9216

APPENDIX B
BOCACCIO

# Status of Bocaccio in the Conception/Monterey/Eureka INPFC Areas in 1992 and Recommendations for Management in 1993.

James R. Bence and Jean Beyer Rogers
NMFS
Southwest Fisheries Science Center
Tiburon Laboratory
3150 Paradise Drive
Tiburon, California 94920

**Abstract**

Analyses using the stock synthesis model indicated that biomass and spawning stock size of the Conception/Monterey/Eureka INPFC areas' bocaccio had declined substantially since 1980. This qualitative result was in agreement with trends in both recreational catch/effort and a research survey index of abundance. As was the case in the last assessment of bocaccio, we had difficulty in ascertaining the absolute biomass level, and the extent to which fishing, along with a reduction in recruitment rates, contributed to the estimated decline. Fishing mortality rates appear to have fallen substantially from 1990 to 1991, following the imposition of trip limits, and were estimated to be below $F_{35\%}$ levels. Based on average estimated 1980-1990 recruitment rates, 1991 landings/catch (about 1700 MT) were estimated to be near the equilibrium $F_{35\%}$ rate. Nevertheless, under continued 1991 landing levels, the bocaccio stock was projected to continue to decline; under some reasonable scenarios the spawning stock was forecast to fall below 20% of 1980 levels within the next few years. The continued forecast decline from 1980 levels occurred because the forecast recruitment rate (the average of 1980-1990 estimated recruitment) was substantially less than the recruitment rate that produced the initial 1980 stock. If recent recruitment is indeed substantially below virgin levels, then the spawning stock may well fall below 20% of its virgin level. If landings were held at the current harvest guideline of 1100 MT, our forecasts were for increases in biomass by 1994. We recommend this conservative approach both because of the apparent decline in recruitment, and because we may have underestimated 1991 fishing mortality rates since discard was not accounted for in our analyses, and could have increased following the imposition of trip limits in 1991.

**Introduction**

This report presents an analysis of data on bocaccio (Sebastes paucispinis) from the Conception, Monterey, and Eureka INPFC areas combined over the period 1980-1991, with a view toward assessing the current status of the stock. Included is a recommendation for management in 1993.

Bocaccio is a viviparous demersal rockfish which is frequently landed together with chilipepper rockfish (S. goodei). Among rockfish, bocaccio are noted for their rapid growth, large adult size and high variation in year-class strength. This species reaches a maximum total length (tl) of approximately 90 cm. Past assessments indicate that bocaccio reach 50% recruitment to the trawl fishery at about age 2 and tl 40 cm (Bence and Hightower 1990), but females do not reach 50% maturity until 48 cm in length. Some individuals older than 30 years have been captured, but the bulk of the population appears to be less than 15 years in age.

Although bocaccio are found from Baja California to north of the US/Canadian border, there appears to be a break in its distribution in southern Oregon, near the boundary between the Eureka and Columbia INPFC areas (Bence and Hightower 1990). Consequently, we confined our assessment to the Conception/ Monterey/Eureka areas.

This document updates earlier assessments prepared by NMFS and CDF&G. The most recent full stock assessment of bocaccio was done in 1990 (Bence and Hightower, 1990). That assessment was based on the separable Stock Synthesis model (Methot 1989 & 1990), and explicitly included the trawl, set-net and recreational fisheries. Bence (1991) provided updated length composition data which appeared to be consistent with the earlier assessment. The 1990 assessment for bocaccio strongly indicated that the biomass and spawning stock size had declined substantially over the 1978-1989 period. Best estimates of stock size suggested that the biomass had fallen to less than 20% (seven to 14 thousand MT) of its 1978 level by 1990. Both the NMFS triennial survey data, and recreational effort data provided evidence for this decline. It was also concluded that a significant fraction of the decline was due to poor recruitment since 1978. Bence and Hightower (1990) emphasized that the available data were not sufficient to firmly fix current fishing mortality rate or the extent to which fishing contributed to the observed decline in bocaccio abundance. Because of the apparent decline in recruitment, a conservative management approach was recommended. Based on that assessment, an ABC of 800 MT and a harvest guideline of 1100 MT were adopted for the Conception/Monterey/Eureka areas combined, representing substantial reductions from the previous ABC of 6100 MT for only the combined Monterey and Conception areas. In an attempt to reduce the landings of bocaccio (and other rockfish), in 1991 a trip limit was set for the area south of Coos Bay, Oregon. The limit was 25,000 lbs. for the Sebastes complex, to not include more than 5000 lbs. of bocaccio.

Our use of the stock synthesis model in this assessment was similar to its use by Bence and Hightower (1990). The most significant changes were (1) a revision of the natural mortality rate downward to 0.20 from 0.25 based on observed maximum ages, (2) the allowance of time-dependence in the selectivity of the trawl fishery, (3) the inclusion of length-at-age data for the trawl fishery, (4) the inclusion of the hook-and-line / long-line fishery, which was not accounted for at all in the previous assessment, and (5) changes in the landings data used (see Attachment 1). (Note that we include in the hook-and-line / longline fishery all commercial landings by hook - for brevity we sometimes refer to this fishery as hook-and-line or just "hook".)

## Methods

The stock synthesis model was the analytical tool we used to assess the current status of the stocks. We used the length-based version of the model termed "stage-2" by Methot (1989). The rationale for our use of this variant of the synthesis model was presented in Bence and Hightower (1990).

The model was fitted by maximizing the weighted log likelihoods attributable to each of the data sources. These included length and age composition observations, length at age data, recreational effort data, and triennial survey data, and penalty functions (see below). The age and length composition data were assumed to demonstrate a "multinomial like" variance pattern, but we set effective sample sizes to 200 whenever more than 200 fish were actually measured or aged (e.g. Methot 1990, Fournier and Archibald 1982). We used a smaller effective sample size for the 1980, 1983 and 1986 triennial survey length composition data because the 1980-1986 length compositions were based on only 9-18 samples containing bocaccio (see below). We also reduced the emphasis for all the triennial survey length composition data to 0.25 from the emphasis of 1 used for other data sources. We did this because of other concerns we had about the length composition data for the triennial survey: (1) during the 1980 and 1983 surveys only samples with 10 or more bocaccio were measured for lengths, and (2) the indicated relative strength of year classes were inconsistent over time and with other samples.

### Available Data

The analysis made use of data from the trawl, set-net, hook-and-line / longline, and recreational fisheries, and from the NMFS triennial trawl surveys. Landing estimates from the commercial fisheries (Tables 1-3) were used together with catch estimates for the recreational fishery for 1980-1989 (Table 4) obtained in a database from John Witzig (NMFS, Washington, DC.) Recreational catch in 1990 and 1991 was assumed to be the average of the estimated values reported for 1987-1989.

We included composition data on ages 1-21+ and on lengths in 2 cm total length bins from 20 to 56 cm, and in 4 cm bins up to an 80+ cm category. These data were separate by sex except for the recreational fishery, and for the hook-and-line / longline fishery in 1990. The length (Fig. 1) and age compositions (Fig. 2) for the trawl fishery were obtained from "CSUM" expansions (see Attachment 1). For the trawl fishery, length compositions were available for each year, while age compositions were available only for 1980-1984. Similar "CSUM" length compositions were provided by CDF&G for the set-net fishery for 1986-1991 (Fig. 3). These expansions for set net did not account for all reported landings, but we believe they are reasonable estimates of the length composition for this fishery. Similar expansions were not available for the other gear types. For hook and line / longline (Fig. 4) and the recreational fishery (Fig. 5), we generated length compositions by simply pooling the available samples for a given year (separately by sex when appropriate). For hook and line / longline we chose to use raw length compositions both because of the sparse sampling and because up-to-date landing data were not available at the time the length compositions were calculated. Recreational length data were only available in raw form (not tied to stratified landing values). Sufficient data were available to generate length compositions for 1986-1991 for the hook-and-line fishery and for 1980-1989 for the recreational fishery. Too few age data were available to generate age compositions for any years for the non-trawl fisheries.

We also used length composition data for the triennial trawl survey (Fig. 6). These length compositions were generated by AFSC as swept area estimates of the numbers at size based on a stratified sampling plan. They were, however, based on relatively few samples each year. There were 14, 9, 18, and 40 samples with length composition data for bocaccio in the respective 1980, 1983, 1986, and 1989 surveys. For this data set, we set the effective samples sizes as 200 x p, where p was the ratio of the number of samples contributing length information in a given year to the number contributing information for the 1989 survey (40). For reasons discussed above, we suspect that this still over-estimated the actual effective sample size.

For the trawl fishery, we also included length-at-age data for 1980-1984 along with the sample sizes used to calculate these values. Auxiliary data included effort data for the recreational fishery and an index of abundance for the NMFS triennial bottom trawl survey. Our past analyses indicated that the swept area estimate of abundance from the triennial survey was highly sensitive to a few very large tows. Therefore, after Bence and Hightower (1990), we used winsorized CPUE (Kg/tow) as an index of abundance (Table 5). For the recreational fishery, the effort values we used were weighted sums of the reported numbers of trips. We calculated the average weight of bocaccio over cells (i.e. regions, areas, and waves (bimonthly periods)). These average values were then used to weight trips from different fishing modes (e.g. shore fishing versus party boats). In Table 6 we report the ratio of estimated catch to these effort values as an index of relative abundance, but we stress that in the synthesis runs these auxiliary data were input as effort estimates.

Implementation of the Synthesis Model

Our implementation covered years 1980-1991, and recognized ages classes 1-21+. The parameters we fixed (i.e. assumed or estimated outside of the synthesis model), and the parameters estimated by synthesis are listed in Table 7.

Natural mortality was assumed constant over time and independent of age, and was fixed at 0.20 in our main set of runs. We revised the natural mortality rate downward from 0.25 used by Bence and Hightower (1990), to be more consistent with the maximum observed age in trawl data of 36 yr. By itself, a maximum age of 36 implies a natural mortality rate under 0.15 (Hoenig 1983), but we chose a value of 0.20, (a) because of the relatively high Brody growth coefficient (k) (see Henry 1986), and because widow rockfish reach greater maximum ages than bocaccio, but catch curve analyses of relatively unexploited stocks of this species indicate a natural mortality rate on the order of 0.15-0.2 (Hightower and Lenarz 1986).

Selectivities of all four fisheries and the survey were modeled as the double logistic form, with the ascending function assumed to be the same for both sexes, but with the descending function allowed to differ between the sexes. The use of the same ascending function for both sexes was based on runs done for the 1990 assessment, where estimated ascending functions for the two sexes were very similar (Bence and Hightower 1990). In general, each selectivity function required that nine parameters be estimated within the synthesis runs: (1) the selectivity at 20 cm, (2-3) the slope and size of inflection for the ascending component of the function, (4-7) the slope and size of inflection for the descending component of the function for each sex, and (8-9) and the selectivity at length 80 cm for each sex. We were able to reduce the number of estimated parameters by fixing the selectivity at 20 cm to near zero for the trawl, set-net and hook-and-line fisheries because these did not catch fish that small. Calculated derivatives for the inflection size of the downward components of the selectivity functions were sometimes ill-behaved, presumably because when the slope parameters approach zero the value of the inflection size becomes irrelevant to the likelihood. To make these derivatives well defined we introduced penalty functions which contributed to the likelihood when the estimated inflection sizes for the downward components deviated from a value of 50 cm. These penalty functions were given an emphasis of 10 and CV's of 20% around the prior value of 50 cm. The penalty functions allowed the estimated values to change from 50 cm when this was required to fit the data, and solved the numerical problem when this was not the case.

There were also numerical problems associated with estimating the triennial selectivity function, as no given selectivity pattern fit all the triennial length composition data well. When free, the parameter for selectivity at 80 cm usually increased toward 1. Given these patterns and the numerical problem, we fixed this parameter close to 1. When freed up again after the model converged to a solution, the parameter generally stayed at this value (an upper bound of allowed values).

Bence and Hightower (1990) argued and presented analyses indicating that the trawl fishery might be targeting on strong year-classes of bocaccio, leading to a time-dependence in selectivity. In preliminary runs we again found evidence for this. We therefore allowed the selectivity of the trawl fishery to be time-dependent, by letting the inflection size of the ascending function be year-specific. By adding 11 additional parameters, the total likelihood of our fit increased by nearly 200 units and a pattern in the trawl residuals was removed. Figure 7 shows that the estimated value of the ascending inflection size fell quite sharply in 1986, when the relatively strong 1984 year class entered the fishery. As a consequence, fish under 40 cm in total length were nearly fully recruited that year, but in other years fish of the same size had very low selectivity (Fig 7).

We assumed that the trawl ages were measured with error, and fixed the proportion agreement between two readers at 0.75 and 0.1 for ages 1 and 21 respectively, with an assumed linear decline with age. These values were calculated from values estimated by the synthesis model for the 1990 assessment. In that assessment, age-composition data for 1978 and 1979 were also used. This allowed ageing error parameters to be well estimated as the strong 1977 year class aged, and coded ages "smeared". With only the 1980-1984 age compositions used here, the ageing error could not be well estimated internally by the synthesis model.

Males and females each followed separate von Bertalanffy growth equations, and all parameters for the growth equations were estimated within the synthesis runs. This differs from the 1990 assessment, where the length at age 1 was fixed based on observed mean length at age seen in the 1977 triennial survey. We have concluded that fixing the length at age in this way gives too much weight to a single survey done prior to the time period covered by the assessment. Following Bence and Hightower (1990), CV's in length at age were fixed at values based on a regression of observed CV in length at age (from trawl data) versus mean length at age for females and at the mean CV in length at age averaged over all ages for males (since there was no significant regression or obvious pattern for males).

The initial age composition for ages 1-15+ were estimated as parameters, except for the initial numbers at age 3 (the 1977 year class). Thus the model recognized the 15+ class in 1980, the 16+ category in 1981, and so on, until all 21 age classes are present. In our runs, we fixed the strength of the 1977 year class by setting the initial numbers at age 3 at values ranging from 15 to 60 million fish.

## Results

<u>Qualitative patterns in the data</u>

Landings/catch estimates are summarized in Tables 1-4. The estimates of commercial landings were revised and extended from those used in the 1990 assessment, and landing estimates for the hook-and-line / longline fishery from 1980-1991, and the set-net fishery prior to 1986 were added. All nominal landings by gear and INPFC area were adjusted for unknown gear landings and landings from Santa Barbara and further south. Details of how the revised landing estimates were obtained are included in Attachment 1.

Historically, bocaccio has been an important mainstay of the California trawl rockfish fishery (Lenarz 1986). In 1985, trawl landings of bocaccio fell sharply from around 4000 MT to just over 1000 MT, as the large 1977 year class left the fishery, and remained at this lower level through 1990 (Table 1). In 1991, trawl landings of bocaccio dropped from over 1400 MT to just below 700 MT. During 1985-1990, landings from set-net (Table 2) and hook-and-line (Table 3) fisheries did not fall, most likely due to increased effort. Set-net landings of bocaccio have varied from 70 to nearly 1200 MT since 1980, with peak landings occurring during 1985-1987 (Table 2). As with trawl, bocaccio set-net landings fell from 1990 to 1991. Hook-and-line / longline landings have varied from less than 20 MT in 1980 to about 500 MT since 1989 (Table 3). Recreational catch reached nearly 2000 MT in 1980 and exceeded 1000 MT in 1982 (Table 4). In the last three years with available estimates (1987-1989), recreational catch was about 200 MT (Table 4).

Most commercial landings for all gear types have come from the Monterey area, although the Conception area set-net and hook-and-line / longline landings exceeded the Monterey landings during the early 1980's. There were essentially no set-net landings in the Eureka area, and hook-and-line / longline landings were relatively low there.

Length and age composition data showed clear indications of three dominant year classes. The strong 1977 year class can be followed in the 1980-1985 trawl length compositions (Fig. 1), and the trawl age compositions for 1980-1984 (Fig. 2). The growth of the 1977 year class can also be tracked in the triennial survey length compositions (Fig. 6). A relatively strong 1984 year class first showed up in the trawl fishery length composition data in 1985, and can be followed as it grows and recruits more fully to the fishery (Fig. 1). This same year class did not create a distinct mode in the set-net fishery until 1987 (Fig. 3), appeared to be evident, but only weakly in the 1986 hook-and-line length composition (Fig. 4), but could be easily detected in the recreational length compositions as 0+'s in 1980 (Fig. 5). This year class was evident in the 1986 triennial survey as small two year old fish, but did not form a distinct mode in the 1989 survey, where 1+ fish from the 1988 year class appeared to dominate (Fig. 6). Like the 1984 year class, the 1988 year class was quite evident as 0+'s in the recreational length composition (Fig. 5), and was evident in the trawl length compositions as two-year-olds (Fig. 1).

The clear pattern in both sets of auxiliary data is for a decline in relative abundance over time. Our winsorized index of CPUE for the triennial trawl survey is reported in Table 5. In Table 6 we report catch/effort for the recreational fishery. These numbers were simply the estimated catch divided by our effort estimates calculated for use in our synthesis runs.

<u>Synthesis fits</u>

In preliminary runs, we found that the model could not discern the best absolute biomass level over a substantial range of levels. We therefore fixed the strength of the 1977 year class by fixing the initial numbers at age-3 (I3) at 1.5, 2.25, 3.0 and 6.0 (in 10's of millions). This was akin to fixing the terminal F in a cohort or VPA analysis. The absolute change in likelihood over this wide range of conditions was not great, but the total weighted likelihoods for the high and low I3 levels indicated somewhat poorer fits (Table 8).

There was no consistent pattern that a given level of I3 provided the best fit to all sources of data. The likelihoods for the trawl age composition data indicated somewhat better fits at the two higher I3 levels, but the trawl size composition likelihoods were roughly equal for all I3's (with the nominally best fit at I3=2.25). The likelihoods indicated that the length-at-age data were fit better as I3 declined. The likelihoods were about equal at the three lower I3 levels for the set-net size-composition data, with a somewhat better fit indicated at I3=6.0. The fit to the recreational size composition data degraded as I3 increased, but the likelihoods were about equal for I3=1.5 and I3=2.25. The fit to the hook-and-line size composition data degraded as I3 increased, but not substantially. The likelihood for the triennial survey index was highest for the lowest I3 and the fit degraded as I3 increased. The range of variation in these likelihoods was not great. The likelihoods for the effort data were roughly equal for all I3, although the values at I3=3 and I3=2.25 were slightly higher than at the extremes.

The model was able to match the qualitative pattern of a decline in biomass, apparent in the auxiliary data, for all values of I3 examined. The match between observed and predicted (by synthesis) triennial index values are given in Fig. 8. None of the fits were especially good because the model was not able to emulate the sharp drop in the observed index from 1986 to 1989. The lower I3 values produced "better" fits because they matched the overall drop in the index from 1980 to 1989. Catch/effort for the recreational survey dropped over time and was well fit by all the synthesis runs (Fig. 9). It is clear from this figure that the nominal differences in effort likelihoods among the cases were insignificant.

Based on the better overall fits, we chose the I3=2.25 and I3=3 runs as our more likely solutions. We ruled out the I3=6 case because we considered implausible the very low fishing mortality rates, the very high initial biomass and the implied very large drop in average recruitment. We decided against the I3=1.5 run based on its lower likelihood. We stress, however, that the entire range of variation in likelihoods was not large, and solely based on the synthesis fits none of the cases we examined can clearly be dismissed.

The fits of our preferred two runs were similar, and we illustrate the fit of the model to all the length, age, and length-at-age only for the I3=2.25 case. Table 9 gives the estimated (by synthesis) and observed mean lengths and ages for each of the composition samples, together with the estimated and observed proportion female. Excluding the triennial trawl length composition data, there was generally good agreement between estimated and observed values, with several notable exceptions. The two most notable such discrepancies were for the 1984 trawl fishery age composition data (both sexes), and for the 1990 hook length composition data (sexes pooled). The lack of fit for the 1984 age data could be due to a change in age (rather than size) dependent selectivity in response to the strong 1977 year class. We have no mechanistic explanation for the generally small size of fish in the 1990 hook-and-line data. Given that the mean length observed in 1990 was smaller than the lowest mean length observed in other years for either sex, and much lower than both 1989 and 1991 values, we suspect that the discrepancy is due to sampling error. The various problems with fitting the triennial data were discussed above. Our conclusion is that these data have high levels of observation error. We suspect that this might be due to clustering of like-size fish within samples, combined with the small sample sizes.

The fit to the proportion female was much poorer, and the observed proportion female was much more variable over time, than were the values estimated by synthesis. This could be due to time-dependent changes in selectivity that were not captured in the model, or to clustering of sexes in the samples leading to large errors in observed sex ratio. It is clear that the variations do not indicate similar variation in the sex ratio of the underlying population because the fluctuations are not concordant for the different gear types.

