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ASSESSMENT OF LINGCOD IN 1997

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Sandra Rosenfield, Kelly Silberberg, and Tom Laidig**

Appendix to

STATUS OF THE PACIFIC COAST GROUNDFISH FISHERY THROUGH 1997 AND RECOMMENDED ACCEPTABLE BIOLOGICAL CATCHES FOR 1998

STOCK ASSESSMENT AND FISHERY EVALUATION

Pacific Fishery Management Council
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ASSESSMENT OF LINGCOD

(*Ophiodon elongatus*)

for the

PACIFIC FISHERY MANAGEMENT COUNCIL

IN 1997

by

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Summary

Lingcod fishery, survey, and biological data are summarized for the Vancouver through Conception INPFC areas, and an age-structured population assessment is presented for the stock from 42° 50' N (Cape Blanco) to 49° 00' N (SW Vancouver Island). The age-structured assessment area spans the Columbia and US-Vancouver INPFC areas and includes the Canadian portion of PMFC area 3C (area 3C-N). The assessment incorporates data from three fisheries and two surveys that each sample a unique aspect of the lingcod population, which is stratified bathymetrically by size and sex. Bi-national landings from the assessment area were 3,544 mt in 1975, peaked at 6,868 mt in 1985, and were 2,052 mt in 1996. Assessment results indicate a heavily exploited stock. Landings exceeded the $F_{35\%}$ exploitation rate (0.14) in 13 of the past 15 years. Landings reached or exceeded the $F_{20\%}$ (overfishing) exploitation rate (0.25) in 1985 and for each of the most recent 7 years (1991-1997). The average exploitation rate for 1991-1997 was 0.30.

1. Introduction

The focus of this analysis is to provide a detailed assessment of the population in the Columbia and US-Vancouver INPFC areas, where sufficient data are available to support an age-structured assessment. An age structured assessment was not conducted for the Eureka, Monterey, and Conception INPFC areas due to the short time series of age data (1992-1996). However, the presently available landings data (Tables 3, 4, and 6), survey data (Table 12) and age composition data (Appendix i) for these southern areas are summarized in this document.

The area covered by the age structured assessment spans the coast from 42° 50' N (Cape Blanco) to 49° 00' N in Canada (the Columbia and Vancouver INPFC areas, through PMFC area 3C-N (Figure 1). Evidence from genetics and tagging studies (Jagielo et al. 1996, Jagielo 1995, Cass et al. 1990) suggest that the fish found within this area are of one intermingling stock unit. Three catch-at-age time series were compiled for this assessment: Washington trawl (1979-1996), British Columbia trawl (1979-1996), and Washington Sport (1986-1996). Auxiliary data sets include Oregon trawl CPUE (1987-1992) (Sampson 1997), NMFS triennial trawl survey biomass and size composition estimates (1977-1995), and WDFW Cape Flattery mark-recapture survey abundance (1986-1992) and size composition (1986-1997) estimates.

1.1 Life History Features

Lingcod (*Ophiodon elongatus*) are top order predators of the family *Hexagrammidae*. The species ranges from Kodiak Island in the Gulf of Alaska to Baja California, with the center of abundance near British Columbia and Washington (Hart 1973). Among the *Hexagrammidae*, the genus *Ophiodon* is ecologically intermediate between the more littoral genera *Hexagrammos*, *Agrammus*, and *Oxylebius* and the more pelagic *Pleurogrammus* (Rutenberg 1962). Lingcod are demersal on the continental shelf, most abundant in waters less than 200 m deep, and patchily distributed among areas of hard bottom and rocky relief (Smith and Forrester 1973; Jagielo 1988). Lingcod are considered non-migratory, though some tagged individuals have moved exceptional distances and

indirect evidence suggests a seasonal onshore movement associated with spawning (Jagielo 1995). Larval lingcod hatch in late winter and become epipelagic. When about 3 months old, juveniles settle on sandy bottom near eelgrass or kelp beds. By age 1 or 2, lingcod move into rocky habitats similar to those occupied as adults, but shallower. Fishery and survey data indicate that male lingcod tend to be more abundant than females in shallow waters, and the size of both sexes increases with depth (Jagielo 1994). An analysis of genetic variation indicates that lingcod are genetically similar throughout the range, but suggests that lingcod in Puget Sound are partially isolated from those along the open coast (Jagielo et al. 1996). A more detailed review of lingcod life history can be found in Jagielo (1994), and Cass et al. (1990).

1.2 Fisheries

1.2.1 Commercial Landings.

Commercial landings of lingcod prior to 1981 were summarized by Adams (1986). Landings by INPFC area since 1981 are available from the PacFIN database (Table 1). Coastwide, landings peaked in 1983 at 4143 mt. Peak landings by INPFC area since 1981 were: U.S.-Vancouver - 1853 mt in 1985, Columbia - 1900 mt in 1983, Eureka - 553 mt in 1982, Monterey - 893 mt in 1989, and Conception - 167 mt in 1981. In 1996, landings totaled 1557 mt and were distributed as follows by area: U.S.-Vancouver 477 mt (31%), Columbia 541 mt (35%), Eureka 185 mt (12%), Monterey 311 mt (20%), Conception 43 mt (3%). Trawl gear accounts for the bulk of landings coastwide (Tables 2-4).

U.S. and Canadian commercial landings for the age structured assessment area are summarized in Table 5. Combined U.S.-Canada commercial removals for the assessment area peaked in 1985 at 6748 mt. In 1996, combined landings for the assessment area totaled 1913 mt.

1.2.2 Recreational Landings.

The Washington Department of Fish and Wildlife conducts an annual creel survey to estimate coastal marine recreational landings. In the age-structured assessment area, estimates of Washington sport landings have ranged from under 30 mt to over 100 mt since

1975, and averaged 102 (mt) from 1992-1996 (Table 5).

Silberberg and Adams (1993) summarized recreational landings by sub-region for 1980-1989 and compared Marine Recreational Fishery Statistics Survey (MRFSS) estimates with estimates from the Washington Department of Fish and Wildlife (WDFW) and the California Department of Fish and Game (CDFG). Based on Marine Recreational Fishery Survey Statistics (MRFSS) estimates, recreational landings accounted for 46% of all landings in the northern California region, and 69% of the total for the southern California region. An updated summary of MRFSS recreational landings estimates, and a comparison with CDFG and WDFW estimates, is presented in Table 6.

1.3 Management History

1.3.1 Canada (Area 3C-N).

Prior to 1987, area 3C-N has had occasional winter closures and a minimum size restriction of 58 cm, implemented initially as a weight restriction in 1942 (McFarlane and Leaman 1993). In 1987, a winter closure (January 1 - April 30) was imposed to protect spawning lingcod. The spawning closure was expanded in 1988 to extend from November 15 - April 30. In 1987, a 1400 mt quota was implemented due to a consensus over low stock abundance. The quota was raised to 2000 mt in 1991, and was 2100 mt for 1993-1995. In 1996, the quota was reduced to 1540 mt, and a 65 cm minimum size restriction was implemented for trawl gear (Bruce Leaman, DFO, Personal Communication).

1.3.2 United States.

In the PFMC management zone, a minimum size limit of 22 inches (56 cm) was established in 1995. Recreational bag limits stand at 5 fish/day in California and 3 fish/day in Oregon and Washington. The current PFMC coastwide ABC is 2,400 mt. The ABC's by INPFC area are: U.S.-Vancouver/Columbia 1,300 mt, Eureka 300 mt, Monterey 700 mt, and Conception 100 mt.

1.4 Management Performance.

In 1995 and 1996, commercial and recreational landings of lingcod have been managed to

a level close to the coastwide harvest guideline of 2,400 mt. Managers assume a recreational catch of 700 mt/year coastwide (Brian Culver, WDFW, personal communication). Adding this value to the commercial totals (Table 1) gives a commercial and recreational coastwide total of 2168 mt in 1995, and 2257 in 1996.

2.0 Age Structured Assessment

2.1 Modeling History

2.1.1 Canada

Canadian assessments of lingcod in area 3C-N were conducted by Richards and Yamanaka (1992) and McFarlane and Leaman (1993). McFarlane and Leaman (1993) concluded that CPUE data indicate that stock abundance has declined since the mid 1980's, and caution was urged in assigning allowable catch because 1990 and 1991 CPUE values were associated with historically high effort levels.

2.1.2 United States

An age-structured stock assessment of lingcod for the Pacific Fishery Management Council (PFMC) was reported by Jagielo (1994). The assessment covered a portion of the Columbia INPFC area (north of Cape Falcon) and the Vancouver INPFC area through PMFC area 3C-N. The assessment described a stock heavily exploited by U.S. and Canadian fisheries, where landings reached or exceeded the $F_{20\%}$ exploitation rate (0.25) in 1985, and from 1991-1997.

2.2 Overview of changes since the last assessment.

The present assessment extends the geographic coverage of the 1994 assessment to the south, and now includes the full Columbia INPFC area (south to Cape Blanco). The time series of data have been updated through 1996 (through 1997 for the WDFW survey), and an additional biomass estimate from the 1995 NMFS triennial trawl survey is incorporated. The previous assessment utilized NMFS biomass estimates for the US-Vancouver INPFC area only; the present assessment utilizes the NMFS biomass estimates for the full Columbia and US-Vancouver INPFC areas. Additionally, a new CPUE time series derived

from Oregon trawl logbook data (Sampson 1997) has been substituted for the US trawl CPUE time series used in the previous assessment. Though presented for comparison, the present assessment does not use the BC trawl CPUE time series. The previous assessment included BC trawl age composition data for 1979-1986; the present assessment incorporates data from 1977-1995.

2.3 Model Description

2.3.1 Assessment Program.

The assessment program employed was the age structured stock synthesis model (SYNA32.EXE - compiled 7/9/97), provided by Richard Methot (NMFS).

2.3.2 Likelihood components.

The stock synthesis model was structured with three fisheries (US Commercial, US Sport, and BC Commercial) and two surveys (WDFW Cape Flattery Survey, and NMFS Triennial Trawl Survey). The likelihood components are described as follows:

1. BC Commercial Catch (Table 5). Trawl and miscellaneous commercial gear landings were compiled for PMFC area 3C from 1956-1996 (Jagielo 1994; Bruce Leaman, DFO, personal communication). In years prior to 1981, some of the BC catch originated from US Waters (area 3C-S).

2. BC Commercial Fishery Age (Table 7, 8). The time period of age samples ranges from 1977 to 1996. In some recent years, sample sizes for age composition were deemed to be too small for use in the age structured assessment. Thus, age composition was not available for the years 1991, 1992, 1994, and 1996. Data were provided by Bruce Leaman, Canadian Department of Fisheries and Oceans (DFO).

3. BC Commercial Fishery CPUE (Table 5). This time series, which runs from 1956-1996, is provided for comparative purposes only. These data were not used to fit the age structured model (emphasis = 0.0 in base model run). The relationship between this time series and lingcod relative abundance is questionable, particularly in recent years, when

changes in trawl effort may have reduced the utility of CPUE data as a reliable index of lingcod availability. Also, it is not clear that trends in this index, which are derived for a relatively small geographic area (PMFC 3C-N), are representative of the entire region covered by the age-structured assessment. Data were provided by Bruce Leaman, Canadian Department of Fisheries and Oceans (DFO).

4. US Commercial Fishery Catch (Table 5). Trawl and miscellaneous commercial gear landings were compiled for 1956-1996, from the Columbia and US-Vancouver INPFC areas, and PMFC area 3-C. Prior to 1981, some of the US catch originated from BC waters (PMFC area 3C-N).

5. US Commercial Fishery Age (Table 7, 8). The proportion of fish by age and sex was estimated for 1979-1996 from trawl fishery samples. To compute the annual frequency by age and sex, each sample was weighted by the poundage of lingcod landed by the vessel sampled. Samples from 1979-1991 were collected and aged by WDFW. Samples from 1992-1996 included both WDFW samples, and samples collected by the Oregon Department of Fish and Wildlife (ODFW) that were aged at the NMFS Tiburon Lab. An apparent trend of decreasing size-at-age, most evident for younger fish, was observed in the WDFW time series (Figure 2). To investigate the possibility that this apparent trend was actually an artifact of age reading differences in the WDFW age data over time, approximately 100 fish/year were re-aged from samples collected in 1982, 1984, 1986, 1990, 1992, and 1994. Comparing the original age assignments with the new age assignments revealed a pattern in the WDFW samples collected in 1982, 1984, and 1986 (Figure 3, left panel). Fish originally assigned an age < 8 tended to be assigned an older age in the re-aging experiment. The pattern did not exist for re-aged samples collected in 1990, 1992, and 1994 (Figure 3, right panel). This apparent bias in age reading was addressed in the stock synthesis model by creating one bin for fish less than age 8 for the years prior to 1988 in the US commercial fishery age composition time series.

6. US Commercial Fishery CPUE (Table 5, Figures 4-7). The methodology used in preparing these estimates of effective, standardized CPUE from trawl fishery logbooks was

detailed by Sampson (1997). The assessment uses estimates of effective CPUE (lb/hr) from Oregon trawl logbook data (1987-1993), ranging from 42.500^0 N. to 48.167^0 N latitude in the 40-240 fm depth range. For each year, a single estimate of CPUE was derived for the entire assessment area by computing a weighted mean of the individual latitude/depth strata estimates. The individual depth/latitude strata were weighted by an estimate of the spatial area for each strata. Data provided by David Sampson, Oregon State University.

7. US Sport Fishery Catch. A time series of Washington sport removals from the assessment area, in metric tons, was compiled for 1975-1996 (Table 5). These estimates were derived from WDFW creel survey estimates of landings (Lai et al 1991), estimates of mean weight-at-age (Table 17), and estimates of the proportion caught at age (Tables 7, 8). A value of 0.00348 mt/fish was applied for years when sex/age composition data were not available. A reliable time series of recreational landings estimates was not available for Oregon. To account for all removals from the assessment area, we made the assumption that the weight of Oregon removals was equal to the Washington estimates for 1975-1996. Thus, the annual US sport fishery catch used in the age-structured stock assessment was 2 times the value given in Table 5.

8. US Sport Fishery Age (Table 7, 8). Age frequencies, derived from Washington sport fishery samples, are available for 1980, and 1986-1996. The age samples were collected from sport landings at Neah Bay, La Push, Westport, and Ilwaco. Age data were not available for Oregon recreational landings. Thus, the Washington age composition data was assumed to apply to the entire assessment area, including Oregon.

9. WDFW Cape Flattery Survey Abundance (Figure 8); WDFW Cape Flattery Survey Size Composition (Table 9, 10); WDFW Cape Flattery Survey Age Composition (Tables 7, 8). A mark-recapture study of lingcod commenced in 1986 at Cape Flattery, Washington (Jagielo 1991, 1995). This survey is conducted in March, operates close to shore (<= 3 miles, approximately 10-20 fm in depth), and tends to select predominantly young, male lingcod, which are relatively scarce in the trawl fishery. Mark-recapture estimates of abundance are available for 1986-1992. Length frequency data are available from 1986-

1997, and age frequency data are available for 1995 and 1996.

10. NMFS Triennial Trawl Survey Biomass (Table 11, Figure 9); NMFS Triennial Trawl Survey Size Composition (Tables 9,10); NMFS Triennial Trawl Survey Age Composition (Tables 7, 8). The assessment incorporates NMFS Triennial trawl survey biomass estimates for the US-Vancouver and Columbia areas, available in three year intervals from 1977-1995. Length compositions are available for 1986, 1989, 1992, and 1995. An estimate of age composition is available for 1995. (Dark and Wilkins, 1994; Weinberg et al., 1994; Mark Wilkins, NMFS, Personal Communication).

11. Spawner-Recruit Individual; Spawner-Recruit Mean. These components were incorporated into the assessment model but were given nil emphasis for base model runs. They were included to explore the spawner-recruitment relationship.

2.3.3 Parameter constraints.

The model was constrained by the following fixed parameters/assumptions:

1. Natural mortality: fixed at 0.18 for females, 0.32 for males.
2. Age reader percent agreement: fixed at age 2 = 50%; at age 14 = 42%. (Age 2 percent agreement was reduced from 79% to 50% following a recommendation of the STAR panel to reduce the age reader percent agreement value for young fish.)
3. Growth coefficient of variation (CV): Females Age 2 = 0.01, Age 14 = 0.09; Males Age 2 = 0.01, Age 14 = 0.12. (The CV for age 2 fish was reduced to 0.01 following a recommendation of the STAR panel to reduce the CV value for young fish.)
3. Selectivity: functional form is a double-logistic curve parameterization; time invariant, and not constrained to be asymptotic for any fishery or survey.
4. Spawner-recruit relationship: given nil emphasis for fitting model. Recruitments in 1995, 1996 and 1997 were estimated from a Beverton-Holt S/R curve with curvature = 0.889
5. Discard mortality: actual amount unknown, set = 0 in model.
6. The maximum multinomial "effective sample size" used for age and size composition

data was set at the following values, as per recommendation by the STAR panel: US Sport Age: 100, US Commercial Age: 100, BC Commercial Age: 50, NMFS Survey Age: 50, NMFS Survey Length: 50, WDFW Survey Age: 50, WDFW Survey Length: 100.

2.3.4 Biological Data used in the age-structured assessment

A summary of biological parameters used in the model is presented in Table 13. Estimated length, weight, and fraction mature at age for male and female lingcod are given in Table 14. Growth curve statistics are provided in Table 15, and fit to the growth model is plotted in Figure 10. Estimated mean lengths and weights at age for each fishery and survey used in the model are given in Tables 16 and 17, respectively.

2.4 Model selection and evaluation.

2.4.1 Model selection.

Examination of the shape of fishery and survey selectivity curves in preliminary runs suggested domed-shaped selectivity for males and females in each of the three fisheries and two surveys. Thus, the full (double logistic) parameterization was used for all subsequent model runs. A limited evaluation of selectivity changes over time for females in the US Commercial fishery was evaluated in early model runs. Comparison of selectivity for two periods (1975-1990 vs. 1991-1997) indicated little difference. Subsequent model evaluation focused on models with time invariant selectivity.

To find an acceptable base model, we conducted model runs over a wide range of fixed ending biomass levels (3,000-27,000 mt) with the preliminary base model, for ages 4-14 in 1997 (Figure 11). The best model fit (highest log-likelihood) occurred at a biomass level of approximately 6000 mt. This preliminary model (which included estimation of 1995 recruitment) was adopted as a base model for further evaluation. At the request of the STAR panel, ending biomass profiles were also conducted for a model with all auxiliary data (surveys and CPUE data) excluded. Compared with the preliminary base model, the ending biomass profile was flatter, indicating that the auxiliary data are informative. Further profiling was then conducted to examine the relative changes in likelihood for each

model component across a narrower range of ending biomass levels (Figure 12). Sensitivity of the preliminary base model was also evaluated with respect to a range of different emphasis levels for the various model likelihood components (Figures 28-34).

A subsequent evaluation of model convergence revealed that the preliminary base model (a model that estimated 1995 recruitment) had unacceptable convergence properties. A model which did not estimate 1995 recruitment was found to have less variable convergence properties than the preliminary base model. Convergence properties for this alternate base model were evaluated by conducting 83 model runs where the starting parameter seeds were offset by a random factor by up to 15%. The resulting distributions of ending biomass (mt), and total likelihood are shown in Figure 11a . The best fitting model from this set of 83 convergence runs was adopted as the final base model for this assessment.

2.4.2 Description of the base model.

Results for the final base model are depicted in Figures 13-15. The stock synthesis model parameter file (base97a.p01), showing model configuration and all base model parameter estimates, is included as Appendix ii.

Biomass declined from approximately 35,000 mt in 1975 to 6,700 mt in 1997 (Table 18, Figure 13). Estimates of the number of age 2 fish showed prominent recruitment in 1977, 1979-1981, 1986, and 1991-1992 (Figure 13). Peaks in recruitment since 1981 failed to reach the higher levels seen prior to 1981. Exploitation rates (% Utilization) peaked in 1985 and 1991-1995. The average exploitation rate for 1991-1997 was 0.30.

Selectivity for both sexes was markedly dome-shaped in each fishery and survey (Figure 14). These selectivity patterns are consistent with the biology and distribution of lingcod, and the timing and spatial characteristics of the respective fisheries and surveys. For example, the late winter WDFW survey captures predominantly young, male lingcod, which are most abundant in relatively shallow depths nearshore (10 fm), while the US commercial trawl fishery captures predominantly older, female lingcod, which are more

abundant on the trawl grounds at 60-100 fm in spring and summer. Also, male lingcod are known to aggregate nearshore in fall and early winter prior to spawning (Jagielo 1994), further reducing their vulnerability to trawl fisheries.

2.4.3 Residual analysis

Comparison of model expected values with observed values indicates good fits to the WDFW survey estimates of abundance, the NMFS survey estimates of biomass, and the US Commercial CPUE (Figure 15). The BC CPUE data were not fit to the model but were examined for comparison with the other auxiliary information. Residuals for the BC CPUE data showed a strong pattern. Model expected values were higher than observed values prior to 1984, and were lower than observed values in recent years.

Model fits are presented graphically for BC commercial age composition (Figures 16-18), US commercial age composition (Figures 19-21), US sport age composition (Figures 22-23), WDFW survey size composition (Figures 24-25), NMFS survey size composition (Figures 26-27), and WDFW and NMFS survey age compositions (Figure 27).

2.4.4 Sensitivity analysis

Sensitivity of the preliminary base model to the individual likelihood components was examined by static profiling. This was conducted by holding the emphasis level of all other components constant while sequentially varying the emphasis of a particular likelihood component to be profiled from 0.5 to 5.0. A summary of the profiling results is given in Table 19. Plots of ending biomass and likelihood value changes for each of the profiling runs are shown for BC commercial fishery age composition (Figure 28), US commercial fishery age composition (Figure 29), US commercial fishery CPUE (Figure 30), WDFW survey abundance (Figure 31), WDFW survey size composition (Figure 32), NMFS survey biomass (Figure 33), and NMFS survey size composition (Figure 34).

In general, the sensitivity analysis results for the preliminary base model indicated that the auxiliary data used in the model were more complimentary than contradictory. It was observed that 1) emphasis of BC commercial age composition reduced model fit to other

components and led to higher biomass estimates, and 2) emphasis of WDFW and NMFS abundance estimates improved model fit to the US commercial age composition and each other.

2.4.5 Retrospective analysis

The base model was examined for retrospective patterns by sequentially removing the final year of input data from a model ending in 1997 (final base model) to a model with an ending year of 1991. Trends in the resulting biomass, recruitment, and exploitation rate estimates for the individual models are shown in Figure 35. Biomass was fairly consistent for 1985-1991 for all retrospective model runs, but diverged somewhat before and after that period (Figure 35 - Top panel). Recruitment estimates for early years were similar for the various time-series models, but tended to diverge for the more recent years as additional data became available. Full selectivity fishing mortality rates (F_{max}) rates were generally higher for the final base model ending in 1997, compared to models ending in earlier years. In general, estimates of fishing mortality tended to diverge toward the end of the respective time series. These retrospective patterns may, in part, be due to the different timing and duration of the available auxiliary data sets used in the base model (US CPUE, NMFS survey, and WDFW survey).

2.4.6 Assumptions of the final base model.

The following is a list of some major assumptions made about the true state of reality that must exist in order for the final base model to be an accurate depiction of lingcod abundance for the assessment area from 1975-1997. It is by no means exhaustive.

1. The BC commercial age composition data, accurately accounts for the proportion of fish by sex and age removed by the BC Commercial fishery (the assignment of ages to sampled fish is correct and the sampling levels are adequate to estimate the true values).
2. The US commercial age composition data accurately accounts for the proportion of fish by sex and age removed by the US Commercial fishery (the assignment of ages to sampled fish is correct and the sampling levels are adequate to estimate the true

values).

3. The decision *not* to include BC Commercial CPUE does not cause us to forgo an opportunity for a more plausible, better base model.
4. US Commercial CPUE, derived from Oregon trawl logbooks, accurately describes the trend in lingcod availability to all trawl gear from 1987-1993 in the assessment area.
5. Given the estimated survey selectivity, the WDFW Cape Flattery survey accurately describes the trend in lingcod abundance from 1986-1992 in the assessment area.
6. Given the estimated survey selectivity, the NMFS triennial trawl survey accurately describes the trend in lingcod abundance from 1977-1995 in the assessment area.
7. Natural mortality is constant at 0.18 for females, and 0.32 for males in the assessment area.
8. Fishery and survey selectivity is adequately described by a double-logistic curve parameterization, and selectivity is time invariant.
9. Lingcod residing in the defined assessment area represent one unit-stock and are a closed population.
10. Catchability for the fisheries and surveys is time invariant.
11. Growth of lingcod (length and weight at age) is constant from 1975-1997.
12. Discard mortality is negligible.
13. Use of a Beverton-Holt (B-H) spawner-recruitment curve with shape parameter of 0.889 yields reasonable values for assumed recruitment from 1995-1997.

2.4.7 Consequence of base model assumption failures.

A full analysis of the impact of base model assumption failures was not conducted for this assessment. It is clearly important however, that our assumptions about US and Canadian age composition data (assumptions 1 and 2) should be evaluated.

Given the differences of mean size at age observed between the BC Commercial fishery, and the US Commercial fishery (Table 16), and considering that separate labs provide the ages for each of these fisheries, it is plausible that differences exist between labs in the assignment of fish ages. A comparative analysis of lingcod age reading has been scheduled, but the results will not be available in time for this assessment.

Another plausible explanation for difference in size at age is historically different minimum size restrictions; BC has had a 58 cm minimum size restriction size 1942 while the US has had none. A minimum size limit can tend to result in disproportionate sampling of the largest fish of a year-class and thus can result in over-estimation of the true size-at-age. It is noteworthy that the largest differences observed between BC and US size at age occur for the partially recruited ages (2-6); however, the BC mean size at age remains consistently less than the US size at age for ages 7-10 as well.

2.4.8 Investigation of spawner-recruitment relationship

Attempts to estimate a Beverton-Holt (B-H) spawner recruitment curve with the stock synthesis model consistantly resulted in a shape parameter > 1.0. This result, and visual inspection of the spawner-recruit relationship (Figure 36) suggested that the B-H curve was not applicable to the relationship between egg production and recruitment. The estimated B-H recruitment curve plotted in Figure 36 represents a curve with a fixed (not estimated) shape parameter of 0.889. This curve was not used to fit the model; rather, it was used to derive recruitment values for the years 1995-1997.

Recruitment estimates were also examined for evidence of serial correlation. The 1-step lagged serial correlation coefficient (r) was relatively small (0.45), indicating little evidence for serial correlation in lingcod recruitment.

2.5 Response to reviewers comments

2.5.1 External anonymous review of 1994 assessment.

A summary of the reviewers comments appears in italics. The responses appear in regular text.

1. *My primary concern is the implicit assumption that fishery CPUE is a reliable measure of lingcod relative abundance. This assumption should be examined. It is possible that the fishery CPUE is not a representative measure of lingcod abundance because fishermen preferentially fish areas of high abundance. For example, fishermen may*

deplete an area in one year, then move to another area the following year. The fishery CPUE would appear constant, whereas relative abundance had decreased. The assessment author should explicitly show that the spatial distribution of "high" lingcod CPUE does not change from year to year.

A new time series of fishery CPUE was used for the present assessment (Sampson 1997). The analysis found no significant interaction between area and year. Additional detailed analysis of geographic differences in CPUE is warranted, however, to evaluate the small-scale spatial effects of the kind referenced by the reviewer.

2. *The fishery CPUE apparently was computed as total catch divided by total effort for the region. Another approach would be to compute fishery CPUE by smaller areas (e.g. by "sardine" block), then weight these small-area CPUE by the geographic size of the area to compute an area-weighted CPUE for the region. This computation should remove any bias as long as all small areas are fished at least a little bit each year.*

   For the present assessment, estimates of CPUE for each of the latitude/depth strata (Figures 4-6) were weighted by estimates of the area of each strata, to obtain an area-weighted CPUE for the entire region (Figure 7).

3. *Modeling selectivity as a double-logistic results in a large number of parameters being estimated (7 parameters per curve). I suggest that a lower parameter function such as the exponential logistic (3 parameters per curve, Thompson 1994) be used to represent dome-shaped selectivity.*

   This sounds like a reasonable suggestion. We note, however, that results of recent catch-at-age analysis on simulated data sets has indicated that estimation of selectivity may be parameterized with up to (the number of ages - 1) free selectivity parameters (Annette Hoffmann, personal communication). The double logistic parameterization did result in bound parameters in some cases, in particular for the most steeply sloped dome-shaped curves. The double logistic curve is not twice continuously differentiable. An alternate parameterization may improve estimation.

4. *Growth equation. The observed length values are greater than the expected values for ages 2 and 3. Faster growing fish of these partially recruited ages may be recruiting first, so that observed length values are not representative of the age group as a whole and the mean length-at-age is biased upward. This may be problem if this equation is used in the population model to translate modeled ages to modeled lengths, depending on how the equation is used in the model.*

   Estimation of mean length-at-age for the population has been improved for present assessment. The curve is now fitted to mean length at age data for only the WDFW and NMFS surveys for ages 2 and 3, and uses survey and US trawl fishery data for ages 4+ (Table 15, Figure 10).

5. *Yield Forecast. Using 2.572 million to forecast yield may give overly optimistic yield forecasts. The highest recruitments were observed for the 1979-81 recruits and recruitment has been lower since then, except for the 1991 recruits (but "evidence for this strong year class is limited at present"). I suggest that forecasts use the mean of the 1982-90 recruits.*

   Forecasts for the present assessment used the geometric mean of recruitment values estimated for the period 1986-1995 (a shorter, more recent period than the time series used in the previous assessment, which may be more representative of current recruitment expectations).

2.6 Yield Forecast

Results of the base model and stock synthesis equilibrium yield calculations were used to forecast yield for 1998-2000. Projections are given for fishing at $F_{35\%}$ (Table 20), $F_{40\%}$ (Table 21), $F_{45\%}$ (Table 22), and $F_{20\%}$ (Table 23).

