaccio management is summarized in Table 1.

The PFMC routinely adopted an acceptable biological catch (ABC) for bocaccio of 4,100 MT for the Monterey INPFC area and 2,000 MT for the Conception area from 1983 through 1990. Landings in other areas were considered too small to warrant a separate ABC. These ABC's were based solely on historical landings during selected periods.

In response to concerns about bocaccio stock conditions, an assessment was conducted in 1990 (Bence and Hightower, 1990). The results of that assessment were used by the PFMC to establish an 800 MT ABC for the combined Conception-Monterey-Eureka INPFC areas for 1991. The PFMC, after hearing public testimony, established a harvest guideline of 1,100 MT for those INPFC areas. The ABC and harvest guideline applied to all gears and include the recreational fishery. The same ABC and harvest guideline were in effect through 1992. During those two years, actual harvest exceeded the harvest guideline by 300-500 tons.

In 1992, the PFMC reviewed a new assessment for bocaccio (Bence and Rogers, 1992). That assessment stated, "...under current harvesting rates, although fishing mortality is estimated to be below F35%, the expected stock biomass and spawning capacity is projected to decline further, and possibly fall to less than 20% of the levels seen in 1980....we recommend harvesting at the current harvest guideline [1100 MT]." Nonetheless, the PFMC adhered strictly to its F35% policy and recommended that the 1993 ABC be increased to 1,540 MT and that the harvest guideline be set equal to the ABC in the same INPFC areas. The new assessment accommodated some expected discard in the trawl and set net fisheries that often fished to the trip limits. By 1994 the Council had determined that few trips were being impacted by trip limits and the reduction to account for discard was unnecessary. Therefore, the 1,540 MT ABC and harvest guideline, in effect since 1993, were adjusted to 1,700 MT for 1995 and was extended through 1996. Actual landings fell short of these ABC levels and declined so rapidly that even an 1100 MT harvest guideline would have had little effect.

A stock assessment conducted in 1996 (Ralston et al., 1996) showed the resource to be in severe decline, and the PFMC drastically reduced the ABC to 265 MT in 1997, and to 230 MT with adoption of an F40% policy in 1998 and 1999. Moreover, the long string of recruitment failures during the 1990's continued. In 1999, the stock was formally designated as "overfished" according to the requirements of the newly amended MSFCMA and the Overfished/Rebuilding Threshold for groundfish adopted by the PFMC in Groundfish FMP Amendment 11. The incoming 1999 year class appeared to be relatively strong, helping to buffer the catch restrictions needed to accomplish rebuilding. The rebuilding policy adopted by the PFMC held the rebuilding OY constant at 100 MT for the years 2000-2002, with the intention of switching to a constant fishing rate policy beginning in 2003.

During the 1983-1990 period bocaccio were managed in combination with other rockfish in the *Sebastes* complex. Trip and frequency limits were used to constrain total complex

landings only. After 1990, various bocaccio trip limits were used to keep total commercial landings within established harvest guidelines. These limits have been specific to the area south of Cape Mendocino and remain nested within overall *Sebastes* complex limits. Constraints on the recreational take of bocaccio were limited to daily bag limits for combined rockfish. Beginning in 2001, a two-fish daily bag limit was imposed for bocaccio, and time-area closures were implemented in 2002 to reduce the recreational catch of bocaccio.

### **Life History**

In most respects bocaccio is typical of other rockfishes. It displays a primitive form of viviparity (Wourms, 1991), with 50% of females maturing by 48 cm FL (Gunderson *et al.*, 1980). Fish copulate early in the fall (Moser, 1967), although fertilization is delayed (Wyllie Echeverria, 1987). Embryonic development takes at least a month to complete and the larvae hatch internally (Moser, 1967). The total fecundity of bocaccio ranges from 250,000-2,500,000 larvae, resulting in weight-specific fecundities of 250-400 larvae/gm (Phillips, 1964). Parturition occurs during the winter months (Wyllie Echeverria, 1987) and larvae eventually metamorphose into pelagic juveniles (Moser and Boehlert, 1991), a stage that takes months to complete (Woodbury and Ralston, 1991). Settlement to littoral and demersal habitats begins in late spring and extends throughout the summer months. Even though subadult growth can be very rapid in absolute terms (24 cm at age I), adults grow slowly (Wilkins, 1980). Moreover, growth is sexually dimorphic, with females reaching larger sizes than males (ca. 90 versus 75 cm). The diet of bocaccio is primarily fish.

### **New Aspects of this Assessment**

The following list highlights the major changes that have been implemented here relative to the last assessment that was conducted on bocaccio (MacCall *et al.*, 1999):

- Separate stock assessments are considered for waters north and south of Pt. Conception (but the final model combines the two areas).
- The beginning of the estimated time series of abundances is 18 years earlier than in previous assessments (previously 1969, now 1951).
- Commercial landings have been re-estimated from port sampling data, and the years 1978 and 1979 have been added.
- Recreational landings have been re-estimated from the MRFSS database, replacing blank strata (formerly treated as zero catch) with estimated catches. Northern California partyboat landings and length compositions are from the CDF&G sampling program, and also fill in recreational fishing information for years 1990-92 in which MRFSS did not conduct sampling.

- Many of the indexes were produced by a delta-lognormal general linear model (GLM), avoiding the potential distortions caused by adding an arbitrary constant before taking logarithms of values. Precision of indexes was estimated by a grouped jackknife approach.
- The Triennial Survey index of abundance and length compositions have been recalculated with off-bottom “water hauls” omitted. This affects abundance estimates and size compositions for the earlier years. The index is based on a GLM.
- New indexes of spawning biomass are based on GLMs of revised CalCOFI larval abundances for Southern California and Central California, from 1951 to 2000 in Southern California, and from 1955 to 2000 in Central California.
- A new Central California partyboat recreational CPUE index (GLM based on CDF&G observers) from 1987 to 1998 is introduced.
- A Southern California recreational CPUE index (GLM, based on MRFSS) from 1980 to 2001 is introduced.
- A recruitment index based on a GLM of impingement rates at five Southern California power plants from 1972 to 2000 is introduced.

### **Stock Structure**

Previous assessments of bocaccio included the Conception, Monterey and Eureka INPFC areas, mainly as a matter of convenience. Although catches of bocaccio occur regularly to the north, especially off Cape Flattery and in Canadian waters, very little northern information is available for purposes of stock assessment. At the time of the 1999 assessment, genetic information indicated lack of intermixing between the fish off the Pacific Northwest and the fish off California. More recent work indicates a somewhat higher possibility of intermixing (Vetter, pers. comm., SWFSC, La Jolla). Historical surveys reported in the 1999 assessment indicated a consistent lack of bocaccio off Northern California and Southern Oregon, which is interpreted as a discontinuity between the Pacific Northwest fish and those off California. For management purposes, the stock off California is considered to be separate and independent of the stock off the Pacific Northwest. Bocaccio off Northern Baja California are presumably associated with the California stock, but no information on catches is available. CalCOFI larval abundances are available for some years during the 1970's and 1980's, but were not worked up for this assessment.

An important unresolved question is the relationship between the Southern California and Central California segments of the resource (the nominal dividing line is Pt. Conception). Current management treats these two areas as a single well-mixed unit. Although a fully developed migration model is not available, this stock assessment uses available tools to examine consequences of partial stock separation.



## Sources of Data and Model Setup

### Landings Statistics

Landings by major fishery segments are summarized in Table 1. The total landings are taken from standard sources, or are estimated from available limited information (especially pre-1980). In some cases, such as recent recreational estimates, landings estimates may be subject to controversy, and alternative values can be obtained by various estimation methods and from alternative data sources. The recreational landings used here are not identical to the official RecFIN estimates (some blanks were filled with estimates if catch in number of fish was available, and some zero catch estimates were replaced with positive estimates). A sensitivity analysis using the unaltered RecFIN landings is included later in the document.

*Early landings:* Estimated landings for the pre-monitoring period follows the estimates developed in the 1996 assessment, except that this assessment requires historical catches for Southern and Central California separately. The estimated statewide bocaccio commercial landings were apportioned north and south of Pt. Conception according to the corresponding fractions of the recorded rockfish landings reported in CDF&G Fish Bulletins. In Central California, catch by gear was apportioned as in the 1996 assessment. Southern California trawl landing prior to 1978 were assumed to be negligible, and the commercial catch was assumed to be from the hook and line fishery. Pre-monitoring recreational catches were similarly apportioned to Southern and Central California in proportion to the partyboat landings for those two areas reported in CDF&G Fish Bulletins.

*Post-1978 monitoring:* In previous assessments, statistics of monitored landings began in 1980, but the database now includes commercial landings for 1978 and partial data for 1979. California's port sampling methodology is based on the statistical methodology of Sen (1986). The expansions of the sampled landings and length frequencies to the estimated statewide landings are described by Pearson and Erwin (1997), and reside in the COMCAL database maintained at the Santa Cruz Laboratory. The expansions have been recalculated since the previous assessment, resulting in a somewhat different time series of landings. Use of nominal landings categories, i.e., "bocaccio-chilipepper" received greater emphasis in the new expansions.

Changes in the recreational catch estimates from the MRFSS database mainly reflect the replacement of blank values (treated as zero in conventional queries) with approximate values. If a catch in numbers is available for the wave, region and fishing mode, the numbers are multiplied by the average weights in the preceding and following wave. If only estimated trips are available, the angler trips is multiplied by the average catch per trip in the preceding and following wave. Estimates for the 1993-95 Central California partyboat catch are not available from MRFSS; values were provided by Deb Wilson-Vandenberg (CDF&G, Pers. Comm.) based

on the CDF&G partyboat monitoring program. Catches for the unsampled recreational segments in the 1993-95 period were estimated as a linear trend between adjacent known values.

The combined effect on the estimated statewide landings (MT) by individual fishery segments is summarized for the period 1980 to 1998 in the following table:

Years	Differences from 1999 Assessment							Revised
	Trawl	SetNet	H&L	Rec'l	Com'l	Total	% Change	Total Landings
1980-84	-15	541	-59	-275	468	193	0.7%	29628
1985-89	121	2801	-359	112	2563	2674	21.1%	15341
1990-94	-81	840	198	377	957	1334	15.8%	9781
1995-98	5	93	-4	65	94	159	7.9%	2166
Total	30	4276	-225	279	4081	4360	8.3%	56916

### Surveys and Abundance Indexes

Methodological Note on Delta-Lognormal GLMs and Jackknife Procedures: The previous assessment used GLMs based on log-transformed observations  $\ln(\text{OBS} + c)$  where  $c$  is a small constant. This approach has the drawback that the resulting indexes are influenced by the value of  $c$ , the value of which is arbitrary. Several of the following indexes were developed from a delta-lognormal GLM, which allows estimation of a multiplicative effects (log-additive) model without use of the arbitrary added constant.

The probability of observing a positive value in a cell is given by a GLM with marginal (i.e., year, location, month) probabilities,

$$P(\text{positive})_{ijk} = \text{PYEAR}_i * \text{PMONTH}_j * \text{PLOCATION}_k * \text{error}.$$

The marginal probabilities are fit under logit transform. A separate GLM is applied to logarithms of the positive observations only, generating another set of marginal effects:

$$\ln(\text{CELL VALUE})_{ijk} = \text{LYEAR}_i + \text{LMONTH}_j + \text{LLOCATION}_k + \text{error}.$$

The year indexes from the delta-lognormal GLM are the product of the two back-transformed marginal year effects. Back-transformation from the logit model is

$$\text{PYEAR}_i = \exp(y_i + y_o) / (1 + \exp(y_i + y_o))$$

where  $y_i$  is the year effect and  $y_o$  is the fitted constant under logit transformation. The back-transform of estimated marginal year effects ( $x_i$ ) from the second GLM for positive values is simply its exponentiated value, so the year index is given by

$$\text{Year Index}_i = \text{PYEAR}_i * \exp(\text{LYEAR}_i).$$

The fitted constant from the second (logarithmic) model component and the traditional bias correction are omitted because they have no effect on the utility of the output as an index.

Estimation of standard errors of the year indexes utilizes resampling methodology. Erik Williams (pers. comm. SEFSC, Beaufort) has designed a bootstrapping procedure, but that approach seems to encounter estimation problems if the data contain a high proportion of zero values. A simple alternative is to use a grouped jackknife procedure (Efron and Gong 1983), where the variance is estimated by

$$s^2(\theta) = ((N_{\text{groups}}-1)/N_{\text{groups}})\sum w_i(\theta_i-\theta\bullet)^2$$

where  $N_{\text{groups}}$  is the number of sets of observations to be deleted,  $w_i$  is a weighting factor based on group sample size given to each subset (the values of  $w_i$  have unit mean),  $\theta_i$  is the estimate of parameter  $\theta$  with the  $i$ th subset of observations deleted, and  $\theta\bullet$  is the mean of the  $N_{\text{groups}}$  different values of  $\theta_i$ . The estimated standard error (SE) is the square root of this estimated variance, and the estimated coefficient of variation (CV) is the ratio of the SE to the estimated parameter value.

***CalCOFI Indexes of Spawning Biomass:*** Abundances of larval bocaccio observed on CalCOFI surveys from 1951 to 2000 (Moser et al. 2000) provide indexes of historical spawning biomass for Southern California and Central California. Development of these two indexes is described separately. In both indexes, jackknifing used five groups of deleted stations, chosen to be widely distributed geographically.

**Southern California CalCOFI Index:** Years with very limited coverage (less than 50 samples) were deleted, leaving 37 years with sufficient data to calculate annual indexes of abundance. Observations from December through April were used, based on consistency of station occupations and positive occurrences. CalCOFI Lines 80 (off Pt. Conception) to 93 (off San Diego) were included in the Southern California index. Offshore stations with rare occurrences of bocaccio larvae were deleted, leaving a total of 39 standard stations. Of the 7215 (37 years x 39 stations x 5 months) cells in this design, there were 3726 observations, 907 of which were positive for bocaccio larvae. These data were fit by a delta-lognormal GLM, estimating year effects (Figure 1), station (location) effects, and month effects. Five jackknife groups were formed from groups of stations chosen to cover the north-south and inshore-offshore range, with approximately equal numbers of observations, and so that no station contained all zero observations within a group. CVs ranged from 20-30% in the early years to 50-80% in recent years due to the progressively rarer occurrence of bocaccio larvae (Figure 1).

**Central California CalCOFI Index:** Bocaccio larvae from CalCOFI Lines 60 (off San Francisco) to 73 (off Piedras Blancas) Conception have only been identified thoroughly since 1972, and were rarely occupied after 1984. However, Line 77 (off Avila) has been identified since 1954, and continued to be occupied through 2000. Year effects from GLMs using Line 77 only and using Lines 60 to 73 are similar for the years 1972-1984, indicating that Line 77 is sufficiently representative of Central California to extend the time series from 1954 to 2000. Numbers of

positive stations are so few (especially in more recent years) that years were combined into nominal years to produce estimates that could be jackknifed for estimation of standard errors. The combined years (and corresponding nominal years) are

1962=61+62  
1959=58+59  
1966=65+66  
1979=1978+1979  
1981=1980+1981+1982  
1984=1983+1984+1985  
1987=1986+1987+1988  
1990=1989+1990+1991  
1995=1992+1993+1994+1995+1996+1997+1998  
2000=1999+2000.

Only the three peak reproductive months of January, February and March, and 26 CalCOFI stations were used. The final design comprised 1404 cells (18 years \* 26 stations \* 3 months) in which there were 568 observations and 154 positive observations.

As was done for Southern California, these data were fit by a delta-lognormal GLM, estimating year, station (location), and month effects. Five jackknife groups were formed from groups of stations chosen to cover the north-south and inshore-offshore range, with approximately equal numbers of observations, and so that no station contained all zero observations within a group. CVs for the Central California Index are much larger than for Southern California and average well over 100%. The most precise estimates are from 1960 to 1972 (average CV approximately 50%), a period during which bocaccio appear to have been significantly less abundant than in the following decade (Figure 2).

The Central California CalCOFI Index was used only in the exploratory Central California model, and was not used in the final combined model.

CalCOFI Index Selectivity: Although the Stock Synthesis program computes spawning biomass (or spawning output), it does not include an option for fitting a spawning biomass index directly. An approximate selectivity curve was derived by fitting a logistic model to the relationship of weight specific fecundity (proportion mature \* eggs/weight) and length (Figure 3). This selectivity curve was applied to the female abundances to obtain predicted values of the CalCOFI indexes.

***Triennial Survey Index (Central California):*** The Alaska Fisheries Science Center has conducted bottom trawl surveys every three years off the west coast since 1977, with the most recent survey in 2001. The Monterey INPFC area was sampled on every survey, but the Conception area was not sampled on the 1980, 1983 and 1986 surveys. The 1977 survey did not

sample the 55-91m depth range, but Ralston et al (1996) showed that very few bocaccio tend to be encountered in this range, so no attempt is made in this assessment to adjust the 1977 index for this small difference. Recent analysis of historical Triennial Survey trawl performance identified a problem with the extent of bottom contact by the net during the early years of the survey (Zimmerman et al. 2001). The questionable trawl samples have been deleted from the Triennial Survey data used in this analysis (pers. comm., Mark Wilkins, AFSC).

I used a simple log-transformed GLM to obtain bocaccio abundance indexes from the triennial survey stratum means; the GLM treatment provided a means of estimating the index despite the Conception region not having been surveyed in some years. Factors were survey year, area (Conception vs. Monterey), and depth stratum (nearshore, 55-183m, vs. and offshore, 184-366m). Values from the Eureka INPFC area were not included, as bocaccio were too rare in the catches to be informative. The coefficient of variation of the GLM index was assumed to be the same as the directly-calculated CV for the combined strata. The resulting index was imprecise, with CVs ranging from 30% to 80% (Figure 4).

***Recreational Fishery CPUE:*** Two separate indexes of abundance were developed from GLM treatment of catch rates of bocaccio in recreational fisheries.

Central California Partyboat CPUE: The California Department of Fish and Game has conducted intensive sampling of partyboat catches in Central California (Deb Wilson-Vandenberg, Pers. Comm.), providing a basis for a CPUE index. The GLM was based on year (1987 through 1998), quarter (4) and boat (29) effects. Boat effects were a surrogate for location effects, and boats with low catch rates or short-term participation were deleted. The database contained 3632 observations, of which 1336 were positive for bocaccio. Quarters were used as groups for deletion in the jackknife procedure. Except for the 1987 index, precision was good, with CVs ranging from about 10% to 25% (Figure 5).

Southern California Recreational CPUE: The MRFSS database provides a basis for estimating a Southern California partyboat CPUE. The GLM was based on bimonthly mean catch per angler according to year (1980-1989, 1993-2001), season (4 bimonthly sampling waves excluding the summer season, i.e., November through June), and fishing mode (partyboat vs. private). Sampling waves were used as groups for deletion in the jackknife procedure. Most of the CVs were in the 30%-50% range, with a few larger or smaller values (Figure 6).

***Trawl Fishery CPUE (Central California):*** Ralston (1999) developed a CPUE index of bocaccio abundance based on California trawl logbooks (Figure 7). Because the logbooks do not identify most individual species such as bocaccio, Ralston applied species compositions from local port sampling to the overall catch rates of rockfish from the trawl logbooks. This assessment uses Ralston's "area-weighted" index of bocaccio CPUE, and the associated standard errors (average CV is 29%).

**Recruitment Indexes:** Two separate recruitment indexes were developed, for Central and Southern California respectively.

Trawl Survey Recruitment Index (Central California): Midwater trawl surveys for juvenile rockfish have been conducted by the Santa Cruz Laboratory in May-June of each year since 1983. The survey region from Monterey to Pt. Reyes is divided into seven geographic strata, with three to five standard trawl locations within each stratum. The geographic area is surveyed three times (“sweeps”). In each year, the two sweeps that encountered the largest number of juvenile bocaccio in all areas combined were retained for use in the GLM (in a few cases of approximately equal catch rates, all three sweeps were retained). All trawls conducted in the same region and year were considered to be equivalent iid observations, yielding 745 observations, of which 171 were positive for bocaccio juveniles. The GLM was based on year and region effects (Figure 8). Three groups of individual trawl stations within the geographic strata were used for deletion in the jackknife procedure. Estimated CVs were quite variable with individual year effects ranging from very precise (ca. 10%) to very imprecise (over 100%).

Power Plant Recruitment Index (Southern California): Annual impingement rates (bocaccio per volume of intake water) at five Southern California electrical generating stations (Kevin Herbinson, pers. comm., Southern California Edison) from 1972 to 2000 form the basis of a recruitment index. These data were fit by a delta-lognormal GLM, estimating year (recruitment index) and station (location) effects. Observations from the three separate units at San Onofre were given fractional weightings summing to unity at that location for each year. Standard errors for the year effects were estimated by a grouped jackknife, deleting individual power plants (Ngroups=5). The only years in which no bocaccio were impinged at any location were the two El Niño years of 1983 and 1998. In three other years (1982, 1993 and 1994) bocaccio were impinged at only one location, preventing jackknife estimates of precision of those years; approximate standard errors for these five recruitment index values were inferred from the approximately linear relationship between standard error and corresponding year index near the origin (Figure 9). The coefficients of variation average about 2, indicating extreme imprecision in this index.