The observed and predicted lengths-at-age, as a function of age, are shown separately by sex in Fig. 10, again for the I3=2.25 run. In general there was a fairly good fit, but the model did tend to underestimate the length-at-age for the oldest fish slightly, especially for males.

All the estimated parameters for our two preferred runs are in Table 7. The estimated selectivity patterns were similar for our two preferred runs, and these patterns for the hook, recreational and set-net fisheries are illustrated for the I3=2.25 case in Fig. 11, (see Fig. 7 for trawl) and for both of the preferred I3 values and all fisheries in Tables 10 and 11. Full selectivity was estimated at all sizes for the triennial survey and is not illustrated.

Selectivity for each of the fisheries was estimated as dome shaped, with peak selectivity for females exceeding peak selectivity for males, and selectivity for males beginning to descend at a smaller size than for females (Figs. 7 and 11). There was also a suggestion that the selectivity for very large males by the hook and recreational fishery may be higher than for females. This latter pattern may not be especially meaningful since very few males reach these sizes. The recreational fishery has the broadest estimated selectivity function, and estimated selectivity for small fish was stronger than for any of the other fisheries. In some years the estimated selectivity of the trawl fishery for small fish was substantially higher than that of the hook or set-net fisheries, and on average, the estimated length of peak selectivity for this fishery was less than for the other commercial fisheries (Figs. 7 and 11). However, the trawl fishery also had higher estimated selectivities for the largest fish than any other fishery. The set-net fishery had the narrowest estimated selectivity pattern, with very low selectivity below 40 cm or above 60 (males) or 65 cm (females) (Fig. 11). The hook fishery had an estimated peak selectivity at a larger size than in any other fishery (near 60 cm), but the estimated selectivity pattern also had a long tail to the left, indicating significant selection for smaller fish also (Fig. 11).

The dynamics of the fish stock and fishery implied by the estimated parameters are illustrated in plots of recruitment (Fig. 12), biomass and spawning stock (Fig. 13) and fishing mortality rate (Fig. 14) for each run. In addition, numbers-at-age over time, by sex, are given for the I=2.25 (Table 12) and I3=3 (Table 13) runs.

The model estimated the 1979, 1983, 1984, 1987 and 1988 year classes as being relatively strong (Fig. 12). The pattern of "double" strong year classes resulted, we suspect, from the model misclassifying the age of some of the larger fish from the 1984 and 1988 year classes. There was some evidence that strong year classes of bocaccio tended to recruit earlier and possibly grow faster, thus leading to larger size at age. We were not able to resolve this possible problem in the absence of recent age composition data. This "splitting" of year classes should not have seriously affected this assessment, but caution should be exercised in using the time series of estimated recruitments in other contexts (e.g. in spawner-recruit relationships).

The I3=6 run estimated substantially higher recruitment rates than the other runs (Fig. 12). In contrast, the differences in average estimated recruitment for the I3=1.5 through I3=3 runs were much less than the differences in the fixed I3 levels. All the runs estimated the 1987/1988 year class to be about as strong as the 1983/1984 year class.

All runs estimated that biomass and spawning stock declined substantially from 1980 through 1991, but the extent of the decline was increased as I3 decreased (Fig. 13). Estimated 1991 biomass levels range from 22 to 42 percent of 1980 levels, and 1991 estimated spawning stock was at 18 to 44 percent of 1980 levels (Fig. 13, Table 15).

Temporal patterns in estimated fishing mortality rates differ substantially among the fisheries because of the different patterns in landings (Fig. 14, Tables 1-4). Trawl fishing mortality peaked in 1984, fell sharply in 1985, and for all runs except the I3=6 case gradually increased through 1990, then fell in 1991 as trip limit regulations came into play (Fig. 14). For all cases, set-net fishing mortality increased dramatically from 1980 through 1986, then declined somewhat, but still remained at much higher levels than was evident at the beginning of the 1980's (Fig. 14). There appeared to be a modest drop in fishing mortality from 1990 to 1991. For all cases, recreational fishing mortality was estimated as being highly variable over time, perhaps because of large observational error associated with the estimated landings (Fig. 14). Overall, estimated fishing mortality rate for this fishery was less in recent years than the average seen in the early to mid-1980's. For all runs, the hook-and-line fishery showed a dramatic increase in estimated fishing mortality from 1986 through 1990, and only a slight drop off in 1991 (Fig. 14).

Such a wide range of cases were able to predict that biomass and spawning stock declined substantially from 1980 to 1991 because they traded off changes in recruitment levels and fishing mortality rates. Average recruitment for 1971-1979 (based on estimated initial numbers at age), for 1980-1990 and for 1971-1990 are presented in Table 14. For all cases, recent (1980-1990) average estimated recruitment was lower than for the early period (1971-1979). Thus, in all cases a decline in recruitment from the rate that produced the initial stock in 1980, in addition to direct effects of fishing, was required to fit the data. Of special interest here is that the early recruitment became proportionally greater than recent recruitment as I3 increased from 1.5 to 6. Thus, when the fishing mortality rate was estimated to be lower, a greater drop in average recruitment from historical levels was required to explain the observed patterns in the data.

## Yield Calculations and Forecasts

The various factors used in our yield calculations are in Table 16. We calculated $F_{35\%}$, $F_{20\%}$, equilibrium yield (MT) and equilibrium spawning stock size (in billions of eggs) under the assumption that the ratio of the fishing mortality rates for the various fisheries averaged over 1989-1991 would be experienced in the future. Selectivity (converted to an age-specific form), and weight-at-age for each fishery used in these calculations were based on the I3=2.25 run. Spawning capacity of an individual female of a given age was measured in expected numbers of eggs carried, and was the product of the proportion of females mature at that age, the weight at age, and the eggs/unit mass carried by a female of that age. Total spawning stock size is then calculated as the sum of spawning capacity over all individuals.

Fig. 15 summarizes the results of our equilibrium yield calculations. Equilibrium spawning stock, as a proportion of the unfished equilibrium, was plotted against trawl F (at selectivity of 1). Because this curve assumed that recruitment rate was constant at all fishing rates and stock sizes, it was equivalent to one for spawning stock per recruit, but started at 1 for F=0 and declined as F increased. We also plotted the equilibrium spawning stock as a proportion of the equilibrium "virgin" spawning stock size. In this case, the equilibrium virgin spawning stock was based on an assumed recruitment equal to the 1971-1990 estimated average, but we calculated the equilibrium stock size using the estimated average 1980-1990 recruitment. Because the estimated average 1980-1990 recruitment was less than the 1971-1990 average, these plots started below 1.0 for F=0. Also, since the ratio of 1980-1990 average recruitment to 1971-1990 average recruitment differed between the I3=2.25 and I3=3.0 run, these curves differed slightly for the two runs.

Equilibrium yield (MT) is also shown in Fig. 15 for the I3=2.25 and I3=3 cases. At an F of 0.105 the spawning stock fell to 35% of the unfished level ($F_{35\%}$), and at an F of 0.175 the spawning stock fell to 20% of the unfished level ($F_{20\%}$). The corresponding yields were 1680 and 2000 MT (I3=2.25) or 1860 and 2230 (I3=3) respectively. Note, however, that the equilibrium spawning stock sizes at $F_{35\%}$ and $F_{20\%}$ were substantially below 35 and 20% (respectively) of the "virgin" spawning stock, based on the estimated average 1971-1990 recruitment (Fig. 15).

Because the 1980 spawning stock was a product of higher recruitment in earlier years, we should expect that given the lower recent estimated recruitment rates, the spawning stock will fall below 35% of the 1980 level, even when F is at or even below $F_{35\%}$. This was evident in our forecasts of stock size based on 1991 landings in 1992-1995, and assumed recruitment equal to the estimated 1980-1990 average (Table 16). For both the I3=2.25 and I3=3.0 cases, biomass and spawning stock continued to decrease through the beginning of 1996 (although stock sizes and F's appear to be stabilizing by that time). Spawning stock in 1996 was projected to be 18 (I3=2.25) or 23% (I3=3) of the 1980 estimate, even though $F_{35\%}$ was never exceeded. If we assumed that total catch would be at the current harvest guideline of 1100 MT, stock biomass was forecast to begin increasing by the beginning of 1994 in both our preferred runs, and spawning stock was projected to begin increasing by the beginning of 1996 for the I3=2.25 run, but not for the I3=3 run (Table 18).

Based on the above analysis we recommend that the current harvest guideline of 1100 MT be retained. With this level of harvest our best estimate is that the expected stock biomass and spawning capacity should remain near its current level. Although the trip limit regulations imposed in 1991 have caused estimated F's for 1991 to fall well below $F_{20\%}$, and even below $F_{35\%}$, current levels of harvest, which exceed the harvest guideline, should be expected to cause further declines in stock size. Given the evidence for the decline in recruitment rates since 1980, we recommend the more conservative approach implied by the harvest guideline. We stress that when interpreting the above forecasts, the highly variable and unpredictable recruitment in this species should be taken into account. The actual stock trajectory could deviate greatly from its expected value.

**Discussion**

Under all conditions we considered, estimated biomass and spawning stock declined substantially from 1980 through 1991. As we let the initial numbers at age-3 double, from 15 to 30 million, estimated 1980 biomass only increased from 57,000 to 72,000 MT, and 1991 biomass varied from 13,000 to 22,000 MT. A further doubling in initial numbers at age-3, however, more than doubled both initial and 1991 biomass, but we consider this lightly fished scenario implausible. These results are qualitatively consistent with the 1990 assessment of Bence and Hightower, but our ending biomass estimates are more optimistic (the I=2.25 case is close to the more optimistic of the preferred runs from 1990). Differences are due to the combination of revised landings, a lowered estimate of natural mortality, the use of additional data, and changes to the assessment model, particularly the allowance of time-dependent selectivity.

Even with the more optimistic scenario reported here, the reduction in landings due to the imposition of trip limits in 1991 was needed to keep the estimated fishing mortality substantially below the $F_{20\%}$ level (a possible reference point for overfishing). Furthermore, under current harvesting rates, although fishing mortality is estimated to be below $F_{35\%}$, 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. This is possible because the initial stock in 1980 appears to have resulted from substantially higher recruitment rates than have been experienced since 1980.

Even though our estimate of current stock status is more optimistic than that of Bence and Hightower (1990), our estimated equilibrium yields at $F_{35\%}$ (1680-1860 MT) are substantially below the $F_{35\%}$ equilibrium yields reported by them (2400-3000 MT). The $F_{35\%}$ rate calculated here is virtually identical to that calculated for the 1990 assessment (after correcting for the fact that they reported F in terms of the trawl fishery on age-5 females and we report in terms of full selectivity for the trawl fishery). The difference in estimated equilibrium yields stems from the fact that they used average 1978-1989 recruitment in their calculations, and this includes the value for the strong 1977 year-class. Although such a strong year class is possible, given the lower recruitments seen since 1980, it is not prudent to count on such an event.

We recommended a conservative approach because, like Bence and Hightower (1990), we estimated that recruitment in recent years had been substantially below the levels seen prior to 1980. If recent lower recruitment is not typical of virgin conditions, then the current biomass could be at or below 20% of virgin levels. If catch continues at the 1991 estimated landings/catch level, on the order of 1700 MT, our forecast is for continued declines in stock biomass and spawning capacity through 1996. Catches on the order of 1100 MT, equal to the current harvest guideline, led to forecast increases in stock biomass by the beginning of 1994. Consequently, we recommend harvesting at the current harvest guideline. A second reason for a conservative approach is that all our analyses have equated landings with catch. If the imposition of trip limits in 1991 led to increased discarding, then we have over-estimated the decline in fishing mortality rates from 1990 to 1991.

Bence and Hightower (1990) noted two major data gaps associated with their assessment of bocaccio. The first having to do with the lack of set-net landing estimates prior to 1986, and the second being the absence of age-compositions after 1984. The first of these gaps has been filled, together with other improvements and additions to our landing estimates. We believe, however, that as Bence and Hightower forecast, the absence of age data after 1984 is making the assignment of year-class strength more difficult. We recommend, as they did, that any future aging work include a comparison of surface aging (the method used for the 1980-1984 samples) with any new method (such as break-and-burn) that is used. It also seems possible that periodic age-composition data (e.g. every three years) would be adequate for use in assessing the status of the bocaccio fishery.

**Acknowledgements**

Rick Methot provided advice and assisted us in the use of the synthesis model. Don Pearson helped process commercial landing and composition data under severe time constraints. Nancy Wiley waded through unexpected troubles to assist us in the transfer of data. Mark Wilkins, Ken Weinberg, and Frank Shaw provided the NMFS triennial survey data and assisted us in interpretation. CDF&G at Menlo Park (particularly Dave Thomas, Frank Henry, Becky Ota and Brenda Erwin) provided advice and gave us input on the history and background of the bocaccio/chilipepper fishery. Brenda Erwin, together with Jerry Kobylinski (PacFin) and the CDF&G Technical Services Branch helped us work with the California landing data. Landings for the Oregon portion of the Eureka area were provided by ODFW. John Witzig (NFMS, Washington D.C.) provided recreational data. We thank participants at the ad hoc stock assessment workshop (May 26-28, 1992), particularly the convener Bill Lenarz, and our rapporteur Mark Wilkins for providing valuable input.

**Literature Cited**


Bence, J. R. and J. E. Hightower. 1990. Status of bocaccio in the Conception/Monterey/ Eureka INPFC areas in 1990. In: Status of the Pacific groundfish fishery through 1990 and recommended acceptable catches for 1991.

Bence, J. R. 1991. Memorandum on bocaccio. In: Status of the Pacific coast groundfish fishery through 1991 and recommended acceptable biological catches for 1992.

Fournier D. and C. P. Archibald. 1982. A general theory of analyzing catch at age data. Can. J. Fish. Aquat. Sci. 39: 1159-1207.

Henry, F.D., Jr. 1986. Status of the coastwide chilipepper (Sebastes goodei) fishery. Appendix 5 *in* Status of the Pacific coast groundfish fishery through 1986 and recommended acceptable biological catches for 1987.

Hightower, J. E. and W. H. Lenarz. 1986. Status of the widow rockfish fishery. In Status of the Pacific coast groundfish fishery through 1986 and recommended biological catches for 1987.

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

Lenarz, W. H. 1986. A history of the California rockfish fisheries. Proc. Int. Rockfish Symposium.

Methot, R.D. 1989. Synthetic estimates of historical abundance and mortality for northern anchovy, p. 66-82. *In* E.F. Edwards and B. Megrey [ed.] Mathematical analysis of fish stock dynamics. American Fisheries Society Symposium 6.

Methot, R.D. 1990. Synthesis model: An adaptable framework for analysis of diverse stock assessment data. Proceedings of the symposium on applications of stock assessment techniques to Gadids. INPFC Bull. 50: 259-277.

Table 1. Estimated trawl landings (MT) of bocaccio for the Conception (C), Monterey (M), and Eureka (E) INPFC areas.

| YEAR | C | M | E | TOTAL |
|---|---|---|---|---|
| 1980 | 938 | 2632 | 169 | 3739 |
| 1981 | 633 | 2498 | 1697 | 4828 |
| 1982 | 830 | 2909 | 554 | 4292 |
| 1983 | 593 | 3069 | 645 | 4307 |
| 1984 | 353 | 3688 | 399 | 4440 |
| 1985 | 100 | 992 | 229 | 1321 |
| 1986 | 127 | 895 | 112 | 1134 |
| 1987 | 206 | 1031 | 112 | 1349 |
| 1988 | 196 | 983 | 98 | 1277 |
| 1989 | 174 | 1005 | 124 | 1303 |
| 1990 | 257 | 983 | 178 | 1418 |
| 1991 | 130 | 521 | 48 | 699 |

Table 2. Estimated set-net landings of bocaccio (MT) for the Conception (C), Monterey (M), and Eureka (E) INPFC areas.

| YEAR | C | M | E | TOTAL |
|---|---|---|---|---|
| 1980 | 66 | 8 | 0 | 74 |
| 1981 | 203 | 27 | 0 | 230 |
| 1982 | 117 | 67 | 0 | 184 |
| 1983 | 176 | 291 | 0 | 468 |
| 1984 | 187 | 182 | 0 | 369 |
| 1985 | 240 | 431 | 0 | 671 |
| 1986 | 362 | 781 | 0 | 1143 |
| 1987 | 374 | 499 | 1 | 873 |
| 1988 | 221 | 340 | 0 | 561 |
| 1989 | 134 | 425 | 0 | 559 |
| 1990 | 165 | 359 | 0 | 524 |
| 1991 | 122 | 271 | 0 | 393 |

Table 3. Estimated hook caught landings of bocaccio (MT) for the Conception (C), Monterey (M), and Eureka (E) INPFC areas.

| YEAR | C | M | E | TOTAL |
|---|---|---|---|---|
| 1980 | 85 | 53 | 28 | 166 |
| 1981 | 17 | 0 | 0 | 18 |
| 1982 | 91 | 19 | 28 | 138 |
| 1983 | 110 | 53 | 13 | 176 |
| 1984 | 96 | 28 | 1 | 124 |
| 1985 | 37 | 34 | 13 | 84 |
| 1986 | 78 | 170 | 30 | 279 |
| 1987 | 55 | 193 | 32 | 281 |
| 1988 | 99 | 213 | 41 | 353 |
| 1989 | 130 | 263 | 57 | 450 |
| 1990 | 107 | 308 | 73 | 488 |
| 1991 | 117 | 255 | 50 | 422 |

Table 4. Estimated recreational catch of bocaccio and for Southern and Northern California (MT).

| Year | S. Cal. | N. Cal. | Total |
|---|---|---|---|
| 1980 | 1749 | 191 | 1940 |
| 1981 | 423 | 192 | 615 |
| 1982 | 1143 | 356 | 1499 |
| 1983 | 265 | 300 | 565 |
| 1984 | 170 | 67 | 237 |
| 1985 | 329 | 64 | 393 |
| 1986 | 413 | 162 | 575 |
| 1987 | 86 | 104 | 190 |
| 1988 | 117 | 52 | 169 |
| 1989 | 169 | 86 | 255 |

Table 5. Triennial index of abundance and standard error of index. This index was calculated as a weighted average of winsorized strata means (deep and shallow). After Bence and Hightower (1990).

| Year | Index | SE |
|---|---|---|
| 1980 | 3.24 | 0.65 |
| 1983 | 2.64 | 0.78 |
| 1986 | 1.69 | 0.56 |
| 1989 | 0.58 | 0.14 |

Table 6. Catch/effort (see text) for the recreational fishery. * indicates years index was not included in synthesis runs because index was heavily influenced by recruitment of 0+ fish, which were not included in the model.

| Year | CPUE |
|---|---|
| 1980 | 1.20 |
| 1981 | 0.73 |
| 1982 | 0.99 |
| 1983 | 0.58 |
| 1984 | 0.23* |
| 1985 | 0.36 |
| 1986 | 0.47 |
| 1987 | 0.28 |
| 1988 | 0.22* |
| 1989 | 0.36 |

Table 7. Summary of parameters used in stock synthesis model. • indicates values that were fixed during a run. ** indicates value determined by constraint, *** indicates values set after run based on other estimated parameters (see text). Fixed and estimated parameters in this table are for synthesis run with initial numbers at age fixed at 22.5 million or 30 million and M (NATMORT) fixed at 0.2.

| | Parameter | Value (22.5) | Value (30) |
|---|---|---|---|
| | NATMORT | 0.200 • | .200 • |
| Trawl selectivity parameters | | | |
| | TRL INIT | 0.001 • | .001 • |
| | TRL 50% YNG | | |
| | 1980 | 39.019 | 39.312 |
| | 1981 | 38.479 | 38.197 |
| | 1982 | 39.911 | 39.103 |
| | 1983 | 44.894 | 44.299 |
| | 1984 | 38.156 | 40.345 |
| | 1985 | 42.999 | 42.505 |
| | 1986 | 35.197 | 34.908 |
| | 1987 | 36.811 | 36.539 |
| | 1988 | 40.563 | 40.196 |
| | 1989 | 38.115 | 37.866 |
| | 1990 | 37.949 | 37.618 |
| | 1991 | 40.825 | 40.544 |
| | TRL SLP YNG | 0.410 | .419 |
| | TRL-F 50% OLD | 57.953 | 57.340 |
| | TRL-F SLP OLD | 0.272 | .272 |
| | TRL-F FINAL | 0.172 | .163 |
| | TRL-M 50% OLD | 52.479 | 52.229 |
| | TRL-M SLP OLD | 0.279 | .278 |
| | TRL-M FINAL | 0.225 | .213 |
| Set net selectivity parameters | | | |
| | SET INIT | 0.001 • | .001 • |
| | SET 50% YNG | 45.918 | 45.669 |
| | SET SLP YNG | 0.481 | .484 |
| | SET-F 50% OLD | 61.888 | 61.545 |
| | SET-F SLP OLD | 0.620 | .610 |
| | SET-F FINAL | 0.051 | .050 |
| | SET-M 50% OLD | 54.262 | 54.295 |
| | SET-M SLP OLD | 0.442 | .488 |
| | SET-M FINAL | 0.056 | .054 |

Table 7 (cont.)

| | | | |
|---|---|---|---|
| Recreational selectivity parameters | | | |
| | REC INIT | 0.020 | .022 |
| | REC 50% YNG | 52.954 | 52.115 |
| | REC SLP YNG | 0.116 | .114 |
| | REC-F 50% OLD | 50.428 | 50.299 |
| | REC-F SLP OLD | 0.320 | .330 |
| | REC-F FINAL | 0.020 | .020 |
| | REC-M 50% OLD | 41.815 | 41.625 |
| | REC-M SLP OLD | 1.028 | 1.183 |
| | REC-M FINAL | 0.062 | .057 |
| Hook and line/longline selectivity parameters | | | |
| | HOOK INIT | 0.001 * | .001 * |
| | HOOK 50% YNG | 50.698 | 49.771 |
| | HOOK SLP YNG | 0.190 | .187 |
| | HOOK-F 50% OLD | 62.097 | 61.835 |
| | HOOK-F SLP OLD | 0.703 | .683 |
| | HOOK-F FINAL | 0.022 | .023 |
| | HOOK-M 50% OLD | 54.531 | 54.362 |
| | HOOK-M SLP OLD | 0.782 | .754 |
| | HOOK-M FINAL | 0.100 | .100 |
| Triennial survey selectivity parameters | | | |
| | TRI INIT | 0.990 | .990 |
| | TRI 50% YNG | 75.000 | 75.000 |
| | TRI SLP YNG | 0.574 | .574 |
| | TRI-F 50% OLD | 50.004 | 49.994 |
| | TRI-F SLP OLD | 0.041 | .037 |
| | TRI-F FINAL | 0.990 * | .990 * |
| | TRI-M 50% OLD | 49.989 | 49.999 |
| | TRI-M SLP OLD | 0.166 | .183 |
| | TRI-M FINAL | 0.990 | .990 |
| Ageing error parameters | | | |
| | p AGREE. @1 | 0.750 * | .750 * |
| | p AGREE @21 | 0.100 * | .100 * |
| Catchability used with recreational effort | | | |
| | Q-REC FISH | 0.063 ** | .055 ** |
| Growth parameters | | | |
| | FEMALE L1 | 25.000 | 25.016 |
| | FEMALE LINF | 75.164 | 75.175 |
| | FEMALE K | 0.189 | .189 |
| | FEMALE CV1 | 0.087 * | .087 * |
| | MALE CV21 | 0.045 * | .045 * |
| | MALE L1 | 27.408 | 27.435 |
| | MALE LINF | 64.300 | 64.367 |
| | MALE K | 0.234 | .233 |
| | MALE CV1 | 0.063 | .063 |
| | MALE CV21 | 0.063 | .063 |

Table 7 (cont.)