2.7 Decision Tables

At the request of the STAR review panel, decision tables were produced to evaluate the implications of alternative management actions (alternate 1998-2000 catch levels) given three alternative "true states of nature" (1997 lingcod biomass). The three levels of 1997 lingcod biomass used were 1) the final base model best estimate (6,714 mt), 2) the lower

bound of a 1 sigma (68%) confidence interval on the best estimate (3,916 mt), and 3) the upper bound of the 68% confidence interval (11,511 mt). Separate tables were derived to show the consequence of fishing at $F_{35\%}$ (Table 24), $F_{40\%}$ (Table 25), and $F_{20\%}$ (Table 26). Each table shows the exploitation rates and values of F_{max} that correspond with the various mean 1998-2000 catch levels used in the forecast. Each cell of the tables also shows the biomass that results in the year 2000 by following the various harvest policies, given the different assumptions about the true level of biomass present in 1997.

3.0 Suggestions for Future Research

1. A comparison of lingcod age reading should be conducted between the three labs that age lingcod on the west coast (DFO, Nanaimo; WDFW, Olympia; and NMFS, Tiburon).

2. To improve estimates of lingcod recruitment, tagging of lingcod at Cape Flattery should be resumed, to obtain annual estimates of lingcod abundance and mortality. These estimates would greatly enhance the utility of the size and age composition data currently collected as part of the ongoing WDFW Cape Flattery survey.

3. The results of this assessment indicate lingcod selectivity curves that are markedly dome-shaped. Alternatives to the double-logistic selectivity parameterization used in this assessment should be evaluated to see if estimation of age specific selectivity may be improved. Further analysis should also be conducted to evaluate the possibility of time-varying selectivity in the trawl fisheries.

4. The time-series of effective effort and CPUE estimates (Sampson 1997) should be updated from 1994 to the present.

5. As additional years of recreational and commercial age composition data become available for the Eureka, Monterey, and Conception INPFC areas, the feasibility of developing an age-structured model for the southern portion of the coast should be evaluated.

4.0 Acknowledgments

Numerous fisheries scientists, technicians, and data management personnel contributed information that made this assessment possible. Coastal port samplers in Canada, Washington, Oregon and California deserve credit for collecting the basic fishery data from the field. Data were contributed by Mark Wilkins and Mark Zimmermann (NMFS), David Sampson (OSU), and Will Daspit and Brad Stenberg (PacFIN). WDFW staff members Greg Konkel, Farron Wallace, Marian Berejikian, Cathy Evans, Brad Pattie, and Mel Stanley provided data management support. Bruce Leaman (DFO) contributed Canadian fishery data and provided constructive insights into its interpretation. Richard Methot (NMFS) and Jack Tagart (WDFW) gave helpful advice on using the Stock Synthesis model. Annette Hoffmann gave useful insights regarding parameter estimability issues with catch-at-age modeling. We also thank the STAR panel members Richard Methot (Chair), Larry Jacobson, Jim Hastie, Russ Brown, and Gordon Swartzman for their review and suggestions for model improvement.

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Table 1. Lingcod landings (mt) by INPFC area, 1981-1996. Data source: PacFIN.

	Landings in Metric Tons						
Year	US-Vancouver	Columbia	Eureka	Monterey	Conception	Unknown	Total
1981	478	1459	380	835	167	1	3320
1982	572	1695	553	846	163	1	3830
1983	1151	1900	395	581	46	70	4143
1984	1746	1261	286	737	21	0	4051
1985	1853	1272	238	493	20	22	3898
1986	569	732	208	356	15	5	1885
1987	728	884	322	580	30	6	2550
1988	620	1028	312	627	38	4	2629
1989	999	1226	390	893	56	4	3568
1990	988	757	422	706	58	2	2933
1991	1452	866	212	559	73	4	3166
1992	556	649	171	442	64	1	1883
1993	651	777	197	490	79	1	2195
1994	611	619	211	397	66	1	1905
1995	367	494	230	319	58	0	1468
1996	477	541	185	311	43	0	1557

PacFinGearGroups.xls

Table 2. Lingcod landings (mt) by gear group, US-Vancouver and Columbia INPFC areas, 1981-1996. Data source: PacFIN.

	US-Vancouver Area: Landings in Metric Tons							
YEAR	Hook&Line	Nets	Pot&Trap	Trolls	Trawls	Shrimp Trawl	Other	Total
1981	74	27	0	60	316	1	0	478
1982	76	77	0	133	286	0	0	572
1983	37	120	0	201	775	18	0	1151
1984	64	131	3	202	1344	2	0	1746
1985	100	247	1	178	1325	2	0	1853
1986	50	0	0	71	442	6	0	569
1987	95	0	0	44	585	4	0	728
1988	69	0	0	75	476	0	0	620
1989	91	0	0	119	789	0	0	999
1990	140	0	0	85	762	1	0	988
1991	81	0	0	26	1345	0	0	1452
1992	55	0	0	31	470	0	0	556
1993	36	0	0	20	594	1	0	651
1994	35	0	0	21	554	1	0	611
1995	21	0	0	9	334	3	0	367
1996	36	0	0	6	430	5	0	477

	Columbia Area: Landings in Metric Tons							
YEAR	Hook&Line	Nets	Pot&Trap	Trolls	Trawls	Shrimp Trawl	Other	Total
1981	28	46	3	31	1274	77	0.8	1459
1982	48	0	3	25	1548	71	0	1695
1983	37	11	2	32	1734	84	0.2	1890
1984	35	3	1	18	1155	49	0	1261
1985	54	0	1	43	1130	44	0	1272
1986	51	0	1	44	554	82	0	732
1987	79	0	1	20	716	68	0	884
1988	76	0	1	19	901	31	0	1028
1989	99	0	0	28	1053	46	0	1226
1990	62	0	0	12	662	21	0	757
1991	32	0	0	4	813	17	0	866
1992	55	0	0	9	571	14	0	649
1993	60	0	0	12	679	26	0	777
1994	102	0	1	6	469	41	0	619
1995	39	0	0	4	410	41	0	494
1996	48	0	0	6	458	29	0	541

PacFinGearGroups.xls

Table 3. Lingcod landings (mt) by gear group, Eureka, and Monterey INPFC areas, 1981-1996. Data source: PacFIN.

	Eureka Area: Landings in Metric Tons							
YEAR	Hook&Line	Nets	Pot&Trap	Trolls	Trawls	Shrimp Trawl	Other	Total
1981	14			8	349	8	0.6	380
1982	14		0	13	511	12	2.3	553
1983	26		1	2	364	0	1.6	395
1984	5	0	0	3	262	1	15	286
1985	42	0	1	1	184	1	9	238
1986	82	0	2	8	95	4	17	208
1987	104	0	0	1	204	1	12	322
1988	107	0	0	0	180	3	22	312
1989	175	0	2	1	189	4	19	390
1990	174	0	0	4	232	3	9	422
1991	65	0	0	0	140	6	1	212
1992	60	0	0	0	105	4	2	171
1993	41	0	0	0	153	2	1	197
1994	54	0	0	0	144	12	1	211
1995	91	1	0	0	130	6	2	230
1996	74	0	0	3	100	8	0	185

	Monterey Area: Landings in Metric Tons							
YEAR	Hook&Line	Nets	Pot&Trap	Trolls	Trawls	Shrimp Trawl	Other	Total
1981	40	8	3	20	760	0	5.1	835
1982	23	59	1	14	734	0	15.6	846
1983	9	72	1	2	431	0	68.2	581
1984	4	26	0	1	406	0	300	737
1985	15	90	2	4	223	0	159	493
1986	51	89	2	1	124	0	89	356
1987	65	152	1	1	288	0	73	580
1988	99	170	3	1	290	0	64	627
1989	197	209	2	0	414	0	71	893
1990	154	174	1	9	319	0	49	706
1991	131	103	1	1	300	0	23	559
1992	128	86	1	1	191	0	35	442
1993	107	106	0	3	271	0	3	490
1994	83	72	0	13	225	1	3	397
1995	74	49	1	9	185	0	1	319
1996	93	7	1	5	202	1	2	311

PacFinGearGroups.xls

Table 4. Lingcod landings (mt) by gear group for the Conception INPFC area, 1981-1996. Data source: PacFIN.

	Conception Area: Landings in Metric Tons							
YEAR	Hook&Line	Nets	Pot&Trap	Trolls	Trawls	Shrimp Trawl	Other	Total
1981	4	10	1	1	149	2	0.1	167
1982	3	18	0	0	134	8	0.1	163
1983	1	3	0	0	41	0	1.3	46
1984	1	3	0	0	9	3	5	21
1985	1	9	0	0	7	0	3	20
1986	2	7	0	0	3	0	3	15
1987	6	13	0	1	7	0	3	30
1988	5	24	0	0	5	0	4	38
1989	4	34	1	0	13	0	4	56
1990	6	25	0	0	24	0	3	58
1991	11	44	0	0	15	0	3	73
1992	20	25	0	0	16	0	3	64
1993	22	44	0	0	10	0	3	79
1994	18	21	2	0	21	3	1	66
1995	27	8	3	0	17	2	1	58
1996	23	5	7	0	6	1	1	43

PacFinGearGroups.xls

Table 5. Lingcod landings by BC Commercial, US Commercial, and Washington Sport fisheries in the Columbia, US Vancouver, and PMFC 3C-N areas (1956-1996).

Year	BC-Commercial		US-Commercial		WA Sport
	Landings (mt)	CPUE (mt/hr)	Landings (mt)	CPUE (lb/hr)	Landings (mt)
1956	874	0.310	920		
1957	849	0.298	1000		
1958	652	0.356	1133		
1959	475	0.306	1863		
1960	691	0.214	2028		
1961	842	0.312	1875		
1962	452	0.227	1323		
1963	344	0.345	938		
1964	527	0.419	1257		
1965	887	0.368	1538		
1966	866	0.308	1813		
1967	1041	0.423	1244		
1968	1123	0.603	1626		
1969	795	0.289	1148		
1970	823	0.282	851		
1971	964	0.358	1009		
1972	784	0.286	952		
1973	991	0.351	1326		
1974	1217	0.304	1549		
1975	1440	0.370	2019		43
1976	989	0.248	1662		24
1977	939	0.289	1671		32
1978	583	0.226	1346		27
1979	780	0.260	2211		23
1980	848	0.283	2004		28
1981	843	0.262	1937		33
1982	1731	0.412	2268		26
1983	1140	0.372	3051		37
1984	1859	0.445	3007		78
1985	3623	0.532	3125		60
1986	1075	0.380	1301		74
1987	726	0.206	1612	35.41	81
1988	678	0.208	1648	30.81	60
1989	981	0.317	2225	28.06	97
1990	1390	0.278	1745	20.93	76
1991	1446	0.260	2318	18.04	104
1992	1137	0.307	1205	13.15	105
1993	1688		1428	8.52	126
1994	881	0.219	1230		126
1995	984	0.234	861		85
1996	895	0.259	1018		70

PacFinGearGroups.xls

Table 6. Lingcod sport catch estimates (number of fish in thousands). Comparison of Marine Recreational Fisheries Statistics Survey (MRFSS) estimates with estimates from the California Department of Fish and Game (CDFG) partyboat fishery, and the Washington Department of Fish and Wildlife (WDFW) coastal port sampling creel survey. Data are not available for years/areas with blank cells.

Year	Marine Recreational Fisheries Statistics Survey (MRFSS)					CDFG	WDFW
	California		Oregon	Washington	Total		
	Southern	Northern					
1980	241.5	385.4	30.6	51.4	708.9	89.3	8.6
1981	43.5	303.9	70.1	175.3	592.8	65.6	9.5
1982	29.7	214.3	167.0	172.5	583.5	49.8	7.4
1983	18.6	149.8	51.7	98.2	318.3	30.5	13.1
1984	28.7	129.4	35.6	61.9	255.6	23.8	22.4
1985	47.5	189.6	57.6	56.5	351.2	20.6	17.2
1986	67.9	197.9	45.5	47.8	359.1	25.6	18.2
1987	78.3	209.0	65.7	51.2	404.2	37.6	20.9
1988	95.0	220.0	50.2	74.6	439.8	47.9	22.0
1989	45.9	246.1	45.4	35.4	372.8	61.0	27.6
1990						47.6	22.8
1991						35.9	22.7
1992						36.5	31.0
1993	19.4	150.2	120.0			31.2	39.3
1994	9.2	87.3	93.2			27.1	36.6
1995	8.1	100.7	39.1			25.7	22.6
1996	8.3	157.7	42.5	23.7	232.2	22.8	19.9

mrfssspt.xls

Table 7. Fishery and survey age frequencies of male lingcod used in the age structured model.

Year	Sample	Males												
	Age:	2	3	4	5	6	7	8	9	10	11	12	13	14
80	SPORT	-0.001	-0.001	-0.001	-0.001	-0.001	0.686	0.049	0.040	0.009	0.004	-0.001	-0.001	-0.001
86	SPORT	-0.001	-0.001	-0.001	-0.001	-0.001	0.418	0.056	0.018	0.015	0.006	0.003	0.003	-0.001
87	SPORT	-0.001	-0.001	-0.001	-0.001	-0.001	0.524	0.052	0.049	0.024	0.007	0.010	0.007	-0.001
88	SPORT	-0.001	0.004	0.178	0.296	0.196	0.052	0.011	0.004	-0.001	-0.001	-0.001	-0.001	-0.001
89	SPORT	-0.001	-0.001	0.071	0.280	0.163	0.117	0.038	0.025	0.029	0.004	0.004	-0.001	-0.001
90	SPORT	-0.001	-0.001	0.051	0.168	0.308	0.117	0.075	0.023	0.005	0.005	0.005	-0.001	-0.001
91	SPORT	0.004	0.004	0.035	0.152	0.163	0.097	0.093	0.016	0.016	0.020	-0.001	-0.001	-0.001
92	SPORT	-0.001	-0.001	0.125	0.195	0.165	0.094	0.029	0.010	0.004	0.002	-0.001	-0.001	-0.001
93	SPORT	-0.001	0.006	0.104	0.233	0.163	0.070	0.017	0.013	0.013	0.007	0.002	-0.001	-0.001
94	SPORT	-0.001	0.007	0.084	0.202	0.144	0.073	0.027	0.013	0.002	0.002	-0.001	-0.001	-0.001
95	SPORT	-0.001	0.002	0.006	0.181	0.217	0.065	0.014	0.012	-0.001	-0.001	-0.001	-0.001	-0.001
96	SPORT	-0.001	-0.001	0.009	0.110	0.249	0.078	0.020	0.007	-0.001	-0.001	-0.001	-0.001	-0.001
79	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.041	0.003	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
80	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.121	0.012	0.006	0.001	0.003	-0.001	-0.001	-0.001
81	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.292	0.024	0.009	0.011	0.002	-0.001	-0.001	-0.001
82	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.134	0.019	0.010	0.004	-0.001	-0.001	-0.001	-0.001
83	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.180	0.015	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
84	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.217	0.001	0.005	0.000	0.007	-0.001	-0.001	-0.001
85	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.137	0.021	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
86	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.294	0.082	0.048	0.029	0.021	0.007	0.008	0.012
87	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.122	0.003	0.007	0.004	-0.001	-0.001	-0.001	-0.001
88	US FISH	-0.001	-0.001	0.025	0.057	0.055	0.019	0.019	0.019	0.009	0.009	0.006	-0.001	-0.001
89	US FISH	-0.001	-0.001	0.007	0.097	0.103	0.033	0.010	0.001	0.002	-0.001	-0.001	-0.001	-0.001
90	US FISH	-0.001	-0.001	0.013	0.048	0.118	0.065	0.014	0.021	0.000	0.008	-0.001	-0.001	-0.001
91	US FISH	-0.001	0.004	0.008	0.040	0.035	0.042	0.026	0.007	-0.001	-0.001	-0.001	-0.001	-0.001
92	US FISH	0.039	0.028	0.055	0.047	0.036	0.023	0.007	0.002	-0.001	-0.001	-0.001	-0.001	-0.001
93	US FISH	0.022	0.051	0.051	0.046	0.018	0.007	0.004	0.001	0.002	-0.001	-0.001	-0.001	-0.001
94	US FISH	0.003	0.013	0.050	0.060	0.045	0.008	0.003	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
95	US FISH	-0.001	0.001	0.008	0.078	0.038	0.023	0.007	0.004	-0.001	-0.001	-0.001	-0.001	-0.001
96	US FISH	0.001	0.005	0.012	0.036	0.036	0.021	0.006	0.000	0.001	-0.001	-0.001	-0.001	-0.001
77	BC FISH	0.026	0.079	0.049	0.075	0.045	0.013	0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
78	BC FISH	-0.001	0.118	0.139	0.098	0.021	0.018	0.006	0.000	0.000	0.003	-0.001	-0.001	-0.001
79	BC FISH	0.004	0.005	0.026	0.068	0.072	0.067	0.054	0.043	0.025	0.005	0.005	0.000	0.004
80	BC FISH	0.003	0.024	0.049	0.245	0.094	0.105	0.049	0.028	0.007	0.003	0.003	-0.001	-0.001
81	BC FISH	0.006	0.070	0.108	0.073	0.141	0.128	0.041	0.038	0.010	0.013	-0.001	-0.001	-0.001
82	BC FISH	-0.001	-0.001	0.061	0.094	0.094	0.077	0.028	0.006	0.017	0.000	0.006	-0.001	-0.001
83	BC FISH	-0.001	0.006	0.048	0.123	0.129	0.042	0.030	0.009	0.012	0.006	0.003	-0.001	-0.001
84	BC FISH	0.006	0.030	0.086	0.143	0.108	0.024	0.007	0.000	0.004	-0.001	-0.001	-0.001	-0.001
85	BC FISH	0.005	0.056	0.056	0.069	0.074	0.032	0.028	0.005	0.019	0.000	0.000	0.005	-0.001
86	BC FISH	0.005	0.061	0.080	0.034	0.042	0.048	0.032	0.005	0.005	-0.001	-0.001	-0.001	-0.001
87	BC FISH	0.046	0.061	0.148	0.209	0.077	0.031	0.005	0.005	0.010	0.000	0.000	0.005	-0.001
88	BC FISH	0.025	0.065	0.077	0.096	0.084	0.025	0.058	0.013	0.013	0.006	0.000	0.006	-0.001
89	BC FISH	-0.001	0.024	0.185	0.057	0.043	0.047	0.009	0.000	0.000	0.000	0.005	0.000	0.005
90	BC FISH	-0.001	0.021	0.021	0.235	0.026	0.057	0.010	0.010	0.010	0.010	0.005	0.005	0.005
93	BC FISH	0.010	0.000	0.100	0.040	0.040	0.000	0.040	0.030	-0.001	-0.001	-0.001	-0.001	-0.001
95	BC FISH	-0.001	0.027	0.101	0.084	0.094	0.033	0.025	0.019	0.024	0.003	0.002	0.002	-0.001
95	NMFS SVY	0.030	0.049	0.035	0.123	0.064	0.025	0.005	0.000	0.005	-0.001	-0.001	-0.001	-0.001
95	WDFW SVY	0.018	0.117	0.245	0.284	0.082	0.018	0.004	0.004	-0.001	-0.001	-0.001	-0.001	-0.001
96	WDFW SVY	0.023	0.163	0.187	0.208	0.076	0.006	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001

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Table 8. Fishery and survey age frequencies of female lingcod used in the age structured model.

Year	Sample	Females												
	Age:	2	3	4	5	6	7	8	9	10	11	12	13	14
80	SPORT	-0.001	-0.001	-0.001	-0.001	-0.001	0.146	0.009	0.013	0.013	0.009	0.000	0.004	0.018
86	SPORT	-0.001	-0.001	-0.001	-0.001	-0.001	0.300	0.068	0.041	0.038	0.012	0.009	0.003	0.012
87	SPORT	-0.001	-0.001	-0.001	-0.001	-0.001	0.188	0.049	0.035	0.014	0.024	0.007	0.000	0.010
88	SPORT	-0.001	-0.001	0.022	0.107	0.056	0.059	0.011	0.000	0.000	0.004	-0.001	-0.001	-0.001
89	SPORT	-0.001	-0.001	0.013	0.042	0.059	0.054	0.038	0.025	0.029	0.004	0.000	0.000	0.004
90	SPORT	-0.001	-0.001	0.028	0.042	0.089	0.028	0.014	0.014	0.019	0.009	-0.001	-0.001	-0.001
91	SPORT	-0.001	-0.001	0.004	0.039	0.082	0.078	0.051	0.047	0.012	0.027	0.027	0.020	0.016
92	SPORT	-0.001	-0.001	0.050	0.081	0.088	0.077	0.025	0.021	0.013	0.006	0.008	0.002	0.008
93	SPORT	-0.001	0.007	0.043	0.119	0.067	0.072	0.026	0.024	0.006	0.002	0.004	0.002	0.002
94	SPORT	-0.001	-0.001	0.027	0.115	0.133	0.093	0.038	0.009	0.016	0.011	0.002	0.000	0.002
95	SPORT	-0.001	0.002	0.004	0.095	0.169	0.134	0.063	0.018	0.008	0.004	0.006	0.002	-0.001
96	SPORT	-0.001	-0.001	0.002	0.087	0.210	0.156	0.037	0.020	0.009	0.007	0.002	-0.001	-0.001
79	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.199	0.207	0.236	0.145	0.050	0.018	0.017	0.085
80	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.377	0.130	0.136	0.085	0.039	0.029	0.023	0.040
81	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.428	0.057	0.058	0.065	0.029	0.007	0.006	0.012
82	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.584	0.064	0.049	0.049	0.049	0.022	0.003	0.014
83	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.540	0.063	0.026	0.026	0.031	0.040	0.018	0.062
84	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.614	0.051	0.047	0.019	0.007	0.020	0.010	0.003
85	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.633	0.120	0.030	0.042	0.003	0.000	0.007	0.007
86	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.294	0.082	0.048	0.029	0.021	0.007	0.008	0.012
87	US FISH	-0.001	-0.001	-0.001	-0.001	-0.001	0.460	0.175	0.119	0.075	0.022	0.006	0.003	0.004
88	US FISH	-0.001	0.002	0.044	0.124	0.124	0.130	0.117	0.070	0.085	0.037	0.025	0.010	0.014
89	US FISH	-0.001	-0.001	0.022	0.206	0.247	0.112	0.059	0.038	0.025	0.022	0.007	0.008	-0.001
90	US FISH	-0.001	-0.001	0.010	0.082	0.222	0.168	0.081	0.065	0.029	0.028	0.023	0.002	0.004
91	US FISH	-0.001	-0.001	0.023	0.097	0.184	0.219	0.148	0.067	0.047	0.016	0.019	0.002	0.017
92	US FISH	0.056	0.071	0.132	0.134	0.102	0.081	0.100	0.038	0.008	0.011	0.012	0.004	0.014
93	US FISH	0.043	0.112	0.144	0.122	0.096	0.095	0.086	0.047	0.026	0.007	0.012	0.003	0.008
94	US FISH	0.009	0.058	0.115	0.217	0.191	0.123	0.063	0.025	0.009	0.003	0.001	0.000	0.004
95	US FISH	-0.001	0.004	0.033	0.258	0.293	0.144	0.043	0.030	0.013	0.009	0.003	0.002	0.010
96	US FISH	-0.001	0.008	0.018	0.098	0.276	0.282	0.128	0.029	0.017	0.011	0.006	0.004	0.004
77	BC FISH	0.017	0.116	0.049	0.101	0.195	0.135	0.039	0.032	0.015	0.002	0.004	0.002	0.002
78	BC FISH	0.003	0.056	0.065	0.077	0.092	0.127	0.086	0.030	0.015	0.024	0.012	0.003	0.009
79	BC FISH	0.005	0.015	0.063	0.074	0.097	0.097	0.099	0.069	0.054	0.023	0.012	0.007	0.009
80	BC FISH	-0.001	0.035	0.038	0.115	0.101	0.042	0.045	0.010	0.000	0.000	0.000	0.003	-0.001
81	BC FISH	0.006	0.032	0.041	0.057	0.061	0.057	0.038	0.025	0.025	0.019	0.006	0.000	0.003
82	BC FISH	-0.001	0.028	0.083	0.126	0.165	0.115	0.050	0.017	0.017	0.006	0.006	0.000	0.006
83	BC FISH	-0.001	0.003	0.063	0.162	0.153	0.093	0.063	0.024	0.015	0.006	0.003	0.006	0.003
84	BC FISH	0.004	0.062	0.085	0.164	0.148	0.058	0.024	0.019	0.006	0.004	0.006	0.006	0.004
85	BC FISH	0.009	0.060	0.088	0.083	0.120	0.139	0.037	0.065	0.023	0.009	0.019	-0.001	-0.001
86	BC FISH	0.003	0.066	0.143	0.106	0.095	0.103	0.085	0.037	0.013	0.005	0.003	0.008	0.019
87	BC FISH	0.031	0.041	0.071	0.097	0.077	0.026	0.020	0.010	0.010	0.000	0.000	0.010	0.010
88	BC FISH	0.006	0.084	0.058	0.153	0.065	0.071	0.025	0.038	0.006	0.006	0.006	0.000	0.013
89	BC FISH	0.009	0.019	0.123	0.076	0.133	0.104	0.047	0.038	0.014	0.038	0.005	0.009	0.010
90	BC FISH	0.021	0.016	0.047	0.146	0.073	0.063	0.057	0.042	0.010	0.016	0.042	0.031	0.020
93	BC FISH	0.020	0.090	0.130	0.050	0.080	0.050	0.180	0.040	0.050	0.020	0.010	0.000	0.020
95	BC FISH	0.003	0.028	0.141	0.105	0.089	0.069	0.037	0.025	0.048	0.016	0.011	0.004	0.010
95	NMFS SVY	0.096	0.067	0.062	0.163	0.168	0.086	0.010	0.010	0.000	0.000	0.005	-0.001	-0.001
95	WDFW SVY	-0.001	0.057	0.082	0.053	0.032	0.004	0.004	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
96	WDFW SVY	0.014	0.068	0.078	0.099	0.058	0.016	0.004	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001

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Table 9. Survey length frequencies of male lingcod used in the age structured model.

Year	Sample	Males																			
	Length (cm):	20	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	120
86	NMFS SVY	0.050	0.004	0.000	0.019	0.007	0.053	0.126	0.022	0.114	0.046	0.018	0.041	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
89	NMFS SVY	0.046	0.002	0.034	0.074	0.013	0.027	0.066	0.110	0.021	0.094	0.004	0.010	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
92	NMFS SVY	0.219	0.019	0.060	0.097	0.019	0.008	0.026	0.022	0.012	0.012	0.007	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
95	NMFS SVY	0.079	0.007	0.000	0.015	0.032	0.050	0.126	0.095	0.045	0.018	0.014	0.014	0.000	0.003	0.000	0.003	-0.001	-0.001	-0.001	-0.001
86	WDFW SVY	0.002	0.017	0.046	0.101	0.174	0.169	0.132	0.103	0.048	0.048	0.029	0.010	0.006	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
87	WDFW SVY	0.006	0.063	0.078	0.033	0.120	0.144	0.172	0.100	0.059	0.028	0.011	0.004	0.004	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
88	WDFW SVY	-0.001	0.003	0.022	0.147	0.268	0.115	0.093	0.089	0.043	0.035	0.014	0.003	0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
89	WDFW SVY	0.001	0.005	0.031	0.029	0.090	0.292	0.253	0.079	0.047	0.032	0.008	0.003	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
90	WDFW SVY	-0.001	0.026	0.076	0.038	0.085	0.069	0.142	0.187	0.067	0.018	0.015	0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
91	WDFW SVY	-0.001	0.021	0.112	0.071	0.187	0.119	0.084	0.082	0.068	0.025	0.008	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
92	WDFW SVY	0.012	0.108	0.163	0.073	0.151	0.106	0.048	0.035	0.025	0.020	0.003	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
93	WDFW SVY	0.002	0.111	0.222	0.122	0.146	0.079	0.039	0.021	0.006	0.002	0.001	0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
94	WDFW SVY	-0.001	0.045	0.075	0.155	0.210	0.113	0.080	0.043	0.018	0.002	0.000	0.002	0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
95	WDFW SVY	0.002	0.083	0.174	0.055	0.101	0.139	0.074	0.048	0.016	0.009	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
96	WDFW SVY	0.002	0.058	0.148	0.093	0.161	0.103	0.049	0.041	0.012	0.002	0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
97	WDFW SVY	0.004	0.108	0.141	0.062	0.143	0.086	0.040	0.022	0.004	0.002	0.004	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001

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Table 10. Survey length frequencies of female lingcod used in the age structured model.