The strength of the 1999 year class has been of particular interest since it was first observed in the power plant entrainments at San Onofre. This database shows that the 1999 year class was observed at only two of the five locations, and was abundant only at San Onofre. The corresponding 1999 index value is extremely imprecise (CV=600%), but is more similar to the “low” (1991 year class equivalent strength) than to the “medium” (1988 year class equivalent strength) case considered in the 1999 assessment and rebuilding analysis.

## **Age Determinations**

The break-and-burn method of age determination from otolith circuli is considered to be more reliable than surface readings, and tends to result in older age determinations (Don Pearson,

SCL, SWFSC, Pers. Comm.). However, Ralston et al. (1996) and Ralston and Ianelli (1998) found that use of the age composition information for bocaccio conflicted with length composition information, and caused peculiar shifts in the years associated with major bocaccio recruitments. The true year of recruitment is clearly established by known length of young-of-the-year fish and clear modal patterns in the length compositions (Figure 10). The results of the previous assessment indicate that an unknown but probably systematic pattern of errors in the age determinations is present, and the age composition information provides misleading information. Age compositions are not used in this assessment, but break-and-burn age determinations are assumed to be approximately correct for purposes of estimating length-at-age and maximum longevity.

## Sample Sizes

Determination of appropriate sample sizes has been a recurring problem in maximum likelihood models such as stock synthesis. Catch and survey samples are taken as clusters of fish, and several mechanisms can cause within-cluster variance to be severely reduced relative to an equivalent number of iid samples. An empirical estimate of “effective” sample size ( $N_{\text{eff}}$ ) is provided by the synthesis model, based on the ratio of the variance of the expected proportion ( $p$ ) from a multinomial distribution to the mean squared error of the observed proportion ( $p'$ ), i.e.,  $N_{\text{eff}} = \text{sum}[p(1-p)]/\text{sum}[(p-p')^2]$ . Rather than direct use of  $N_{\text{eff}}$  (e.g., McAllister and Ianelli, 1997), this assessment follows the iterative regression “smoothing” approach developed in the 1999 bocaccio assessment: actual sample sizes are replaced by nominal sample sizes based on the predicted effective sample sizes from a regression of  $N_{\text{eff}}$  on actual number of fish measured (actual sample size is used if it is a smaller number than is predicted by the regression). After the first iteration the effective sample size values from the regression predictions tend to be stable. The relationships between actual and effective sample sizes are shown for various sources in Figure 11. The ratios of nominal to actual and effective (based on the final model) to actual sample sizes is given in Table 4. The nominal sample sizes used in this assessment are higher than final effective sample sizes because the nominal sizes were derived from separate Southern and Central California models in which length compositions could be fit more precisely than in the combined model. Because the fits in the separate models were better, the quantity  $\text{sum}[(p-p')^2]$  was lower, producing higher estimated effective sample sizes than are given by the combined model.

## Natural Mortality Rate

Previous estimates of the natural mortality rate ( $M$ ) have decreased over the history of bocaccio stock assessments, partially due to improvements in age determination methods and resulting increases in maximum observed ages: Bence and Hightower (1990) used 0.25, Bence and Rogers (1992) used 0.20, and in 1996, Ralston et al. used 0.15 (the units  $\text{yr}^{-1}$  are omitted). In 1999, MacCall et al. returned to use of 0.20. This assessment assumes  $M=0.2$ , but examines implications of the alternative values of 0.15 and 0.25.

## Growth

This assessment is based on length compositions rather than age compositions, and the growth curve has nearly as large an influence as the natural mortality rate in determining the stock dynamics. The influence of abundant small fish in some years of the Triennial Survey length compositions tended to “trap” the estimated length at age 1.5 at an unrealistically small value (abundance, length and selectivity were confounded), so the initial (age 1.5) length was fixed at 27cm for both sexes, and the asymptotic length was fixed at 75.89cm for females and at 65.56cm for males. The growth rate parameter was estimated freely for each sex.

## Model Results

The calculations utilize the length-based version of the Stock Synthesis model (Methot 1990). During model development, separate models were constructed for Southern and Central California. However, the STAR Panel preferred a final assessment model using combined data for both areas. The results presented here are for the combined model (Table 4 and Appendix 1). The projections are based on either the stock synthesis program with separate selectivity patterns for each fishery or Andre Punt’s rebuilding simulation model, using the composite selectivity pattern given in Appendix 1 (see section on Stock Projections for more details).

*Selectivity:* Length-based selectivity patterns were examined in the 1996 and 1999 assessments. Because of potential interactions with isolated strong year classes, time-varying selectivity was not considered. As in the previous assessments, most selectivity patterns have a strong descending limb. In previous assessments, male-female differences were seen only in the trawl selectivities; this assessment found no sex-related difference in the Central California trawl selectivities. Trawl size compositions from the Southern California fishery were available only for two years, and produced highly questionable selectivity curves with a very narrow peak. Consequently, the Southern California trawl length compositions were deleted from the likelihood function, and selectivity of the Central California trawl fishery was also applied to trawl catches from Southern California. There is no clear systematic relationship between selectivity curves of equivalent gears in Central and Southern California (Figure 12).

*Fits to abundance indexes:* The fit to the Triennial Survey (Figure 13) reflects the high error variability shown in Figure 4; a precise fit should not be expected. In addition, the model had difficulty identifying an appropriate selectivity curve for the length composition information from the Triennial Survey; the final selectivity curve favors smaller fish (Figure 12). Fits to the trawl CPUE (Figure 14) and Central and Southern California recreational CPUE (Figures 15 and 16) are good. The fit to the CalCOFI index (Figure 17) is also quite good.

The fit to the Central California recruitment index is similar to that seen in the previous assessment (Figure 18). The survey identifies some, but not all of the stronger year classes. The fit to the Southern California recruitment index similarly shows general agreement (Figure 19),



but with some strong differences for individual years. This is expected, given the imprecision of the Southern California recruitment index.

## **Recruitment**

Minimum recruitment was set at 50,000 fish. Recruitment estimates for several of the weakest years, especially El Niño years, were constrained by this bound. The model did not include a likelihood component for the fit to a stock-recruitment relationship. Recruitment estimates for the 1950's and 1960's are not based on length compositions, so are not reliable for date, but only for magnitude when averaged over decadal time scales. As has been seen in previous assessments, recruitment is irregular (Figure 20). The stock-recruitment relationship (Figure 21) suggest that larger recruitments have been associated with higher abundances, but shows no curvature. The relative reproductive success (measured by the logarithm of recruits per spawning output) is level over the range of spawning abundances (Figure 22), indicating that the recent history of bocaccio reproduction shows no evidence of density dependent compensation. In the 30 year history shown in Figure 22, recruitment exceeded the replacement level in only eight years. The most recent successful reproduction was in 1999, which is the leftmost point above the horizontal replacement line. The CV on the estimated strength of the 1999 yearclass is estimated to be approximately 78% based on treating estimates obtained by omitting individual likelihood components (see the sensitivity analysis of component emphasis, documented below) as a grouped jackknife.

The history of recruitments and parental abundances provides the basis for estimating an approximate sustainable fishing rate. The 41-year average recruitment per spawning output was 1.466. The spawning output per recruit (SPR) at  $F=0$  is 1.379. A fishing rate that reduces SPR to  $1/1.466 = 0.682$  or 49% of the unfished level should be sustainable. Thus, the F50% proxy being used by the PFMC to manage rockfish stocks is sustainable for bocaccio. This calculation does not indicate whether F50% would produce MSY, however.

## **Abundance**

The trend of abundances after 1969 (the initial year in the previous assessment) resembles those from previous stock assessments except that the size of the resource is now estimated to have been about 50% larger (Figure 23). Extension of the assessment back to 1951 reveals that abundances were lower in the two decades preceding the 1969 peak, and shows the fluctuating pattern that would be expected from dynamics based on rare large recruitments. The spawning output lags the total biomass by a few years, reflecting the time to maturity. The unfished abundance (Bunfished) is estimated based on the average recruitment from 1955 to 1995 multiplied by the spawning output per recruit in the absence of fishing, giving an estimated unfished spawning output of 14850 billion eggs (shown as a horizontal line in Figure 23). This estimate is very imprecise ( $CV=31\%$ ) due to the extreme variability of recruitment. The current

(2002) spawning output is estimated to be 720 billion eggs, or 4.8% of the estimated unfished level, and the estimated current total (age 2+) biomass is 2958MT.

*Fishing rate time series:* Figure 24 shows the history of exploitation rate (catch as a fraction of total (age 2+) biomass). Exploitation rates have exceeded F50% in most years since 1951.

## **Sensitivity Analysis**

*Random restarts:* Convergence properties of the base model are demonstrated by varying the starting parameters by plus-or-minus 30%, and re-estimating the maximum likelihood fit. The result of this procedure (Figure 25) indicates good convergence of the model.

*Retrospective analysis:* Some forms of bias can be detected by simulating a time series of model estimates with progressively earlier final years of the analysis (note that the GLM indexes of abundance were not recomputed). The retrospective pattern of the bocaccio assessment shows no bias, but does show an irregular effect due to the Triennial Survey data that contributes a new data point only every third year (Figure 26).

*Effect of alternative catch data:* The estimates of bocaccio catch used as data in this assessment are a major source of uncertainty. Catches for the pre-1978 years are approximations based on very limited information. Catches in the most recent years pose a different problem. Commercial landings do not include the portion of the catch that was discarded at sea, and anecdotal information suggests that discards have been increased substantially in 2000 and 2001 due to the restrictive limit on landings. Recreational catch have become imprecise, with an increasing number of two-month waves in which no bocaccio are estimated to have been landed by recreational fishery segments. This seems questionable in view of frequent complaints by recreational fishermen and partyboat operators that bocaccio are abundant and impossible to avoid.

Results of some alternative catch scenarios relative to the base model are examined in the following table. Following the base model, the first case represents a pre-1978 catch history where Southern California catches are half the values used in the base model (recreational and Central California commercial catches are considered to be more reliable). The second case uses the RecFIN data from 1980 to present without adjustment for unsampled waves or zero catch estimates. The third case assumes that commercial catches in 2000 and 2001 have been twice the reported landings due to at-sea discards.

Case	Base Model	50% Early SoCal Commercial	Unadjusted RecFIN Catch	200% Commercial in 2000, 2001
TotBiomass2002(MT age2+)	2958	2896	3367	2907
SpOut2002/Bunfished	4.8%	4.1%	5.3%	4.8%
SPRsustainable	49%	51%	51%	49%
Exploitation rate 2001	6.4%	6.5%	3.9%	7.1%
Years to Rebuild@F=0	97	103	99	97
Rebuilding OY2003 (MT)	5.8	4.9	6.4	5.3

The alternative catch scenarios do not alter the model results substantially. Use of the alternative recent catches result in similar estimates of current relative abundance, and do not indicate substantially different rebuilding scenarios. The smaller historical Southern California catch results in a lower estimate of Bunfished, but that is offset by a slightly lower productivity rate. The RecFIN catches indicate a lower current exploitation rate (consistent with lower current catch), but the 2001 data were incomplete (lacking wave 6) at the time of model development. It is likely that the base model overestimates recent recreational catches and underestimates recent commercial catches; however, the results are influenced mainly by the magnitude of combined removals, irrespective of fishery segment.

*Effect of alternative natural mortality rates:* The natural mortality rate of bocaccio is not known, and use of  $M=0.20$  in the base model is based on convention rather than on knowledge of the true rate. To examine this source of uncertainty, the population model was run at two alternative natural mortality rates,  $M=0.15$  and  $0.25$ , which are thought to bracket the likely range of true values. Results are shown in the following table.

Case	M=0.15	M=0.20	M=0.25
TotBiomass2002(MT age2+)	2820	2958	4397
SpOut2002/Bunfished	4.5%	4.8%	6.9%
SPRsustainable	39%	49%	61%
Exploitation rate 2001	6.8%	6.4%	4.9%
Years to Rebuild@F=0	64	97	257
Rebuilding OY2003 (MT)	9.8	5.8	1.5

Models based on the three alternative natural mortality rates roughly agree on the present level of depletion relative to estimated unfished conditions. Use of a higher natural mortality rate results in generally higher estimated biomasses and recruitments throughout the time series, but the relative decline indicates lower per capita productivity. Use of  $M=0.15$  yields an average recruit per spawner ratio that implies sustainability at a higher fishing rate, whereas use of  $M=0.25$  would indicate a sustainable fishing rate that is lower than the current proxy of  $F50\%$ . The differences in productivity are most noticeable in the projected median rebuilding times: Whereas the  $M=0.15$  case indicates a somewhat more rapid rebuilding trajectory and a slightly higher rebuilding OY, the  $M=0.25$  case shows extremely slow rebuilding.

*Effect of alternative emphasis values:* Emphasis was set at 1.0 for all likelihood components in the base model so that the likelihood function and model properties can be given

standard statistical interpretation. In this sensitivity analysis, emphasis factors for likelihood component groups were set individually at 0.1 or 10.0 to determine how the interactions among the components influence the final model (Table 5). Model results are unusually stable with regard to changes in emphasis, perhaps partially as a result of having a wide variety of separate data sources. The main pattern in Table 5 is that the Southern California components tend to raise the ending biomass estimate (and the status relative to the unfished level), suggesting that the resource may be less depressed in Southern California relative to the condition in Central California.

Alternative emphases on groups of components are also informative. The difference between relative condition of the resource in Central and Southern California is clear in the results of the respective group emphases. Also, the Southern California components indicate a potential for more rapid attainment of the rebuilding target. [IMPORTANT NOTE: This does not mean that a separate Southern California rebuilding OY of 39.1 MT is a viable management option—these results are based on combined catch data for both areas and cannot be separated in this model.]

<u>Group Emphasis (x10)</u>	<u>Base Model</u>	<u>Central Calif</u>	<u>Southern Calif</u>
TotBiomass2002(MT,2+)	2958	1695	5015
SpOut2002/Bunfished	4.8%	3.8%	7.0%
SPRsustainable	49%	47%	46%
Exploitation rate 2001	6.4%	10.6%	4.0%
Years to Rebuild@F=0	97	106	47
Rebuilding OY2003 (MT)	5.8	2.5	39.1

There is similar contrast between the model results emphasizing surveys and abundance indexes vs. the model emphasizing length compositions, with the length compositions tending to indicate a more depleted resource. However, in this case the difference in current status does not result in a difference in median rebuilding time.

<u>Group Emphasis (x10)</u>	<u>Base Model</u>	<u>Length Comp</u>	<u>Abundance Indexes</u>
TotBiomass2002(MT,2+)	2958	2126	4146
SpOut2002/Bunfished	4.8%	3.2%	9.5%
SPRsustainable	49%	47%	48%
Exploitation rate 2001	6.4%	9.0%	4.5%
Years to Rebuild@F=0	97	94	77
Rebuilding OY2003 (MT)	5.8	5.2	7.9

## Stock Projections

The stock projections presented in this analysis utilize both stock synthesis (sample size = 100 simulations) and the rebuilding simulation developed by Andre Punt for the SSC (V1.5, sample size = 10,000 simulations). Strength of future model recruitments is based on randomly resampling the historical reproductive success (recruits per spawning output, R/S) from recruitment (age 1) years 1954 to 2000, and multiplying by the parental spawning output for the year being simulated. As shown in Figure 22, the mean and distribution of R/S values have been

invariant with stock abundance, justifying this approach. The resulting projections are very imprecise. Spawning success has exceeded replacement level (the condition necessary for population growth) in relatively few historical years (Figure 22).

*Long-term projections:* In the absence of fishing, the median time to reach the rebuilding target spawning output of 5943 billion eggs is 97 (SE = 1) years. The rebuilding target of 0.4\*Bunfished is imprecisely estimated, with a 50% probability that the true value lies between 4700 and 7200 billion eggs. Based on stock synthesis projections, this range of rebuilding targets translates to an uncertainty in rebuilding times of  $\pm 5$  years. The distribution of projected abundances after 100 years without fishing is shown in Figure 27 (this projection is from stock synthesis).

If the rebuilding time frame is extended by one mean generation time (12 yr), less the 3 years already elapsed, the new rebuilding horizon is 106 yr. The allowable catch under rebuilding is very small, approximately 6 MT. These results indicate that the previously adopted 38 yr rebuilding time frame is not feasible, and the draft rebuilding plan will need to be revised. It is worth noting that these results are consistent with the “low-1999” projections in the previous stock assessment and rebuilding analysis (which indicated a minimum rebuilding time of 76 years and allowable catches of about 10MT).

*Near-term projections:* In Figure 28, stock abundance is projected (using stock synthesis) to the year 2025 for a condition of no fishing. Median abundance declines slightly at the beginning and rises slightly toward the end, but is level overall. Because of the effect of a few strong year classes in the simulations, the average projected abundance begins to rise slowly after about 10 years. Given the present assessment, it is unlikely that the resource condition will change significantly in the coming decade.

There are many sources of error and imprecision both inside and outside the model. Within the model, alternative assumptions of the natural mortality rate and emphasis on Southern and Central California data give different results (see sensitivity analyses), but do not radically change the outlook. The ocean climate was extraordinarily bad during the 1990s, and if the climate has changed to a more favorable state, the probability of strong year classes in the near future may be higher than in this analysis. If strong yearclasses appear during the coming decade, they will not only contribute to an increase in abundance, but will also contribute to a higher frequency of good reproductive successes in future stock projections, giving some hope for more liberal fishing opportunities. However, such strong year classes must first be documented quantitatively, e.g., in recruitment surveys and power plant impingements.

## **STAT Team Comment on Southern vs. Central California**

During development of the assessment model, the STAT Team examined separate models for Southern and Central California, but the STAR Panel preferred a single combined model. The two independent models were statistically well-behaved (lacking internal conflicts among data elements), and provided an alternative view of resource dynamics. Estimated yearclass strengths were highly correlated for the strong recruitments, but were independent for the weaker recruitments. This could result from migration of fish between the two regions, or from parallel responses to widespread oceanic conditions (or both). Abundances and recruitment strengths averaged two to three times higher in Central California than in Southern California, but exploitation reduced the abundance in the Central California segment to a greater extent than that in the Southern California segment, indicating a condition of localized depletion that cannot be modeled under the STAR Panel's preferred combined model. Reproductive successes were somewhat higher in the Southern California model, and were lower but more variable in the Central California model. This leads to the inference that the Southern California segment may be more resilient, while the Central California segment, although historically larger, may have lower resilience, and may be subject to wide fluctuations in a natural condition. This kind of differential variability in geographically separated segments of a single population is a well-known phenomenon (MacCall 1990), would provide a justifiable basis for area-specific management, including area-specific rebuilding goals and programs. Ideally, a model with explicit diffusion (larvae) and migration (adults) components would allow exploration of geographic structure and implications for bocaccio management. However, the necessary model does not currently exist in a form that is compatible with the length-based bocaccio data.

### **Recommendations for Next Assessment**

A minimal bocaccio reassessment, utilizing the new expedited stock assessment review process, is recommended in 2003. The strength of the 1999 year class continues to have a strong influence on stock status and rebuilding projections. This year class will be more evident in the length compositions, and new information on discard rates may be available for the observer program. Under consultation with knowledgeable fishery scientists, it may be worthwhile to reconsider the value of the assumed natural mortality rate (presently 0.20). Use of  $M=0.15$  results in slightly higher estimated productivity, but must be justified objectively.

The next full assessment should attempt to explore the geographic relationships of the Southern and Central California segments of the stock. This will require development of new modeling tools.

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Table 1. Historical summary of bocaccio management.