Additional parameters used to determine virgin biomass

| | | |
|---|---|---|
| VIR. RECR. MULT. | 0.900 *** | 1.009 *** |
| REC. STD. | 0.500 *** | .500 *** |

Initial numbers at age and recruitment estimates

| | | |
|---|---|---|
| INIT AGE 15+ | 0.550 | .603 |
| INIT AGE 14 | 0.056 | .076 |
| INIT AGE 13 | 0.0001 | .002 |
| INIT AGE 12 | 0.193 | .221 |
| INIT AGE 11 | 0.054 | .050 |
| INIT AGE 10 | 0.194 | .223 |
| INIT AGE 9 | 0.242 | .260 |
| INIT AGE 8 | 0.104 | .129 |
| INIT AGE 7 | 0.277 | .321 |
| INIT AGE 6 | 0.316 | .331 |
| INIT AGE 5 | 0.264 | .334 |
| INIT AGE 4 | 1.090 | 1.004 |
| INIT. AGE 3 | 2.250 * | 3.000 * |
| INIT AGE 2 | 0.600 | .604 |
| RECRUIT 80 | 1.030 | 1.096 |
| RECRUIT 81 | 0.348 | .356 |
| RECRUIT 82 | 0.100 | .128 |
| RECRUIT 83 | 0.025 | .028 |
| RECRUIT 84 | 1.026 | 1.112 |
| RECRUIT 85 | 1.074 | 1.195 |
| RECRUIT 86 | 0.298 | .333 |
| RECRUIT 87 | 0.217 | .250 |
| RECRUIT 88 | 0.891 | .993 |
| RECRUIT 89 | 1.076 | 1.241 |
| RECRUIT 90 | 0.001 | .001 |
| RECRUIT 91 | 0.550 *** | .612 *** |

Table 8. Value of likelihood components for synthesis fit when initial numbers at age-3 fixed to 15 million [L(1.5)] through 60 million [L(6.0)] with M=0.2.

| LIKELIHOOD TYPE | EMPHASIS | L(1.5) | L(2.25) | L(3.0) | L(6.0) |
|---|---|---|---|---|---|
| TRL AGE COMPS | 1.0 | -142.72 | -112.86 | -99.21 | -100.179 |
| TRL SIZE COMPS | 1.000 | -274.66 | -271.54 | -272.29 | -275.434 |
| TRL SIZE@AGE | 1.0 | -229.56 | -234.25 | -245.58 | -247.487 |
| SN SIZE COMPS | 1.0 | -171.86 | -171.02 | -171.72 | -174.893 |
| REC SIZE COMPS | 1.0 | -171.15 | -172.43 | -177.27 | -186.436 |
| HKLI SIZE COMPS | 1.0 | -233.37 | -233.36 | -229.79 | -228.537 |
| TRI SURVEY BIO | 1.0 | 2.65 | 2.26 | 1.66 | -.434 |
| TRI SIZE COMPS | 0.250 | -250.51 | -241.16 | -235.47 | -252.341 |
| REC. EFFORT EST | 1.0 | 8.55 | 8.73 | 8.86 | 8.485 |
| PENALTY FUNCTION | 10.0 | -4.35 | -4.07 | -3.91 | -3.456 |
| TOTAL LIKELIHOOD: | | 1318.2 | -1285.5 | -1283.3 | -1302.6 |

Table 9. Estimated (by synthesis) and observed mean lengths (or ages) and fraction of composition female for length and age composition samples. Shown are results for run with initial numbers at age-3 set to 22.5 million and M=0.2.

| | | F (or comb.) | | M | | FRAC F | |
|---|---|---|---|---|---|---|---|
| YR | TYPE | EST | OBS | EST | OBS | EST | OBS |
| 80 | TRAWL AGE | 5.5 | 5.6 | 5.5 | 5.0 | .494 | .513 |
| 80 | TRAWL L | 48.9 | 49.6 | 47.3 | 47.0 | .494 | .515 |
| 81 | TRAWL AGE | 5.8 | 5.4 | 6.0 | 5.6 | .497 | .524 |
| 81 | TRAWL L | 50.3 | 48.8 | 48.6 | 47.5 | .497 | .517 |
| 82 | TRAWL AGE | 6.3 | 6.8 | 6.6 | 6.5 | .495 | .489 |
| 82 | TRAWL L | 52.6 | 54.1 | 50.4 | 50.8 | .495 | .482 |
| 83 | TRAWL AGE | 7.4 | 7.6 | 7.8 | 6.9 | .498 | .554 |
| 83 | TRAWL L | 56.1 | 58.2 | 53.4 | 53.5 | .498 | .570 |
| 84 | TRAWL AGE | 7.7 | 9.4 | 8.0 | 9.0 | .476 | .444 |
| 84 | TRAWL L | 56.1 | 60.7 | 53.2 | 55.4 | .476 | .453 |
| 85 | TRAWL L | 58.8 | 59.3 | 54.9 | 55.2 | .462 | .416 |
| 86 | TRAWL L | 46.7 | 45.2 | 45.5 | 43.0 | .458 | .478 |
| 87 | TRAWL L | 47.6 | 46.4 | 46.9 | 45.0 | .479 | .518 |
| 88 | TRAWL L | 51.0 | 50.3 | 49.8 | 48.6 | .491 | .477 |
| 89 | TRAWL L | 50.3 | 50.9 | 48.2 | 48.2 | .475 | .392 |
| 90 | TRAWL L | 47.4 | 47.9 | 46.0 | 46.8 | .473 | .436 |
| 91 | TRAWL L | 48.8 | 48.7 | 47.9 | 47.5 | .493 | .452 |
| 86 | SET L | 57.9 | 60.0 | 53.8 | 55.8 | .514 | .452 |
| 87 | SET L | 53.9 | 53.6 | 51.5 | 52.2 | .509 | .472 |
| 88 | SET L | 52.6 | 54.3 | 51.0 | 50.0 | .524 | .632 |
| 89 | SET L | 54.0 | 53.8 | 51.7 | 51.1 | .532 | .542 |
| 90 | SET L | 54.4 | 53.2 | 51.5 | 50.5 | .528 | .551 |
| 91 | SET L | 52.6 | 51.8 | 50.3 | 50.3 | .530 | .587 |
| 80 | REC L | 43.6 | 44.2 | (sexes combined) | | | |
| 81 | REC L | 45.9 | 45.0 | " | | | |
| 82 | REC L | 48.1 | 48.4 | " | | | |
| 83 | REC L | 50.6 | 51.2 | " | | | |
| 84 | REC L | 47.5 | 47.3 | " | | | |
| 85 | REC L | 41.6 | 38.3 | " | | | |
| 86 | REC L | 41.7 | 40.0 | " | | | |
| 87 | REC L | 43.9 | 46.0 | " | | | |
| 88 | REC L | 43.4 | 43.7 | " | | | |
| 89 | REC L | 40.5 | 43.0 | " | | | |
| 86 | HOOK L | 55.0 | 55.6 | 51.1 | 51.4 | .518 | .472 |
| 87 | HOOK L | 52.3 | 50.0 | 50.2 | 48.2 | .503 | .457 |
| 88 | HOOK L | 52.1 | 54.3 | 50.3 | 50.0 | .507 | .632 |
| 89 | HOOK L | 52.7 | 53.1 | 50.1 | 49.9 | .514 | .501 |
| 90 | HOOK L | 50.6 | 45.8 | (sexes combined) | | | |
| 91 | HOOK L | 51.4 | 56.8 | 49.1 | 52.3 | .521 | .511 |
| 80 | TRI L | 46.5 | 43.8 | 45.1 | 43.4 | .497 | .474 |
| 83 | TRI L | 57.4 | 56.9 | 53.4 | 54.0 | .479 | .465 |
| 86 | TRI L | 46.1 | 62.0 | 45.1 | 50.1 | .489 | .552 |
| 89 | TRI L | 39.5 | 32.8 | 39.9 | 31.2 | .492 | .431 |

Table 10. Length-specific selectivity (x 100) as estimated by synthesis model when initial numbers at age-3 set to 22.5 million and M=0.2.

| | | Total length at bottom of length bin | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gear | Sex | 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 |
| setnet | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 13 | 29 | 52 | 75 | 90 | 97 | 100 | 99 | 79 | 26 | 7 | 5 | 5 | 5 |
| setnet | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 13 | 29 | 51 | 71 | 78 | 72 | 55 | 36 | 12 | 7 | 5 | 5 | 5 | 5 |
| rec | F | 7 | 9 | 12 | 15 | 20 | 25 | 31 | 39 | 48 | 58 | 70 | 82 | 92 | 100 | 99 | 90 | 73 | 54 | 37 | 17 | 10 | 7 | 7 | 7 | 7 |
| rec | M | 7 | 9 | 12 | 15 | 20 | 25 | 31 | 39 | 48 | 58 | 63 | 42 | 15 | 9 | 9 | 10 | 11 | 13 | 14 | 17 | 19 | 21 | 22 | 23 | 24 |
| hkli | F | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 5 | 7 | 11 | 15 | 22 | 30 | 40 | 51 | 64 | 77 | 89 | 100 | 96 | 28 | 4 | 3 | 3 | 3 |
| hkli | M | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 5 | 7 | 11 | 15 | 22 | 30 | 40 | 51 | 62 | 69 | 57 | 32 | 13 | 12 | 13 | 13 | 13 | 13 |
| Year: | 80 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 1 | 2 | 5 | 12 | 24 | 42 | 64 | 82 | 93 | 99 | 100 | 97 | 92 | 85 | 74 | 51 | 32 | 23 | 20 | 19 | 18 |
| trawl | M | 0 | 0 | 0 | 0 | 1 | 2 | 5 | 12 | 24 | 42 | 63 | 80 | 89 | 91 | 87 | 79 | 68 | 57 | 47 | 33 | 27 | 25 | 24 | 24 | 24 |
| year: | 81 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 14 | 28 | 48 | 69 | 86 | 95 | 99 | 100 | 97 | 92 | 84 | 74 | 50 | 32 | 23 | 20 | 18 | 18 |
| trawl | M | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 14 | 28 | 47 | 68 | 83 | 90 | 91 | 87 | 79 | 68 | 57 | 46 | 33 | 27 | 25 | 24 | 24 | 24 |
| year: | 82 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 8 | 18 | 34 | 55 | 75 | 90 | 97 | 100 | 98 | 93 | 85 | 75 | 51 | 33 | 24 | 20 | 19 | 18 |
| trawl | M | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 8 | 18 | 33 | 54 | 73 | 85 | 89 | 87 | 79 | 69 | 57 | 47 | 33 | 27 | 25 | 24 | 24 | 24 |
| year: | 83 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 6 | 14 | 28 | 49 | 72 | 90 | 99 | 100 | 94 | 83 | 57 | 37 | 26 | 22 | 21 | 21 |
| trawl | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 6 | 14 | 27 | 46 | 66 | 79 | 80 | 73 | 63 | 52 | 37 | 31 | 28 | 27 | 27 | 27 |
| year: | 84 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 1 | 3 | 8 | 16 | 31 | 51 | 72 | 87 | 96 | 100 | 99 | 97 | 92 | 84 | 74 | 50 | 32 | 23 | 20 | 18 | 18 |
| trawl | M | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 16 | 31 | 51 | 71 | 85 | 91 | 91 | 87 | 78 | 68 | 56 | 46 | 33 | 27 | 25 | 24 | 24 | 24 |
| year: | 85 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 6 | 13 | 26 | 45 | 68 | 86 | 97 | 100 | 97 | 90 | 79 | 54 | 35 | 25 | 21 | 20 | 19 |
| trawl | M | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 6 | 13 | 25 | 44 | 64 | 79 | 84 | 81 | 71 | 60 | 50 | 35 | 29 | 27 | 26 | 26 | 25 |
| year: | 86 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 2 | 5 | 10 | 22 | 39 | 60 | 78 | 91 | 97 | 99 | 100 | 98 | 95 | 89 | 82 | 72 | 49 | 31 | 23 | 19 | 18 | 17 |
| trawl | M | 0 | 0 | 0 | 2 | 5 | 10 | 22 | 39 | 60 | 78 | 89 | 94 | 94 | 91 | 85 | 77 | 66 | 55 | 45 | 32 | 26 | 24 | 23 | 23 | 23 |
| year: | 87 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 1 | 2 | 6 | 12 | 25 | 44 | 65 | 82 | 93 | 98 | 100 | 99 | 96 | 90 | 83 | 73 | 49 | 32 | 23 | 19 | 18 | 18 |
| trawl | M | 0 | 0 | 0 | 1 | 2 | 6 | 12 | 25 | 43 | 64 | 81 | 90 | 93 | 91 | 86 | 77 | 67 | 56 | 46 | 32 | 26 | 24 | 24 | 23 | 23 |
| year: | 88 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 14 | 28 | 48 | 70 | 87 | 96 | 100 | 98 | 94 | 86 | 76 | 52 | 33 | 24 | 20 | 19 | 19 |
| trawl | M | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 14 | 28 | 47 | 68 | 82 | 88 | 87 | 80 | 69 | 58 | 48 | 34 | 28 | 25 | 25 | 24 | 24 |
| year: | 89 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 1 | 3 | 8 | 16 | 31 | 52 | 72 | 88 | 96 | 100 | 99 | 97 | 92 | 84 | 74 | 50 | 32 | 23 | 20 | 18 | 18 |
| trawl | M | 0 | 0 | 0 | 0 | 1 | 3 | 8 | 16 | 31 | 51 | 71 | 85 | 91 | 91 | 87 | 78 | 68 | 56 | 46 | 33 | 27 | 25 | 24 | 24 | 24 |
| year: | 90 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 1 | 3 | 8 | 17 | 33 | 53 | 74 | 88 | 96 | 100 | 99 | 97 | 92 | 84 | 74 | 50 | 32 | 23 | 20 | 18 | 18 |
| trawl | M | 0 | 0 | 0 | 0 | 1 | 3 | 8 | 17 | 32 | 53 | 73 | 86 | 92 | 91 | 87 | 78 | 68 | 56 | 46 | 33 | 27 | 25 | 24 | 24 | 24 |
| year: | 91 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 6 | 13 | 26 | 45 | 67 | 85 | 96 | 100 | 99 | 94 | 87 | 76 | 52 | 33 | 24 | 20 | 19 | 19 |
| trawl | M | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 6 | 13 | 26 | 45 | 65 | 81 | 88 | 87 | 80 | 70 | 58 | 48 | 34 | 28 | 26 | 25 | 25 | 24 |

Table 11. Length-specific selectivity (x 100) as estimated by synthesis model when initial numbers at age-3 set to 30 million and M=0.2.