Year	Sample	Females																			
	Length (cm):	20	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	120
86	NMFS SVY	0.010	0.013	0.012	0.000	0.001	0.013	0.048	0.031	0.090	0.048	0.099	0.038	0.029	0.029	0.020	0.006	0.010	0.000	0.005	-0.001
89	NMFS SVY	0.065	0.002	0.038	0.021	0.003	0.017	0.070	0.076	0.058	0.032	0.018	0.017	0.016	0.019	0.030	0.005	0.006	0.006	0.002	-0.001
92	NMFS SVY	0.132	0.020	0.038	0.068	0.020	0.018	0.026	0.007	0.023	0.010	0.020	0.016	0.034	0.026	0.019	0.006	0.003	0.006	0.008	-0.001
95	NMFS SVY	0.104	0.010	0.011	0.013	0.021	0.052	0.056	0.064	0.047	0.035	0.018	0.009	0.016	0.002	0.026	0.015	0.000	0.000	0.002	-0.001
86	WDFW SVY	-0.001	-0.001	0.012	0.010	0.017	0.025	0.033	0.006	0.006	0.002	0.000	0.002	0.000	0.000	0.002	-0.001	-0.001	-0.001	-0.001	-0.001
87	WDFW SVY	-0.001	0.013	0.035	0.028	0.011	0.020	0.022	0.017	0.009	0.013	0.002	0.004	0.000	0.002	0.004	0.002	-0.001	-0.001	-0.001	-0.001
88	WDFW SVY	-0.001	-0.001	0.004	0.011	0.043	0.049	0.014	0.011	0.004	0.010	0.011	0.005	0.001	0.001	0.001	0.000	0.001	-0.001	-0.001	-0.001
89	WDFW SVY	-0.001	0.001	0.008	0.005	0.009	0.020	0.023	0.030	0.014	0.004	0.005	0.004	0.001	0.001	0.001	0.001	0.000	0.001	0.001	-0.001
90	WDFW SVY	-0.001	0.018	0.060	0.028	0.014	0.057	0.016	0.014	0.016	0.027	0.018	0.002	0.002	0.000	0.004	-0.001	-0.001	-0.001	-0.001	-0.001
91	WDFW SVY	-0.001	0.004	0.040	0.020	0.037	0.066	0.020	0.016	0.007	0.005	0.003	0.004	0.002	0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
92	WDFW SVY	-0.001	0.021	0.065	0.019	0.048	0.045	0.030	0.014	0.008	0.005	0.002	0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
93	WDFW SVY	-0.001	0.019	0.064	0.042	0.032	0.051	0.017	0.009	0.006	0.002	0.002	0.002	0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
94	WDFW SVY	0.002	0.008	0.038	0.020	0.065	0.068	0.030	0.010	0.007	0.008	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
95	WDFW SVY	-0.001	0.022	0.091	0.053	0.029	0.019	0.017	0.024	0.022	0.009	0.009	0.002	0.003	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
96	WDFW SVY	-0.001	0.016	0.066	0.049	0.031	0.052	0.043	0.019	0.012	0.019	0.016	0.006	0.000	0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
97	WDFW SVY	0.004	0.042	0.100	0.030	0.044	0.076	0.026	0.016	0.024	0.008	0.004	0.008	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001

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Table 11. NMFS trawl survey results for lingcod in the Canadian Vancouver, US-Vancouver, and Columbia INPFC areas, 1977-1995. Estimated abundance (numbers in thousands) and biomass (mt), for both sexes combined. ** Note: In 1977, the shallow depth strata was 50-100 fm, not 30-100 fm. Sources: 1977-1980: Wilkins (1994), Mark Wilkins (Personal communication); 1989: Weinberg et.al. (1994); 1992, 1995: Mark Wilkins (Personal Communication). NMFSsurv.xls

Area/Depth	1977 **		1980		1983		1986		1989		1992		1995	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
Canadian Vancouver														
Abundance (Thous.)														
30-100 fm			453		1067				1788		887		1501	26.3
100-200 fm			127		10				44		41		20	66.8
Total			580	23.3	1077	33.2			1832	26.4	928	26.1	1521	26.0
Biomass (mt)														
30-100 fm			2100		7162				8175		2704		3243	31.2
100-200 fm			536		65				352		129		114	66.5
Total			2636	23.7	7227	55.2			8527	31.3	2833	37.0	3356	30.2
US Vancouver														
Abundance (Thous.)														
30-100 fm	273		220		302		227		491		364		220	27.6
100-200 fm	3		442		107		7		41		41		18	31.9
Total	276	52.9	663	68.1	409	19.6	234	12.2	533	27.3	405	28.0	237	25.6
Biomass (mt)														
30-100 fm	2260		951		1152		960		1616		973		478	30.9
100-200 fm	17		393		652		28		247		96		74	37.6
Total	2277	66.2	1343	46.5	1805	20.8	988	14.8	1863	23.4	1069	56.3	552	27.2
Columbia														
Abundance (Thous.)														
30-100 fm	1503		1118		789		483		800		1266		745	19.5
100-200 fm	37		19		118		24		131		85		61	26.9
Total	1541	83.5	1137	61.6	908	16.0	507	12.8	931	25.4	1351	23.2	807	18.1
Biomass (mt)														
30-100 fm	12341		8547		3419		1695		2920		2934		1165	21.1
100-200 fm	307		167		597		132		730		138		158	28.8
Total	12648	90.7	8714	73.6	4016	20.2	1828	15.9	3649	42.5	3071	63.8	1323	18.9

Table 12. NMFS trawl survey results for lingcod in the Eureka, Monterey, and Conception INPFC areas, 1977-1995. Estimated abundance (numbers in thousands) and biomass (mt), for both sexes combined. ** Note: In 1977, the shallow depth strata was 50-100 fm, not 30-100 fm. Sources: 1977-1980: Wilkins (1994), Mark Wilkins (Personal communication); 1989: Weinberg et.al. (1994); 1992, 1995: Mark Wilkins (Personal Communication). NMFSsurv.xls

Area/Depth	1977 **		1980		1983		1986		1989		1992		1995	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
Eureka														
Abundance (Thous.)														
30-100 fm	41		130		91		168		133		76		98	26.1
100-200 fm	2		13		20		11		31		27		19	52.2
Total	44	44.1	142	50.8	111	25.7	179	15.6	164	32.7	103	22	117	23.5
Biomass (mt)														
30-100 fm	242		356		391		247		362		60		130	26.9
100-200 fm	32		67		108		69		111		88		52	56.8
Total	274	38.3	423	55.1	498	38.2	316	28.1	473	30.9	148	33.0	182	25.1
Monterey														
Abundance (Thous.)														
30-100 fm	379		265		546		366		1195		654		546	25.7
100-200 fm	80		22		21		17		18		0		106	63.9
Total	459	36.7	287	22.4	567	24.4	382	18.4	1214	24.1	654	22.3	652	23.9
Biomass (mt)														
30-100 fm	1390		504		1443		503		2070		484		300	21.3
100-200 fm	410		210		26		108		38		0		410	57.8
Total	1800	25.4	714	32	1469	42.4	611	18.3	2107	24.1	484	29.9	710	34.5
Conception														
Abundance (Thous.)														
30-100 fm	14								142		66		110	34.3
100-200 fm	14								1		0		9	51.2
Total	27	27.1							143	28.3	66	38.9	119	32.0
Biomass (mt)														
30-100 fm	17								52		27		30	35.4
100-200 fm	52								2		0		12	63.4
Total	69	25.3							54	40.9	27	42.6	42	31.1

Table 13. Summary of lingcod biological parameters used in the age structured assessment. Data were fit using non-linear least squares.

Parameter	Male		Female	
	Estimate	SE	Estimate	SE
Growth[1]				
Linf	97.053		126.572	
K	0.152		0.126	
L1	26.282		22.662	
Length-Weight[2]				
a	0.003953	0.000732	0.001760	0.000289
b	3.214900	0.042400	3.397800	0.036200
R sq	0.52		0.71	
n	5149		12079	
Maturity[3]				
Alpha	0.7076	0.1042	0.6679	0.0298
Beta	3.4382	0.2001	4.5518	0.0693
R sq	0.95		0.99	
n	10		19	
Natural Mortality[4]				
M	0.32		0.18	
Fecundity[5]				
a			2.82406E-04	
b			3.0011	

[1] Growth Model: L = Linf+(L1-Linf)*exp(K*(1-Age)); Data Source: Present Study
[2] Length-Weight Model: $W=aL^b$; Data Source: Jagielo(1994)
[3] Maturity Model: P=1/(1+exp(-Alpha*(Age-Beta))); Data Source: Jagielo(1994)
[4] Natural Mortality: Data source: Jagielo(1994)
[5] Fecundity Model: $N=aL^b$; Data source: Hart(1967)

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Table 14. Estimated length, weight, and fraction mature at age for male and female lingcod used in the age structured model.

	Males					Females				
	Length		Weight		Fraction	Length		Weight		Fraction
Age	(Cm.)	(In.)	(Kg.)	(Lbs.)	Mature	(Cm.)	(In.)	(Kg.)	(Lbs.)	Mature
1	26.3	10.3	0.14	0.3	0.15	22.7	8.9	0.07	0.2	0.09
2	36.3	14.3	0.41	0.9	0.27	34.9	13.8	0.31	0.7	0.15
3	44.8	17.7	0.81	1.8	0.42	45.8	18.0	0.77	1.7	0.26
4	52.2	20.5	1.31	2.9	0.60	55.3	21.8	1.47	3.2	0.41
5	58.5	23.0	1.90	4.2	0.75	63.7	25.1	2.38	5.2	0.57
6	64.0	25.2	2.53	5.6	0.86	71.1	28.0	3.46	7.6	0.72
7	68.6	27.0	3.17	7.0	0.93	77.7	30.6	4.66	10.3	0.84
8	72.6	28.6	3.80	8.4	0.96	83.5	32.9	5.95	13.1	0.91
9	76.1	29.9	4.41	9.7	0.98	88.6	34.9	7.27	16.0	0.95
10	79.0	31.1	4.99	11.0	0.99	93.0	36.6	8.60	19.0	0.97
11	81.6	32.1	5.53	12.2	1.00	97.0	38.2	9.91	21.9	0.99
12	83.8	33.0	6.01	13.3	1.00	100.5	39.6	11.18	24.6	0.99
13	85.6	33.7	6.46	14.2	1.00	103.6	40.8	12.39	27.3	1.00
14	87.2	34.3	6.86	15.1	1.00	106.3	41.8	13.53	29.8	1.00
15	88.6	34.9	7.21	15.9	1.00	108.7	42.8	14.59	32.2	1.00
16	89.8	35.4	7.53	16.6	1.00	110.8	43.6	15.58	34.3	1.00
17	90.8	35.8	7.81	17.2	1.00	112.7	44.4	16.48	36.3	1.00
18	91.7	36.1	8.05	17.8	1.00	114.3	45.0	17.31	38.2	1.00
19	92.5	36.4	8.27	18.2	1.00	115.8	45.6	18.07	39.8	1.00
20	93.1	36.7	8.45	18.6	1.00	117.0	46.1	18.76	41.4	1.00
Linf	97.053					Linf	126.572			
K	0.152					K	0.126			
L1	26.282					L1	22.662			

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Table 15. Summary statistics for estimation of mean length (cm), and mean weight (kg.) at age of male and female lingcod used in the age-structured stock assessment. Survey data only were used for estimating mean size at age for ages 1-3. Survey and fishery data were used for ages 4+ .Growth97.xls

	Male						Female					
	Mean Length (cm)					Mean Wt.	Mean Length (cm)					Mean Wt
Age	Observed	Predicted	N Obs.	Std Dev	CV	(Kg.)	Observed	Predicted	N Obs.	Std Dev	CV	(Kg.)
1	25.3	26.3	3	3.51	0.14	0.14	26.5	22.7	2	7.78	0.29	0.07
2	38.9	36.3	38	5.51	0.14	0.41	35.9	34.9	51	4.13	0.12	0.31
3	44.6	44.8	132	3.41	0.08	0.81	43.7	45.8	83	4.89	0.11	0.77
4	51.0	52.2	942	4.90	0.10	1.31	52.5	55.3	1352	5.55	0.11	1.47
5	57.1	58.5	1638	4.88	0.09	1.90	60.1	63.7	2430	6.53	0.11	2.38
6	62.9	64.0	1320	5.54	0.09	2.53	67.3	71.1	2695	6.70	0.10	3.46
7	68.4	68.6	558	6.54	0.10	3.17	75.9	77.7	1902	7.60	0.10	4.66
8	73.9	72.6	348	7.14	0.10	3.80	84.9	83.5	1906	7.84	0.09	5.95
9	77.7	76.1	152	6.83	0.09	4.41	91.2	88.6	1271	7.81	0.09	7.27
10	79.1	79.0	71	7.32	0.09	4.99	96.2	93.0	798	7.13	0.07	8.60
11	83.1	81.6	35	5.61	0.07	5.53	98.9	97.0	451	7.63	0.08	9.91
12	83.8	83.8	13	9.98	0.12	6.01	102.6	100.5	272	7.08	0.07	11.18
13	83.4	85.6	5	4.62	0.06	6.46	105.8	103.6	178	7.21	0.07	12.39
14							107.7	106.3	120	9.23	0.09	13.53
15							109.2	108.7	95	7.13	0.07	14.59
16							111.0	110.8	56	8.46	0.08	15.58
17							113.2	112.7	25	6.75	0.06	16.48
18							117.4	114.3	14	5.54	0.05	17.31
19							106.0	115.8	2	19.80	0.19	18.07
20							117.0	117.0	4	4.76	0.04	18.76
Linf	97.053						Linf	126.572				
K	0.152						K	0.12568				
L1	26.282						L1	22.6619				

Table 16. Estimated mean length (cm) at age by each fishery and survey used in the age structured model.

	BC Commercial		US Commercial		US Sport		WDFW Survey		NMFS Survey	
Age	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1	39.2	40.4	33.7	30.4	37.0	15.4	35.9	35.9	24.8	24.1
2	48.7	50.0	40.7	40.2	43.1	29.3	41.7	42.3	34.1	33.5
3	56.2	58.4	47.2	49.1	48.8	41.4	47.2	48.7	42.5	42.5
4	62.2	65.8	53.1	57.2	54.1	52.0	52.3	55.1	50.2	50.9
5	66.9	72.3	58.5	64.6	59.0	61.2	57.1	61.6	57.2	59.0
6	70.6	78.0	63.5	71.3	63.5	69.4	61.6	68.0	63.6	66.6
7	73.5	83.1	68.1	77.5	67.8	76.4	65.8	74.4	69.4	73.8
8	75.9	87.5	72.2	83.0	71.7	82.6	69.8	80.8	74.8	80.7
9	77.7	91.4	76.1	88.1	75.4	88.1	73.4	87.2	79.6	87.2
10	79.2	94.8	79.6	92.7	78.8	92.8	76.9	93.6	84.1	93.3
11	80.3	97.7	82.8	96.9	81.9	97.0	80.1	100.0	88.2	99.2
12	81.2	100.4	85.8	100.8	84.9	100.6	83.2	106.4	91.9	104.7
13	82.0	102.7	88.5	104.2	87.6	103.8	86.0	112.8	95.3	109.9
14	82.5	104.7	91.0	107.4	90.2	106.6	88.7	119.2	98.4	114.9
Linf	84.717	119.399	118.366	139.536	123.664	125.934	127.841	17578	130.926	205.318
K	0.234	0.129	0.087	0.094	0.073	0.134	0.066	0.000	0.091	0.053
L1	39.212	40.413	33.652	30.354	37.004	15.395	35.875	35.874	24.833	24.083

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Table 17. Estimated mean weight (kg) at age by each fishery and survey used in the age structured model.

	BC Commercial		US Commercial		US Sport		WDFW Survey		NMFS Survey	
Age	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1	0.524	0.506	0.321	0.191	0.435	0.019	0.394	0.338	0.121	0.087
2	1.053	1.043	0.591	0.495	0.711	0.169	0.640	0.591	0.333	0.268
3	1.669	1.770	0.949	0.979	1.059	0.548	0.951	0.955	0.678	0.599
4	2.306	2.655	1.389	1.648	1.473	1.189	1.324	1.455	1.157	1.112
5	2.916	3.657	1.899	2.491	1.947	2.078	1.756	2.115	1.762	1.829
6	3.471	4.735	2.469	3.488	2.474	3.170	2.240	2.963	2.479	2.764
7	3.959	5.852	3.087	4.615	3.044	4.413	2.771	4.025	3.291	3.921
8	4.377	6.977	3.740	5.844	3.651	5.753	3.340	5.330	4.176	5.301
9	4.728	8.084	4.417	7.149	4.285	7.140	3.942	6.909	5.117	6.895
10	5.020	9.154	5.108	8.505	4.939	8.534	4.570	8.791	6.096	8.693
11	5.259	10.174	5.803	9.888	5.605	9.902	5.218	11.007	7.095	10.681
12	5.454	11.134	6.496	11.278	6.278	11.219	5.879	13.590	8.102	12.843
13	5.612	12.029	7.179	12.658	6.951	12.469	6.549	16.573	9.103	15.162
14	5.739	12.856	7.848	14.015	7.621	13.639	7.222	19.989	10.089	17.619

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Table 18. Biomass, recruitment, and fishing mortality rate estimates (1975-1997). Catch in 1997 is assumed to equal catch in 1996. Recruitment in 1995, 1996 and 1997 was assumed from a Beverton-Holt stock-recruitment curve with shape parameter = 0.889. F_{max} is the instantaneous rate of fishing mortality for fully selected age classes.

Year	Pop. Biomass (mt)	Female Egg Prod. (mil)	Recruitment (mil)	Exploit. Rate	Total Catch (mt)	BC Commercial		US Commercial		US Sport	
						F_{max}	Catch (mt)	F_{max}	Catch (mt)	F_{max}	Catch (mt)
Pristine	54544	108018	3399	0.00	0	0.0000	0	0.0000	0	0.0000	0
Equilibrium	35140	61683	3399	0.06	2000	0.1278	2000	0.0000	0	0.0000	0
1975	34601	61551	1084	0.10	3544	0.0754	1440	0.1321	2019	0.0142	85
1976	32667	58935	2611	0.08	2699	0.0542	989	0.1128	1662	0.0084	48
1977	31607	57274	3864	0.08	2674	0.0548	939	0.1167	1671	0.0115	64
1978	30333	55098	2060	0.07	1983	0.0366	583	0.0978	1346	0.0107	54
1979	30015	53950	3911	0.10	3037	0.0510	780	0.1740	2211	0.0103	46
1980	29273	50864	5127	0.10	2907	0.0571	848	0.1725	2004	0.0123	55
1981	28993	48843	3909	0.10	2846	0.0570	843	0.1748	1937	0.0151	66
1982	28698	47825	2142	0.14	4050	0.1135	1731	0.2140	2268	0.0119	51
1983	27318	45726	2363	0.16	4265	0.0739	1140	0.2969	3051	0.0161	74
1984	25344	42877	2209	0.20	5022	0.1294	1859	0.3002	3007	0.0337	156
1985	22495	38509	2155	0.31	6868	0.3116	3623	0.3611	3125	0.0326	120
1986	18277	30559	3365	0.14	2524	0.1090	1075	0.1755	1301	0.0504	148
1987	17500	29159	1252	0.14	2499	0.0759	726	0.2266	1612	0.0571	161
1988	16573	27710	1102	0.15	2445	0.0711	678	0.2415	1648	0.0431	119
1989	15611	26387	1559	0.22	3400	0.1092	981	0.3486	2225	0.0690	194
1990	13678	23087	1787	0.24	3287	0.1856	1390	0.3089	1745	0.0621	152
1991	12111	19868	2534	0.33	3971	0.2523	1446	0.5405	2318	0.1231	207
1992	10117	15072	2535	0.25	2552	0.2370	1137	0.3859	1205	0.1683	210
1993	9353	13411	833	0.36	3367	0.3737	1688	0.5693	1428	0.2331	251
1994	7979	11240	1338	0.30	2362	0.1963	881	0.5437	1230	0.2291	251
1995	7368	10505	1682	0.27	2014	0.2208	984	0.3495	861	0.1302	169
1996	7080	10258	1534	0.29	2052	0.2192	895	0.3974	1018	0.1167	139
1997	6714	9499	1477	0.31	2052	0.2356	895	0.4395	1018	0.1401	139

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Table 19. Summary table showing qualitative effect of emphasis profiling results (preliminary base model). For each model component emphasized (leftmost column), the direction of model fit is shown for each other model component. A "+" indicates model fit improvement to that data series. A "-" indicates degraded model fit to that data series. Little change in model fit to the data series is denoted by "nil". The effect on ending biomass is shown in the rightmost column; a "+" indicates increased ending biomass, a "-" indicates decreased ending biomass, and "nil" indicates little change in ending biomass.

	Effect on model fit by component and on ending biomass								
Component Emphasized	BC Comm Age	US Comm Age	BC CPUE	US CPUE	WDFW Survey Abundance	WDFW Survey Size Comp.	NMFS Survey Biomass	NMFS Survey Size Comp.	Ending Biomass
BC Comm Age (Figure 26)		-	+	-	-	-	+	nil	+
US Comm Age (Figure 27)	-		+	-	+	-	+	nil	nil
US CPUE (Figure 29)	-	nil	-		-	+	-	nil	-
WDFW Survey Abundance (Figure 30)	-	+	+	-		nil	+	+	-
WDFW Survey Size Comp. (Figure 31)	-	-	-	+	-		-	-	-
NMFS Survey Biomass (Figure 32)	-	+	+	-	+	-		nil	nil
NMFS Survey Size Comp. (Figure 33)	+	-	+	-	-	-	+		+

Table 20. Forecast yields for 1998-2000 at $F_{35\%}$. Recruitment for 1998-2000 is set at the geometric mean of recruitment estimates for 1986-1995 (1.637 million age 2 fish). $F_{35\%}$ corresponds to an exploitation rate of 0.14.

Year	Biomass	Female Egg	Recruitment	Exploitation	$F_{35\%}$ Catch	BC Commercial			US Commercial			US Sport		
	(mt)	Prod. (Mil)	Mil. Age 2	Rate	(mt)	F	Catch (mt)	Exp Bio (mt)	F	Catch (mt)	Exp Bio (mt)	F	Catch (mt)	Exp Bio (mt)
1997	6714	9499	1.477	0.31	2052	0.24	895	3137	0.44	1018	2775	0.14	139	1258
1998	6404	8704	1.637	0.13	862	0.09	383	2988	0.17	417	2493	0.06	62	1227
1999	7197	9987	1.637	0.14	1029	0.09	445	3532	0.17	508	3051	0.06	77	1539
2000	7915	11256	1.637	0.15	1172	0.09	494	3991	0.17	592	3585	0.06	86	1741
1998-2000 Av	7172			0.14	1021	0.09	441	3503	0.17	506	3043	0.06	75	1502

Table 21. Forecast yields for 1998-2000 at $F_{40\%}$. Recruitment for 1998-2000 is set at the geometric mean of recruitment estimates for 1986-1995 (1.637 million age 2 fish). $F_{40\%}$ corresponds to an exploitation rate of 0.12.

Year	Biomass	Female Egg	Recruitment	Exploitation	$F_{40\%}$ Catch	BC Commercial			US Commercial			US Sport		
	(mt)	Prod. (Mil)	Mil. Age 2	Rate	(mt)	F	Catch (mt)	Exp Bio (mt)	F	Catch (mt)	Exp Bio (mt)	F	Catch (mt)	Exp Bio (mt)
1997	6714	9499	1.477	0.31	2052	0.24	895	3137	0.44	1018	2775	0.14	139	1258
1998	6404	8704	1.637	0.11	736	0.08	327	2988	0.15	357	2493	0.05	53	1227
1999	7308	10190	1.637	0.12	898	0.08	386	3603	0.15	445	3130	0.05	67	1574
2000	8145	11690	1.637	0.13	1041	0.08	435	4138	0.15	529	3752	0.05	77	1812
1998-2000 Av	7286			0.12	892	0.08	383	3576	0.15	444	3125	0.05	66	1537

Table 22. Forecast yields for 1998-2000 at $F_{45\%}$. Recruitment for 1998-2000 is set at the geometric mean of recruitment estimates for 1986-1995 (1.637 million age 2 fish). $F_{45\%}$ corresponds to an exploitation rate of 0.10.

Year	Biomass	Female Egg	Recruitment	Exploitation	$F_{45\%}$ Catch	BC Commercial			US Commercial			US Sport		
	(mt)	Prod. (Mil)	Mil. Age 2	Rate	(mt)	F	Catch (mt)	Exp Bio (mt)	F	Catch (mt)	Exp Bio (mt)	F	Catch (mt)	Exp Bio (mt)
1997	6714	9499	1.477	0.31	2052	0.24	895	3137	0.44	1018	2775	0.14	139	1258
1998	6404	8704	1.637	0.10	630	0.07	279	2988	0.12	306	2493	0.04	45	1227
1999	7402	10362	1.637	0.11	783	0.07	335	3664	0.12	389	3196	0.04	59	1604
2000	8345	12068	1.637	0.11	920	0.07	381	4265	0.12	471	3898	0.04	68	1873
1998-2000 Av	7384			0.10	777	0.07	332	3639	0.12	388	3196	0.04	57	1568

Table 23. Forecast yields for 1998-2000 at $F_{20\%}$. Recruitment for 1998-2000 is set at the geometric mean of recruitment estimates for 1986-1995 (1.637 million age 2 fish). $F_{20\%}$ corresponds to an exploitation rate of 0.25.

Year	Biomass	Female Egg	Recruitment	Exploitation	$F_{20\%}$ Catch	BC Commercial			US Commercial			US Sport		
	(mt)	Prod. (Mil)	Mil. Age 2	Rate	(mt)	F	Catch (mt)	Exp Bio (mt)	F	Catch (mt)	Exp Bio (mt)	F	Catch (mt)	Exp Bio (mt)
1997	6714	9499	1.477	0.31	2052	0.24	895	3137	0.44	1018	2775	0.14	139	1258
1998	6404	8704	1.637	0.23	1504	0.17	675	2988	0.33	723	2493	0.10	107	1227
1999	6632	8964	1.637	0.24	1601	0.17	712	3167	0.33	771	2659	0.10	118	1358
2000	6834	9242	1.637	0.25	1675	0.17	740	3303	0.33	813	2812	0.10	122	1410
1998-2000 Av.	6623			0.24	1593	0.17	709	3153	0.33	769	2655	0.10	115	1331

Table 24. Decision table (F35%) showing possible alternative states of nature (Top - 1977 biomass in metric tons) and the consequence of alternate management actions (Side - 1998-2000 annual catch).

			True State of Nature: 1997 Biomass		
			1 Sigma low 3916 mt	Best Estimate 6714 mt	1 Sigma high 11511 mt
Management Action	Fish at 1 Sigma low (593 mt)	1998-2000 Av. Catch (mt)	593	593	593
		1998-2000 Av. Expl Rate	0.141	0.078	0.044
		F_{max}	0.323 ($F_{35\%}$)	0.169	0.093
		Biomass in 2000 (mt)	4617	8659	15553
	Fish at Best Estimate (1017 mt)	1998-2000 Av. Catch (mt)	1017	1017	1017
		1998-2000 Av. Expl Rate	0.270	0.141	0.078
		F_{max}	0.703	0.323 ($F_{35\%}$)	0.169
		Biomass in 2000 (mt)	3801	7916	14845
	Fish at 1 Sigma high (1744 mt)	1998-2000 Av. Catch (mt)	1744	1744	1744
		1998-2000 Av. Expl Rate	0.620	0.270	0.141
		F_{max}	2.71	0.703	0.323 ($F_{35\%}$)
		Biomass in 2000 (mt)	2107	6517	13572

Table 25. Decision table (F40%) showing possible alternative states of nature (Top - 1977 biomass in metric tons) and the consequence of alternate management actions (Side - 1998-2000 annual catch).

			True State of Nature: 1997 Biomass		
			1 Sigma low 3916 mt	Best Estimate 6714 mt	1 Sigma high 11511 mt
Management Action	Fish at 1 Sigma low (518 mt)	1998-2000 Av. Catch (mt)	518	518	518
		1998-2000 Av. Expl Rate	0.121	0.068	0.039
		F_{max}	0.272 ($F_{40\%}$)	0.145	0.081
		Biomass in 2000 (mt)	4751	8786	15675
	Fish at Best Estimate (888 mt)	1998-2000 Av. Catch (mt)	888	888	888
		1998-2000 Av. Expl Rate	0.227	0.121	0.068
		F_{max}	0.5654	0.272 ($F_{40\%}$)	0.145
		Biomass in 2000 (mt)	4061	8147	15062
	Fish at 1 Sigma high (1523 mt)	1998-2000 Av. Catch (mt)	1523	1523	1523
		1998-2000 Av. Expl Rate	0.485	0.227	0.121
		F_{max}	1.684	0.566	0.272
		Biomass in 2000 (mt)	2657	6962	13967

Table 26. Decision table (F20%) showing possible alternative states of nature (Top - 1977 biomass in metric tons) and the consequence of alternate management actions (Side - 1998-2000 annual catch).

			True State of Nature: 1997 Biomass		
			1 Sigma low 3916 mt	Best Estimate 6714 mt	1 Sigma high 11511 mt
Management Action	Fish at 1 Sigma low (925 mt)	1998-2000 Av. Catch (mt)	925	925	925
		1998-2000 Av. Expl Rate	0.239	0.127	0.071
		F_{max}	0.603 ($F_{20\%}$)	0.286	0.152
		Biomass in 2000 (mt)	3987	8082	15000
	Fish at Best Estimate (1587 mt)	1998-2000 Av. Catch (mt)	1587	1587	1587
		1998-2000 Av. Expl Rate	0.521	0.239	0.127
		F_{max}	1.914	0.603 ($F_{20\%}$)	0.287
		Biomass in 2000 (mt)	2498	6836	13854
	Fish at 1 Sigma high (2720 mt)	1998-2000 Av. Catch (mt)	2720	2720	2720
		1998-2000 Av. Expl Rate	3+	0.520	0.239
		F_{max}	++++	1.911	0.603 ($F_{20\%}$)
		Biomass in 2000 (mt)	nil	4286	11719

Figure 1. Map showing INPFC areas and the area covered by the age-structured stock assessment (Map produced by Marion Berejikian, WDFW).

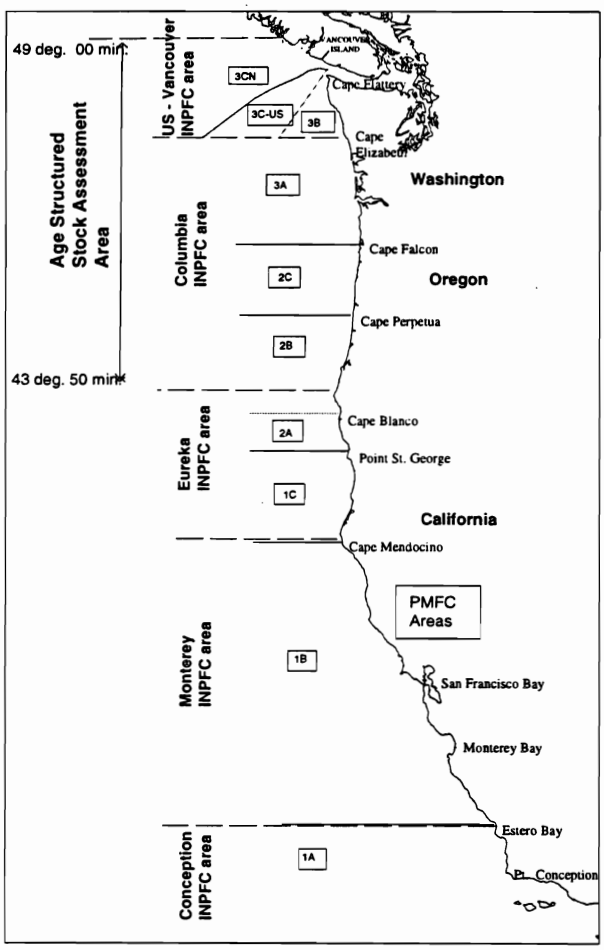


Figure 2. Lingcod mean length at age (cm), by year (1979-1996) for WDFW trawl samples.