YEAR	ABC	HG	ACTUAL	RELEVANT QUOTES AND (NOTES)
1983	6100		6486	(4100 MT Monterey, 2000mt Conception, managed as "other rockfish")
to				
1987	6100		3461	
1988	6100		2287	"ABC may be too high [will be revised pending new assessment]"
1989	6100		3429	"ABC may be too high [GMT hopes a new assessment will be available]"
1990	6100		2836	"no new analysis has been conducted"
1991	800	1100	1757	"The spawning biomass in 1991 is probably less than 25% of the average, unfished level"
1992	800	1100	2054	"The spawning biomass in 1991 is probably less than 25% of the average, unfished level"
1993	1540	1540	1811	"catch in 1991[1700MT]...was near the target catch level now indicated by application of the F35% harvest policy"
1994	1540	1540	1333	"biomass has declined substantially since 1980 and is approaching 20 percent of its estimated unfished level" "there is some risk in maintaining harvests at this level"
1995	1700	1700	865	"weak recruitments since 1979 will cause the stock to decline unless total harvest is kept closer to 1100MT, However, reported commercial catch in 1994 totaled only 1,260MT."
1996	1700	1700	600	"weak recruitments since 1979 will cause the stock to decline unless total harvest is kept closer to 1100MT, However, reported commercial catch in 1994 totaled only 1,025MT."
1997	265		488	"unlikely that the current stock is greater than 17 to 20 percent of the 1970 level"
1998	230		215	(Fmsy proxy changed to F40%) "a one-fish daily bag limit would be necessary to accomplish a reduction in recreational catch"
1999	230		213	"OY account[s] for unavoidable bycatch...under existing management of other rockfish species"
2000	100		233	Rebuilding initiated assuming "medium" 1999 year class strength
2001	100		214	
2002	100			

Table 2. Recent bocaccio fishing regulations.

January 2001

Recreational

Bag limit: 10 rockfish, only 2 bocaccio, 10" minimum size

North of Cape Mendocino: open year round

Cape Mendocino-Pt Conception: Closed March-June except inside 20 fathoms - open May-June

Pt Conception South: Closed January-February except inside 20 fathoms (open all year)

Commercial

Limited Entry (fixed and trawl):

Southern Area: 300 lbs/month Jan-April and Nov-Dec, otherwise 500 lbs/month

Open Access: 200 lbs/month, year round

January 2002

Recreational

Bag limit: 10 rockfish, no more than 2 bocaccio if not prohibited

Inside 20 fathoms, central area: recreational fishing allowed May-June and Sept-Oct, but bocaccio may not be retained

Outside 20 fathoms, central area: open January-February and July-August

All southern waters: open March-October

Commercial

Limited Entry Trawl: Jan-April 600 lbs/2 months, May-Oct. 1,000 lbs/2 months, Nov-Dec 600lbs/2 months

Limited Entry Fixed Gear:

North of Cape Mendocino: 200lbs/month

Cape Mendocino - Pt Arguello: 200 lbs/month Jan-Feb and July-Aug, closed otherwise

South of Pt. Arguello: 200 lbs/month March-Oct, closed otherwise

Open Access:

North of Cape Mendocino: 200lbs/month

Cape Mendocino - Pt. Arguello: 200 lbs/month Jan-Feb and July-Aug, closed otherwise

South of Pt. Arguello: 200 lbs/month March-Oct, closed otherwise

Table 3. Estimated historical bocaccio landings (MT) in California (for assessment use only).

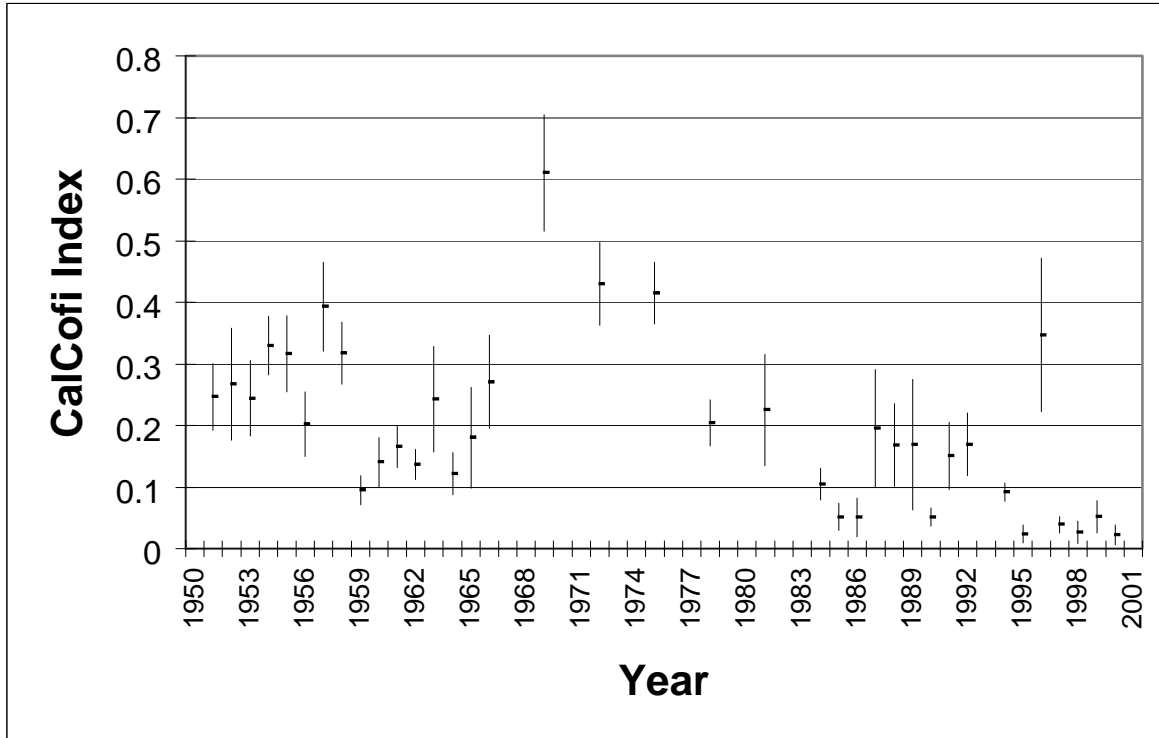
	Southern California					Northern California					Statewide
	Trawl	H&L	Setnet	Rec'l	Total	Trawl	H&L	Setnet	Rec'l	Total	Total
1950	0	428	0	39	468	2816	438	0	86	3339	3807
1951	0	471	0	35	506	3895	620	0	98	4613	5119
1952	0	366	0	45	411	3866	630	0	86	4582	4993
1953	0	298	0	56	355	4494	750	0	72	5316	5671
1954	36	547	0	122	705	4401	750	0	91	5242	5946
1955	1305	504	0	213	2023	3451	492	0	108	4051	6074
1956	942	540	0	256	1738	4608	689	0	121	5418	7155
1957	1296	522	0	138	1956	4803	678	0	120	5601	7557
1958	1199	604	0	95	1899	5041	1249	0	193	6483	8382
1959	444	611	0	57	1113	4691	1185	0	160	6036	7149
1960	1054	609	0	63	1725	3922	636	0	125	4683	6408
1961	826	654	0	72	1552	2821	612	0	94	3527	5079
1962	690	670	0	68	1427	2460	642	0	109	3210	4637
1963	953	657	0	67	1677	3102	617	0	111	3830	5507
1964	492	555	0	94	1140	2177	459	0	85	2721	3861
1965	559	654	0	117	1330	2508	540	0	132	3179	4509
1966	800	630	0	170	1600	2571	564	0	142	3277	4877
1967	1086	713	0	210	2010	2162	483	0	140	2785	4795
1968	961	655	0	223	1838	2173	495	0	166	2834	4673
1969	906	611	0	212	1728	2190	479	0	154	2823	4551
1970	888	529	0	289	1706	2908	523	0	204	3634	5340
1971	642	603	0	244	1489	3031	791	0	167	3988	5477
1972	1266	814	0	339	2419	4302	1066	0	226	5595	8013
1973	1532	875	0	401	2808	6043	1553	0	260	7855	10663
1974	376	2262	0	459	3097	5673	1441	0	289	7403	10500
1975	1941	1058	0	450	3449	6132	1586	0	276	7993	11442
1976	2424	1015	0	417	3856	6113	1608	0	248	7969	11825
1977	2286	895	0	377	3558	4969	1330	0	218	6517	10075
1978	587	145	83	350	1165	2243	35	47	196	2522	3686
1979	2423	1507	0	445	4375	1479	228	3	242	1952	6327
1980	39	84	121	1691	1936	3607	215	77	190	4090	6026
1981	84	161	213	844	1302	3904	76	227	233	4439	5741
1982	217	301	176	1010	1703	4123	559	423	329	5433	7136
1983	356	156	135	261	907	3941	138	1227	272	5578	6486
1984	63	75	242	170	550	3125	131	385	47	3688	4238
1985	18	81	305	309	714	1205	36	973	67	2281	2995
1986	13	147	327	395	882	1033	20	1065	172	2290	3172
1987	52	73	253	104	482	1101	181	1585	113	2979	3461
1988	0	144	76	111	332	1226	172	505	52	1955	2287
1989	0	112	193	266	572	1120	172	1476	88	2857	3429
1990	0	198	8	233	439	1102	143	1061	91	2397	2836
1991	1	26	174	200	401	703	157	404	92	1356	1757
1992	6	335	98	167	606	484	212	659	92	1448	2054
1993	1	270	160	135	565	558	222	366	99	1245	1811
1994	13	151	53	195	412	514	86	268	43	911	1323
1995	1	21	62	43	127	376	50	281	30	738	865
1996	1	36	27	78	142	287	64	76	30	457	600
1997	1	24	7	66	97	229	34	31	97	391	488
1998	1	12	4	30	47	72	29	37	29	168	215
1999	0	3	2	60	66	45	18	5	80	148	213
2000	0	2	0	59	61	19	5	1	147	172	233
2001	0	3	0	105	108	13	5	1	87	107	214

Table 4. Summary of historical estimates from bocaccio base model. Recruits are at age 1.

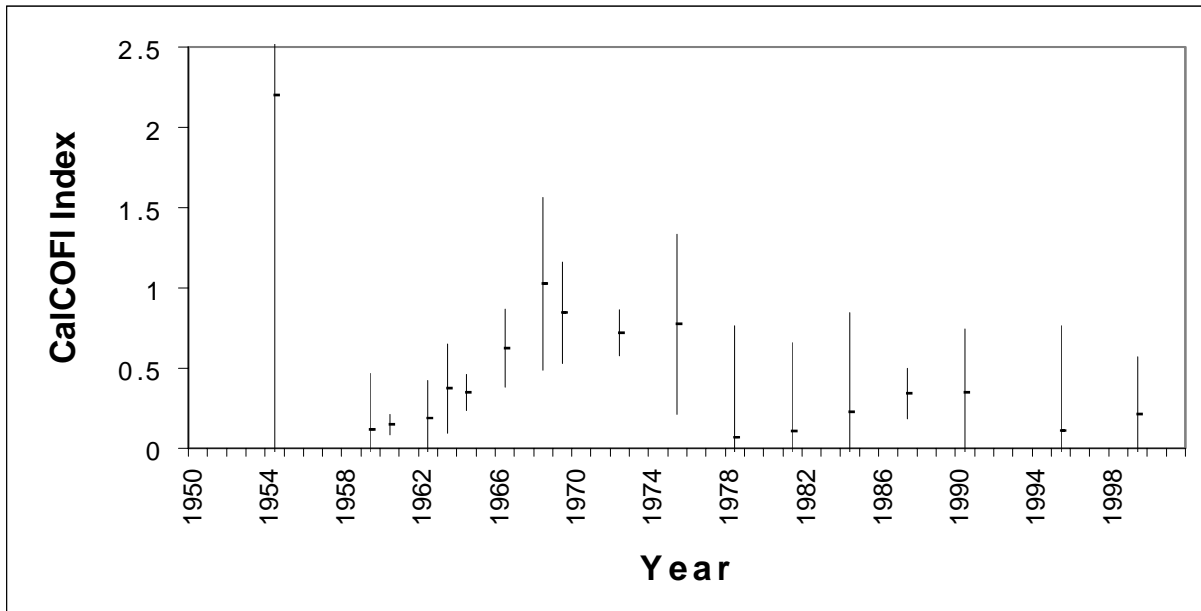
Year	Bage2+ (MT)	SpOut(10 <sup>9</sup> eggs)	Recruits(10 <sup>3</sup> )	Catch	ExploitRate	Year	Bage2+ (MT)	SpOut(10 <sup>9</sup> eggs)	Recruits(10 <sup>3</sup> )	Catch	ExploitRate
pre-51	58754	9521	12168	3807	6.5%	1976	81031	14840	2955	11825	14.6%
1951	58754	9522	61065	5119	8.7%	1977	67893	13233	455	10075	14.8%
1952	71522	9374	175	4993	7.0%	1978	54849	11621	44923	3686	6.7%
1953	74110	9609	90	5670	7.7%	1979	60297	10731	1779	3401	5.6%
1954	72372	10537	50	5947	8.2%	1980	59619	10065	10397	6024	10.1%
1955	66730	11402	50	6074	9.1%	1981	56986	9678	2660	5742	10.1%
1956	58322	11324	50	7155	12.3%	1982	51931	9459	1127	7138	13.7%
1957	47224	10133	96	7557	16.0%	1983	43686	8735	50	6486	14.8%
1958	35294	8365	53201	8382	23.7%	1984	34817	7666	3053	4238	12.2%
1959	38311	6296	9922	7149	18.7%	1985	28647	6629	12986	2994	10.5%
1960	38779	5135	580	6409	16.5%	1986	26981	5699	1170	3172	11.8%
1961	36856	5166	769	5079	13.8%	1987	23673	4867	1801	3462	14.6%
1962	33771	5538	8713	4638	13.7%	1988	20169	4249	2587	2286	11.3%
1963	31600	5526	169111	5508	17.4%	1989	17865	3846	8436	3427	19.2%
1964	74859	5066	388	3861	5.2%	1990	16110	3222	2078	2836	17.6%
1965	95179	6006	232	4510	4.7%	1991	14112	2703	998	1757	12.5%
1966	108008	9753	219	4877	4.5%	1992	12791	2466	2732	2053	16.1%
1967	112425	14630	256	4794	4.3%	1993	11382	2239	50	1811	15.9%
1968	110057	17909	478	4673	4.2%	1994	9474	1976	795	1324	14.0%
1969	102533	18927	7360	4551	4.4%	1995	7993	1749	569	864	10.8%
1970	93780	18429	92424	5341	5.7%	1996	6874	1556	50	599	8.7%
1971	108159	17121	154	5478	5.1%	1997	5863	1383	379	489	8.3%
1972	108763	16216	50	8013	7.4%	1998	5006	1217	52	214	4.3%
1973	103319	16526	31983	10664	10.3%	1999	4373	1089	50	213	4.9%
1974	100394	16808	1752	10500	10.5%	2000	3738	961	971	233	6.2%
1975	90591	16150	15045	11443	12.6%	2001	3364	832	93	215	6.4%
1976	81031	14840	2955	11825	14.6%	2002	2914	720	316		

Table 5. Effects of varying emphasis on individual likelihood components.

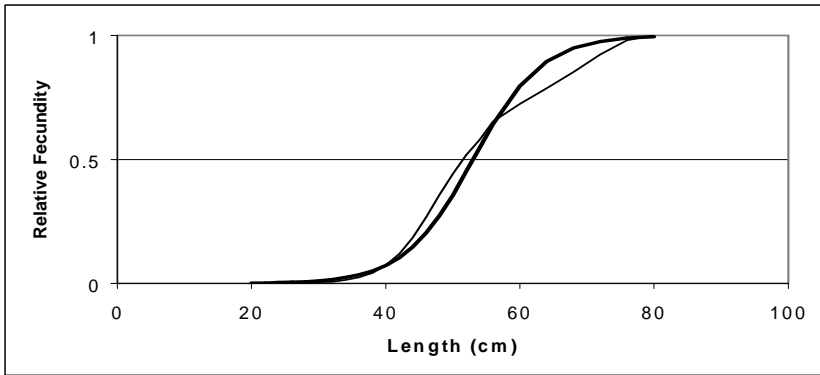
Base Model Value GROUP	TotBiomass2002(MT, 2+)		SpOut2002/Bunfished		SPRsustainable	
	2914		4.83%		49.5%	
	EMPH=10	EMPH=0.1	EMPH=10	EMPH=0.1	EMPH=10	EMPH=0.1
Length Comps						
TrawlCenCal	2036	3234	3.68%	5.33%	46.9%	49.4%
H&L CenCal	2197	3047	3.42%	5.24%	49.0%	49.4%
SetNetCenCal	2629	3079	3.98%	5.22%	36.6%	50.9%
Rec'ICenCal	3485	2848	5.97%	4.79%	50.5%	49.3%
TriennialSurvCenCal	4791	2747	6.66%	4.82%	56.6%	48.1%
H&LSoCal	2175	2974	3.43%	5.09%	46.8%	49.4%
SetNetSoCal	1953	3048	3.47%	5.13%	42.0%	50.3%
Rec'ISoCal	2647	3421	4.37%	5.70%	51.5%	49.2%
Abundance Indexes						
Rec'ICPUECenCal	2971	2914	5.03%	4.95%	49.5%	49.5%
TrawlCPUECenCal	2574	2994	4.52%	5.06%	49.5%	49.4%
TriennialSurvCenCal	1998	3214	3.70%	5.34%	48.2%	49.4%
Rec'ICPUESoCal	5609	1759	7.73%	3.43%	49.2%	48.6%
CalCOFISoCal	5563	2167	8.81%	3.67%	46.6%	47.6%
Recruitment Indexes						
JuvenileSurvCenCal	2685	3563	4.93%	5.47%	51.5%	48.9%
PowerPlantsSoCal	2841	3109	4.90%	5.20%	53.1%	49.2%



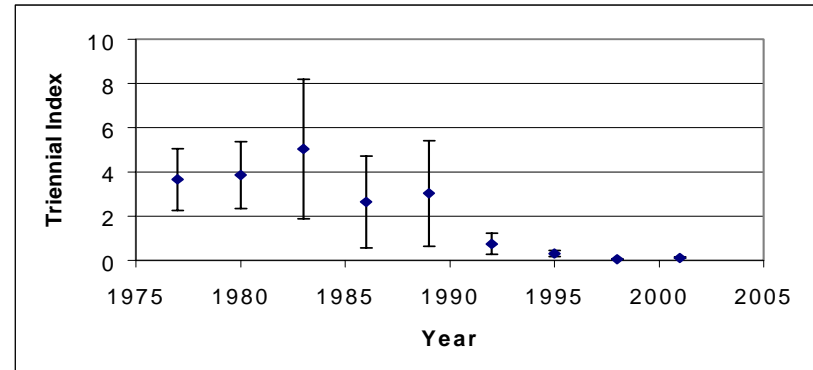
**Figure 1.** Index of bocaccio spawning abundance from GLM of larval densities from CalCOFI Surveys in Southern California. Error bars are  $\pm 1SE$ .



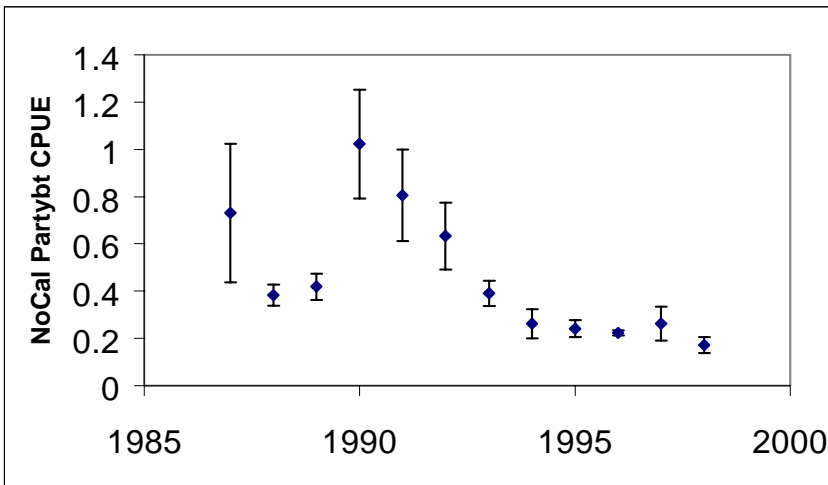
**Figure 2.** Index of bocaccio spawning abundance from GLM of larval densities from CalCOFI Surveys in Central California. Error bars are  $\pm 1SE$ .



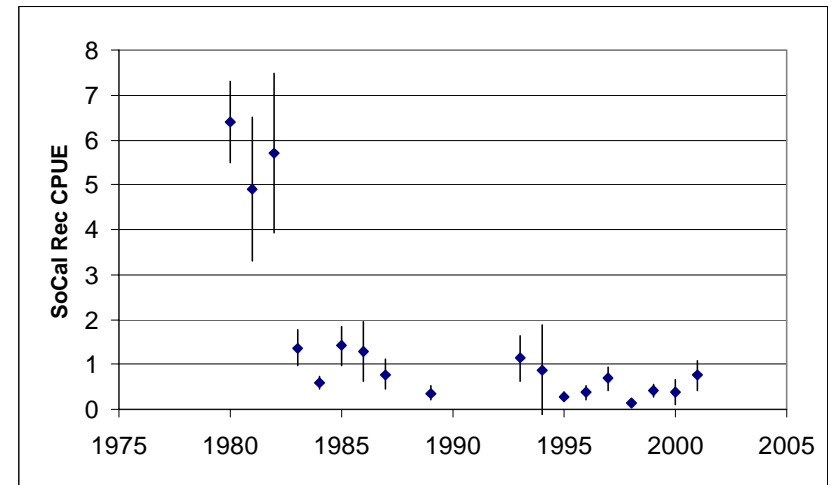
**Figure 3.** Bocaccio fecundity per weight, relative to maximum. Thin line is best estimate, thick line is logistic approximation used as selectivity curve.



