Status of the Yellowtail Rockfish Resource in 2000

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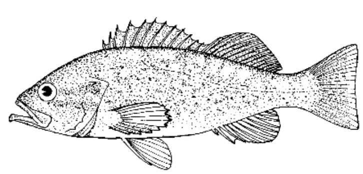

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Table of Contents

List of Figures

List of Tables

Executive Summary

Yellowtail rockfish abundance was last assessed in 1997, this report represents the scheduled triennial update on the status of stocks. Data, compiled for four separate stock units, and evaluated for three model configurations are analyzed using the ADMB version of the assessment model

Stocks: The Pacific Fishery Management Council (PFMC) manages the U.S. fishery as two stocks separated at Cape Mendocino, California (40°30' N Lat.). Within the assessment we evaluate four separate stock groupings: a coast-wide stock (Cst) extending from Cape Mendocino to approximately 49° N. Latitude, and three subarea stocks. Subarea stocks include: the Eureka/South Columbia stock (EUR) extending from 40° 30' N. latitude (Cape Mendocino) to 45° 46' N. latitude (Cape Falcon); the Northern Columbia stock (COL) extending north from Cape Falcon to 47° 20' N. latitude (Cape Elizabeth); and, the Southern Vancouver stock (VAN) reaching north from Cape Elizabeth to approximately 49° N. latitude.

Catches: U.S. yellowtail rockfish catch increased from 1200 mt in 1967 to 9500 mt in 1983 After imposition of specific yellowtail rockfish trip limits in 1985, catch declined markedly. Over the past five years, 1995-1999, annual U.S. catch has averaged 4300 mt. Coast-wide catch (including Canada) increased from 5000 to 7800 mt or 56% from 1991 to 1992, then gradually declined to 6900 mt in 1995. In 1996, landings rose sharply to 8300 mt due to a strong Canadian catch. Severe restrictions on the U.S. fishery dropped coast-wide landing to 2900 mt in 1997. Since then, landings have gradually increased to 4500 mt in 1999.

Data and assessment: Yellowtail rockfish stock abundance was last assessed in 1997, using a customized statistical age-structured model written with AD Model Builder software. The updated assessment uses the same model with minor modifications. Input data include catch from 1997 to 2000 (2000 catch is assumed equal to 1999 catch), fishery catch at age data from 1977 to 1999 (time series depends on the stock unit evaluated), 1977 to 1998 NMFS triennial trawl survey biomass estimates, 1980 to 1998 NMFS trawl survey age data (sexes combined), a domestic trawl logbook CPUE index from 1988 to 1999, and a whiting fishery bycatch index from 1978 to 1999. In addition the model uses year specific estimates of weight-at-age, area specific estimates of proportion mature-at-age, and an age transition matrix to account for ageing error.

Unresolved problems and major uncertainties: There are significant issues regarding the appropriateness of auxiliary abundance indices used in the model. The whiting bycatch index is uninformative, but the presumptive trend in stock biomass has been fairly flat and a strong signal in the bycatch index may not be expected. The logbook CPUE index may contain some signal relative to stock trends, but there are concerns over bias resulting from annual variability in fishery catchability, the effect of regulations on fishery CPUE, and the unmonitored discard of actual catch. The trawl survey biomass estimates are imprecise which can lead to wide fluctuations in the perception of stock trends. However, we feel the survey abundance indices are least likely to have systematic bias.

Reference points: Benchmark values reported here are from the reference model, which uses all three auxiliary indices. Estimates of unfished biomass (B_0) assume a constant level of annual recruitment equal to the long-term (1967-1997) mean of 14.0 million fish. B_0 is 114,700 mt. Unfished spawning biomass (SPB_0) is 32,500 mt. Target level spawning biomass ($SPB_{40\%}$) is 13,000 mt. The overfishing threshold spawning biomass ($SPB_{25\%}$) is 8,100 mt. The recommended fishing mortality rate ($F_{50\%}$) is 0.09.

Stock biomass: Using results from the reference model, estimated coast-wide biomass in year 2000 was 69,400 mt with a 23% CV. Estimated 1997 biomass was 80,800 mt compared with 56,700 mt estimated in the prior assessment. The revised estimates of biomass are higher than those estimated in the 1997 assessment reflecting the sensitivity of the model to the trawl survey biomass index and assumptions about increases in effective effort of the fleet. Biomass trend in the current assessment shows a period of stability in the mid-to-late 1980s extending through 1995, with recent biomass trending down. Current (year 2000) biomass is 50% of the 1967 estimated biomass and spawning biomass is estimated to be 158% of the target spawning biomass ($SPB_{40\%}$).

Recruitment: There is no obvious spawner/recruit relationship. Median (1967-2000) annual recruitment is 11.0 million fish at age 4, with average recruitment reaching 13.6 million. The 1989 and 1990 year classes (age 4 in 1993 and 1994) were the last to be above average. The 1995 through 1998 recruitment estimates are about half the median estimate. The current assessment suggests that recruitment is more volatile than depicted in the 1997 assessment, particularly for recent years.

Exploitation status: Fishing mortality peaked in 1983 the last year of essentially unconstrained removals. After imposition of trip limits on the "Sebastes Complex", fishing mortality declined to a low in 1985, and then increased until 1996. Following the 1996 stock assessment, more severe catch restrictions were imposed and fishing mortality dropped to a modern era low in 1997. Since 1997, fishing mortality has climbed back to the1985 level.

Management performance: Over the last 18 years, yellowtail rockfish trip limits have been ineffective at constraining catch within the HG set for the US fishery. In 14 of the last 18 years, total catch (including estimated discard) exceeded the HG by more than 10%. Since 1983, annual estimated catch has averaged 51% greater than the HG. In the last 10 years, catch has exceeded the HG by 26% and over the last 5 years by 11%. Total catch has exceed Council ABC's an average 53%, 29% and 24% over the last 18, 10 and 5 years respectively. Moreover, total catch has always exceeded the assessment's low estimate of ABC and has exceeded the high ABC 44% of the time since 1983.

Forecasts: Average projected coast-wide yield over the next three years (2001-2003), is 4500 mt for the Ref Model and ranges from 3900 to 4700 mt for other models evaluated. Total stock biomass is projected to decline. This is consistent with the low level of recruitment experienced between 1995 and 1998 and the fact that the stock is above the target level biomass. Over the next three years, recruitment from these below average year classes will form the heart of the fishery, which remains dependent on 7 to 14 year old fish. Spawning biomass in year 2003 is projected to be 112% to 125% of the $SPB_{40\%}$ depending on the model used. Based on stock specific yield projections, we estimate that 14% of the yield should be harvested in the Eureka/S.Columbia area, 42% in the N.Columbia area, and 44% in the S.Vancouver area. Council ABC and OY determinations need to account for expected harvest by Canadian fishers. From 1995 to 1999, the U.S fisheries took on average 81% of the coast-wide catch of yellowtail rockfish.

A more risk adverse harvest strategy could be selected by requiring a higher level of certainty in the projected yield. Cumulative probability profiles of projected yield facilitate such an estimate. For the coast-wide reference case model, and the $F_{50\%}$ SPR rate, the 3-year mean projected yield, consistent with a 75% probability that yield is no less than projected, is 3600 mt, and the estimate consistent with a 25% probability that it is no more than projected is 5400 mt. The lower estimate (3600 mt) is approximately 80% of the mean point estimate (4500 mt). If desired, the lower projected yield could be the basis of a more conservative ABC and OY recommendation.

Recommendations: We have identified three areas of research for yellowtail rockfish: 1) updating estimates of the proportion mature-at-age; 2) evaluating the effectiveness of trawl surveys for species like yellowtail rockfish with particular attention to variation in annual catchability, and 3) stock structure studies using microsatellite DNA

1.0 Introduction

Yellowtail rockfish abundance and acceptable biological catch (ABC) were last assessed in 1997 (Tagart et al., 1997). In that assessment a thorough review of all data inputs was conducted, data were evaluated for bias, new indices of stock abundance were provided, a coast-wide (Cape Mendocino to Vancouver Island) model was introduced, and the assessment transitioned from the Stock Synthesis model to a customized model (similar to Stock Synthesis) written with AD Model Builder (ADMB). This report represents the scheduled triennial update of yellowtail rockfish status of stocks. Data, compiled for four separate stock units, and evaluated for three model configurations are analyzed using the ADMB version of the assessment model.

1.1 General Description

Yellowtail rockfish (*Sebastes flavidus*) are found throughout the northeast Pacific Ocean. Their range reportedly extends from San Diego, California to Kodiak and Admiralty Island, Alaska (Hart, 1975), although Eschmeyer et al. (1983) report the species is rare south of Point Conception, California (approximately 34^{o} 25' N. latitude). Their center of abundance is from Oregon to British Columbia (Alverson et al., 1964, Westrheim, 1970; Gunderson and Sample, 1980). Yellowtail rockfish are reported to occur at depths of 0 to 549 m (0 to 300 fm) (Hart, 1975). Commercial fishermen typically harvest yellowtail rockfish with bottom and midwater trawls fished at depths of 110 to 201 m (60 to 110 fm) (Fraidenburg, 1980; Tagart and Kimura, 1982).

Yellowtail rockfish form large schools and can be found alone or in association with other rockfish. Nagtegaal (1983) identifies canary rockfish (*Sebastes pinniger*) silvergray rockfish (*S. brevispinis*) and widow rockfish (*S. entomelas*) as other species forming seasonal assemblages with yellowtail rockfish along the British Columbia coast. Yellowtail rockfish are also caught incidentally in the midwater trawl fisheries for widow rockfish (Tagart 1987) and Pacific whiting (*Merluccius productus*). Rogers and Pikitch (1992) evaluating assemblage patterns observed in commercial catches off the Oregon and Washington coast assign yellowtail rockfish to the "Bottom Rockfish Assemblage" associating them most strongly with canary, yelloweye (*S. rubberimus*) and sharpchin rockfish (*S. zacentrus*), bocaccio (*S. paucispinis*) and lingcod (*Ophiodon elongatus*).

1.2 Stock structure and management units

Genetic investigations of yellowtail rockfish by Wishard et al. (1980) and McGauley (1991) were inconclusive with respect to stock structure. Wishard et al. (1980) conducted an electrophoretic examination of 593 yellowtail rockfish collected along the Oregon and Washington coast during the National Marine Fisheries Service 1977 coastal groundfish trawl survey. These authors found little variability among samples and concluded that without further sampling, "yellowtail rockfish must be regarded as one homogenous group within the sampling area." McGauley applied the polymerase chain reaction technique to amplify a 1600 base pair region of mitochondria ribosomal RNA for 74 yellowtail rockfish collected from three localities: off Nootka Sound along north-central Vancouver Island, off Grays Harbor and the central Washington coast, and from Cordell Bank, California. She found no variability among her samples and concluded that her results confirmed the homogenous stock hypothesis.

Using electrophoretic analysis, Tagart, Phelps and Stanley (personal communication) examined 1000 yellowtail rockfish taken in 10 samples from five areas over two seasons. The sample area extended from southern Oregon to Queen Charlotte Sound in British Columbia. Samples were collected between September 30 and November 6, 1990 and again between March 23 and May 23, 1991. Data were gathered for 33 presumptive loci, 23 of which were polymorphic. Average observed heterozygosity was 0.04. There was significant genetic heterogeneity among samples refuting the coast-wide homogenous stock hypothesis. There were significant differences between samples from Oregon and those taken elsewhere; in addition, northern Washington samples were different from southern Washington samples. Samples from northern Washington were not different from Canadian samples, and there were no detectable differences among Canadian samples.

Stanley et al. (1992) provide supporting evidence that the coast-wide yellowtail rockfish population may be composed of separate stocks. The authors conducted a necropsy of 238 fish collected in 15 samples from seven locations between Queen Charlotte Sound and the central Oregon coast to determine the prevalence and intensity of infestation of parasites on yellowtail rockfish. They found a cline in the prevalence of a monogenean gill parasite (*Monogenea sebastis*) with decreasing prevalence from north (80-100%) to south (0-10%). There were no clear boundaries between sampled regions, and the observed differences do not exclude the possibility of mixing between adjacent areas. Nevertheless, the differences at the extremes of the sampled range certainly suggest separation of these areas, and taken with the unpublished allozyme data support the multi-stock hypothesis.

Currently, the yellowtail rockfish fishery is managed as if composed of four stocks. The Canadian Department of Fisheries and Oceans (DFO) manages their fishery as two unit stocks; a "boundary" stock equivalent to the Southern Vancouver stock identified below and a "coastal stock" from PMFC area 3D to the northern Canada/U.S. border (Stanley, 1993). The Pacific Fishery Management Council (PFMC) manages the U.S. fishery as two stocks separated at Cape Mendocino, California (40^{o}30' N Lat.). Tagart (1991) suggested that the U.S. fishery north of Cape Mendocino could be divided into three stocks (Figure 1): the Eureka/South Columbia stock extending from 40^{o} 30' N. latitude (Cape Mendocino) to 45^{o} 46' N. latitude (Cape Falcon); the Northern Columbia stock extending north from Cape Falcon to 47^{o} 20' N. latitude (Cape Elizabeth); and, the Southern Vancouver stock reaching north from Cape Elizabeth to approximately 49^{o} N. latitude (the southern boundary of PMFC area 3D).

Examination of yellowtail rockfish catch rates from the National Marine Fisheries Service (NMFS) trawl survey, and catch rates from fishery trawl logbook data suggest that the southern boundary of the N.Columbia stock may be better positioned at Cape Lookout (45^{o} 20’ N Lat). A stock boundary at Cape Lookout presents logistical problems for catch accounting because the boundary splits a catch reporting statistical area (PMFC area 2C). While catch accounting should not dictate the placement of legitimate stock boundaries, it can complicate analyses. We could evaluate analytical problems associated with moving the N.Columbia stock’s southern boundary and report on the feasibility in a future analysis.

The boundaries of the presumed stock units remain elusive and further research may serve to identify them. Nevertheless, it is clear that yellowtail rockfish do form separate, genetically distinct, localized aggregations which can be prudently managed as stock units. In this analysis, we continue to use stock designations proposed in Tagart (1991); in addition, we evaluate a coast-wide stock extending from Cape Mendocino to Vancouver Island.

1.3 Life history

Yellowtail rockfish are long lived. Recruited to the commercial fishery at 4 years of age (Tagart, 1988), the age distribution of fish sampled from the commercial fishery can span six decades. The oldest recorded yellowtail rockfish is a 64-year-old male (Shaw and Archibald, 1981). Yellowtail rockfish reach their maximum size at approximately 15 years of age. The largest recorded yellowtail rockfish was 70 cm female caught by bottom trawl from PMFC area 3A in 1996. Females begin to mature at 27 cm to 37 cm (4 to 6 years of age) with the size at 50% maturity ranging from 37 cm to 45 cm (6 to 11 years old) (Westrheim 1975; Gunderson et al. 1980; Echeverria 1987; Tagart 1991). Males mature at a slightly smaller size and younger age than females. First maturity for males occurs at 30 cm (4 years old), with 50% maturity at 34 cm to 41 cm (5 to 9 years of age).

1.4 History of the fishery

Rockfish have been reported in Pacific coast landings since 1875 (Phillips, 1964). Although taken in trawls as early as the 1920s, rockfish were primarily harvested by line fisheries through the early 1940s. Since the 1940s, the fishery has been predominately a trawl fishery. During World War II the high demand for food brought an upsurge in rockfish landings (Anonymous, 1948; Alverson et al., 1964). In 1941-42, the coast-wide landings of all groundfish in Washington, Oregon and California was approximately 4500 t for each state; however, by 1945 those landings had increased to about 11,000 t in California and Oregon and 20,000 t in Washington (Anonymous, 1948). Along with total groundfish landings, coast-wide rockfish landings peaked in 1945-46. The collapse of groundfish markets following World War II sent rockfish landings into a 15 year slump and it wasn't until the 1960s that landings again began to climb.

Immediately, following World War II, the trawl fishery began to shift its attention from the continental shelf to the slope in pursuit of Pacific ocean perch (*Sebastes alutus*). Alverson and Westrheim (1961) state that the commercial fishery for Pacific ocean perch began off Oregon in 1946 and by 1955 this fishery had spread to Hecate Strait along the northern British Columbia coast. The Pacific Marine Fisheries Commission reports in their 1948 bulletin (Anonymous, 1948) that most of the Washington trawl fleet had already moved to Hecate Strait. So with the post-war collapse of the groundfish markets, there also came a shift of effort away from the waters contiguous to the Washington coast.

Distant water foreign fisheries began to harvest rockfish along the Pacific coast of Washington, Oregon and British Columbia by the mid-1960s. The Soviet fleet arrived in 1965, followed by the Japanese in 1966 (Gunderson, 1977; Fraidenburg et al., 1977; Westrheim, 1986). These fisheries predominately targeted Pacific Ocean perch and Pacific whiting resources, but as Fraidenburg et al. (1977) disclose, they also made substantive catches of other rockfish.

During the early development period of the rockfish fishery there was little attention paid to quantifying the species composition of the landings. Nonetheless, we do know that yellowtail rockfish were a part of the fishery. For example, Phillips (1964) reports that prior to the 1940s, yellowtail rockfish were predominant in commercial catches in northern and central California. Similarly, Alverson and Welander (1952) report yellowtail rockfish among the primary species landed in Washington during World War II. Although we know yellowtail rockfish were caught during this time, we have no substantive knowledge of the proportion of their contribution to the total landings.

It wasn't until the early 1960s that coastal states began to report landings by species (Niska, 1976; Tagart and Kimura, 1982). Prior to 1967 sampling for species other than Pacific Ocean perch was sporadic. Species composition reports for "other rockfish" began to be routinely collected in 1967.

Between 1967 and 1974, there was a steady but low-level fishery in the Columbia area, primarily prosecuted by Oregon based fishermen. By 1975, an increasing number of U.S. fishermen had begun to prospect fishing grounds along the south central Washington coast. In 1977, the U.S. and Canada extended their fisheries jurisdiction out to 200 nautical miles, and began bilateral negotiations that eliminated U.S. fishing in Canadian waters in April 1981 (Westrheim, 1987).

With the exception of a large midwater trawl fishery for widow rockfish, yellowtail rockfish off Oregon and Washington were the main target of the expanding fishery in the late 1970's. The development of the yellowtail rockfish fishery provoked improvements in fishing strategies and fishing gear, such as three-seam, triple-bridle trawls to increase the vertical opening of the net, and improvements in roller gear needed to access rockfish habitat.

As noted above, yellowtail rockfish co-occur with canary and widow rockfish. Association with these and other rockfish species has substantially altered fishing opportunity for yellowtail rockfish. Canary rockfish stocks are currently at very low levels of abundance and have been declared overfished by National Marine Fisheries service. In order to achieve the necessary reduction in the canary rockfish catch, the Council adopted stringent management measures in 2000. Harvest of Canary rockfish and their co-occurring species was limited. Notably, yellowtail rockfish in the Eureka through Vancouver areas may no longer be landed if a vessel has trawl gear aboard with a footrope diameter greater than eight inches and only 1,500 pounds per month may be landed using bottom trawls with a footrope diameter less than eight inches. The high-rise, roller gear trawls developed for the yellowtail rockfish fishery are no longer legal gear for this species.

Fishery logbook data indicates that yellowtail rockfish can be harvested with midwater trawl gear with relatively minor canary rockfish bycatch. As a result, the targeted yellowtail rockfish fishery is now limited to midwater trawl gear. However, widow rockfish still co-occur with yellowtail rockfish in the midwater trawl fishery. Widow rockfish are not currently overfished, however, the status of stocks is under review in 2000. Should the 2000 widow rockfish assessment indicate a need to implement additional constraints on widow rockfish harvest, harvest opportunities for yellowtail rockfish may become even more limited.

Bycatch of yellowtail rockfish in the directed midwater trawl fishery for Pacific whiting has also generated management problems. In 1999, yellowtail rockfish bycatch in the whiting fishery closed the directed fishery for yellowtail rockfish for the last three months of the year in order to remain within the optimum yield. A number of measures have been adopted in the Pacific whiting fishery to reduce yellowtail bycatch, including real time information sharing concerning areas of high yellowtail bycatch among catcher-processor vessels in the at-sea fleet. Directed whiting fishers landing catch to shoreside processors deliver unsorted catches. Shoreside whiting vessels are now required to lose fishing days when yellowtail bycatch exceeds proscribed levels.

1.5 Management history

Prior to 1983, the domestic trawl fishery for yellowtail rockfish was constrained only by market forces. In 1983, U.S. managers imposed a 40,000 lb trip limit on landings from the *Sebastes* complex (an collection of rockfish species that included yellowtail rockfish). In addition to trip limits, the PFMC set a harvest guideline (HG), or target quota, for the complex. By September 1983, harvest was approaching the quota (18,500 mt) in Columbia and Vancouver areas. Managers responded by reducing the trip limit to 3,000 lbs and requiring fishers not to exceed one trip per week. This began a tumultuous management history for *Sebastes* complex species and yellowtail rockfish in particular.

Constraints on yellowtail rockfish landings by controls on the *Sebastes* complex were replaced in 1985 with direct limits on yellowtail rockfish. The Council used trip limits and trip frequency regulations in an attempt to spread the harvest throughout a calendar year, reduce bycatch in the directed fishery and limit regulatory induced discard. In-season adjustments, usually reductions, to the limits have occurred frequently (Table 1).

From 1985 to 1991 trip limits were changed often. Managers attempted to provide flexibility for individual harvests by devising weekly, bi-weekly and twice weekly trip limit options. Increasing harvest rates and declining abundance of coastal groundfish species subsequently resulted in smaller and smaller trip limits. Yellowtail weekly trip limits diminished from a high of 12,500 lbs mid-1986 to a weekly equivalent of 2,500 lbs in 1991 (Figure 2).

In an effort to continue a year-round fishery and reduce the risk of increasing discard anticipated from smaller trip limits, the Council provided fishers a larger retainable catch by adopting a two-week cumulative limit strategy in 1992. Cumulative limits allowed harvesters to combine landings over multiple trips within a specified time interval. The two-week cumulative limit period was extended to monthly in 1994, bi-monthly in 1996, and tri-monthly by 1999.

The PFMC has struggled with forms of area management. Yellowtail rockfish populations have typically been divided into two management stocks, a southern and northern management group. Although the boundary separating the stocks has changed over time, moving from Coos Bay to Cape Mendocino. In addition, in 1992 the northern stock was briefly split at Cape Lookout. At it's northern management boundary, the yellowtail rockfish stock is assumed to be transboundary, extending into Canada. U.S. managers have attempted to accommodate the transboundary nature of the stock by limiting harvest in the northern stock to an anticipated U.S. share. Canadian managers have behaved similarly. There have been no bilateral negotiations between the U.S and Canada regarding allocation of these transboundary resources.

From the inception of regulation in 1993, through 1999, yellowtail rockfish were managed as part of the *Sebastes* complex. In 2000, the Council adopted a new partitioning of rockfish species, abandoning the former complex. To better monitor and control fishing strategies and harvest on minor rockfish, rockfish are now either managed as a single independent species or in one of three species-specific groups. South of Cape Mendocino, yellowtail rockfish are now assigned to the Minor Shelf Rockfish group; north of Cape Mendocino, they are managed as a single species.

1.6 Management performance

Stock assessments provide managers with an estimate of the acceptable biological catch (ABC). This represents the assessment author's evaluation of the sustainable productivity of the stock. The ABC is sometimes presented as a range reflecting uncertainty in the estimated abundance. Typically, the PFMC has selected an "official" ABC within the range of the assessment's upper and lower ABC estimate. In addition, from 1983 to 1998, the Council also designated a harvest guideline. The harvest guideline was a catch target level or "soft" quota. As landings neared the HG, more stringent management regulations were imposed, but landings in excess of the HG did not necessarily prompt closure of the fishery. Since 1998, the HG has been replaced with an optimum yield (OY) designation. The OY is treated much the same as the HG, except that OY can be no greater than the Council's designated ABC. The ABC is now treated as a hard quota, as landings approach the ABC managers are required to close fisheries expected to contribute to further catch.

Between 1985 and 1990, for assessed stocks north of Cape Mendocino, the Council set the yellowtail rockfish HGs equal to ABC and near the mid-point values for high and low ABC estimates reported in the most current assessment (Table 2). From 1991 to 1993, the Council set their ABC 10% higher than the assessment's lower ABC estimate (Tagart, 1991), and their HG was set at the lower estimate of ABC. Through 1993, HGs were set without regard to discarded catch.

Beginning in 1994, the in-season yellowtail rockfish catch monitoring included an estimated 16% discard rate. The 1994-1996 ABC was again set at the mid-point of the assessment estimated high and low ABC (Tagart, 1993). The 1994 HG was set equal to the Council ABC. In 1996, the HG was set below the estimated ABC after discounting for anticipated discards.

In 1997, the Council's official yellowtail rockfish ABC was based on a range derived from the 1996 assessment ABC estimates (Tagart and Wallace, 1996). Because this assessment was controversial, and pending an updated assessment the following year, the Council adjusted the HG toward the level recommended in the assessment but significantly above the assessment's ABC. The upper end of the 1997 HG was set approximately 50% higher than the assessment estimated high ABC. The stock assessment was updated in 1997. Based on 1997 assessment estimates, the Council set the 1998-2000 ABC equal to the high range estimate of ABC and they set HG/OY 10% below the ABC.

Over the last 18 years, yellowtail rockfish trip limits have been ineffective at constraining catch within the HG set for the US fishery. In 14 of the last 18 years, total catch (including estimated discard) exceeded the HG by more than 10%. Since 1983, annual estimated catch has averaged 51% greater than HG. In the last 10 years, catch has exceeded the HG by 26% and over the last 5 years by 11%. Results are similar when contrasting catch to Council recommended ABC's. Total catch has exceed Council ABC's an average 53%, 29% and 24% over the last 18, 10 and 5 years respectively. Moreover, total catch has always exceeded the assessment's low estimate of ABC and has exceeded the high ABC 44% of the time since 1983 (Figure 3). Unmonitored discards represent an ongoing problem for catch accounting and evaluation of management performance.

2.0 Changes since the last assessment

The biological database (sex, size and age) was updated with sample data for 1997 to 1999. In addition we replaced biological data for 1996 to assure inclusion of all available samples (1996 was the last year of the biological data time series in the previous analysis, replacement with current data assures inclusion of late samples, deletion of bad samples, and updates of corrected samples.) Canadian scientists provided a complete replacement for their portion of the biological database. Age data from the shrimp trawl fishery was available for the first time. Catch data was revised and updated. New weight-at-age schedules were calculated for the 1997-1999 fishery. The coast-wide whiting bycatch index was reconstructed and updated. We replaced the area-weighted domestic trawl CPUE index with a revised CPUE index and extended the time series to 1999. A new datum based on estimated 1998 biomass was added to the NMFS triennial trawl survey abundance index. Age data for the 1998 survey were also added. Catch-at-age for all commercial fisheries were recomputed using the updated time series of total catch and revised biological data.

The statistical age-structured model used to analyze data was amended to include the estimated variance for the trawl logbook CPUE index (this variance was formerly estimated internally in the model). The model constructed using AD Model Builder software is described in detail elsewhere in this document.

3.0 Data

3.1 Catch

Catch data are compiled from agency reports, PacFIN, U.S observer data, and personal communication with agency personnel. Rockfish landings from the domestic trawl fishery are routinely sampled for species composition, as are incidental rockfish landings in the at-sea whiting fishery. Don Pearson (NMFS/SWFC) provided revised estimates of California 1980 to 1998 landed catch. California's 1999 landings were taken from PacFIN. Contributing agencies have revised landings data submitted to PacFIN over the past three years, resulting in some substantive redistribution of catch among areas. For this analysis, we extracted yellowtail rockfish catch data for the period 1985 to 1999 from the PacFIN database on January 5, 2000. Rick Stanley (Canadian Department of Fisheries and Oceans) provided Canadian landings data. Yellowtail rockfish catch (retained plus discarded) from the at-sea whiting fishery were updated for 1997-1999. Data for 1997 and 1998 were obtained from Martin Loefflad (NMFS/AFSC Observer Program); Becky Renko (NMFS/NWR) provided 1999 data.

Yellowtail rockfish catch taken by the shore-based whiting fishery was estimated from reported landings on fish receiving tickets (sales receipts). In the PacFIN database, fish tickets were filtered for a whiting catch greater than or equal to 5000 pounds. All yellowtail rockfish landings on these fish tickets were assumed to be from the directed shore-based whiting fishery. The estimated shore-based whiting fishery catch was subtracted from the domestic trawl yellowtail rockfish catch reported on the January 5, 2000 PacFIN extract. Estimated landings for the shore-based whiting fishery probably underestimate the actual of that fishery. Landings in excess of the allowed trip limits for yellowtail rockfish are reported on "overage tickets", and consequently may loose their association with the whiting catch. Thus when filtering fish tickets for a directed whiting landing, the overage tickets would be missed. Landings recorded on overage tickets are part of the total yellowtail rockfish landings extraction for the domestic trawl fishery; so they are not missing from the account of total landings but may be assigned to the wrong target fishery. (As noted later in the document, the consequence of the incorrectly categorized catch may be trivial, since the age composition of the catch in the various fisheries is similar).

We do not have historical species composition samples for rockfish landings from the shrimp trawl fishery. Prior to 1987, yellowtail landings from the shrimp trawl fishery were assumed to represent a fixed fraction of the nominal rockfish landings: 0.787 for the S.Vancouver area, and 0.686 for the other stock areas (personal communication from Jim Golden, ODFW). In the S. Vancouver area, shrimp landings of yellowtail rockfish from 1987 are assumed to be 90% of the nominal rockfish landed catch based on limited WDFW fish-ticket market samples. Since 1987, yellowtail landings from the shrimp trawl fishery are taken directly from PacFIN.

Discarded catch from the domestic trawl fishery is assumed to represent 16% of the total catch, i.e., total domestic catch equals domestic landed catch divided by 0.84. We assume no discard prior to 1985. Since 1985, PFMC regulations limiting the volume of yellowtail rockfish landed catch (trip limits) have become increasingly severe (Figure 4). There is speculation, but little direct evidence, that at-sea discard of yellowtail rockfish may be higher than assumed. The estimates of discarded catch should probably be regarded as minimal estimates.

U.S. yellowtail rockfish catch increased from 1200 mt in 1967 to 9500 mt in 1983 (Table 3). After imposition of specific yellowtail rockfish trip limits (Figure 4) in 1985, catch declined markedly (Figure 5). Over the past five years, 1995-1999, annual U.S. catch has averaged 4300 mt. Coast-wide catch increased from 5000 to 7800 mt or 56% from 1991 to 1992, then gradually declined to 6900 mt in 1995. In 1996, landings rose sharply to 8300 mt due to a strong Canadian catch. Severe restrictions on the U.S. fishery dropped coast-wide landing to 2900 mt in 1997. Since then, landings have gradually increased to 4500 mt in 1999.

In 1996, the last year of catch data for the 1997 assessment, 28% of the U.S. catch was taken from the Eureka/S.Columbia stock, 41% from the N. Columbia stock, and 31% from the S. Vancouver stock. By 1999, the distribution had changed to 16%, 34% and 50% respectively. In the past five years, approximately 73% of the coast-wide annual catch was taken in the directed groundfish trawl fishery, 3% in the shrimp trawl fishery and the remainder, 24%, was taken in the whiting fisheries. In 1999, the whiting fishery landed 32%, the shrimp fishery 1% and the domestic trawl fishery 66% of the coast-wide catch. The U.S. fishery currently takes about 80% of the total annual catch.

Since 1996, Eureka/S. Columbia area annual catch has dropped to approximately 40% of the pre-1997 catch levels. Over the last 5 years, annual catch averaged 1000 mt, compared with the 1992-1996 5-year average of 1700 mt. Catch peaked in 1992 at 2700 mt, then dropped but remained above a 1000 mt annually through 1996. It has hovered around 600 mt since then (Table 4, Figure 4). The domestic trawl fishery accounts for 92% of the 580 mt 1999 catch.

Annual catch in the N. Columbia area has been declining slowly for the past 10 years (Figure 4). Mean catch since 1990 has been 2100 mt while mean catch in the last 5 years is 1800 mt (Table 5). Estimated annual catch from 1997 to 1999 was approximately one-half to one-third the volume for the three-year period 1994-1996. The domestic trawl fishery accounted for 63% of the 1999 catch compared with 75% of the 1996 catch.

Annual catch in the S. Vancouver area peaked in 1982. Regulation provoked a drop in catch during the 1984-1986 time period. Thereafter, annual catch grew gradually from 1987 to 1996. Following the disputed 1996 stock assessment, and as a result of increased regulatory constraints, landings dropped in 1997 (Figure 4). Since 1997, the annual catch has again been rising, but is still below the total estimated catch for 1996. Over the past 10 years mean annual catch was 2600 mt, compared with average landings of 2500 mt for the past 5 years (Table 6).

3.2 Mean size-at-age

Tagart et al. (1997) reported that yellowtail rockfish growth patterns had apparently changed in the late 1980s. From 1974 to 1986 mean size-at-age tended to fluctuate annually, but without any obvious trend, while from 1987 to 1996, mean size-at-age showed a marked decline. That decline has continued through 1999 (Figure 5). In 1996, fish 7 to 15 years of age were 1.4 cm smaller on average than they were prior to 1987, by 1999 the disparity had grown to more than a 2 cm difference. The cause of this change in growth is unknown, it could be environmental and/or fishery related.

Estimated length/weight parameters (a and b), where Weight = a (length) ^{b} are unchanged from the prior assessment. Tagart et. al (1997) tested for a year and season effect on the parameter estimates of this and found none. The parameter values are a = 0.0214 and b= 2.920. The length/weight relationship is the same for both sexes.

3.3 Weight-at-age

Estimated weight for an individual fish of known length can be computed from the allometric length/weight relationship. The von Bertalanffy function is used to estimate the length of fish of known age (Estimated Length = $L_{\infty}(1-e^{-k\,(\mathrm{Age}\,-\,t_0)})$). We use the von Bertalanffy function in conjunction with the length/weight function to generate predicted weight-at-age (Figure 6). Predicted weight-at-age is used in the simulation model to estimate stock biomass. We estimated von Bertalanffy parameters for each stock (or stock grouping), year (pre-1987; 1987…1999), and sex (Table 7). Corresponding predicted weight-at-age is reported in Table 8.

3.4 Maturity-at-age

We estimated the proportion mature-at-age for female yellowtail rockfish based on logistic functions $p_t = 1/\left(1+e^{at+b}\right)$ from (Tagart, 1991). Parameters of the logistic (a, b) are estimated separately for the N. Columbia and U.S. Vancouver area (Table 9). We used parameter values from the N. Columbia stock for the Coast-wide and the Eureka/S.Columbia area.

3.5 Natural mortality

Fraidenburg (1981) made the first estimate of yellowtail rockfish natural mortality (M=0.25), using surface aged otolith for samples collected from PMFC area 3A (N. Columbia stock). Leaman and Nagtegall (1987) estimated a yellowtail rockfish natural mortality rate of M=0.07 for a lightly exploited stock from Northern British Columbia aged using the break-and-burned method. Tagart (1991) reprised Fraidenburg’s estimate after re-aging Fraidenburg’s specimens using the break-and-burn aging method. Tagart’s estimated yellowtail rockfish natural mortality rate was M=0.11. Using the Stock Synthesis model, Tagart profiled the fit to fishery age data across a range of constant natural mortality rates, demonstrating that the best fit occurred when M=0.11. However, female yellowtail rockfish appeared to show an increasing mortality with age (senescent mortality hypothesis), while males did not.

Tagart (1991) evaluated the assumption that natural mortality was constant for all ages using the stock synthesis model. Male natural mortality was assumed to be constant for all ages at M=0.11. Female natural mortality was allowed to rise linearly from age 6 at M=0.11 to a model determined maximum at age 25+. Tagart concluded that the senescent mortality hypothesis fit the fishery age data well, and was a better biological explanation for the disappearance of older age females than the alternative hypothesis that the older females were not vulnerable to the fishery. Because the natural mortality rate is confounded in age-structured models with fishery selectivity, there has been an active debate on whether female natural mortality is actually increasing with age, or whether the apparent disappearance of older age females is related to fishery selectivity. Tagart et al. (1997) did an extensive analysis to determine if there was any evidence that older age fishes were strategically separated from their younger counterparts. Their conclusions are as follows:

- Age samples are representative of the landed catch. Although vessels are sometimes disproportionately sampled relative to the number of landings they make, we have observed no substantive impact on the estimated yellowtail rockfish age distribution from this sampling.

- The fishery has effectively been prosecuted over a constant bathymetric range throughout the period evaluated in this analysis [1974-1996]. So, we would not expect depth-induced differences in size or age to be reflected in the samples from the fishery.

- There are no apparent concentrations of old fish at different latitudes. Therefore, any temporal changes in the latitudinal distribution of the fleet would not be expected to change the proportion of older age fishes observed in samples from the domestic trawl fishery.

- The evidence on changes in age distribution with depth is inconclusive. We know that young fishes are predominately found in shallow water, <90 m. We sometimes find significant increases in size with depth implying older fish may be more likely to be in deeper water, but this is not always apparent.

- There are no hard data identifying any locale as a reservoir of old fish.

Given the results of the above analysis, fishery selectivity is unlikely to explain the disappearance of older age female yellowtail rockfish. Consequently, for this assessment, we assume that the female senescent mortality hypothesis applies.

3.6 Sample size

The coast-wide yellowtail rockfish database compiled in 1997 (Tagart et al., 1997) was updated with samples collected between 1996 and 1999. Biological data from the Washington and Oregon commercial trawl fishery was obtained from the WDFW Biological Data System (Cathy Evans, WDFW). Don Pearson (NMFS/SWFC) provided data for samples drawn from the 1997 and 1998 California commercial trawl fishery. California biological data for 1999 were unavailable. Rick Stanley (Canadian DFO/PBS) supplied updated Canadian biological data for the period 1980 to 1999.

We reconciled new data with previously collected data to be certain that there were no overlooked or repeat samples. The revised master database represents 92,607 aged fish from 2,284 samples (Tables 10-13).

Between 1977 and 1998, in the triennial trawl survey, the NMFS made 3,381 hauls north of Cape Mendocino. Yellowtail rockfish otoliths were sampled for age determination from 250 of the 932 hauls where the catch of yellowtail rockfish was one or more fish. From the 250 age-sampled hauls, ages were determined for 7,121 fish (Table 14).

3.7 Catch-at-age

North of Cape Mendocino, the yellowtail rockfish fishery is prosecuted by three predominant fisheries: the directed domestic trawl fishery, the shrimp trawl fishery and the whiting fishery. In the late 1960s and 1970s, landings were distributed among fisheries with the directed trawl fishery landing about two-thirds of the total catch. During this period the whiting fishery was responsible for about 20% of landed catch with the remainder taken by the shrimp trawl fishery. In the late 1970s, the domestic directed trawl fishery began to actively exploit yellowtail rockfish, such that by the 1980s, they accounted for more than 80% of the landed catch. While sporadic biological sampling of yellowtail rockfish had occurred in the late 1960s and early 1970s, serious efforts to sample the landed catch followed the development of the domestic directed trawl fishery. Attention was focused on the directed fishery and the shrimp trawl and whiting fisheries were seldom sampled for age composition.

Regulatory constraints on the directed trawl fishery were imposed in the late 1980s and intensified in the 1990s. With the limitation on landings in the directed fishery, the distribution of catch among fisheries shifted away from the directed fishery and toward the whiting fishery. Even so, biological sampling of the whiting fishery still lagged. Since 1995, there has been a concerted effort to sample the whiting fishery for age composition, but prior to 1995 sampling was sporadic. Further regulatory changes have diminished the shrimp trawl catch of yellowtail rockfish in recent years, nevertheless, responding to inquiries regarding the age distribution in that fishery, we did sample for age composition from 1997 to 1999. When age data was available for these three fisheries, catch-at-age was estimated for each fishery. When fishery independent data were unavailable, the age composition of the unsampled catch was assumed to follow the composition of the domestic trawl fishery.

In the South Vancouver stock area, the Canadian yellowtail rockfish fishery is predominately a midwater-trawl fishery. The biological samples provided by Canada from landings taken with midwater trawl gear, were aggregated with samples from the whiting fishery when determining catch-at-age.

We revised the estimates of catch-at-age (CAA) for each stock using recompiled catch and age data. Computational methods for the Canadian, ODFW, and WDFW data followed Tagart (1991) in which the frequency distribution for each sample is scaled to a sample of standard weight. The scaled data are then pooled by stock and year to determine the proportion of each age and sex by weight. The total catch is distributed across the ages by these proportions and divided by the mean weight-at-age to estimate the number of fish caught at each age. Don Pearson (NMFS/SWFC personal communication) provided CAA estimates for the California fishery. Estimates from the Washington and Oregon fisheries were summed with those from California to construct a single CAA matrix for each stock (Tables 15-18, Figures 8-10).

Direct comparison of age distributions among fisheries is achievable for 1997-1999. The shrimp trawl fishery was sampled in the Eureka/S.Columbia and N.Columbia areas, and the whiting fishery was sampled in all stock areas. Yellowtail rockfish age distributions from the three fisheries are superficially similar (Figure 11); however, the whiting and shrimp trawl fisheries tend to land fishes that are on average older than those landed by the domestic trawl fishery (Figure 12).

Coast-wide catch-at-age data reflect a pattern of irregular occurrence of dominant year classes in the fishery. Apparently strong year classes can be observed for 1949, 1962, 1968, 1974 and 1984 (Figure 13). The pattern is detectable in each of the sub-stocks, with some modest differences.

The domestic fishery is dependent on fishes 7-14 years of age. These age groups make up 80% or more of the current catch (Figure 14). Early in the fishery, the late 1970s, the catch was distributed over more age classes with only 50-60% of the catch coming from the 7-14 year old fishes. Older age fishes remained abundant in the fishery through the early 1980s, but have all but disappeared from current catches. However, since 1996, there has been a slight increase in the proportion of older age males in the catch.

Catch expanded estimates of the number of fish-at-age from the NMFS trawl survey were provided by Mark Wilkins (NMFS/AFSC, Seattle) (Table 19, Figure 15). In 1997, ages were determined using the "surface age reading method". These data are therefore incompatible with the break-and-burn ageing method applied to samples from all subsequent surveys. While we display the age distribution, it is not used in fitting our model. The coast-wide (Eureka/S.Columbia to S.Vancouver) age distribution is reasonably consistent, but the area-specific data are noisier. Fish are recruited to the trawl survey as young as age 1, but typically aren't caught with regularity until age 4. The modal age appears to be between 5 and 12 years old. The 1998 survey showed a bimodal age distribution (well illustrated for the Coast-wide stock) with peaks at age 9 (1989 year class) and ages 11 and 12 (the 1986-1987 year classes).

3.8 Abundance Indices

The yellowtail rockfish analysis employs three independent abundance indices: domestic trawl CPUE (tow-by-tow catch per unit effort), whiting bycatch, and the NMFS triennial trawl survey.

3.8.1 Domestic Trawl CPUE

Yellowtail rockfish CPUE indices were constructed from Washington, Oregon and California domestic trawl fishery logbook and fish ticket data. Skippers' tow-by-tow estimates of retained catch were reconciled with fish ticket data (landing receipts). The adjusted catch and skippers' estimate of tow duration was used to compute CPUE (lbs/hour). If skippers failed to hail catch and yellowtail rockfish were recorded on the landing receipt, the data were excluded from the analysis. The data were further restricted to those vessels which landed yellowtail in at least 9 of the 12 years between1988 and 1999. Only non-whiting fishery roller and bottom trawl tows with greater than 50lbs of yellowtail catch were included in the analysis. Tow data from depth strata with limited yellowtail catch (<50 and > 125 fathoms) and tows south of Cape Mendocino, 40^{o} 30'N Latitude, were also excluded.

Four separate indices were computed, one for each of the three presumptive stocks and one for a coast-wide stock (Table 20). Data were treated similarly for each index. After filtering, approximately 20% of the tow-by-tow data was used in the analysis, resulting in 13,022 tows used to generate the coast-wide index, 5,260 tows for the Eureka/S.Columbia index, 5,218 tows for the N.Columbia index and 2,544 tows for the S.Vancouver index.

The CPUE data were analyzed with a General Factorial General Linear Model (GLM) using SPSS version 8.0 statistical software. Analysis employed type III sum or squares (SPSS Inc., 1998) a method robust to unequal sample sizes within cells of the factorial matrix. Main-effects included year, vessel, season (December-March, April-July, and August-November), depth (25 fathom intervals between 50 and 125 fms) and latitude (20 minute intervals). Data were analyzed for the period 1988 to 1999 for all indices except the S.Vancouver. Limited sample size restricted the S.Vancouver index to 1989 to 1999.

Analysis was limited to main effects (i.e., no interaction terms). With the exception of depth interval, all main-effects were found to be highly significant (P<1%). Depth interval was significant at the P<5% level for all but the N.Columbia index. Index values were estimated from the marginal means for the Year factor. The Coast-wide index shows a slight decrease from 1988 to 1999, while the Eureka/S.Columbia index indicates a steep decline (Figure 16). The N.Columbia and S.Vancouver indices are without apparent trend. There was a fairly wide variance on the estimates of the marginal means, with CVs (coefficient of variation: standard deviation divided by the mean) ranging from 19 to 63% for the coast-wide index; the average CV was 27%.

3.8.2 Whiting Bycatch

The whiting bycatch index (Table 21, Figure 17) was computed from NMFS observer data from the at-sea whiting fishery (joint venture, domestic catcher processor and mothership). Tow-by-tow yellowtail rockfish catches taken incidentally in the targeted whiting fishery were converted to index values using a ratio estimator of yellowtail rockfish catch to whiting catch (Rogers and Lenarz, 1993):

$$I = \left(\frac{C_h}{F_h}\right)\left(\frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} h_i}\right) \qquad \text{Eq. 1.}$$

where, C_h is the annual whiting catch, F_h is the annual whiting fishing mortality, y_i is the catch of yellowtail rockfish on tow i and , h_i is the whiting catch on tow i. Qualified tows were those between 43.5 to 48 degrees N. latitude. The ratio index was scaled by annual estimates of whiting catch-per-effort as determined in the 1999 whiting stock assessment (Dorn, 1999). We constructed a single coast-wide index for the period 1978 to 1999.

The variance for the index given the ratio of yellowtail to whiting catch (r) is estimated using the delta method assuming that the covariance between r and F_h is zero:

$$\hat{V}(I) = \hat{V}\left(\frac{rC_h}{F_h}\right) = \left(\frac{C_h}{F_h}\right)^2 \hat{V}(r) + \left(\frac{-rC_h}{F_h^2}\right)^2 \hat{V}(F_h) \qquad \text{Eq. 2.}$$

The variance for F_h is estimated by Dorn (1999) and fixed at CV of 0.15. The variance of the ratio (r) is:

$$\hat{V}(r) = \frac{(N-n)}{(nN)}\left(\frac{1}{\bar{h}^2}\right)\left(\frac{\sum_{i=1}^{n}(w_i - rh_i)^2}{n-1}\right) \qquad \text{Eq. 3.}$$

Taken overall, the index is without apparent trend. It reaches a peak in 1986, falls then rises to a new peak in 1992, then falls once more through 1995, again rising but not reaching the level of the 1992 peak.

3.8.3 NMFS Triennial Trawl Survey

Yellowtail rockfish biomass estimates are available from NMFS trawl surveys at three-year intervals from 1977 to 1998 (Gunderson and Sample 1980; Weinberg et al. 1984; Coleman 1986 and 1988; Zimmermann et al. 1994; and Mark Wilkins, personal communication)(Table 22, Figure 18). These surveys provide an index of the trend in yellowtail rockfish abundance. The NMFS typically provides estimates of abundance in geographic blocks corresponding to the old INPFC areas. In order to obtain estimates of abundance by stock unit, we requested a post-stratification of the Columbia area, split at Cape Falcon. The resulting estimates, provided by

Mark Wilkins (NMFS personal communication), are identified as S. Col and N. Col on Table 22. The original estimate for the entire Columbia area is also reported. In past assessments, the trawl survey biomass for the Columbia area was assigned to stock units by prorating the Columbia area abundance estimate based on the proportion of surveyed area between 55 and 183 m north and south of Cape Falcon. The southern Columbia area represents 59.46% of the survey area in this depth zone. The southern Columbia and Eureka area biomass were summed to determine the abundance trend for the Eureka/S. Columbia area stock. Since the survey does not extend into Canada every year, biomass trends in the S. Vancouver area were assumed to follow the observed trend for estimates from the U.S. Vancouver area.

Following 1977, in each successive survey through 1986, the NMFS increased the density of survey tracklines in designated high density or rockfish sampling areas in an attempt to improve the precision of rockfish biomass estimates (Figure 19). In 1977, high density sample areas had tracklines 9.3 km (5 nm) apart; in 1980 and 1983 spacing was reduced to 5.6 km (3 nm) and by 1986 high density tracklines were placed at intervals of 3.7 km (2 nm). Despite higher density sampling in 1980, the CV for Columbia area yellowtail rockfish biomass estimates actually increased from 0.42 in 1977 to 0.56 in 1980. In the Vancouver area, although there were no high density tracklines in 1980, they were used in this area in 1983. Again rather than decrease, the CV increased between 1980 and 1983 from 0.68 to 0.90. After 1986, the high density track-line sampling design was abandoned.