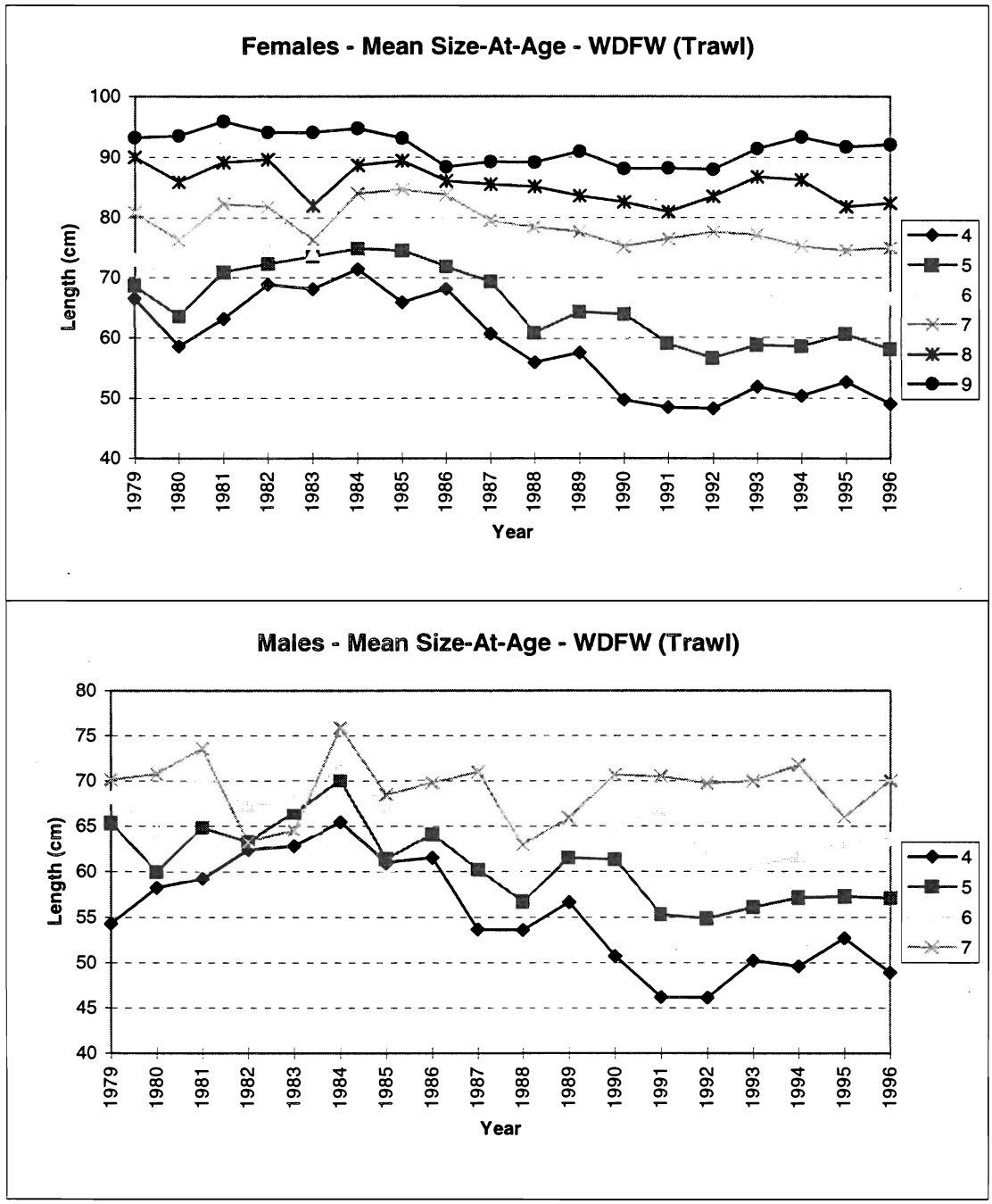


Figure 3. Results of re-aging experiment for selected samples collected in 1982, 1984, and 1986 (left panel), and selected samples collected in 1990, 1992, and 1994 (right panel). Approximately 100 fish per year were re-aged. In each panel, the original age assigned is shown on the left axis, and the distribution of new ages assigned is shown on the bottom axis.

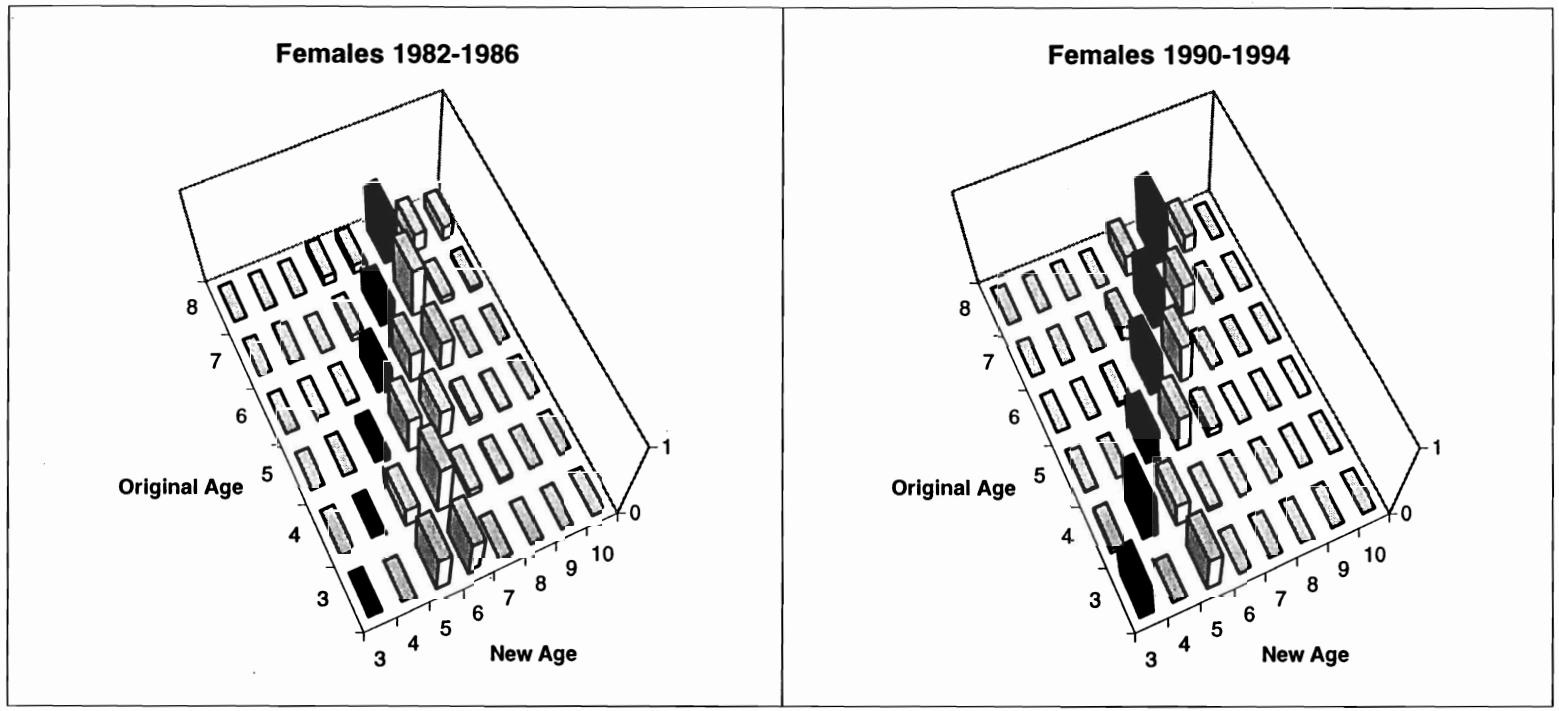
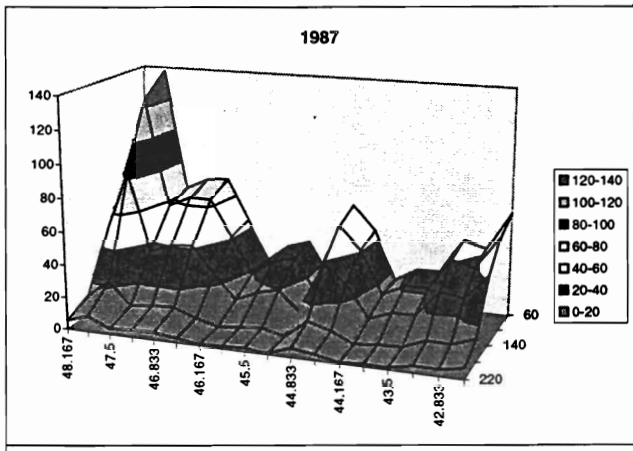
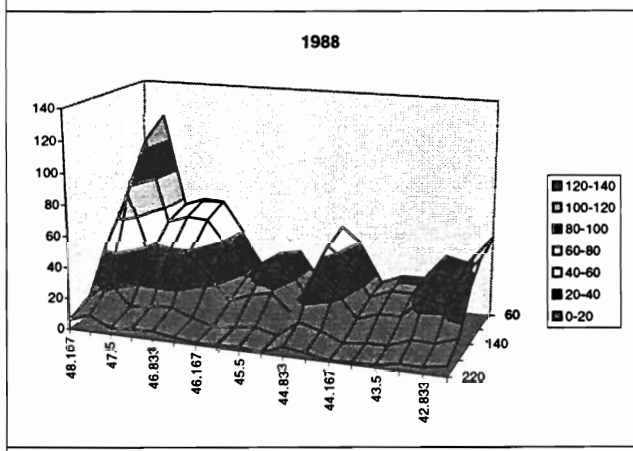


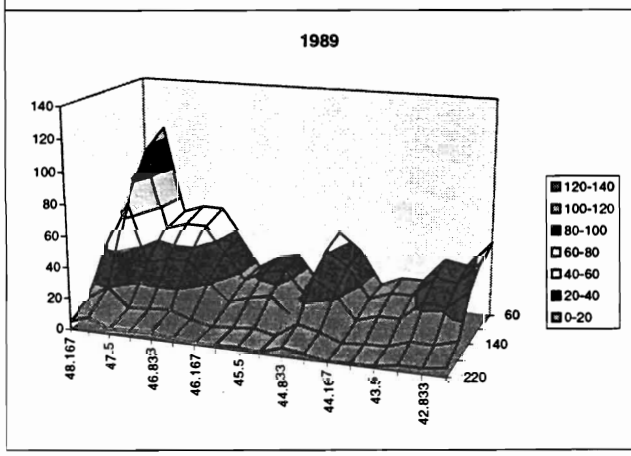
Figure 4. Effective lingcod CPUE (lb/hr) for the Oregon trawl fishery, by depth zone (fm) and latitude degrees N) (1987-1989). Source: Sampson(1997).



1987	Depth Midpoint				
Lat (Deg.)	220 fm	180 fm	140 fm	100 fm	60 fm
48.167	5.325	12.541	48.854	76.611	83.863
47.833	9.907	22.801	83.365	124.911	137.406
47.500	3.724	8.876	35.822	57.750	63.023
47.167	4.470	10.511	40.786	63.766	69.826
46.833	4.844	11.241	42.027	63.950	70.232
46.500	2.524	6.068	25.146	41.433	45.104
46.167	0.931	2.302	10.454	18.748	20.205
45.833	1.536	3.750	16.345	28.168	30.503
45.500	2.124	5.033	19.954	31.717	34.668
45.167	0.573	1.409	6.285	11.070	11.956
44.833	5.589	12.214	39.403	54.668	60.609
44.500	3.546	8.038	28.262	41.272	45.522
44.167	0.701	1.736	7.923	14.284	15.384
43.833	1.367	3.265	13.275	21.531	23.481
43.500	1.466	3.471	13.742	21.818	23.850
43.167	4.217	9.198	29.549	40.901	45.356
42.833	4.049	8.736	27.416	37.471	41.603
42.500	6.435	13.781	42.571	57.704	64.120



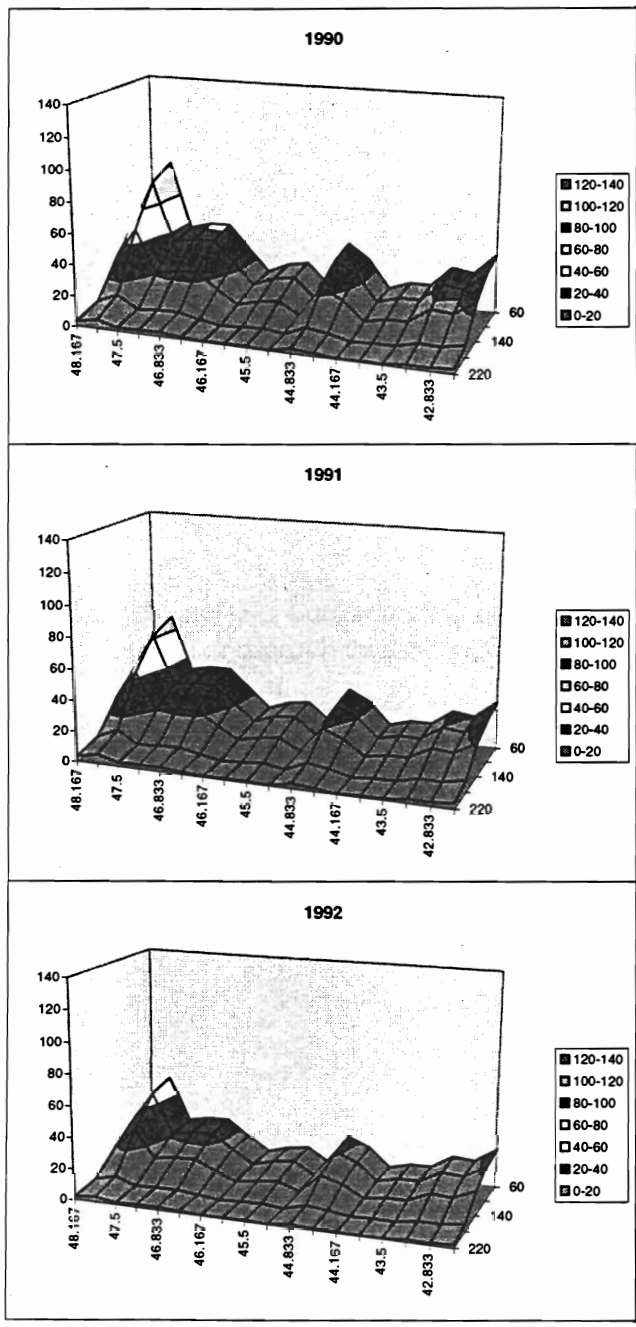
1988	Depth Midpoint				
Lat (Deg.)	220 fm	180 fm	140 fm	100 fm	60 fm
48.167	5.763	13.024	45.465	66.091	72.931
47.833	10.634	23.309	75.702	105.424	116.838
47.500	4.047	9.296	33.829	50.525	55.598
47.167	4.834	10.906	37.896	54.929	60.631
46.833	5.215	11.557	38.484	54.366	60.167
46.500	2.751	6.395	24.020	36.670	40.258
46.167	1.025	2.476	10.427	17.419	18.933
45.833	1.683	3.998	15.978	25.558	27.916
45.500	2.304	5.249	18.704	27.549	30.359
45.167	0.630	1.510	6.212	10.174	11.083
44.833	5.888	12.076	34.288	44.604	49.756
44.500	3.786	8.134	25.305	34.427	38.242
44.167	0.772	1.869	7.923	13.314	14.461
43.833	1.486	3.426	12.576	18.897	20.781
43.500	1.589	3.619	12.873	18.939	20.874
43.167	4.440	9.084	25.679	33.339	37.197
42.833	4.246	8.571	23.656	30.384	33.933
42.500	6.729	13.459	36.560	46.634	52.114



1989	Depth Midpoint				
Lat (Deg.)	220 fm	180 fm	140 fm	100 fm	60 fm
48.167	4.833	11.105	40.435	60.417	66.480
47.833	8.948	19.998	67.938	97.118	107.352
47.500	3.388	7.900	29.922	45.957	50.421
47.167	4.055	9.302	33.723	50.239	55.298
46.833	4.383	9.893	34.431	49.956	55.137
46.500	2.301	5.421	21.154	33.217	36.356
46.167	0.854	2.082	9.032	15.501	16.795
45.833	1.404	3.373	13.949	22.943	24.981
45.500	1.930	4.468	16.590	25.123	27.605
45.167	0.525	1.271	5.400	9.090	9.871
44.833	4.992	10.497	31.248	41.572	46.277
44.500	3.192	7.007	22.827	31.845	35.286
44.167	0.643	1.571	6.857	11.834	12.813
43.833	1.244	2.909	11.111	17.169	18.824
43.500	1.332	3.081	11.421	17.275	18.984
43.167	3.765	7.899	23.414	31.083	34.608
42.833	3.606	7.472	21.623	28.379	31.631
42.500	5.722	11.754	33.475	43.606	48.637

EffectiveEff-OR.xls

Figure 5. Effective lingcod CPUE (lb/hr) for the Oregon trawl fishery, by depth zone (fm) and latitude (Degrees N) (1990-1992). Source: Sampson(1997).



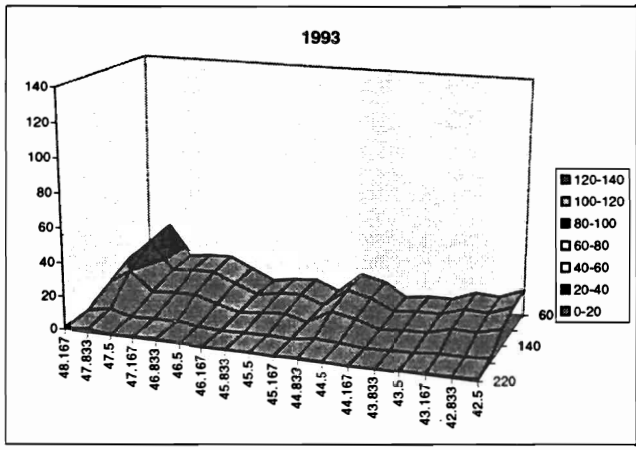
1990 Lat (Deg.)	Depth Midpoint 220 fm	180 fm	140 fm	100 fm	60 fm
48.167	3.013	7.147	28.439	45.333	49.535
47.833	5.613	13.032	48.778	74.286	81.576
47.500	2.106	5.051	20.790	34.065	37.107
47.167	2.529	5.991	23.750	37.745	41.257
46.833	2.743	6.418	24.547	37.968	41.624
46.500	1.426	3.449	14.561	24.378	26.489
46.167	0.526	1.304	6.002	10.918	11.745
45.833	0.867	2.127	9.422	16.484	17.819
45.500	1.202	2.866	11.599	18.739	20.445
45.167	0.324	0.799	3.615	6.461	6.966
44.833	3.177	7.025	23.270	32.774	36.282
44.500	2.011	4.603	16.586	24.612	27.102
44.167	0.396	0.983	4.547	8.312	8.937
43.833	0.773	1.857	7.700	12.692	13.815
43.500	0.829	1.977	7.989	12.892	14.068
43.167	2.397	5.291	17.456	24.526	27.158
42.833	2.304	5.032	16.222	22.498	24.944
42.500	3.663	7.945	25.217	34.675	38.476

1991 Lat (Deg.)	Depth Midpoint 220 fm	180 fm	140 fm	100 fm	60 fm
48.167	3.238	7.381	26.314	38.772	42.725
47.833	5.986	13.251	44.010	62.078	68.712
47.500	2.272	5.259	19.527	29.568	32.489
47.167	2.717	6.182	21.940	32.232	35.529
46.833	2.934	6.563	22.339	31.974	35.338
46.500	1.544	3.613	13.835	21.416	23.477
46.167	0.574	1.393	5.956	10.085	10.944
45.833	0.943	2.254	9.163	14.861	16.207
45.500	1.294	2.972	10.811	16.142	17.763
45.167	0.353	0.850	3.555	5.902	6.419
44.833	3.327	6.910	20.085	26.413	29.435
44.500	2.133	4.634	14.749	20.312	22.536
44.167	0.432	1.051	4.524	7.704	8.354
43.833	0.834	1.937	7.255	11.052	12.137
43.500	0.893	2.049	7.442	11.099	12.215
43.167	2.509	5.199	15.045	19.746	22.009
42.833	2.401	4.912	13.877	18.011	20.096
42.500	3.808	7.720	21.464	27.659	30.881

1992 Lat (Deg.)	Depth Midpoint 220 fm	180 fm	140 fm	100 fm	60 fm
48.167	1.769	4.240	17.427	28.517	31.068
47.833	3.302	7.765	30.133	47.117	51.593
47.500	1.235	2.990	12.681	21.319	23.154
47.167	1.485	3.556	14.561	23.757	25.891
46.833	1.612	3.818	15.122	24.015	26.252
46.500	0.836	2.038	8.849	15.194	16.461
46.167	0.307	0.766	3.601	6.694	7.181
45.833	0.507	1.254	5.686	10.186	10.979
45.500	0.705	1.699	7.091	11.759	12.791
45.167	0.189	0.470	2.175	3.975	4.274
44.833	1.878	4.226	14.592	21.069	23.265
44.500	1.184	2.750	10.296	15.682	17.221
44.167	0.231	0.578	2.726	5.091	5.459
43.833	0.453	1.099	4.692	7.934	8.611
43.500	0.486	1.172	4.885	8.091	8.803
43.167	1.417	3.184	10.951	15.773	17.422
42.833	1.363	3.034	10.204	14.499	16.037
42.500	2.169	4.797	15.889	22.379	24.774

EffectiveEff-OR.xls

Figure 6. Effective lingcod CPUE (lb/hr) for the Oregon trawl fishery, by depth zone (fm) and latitude (Degrees N) (1993). Source: Sampson(1997).



1993	Depth Midpoint				
Lat (Deg.)	220 fm	180 fm	140 fm	100 fm	60 fm
48.167	1.216	2.888	11.544	18.467	20.171
47.833	2.266	5.270	19.822	30.294	33.255
47.500	0.849	2.040	8.434	13.867	15.100
47.167	1.021	2.421	9.641	15.377	16.801
46.833	1.107	2.595	9.972	15.478	16.962
46.500	0.575	1.393	5.904	9.919	10.773
46.167	0.212	0.526	2.430	4.432	4.766
45.833	0.350	0.859	3.817	6.699	7.238
45.500	0.485	1.158	4.707	7.631	8.323
45.167	0.131	0.322	1.464	2.624	2.828
44.833	1.283	2.844	9.475	13.389	14.817
44.500	0.812	1.862	6.745	10.043	11.055
44.167	0.160	0.397	1.840	3.374	3.626
43.833	0.312	0.750	3.123	5.166	5.621
43.500	0.335	0.799	3.242	5.250	5.727
43.167	0.968	2.143	7.108	10.020	11.092
42.833	0.931	2.038	6.608	9.194	10.190
42.500	1.480	3.219	10.275	14.173	15.722

EffectiveEff-OR.xls

Figure7. Effective standardized lingcod CPUE (lb/hr) for the Columbia and US-Vancouver INPFC area (42.500 - 48.167 deg. N lat.; 40-240 fm depth range). Data Source: Sampson (1997).

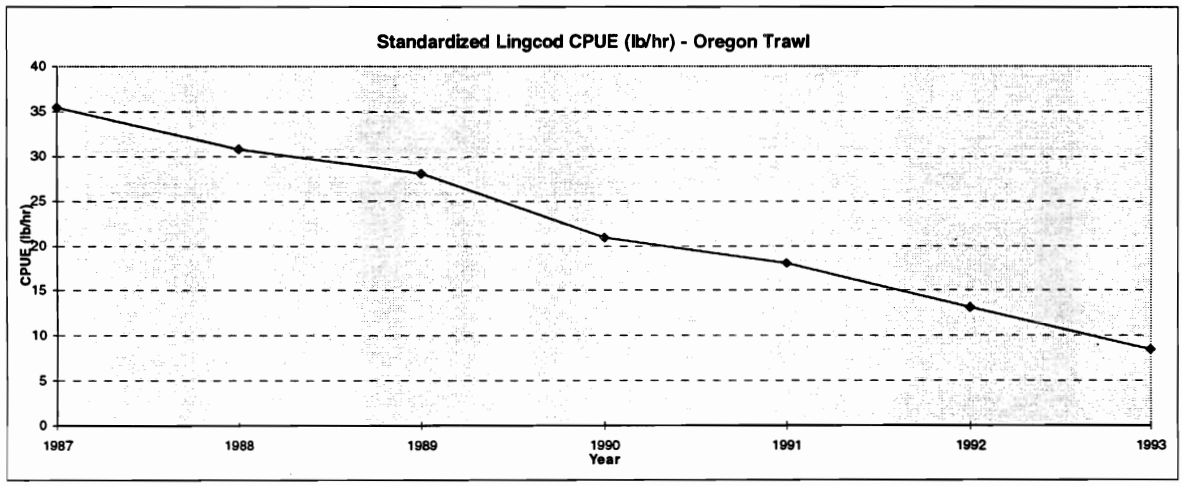
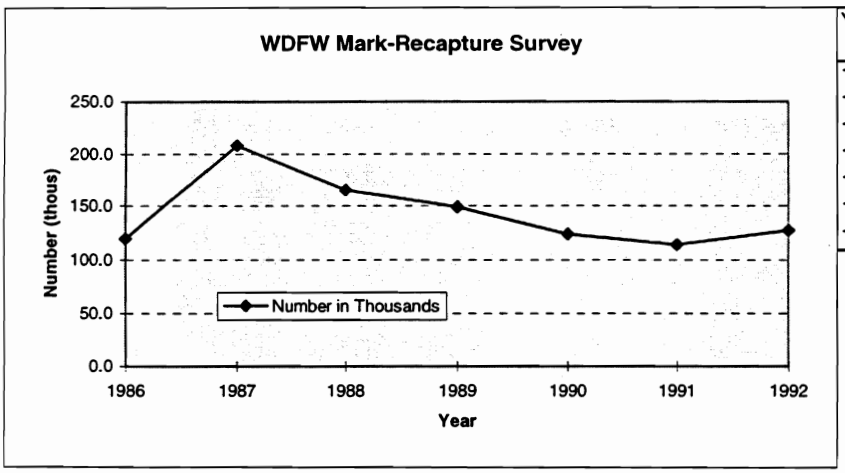


Figure 8. WDFW Cape Flattery mark-recapture survey abundance estimates (thousands), (1986-1992). Data Source: Jagielo(1995).



Year	Number (Thousands)	SE
1986	119.7	18.8
1987	208.5	31.8
1988	165.4	19.0
1989	149.0	13.5
1990	123.8	10.3
1991	114.4	9.5
1992	127.3	11.0

Figure 9. NMFS triennial trawl survey lingcod biomass estimates (mt) for the Columbia and US-Vancouver area (1977-1995). Data Source: Table 11.

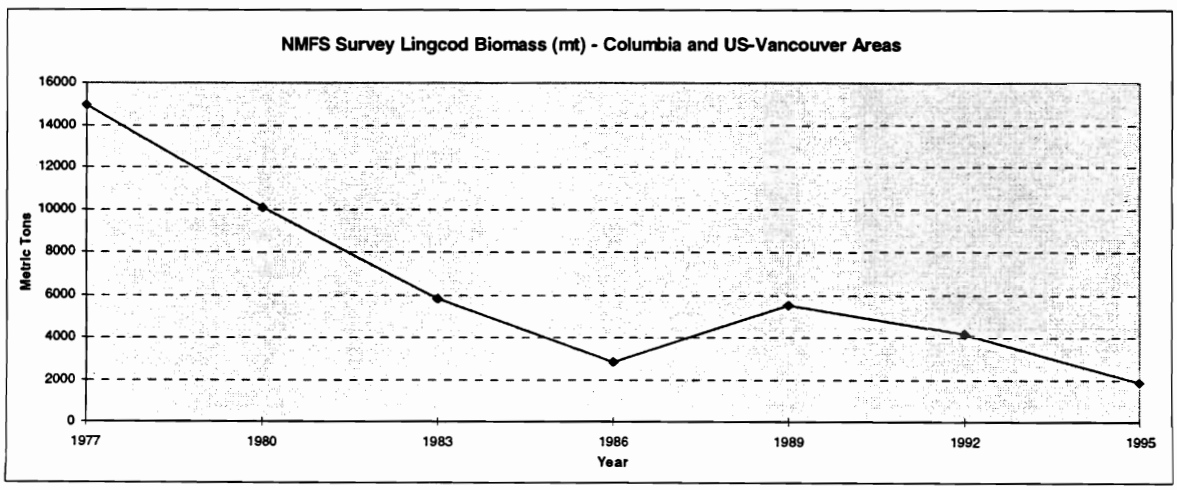
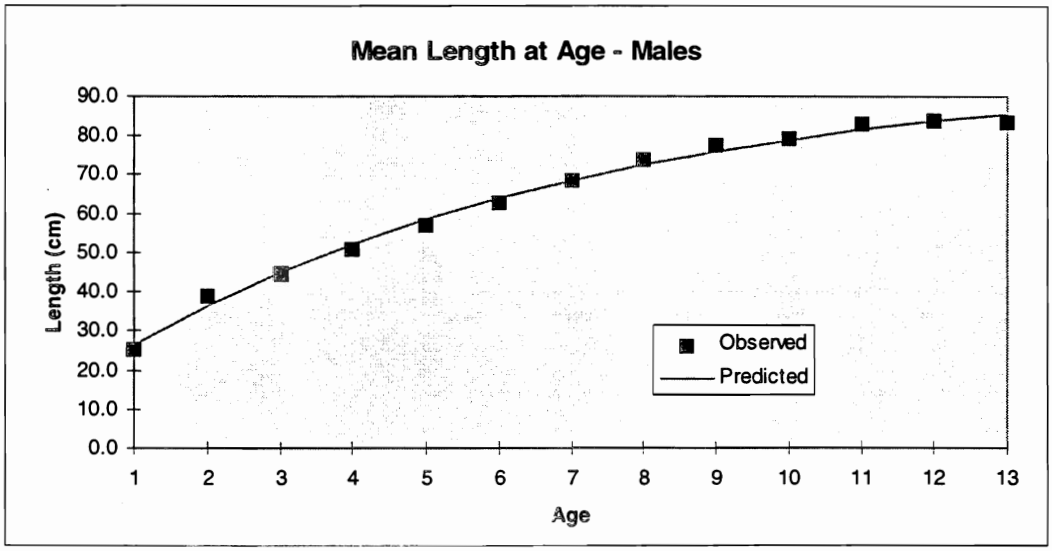
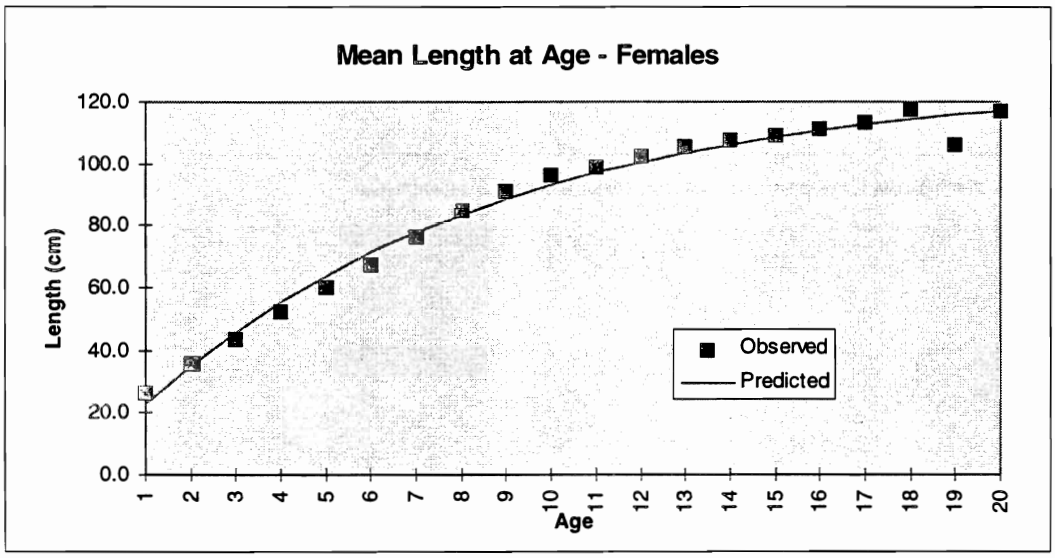


Figure 10. Fit of predicted male and female mean length at age for the lingcod population.