**Figure 4.** Triennial Trawl Survey GLM index of abundance for Central California (Monterey and Conception INPFC areas). Error bars are  $\pm 1SE$ .

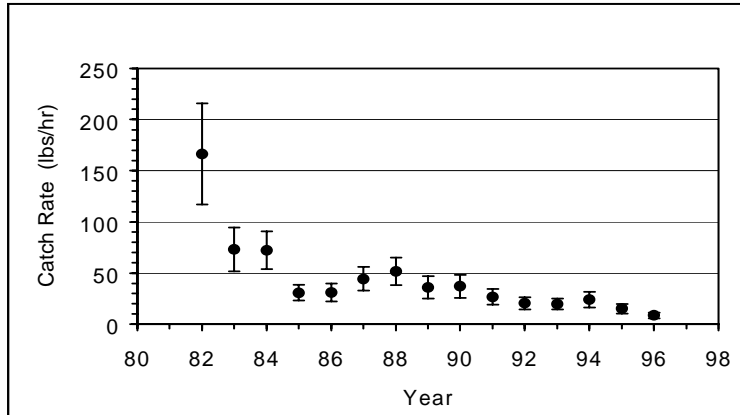


**Figure 5.** CPUE index of Central California bocaccio abundance from GLM of CDF&G observed partyboat catches. Error bars are  $\pm 1SE$ .

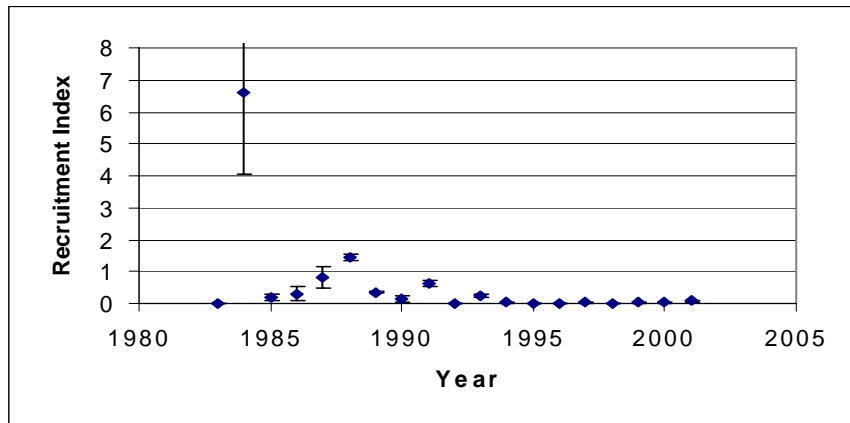


**Figure 6.** CPUE index of Southern California bocaccio abundance from GLM of MRFSS observed private and partyboat catches. Error bars are  $\pm 1SE$ .

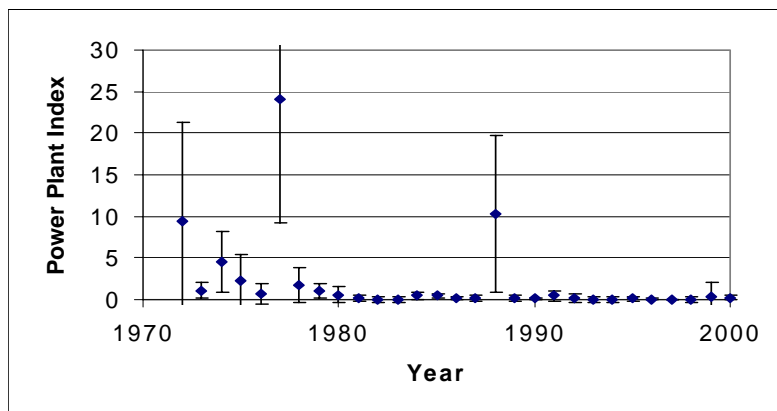




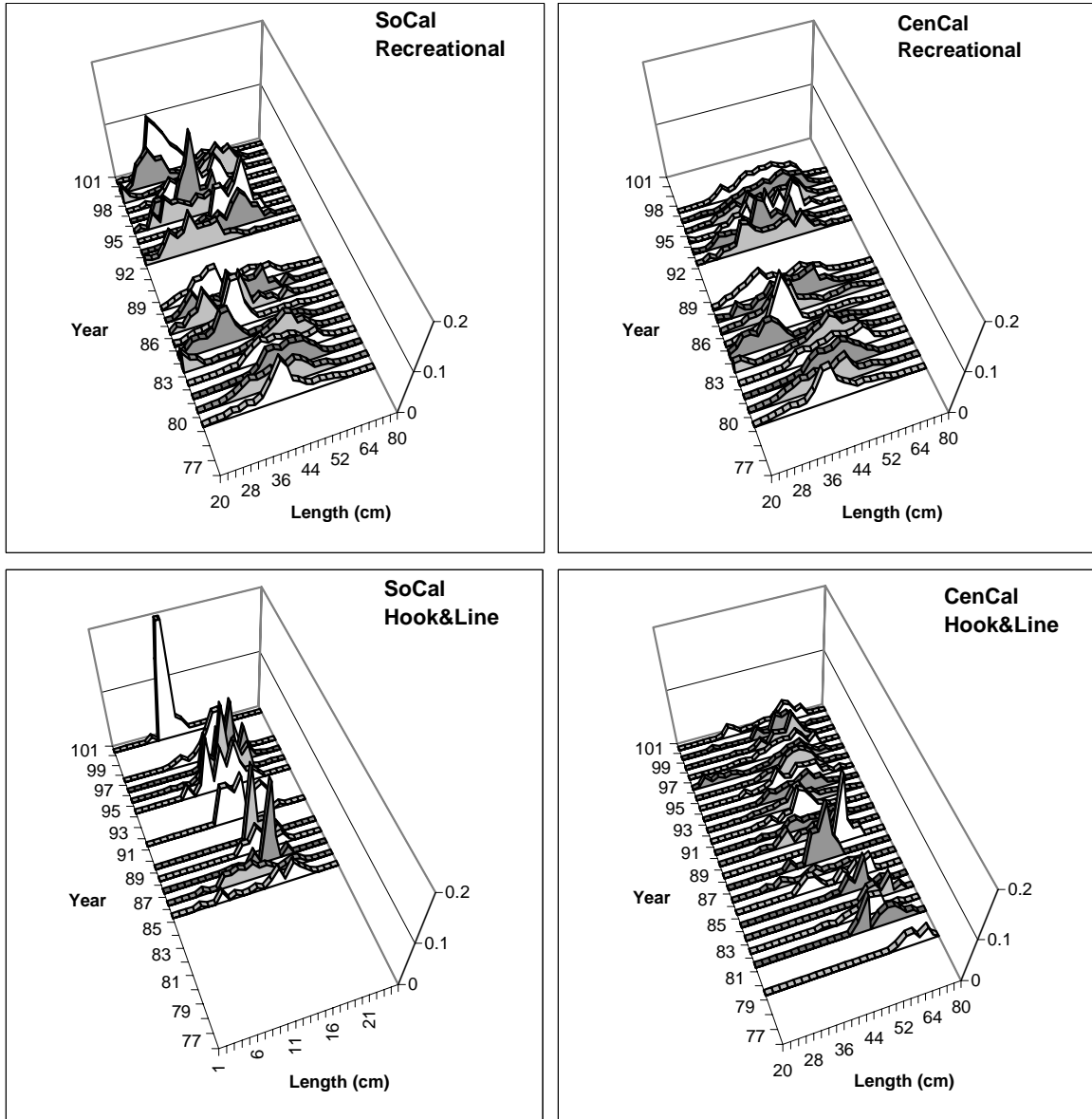
**Figure 7.** CPUE index of Central California bocaccio abundance from California trawl fishery logbooks (Ralston 1999). Error bars are  $\pm 1SE$ .



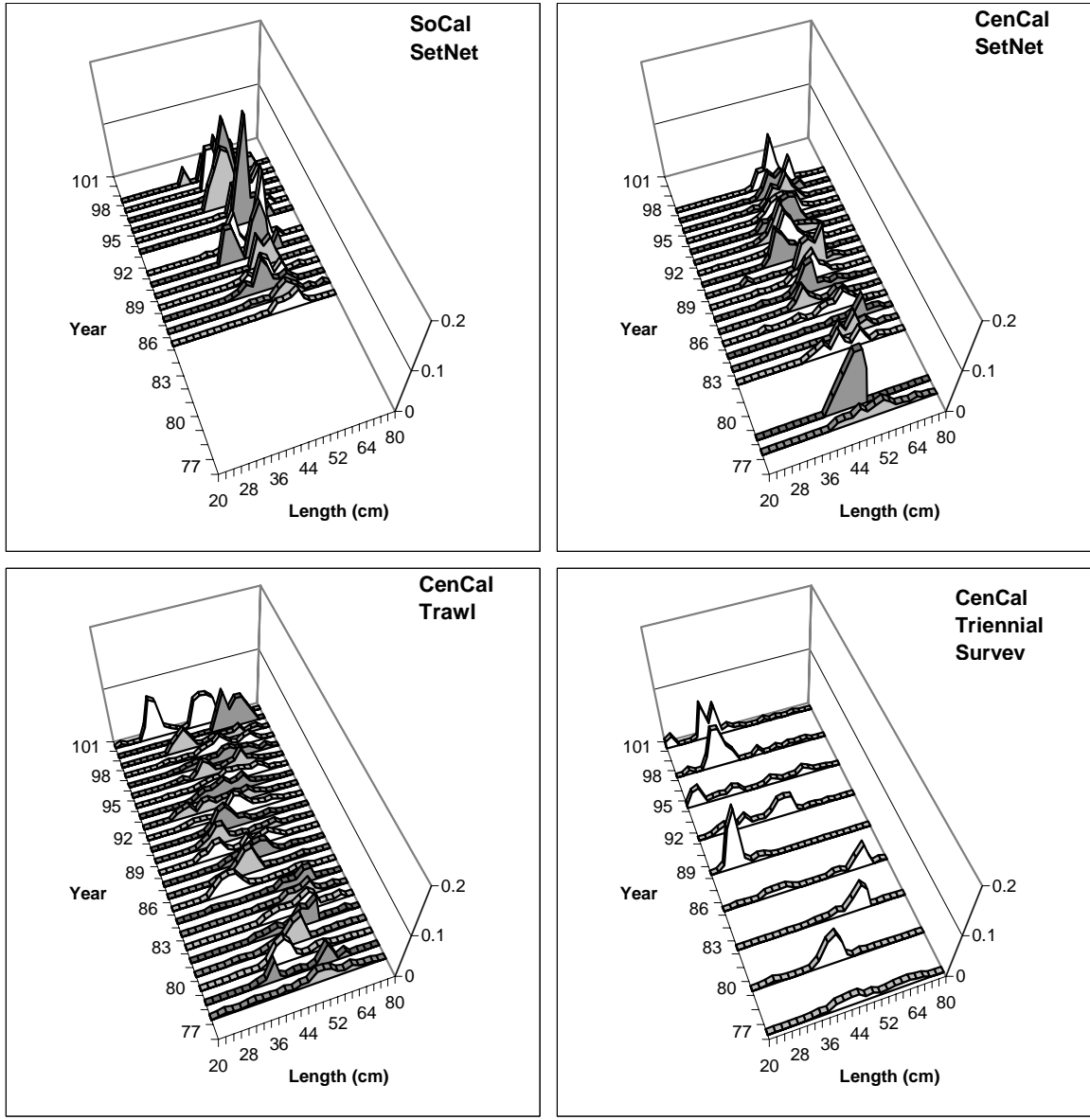
**Figure 8.** Central California bocaccio recruitment index (at age 0) from GLM of juvenile bocaccio catch rates on Santa Cruz Laboratory midwater trawl surveys. Error bars are  $\pm 1SE$ .



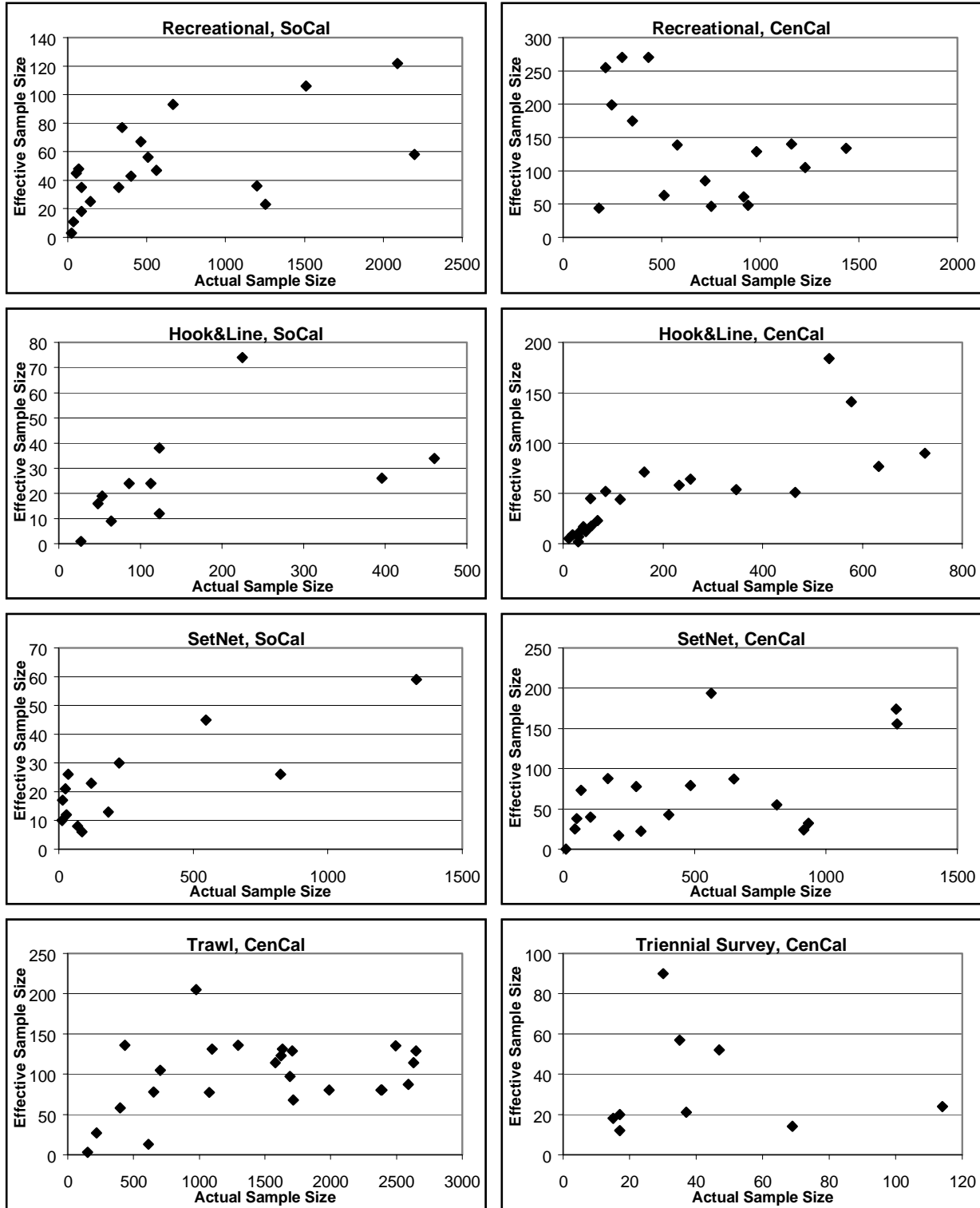
**Figure 9.** Southern California bocaccio recruitment index from GLM of impingement rates at five electrical power plants. Error bars are  $\pm 1SE$ .



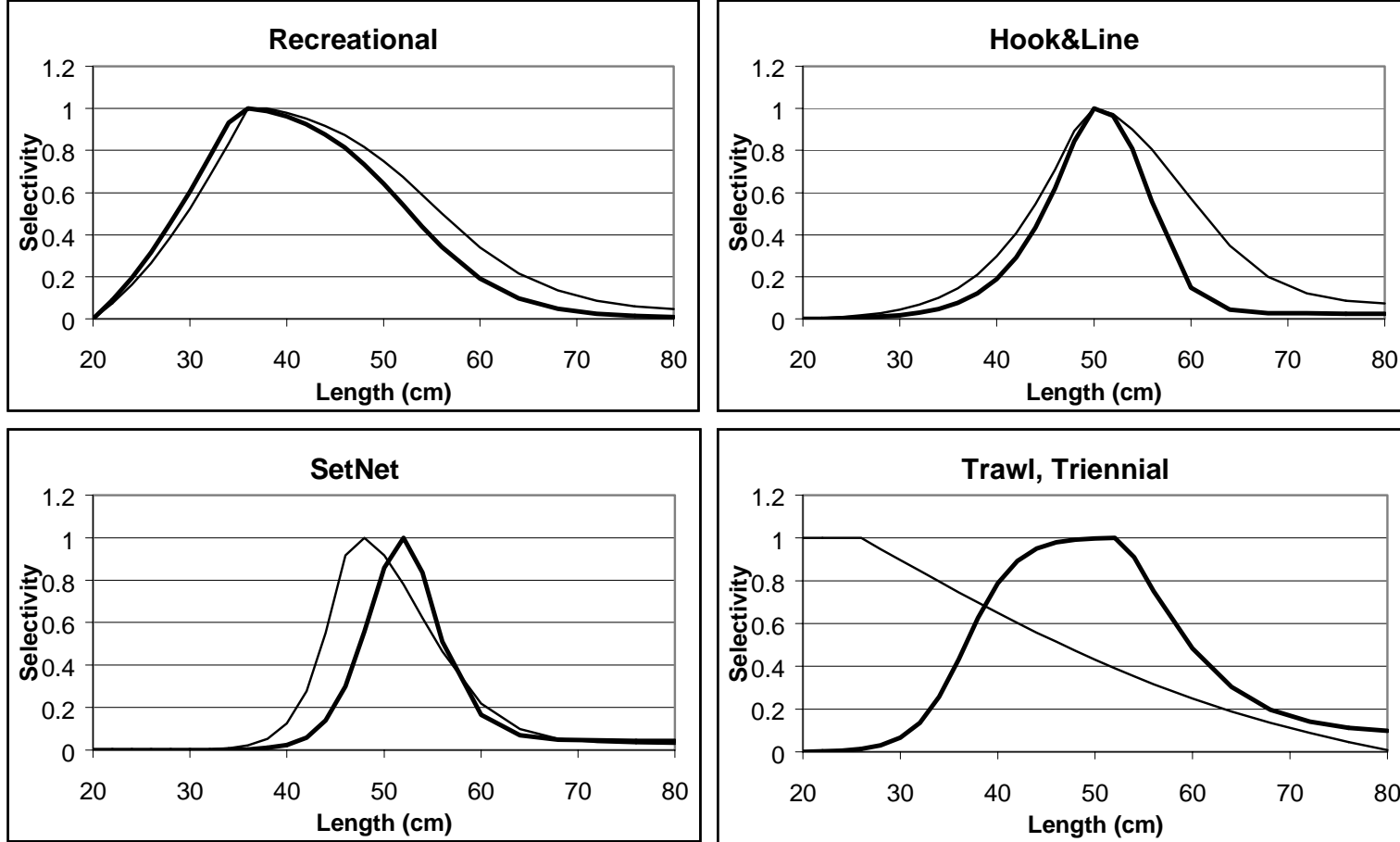
**Figure 10.** Length frequencies of female bocaccio used in the assessment.



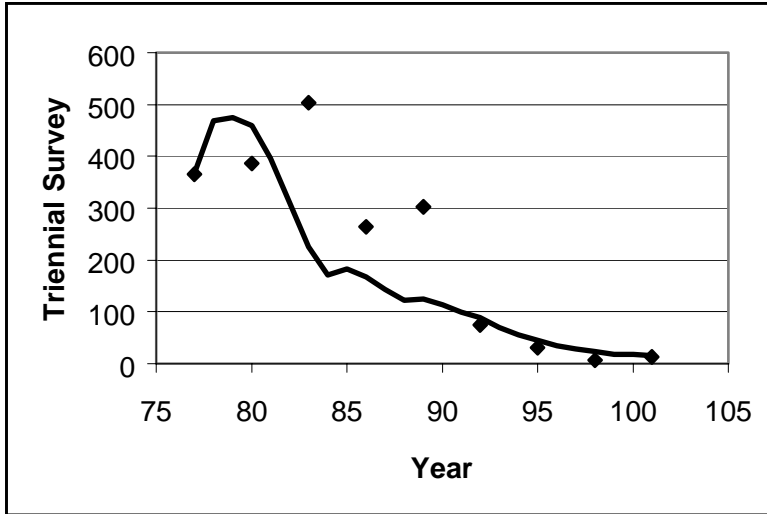
**Figure 10 cont.** Length frequencies of female bocaccio used in the assessment.