The yellowtail rockfish catchability coefficient for the triennial trawl survey has been estimated to be low, <0.3 (Tagart, et. al, 1997). Moreover, the wide swings in survey-to-survey estimated biomass suggest that yellowtail rockfish could be showing differential vulnerability to the survey over time. Dark et al. (1983), in their review of the 1980 trawl survey, attribute problems of increasing precision on rockfish biomass estimates to "different availability and vulnerability of shelf rockfish to the sampling gear from year to year." To underscore this statement they note the change from 1.0 to 16.8 kg/km towed in the 1980 CPUE of yellowtail rockfish at 43 stations sampled twice two weeks apart. This apparent change in abundance was a consequence of the variable distribution and availability of this species in the sample area.

The 1998 survey estimates increased 300 to 1000 percent over those of the 1995 survey. This occurred despite the fact that year-classes observed in the 1998 survey (Figure 15) were alive and ostensibly available for capture during the 1995 survey. For inexplicable reasons, yellowtail rockfish appear to have been more vulnerable to the trawl survey in 1998 than they were in 1995.

Historically, the highest survey yellowtail rockfish catch rates have occurred in the S. Vancouver area (Figure 20, Table 23). Over time, the incidence of large catch rates has declined. Coast-wide survey estimates of yellowtail rockfish abundance are without trend, i.e., flat over the survey time series. Since 1977, N.Columbia and Eureka/S.Columbia stocks show a slight decline in abundance, while the S.Vancouver stock reflects an increase. These trends should be interpreted cautiously because the variability associated with the biomass estimates is high (average CV ranges from 0.34 to 0.60, with year specific CVs as high as 0.90).

3.9 Ageing Error

The ageing error matrix is employed to generate expected numbers at age from our model's synthetic population for comparison with observed numbers-at-age (our input data). Since the synthetic population of fish created in our model are by design of "true known age", and because the age reading or age assignment process will inevitably incorrectly determine the age of some fish, the ageing error matrix converts true ages into the probable assigned age.

Since 1991, the WDFW age reader routinely provided replicate age assignments for every forth fish in a sample. In 1997, these data were used to estimate age reading error. We computed the mean difference and the standard deviation (s) of the mean difference between the first and second age assignment for each fish aged (Table 24, Figure 21). We then regressed ($s=\alpha Age+\beta$) the standard deviation of the difference against the first assigned age (*Age*) (R^2=0.80, N=22, α=0.055, β=0.429).

Probabilities assigned in the ageing error matrix were derived using the NORMDIST() function in Microsoft Excel. NORMDIST() integrates the normal probability density function given a value of interest (X), a mean (μ) and standard deviation (σ) for the distribution. We set the function to provide cumulative density. The age range in the matrix is 4 to 25. The quantity X was set at the half-interval between "observed ages", i.e., 4.5, 5.5 ….25.5; the quantity μ was assigned to the "true age", and σ was set equal to predicted standard deviation from the above regression. Probability at observed age 4 was set equal to the tail area probability to the left of X=4.5. Probability at observed age 25 was set equal to the tail area probability to the right of X=24.5. The remaining probabilities (observed ages 5 to 24) were set at the difference between the cumulative probabilities at X and X+1, e.g., 6.5-7.5, 7.5-8.5…etc. For each true age, the probabilities across all observed ages were forced to sum to 1.

4.0 Assessment

4.1 Model description

In 1997 we constructed a version of a statistical age structured model using a C++ software language extension and automatic differentiation library. We use the same model in four configurations for this assessment. For some models, over 100 parameters are estimated. Most of these parameters are associated with year-to-year and age specific deviations in coefficients such as selectivity and catchability. To easily estimate such a large number of parameters in a non-linear model, automatic differentiation software extended from Greiwank and Corliss (1991) and developed into C++ class libraries was used. This software provided the derivative calculations needed for finding the objective function via a quasi-Newton function minimization routine (e.g., Press et al. 1992). The model implementation language (ADModel Builder) gave simple and rapid access to these routines and provided the ability to estimate the variance-covariance matrix for all dependent and independent parameters of interest. For key quantities of interest, e.g., current stock size, the software can also produce likelihood profiles, which avoids having to make the assumption that the likelihood shape is quadratic (implied when the inverse Hessian estimates are used). A copy of the model source code (*.tpl file) is provided in the appendix.

4.1.1 General description

We used an explicit age-structured model with the Baranov catch equation (Ricker, 1975) as the underlying population model (e.g., Fournier and Archibald 1982, Deriso et al. 1985, Hilborn and Walters 1992, Schnute and Richards 1995, McAllister and Ianelli 1997). Key equations and parameter definitions are given in Table 25, variance assumptions are in Table 26.

The population model begins in 1967, in conjunction with total catch biomass data. The model tracks numbers and catches of male and female yellowtail rockfish in the age classes 4 through 25+ (as in the past assessments). We assume that the initial age distribution of the stock was at equilibrium with an exponential decay rate that is a function of natural mortality and a historical fishing mortality set to 10% of the estimated 1967 fishing mortality rate. The value of 10% was arbitrarily set to reflect the low level of fishing occurring prior to 1967. The first age composition data estimates used in the model are from the late-1970s (the exact year depends on the level of stock aggregation) and the most recent data were from 1999. Individual recruitment estimates are made for each year from 1967 to the year 2000. However, for the year 2000 recruitment is equal to the geometric mean of the recruitment time series. No stock-recruitment relationship was evaluated at this time.

The data used in the model are the fishery catch-at-age sample proportions (by sex), total catch in weight, survey age composition (sexes combined), triennial survey abundance indices since 1977, Washington-Oregon-California (WOC) fishery logbook CPUE data from 1988-1999, and a whiting bycatch index from 1978-1999. Fishing mortality in each year is scaled so that total catch biomass is fit precisely (actually, here we assume a CV of 3%). Weight-at-age data is provided on an annual basis (see section 3.2 and 3.3 above).

We estimate variances for a variety of parameters of interest. This is facilitated by use of the automatic-differentiation software that provides precise derivative information. A requirement for variance (and covariance) estimation is that the shape of the objective function follows that of a true likelihood. In this analysis we have attempted to provide objective variances for all data types used in the model. Another part of the objective function involves “penalties” for model processes (e.g., smoothness in selectivity between age-groups).

Two methods of approximating the variances of parameters of interest are presented below. The most common method is simply through propagation of errors (i.e., the Delta method, Seber 1982). This approximation assumes that the likelihood is reasonably approximated by a quadratic function (which is exact if the parameters are multivariate normally distributed). This method is used to show the 95% confidence bands for quantities like the time series of recruitment and stock biomass. The second method, referred to as the profile likelihood (e.g., Aitkin et al. 1989), does not require assumptions about normality and provides a more accurate reflection of the relative probability of different values of parameters. The way the profile likelihood works can be described as follows. Say the parameter of interest, *A*, is a positive number that has as it’s maximum likelihood estimate a value of 1,000. A profile likelihood of *A* would then be the maximum likelihood estimate of all other parameters at alternative *fixed* values of *A* with each resulting likelihood reflecting the relative probability of each alternative value. For example, fixing the value of *A* at 500, 750, 1250, and 1500 and computing the likelihood value for each would give some idea about the relative probability of different values of *A*. In practice, these intervals are small enough to approximate the desired marginal posterior probability density (for *A*) and express the uncertainty more clearly since fewer assumptions are required.

4.1.2 Bayesian aspects

A Bayesian perspective is helpful in discussions of our approach to evaluating some assumptions of an age-structured model. That is, rather than assuming fixed values for some parameters, (commonly done in many stock assessment applications), we choose to evaluate them with some degree of uncertainty. In Bayesian theory, parameters are treated as random variables rather than as fixed quantities. As random variables, the collection of parameters in a model shares a joint probability distribution. Before any data are collected this probability distribution is called the prior. Typically, a prior is thought of as a way of describing ones belief regarding which values the parameters are more likely to take on. Once data are collected, information from the data is added to that from the prior and the resulting probability distribution about the parameters is known as the posterior distribution. This distribution represents our objective function that is maximized with respect to the population dynamics parameters. Thus, the posterior distribution reflects both the information in the data as well as one's prior beliefs about a set of parameters. The parameter estimators are those that maximize the posterior distribution and their values are the Bayesian posterior mode estimates.

In the yellowtail rockfish models presented here, non-informative prior probability distributions are included for most parameters (that is, no prior assumptions are made about their values). Some aspects of the recruitment and fishing mortality process errors are given diffuse prior distributions that effectively stabilize model behavior during the non-linear optimization procedure and have very low influence on model outcomes. The key "prior" distribution that we specify is the extent to which we allow inter-annual changes in the catchability parameters for our abundance indices (described below).

4.1.3 Applicability of abundance indices

An abundance index can be an index of total population abundance or an index of abundance-at-age. More information is available for an index of abundance-at-age. Catch-per-tow data collected from the triennial trawl survey is converted into an index of total abundance that is subsequently distributed to abundance-at-age based on the age composition of that catch. Thus, this source of data provides an index of total abundance and abundance-at-age. Catch-per-tow data collected from logbook records of the domestic trawl fishery is an index of total abundance only, as is the yellowtail rockfish catch rate data from the whiting fishery.

4.1.3.1 Assumptions of an abundance index

An abundance index needs to be proportional to the absolute abundance, i.e.,

$$I = \alpha N \;\pi\; N \qquad \text{Eq. 4.}$$

where the proportionality constant is α. A statistical model for a proportional index is:

$$I_i \sim Normal\left(\alpha N_i, \sigma^2\right) \qquad \text{Eq. 5.}$$

$$I_{ij} \sim Normal\left(\alpha N_{ij}, \sigma^2\right) \qquad \text{Eq. 3.}$$

where

I_i = index for year i ($i = 1,\ldots,n$),

I_{ij} = index for year i ($i = 1,\ldots,n$) and age j ($j = 1,\ldots,J$),

N_i = the unknown absolute abundance in numbers for year i ($i = 1,\ldots,n$),

N_{ij} = the unknown absolute abundance in numbers for year i ($i = 1,\ldots,n$) and age j ($j = 1,\ldots,J$),

α = the unknown proportionality constant (which may be year specific $\{\alpha_i\}$ if the index is an index of abundance at age), and

σ^2 = the unknown variance of the index.

Four assumptions of this model are:

A1) the indices are normally distributed,

A2) the indices are independent of each other,

A3) the indices are homogeneous,

A4) the proportionality constant does not change from year to year, and

A5) for an index of abundance-at-age (Eq. 3), the proportionality constant does not change from age to age within a year.

If the assumptions are true, then the statistical model is appropriately described. However, if an assumption cannot be verified there are risks to the statistical validity of the estimation and inference made from the model. Unverified assumptions fall into two categories: robust and critical. If an assumption is false, yet the probabilistic structure of the model is relatively unchanged then that assumption is considered "robust." On the other hand, if violation of an assumption causes significant changes in the probabilistic structure of the model, then that assumption is considered "critical." The consequences of violating a critical assumption are more severe than of violating a robust assumption. Annette Hoffmann in Tagart et al. (1997), made a critical evaluation of the assumptions associated with each of the auxiliary indices used in the yellowtail rockfish model. Different types of indices were evaluated with simulation modeling, then the indices used in the yellowtail stock assessment were ranked on their compliance with assumptions A1 through A5. Her evaluation is summarized below.

4.1.3.2 Summary

"*The lack of a sampling design in the CPUE and whiting bycatch indices was responsible for their lower rankings. Their "design" is at most haphazard and one cannot describe and/or verify the statistical properties of a haphazard design. Without a description of the statistical properties of an estimator, it is difficult to assess its value scientifically. The triennial trawl survey index was determined to have the best statistical properties, i.e., it is the index most likely to meet the assumptions. In particular, it is the most likely to meet the critical assumption A4 of constant yearly "catchability". Therefore, of the three indices considered here, it is the most scientifically credible choice.*" (Tagart et al., 1997)

We are sensitive to the realization that the trawl survey may experience variability in annual catchability. Wide fluctuations in catch rates from one survey to the next could reflect that variability. Nevertheless, of the three indices used in this assessment, we believe the triennial trawl survey is the least likely to have systematic bias.

4.1.4 Treatment of abundance indices

We model all indices as relative abundance estimates. Since commercial CPUE (and whiting bycatch) indices may fail to meet the assumption that they are proportional to true abundance, we model potential changes in catchability of these indices as randomly varying over time (but with dependence on previous-year's estimates). Gudmundsson (1994) introduced this type of time series structure in catchability (and selectivity) for analyses of catch-at-age data. Here we simply apply this method as a means to evaluate hypotheses regarding the quality of our auxiliary abundance indices. For example, the parameters describing abundance index catchability are contained in the set $\{\mu^l, \alpha_1, \alpha_2, \ldots, \alpha_{30}\}$. The prior function, L_9 (Table 25), describes a log normal probability joint density of the $\{\alpha_i$'s$\}$, but does not include probabilistic information about

μ^l. In our application, the {α_i's} are believed to be log normally distributed with some pre-specified variance. In practice, the multiplier, λ_7^f (Table 26), is the inverse of twice this unknown variance among the {α_i's} for the logbook CPUE data, i.e., $1/(2\sigma_\alpha{}^2)$. Thus, setting a value for λ_7^f is equivalent to setting the unknown variance. For readers uncomfortable with this concept, assumptions of changing catchability versus constant catchability can be represented in arguments made for and against inclusion of any abundance index. For example, consider the following options typically presented to stock assessment scientists:

Scenario	**Implied σ_α value**
Ignore an index because it may have problems with non-constant catchability	Infinite
Include an index and assume it tracks abundance proportionately	0.0

One of our approaches is to say that either option is probably too extreme and that some middle ground may be more appropriate. The model presented here allows *explicit* consideration of how catchability may change over time as opposed to the more extreme assumptions implied by traditional models.

Selectivity parameters are also included in the modeling of the index data. We assumed that the selectivity for the whiting bycatch index data and the WOC logbook CPUE data are reasonably approximated by the estimates from the fishery catch-at-age data. Thus, there was no need to estimate them separately. On the other hand, for the triennial trawl survey index, we estimated separate selectivity parameters from the age data provided with the survey.

The abundance indices are assumed to be log normally distributed. In the log likelihood functions for these data, there is a variance term that either must be supplied or estimated. For the NMFS triennial trawl survey index of abundance, the model variance was set equal to the observed mean variance across all survey years. Likewise, for the whiting bycatch and WOC logbook CPUE index, the variance was supplied by the estimate of variance derived from that index.

4.1.5 Selectivity

Selectivity-at-age estimates are effectively treated as individually estimated parameters with three constraints. Individual parameters are normalized to have a mean value of 1.0 causing the annual fishing mortality term to be interpreted as the *average* fishing mortality rate across all ages. This is in contrast to models that use selectivity having a maximum value of 1.0, where the annual fishing mortality rate is interpreted as a *fully recruited* rate.

The first two constraints imposed on the selectivity parameters are constraints on the second differences (among ages) and constraints on the first difference between consecutive ages provided the first differences are negative (selectivity for older age - selectivity for younger age). The first constraint is referred to as a curvature penalty using squared second-differences (Press et al. 1992). This constraint prevents irregular shifts between adjacent age classes and is an alternative to forcing the selectivity curve to be smooth by modeling it with a function (e.g., the logistic). The parameter determining the degree of smoothness imposed by this constraint is λ_2^f. We used a value of λ_2^f = 0.20 (Table 26) which imposed a reasonably smooth pattern in selectivity without much deviation from age to age.

The second constraint allowed specification of the degree to which fishery selectivity decreased with older ages (controlled by λ_3^f). Since λ_3^f controlled the extent that selectivity appears to be relatively asymptotic with increasing age, it played a critical role in the estimation of the older-age female natural mortality. Manipulating the value of λ_3^f provided a simple way of evaluating the trade-off between natural mortality and the extent to which older fish became less vulnerable to the fishing gear.

The third constraint set the age beyond which selectivity is constant. We selected age 20 as the value representing the age beyond which growth in length is largely complete. Setting this term (*maxage*, Table 25) equal to age 25 was considered undesirable since the information on the last few age groups was noisy.

4.1.6 Natural Mortality

We assumed that male natural mortality was constant for all ages at a value of 0.11. For females, we assumed the same constant mortality from age 4 to 6, after which, mortality was assumed to increase linearly with age to an estimated maximum value at age 25.

4.1.7 Age composition predictions

Ageing error for both the survey and fishery age composition data was incorporated by use of a transition matrix (*A*, Table 25). The age data were modeled as multinomial random variables. The sample size used for the multinomial component of the likelihood (which effectively scales the variance for the age composition data) was set to the number of age samples actually taken in each year rather than to the number of fish actually aged. Similarly, the sample size used for the multinomial component of the likelihood for the survey age composition data was set to the number of hauls from which age data were collected.

4.1.8 Model configurations

We constructed three models (Table 27) and evaluated four data sets within each model. The nomenclature for our models includes a prefix that describes the type of model and a suffix that identifies the data set, e.g. RefCst identifies the Reference model utilizing the coast-wide data set. The reference (base case) model (Ref) utilizes catch, fishery catch-at-age and three abundance indices: NMFS triennial trawl survey biomass (with survey abundance-at-age), the whiting bycatch index, and the WOC domestic trawl logbook or CPUE index. The catchability coefficient for the trawl survey biomass (Q_i^s) is estimated and held constant for all survey years, whiting bycatch and logbook CPUE catchability indices (Q_i^f and Q_i^w) are estimated and vary year to year. The Srvon (Survey only) model uses the Ref configuation but excludes the whiting bycatch and logbook CPUE indices. The Fshon (Fish only) model excludes all auxiliary data. We ran each model with data sets for each of the three presumptive stock units (Eureka/S.Columbia: Eur; N. Columbia: Col, and S. Vancouver: Van) as well as a coast-wide stock configuration (Cape Medocino to 49 degrees N. Latitude: Cst).

4.2 Uncertainty and sensitivity analyses

In 1997, we argued that the differences between the reference model and the survey only model were predominately due to the arbitrarily chosen prior variance ($\sigma = 0.40$) on catchability for the trawl logbook CPUE and whiting bycatch indices (λ_7^f *and* λ_7^w). Recall from section 4.14 above, that as the prior variance increases (i.e. as sigma increases) the effect is to ignore the auxiliary data. We recognized that biomass estimates were sensitive to the choice of this prior variance but we did not formally explore the range of sensitivity in the 1997 analysis. In this analysis, we profiled on the prior variance to explore the model's sensitivity to the selected value (Figure 22). The negative log-likelihood profiles for the fit to the fishery age composition and survey biomass were minimized at a value for sigma of 0.14. The remaining likelihood values declined to a near asymptotic minimum at sigma values greater than 0.2. This implies that at sigma values beyond 0.2 the auxiliary data is, for all intents and purposes, ignored. Rather than retain the initial prior variance at sigma of 0.4, we selected the prior to coincide with an estimated RMSE for the coast-wide trawl logbook CPUE index that approximated the median predicted variance (CV=0.22) over the time series. The new prior corresponds to a sigma value of 0.16. Lowering the sigma value for the prior variance implies that there is less annual variability in the CPUE index catchability than previously allowed increasing the auxiliary data's opportunity to affect the overall fit to the model.

The large difference in the 1997 assessment's estimated model abundance and fishing mortality rates was a concern to many reviewers. The high level of fishing mortality in particular provoked analysts to suggest that the estimates were unreasonable, failing to pass the "common sense" test. Because of this, the 1997 STAR panel rejected Model 3 (the Srvon Model) when constructing their advice to the Council. We performed a limited retrospective analysis to determine if we would generate the same disparity between the Ref Model and the Srvon Model given the current data sets (Table 28). The "unreasonable" fishing mortality rates that concerned analysts in 1997 persist in the retrospective (Figure 23). However, biomass between the Srvon Model and the Ref Model changes slightly less in the retrospective than it did in the 1997 assessment (Table 29). We attribute this result to the change in the logbook CPUE index since the remaining indices are nearly identical to those used in 1997. Similarity of results between the Ref Model and the Srvon Model in the current assessment suggest that the concerns raised by previous reviewers were generated by data inputs as oppose to model misspecification.

4.3 Model selection and evaluation

As noted in our discussion of abundance indices, the trawl survey auxiliary data are regarded as the best auxiliary data set. Arguments against this point of view focus on the logistical difficulties encountered when implementing the survey design and the possibility that survey catchability varies annually. Although survey stations were originally selected in a systematic random design, some stations could not be fished with the survey gear. The predetermined location of the sampling station was occasionally moved to avoid an untrawlable obstacle. A decision rule limited the distance a station could be moved, causing some stations to be skipped entirely. It is possible that the remedies employed to cope with these logistical problems could introduce minimal bias to the survey abundance estimates, but from a pragmatic perspective the execution of the trawl survey effectively meets the systematic random survey design. It would be grossly misleading to suggest that the potential bias introduced in the execution of the trawl survey was in any way comparable to the systematic bias expected from indices of CPUE in a directed fishery. Therefore, we believe the trawl survey should continue to be regarded as an unbiased, yet imprecise, index of the trend in fish abundance, and that it remains the best auxiliary data set.

The whiting bycatch index appears uninformative, whereas the logbook CPUE index may have some signal. The variable annual catchability of these surveys assures that they are biased with respect to the trend in population abundance. The model attempts to account for annual changes in catchability, but the process may simply filter noise in the data. Searching for yellowtail rockfish with acoustic gear is an efficient means of finding likely concentrations of the species. Because of this, the catchability of the species is expected to be "hyperstable" with respect to stock biomass (Hilborn and Walters, 1992). This means the expected catch rate is greater than one strictly proportional to biomass. Examples of overfished stocks are common in many parts of the world. These cases are often linked to problems relating fishery catch rates to changes in abundance.

When contrasting the use of the survey index against the two catch rate indices, we are attempting to evaluate the impacts of expected bias introduced while using the catch rate data as oppose to imprecision in the survey data set. Based on results from analysis of simulated data sets, the National Research Council (1998) advises stock assessment scientists that "*Fishery independent surveys offer the best opportunity for controlling sampling condition over time and the best choice for achieving a reliable index if they are designed well with respect to location, timing, sampling gear, and other considerations of statistically valid survey design.*" Furthermore, the National Research Council writes, "*CPUE data from commercial fisheries, if not properly standardized, do not usually provide the most appropriate index.*" Consequently, outcomes from the Ref model should be viewed cautiously due to the application of catch rate indices.

The three models evaluated (Ref, Srvon, and Fshon) produced fairly similar results. All models fit the fishery data and auxiliary indices equally well (Table 30, Figure 24-27). For the coast-wide stock, fit to the survey age data was predictably best with the Srvon model, but this expectation was not necessarily realized among individual area stocks (Tables 31-33). Differences in fit to survey biomass were very small for all stock configurations. For the coast-wide stock (Cst), model estimated RMSE for the survey (0.58) was always greater than the mean coefficient of variation on survey estimated biomass (0.36). The model does not predict the high survey biomass observed in 1977 and 1998, rather it suggest that coast-wide stock biomass has been relatively stable.

All models show a declining trend in biomass, with the greatest rate of decline in the Fshon Model. For all stocks other than the N. Columbia, estimated year 2000 biomass was greatest for the Srvon model, and lowest for the Fshon model (Table 30-33). For the N. Columbia stock, the Srvon model produced the lowest year 2000 biomass. Typically, the Srvon and Fshon estimated year 2000 biomass was within 15% of the estimate from the Ref model. Precision of the year 2000 estimated biomass worsened as auxiliary data sets were removed. Regardless of model or stock, it is estimated that the year 2000 spawning biomass exceeds the target spawning biomass, SPB(40%). For the coast-wide model, the trawl survey catchability coefficient was estimated at Q_i^s=0.19 The estimated value for the survey catchability among independent stocks ranged from 0.10 in the N. Columbia stock to 0.23 in the S. Vancouver stock.

4.4 Base-run(s) results

Using results from the reference model, estimated coast-wide biomass in year 2000 was 69,400 mt with a 23% CV (Table 30, Figure 28). Estimated 1997 biomass was 80,800 mt compared with 56,700 mt estimated in the prior assessment (Tagart et. al, 1997). The revised estimates of biomass are higher than those estimated in the 1997 assessment (Figure 30) reflecting the sensitivity of the model to the trawl survey biomass index. Given the wide degree of uncertainty in the 1997 assessment estimated abundance, current estimates of 1997 biomass are within the confidence interval of the former assessment. Biomass trend in the current assessment shows a period of stability in the mid-to-late 1980s extending through 1995, with recent biomass trending down. This trend differs from the trend estimated in the 1997 assessment where the stock began a steady down turn in 1990. Current biomass is 50% of the 1967 estimated biomass.

There is no obvious spawner/recruit relationship. Current spawning biomass is estimated to be 158% of the target equilibrium spawning biomass ($SPB_{40\%}$). Median annual recruitment is 11.0 million fish at age 4, with average recruitment reaching 13.6 million. The 1989 and 1990 year classes (age 4 in 1993 and 1994) were the last to be above average. The 1995 through 1998 recruitment estimates are about half the median estimate. The current assessment suggests that recruitment is more volatile than depicted in the 1997 assessment, particularly for recent years (Figure 30)

Yellowtail rockfish are first selected to the fishery at age 4 (Figure 29), although a very small fraction (<1%) of the population is taken at that age. By age 7 the selectivity coefficient reaches about 25 %. Fish are fully selected by age 12. Selectivity coefficients drop to about 85% by age 19 and are held constant thereafter. Selectivity for males and females is nearly the same. Female natural mortality rises from 0.11 at age 6 to an estimated maximum of 0.25 at age 25, while male natural mortality is held constant at 0.11.

NMFS trawl survey selects a greater fraction of young age fish than does the fishery. About 10% of the population is selected by the survey at age 4 and 34% by age 7. However, from age 9 to 13 a smaller fraction of the population is caught by the survey than by the fishery. Survey selectivity peaks at age 15 and is nearly constant thereafter.

Fishing mortality peaked in 1983 the last year of essentially unconstrained removals (Table 34, Figure 29). After imposition of trip limits on the Sebastes Complex, fishing mortality declined to a low in 1985, and then although fluctuating, rose steadily until 1996. Following the 1996 stock assessment, more severe catch restrictions were imposed and fishing mortality dropped to a modern era low in 1997. Since 1997, fishing mortality has climbed back to a level equivalent to that fished in 1985.

4.5 Coast-wide versus area specific stocks

Stock trends and cumulative biomass estimates for individual stocks (EUR, COL, VAN) are similar but not the same as those for the coast-wide stock (Tables 35-37, Figure 31). Differences in the combined stock versus coast-wide outcomes are due in part to the lower precision of the estimates for the combined individual stocks. The analysis of individual stocks provides an opportunity to examine differential exploitation patterns among regions. For example, the recent exploitation history (% Utility) in the Eureka/S.Columbia area is higher than other stocks, averaging 8% over the last 10 years (1990-1999), compared to approximately 5% in the N.Columbia area and 6.5% in the S.Vancouver area. Another utility of the individual stock analysis is the ability to estimate the regional distribution of biomass, and ultimately apportion total allowable catch accordingly. Estimated year 2000 total biomass was distributed 14% to the Eureka/S.Columbia area, 44% to the N.Columbia area and 41% to the S.Vancouver area.

4.6 Target fishing mortality rates

In 2000, the PFMC held a workshop to review the exploitation strategy employed for various fisheries. Subsequently, the Council adopted revised target exploitation rates. In the 1997 assessment, the target exploitation rate was based on an $F_{40\%}$ spawner-per-recruit (SPR) fishing mortality rate. This fishing mortality rate is a proxy for the unknown F_{MSY}. The Council revised the rate for all rockfish to $F_{50\%}$, a lower exploitation rate than previously used. $F_{50\%}$ is the equilibrium fishing mortality rate that drives the spawning biomass-per-recruit to 50% of the unfished spawning biomass-per-recruit. In conducting their review, the Council's advisors noted that the Pacific coast rockfishes were not as productive as previously believed. Rockfish are expected to show density dependence in recruitment such that, exploitation at the $F_{50\%}$ fishing mortality rate will actually drive spawning biomass to approximately 40% of the unfished spawning biomass-per-recruit. Thus, the target spawning biomass level is $SPB_{40\%}$.

For stocks with an estimable spawner/recruit relationship, F_{MSY} can be calculated and yield would be projected based on the F_{MSY} fishing mortality rate rather than the proxy. Given the recruitment and spawning biomass estimates from our models, we could not estimate a significant spawner/recruit relationship for yellowtail rockfish. Therefore, we could not estimate yellowtail rockfish F_{MSY}, and thus we utilize the proxy yield-per-recruit fishing mortality rates for yield projections.

Absolute estimates of unfished biomass are a function of a recruitment multiplier and the per-recruit estimates of population size. The latter are a function of age specific mortality rates, weight, and fishery selectivity. To compute spawning biomass we also need the estimates of the proportion mature-at-age. Estimates of the unfished total biomass (B_0) and unfished spawning biomass (SPB_0) were based on the equilibrium numbers-per-recruit, average of model estimated annual recruitment from 1967 to 1997, the 1999 estimated weight-at-age, area specific proportion mature-at-age, and model estimated fishery selectivity. If the recruitment time series is blocked into 10-year stanzas, there is no significant difference in average recruitment over the time series; therefore, utilizing overall mean recruitment is appropriate. For the calculation of B_0 we used recruitment estimates through 1997 to assure that the recent recruitment had an opportunity to be reasonably estimated from data. These fish are observed as 4, 5 and 6 year olds in 1997, 1998 and 1999. Because yellowtail rockfish have shown a marked decline in mean-size-at-age in recent years, the 1999 wt-at-age is about 20% lower than the pre-1987 wt-at-age. This means we estimate a lower absolute B_0 using the 1999 vector, which may bias our perception of the ratio of current spawning biomass to unfished spawning biomass.

4.7 Harvest projections

Yield is projected for the next 10 years (Table 38), based on an $F_{50\%}$ SPR rate, and projected annual recruitment equal to the geometric mean recruitment over the time series (1967-2000). Mean yield over the next 3 years and next 10 years is summarized in Table 38. This table also provides benchmark spawning biomass levels, and fishing mortality rates. Yield projections are given for each model and stock evaluated. Given the precision of the biomass estimates and the similarity of estimates among the models, we thought it unnecessary to present a decision table.

Average projected coast-wide yield over the next three years (2001-2003), is 4500 mt for the Ref Model and ranges from 3900 to 4700 mt for other models evaluated (Table 38). Total stock biomass is projected to continue to decline consistent with the low level of recruitment experienced between 1995 and 1998. Over the next three years, recruitment from these below average year classes will form the heart of the fishery, which remains dependent on 7 to 14 year old fish. Spawning biomass in year 2003 is projected to be 112% to 125% of the $SPB_{40\%}$ depending on the model used. Based on stock specific yield projections, we estimate that 14% of the yield should be harvested in the Eureka/S.Columbia area, 42% in the N.Columbia area, and 44% in the S.Vancouver area. Council ABC and OY determinations need to account for expected harvest by Canadian fishers. From 1995 to 1999, the U.S fisheries took on average 81% of the coast-wide catch of yellowtail rockfish (Table 3).

Cumulative probability profiles for the coast-wide reference model of expected yield for slightly more liberal ($F_{45\%}$) and more conservative ($F_{55\%}$) exploitation rates are presented in Figure 32. Point estimates of the expected yield based on these target rates are located at the intersection of the profiled distribution and the 0.5 cumulative probability. A more risk adverse harvest strategy could be selected by requiring a higher level of certainty in the projected yield. A lower cumulative probability implies greater certainty that the true projected yield will not be higher than the estimated amount. For example, under the $F_{50\%}$ SPR rate, the target 2001 yield is 5146 mt. The cumulative probability profile implies that there is a 75% chance that the true yield is at least 3900 mt (intersection with 0.25 cumulative probability), and only a 25% chance that it is greater than 6000 mt (intersection with the 0.75 cumulative probability). Under the $F_{50\%}$ SPR rate, the 3-year mean projected yield, consistent with a 75% probability that yield is no less than projected, is 3600 mt, and the estimate consistent with a 25% probability that it is no more than projected is 5400 mt. The lower estimate (3600 mt) is approximately 80% of the mean point estimate (4500 mt) for yield at the $F_{50\%}$ SPR rate. Because of the lower precision on estimated biomass, and consequently projected yield, the upper and lower bounds on yield widen to 3300 to 6200 mt for the Srvon model, and 2500 to 5700 mt for the Fshon only model. If desired, these lower projected yields could be the basis of a more conservative ABC and OY recommendation.

5.0 Management recommendations

The year 2000 assessment paints a rosier picture of yellowtail rockfish biomass than has been the case in the previous two assessments. The optimism about stock biomass may be warranted but should be tempered with the realization of its sensitivity to the estimates of trawl survey biomass. The 1998 trawl survey estimate is at near record highs. Recognizing the broad variance of survey estimated abundance, managers may want to be cautious when setting harvest guidelines. The stock assessment team believes that to the extent practicable, managers should attempt to distribute allowable catch in proportion to the projected yield for each of the assessed substocks.

6.0 Research needs

Yellowtail rockfish size at age has declined markedly over the past decade. Maturation is correlated with size and we have not updated estimates of the proportion mature-at-age since 1990. Updating these parameter estimates should be accomplished by histological examination of ovaries. We recommend that the maturity parameter estimates be updated if funding can be made available.

Effectiveness of trawl surveys for species like yellowtail rockfish should be evaluated with particular attention to variation in annual catchability. NMFS has ongoing research in this area, but those studies should be brought to fruition to assist in the interpretation of trawl survey results for the next analysis.

Stock structure for yellowtail rockfish remains in dispute. If the coast-wide population is organized in distinct sub-stocks, as we believe it is, then coast-wide management risks overexploitation of local stocks. Past DNA analysis of stock structure was inconclusive, while electrophoretic analysis of allozyme frequencies implied stock structure. Additional work with microsatellite DNA could shed light on this question.

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8.0 Literature cited

Alverson, D.L. and A. Welander. 1952. Notes on the scorpaenid fishes of Washington and adjacent areas, with a key for their identification. Copeia 3: 138-143.

Alverson, D.L. and S.J. Westrheim. 1961. A review of the taxonomy and biology of the Pacific Ocean perch and its fishery. Cons. Internat. Explor. de la Mer., Rapp. Et Proc.-Verb Vol 150: 12:27

Alverson, D.L., A.T. Pruter, and L.L. Ronholt. 1964. A study of demersal fishes and fisheries of the northeastern Pacific Ocean. H.R. MacMillan Lectures in Fisheries. Inst. Fish., Univ. B.C., Vancouver, 190 p.

Aitkin, M, D. Anderson, B. Francis, and J. Hinde. 1989. Statistical modeling in GLIM. Oxford Sci. Pub. New York. 374p.

Anonymous. 1948. History and development of the commission. Coordinated plans for the management of the fisheries of the Pacific coast. Pac. Mar. Fish. Comm. Bull. No. 1, 64 p.

Coleman, B.A. 1986. The 1980 Pacific west coast bottom trawl survey of groundfish resources: estimates of distribution, abundance, length and age composition. U.S. Dept. Commerce, NOAA Tech. Mem. NMFS F/NWC-100: 181 p.

Coleman, B.A. 1988. The 1986 Pacific West Coast bottom trawl survey of groundfish resources: estimates of distribution, abundance, length and age composition. U.S. Dept. Commerce, NOAA Tech. Mem. NMFS F/NWC-152: 136 p.

Dark, T.A., M.E. Wilkins, and K. Edwards. 1983. Bottom trawl survey of canary rockfish (*Sebastes pinniger*), yellowtail rockfish (*S. flavidus*), bocaccio (*S. paucispinis*) and chilipepper (*S. goodei*) off Washington-California, 1980. U.S. Dept. Commerce, NOAA Tech. Mem. NMFS F/NWC-48: 40 p.

Deriso, R.B., T.J. Quinn II, and P.R. Neal. 1985. Catch-age analysis with auxiliary information. Can. J. Fish. Aquat. Sci. 42:815-824

Dorn, M.W. , M.W. Saunders, C.D. Wilson, M.A. Guttormsen, K. Cooke, R. Kieser, and M.E. Wilkens, 1999. Status of the coastal Pacific hake/whiting stock in U.S. and Canada in 1998. *In*, Appendices to the Status of the Pacific Coast Groundfish Fishery Through 1999 and Recommended Acceptable Biological Catches for 2000, Stock Assessment and Fishery Evaluation. 101p. Pacific Fishery Management Council, Portland, Oregon, October 1999.

Echeverria, T.W. 1987. Thirty-four species of California rockfishes: maturity and seasonality of reproduction. Fishery Bulletin 85(2): 229-250.

Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. A field guide to Pacific coast fishes of North America from the Gulf of Alaska to Baja California. Houghton Mifflin Co., Boston, MA. 336 p.

Fournier, D. 1996. An Introduction to AD Model Builder For Use in Nonlinear Modeling and Statistics. Otter Research Ltd.

Fournier, D.A. and C.P. Archibald. 1982. A general theory for analyzing catch-at-age data. Can. J. Fish. Aquat. Sci. 39:1195-1207.

Fraidenburg, M.E. 1980. Biological statistic of yellowtail rockfish (*Sebastes flavidus*, Ayres) in the northeast Pacific. Wash. Dept. Fish. Tech. Rept. No. 55: 64 p.

Fraidenburg, M.E. 1981. First estimates of natural mortality for yellowtail rockfish. Trans. Am. Fish. Soc. 110: 551-553.

Fraidenburg, M.E., J.E. Smith, W.H. Barss and T. Jow. 1977. Minimum estimates of the all nation removals, North American trawl species composition and CPUE for "other rockfish" in the Northeastern Pacific ocean. Wash. Dept. Fish. Tech. Rep. No. 34: 31 p.

Greiwank, A., and G.F. Corliss (eds.) 1991. Automatic differentiation of algorithms: theory, implementation and application. Proceedings of the SIAM Workshop on the Automatic Differentiation of Algorithms, held Jan. 6-8, Breckenridge, CO. Soc. Indust. And Applied Mathematics, Philadelphia

Gudmundsson, G. 1994. Time series analysis of catch-at-age observations. Appl. Statist. 43:117-126

Gunderson, D.R. 1977. Population biology of the Pacific ocean perch, *Sebastes alutus*, stock in the Washington-Queen Charlotte Sound region, and their response to fishing. Fishery Bulletin 75(2): 369-403Gunderson, D.R. and T.M Sample. 1980. Distribution and abundance of rockfish off Washington, Oregon, and California during 1977. Mar. Fish. Review 42(3-4): 2-16.

Gunderson, D.R., P. Callahan and B. Goiney. 1980. Maturation and fecundity of four species of *Sebastes*. Marine Fisheries Review 42(3-4): 74-79.

Hart, J.L. 1975. Pacific fishes of Canada. Fish. Res. Board. Can. Bulletin 180: 740 p.

Hilborn, R. and C.J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics, and uncertainty. Chapman and Hall, New York, N.Y. 570 p.

Leaman, B.M., and D.A. Nagtegaal. Age validation and revised natural mortality rate for yellowtail rockfish. Trans. Am. Fish. Soc. 116(2): 171-175.

McAllister, M.K. and Ianelli, J.N. 1997. Bayesian stock assessment using catch-age data and the sampling-importance resampling algorithm. Can. J. Fish. Aquat. Sci. 54:284-300.

McGauley, K., 1991. An application of polymerase chain reaction: examination of yellowtail rockfish (*Sebastes flavidus*) mitochondrial DNA. MS thesis, Humbolt State Univ., Arcata, California.

Nagtegaal, D.A. 1983. Identification and description of assemblages of some commercially important rockfishes (*Sebastes spp.*) off British Columbia, Canada. Can. Tech. Rept. Fish. Aquat. Sci. No. 1183: 82 p.

National Research Council. 1998. Improving Fish Stock Assessments. Committee on Fish Stock Assessment Methods Ocean Studies Board, Commission on Geosciences, Environment and Resources, National Research Council. National Academy Press, Washington D.C. 177 p.

Niska, E.L. 1976. Species composition of rockfish in catches by Oregon trawlers 1963-71. Oregon Dept. Fish and Wildlife Information Rept. 76-7. 79 p.

Phillips, J.B. 1964. Life history studies on ten species of rockfish (Genus *Sebastodes*). California Dept. Fish and Game, Fish Bulletin 126. 70 p.

Press, W.H. Teukolsky, S.A. Vetterling, W.T. Flannery, B.P.. 1992. Numerical recipes in C. The art of scientific computing. 2nd Edn. Cambridge University Press. New York, NY. 963p.

Press, W.H., B.P Flannery, S.A. Teukolsky and W.T. Vetterling. 1992. Numerical Recipes, the are of scientific computing. Second Edition. Cambridge University Press, New York, N.Y.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fish Res. Board of Can. Bulletin 191: 383 p.

Rogers, J.B. and E.K. Pikitch. 1992. Numerical definition of groundfish assemblages caught off the coasts of Oregon and Washington using commercial fishing strategies. Can. J. Fish. Aquat. Sci. 49:2648-2656.

Rogers, J.B. and W.H. Lenarz. 1993. Status of the Widow rockfish stock in 1993. *In*, Appendices to the Status of the Pacific Coast Groundfish Fishery Through 1993 and Recommended Acceptable Biological Catches for 1994, Stock Assessment and Fishery Evaluation. Appendix B, 37p. Pacific Fishery Management Council, Portland, Oregon, October 1993.

Schnute, J.T. and Richards, L.J. 1995. The influence of error on population estimates from catch-age models. Can. J. Fish. Aquat. Sci. 52:2063-2077.

Seber, G.A.F. 1982. The estimation of animal abundance. Charles Griffin and Company. London. 654 p.

Sen, A.R. 1984. Sampling commercial rockfish landings in California. NOAA Tech. Memo. NMFS-SWFC-45, 95p

Shaw, W. and C.P. Archibald. 1981. Length and age data of rockfishes collected from B.C. coastal waters during 1977, 1978, and 1979. Can. Data. Rept. Fish. Aquat. Sci. No. 289: 119 p.

Stanley, R.D. 1993. Shelf rockfish. *In*, Groundfish stock assessments for the west coast of Canada in 1992 and recommended yield options for 1993, ed. B.L. Leaman and M. Stoker, pp 245-335. Can. Tech. Rept. Fish. Aquat. Sci. No. 1919: 407 p.

Stanley, R.D., D.L. Lee, and D.J. Whitaker. 1992. Parasites of yellowtail rockfish, *Sebastes flavidus* (Ayres 1862)(Pisces: Teleostei) from the Pacific coast of North America as potential biological tags for stock identification. Can. J. Zool. 70:1086-1096.

Tagart, J.V. 1987. Description of the Washington State fishery for widow rockfish. pp 11-12. *In*, Widow rockfish proceedings of a workshop, Tiburon, California, December 11-12, 1980, ed. W.H. Lenarz and D.R. Gunderson. U.S. Dept. Commerce, NOAA Tech. Rept. NMFS 48:57 p.

Tagart, J.V. 1988. Status of the yellowtail rockfish stocks in the International North Pacific Fishery Commission Vancouver and Columbia areas. Wash. Dept. Fisheries Tech. Rept. No. 104, 118 p.

Tagart, J.V. 1991. Population dynamics of yellowtail rockfish (*Sebastes flavidus*) in the northern California to southwest Vancouver Island region. Ph.D Thesis, Univ. of Wash., Seattle, 323p.

Tagart, J.V. 1993. Status of the yellowtail rockfish resource in 1993. *In*, Appendices to the Status of the Pacific Coast Groundfish Fishery Through 1993 and Recommended Acceptable Biological Catches for 1994, Stock Assessment and Fishery Evaluation. Appendix E, 51p. Pacific Fishery Management Council, Portland, Oregon, October 1993.

Tagart, J.V. and F.R. Wallace. 1996. Status of the yellowtail rockfish resource in 1996. *In*, Appendix Volume II to the Status of the Pacific Coast Groundfish Fishery Through 1996 and Recommended Acceptable Biological Catches for 1997, Stock Assessment and Fishery Evaluation. Appendix D, 166p. Pacific Fishery Management Council, Portland, Oregon, September 1996.

Tagart, J.V., J.N. Ianelli, A. Hoffmann, and F.R. Wallace. 1997. Status of the Yellowtail Rockfish Resource in 1997. *In*, Yellowtail Rockfish Appendix to the Status of the Pacific Coast Groundfish Fishery Through 1997 and Recommended Acceptable Biological Catches for 1998, Stock Assessment and Fishery Evaluation. 146p. Pacific Fishery Management Council, Portland, Oregon, July 1997.

Tagart, J.V. and D.K. Kimura. 1982. Review of Washington's coastal trawl rockfish fisheries. Wash. Dept. Fisheries Tech. Rept. No. 68, 66 p.

Weinberg, K.L., M.E. Wilkins, and T.A. Dark. 1984. The 1983 Pacific west coast bottom trawl survey of groundfish resources: estimates of distribution, abundance, age and length composition. U.S. Department of Commerce, NOAA Tech. Mem. NMFS-FNWC-70, 376 p.

Westrheim, S.J. 1970. Survey of rockfishes, especially Pacific ocean perch in the northeast Pacific ocean, 1963-66. J. Fish. Res. Board. Can. 27(10): 1781-1809.

Westrheim, S.J. 1975. Reproduction, maturation, and identification of larvae of some *Sebastes* (Scorpaenidae) in the northeast Pacific ocean. J. Fish. Res. Board Can. 32(12): 2399-2411.

Westrheim, S.J. 1986. The rockfish fisheries off western Canada, 1860-1985. *In*, Proceedings of the International Rockfish Symposium, Anchorage, Alaska, Univ. Alaska, Alaska Sea Grant Rept. 87-2, 393 p.

Wishard, L.N., F.M. Utter, and D.R. Gunderson. 1980. Stock separation of five rockfish species using naturally occurring biochemical genetic markers. Mar. Fish. Review 42(3-4): 64-73.

Zimmermann. M., M.E. Wilkins, R.R. Lauth, and K.L. Weinberg. 1994. The 1992 Pacific west coast bottom trawl survey of groundfish resources: estimates of distribution, abundance, and length composition. U.S. Department of Commerce, NOAA Tech. Mem. NMFS-FNWC-42, 110 p.

9.0 Tables

Table 1 History of trip limits imposed on the yellowtail rockfish fishery by the Pacific Fishery Management Council.

		North/South		Limit (1000's of lbs)			
		Management	Trip	North		South[1]	
Year	Month	Boundary	Frequency	Sebastes	Yellowtail	Sebastes	Yellowtail
1983	1	CoosBay	None	40	na	40	40
1983	6	CoosBay	Weekly	40	na	40	40
1983	9	CoosBay	Weekly	3	na	40	40
1984	1	CoosBay	Weekly	30	na	40	40
1984	5	CoosBay	Weekly / Bi-weekly	15/30	na	40	40
1984	8	CoosBay	Weekly / Bi-weekly	7.5/15	na	40	40
1985	1	CoosBay	Weekly / Bi-weekly	30/60	10/20	40	40
1985	4	CoosBay	Weekly / Bi-weekly / Twice-weekly	15/30/7.5	5/10/3	40	40
1985	10	CoosBay	Weekly / Bi-weekly / Twice-weekly	20/40/10	5/10/3	40	40
1986	1	CoosBay	Weekly / Bi-weekly / Twice-weekly	25/50/12.5	10/20/5	40	40
1986	8	CoosBay	Weekly / Bi-weekly / Twice-weekly	30/60/15	12.5/25/6.5	40	40
1987	1	CoosBay	Weekly / Bi-weekly / Twice-weekly	25/50/12.5	10/20/5	40	40
1988	1	CoosBay	Weekly / Bi-weekly / Twice-weekly	25/50/12.5	10/20/5	40	40
1989	1	CoosBay	Weekly / Bi-weekly / Twice-weekly	25/50/12.5	7.5/15/3.75	40	40
1989	7	CoosBay	Weekly / Bi-weekly / Twice-weekly	25/50/12.5	3 or 20% [2]	40	40
1990	1	CoosBay	Weekly / Bi-weekly / Twice-weekly	25/50/12.5	7.5/15/3.75	40	40
1990	7	CoosBay	Weekly / Bi-weekly / Twice-weekly	25/50/12.5	3 or 20% [2]	40	40
1991	1	CoosBay	Weekly / Bi-weekly / Twice-weekly	25/50/12.5	5/10/3	25	25
1991	4	CoosBay	Weekly / Bi-weekly / Twice-weekly	25/50/12.5	na/5/na	25	25
1992	1	Cape Lookout	Cumulative Bi-weekly	50	8	50	50
1992	7	CoosBay	Cumulative Bi-weekly	50	6	50	50
1993	1	CoosBay	Cumulative Bi-weekly	50	8	50	50
1993	4	CoosBay	Cumulative Bi-weekly	50	6	50	50
1994	1	Cape Lookout	Cumulative Monthly	80	14	80	80
1994	10	Cape Lookout	Cumulative Monthly	100	14	100	100
1995	1	Cape Lookout	Cumulative Monthly	35	14	50	50
1995	5	Cape Lookout	Cumulative Monthly	35	18	50	50
1996	1	Cape Lookout	Cumulative Bi-Monthly	70	32	70	70
1996	9	Cape Lookout	Cumulative Monthly	70	20	70	70
1997	1	Cape Mendocino	Cumulative Bi-Monthly	30	6	150	150
1997	5	Cape Mendocino	Cumulative Bi-Monthly	30	6	10	10
1997	10	Cape Mendocino	Cumulative Monthly	20	5	75	75
1998	1	Cape Mendocino	Cumulative Bi-Monthly	40	11	150	150
1998	5	Cape Mendocino	Cumulative Bi-Monthly	40	13	150	150
1998	10	Cape Mendocino	Cumulative Monthly	40	13	150	150
1999	1	Cape Mendocino	Cumulative Tri-Monthly	24	15	13	13
1999	4	Cape Mendocino	Cumulative Bi-Monthly	25	13	6.5	6.5
1999	6	Cape Mendocino	Cumulative Bi-Monthly	30	16	3.5	3.5
1999	8	Cape Mendocino	Cumulative Bi-Monthly	35	20	3.5	3.5
1999	10	Cape Mendocino	Cumulative Monthly	0.5	0.3	0.5	0.5
2000	1	Cape Mendocino	Cumulative Bi-Monthly		10		1
2000	5	Cape Mendocino	Cumulative Bi-Monthly		30		2

1 No constraints on trip frequency 1983 through 1991

2 3000 pounds or 20% of the total catch on board, which ever is greater

Table 2. Comparison of assessment estimated and PFMC selected ABC and HGs for yellowtail rockfish stocks in the U.S. portions of the Eureka to Vancouver areas only. [VUS is the U.S. portion of the Vancouver area, Cape Elizabeth to the US/Canada provisional boundary; EUR/COL is the combined Eureka and Columbia areas, Cape Mendocino to Cape Elizabeth].