Growth97.xls

Figure11. Profile of total likelihood over fixed levels of ending biomass (metric tons), for ages 4-14 (preliminary base model). run95.xls

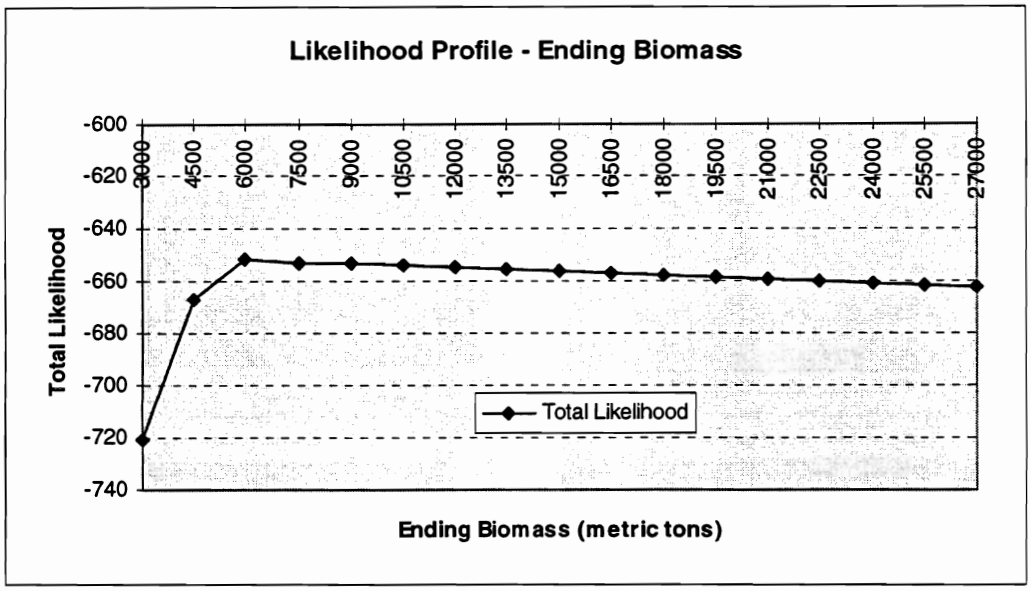
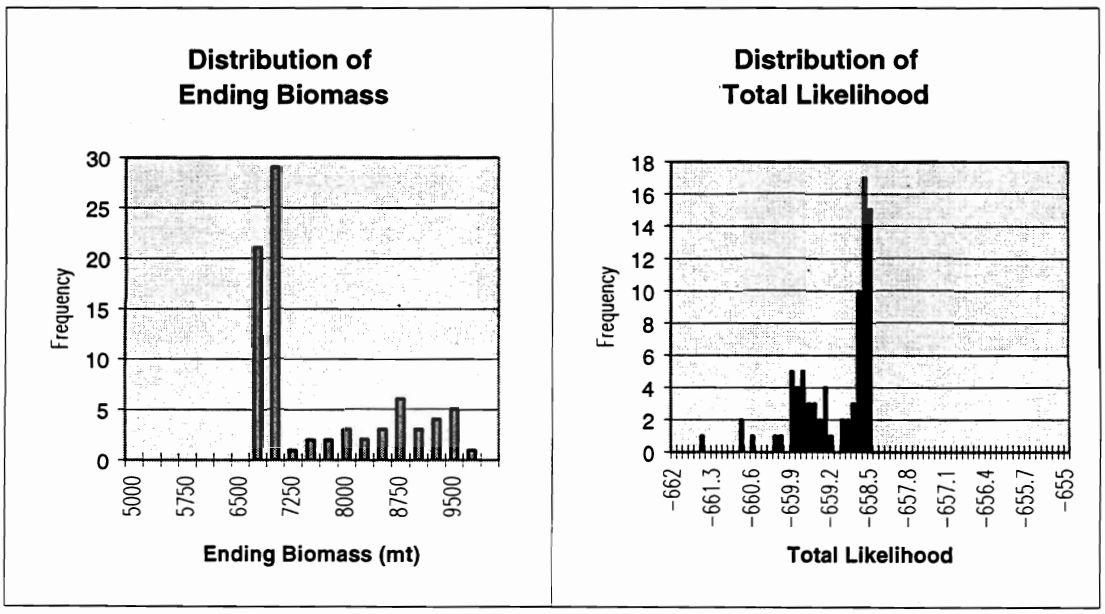


Figure 11a. Distribution of ending biomass (left panel) and total likelihood (right panel) for 83 model runs, where the starting parameter seed values were offset randomly from the base model parameter estimates by a factor of up to 15% (final base model).



conv.xls

Figure 12. Profile of preliminary base model likelihood values, by model component, over a range of ending biomass for ages 4-14, from 3000 to 15,000 metric tons. Run95.xls.

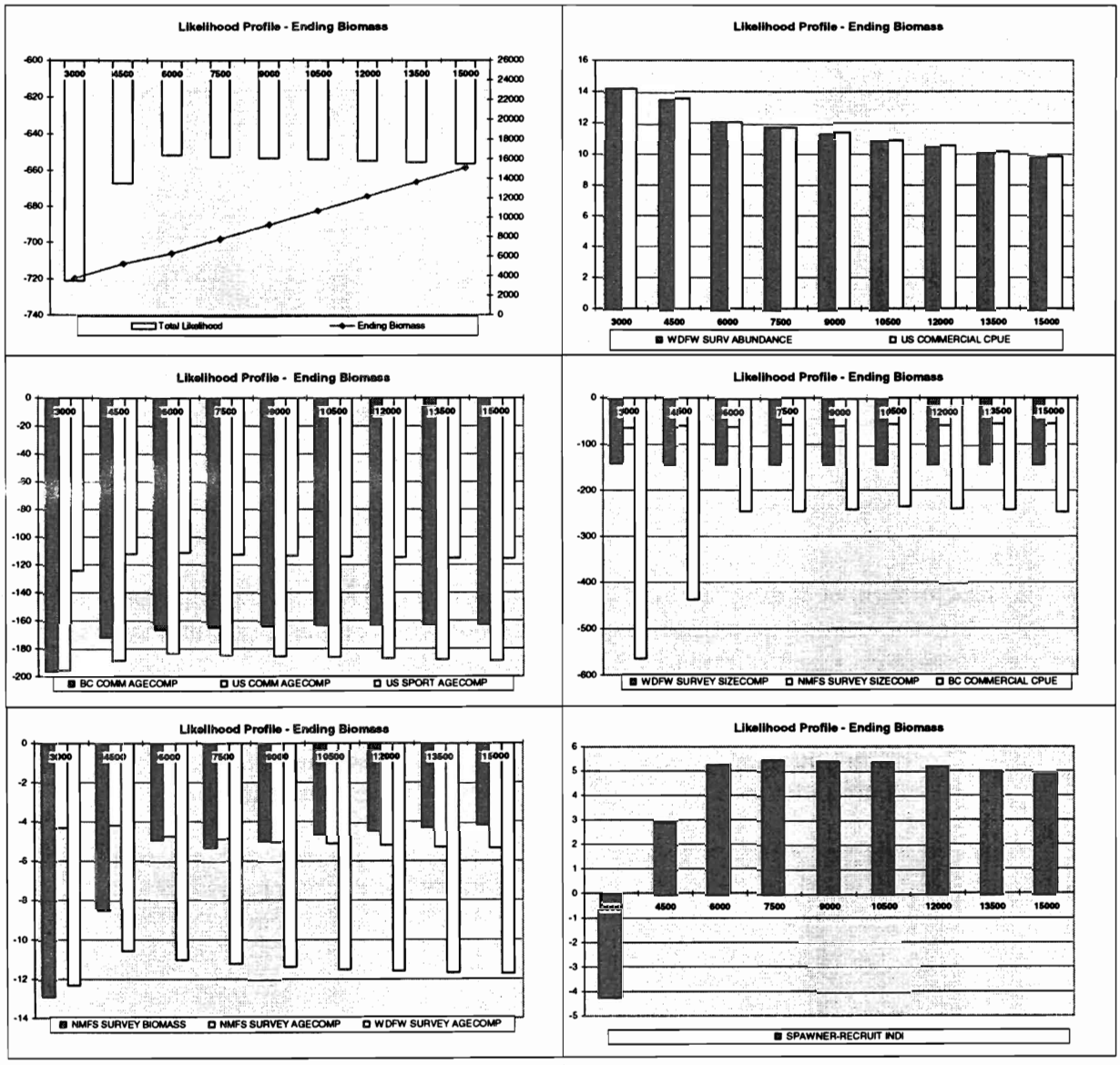
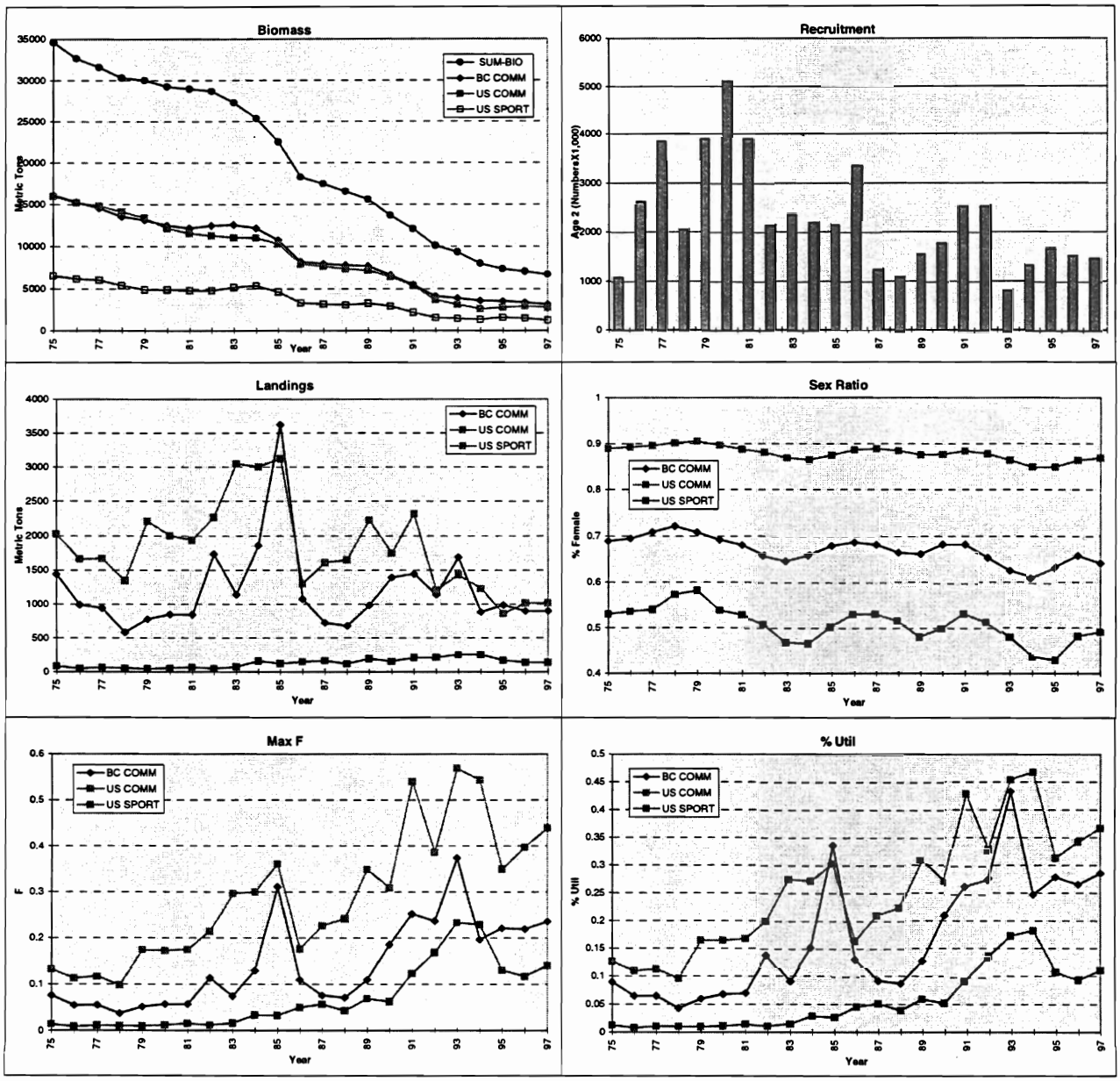
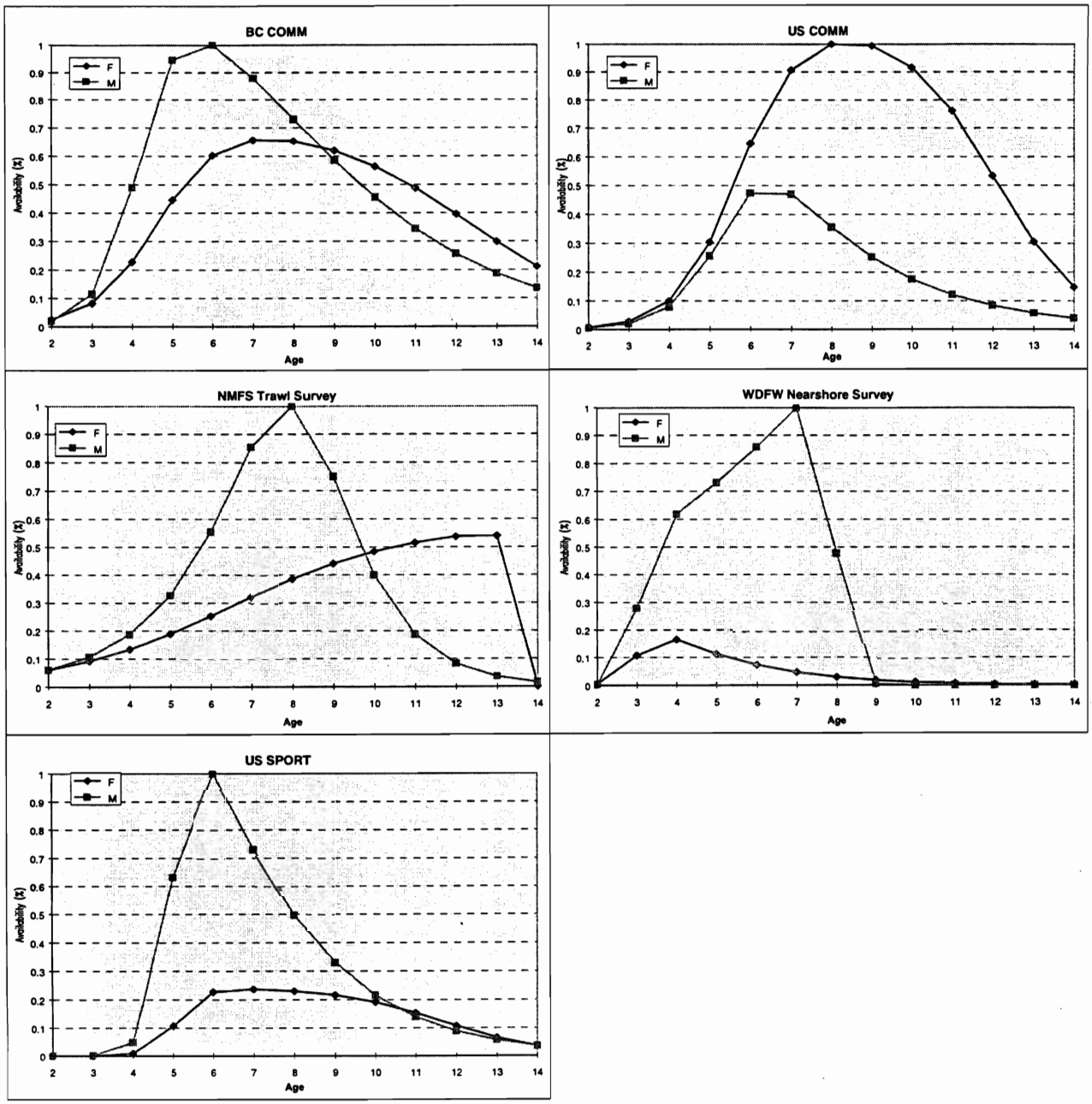


Figure 13. Final base model biomass (mt), recruitment (number of age two fish in thousands), landings (mt), sex ratio, instantaneous rate of fishing mortality at age of full selectivity (Max F), and percent utilization (% Util).



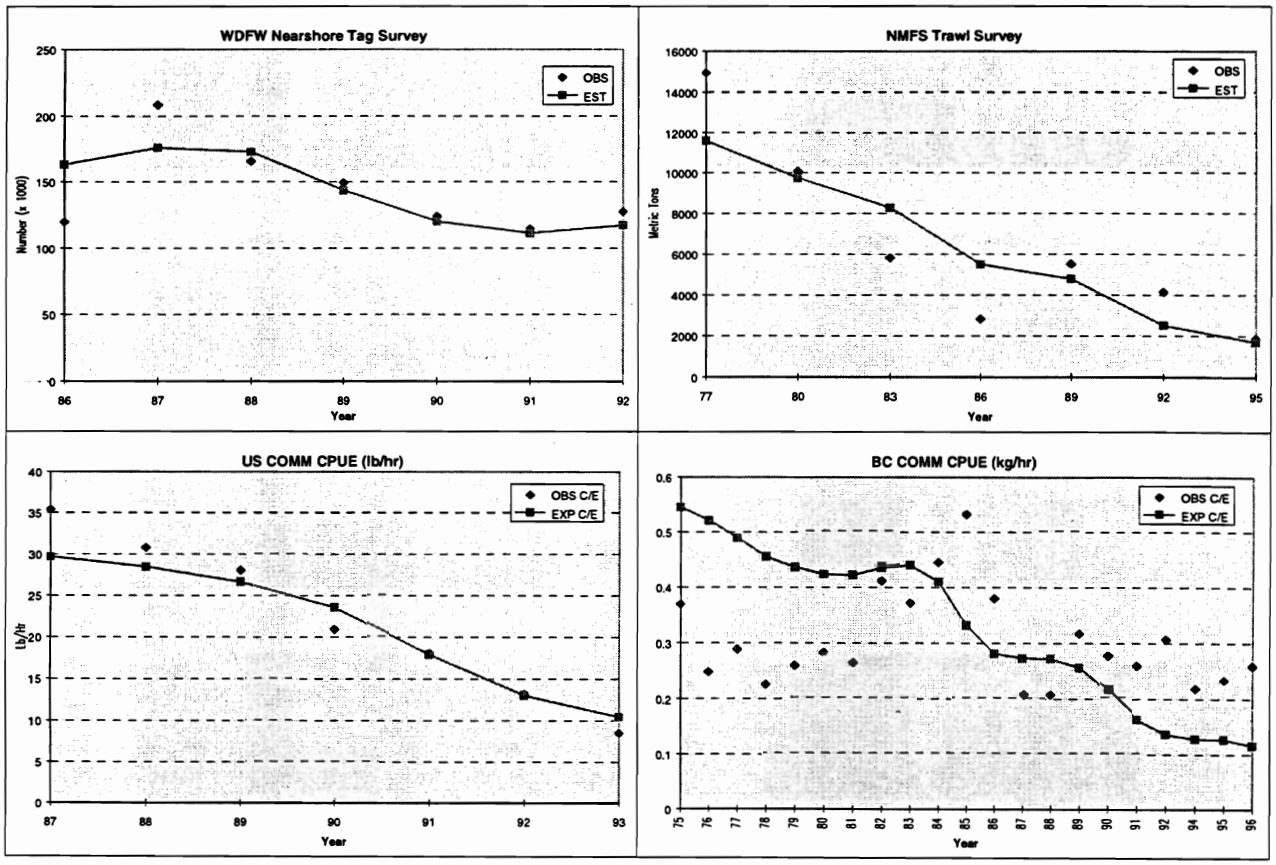
base97a2.xls

Figure 14. Final base model selectivity estimates for BC Commercial fishery, US Commercial fishery, US Sport fishery, NMFS triennial trawl survey, and WDFW Cape Flattery survey.



base97a2.xls

Figure 15. Final base model fit to WDFW survey, NMFS Survey, US Commercial fishery CPUE, and BC Commercial fishery CPUE time series.



base97a2.xls

Figure 16. Model fit to observed catch at age for female and male lingcod; BC Commercial fishery 1977-1982.

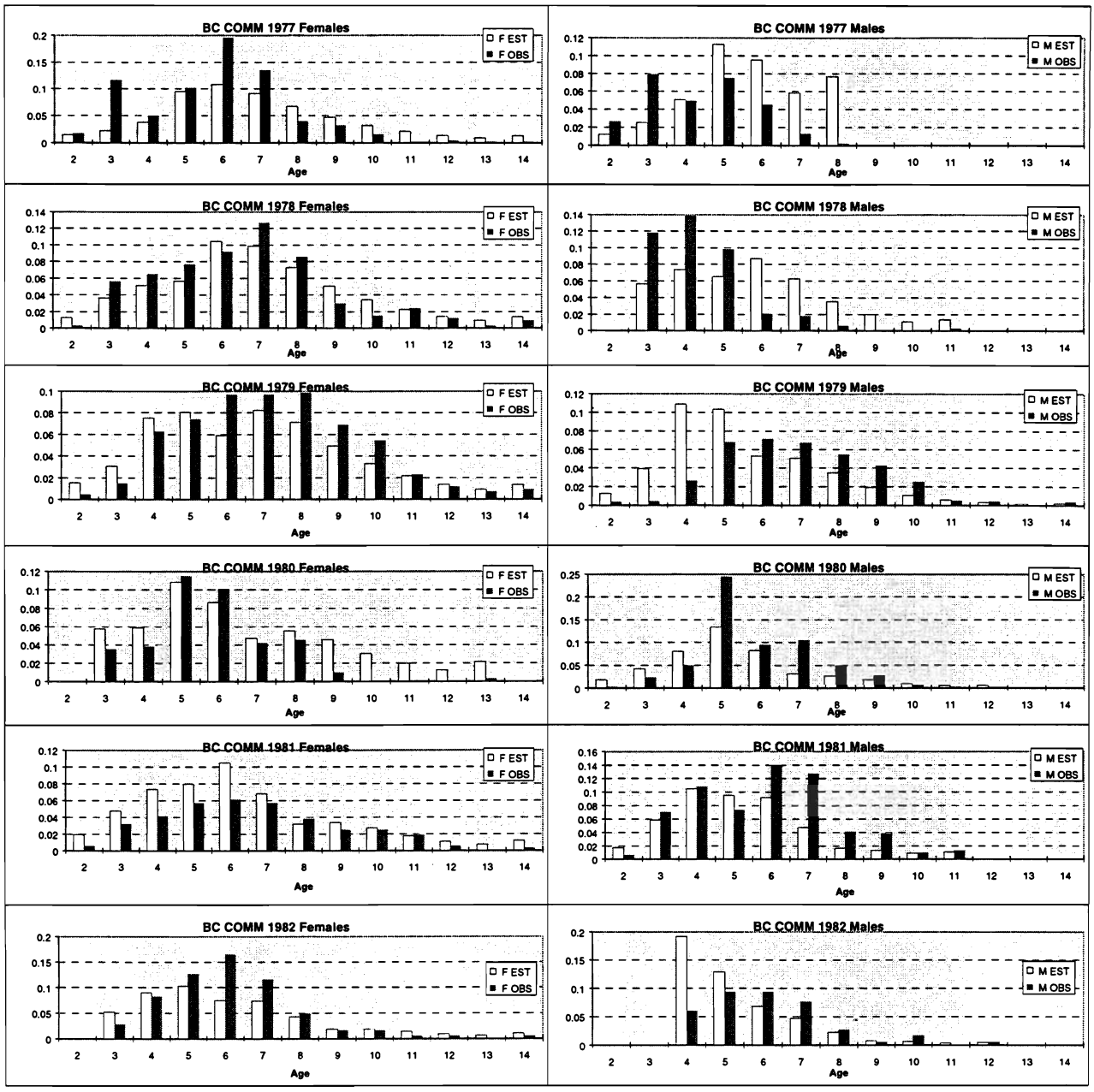


Figure 17. Model fit to observed catch at age for female and male lingcod; BC Commercial fishery 1983-1988.

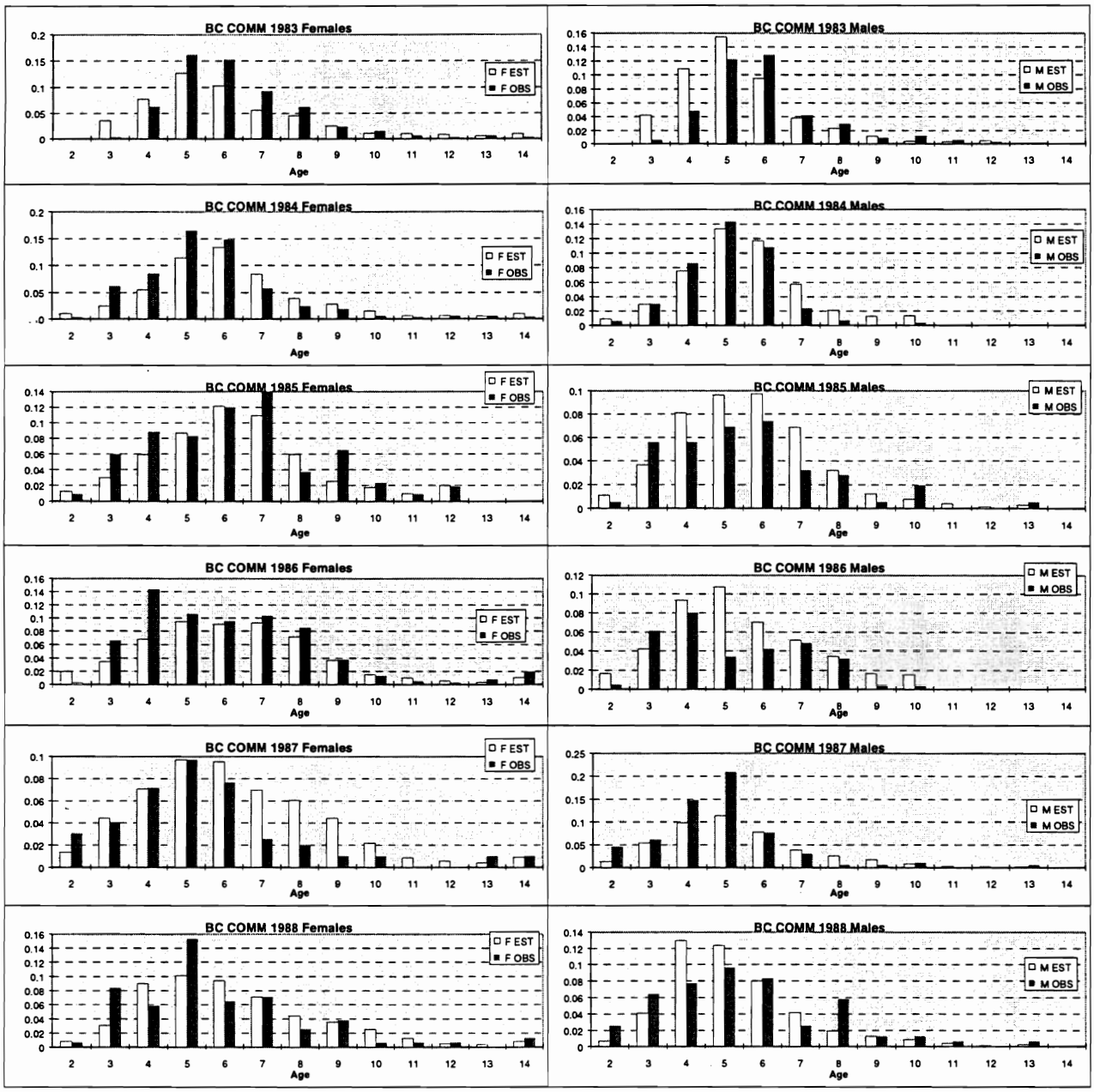


Figure 18. Model fit to observed catch at age for female and male lingcod; BC Commercial fishery 1989-1995.