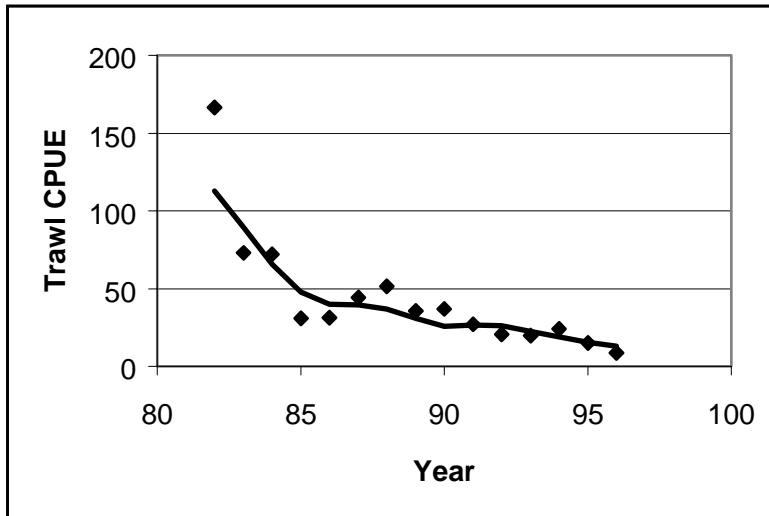
**Figure 11.** Relationships between effective sample size and number of fish examined for various data sources.



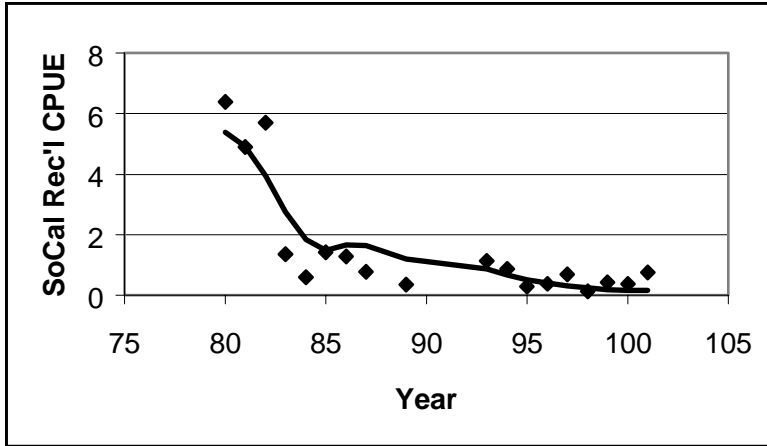
**Figure 12.** Fitted selectivity curves for size compositions in the bocaccio model. Thick line is Southern California, thin line is Central California. Lower right pane: Thick line is Central California trawl, thin line is Triennial Survey.



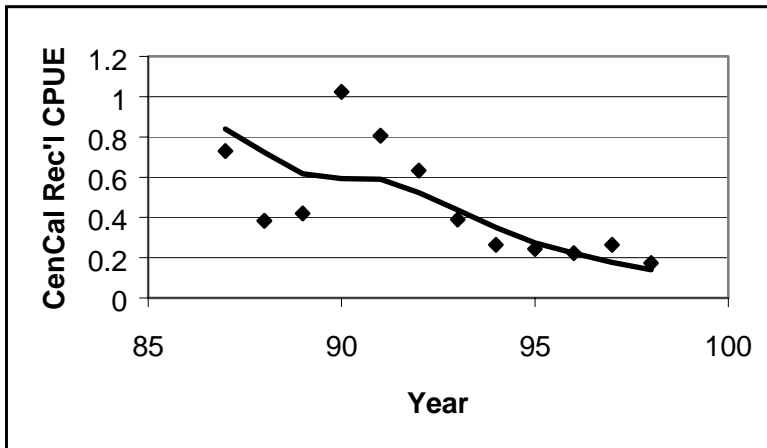
**Figure 13.** Fit to Triennial Survey abundances.



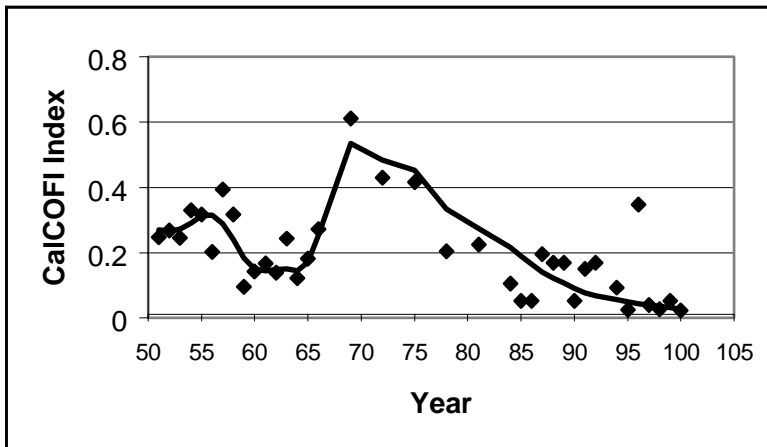
**Figure 14.** Fit to Central California Trawl CPUE.



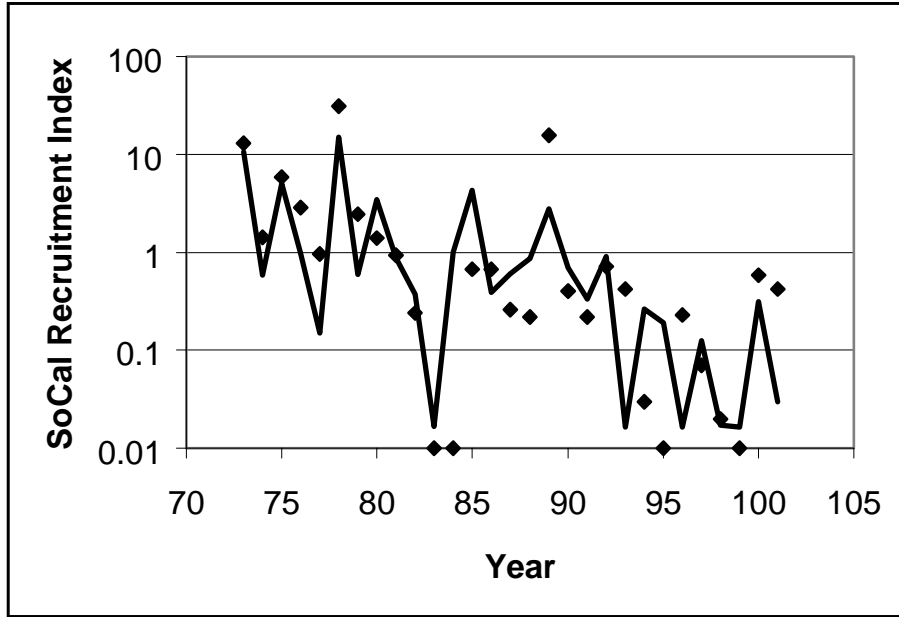
**Figure 15.** Fit to Southern California recreational CPUE.



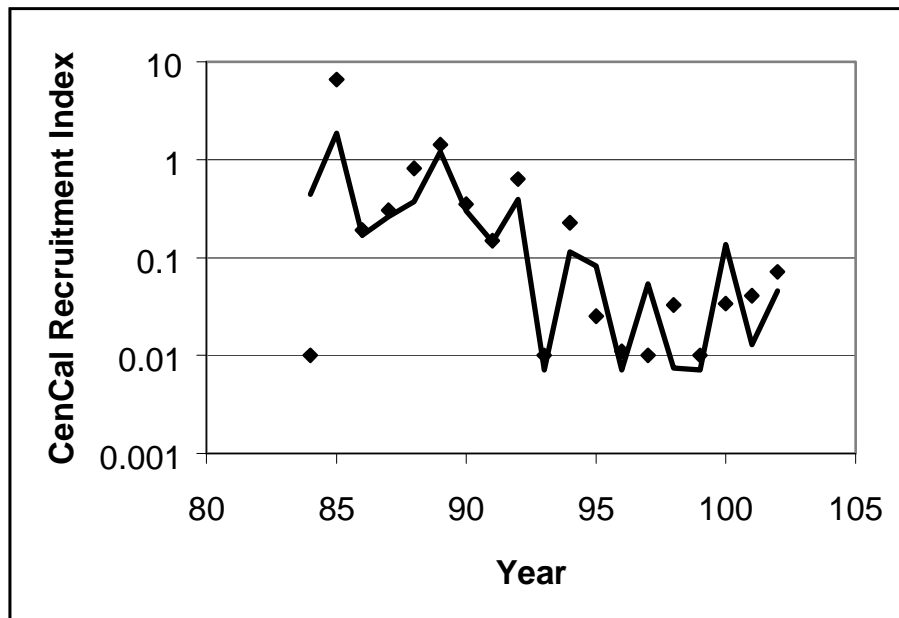
**Figure 16.** Fit to Central California recreational CPUE.



**Figure 17.** Fit to CalCOFI larval abundance index.

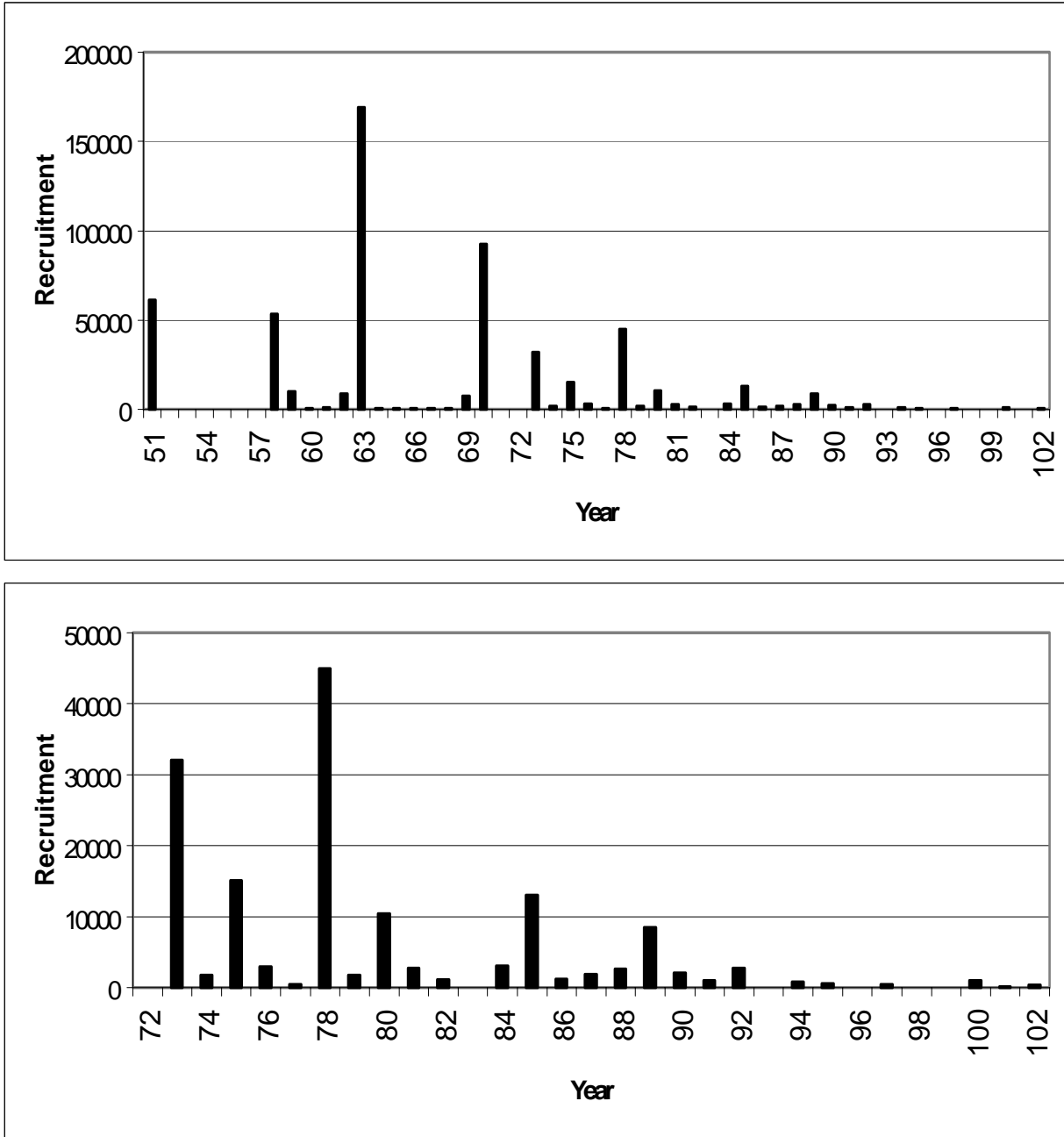


**Figure 18.** Fit to Southern California (power plant) recruitment index.

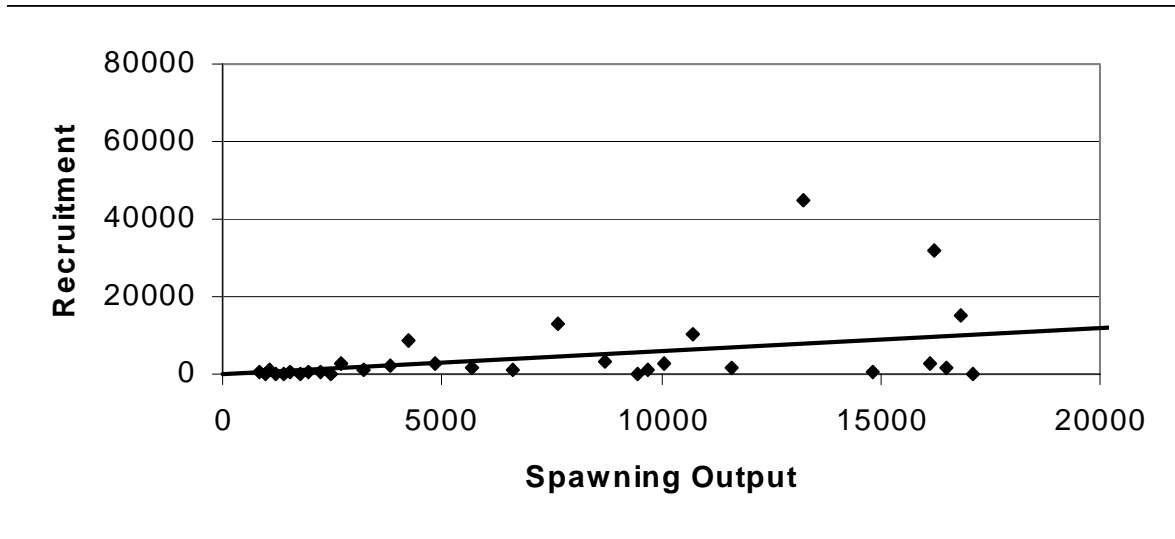


**Figure 19.** Fit to Central California (midwater trawl survey) recruitment index.

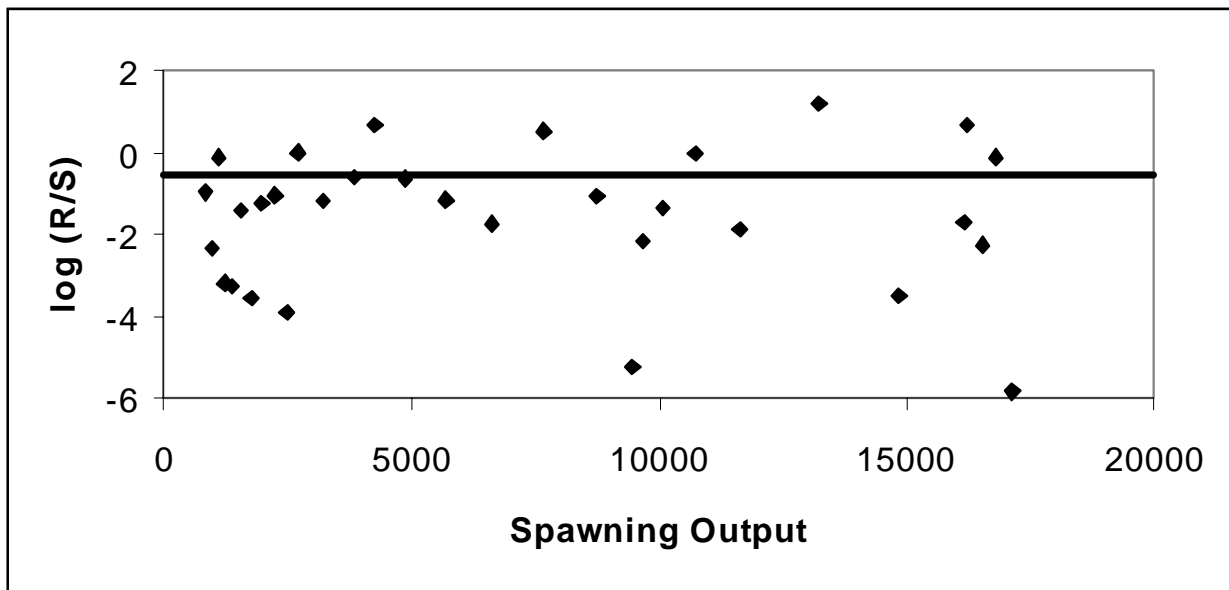




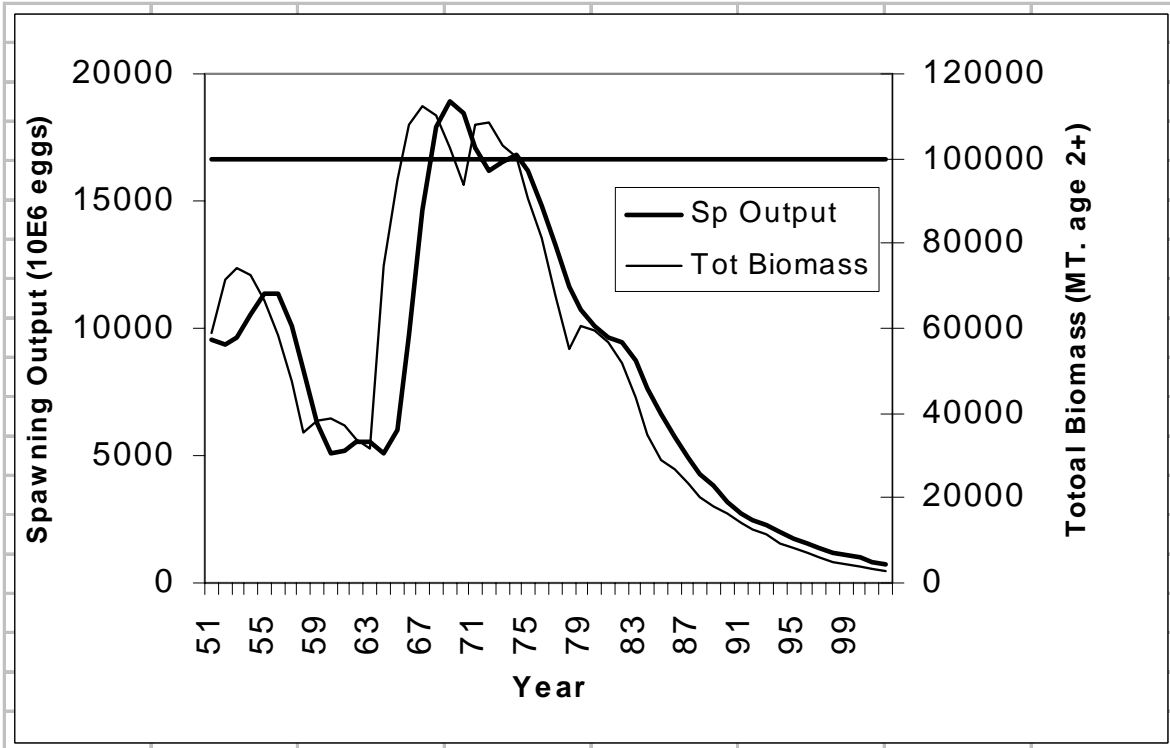
**Figure 20.** Estimated bocaccio recruitment strengths. Lower panel shows detail of recent years.