	STOCK ASSESSMENT ABCs [1]						PFMC VALUES [1]					
	EUR/COL		VUS		TOTAL		ABC's [2]			HG'S		
YEAR	LOW	HIGH	LOW	HIGH	LOW	HIGH	EUR/COL	VUS	TOTAL	LOW	HIGH	STAND. [3]
1983	2,900	4,900	1,200	1,600	4,100	6,500	1,800	1,400	3,200	1,400	3,200	3,200
1984	2,900	4,900	1,200	1,600	4,100	6,500	1,800	1,400	3,200	1,400	3,200	3,200
1985	785	2,897	277	856	1,062	3,753	2,400	600	3,000	600	3,000	3,000
1986	2,227	3,154	854	1,812	3,081	4,966	2,900	1,100	4,000	1,100	4,000	4,000
1987	2,227	3,154	854	1,812	3,081	4,966	2,900	1,100	4,000	1,100	4,000	4,000
1988	2,227	3,154	854	1,812	3,081	4,966	2,900	1,100	4,000	1,100	4,000	4,000
1989	1,990	4,031	1,196	3,028	3,186	7,059	3,200	1,100	4,300	1,100	4,300	4,300
1990	1,990	4,031	1,196	3,028	3,186	7,059	3,200	1,100	4,300	1,100	4,300	4,300
1991	3,433	5,853	1,226	1,801	4,659	7,654	3,400	1,200	4,600	4,300	4,300	4,300
1992	3,433	5,853	1,226	1,801	4,659	7,654	3,400	1,200	4,600	4,300	4,300	4,300
1993	3,433	5,853	1,226	1,801	4,659	7,654	3,400	1,300	4,700	4,400	4,400	4,400
1994	5,466	6,049	131	2,239	5,597	8,288	5,550	1,190	6,740	6,740	6,740	6,740
1995	5,466	6,049	131	2,239	5,597	8,288	5,550	1,191	6,741	6,740	6,740	6,740
1996	5,466	6,049	131	2,239	5,597	8,288	5,550	1,192	6,742	6,170	6,170	6,740
1997	536	1,423	337	529	873	1,952	1,319	454	1,773	825	2,924	2,924
1998	839	1,582	380	1,957	1,218	3,539	1,770	1,770	3,539	2,619	2,911	3,539
1999	937	1,615	449	1,919	1,386	3,534	1,770	1,770	3,539	2,407	2,407	3,539
2000	1,072	1,680	540	1,864	1,613	3,544	1,770	1,770	3,539	2,980	2,980	3,539

1 ABC and HG reference the U.S. portion of the area specific stock estimates only.

2 For 1998 and beyond, this is the Council's upper range ABC, distributed to stock based on assessment estimates of area specific yield.

3 STAND., represents a standardize HG inclusive of estimated discard.

Table 3. Estimated total yellowtail rockfish catch (mt) by stock, 1963 to 1999.

	STOCK					
YEAR	EUR/SCOL	N.COL	S.VAN	TOTAL	TOTAL US	PCT. US
1963	149	693	No data	842	842	100
1964	4	497	No data	501	501	100
1965	144	345	No data	489	489	100
1966	111	566	No data	677	677	100
1967	270	582	362	1214	1189	98
1968	228	747	1496	2471	2471	100
1969	194	548	2150	2892	2705	94
1970	218	122	689	1030	993	96
1971	298	152	483	933	922	99
1972	425	744	741	1910	1894	99
1973	371	1979	636	2985	2963	99
1974	250	421	741	1413	1388	98
1975	197	1140	266	1603	1576	98
1976	177	2644	1134	3954	3814	96
1977	302	3183	1613	5098	4865	95
1978	1042	6113	1672	8827	8463	96
1979	1099	6397	2012	9508	9174	96
1980	855	5514	2489	8857	8664	98
1981	1198	4788	3343	9330	9184	98
1982	1281	4095	4250	9627	9185	95
1983	1173	4912	3778	9864	9500	96
1984	1421	2861	1483	5766	5393	94
1985	986	1805	1406	4197	3830	91
1986	821	2976	2442	6239	5478	88
1987	1270	3247	2103	6620	5785	87
1988	1029	3863	2378	7271	6670	92
1989	1306	2170	2815	6291	5046	80
1990	1122	1869	2424	5416	4754	88
1991	1294	1808	1936	5037	4273	85
1992	2680	2477	2612	7770	6822	88
1993	1345	2569	3609	7523	5861	78
1994	1567	2812	3087	7466	6456	86
1995	1296	3039	2519	6854	6069	89
1996	1757	2582	3994	8333	6344	76
1997	477	1069	1326	2871	2323	81
1998	694	1249	1909	3851	3144	82
1999	580	1216	2717	4513	3598	80
Mean	801	2,265	2,019	4,866	4,414	92
Last 10 y	1,281	2,069	2,613	5,963	4,964	83
Last 5 y	961	1,831	2,493	5,284	4,296	81

Table 4. Estimated yellowtail rockfish catch by fishery, 1963 to 1999 for the Eureka/S.Columbia stock.

Year	Domestic Trawl	Domestic Trawl Discard	Shrimp Trawl	At-Sea Whiting	Shoreside Whiting	Total
1963	149	-	0	-	-	149
1964	4	-	0	-	-	4
1965	144	-	0	-	-	144
1966	26	-	85	-	-	111
1967	134	-	136	0	-	270
1968	100	-	128	0	-	228
1969	84	-	110	0	-	194
1970	81	-	137	0	-	218
1971	175	-	123	0	-	298
1972	159	-	266	0	-	425
1973	98	-	273	0	-	371
1974	37	-	213	0	-	250
1975	79	-	118	0	-	197
1976	1	-	176	0	-	177
1977	85	-	198	20	-	302
1978	440	-	498	104	-	1042
1979	568	-	414	117	-	1099
1980	428	-	399	28	-	855
1981	852	-	286	60	-	1198
1982	1051	-	217	13	-	1281
1983	1036	-	92	46	-	1173
1984	1276	-	58	88	-	1421
1985	720	137	81	48	-	986
1986	414	79	245	83	-	821
1987	664	126	343	136	-	1270
1988	695	132	116	85	-	1029
1989	878	167	217	44	0	1306
1990	778	148	135	59	2	1122
1991	873	166	123	125	6	1294
1992	2071	394	181	19	15	2680
1993	984	187	89	67	17	1345
1994	1190	227	41	58	51	1567
1995	998	190	30	2	77	1296
1996	1295	247	99	0	116	1757
1997	369	70	22	2	14	477
1998	524	100	54	0	16	694
1999	446	85	19	0	30	580
Mean	538	154	155	36	31	780
Last 10 y	953	181	79	33	34	1,281
Last 5 y	726	138	45	1	51	961

Table 5. Estimated yellowtail rockfish catch by fishery, 1963 to 1999 for the N.Columbia stock.

Year	Domestic Trawl	Domestic Trawl Discard	Shrimp Trawl	At-Sea Whiting	Shoreside Whiting	Total
1963	679	-	14	-	-	693
1964	493	-	4	-	-	497
1965	338	-	7	-	-	345
1966	563	-	3	-	-	566
1967	457	-	11	114	-	582
1968	491	-	17	240	-	747
1969	519	-	28	1	-	548
1970	115	-	3	4	-	122
1971	133	-	13	6	-	152
1972	522	-	16	207	-	744
1973	470	-	124	1385	-	1979
1974	247	-	163	11	-	421
1975	582	-	151	407	-	1140
1976	2412	-	232	0	-	2644
1977	2817	-	361	5	-	3183
1978	5681	-	315	117	-	6113
1979	5726	-	573	97	-	6397
1980	4623	-	658	233	-	5514
1981	4187	-	471	130	-	4788
1982	3558	-	376	161	-	4095
1983	4404	-	312	196	-	4912
1984	2543	-	132	186	-	2861
1985	1317	251	131	107	-	1805
1986	1642	313	610	411	-	2976
1987	1913	364	601	368	-	3247
1988	2857	544	178	285	-	3863
1989	1464	279	337	87	4	2170
1990	1311	250	275	23	10	1869
1991	1123	214	271	173	28	1808
1992	1517	289	222	411	39	2477
1993	1385	264	617	228	76	2569
1994	1655	315	316	381	144	2812
1995	1717	327	163	651	181	3039
1996	1661	316	136	197	272	2582
1997	574	109	96	220	70	1069
1998	786	150	68	164	82	1249
1999	646	123	40	216	191	1216
Mean	1,706	257	217	225	100	2,205
Last 10 y	1,237	236	220	266	109	2,069
Last 5 y	1,077	205	100	290	159	1,831

Table 6. Estimated yellowtail rockfish catch by fishery, 1963 to 1999 for the S.Vancouver stock.

	Domestic trawl			Shrimp trawl		Whiting			Total		Grand
Year	US	US Discard	CN	US	CN	US At-sea	US Shore	CN	US	CN	Total
1963	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	-	-	-
1967	35	-	25	0	0	302	-	0	337	25	362
1968	952	-	0	0	0	544	-	0	1496	0	1496
1969	1373	-	187	4	0	587	-	0	1963	187	2150
1970	467	-	37	0	0	185	-	0	652	37	689
1971	365	-	11	0	0	107	-	0	472	11	483
1972	457	-	16	0	0	268	-	0	725	16	741
1973	276	-	22	5	0	332	-	0	614	22	636
1974	50	-	25	37	0	629	-	0	716	25	741
1975	66	-	27	38	0	135	-	0	239	27	266
1976	883	-	127	55	14	55	-	0	993	141	1134
1977	1340	-	200	40	33	0	-	0	1380	233	1613
1978	1212	-	228	95	17	0	-	120	1307	365	1672
1979	1361	-	146	317	1	0	-	187	1678	334	2012
1980	2028	-	50	230	1	38	-	142	2296	193	2489
1981	2904	-	25	237	1	57	-	120	3198	146	3343
1982	3342	-	122	85	0	381	-	320	3808	442	4250
1983	2891	-	17	256	0	268	-	347	3414	364	3778
1984	980	-	23	60	0	70	-	350	1110	373	1483
1985	943	180	103	46	0	49	-	264	1039	367	1406
1986	1544	294	450	43	0	95	-	311	1681	761	2442
1987	1193	227	505	15	0	61	-	330	1268	835	2103
1988	1680	320	267	0	0	97	-	334	1777	601	2378
1989	1521	290	260	0	0	49	-	985	1570	1245	2815
1990	1448	276	264	0	0	39	0	398	1762	662	2424
1991	943	180	350	4	0	43	2	414	1172	764	1936
1992	1223	233	512	0	0	209	0	436	1664	948	2612
1993	1612	307	833	14	0	14	0	829	1947	1662	3609
1994	1580	301	328	18	0	178	0	682	2077	1010	3087
1995	1310	249	626	25	0	137	13	159	1734	785	2519
1996	1269	242	1009	61	0	434	0	980	2005	1989	3994
1997	497	95	342	2	0	181	4	206	778	548	1326
1998	679	129	497	3	0	366	25	210	1202	707	1909
1999	714	136	850	1	0	908	44	65	1802	915	2717
Mean	1,186	216	250	51	2	207	9	248	1,467	492	1,959
Last 10 y	1,127	215	561	13	0	251	9	438	1,614	999	2,613
Last 5 y	894	170	665	18	0	405	17	324	1,504	989	2,493

Table 7. Yellowtail rockfish von Bertalanffy growth function parameter estimates.

	S. Vancouver							
	Male				Female			
Year	N	Linf	t0	K	N	Linf	t0	K
PRE 1987	6965	48.1547	-2.2017	0.1716	4604	53.6603	-1.2230	0.1583
1987	677	48.6970	-2.4991	0.1712	522	55.1158	-1.7835	0.1411
1988	589	48.5984	-1.9457	0.1751	461	56.5024	-1.3878	0.1367
1989	586	48.6225	-2.6011	0.1669	369	53.2499	-0.6465	0.1697
1990	677	47.4511	-2.2154	0.1767	517	53.6374	-0.8704	0.1588
1991	542	48.7655	-4.0618	0.1424	419	56.6586	-2.8797	0.1166
1992	788	48.7211	-4.1212	0.1386	863	52.5533	0.0820	0.1842
1993	940	48.2401	-1.5827	0.1695	764	53.5064	-1.2533	0.1451
1994	922	47.5288	-2.1581	0.1647	882	53.8604	-0.8724	0.1450
1995	719	48.0801	-2.1933	0.1684	585	55.4054	-1.3443	0.1368
1996	443	47.6674	-1.4453	0.1812	436	53.6469	-2.5486	0.1300
1997	727	48.6824	-2.1253	0.1591	705	54.5531	-1.8246	0.1388
1998	679	48.2265	-3.5098	0.1366	754	53.1663	-1.7673	0.1365
1999	717	48.1899	-3.6810	0.1329	655	54.1599	-0.8709	0.1398
	N.Columbia							
	Male				Female			
Year	N	Linf	t0	K	N	Linf	t0	K
PRE 1987	8120	47.3819	-1.2573	0.1989	6558	53.0126	-0.4407	0.1779
1987	1121	47.1137	-0.8411	0.2191	963	53.4385	-1.6147	0.1634
1988	774	48.1398	-0.8717	0.2046	860	54.6578	-0.9348	0.1649
1989	1028	48.1074	-0.7087	0.2004	880	52.7113	-0.2128	0.1918
1990	911	47.7733	-1.3672	0.1955	790	56.9283	-2.9605	0.1203
1991	688	48.3811	-3.1562	0.1594	667	55.3390	-2.5188	0.1338
1992	769	45.8315	-1.4586	0.2093	700	50.7430	0.1204	0.2141
1993	884	47.0248	-1.2265	0.1913	763	53.4957	-0.7265	0.1653
1994	1074	47.3998	-2.4605	0.1655	1068	54.4084	-2.2189	0.1345
1995	1125	48.2003	-2.7647	0.1508	1171	52.6433	-0.9789	0.1594
1996	1054	46.7047	-2.2525	0.1758	1083	53.7842	-2.9172	0.1264
1997	1137	47.2876	-1.1476	0.1852	974	52.9116	-0.6575	0.1622
1998	1144	47.2293	-3.3135	0.1423	1146	52.2322	-2.5667	0.1335
1999	1459	48.9587	-5.5170	0.1117	1387	53.6978	-2.3462	0.1249
	Eureka/S.Columbia							
	Male				Female			
Year	N	Linf	t0	K	N	Linf	t0	K
PRE 1987	2197	46.2246	-1.3580	0.2058	2208	53.1179	-0.8557	0.1708
1987	418	45.2585	-2.1634	0.2165	328	51.0767	-1.1438	0.1919
1988	340	45.5001	-0.9018	0.2437	327	51.6137	0.2018	0.2233
1989	735	47.2928	-8.0864	0.1191	800	50.1521	-1.2852	0.2049
1990	501	45.8759	-1.5792	0.2060	379	51.7215	-0.3827	0.1962
1991	423	45.5824	0.2013	0.2492	497	55.3166	-3.7570	0.1169
1992	828	46.7730	-3.5900	0.1597	887	52.1340	-0.4476	0.1809
1993	553	46.6414	-2.6486	0.1696	549	54.8923	-4.5197	0.1079
1994	699	46.3773	-2.7878	0.1602	650	52.8679	-3.5657	0.1214
1995	339	45.4908	-1.3543	0.2084	346	51.1799	-1.6080	0.1608
1996	431	45.3580	-3.0608	0.1592	449	50.4355	-1.2162	0.1624
1997	843	44.9719	-0.2343	0.2353	823	50.8428	-0.9949	0.1751
1998	611	45.3293	-3.5286	0.1500	581	51.1669	-2.1679	0.1385
1999	844	44.5485	-1.8372	0.1919	757	49.9390	-1.0723	0.1671

Table 7. (continued)

	Coast-wide							
	Male				Female			
Year	N	Linf	t0	K	N	Linf	t0	K
PRE 1987	17282	47.5654	-1.6874	0.1874	13370	53.2083	-0.7470	0.1705
1987	2216	47.3712	-1.7142	0.1964	1813	53.2287	-1.5261	0.1638
1988	1703	47.4306	-0.9817	0.2103	1648	54.3370	-0.9609	0.1647
1989	2349	47.9936	-3.7723	0.1553	2049	51.6994	-1.2558	0.1825
1990	2089	46.9167	-1.4563	0.2005	1686	54.6771	-2.3212	0.1379
1991	1653	47.1617	-1.1368	0.2023	1583	55.6351	-3.2248	0.1217
1992	2385	47.3332	-3.3219	0.1587	2450	52.0063	-0.2305	0.1870
1993	2377	47.4356	-1.6756	0.1769	2076	53.2656	-1.4051	0.1502
1994	2695	46.8561	-2.2585	0.1706	2600	52.5625	-1.2526	0.1538
1995	2183	47.3640	-1.7810	0.1764	2102	52.8760	-1.0284	0.1571
1996	1925	46.0703	-1.3735	0.1966	1968	52.6637	-2.1387	0.1401
1997	2707	46.8210	-0.7994	0.1981	2502	52.7701	-1.0924	0.1582
1998	2434	46.4740	-2.4614	0.1601	2481	52.1126	-1.8428	0.1412
1999	3020	47.1195	-4.1345	0.1359	2799	52.7334	-1.6727	0.1382

Table 8. Predicted yellowtail rockfish weight-at-age (kg) by stock or stock grouping.

S. Vancouver														
	Males													
Age	Pre 1987	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.142	0.176	0.126	0.177	0.146	0.259	0.251	0.085	0.121	0.134	0.085	0.117	0.182	0.185
2	0.250	0.294	0.236	0.291	0.256	0.366	0.354	0.177	0.217	0.239	0.181	0.213	0.273	0.274
3	0.375	0.427	0.365	0.419	0.381	0.480	0.464	0.291	0.330	0.360	0.301	0.328	0.375	0.373
4	0.508	0.564	0.504	0.553	0.512	0.595	0.576	0.419	0.452	0.490	0.435	0.453	0.480	0.475
5	0.642	0.701	0.644	0.686	0.643	0.709	0.687	0.552	0.575	0.620	0.572	0.581	0.588	0.579
6	0.770	0.832	0.779	0.813	0.769	0.818	0.794	0.683	0.696	0.747	0.706	0.708	0.693	0.682
7	0.891	0.953	0.907	0.933	0.885	0.922	0.896	0.809	0.811	0.866	0.833	0.829	0.794	0.781
8	1.002	1.065	1.023	1.042	0.991	1.018	0.991	0.926	0.917	0.976	0.949	0.942	0.890	0.875
9	1.102	1.165	1.129	1.141	1.086	1.107	1.079	1.033	1.015	1.076	1.054	1.047	0.980	0.963
10	1.191	1.254	1.222	1.230	1.171	1.188	1.160	1.130	1.102	1.166	1.147	1.142	1.063	1.045
11	1.270	1.332	1.305	1.308	1.244	1.261	1.234	1.216	1.180	1.245	1.229	1.227	1.139	1.120
12	1.339	1.401	1.377	1.377	1.309	1.327	1.300	1.292	1.249	1.315	1.300	1.303	1.209	1.189
13	1.399	1.460	1.440	1.437	1.364	1.386	1.360	1.359	1.310	1.376	1.361	1.370	1.271	1.251
14	1.451	1.511	1.493	1.489	1.412	1.439	1.413	1.417	1.362	1.429	1.413	1.430	1.327	1.308
15	1.495	1.556	1.540	1.534	1.452	1.485	1.461	1.467	1.408	1.475	1.458	1.481	1.378	1.358
16	1.533	1.594	1.579	1.573	1.487	1.526	1.503	1.510	1.448	1.514	1.496	1.526	1.423	1.404
17	1.566	1.626	1.613	1.607	1.516	1.563	1.541	1.547	1.482	1.548	1.528	1.565	1.463	1.444
18	1.594	1.654	1.641	1.635	1.541	1.595	1.574	1.579	1.512	1.577	1.556	1.599	1.498	1.481
19	1.618	1.677	1.666	1.660	1.563	1.623	1.603	1.606	1.537	1.601	1.579	1.629	1.530	1.513
20	1.638	1.697	1.686	1.681	1.581	1.647	1.629	1.629	1.559	1.623	1.598	1.654	1.558	1.541
21	1.655	1.714	1.704	1.699	1.596	1.669	1.652	1.648	1.577	1.641	1.614	1.676	1.582	1.567
22	1.670	1.728	1.718	1.714	1.608	1.688	1.672	1.665	1.593	1.656	1.628	1.694	1.604	1.589
23	1.682	1.741	1.731	1.727	1.619	1.704	1.689	1.679	1.606	1.669	1.639	1.710	1.623	1.609
24	1.692	1.751	1.741	1.738	1.628	1.719	1.704	1.692	1.618	1.680	1.649	1.724	1.639	1.626
25	1.701	1.760	1.750	1.747	1.636	1.731	1.718	1.702	1.628	1.689	1.657	1.736	1.654	1.642
	Females													
1	0.069	0.097	0.067	0.038	0.045	0.147	0.010	0.057	0.037	0.060	0.131	0.094	0.080	0.034
2	0.165	0.197	0.154	0.121	0.127	0.246	0.066	0.137	0.104	0.141	0.227	0.189	0.163	0.097
3	0.294	0.325	0.273	0.245	0.247	0.363	0.174	0.247	0.206	0.253	0.343	0.310	0.271	0.193
4	0.447	0.472	0.416	0.400	0.393	0.495	0.323	0.380	0.333	0.387	0.472	0.450	0.397	0.314
5	0.613	0.630	0.575	0.571	0.556	0.636	0.498	0.526	0.478	0.537	0.608	0.601	0.533	0.453
6	0.782	0.794	0.743	0.749	0.725	0.781	0.682	0.679	0.632	0.696	0.747	0.756	0.675	0.602
7	0.949	0.956	0.913	0.924	0.894	0.928	0.866	0.833	0.789	0.857	0.885	0.912	0.817	0.756
8	1.109	1.113	1.081	1.091	1.057	1.072	1.042	0.983	0.944	1.015	1.019	1.063	0.955	0.909
9	1.258	1.263	1.243	1.247	1.210	1.212	1.205	1.126	1.093	1.169	1.148	1.207	1.088	1.057
10	1.396	1.404	1.397	1.389	1.352	1.347	1.352	1.261	1.233	1.314	1.269	1.342	1.214	1.198
11	1.521	1.534	1.541	1.518	1.481	1.475	1.484	1.386	1.364	1.451	1.382	1.468	1.331	1.331
12	1.634	1.653	1.674	1.631	1.598	1.595	1.599	1.500	1.485	1.577	1.487	1.584	1.439	1.453
13	1.734	1.761	1.796	1.732	1.702	1.708	1.700	1.603	1.594	1.693	1.583	1.689	1.538	1.566
14	1.822	1.859	1.907	1.820	1.794	1.812	1.786	1.696	1.693	1.798	1.670	1.784	1.628	1.668
15	1.900	1.947	2.008	1.896	1.876	1.908	1.860	1.780	1.782	1.893	1.750	1.870	1.709	1.761
16	1.969	2.025	2.098	1.962	1.947	1.996	1.924	1.854	1.862	1.979	1.822	1.947	1.782	1.844
17	2.028	2.094	2.180	2.019	2.009	2.077	1.977	1.920	1.932	2.056	1.886	2.015	1.847	1.918
18	2.080	2.156	2.252	2.068	2.063	2.151	2.023	1.978	1.994	2.125	1.944	2.076	1.905	1.984
19	2.125	2.211	2.316	2.110	2.110	2.218	2.061	2.030	2.049	2.186	1.996	2.130	1.957	2.043
20	2.164	2.259	2.374	2.146	2.150	2.279	2.093	2.075	2.098	2.240	2.042	2.178	2.002	2.095
21	2.197	2.301	2.424	2.176	2.185	2.334	2.120	2.114	2.140	2.288	2.084	2.220	2.043	2.141
22	2.226	2.338	2.469	2.202	2.215	2.384	2.143	2.149	2.177	2.331	2.120	2.257	2.079	2.182
23	2.251	2.371	2.509	2.224	2.241	2.429	2.162	2.179	2.210	2.368	2.153	2.290	2.110	2.217
24	2.272	2.400	2.543	2.243	2.264	2.469	2.178	2.205	2.238	2.401	2.182	2.319	2.138	2.249
25	2.290	2.425	2.574	2.259	2.283	2.505	2.191	2.228	2.263	2.430	2.207	2.344	2.163	2.276

Table 8. (Continued)

N.Columbia														
	Males													
Age	Pre 1987	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.086	0.066	0.062	0.047	0.094	0.214	0.106	0.074	0.148	0.152	0.141	0.064	0.170	0.267
2	0.192	0.174	0.164	0.137	0.203	0.327	0.218	0.170	0.250	0.249	0.246	0.153	0.260	0.352
3	0.325	0.316	0.300	0.265	0.338	0.450	0.352	0.292	0.367	0.359	0.365	0.269	0.359	0.441
4	0.471	0.474	0.455	0.413	0.485	0.576	0.493	0.427	0.489	0.475	0.490	0.400	0.463	0.532
5	0.619	0.634	0.615	0.569	0.634	0.700	0.631	0.567	0.612	0.593	0.614	0.537	0.568	0.624
6	0.760	0.784	0.769	0.722	0.776	0.819	0.761	0.702	0.731	0.709	0.733	0.672	0.671	0.714
7	0.890	0.921	0.911	0.865	0.908	0.930	0.878	0.828	0.842	0.820	0.844	0.799	0.769	0.801
8	1.007	1.042	1.040	0.996	1.026	1.033	0.981	0.943	0.945	0.923	0.945	0.917	0.862	0.885
9	1.111	1.146	1.153	1.112	1.131	1.126	1.070	1.046	1.039	1.019	1.036	1.022	0.948	0.965
10	1.200	1.234	1.251	1.213	1.222	1.209	1.146	1.135	1.123	1.107	1.116	1.116	1.027	1.040
11	1.277	1.308	1.335	1.300	1.301	1.284	1.210	1.214	1.197	1.186	1.186	1.198	1.099	1.110
12	1.343	1.370	1.405	1.374	1.368	1.349	1.264	1.281	1.263	1.256	1.247	1.269	1.164	1.176
13	1.398	1.420	1.465	1.437	1.425	1.407	1.309	1.338	1.320	1.320	1.300	1.330	1.223	1.237
14	1.445	1.462	1.515	1.490	1.473	1.457	1.346	1.386	1.370	1.376	1.346	1.382	1.275	1.293
15	1.483	1.496	1.556	1.534	1.513	1.501	1.377	1.427	1.413	1.425	1.385	1.427	1.321	1.344
16	1.516	1.524	1.590	1.571	1.547	1.540	1.402	1.461	1.450	1.468	1.418	1.464	1.362	1.391
17	1.542	1.546	1.619	1.601	1.575	1.573	1.423	1.490	1.483	1.506	1.446	1.496	1.399	1.435
18	1.565	1.565	1.642	1.627	1.598	1.601	1.440	1.514	1.510	1.539	1.470	1.523	1.431	1.474
19	1.583	1.579	1.661	1.648	1.617	1.626	1.453	1.534	1.534	1.568	1.491	1.545	1.459	1.510
20	1.598	1.591	1.677	1.665	1.633	1.647	1.465	1.551	1.554	1.593	1.508	1.564	1.484	1.542
21	1.611	1.601	1.690	1.679	1.646	1.665	1.474	1.565	1.571	1.615	1.522	1.580	1.505	1.571
22	1.621	1.609	1.700	1.691	1.657	1.681	1.481	1.576	1.586	1.634	1.535	1.593	1.524	1.598
23	1.629	1.615	1.709	1.700	1.666	1.694	1.487	1.586	1.599	1.651	1.545	1.604	1.541	1.622
24	1.636	1.620	1.716	1.708	1.674	1.706	1.492	1.594	1.610	1.665	1.554	1.613	1.556	1.644
25	1.642	1.624	1.722	1.714	1.680	1.715	1.496	1.600	1.619	1.677	1.561	1.620	1.568	1.663
	Females													
1	0.030	0.108	0.057	0.023	0.168	0.150	0.012	0.041	0.118	0.050	0.155	0.034	0.130	0.104
2	0.110	0.224	0.154	0.103	0.276	0.261	0.081	0.123	0.217	0.132	0.255	0.108	0.225	0.189
3	0.236	0.370	0.292	0.236	0.403	0.394	0.211	0.246	0.339	0.250	0.372	0.220	0.337	0.294
4	0.396	0.535	0.458	0.406	0.544	0.540	0.383	0.398	0.476	0.391	0.500	0.361	0.461	0.414
5	0.574	0.707	0.639	0.596	0.693	0.695	0.575	0.567	0.622	0.547	0.634	0.520	0.591	0.542
6	0.757	0.878	0.826	0.791	0.846	0.852	0.768	0.742	0.772	0.708	0.770	0.685	0.723	0.675
7	0.938	1.044	1.009	0.980	0.999	1.007	0.953	0.915	0.921	0.868	0.905	0.851	0.854	0.809
8	1.109	1.200	1.184	1.157	1.149	1.156	1.121	1.082	1.066	1.022	1.037	1.011	0.980	0.941
9	1.267	1.344	1.347	1.318	1.293	1.299	1.270	1.238	1.204	1.166	1.162	1.162	1.100	1.069
10	1.411	1.475	1.496	1.461	1.431	1.432	1.400	1.381	1.334	1.299	1.281	1.301	1.212	1.190
11	1.538	1.593	1.631	1.587	1.561	1.557	1.511	1.510	1.455	1.420	1.391	1.428	1.317	1.305
12	1.651	1.697	1.752	1.695	1.682	1.671	1.604	1.626	1.566	1.529	1.494	1.542	1.413	1.411
13	1.749	1.789	1.858	1.789	1.795	1.775	1.683	1.729	1.668	1.626	1.589	1.643	1.500	1.510
14	1.835	1.870	1.952	1.869	1.898	1.870	1.748	1.819	1.761	1.712	1.675	1.733	1.580	1.602
15	1.908	1.940	2.034	1.936	1.994	1.955	1.801	1.898	1.844	1.788	1.754	1.811	1.652	1.685
16	1.971	2.002	2.105	1.993	2.081	2.032	1.845	1.966	1.919	1.854	1.825	1.880	1.717	1.761
17	2.025	2.055	2.166	2.041	2.160	2.101	1.881	2.026	1.987	1.912	1.890	1.940	1.775	1.829
18	2.070	2.100	2.219	2.081	2.232	2.162	1.911	2.077	2.047	1.962	1.948	1.991	1.827	1.892
19	2.109	2.140	2.265	2.114	2.298	2.217	1.935	2.121	2.100	2.005	2.000	2.036	1.873	1.948
20	2.142	2.173	2.304	2.142	2.356	2.266	1.954	2.159	2.148	2.043	2.046	2.075	1.914	1.998
21	2.169	2.202	2.338	2.165	2.409	2.309	1.970	2.191	2.190	2.075	2.088	2.108	1.950	2.043
22	2.193	2.227	2.367	2.185	2.457	2.347	1.983	2.219	2.227	2.103	2.125	2.136	1.982	2.083
23	2.212	2.248	2.391	2.201	2.500	2.380	1.994	2.243	2.260	2.127	2.158	2.161	2.011	2.119
24	2.229	2.266	2.412	2.214	2.538	2.410	2.002	2.263	2.289	2.147	2.188	2.181	2.036	2.152
25	2.243	2.282	2.430	2.225	2.572	2.436	2.009	2.280	2.315	2.165	2.214	2.199	2.058	2.180

Table 8. (Continued)

Eureka/S.Columbia														
	Males													
Year	Pre 1987	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.095	0.188	0.082	0.496	0.114	0.010	0.237	0.167	0.157	0.093	0.168	0.026	0.186	0.111
2	0.204	0.319	0.204	0.584	0.227	0.076	0.345	0.271	0.253	0.199	0.261	0.105	0.275	0.208
3	0.336	0.459	0.356	0.670	0.360	0.199	0.458	0.388	0.360	0.328	0.362	0.228	0.370	0.321
4	0.478	0.598	0.517	0.753	0.499	0.355	0.573	0.508	0.472	0.465	0.466	0.373	0.469	0.440
5	0.619	0.728	0.672	0.832	0.635	0.520	0.684	0.627	0.583	0.600	0.569	0.523	0.566	0.558
6	0.751	0.845	0.813	0.907	0.763	0.680	0.789	0.741	0.691	0.728	0.668	0.666	0.659	0.669
7	0.872	0.947	0.935	0.977	0.879	0.824	0.886	0.847	0.792	0.844	0.761	0.796	0.747	0.771
8	0.980	1.036	1.040	1.042	0.981	0.949	0.975	0.943	0.885	0.946	0.847	0.909	0.829	0.863
9	1.073	1.111	1.127	1.102	1.069	1.054	1.056	1.030	0.971	1.035	0.924	1.006	0.903	0.944
10	1.154	1.174	1.198	1.157	1.145	1.142	1.128	1.108	1.047	1.111	0.994	1.087	0.971	1.014
11	1.222	1.226	1.256	1.208	1.209	1.214	1.191	1.176	1.116	1.175	1.057	1.155	1.032	1.075
12	1.279	1.269	1.303	1.254	1.263	1.271	1.247	1.236	1.176	1.229	1.112	1.210	1.087	1.126
13	1.327	1.305	1.340	1.296	1.308	1.318	1.297	1.287	1.229	1.274	1.160	1.254	1.135	1.170
14	1.368	1.334	1.370	1.334	1.346	1.354	1.340	1.332	1.276	1.312	1.203	1.290	1.178	1.207
15	1.401	1.358	1.394	1.368	1.377	1.384	1.377	1.371	1.317	1.342	1.240	1.319	1.215	1.239
16	1.428	1.377	1.413	1.399	1.402	1.407	1.409	1.404	1.352	1.368	1.272	1.342	1.249	1.265
17	1.451	1.393	1.427	1.426	1.423	1.425	1.437	1.433	1.382	1.389	1.299	1.361	1.277	1.287
18	1.469	1.406	1.439	1.451	1.441	1.439	1.462	1.457	1.409	1.406	1.323	1.376	1.303	1.305
19	1.484	1.416	1.448	1.474	1.455	1.450	1.482	1.478	1.431	1.420	1.344	1.387	1.325	1.320
20	1.497	1.424	1.456	1.494	1.467	1.459	1.500	1.495	1.451	1.431	1.362	1.397	1.344	1.333
21	1.507	1.431	1.461	1.512	1.476	1.466	1.516	1.510	1.468	1.440	1.377	1.404	1.360	1.343
22	1.515	1.436	1.466	1.528	1.484	1.471	1.529	1.523	1.482	1.448	1.391	1.410	1.375	1.352
23	1.522	1.441	1.469	1.542	1.490	1.475	1.540	1.534	1.495	1.454	1.402	1.415	1.387	1.359
24	1.527	1.444	1.472	1.555	1.495	1.478	1.550	1.543	1.505	1.459	1.412	1.418	1.398	1.365
25	1.532	1.447	1.474	1.567	1.499	1.481	1.558	1.551	1.514	1.463	1.420	1.421	1.407	1.370
	Females													
1	0.052	0.087	0.011	0.111	0.032	0.218	0.030	0.247	0.189	0.091	0.061	0.058	0.102	0.054
2	0.145	0.206	0.085	0.245	0.121	0.326	0.110	0.349	0.288	0.190	0.145	0.150	0.188	0.135
3	0.277	0.360	0.228	0.410	0.261	0.448	0.234	0.461	0.400	0.315	0.258	0.276	0.294	0.248
4	0.437	0.532	0.419	0.589	0.432	0.579	0.390	0.580	0.519	0.457	0.391	0.424	0.414	0.380
5	0.610	0.710	0.629	0.767	0.618	0.715	0.564	0.703	0.643	0.606	0.533	0.582	0.540	0.522
6	0.788	0.883	0.841	0.936	0.806	0.852	0.742	0.826	0.767	0.755	0.678	0.742	0.669	0.667
7	0.961	1.045	1.040	1.091	0.986	0.987	0.916	0.949	0.890	0.900	0.820	0.896	0.797	0.809
8	1.126	1.193	1.220	1.229	1.152	1.119	1.080	1.068	1.009	1.037	0.955	1.041	0.921	0.943
9	1.278	1.325	1.378	1.349	1.301	1.245	1.231	1.184	1.122	1.164	1.081	1.174	1.038	1.067
10	1.416	1.440	1.513	1.452	1.433	1.365	1.367	1.294	1.230	1.279	1.196	1.293	1.147	1.180
11	1.540	1.541	1.627	1.540	1.547	1.478	1.488	1.399	1.330	1.383	1.300	1.400	1.249	1.282
12	1.650	1.627	1.723	1.615	1.646	1.584	1.594	1.497	1.424	1.476	1.392	1.493	1.342	1.372
13	1.747	1.700	1.802	1.677	1.730	1.682	1.686	1.589	1.510	1.559	1.475	1.575	1.426	1.452
14	1.831	1.762	1.867	1.729	1.801	1.772	1.766	1.675	1.589	1.631	1.547	1.645	1.503	1.522
15	1.904	1.815	1.920	1.772	1.861	1.856	1.834	1.755	1.661	1.695	1.610	1.706	1.571	1.583
16	1.967	1.859	1.963	1.807	1.911	1.932	1.892	1.828	1.727	1.750	1.665	1.759	1.633	1.635
17	2.021	1.896	1.998	1.837	1.953	2.001	1.942	1.896	1.787	1.798	1.713	1.803	1.687	1.681
18	2.068	1.927	2.026	1.861	1.988	2.064	1.984	1.958	1.841	1.839	1.755	1.842	1.736	1.720
19	2.107	1.953	2.049	1.880	2.017	2.121	2.020	2.016	1.890	1.875	1.790	1.874	1.779	1.753
20	2.141	1.974	2.067	1.897	2.041	2.173	2.049	2.068	1.934	1.906	1.821	1.901	1.817	1.782
21	2.170	1.992	2.082	1.910	2.061	2.220	2.075	2.115	1.973	1.932	1.847	1.925	1.851	1.806
22	2.194	2.006	2.094	1.921	2.078	2.262	2.096	2.158	2.009	1.955	1.870	1.944	1.880	1.827
23	2.215	2.019	2.103	1.930	2.091	2.300	2.114	2.198	2.040	1.975	1.889	1.961	1.906	1.845
24	2.233	2.029	2.111	1.937	2.102	2.334	2.129	2.233	2.069	1.992	1.906	1.975	1.929	1.860
25	2.248	2.037	2.117	1.943	2.112	2.365	2.141	2.266	2.094	2.006	1.920	1.987	1.949	1.873

Table 8. (Continued)

Coast-wide														
	Males													
Age	Pre 1987	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.113	0.126	0.072	0.262	0.103	0.077	0.215	0.097	0.134	0.105	0.086	0.048	0.130	0.220
2	0.222	0.244	0.180	0.375	0.214	0.181	0.323	0.194	0.234	0.204	0.186	0.133	0.221	0.311
3	0.352	0.382	0.319	0.494	0.349	0.314	0.438	0.312	0.350	0.322	0.308	0.251	0.326	0.408
4	0.492	0.528	0.474	0.614	0.493	0.460	0.556	0.442	0.472	0.451	0.441	0.387	0.437	0.507
5	0.632	0.672	0.630	0.730	0.636	0.608	0.672	0.574	0.594	0.582	0.575	0.529	0.550	0.606
6	0.766	0.808	0.779	0.841	0.772	0.750	0.782	0.702	0.712	0.710	0.704	0.669	0.659	0.702
7	0.891	0.932	0.915	0.944	0.897	0.880	0.885	0.824	0.823	0.830	0.822	0.800	0.763	0.794
8	1.004	1.043	1.037	1.038	1.008	0.998	0.979	0.936	0.925	0.940	0.929	0.919	0.860	0.880
9	1.105	1.140	1.142	1.124	1.105	1.101	1.065	1.037	1.017	1.039	1.023	1.025	0.949	0.960
10	1.193	1.225	1.233	1.201	1.189	1.190	1.142	1.127	1.099	1.128	1.105	1.118	1.029	1.034
11	1.270	1.297	1.310	1.270	1.261	1.266	1.211	1.206	1.171	1.206	1.175	1.198	1.100	1.101
12	1.335	1.359	1.374	1.330	1.322	1.331	1.271	1.275	1.235	1.274	1.235	1.266	1.164	1.162
13	1.392	1.411	1.428	1.384	1.374	1.385	1.325	1.335	1.290	1.332	1.286	1.324	1.220	1.217
14	1.440	1.454	1.472	1.431	1.416	1.431	1.371	1.386	1.338	1.383	1.328	1.373	1.269	1.266
15	1.480	1.491	1.509	1.472	1.452	1.469	1.412	1.430	1.379	1.427	1.364	1.414	1.311	1.310
16	1.514	1.521	1.539	1.507	1.482	1.500	1.447	1.468	1.414	1.464	1.394	1.448	1.349	1.350
17	1.543	1.547	1.564	1.538	1.507	1.526	1.477	1.500	1.444	1.495	1.419	1.477	1.381	1.385
18	1.567	1.568	1.584	1.565	1.527	1.547	1.504	1.528	1.470	1.522	1.439	1.500	1.409	1.416
19	1.587	1.585	1.601	1.589	1.544	1.565	1.526	1.551	1.492	1.545	1.456	1.520	1.433	1.443
20	1.604	1.599	1.615	1.609	1.557	1.580	1.546	1.570	1.511	1.564	1.471	1.536	1.453	1.467
21	1.618	1.611	1.626	1.626	1.569	1.592	1.563	1.587	1.527	1.580	1.482	1.549	1.471	1.489
22	1.630	1.621	1.635	1.641	1.578	1.601	1.577	1.601	1.541	1.594	1.492	1.560	1.486	1.508
23	1.639	1.629	1.642	1.654	1.586	1.609	1.590	1.612	1.552	1.606	1.500	1.569	1.500	1.524
24	1.647	1.636	1.648	1.665	1.592	1.616	1.600	1.622	1.562	1.615	1.506	1.577	1.511	1.539
25	1.654	1.642	1.652	1.674	1.597	1.621	1.609	1.630	1.570	1.623	1.512	1.583	1.520	1.552
	Females													
1	0.045	0.099	0.058	0.090	0.136	0.186	0.022	0.072	0.063	0.052	0.111	0.057	0.087	0.074
2	0.132	0.211	0.154	0.206	0.244	0.295	0.095	0.162	0.148	0.135	0.207	0.143	0.173	0.155
3	0.262	0.354	0.290	0.356	0.375	0.420	0.217	0.282	0.265	0.252	0.324	0.262	0.283	0.260
4	0.419	0.516	0.454	0.525	0.521	0.557	0.375	0.423	0.403	0.393	0.455	0.406	0.409	0.384
5	0.592	0.686	0.632	0.700	0.675	0.700	0.552	0.576	0.553	0.548	0.595	0.562	0.544	0.519
6	0.770	0.857	0.815	0.872	0.831	0.845	0.735	0.733	0.708	0.709	0.737	0.723	0.683	0.658
7	0.945	1.022	0.995	1.035	0.985	0.988	0.914	0.889	0.862	0.869	0.877	0.883	0.820	0.799
8	1.112	1.177	1.166	1.186	1.133	1.128	1.082	1.039	1.010	1.023	1.012	1.036	0.954	0.936
9	1.266	1.320	1.326	1.321	1.274	1.262	1.235	1.182	1.149	1.168	1.141	1.180	1.081	1.067
10	1.406	1.451	1.473	1.442	1.405	1.390	1.373	1.314	1.278	1.302	1.260	1.312	1.199	1.191
11	1.533	1.568	1.605	1.547	1.527	1.509	1.495	1.435	1.396	1.424	1.371	1.433	1.309	1.306
12	1.645	1.672	1.723	1.639	1.638	1.620	1.601	1.545	1.503	1.535	1.472	1.542	1.410	1.413
13	1.743	1.764	1.827	1.718	1.739	1.723	1.693	1.644	1.598	1.633	1.564	1.638	1.501	1.509
14	1.829	1.845	1.919	1.786	1.831	1.818	1.772	1.732	1.683	1.721	1.646	1.724	1.584	1.597
15	1.904	1.915	1.999	1.844	1.913	1.904	1.839	1.811	1.759	1.798	1.721	1.800	1.657	1.677
16	1.969	1.976	2.069	1.893	1.987	1.983	1.896	1.880	1.825	1.866	1.787	1.866	1.723	1.748
17	2.024	2.029	2.130	1.935	2.052	2.055	1.944	1.941	1.883	1.925	1.846	1.924	1.782	1.811
18	2.072	2.075	2.182	1.970	2.111	2.120	1.985	1.995	1.934	1.976	1.898	1.974	1.834	1.868
19	2.112	2.114	2.227	2.000	2.163	2.178	2.019	2.042	1.978	2.021	1.945	2.018	1.880	1.918
20	2.147	2.147	2.265	2.025	2.208	2.231	2.047	2.083	2.017	2.060	1.985	2.055	1.921	1.962
21	2.177	2.176	2.298	2.045	2.249	2.278	2.071	2.119	2.050	2.094	2.021	2.088	1.956	2.002
22	2.202	2.201	2.326	2.063	2.284	2.320	2.091	2.150	2.079	2.122	2.053	2.116	1.988	2.036
23	2.223	2.222	2.351	2.078	2.315	2.358	2.107	2.177	2.104	2.147	2.081	2.140	2.015	2.067
24	2.241	2.240	2.371	2.090	2.343	2.392	2.121	2.200	2.125	2.169	2.105	2.161	2.039	2.093
25	2.257	2.255	2.389	2.100	2.367	2.423	2.133	2.220	2.144	2.187	2.126	2.179	2.060	2.117

Table 9. Female yellowtail rockfish proportion mature-at-age.

Age	S. Vancouver	N. Columbia	Eureka/S.Columbia	Coast-wide
1	0.000	0.000	0.000	0.000
2	0.000	0.001	0.001	0.001
3	0.000	0.002	0.002	0.002
4	0.001	0.004	0.004	0.004
5	0.003	0.011	0.011	0.011
6	0.007	0.029	0.029	0.029
7	0.019	0.072	0.072	0.072
8	0.050	0.169	0.169	0.169
9	0.126	0.347	0.347	0.347
10	0.283	0.581	0.581	0.581
11	0.519	0.784	0.784	0.784
12	0.746	0.904	0.904	0.904
13	0.890	0.961	0.961	0.961
14	0.957	0.985	0.985	0.985
15	0.984	0.994	0.994	0.994
16	0.994	0.998	0.998	0.998
17	0.998	0.999	0.999	0.999
18	0.999	1.000	1.000	1.000
19	1.000	1.000	1.000	1.000
20	1.000	1.000	1.000	1.000
21	1.000	1.000	1.000	1.000
22	1.000	1.000	1.000	1.000
23	1.000	1.000	1.000	1.000
24	1.000	1.000	1.000	1.000
25	1.000	1.000	1.000	1.000
Parameters				
a	-1.0058	-0.96	-0.96	-0.96
b	10.9896	9.273	9.273	9.273

Table 10. Number of aged yellowtail rockfish biological samples taken from the S. Vancouver area commercial trawl fisheries, 1974 to 1999.

	Domestic Trawl		Shrimp		Hake		Total	
Year	Samples	Fish	Samples	Fish	Samples	Fish	Samples	Fish
1974	1	122	0	0	0	0	1	122
1975	2	205	0	0	0	0	2	205
1976	5	497	0	0	0	0	5	497
1977	1	97	0	0	0	0	1	97
1978	2	200	0	0	0	0	2	200
1979	6	582	0	0	1	98	7	680
1980	6	584	0	0	8	866	14	1450
1981	3	298	0	0	0	0	3	298
1982	17	1641	0	0	1	196	18	1837
1983	14	1290	0	0	0	0	14	1290
1984	18	1694	0	0	0	0	18	1694
1985	16	1598	0	0	0	0	16	1598
1986	16	1597	0	0	1	298	17	1895
1987	23	1199	0	0	0	0	23	1199
1988	21	1050	0	0	0	0	21	1050
1989	18	897	0	0	11	58	29	955
1990	24	1194	0	0	0	0	24	1194
1991	20	961	0	0	4	168	24	1129
1992	24	1135	0	0	12	568	36	1703
1993	22	1097	0	0	4	204	26	1301
1994	20	1032	0	0	16	738	36	1770
1995	27	1304	0	0	7	372	34	1676
1996	17	849	0	0	13	714	30	1563
1997	25	1119	2	70	5	243	32	1432
1998	23	1150	0	0	8	400	31	1550
1999	23	1096	0	0	9	349	32	1445

Table 11. Number of aged yellowtail rockfish biological samples taken from the N. Columbia area commercial trawl fisheries, 1974 to 1999.