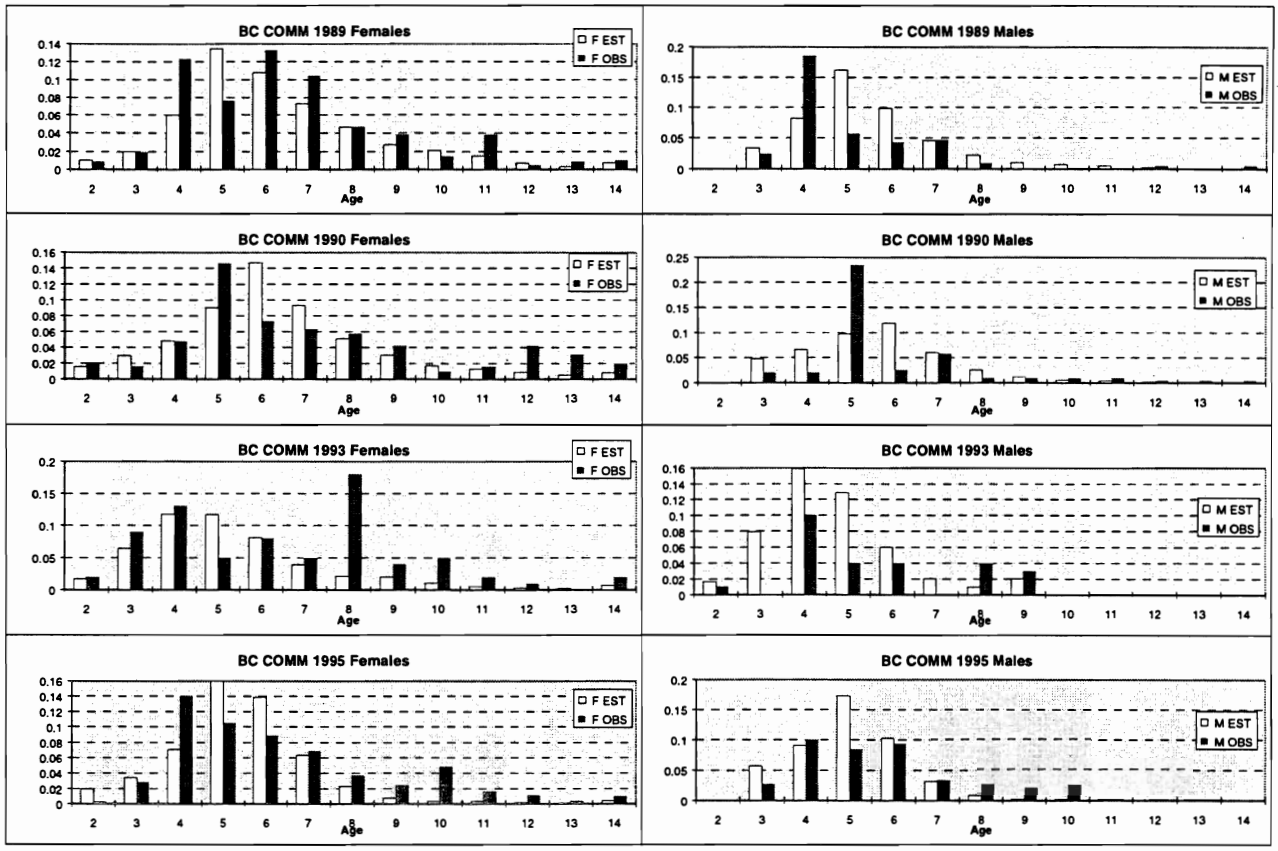


Figure 19. Model fit to observed catch at age for female and male lingcod; US Commercial fishery 1979-1984.

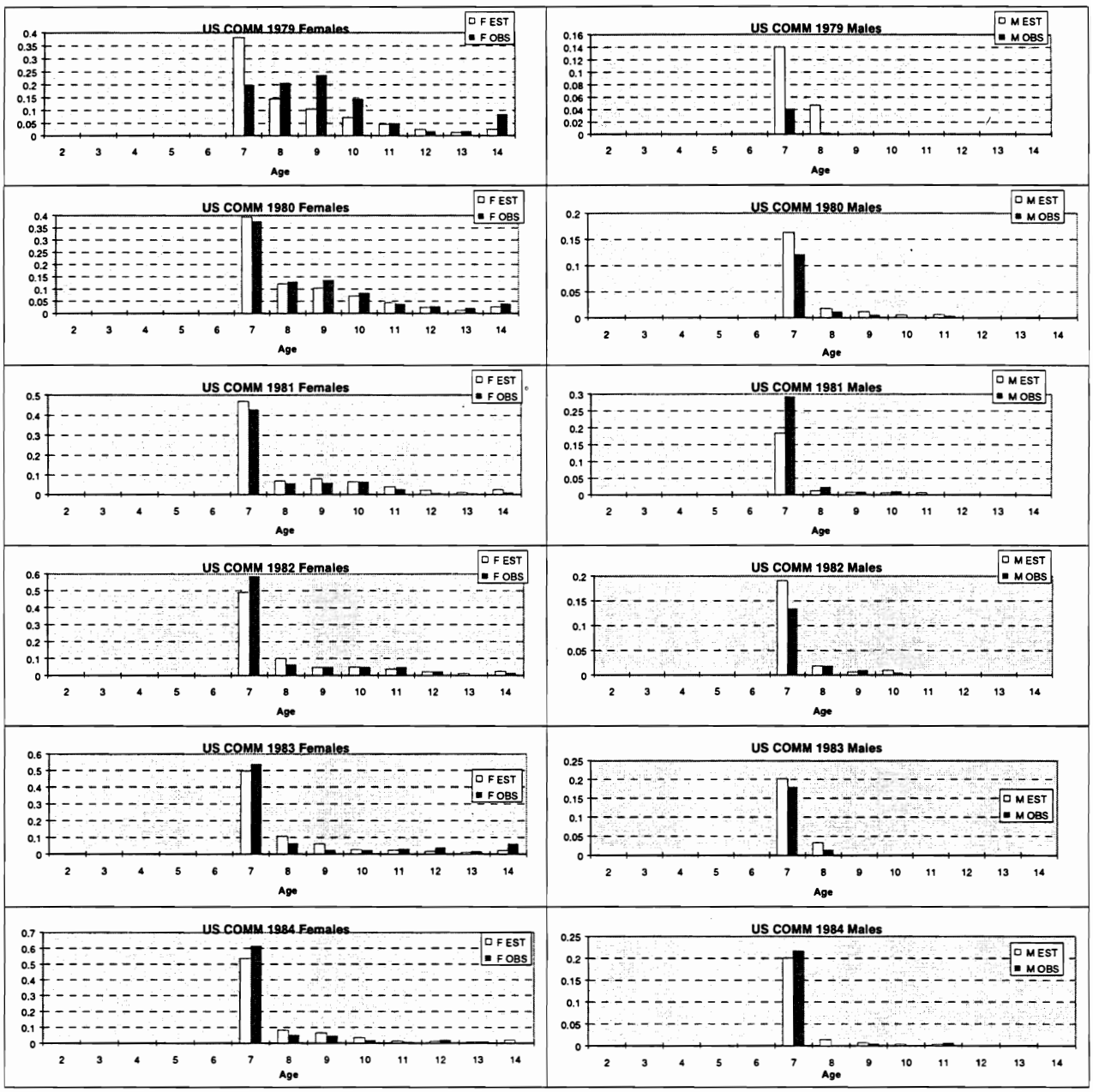


Figure 20. Model fit to observed catch at age for female and male lingcod; US Commercial fishery 1985-1990.

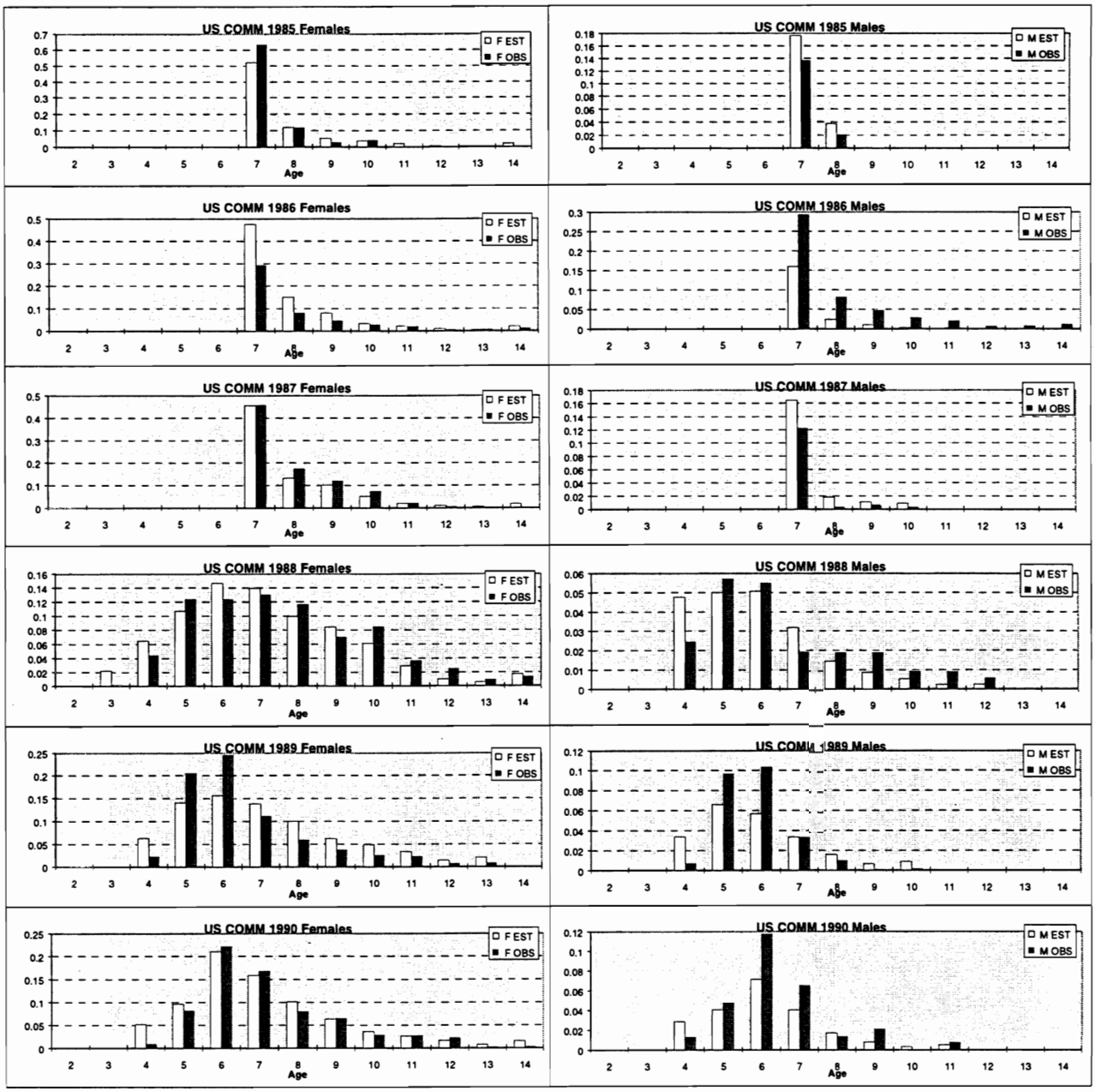


Figure 21. Model fit to observed catch at age for female and male lingcod; US Commercial fishery 1991-1996.

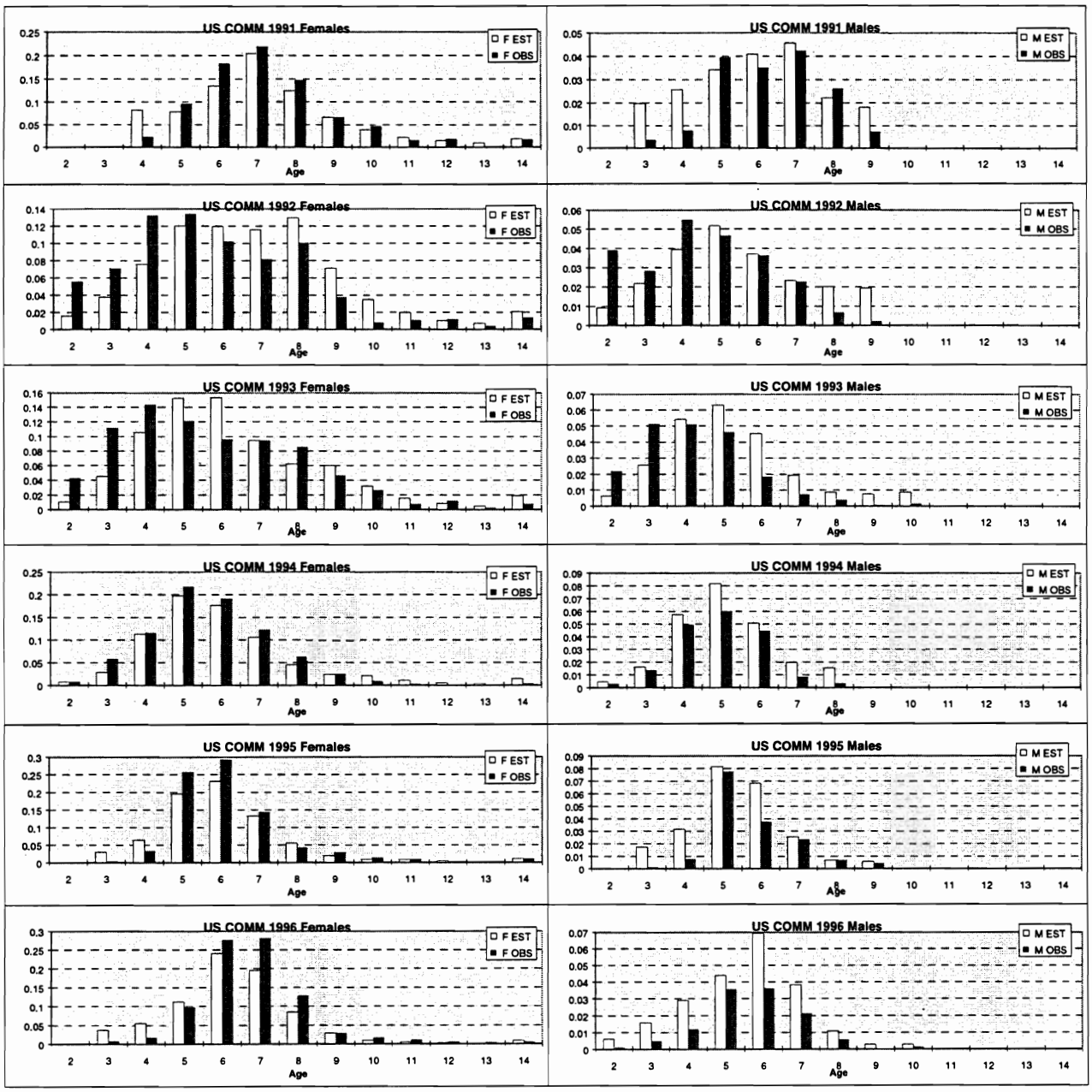


Figure 22. Model fit to observed catch at age for female and male lingcod; US Sport fishery 1980-1990.

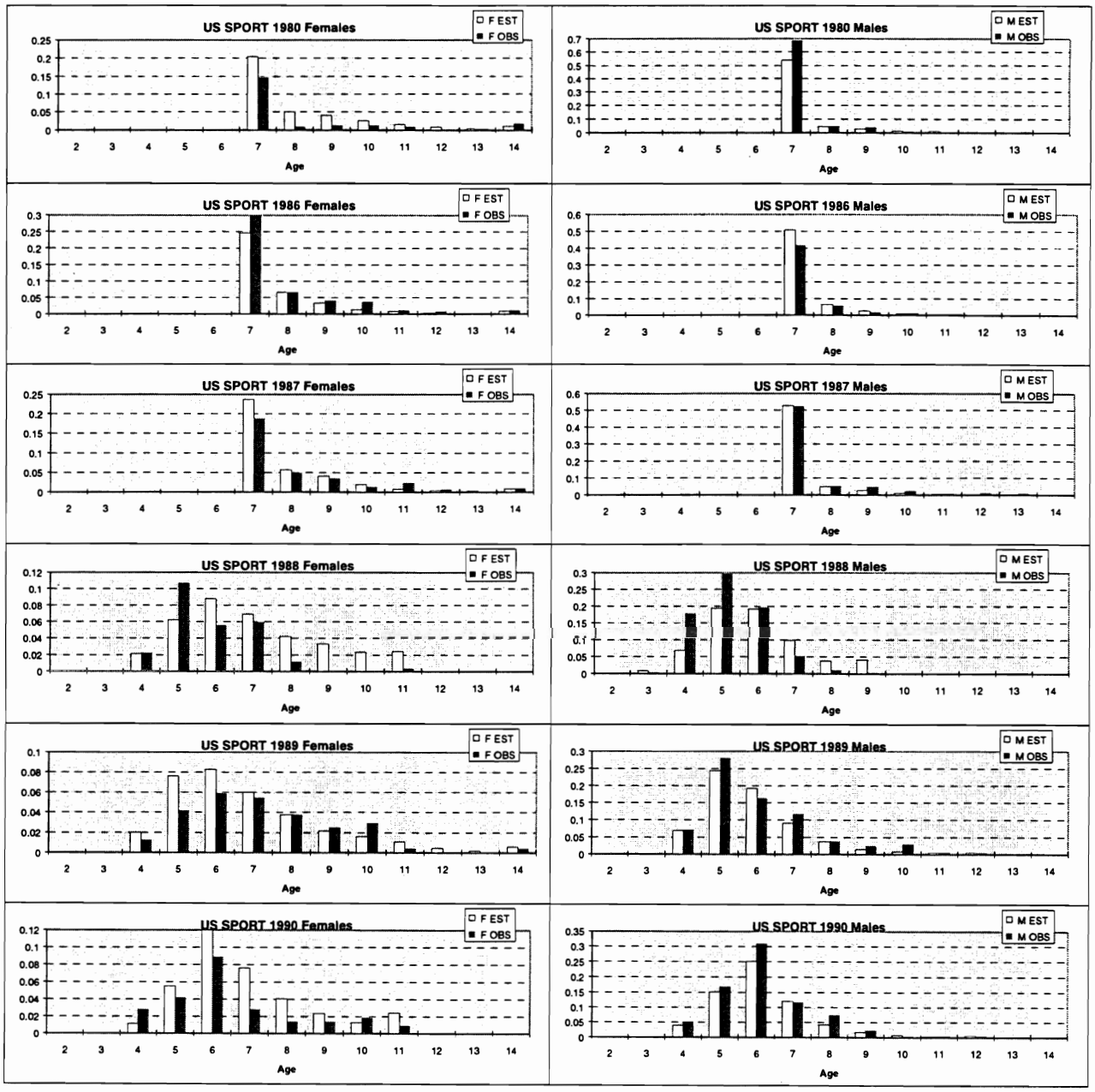


Figure 23. Model fit to observed catch at age for female and male lingcod; US Sport fishery 1991-1996.

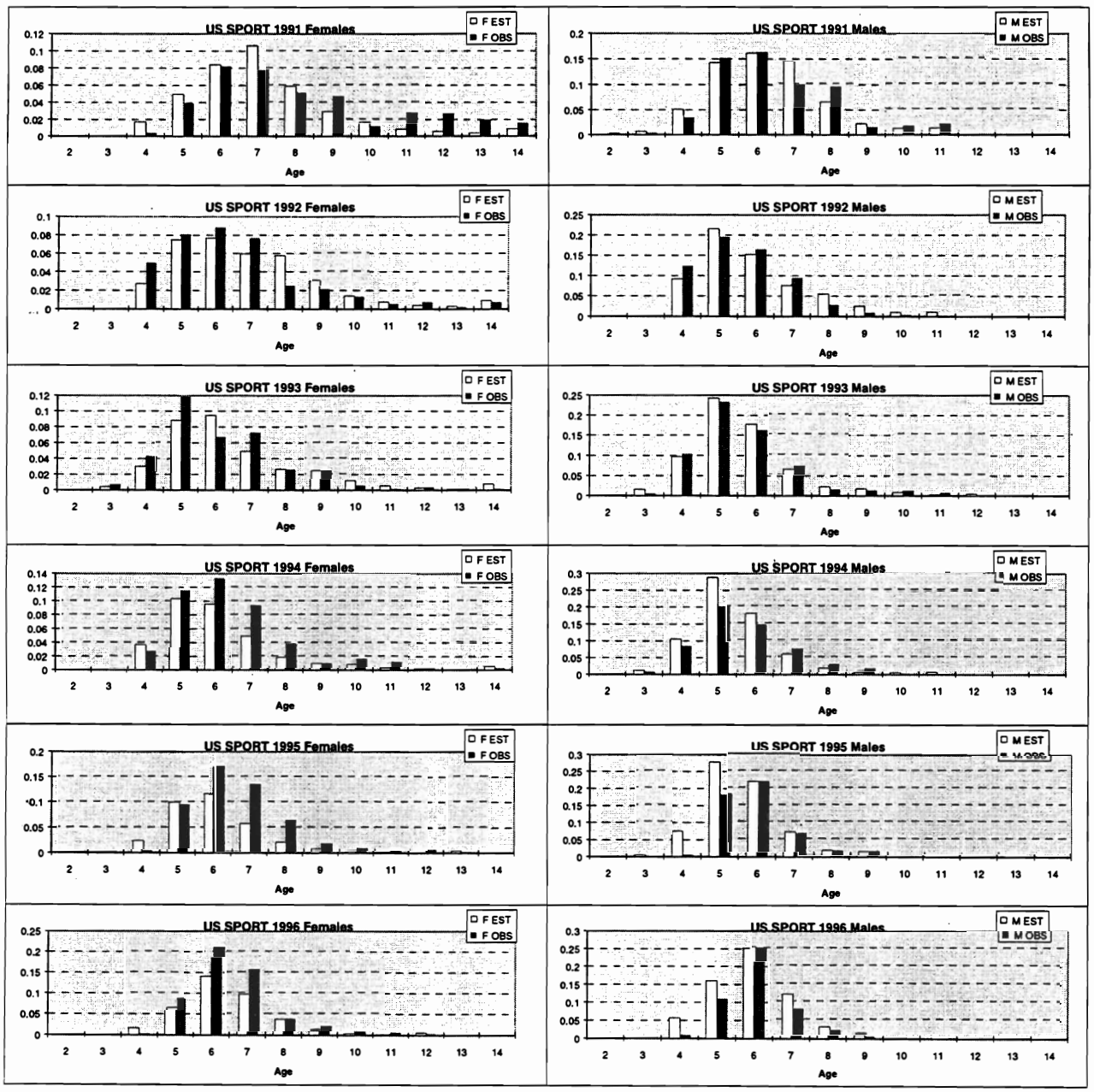


Figure 24. Model fit to observed catch at size for female and male lingcod; WDFW Survey 1986-1991.

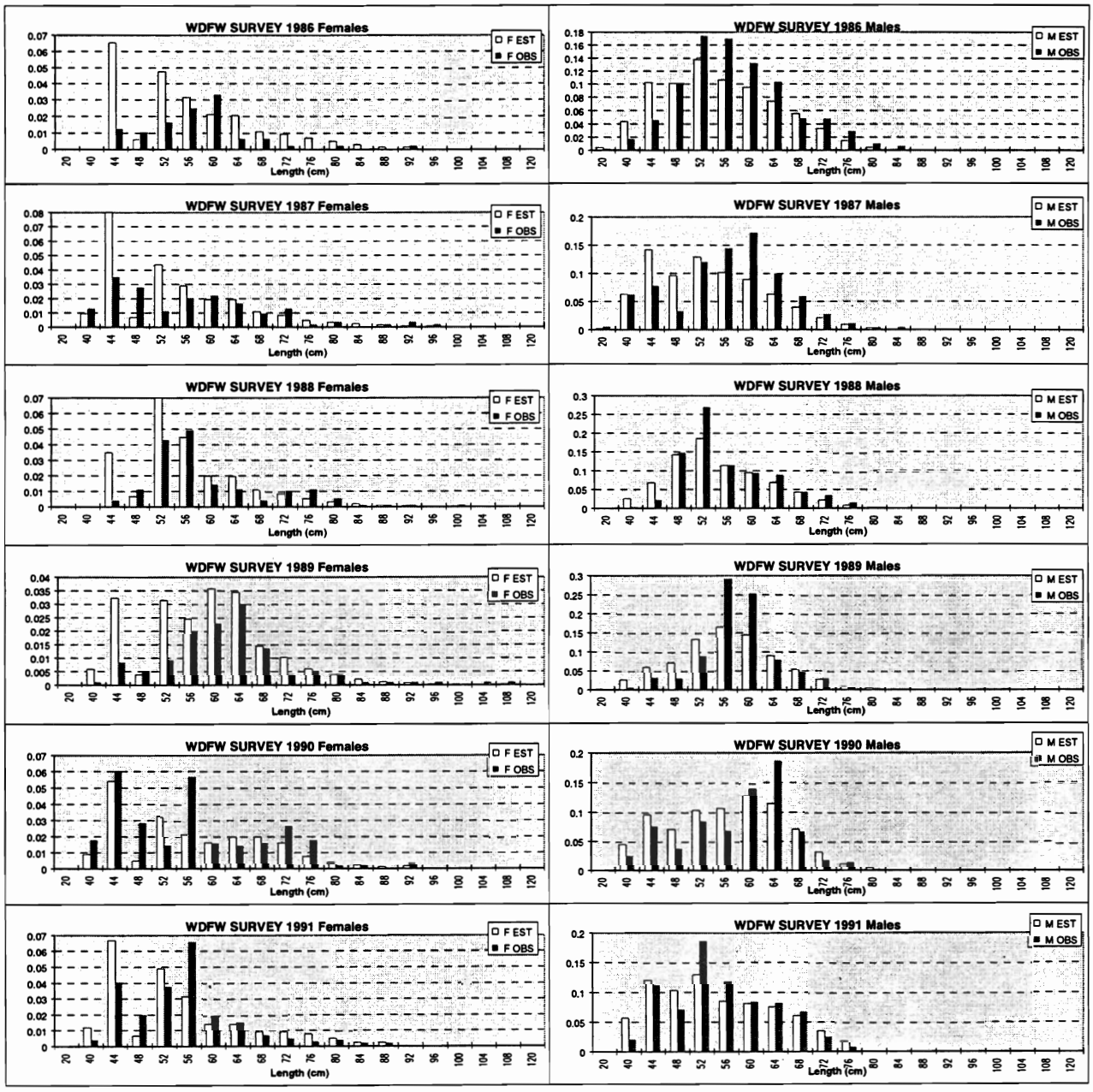


Figure 25. Model fit to observed catch at size for female and male lingcod; WDFW Survey 1992-1997.

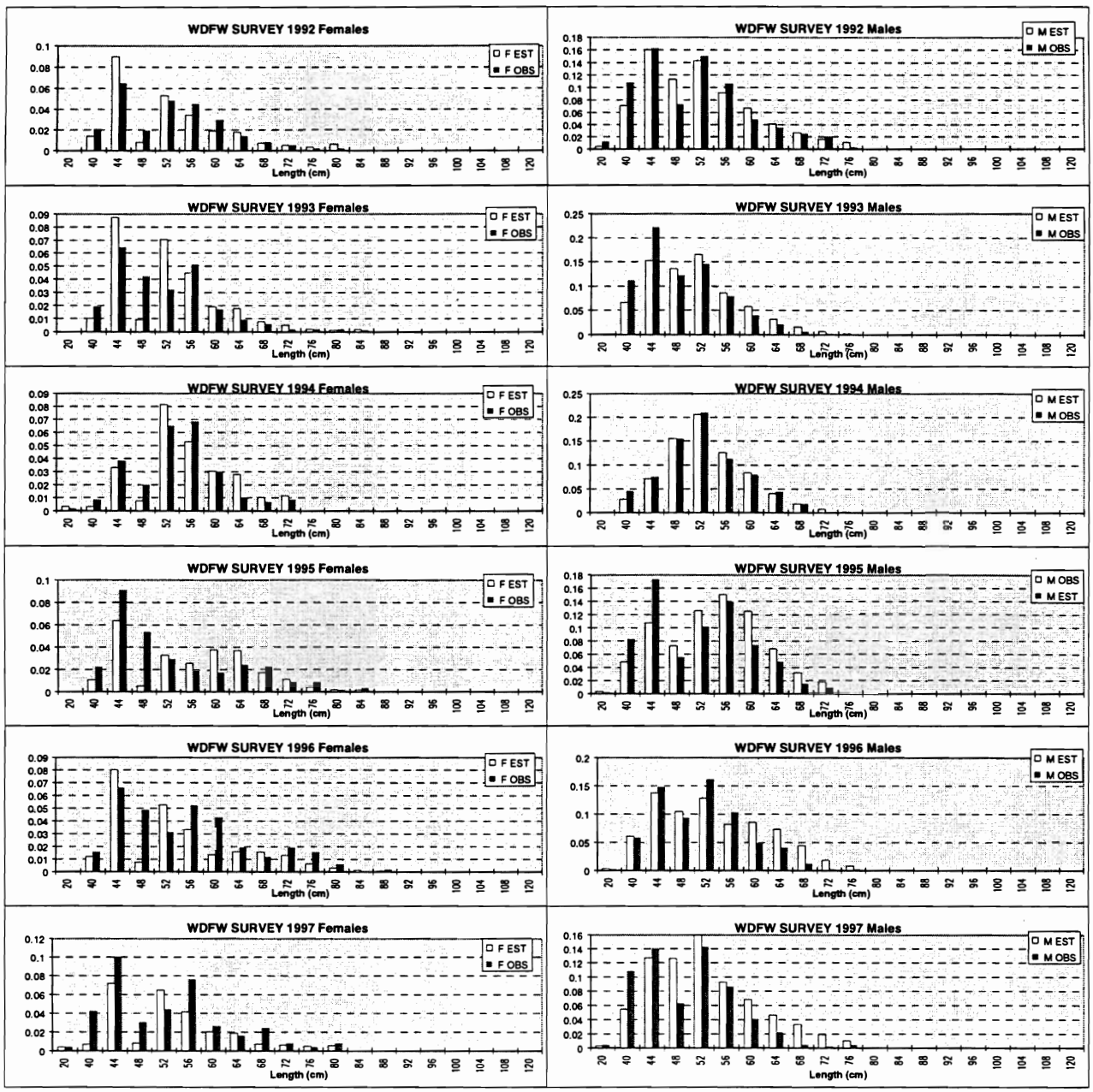


Figure 26. Model fit to observed catch at size for female and male lingcod; NMFS Survey 1986-1995.