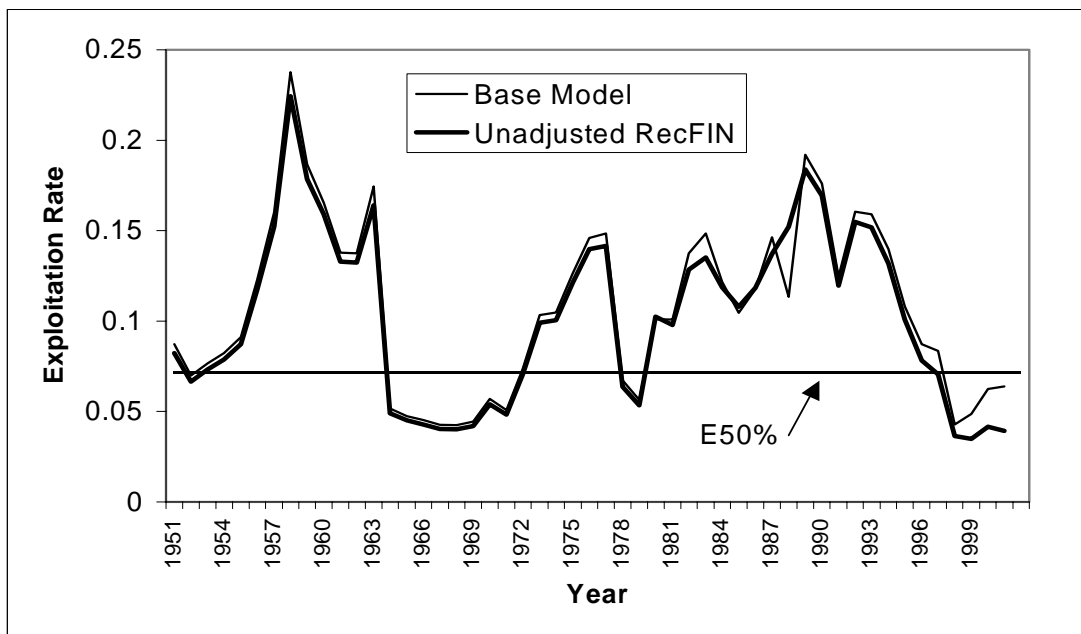
**Figure 21.** Bocaccio stock and recruitment relationship. Diagonal line is replacement level in the absence of fishing.



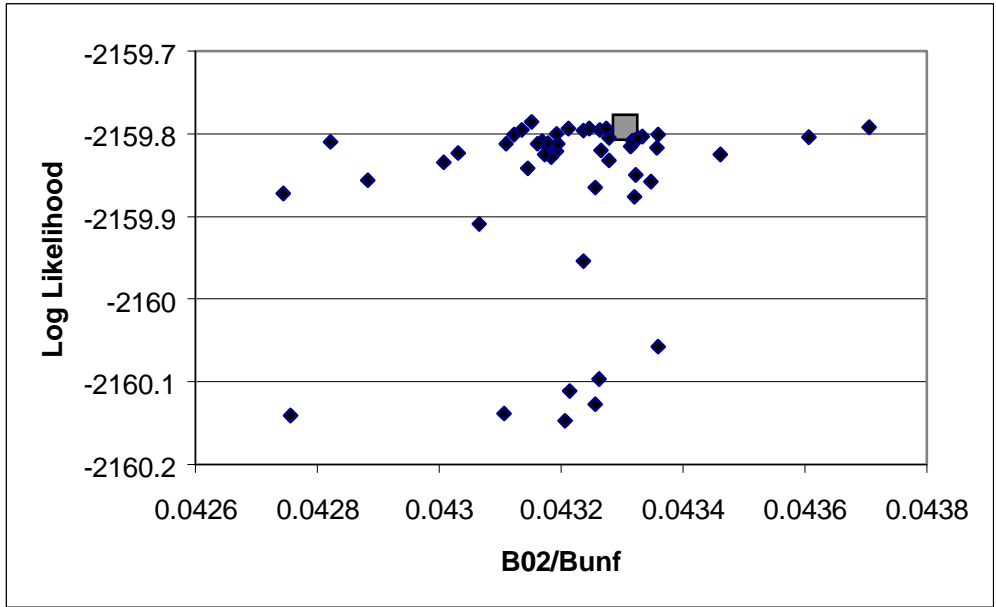
**Figure 22.** Historical reproductive success related to parental abundance. Horizontal line is replacement level in the absence of fishing.



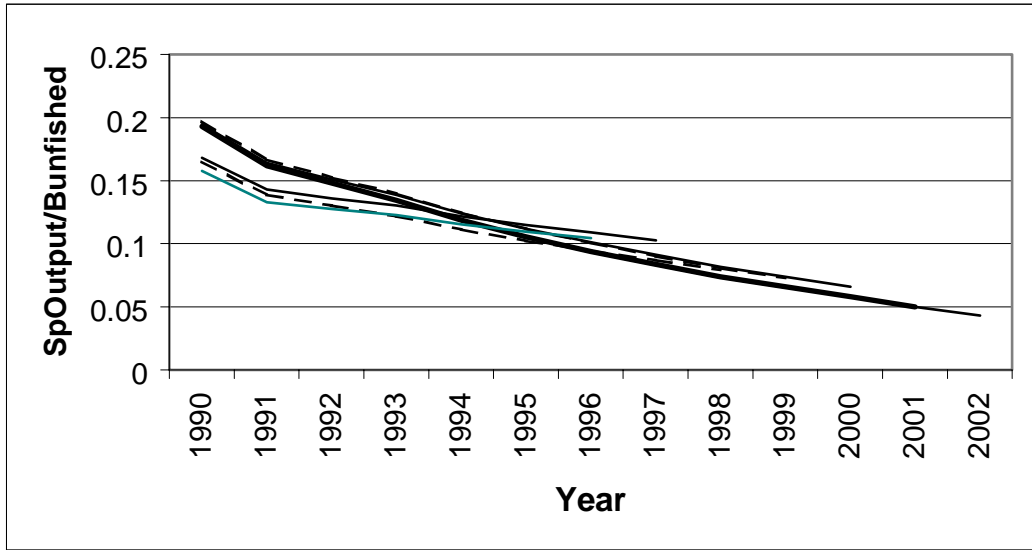
**Figure 23.** Estimated historical bocaccio abundances. Horizontal line is estimated unfished spawning output (Bunfished).



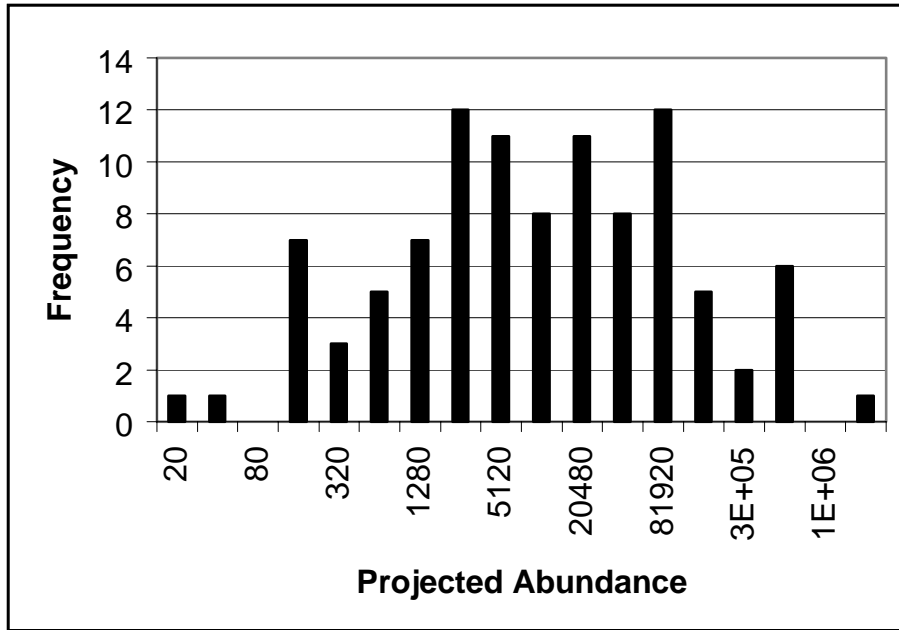
**Figure 24.** History of estimated bocaccio exploitation rates. Results based on use of unadjusted RecFIN catches are shown for comparison.



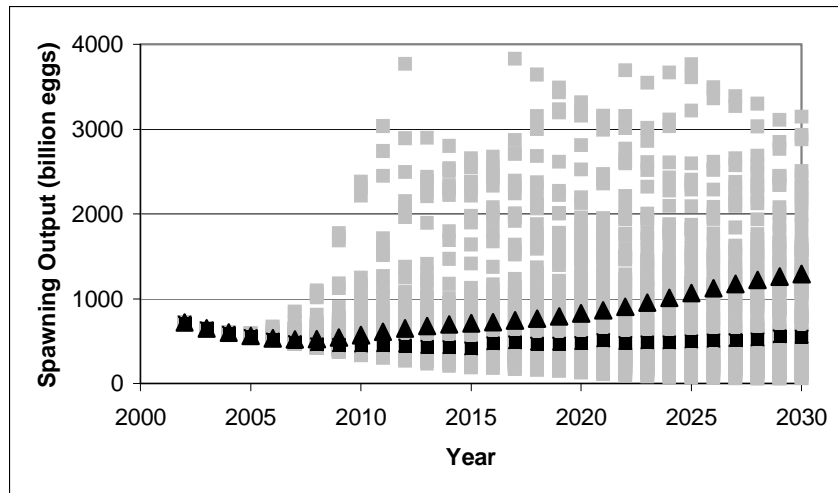
**Figure 25.** Convergence test of bocaccio model.



**Figure 26.** Retrospective pattern of relative abundance estimates.



**Figure 27.** Distribution of projected bocaccio abundances (log scale) after 100 yr with no fishing.



**Figure 28.** Near-term projections of bocaccio abundance in the absence of fishing. Light symbols are individual outcomes, lower dark square symbols are median value, upper dark triangles are average value.

Appendix 1. Results of the bocaccio base model.

Year	Bage2+ (MT)	SpOut(10 <sup>9</sup> eggs)	Recruits(10 <sup>3</sup> )	Catch	ExploitRate
pre-51	58754	9521	12168	3807	6.5%
1951	58754	9522	61065	5119	8.7%
1952	71522	9374	175	4993	7.0%
1953	74110	9609	90	5670	7.7%
1954	72372	10537	50	5947	8.2%
1955	66730	11402	50	6074	9.1%
1956	58322	11324	50	7155	12.3%
1957	47224	10133	96	7557	16.0%
1958	35294	8365	53201	8382	23.7%
1959	38311	6296	9922	7149	18.7%
1960	38779	5135	580	6409	16.5%
1961	36856	5166	769	5079	13.8%
1962	33771	5538	8713	4638	13.7%
1963	31600	5526	169111	5508	17.4%
1964	74859	5066	388	3861	5.2%
1965	95179	6006	232	4510	4.7%
1966	108008	9753	219	4877	4.5%
1967	112425	14630	256	4794	4.3%
1968	110057	17909	478	4673	4.2%
1969	102533	18927	7360	4551	4.4%
1970	93780	18429	92424	5341	5.7%
1971	108159	17121	154	5478	5.1%
1972	108763	16216	50	8013	7.4%
1973	103319	16526	31983	10664	10.3%
1974	100394	16808	1752	10500	10.5%
1975	90591	16150	15045	11443	12.6%
1976	81031	14840	2955	11825	14.6%
1977	67893	13233	455	10075	14.8%
1978	54849	11621	44923	3686	6.7%
1979	60297	10731	1779	3401	5.6%
1980	59619	10065	10397	6024	10.1%
1981	56986	9678	2660	5742	10.1%
1982	51931	9459	1127	7138	13.7%
1983	43686	8735	50	6486	14.8%
1984	34817	7666	3053	4238	12.2%
1985	28647	6629	12986	2994	10.5%
1986	26981	5699	1170	3172	11.8%
1987	23673	4867	1801	3462	14.6%
1988	20169	4249	2587	2286	11.3%
1989	17865	3846	8436	3427	19.2%
1990	16110	3222	2078	2836	17.6%
1991	14112	2703	998	1757	12.5%
1992	12791	2466	2732	2053	16.1%
1993	11382	2239	50	1811	15.9%
1994	9474	1976	795	1324	14.0%
1995	7993	1749	569	864	10.8%
1996	6874	1556	50	599	8.7%
1997	5863	1383	379	489	8.3%
1998	5006	1217	52	214	4.3%
1999	4373	1089	50	213	4.9%
2000	3738	961	971	233	6.2%
2001	3364	832	93	215	6.4%
2002	2914	720	316		

Appendix 1, cont. Results of the bocaccio base model.

AGE	FEMALES					MALES			
	BEGWT	MIDWT	RELATIVE F	N 102	SPAWN	BEGWT	MIDWT	RELATIVE F	N 102
1	0.136	0.214	0.297	61.6	0.000	0.145	0.215	0.300	61.6
2	0.364	0.492	0.845	34.5	0.002	0.341	0.445	0.782	34.5
3	0.698	0.860	1.000	249.9	0.024	0.605	0.728	1.000	253.4
4	1.103	1.284	0.901	8.8	0.123	0.905	1.035	0.974	8.9
5	1.547	1.739	0.731	6.5	0.310	1.216	1.345	0.882	6.5
6	2.009	2.197	0.560	38.5	0.536	1.523	1.647	0.767	36.9
7	2.450	2.624	0.420	4	0.754	1.815	1.931	0.654	3.7
8	2.858	3.019	0.313	34.6	0.955	2.085	2.187	0.559	32
9	3.234	3.381	0.235	36.7	1.144	2.319	2.405	0.484	33.2
10	3.576	3.707	0.182	1.7	1.321	2.517	2.591	0.424	1.5
11	3.880	3.996	0.146	63.6	1.484	2.687	2.751	0.376	55.3
12	4.148	4.249	0.121	15.6	1.632	2.834	2.889	0.337	12.9
13	4.381	4.468	0.104	23.6	1.764	2.959	3.006	0.306	18.5
14	4.581	4.656	0.092	63.8	1.880	3.065	3.105	0.282	46.7
15	4.754	4.818	0.083	13	1.981	3.155	3.187	0.263	8.7
16	4.901	4.955	0.076	6.2	2.068	3.229	3.257	0.248	3.7
17	5.025	5.071	0.071	2.9	2.143	3.292	3.314	0.236	1.5
18	5.131	5.169	0.067	25.6	2.206	3.344	3.363	0.227	11.1
19	5.219	5.252	0.064	4.6	2.259	3.387	3.402	0.220	1.8
20	5.293	5.321	0.062	0.1	2.304	3.422	3.435	0.214	0.0
21+	5.536	5.536	0.056	88	2.451	3.534	3.534	0.199	20.5

2002 Relative fishing intensity by gear and area

Southern California	Relative Fmax	Central California	Relative Fmax
Recreational	1.000	Recreational	0.601
Hook & Line	0.038	Hook & Line	0.030
Set Net	0.000	Set Net	0.012
		Trawl	0.082

## Appendix 2. Stock Synthesis parameter file.

```

fincomb.dat      **** UNKNOWN CONVERGENCE STATUS
fincom.run
fincomb.par
final 2002 bocaccio assessment, combined so&cent calif
  100.000000      .010000      BEGIN AND END DELTA F PER LOOP1
  2      .99      FIRST LOOP1 FOR LAMBDA & VALUE
  1.100      MAX VALUE FOR CROSS DERIVATIVE
  0 READ HESSIAN
fincomb.hes
  1 WRITE HESSIAN
fincomb.hes
  .001      MIN SAMPLE FRAC. PER AGE
  1 21 2 21      MINAGE, MAXAGE, SUMMARY AGE RANGE
  51 102      BEGIN YEAR, END YEAR
  1      12 0 0 0      NPER, MON/PER
  1.00      SPAWNMONTH
  7 8 NFISHERY, NSURVEY
  2 N SEXES
  50000. REF RECR LEVEL
  0 MORTOPT
  .200000      .010000      .250000 'M ' 0 1 0      .000000      .0000 ! 1 NO PICK      .000      -1.      .0000000
-999.000000      .010000      1.000000 'M SAME FOR M+F ' 0 1 0      .000000      .0000 ! 2 NO PICK      .000      -1.      .0000000
TRAWL TYPE: 1
  7 SELECTIVITY PATTERN
  0 0 0 2 0 0 0 AGE TYPES USED
  1.00000      .10 ' TWL CATCH BIOMASS ' ! # = 1 VALUE:      .00000
  1.00000      .30 ' TWL SIZE COMPS ' ! # = 2 VALUE:      -440.53364
  1 1 0 0 0 0 SEL. COMPONENTS
  .543698      .001000      1.000000 'Trawl:transition' 2 1 0      .000000      .0000 ! 3 OK      .000      -69245.      -1.0000000
  .000001      .000001      1.000000 'Trawl:InitSelect' 0 1 0      .000000      .0000 ! 4 NO PICK      .000      -1.      .0000000
  .540193      .001000      1.000000 'Trawl:SmlInflct' 2 1 0      .000000      .0000 ! 5 OK      .000      -21733.      -1.0000000
  .393077      .001000      3.000000 'Trawl:SmlSlope ' 2 1 0      .000000      .0000 ! 6 OK      .000      -2876.      -1.0000000
  .097800      .001000      1.000000 'Trawl:femfinal ' 2 1 0      .000000      .0000 ! 7 OK      .000      -4623.      -1.0000000
  .001000      .001000      1.000000 'Trawl:feminflct ' 2 1 0      .000000      .0000 ! 8 BOUND      .000      -1.      -1.0000000
  .180806      .001000      5.000000 'Trawl:femSlope ' 2 1 0      .000000      .0000 ! 9 OK      .000      -11727.      -1.0000000
&Lso T TYPE: 2
  7 SELECTIVITY PATTERN
  0 0 0 4 0 0 0 AGE TYPES USED
  1.00000      .10 ' H&Lso CATCH BIOMASS ' ! # = 3 VALUE:      .00000
  1.00000      .30 ' H&Lso SIZE COMPS ' ! # = 4 VALUE:      -139.95620
  1 1 0 0 0 0 SEL. COMPONENTS
  .514679      .001000      1.000000 'H&Lso:transition' 2 1 0      .000000      .0000 ! 10 OK      .000      -39191.      -1.0000000
  .000001      .000001      1.000000 'H&Lso:InitSelect' 0 1 0      .000000      .0000 ! 11 NO PICK      .000      -1.      .0000000
  1.000000      .001000      1.000000 'H&Lso:YngInflct' 2 1 0      .000000      .0000 ! 12 BOUND      .000      -1.      -1.0000000
  .241380      .001000      3.000000 'H&Lso:YngSlope ' 2 1 0      .000000      .0000 ! 13 OK      .000      -7023.      -1.0000000
  .025479      .001000      1.000000 'H&Lso:femfinal ' 2 1 0      .000000      .0000 ! 14 OK      .000      -8792.      -1.0000000
  .163889      .001000      1.000000 'H&Lso:feminflct ' 2 1 0      .000000      .0000 ! 15 OK      .000      -3174.      -1.0000000
  .509347      .001000      5.000000 'H&Lso:femSlope ' 2 1 0      .000000      .0000 ! 16 OK      .000      -229.      -1.0000000
&Lcen TYPE: 3
  7 SELECTIVITY PATTERN
  0 0 0 6 0 0 0 AGE TYPES USED