	Domestic Trawl		Shrimp		Hake		Total	
Year	Samples	Fish	Samples	Fish	Samples	Fish	Samples	Fish
1974	0	0	0	0	0	0	0	0
1975	1	100	0	0	0	0	1	100
1976	8	755	0	0	0	0	8	755
1977	5	486	0	0	0	0	5	486
1978	3	297	0	0	0	0	3	297
1979	8	783	0	0	0	0	8	783
1980	10	966	0	0	0	0	10	966
1981	7	686	0	0	0	0	7	686
1982	19	1880	0	0	0	0	19	1880
1983	14	1354	0	0	0	0	14	1354
1984	22	2195	0	0	0	0	22	2195
1985	30	2992	0	0	0	0	30	2992
1986	22	2184	0	0	0	0	22	2184
1987	40	2084	0	0	0	0	40	2084
1988	33	1634	0	0	0	0	33	1634
1989	36	1752	0	0	24	156	60	1908
1990	34	1701	0	0	0	0	34	1701
1991	31	1355	0	0	0	0	31	1355
1992	35	1469	0	0	0	0	35	1469
1993	36	1585	0	0	2	62	38	1647
1994	50	2085	0	0	2	57	52	2142
1995	44	1947	0	0	12	349	56	2296
1996	39	1750	0	0	13	387	52	2137
1997	25	999	16	518	21	594	62	2111
1998	27	1191	15	607	15	492	57	2290
1999	27	1217	15	690	28	939	70	2846

Table 12. Number of aged yellowtail rockfish biological samples taken from the Eureka/S. Columbia area commercial trawl fisheries, 1974 to 1999.

	Domestic Trawl		Shrimp		Hake		Total	
Year	Samples	Fish	Samples	Fish	Samples	Fish	Samples	Fish
1974	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0
1977	2	170	0	0	0	0	2	170
1978	0	0	0	0	0	0	0	0
1979	1	99	0	0	0	0	1	99
1980	44	232	0	0	0	0	44	232
1981	30	317	0	0	0	0	30	317
1982	88	499	0	0	0	0	88	499
1983	94	463	0	0	0	0	94	463
1984	96	1834	0	0	0	0	96	1834
1985	54	1715	0	0	0	0	54	1715
1986	42	673	0	0	0	0	42	673
1987	45	843	0	0	0	0	45	843
1988	25	704	0	0	0	0	25	704
1989	55	1505	0	0	37	259	92	1764
1990	46	1067	0	0	0	0	46	1067
1991	45	1185	0	0	0	0	45	1185
1992	64	1865	0	0	0	0	64	1865
1993	30	1102	0	0	0	0	30	1102
1994	42	1488	0	0	0	0	42	1488
1995	16	546	0	0	7	207	23	753
1996	25	1004	0	0	4	120	29	1124
1997	29	1117	7	272	12	353	48	1742
1998	20	756	5	187	10	296	35	1239
1999	19	844	4	132	21	625	44	1601

Table 13. Number of aged yellowtail rockfish biological samples taken from the Coast-wide (Eureka to Vancouver) commercial trawl fisheries, 1974 to 1999.

	Domestic Trawl		Shrimp		Hake		Total	
Year	Samples	Fish	Samples	Fish	Samples	Fish	Samples	Fish
1974	1	122	0	0	0	0	1	122
1975	3	305	0	0	0	0	3	305
1976	13	1252	0	0	0	0	13	1252
1977	8	753	0	0	0	0	8	753
1978	5	497	0	0	0	0	5	497
1979	15	1464	0	0	1	98	16	1562
1980	60	1782	0	0	8	866	68	2648
1981	40	1301	0	0	0	0	40	1301
1982	124	4020	0	0	1	196	125	4216
1983	122	3107	0	0	0	0	122	3107
1984	136	5723	0	0	0	0	136	5723
1985	100	6305	0	0	0	0	100	6305
1986	80	4454	0	0	1	298	81	4752
1987	108	4126	0	0	0	0	108	4126
1988	79	3388	0	0	0	0	79	3388
1989	109	4154	0	0	72	473	181	4627
1990	104	3962	0	0	0	0	104	3962
1991	96	3501	0	0	4	168	100	3669
1992	123	4469	0	0	12	568	135	5037
1993	88	3784	0	0	6	266	94	4050
1994	112	4605	0	0	18	795	130	5400
1995	87	3797	0	0	26	928	113	4725
1996	81	3603	0	0	30	1221	111	4824
1997	79	3235	25	860	38	1190	142	5285
1998	70	3097	20	794	33	1188	123	5079
1999	69	3157	19	822	58	1913	146	5892

Table 14. Summary data regarding sample size in the NMFS triennial trawl survey, 1977-1998.

	ALL TOWS		TOWS WITH AGED FISH	
YEAR	TOTAL	CATCH>0	TOTAL	FISH
S. VANCOUVER				
1977	81	31	6	437
1980	97	37	6	315
1983	137	33	6	460
1986	248	54	9	135
1989	131	35	5	123
1992	130	45	7	334
1995	121	29	25	184
1998	88	61	30	600
N. COLUMBIA				
1977	84	39	10	626
1980	180	56	4	295
1983	127	65	7	639
1986	105	57	10	23
1989	81	16	4	121
1992	80	29	7	159
1995	57	19	15	88
1998	56	30	25	469
EUREKA/S. COLUMBIA				
1977	200	27	3	257
1980	229	61	9	529
1983	254	87	9	652
1986	143	37	9	174
1989	177	19	2	110
1992	181	16	1	17
1995	198	15	7	23
1998	196	34	34	351
COAST-WIDE				
1977	365	97	19	1320
1980	506	154	19	1139
1983	518	185	22	1751
1986	496	148	28	332
1989	389	70	11	354
1992	391	90	15	510
1995	376	63	47	295
1998	340	125	89	1420

Table 15. S. Vancouver area yellowtail rockfish estimated catch-at-age (numbers).

YEAR	4	5	6	7	8	9	10	11	12	13	14	15
						MALES						
1974	0	9798	14687	19639	58821	39229	9790	24555	39248	9832	4885	0
1975	1603	13779	23929	32699	11003	7001	1606	2590	3447	2594	8645	2588
1976	0	0	1437	11600	21547	20423	21445	15844	20278	30224	40942	39101
1977	0	0	0	32393	32428	86292	21555	32413	32309	32369	75547	64725
1978	0	13460	33835	27085	40528	33789	48162	6712	44698	25480	10232	31994
1979	0	15453	11518	80701	56296	131435	116805	100060	77295	43237	40938	21144
1980	0	223	3523	35523	45888	52554	130437	129619	86243	78121	42106	68282
1981	0	0	91241	132717	130111	66325	60141	32844	47472	99380	74933	47193
1982	0	13588	25064	151448	260824	207531	140396	103691	180313	153413	93182	69041
1983	0	14443	122757	163951	285035	285978	173756	59173	47020	57298	75092	45107
1984	0	2514	15896	36352	50605	75350	87250	38661	21938	23808	19472	17695
1985	0	2642	22507	71254	152618	110171	105845	94949	55414	20805	8361	9491
1986	0	5591	29727	49650	80193	107563	135728	92631	151978	93055	34449	37147
1987	9285	10855	24798	16793	45075	94866	109956	64072	108476	89436	54542	28655
1988	0	8466	17760	73796	60958	88632	155140	137985	113661	115735	78445	59069
1989	0	1950	41518	64134	104920	166339	92241	186290	160260	149407	114974	80944
1990	0	0	15048	39868	57193	125556	90454	101645	102157	113780	98303	59751
1991	0	0	13822	46020	64741	56072	119400	93809	67140	76351	49468	31834
1992	0	2645	15202	57315	98730	102727	100597	109045	85865	39847	52721	51563
1993	0	2405	34197	57126	181399	160042	177107	169410	182074	126211	59728	65476
1994	0	5229	22482	101949	134244	173797	200781	137967	129623	88883	58562	45520
1995	0	4000	16553	30614	127198	127876	170285	129172	100310	58420	56389	48287
1996	0	6316	23975	66019	109475	305524	235482	257966	183646	111028	77390	36008
1997	0	638	4244	21024	39001	35675	78680	71659	60690	45608	27485	15080
1998	0	1137	5620	19360	60811	94503	70303	99621	93814	69282	62261	39559
1999	0	0	0	32453	75397	219042	206235	127510	122746	91041	83401	48936
						FEMALES						
1974	0	9862	14687	44149	39229	14736	9805	24513	19619	9811	4895	0
1975	0	20746	24161	27132	4781	3811	866	1734	1726	2369	3321	3461
1976	0	0	1292	7335	16200	14819	14062	2870	17072	22572	37135	20907
1977	0	0	0	0	21533	53974	10762	10838	10759	21582	21589	53973
1978	0	13557	40658	6688	106270	52005	69251	6824	21997	20338	17017	22089
1979	0	3121	31445	31860	43151	75553	76976	83455	44257	18737	22923	21947
1980	0	235	1007	23958	51567	42355	76104	160298	90279	43540	41121	23739
1981	0	16574	50047	81022	155845	74621	33035	32995	54199	86903	58103	28139
1982	0	4344	15292	91964	200778	132915	113605	86120	131327	89325	78916	33741
1983	0	2979	87185	133316	239949	284842	156264	62119	27266	85289	63403	35709
1984	468	2018	11815	36643	55107	75463	92741	37375	25806	16148	18759	17117
1985	0	3504	15632	52460	103070	79518	88183	86542	46397	13054	10166	8273
1986	0	7253	26782	57951	55818	109152	110390	130169	186291	94308	33422	23166
1987	4036	23916	25509	41015	35280	73919	122453	65150	94395	73381	43250	18723
1988	0	9866	12396	51331	63183	69447	129154	134452	99012	93646	63252	40581
1989	0	1782	27187	48143	119916	61527	52449	57041	139155	106917	43489	58325
1990	0	0	7197	28727	39861	71583	74714	74013	127885	98756	75200	54329
1991	0	0	10626	48591	78281	53496	143108	90812	53115	65409	39128	27488
1992	0	3711	18254	79695	122235	100294	103392	140352	88166	66461	68061	58017
1993	0	0	36372	44862	126059	174211	131959	176286	185459	121807	45504	39984
1994	1509	5212	32014	107437	142608	199525	148194	118197	122031	123620	59869	46089
1995	0	2523	27655	50470	108982	147700	139351	119695	68989	57609	51481	26767
1996	0	3654	7999	55861	108252	282637	255334	219537	183568	69774	91223	70794
1997	0	0	3583	15750	32951	32702	68864	63873	68563	53751	37071	26492
1998	0	0	4332	18333	66321	95196	83519	114482	102595	70480	64975	56843
1999	0	8156	14953	35794	68902	160237	176480	115490	123230	86728	58817	61248

Table 15. (Continued) S. Vancouver area catch-at-age

YEAR	16	17	18	19	20	21	22	23	24	25	Total
						MALES					
1974	0	0	14725	0	4896	4902	9822	9825	0	107975	382629
1975	5180	1735	1728	863	3451	1724	0	1736	3455	25759	157115
1976	21276	14450	12659	18586	11390	9907	15865	10126	10035	171783	518918
1977	75547	21583	32342	21602	0	10767	0	10768	21612	172712	776964
1978	62583	47563	32212	27135	10245	32221	11907	17149	20422	147952	725364
1979	43703	28555	58245	15439	20604	2218	9286	12485	7674	65304	958395
1980	29687	39931	47799	39073	17177	24925	13401	19497	14238	103703	1021950
1981	33110	39054	32411	26532	43069	75987	20084	6162	12326	465821	1536913
1982	40515	31733	31708	37648	55098	67590	38636	36707	26184	211444	1975754
1983	29673	20142	20951	16382	41091	22940	37612	30073	32744	156811	1738029
1984	22539	13227	9324	7297	10915	7009	12983	12291	6046	148062	639234
1985	12578	11905	6799	7920	3572	6964	4496	4982	10375	27108	750756
1986	34245	24274	22111	11117	9052	8148	7117	12138	10085	47574	1003573
1987	22491	26441	27814	19249	19797	3967	12966	3631	9267	104951	907383
1988	30140	12410	6025	23933	15284	10505	3413	4941	4953	37541	1058792
1989	64550	16419	3392	13281	28624	23015	27094	1482	13020	38100	1391954
1990	54515	26772	13441	8369	11654	11274	12275	2749	4184	39204	988192
1991	36360	30268	7909	11815	8240	3695	3036	1885	0	33894	755759
1992	44403	24206	27266	17563	5646	5967	3582	3873	5831	51017	905611
1993	63843	33207	21469	39177	29558	18979	3388	11560	10985	69755	1517096
1994	34767	35049	31729	18958	15480	11739	3446	4465	1774	28492	1284936
1995	27841	24640	26746	18542	12651	8734	6543	3451	2062	14964	1015278
1996	43591	32361	27596	22885	14511	11657	11281	2948	6802	26589	1613050
1997	16790	4916	7945	3834	7250	3946	1560	4317	2245	10146	462733
1998	28303	19081	8921	5821	3100	4600	2413	5644	2493	10542	707189
1999	48402	17436	14131	13021	4489	4749	9313	8893	6093	24987	1158275
						FEMALES					
1974	0	0	4897	4897	0	0	0	0	0	14691	215791
1975	866	860	0	0	0	0	870	0	0	0	96704
1976	15575	5650	0	4224	4146	1360	0	1368	1396	4154	192137
1977	21553	10759	0	10803	10802	0	0	0	0	10816	269743
1978	10199	17049	13553	6753	0	20299	0	0	0	13518	458065
1979	16526	15930	7369	5092	0	0	0	5624	0	9695	513661
1980	22423	21272	26808	3640	10843	5147	2390	141	0	8191	655058
1981	6153	6164	0	0	6143	0	0	0	6143	18296	714382
1982	37217	11200	15026	10458	8195	10650	1466	1613	3203	9443	1086798
1983	27185	10591	22563	3580	3683	9715	13110	5492	3881	5242	1283363
1984	13385	3177	2759	2491	1859	1531	2877	1142	0	4266	422947
1985	10978	8810	3847	2986	2193	722	0	0	1481	0	537816
1986	19390	15583	9013	7548	2061	1059	1187	0	1121	4493	896157
1987	19571	6407	11938	14714	7205	2426	2370	1106	1208	3467	691439
1988	9795	19390	7954	1562	3467	1432	3318	1763	2446	5893	823340
1989	10006	6185	5797	25756	9336	4502	0	0	0	4817	782330
1990	41682	13362	6323	3092	2437	1363	3964	0	0	1254	725742
1991	21965	12825	12561	2945	3900	0	3785	4976	0	1028	674039
1992	45366	16970	23391	10136	8427	3686	2669	6893	1940	11081	979197
1993	33315	21503	29554	18725	12066	6479	0	3166	3166	0	1210477
1994	31504	20861	10189	13278	3448	5400	3341	3107	1720	1625	1200778
1995	18134	24292	10254	13203	8305	2253	0	2932	1136	3060	884791
1996	50218	22133	10002	8634	7018	1296	7017	1341	0	0	1456292
1997	19442	11500	7486	6268	2893	3926	4797	1986	2215	2266	466379
1998	16584	19570	15530	6926	4959	2463	1192	3051	658	4814	752823
1999	37540	25526	16016	5790	8068	6115	5376	889	1894	3104	1020353

Table 16. N. Columbia area yellowtail rockfish estimated catch-at-age (numbers).

YEAR	4	5	6	7	8	9	10	11	12	13	14	15
						MALES						
1975	0	7435	45074	67691	60184	22589	0	15066	15051	0	15079	37585
1976	7133	8732	28919	88559	199062	74164	40389	42690	49207	30363	60613	63088
1977	0	0	0	45471	93129	96282	73993	51710	59435	45073	92015	128301
1978	0	17356	118462	147944	155628	209898	212859	152825	89651	91186	91402	122177
1979	0	5971	40754	121366	183182	164746	282809	197216	201690	93811	128203	123923
1980	0	21494	34613	190869	187687	134234	175409	228815	190603	145412	103252	93641
1981	0	7214	89160	124813	266249	207986	94016	79257	96489	151670	93165	53973
1982	11184	22184	101386	194853	346713	251668	111962	50759	56306	82410	86091	70370
1983	0	3700	107083	269221	468271	445280	245171	86344	58735	40280	64193	64758
1984	0	17636	52385	166476	161382	230569	239023	122350	76571	39227	23735	33065
1985	1265	10341	36002	105964	120711	118890	115701	80899	52327	19654	12332	12386
1986	0	6102	27627	67065	139931	164421	143539	113680	117814	77787	48021	18348
1987	1476	16109	89423	99700	105958	166912	221010	130687	129928	93129	58503	28103
1988	5268	45973	52306	120771	132350	131868	188424	221363	136535	79587	73175	37455
1989	0	13860	62045	38049	100438	77776	66063	118085	111105	65537	59667	50299
1990	0	13884	65655	80369	75188	80699	67085	54880	77259	63871	39156	35893
1991	0	1598	6710	75611	89347	62511	89205	56732	47938	76608	53424	31459
1992	3069	5385	29511	102635	169995	172430	94178	100856	90214	59653	52422	33811
1993	1288	8330	51159	102090	203889	190588	162429	96797	86766	56209	35219	22978
1994	0	3328	38800	105611	182692	202820	183575	122496	94464	60080	25000	24153
1995	0	8210	55287	132442	221618	221766	164166	131928	87619	59753	42926	23733
1996	0	15978	46645	86346	131691	184371	153770	129211	98006	48816	33245	29497
1997	0	2432	14974	44552	56065	51061	53893	58265	35892	36569	21983	11713
1998	0	0	8393	33507	72897	79535	53817	73116	47530	41536	27912	23372
1999	1142	3128	7690	28929	59952	97492	109031	52384	44878	37075	24172	19257
						FEMALES						
1975	7537	7456	30023	45103	75177	30059	7515	30088	15020	15020	30101	22555
1976	2448	14636	22495	54303	168606	110068	41873	37593	39134	36530	34033	29740
1977	0	0	12051	31316	64998	92403	92720	93790	31240	44339	65619	87115
1978	15094	50521	142759	81339	158138	249340	431728	148932	106928	71801	147930	140082
1979	0	17315	53475	52697	148502	270393	296014	237868	183085	129994	71958	72178
1980	0	0	83328	157453	190364	89036	176802	229079	195465	151258	71304	35224
1981	0	11722	45683	136861	280180	203692	91384	123931	146549	157596	151319	80456
1982	10976	10198	75577	125349	261428	172122	121187	69804	50791	84296	70529	26550
1983	0	13504	87786	259522	395488	487236	277989	117645	55735	28697	40245	36551
1984	2799	16515	73807	161390	128503	170158	203584	72889	68328	32540	22738	16461
1985	0	14670	41224	105275	130604	98149	101090	91138	45296	13301	10228	6986
1986	0	8171	13850	62510	109202	187863	119808	149257	162628	86975	36184	31122
1987	4148	11581	55047	73300	101057	169581	186267	145454	121926	91460	48722	23716
1988	18179	47809	31679	136991	156227	130352	210641	236151	194717	114437	63693	32902
1989	0	7298	32647	31093	74460	66797	44644	96641	121861	71656	57974	43715
1990	2286	8028	58167	93546	41639	82827	59474	43406	70021	64892	40224	30647
1991	0	3577	5069	45678	74557	86057	108250	73689	47821	48545	44661	27438
1992	0	6810	24831	80328	184049	157806	110850	85667	68306	42137	39172	38655
1993	0	7136	42650	77013	151188	211927	135798	88896	78454	50420	17814	24374
1994	1278	3353	27627	102588	152674	234565	207429	107501	93019	68525	48716	19361
1995	855	9894	70089	110989	214045	203297	171522	140584	107665	70212	59301	35490
1996	2048	17250	55717	98139	99627	179583	148057	138038	107563	62581	39983	36861
1997	461	3321	9087	39444	46383	41126	55948	43221	35255	38990	21189	11252
1998	0	678	3258	25219	71526	82578	52362	80383	69921	43480	39870	24958
1999	0	3081	3998	29366	44021	99887	88025	50559	56259	34469	24525	17709

Table 16. (Continued). N.Columbia area catch-at-age

YEAR	16	17	18	19	20	21	22	23	24	25	Total
						MALES					
1975	0	0	15052	0	0	7539	7539	0	0	15060	330944
1976	63435	20518	18463	10025	11468	23491	13555	19631	14889	143985	1032379
1977	105468	68724	30141	11083	28136	25144	19052	11825	31049	198562	1214593
1978	152492	198347	64816	31706	46062	89862	60720	14069	29849	306754	2404065
1979	120505	118596	141217	155647	32691	60982	33004	20806	21208	271734	2520061
1980	41925	50904	85904	82844	65042	36825	17011	25397	48737	227044	2187662
1981	47005	32325	61515	39442	66715	39295	22300	26384	29477	123164	1751614
1982	27951	31172	27478	33776	60288	67827	37343	29857	12476	117878	1831932
1983	45872	41160	10923	15647	21278	22773	17890	30660	6155	117170	2182564
1984	28955	18421	17051	18776	14102	9316	18553	17045	17513	44953	1367104
1985	13054	8706	13709	9342	5793	6368	6552	9972	9401	33564	802933
1986	20318	19070	16896	18782	5479	9057	4467	11345	10888	52815	1093452
1987	20994	13321	9961	20787	3152	3969	8118	2731	4234	53264	1281469
1988	18934	19934	14573	11897	4993	1558	8475	1512	1656	32341	1340948
1989	28463	15251	2241	4400	868	6673	4488	1587	1528	28674	857097
1990	29697	15565	5030	6901	3797	5550	5030	3814	3755	15745	748823
1991	17651	12061	8154	3087	3386	826	4515	2132	2216	13089	658260
1992	34957	21413	14509	9886	7346	3640	3030	8904	2504	20576	1040924
1993	36359	32089	22904	12381	2434	4390	1101	3462	3688	13482	1150032
1994	16369	23206	9593	11954	7757	6440	3443	2309	3035	9581	1136706
1995	17894	20489	20120	8243	8558	10535	4845	0	0	7111	1247243
1996	17076	14839	15563	8119	9008	6840	3662	3109	1642	10038	1047472
1997	6535	9029	5067	4784	5897	6093	3616	1868	2767	7993	441048
1998	10133	10341	5587	6288	1313	3935	1456	1463	2642	3625	508398
1999	9706	8331	7339	2095	5469	2665	3415	1886	1519	7950	535505
						FEMALES					
1975	15052	15064	15058	0	22568	0	15022	7534	0	15040	420992
1976	28875	19917	11133	17580	8263	16550	6593	1928	4658	57921	764877
1977	59585	19342	11166	15115	4093	3639	11636	3706	0	19715	763588
1978	151622	60123	91725	48021	44716	0	14744	0	0	0	2155543
1979	56841	64672	61781	27017	15275	15716	15525	0	4702	16056	1811064
1980	55808	20932	41784	16512	33590	10516	0	0	0	9657	1568112
1981	42434	34200	13851	17984	27391	21887	4801	0	9273	22946	1624140
1982	26566	20766	19268	14375	25821	19500	12205	10581	2839	18399	1249127
1983	29770	12337	15297	11112	5963	3209	19761	17881	6020	8210	1929958
1984	14628	7870	8000	3027	995	987	5075	3052	4061	7574	1024981
1985	7887	7113	4660	3372	1715	1936	1758	2487	2499	2282	693670
1986	15404	11931	13298	6364	4538	5415	2316	3460	3999	5290	1039585
1987	15979	11475	3965	8756	3876	888	2602	1767	1120	10394	1093081
1988	23553	9648	4735	4447	4340	2963	4488	3107	0	7647	1438706
1989	21119	9397	1475	2248	2023	4147	896	225	204	6221	696741
1990	15590	12760	4324	2849	1333	723	646	0	782	7813	641977
1991	32039	11978	12785	2841	2043	700	2810	0	0	739	631277
1992	32605	16235	8324	8039	3121	1293	0	0	0	4971	913199
1993	14881	12685	13240	2352	3859	1108	1036	0	1405	2444	938680
1994	25367	17413	11158	3330	4461	3584	1091	1213	0	2368	1136621
1995	14973	15247	30487	10768	6927	3624	8671	0	1405	4017	1290062
1996	16618	10395	11537	12807	6929	6447	4584	3439	2235	3011	1063449
1997	12045	8274	9852	5778	7731	4947	3721	2496	560	969	402050
1998	15003	5741	3914	1175	2130	2417	2929	579	194	1692	530007
1999	13281	5310	6183	3471	2924	1021	1571	2151	914	2013	490738

Table 17. Eureka/S. Columbia area yellowtail rockfish estimated catch-at-age (numbers).

YEAR	4	5	6	7	8	9	10	11	12	13	14	15
						MALES						
1977	0	0	0	0	0	3885	2588	6213	2584	2193	6061	4395
1979	0	0	0	0	0	12418	31114	6192	18661	6198	0	12471
1980	0	0	0	11532	10566	42412	59331	31538	36305	1235	55992	24530
1981	0	5112	4637	9233	36096	8121	22601	39499	21200	57535	34531	7085
1982	0	0	6586	26457	34958	49875	3341	9995	22133	16849	19941	24988
1983	0	12053	6024	44786	49293	43263	24269	8963	43604	12577	12866	23445
1984	731	7923	15743	55812	77549	80174	52246	17995	21700	21691	8871	9987
1985	0	10129	20157	46918	24093	38754	45978	37149	14716	19795	7311	6719
1986	0	7547	69243	9793	37713	26390	18929	24439	26366	14445	2656	751
1987	0	3481	8530	26918	22313	20019	46143	59565	37507	32208	39951	9793
1988	2665	9422	9741	17442	23420	28253	28971	28785	33495	32888	21621	14801
1989	32530	46242	31826	30544	29943	67875	30132	27846	23663	35713	29744	30666
1990	0	18585	78783	53760	10431	56623	67424	22756	23046	32567	26309	28960
1991	2623	7094	11789	114278	27351	16892	38992	31663	23299	31081	30606	32137
1992	0	2288	6691	39082	191048	118512	74615	76733	39848	32242	51498	74287
1993	0	0	4812	26189	56326	80277	72749	42908	29849	20587	29534	26889
1994	0	1130	9087	46180	51329	110933	98980	58349	36668	36730	19556	24744
1995	1908	5372	19771	33552	61080	65969	67916	76648	34602	32875	19892	16638
1996	4052	39055	76092	109296	73540	77830	89775	79551	65454	30475	35001	13050
1997	1454	6948	29162	30331	30287	26363	16621	14338	15856	16506	10843	5269
1998	920	6606	15704	61621	49262	55775	35842	25640	22086	29121	15398	13483
1999	0	600	11779	15574	45990	40846	40249	22566	20337	12913	8740	12836
						FEMALES						
1977	0	0	0	0	0	0	1296	3884	2182	4308	0	6479
1979	0	0	0	0	6209	18662	18646	37318	55984	37328	31108	31083
1980	0	0	16098	3194	0	8576	1256	32550	15537	18797	18543	30048
1981	603	5205	2282	111250	26339	2888	17891	19001	16081	62346	16247	34706
1982	0	0	80199	12724	71161	93275	31332	14600	76883	6385	26948	6965
1983	0	48803	40161	20377	17205	57601	15254	21079	15039	7885	1493	6099
1984	1841	12171	21885	24207	64276	71524	62779	22062	28878	10196	9265	17350
1985	50386	16806	17727	47997	17631	66141	59135	43717	33949	8639	6356	6265
1986	0	9177	32517	9062	4048	14719	57812	18982	50506	10273	4482	1527
1987	0	10451	55722	73196	70431	12823	39964	57105	27764	24052	13922	5507
1988	2942	9861	4622	28927	37475	49357	43615	38753	54423	54500	12576	12697
1989	38841	74991	38229	71550	28813	44887	35798	34539	55719	46461	34320	28389
1990	0	8598	49566	29536	30286	50105	31801	18506	46360	29283	33041	19222
1991	0	3172	9886	105340	37404	42470	72975	55386	22199	29221	46622	39213
1992	0	8090	12670	34875	229335	128812	95578	96889	61565	55365	83086	53534
1993	476	727	2744	30713	45237	111270	91699	39547	46841	25167	18879	17228
1994	0	2150	5740	27686	39789	62509	115962	68435	33362	39909	28386	17757
1995	0	994	3348	33157	83050	62242	55085	70125	62240	40089	25749	18296
1996	2277	25761	82996	57735	107088	115270	99539	110936	97033	73665	46206	12754
1997	1925	4532	19538	26887	29947	22693	29071	28470	17500	16406	9869	6628
1998	0	3684	10129	93942	62438	58115	34444	40225	25467	27110	12143	8543
1999	0	3089	11372	14971	46424	39924	40739	22326	23576	21474	9484	8997

Table 17. (Continued) Eureka/S.Columbia area catch-at-age

YEAR	16	17	18	19	20	21	22	23	24	25	Total
						MALES					
1977	14596	6196	8845	3487	7171	920	1304	1304	923	39975	112640
1979	18668	37323	24893	31112	0	18683	6192	0	0	43422	267347
1980	11617	13177	7812	1492	747	1268	5254	491	254	2048	317601
1981	18511	1688	7808	1704	5540	2330	4417	882	463	10415	299408
1982	6705	12965	5967	40726	51603	11934	487	377	2834	6928	355649
1983	1492	12355	1372	3637	12674	13621	4084	1492	8602	64055	404527
1984	34445	7476	4045	7609	6527	24212	25105	4285	13248	44520	541894
1985	3902	4125	2155	2410	2598	17052	6909	9662	7662	23503	351697
1986	10365	30123	3439	211	6471	3725	5671	1141	478	52368	352264
1987	34815	7978	2051	4354	1555	2233	999	15164	1516	32236	409329
1988	12208	2942	2471	9727	8932	2098	1496	1389	3059	18152	313978
1989	15501	9531	5226	23265	868	1423	3289	1838	1266	20504	499435
1990	24373	13181	7094	2180	1661	2483	792	4061	754	23122	498945
1991	19914	16275	3489	4302	689	12327	0	5567	5723	19134	455225
1992	48776	32773	37950	16813	10424	6628	4991	3904	4770	65598	939471
1993	23849	15844	21275	10531	7023	6112	1667	1056	3371	22612	503460
1994	22942	33709	20918	16296	16989	9104	6771	2436	3328	36962	663141
1995	7514	21789	15396	9498	6820	6494	234	10407	6658	18827	539860
1996	16649	10726	12540	13533	18084	22915	3395	8216	10161	7266	816656
1997	2025	4219	3805	4000	2667	1279	3031	1177	417	2813	229411
1998	5870	4143	2903	3453	2672	2882	3890	1195	3505	5704	367675
1999	6985	1450	3853	4068	649	1407	3062	3589	5959	5532	268984
						FEMALES					
1977	13935	7376	3494	5517	4597	1296	0	1836	2751	11541	70492
1979	49775	18656	12422	6211	0	6211	0	6215	6210	6238	348276
1980	3204	34085	14338	8851	0	0	0	0	0	0	205077
1981	9285	34432	24614	2278	13257	0	10842	448	451	875	411321
1982	5162	9954	5125	1149	13859	24426	331	0	0	12223	492701
1983	9079	17867	8158	11516	7683	0	0	14378	0	9364	329041
1984	12088	14183	4692	3490	552	5062	12228	1855	1725	8337	410646
1985	5905	6115	4459	4430	666	430	1099	908	1677	6528	406966
1986	4321	3509	3536	0	4447	15266	0	4389	474	6577	255624
1987	2639	1423	9549	1492	6060	0	9272	1064	1546	32091	456073
1988	7178	2154	33717	0	2113	645	0	0	0	2769	398324
1989	15260	7169	3977	857	3674	1889	2070	1601	1273	7757	578064
1990	17633	9552	4261	3478	918	3619	0	403	0	14505	400673
1991	23173	15849	24571	2665	2625	2765	1947	4007	0	9795	551285
1992	47499	42104	34691	21752	5153	3736	8588	2053	3499	20530	1049404
1993	24516	14081	16011	10239	7726	2656	1344	807	0	5755	513663
1994	28575	22509	23498	17045	17226	8437	5884	1739	870	6483	573951
1995	20999	10650	16394	10151	8542	6030	8553	2547	320	3991	542552
1996	11840	9615	6224	5618	1846	5617	1979	0	2389	6204	882592
1997	2802	2617	1644	2515	1706	2563	1251	1421	482	1218	231685
1998	4154	2730	1751	1106	888	673	0	269	1707	544	390062
1999	8504	1952	1358	1739	1370	34	136	747	48	533	258797

Table 18. Coast-wide area yellowtail rockfish estimated catch-at-age (numbers).

YEAR	4	5	6	7	8	9	10	11	12	13	14	15
MALES												
1977	0	0	0	77864	125557	186459	98136	90336	94328	79635	173623	197421
1978	0	30816	152297	175029	196156	243687	261021	159537	134349	116666	101634	154171
1979	0	21424	52272	202067	239478	308599	430728	303468	297646	143246	169141	157538
1980	0	21717	38136	237924	244141	229200	365177	389972	313151	224768	201350	186453
1981	0	12326	185038	266763	432456	282432	176758	151600	165161	308585	202629	108251
1982	11184	35772	133036	372758	642495	509074	255699	164445	258752	252672	199214	164399
1983	0	30196	235864	477958	802599	774521	443196	154480	149359	110155	152151	133310
1984	731	28073	84024	258640	289536	386093	378519	179006	120209	84726	52078	60747
1985	1265	23112	78666	224136	297422	267815	267524	212997	122457	60254	28004	28596
1986	0	19240	126597	126508	257837	298374	298196	230750	296158	185287	85126	56246
1987	10761	30445	122751	143411	173346	281797	377109	254324	275911	214773	152996	66551
1988	7933	63861	79807	212009	216728	248753	372535	388133	283691	228210	173241	111325
1989	32530	62052	135389	132727	235301	311990	188436	332221	295028	250657	204385	161909
1990	0	32469	159486	173997	142812	262878	224963	179281	202462	210218	163768	124604
1991	2623	8692	32321	235909	181439	135475	247597	182204	138377	184040	133498	95430
1992	3069	10318	51404	199032	459773	393669	269390	286634	215927	131742	156641	159661
1993	1288	10735	90168	185405	441614	430907	412285	309115	298689	203007	124481	115343
1994	0	9687	70369	253740	368265	487550	483336	318812	260755	185693	103118	94417
1995	1908	17582	91611	196608	409896	415611	402367	337748	222531	151048	119207	88658
1996	4052	61349	146712	261661	314706	567725	479027	466728	347106	190319	145636	78555
1997	1454	10018	48380	95907	125353	113099	149194	144262	112438	98683	60311	32062
1998	920	7743	29717	114488	182970	229813	159962	198377	163430	139939	105571	76414
1999	1142	3728	19469	76956	181339	357380	355515	202460	187961	141029	116313	81029
FEMALES												
1977	0	0	12051	31316	86531	146377	104778	108512	44181	70229	87208	147567
1978	15094	64078	183417	88027	264408	301345	500979	155756	128925	92139	164947	162171
1979	0	20436	84920	84557	197862	364608	391636	358641	283326	186059	125989	125208
1980	0	235	100433	184605	241931	139967	254162	421927	301281	213595	130968	89011
1981	603	33501	98012	329133	462364	281201	142310	175927	216829	306845	225669	143301
1982	10976	14542	171068	230037	533367	398312	266124	170524	259001	180006	176393	67256
1983	0	65286	215132	413215	652642	829679	449507	200843	98040	121871	105141	78359
1984	5108	30704	107507	222240	247886	317145	359104	132326	123012	58884	50762	50928
1985	50386	34980	74583	205732	251305	243808	248408	221397	125642	34994	26750	21524
1986	0	24601	73149	129523	169068	311734	288010	298408	399425	191556	74088	55815
1987	8184	45948	136278	187511	206768	256323	348684	267709	244085	188893	105894	47946
1988	21121	67536	48697	217249	256885	249156	383410	409356	348152	262583	139521	86180
1989	38841	84071	98063	150786	223189	173211	132891	188221	316735	225034	135783	130429
1990	2286	16626	114930	151809	111786	204515	165989	135925	244266	192931	148465	104198
1991	0	6749	25581	199609	190242	182023	324333	219887	123135	143175	130411	94139
1992	0	18611	55755	194898	535619	386912	309820	322908	218037	163963	190319	150206
1993	476	7863	81766	152588	322484	497408	359456	304729	310754	197394	82197	81586
1994	2787	10715	65381	237711	335071	496599	471585	294133	248412	232054	136971	83207
1995	855	13411	101092	194616	406077	413239	365958	330404	238894	167910	136531	80553
1996	4325	46665	146712	211735	314967	577490	502930	468511	388164	206020	177412	120409
1997	2386	7853	32208	82081	109281	96521	153883	135564	121318	109147	68129	44372
1998	0	4362	17719	137494	200285	235889	170325	235090	197983	141070	116988	90344
1999	0	14326	30323	80131	159347	300048	305244	188375	203065	142671	92826	87954

Table 18. (Continued) Coast-wide area catch-at-age

YEAR	16	17	18	19	20	21	22	23	24	25	Total
						MALES					
1977	195611	96503	71328	36172	35307	36831	20356	23897	53584	411249	2104197
1978	215075	245910	97028	58841	56307	122083	72627	31218	50271	454706	3129429
1979	182876	184474	224355	202198	53295	81883	48482	33291	28882	380460	3745803
1980	83229	104012	141515	123409	82966	63018	35666	45385	63229	332795	3527213
1981	98626	73067	101734	67678	1E+05	117612	46801	33428	42266	599400	3587935
1982	75171	75870	65153	112150	2E+05	147351	76466	66941	41494	336250	4163335
1983	77037	73657	33246	35666	75043	59334	59586	62225	47501	338036	4325120
1984	85939	39124	30420	33682	31544	40537	56641	33621	36807	237535	2548232
1985	29534	24736	22663	19672	11963	30384	17957	24616	27438	84175	1905386
1986	64928	73467	42446	30110	21002	20930	17255	24624	21451	152757	2449289
1987	78300	47740	39826	44390	24504	10169	22083	21526	15017	190451	2598181
1988	61282	35286	23069	45557	29209	14161	13384	7842	9668	88034	2713718
1989	108514	41201	10859	40946	30360	31111	34871	4907	15814	87278	2748486
1990	108585	55518	25565	17450	17112	19307	18097	10624	8693	78071	2235960
1991	73925	58604	19552	19204	12315	16848	7551	9584	7939	66117	1869244
1992	128136	78392	79725	44262	23416	16235	11603	16681	13105	137191	2886006
1993	124051	81140	65648	62089	39015	29481	6156	16078	18044	105849	3170588
1994	74078	91964	62240	47208	40226	27283	13660	9210	8137	75035	3084783
1995	53249	66918	62262	36283	28029	25763	11622	13858	8720	40902	2802381
1996	77316	57926	55699	44537	41603	41412	18338	14273	18605	43893	3477178
1997	25350	18164	16817	12618	15814	11318	8207	7362	5429	20952	1133192
1998	44306	33565	17411	15562	7085	11417	7759	8302	8640	19871	1583262
1999	65093	27217	25323	19184	10607	8821	15790	14368	13571	38469	1962764
						FEMALES					
1977	95073	37477	14660	31435	19492	4935	11636	5542	2751	42072	1103823
1978	161821	77172	105278	54774	44716	20299	14744	0	0	13518	2613608
1979	123142	99258	81572	38320	15275	21927	15525	11839	10912	31989	2673001
1980	81435	76289	82930	29003	44433	15663	2390	141	0	17848	2428247
1981	57872	74796	38465	20262	46791	21887	15643	448	15867	42117	2749843
1982	68945	41920	39419	25982	47875	54576	14002	12194	6042	40065	2828626
1983	66034	40795	46018	26208	17329	12924	32871	37751	9901	22816	3542362
1984	40101	25230	15451	9008	3406	7580	20180	6049	5786	20177	1858574
1985	24770	22038	12966	10788	4574	3088	2857	3395	5657	8810	1638452
1986	39115	31023	25847	13912	11046	21740	3503	7849	5594	16360	2191366
1987	38189	19305	25452	24962	17141	3314	14244	3937	3874	45952	2240593
1988	40526	31192	46406	6009	9920	5040	7806	4870	2446	16309	2660370
1989	46385	22751	11249	28861	15033	10538	2966	1826	1477	18795	2057135
1990	74905	35674	14908	9419	4688	5705	4610	403	782	23572	1768392
1991	77177	40652	49917	8451	8568	3465	8542	8983	0	11562	1856601
1992	125470	75309	66406	39927	16701	8715	11257	8946	5439	36582	2941800
1993	72712	48269	58805	31316	23651	10243	2380	3973	4571	8199	2662820
1994	85446	60783	44845	33653	25135	17421	10316	6059	2590	10476	2911350
1995	54106	50189	57135	34122	23774	11907	17224	5479	2861	11068	2717405
1996	78676	42143	27763	27059	15793	13360	13580	4780	4624	9215	3402333
1997	34289	22391	18982	14561	12330	11436	9769	5903	3257	4453	1100114
1998	35741	28041	21195	9207	7977	5553	4121	3899	2559	7050	1672892
1999	59325	32788	23557	11000	12362	7170	7083	3787	2856	5650	1769888

Table 19. NMFS triennial trawl survey yellowtail rockfish numbers-at-age (sexes combined).

YEAR	4	5	6	7	8	9	10	11	12	13	14	15
					S.VAN							
1977	0	3717	18828	132269	691174	1076260	835042	673772	523578	928435	954378	698805
1980	0	36995	234374	448770	582712	963815	959533	1060993	848962	726672	755691	473739
1983	276786	980535	1002388	1695015	2166878	2222128	1466559	1089983	893301	613105	876745	723477
1986	1716	46953	62388	79960	138122	219833	248076	307338	174987	202506	62747	46549
1989	72017	67014	41712	156263	495242	482170	576362	545832	1043150	1016036	906485	1199757
1992	342109	164025	252712	584442	1004732	988636	779515	1111069	1211319	893880	716844	658272
1995	1113	7010	30765	55892	89326	83733	85651	60386	34584	23987	25782	10105
1998	0	44951	282863	1311196	4196627	4868951	2061869	3733507	3719705	2396413	1756004	940376
					N.COL							
1977	0	0	0	0	11319	51777	121273	157903	193287	494927	615890	445577
1980	4985	22824	36537	27722	17732	23696	21028	20949	17116	13558	14874	8306
1983	78846	317618	414128	529426	388635	255052	136644	72063	53956	31310	43726	38550
1986	4254	80786	59686	82873	128878	233268	216996	304757	169069	177601	65426	42317
1989	0	9610	15014	67598	185941	134841	152757	122220	251082	267825	166060	265372
1992	9467	5446	45911	128607	317801	267786	252839	330306	354823	232987	210069	174894
1995	959	3377	17265	17377	34307	39635	43182	31844	22753	20166	25562	12417
1998	0	0	63249	261781	515799	544177	226291	389989	281965	277192	250091	185296
					EUR/S.COL							
1977	0	5182	23483	51647	127728	235857	202128	140934	95938	120647	134262	88552
1980	21006	108553	188208	178952	171387	291398	293243	382898	364131	359411	379722	237803
1983	36950	145730	264801	584595	531992	406953	237048	148767	113415	66499	97063	93458
1986	17779	1696827	1139260	306919	173692	272127	205285	260430	139158	149903	29753	26145
1989	8357	78559	82575	127425	272765	193660	237347	146119	287545	348491	203271	313132
1992	972	727	9438	48111	131391	126051	112989	153067	179471	103792	81513	80456
1995	9360	245789	336915	255744	89055	43680	16443	12159	13064	7891	8929	3841
1998	0	24359	77378	364990	294959	321428	190697	110303	156012	128175	136163	164807
					COAST-WIDE							
1977	0	8899	42311	183917	830221	1363894	1158443	972609	812804	1544009	1704531	1232935
1980	25992	168371	459120	655444	771831	1278908	1273804	1464840	1230209	1099642	1150287	719849
1983	392581	1443883	1681318	2809036	3087505	2884133	1840251	1310813	1060673	710914	1017534	855485
1986	23750	1824567	1261334	469751	440692	725227	670356	872525	483214	530011	157926	115011
1989	80374	155183	139301	351286	953948	810671	966466	814172	1581777	1632351	1275816	1778261
1992	352548	170199	308061	761160	1453924	1382473	1145343	1594442	1745613	1230659	1008425	913622
1995	11433	256176	384944	329013	212689	167048	145276	104389	70400	52045	60273	26363
1998	0	69310	423489	1937967	5007385	5734557	2478857	4233799	4157682	2801779	2142258	1290480

Table 19. (Continued) Trawl survey numbers-at-age

YEAR	16	17	18	19	20	21	22	23	24	25	TOTAL
					S.VAN						
1977	461894	202639	117324	41773	13289	0	0	0	0	0	7377132
1980	260445	365259	306243	223085	253024	197886	92493	23323	109398	274413	9201786
1983	503408	532130	402058	304010	510060	417190	538201	456782	99037	1068553	18865386
1986	16027	31343	19702	3748	13690	20055	6394	19928	38839	34437	1814680
1989	767211	333220	194296	55190	141177	109089	43650	78701	99921	241640	8686888
1992	418373	395710	132716	186172	145242	71810	25259	23143	50476	216406	10463689
1995	6129	5375	9920	8284	6858	6970	1474	0	2075	6318	570068
1998	814766	465290	956528	91951	175559	160340	157397	127021	62692	418459	28746460
					N.COL						
1977	326094	151483	112418	38169	6441	0	0	0	0	0	2730513
1980	6081	6612	5819	3668	4271	2785	1918	385	1430	4324	272216
1983	35743	33828	23786	20088	35879	37099	26465	32189	9434	81945	2704360
1986	16104	36224	19046	5267	17456	20016	6434	14996	36487	27515	1795910
1989	170889	99497	44592	12436	48387	26954	16355	22389	41273	105663	2230733
1992	122345	94657	27750	70851	25817	16951	3674	14904	6711	46090	2764673
1995	13456	6635	12185	8483	7126	19232	2047	0	2296	9695	353988
1998	94061	67740	55648	31462	13670	14720	10681	2359	18911	2359	3311436
					EUR/S.COL						
1977	48653	14962	11113	3345	0	0	0	0	0	0	1308386
1980	128963	196307	164504	101700	145924	117757	51539	12818	76485	163037	4140576
1983	68597	55185	42554	33033	75782	49522	53740	53683	8219	98170	3305979
1986	6509	20603	10317	4831	4108	16567	4731	10906	21659	12470	4573615
1989	212061	134533	58456	15953	58951	38539	25190	29437	55643	149988	3085419
1992	51634	33529	15445	23246	15108	4931	3119	8871	4616	19044	1211503
1995	2764	1220	962	3854	2231	759	0	0	328	0	1087791
1998	79594	59668	55422	6760	12715	19673	4644	23713	14960	89734	2340151
					COAST-WIDE						
1977	836640	369084	240855	83287	19730	0	0	0	0	0	11416031
1980	395489	568178	476566	328453	403219	318427	145950	36526	187313	441773	13614578
1983	607748	621143	468399	357131	621721	503811	618405	542654	116690	1248667	24875725
1986	38640	88170	49065	13846	35254	56638	17559	45830	96985	74421	8184205
1989	1150161	567250	297344	83578	248515	174582	85195	130526	196837	497291	14003040
1992	592352	523896	175910	280268	186167	93692	32052	46918	61803	281540	14439865
1995	22349	13229	23067	20622	16215	26961	3521	0	4699	16013	2011847
1998	988421	592698	1067597	130174	201944	194734	172722	153092	96562	510552	34398047

Table 20. Yellowtail rockfish domestic trawl CPUE index.

	S. Vancouver		N. Columbia		Eureka/S. Columbia		Coast-wide	
Year	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev
1988			979.9	318.58	1997.3	363.79	977.9	187.05
1989	599.9	363.45	895.4	317.21	1871.5	346.50	820.4	181.29
1990	700.5	361.12	1142.8	317.80	1103.9	341.35	914.7	178.40
1991	748.1	344.13	1139.5	316.33	959.4	322.00	911.5	175.81
1992	827.3	335.14	1033.1	314.02	937.8	291.08	935.2	171.46
1993	291.8	338.39	873.4	315.04	483.2	293.11	586.7	171.08
1994	707.3	345.79	832.0	313.63	236.1	285.24	503.7	169.32
1995	1147.0	345.81	905.4	315.78	607.6	298.52	726.2	172.84
1996	986.1	353.84	1020.8	314.83	648.6	283.32	778.1	169.25
1997	519.2	364.47	786.4	319.44	51.3	300.44	280.6	176.38
1998	496.4	347.46	928.9	319.66	155.1	292.04	462.9	172.84
1999	313.0	371.71	1118.5	316.57	272.2	328.10	823.4	182.31

Table 21. “Whiting bycatch index”: index of yellowtail rockfish bycatch in the at-sea whiting fishery, 1978-1999.

YEAR	2000 INDEX	1997 INDEX
1978	0.587	2039.8
1979	0.554	1705.4
1980	1.301	4096.7
1981	1.012	4088.7
1982	0.759	2465.4
1983	1.156	4160.3
1984	1.349	4328.9
1985	1.443	4341.3
1986	1.870	9070.5
1987	1.292	4088.9
1988	1.447	5802.0
1989	0.666	2040.6
1990	1.024	3180.5
1991	0.925	5993.0
1992	1.953	5678.9
1993	1.187	2197.6
1994	0.340	1700.5
1995	0.313	3573.5
1996	0.709	
1997	0.501	
1998	0.760	
1999	0.851	

Table 22. Estimated yellowtail rockfish biomass (mt) and coefficient of variation (CV) based on NMFS triennial trawl surveys, 1977-1998.