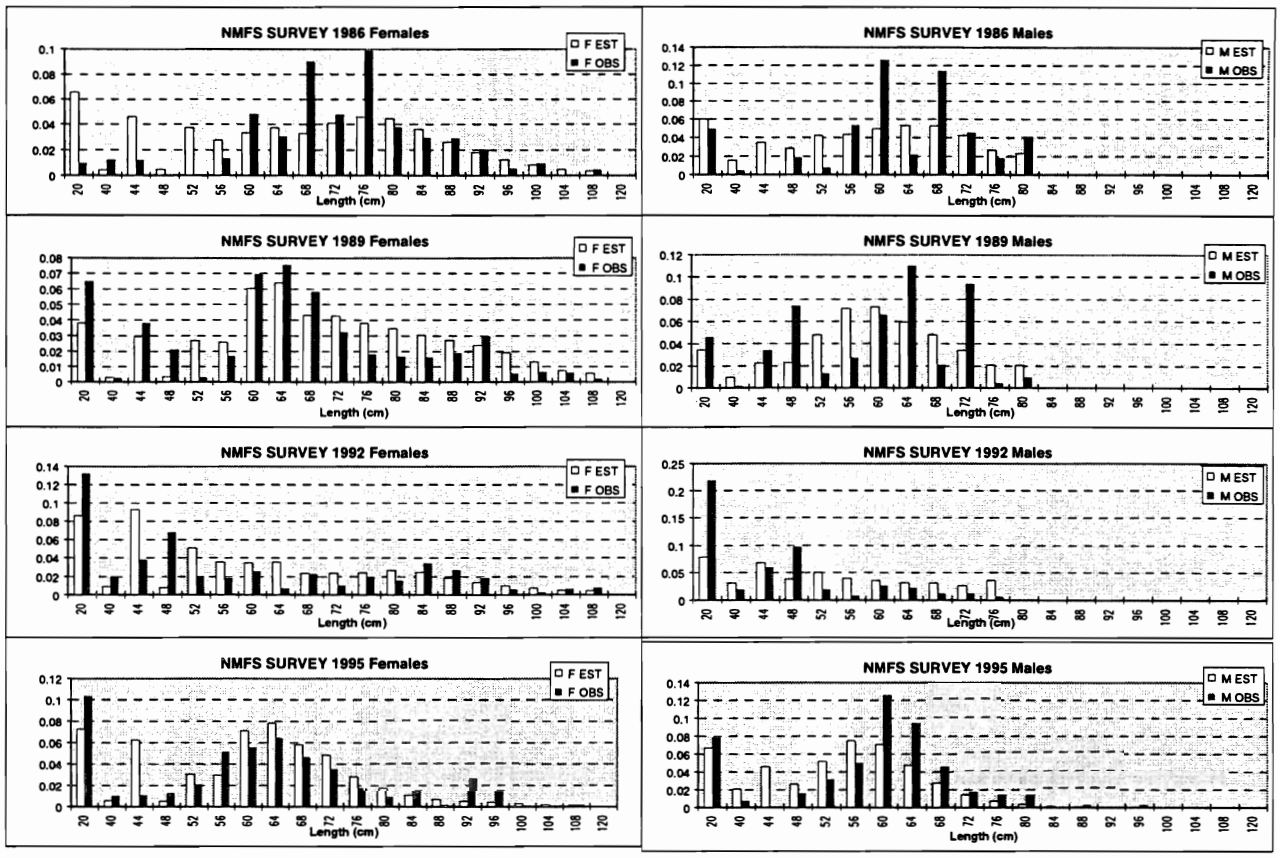


Figure 27. Model fit to observed catch at age for female and male lingcod; NMFS Survey (1995), WDFW Survey (1995, 1996).

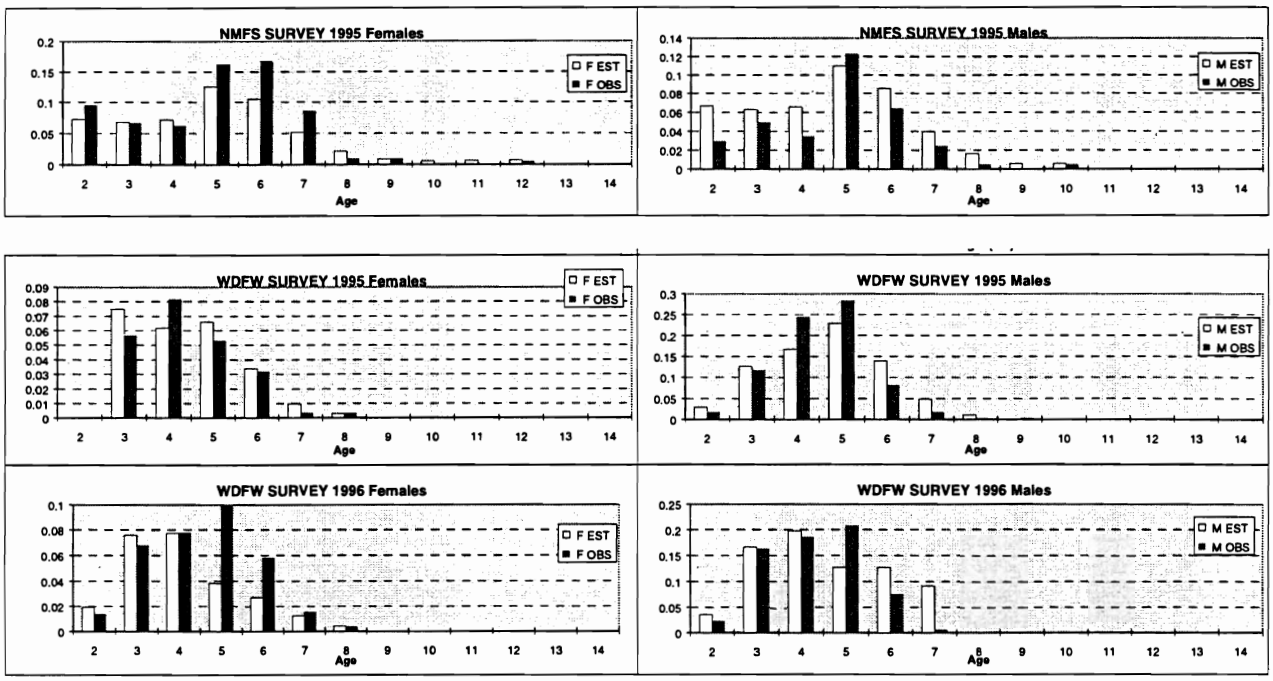
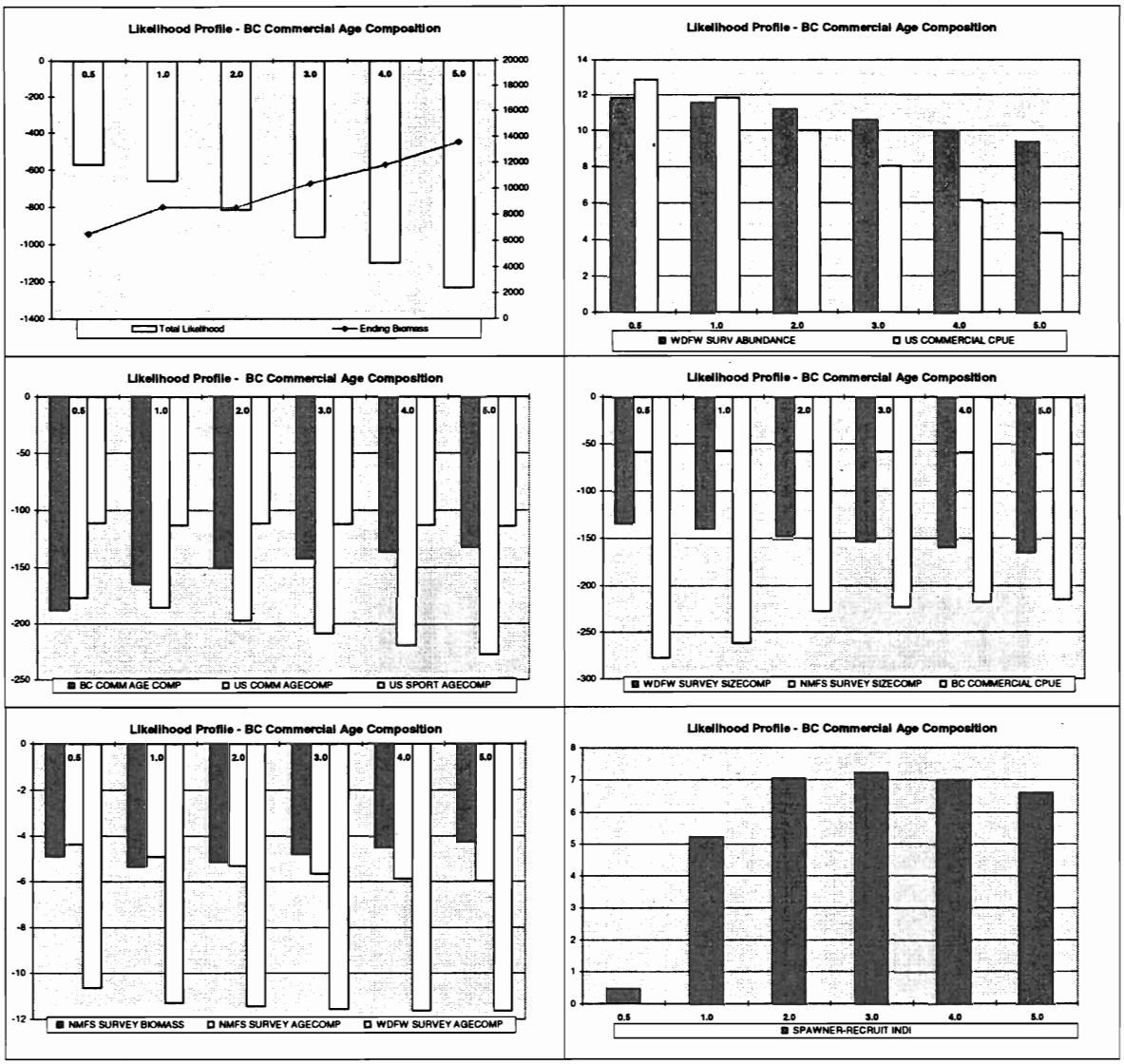
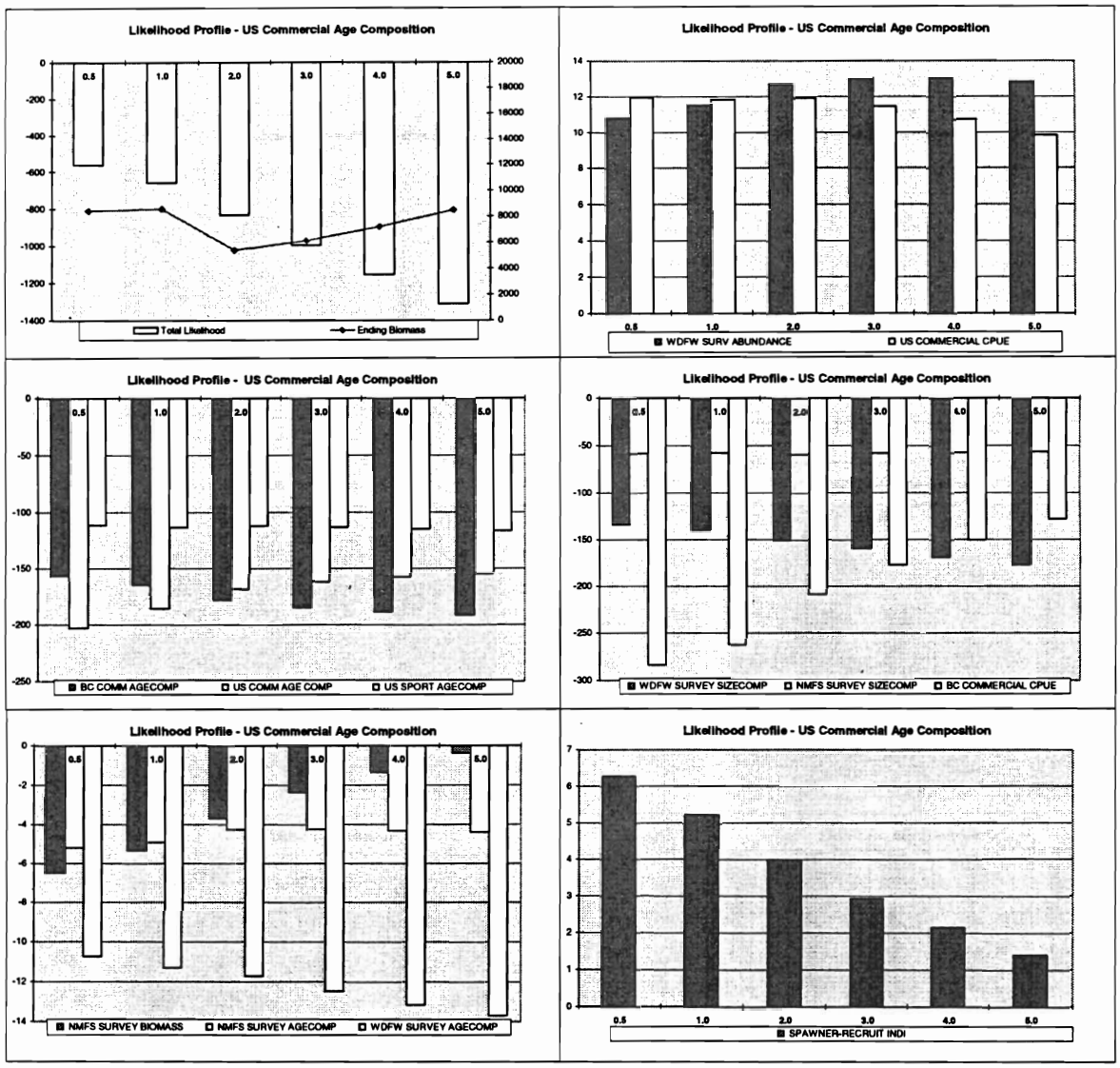


Figure 28. Profile of likelihood values and ending biomass over a range of fixed levels of BC Commercial Age Composition emphasis (0.5 - 5.0) (preliminary base model).



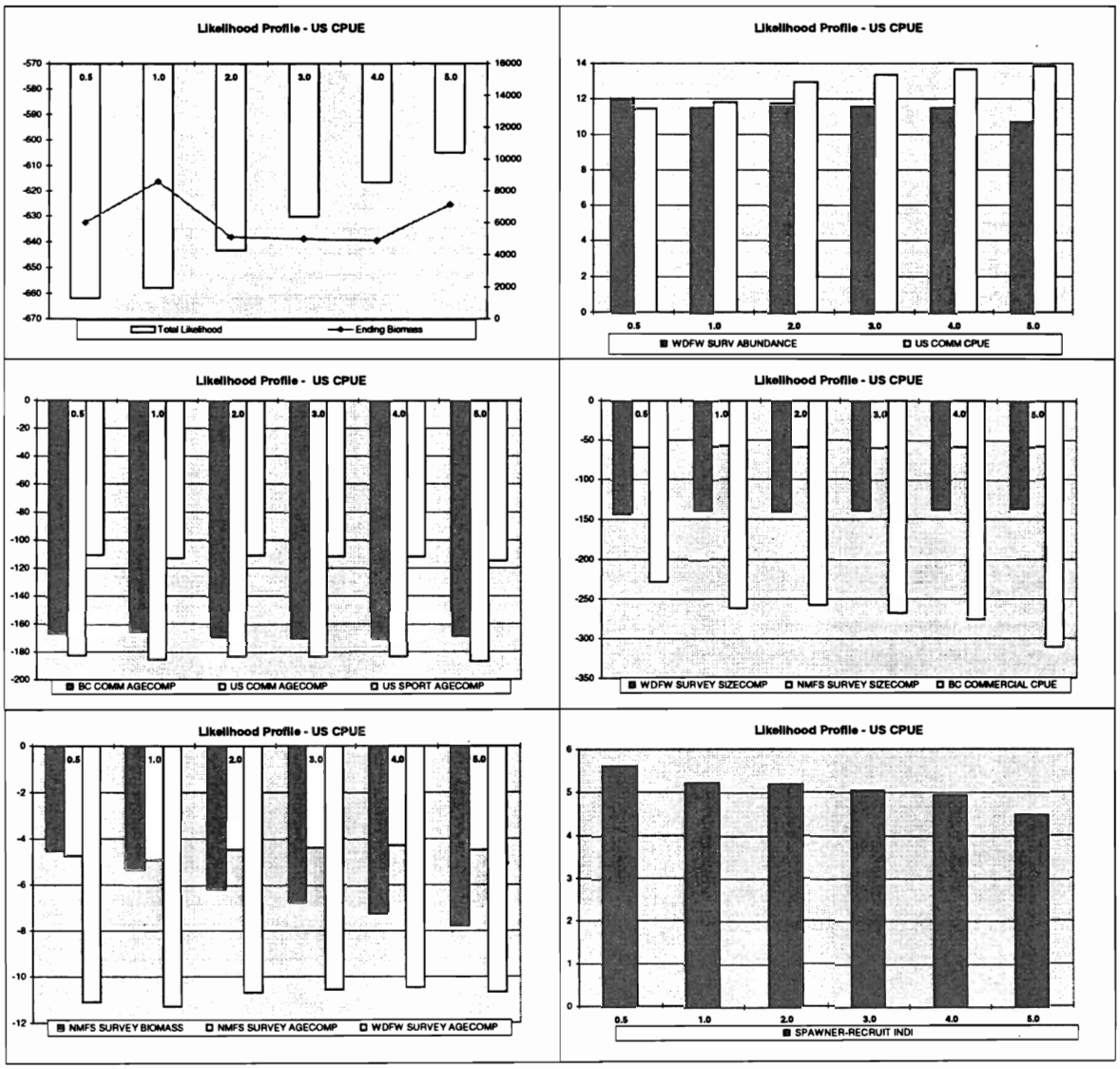
run78.xls

Figure 29. Profile of likelihood values and ending biomass over a range of fixed levels of US Commercial Age Composition emphasis (0.5 - 5.0) (preliminary base model).



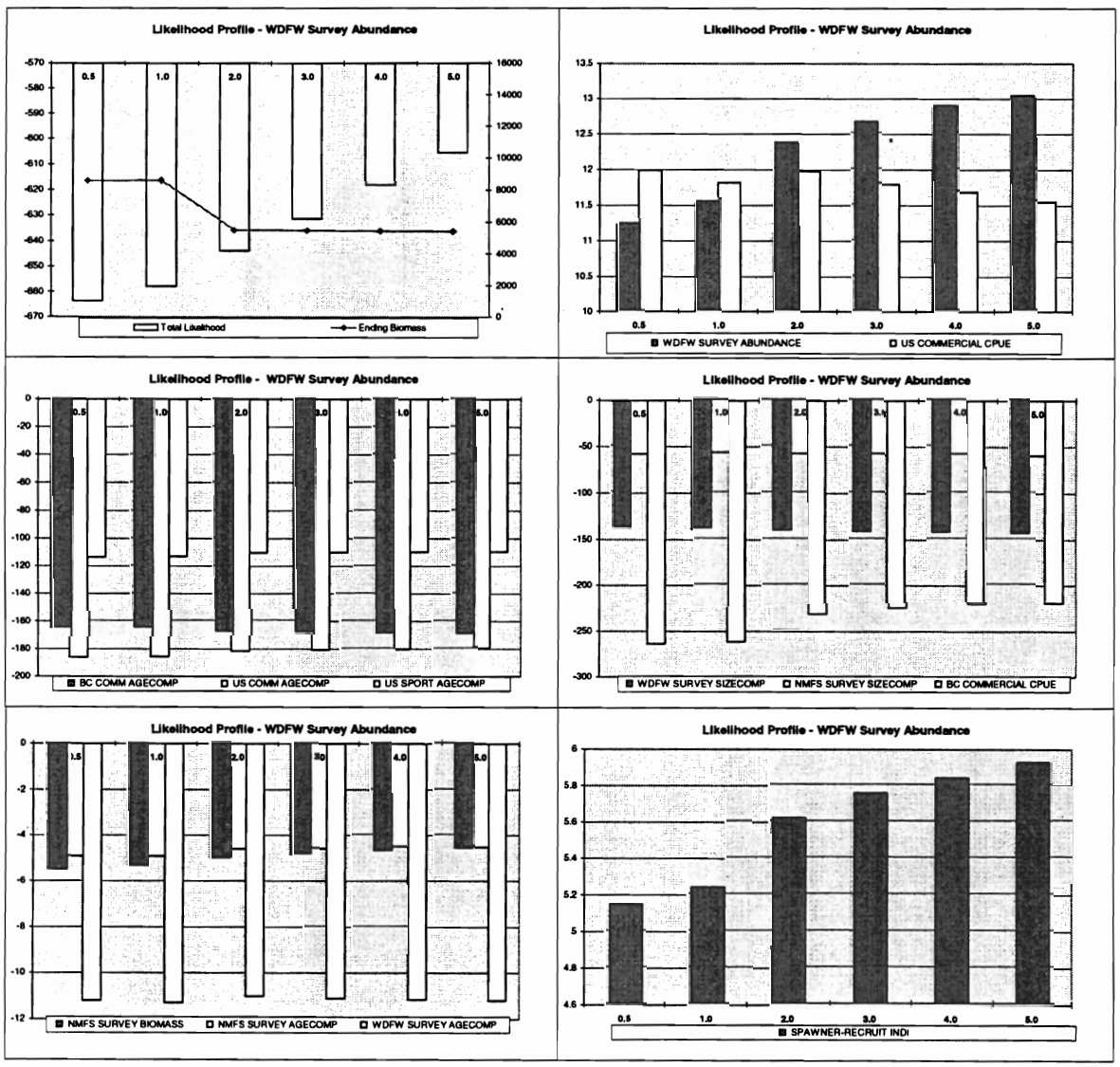
run79.xls

Figure 30. Profile of likelihood values and ending biomass over a range of fixed levels of US Commercial CPUE emphasis (0.5 - 5.0) (preliminary base model).



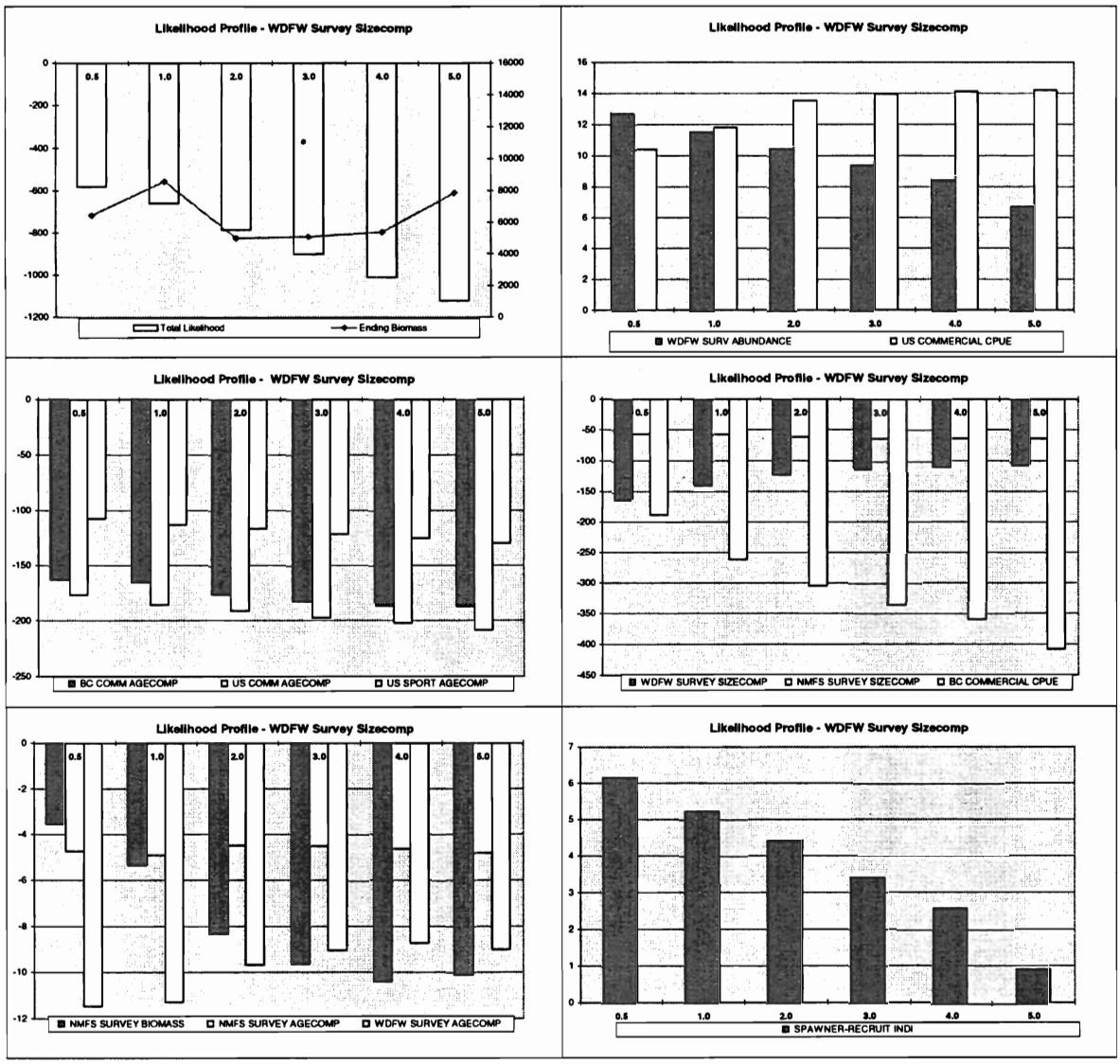
run89.xls

Figure 31. Profile of likelihood values and ending biomass over a range of fixed levels of WDFW Survey Abundance emphasis (0.5 - 5.0) (preliminary base model).



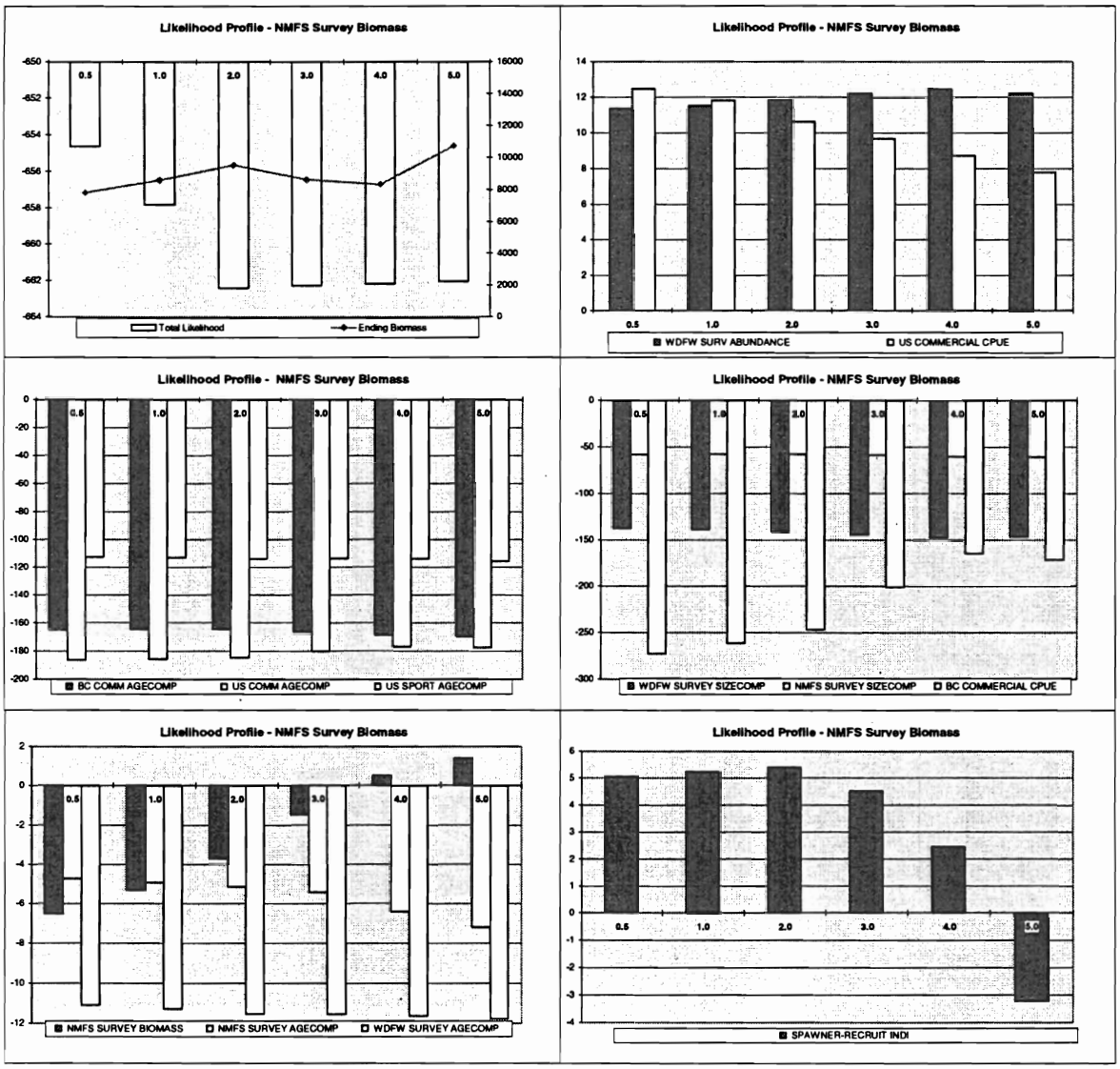
run90.xls

Figure 32. Profile of likelihood values and ending biomass over a range of fixed levels of WDFW Survey Size Composition emphasis (0.5 - 5.0) (preliminary base model).