```



```

1.00000      .10 ' H&Lcen CATCH BIOMAS' ! # = 5 VALUE:      .00000
1.00000      .30 ' H&Lcen SIZE COMPS ' ! # = 6 VALUE:      -219.93826
1 1 0 0 0 0 SEL. COMPONENTS
.511224      .001000      1.000000 'HLcen:transition' 2 1 0      .000000      .0000 ! 17 OK      .000 -15006.      -1.0000000
.000001      .000001      1.000000 'HLcen:InitSelect' 0 1 0      .000000      .0000 ! 18 NO PICK      .000 -1.      .0000000
1.000000      .001000      1.000000 'HLcen:YngInflct' 2 1 0      .000000      .0000 ! 19 BOUND      .000 -1.      -1.0000000
.189829      .001000      3.000000 'HLcen:YngSlope ' 2 1 0      .000000      .0000 ! 20 OK      .000 -6948.      -1.0000000
.072025      .001000      1.000000 'HLcen:femfinal ' 2 1 0      .000000      .0000 ! 21 OK      .000 -1027.      -1.0000000
.292344      .001000      1.000000 'HLcen:feminflct ' 2 1 0      .000000      .0000 ! 22 OK      .000 -551.      -1.0000000
.227318      .001000      5.000000 'HLcen:femSlope ' 2 1 0      .000000      .0000 ! 23 OK      .000 -721.      -1.0000000
ETNso      TYPE: 4
7 SELECTIVITY PATTERN
0 0 0 8 0 0 0 AGE TYPES USED
1.00000      .10 'SetNsoCATCHBIOM ' ! # = 7 VALUE:      .00000
1.00000      .30 'SetNsoSizeComps ' ! # = 8 VALUE:      -104.70210
1 1 0 0 0 0 SEL. COMPONENTS
.547453      .001000      1.000000 'StNso:transition' 2 1 0      .000000      .0000 ! 24 OK      .000 -58700.      -1.0000000
.000001      .000001      1.000000 'StNso:InitSelect' 0 1 0      .000000      .0000 ! 25 NO PICK      .000 -1.      .0000000
.922931      .001000      .990000 'StNso:YngInflct' 2 1 0      .000000      .0000 ! 26 OK      .000 -3333.      -1.0000000
.457047      .001000      3.000000 'StNso:YngSlope ' 2 1 0      .000000      .0000 ! 27 OK      .000 -1301.      -1.0000000
.043270      .001000      1.000000 'StNso:femfinal ' 2 1 0      .000000      .0000 ! 28 OK      .000 -6437.      -1.0000000
.001000      .001000      1.000000 'StNso:feminflct ' 2 1 0      .000000      .0000 ! 29 BOUND      .000 -1.      -1.0000000
.391704      .001000      5.000000 'StNso:femSlope ' 2 1 0      .000000      .0000 ! 30 OK      .000 -695.      -1.0000000
SETcen      TYPE: 5
7 SELECTIVITY PATTERN
0 0 0 10 0 0 0 AGE TYPES USED
1.00000      .10 'SetNcenCATCHBIOM ' ! # = 9 VALUE:      .00000
1.00000      .30 'SetNcenSizeComps ' ! # = 10 VALUE:      -276.54877
1 1 0 0 0 0 SEL. COMPONENTS
.462606      .001000      1.000000 'StNcn:transition' 2 1 0      .000000      .0000 ! 31 OK      .000 -131223.      -1.0000000
.000001      .000001      1.000000 'StNcn:InitSelect' 0 1 0      .000000      .0000 ! 32 NO PICK      .000 -1.      .0000000
.968272      .001000      .990000 'StNcn:YngInflct' 2 1 0      .000000      .0000 ! 33 OK      .000 -4309.      -1.0000000
.450869      .001000      3.000000 'StNcn:YngSlope ' 2 1 0      .000000      .0000 ! 34 OK      .000 -3766.      -1.0000000
.029396      .001000      1.000000 'StNcn:femfinal ' 2 1 0      .000000      .0000 ! 35 OK      .000 -12757.      -1.0000000
.178693      .001000      1.000000 'StNcn:feminflct ' 2 1 0      .000000      .0000 ! 36 OK      .000 -3185.      -1.0000000
.276661      .001000      5.000000 'StNcn:femSlope ' 2 1 0      .000000      .0000 ! 37 OK      .000 -3121.      -1.0000000
RECLso      TYPE: 6
7 SELECTIVITY PATTERN
0 0 0 12 0 0 0 AGE TYPES USED
1.00000      .10 'RECLsoCATCHBIOM ' ! # = 11 VALUE:      .00000
1.00000      .30 'RECLsoSIZECOMPS ' ! # = 12 VALUE:      -340.66430
1 1 0 0 0 0 SEL. COMPONENTS
.250736      .101000      1.000000 'RCLso:transition' 2 1 0      .000000      .0000 ! 38 OK      .000 -12886.      -1.0000000
.000001      .000001      1.000000 'RCLso:InitSelect' 0 1 0      .000000      .0000 ! 39 NO PICK      .000 -1.      .0000000
1.000000      .001000      1.000000 'RCLso:SmlInflct' 2 1 0      .000000      .0000 ! 40 BOUND      .000 -1.      -1.0000000
.122279      .001000      5.000000 'RCLso:SmlSlope ' 2 1 0      .000000      .0000 ! 41 OK      .000 -1106.      -1.0000000
.008163      .001000      1.000000 'RCLso:femfinal ' 2 1 0      .000000      .0000 ! 42 OK      .000 -10141.      -1.0000000
.359000      .001000      1.000000 'RCLso:feminflct ' 2 1 0      .000000      .0000 ! 43 OK      .000 -3973.      -1.0000000
.197017      .001000      5.000000 'RCLso:femSlope ' 2 1 0      .000000      .0000 ! 44 OK      .000 -3996.      -1.0000000
RECLcen      TYPE: 7
7 SELECTIVITY PATTERN
0 0 0 14 0 0 0 AGE TYPES USED
1.00000      .10 'RECLcenCATCHBIOM ' ! # = 13 VALUE:      .00000
1.00000      .30 'RECLcenSIZECOMPS ' ! # = 14 VALUE:      -310.77890

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1 1 0 0 0 0 SEL. COMPONENTS
.272747 .101000 1.000000 'RCLcn:transition' 2 1 0 .000000 .0000 ! 45 OK .000 -133629. -1.0000000
.000001 .000001 1.000000 'RCLcn:InitSelect' 0 1 0 .000000 .0000 ! 46 NO PICK .000 -1. .0000000
1.000000 .001000 1.000000 'RCLcn:SmlInflct' 2 1 0 .000000 .0000 ! 47 BOUND .000 -1. -1.0000000
.129618 .001000 5.000000 'RCLcn:SmlSlope ' 2 1 0 .000000 .0000 ! 48 OK .000 -2647. -1.0000000
.045887 .001000 1.000000 'RCLcn:femfinal ' 2 1 0 .000000 .0000 ! 49 OK .000 -3872. -1.0000000
.406861 .001000 1.000000 'RCLcn:feminflct ' 2 1 0 .000000 .0000 ! 50 OK .000 -2884. -1.0000000
.169538 .001000 5.000000 'RCLcn:femSlope ' 2 1 0 .000000 .0000 ! 51 OK .000 -3632. -1.0000000
SoRect TYPE: 8
3 SELECTIVITY PATTERN
0 0 0 0 0 0 AGE TYPES USED
.000369 0 1 2 Q, QUANT, LOGERROR=1, BIO=1 or NUM=2
1.000000 .50 'SoCalRectIndex ' ! # = 15 VALUE: -56.42015
1.000000 .000000 1.000000 'SoCalAge1Nos ' 0 73 0 .000000 .0000 ! 52 NO PICK .000 -1. .0000000
1.000000 .000000 1.000000 'SoCalAge1Nos ' 0 73 0 .000000 .0000 ! 53 NO PICK .000 -1. .0000000
SoMRFS TYPE: 9
2 SELECTIVITY PATTERN
0 0 0 0 0 0 AGE TYPES USED
.000202 0 1 1 Q, QUANT, LOGERROR=1, BIO=1 or NUM=2
1.000000 .20 'MRFFSINDEX ' ! # = 16 VALUE: -23.10905
6.000000 -.200000 1.000000 'SoCalReclSeltype' 0 -80 0 .000000 .0000 ! 54 NO PICK .000 -1. .0000000
20.000000 .010000 20.000000 'SoCalRecl:minsiz' 0 -80 0 .000000 .0000 ! 55 NO PICK .000 -1. .0000000
84.000000 .001000 84.000000 'SoCalRecl:maxsiz' 0 -80 0 .000000 .0000 ! 56 NO PICK .000 -1. .0000000
CALCOFI TYPE: 10
14 SELECTIVITY PATTERN
0 0 0 0 0 0 AGE TYPES USED
.000013 0 1 1 Q, QUANT, LOGERROR=1, BIO=1 or NUM=2
1.000000 .10 'CALCOFI INDEX ' ! # = 17 VALUE: -14.18740
.000001 .001000 1.000000 'CALCOFI:Initsele' 0 51 0 .000000 .0000 ! 57 NO PICK .000 -1. .0000000
53.000000 .001000 1.000000 'CALCOFI:YngInfle' 0 51 0 .000000 .0000 ! 58 NO PICK .000 -1. .0000000
.195700 .001000 3.000000 'CALCOFI:YngSlope' 0 51 0 .000000 .0000 ! 59 NO PICK .000 -1. .0000000
.999999 .001000 1.000000 'CALCOFI:Transtn ' 0 51 0 .000000 .0000 ! 60 NO PICK .000 -1. .0000000
1.000000 .001000 1.000000 'CALCOFI:FemFinal' 0 51 0 .000000 .0000 ! 61 NO PICK .000 -1. .0000000
.700000 .001000 5.000000 'CALCOFI:FemInflc' 0 51 0 .000000 .0000 ! 62 NO PICK .000 -1. .0000000
.100000 .001000 5.000000 'CALCOFI:Femslope' 0 51 0 .000000 .0000 ! 63 NO PICK .000 -1. .0000000
.000001 .001000 2.000000 'CALCOFI:MalStart' 0 51 0 .000000 .0000 ! 64 NO PICK .000 -1. .0000000
.000001 .100000 10.000000 'CALCOFI:MalShape' 0 51 0 .000000 .0000 ! 65 NO PICK .000 -1. .0000000
.000001 .000001 1.000000 'CALCOFI:MalFinal' 0 51 0 .000000 .0000 ! 66 NO PICK .000 -1. .0000000
TRITRAWL TYPE: 11
7 SELECTIVITY PATTERN
0 0 0 19 0 0 AGE TYPES USED
.020355 0 1 1 Q, QUANT, LOGERROR=1, BIO=1 or NUM=2
1.000000 .16 'TRI SURVEY BIO ' ! # = 18 VALUE: .71092
1.000000 .30 'TRI SIZE COMPS ' ! # = 19 VALUE: -209.12397
1 1 0 0 0 0 SEL. COMPONENTS
.054545 .010000 1.000000 'TriSv:transition' 2 77 0 .000000 .0000 ! 67 OK -.001 -9080. -1.0000000
1.000000 .001000 1.000000 'TriSv:InitSelect' 0 77 0 .000000 .0000 ! 68 NO PICK .000 -1. .0000000
.083549 .001000 1.000000 'TriSv:YngInflct' -2 77 0 .000000 .0000 ! 69 NO PICK .000 -1. -1.0000000
.701782 .001000 3.000000 'TriSv:YngSlope ' -2 77 0 .000000 .0000 ! 70 NO PICK .000 -1. -1.0000000
.009068 .001000 1.000000 'TriSv:femfinal ' 2 77 0 .000000 .0000 ! 71 OK .000 -885. -1.0000000
.001000 .001000 1.000000 'TriSv:feminflct ' 2 77 0 .000000 .0000 ! 72 BOUND .000 -1. -1.0000000
.042465 .001000 5.000000 'TriSv:femSlope ' 2 77 0 .000000 .0000 ! 73 OK .000 -12324. -1.0000000
CenRect TYPE: 12
3 SELECTIVITY PATTERN

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0 0 0 0 0 0 0 AGE TYPES USED
.000160 0 1 2 Q, QUANT, LOGERROR=1, BIO=1 or NUM=2
1.000000 .50 'CenCalRectIndex ' ! # = 20 VALUE: -35.14511
1.000000 .000000 1.000000 'CenCalAge1Nos ' 0 84 0 .000000 .0000 ! 74 NO PICK .000 -1. .0000000
1.000000 .000000 1.000000 'CenCalAge1Nos ' 0 84 0 .000000 .0000 ! 75 NO PICK .000 -1. .0000000
TwlCPUE TYPE: 13
2 SELECTIVITY PATTERN
0 0 0 0 0 0 0 AGE TYPES USED
.003894 0 1 1 Q, QUANT, LOGERROR=1, BIO=1 or NUM=2
1.000000 .20 'TrawlCPUE ' ! # = 21 VALUE: 12.60428
1.000000 -.200000 1.000000 'TrawlSeltype ' 0 -82 0 .000000 .0000 ! 76 NO PICK .000 -1. .0000000
20.000000 .010000 20.000000 'TrawlCPUE:minsiz' 0 -82 0 .000000 .0000 ! 77 NO PICK .000 -1. .0000000
84.000000 .001000 84.000000 'TrawlCPUE:maxsiz' 0 -82 0 .000000 .0000 ! 78 NO PICK .000 -1. .0000000
CenMRFS TYPE: 14
2 SELECTIVITY PATTERN
0 0 0 0 0 0 0 AGE TYPES USED
.000086 0 1 1 Q, QUANT, LOGERROR=1, BIO=1 or NUM=2
1.000000 .20 'CenCalMRFS ' ! # = 22 VALUE: -1.84971
7.000000 -.200000 1.000000 'CenCalReclSeltyp' 0 -87 0 .000000 .0000 ! 79 NO PICK .000 -1. .0000000
20.000000 .010000 20.000000 'CenCalRecl:minsi' 0 -87 0 .000000 .0000 ! 80 NO PICK .000 -1. .0000000
84.000000 .001000 84.000000 'CenCalRecl:maxsi' 0 -87 0 .000000 .0000 ! 81 NO PICK .000 -1. .0000000
ROF-BIO TYPE: 15
1 SELECTIVITY PATTERN
0 0 0 0 0 0 0 AGE TYPES USED
10.351493 0 1 1 Q, QUANT, LOGERROR=1, BIO=1 or NUM=2
.000000 .01 'PROF-BIO ABUND ' ! # = 23 VALUE: 3.91212
4.000000 -.200000 1.000000 'PROFBIO MINAGE ' 0 1 0 .000000 .0000 ! 82 NO PICK .000 -1. .0000000
21.000000 .010000 55.000000 'PROFBIO MAXAGE ' 0 1 0 .000000 .0000 ! 83 NO PICK .000 -1. .0000000
1.000000 .001000 4.000000 'PROFBIO MULT ' 0 1 0 .000000 .0000 ! 84 NO PICK .000 -1. .0000000
1 AGEERR: 1: MULTINOMIAL, 0: S(LOG(P))=CONSTANT, -1: S=P*Q/N
500.000 : MAX N FOR MULTINOMIAL
3 1=%CORRECT, 2=C.V., 3=%AGREE, 4=READ %AGREE @AGE
.800000 .300000 .950000 'p AGREE. @1 ' 0 80 0 .000000 .0000 ! 85 NO PICK .000 -1. .0000000
.050000 .000000 .900000 'p agree @21 ' 0 80 0 .000000 .0000 ! 86 NO PICK .000 -1. .0000000
1.000000 .001000 2.000000 'POWER ' 0 80 0 .000000 .0000 ! 87 NO PICK .000 -1. .0000000
.150000 .010000 .300000 'OLD DISCOUNT ' 0 80 0 .000000 .0000 ! 88 NO PICK .000 -1. .0000000
.000001 .001000 .100000 '%MIS-SEXED ' 0 80 0 .000000 .0000 ! 89 NO PICK .000 -1. .0000000
0 END OF EFFORT
0 FIX n FMORTs
0 CANNIBALISM
1 GROWTH: 1=CONSTANT, 2=MORT. INFLUENCE
1.5000 99.0000 AGE AT WHICH L1 AND L2 OCCUR
1 1=NORMAL, 2=LOGNORMAL
27.000000 20.000000 60.000000 'FEMALE L1 ' 0 1 0 .000000 .0000 ! 90 NO PICK .000 -1. .0000000
75.892728 60.000000 90.000000 'FEMALE LINF ' 0 1 0 .000000 .0000 ! 91 NO PICK .000 -1. .0000000
.180233 .050000 .400000 'FEMALE K ' 2 1 0 .000000 .0000 ! 92 OK .000 -396064. -1.0000000
.107000 .010000 .990000 'FEMALE CV1 ' 0 1 0 .000000 .0000 ! 93 NO PICK .000 -1. .0000000
.033000 .010000 .990000 'FEMALE CV21 ' 0 1 0 .000000 .0000 ! 94 NO PICK .000 -1. .0000000
-999.000000 20.000000 40.000000 'MALE L1 ' 0 1 0 .000000 .0000 ! 95 NO PICK .000 -1. .0000000
65.555310 50.000000 80.000000 'MALE LINF ' 0 1 0 .000000 .0000 ! 96 NO PICK .000 -1. .0000000
.198393 .100000 .400000 'MALE K ' 2 1 0 .000000 .0000 ! 97 OK .000 -337895. -1.0000000
-999.000000 .010000 .990000 'MALE CV1 ' 0 1 0 .000000 .0000 ! 98 NO PICK .000 -1. .0000000
-999.000000 .010000 .990000 'MALE CV21 ' 0 1 0 .000000 .0000 ! 99 NO PICK .000 -1. .0000000
0 DEFINE MARKET CATEGORIES

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0 ENVIRONMENTAL FXN:      [-INDEX] [FXN TYPE(1-4)] [ENVVAR USED]
0 ESTIMATE N ENVIRON VALUES
0 PENALTIES
0 ENVIRONMENT EFFECT ON EXP(RECR)
24 STOCK-RECR
1 1=B-H, 2=RICKER, 3=new B-H
0 0=USE S-R CURVE, 1=SCALE CURVE
.00001      -1.00 'SPAWN RECR.      ' ! # = 24 VALUE:      -365.38087
.00001      -.30 'S-R means      ' ! # = 25 VALUE:      -14594.02356
1.000000    .001000    10.000000 'VIR. RECR. MULT.' -2 1 0 .000000 .0000 ! 100 NO PICK .000 -1. -1.0000000
.889568     .100000     .990000 'B-H S/R PAR.' -2 1 0 .000000 .0000 ! 101 NO PICK .000 -1. -1.0000000
.243361     .001000     10.000000 'BACK RECR.' 2 1 0 .000000 .0000 ! 102 OK .000 -6984. -1.0000000
1.000000    .010000    2.000000 'S/R STD.' -2 1 0 .000000 .0000 ! 103 NO PICK .000 -1. -1.0000000
.000000     -.100000     .100000 'RECR. TREND' 0 1 0 .000000 .0000 ! 104 NO PICK .000 -1. .0000000
1.000000    .000000    2.000000 'RECR. MULT.' 0 1 0 .000000 .0000 ! 105 NO PICK .000 -1. .0000000
-2 INIT AGE COMP
1.221301    .001000    30.000000 'Recruit 51' 2 51 0 .000000 .0000 ! 106 OK .000 -70. -1.0000000
.003504     .001000    30.000000 'Recruit 52' 2 52 0 .000000 .0000 ! 107 OK .000 -281. -1.0000000
.001807     .001000    30.000000 'Recruit 53' 2 53 0 .000000 .0000 ! 108 OK .000 -914. -1.0000000
.001000     .001000    30.000000 'Recruit 54' 2 54 0 .000000 .0000 ! 109 OK .000 -3002. -1.0000000
.001000     .001000    30.000000 'Recruit 55' 2 55 0 .000000 .0000 ! 110 BOUND .000 -1. -1.0000000
.001000     .001000    30.000000 'Recruit 56' 2 56 0 .000000 .0000 ! 111 BOUND .000 -1. -1.0000000
.001925     .001000    30.000000 'Recruit 57' 2 57 0 .000000 .0000 ! 112 OK .000 -792. -1.0000000
1.064012    .001000    30.000000 'Recruit 58' 2 58 0 .000000 .0000 ! 113 OK .000 -38. -1.0000000
.198434     .001000    30.000000 'Recruit 59' 2 59 0 .000000 .0000 ! 114 OK -.001 -29. -1.0000000
.011604     .001000    30.000000 'Recruit 60' 2 60 0 .000000 .0000 ! 115 OK .000 -40. -1.0000000
.015380     .001000    30.000000 'Recruit 61' 2 61 0 .000000 .0000 ! 116 OK .000 -33. -1.0000000
.174266     .001000    30.000000 'Recruit 62' 2 62 0 .000000 .0000 ! 117 OK .000 -29. -1.0000000
3.382221    .001000    30.000000 'Recruit 63' 2 63 0 .000000 .0000 ! 118 OK -.002 -37. -1.0000000
.007769     .001000    30.000000 'Recruit 64' 2 64 0 .000000 .0000 ! 119 OK .000 -86. -1.0000000
.004632     .001000    30.000000 'Recruit 65' 2 65 0 .000000 .0000 ! 120 OK .000 -177. -1.0000000
.004381     .001000    30.000000 'Recruit 66' 2 66 0 .000000 .0000 ! 121 OK .000 -217. -1.0000000
.005110     .001000    30.000000 'Recruit 67' 2 67 0 .000000 .0000 ! 122 OK .000 -218. -1.0000000
.009554     .001000    30.000000 'Recruit 68' 2 68 0 .000000 .0000 ! 123 OK .000 -192. -1.0000000
.147198     .001000    30.000000 'Recruit 69' 2 69 0 .000000 .0000 ! 124 OK .000 -222. -1.0000000
1.848470    .001000    30.000000 'Recruit 70' 2 70 0 .000000 .0000 ! 125 OK .000 -291. -1.0000000
.003089     .001000    30.000000 'Recruit 71' 2 71 0 .000000 .0000 ! 126 OK .000 -659. -1.0000000
.001000     .001000    30.000000 'Recruit 72' 2 72 0 .000000 .0000 ! 127 BOUND .000 -1. -1.0000000
.639650     .001000    30.000000 'Recruit 73' 2 73 0 .000000 .0000 ! 128 OK .000 -716. -1.0000000
.035030     .001000    30.000000 'Recruit 74' 2 74 0 .000000 .0000 ! 129 OK .000 -2057. -1.0000000
.300902     .001000    30.000000 'Recruit 75' 2 75 0 .000000 .0000 ! 130 OK .000 -1725. -1.0000000
.059102     .001000    30.000000 'Recruit 76' 2 76 0 .000000 .0000 ! 131 OK .000 -4660. -1.0000000
.009104     .001000    30.000000 'Recruit 77' 2 77 0 .000000 .0000 ! 132 OK .000 -26373. -1.0000000
.898468     .001000    30.000000 'Recruit 78' 2 78 0 .000000 .0000 ! 133 OK .000 -2969. -1.0000000
.035590     .001000    30.000000 'Recruit 79' 2 79 0 .000000 .0000 ! 134 OK .000 -8317. -1.0000000
.207930     .001000    30.000000 'RECRUIT 80' 2 80 0 .000000 .0000 ! 135 OK .000 -7813. -1.0000000
.053193     .001000    30.000000 'RECRUIT 81' 2 81 0 .000000 .0000 ! 136 OK .000 -19026. -1.0000000
.022538     .001000    30.000000 'RECRUIT 82' 2 82 0 .000000 .0000 ! 137 OK .000 -59335. -1.0000000
.001000     .001000    30.000000 'RECRUIT 83' 2 83 0 .000000 .0000 ! 138 BOUND .000 -1. -1.0000000
.061052     .001000    30.000000 'RECRUIT 84' 2 84 0 .000000 .0000 ! 139 OK .000 -35217. -1.0000000
.259723     .001000    30.000000 'RECRUIT 85' 2 85 0 .000000 .0000 ! 140 OK .000 -15837. -1.0000000
.023397     .001000    30.000000 'RECRUIT 86' 2 86 0 .000000 .0000 ! 141 OK .000 -42396. -1.0000000
.036014     .001000    30.000000 'RECRUIT 87' 2 87 0 .000000 .0000 ! 142 OK .000 -50043. -1.0000000
.051744     .001000    30.000000 'RECRUIT 88' 2 88 0 .000000 .0000 ! 143 OK .000 -39453. -1.0000000