| | | Total length at bottom of length bin | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gear | Sex | 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 |
| setnet | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 6 | 14 | 31 | 55 | 77 | 91 | 97 | 100 | 98 | 75 | 22 | 6 | 5 | 5 | 5 |
| setnet | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 6 | 14 | 31 | 54 | 74 | 82 | 75 | 56 | 34 | 11 | 6 | 5 | 5 | 5 | 5 |
| rec | F | 7 | 10 | 13 | 16 | 20 | 26 | 32 | 40 | 49 | 60 | 71 | 83 | 93 | 100 | 98 | 87 | 69 | 50 | 34 | 15 | 9 | 7 | 7 | 7 | 7 |
| rec | M | 7 | 10 | 13 | 16 | 21 | 26 | 32 | 40 | 49 | 60 | 65 | 37 | 11 | 7 | 8 | 9 | 10 | 11 | 13 | 15 | 17 | 18 | 19 | 20 | 20 |
| hkli | F | 0 | 0 | 0 | 1 | 1 | 2 | 4 | 6 | 9 | 13 | 18 | 25 | 33 | 43 | 55 | 68 | 80 | 91 | 100 | 91 | 25 | 4 | 3 | 3 | 3 |
| hkli | M | 0 | 0 | 0 | 1 | 1 | 2 | 4 | 6 | 9 | 13 | 18 | 25 | 33 | 43 | 55 | 65 | 70 | 56 | 30 | 13 | 12 | 12 | 13 | 13 | 13 |
| year: | 80 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 1 | 2 | 4 | 10 | 21 | 39 | 62 | 81 | 93 | 99 | 100 | 97 | 91 | 82 | 71 | 47 | 30 | 22 | 19 | 18 | 17 |
| trawl | M | 0 | 0 | 0 | 0 | 1 | 2 | 4 | 10 | 21 | 39 | 60 | 78 | 88 | 90 | 86 | 78 | 67 | 55 | 45 | 32 | 26 | 24 | 23 | 23 | 23 |
| year: | 81 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 15 | 30 | 51 | 72 | 88 | 96 | 100 | 99 | 96 | 90 | 81 | 70 | 46 | 30 | 22 | 19 | 17 | 17 |
| trawl | M | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 15 | 30 | 50 | 71 | 85 | 91 | 91 | 86 | 77 | 66 | 55 | 44 | 31 | 26 | 23 | 23 | 23 | 22 |
| year: | 82 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 1 | 2 | 5 | 11 | 23 | 42 | 64 | 83 | 94 | 99 | 100 | 97 | 91 | 82 | 71 | 47 | 30 | 22 | 19 | 18 | 17 |
| trawl | M | 0 | 0 | 0 | 0 | 1 | 2 | 5 | 11 | 23 | 41 | 63 | 80 | 89 | 91 | 86 | 78 | 67 | 55 | 45 | 32 | 26 | 24 | 23 | 23 | 23 |
| year: | 83 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 8 | 17 | 33 | 55 | 78 | 93 | 100 | 98 | 90 | 79 | 52 | 33 | 24 | 21 | 20 | 19 |
| trawl | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 8 | 16 | 32 | 52 | 71 | 81 | 80 | 72 | 61 | 50 | 35 | 29 | 27 | 26 | 25 | 25 |
| year: | 84 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 15 | 30 | 51 | 72 | 89 | 97 | 100 | 98 | 92 | 83 | 72 | 48 | 30 | 22 | 19 | 18 | 18 |
| trawl | M | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 15 | 29 | 50 | 70 | 84 | 89 | 86 | 78 | 68 | 56 | 46 | 32 | 26 | 24 | 23 | 23 | 23 |
| year: | 85 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 15 | 29 | 51 | 73 | 90 | 98 | 100 | 95 | 87 | 75 | 50 | 32 | 23 | 20 | 19 | 18 |
| trawl | M | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 15 | 29 | 49 | 70 | 83 | 85 | 80 | 70 | 58 | 48 | 34 | 28 | 25 | 25 | 24 | 24 |
| year: | 86 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 2 | 5 | 11 | 23 | 42 | 63 | 81 | 92 | 98 | 100 | 99 | 97 | 93 | 87 | 79 | 68 | 45 | 29 | 21 | 18 | 17 | 17 |
| trawl | M | 0 | 0 | 0 | 2 | 5 | 11 | 23 | 42 | 63 | 80 | 91 | 95 | 94 | 91 | 84 | 75 | 64 | 53 | 43 | 30 | 25 | 23 | 22 | 22 | 22 |
| year: | 87 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 1 | 2 | 6 | 13 | 27 | 46 | 68 | 85 | 94 | 99 | 100 | 98 | 94 | 88 | 80 | 69 | 46 | 29 | 21 | 18 | 17 | 17 |
| trawl | M | 0 | 0 | 0 | 1 | 2 | 6 | 13 | 27 | 46 | 67 | 83 | 91 | 93 | 91 | 85 | 76 | 65 | 54 | 44 | 31 | 25 | 23 | 22 | 22 | 22 |
| year: | 88 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 16 | 31 | 52 | 74 | 89 | 97 | 100 | 97 | 92 | 83 | 72 | 48 | 30 | 22 | 19 | 18 | 18 |
| trawl | M | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 16 | 31 | 51 | 72 | 85 | 89 | 86 | 78 | 67 | 56 | 46 | 32 | 26 | 24 | 23 | 23 | 23 |
| year: | 89 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 1 | 3 | 8 | 17 | 33 | 54 | 75 | 89 | 97 | 100 | 99 | 95 | 89 | 81 | 70 | 46 | 29 | 22 | 18 | 17 | 17 |
| trawl | M | 0 | 0 | 0 | 0 | 1 | 3 | 8 | 17 | 33 | 54 | 74 | 87 | 92 | 91 | 86 | 77 | 66 | 54 | 44 | 31 | 25 | 23 | 23 | 22 | 22 |
| year: | 90 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 1 | 4 | 9 | 19 | 35 | 57 | 77 | 91 | 97 | 100 | 99 | 95 | 89 | 81 | 70 | 46 | 29 | 21 | 18 | 17 | 17 |
| trawl | M | 0 | 0 | 0 | 0 | 1 | 4 | 9 | 19 | 35 | 56 | 76 | 88 | 92 | 91 | 85 | 77 | 66 | 54 | 44 | 31 | 25 | 23 | 23 | 22 | 22 |
| year: | 91 | | | | | | | | | | | | | | | | | | | | | | | | | |
| trawl | F | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 6 | 14 | 28 | 48 | 71 | 88 | 97 | 100 | 98 | 92 | 84 | 72 | 48 | 31 | 22 | 19 | 18 | 18 |
| trawl | M | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 6 | 14 | 28 | 48 | 68 | 83 | 89 | 86 | 79 | 68 | 56 | 46 | 32 | 26 | 24 | 24 | 23 | 23 |

Table 12. Numbers at age (0000), by sex, as estimated by the synthesis model when total initial numbers at age-3 were fixed at 22.5 million and M=.2.

**Females**

| | Age | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yr | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 80 | 515 | 300 | 1125 | 544 | 131 | 157 | 138 | 51 | 121 | 97 | 27 | 96 | 0 | 28 | 274 | 0 | 0 | 0 | 0 | 0 | 0 |
| 81 | 173 | 416 | 234 | 797 | 360 | 87 | 109 | 99 | 38 | 91 | 74 | 21 | 75 | 0 | 22 | 216 | 0 | 0 | 0 | 0 | 0 |
| 82 | 50 | 141 | 329 | 168 | 539 | 243 | 60 | 78 | 73 | 28 | 70 | 57 | 16 | 58 | 0 | 17 | 170 | 0 | 0 | 0 | 0 |
| 83 | 12 | 40 | 110 | 229 | 106 | 340 | 160 | 42 | 56 | 54 | 21 | 53 | 44 | 12 | 45 | 0 | 13 | 132 | 0 | 0 | 0 |
| 84 | 513 | 9 | 32 | 83 | 152 | 66 | 216 | 106 | 29 | 40 | 39 | 16 | 40 | 33 | 9 | 34 | 0 | 10 | 102 | 0 | 0 |
| 85 | 536 | 417 | 7 | 21 | 48 | 89 | 40 | 137 | 71 | 20 | 28 | 29 | 12 | 30 | 25 | 7 | 26 | 0 | 7 | 78 | 0 |
| 86 | 148 | 435 | 332 | 5 | 14 | 31 | 58 | 27 | 97 | 51 | 15 | 21 | 22 | 9 | 23 | 19 | 5 | 20 | 0 | 6 | 62 |
| 87 | 108 | 120 | 333 | 227 | 3 | 8 | 17 | 34 | 17 | 65 | 36 | 11 | 16 | 17 | 7 | 18 | 15 | 4 | 16 | 0 | 53 |
| 88 | 445 | 88 | 94 | 237 | 144 | 2 | 4 | 10 | 22 | 11 | 47 | 27 | 8 | 12 | 13 | 5 | 14 | 12 | 3 | 12 | 42 |
| 89 | 538 | 363 | 70 | 69 | 155 | 89 | 1 | 3 | 7 | 15 | 8 | 35 | 20 | 6 | 9 | 10 | 4 | 11 | 9 | 2 | 43 |
| 90 | 0 | 437 | 284 | 49 | 43 | 91 | 52 | 0 | 1 | 4 | 11 | 6 | 26 | 15 | 4 | 7 | 7 | 3 | 8 | 7 | 35 |
| 91 | - | 0 | 342 | 196 | 29 | 24 | 51 | 31 | 0 | 1 | 3 | 8 | 4 | 19 | 11 | 3 | 5 | 6 | 2 | 6 | 33 |

**Males**

| | Age | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yr | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 80 | 515 | 300 | 1125 | 544 | 131 | 157 | 138 | 51 | 121 | 97 | 27 | 96 | 0 | 28 | 274 | 0 | 0 | 0 | 0 | 0 | 0 |
| 81 | 173 | 414 | 231 | 810 | 391 | 95 | 116 | 103 | 39 | 91 | 73 | 20 | 73 | 0 | 21 | 211 | 0 | 0 | 0 | 0 | 0 |
| 82 | 50 | 141 | 324 | 167 | 570 | 277 | 69 | 85 | 77 | 29 | 69 | 56 | 15 | 56 | 0 | 16 | 162 | 0 | 0 | 0 | 0 |
| 83 | 12 | 40 | 108 | 229 | 115 | 398 | 197 | 50 | 62 | 57 | 21 | 52 | 42 | 11 | 42 | 0 | 12 | 122 | 0 | 0 | 0 |
| 84 | 513 | 9 | 32 | 82 | 163 | 79 | 273 | 137 | 35 | 45 | 41 | 16 | 38 | 31 | 8 | 31 | 0 | 9 | 91 | 0 | 0 |
| 85 | 536 | 416 | 7 | 20 | 50 | 101 | 51 | 182 | 94 | 24 | 31 | 29 | 11 | 27 | 22 | 6 | 22 | 0 | 6 | 66 | 0 |
| 86 | 148 | 434 | 329 | 5 | 15 | 35 | 72 | 36 | 133 | 70 | 18 | 24 | 22 | 8 | 21 | 17 | 4 | 17 | 0 | 5 | 51 |
| 87 | 108 | 119 | 326 | 228 | 3 | 9 | 23 | 48 | 25 | 94 | 50 | 13 | 17 | 16 | 6 | 15 | 12 | 3 | 13 | 0 | 42 |
| 88 | 445 | 88 | 92 | 232 | 152 | 2 | 6 | 15 | 33 | 18 | 68 | 37 | 10 | 13 | 12 | 4 | 11 | 9 | 2 | 9 | 32 |
| 89 | 538 | 362 | 70 | 68 | 159 | 101 | 1 | 4 | 11 | 24 | 13 | 50 | 27 | 7 | 9 | 9 | 3 | 8 | 7 | 2 | 32 |
| 90 | 0 | 435 | 280 | 49 | 45 | 102 | 66 | 1 | 3 | 7 | 17 | 9 | 37 | 20 | 5 | 7 | 6 | 2 | 6 | 5 | 25 |
| 91 | - | 0 | 336 | 193 | 31 | 28 | 64 | 43 | 0 | 2 | 5 | 12 | 7 | 27 | 14 | 4 | 5 | 5 | 2 | 4 | 23 |

Table 13. Numbers at age (0000), by sex, as estimated by the synthesis model when total initial numbers at age-3 were fixed at 30 million and M=0.2.

**Females**

| Yr | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 547 | 302 | 1500 | 501 | 166 | 165 | 160 | 64 | 129 | 111 | 24 | 110 | 0 | 38 | 301 | 0 | 0 | 0 | 0 | 0 | 0 |
| 81 | 177 | 443 | 236 | 1079 | 338 | 113 | 116 | 117 | 48 | 99 | 86 | 19 | 86 | 0 | 30 | 238 | 0 | 0 | 0 | 0 | 0 |
| 82 | 64 | 144 | 352 | 173 | 748 | 236 | 81 | 85 | 88 | 37 | 77 | 67 | 15 | 68 | 0 | 23 | 189 | 0 | 0 | 0 | 0 |
| 83 | 14 | 51 | 112 | 247 | 112 | 491 | 162 | 58 | 63 | 66 | 28 | 59 | 52 | 11 | 53 | 0 | 18 | 149 | 0 | 0 | 0 |
| 84 | 555 | 11 | 41 | 85 | 168 | 73 | 327 | 111 | 41 | 46 | 50 | 21 | 46 | 40 | 9 | 41 | 0 | 14 | 116 | 0 | 0 |
| 85 | 597 | 452 | 9 | 29 | 53 | 104 | 47 | 219 | 78 | 30 | 34 | 37 | 16 | 35 | 31 | 7 | 32 | 0 | 11 | 90 | 0 |
| 86 | 166 | 485 | 361 | 6 | 20 | 36 | 71 | 33 | 160 | 58 | 23 | 26 | 29 | 13 | 27 | 24 | 5 | 25 | 0 | 9 | 72 |
| 87 | 125 | 134 | 374 | 253 | 4 | 12 | 22 | 46 | 22 | 114 | 43 | 17 | 20 | 23 | 10 | 21 | 19 | 4 | 20 | 0 | 64 |
| 88 | 496 | 101 | 106 | 271 | 168 | 2 | 7 | 14 | 31 | 16 | 84 | 32 | 13 | 16 | 18 | 8 | 17 | 15 | 3 | 16 | 51 |
| 89 | 620 | 404 | 81 | 79 | 184 | 109 | 1 | 5 | 10 | 22 | 12 | 64 | 25 | 10 | 12 | 14 | 6 | 13 | 12 | 2 | 53 |
| 90 | 0 | 504 | 319 | 58 | 51 | 116 | 69 | 1 | 3 | 7 | 17 | 9 | 49 | 19 | 8 | 9 | 11 | 4 | 10 | 9 | 44 |
| 91 | 306 | 0 | 397 | 226 | 37 | 32 | 72 | 44 | 0 | 2 | 5 | 12 | 7 | 38 | 15 | 6 | 7 | 8 | 3 | 8 | 42 |

**Males**

| Yr | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 547 | 302 | 1500 | 501 | 166 | 165 | 160 | 64 | 129 | 111 | 24 | 110 | 0 | 38 | 301 | 0 | 0 | 0 | 0 | 0 | 0 |
| 81 | 177 | 441 | 234 | 1096 | 366 | 123 | 123 | 121 | 49 | 99 | 85 | 19 | 85 | 0 | 29 | 233 | 0 | 0 | 0 | 0 | 0 |
| 82 | 64 | 144 | 347 | 171 | 787 | 265 | 90 | 92 | 91 | 37 | 76 | 66 | 14 | 66 | 0 | 22 | 181 | 0 | 0 | 0 | 0 |
| 83 | 14 | 51 | 111 | 247 | 121 | 564 | 193 | 67 | 69 | 69 | 28 | 58 | 50 | 11 | 50 | .0 | 17 | 139 | 0 | 0 | 0 |
| 84 | 555 | 11 | 41 | 85 | 179 | 85 | 399 | 139 | 49 | 51 | 51 | 21 | 43 | 38 | 8 | 38 | 0 | 13 | 106 | 0 | 0 |
| 85 | 597 | 452 | 9 | 29 | 56 | 117 | 57 | 277 | 98 | 35 | 37 | 37 | 15 | 32 | 28 | 6 | 28 | 0 | 10 | 79 | 0 |
| 86 | 166 | 483 | 358 | 6 | 21 | 40 | 85 | 42 | 207 | 74 | 26 | 28 | 29 | 12 | 25 | 21 | 4 | 22 | 0 | 7 | 62 |
| 87 | 125 | 134 | 367 | 255 | 4 | 14 | 27 | 60 | 30 | 152 | 55 | 20 | 21 | 22 | 9 | 19 | 16 | 3 | 17 | 0 | 53 |
| 88 | 496 | 101 | 104 | 267 | 176 | 3 | 9 | 19 | 43 | 22 | 113 | 41 | 15 | 16 | 16 | 7 | 14 | 12 | 2 | 13 | 41 |
| 89 | 620 | 403 | 81 | 78 | 188 | 121 | 2 | 7 | 14 | 32 | 16 | 86 | 31 | 11 | 12 | 13 | 5 | 11 | 9 | 2 | 42 |
| 90 | 0 | 502 | 314 | 58 | 53 | 127 | 83 | 1 | 5 | 10 | 23 | 12 | 64 | 24 | 8 | 9 | 9 | 4 | 8 | 7 | 34 |
| 91 | 306 | 0 | 391 | 223 | 39 | 35 | 85 | 57 | 1 | 3 | 7 | 17 | 9 | 48 | 18 | 6 | 7 | 7 | 3 | 6 | 31 |

Table 14. Average estimated recruitment for 1980-1990, 1971-1979, and 1971-1990 (10's of millions) for four levels of fixed initial numbers at age 3, I3, in tens of millions. Recruitment estimates prior to 1980 are based on an assumed total mortality rate (Z) of 0.25.

| Period | Initial numbers at age-3 | | | |
|---|---|---|---|---|
| | 1.5 | 2.25 | 3.0 | 6.0 |
| 71-79 (early) | 1.42 | 1.56 | 1.79 | 4.65 |
| 80-90 (recent) | 0.52 | 0.55 | 0.61 | 1.43 |
| 71-90 (total) | 0.92 | 1.01 | 1.14 | 2.88 |
| early/recent | 2.77 | 2.83 | 2.93 | 3.25 |

Table 15. Estimate biomass (MT) and spawning stock (billions of eggs) in 1980 and in 1991 for four levels of initial numbers at age 3, I3 (10's of millions).

| | Initial numbers at age-3 | | | |
|---|---|---|---|---|
| | 1.5 | 2.25 | 3.0 | 6.0 |
| 1980 | | | | |
| Biomass | 57241 | 63678 | 72194 | 211468 |
| Spawning Stock | 9992 | 11107 | 12450 | 41334 |
| 1991 | | | | |
| Biomass | 12844 | 16623 | 21890 | 89312 |
| Spawning Stock | 1846 | 2665 | 3782 | 18336 |

Table 16. Quantities used in equilibrium yield calculations. sxxy, and wxxy are selectivity and mean weight (kg) at age for gear xx (tr, sn, rc, hk) and sex y (f, m). These were taken from the I3=2.25 run (stry's from 1991). TL and W are the population mean total length (cm) and weight (kg) at age. TL was calculated from growth parameters estimated by the I3=2.25 run, W is calculated based on the length weight relationship in Table 7, pmat is the proportion of females mature and egg/kg is millions of eggs per kg at age. pmat was calculated as a function of TL and egg/kg as a function of W using equations in Table 7. Yield was calculated assuming that F (at selectivity = 1.0) for hk, sn and rc relative to trawl were 0.705, 0.724 and 0.326.

| Age | strf | wtrf | strm | wtrm | ssnf | wsnf | ssnm | wsnm | srcf | wrcf | srcm | wrcm | shkf | whkf | shkm | whkm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.14 | 0 | 0.17 | 0 | 0.12 | 0 | 0.16 | 0.12 | 0.12 | 0.17 | 0.16 | 0 | 0.14 | 0.01 | 0.17 |
| 2 | 0.05 | 0.38 | 0.08 | 0.4 | 0 | 0.38 | 0 | 0.41 | 0.35 | 0.32 | 0.4 | 0.36 | 0.05 | 0.34 | 0.06 | 0.37 |
| 3 | 0.46 | 0.62 | 0.48 | 0.62 | 0.1 | 0.7 | 0.1 | 0.68 | 0.69 | 0.58 | 0.49 | 0.54 | 0.18 | 0.61 | 0.19 | 0.62 |
| 4 | 0.87 | 0.87 | 0.78 | 0.82 | 0.5 | 0.94 | 0.42 | 0.89 | 0.9 | 0.85 | 0.19 | 0.69 | 0.43 | 0.91 | 0.39 | 0.86 |
| 5 | 0.92 | 1.14 | 0.78 | 1.01 | 0.85 | 1.2 | 0.65 | 1.06 | 0.77 | 1.09 | 0.1 | 1.01 | 0.7 | 1.22 | 0.54 | 1.06 |
| 6 | 0.8 | 1.42 | 0.68 | 1.2 | 0.94 | 1.46 | 0.63 | 1.2 | 0.5 | 1.34 | 0.1 | 1.29 | 0.87 | 1.5 | 0.55 | 1.22 |
| 7 | 0.65 | 1.67 | 0.58 | 1.37 | 0.85 | 1.69 | 0.52 | 1.33 | 0.31 | 1.59 | 0.11 | 1.48 | 0.88 | 1.72 | 0.47 | 1.34 |
| 8 | 0.51 | 1.9 | 0.5 | 1.51 | 0.68 | 1.87 | 0.42 | 1.43 | 0.2 | 1.82 | 0.12 | 1.65 | 0.75 | 1.89 | 0.38 | 1.45 |
| 9 | 0.41 | 2.13 | 0.45 | 1.64 | 0.49 | 2.02 | 0.33 | 1.53 | 0.14 | 2.07 | 0.13 | 1.78 | 0.56 | 2.02 | 0.31 | 1.55 |
| 10 | 0.34 | 2.34 | 0.41 | 1.74 | 0.34 | 2.16 | 0.27 | 1.6 | 0.11 | 2.31 | 0.14 | 1.89 | 0.38 | 2.14 | 0.26 | 1.65 |
| 11 | 0.3 | 2.53 | 0.38 | 1.83 | 0.24 | 2.29 | 0.23 | 1.66 | 0.09 | 2.53 | 0.14 | 1.98 | 0.26 | 2.24 | 0.23 | 1.73 |
| 12 | 0.26 | 2.71 | 0.36 | 1.91 | 0.17 | 2.45 | 0.2 | 1.73 | 0.08 | 2.74 | 0.14 | 2.06 | 0.18 | 2.37 | 0.21 | 1.81 |
| 13 | 0.25 | 2.86 | 0.35 | 1.97 | 0.13 | 2.59 | 0.18 | 1.77 | 0.08 | 2.89 | 0.15 | 2.12 | 0.13 | 2.48 | 0.2 | 1.87 |
| 14 | 0.23 | 2.99 | 0.34 | 2.01 | 0.1 | 2.73 | 0.16 | 1.81 | 0.07 | 3.03 | 0.15 | 2.17 | 0.1 | 2.59 | 0.18 | 1.93 |
| 15 | 0.22 | 3.1 | 0.33 | 2.05 | 0.09 | 2.86 | 0.15 | 1.85 | 0.07 | 3.14 | 0.15 | 2.21 | 0.08 | 2.71 | 0.18 | 1.97 |
| 16 | 0.21 | 3.2 | 0.33 | 2.09 | 0.07 | 3.04 | 0.14 | 1.87 | 0.07 | 3.24 | 0.15 | 2.24 | 0.06 | 2.91 | 0.17 | 2.01 |
| 17 | 0.21 | 3.27 | 0.32 | 2.12 | 0.07 | 3.12 | 0.14 | 1.91 | 0.07 | 3.31 | 0.15 | 2.26 | 0.05 | 2.99 | 0.17 | 2.05 |
| 18 | 0.21 | 3.33 | 0.32 | 2.14 | 0.06 | 3.2 | 0.13 | 1.93 | 0.07 | 3.38 | 0.15 | 2.28 | 0.05 | 3.07 | 0.16 | 2.08 |
| 19 | 0.2 | 3.38 | 0.32 | 2.15 | 0.06 | 3.26 | 0.13 | 1.94 | 0.07 | 3.42 | 0.15 | 2.3 | 0.04 | 3.14 | 0.16 | 2.09 |
| 20 | 0.2 | 3.43 | 0.31 | 2.17 | 0.06 | 3.31 | 0.13 | 1.96 | 0.07 | 3.47 | 0.16 | 2.31 | 0.04 | 3.19 | 0.16 | 2.11 |
| 21 | 0.2 | 3.51 | 0.31 | 2.19 | 0.06 | 3.42 | 0.12 | 1.98 | 0.07 | 3.55 | 0.16 | 2.33 | 0.04 | 3.31 | 0.16 | 2.14 |

| Age | TL | W | pmat | egg/kg (mill.) |
|---|---|---|---|---|
| 1 | 25 | 0.12 | 0.001 | 0.225011 |
| 2 | 33.64 | 0.31 | 0.017 | 0.240353 |
| 3 | 40.79 | 0.56 | 0.122 | 0.261159 |
| 4 | 46.71 | 0.84 | 0.433 | 0.28527 |
| 5 | 51.61 | 1.15 | 0.758 | 0.310716 |
| 6 | 55.67 | 1.45 | 0.910 | 0.33598 |
| 7 | 59.03 | 1.74 | 0.964 | 0.360023 |
| 8 | 61.81 | 2.01 | 0.983 | 0.382214 |
| 9 | 64.11 | 2.25 | 0.991 | 0.402233 |
| 10 | 66.01 | 2.46 | 0.995 | 0.419981 |
| 11 | 67.59 | 2.64 | 0.997 | 0.435506 |
| 12 | 68.89 | 2.80 | 0.998 | 0.448944 |
| 13 | 69.98 | 2.94 | 0.998 | 0.460477 |
| 14 | 70.87 | 3.06 | 0.999 | 0.47031 |
| 15 | 71.61 | 3.16 | 0.999 | 0.478649 |
| 16 | 72.22 | 3.25 | 0.999 | 0.485689 |
| 17 | 72.73 | 3.32 | 0.999 | 0.491612 |
| 18 | 73.15 | 3.38 | 0.999 | 0.496581 |
| 19 | 73.50 | 3.43 | 0.999 | 0.500739 |
| 20 | 73.79 | 3.47 | 0.999 | 0.504213 |
| 21 | 74.02 | 3.50 | 0.999 | 0.507109 |