	Area[a]																	
Year	Monterey	CV	Eureka	CV	S. Col	CV	N. Col	CV	Columbia	CV	US Van	CV	CN Van	CV	Vancouver	CV
1977	683	0.58	661	0.66	1,467	0.59	10,218	0.47	11,800	0.42	11,451	0.58	No survey			
1980	205	0.62	522	0.57	4,842	0.35	411	0.68	5,284	0.56	4,979	0.68	8,625	0.80	13,604	0.56
1983	1,586	0.80	673	0.54	3,349	0.39	3,366	0.40	6,718	0.28	4,666	0.90	20,823	0.57	25,489	0.49
1986	2,222	0.56	1,086	0.50	2,841	0.54	2,642	0.31	5,415	0.32	2,592	0.36	No survey			
1989	880	0.67	387	0.70	5,172	0.63	1,824	0.80	7,031	0.51	9,443	0.80	3,574	0.57	13,017	0.65
1992	652	0.70	74	0.56	1,142	0.77	4,399	0.44	5,398	0.39	5,174	0.47	7,627	0.45	12,801	0.35
1995	408	0.67	31	0.55	870	0.89	497	0.33	1,384	0.57	1,519	0.63	627	0.53	2,146	0.51
1998	3,858	0.67	385	0.84	2,096	0.35	3,922	0.24	6,017	0.21	16,212	0.34	14,659	0.33	31,526	0.27
Mean	1,312	0.66	477	0.61	2,722	0.56	3,410	0.46	6,131	0.41	7,004	0.60	9,323	0.54	16,431	0.47

	STOCK[b]							
Year	EUR/S.COL	CV	N.COL	CV	S.VAN	CV	TOTAL US[c]	CV
1977	2,128	0.46	10,218	0.47	11,451	0.58	23,912	0.35
1980	5,364	0.32	411	0.68	4,979	0.68	10,785	0.42
1983	4,022	0.34	3,366	0.40	4,666	0.90	12,057	0.38
1986	3,927	0.41	2,642	0.31	2,592	0.36	9,093	0.22
1989	5,559	0.59	1,824	0.80	9,443	0.80	16,861	0.50
1992	1,216	0.72	4,399	0.44	5,174	0.47	10,646	0.30
1995	901	0.86	497	0.33	1,519	0.63	2,934	0.42
1998	2,481	0.32	3,922	0.24	16,212	0.34	22,614	0.25
Mean	3,200	0.50	3,410	0.46	7,004	0.60	13,613	0.36
Geometric mean	2,688	0.47	2,217	0.43	5,494	0.57	11,639	0.34

[a] INPFC area : Eureka, Columbia, Vancouver; S.Col and N.Col are requested division of the Columbia area at Cape Falcon, US Van and CN Van are the United States and Canadian portions of the Vancouver area. The Columbia area was divided by special request the estimated Columbia area biomass is not necessarily equal to the sum of the S.Col and N.Col area biomass.

[b] Stock units: Eureka/S.Col is Cape Mendocino to Cape Falcon, N.Col is Cape Falcon to Cape Elizabeth, S. Van is Cape Elizabeth to 49 degrees N. Latitude.

[c] Total US biomass is the sum of the Area biomass for Eureka, Columbia and US Van.

Table 23. Frequency distribution of the NMFS triennial trawl survey yellowtail rockfish catch (kg) per hectare (excludes hauls designated as bad tows).

STOCK	CATCH RANGE (kg/HA)	1977	1980	1983	1986	1989	1992	1995	1998	Total
S.VANCOUVER	200-1200	3	1	3	3	1	2		4	17
	30-200	3	2	3	6	5	6	2	9	36
	3-30	10	7	9	5	4	11	5	21	72
	0-3	58	56	96	210	90	77	78	54	719
S.VAN Total		74	66	111	224	100	96	85	88	844
N.COLUMBIA	200-1200	2		1						3
	30-200	4		4	3	1	2		3	17
	3-30	13	4	15	13	2	11	3	11	72
	0-3	64	117	105	83	77	65	51	42	604
N.COL Total		83	121	125	99	80	78	54	56	696
EUREKA/	200-1200		1	1		1				3
S.COLUMBIA	30-200	2	3		2	2	2	1	1	13
	3-30	4	13	27	10	7	1		10	72
	0-3	191	203	214	126	163	170	191	185	1443
EUR/S.COL Total		197	220	242	138	173	173	192	196	1531
COAST-WIDE	200-1200	5	2	5	3	2	2	0	4	23
	30-200	9	5	7	11	8	10	3	13	66
	3-30	27	24	51	28	13	23	8	42	216
	0-3	313	376	415	419	330	312	320	281	2766
COAST Total		354	407	478	461	353	347	331	340	3071

Table 24. Mean difference and standard deviation of the mean difference between replicate age assignments for yellowtail rockfish.

AGE	N	MEAN DEV	STD	PREDICTED
4	2	0.500	0.707	0.651
5	26	0.308	0.679	0.706
6	131	0.199	0.574	0.762
7	305	0.216	0.895	0.817
8	507	0.073	0.765	0.873
9	695	0.006	0.826	0.928
10	668	-0.153	0.923	0.983
11	495	-0.297	0.960	1.039
12	384	-0.372	1.105	1.094
13	266	-0.323	1.179	1.150
14	197	-0.508	1.354	1.205
15	144	-0.417	1.298	1.261
16	104	-0.433	1.519	1.316
17	88	-0.489	1.788	1.372
18	76	-0.250	1.256	1.427
19	58	-0.379	1.576	1.483
20	42	-0.429	1.434	1.538
21	35	-1.229	1.800	1.594
22	21	-0.571	1.859	1.649
23	13	-0.385	1.387	1.705
24	9	-0.556	1.424	1.760
25+	48	-0.583	1.820	1.816
TOTAL	4314			

Table 25. Description of the yellowtail rockfish stock assessment model used in year 2000.

General Definitions	Symbol/Value	Use in Catch-at-Age Model
Sex index: $k = \{1,2\}$	1 => female 2 => male	
Year index: $i = \{1967, …., 2000\}$	1967 … 96 = 30 years	
Age index: $j = \{4, 5, …, 24, 25^+\}$	4 … 25^+ = 22 age groups	
Mean weight by sex k, year i, and age j	W_{kij}	
Proportion females mature at age j South Vancouver Stock: a=1.0058, b=10.9896 All others: a=0.9603, b= 9.2732	p_j	$p_j = \frac{1}{1+e^{-a(j-b)}}$ (source: Tagart 1991)
Maximum age beyond which selectivity is constant	*maxage*	Selectivity parameterization--set equal to age 20 (the age after which growth in length diminishes).
Instantaneous Natural Mortality initial for females aged j = 4, …, 6 = 0.11 (Estimated) mortality for oldest modeled age group (25+) = M_{25+} males all ages = 0.11	M_{kj}	$\Delta = (M_{25+} - 0.11)/19$ $M_{1j} = 0.11 + \Delta(j-6)\mathrm{I}(j \ge 6)$, I($X$) = indicator of X, e.g., if X is true then I(X)=1.0, otherwise I(X)=0 $M_{2j} = 0.11$
Ageing error, $j = 4, …, 25^+$: the probability of ageing a fish of true age j as age j', i.e.,	$A_{jj'}$ $\sum_{j'=4}^{25^+} A_{jj'} = 1.0$	$\hat{P}_{kij'} = E[P_{kij'}] = \sum_{j=4}^{25^+} P_{kij} A_{jj'}$
Sample size for proportion at sex k and age j in year I	T_i	Scales multinomial assumption about estimates of proportion at age
Historical fishing mortality (relative to mean 1967 estimate)	h_f	Sets initial (1967) equilibrium numbers at age

Table 25. (continued)

Data Description	Symbol/Constraints	Expected Values Based on Catch-At-Age Model
Survey abundance index by year i = 1977, 80, 83, 86, 89, 92, 95,98	Y_i^s	$\hat{Y}_i^s = Q_i^s \sum_{k=1}^{2} \sum_{j=4}^{25^+} s_j^s W_{kij} N_{kij} e^{\frac{-Z_{kij} 8.5}{12}}$
Whiting bycatch index by year i = 1978, 79, 80, …, 99	Y_i^w	$\hat{Y}_i^w = Q_i^w \sum_{k=1}^{2} \sum_{j=4}^{25^+} s_j^f W_{kij} N_{kij}$
Logbook CPUE index by year i = 1988, 89, …, 99	Y_i^f	$\hat{Y}_i^f = Q_i^f \sum_{k=1}^{2} \sum_{j=4}^{25^+} s_j^f W_{kij} N_{kij}$
Catch biomass by Year, i = 1967,…,2000	C_i	$\hat{C}_i = \sum_{k,j} W_{kij} N_{kij} \frac{F_{kij}}{Z_{kij}} \left(1 - e^{-Z_{kij}}\right)$
Proportion at sex k, age j, in year i	P_{kij}, $\sum_{j=4}^{25^+} P_{kij} = 1.0$	$P_{kij} = \frac{N_{kij} s_{kij}^f}{\sum_{k=1}^{2} \sum_{l=4}^{25^+} N_{kil} s_{kil}^f}$
Initial numbers at age	$j = 4$	$N_{k,1967,4} = e^{\mu_R + \rho_{1967}}$
	$4 < j < 25$	$N_{k,1967,j} = e^{\mu_R} \prod_{l=5}^{j} e^{-\left(h_f f_{k,1967,l} + M_{k,l}\right)}$
	$j = 25^+$	$N_{k,1967,25} = \frac{e^{\mu_R} \prod_{l=5}^{25} e^{-\left(h_f f_{k,1967,l} + M_{k,l}\right)}}{1 - e^{-\left(h_f f_{k,1967,25} + M_{k,25}\right)}}$
Subsequent years…	$j = 4$	$N_{k,i,4} = e^{\mu_R + \rho_i}$
(i >1967)	$4 < j < 25$	$N_{k,i,j} = N_{k,i-1,j-1} e^{-Z_{k,i-1,j-1}}$
	$j = 25^+$	$N_{k,i,25^+} = N_{k,i-1,24} e^{-Z_{k,i-1,24}} + N_{k,i-1,25^+} e^{-Z_{k,i-1,25^+}}$

Table 25. (continued)

Parameter Description	Estimated Parameter, Constraints	Derived Parameters, Use in Catch-at-Age Model
Natural Mortality (old-age females)	M_{25+}	$\Delta = (M_{25+} - 0.11)/19$ $M_{1j} = 0.11 + \Delta\left(j-6\right)\mathrm{I}(j \geq 6)$, $M_{2j} = 0.11$
Instantaneous fishing mortality		$F_{kij} = e^{\mu_f + \phi_i + \eta^f_{kj}}$
Mean fishing effect	μ_f	
Annual effect of fishing in year *i*	ϕ_i, $\sum_{i=1967}^{2000} \phi_i = 0$	
sex and age effect of fishing (regularized form)	η^f_{kj}, $\sum_{j=4}^{25^+} \eta^f_{kj} = 0$	$s^f_{kj} = e^{\eta^f_{kj}}$, $j \leq$ maxage $s^f_{kj} = e^{\eta^f_{k,\mathrm{maxage}}}$ $j >$ maxage
(logistic case)	a_k, b_k	$s^f_{kj} = \frac{1}{1+e^{-a_k(j-b_k)}}$
Survey age effect	η^s_j, $\sum_{j=4}^{25^+} \eta^s_j = 0$	$s^s_j = e^{\eta^s_j}$
Total mortality		$Z_{kij} = F_{kij} + M_{kj}$
Recruitment: mean effect	μ_R	
year effect, *i* = 1967, …, 2000	ρ_i, $\sum_{i=1967}^{2000} \rho_i = 0$	$N_{k,i,4} = e^{\mu_R + \rho_i}$
Index catchability Mean effect	μ^s, μ^f, μ^w	
Time trend	α^f_i, α^w_i, $\sum_{i=1967}^{2000} \alpha^f_i = 0$, $\sum_{i=1967}^{2000} \alpha^w_i = 0$	$Q^s_i = e^{\mu^s}$, $Q^w_i = e^{\mu^w + \alpha^w_i}$, $Q^f_i = e^{\mu^f + \alpha^f_i}$
Variance for logbook CPUE data	σ^2_f	Used in likelihood component

Table 25. (continued)

Parameter Description	Estimated Parameter, Constraints	Derived Parameters, Use in Catch-at-Age Model
Spawner-per-recruit harvest rates	$F_{55\%}, F_{50\%}, F_{45\%}$	The level of fishing mortality that will reduce the spawner biomass *per recruit* to 55%, 50%, and 45% (respectively) of the equilibrium unfished level)
Spawner-per-recruit harvest rates Constraints	$\frac{S^{eq}_{F_{55\%}}}{S^{eq}_{F=0}} = 0.55$ $\frac{S^{eq}_{F_{50\%}}}{S^{eq}_{F=0}} = 0.50$ $\frac{S^{eq}_{F_{45\%}}}{S^{eq}_{F=0}} = 0.45$	$N^{eq}_{F_0,j} = \prod_{\lambda=5}^{j} e^{-M_{1,\lambda-1}} \quad j < 25$ $N^{eq}_{F_0,j} = \frac{\prod_{\lambda=5}^{25} e^{-M_{1,\lambda-1}}}{1-e^{-M_{1,25}}} \quad j = 25$ $S^{eq}_{F_0} = \sum_{j=4}^{25} p_j W_{1,99,j} N^{eq}_{F_0,j}\, e^{-\frac{3M_{1,j}}{12}}$
Example for $F_{50\%}$ case: (note, for the $F_{55\%}$ and $F_{45\%}$ cases the computations are the same)		$N^{eq}_{F_{50\%},j} = \prod_{\lambda=5}^{j} e^{-\left(M_{1,\lambda-1} + s^{f}_{1,\lambda-1} F_{50\%}\right)} \quad j < 25$ $N^{eq}_{F_{50\%},25} = \frac{\prod_{\lambda=5}^{25} e^{-\left(M_{1,\lambda-1} + s^{f}_{1,\lambda-1} F_{50\%}\right)}}{1-e^{-\left(M_{1,25} + s^{f}_{1,\lambda-1} F_{50\%}\right)}} \quad j = 25$ $S^{eq}_{F_{50\%}} = \sum_{j=4}^{25} p_j W_{k=1,99,j} N^{eq}_{F_{50\%},j}\, e^{-\frac{3\left(M_{1,j} + s^{f}_{1,\lambda-1} F_{50\%}\right)}{12}}$

Table 25. (continued)

Likelihood Component	Specification	Description / notes
Abundance indices	$L_1 = \lambda_1^s \sum_i \ln\left(Y_i^s / \hat{Y}_i^s\right)^2$	Triennial Survey
	$L_2 = \dfrac{\sum_i \ln\left(Y_i^f / \hat{Y}_i^f\right)^2}{2\sigma_f^2}$	Logbook CPUE index (note that the σ_f^2 as an estimated parameter)
	$L_3 = \lambda_1^w \sum_i \ln\left(Y_i^w / \hat{Y}_i^w\right)^2$	Whiting bycatch index
Smoother for selectivities	$L_4 = \sum_{k,l} \lambda_2^l \sum_{j=4}^{23} \left(\eta_{k,j+2}^l + \eta_{kj}^l - 2\eta_{k,j+1}^l\right)^2 +$	Smoothness
	$\lambda_3^l \sum_{j=5}^{25^+} \mathrm{I}\left(\eta_{kj}^l < \eta_{k,j-1}^l\right)\left(e^{\eta_{k,j}^l} - e^{\eta_{k,j-1}^l}\right)^2$	Degree of declining selectivity with age Note: *l={s, f}* for survey and fishery selectivity, respectively.
Recruitment prior	$L_5 = \lambda_4 \sum_{i=1967}^{2000} \rho_i^2$	Influences estimates where data are lacking (e.g., if no signal of recruitment strength is available, then the recruitment estimate will converge to median value).
Catch biomass likelihood	$L_6 = \lambda_5 \sum_{i=1967}^{2000} \ln\left(C_i / \hat{C}_i\right)^2$	
Proportion at age likelihood	$L_7 = -\sum_{l,k,i,j} T_{kij}^l P_{kij}^l \log\left(\hat{P}_{kij}^l \cdot P_{kij}^l\right)$	*l={s, f}* for survey and fishery age composition observations
Fishing mortality prior	$L_8 = \lambda_6 \sum_{i=1967}^{2000} \phi_i^2$	(relaxed in final phases of estimation)
Prior on catchability changes	$L_9 = \sum_l \lambda_7^l \sum_i \left(\alpha_i^l\right)^2$	*l={ f, w}* for fishery CPUE and whiting bycatch indices
Overall objective function to be minimized	$\dot{L} = \sum_{i=1}^{9} L_i$	

Table 26. List of lambda's, their influence on model fitting, and standard deviations.

Lambda	Description	Log-scale standard deviation (unless otherwise noted)
λ_1^s	Variance term for triennial survey (sample variance)	0.55
λ_1^w	Variance term for Whiting Bycatch index (sample variance)	0.20
λ_1^f	Variance term for Logbook CPUE data	Cst: 0.22, Eur: 0.46, Col: 0.33, Van: 0.52
λ_2^f	Penalty term for fishery selectivity stability	0.20
λ_2^s	Penalty term for survey selectivity stability	0.20
λ_3^f	Penalty term for degree of declining fishery selectivity	0.07
λ_3^s	Penalty term for degree of declining survey selectivity	0.07
λ_4	Variance term for prior on recruitment fluctuations	1.00
λ_5	Variance term for matching catch biomass	0.03
λ_6	Variance term for prior on annual fluctuations in fishing mortality	2.24
λ_7^w	Variance term for prior on whiting bycatch catchability changes	0.40, 0.16
λ_7^f	Variance term for how much logbook CPUE catchability changes	0.40, 0.16

Table 27. Characteristics of the four models evaluated in the year 2000 yellowtail rockfish stock assessment.

	Indices				Catchability variable by year		
Models [a]	**Survey**	**Bycatch**	**Logbook**	**Survey q**	**Survey**	**Bycatch**	**Logbook**
Ref	Yes	Yes	Yes	Estimated	No	Yes	Yes
Srvon	Yes	No	No	Estimated	No	-	-
Fshon	No	No	No	-	-	-	-

[a] Ref: reference case (base model), Srvon: survey only, and Fshon: fish only.

Table 28. Summary output indicators for the retrospective analysis of the coast-wide yellowtail rockfish Ref and Srvon models.

Output	Ref97Cst	Srvon97Cst
1997 Total Biomass	55,313	25,989
CV 1997 Total Biomass	23%	51%
1997 Biomass / 1967 Biomass	42%	20%
CV Biomass ratio	24%	51%
1997 Female Spawner Biomass	14,922	10,308
Average Female Spawner biomass (1967-1997)	22,692	20,572
1997 average F	0.08	0.22
Average Recruitment (1967-1995)	12,609	10,565
CV Recruitment	47%	53%
Median Recruitment (1967-1997)	10,904	8,651
Survey Catchability (q)	0.20	0.26

Table 29. Comparison of the retrospective and 1997 assessment estimates for biomass (mt) and yield (mt).

	Retrospecitve		1997 Assessment	
Indicator	**Ref97Cst**	**Svon97Cst**	**Model 8**	**Model 3**
1997 Total biomas	55,313	25,989	56,736	27,784
Biomass ratio (Srvon/Ref)	0.47		0.49	
1998 Yield	5,096	1,825	4,658	1,603
Yield ratio (Srvon/Ref)	0.36		0.34	

Table 30. Summary results for alternative model configurations based on the yellowtail rockfish coast-wide data set.

Output Indicator	RefCst	SrvonCst	FshonCst
2000 Total Biomass	69,364	71,722	62,764
CV 2000 Total Biomass	23%	38%	51%
2000 Biomass / 1967 Biomass	50%	52%	45%
CV Biomass ratio	23%	37%	50%
2000 SPB	20,528	21,433	16,858
Equil SPB(40%)	13,016	13,137	12,409
2000 SPB/Equil SPB (40%)	158%	163%	136%
Average Female Spawner biomass (1967-1997)	25,169	25,322	24,769
Average Female Spawner biomass (1996-1999)	19,530	20,304	17,020
2000 average F	0.08	0.07	0.09
Average Recruitment (1967-2000)	13,620	13,748	13,062
CV Average Recruitment	56%	56%	50%
Avg Rec 1993-1997	12,663	13,006	11,064
Median Recruitment (1967-2000)	11,009	11,141	10,680
Survey Catchability (q)	0.19	0.19	0.19
Fishery Age Comp Fit	69.91	69.99	68.79
Survey Age Comp fit	31.07	30.85	-
Survey Abundance	4.48	4.49	-
Whiting bycatch	19.84	-	-
Logbook CPUE	-12.04	0.00	-0.01
Total -ln L	113.26	105.33	68.78
Effective N	701	709	729
$RMSE = \left(\sqrt{\frac{\sum \ln (Obs / \Pr ed)^2}{n}} \right)$			
Triennial Survey fit	0.582	0.582	0.597
Whiting bycatch	0.269	0.505	0.486
Logbook CPUE	0.222	0.356	0.324

Table 31. Summary results for alternative model configurations based on the yellowtail rockfish S. Vancouver data set.

Output Indicator	RefVan	SrvonVan	FshonVan
2000 Total Biomass	32,224	33,476	27,699
CV 2000 Total Biomass	26%	38%	51%
2000 Biomass / 1967 Biomass	68%	68%	56%
CV Biomass ratio	27%	39%	51%
2000 SPB	6,913	7,327	5,458
Equil SPB(40%)	5,010	5,086	4,729
2000 SPB/Equil SPB (40%)	138%	144%	115%
Average Female Spawner biomass (1967-1997)	7,018	7,213	7,079
Average Female Spawner biomass (1996-1999)	6,362	6,710	5,730
2000 average F	0.11	0.10	0.14
Average Recruitment (1967-2000)	5,831	5,891	5,494
CV Average Recruitment	44%	44%	37%
Avg Rec 1993-1997	5,958	6,100	4,772
Median Recruitment (1967-2000)	4,952	4,989	4,924
Survey Catchability (q)	0.23	0.23	0.22
Fishery Age Comp Fit	28.39	28.02	27.34
Survey Age Comp fit	12.93	12.96	-
Survey Abundance	6.60	6.49	-
Whiting bycatch	18.38	-	-
Logbook CPUE	-4.19	0.00	0.00
Total -ln L	62.12	47.46	27.33
Effective N	395	406	406
$RMSE = \left(\sqrt{\frac{\sum \ln(Obs/Pred)^2}{n}} \right)$			
Triennial Survey fit	0.706	0.701	0.738
Whiting bycatch	0.259	0.510	0.490
Logbook CPUE	0.384	0.424	0.389

Table 32. Summary results for alternative model configurations based on the yellowtail rockfish N. Columbia data set.

Output Indicator	**RefCol**	**SrvonCol**	**FshonCol**
2000 Total Biomass	34,729	30,903	33,565
CV 2000 Total Biomass	24%	39%	48%
2000 Biomass / 1967 Biomass	69%	60%	60%
CV Biomass ratio	29%	42%	52%
2000 SPB	9,846	8,701	9,129
Equil SPB(40%)	6,038	5,818	5,934
2000 SPB/Equil SPB (40%)	163%	150%	154%
Average Female Spawner biomass (1967-1997)	9,816	9,676	10,041
Average Female Spawner biomass (1996-1999)	8,594	7,686	7,957
2000 average F	0.04	0.05	0.04
Average Recruitment (1967-2000)	6,127	5,799	5,862
CV Average Recruitment	44%	43%	37%
Avg Rec 1993-1997	6,058	5,393	5,768
Median Recruitment (1967-2000)	5,693	5,535	5,419
Survey Catchability (q)	0.11	0.12	0.10
Fishery Age Comp Fit	29.40	28.31	27.46
Survey Age Comp fit	21.04	21.68	-
Survey Abundance	11.95	11.95	-
Whiting bycatch	19.63	-	-
Logbook CPUE	-12.72	-0.01	-0.01
Total -ln L	69.30	61.92	27.45
Effective N	474	499	520
$RMSE = \left(\sqrt{\frac{\sum \ln (Obs / \Pr ed)^2}{n}} \right)$			
Triennial Survey fit	0.951	0.951	0.980
Whiting bycatch	0.268	0.532	0.563
Logbook CPUE	0.103	0.145	0.172

Table 33. Summary results for alternative model configurations based on the yellowtail rockfish Eureka/S.Columbia data set.

Output Indicator	**RefEur**	**SrvonEur**	**FshonEur**
2000 Total Biomass	11,129	12,370	11,876
CV 2000 Total Biomass	24%	40%	62%
2000 Biomass / 1967 Biomass	65%	69%	66%
CV Biomass ratio	25%	38%	58%
2000 SPB	3,265	3,701	3,056
Equil SPB(40%)	2,708	2,782	2,705
2000 SPB/Equil SPB (40%)	121%	133%	113%
Average Female Spawner biomass (1967-1997)	4,730	4,897	4,814
Average Female Spawner biomass (1996-1999)	2,838	3,174	2,761
2000 average F	0.06	0.05	0.06
Average Recruitment (1967-2000)	2,403	2,497	2,446
CV Average Recruitment	70%	71%	67%
Avg Rec 1993-1997	2,562	2,800	2,541
Median Recruitment (1967-2000)	1,929	1,965	2,058
Survey Catchability (q)	0.22	0.21	0.21
Fishery Age Comp Fit	179.40	179.32	175.67
Survey Age Comp fit	51.84	51.49	-
Survey Abundance	4.05	4.28	-
Whiting bycatch	20.52	-	-
Logbook CPUE	6.99	0.02	0.01
Total -ln L	262.80	235.10	175.68
Effective N	147	145	168
$RMSE = \left(\sqrt{\frac{\sum \ln(Obs / Pred)^2}{n}} \right)$			
Triennial Survey fit	0.554	0.569	0.551
Whiting bycatch	0.274	0.451	0.445
Logbook CPUE	0.758	0.933	0.897

Table 34. Estimated coast-wide yellowtail rockfish biomass (mt), recruitment (x1000), fishing mortality at age of full selection (age 12), catch (mt) and percent utility (Catch/Exploitable Biomass) for the year 2000 reference model.

YEAR	TOTAL BIOMASS (MT)	EXPLOITABLE BIOMASS (MT)	SPAWNING BIOMASS (MT)	AGE 4 RECRUITS (NUMBER x1000)	FULL SELECTION F		CATCH (MT)	% UTILITY
					FEMALE	MALE		
1967	137,590	94,989	37,480	13,744	0.014	0.013	1,214	1.3
1968	135,210	94,027	37,078	10,855	0.029	0.028	2,471	2.6
1969	130,160	91,997	36,229	8,052	0.035	0.033	2,892	3.1
1970	124,600	89,626	35,264	8,385	0.013	0.012	1,030	1.1
1971	121,730	88,702	35,007	10,385	0.012	0.011	933	1.1
1972	121,610	87,222	34,702	16,003	0.025	0.023	1,910	2.2
1973	122,300	84,158	33,817	18,413	0.040	0.037	2,985	3.5
1974	118,510	80,055	32,245	8,914	0.020	0.019	1,413	1.8
1975	115,060	78,188	31,144	6,462	0.023	0.022	1,603	2.1
1976	111,690	77,384	30,151	7,948	0.058	0.054	3,954	5.1
1977	107,140	75,274	28,805	10,754	0.077	0.073	5,098	6.8
1978	109,730	71,729	27,584	28,002	0.144	0.135	8,827	12.3
1979	108,520	64,222	25,119	22,915	0.175	0.164	9,508	14.8
1980	102,430	56,864	22,164	10,148	0.185	0.174	8,857	15.6
1981	106,020	52,412	19,550	29,941	0.213	0.200	9,330	17.8
1982	102,670	50,768	17,645	11,908	0.227	0.213	9,627	19.0
1983	96,481	50,809	17,006	7,182	0.232	0.217	9,864	19.4
1984	91,979	50,537	17,252	13,182	0.132	0.124	5,766	11.4
1985	94,567	53,639	18,960	19,933	0.093	0.087	4,197	7.8
1986	92,620	56,857	20,946	6,031	0.133	0.125	6,239	11.0
1987	96,346	57,085	22,153	16,052	0.139	0.131	6,620	11.6
1988	100,540	56,145	22,616	28,383	0.159	0.149	7,271	12.9
1989	100,680	52,887	20,557	10,112	0.145	0.136	6,291	11.9
1990	98,386	51,217	20,149	17,794	0.122	0.115	5,416	10.6
1991	103,840	51,971	20,120	23,574	0.111	0.104	5,037	9.7
1992	97,943	53,086	19,989	7,166	0.173	0.162	7,770	14.6
1993	94,860	52,182	19,404	19,723	0.171	0.160	7,523	14.4
1994	97,720	50,604	19,051	28,830	0.173	0.162	7,466	14.8
1995	94,227	51,876	19,506	5,640	0.152	0.143	6,854	13.2
1996	88,013	50,637	19,107	4,874	0.192	0.180	8,333	16.5
1997	80,799	50,763	19,431	4,248	0.063	0.059	2,871	5.7
1998	72,672	50,633	19,285	4,643	0.086	0.081	3,851	7.6
1999	71,341	51,386	20,298	11,163	0.100	0.094	4,513	8.8
2000	69,364	48,634	20,528	11,726	0.106	0.100	4,513	9.3

Table 35. Estimated Eureka/S.Columbia yellowtail rockfish biomass (mt), recruitment (x1000), fishing mortality at age of full selection (age 12), catch (mt) and percent utility (Catch/Exploitable Biomass) for the year 2000 reference model.

YEAR	TOTAL BIOMASS (MT)	EXPLOITABLE BIOMASS (MT)	SPAWNING BIOMASS (MT)	RECRUITS (NUMBER x1000)	FULL SELECTION F		CATCH (MT)	% UTILITY
					FEMALE	MALE		
1967	17,161	12,496	5,488	1,656	0.024	0.020	270	2.2
1968	18,772	12,355	5,391	5,700	0.020	0.017	228	1.8
1969	18,858	12,320	5,321	1,408	0.017	0.015	194	1.6
1970	18,899	12,469	5,285	1,483	0.019	0.016	218	1.8
1971	18,978	12,796	5,286	1,841	0.026	0.022	298	2.3
1972	19,094	13,154	5,342	2,215	0.036	0.031	425	3.2
1973	19,017	13,273	5,466	2,079	0.031	0.026	371	2.8
1974	19,095	13,304	5,668	2,316	0.021	0.018	250	1.9
1975	18,890	13,419	5,841	1,402	0.016	0.014	197	1.5
1976	18,411	13,543	5,921	867	0.014	0.012	177	1.3
1977	18,096	13,537	5,954	1,436	0.025	0.021	302	2.2
1978	19,268	13,408	5,928	5,027	0.088	0.075	1,042	7.8
1979	18,613	12,588	5,579	1,894	0.099	0.084	1,099	8.7
1980	19,369	11,880	5,186	5,059	0.081	0.069	855	7.2
1981	19,430	11,656	4,891	2,331	0.117	0.100	1,198	10.3
1982	18,949	11,458	4,534	1,996	0.128	0.109	1,281	11.2
1983	18,044	11,344	4,330	1,383	0.117	0.100	1,173	10.3
1984	18,657	11,405	4,348	4,696	0.143	0.122	1,421	12.5
1985	18,320	11,177	4,353	2,654	0.099	0.085	986	8.8
1986	17,667	11,201	4,495	1,001	0.082	0.070	821	7.3
1987	18,198	11,358	4,516	2,142	0.127	0.109	1,270	11.2
1988	20,290	11,576	4,618	7,967	0.100	0.086	1,029	8.9
1989	21,059	11,402	4,347	932	0.130	0.112	1,306	11.5
1990	18,403	11,032	4,366	1,104	0.115	0.099	1,121	10.2
1991	17,771	11,078	4,316	2,257	0.133	0.114	1,288	11.6
1992	16,953	11,065	4,182	1,826	0.295	0.253	2,665	24.1
1993	16,275	9,440	3,555	4,804	0.164	0.140	1,327	14.1
1994	15,804	8,561	3,343	4,080	0.209	0.179	1,516	17.7
1995	15,610	8,318	3,191	2,511	0.170	0.145	1,220	14.7
1996	13,573	7,684	2,849	799	0.254	0.217	1,641	21.4
1997	12,815	7,836	2,740	613	0.066	0.056	463	5.9
1998	11,366	7,685	2,742	638	0.099	0.085	678	8.8
1999	11,219	7,958	3,021	1,608	0.077	0.066	550	6.9
2000	11,129	7,888	3,265	1,964	0.078	0.067	550	7.0

Table 36. Estimated N. Columbia yellowtail rockfish biomass (mt), recruitment (x1000), fishing mortality at age of full selection (age 12), catch (mt) and percent utility (Catch/Exploitable Biomass) for the year 2000 reference model.

YEAR	TOTAL BIOMASS (MT)	EXPLOITABLE BIOMASS (MT)	SPAWNING BIOMASS (MT)	AGE 4 RECRUITS (NUMBER x1000)	FULL SELECTION F: FEMALE	FULL SELECTION F: MALE	CATCH (MT)	% UTILITY
1967	50,536	35,916	14,131	5,038	0.018	0.017	582	1.6
1968	50,411	35,460	13,937	5,931	0.023	0.022	747	2.1
1969	49,716	34,900	13,694	4,675	0.017	0.016	548	1.6
1970	49,229	34,590	13,545	4,703	0.004	0.004	122	0.4
1971	49,503	34,745	13,580	5,511	0.005	0.005	152	0.4
1972	50,344	34,936	13,629	6,792	0.023	0.022	744	2.1
1973	50,658	34,593	13,485	6,540	0.063	0.061	1,979	5.7
1974	49,224	33,155	12,905	4,966	0.014	0.013	421	1.3
1975	49,053	33,373	12,937	4,233	0.037	0.036	1,140	3.4
1976	48,143	33,281	12,759	4,520	0.088	0.085	2,644	7.9
1977	46,254	32,008	12,145	5,769	0.112	0.108	3,183	9.9
1978	46,964	30,117	11,443	12,447	0.239	0.231	6,113	20.3
1979	44,645	25,495	9,685	9,892	0.301	0.291	6,397	25.1
1980	41,083	21,184	7,851	5,919	0.314	0.304	5,514	26.0
1981	41,210	18,913	6,539	12,087	0.302	0.292	4,788	25.3
1982	39,965	18,761	5,930	5,756	0.254	0.246	4,095	21.8
1983	38,053	19,898	6,053	3,129	0.293	0.283	4,912	24.7
1984	35,216	19,957	6,214	4,083	0.163	0.157	2,861	14.3
1985	35,176	21,322	6,980	6,350	0.094	0.091	1,805	8.5
1986	35,022	22,985	8,002	3,674	0.147	0.142	2,976	12.9
1987	36,811	23,074	8,672	6,914	0.161	0.156	3,247	14.1
1988	37,260	21,982	8,754	8,862	0.205	0.198	3,863	17.6
1989	34,771	19,533	7,722	5,803	0.125	0.121	2,170	11.1
1990	37,955	19,794	7,677	7,386	0.105	0.102	1,869	9.4
1991	41,367	20,659	7,731	8,982	0.097	0.094	1,808	8.8
1992	38,168	20,909	7,597	3,792	0.134	0.130	2,477	11.8
1993	38,546	21,901	8,004	8,378	0.133	0.129	2,569	11.7
1994	42,641	22,316	8,111	13,010	0.143	0.138	2,812	12.6
1995	39,996	22,295	8,069	3,440	0.155	0.150	3,039	13.6
1996	39,004	22,294	8,072	2,846	0.130	0.126	2,582	11.6
1997	35,979	22,989	8,447	2,617	0.051	0.049	1,069	4.6
1998	34,162	23,499	8,576	3,260	0.058	0.056	1,249	5.3
1999	34,446	24,768	9,282	5,388	0.054	0.052	1,216	4.9
2000	34,729	24,523	9,846	5,629	0.054	0.053	1,216	5.0

Table 37. Estimated S. Vancouver yellowtail rockfish biomass (mt), recruitment (x1000), fishing mortality at age of full selection (age 12), catch (mt) and percent utility (Catch/Exploitable Biomass) for the year 2000 reference model.

YEAR	TOTAL BIOMASS (MT)	EXPLOITABLE BIOMASS (MT)	SPAWNING BIOMASS (MT)	AGE 4 RECRUITS (NUMBER x1000)	FULL SELECTION F		CATCH (MT)	% UTILITY
					FEMALE	MALE		
1967	47,113	30,732	9,678	4,812	0.013	0.013	362	1.2
1968	46,360	30,442	9,580	3,895	0.054	0.054	1,496	4.9
1969	44,299	29,169	9,144	3,553	0.082	0.082	2,150	7.4
1970	41,677	27,407	8,541	3,585	0.027	0.027	689	2.5
1971	40,728	27,038	8,426	3,818	0.019	0.019	483	1.8
1972	40,420	26,800	8,394	4,661	0.030	0.030	741	2.8
1973	40,927	26,199	8,281	6,680	0.026	0.026	636	2.4
1974	41,068	25,580	8,165	5,092	0.032	0.031	741	2.9
1975	40,447	24,874	7,958	3,535	0.012	0.011	266	1.1
1976	40,113	24,797	7,862	3,300	0.050	0.050	1,134	4.6
1977	39,239	24,274	7,523	4,193	0.074	0.073	1,613	6.6
1978	41,314	23,669	7,159	11,220	0.078	0.078	1,672	7.1
1979	42,774	23,117	6,942	8,595	0.097	0.097	2,012	8.7
1980	43,018	22,186	6,736	6,063	0.127	0.126	2,489	11.2
1981	44,598	20,966	6,377	9,756	0.185	0.183	3,343	15.9
1982	43,492	19,702	5,746	5,188	0.255	0.253	4,250	21.6
1983	40,662	18,754	5,047	3,652	0.235	0.233	3,778	20.1
1984	38,652	18,842	4,860	4,767	0.087	0.087	1,483	7.9
1985	40,911	20,819	5,578	9,103	0.084	0.084	1,585	7.6
1986	41,075	22,270	6,383	4,587	0.140	0.139	2,737	12.3
1987	41,642	22,747	6,842	5,141	0.115	0.115	2,331	10.2
1988	41,044	22,342	7,243	7,743	0.138	0.137	2,698	12.1
1989	41,550	21,331	6,850	7,512	0.167	0.166	3,105	14.6
1990	41,144	19,719	6,332	10,144	0.140	0.139	2,424	12.3
1991	45,564	20,007	6,246	9,707	0.109	0.108	1,936	9.7
1992	42,859	20,180	6,231	3,755	0.148	0.147	2,612	12.9
1993	42,028	19,673	5,868	10,232	0.216	0.214	3,609	18.3
1994	41,773	18,966	5,515	10,365	0.188	0.187	3,087	16.3
1995	43,195	20,630	5,869	3,052	0.138	0.137	2,519	12.2
1996	41,101	21,138	5,904	2,913	0.220	0.218	3,994	18.9
1997	38,659	21,276	6,277	3,225	0.069	0.068	1,326	6.2
1998	35,293	21,137	6,393	3,851	0.101	0.100	1,909	9.0
1999	33,732	21,558	6,873	5,229	0.144	0.143	2,717	12.6
2000	32,224	20,697	6,913	5,342	0.150	0.149	2,717	13.1

Table 38. Yellowtail rockfish projected yield (mt), biomass (mt), and stock benchmarks, for four stock configurations: Coast-wide (Cst), Eureka/S. Columbia (Eur), N. Columbia (Col), and S. Vancouver (Van), and three models (Ref, Srvon, Fshon).

Projections	RefCst	SrvonCst	FshonCst	RefEur	SrvonEur	FshonEur	RefCol	SrvonCol	FshonCol	RefVan	SrvonVan	FshonVan
Unfished Biomass: B(0)	114,681	115,784	111,751	20,177	20,892	20,863	54,837	52,141	53,436	48,957	49,550	46,746
Unfished Spawning Biomass: SPB(0)	32,541	32,843	31,023	6,771	6,955	6,763	15,095	14,546	14,835	12,524	12,715	11,823
SPB(50%)	16,271	16,422	15,512	3,386	3,478	3,382	7,547	7,273	7,418	6,262	6,358	5,911
SPB(40%)	13,016	13,137	12,409	2,708	2,782	2,705	6,038	5,818	5,934	5,010	5,086	4,729
SPB(25%)	8,135	8,211	7,756	1,693	1,739	1,691	3,774	3,636	3,709	3,131	3,179	2,956
Equilibrium Yield 50%	4,542	4,587	4,413	730	760	757	2,104	1,991	2,029	2,080	2,103	1,975
F(50%)	0.090	0.091	0.090	0.076	0.076	0.076	0.086	0.086	0.087	0.112	0.113	0.111
F(40%)	0.127	0.128	0.127	0.106	0.106	0.106	0.120	0.121	0.122	0.161	0.162	0.159
F(20%)	0.279	0.281	0.277	0.224	0.224	0.223	0.259	0.262	0.266	0.375	0.379	0.368
Projected Recriuitment 2001-2010	11,726	11,843	11,674	1,964	2,043	2,106	5,629	5,321	5,510	5,342	5,402	5,161
Yield 50%												
2001	4,930	5,146	4,158	681	777	711	2,419	2,106	2,253	2,563	2,691	1,953
2002	4,447	4,627	3,899	643	727	688	2,209	1,937	2,117	2,304	2,417	1,850
2003	4,108	4,263	3,741	615	689	669	2,079	1,839	2,028	2,111	2,206	1,789
2004	3,950	4,078	3,693	599	664	658	2,021	1,804	1,983	2,004	2,082	1,770
2005	3,898	4,009	3,716	594	651	655	1,999	1,803	1,963	1,961	2,024	1,780
2006	3,907	4,004	3,771	595	646	656	1,991	1,812	1,955	1,951	2,003	1,800
2007	3,945	4,029	3,834	599	645	659	1,989	1,823	1,951	1,953	1,997	1,822
2008	3,985	4,058	3,893	605	646	663	1,989	1,834	1,950	1,956	1,995	1,841
2009	4,019	4,086	3,942	610	649	666	1,990	1,844	1,950	1,961	1,996	1,856
2010	4,049	4,109	3,982	615	652	670	1,991	1,852	1,950	1,965	1,997	1,868
Total Biomass 50%												
2001	67,664	69,927	61,756	11,077	12,282	11,947	35,016	31,244	34,014	30,833	32,038	26,601
2002	65,849	67,800	61,345	10,935	12,005	11,871	34,130	30,733	33,419	29,750	30,779	26,413
2003	64,866	66,559	61,415	10,875	11,829	11,842	33,567	30,488	33,031	29,076	29,953	26,410
2004	64,494	65,973	61,806	10,879	11,734	11,852	33,230	30,417	32,790	28,717	29,471	26,525
2005	64,473	65,780	62,344	10,921	11,694	11,887	33,023	30,434	32,641	28,551	29,210	26,693
2006	64,627	65,797	62,914	10,983	11,688	11,933	32,892	30,490	32,546	28,487	29,074	26,867
2007	64,849	65,908	63,448	11,052	11,702	11,982	32,807	30,560	32,486	28,470	29,003	27,027
2008	65,077	66,050	63,918	11,120	11,725	12,030	32,755	30,633	32,449	28,475	28,968	27,162
2009	65,288	66,195	64,319	11,183	11,751	12,074	32,723	30,704	32,427	28,489	28,952	27,274
2010	65,472	66,327	64,651	11,239	11,777	12,112	32,703	30,768	32,414	28,507	28,947	27,364
Spawning Biomass 50%												
2001	19,692	20,583	16,091	3,341	3,798	3,232	9,993	8,786	9,317	8,327	8,799	6,296
2002	17,757	18,511	14,960	3,178	3,590	3,205	9,223	8,143	8,777	7,487	7,883	5,899
2003	15,821	16,448	13,888	2,938	3,296	3,086	8,418	7,477	8,215	6,741	7,065	5,605
2004	14,416	14,932	13,178	2,729	3,035	2,956	7,798	6,983	7,781	6,238	6,502	5,458
2005	13,690	14,115	12,893	2,607	2,869	2,869	7,425	6,718	7,511	5,983	6,199	5,436
2006	13,476	13,831	12,928	2,567	2,793	2,834	7,243	6,625	7,370	5,893	6,075	5,487
2007	13,519	13,820	13,123	2,577	2,773	2,835	7,166	6,623	7,305	5,885	6,042	5,565
2008	13,652	13,913	13,360	2,605	2,777	2,851	7,140	6,656	7,278	5,908	6,048	5,643
2009	13,802	14,032	13,584	2,637	2,790	2,872	7,136	6,700	7,269	5,939	6,067	5,711
2010	13,940	14,148	13,776	2,667	2,805	2,892	7,143	6,743	7,269	5,971	6,089	5,766
3-Year average												
Mean Yield 2001-2003	4,495	4,678	3,933	647	731	689	2,236	1,961	2,133	2,326	2,438	1,864
Total Biomass 2003	64,866	66,559	61,415	10,875	11,829	11,842	33,567	30,488	33,031	29,076	29,953	26,410
Spawning Biomass 2003	15,821	16,448	13,888	2,938	3,296	3,086	8,418	7,477	8,215	6,741	7,065	5,605
SPB(2003)/SPB(40%)	122%	125%	112%	108%	118%	114%	139%	129%	138%	135%	139%	119%
10-Year average												
Mean Yield 2001-2010	4,124	4,241	3,863	616	675	669	2,068	1,865	2,010	2,073	2,141	1,833
Total Biomass 2010	65,472	66,327	64,651	11,239	11,777	12,112	32,703	30,768	32,414	28,507	28,947	27,364
Spawning Biomass 2010	13,940	14,148	13,776	2,667	2,805	2,892	7,143	6,743	7,269	5,971	6,089	5,766
SPB(2010)/SPB(40%)	107%	108%	111%	98%	101%	107%	118%	116%	123%	119%	120%	122%

10.0 Figures

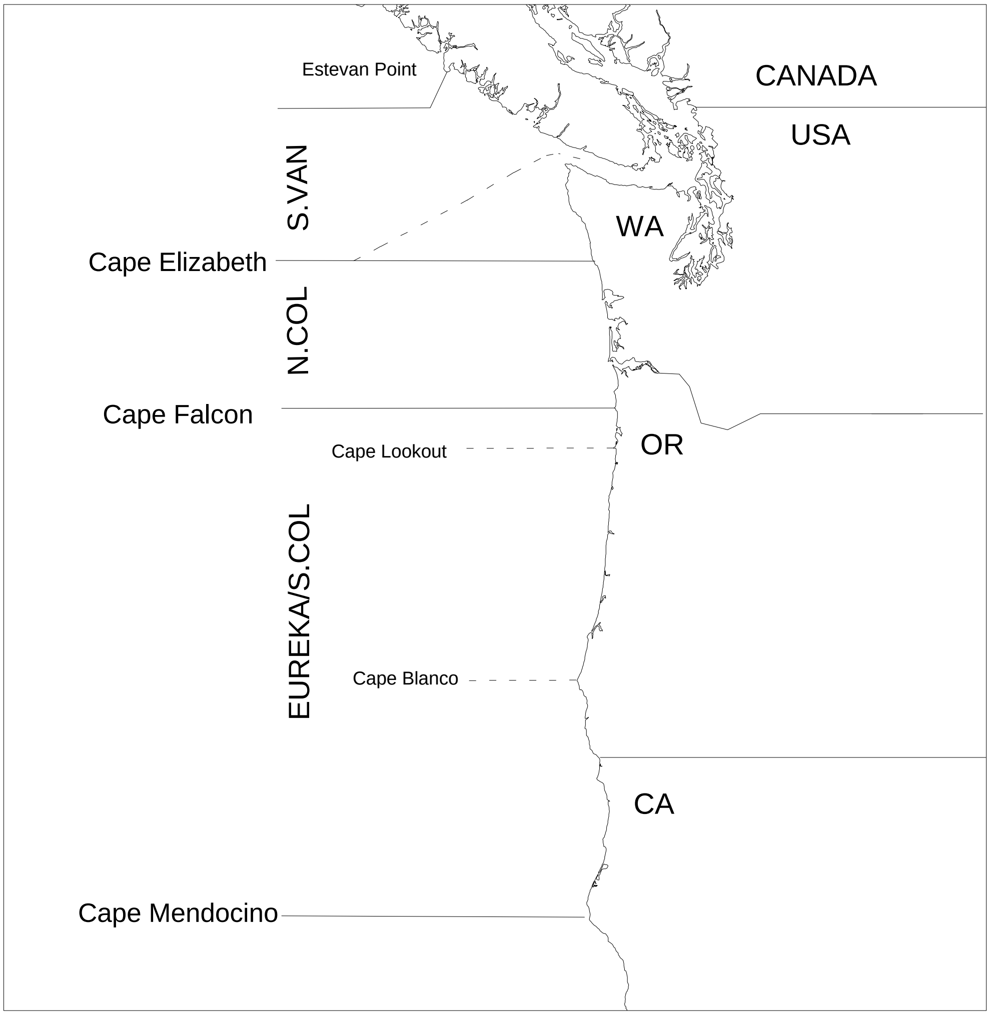
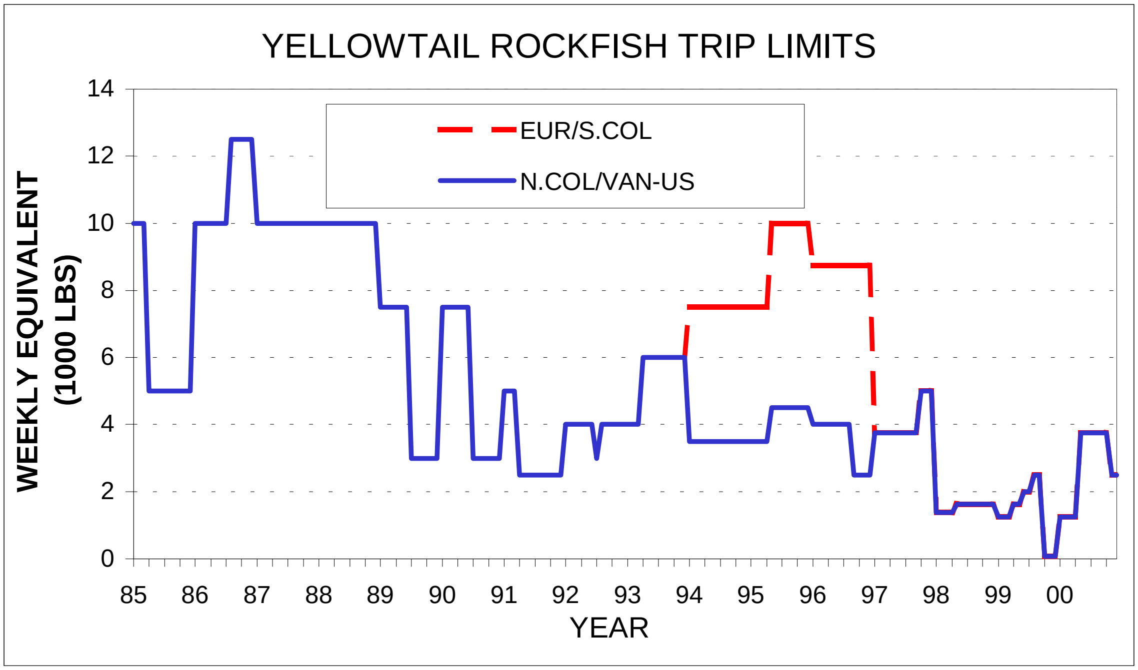


Figure 1. Yellowtail rockfish stock boundaries.