```

.168729	.001000	30.000000	'RECRUIT 89	'	2	89	0	.000000	.0000 ! 144 OK	.000	-29708.	-1.0000000
.041559	.001000	30.000000	'RECRUIT 90	'	2	90	0	.000000	.0000 ! 145 OK	.000	-120307.	-1.0000000
.019951	.001000	30.000000	'RECRUIT 91	'	2	91	0	.000000	.0000 ! 146 OK	.000	-67755.	-1.0000000
.054646	.001000	30.000000	'RECRUIT 92	'	2	92	0	.000000	.0000 ! 147 OK	.000	-104905.	-1.0000000
.001000	.001000	30.000000	'RECRUIT 93	'	2	93	0	.000000	.0000 ! 148 BOUND	.000	-1.	-1.0000000
.015899	.001000	30.000000	'RECRUIT 94	'	2	94	0	.000000	.0000 ! 149 OK	.000	-444138.	-1.0000000
.011388	.001000	30.000000	'RECRUIT 95	'	2	95	0	.000000	.0000 ! 150 OK	.000	-636224.	-1.0000000
.001000	.001000	30.000000	'RECRUIT 96	'	2	96	0	.000000	.0000 ! 151 BOUND	.000	-1.	-1.0000000
.007573	.001000	30.000000	'RECRUIT 97	'	2	97	0	.000000	.0000 ! 152 OK	.000	-1213547.	-1.0000000
.001032	.001000	30.000000	'RECRUIT 98	'	2	98	0	.000000	.0000 ! 153 OK	.000	-9818191.	-1.0000000
.001000	.001000	30.000000	'RECRUIT 99	'	2	99	0	.000000	.0000 ! 154 BOUND	.000	-1.	-1.0000000
.019410	.001000	30.000000	'RECRUIT 100	'	2	100	0	.000000	.0000 ! 155 OK	.000	-126144.	-1.0000000
.001853	.001000	30.000000	'RECRUIT 101	'	2	101	0	.000000	.0000 ! 156 OK	.000	-3099014.	-1.0000000
.006326	.001000	30.000000	'RECRUIT 102	'	2	102	0	.000000	.0000 ! 157 OK	.000	-333911.	-1.0000000

Appendix 3. Stock Synthesis data file (truncated at right and bottom).

Alec's2002CombinedBocacciodataforCalifornia									
3807	1	trawl	H&Lso	H&Lcen	setnetSO		setnetCEN	recSO	recCEN
50	1	2816	428	438	0	0	39	86	
51	1	3895	471	620	0	0	35	98	
52	1	3866	366	630	0	0	45	86	
53	1	4494	298	750	0	0	56	72	
54	1	4401	583	750	0	0	122	91	
55	1	3451	1810	492	0	0	213	108	
56	1	4608	1481	689	0	0	256	121	
57	1	4803	1818	678	0	0	138	120	
58	1	5041	1804	1249	0	0	95	193	
59	1	4691	1056	1185	0	0	57	160	
60	1	3922	1663	636	0	0	63	125	
61	1	2821	1480	612	0	0	72	94	
62	1	2460	1359	642	0	0	68	109	
63	1	3102	1611	617	0	0	67	111	
64	1	2177	1046	459	0	0	94	85	
65	1	2508	1213	540	0	0	117	132	
66	1	2571	1430	564	0	0	170	142	
67	1	2162	1799	483	0	0	210	140	
68	1	2173	1616	495	0	0	223	166	
69	1	2190	1516	479	0	0	212	154	
70	1	2908	1417	523	0	0	289	204	
71	1	3031	1245	791	0	0	244	167	
72	1	4302	2080	1066	0	0	339	226	
73	1	6043	2407	1553	0	0	401	260	
74	1	5673	2638	1441	0	0	459	289	
75	1	6132	2999	1586	0	0	450	276	
76	1	6113	3439	1608	0	0	417	248	
77	1	4969	3181	1330	0	0	377	218	
78	1	2830	145	35	83	47	350	196	
79	1	1792	115	228	0	3	1021	242	
80	1	3646	84	215	121	77	1691	190	
81	1	3988	161	76	213	227	844	233	
82	1	4340	301	559	176	423	1010	329	
83	1	4297	156	138	135	1227	261	272	
84	1	3188	75	131	242	385	170	47	
85	1	1223	81	36	305	973	309	67	
86	1	1046	147	20	327	1065	395	172	
87	1	1153	73	181	253	1585	104	113	
88	1	1226	144	172	76	505	111	52	
89	1	1120	112	172	193	1476	266	88	
90	1	1102	198	143	8	1061	233	91	
91	1	704	26	157	174	404	200	92	
92	1	490	335	212	98	659	167	92	
93	1	559	270	222	160	366	135	99	
94	1	528	151	86	53	268	195	43	
95	1	377	21	50	62	281	43	30	
96	1	288	36	64	27	76	78	30	
97	1	230	24	34	7	31	66	97	
98	1	73	12	29	4	37	30	29	

99	1	45	3	18	2	5	60	80				
100	1	19	2	5	0	1	59	147				
101	1	14	3	5	0	1	105	87				
-1	1	1	1	1	1	1	1	1	END	OF	CATCH	DATA
-1	1	1	1	END	OF	EFFORT	DATA					
73	1	6	8	13	3.61	Agelrec	'tIndex(powerplants)					
74	1	6	8	1.41	1.19	Agelrec	'tIndex(powerplants)					
75	1	6	8	5.87	2.42	Agelrec	'tIndex(powerplants)					
76	1	6	8	2.87	1.69	Agelrec	'tIndex(powerplants)					
77	1	6	8	0.96	0.98	Agelrec	'tIndex(powerplants)					
78	1	6	8	30.99	5.57	Agelrec	'tIndex(powerplants)					
79	1	6	8	2.44	1.56	Agelrec	'tIndex(powerplants)					
80	1	6	8	1.39	1.18	Agelrec	'tIndex(powerplants)					
81	1	6	8	0.93	0.96	Agelrec	'tIndex(powerplants)					
82	1	6	8	0.24	0.49	Agelrec	'tIndex(powerplants)					
83	1	6	8	0.01	0.27	Agelrec	'tIndex(powerplants)					
84	1	6	8	0.01	0.27	Agelrec	'tIndex(powerplants)					
85	1	6	8	0.67	0.82	Agelrec	'tIndex(powerplants)					
86	1	6	8	0.67	0.82	Agelrec	'tIndex(powerplants)					
87	1	6	8	0.26	0.51	Agelrec	'tIndex(powerplants)					
88	1	6	8	0.22	0.47	Agelrec	'tIndex(powerplants)					
89	1	6	8	15.65	3.96	Agelrec	'tIndex(powerplants)					
90	1	6	8	0.4	0.64	Agelrec	'tIndex(powerplants)					
91	1	6	8	0.22	0.47	Agelrec	'tIndex(powerplants)					
92	1	6	8	0.72	0.85	Agelrec	'tIndex(powerplants)					
93	1	6	8	0.42	0.65	Agelrec	'tIndex(powerplants)					
94	1	6	8	0.03	0.27	Agelrec	'tIndex(powerplants)					
95	1	6	8	0.01	0.27	Agelrec	'tIndex(powerplants)					
96	1	6	8	0.23	0.48	Agelrec	'tIndex(powerplants)					
97	1	6	8	0.07	0.26	Agelrec	'tIndex(powerplants)					
98	1	6	8	0.02	0.13	Agelrec	'tIndex(powerplants)					
99	1	6	8	0.01	0.27	Agelrec	'tIndex(powerplants)					
100	1	6	8	0.58	0.76	Agelrec	'tIndex(powerplants)					
101	1	6	8	0.42	0.65	Agelrec	'tIndex(powerplants)					
80	1	6	9	6.388	0.907	MRFSSg1mCPUE						
81	1	6	9	4.905	1.601	MRFSSg1mCPUE						
82	1	6	9	5.702	1.775	MRFSSg1mCPUE						
83	1	6	9	1.359	0.399	MRFSSg1mCPUE						
84	1	6	9	0.598	0.135	MRFSSg1mCPUE						
85	1	6	9	1.409	0.45	MRFSSg1mCPUE						
86	1	6	9	1.285	0.656	MRFSSg1mCPUE						
87	1	6	9	0.773	0.336	MRFSSg1mCPUE						
89	1	6	9	0.365	0.15	MRFSSg1mCPUE						
93	1	6	9	1.137	0.503	MRFSSg1mCPUE						
94	1	6	9	0.866	1	MRFSSg1mCPUE						
95	1	6	9	0.284	0.101	MRFSSg1mCPUE						
96	1	6	9	0.38	0.155	MRFSSg1mCPUE						
97	1	6	9	0.683	0.257	MRFSSg1mCPUE						
98	1	6	9	0.134	0.047	MRFSSg1mCPUE						
99	1	6	9	0.42	0.139	MRFSSg1mCPUE						
100	1	6	9	0.377	0.283	MRFSSg1mCPUE						
101	1	6	9	0.751	0.318	MRFSSg1mCPUE						
51	1	2	10	0.247	0.054	CalCOFIindex						
52	1	2	10	0.267	0.091	CalCOFIindex						

53	1	2	10	0.244	0.062	CalCOFIindex	
54	1	2	10	0.330	0.047	CalCOFIindex	
55	1	2	10	0.316	0.062	CalCOFIindex	
56	1	2	10	0.202	0.052	CalCOFIindex	
57	1	2	10	0.393	0.072	CalCOFIindex	
58	1	2	10	0.317	0.050	CalCOFIindex	
59	1	2	10	0.095	0.023	CalCOFIindex	
60	1	2	10	0.141	0.040	CalCOFIindex	
61	1	2	10	0.166	0.034	CalCOFIindex	
62	1	2	10	0.137	0.024	CalCOFIindex	
63	1	2	10	0.243	0.085	CalCOFIindex	
64	1	2	10	0.122	0.034	CalCOFIindex	
65	1	2	10	0.180	0.082	CalCOFIindex	
66	1	2	10	0.271	0.075	CalCOFIindex	
69	1	2	10	0.61	0.094	CalCOFIindex	
72	1	2	10	0.43	0.067	CalCOFIindex	
75	1	2	10	0.415	0.05	CalCOFIindex	
78	1	2	10	0.204	0.037	CalCOFIindex	
81	1	2	10	0.225	0.09	CalCOFIindex	
84	1	2	10	0.105	0.026	CalCOFIindex	
85	1	2	10	0.052	0.022	CalCOFIindex	
86	1	2	10	0.051	0.031	CalCOFIindex	
87	1	2	10	0.196	0.095	CalCOFIindex	
88	1	2	10	0.168	0.067	CalCOFIindex	
89	1	2	10	0.169	0.105	CalCOFIindex	
90	1	2	10	0.051	0.015	CalCOFIindex	
91	1	2	10	0.151	0.054	CalCOFIindex	
92	1	2	10	0.169	0.05	CalCOFIindex	
94	1	2	10	0.092	0.015	CalCOFIindex	
95	1	2	10	0.024	0.015	CalCOFIindex	
96	1	2	10	0.347	0.125	CalCOFIindex	
97	1	2	10	0.039	0.014	CalCOFIindex	
98	1	2	10	0.027	0.018	CalCOFIindex	
99	1	2	10	0.052	0.026	CalCOFIindex	
100	1	2	10	0.023	0.016	CalCOFIindex	
77	1	8	11	365.7	140.1	1977 TRIENNIAL	INDEX
78	1	8	11	-9	-9	Placeholder	
79	1	8	11	-9	-9	Placeholder	
80	1	8	11	386.2	150.3	1980 TRIENNIAL	INDEX
81	1	8	11	-9	-9	Placeholder	
82	1	8	11	-9	-9	Placeholder	
83	1	8	11	503.5	315.6	1983 TRIENNIAL	INDEX
84	1	8	11	-9	-9	Placeholder	
85	1	8	11	-9	-9	Placeholder	
86	1	8	11	264.4	207.2	1986 TRIENNIAL	INDEX
87	1	8	11	-9	-9	Placeholder	
88	1	8	11	-9	-9	Placeholder	
89	1	8	11	303.2	238.4	1989 TRIENNIAL	INDEX
90	1	8	11	-9	-9	Placeholder	
91	1	8	11	-9	-9	Placeholder	
92	1	8	11	75	47.6	1992 TRIENNIAL	INDEX
93	1	8	11	-9	-9	Placeholder	
94	1	8	11	-9	-9	Placeholder	
95	1	8	11	31	14	1995 TRIENNIAL	INDEX



96	1	8	11	-9	-9	Placeholder
97	1	8	11	-9	-9	Placeholder
98	1	8	11	7	3.61	1998 TRIENNIAL INDEX
99	1	8	11	-9	-9	Placeholder
100	1	8	11	-9	-9	Placeholder
101	1	8	11	12.4	3.6	2001 TRIENNIAL INDEX
84	1	6	12	0.01	0.02	Agelrec'tIndex(midwatertrawl)
85	1	6	12	6.582	2.513	Agelrec'tIndex(midwatertrawl)
86	1	6	12	0.191	0.115	Agelrec'tIndex(midwatertrawl)
87	1	6	12	0.303	0.222	Agelrec'tIndex(midwatertrawl)
88	1	6	12	0.81	0.333	Agelrec'tIndex(midwatertrawl)
89	1	6	12	1.431	0.105	Agelrec'tIndex(midwatertrawl)
90	1	6	12	0.352	0.029	Agelrec'tIndex(midwatertrawl)
91	1	6	12	0.148	0.091	Agelrec'tIndex(midwatertrawl)
92	1	6	12	0.637	0.087	Agelrec'tIndex(midwatertrawl)
93	1	6	12	0.01	0.02	Agelrec'tIndex(midwatertrawl)
94	1	6	12	0.225	0.049	Agelrec'tIndex(midwatertrawl)
95	1	6	12	0.025	0.027	Agelrec'tIndex(midwatertrawl)
96	1	6	12	0.011	0.006	Agelrec'tIndex(midwatertrawl)
97	1	6	12	0.01	0.02	Agelrec'tIndex(midwatertrawl)
98	1	6	12	0.033	0.015	Agelrec'tIndex(midwatertrawl)
99	1	6	12	0.01	0.02	Agelrec'tIndex(midwatertrawl)
100	1	6	12	0.034	0.011	Agelrec'tIndex(midwatertrawl)
101	1	6	12	0.041	0.018	Agelrec'tIndex(midwatertrawl)
102	1	6	12	0.072	0.02	Agelrec'tIndex(midwatertrawl)
82	1	6	13	166.4	49.5	areaweightedCPUEfromRalston
83	1	6	13	73.1	21.5	areaweightedCPUEfromRalston
84	1	6	13	72.3	18.3	areaweightedCPUEfromRalston
85	1	6	13	30.7	7.7	areaweightedCPUEfromRalston
86	1	6	13	31.2	8.8	areaweightedCPUEfromRalston
87	1	6	13	44.4	11.7	areaweightedCPUEfromRalston
88	1	6	13	51.6	13.7	areaweightedCPUEfromRalston
89	1	6	13	35.8	11	areaweightedCPUEfromRalston
90	1	6	13	37.1	11.2	areaweightedCPUEfromRalston
91	1	6	13	26.9	7.7	areaweightedCPUEfromRalston
92	1	6	13	20.4	5.9	areaweightedCPUEfromRalston
93	1	6	13	19.7	5.2	areaweightedCPUEfromRalston
94	1	6	13	23.9	7.6	areaweightedCPUEfromRalston
95	1	6	13	15.2	4.5	areaweightedCPUEfromRalston
96	1	6	13	8.7	2.8	areaweightedCPUEfromRalston
87	1	6	14	0.731	0.855	VandenbergCPUE
88	1	6	14	0.384	0.619	VandenbergCPUE
89	1	6	14	0.419	0.648	VandenbergCPUE
90	1	6	14	1.022	1.011	VandenbergCPUE
91	1	6	14	0.805	0.897	VandenbergCPUE
92	1	6	14	0.634	0.796	VandenbergCPUE
93	1	6	14	0.391	0.625	VandenbergCPUE
94	1	6	14	0.263	0.513	VandenbergCPUE
95	1	6	14	0.243	0.493	VandenbergCPUE
96	1	6	14	0.224	0.474	VandenbergCPUE
97	1	6	14	0.264	0.513	VandenbergCPUE
98	1	6	14	0.173	0.416	VandenbergCPUE
98	1	1	15	3000	1000	dummy survey for profiling
-1	1	1	1	1	1	END OF SURVEY DATA

```

-1      -1      <==      No      aging      error(not      used)
-1      -1
-1      -1
25      25      <==25lengthbins20..56at2cm56-84at4cmbins

20      22      24      26      28      30      32      34      36      38      40      42      44      46      48      50      52      54
56      60      64      68      72      76      80      84
47.6    -0.2876    length@50%maturesslopeEcheverria1987

6.17E-06    3.1712    Length-weightparsfemale1995TriennialTrawl(Ralston)

0.22475    0.03657    eggs/kginterceptandslopeReinterpretedfromPhillipsbyRalston1996

6.17E-06    3.1712    Length-weightparsmale1995TriennialTrawl(Ralston)

Beginning    OF    SIZEANDAGECOMPOSITION

77      1      11      4      3      44      1      1      25      25      0

0      1633    1312    0      1088    2522    16102    46055    34002    145829    163170    185794    187458    88912    112216    49690    61727    90483
185646    214148    158431    122739    11324    595    0      0
0      0      4435    2010    4354    4916    16976    32715    46229    71639    219520    220071    154286    109503    81919    111659    137280    211871
353847    244290    62672    9278    0      0      0      0
78      1      1      4      3      100    1      1      25      25      0

0      3105    7757.5    1784    828    6164    9640    5625    4831    1794.5    10039.5    3519    13671    14338.5    43573.5
42287    36842.5    18758    24839    45007    21772    14923.5    13390.5    1280    164    6033
0      3105    7657.5    1663    317    3834    3960    4191    5533    6404.5    6234.5    13924    39302    63525.5    52157.5    30780
26446.5    11019    42493    25054    6850    1255.5    654.5    0      603    0
78      1      5      4      3      40      1      1      25      25      0

0      0      0      0      0      0      0      0      0      0      417    476    441    900    494    763    999    685
569    524    354    607    209    163    0      0      0
0      0      0      0      0      0      0      0      0      0      0    166    209    288    1508    1021    859    807
418    548.5    122    0      0      122    0      0

```

Remainder of file (332 lines) omitted