Table 17. Projections of bocaccio biomass and spawning stock (billions of eggs) at the beginning of the year, and F (at selectivity=1.0) for four fisheries, at two fixed levels initial numbers at age 3. The projections assume landings in 1992-1995 are the same as landings in 1991. V1 indicates the equilibrium unfished condition assuming average 1971-1990 recruitment, V2 indicates equilibrium unfished condition assuming average 1980-1990 recruitment.

Initial numbers at Age 3 = 2.25

| YEAR | BIOMASS (mt) | EGGS (billions) | F trawl | F setnet | F rec. | F hook&line |
|---|---|---|---|---|---|---|
| V1 | 54687 | 10736 | 0 | 0 | 0 | 0 |
| V2 | 29986 | 5887 | 0 | 0 | 0 | 0 |
| 92 | 15978 | 2531 | .088 | .069 | .042 | .082 |
| 93 | 15430 | 2429 | .097 | .071 | .045 | .081 |
| 94 | 15014 | 2262 | .101 | .077 | .046 | .084 |
| 95 | 14718 | 2106 | .101 | .079 | .045 | .088 |
| 96 | 14523 | 1999 | .100 | .079 | .044 | .088 |

Initial numbers at Age 3 = 3.0

| YEAR | BIOMASS (mt) | EGGS (billions) | F trawl | F setnet | F rec. | F hook&line |
|---|---|---|---|---|---|---|
| V1 | 72194 | 12204 | 0 | 0 | 0 | 0 |
| V2 | 33265 | 6538 | 0 | 0 | 0 | 0 |
| 92 | 21026 | 3600 | .069 | .053 | .035 | .061 |
| 93 | 20271 | 3464 | .076 | .054 | .038 | .060 |
| 94 | 19661 | 3257 | .080 | .059 | .039 | .063 |
| 95 | 19181 | 3054 | .081 | .061 | .038 | .066 |
| 96 | 18828 | 2904 | .080 | .061 | .038 | .067 |

Table 18. Projections of bocaccio biomass and spawning stock (billions of eggs) at the beginning of the year, and F (at selectivity=1.0) for four fisheries, at two fixed levels of initial numbers at age 3. The projections assume landings in 1992 are the same as landings in 1991, and total landings in 1993-1995 are equal to 1100 mt (the current harvest guideline), allocated to the fisheries in proportion to 1991 landings.

Initial numbers at Age 3 = 2.25

| YEAR | BIOMASS (mt) | EGGS (billions) | F | | | |
|---|---|---|---|---|---|---|
| | | | trawl | setnet | rec. | hook&line |
| 92 | 15978 | 2531 | .088 | .069 | .042 | .082 |
| 93 | 15430 | 2429 | .060 | .044 | .028 | .050 |
| 94 | 15644 | 2376 | .060 | .045 | .027 | .049 |
| 95 | 15960 | 2340 | .057 | .044 | .026 | .048 |
| 96 | 16345 | 2353 | .054 | .041 | .025 | .046 |

Initial numbers at Age 3 = 3.0

| YEAR | BIOMASS (mt) | EGGS (billions) | F | | | |
|---|---|---|---|---|---|---|
| | | | trawl | setnet | rec. | hook&line |
| 92 | 21026 | 3600 | .069 | .053 | .035 | .061 |
| 93 | 20271 | 3464 | .048 | .034 | .024 | .038 |
| 94 | 20294 | 3374 | .048 | .035 | .023 | .038 |
| 95 | 20425 | 3295 | .047 | .035 | .022 | .038 |
| 96 | 20647 | 3270 | .046 | .034 | .022 | .037 |

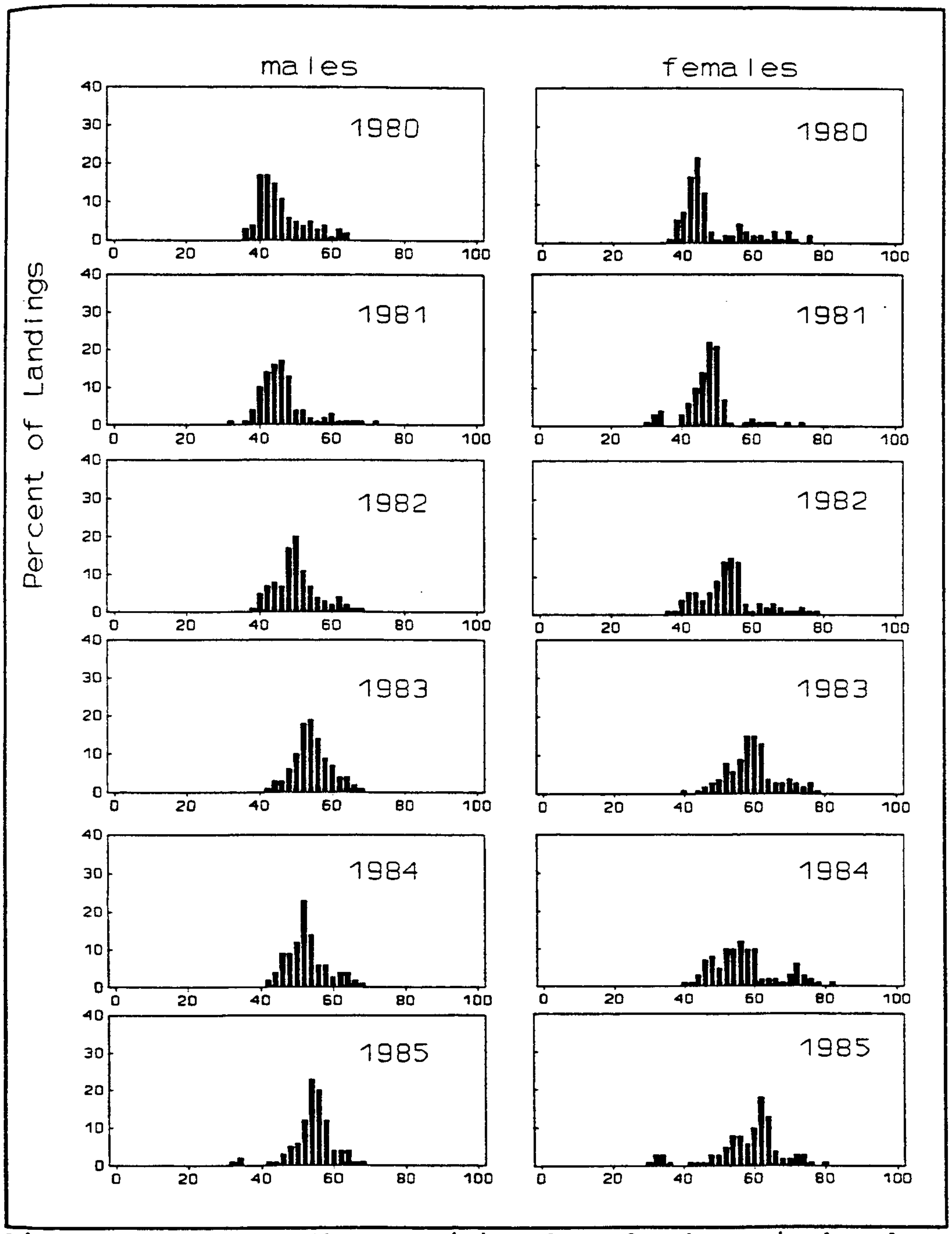



**Figure 1 (1/2).** Length composition data for bocaccio based on samples from the California trawl fishery landings.

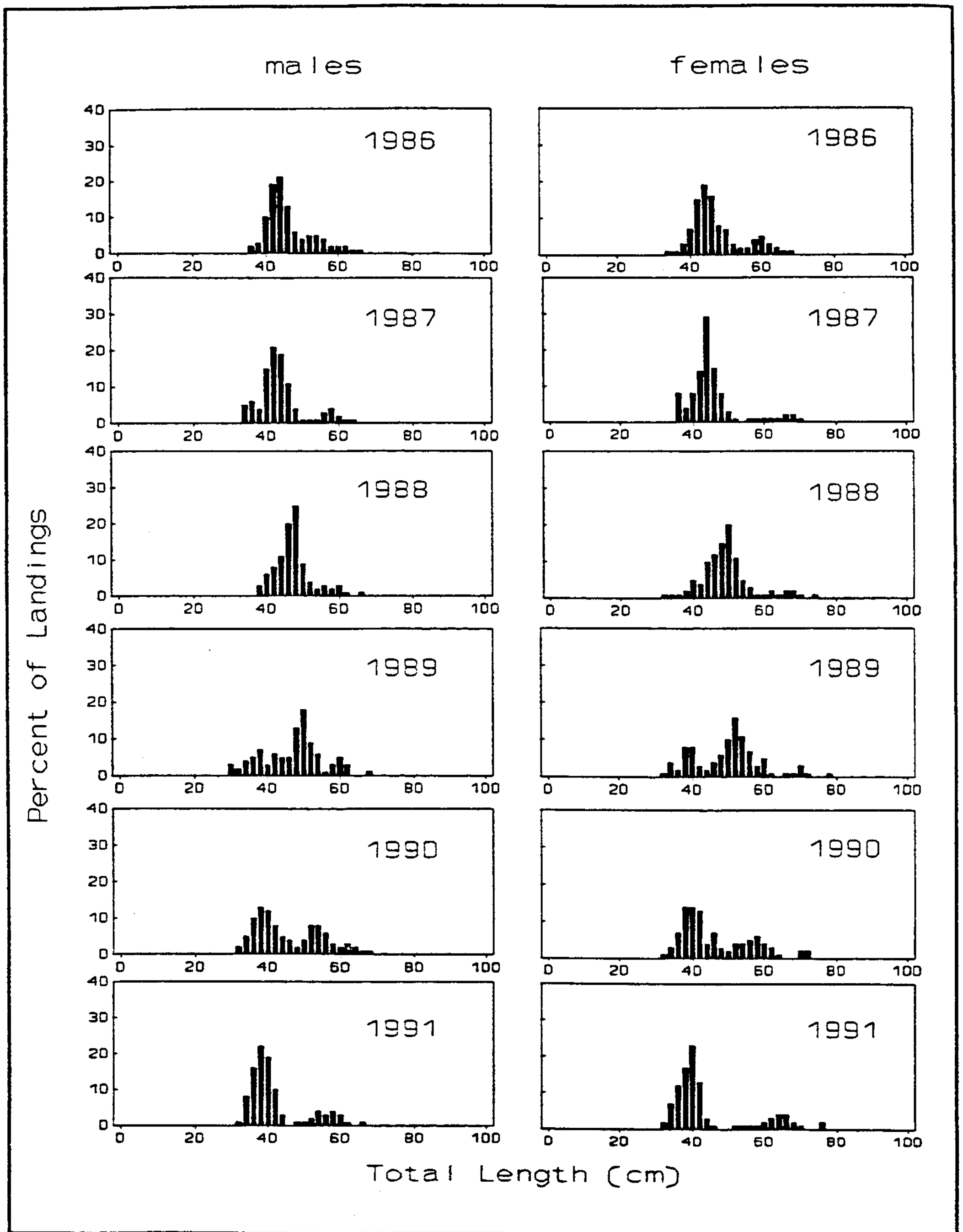



**Figure 1 (continued 2/2).** Length composition data for bocaccio based on samples from the California trawl fishery landings.