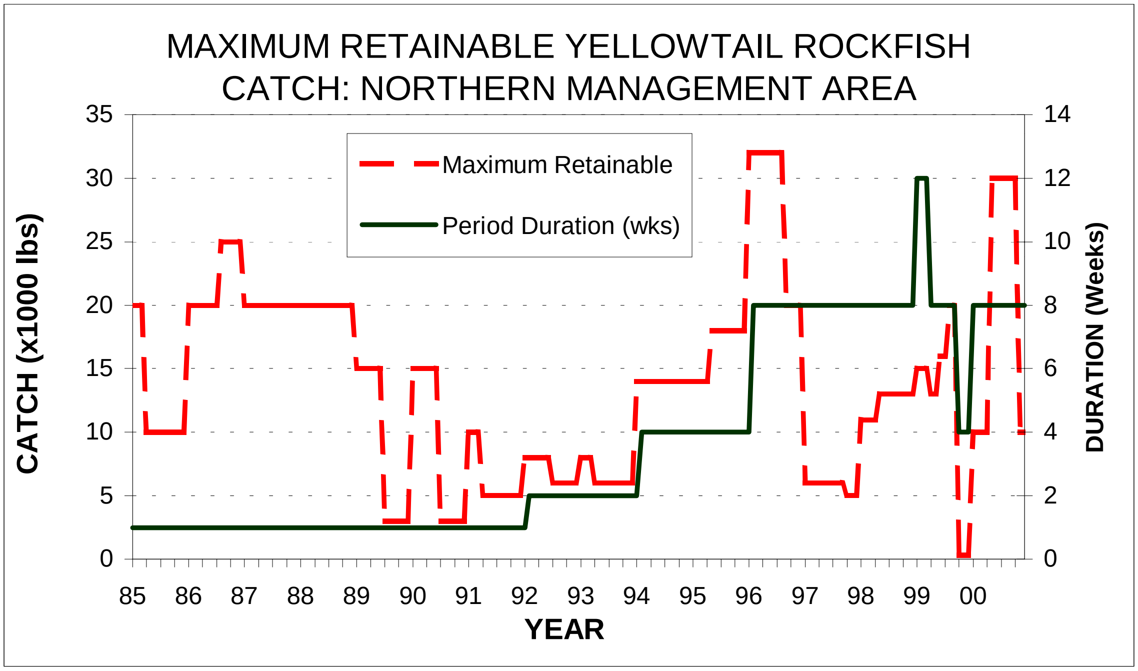


Figure 2. Yellowtail rockfish weekly equivalent trip limits and maximum retainable catch, 1985 to 1999 for areas north of Cape Mendocino.

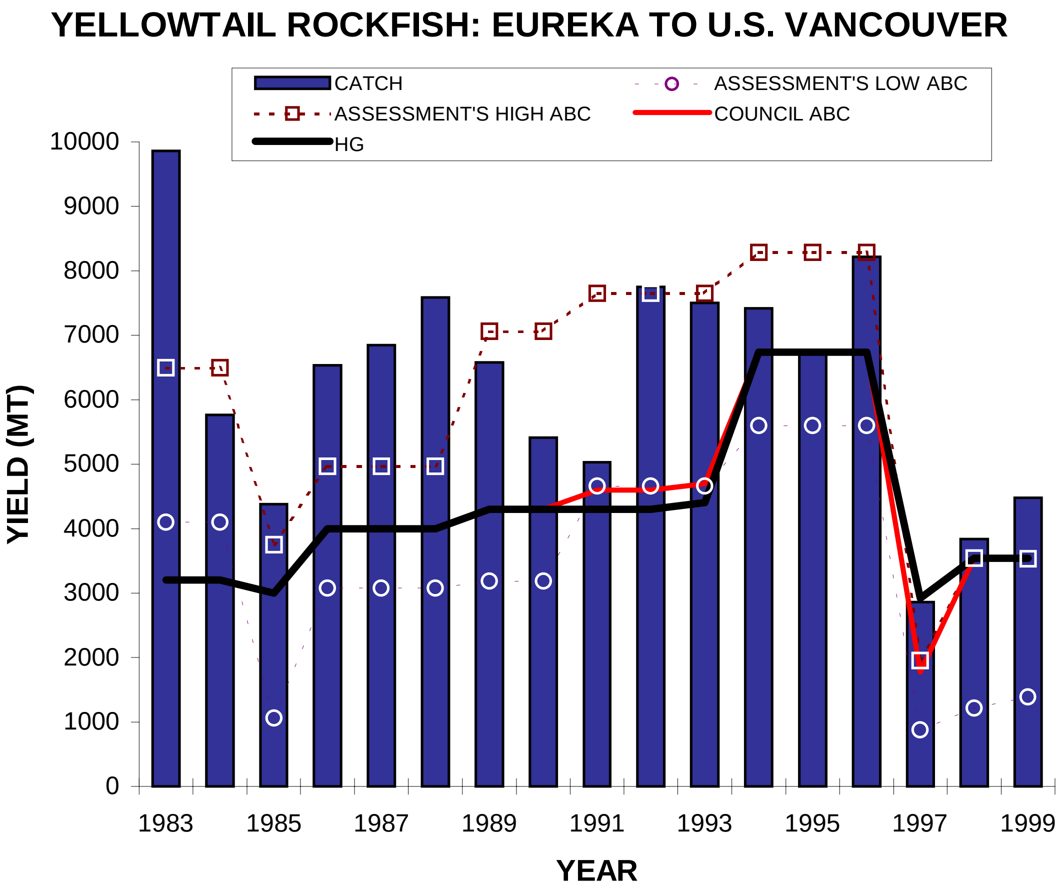


Figure 3. Comparison of stock assessment estimated and PFMC selected yellowtail rockfish ABCs and HGs for the U.S. portion of the Eureka to Vancouver stock assessment areas. [Low and High ABCs are from the stock assessment estimates, Council ABC is the “official” or designated ABC for the stock, in 1998 and 1999 the displayed HG is actually the Council’s OY]

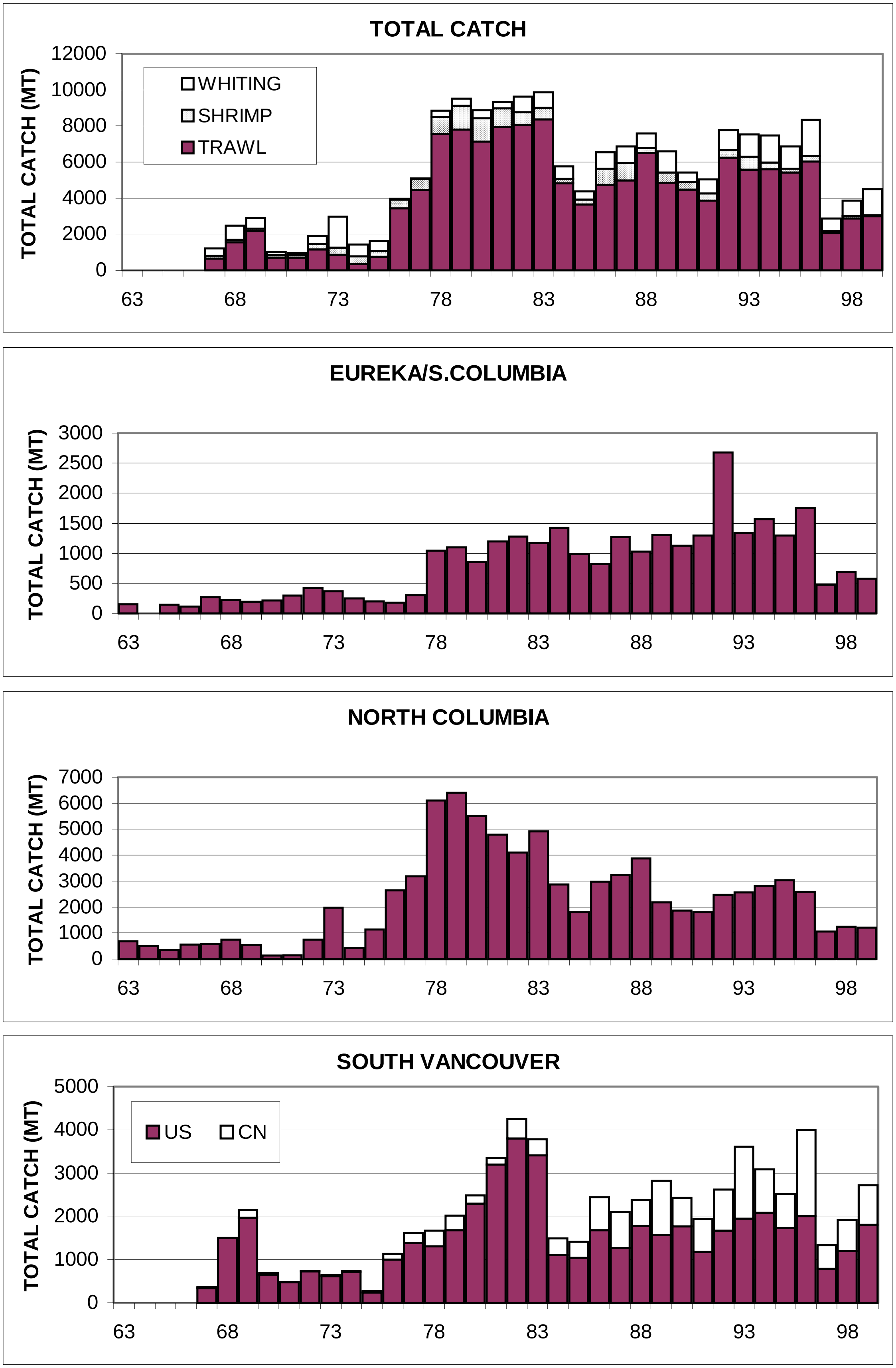


Figure 4. Yellowtail rockfish catch (mt), 1963-1999.

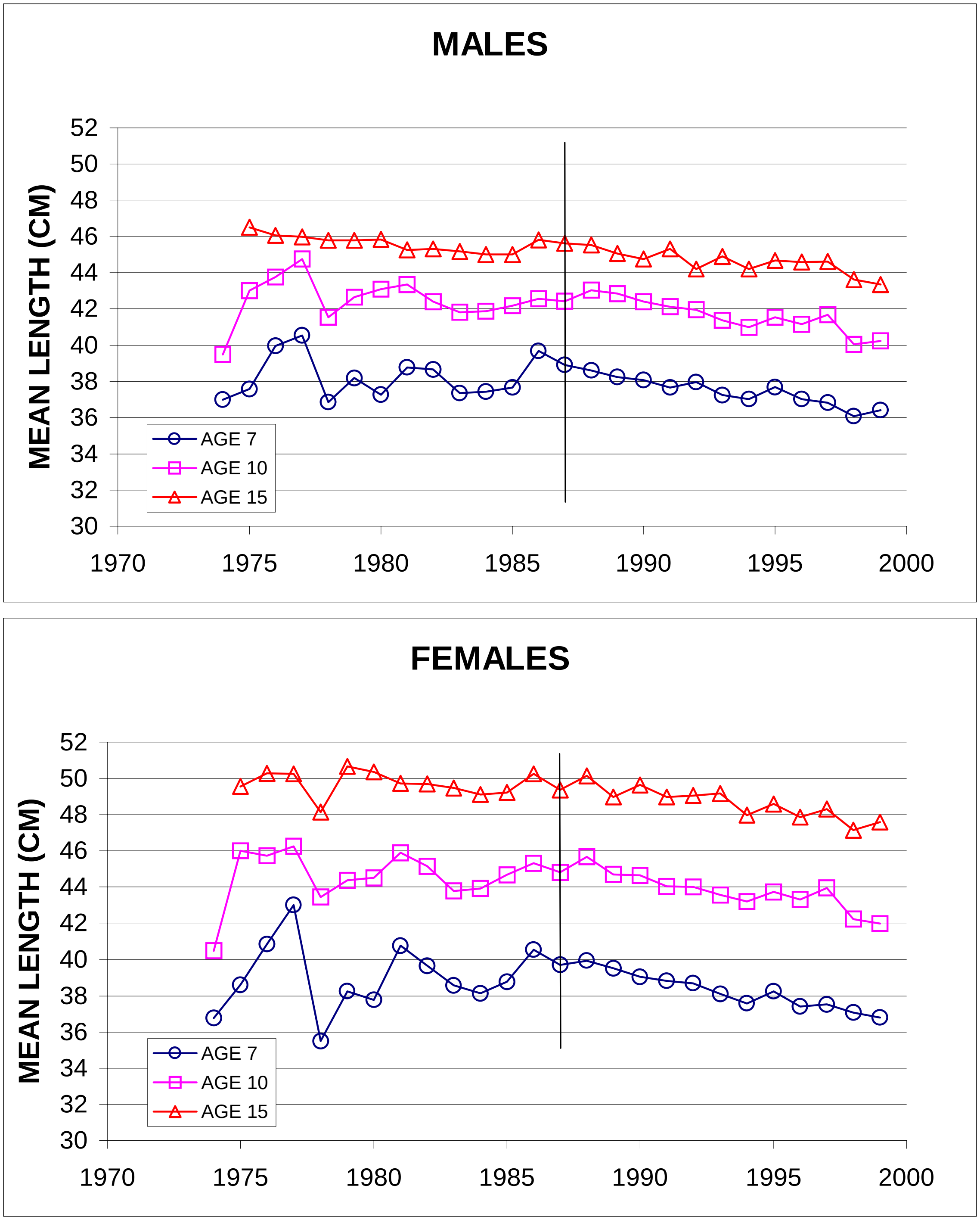


Figure 5. The coast-wide yellowtail rockfish mean size-at-age, 1974 to 1999. [The vertical line is drawn through the 1987 data points.]

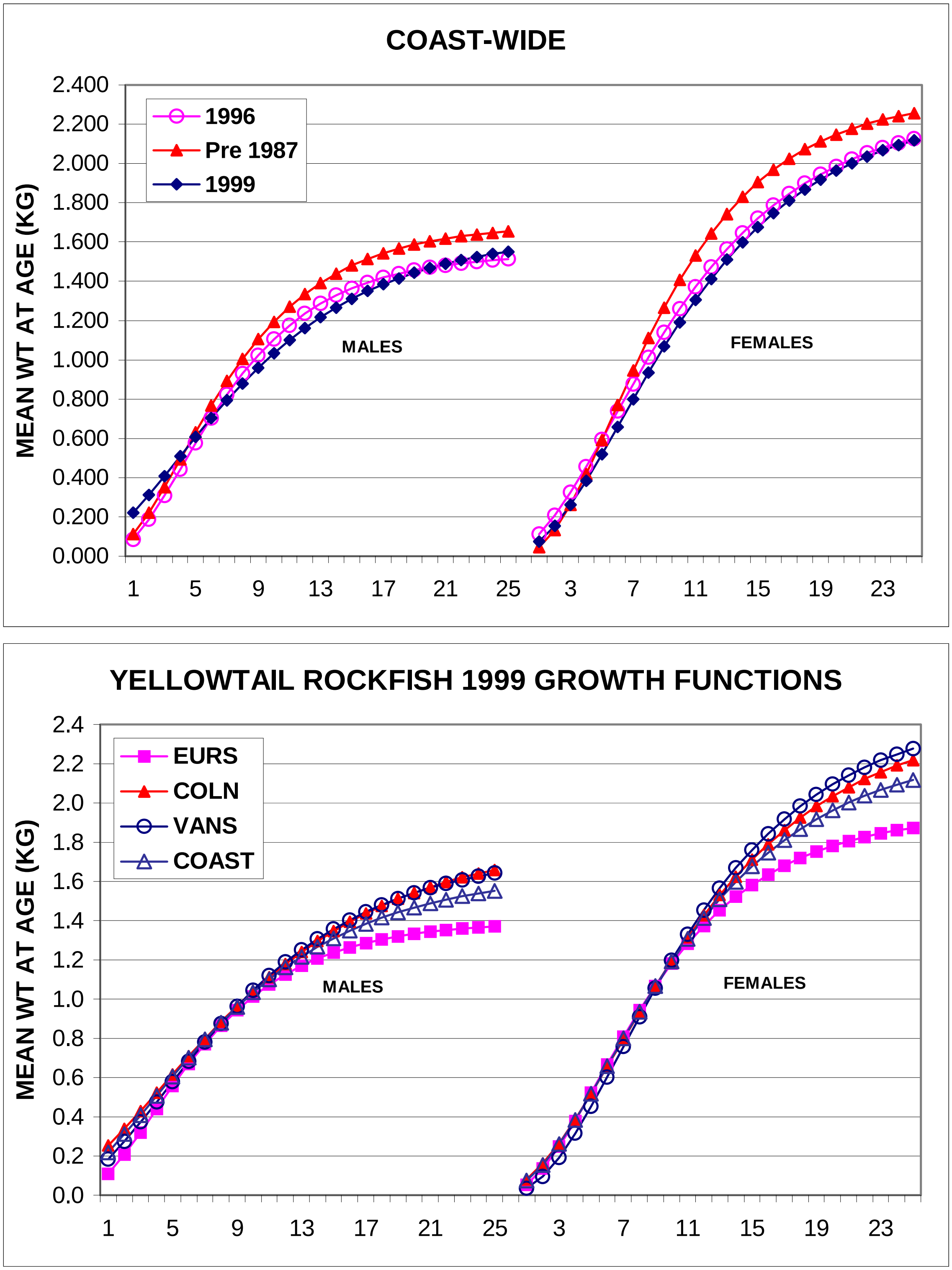


Figure 6. Comparison of yellowtail rockfish von Bertalanffy growth functions over time and among stocks.

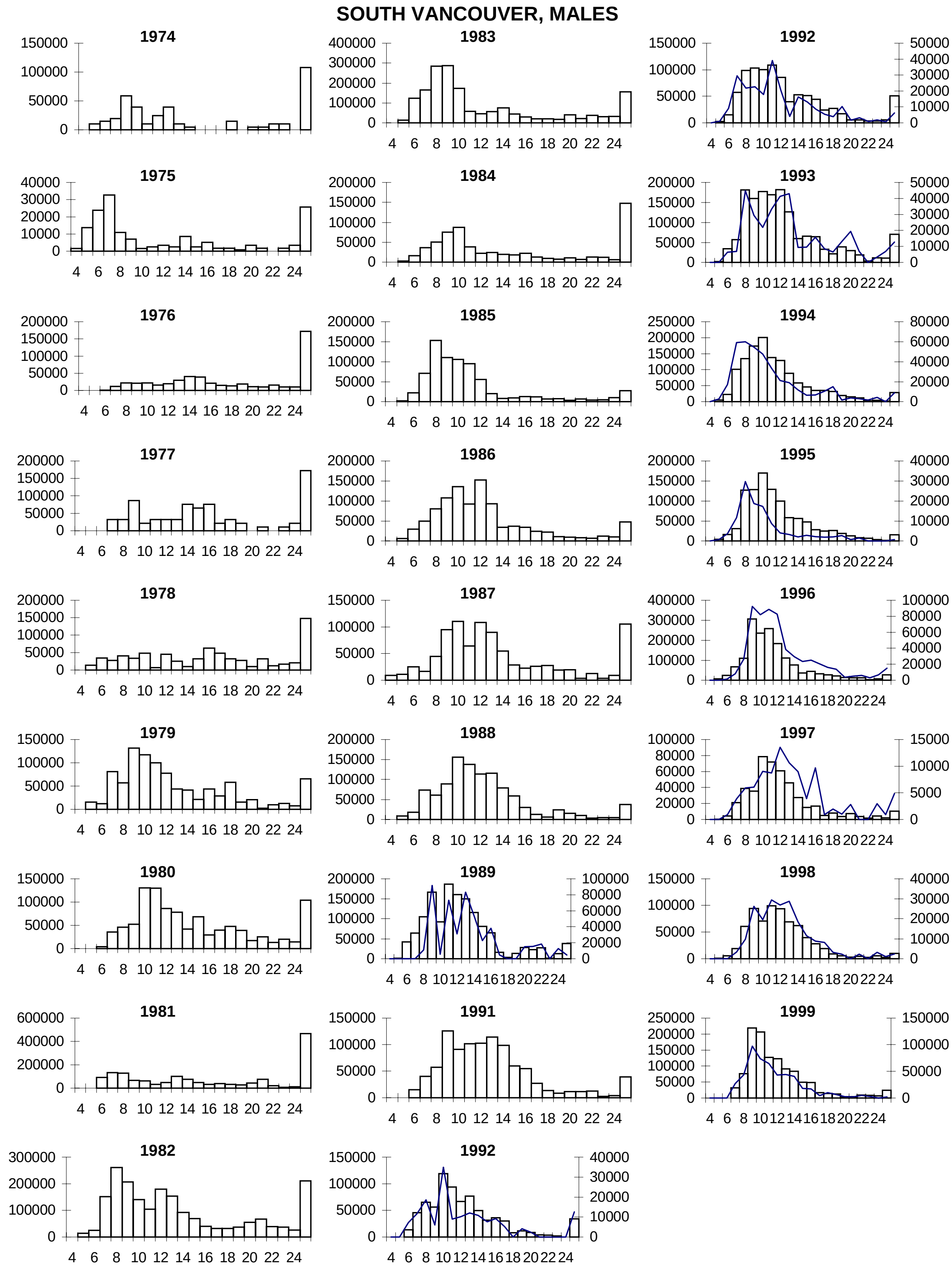


Figure 7. South Vancouver area yellowtail rockfish catch-at-age (numbers). [Histogram (left Yaxis) represents the age distribution of all fisheries combined; the overlapping line graph (right Y axis) represents the age distribution for the whiting fishery].

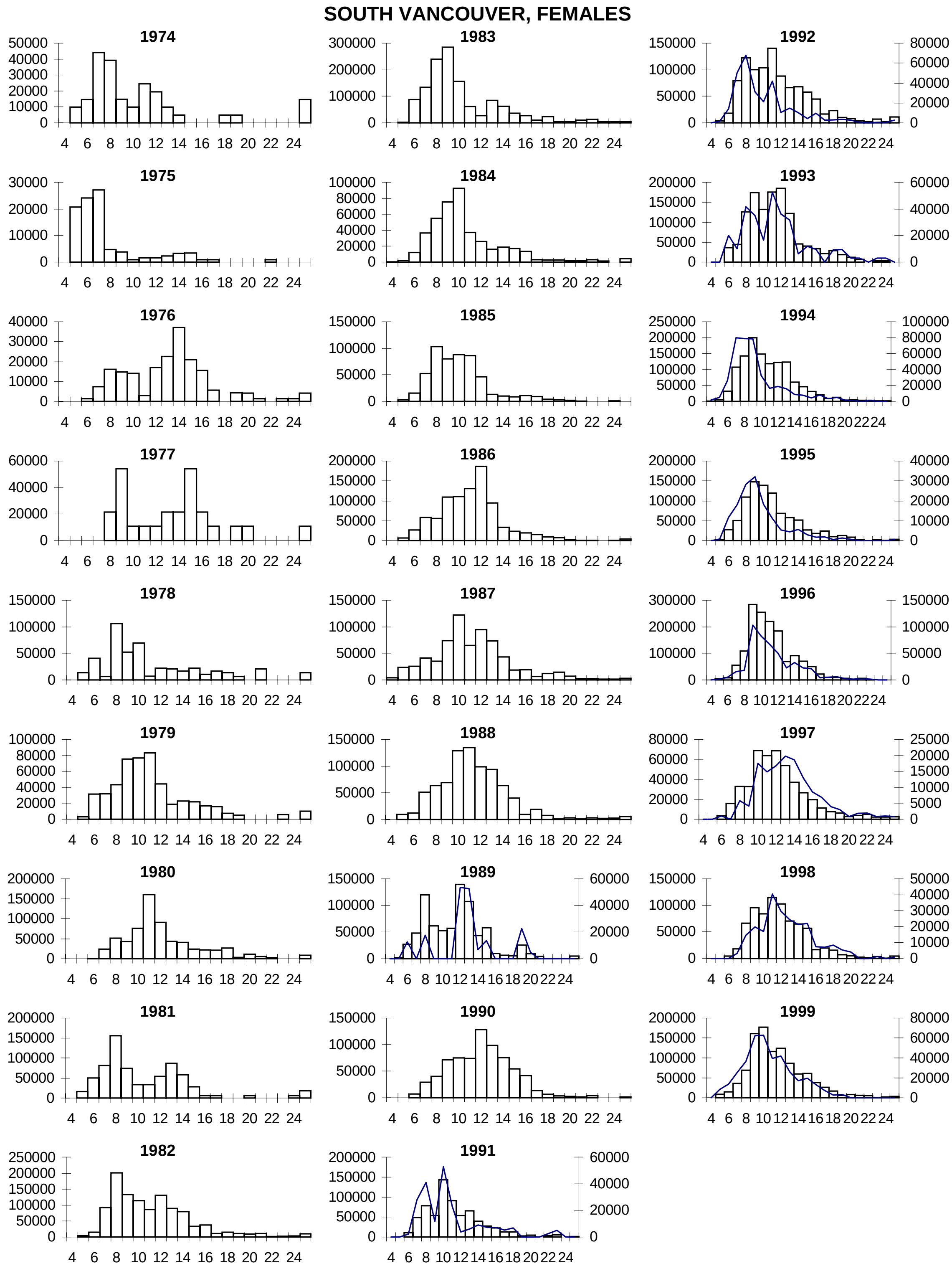


Figure. 7. (Continued) South Vancouver area yellowtail rockfish catch-at-age (numbers). [Histogram (left Yaxis) represents the age distribution of all fisheries combined; the overlapping line graph (right Y axis) represents the age distribution for the whiting fishery].

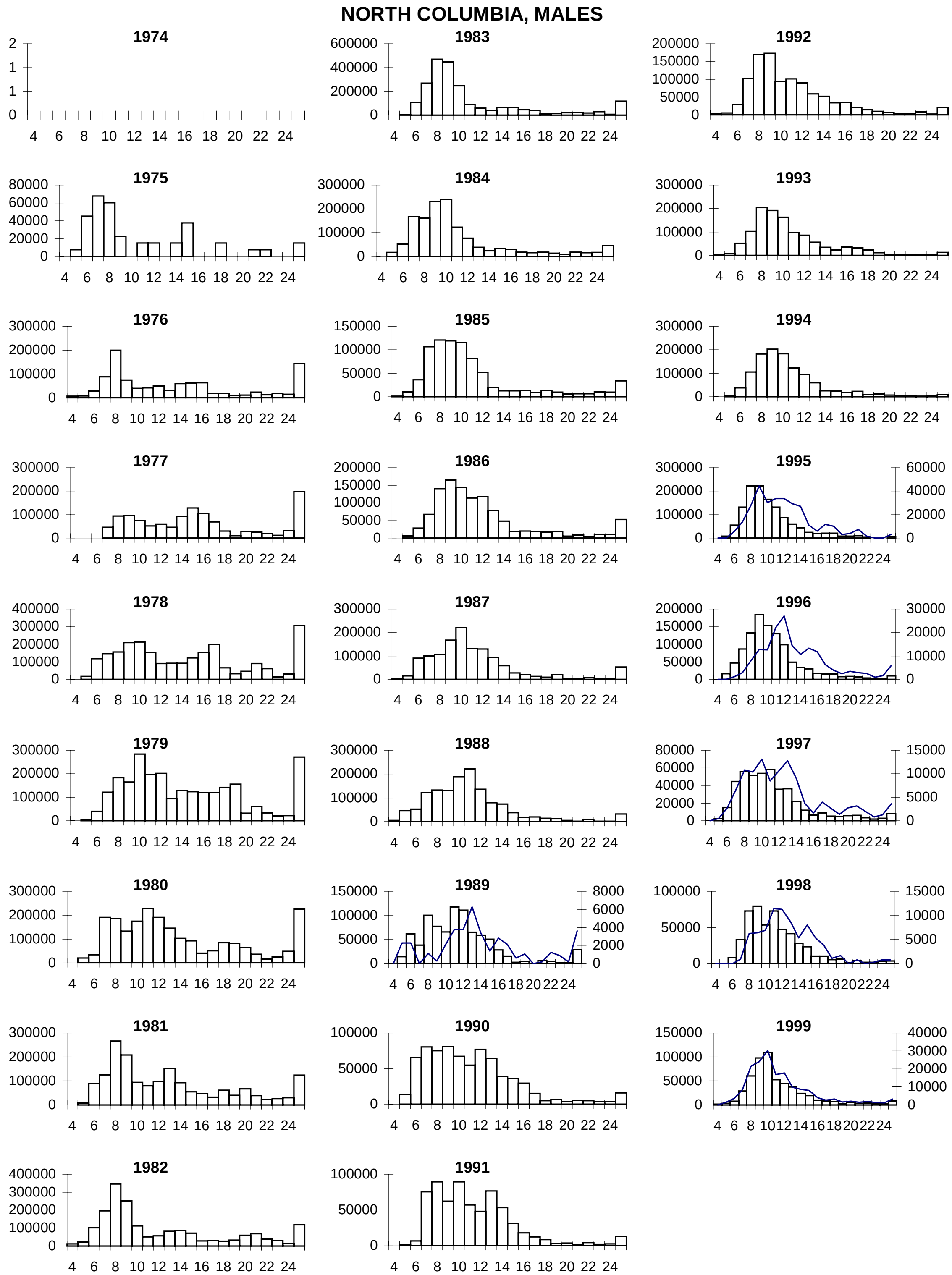


Figure 8. North Columbia area yellowtail rockfish catch-at-age (numbers). [Histogram (left Yaxis) represents the age distribution of all fisheries combined; the overlapping line graph (right Y axis) represents the age distribution for the whiting fishery].

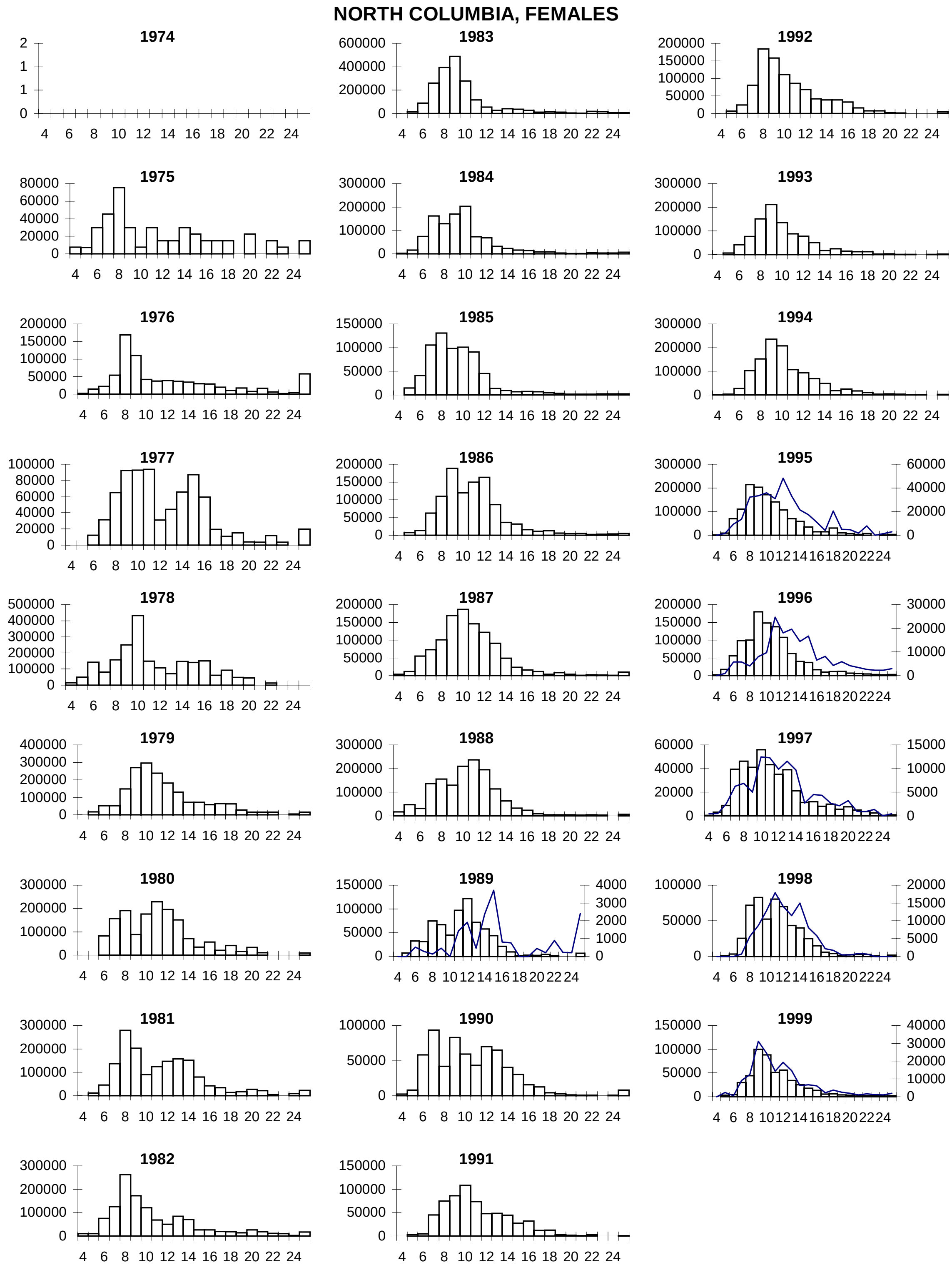


Figure. 8. (Continued) North Columbia area yellowtail rockfish catch-at-age (numbers). [Histogram (left Yaxis) represents the age distribution of all fisheries combined; the overlapping line graph (right Y axis) represents the age distribution for the whiting fishery].

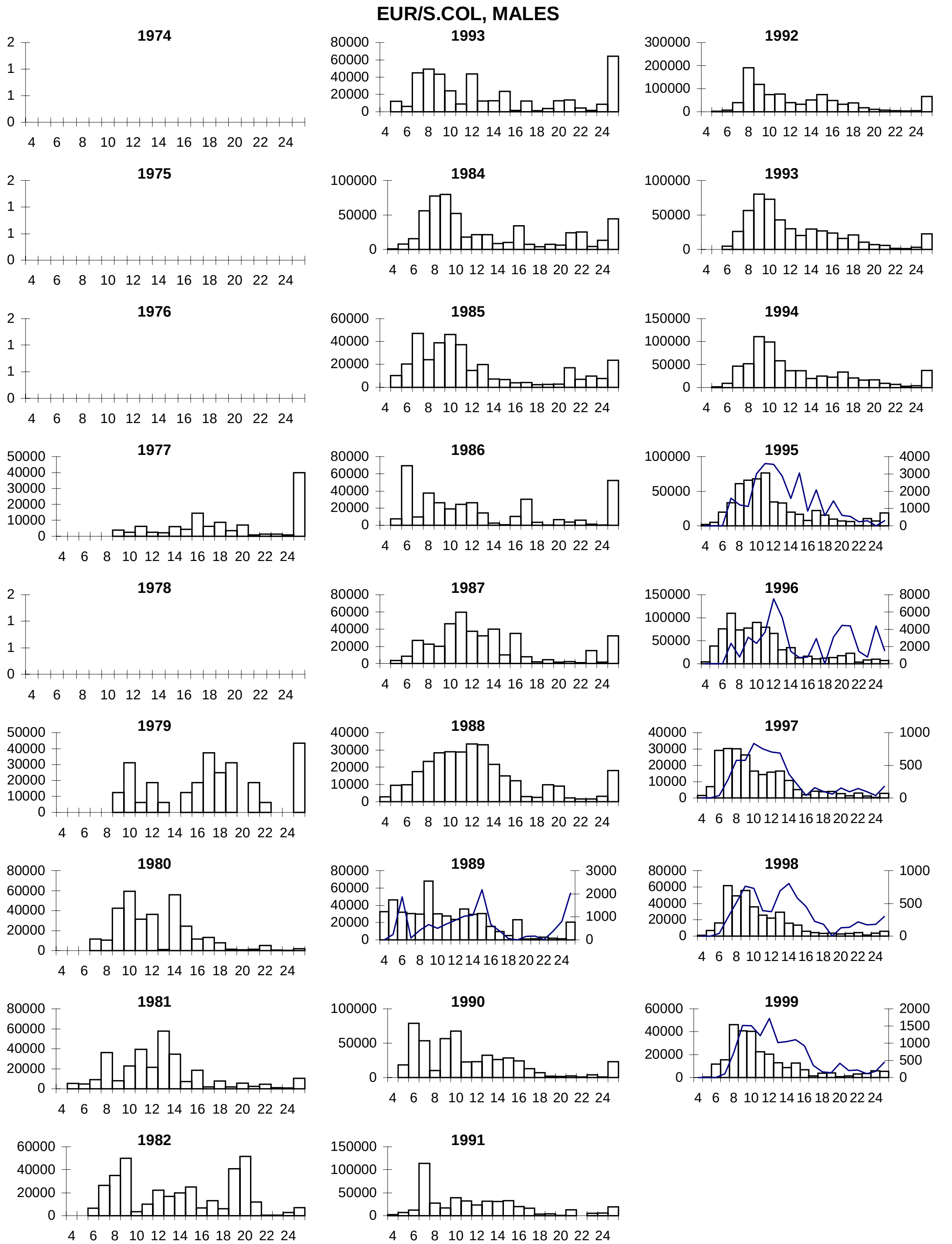


Figure 9. Eureka/S.Columbia area yellowtail rockfish catch-at-age (numbers). [Histogram (left Y axis) represents the age distribution of all fisheries combined; the overlapping line graph (right Y axis) represents the age distribution for the whiting fishery].

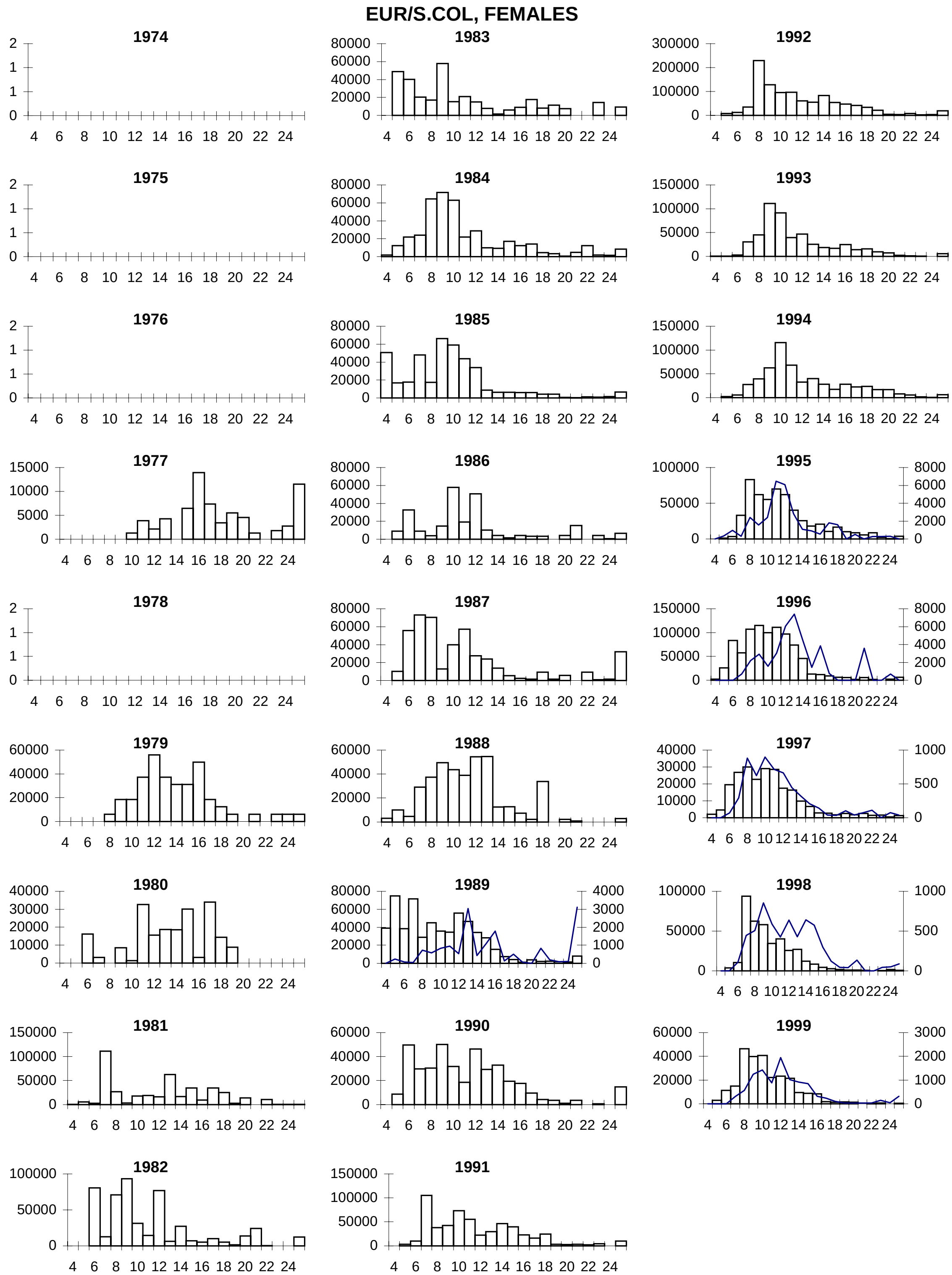


Figure. 9. (Continued) Eureka/S.Columbia area yellowtail rockfish catch-at-age (numbers). [Histogram (left Y axis) represents the age distribution of all fisheries combined; the overlapping line graph (right Y axis) represents the age distribution for the whiting fishery].

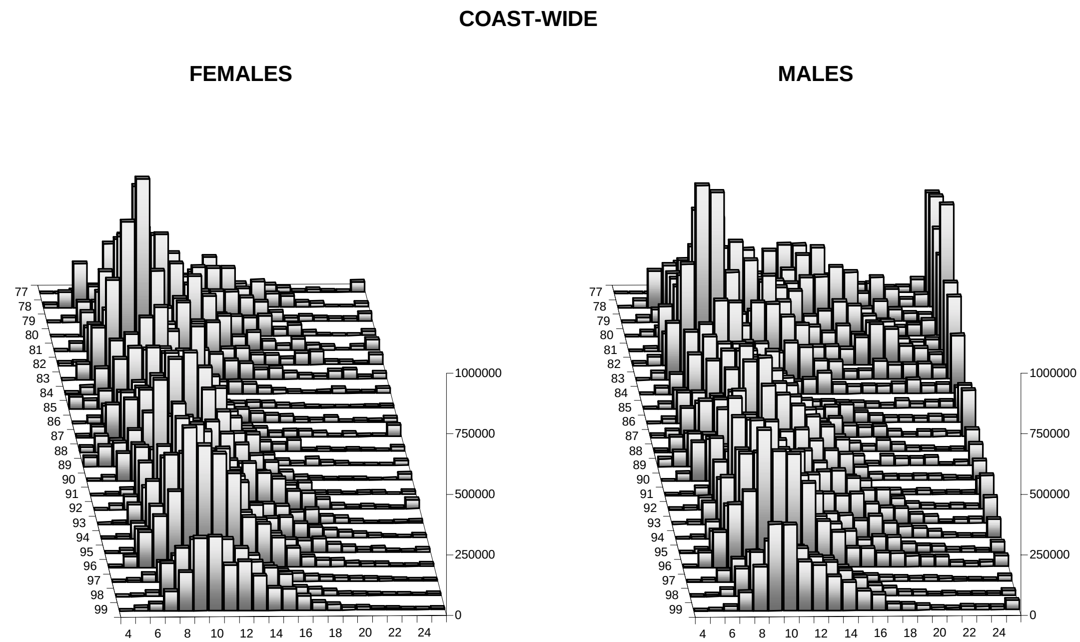


Figure 10. Yellowtail rockfish catch-at-age (numbers) for the Coast-wide stock, 1977-1999.

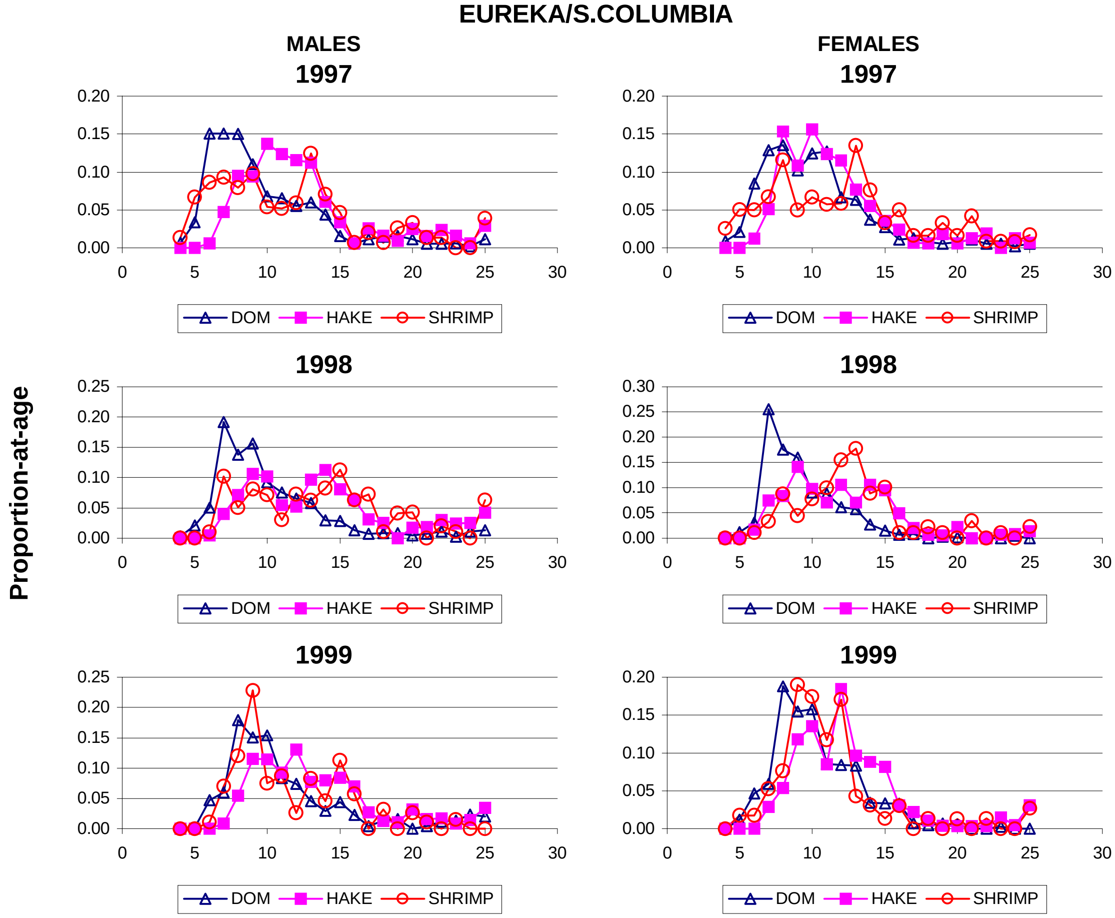


Figure 11. Comparison of the yellowtail rockfish age distributions for the domestic directed trawl (DOM), shrimp trawl (SHRIMP) and whiting (HAKE) fisheries, 1997-1999.