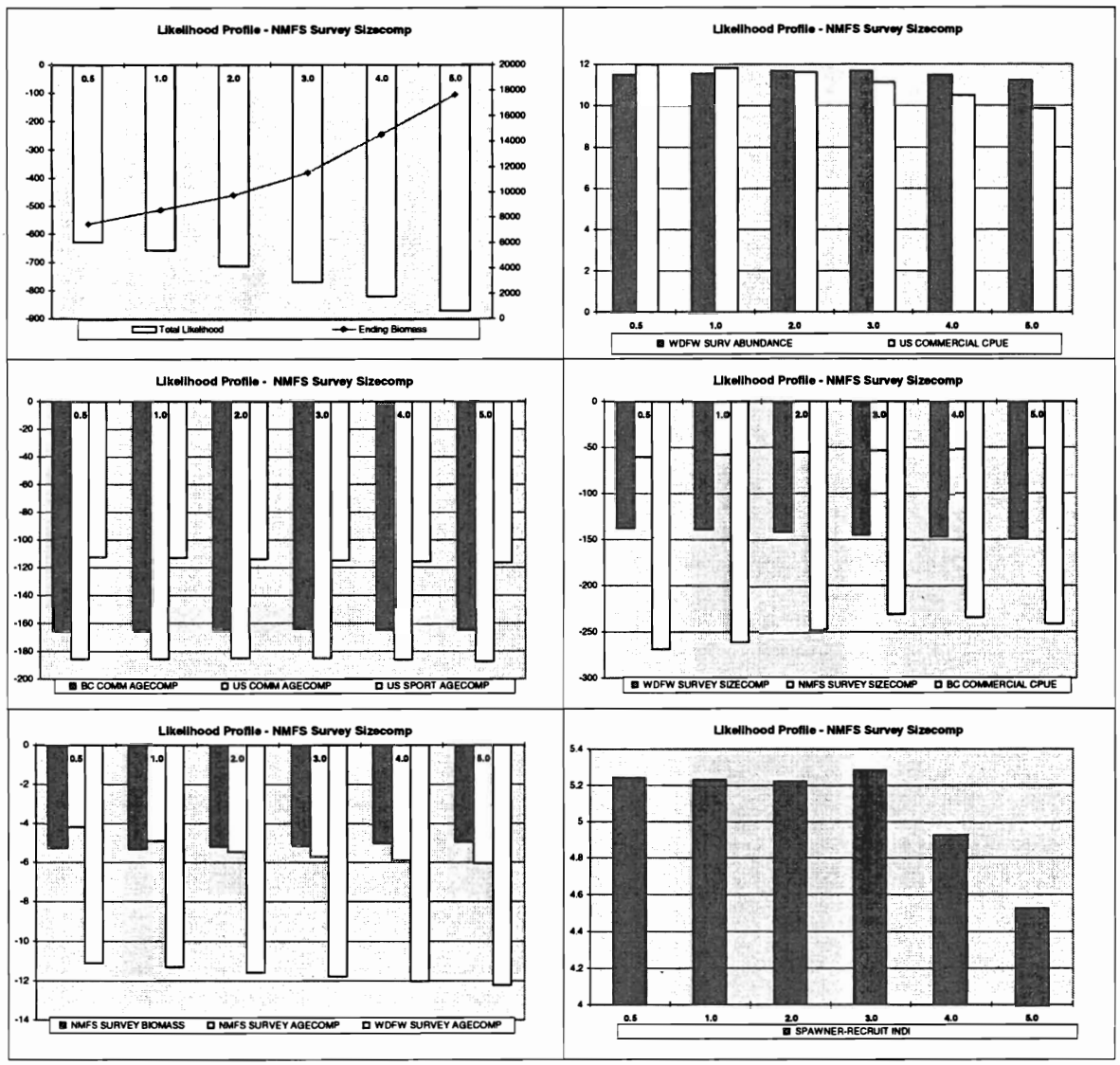
run91.xls

Figure 33. Profile of likelihood values and ending biomass over a range of fixed levels of NMFS Survey Biomass emphasis (0.5 - 5.0) (preliminary base model).



run92.xls

Figure 34. Profile of likelihood values and ending biomass over a range of fixed levels of NMFS Survey Size Composition emphasis (0.5 - 5.0) (preliminary base model).



run93.xls

Figure 35. Results of retrospective analysis, 1991-1997. Top: biomass (mt). Second from Top: recruitment (age 2 fish in 000's), Third from Top: Full selectivity instantaneous fishing mortality (F_{max}) for US Commercial. Bottom: Full selectivity instantaneous fishing mortality (F_{max}) for BC Commercial.

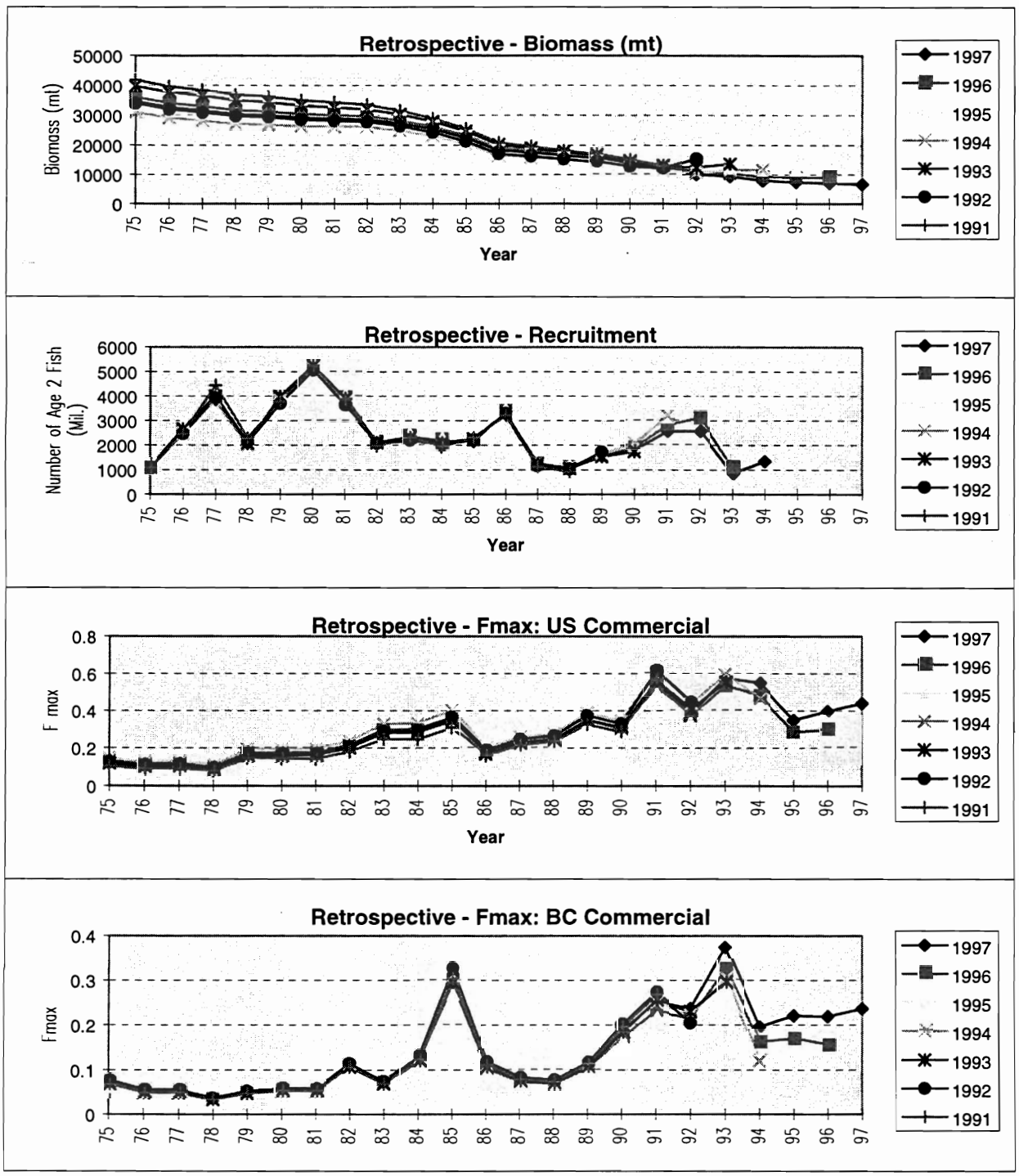
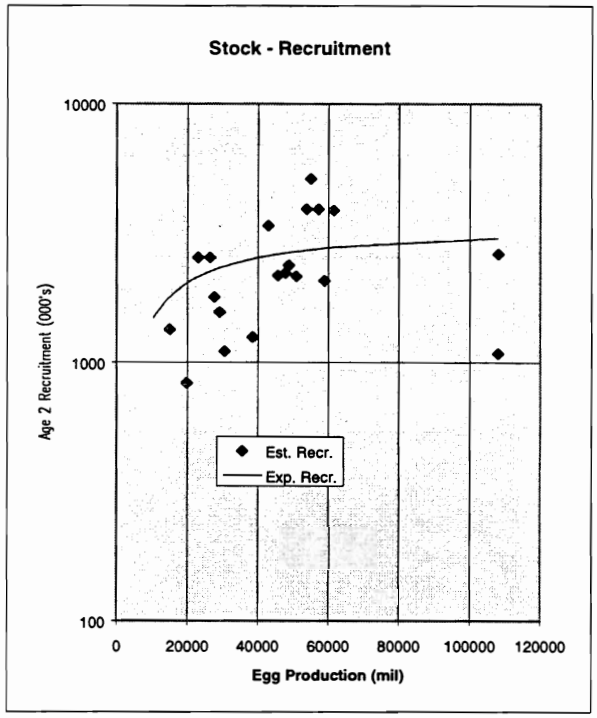


Figure 36. Spawner-recruit plot showing relationship between egg production (millions) and recruitment (thousands of age 2 fish). The model was not constrained to fit the "expected recruitment" curve. The expected recruitment curve was used to obtain recruitment values for 1995-1997 only, and corresponds to a Beverton-Holt curve with shape parameter = 0.889.

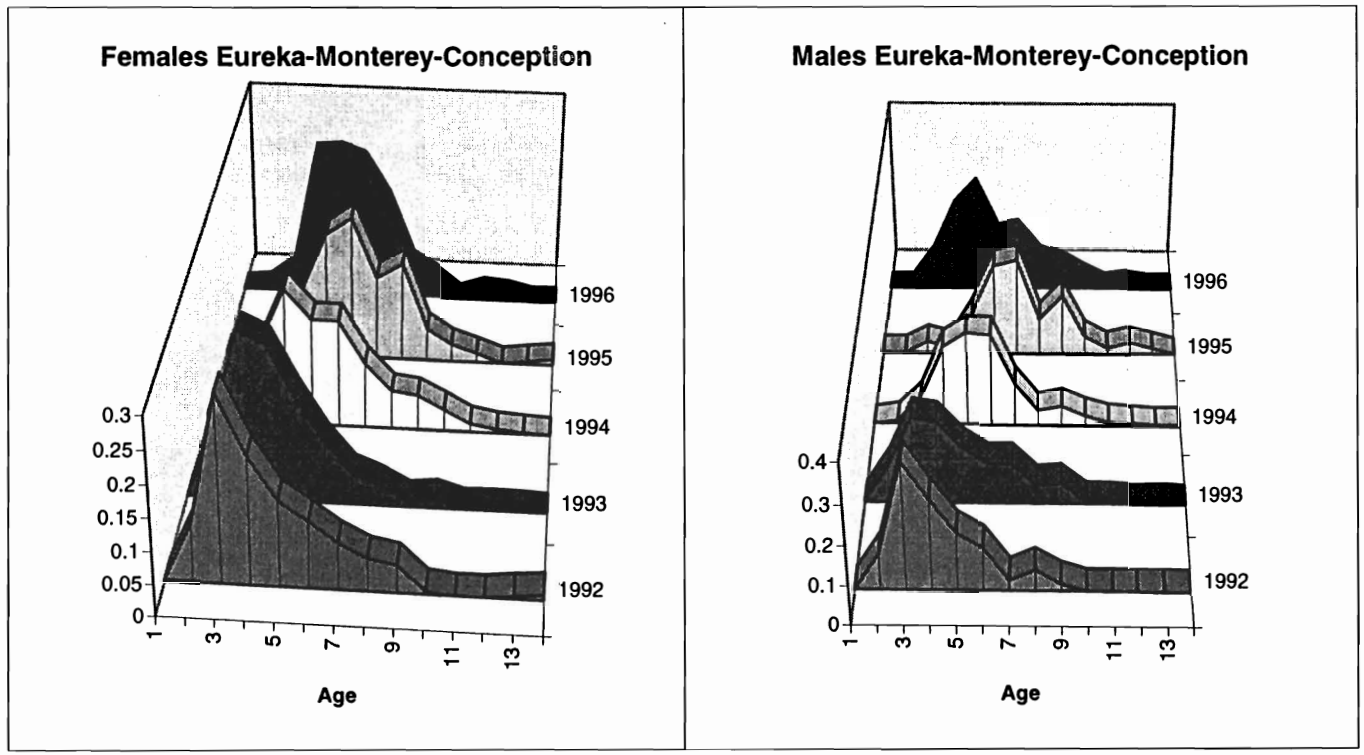
Year Class	Egg Prod. (mil)	Est. Recr.	Exp. Recr.	Deviate
73	108018	1084	3000	-1.02
74	108018	2611	3000	-0.14
75	61551	3864	2768	0.33
76	58935	2060	2746	-0.29
77	57274	3911	2731	0.36
78	55098	5127	2711	0.64
79	53949	3909	2700	0.37
80	50863	2142	2667	-0.22
81	48843	2363	2644	-0.11
82	47824	2209	2632	-0.18
83	45726	2155	2606	-0.19
84	42877	3365	2567	0.27
85	38509	1252	2499	-0.69
86	30559	1102	2341	-0.75
87	29159	1559	2307	-0.39
88	27710	1787	2270	-0.24
89	26387	2534	2233	0.13
90	23087	2535	2130	0.17
91	19868	833	2010	-0.88
92	15072	1338	1781	-0.29
93	13411		1682	0
94	11240		1534	0
95	10505		1477	0



sprecr.xls

Appendix i

Frequency of male and female lingcod ages in trawl samples from Eureka, Monterey, and Conception INPFC areas, 1992-1996. (Frequencies not adjusted for weight of landed catch).



Appendix ii: Stock synthesis parameter file base97a.p01.

```
LING97AX.DAT      LOOP1:  7  LIKE: -658.59  DELTA LIKE:     .01 ENDBIO:     6714.
LING97A.BIO
temp.R01
temp.P01
.01 GROWTH CV, 50% AGE AGREE, FIX 95 RECR
   100.000      .010     BEGIN AND END DELTA F PER LOOP1
   2   .95               FIRST LOOP1 FOR LAMBDA & VALUE
   1.500                 MAX VALUE FOR CROSS DERIVATIVE
   0 READ HESSIAN
CONV.H53
   1 WRITE HESSIAN
CONV.H53
    .001                 MIN SAMPLE FRAC. PER AGE
   2  14   2  14         MINAGE, MAXAGE,  SUMMARY AGE RANGE
  75  97                 BEGIN YEAR, END YEAR
  1       12  0  0  0    N PERIODS PER YEAR, MONTHS PER PERIOD
  1.00                   SPAWNMONTH
  7.00                   POPWTMONTH
 1.000 1.000  .000  .000  .000  SEASONAL WT FACTORS
  3  2 NFISHERY, NSURVEY
  2 N SEXES
    3000.  REFERENCE RECRUITMENT LEVEL
  0 MORTOPT
     .180000     .100000     .300000 'NATMORT Female  '   0  56 !   1 NO PICK    .000       0.
     .320000     .100000     .400000 'NATMORT Male    '   0  56 !   2 NO PICK    .000       0.
 BC FISH    TYPE:  1
  2  2 -1  2  1 KIND, MINAGE, NORMAGE, SEX, WT-BY-YEAR
   0   2   0   3  AGE TYPES USED
     1.00000       .01 'BC COMM CATCH       '  ! # =  1 VALUE:       .00
     1.00000     -1.00 'BC COMM AGECOMP     '  ! # =  2 VALUE:   -166.29
      .00000     -1.00 'BC COMM SIZECOMP    '  ! # =  3 VALUE:       .00
    4.600751    1.000000   30.000000 'BCFEM  50% YOUNG'   2  56 !   3 OK         .000     -78.
    1.277254     .001000   10.000000 'BCFEM  SLOP YOUN'   2  56 !   4 OK         .000    -107.
   12.331139    1.000000   30.000000 'BCFEM  50% OLD  '   2  56 !   5 OK         .001      -2.
     .534601    -.100000   10.000000 'BCFEM  SLOP OLD '   2  56 !   6 OK         .003     -30.
    4.266891    1.000000   30.000000 'BCMALE 50% YOUNG'   2  56 !   7 OK         .000    -149.
    1.908034     .001000   10.000000 'BCMALE SLOP YOUN'   2  56 !   8 OK         .000     -50.
    7.123398    1.000000   30.000000 'BCMALE 50% OLD  '   2  56 !   9 OK        -.004      -1.
     .358134    -.100000   10.000000 'BCMALE SLOP OLD '   2  56 !  10 OK         .000    -245.
    1.522886     .002000   10.000000 ' SEXRATIO       '   2  56 !  11 OK         .000    -110.
  US FISH   TYPE:  2
  2  2 -1  2  1 KIND, MINAGE, NORMAGE, SEX, WT-BY-YEAR
```

```
  0   5   0   6  AGE TYPES USED
    1.00000        .01 'US COMM CATCH       '  ! # =  4 VALUE:       .00
    1.00000      -1.00 'US COMM AGECOMP     '  ! # =  5 VALUE:   -181.30
     .00000      -1.00 'US COMM SIZECOMP    '  ! # =  6 VALUE:       .00
   5.681140    1.000000   30.000000 'USFEM  50% YOUNG'   2  56 !  12 OK         .000    -355.
   1.356872     .001000   10.000000 'USFEM  SLOP YOUN'   2  56 !  13 OK         .000    -374.
  11.989532    1.000000   30.000000 'USFEM  50% OLD  '   2  56 !  14 OK         .002     -76.
    .910446    -.100000   10.000000 'USFEM  SLOP OLD '   2  56 !  15 OK         .001    -187.
   5.620794    1.000000   30.000000 'USMALE 50% YOUNG'   2  56 !  16 OK         .001    -122.
   1.707258     .001000   10.000000 'USMALE SLOP YOUN'   2  56 !  17 OK         .000    -201.
   1.000000    1.000000   30.000000 'USMALE 50% OLD  '   2  56 !  18 BOUND      .000       0.
    .380393    -.100000   10.000000 'USMALE SLOP OLD '   2  56 !  19 OK         .000   -1079.
    .473402     .002000   10.000000 ' SEXRATIO       '   2  56 !  20 OK         .000   -1175.
 SPORT     TYPE:  3
 2  2 -1  2  1 KIND, MINAGE, NORMAGE, SEX, WT-BY-YEAR
  0   8   0   9  AGE TYPES USED
    1.00000        .01 'US SPORT CATCH      '  ! # =  7 VALUE:       .00
    1.00000      -1.00 'US SPORT AGECOMP    '  ! # =  8 VALUE:   -111.48
     .00000      -1.00 'US SPORT SIZECOMP   '  ! # =  9 VALUE:       .00
   5.078251    1.000000   30.000000 'SPTFEM 50% YNG  '   2  56 !  21 OK         .000    -212.
   3.026838     .001000   10.000000 'SPTFEM SLOP YNG '   2  56 !  22 OK        -.002      -5.
  11.692722    1.000000   30.000000 'SPTFEM 50% OLD  '   2  56 !  23 OK         .003      -5.
    .763236    -.100000   10.000000 'SPTFEM SLOP OLD '   2  56 !  24 OK         .001     -38.
   5.068240    1.000000   30.000000 'SPTMALE 50% YNG '   2  56 !  25 OK         .000    -555.
   3.391426     .001000   10.000000 'SPTMALE SLOP YNG'   2  56 !  26 OK         .000     -19.
   3.802028    1.000000   30.000000 'SPTMALE 50% OLD '   2  56 !  27 OK        -.017      -1.
    .458008    -.100000   10.000000 'SPTMALE SLOP OLD'   2  56 !  28 OK         .000   -1023.
   4.228563     .002000   10.000000 ' SEXRATIO       '   2  56 !  29 OK         .000     -14.
TAG SVY    TYPE:  4
 2  2 -1  2  1 KIND, MINAGE, NORMAGE, SEX, WT-BY-YEAR
  0  11   0  12  AGE TYPES USED
    .110346    0    1    2 Q, QUANT=1, LOGERROR=1, BIOMASS=1 or NUM
    1.00000      -.15 'WDFW SURV ABUNDANCE '  ! # = 10 VALUE:     12.40
    1.00000     -1.00 'WDFW SURVEY AGECOMP '  ! # = 11 VALUE:    -11.05
    1.00000     -1.00 'WDFW SURVEY SIZECOMP'  ! # = 12 VALUE:   -145.69
   3.061607    1.000000   30.000000 'TAGFEM 50% YNG  '   2 -86 !  30 OK         .000    -418.
   4.017799   -5.000000   10.000000 'TAGFEM SLOP YNG '   2 -86 !  31 OK        -.001      -3.
   1.000000    1.000000   30.000000 'TAGFEM 50% OLD  '   2 -86 !  32 BOUND      .000       0.
    .481161    -.100000   10.000000 'TAGFEM SLOP OLD '   2 -86 !  33 OK         .000    -540.
   7.924123    1.000000   30.000000 'TAGMALE 50% YNG '   2 -86 !  34 OK         .000     -60.
   5.153807     .001000   10.000000 'TAGMALE SLOP YNG'   2 -86 !  35 OK         .000   -2733.
   2.979557    1.000000   30.000000 'TAGMALE 50% OLD '   2 -86 !  36 OK         .000    -877.
   4.992669    -.100000   10.000000 'TAGMALE SLOP OLD'   2 -86 !  37 OK         .000   -2722.
   6.055968     .002000   10.000000 ' SEXRATIO       '   2 -86 !  38 OK         .002      -7.
NMFS SVY   TYPE:  5
```

```
 2  2 -1  2  1 KIND, MINAGE, NORMAGE, SEX, WT-BY-YEAR
  0  14   0  15  AGE TYPES USED
   1.351799    0    1    1 Q, QUANT=1, LOGERROR=1, BIOMASS=1 or NUM
    1.00000      -.39 'NMFS SURVEY BIOMASS '  ! # = 13 VALUE:     -4.13
    1.00000     -1.00 'NMFS SURVEY AGECOMP '  ! # = 14 VALUE:     -4.61
    1.00000     -1.00 'NMFS SURVEY SIZECOMP'  ! # = 15 VALUE:    -57.72
   6.527385    1.000000   30.000000 'SVYFEM 50% YNG  '   2 -77 !  39 OK          .006      -6.
    .474235     .001000   10.000000 'SVYFEM SLOP YNG '   2 -77 !  40 OK          .000    -422.
  13.384157    1.000000   30.000000 'SVYFEM 50% OLD  '   2 -77 !  41 OK         -.003      -4.
  10.000000    -.100000   10.000000 'SVYFEM SLOP OLD '   2 -77 !  42 BOUND       .000       0.
  27.769964    1.000000   30.000000 'SVYMALE 50% YNG '   2 -77 !  43 BAD DX2     .000       0.
    .567808     .001000   10.000000 'SVYMALE SLOP YNG'   2 -77 !  44 OK          .000    -962.
   8.147562    1.000000   30.000000 'SVYMALE 50% OLD '   2 -77 !  45 OK          .000     -21.
   1.389357    -.100000   10.000000 'SVYMALE SLOP OLD'   2 -77 !  46 OK         -.003      -7.
   1.851529     .002000   10.000000 ' SEXRATIO       '   2 -77 !  47 OK         -.001     -18.
 0 0=CONSTANT, 1=YEAR-SPECIFIC POP. WTATAGE
 0 VULNERABILITY (1=MIGRATION, 2=AREA-SPLIT)
 0 EXAMINE DISCARD
 1 AGEERR: 1: MULTINOMIAL,  0: S(LOG(P))=CONSTANT,  -1: S=P*Q/N
200.000 MAXNAGED: MAX SAMPLE SIZE FOR MULTINOMIAL PROPORTION
 3 1=%CORR, 2=C.V., 3=%AGREE, 4=READ %AGREE @ AGE
    .500000     .002000     .990000 'AGE ERROR @2    '   0 -77 !  48 NO PICK     .000       0.
    .420000     .002000     .990000 'AGE ERROR @OLD  '   0 -77 !  49 NO PICK     .000       0.
   1.000000     .500000    4.000000 'AGEERR POWER    '   0 -77 !  50 NO PICK     .000       0.
    .180000     .010000     .500000 'OLD DISCOUNT    '   0 -77 !  51 NO PICK     .000       0.
 0 DENSITY-DEPENDENCE IN SELECTIVITY
-1 CPUE FOR TYPE:   1
     .00000       .10 'BC COMMERCIAL CPUE  '  ! # = 16 VALUE:   -197.01
    .000029     .001000    1.000000 'MEAN Q BC       '   0  56 !  52 NO PICK     .000       0.
    .000000     .000000     .000000 'BIO Q BC        '   0  56 !  53 NO PICK     .000       0.
-2 CPUE FOR TYPE:   2
    1.00000       .10 'US COMMERCIAL CPUE  '  ! # = 17 VALUE:     11.29
    .004173     .001000    1.000000 'MEAN Q US       '   0  56 !  54 NO PICK     .000       0.
    .000000     .000000     .000000 'BIO Q  US       '   0  56 !  55 NO PICK     .000       0.
 0 END OF EFFORT
 1 FIX n FMORTs
110   1   1  YEAR,  PER,  TYPE
    .050000     .010000   10.000000 'FMORT 89        '   0  89 !  56 NO PICK     .000       0.
 0  CANNIBALISM
 0 ENVIRONMENTAL DEPENDENCE
 0 ESTIMATE N ENVIRONMENT VALUES
 0 PENALTIES: PARM, PRIOR, SD or CV, PICK, LABEL, X, PENALTY
18  STOCK-RECRUITMENT
 1 1=B-H, 2=RICKER
 1 0=USE S-R CURVE, 1=SCALE CURVE
```

```
     .00001      -.50 'SPAWNER-RECRUIT INDI'  ! # = 18 VALUE:      6.27
     .00001      -.80 'SPAWNER-RECRUIT MEAN'  ! # = 19 VALUE:      -.89
    .869513     .200000    2.200000 'VIRGIN RECR MULT'   2   1 !  57 OK          .000   -2655.
    .889000     .200000     .999999 'CURVATURE        '   0   1 !  58 NO PICK     .000       0.
   1.000000     .010000    1.000000 'BACKGROUND REC   '   0   1 !  59 NO PICK     .000       0.
    .500000     .100000     .990000 'S/R STD.DEV.      '   0   1 !  60 NO PICK     .000       0.
    .000000     .000000     .000000 ' Recr-trend       '   0  80 !  61 NO PICK     .000       0.
   1.150000     .100000   10.000000 'RECR MULT        '   0   1 !  62 NO PICK     .000       0.
  0 INITIAL AGE COMP
    .314192     .001000   10.000000 'RECRUIT 75       '   2  75 !  63 OK          .001    -130.
    .756949     .001000   10.000000 'RECRUIT 76       '   2  76 !  64 OK          .000    -115.
   1.120072     .001000   10.000000 'RECRUIT 77       '   2  77 !  65 OK          .000    -109.
    .597216     .001000   10.000000 'RECRUIT 78       '   2  78 !  66 OK          .000    -120.
   1.133646     .001000   10.000000 'RECRUIT 79       '   2  79 !  67 OK          .001    -122.
   1.486116     .001000   10.000000 'RECRUIT 80       '   2  80 !  68 OK          .000    -137.
   1.133177     .001000   10.000000 'RECRUIT 81       '   2  81 !  69 OK          .000    -174.
    .620998     .001000   10.000000 'RECRUIT 82       '   2  82 !  70 OK          .000    -239.
    .684873     .001000   10.000000 'RECRUIT 83       '   2  83 !  71 OK          .000    -339.
    .640333     .001000   10.000000 'RECRUIT 84       '   2  84 !  72 OK          .000    -458.
    .624748     .001000   10.000000 'RECRUIT 85       '   2  85 !  73 OK          .000    -549.
    .975225     .001000   10.000000 'RECRUIT 86       '   2  86 !  74 OK          .000    -553.
    .362852     .001000   10.000000 'RECRUIT 87       '   2  87 !  75 OK          .000    -875.
    .319410     .001000   10.000000 'RECRUIT 88       '   2  88 !  76 OK          .000   -1074.
    .451922     .001000   10.000000 'RECRUIT 89       '   2  89 !  77 OK          .000    -894.
    .517932     .001000   10.000000 'RECRUIT 90       '   2  90 !  78 OK          .000    -666.
    .734424     .001000    2.500000 'RECRUIT 91       '   2  91 !  79 OK          .000    -398.
    .734715     .001000   10.000000 'RECRUIT 92       '   2  92 !  80 OK          .000    -306.
    .241500     .001000   10.000000 'RECRUIT 93       '   2  93 !  81 OK          .000    -759.
    .387758     .001000    2.500000 'RECRUIT 94       '   2  94 !  82 OK          .000    -444.
   -.487656     .001000   10.000000 'RECRUIT 95       '   0  95 !  83 NO PICK     .000       0.
   -.444591     .001000    2.500000 'RECRUIT 96       '   0  96 !  84 NO PICK     .000       0.
   -.428255     .001000   10.000000 'RECRUIT 97       '   0  97 !  85 NO PICK     .000       0.
CONVERGENCE
  NUMBER OF ESTIMATED PARAMETERS =          66
  N CATCHES WITH F ESTIMATED     =          69
  N SURV OBS WITH EMPH > 0.001   =          14
  N EFFORT OBS WITH EMPH > 0.001 =           7
  N COMPOSITION OBS WITH NAGES>1 =          65
  N COMPOSITION BINS WITH DATA   =        1335
```