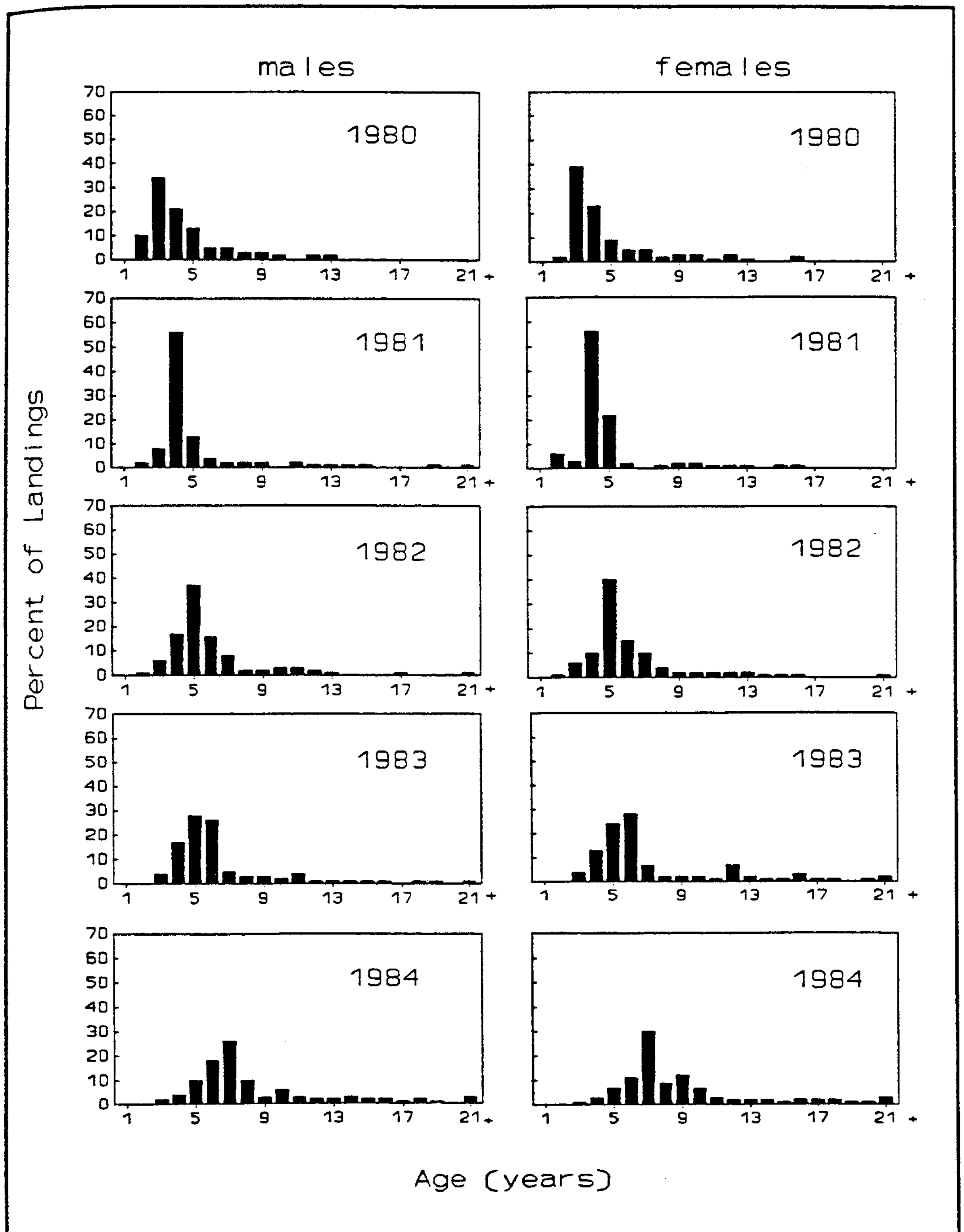



**Figure 2.** Age composition data for bocaccio based on samples from the California trawl fishery landings.

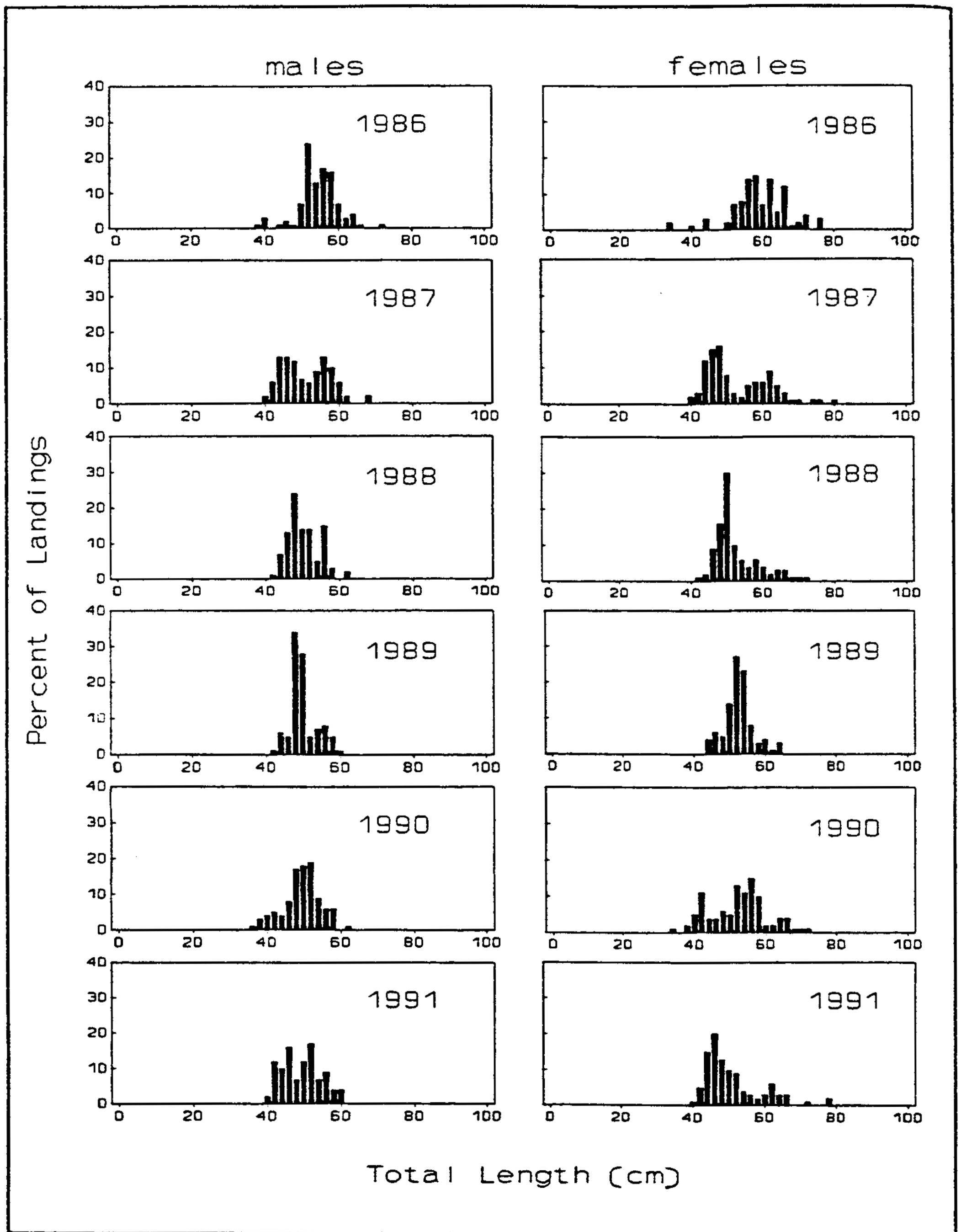



**Figure 3.** Length composition data for bocaccio based on samples from the California set-net fishery landings.

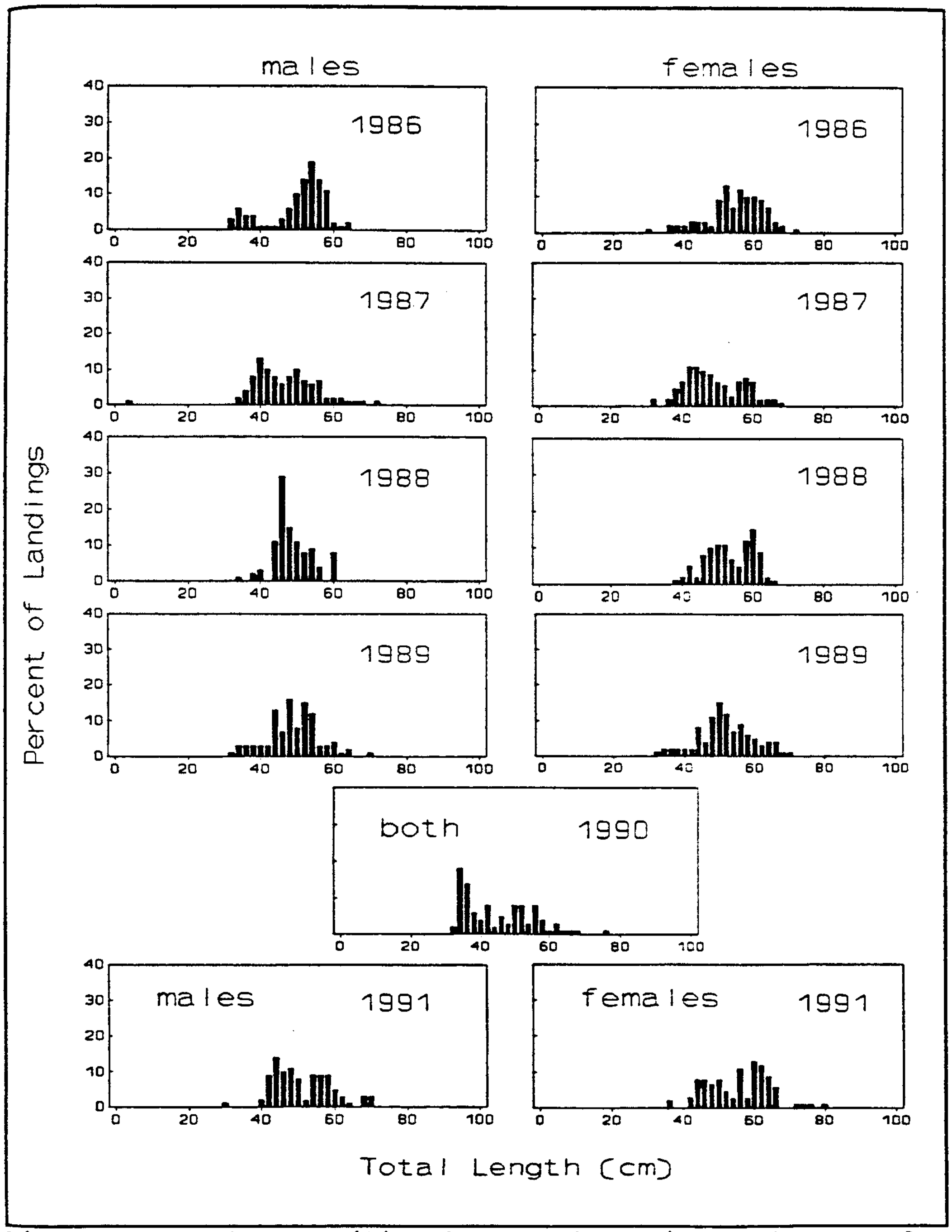



**Figure 4.** Length composition data for bocaccio based on samples from the California hook-and-line/longline fishery.

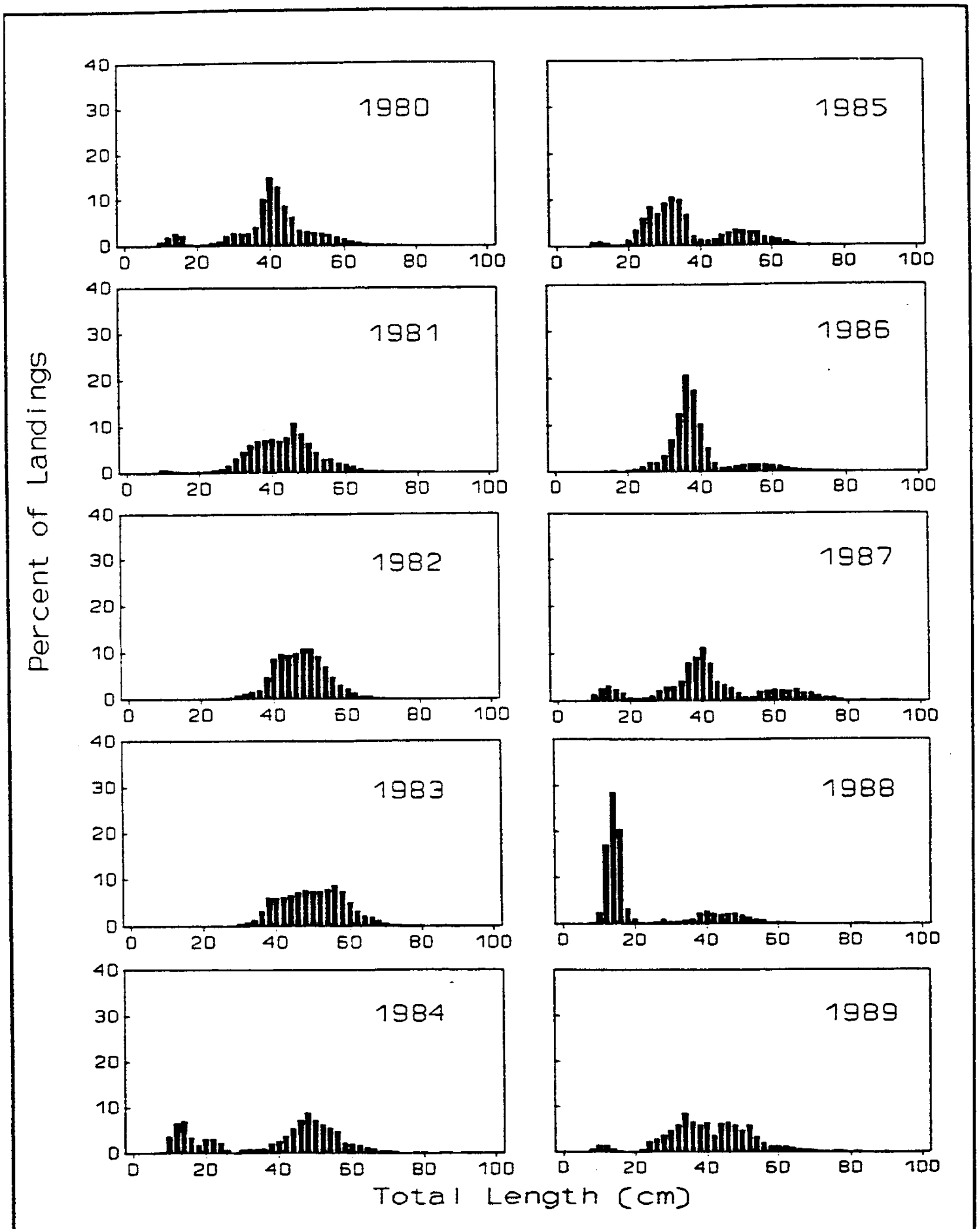



**Figure 5.** Length composition data for bocaccio based on samples from the California recreational fishery landings.

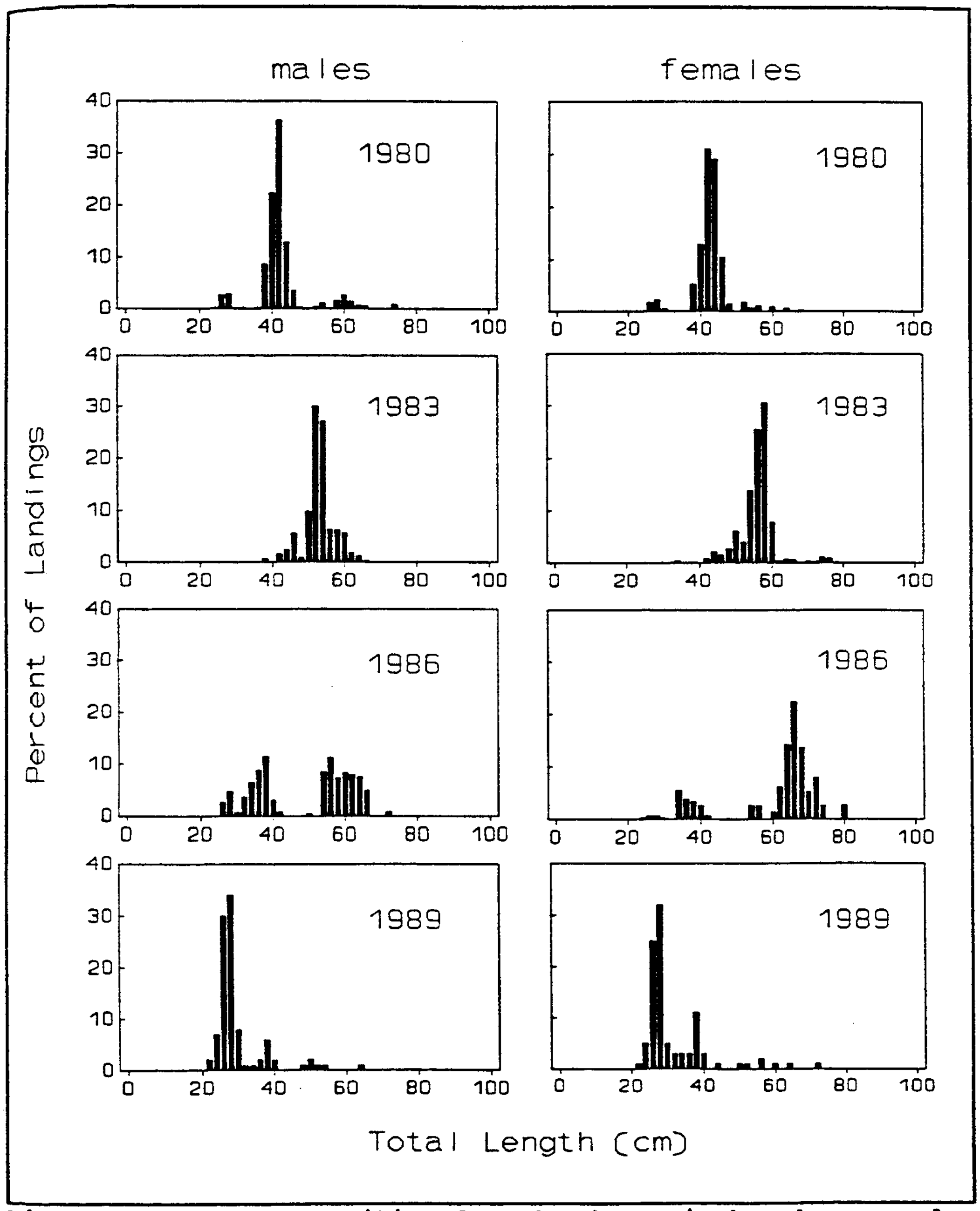



**Figure 6. Length composition data for bocaccio based on samples from the NMFS triennial bottom trawl surveys.**

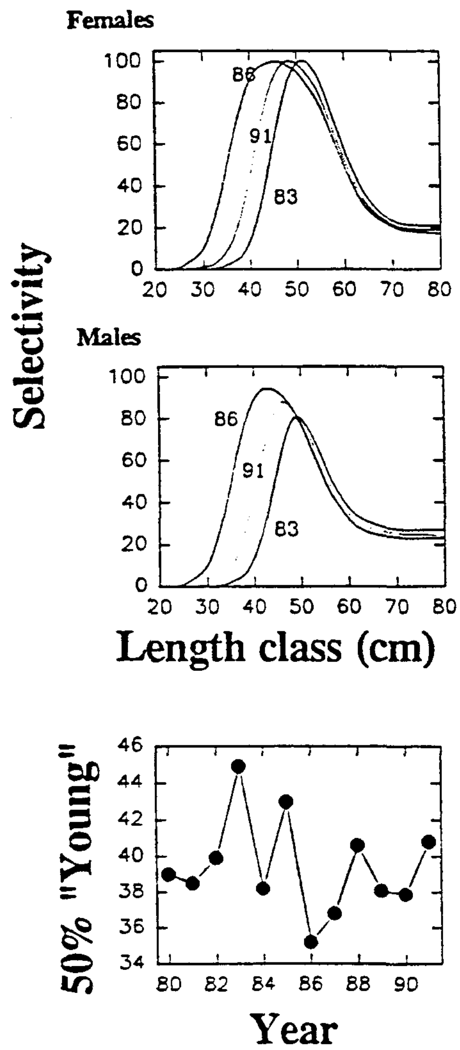



Figure 7. Selectivity of commercial trawl as a function of total length for female and male bocaccio (top and middle panels), and temporal variation in inflection point (cm) of the ascending limb of the selectivity function (50% young), the parameter that introduces time-dependent selectivity.

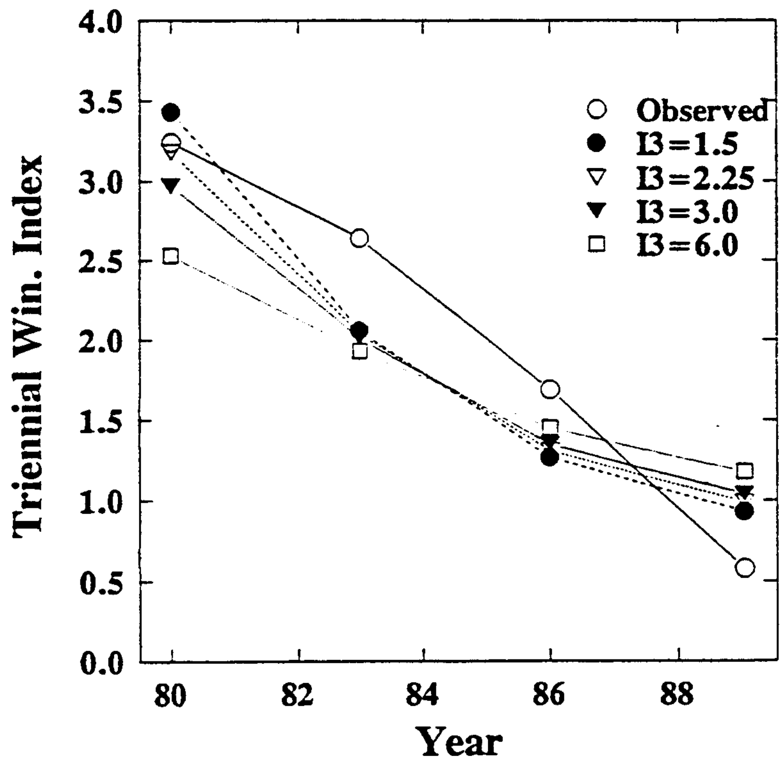



Figure 8. Observed and estimated values (at four fixed levels of initial numbers at age-3 [I3]) of the triennial winsorized index over time.

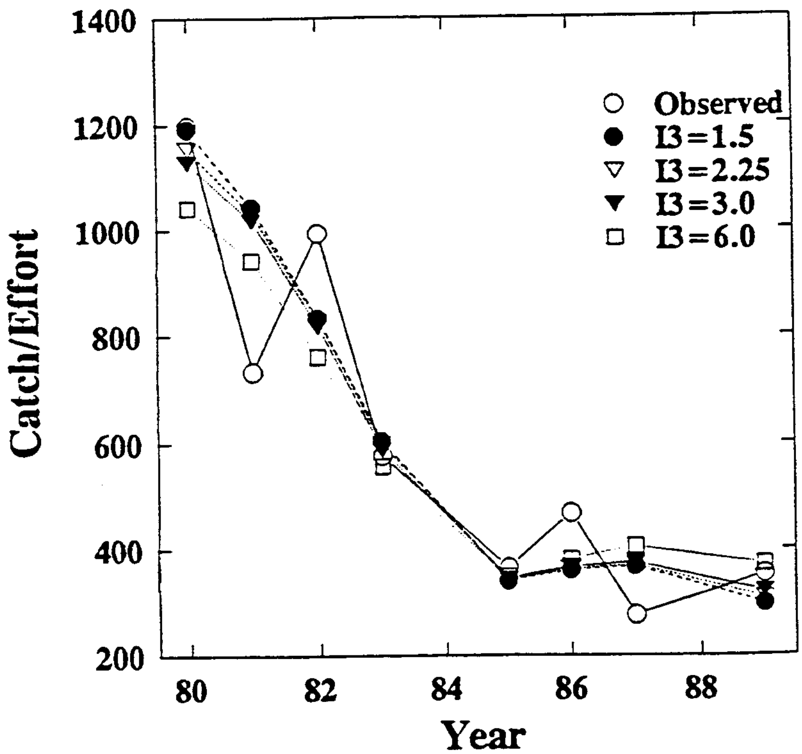



Figure 9. Observed and estimated (at four fixed levels of initial numbers at age-3 [I3]) of Recreational catch/effort (see text) over time.

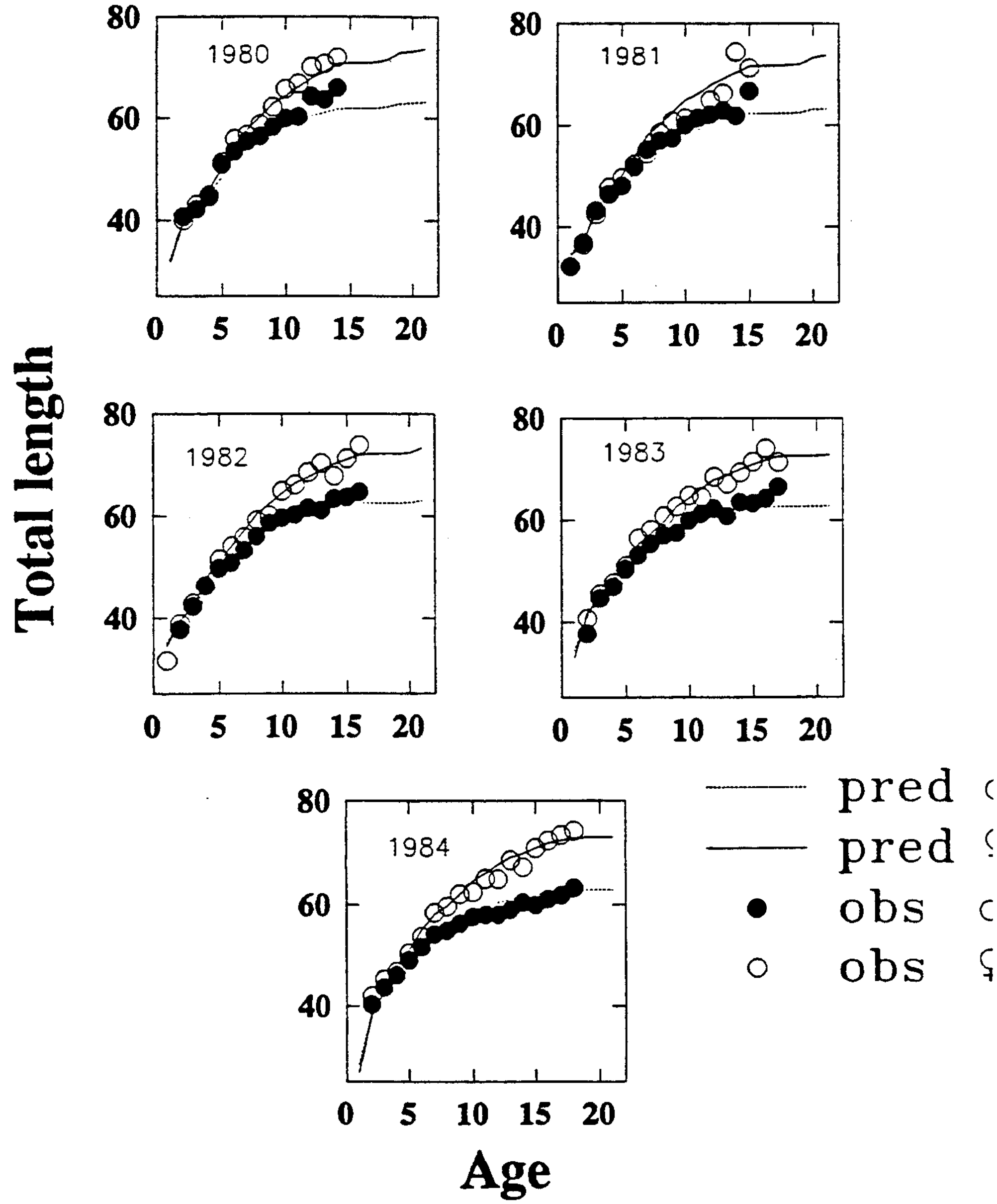



Figure 10. Observed and predicted (at I3=2.25) length at age for trawl landings.