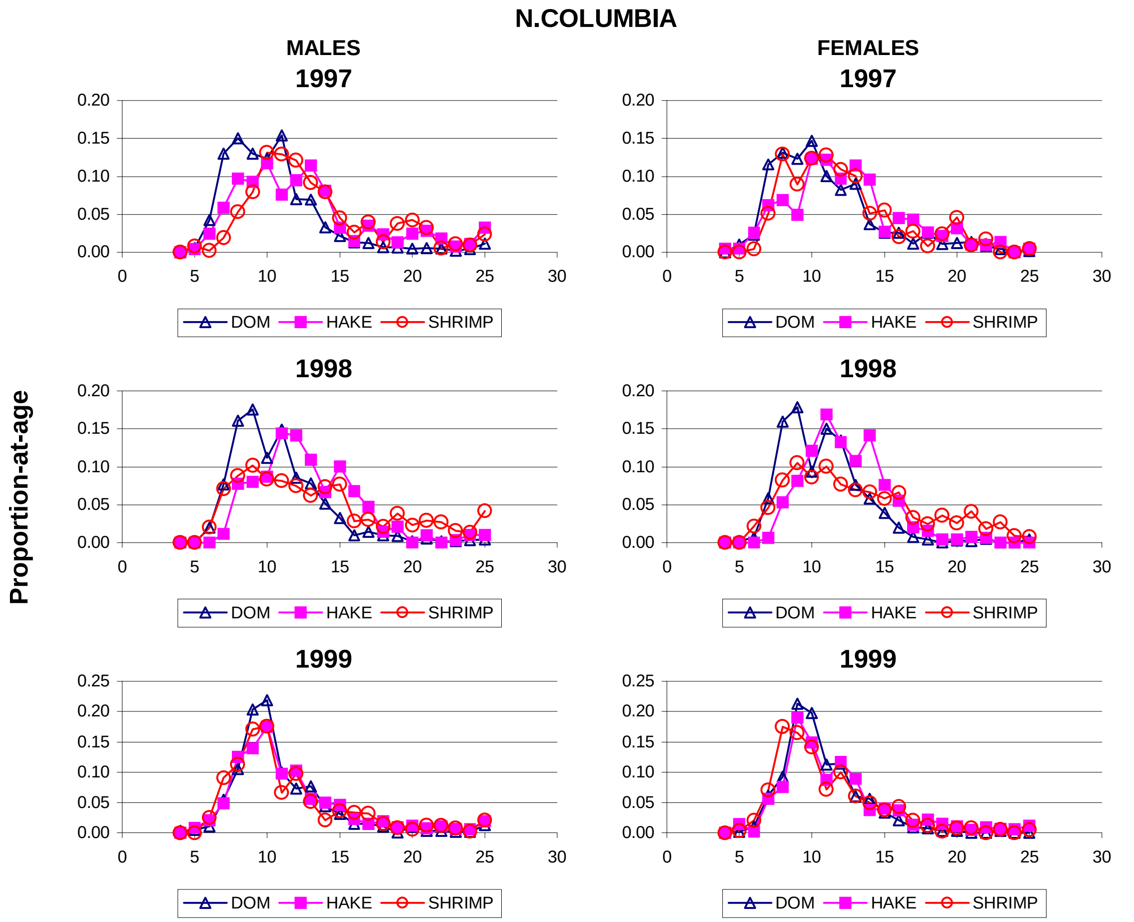


Figure 11. (Continued) Comparison of the yellowtail rockfish age distributions for the domestic directed trawl (DOM), shrimp trawl (SHRIMP) and whiting (HAKE) fisheries, 1997-1999.

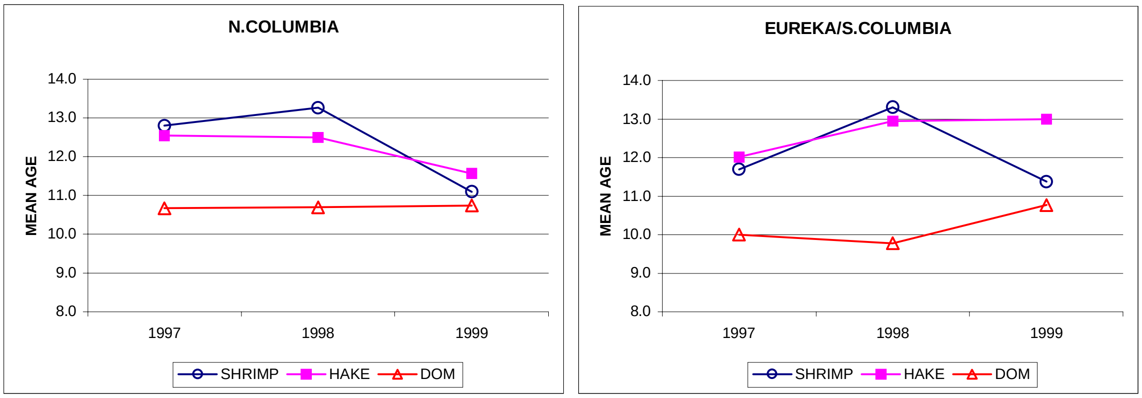


Figure 12. Mean age of landed yellowtail rockfish for each of three commercial fisheries, 1997-1999.

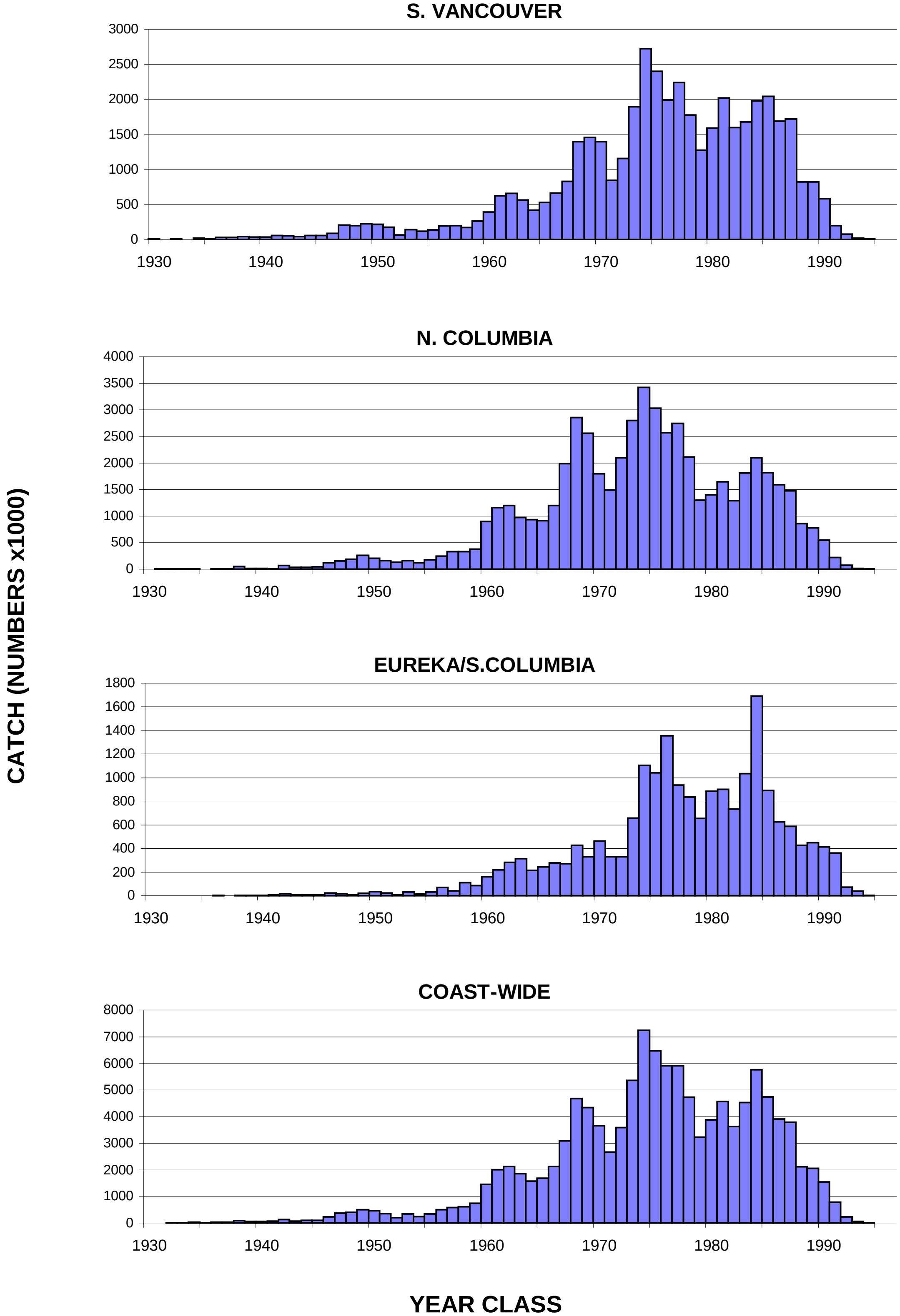


Figure 13. Yellowtail rockfish landed catch (numbers) by year class.

C0AST-WIDE

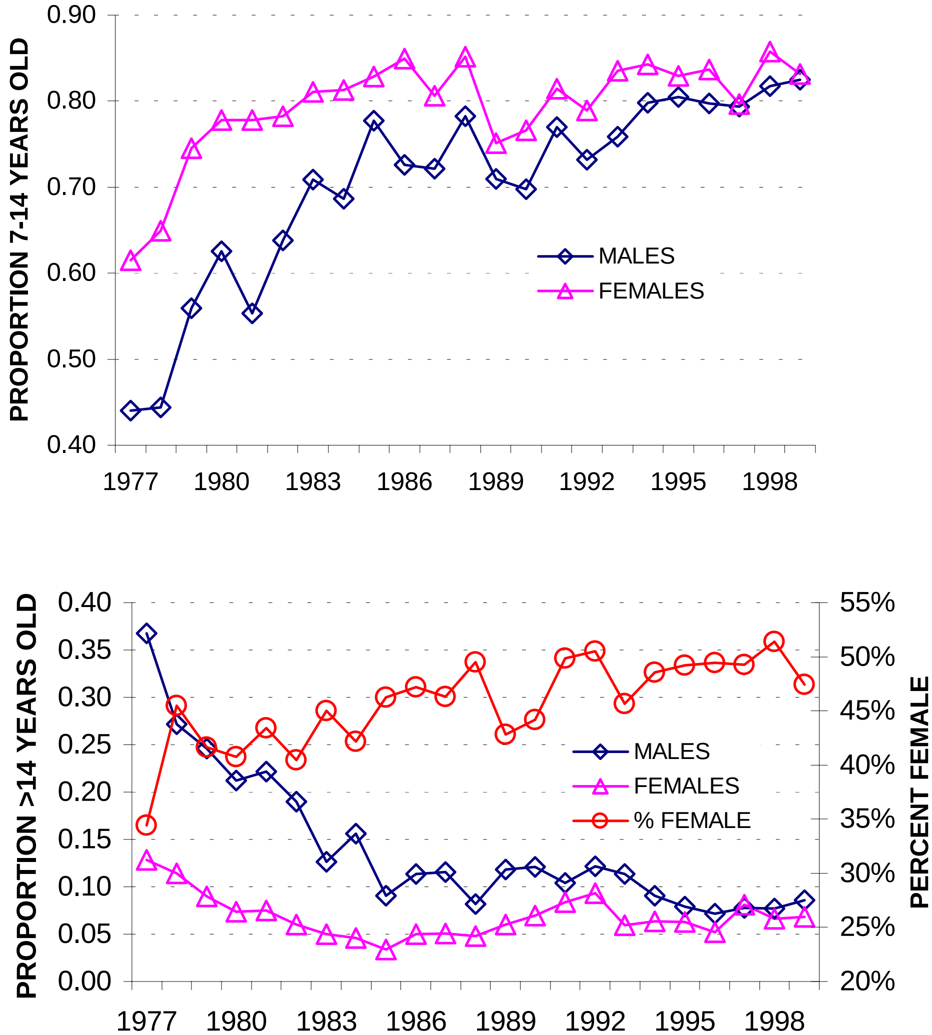


Figure 14. Yellowtail rockfish changes in catch proportion-at-age for various age and sex groupings.

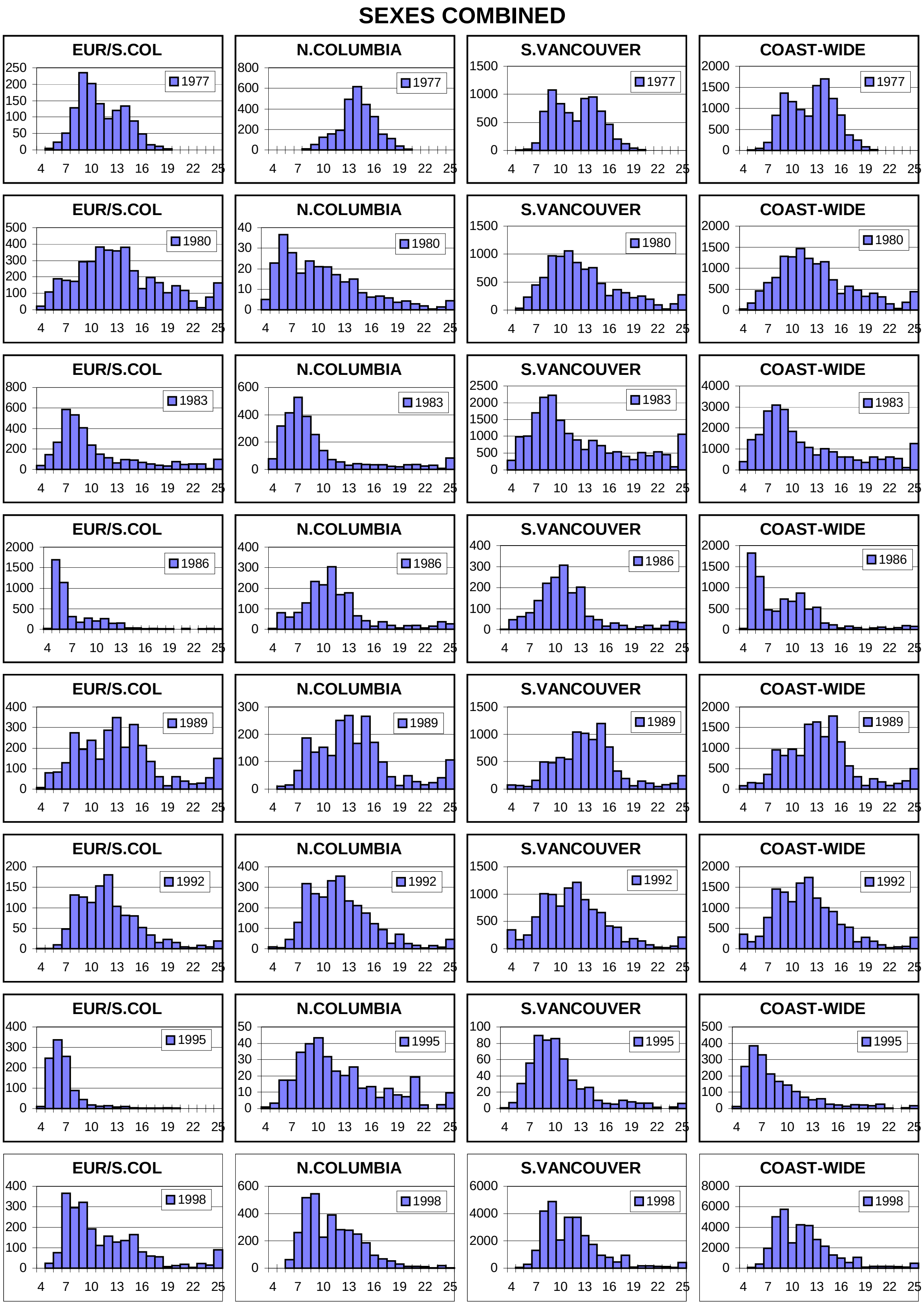


Figure 15. NMFS triennial trawl survey yellowtail rockfish numbers-at-age.

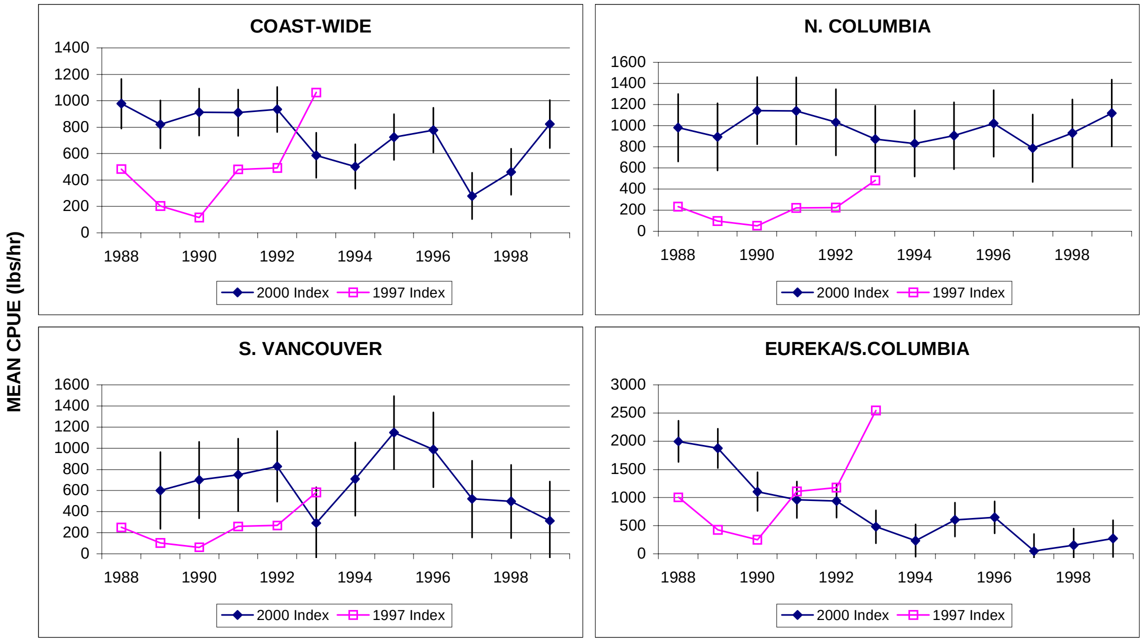


Figure 16. Yellowtail rockfish domestic trawl CPUE (lbs/hr) index. (Error bars are ± one standard deviation)

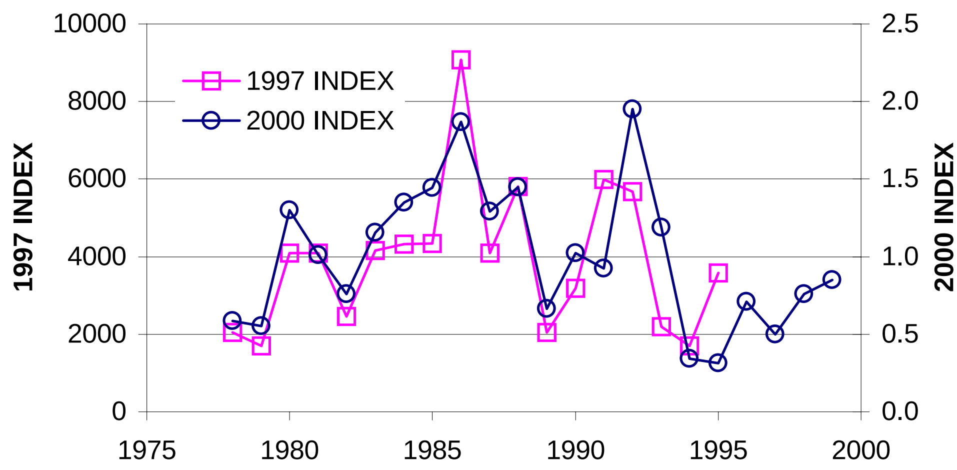


Figure 17. Yellowtail rockfish whiting bycatch index, 1978-1999.

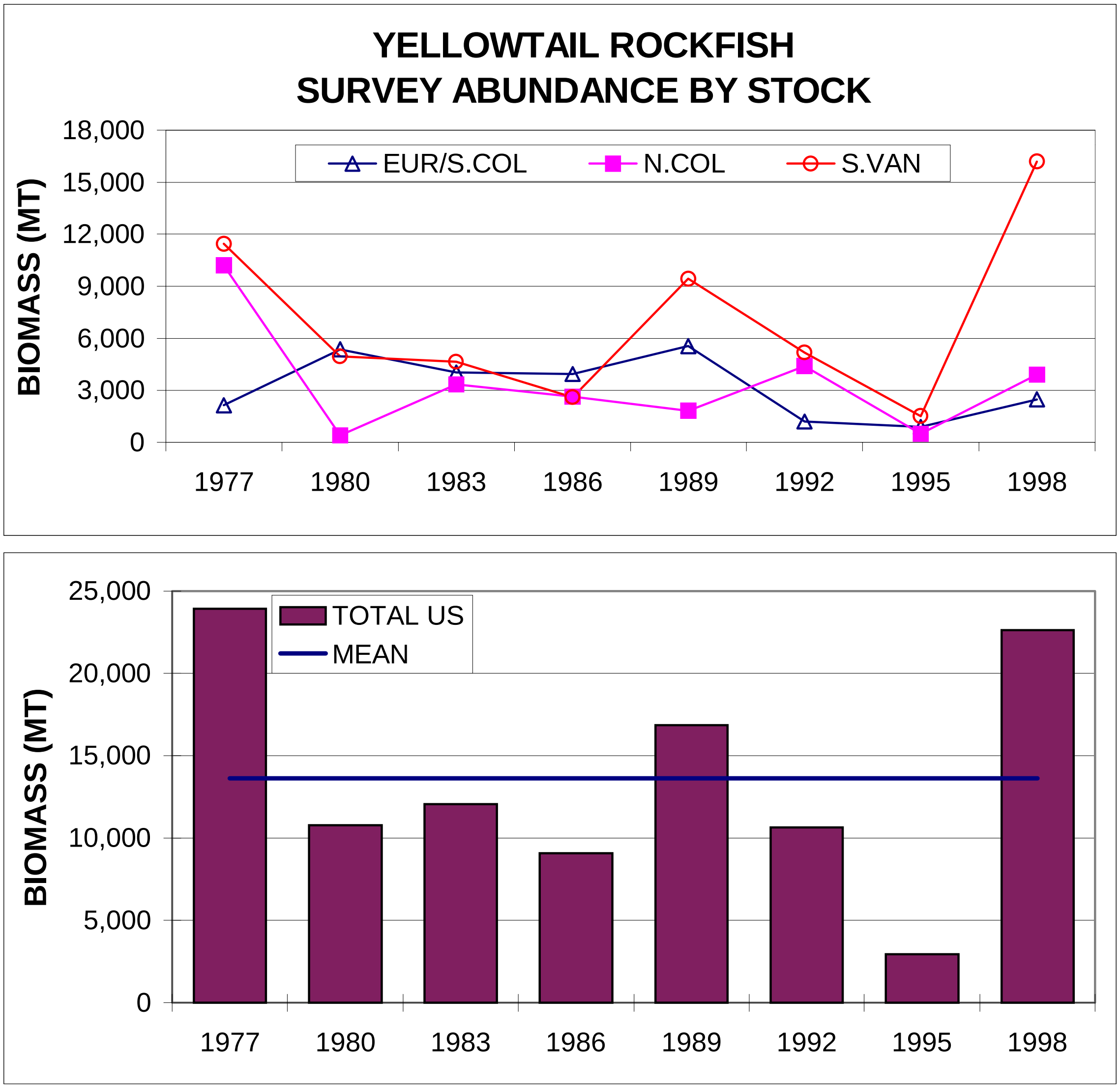


Figure 18. NMFS triennial survey estimated yellowtail rockfish biomass, 1977-1998. [in the top panel, S.VAN index is from the US portion of the S.Vancouver area only.]

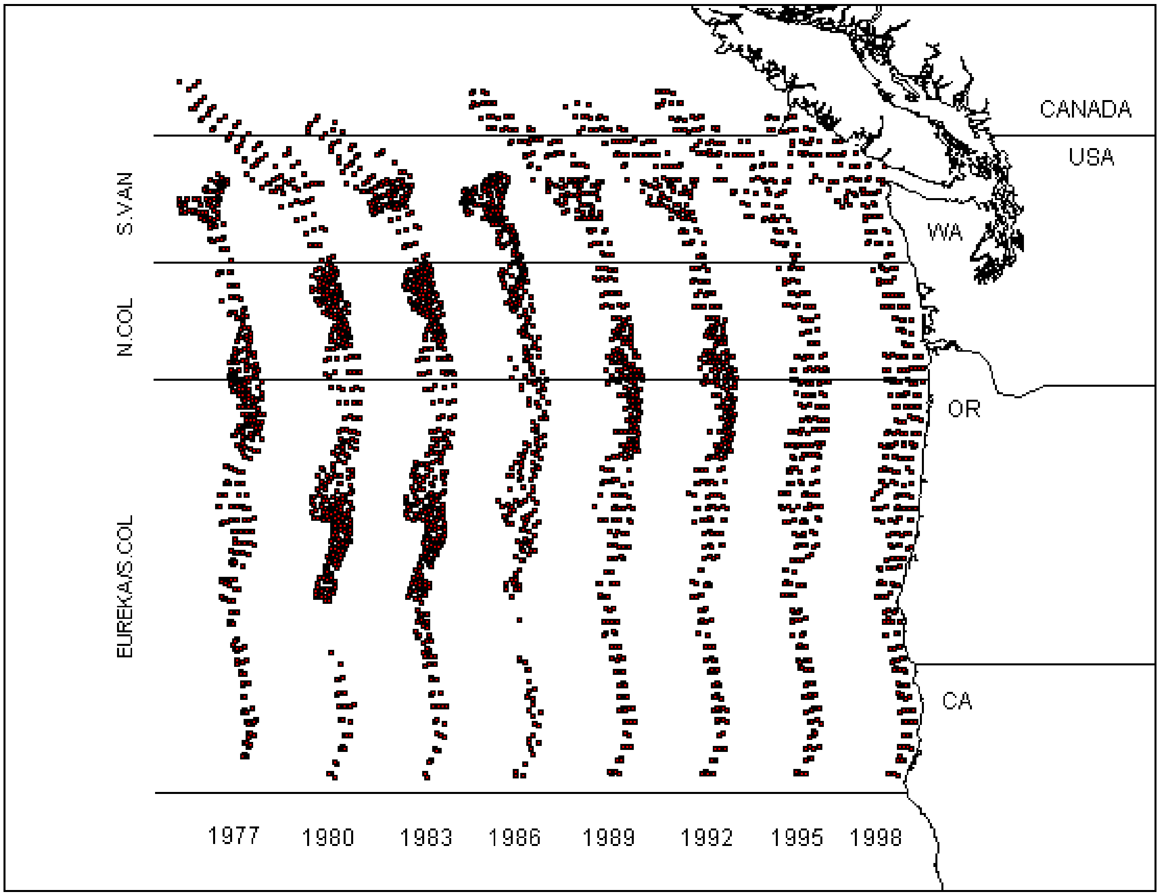


Figure 19. NMFS triennial trawl survey haul locations, 1977-1998. (Note that each annual data set, 1977-1995, is displaced longitudinally for illustrative purposes only, all hauls were adjacent to the shoreline as shown for the 1998 data set.)

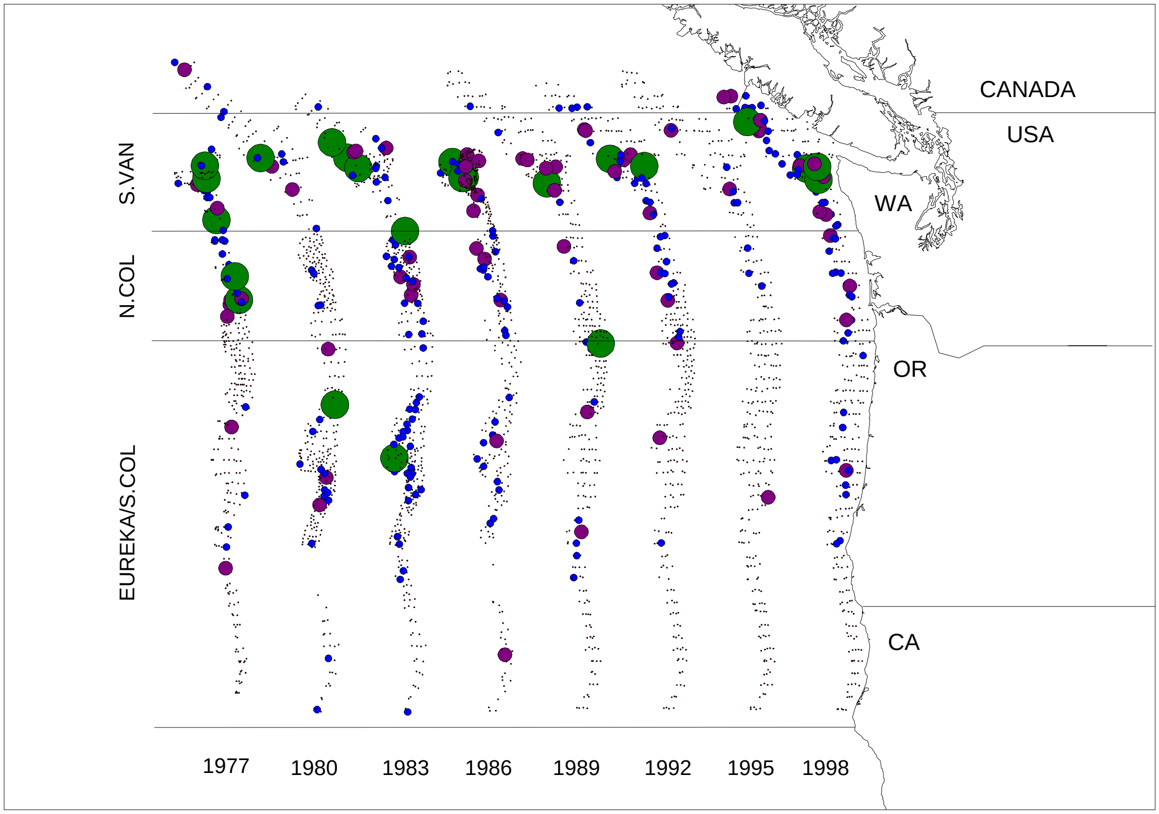
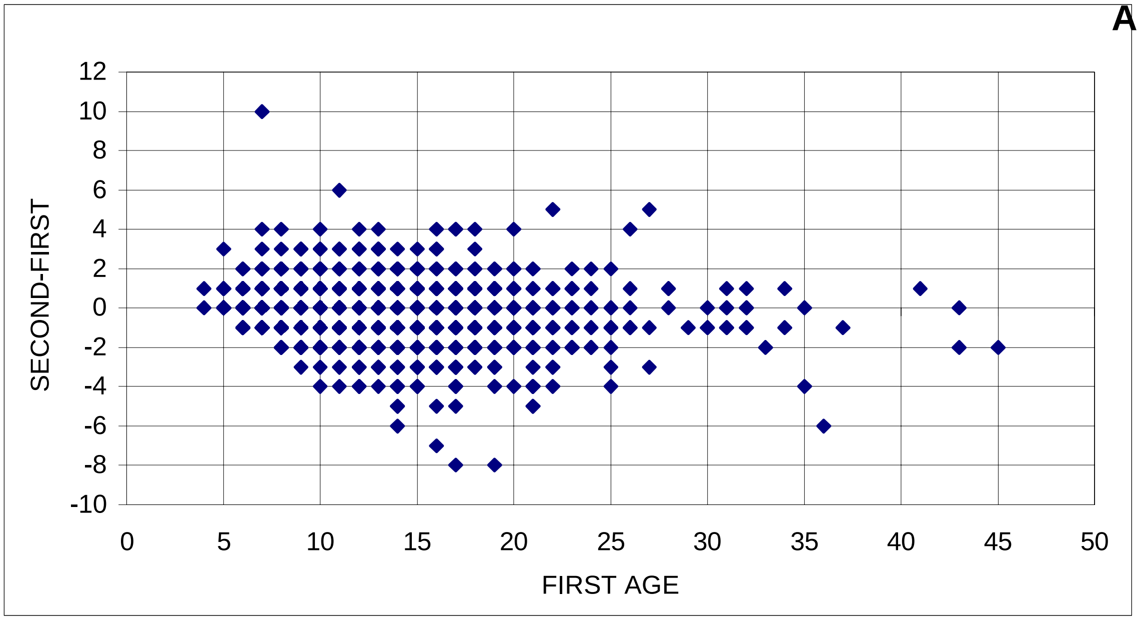


Figure 20. NMFS triennial trawl survey estimated catch weight-per-unit area (kg/ha), 1977-1998. [There are four catch levels displayed: 0-3 kg/ha, 3-30 kg/ha, 30-200 kg/ha, and 200-1200 kg/ha. See Table 21 for the frequency distribution by year]



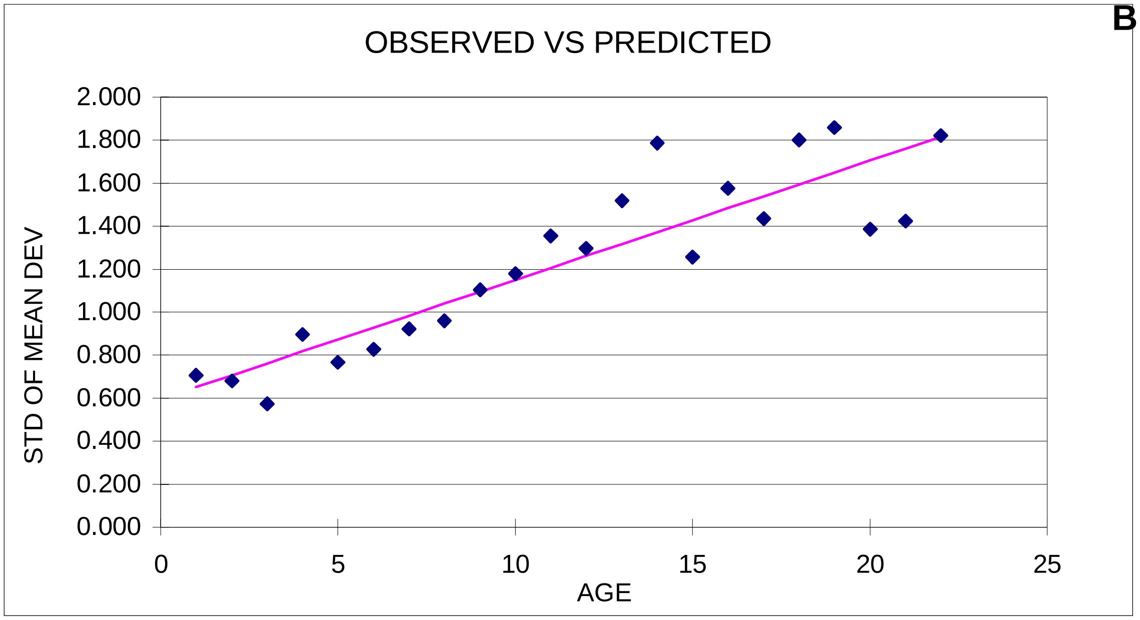


Figure 21. Variability in the replicate age assignment of Yellowtail rockfish. (Ageing error) Panel A represents the deviations between the first and second age assignment for the same age structure. Panel B shows the estimated standard deviation for the mean deviation between first and second age, and a predicted line through the standard deviations.

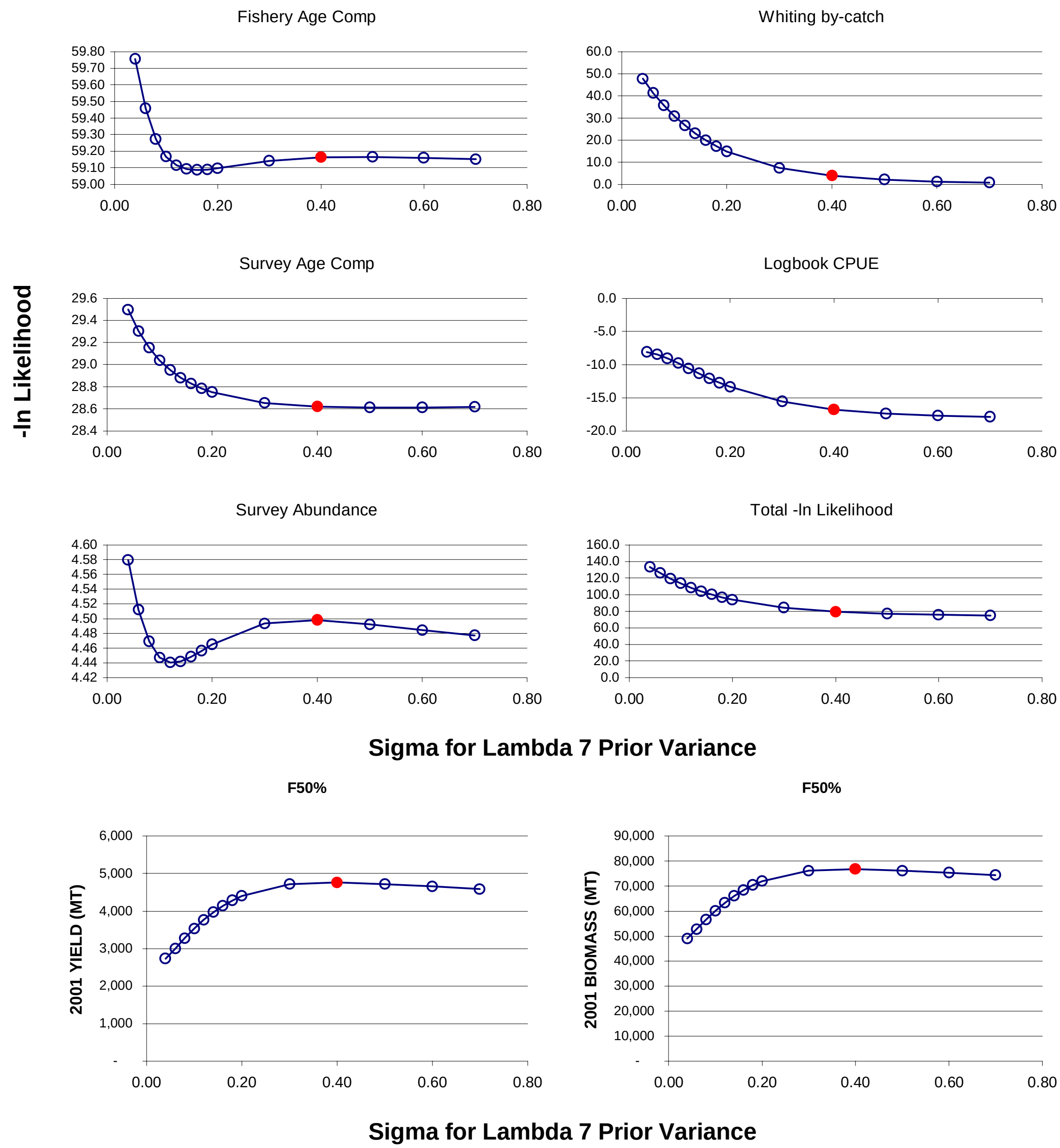
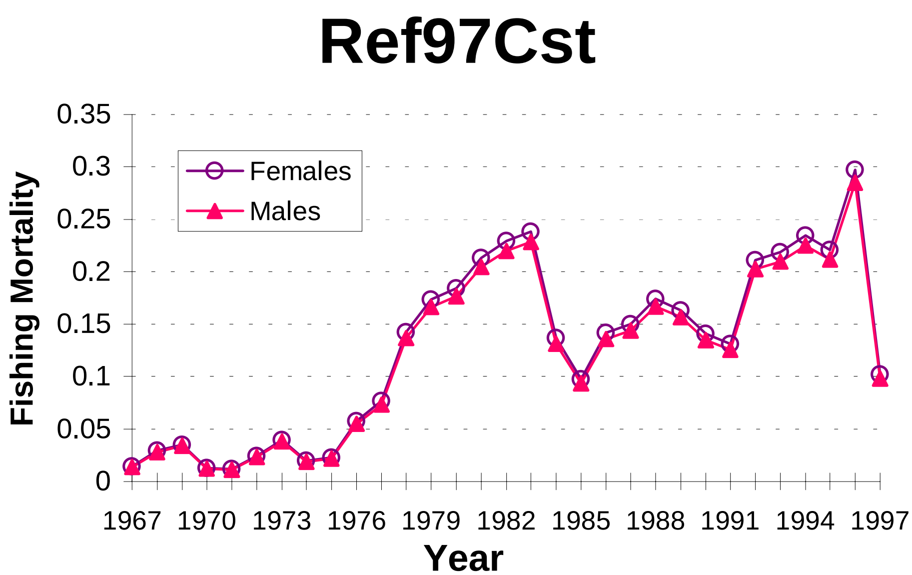


Figure 22. Likelihood profile of the yellowtail rockfish Ref model sensitivity to the prior variance on trawl logbook and whiting bycatch catchability. [λ_7^f and λ_7^w are the prior variance terms for the logbook CPUE and whiting bycatch indices. $\lambda = \left(1/2\sigma^2\right)$. The 1997 assessment arbitrarily set sigma to a value of 0.4]



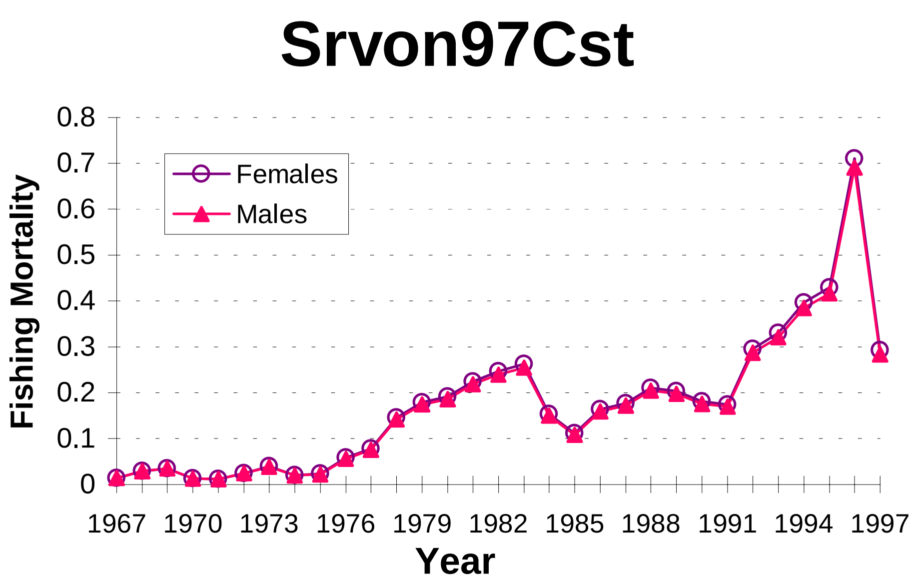


Figure 23. Retrospective comparison of the estimated fishing mortality rates from the Ref and Srvon Models using data through 1997. [Excludes 1998 trawl survey biomass and age data.]

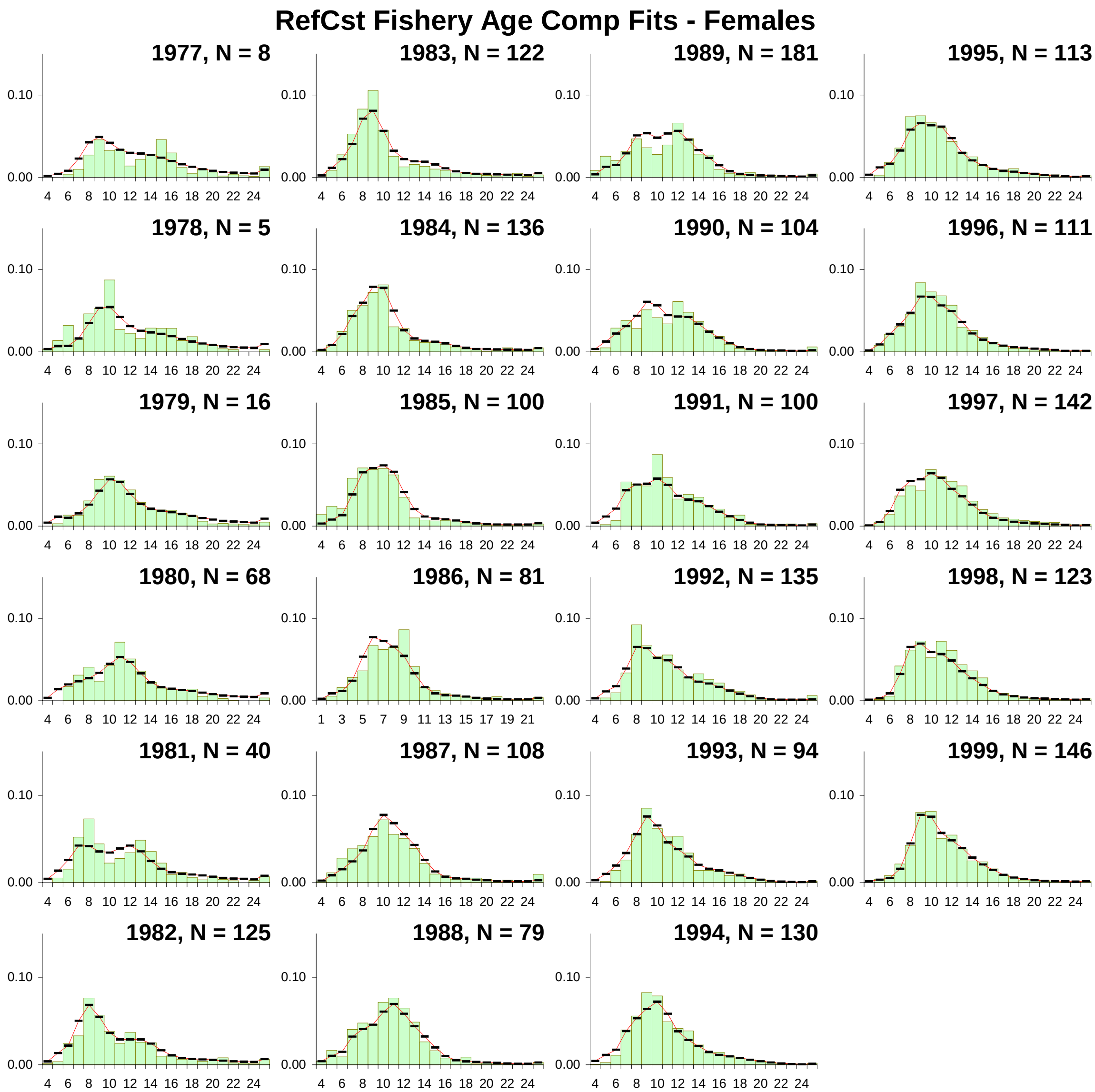


Figure 24. Fit to the female fishery age composition data for the Coast-wide Reference model configuration. [Bars are the observed values, lines are the predicted values].

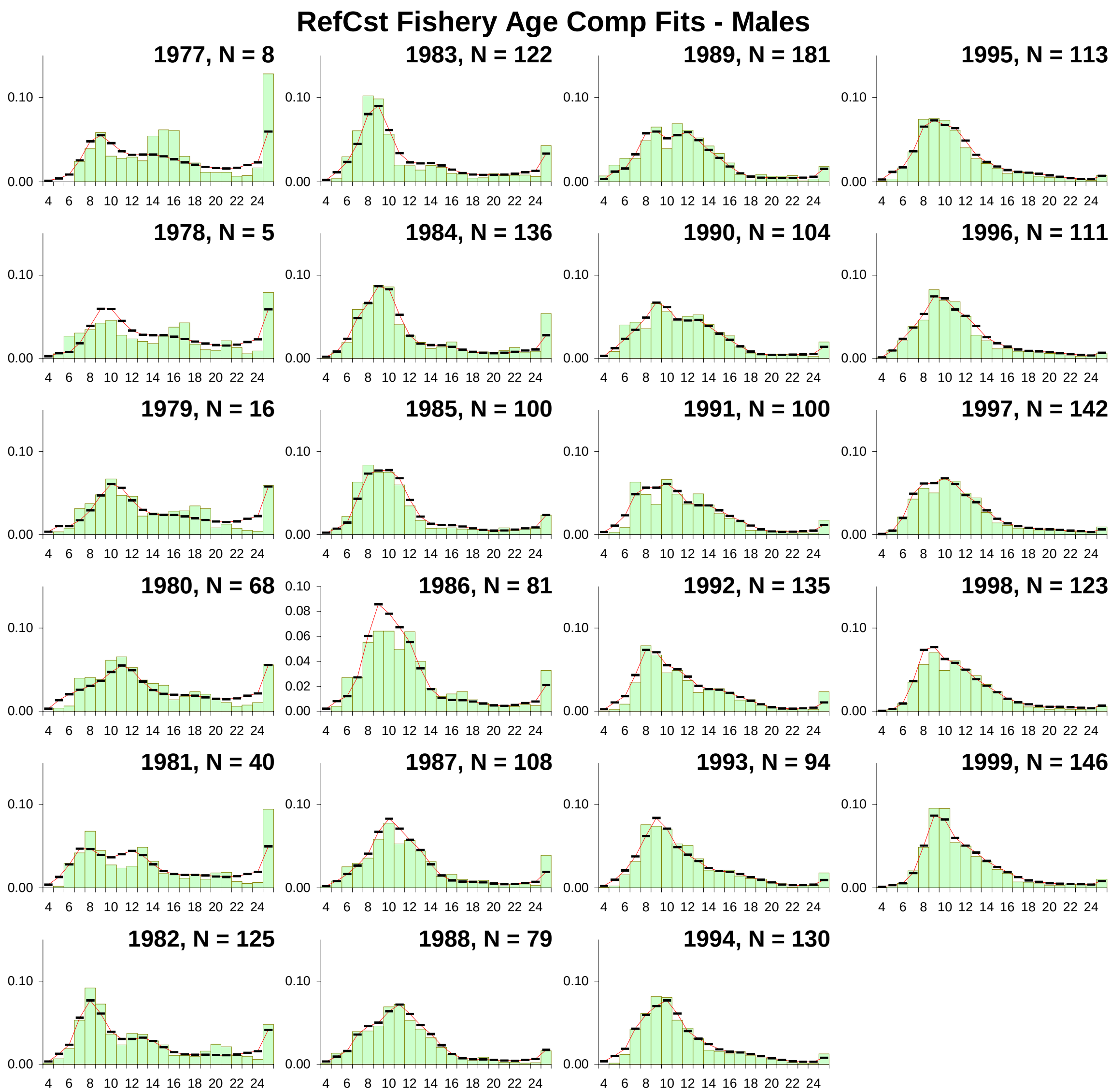


Figure 25. Fit to the male fishery age composition data for the Coast-wide Reference model configuration. [Bars are the observed values, lines are the predicted values].