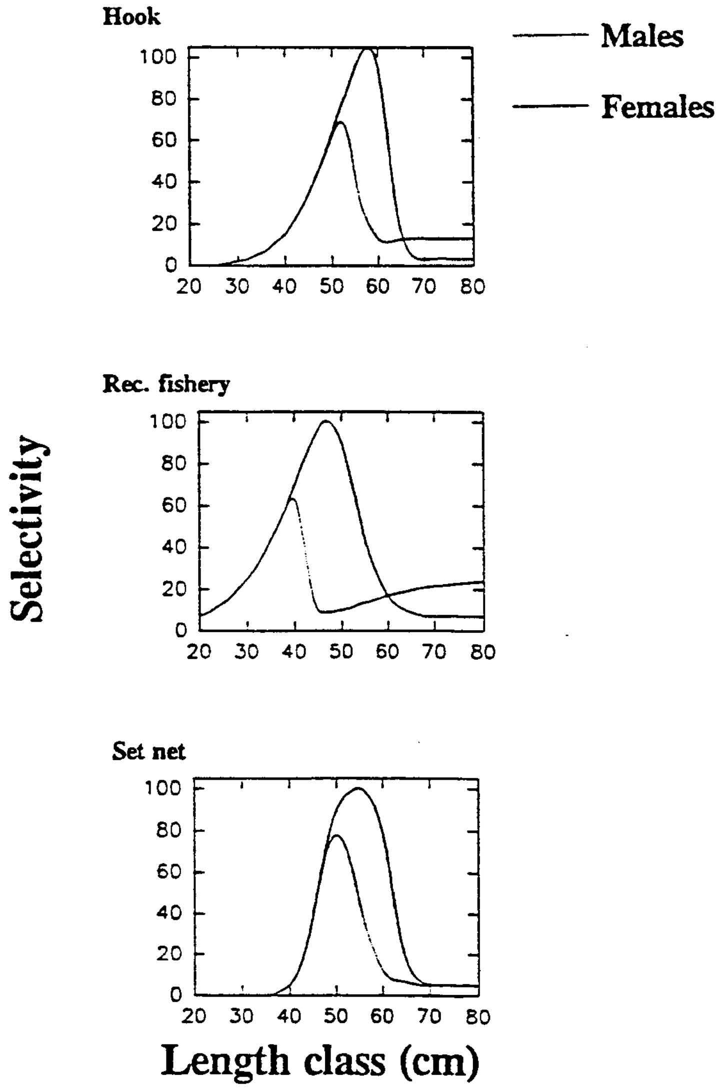



Figure 11. Estimated selectivity versus length (at I3=2.25) for hook and line, recreational and set net fisheries.

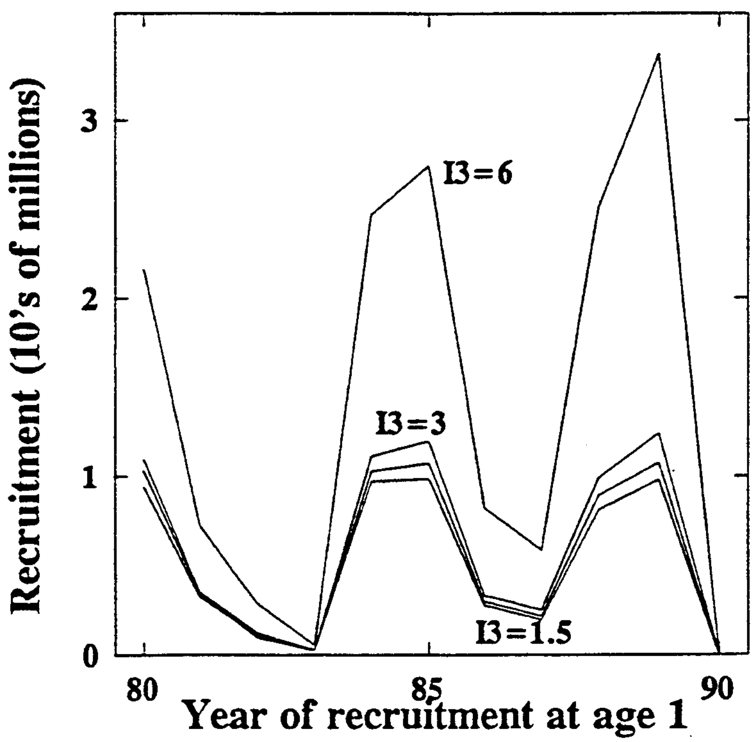



Figure 12. Estimated recruitment over time at four fixed levels of I3.

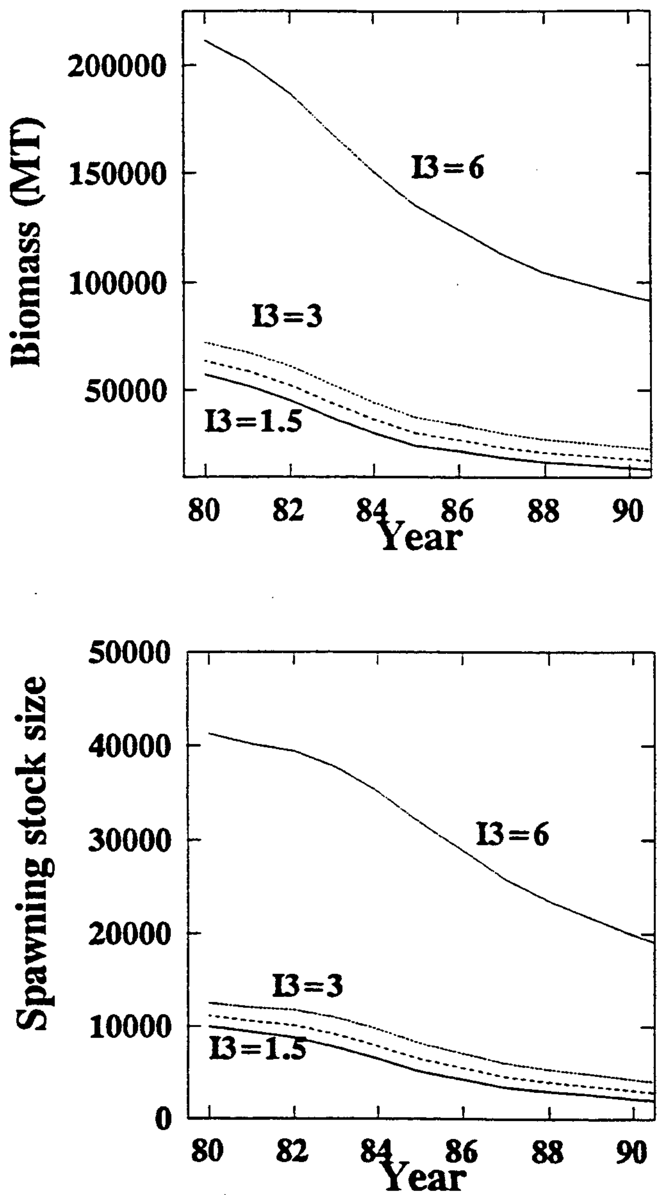



Figure 13. Estimated biomass (top panel) and spawning stock size in billions of eggs (bottom panel) over time for four fixed levels of I3.

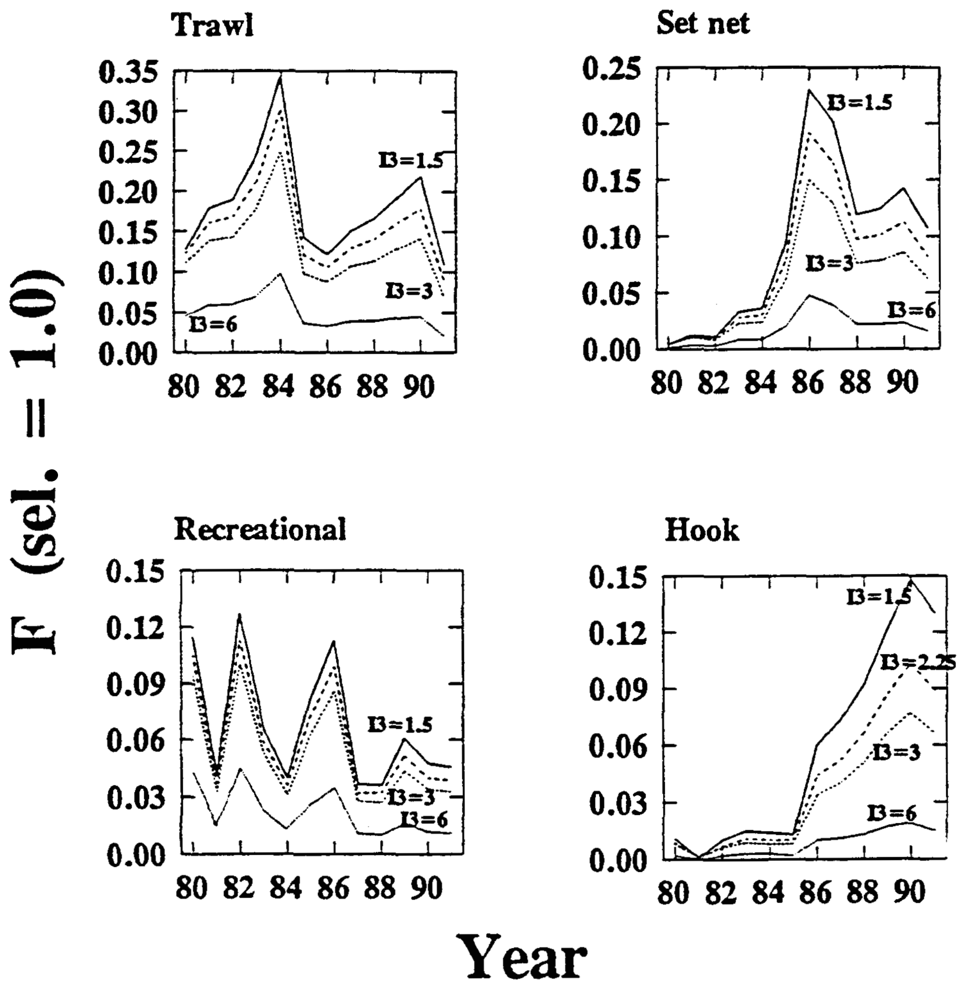



Figure 14. Estimated fishing mortality (for selectivity of 1.0) over time for each of four fisheries. Results are shown for four levels of fixed I3.

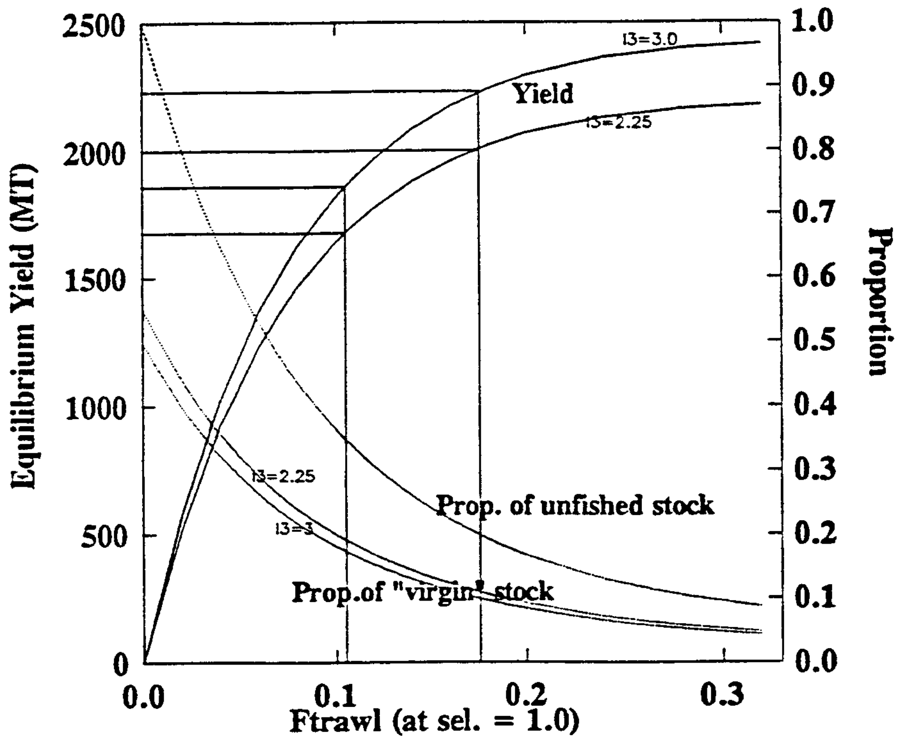



Figure 15. Equilibrium yield results. Increasing functions are yield for the two preferred levels of I3 versus the F at selectivity = 1.0 for the trawl fishery. Vertical lines intersect these curves at $F=F_{20\%}$ and $F=F_{35\%}$, and the horizonal lines indicate the corresponding yield. The descending functions indicate the equilibrium size of the spawning stock as a proportion of either the unfished stock or the "virgin" stock (see text).

**Attachment 1: Estimation of commercial landings and the assignment of unknown sex individuals in composition data**

The trawl landing estimates for bocaccio (and chilipepper) were calculated by apportioning rockfish market category landings to the appropriate species, for each port complex/quarter combination based on samples of the landings. This is the standard "CSUM" expansion done as part of the cooperative CDF&G and NMFS groundfish sampling program. These expansions were recalculated in May 1992 using recently updated data sets. Landing figures at this stage differ from previous values because improvements in data processing have made the databases more complete.

These trawl landings estimates were then adjusted in three ways. First, a certain portion of the reported landings in California have no reported gear code. We upwardly adjusted California landings to account for trawl landings with an unreported gear code. To do this, we first calculated the reported landings of mixed rockfish (market categories likely to contain significant numbers of chilipepper or bocaccio) for trawl, hook and line / longline, set net, and other gear (largely unreported gear code) for each INPFC area for each year. We then calculated the proportion known trawl landings made up of the known trawl, hook- and-line / longline, and set-net landings. We then allocated that proportion of the "other" gear landings to trawl.

Our second adjustment was to incorporate landings from southern California. In recent years, landings from south of the Morro Bay port complex have accounted for only a few percent of the trawl landing of mixed rockfish. Consequently almost no trawl sampling has been done south of Morro Bay (Attachment Table 1) and expansions generally have not been performed for southern California. However, in earlier years the southern ports accounted for a larger portion of the Conception area landings, exceeding 10% in several years, and reaching 40% of the Morro Bay landings in one year. To take this into account, we simply multiplied the Conception area landings generated by the expansion by a factor of (MB+SC)/MB, where MB and SC are the Morro Bay and Southern California landings of mixed rockfish. Finally, we added in landings from the Oregon portion of the Eureka INPFC area.

For the set-net and hook-and-line fisheries, apportionment to species by port complex and quarter was generally not possible, because in many years few or no samples were collected for a given port complex (Attachment Table 1). In some years, few samples were collected at any ports. For these gears, we apportioned landings as follows. First, we treated all samples from market categories that might contain significant numbers of bocaccio or chilipepper as a single "super-market category" (our "mixed rockfish group" mentioned above for trawl landings). Furthermore, we did not attempt to apportion separately by quarter, instead we stratified temporally by year. When we had at least 5 samples for the year/port complex combination, we estimated proportions of the supermarket category that were bocaccio and chilipepper directly from the data for that year/port complex, weighting the samples equally.

For port complex/year combinations with fewer than 5 samples, we estimated the proportions using information from other years and locations that were more intensively sampled. We did this by developing a general linear model for proportions of bocaccio (or chilipepper), including year and region effects. To do this we first defined the regions of southern California (the port complexes of San Diego, Los Angeles, Ventura, and Santa Barbara), the port complex of Morro Bay, the port complex of Monterey, and finally all ports further north. Although we recognize that differences exist within these areas, the sampling was, in our judgement, too sparse to justify any finer stratification at this point. For each port complex, for each year, we then calculated the proportions of our super-market category that were bocaccio and chilipepper. We fit a general linear model (GLM) to the proportions, including both year and region as class variables (i.e. fixed effects), and weighting the proportions by the sample sizes used to calculate them. Thus, for poorly sampled year/port complexes (i.e. fewer than five samples), we used the predicted proportions from the GLM for the appropriate year/geographical strata as our estimates of the proportion bocaccio (or chilipepper). For set net, sample data were not available before 1982, so for 1980 and 1981 we used the least-square means for the appropriate region as our estimates of the proportions. In a few cases, the model estimated a proportion less than zero, and in these situations we used a value of zero in our calculations. The predicted and observed proportions matched reasonably well in cases where our samples sizes exceeded 5 (Attachment Fig. 1). This observed fit, using raw proportions as the dependent variable, was better than the fit we obtained using logarithmic or logit transformations.

Our initial estimates following the above procedure indicated significant landings from the Eureka area for the hook-and-line / longline fishery. This was of some concern because it is generally known that bocaccio landings were not generally high in that area, there were very few samples from Eureka, and this area was being lumped with ports to the south in our calculations of the proportion bocaccio. To evaluate this, we examined the proportion bocaccio in Eureka and at the port complexes it was being lumped with (San Francisco, Bodega Bay, and Fort Bragg) by year for the trawl fishery, which was generally well sampled. We found that the proportion bocaccio in trawl landings at Eureka was comparable to the proportion trawl at the other port complexes through 1984, but dropped in 1985 to an average of 42.7% of the proportion seen at the other ports. Consequently we reduced the 1985-1991 hook-and-line landings in the Eureka area to 42.7% of the values estimated by the GLM model. (A similar evaluation for chilipepper found that the proportion at Eureka was 37.5% of the proportion landed at the San Francisco, Bodega Bay and Fort Bragg port complexes over the entire time series, and the landings of hook-and-line chilipepper were adjusted accordingly.)

There were also some assumptions and calculations required to generate length or age compositions from the raw data or originally provided compositions. This is because not all fish were sexed, and unsexed fish needed to be assigned to a sex. This was done based on the other data for that year. For the length-composition data, we classified the lengths into 2 cm tl groups and applied the sex ratio in their group to the unsexed fish. If none of the fish in the group were sexed, they were assigned a sex based on the sex ratios in the closest size group with available information, or the average of the closest size groups if two groups were equally close.

Assigning sexes to the age composition data was more complex because there were fish of unknown age as well as unknown sex. There were several categories of data. These included unknown sex and unknown age (USUA), unknown sex and known age (USKA), known sex and unknown age (KSUA), and known sex and age (KSKA). First, the USUA fish were assigned an age based on the proportion of USKA fish at each age to the total USKA fish at all ages. These USUA fish were now considered to be in the USKA category. Next, the USKA fish at each age were assigned a sex based on the sex ratio in the KSKA fish at that age. The USUA fish were now considered part of the KSKA category. Finally, the KSUA fish were assigned an age based on the proportion of KSKA fish of that sex at each age to the total KSKA fish of that sex.

In the case of bocaccio hook and line in 1990 we reported the data as a combined sex length composition because a majority of the lower half of the length composition consisted of unsexed fish.

Attachment Table 1. Number of trips sampled (COUNT), and reported landings (MT) of mixed rockfish likely to contain bocaccio or chilipepper (a specified list of market categories), by CDF&G port complex (PORTGRP), year and gear type.

--------- YEAR=1980 Gear type=Hook -----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 4 | 306.723 |
| Monterey | 1 | 240.863 |
| San Francisco | 10 | 87.049 |
| Bodega Bay | 0 | 13.345 |
| Fort Bragg | 0 | 39.995 |
| Eureka | 0 | 136.867 |
| Santa Barbara | 0 | 53.511 |
| Ventura | 0 | 177.665 |
| Los Angeles | 0 | 220.138 |
| San Diego | 0 | 91.395 |

---------- YEAR=1980 Gear type=Set net ---------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 0 | 13.132 |
| Monterey | 0 | 32.089 |
| San Francisco | 0 | 1.227 |
| Bodega Bay | 0 | 0.568 |
| Santa Barbara | 0 | 6.209 |
| Ventura | 0 | 16.129 |
| Los Angeles | 0 | 147.765 |
| San Diego | 0 | 15.684 |

--------- YEAR=1980 Gear type=Trawl ----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 43 | 1533.32 |
| Monterey | 45 | 2338.84 |
| San Francisco | 30 | 1854.12 |
| Bodega Bay | 0 | 231.23 |
| Fort Bragg | 91 | 1936.08 |
| Eureka | 96 | 5450.10 |
| Santa Barbara | 0 | 59.66 |
| Ventura | 0 | 0.04 |

Attachment Table 1 (cont.)

--------- YEAR=1981 Gear type=Hook ----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 0 | 279.629 |
| Monterey | 0 | 172.201 |
| San Francisco | 0 | 137.157 |
| Bodega Bay | 0 | 21.237 |
| Fort Bragg | 0 | 54.626 |
| Eureka | 1 | 237.088 |
| Santa Barbara | 0 | 64.033 |
| Ventura | 0 | 176.817 |
| Los Angeles | 0 | 367.816 |
| San Diego | 0 | 95.237 |

--------- YEAR=1981 Gear type=Set net ---------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 0 | 1.746 |
| Monterey | 0 | 106.549 |
| San Francisco | 0 | 4.471 |
| Bodega Bay | 0 | 0.265 |
| Eureka | 0 | 0.029 |
| Santa Barbara | 0 | 2.386 |
| Ventura | 0 | 135.847 |
| Los Angeles | 0 | 309.403 |
| San Diego | 0 | 597.684 |

--------- YEAR=1981 Gear type=Trawl ----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 40 | 1324.10 |
| Monterey | 37 | 1689.53 |
| San Francisco | 11 | 1838.14 |
| Bodega Bay | 3 | 557.85 |
| Fort Bragg | 56 | 2252.19 |
| Eureka | 64 | 4098.93 |
| Santa Barbara | 0 | 92.99 |
| Ventura | 0 | 4.50 |
| Los Angeles | 0 | 0.77 |

Attachment Table 1 (cont.)

--------- YEAR=1982 Gear type=Hook ----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 2 | 623.248 |
| Monterey | 2 | 296.308 |
| San Francisco | 0 | 154.552 |
| Bodega Bay | 0 | 28.101 |
| Fort Bragg | 0 | 45.458 |
| Eureka | 4 | 330.433 |
| Santa Barbara | 0 | 121.683 |
| Ventura | 0 | 263.489 |
| Los Angeles | 0 | 532.699 |
| San Diego | 0 | 141.576 |

--------- YEAR=1982 Gear type=Set net --------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 1 | 182.722 |
| Monterey | 1 | 378.121 |
| San Francisco | 0 | 16.126 |
| Bodega Bay | 0 | 1.644 |
| Fort Bragg | 0 | 0.883 |
| Santa Barbara | 0 | 1.756 |
| Ventura | 0 | 51.078 |
| Los Angeles | 0 | 288.161 |
| San Diego | 0 | 605.029 |

--------- YEAR=1982 Gear type=Trawl ----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 33 | 1401.36 |
| Monterey | 85 | 1882.02 |
| San Francisco | 36 | 1544.77 |
| Bodega Bay | 9 | 491.41 |
| Fort Bragg | 54 | 1941.26 |
| Eureka | 143 | 1830.87 |
| Santa Barbara | 0 | 132.00 |
| Ventura | 0 | 54.93 |
| Los Angeles | 0 | 21.47 |
| San Diego | 0 | 1.40 |

Attachment Table 1 (cont.)

--------- YEAR=1983 Gear type=Hook -----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 5 | 166.500 |
| Monterey | 1 | 123.343 |
| San Francisco | 0 | 84.700 |
| Bodega Bay | 0 | 13.671 |
| Fort Bragg | 0 | 12.071 |
| Eureka | 3 | 49.196 |
| Santa Barbara | 0 | 79.531 |
| Ventura | 0 | 203.975 |
| Los Angeles | 0 | 193.638 |
| San Diego | 0 | 131.365 |

--------- YEAR=1983 Gear type=Set net ---------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 1 | 38.105 |
| Monterey | 8 | 761.465 |
| San Francisco | 0 | 76.696 |
| Bodega Bay | 0 | 0.356 |
| Santa Barbara | 0 | 6.894 |
| Ventura | 0 | 74.985 |
| Los Angeles | 0 | 141.904 |
| San Diego | 0 | 565.705 |

--------- YEAR=1983 Gear type=Trawl ----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 66 | 936.43 |
| Monterey | 84 | 1353.54 |
| San Francisco | 30 | 1271.31 |
| Bodega Bay | 21 | 1871.18 |
| Fort Bragg | 130 | 2449.74 |
| Eureka | 165 | 1742.73 |
| Santa Barbara | 0 | 158.60 |
| Ventura | 0 | 6.87 |
| Los Angeles | 0 | 256.62 |
| San Diego | 0 | 0.37 |

Attachment Table 1 (cont.)

--------- YEAR=1984 Gear type=Hook ----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 3 | 111.753 |
| Monterey | 0 | 18.793 |
| San Francisco | 1 | 39.036 |
| Bodega Bay | 0 | 12.864 |
| Fort Bragg | 0 | 3.124 |
| Eureka | 2 | 2.041 |
| Santa Barbara | 0 | 51.416 |
| Ventura | 0 | 97.634 |
| Los Angeles | 0 | 209.646 |
| San Diego | 0 | 121.106 |

--------- YEAR=1984 Gear type=Set net --------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 8 | 42.981 |
| Monterey | 1 | 288.883 |
| San Francisco | 0 | 152.608 |
| Bodega Bay | 0 | 4.008 |
| Santa Barbara | 0 | 113.406 |
| Ventura | 0 | 96.763 |
| Los Angeles | 0 | 258.512 |
| San Diego | 0 | 468.689 |

---------- YEAR=1984 Gear type=Trawl ----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 95 | 688.07 |
| Monterey | 106 | 1430.53 |
| San Francisco | 44 | 2011.32 |
| Bodega Bay | 49 | 2269.37 |
| Fort Bragg | 73 | 1845.80 |
| Eureka | 90 | 1355.31 |
| Santa Barbara | 0 | 77.54 |
| Ventura | 0 | 14.38 |
| Los Angeles | 0 | 21.12 |
| San Diego | 0 | 1.24 |

Attachment Table 1 (cont.)

--------- YEAR=1985 Gear type=Hook -----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 10 | 156.330 |
| Monterey | 0 | 62.447 |
| San Francisco | 0 | 81.602 |
| Bodega Bay | 0 | 44.654 |
| Fort Bragg | 0 | 38.941 |
| Eureka | 1 | 191.515 |
| Santa Barbara | 0 | 51.978 |
| Ventura | 0 | 140.233 |
| Los Angeles | 0 | 120.073 |
| San Diego | 0 | 121.096 |

--------- YEAR=1985 Gear type=Set net ---------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 8 | 156.635 |
| Monterey | 26 | 643.804 |
| San Francisco | 24 | 700.376 |
| Bodega Bay | 0 | 6.266 |
| Eureka | 0 | 0.401 |
| Santa Barbara | 0 | 107.159 |
| Ventura | 0 | 32.951 |
| Los Angeles | 0 | 330.691 |
| San Diego | 0 | 555.063 |

--------- YEAR=1985 Gear type=Trawl -----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 112 | 563.97 |
| Monterey | 121 | 1117.22 |
| San Francisco | 54 | 1171.61 |
| Bodega Bay | 42 | 1016.85 |
| Fort Bragg | 74 | 1057.67 |
| Eureka | 87 | 1497.23 |
| Santa Barbara | 0 | 32.88 |
| Ventura | 0 | 0.89 |
| San Diego | 0 | 0.47 |

Attachment Table 1 (cont.)

--------- YEAR=1986 Gear type=Hook ----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 8 | 77.110 |
| Monterey | 0 | 34.555 |
| San Francisco | 0 | 153.012 |
| Bodega Bay | 0 | 192.963 |
| Fort Bragg | 0 | 140.147 |
| Eureka | 0 | 236.490 |
| Santa Barbara | 1 | 58.385 |
| Ventura | 40 | 213.090 |
| Los Angeles | 24 | 112.592 |
| San Diego | 53 | 191.384 |

--------- YEAR=1986 Gear type=Set net --------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 9 | 354.40 |
| Monterey | 21 | 761.99 |
| San Francisco | 13 | 1069.60 |
| Bodega Bay | 0 | 6.27 |
| Fort Bragg | 0 | 0.01 |
| Eureka | 0 | 0.71 |
| Santa Barbara | 25 | 168.73 |
| Ventura | 11 | 39.89 |
| Los Angeles | 63 | 346.74 |
| San Diego | 157 | 577.30 |

--------- YEAR=1986 Gear type=Trawl ----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 67 | 1039.15 |
| Monterey | 85 | 1114.60 |
| San Francisco | 8 | 176.68 |
| Bodega Bay | 8 | 369.97 |
| Fort Bragg | 63 | 634.63 |
| Eureka | 74 | 696.64 |
| Santa Barbara | 4 | 57.19 |
| Ventura | 1 | 3.85 |
| Los Angeles | 0 | 0.46 |

Attachment Table 1 (cont.)

--------- YEAR=1987 Gear type=Hook -----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 2 | 71.955 |
| Monterey | 0 | 76.368 |
| San Francisco | 5 | 216.759 |
| Bodega Bay | 0 | 186.269 |
| Fort Bragg | 0 | 106.471 |
| Eureka | 0 | 267.456 |
| Santa Barbara | 0 | 38.712 |
| Ventura | 1 | 164.120 |
| Los Angeles | 22 | 50.538 |
| San Diego | 51 | 128.670 |

--------- YEAR=1987 Gear type=Set net ---------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 18 | 361.34 |
| Monterey | 19 | 1181.49 |
| San Francisco | 9 | 432.21 |
| Bodega Bay | 0 | 1.45 |
| Eureka | 0 | 2.05 |
| Santa Barbara | 15 | 304.52 |
| Ventura | 8 | 242.84 |
| Los Angeles | 50 | 190.33 |
| San Diego | 68 | 321.68 |

--------- YEAR=1987 Gear type=Trawl ----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 56 | 504.84 |
| Monterey | 30 | 722.54 |
| San Francisco | 23 | 636.89 |
| Bodega Bay | 26 | 484.88 |
| Fort Bragg | 65 | 984.53 |
| Eureka | 86 | 2279.16 |
| Santa Barbara | 2 | 33.14 |
| Ventura | 4 | 20.77 |
| Los Angeles | 0 | 0.39 |
| San Diego | 0 | 0.48 |

Attachment Table 1 (cont.)

--------- YEAR=1988 Gear type=Hook -----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 2 | 121.680 |
| Monterey | 2 | 79.485 |
| San Francisco | 0 | 318.329 |
| Bodega Bay | 0 | 189.678 |
| Fort Bragg | 0 | 155.611 |
| Eureka | 0 | 311.017 |
| Santa Barbara | 1 | 31.851 |
| Ventura | 8 | 185.558 |
| Los Angeles | 7 | 62.502 |
| San Diego | 21 | 86.866 |

--------- YEAR=1988 Gear type=Set net ---------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 15 | 486.314 |
| Monterey | 56 | 950.901 |
| San Francisco | 0 | 241.406 |
| Bodega Bay | 0 | 3.785 |
| Santa Barbara | 11 | 238.026 |
| Ventura | 1 | 132.606 |
| Los Angeles | 19 | 45.240 |
| San Diego | 27 | 93.497 |

--------- YEAR=1988 Gear type=Trawl -----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 55 | 884.11 |
| Monterey | 56 | 585.52 |
| San Francisco | 8 | 563.27 |
| Bodega Bay | 22 | 734.45 |
| Fort Bragg | 50 | 1076.59 |
| Eureka | 41 | 1227.44 |
| Santa Barbara | 1 | 5.15 |
| Ventura | 0 | 3.35 |
| Los Angeles | 0 | 0.01 |
| San Diego | 0 | 2.51 |

Attachment Table 1 (cont.)

--------- YEAR=1989 Gear type=Hook -----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 1 | 149.204 |
| Monterey | 3 | 96.966 |
| San Francisco | 0 | 367.805 |
| Bodega Bay | 0 | 129.628 |
| Fort Bragg | 0 | 221.540 |
| Eureka | 0 | 395.634 |
| Santa Barbara | 0 | 28.514 |
| Ventura | 22 | 364.729 |
| Los Angeles | 27 | 95.920 |
| San Diego | 16 | 49.301 |

--------- YEAR=1989 Gear type=Set net ---------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 8 | 381.76 |
| Monterey | 135 | 1245.36 |
| San Francisco | 0 | 180.73 |
| Bodega Bay | 0 | 0.08 |
| Fort Bragg | 0 | 0.54 |
| Santa Barbara | 0 | 25.80 |
| Ventura | 2 | 236.86 |
| Los Angeles | 7 | 55.48 |
| San Diego | 9 | 45.82 |

--------- YEAR=1989 Gear type=Trawl -----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 41 | 1034.29 |
| Monterey | 76 | 892.47 |
| San Francisco | 6 | 990.57 |
| Bodega Bay | 8 | 819.92 |
| Fort Bragg | 51 | 1358.60 |
| Eureka | 39 | 853.89 |
| Santa Barbara | 0 | 11.16 |
| Ventura | 0 | 6.67 |
| Los Angeles | 0 | 0.03 |
| San Diego | 0 | 0.31 |

Attachment Table 1 (cont.)

--------- YEAR=1990 Gear type=Hook -----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 2 | 155.379 |
| Monterey | 12 | 122.112 |
| San Francisco | 2 | 476.090 |
| Bodega Bay | 0 | 119.550 |
| Fort Bragg | 0 | 281.110 |
| Eureka | 0 | 570.489 |
| Santa Barbara | 1 | 29.454 |
| Ventura | 2 | 316.122 |
| Los Angeles | 0 | 85.049 |
| San Diego | 7 | 50.459 |

--------- YEAR=1990 Gear type=Set net --------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 9 | 361.78 |
| Monterey | 134 | 1065.07 |
| San Francisco | 0 | 235.71 |
| Bodega Bay | 0 | 0.29 |
| Eureka | 0 | 0.03 |
| Santa Barbara | 0 | 17.21 |
| Ventura | 0 | 298.85 |
| Los Angeles | 0 | 38.92 |
| San Diego | 10 | 65.82 |

--------- YEAR=1990 Gear type=Trawl ----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 51 | 760.84 |
| Monterey | 52 | 152.12 |
| San Francisco | 18 | 1668.40 |
| Bodega Bay | 16 | 754.15 |
| Fort Bragg | 59 | 1629.15 |
| Eureka | 37 | 1130.39 |
| Santa Barbara | 0 | 8.19 |
| Ventura | 0 | 2.57 |
| Los Angeles | 0 | 1.13 |
| San Diego | 0 | 1.40 |

Attachment Table 1 (cont.)

--------- YEAR=1991 Gear type=Hook ------------------------

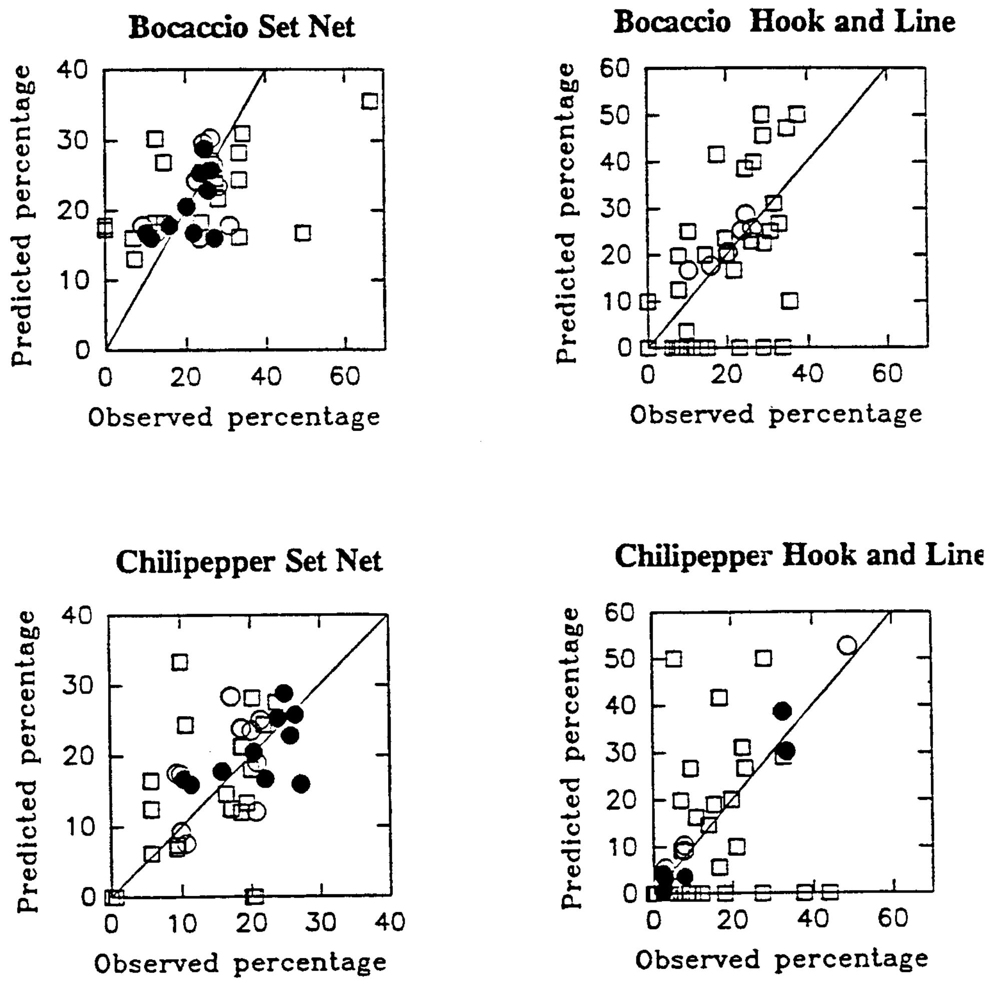
| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 1 | 264.338 |
| Monterey | 25 | 273.011 |
| Princeton | 2 | 119.328 |
| San Francisco | 32 | 392.914 |
| Bodega Bay | 7 | 120.205 |
| Fort Bragg | 0 | 143.939 |
| Eureka | 0 | 466.350 |
| Santa Barbara | 0 | 42.371 |
| Ventura | 0 | 373.108 |
| Los Angeles | 0 | 124.538 |
| San Diego | 0 | 58.722 |

--------- YEAR=1991 Gear type=Set net ---------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 0 | 119.327 |
| Monterey | 40 | 463.054 |
| Princeton | 2 | 29.172 |
| San Francisco | 5 | 162.146 |
| Eureka | 0 | 0.428 |
| Santa Barbara | 0 | 0.656 |
| Ventura | 0 | 221.948 |
| Los Angeles | 0 | 119.976 |
| San Diego | 0 | 34.708 |

--------- YEAR=1991 Gear type=Trawl -----------------------

| PORTGRP | COUNT | MT |
|---|---|---|
| Morro Bay | 67 | 640.07 |
| Monterey | 59 | 214.21 |
| Princeton | 17 | 246.14 |
| San Francisco | 33 | 448.81 |
| Bodega Bay | 44 | 504.28 |
| Fort Bragg | 46 | 1144.28 |
| Eureka | 24 | 911.84 |
| Santa Barbara | 0 | 4.46 |
| Ventura | 0 | 7.68 |
| Los Angeles | 0 | 1.59 |
| San Diego | 0 | 0.07 |




Attachment Figure 1. Relationship between predicted (by GLM model, see text) and directly observed proportions bocaccio and chilipepper for port complex x year combinations. Solid circles indicate observed proportions based on 25 or more sampled trips. Open circles indicate 10<=N<25, and open squares indicate 5<=N<10.