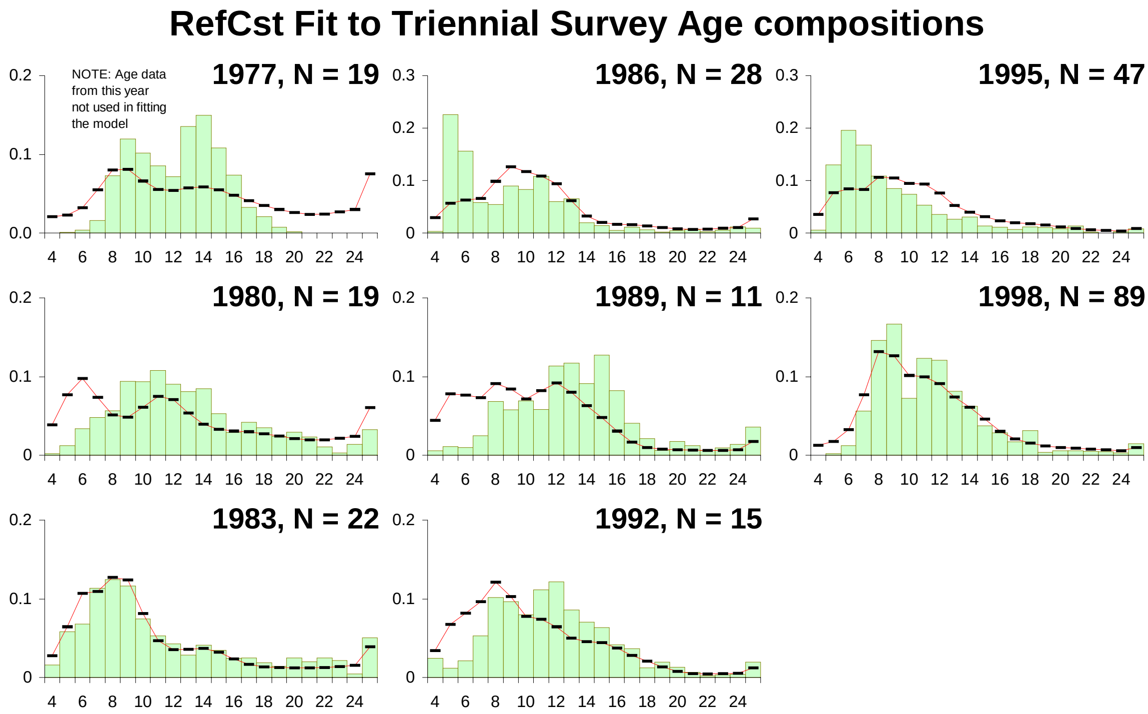


Figure 26. Fit to the survey age composition data for the Coast-wide Reference model configuration. [Bars are the observed values, lines are the predicted values].

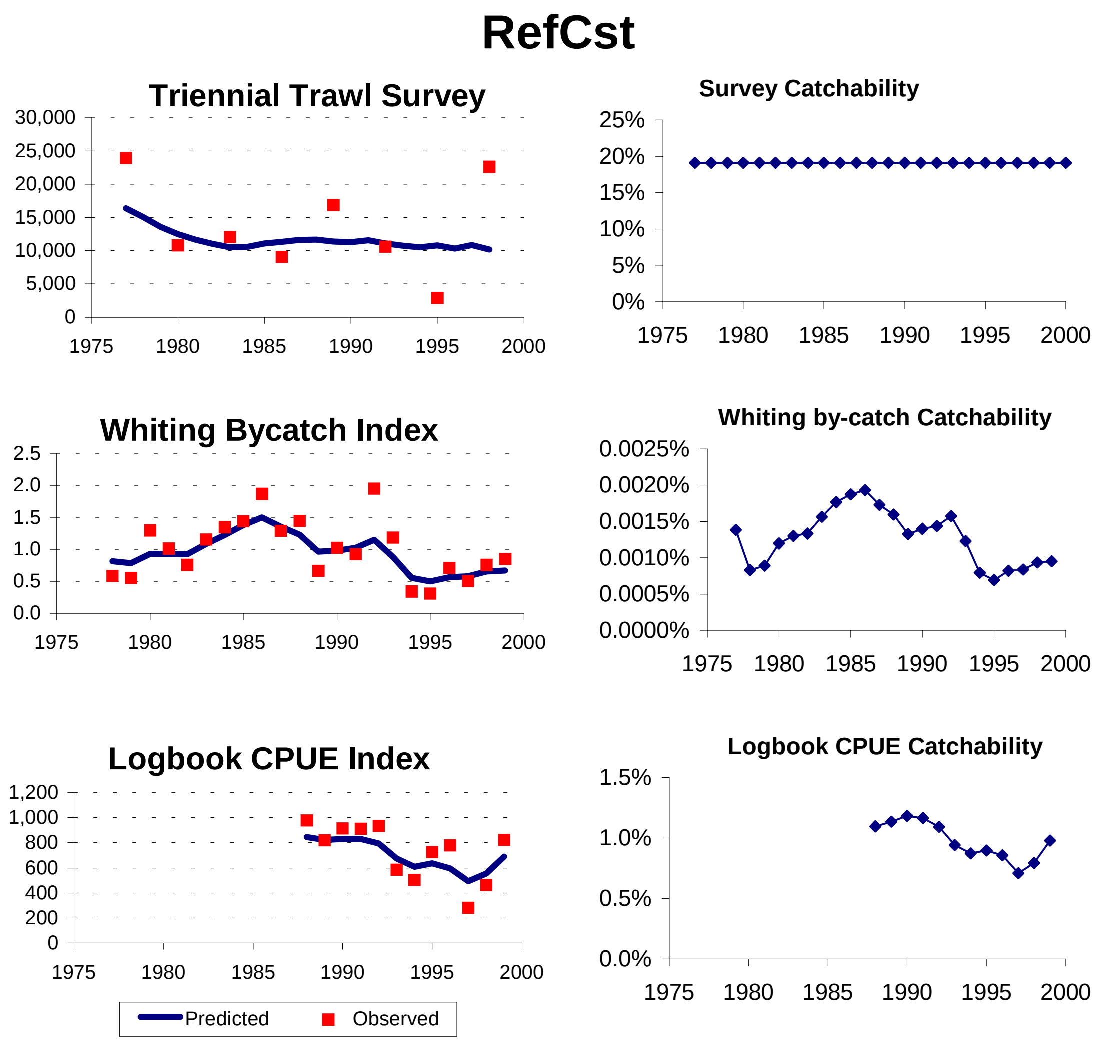


Figure 27. Yellowtail rockfish coast-wide reference case model fit to the auxiliary indices.

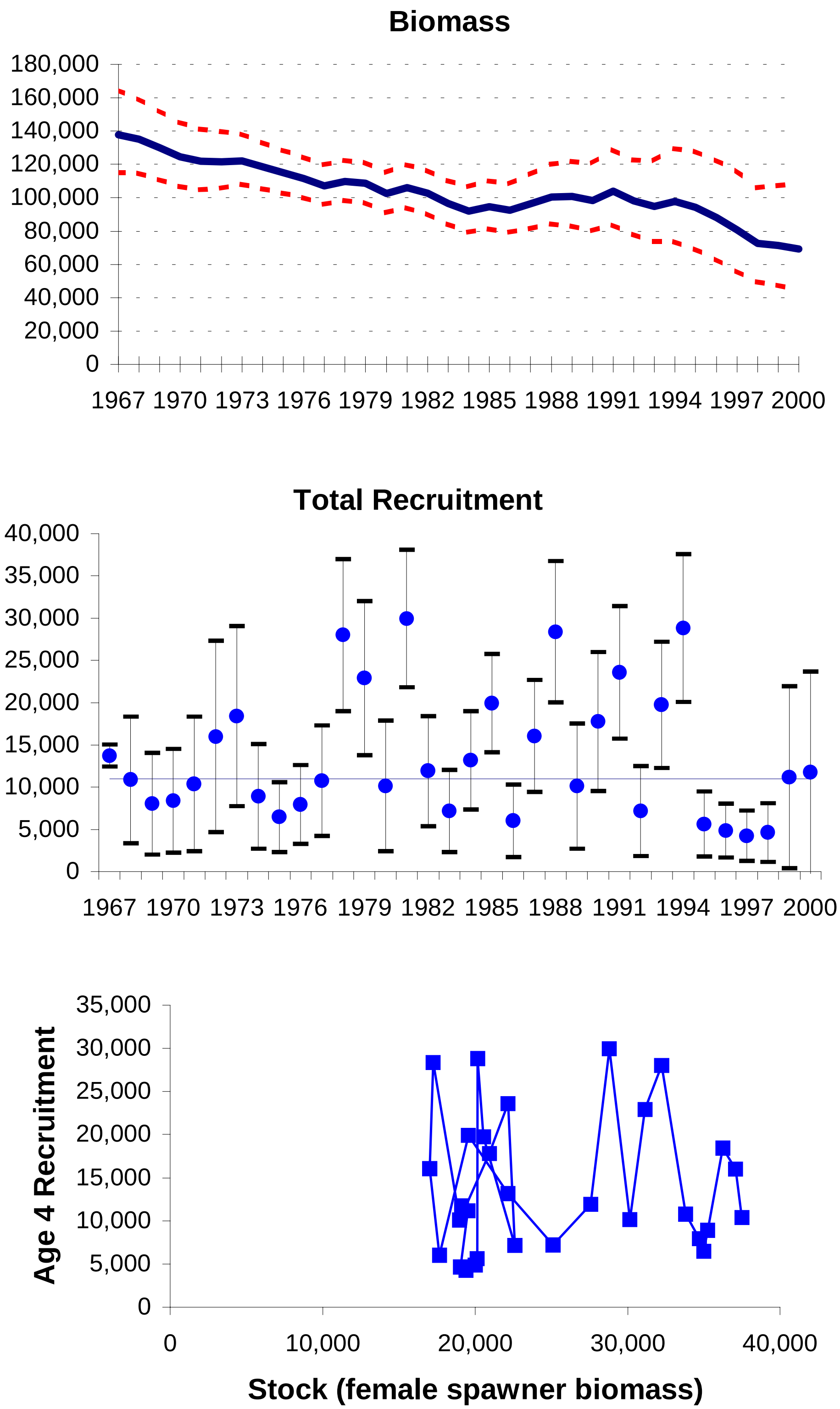


Figure 28. Yellowtail rockfish age 4+ biomass (mt), recruitment (numbers x1000) at age 4, and spawner/recruit relationship as estimated for the year 2000 reference model.

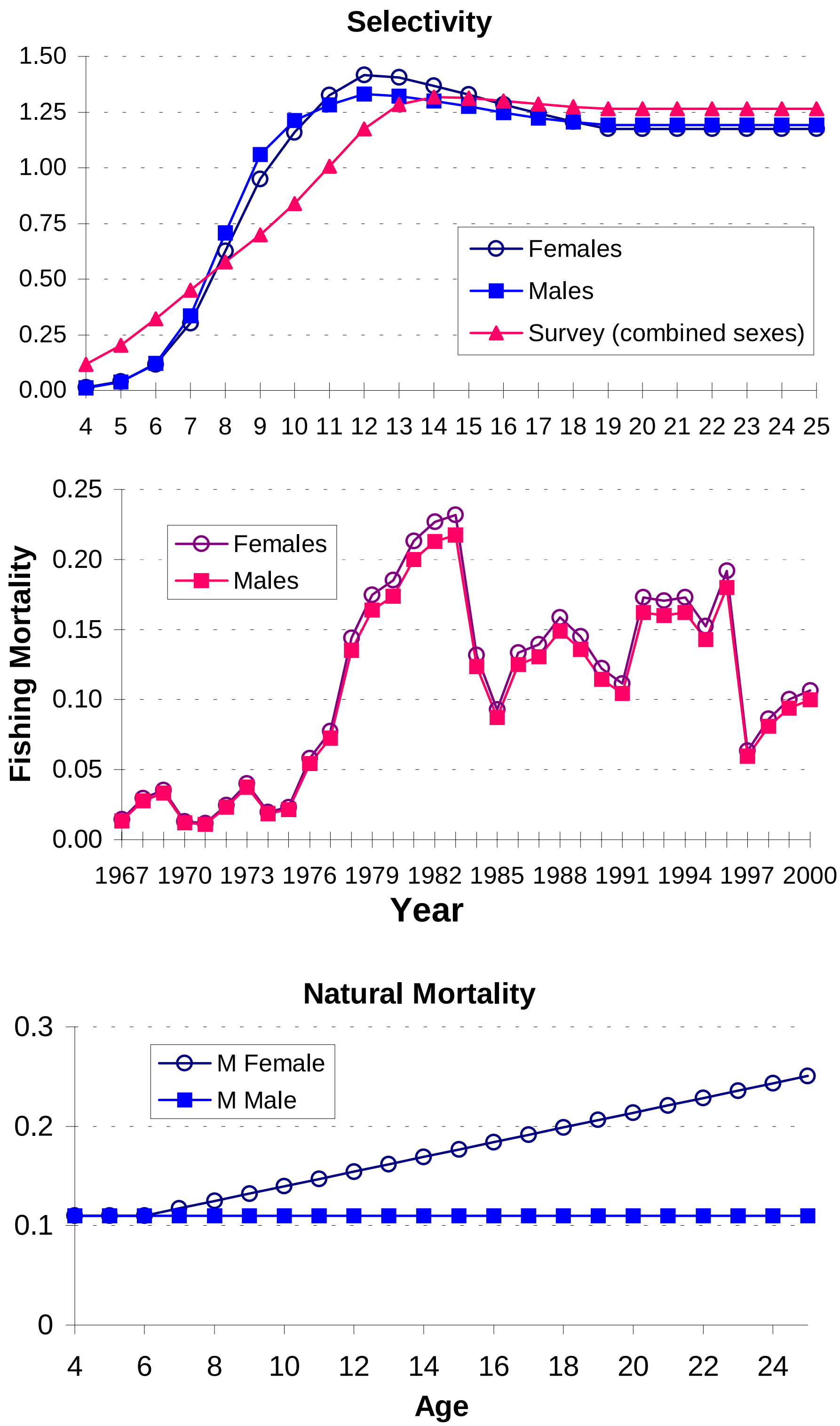


Figure 29. Yellowtail rockfish selectivity, fully selected fishing mortality (age 12) and age specific natural mortality as estimated for the year 2000 reference model.

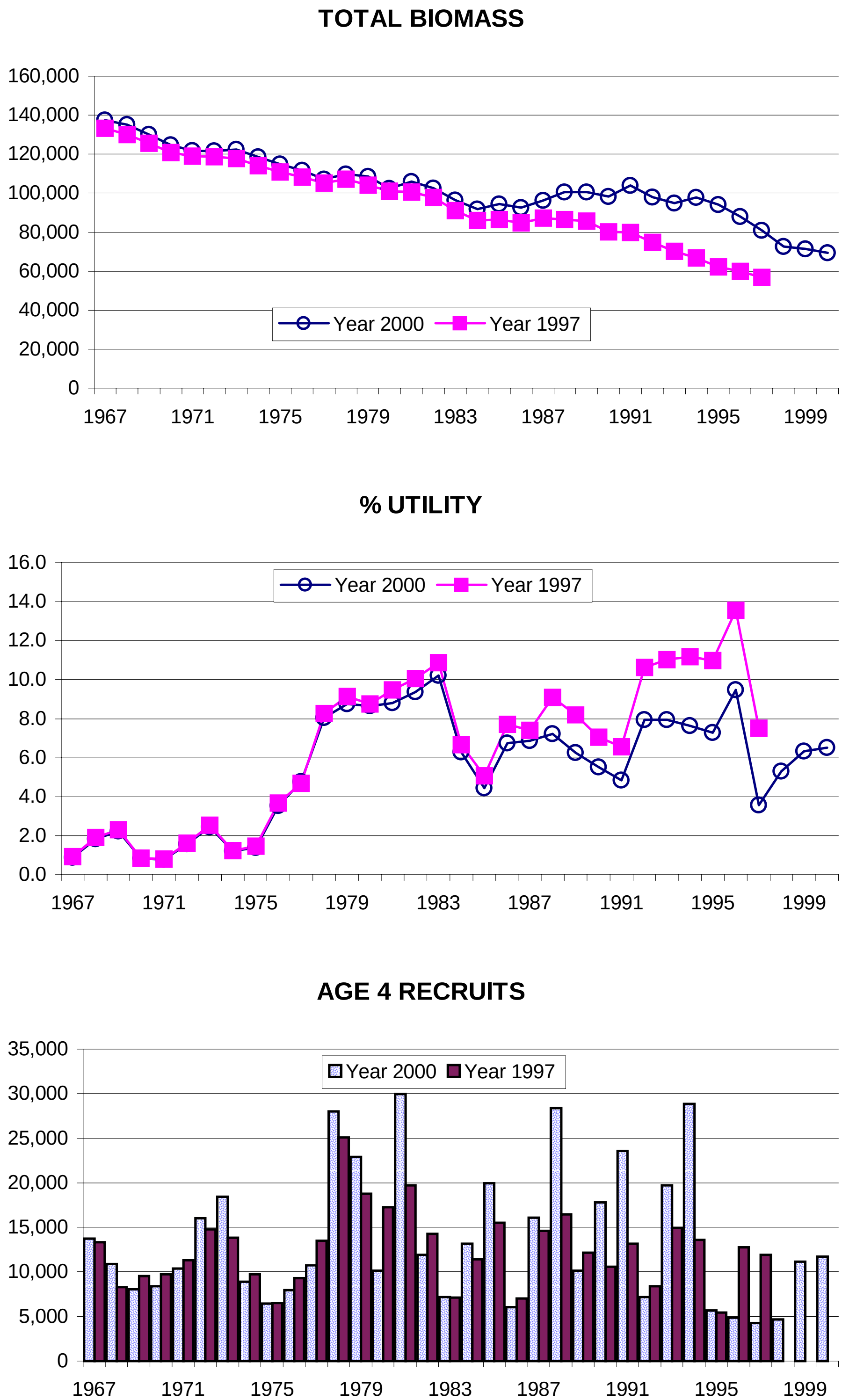


Figure 30. Comparison of estimated yellowtail rockfish biomass (mt), percent utility (Catch/Total Biomass) and recruitment (x1000) between the year 2000 Reference Model and the 1997 Model 8.

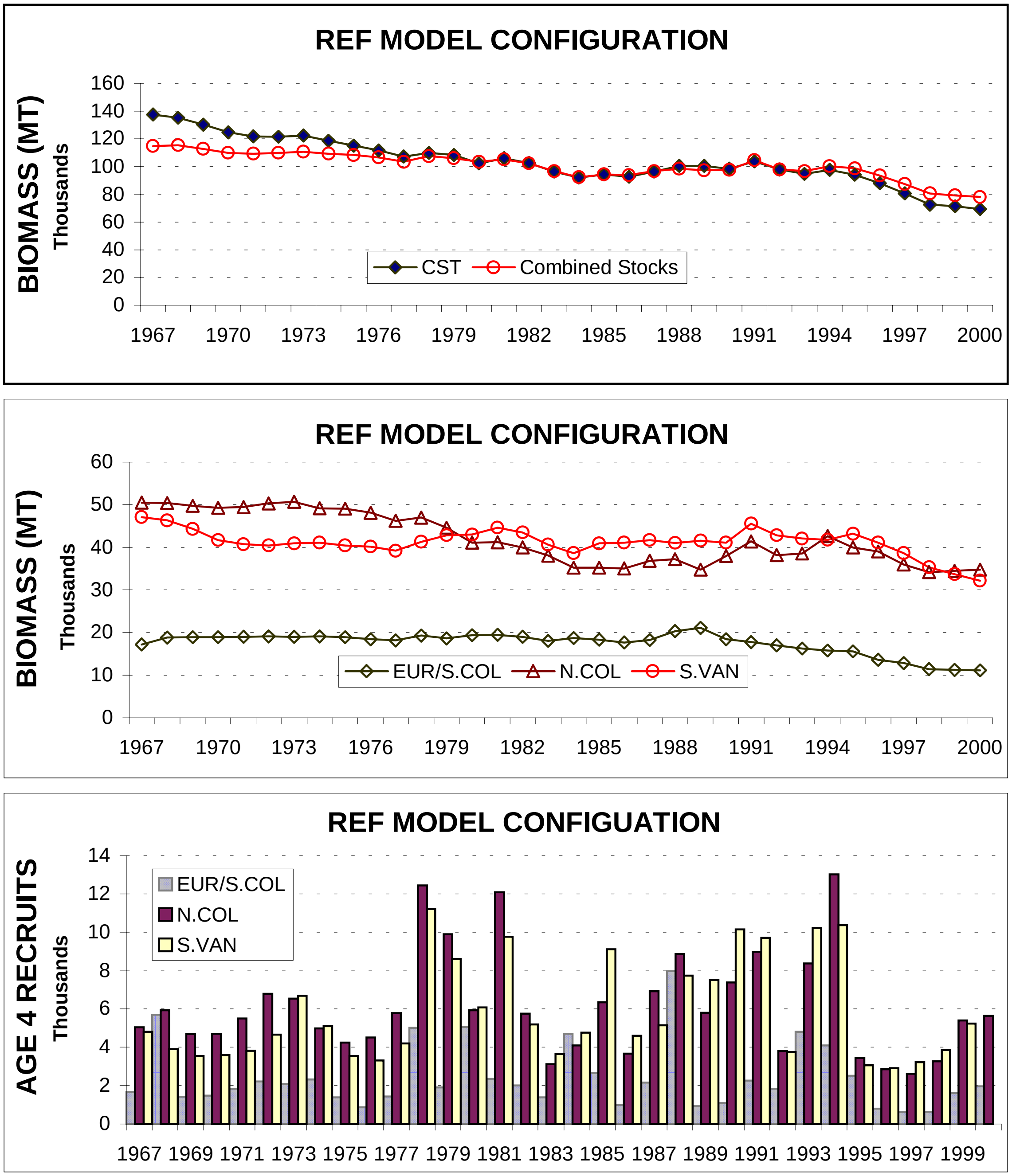


Figure 31. Trends in estimated biomass (mt) and recruitment (numbers) for individually assessed stock units (Eureka/S.Columbia, N.Columbia, and S.Vancouver) and comparison of cumulative biomass for the sum of the independent stocks with the estimated biomass for the coast-wide stock.

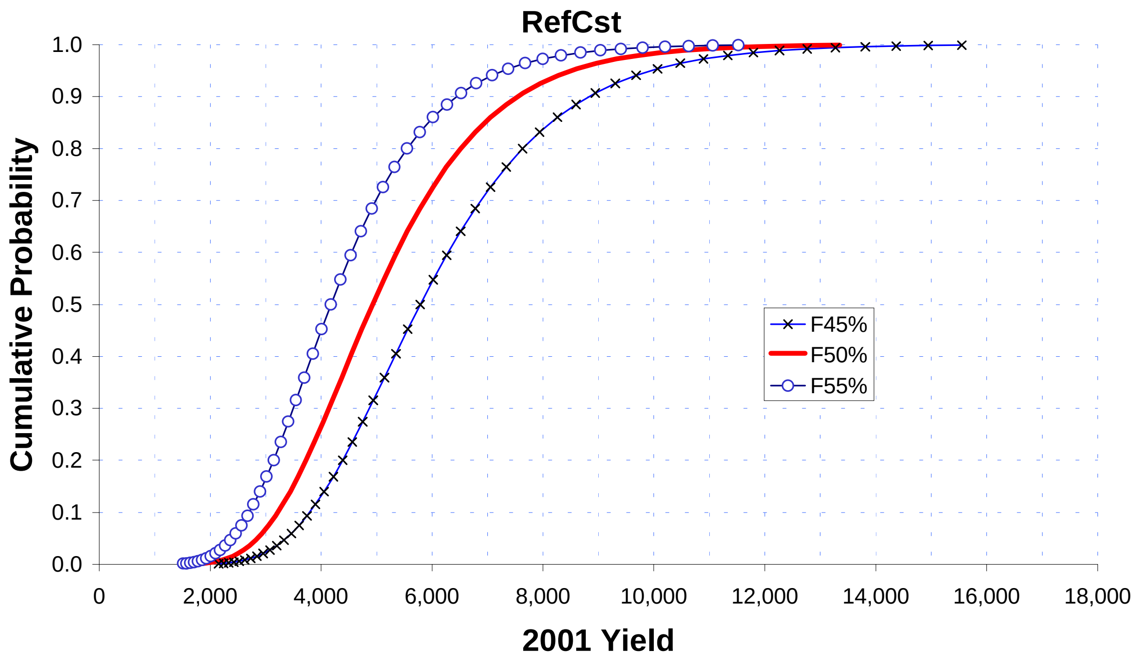


Figure 32. Cumulative probability distribution for the yellowtail rockfish 2001 yield estimates over a range of SPR fishing mortality rates. [Yield estimates based on the Ref Model using coast-wide data. Point estimates for yield are displayed at the intersection with the 0.5 Cumulative Probability.]

11.0 Appendicies

11.1 ADMB Source Code

```
   ///////////////////////////////////////////////////////////////////////
  //  Template File for Yellowtail rockfish
 //   James Ianelli, July 1997 (jianelli@afsc.noaa.gov)
///////////////////////////////////////////////////////////////////////
   // This template was used to produce results in
  //    Tagart et al., 1997, Pacific Fishery Mgt Council
 //
/////////////////////////////////////////////////////////////////////
   // Data notes: 1977 survey age comps based on surface ages and therefore
  //             not used in estimating selectivity
 //
///////////////////////////////////////////////////////////////////
DATA_SECTION
  init_int styr                            // Begin year of data
  init_int endyr                           // End year of data
  init_int nages                           // Number of age classes
  init_vector obs_catch_bio(styr,endyr)    // Observed catch Biomass

  init_int nobs_srv                        // Number of observations in survey
  init_ivector yrs_srv(1,nobs_srv)         // Actual years of survey occurrence
  init_vector obs_srv(1,nobs_srv)          // Biomass index values from survey

  init_vector nsamples_srv(1,nobs_srv)     // Number of age-samples assumed by yr
  init_matrix obs_ac_srv(1,nobs_srv,1,nages)// Observed numbers at age from survey

  init_int nobs_whi                        // Number of observations in Whiting Bycatch
index
  init_ivector yrs_whi(1,nobs_whi)         // Actual years of whiting bycatch index
  init_vector obs_whi(1,nobs_whi)          // Biomass index values from whiting bycatch

  init_int nobs_log                        // Number of observations in logbook CPUE
index
  init_ivector yrs_log(1,nobs_log)         // Actual years of logbook CPUE index
  init_vector obs_log(1,nobs_log)          // Biomass index values from logbook CPUE
  init_vector obs_log_se(1,nobs_log)       // Biomass index std errors from logbook CPUE
  !! cout << obs_log<<endl<<obs_log_se<<endl;
  init_int styr_fish                       // Year fishery age comps begin
  init_int endyr_fish                      // Year fishery age comps end
  init_vector nsamples_fish(styr_fish,endyr_fish)        // Number samples assumed for
fishery age comps
  init_3darray obs_ac_fish(1,2,styr_fish,endyr_fish,1,nages) // Sex, year, age fishery
age comps
  init_matrix age_err(1,nages,1,nages)     // Transition matrix of ageing errors
  init_3darray wt(1,2,styr,endyr,1,nages)  // Wt at sex, yr, and age
  init_vector maturity(1,nages)            // Maturity at age

  vector obs_sexr(styr_fish,endyr_fish)    // Observed sex ratio in fishery (computed
from above data)
  int i                                    // Index for year
  int j                                    // Index for age
  int k                                    // Index for sex
  int styr_q                               // start q-dev vector for fshry
  int styr_q_whi                           // start q-dev vector for whiting bycatch
  int styr_q_log                           // start q-dev vector for logbook cpue
 LOCAL_CALCS
   ad_comm::change_datafile_name("yt.ctl");
   styr_q=yrs_srv(1)+1;
   styr_q_whi=yrs_whi(1)+1;
   styr_q_log=yrs_log(1)+1;
 END_CALCS

  init_int ph_q_dev_srv   //Phase when survey catchability changes are estimated
```

```
  init_int ph_q_dev_whi   //Phase when whiting index catchability changes are estimated
  init_int ph_q_dev_log   //Phase when logbook index catchability changes are estimated
  init_int ph_sel_coffs   //Phase when smoothed selectivity parameters are estimated
  init_int ph_sel_log     //Phase when logistic sel parameters are estimated
  init_int ph_sel_srv     //Phase when survey selectivity parameters are est.
  init_int ph_q           //Phase when absolute survey catchability is estimated
  init_int ph_M_old       //Phase when M old age is estimated
  init_number ph_sigmau   //Phase to estimate sigmau (Logbook CPUE variance)
  init_number use_age_err //Flag to use (=1; or not use =0) ageing error trans. matrix
  init_int age_decrease   //Age beyond which to penalized dome-shapedness
  init_int sel_max_age    //Age behond which selectivity is held constant
  init_number Hist_F      //Historical F relative to styr F
  init_vector lambda(1,20)//Vector of wts etc (see .ctl file)

  int endyr_fut;
  int styr_fut;
  int nFs;
 LOCAL_CALCS
    int nyrs_future=12;
    endyr_fut=endyr+nyrs_future;
    styr_fut=endyr+1;
    nFs=3;
 END_CALCS

INITIALIZATION_SECTION
  M .11
  mean_log_rec 6.0
  avg_F -1.6
  log_q_srv -1.609437912 // Q = 0.2 as a default....
  log_q_log -2.9
  log_q_whi -11.9
  sel_coffs_srv -.01
  //sigmau .20
  F55 .1
  F50 .13
  F45 .23


PARAMETER_SECTION
  init_number mean_log_rec(1)
  //init_number prist_log_rec(1)
  init_number avg_F(1)
  init_bounded_vector rec_dev(styr,endyr,-8,8,3)
  init_bounded_dev_vector fmort_dev(styr,endyr,-6.,6.,2)
  init_bounded_dev_vector q_dev_srv(styr_q,endyr,-6.,6.,ph_q_dev_srv)
  init_bounded_dev_vector q_dev_whi(styr_q_whi,endyr,-6.,6.,ph_q_dev_whi)
  init_bounded_dev_vector q_dev_log(styr_q_log,endyr,-6.,6.,ph_q_dev_log)

  init_bounded_vector M(1,2,.1,.45,-1)
  init_bounded_number M_old(.02,.5,ph_M_old)
  init_matrix sel_coffs(1,2,1,sel_max_age,ph_sel_coffs)
  init_bounded_vector fish_sel50(1,2,1.,10.,ph_sel_log)
  init_bounded_vector fish_slope(1,2,0.001,10.,ph_sel_log)
  init_vector sel_coffs_srv(1,sel_max_age,ph_sel_srv)
  init_number log_q_srv(ph_q)
  init_number log_q_whi(1)
  init_number log_q_log(2)
  //init_bounded_number sigmau(0.05,2.,ph_sigmau)
  number sigmau
  !!sigmau=.22;

  init_bounded_number F55(0.05,1.,ph_sigmau)
  init_bounded_number F50(0.05,1.,ph_sigmau)
  init_bounded_number F45(0.05,1.,ph_sigmau)

  number sigmar
  number ftmp
  number SB0
  number SBF55
  number SBF50
  number SBF45
```

```
  number sprpen
  matrix Nspr(1,4,1,nages)

  3darray nage_future(1,2,styr_fut,endyr_fut,1,nages)
  init_vector rec_dev_future(styr_fut,endyr_fut,8);
  3darray F_future(1,2,styr_fut,endyr_fut,1,nages);
  3darray Z_future(1,2,styr_fut,endyr_fut,1,nages);
  3darray S_future(1,2,styr_fut,endyr_fut,1,nages);
  3darray catage_future(1,2,styr_fut,endyr_fut,1,nages);
  number avg_rec_dev_future


  vector fmort(styr,endyr)
  matrix log_sel(1,2,1,nages)
  vector log_sel_srv(1,nages)
  vector catchab_srv(styr,endyr)
  vector catchab_whi(styr,endyr)
  vector catchab_log(styr,endyr)
  matrix nat_mort(1,2,1,nages)
  matrix sel(1,2,1,nages)
  vector sel_srv(1,nages)
  vector avg_sel(1,2)
  number avg_sel_srv
  vector pred_srv(styr,endyr)
  vector pred_whi(styr,endyr)
  vector pred_log(styr,endyr)
  matrix popn(1,2,styr,endyr)
  number deltaM
  number yr_fraction
  3darray natage(1,2,styr,endyr,1,nages)
  3darray pred_p(1,2,styr,endyr,1,nages)
  3darray eac_srv(1,2,styr,endyr,1,nages)
  matrix pred_p_srv(styr,endyr,1,nages)

  //3darray u(1,2,styr,endyr,1,nages)
  3darray Z(1,2,styr,endyr,1,nages)
  3darray F(1,2,styr,endyr,1,nages)
  3darray S(1,2,styr,endyr,1,nages)
  3darray catage(1,2,styr,endyr,1,nages)
  3darray obs_p(1,2,styr_fish,endyr_fish,1,nages)
  matrix obs_p_srv(1,nobs_srv,1,nages)
  vector pred_catch_bio(styr,endyr)
  vector pred_sexr(styr,endyr)
  number rbar
  vector offset(1,2)
  number rec_like
  number q_like
  number M_like
  number sex_like
  number catch_like
  vector sel_like(1,10)
  vector age_like(1,2)
  number fpen
  vector index_like(1,3)
  sdreport_vector totbiom(styr,endyr)
  sdreport_vector rec(styr,endyr)
  sdreport_number depletion
  sdreport_matrix catch_future(1,3,styr_fut,endyr_fut);
  sdreport_matrix future_biomass(1,3,styr_fut,endyr_fut)

  likeprof_number stock01
  objective_function_value f

RUNTIME_SECTION
  maximum_function_evaluations 4000
  convergence_criteria 1e-3 1e-4 1e-7

PRELIMINARY_CALCS_SECTION
  yr_fraction=(8.5)/12;
  for (i=styr_fish; i <= endyr_fish; i++)
    obs_sexr(i)=sum(obs_ac_fish(1,i))/(sum(obs_ac_fish(1,i))+sum(obs_ac_fish(2,i)));
```

```
  //cout<<" ObsP "<< endl<<obs_ac_srv<<endl;
  // Normalize the survey age compositions
  for (i=1;i<=nobs_srv;i++)
    obs_p_srv(i)=obs_ac_srv(i)/(sum(obs_ac_srv(i)));

  for (k=1;k<=2;k++)
    for (i=styr_fish;i<=endyr_fish;i++)
      obs_p(k,i)=obs_ac_fish(k,i)/(sum(obs_ac_fish(1,i))+sum(obs_ac_fish(2,i)));
  for (k=1; k <= 2; k++)
  {
    for (i=styr_fish; i <= endyr_fish; i++)
    {
      // this is to mimic accumulation from synthesis
      obs_p(k,i,2)+=obs_p(k,i,1);
      for (j=2; j<=nages; j++)
        offset(1)-=nsamples_fish(i)*(1e-3+obs_p(k,i,j))* log((1e-3+obs_p(k,i,j)));
     }
   }
   //Computing offset for survey (ignoring 77 data)
   for (i=2; i<=nobs_srv; i++)
     for (j=1; j<=nages; j++)
       offset(2)-=nsamples_srv(i)* (1e-3+obs_p_srv(i,j))*log((1e-3+obs_p_srv(i,j)));

   if(use_age_err==0)
     for (j=1; j<=nages; j++)
       for (int jj=1; jj<=nages; jj++)
         if(jj==j)
           age_err(j,jj)=1.;
         else
           age_err(j,jj)=0.;

  cout<<" samplesize "<<endl<<nsamples_fish<<endl<<endl;
  cout<<" Offset "<<offset<<endl<<endl;
  cout<<" HistF"<<endl<< Hist_F<<endl;
  cout<<" Lambda "<<endl<< lambda<<endl;
  //cout<<" agerr "<<endl<< age_err<<endl;
  //cout<<" ObsP "<< endl<<obs_p_srv<<endl;


PROCEDURE_SECTION
  get_selectivity();
  get_mortality();
  get_numbers_at_age();
  get_predicted_values();
  get_catch_at_age();
  evaluate_the_objective_function();

FUNCTION get_selectivity

  if (ph_sel_coffs>0)
  {
    for (k=1;k<=2;k++)
    {
      log_sel(k)(1,sel_max_age)=sel_coffs(k);
      log_sel(k)(sel_max_age+1,nages)=sel_coffs(k,sel_max_age);
      avg_sel(k)=log(mean(mfexp(log_sel(k))));
      log_sel(k)-=log(mean(exp(log_sel(k))));
      sel(k)=mfexp(log_sel(k));
    }
  }
  else
  {
    for (k=1;k<=2;k++)
      for (j=1; j<=nages; j++)
         sel(k,j)=1./(1.+mfexp(-1.*fish_slope(k)*(double(j)-fish_sel50(k))));

  }

  log_sel_srv(1,sel_max_age)=sel_coffs_srv;
  log_sel_srv(sel_max_age+1,nages)=sel_coffs_srv(sel_max_age);
```

```
  avg_sel_srv=log(mean(mfexp(log_sel_srv)));
  log_sel_srv-=log(mean(exp(log_sel_srv)));
  sel_srv=mfexp(log_sel_srv);

FUNCTION get_mortality
  fmort=mfexp(avg_F+fmort_dev);
  nat_mort(1)(1,3)=M(1);
  nat_mort(2)=M(2);
  deltaM=(M_old-M(1))/19.;
  for (j=4;j<=nages;j++)
    nat_mort(1,j)=nat_mort(1,j-1)+deltaM;

  for (k=1;k<=2;k++)
   {
    for (i=styr;i<=endyr;i++)
      {
        F(k,i) = sel(k) * fmort(i);
        Z(k,i) = F(k,i) + nat_mort(k);
      }
    }
  S=mfexp(-1.0*Z);

// Catchability in initial years
  catchab_srv(yrs_srv(1)) = exp(log_q_srv);
  catchab_whi(yrs_whi(1)) = exp(log_q_whi);
  catchab_log(yrs_log(1)) = exp(log_q_log);

  if (active(q_dev_srv))
     for (i=styr_q;i<=endyr;i++)
        catchab_srv(i) = catchab_srv(i-1)*exp(q_dev_srv(i));
  else
    catchab_srv = catchab_srv(yrs_srv(1));

  if (active(q_dev_whi))
    for (int i =styr_q_whi;i<=endyr;i++)
      catchab_whi(i) = catchab_whi(i-1)*exp(q_dev_whi(i));
  else
    catchab_whi = catchab_whi(yrs_whi(1)) ;

  if (active(q_dev_log))
    for (i=styr_q_log;i<=endyr;i++)
        catchab_log(i) = catchab_log(i-1)*exp(q_dev_log(i));
  else
    catchab_log = catchab_log(yrs_log(1)) ;


FUNCTION get_numbers_at_age
  // Initial Age composition here
  natage(1,styr,1)=mfexp(mean_log_rec+rec_dev(styr));
  natage(2,styr,1)=natage(1,styr,1);
  for (j=2;j<nages;j++)
    {
      natage(1,styr,j)=natage(1,styr,j-1)*mfexp(
                      -1.*(F(1,styr,j-1)*Hist_F+nat_mort(1,j-1)));
      natage(2,styr,j)=natage(2,styr,j-1)*mfexp(
                      -1.*(F(2,styr,j-1)*Hist_F+nat_mort(2,j-1)));
    }
  //Cumulative Plus group in initial age comp-------------------
    natage(1,styr,nages)=natage(1,styr,nages-1)*
                         mfexp(-1.*(F(1,styr,nages-1)*Hist_F+nat_mort(1,nages)))
                /(1.-exp(-1.*(F(1,styr,nages)*Hist_F+nat_mort(1,nages))));

    natage(2,styr,nages)=natage(2,styr,nages-1)*
                         mfexp(-1.*(F(2,styr,nages-1)*Hist_F+nat_mort(2,nages)))
                   /(1.-exp(-1.*(F(2,styr,nages)*Hist_F+nat_mort(2,nages))));

 // Now do for next several years---------------------------------
  for (i=styr+1;i<=endyr;i++)
    {
      natage(1,i,1)=mfexp(mean_log_rec+rec_dev(i));
      natage(2,i,1)=natage(1,i,1);
```

```
    }

  for (k=1;k<=2;k++)
  {
    for (i=styr;i<endyr;i++)
    {
      natage(k,i+1)(2,nages) = ++elem_prod(natage(k,i)(1,nages-1),
                                    S(k,i)(1,nages-1));
       natage(k,i+1,nages)+=natage(k,i,nages)*S(k,i,nages);
       popn(k,i)=natage(k,i)*sel(k);
    }
    popn(k,endyr)=natage(k,endyr)*sel(k);
  }
  if (last_phase())
  {
   future_biomass=0.;
   catch_future=0.;
   for (int l=1;l<=3;l++)
   {
    switch (l)
   {
    case 1:
     ftmp=F55;
     break;
    case 2:
     ftmp=F50;
     break;
    case 3:
     ftmp=F45;
     break;
   }

    for (k=1;k<=2;k++)
    {
    // Get future F's
      for (i=endyr+1;i<=endyr_fut;i++)
      {
      for (j=1;j<=nages;j++)
         {
          F_future(k,i,j) = sel(k,j)*ftmp;
          Z_future(k,i,j) = F_future(k,i,j)+nat_mort(k,j);
          S_future(k,i,j) = exp(-1.*Z_future(k,i,j));
         }
      }
      for (i=styr_fut;i<=endyr_fut;i++)
      {
        nage_future(k,i,1)=exp(mean_log_rec + rec_dev_future(i));
      }

      nage_future(k,styr_fut)(2,nages)=++elem_prod(natage(k,endyr)(1,nages-
1),S(k,endyr)(1,nages-1));
      nage_future(k,styr_fut,nages)+=natage(k,endyr,nages)*S(k,endyr,nages);

      for (i=styr_fut;i<endyr_fut;i++)
      {
        nage_future(k,i+1)(2,nages)=++elem_prod(nage_future(k,i)(1,nages-1),
                                     S_future(k,i)(1,nages-1));
        nage_future(k,i+1,nages)+=nage_future(k,i,nages)*S_future(k,i,nages);
      }

    // Now get catch at future ages
      for (i=styr_fut; i<=endyr_fut; i++)
      {
        for (j = 1 ; j<= nages; j++)
        {
         catage_future(k,i,j) = nage_future(k,i,j) * F_future(k,i,j) *
                       (1.- S_future(k,i,j) ) / Z_future(k,i,j);
        }
     catch_future(l,i)    +=catage_future(k,i)*wt(k,endyr);
     future_biomass(l,i)  +=nage_future(k,i)*wt(k,endyr);
     }
```

```
   } // End of loop over Sex
  }   //End of loop over F's
 }   //End of Future_phase


FUNCTION get_predicted_values
 //Now get predictive parts-------------------------
  pred_srv=0.;
  pred_whi=0.;
  pred_log=0.;
  for (i=styr;i<=endyr;i++)
  {
    for (k=1;k<=2;k++)
    {
      pred_p(k,i)=(elem_prod(sel(k),natage(k,i))/ (popn(1,i)+popn(2,i)))*age_err;

      for (j = 1 ; j<= nages; j++)
      {
        eac_srv(k,i,j)=  sel_srv(j)* pow(S(k,i,j),yr_fraction)* natage(k,i,j);
        pred_srv(i)+=eac_srv(k,i,j)*wt(k,i,j);
        pred_whi(i)+=catchab_whi(i)*wt(k,i,j)*sel(k,j)*natage(k,i,j);
        pred_log(i)+=catchab_log(i)*wt(k,i,j)*sel(k,j)*natage(k,i,j);
      }
    }
    pred_p_srv(i)=(eac_srv(1,i)+eac_srv(2,i))/ sum((eac_srv(1,i)+eac_srv(2,i)))*age_err;
    pred_srv(i)*=catchab_srv(i);
  }

  if (sd_phase())
  {
    for (i=styr;i<=endyr;i++)
    {
      totbiom(i)=(natage(1,i)*wt(1,i)) + (natage(2,i)*wt(2,i));
      rec(i)=natage(1,i,1) + natage(2,i,1);
    }
    depletion=totbiom(endyr)/totbiom(styr);
  }
  stock01=elem_prod(natage(1,endyr),wt(1,endyr))*S(1,endyr) +
elem_prod(natage(2,endyr),wt(2,endyr))*S(2,endyr);

FUNCTION get_catch_at_age
  pred_catch_bio.initialize();
  for (i=styr; i<=endyr; i++)
    for (k=1;k<=2;k++)
      for (j = 1 ; j<= nages; j++)
      {
        //--Baranov's equation here-----------------------------------
        catage(k,i,j)     = natage(k,i,j)*F(k,i,j)*(1.-S(k,i,j))/Z(k,i,j);
        pred_catch_bio(i)+=catage(k,i,j)*wt(k,i,j);
      }

FUNCTION evaluate_the_objective_function
  catch_like=lambda(3)*norm2(log(obs_catch_bio)-log(pred_catch_bio));

  index_like(1)= lambda(9) * norm2(log(obs_srv + .001)-log(pred_srv(yrs_srv)+.001));
  index_like(2)=lambda(10) * norm2(log(obs_whi + .001)-log(pred_whi(yrs_whi)+.001));
  //index_like(3)=0.;
  index_like(3)=lambda(11)*(norm2(log(obs_log+.001)-
log(pred_log(yrs_log)+.001))/(2*sigmau*sigmau)+size_count(obs_log)*log(sigmau));

  //for (i=1;i<=nobs_log;i++)
  //{
    //index_like(3) += square(obs_log(i) - pred_log(yrs_log(i)))
/(2*obs_log_se(i)*obs_log_se(i));
  //}
  //index_like(3) *= lambda(11);

  //cout << index_like(3)<<" "<<lambda(11)<<endl;

  //index_like(3)=lambda(11)*norm2(log(obs_log+ .001)- log(pred_log(yrs_log)+.001));
```

```
  age_like=0.;

  for (k=1; k <= 2; k++)
    for (i=styr_fish; i <= endyr_fish; i++)
    {
     // this is to mimic accumulation from synthesis
      pred_p(k,i,2)+=pred_p(k,i,1);
      for (j=2; j<=nages; j++)
        age_like(1)-=nsamples_fish(i)*(1e-3+obs_p(k,i,j))*log(1e-3+pred_p(k,i,j));
    }

  //cout<<age_like(1)<<endl;
  // cout<<nsamples_fish <<endl;
  age_like(1)-=offset(1);
//Computing multinomial for survey age comp data (ignoring 1977 (first obs))
  for (i=2; i <= nobs_srv; i++)
    age_like(2)-=nsamples_srv(i)*(1e-3+obs_p_srv(i))*log(1e-3+pred_p_srv(yrs_srv(i)));

  //cout<<nsamples_srv <<endl;
  //cout<<age_like(1)<<endl;
  age_like(2)-=offset(2);
  age_like(2)*=lambda(16);  // This is to have the option to turn this part off

// Prior kind of stuff here----------------------------------------------------
  rec_like=lambda(1)*norm2(rec_dev); //Regularity assumption about recruitment
variability
  sigmar   =  norm2(rec_dev)/size_count(rec_dev);
  // This sets variability of future recruitment to same as in past....
  rec_like+= norm2(rec_dev_future)/(2.*sigmar+.001);

  sel_like=0.;
  if (ph_sel_coffs>0)
  {
    sel_like(1)=lambda(5)*norm2(first_difference(first_difference(log_sel(1))));
    sel_like(2)=lambda(6)*norm2(first_difference(first_difference(log_sel(2))));
    sel_like(7)=lambda(4)*norm2(log_sel(2)-log_sel(1));
    for (k=1; k <= 2; k++)
      for (j=age_decrease; j <= nages; j++)
          if (sel(k,j-1)>sel(k,j)) sel_like(4)+=lambda(2) * square(log_sel(k,j-1)-
log_sel(k,j));
  }
  sel_like(3)=lambda(7)*norm2(first_difference(first_difference(log_sel_srv)));

  //For survey selectivity dome-shapedness
  for (j=age_decrease; j <= nages; j++)
    if (sel_srv(j-1)>sel_srv(j))
      sel_like(5)+=lambda(8) * square(log_sel_srv(j-1)-log_sel_srv(j));

  // Normalizing part of selectivity vector (to give it mean zero, log-scale)
  sel_like(6) = norm2(avg_sel) + square(avg_sel_srv);

  // Phases less than 5, penalize low F's
  if(current_phase() < 5)
    fpen=10.*square(mfexp(avg_F)-.1);

  fpen=lambda(12)*norm2(fmort_dev);

  q_like  = lambda(13)*norm2(q_dev_srv);
  q_like += lambda(14)*norm2(q_dev_whi);
  q_like += lambda(15)*norm2(q_dev_log);

  if (active(F55))
  { //Compute SPR Rates and add them to the likelihood for Females
    SB0=0.;
    SBF55=0.;
    SBF50=0.;
    SBF45=0.;
    for (i=1;i<=4;i++)
      Nspr(i,1)=1.;

       for (j=2;j<nages;j++)
```

```
      {
          Nspr(1,j)=Nspr(1,j-1)*exp(-1.*nat_mort(1,j-1));
          Nspr(2,j)=Nspr(2,j-1)*exp(-1.*(nat_mort(1,j-1)+F55*sel(1,j-1)));
          Nspr(3,j)=Nspr(3,j-1)*exp(-1.*(nat_mort(1,j-1)+F50*sel(1,j-1)));
          Nspr(4,j)=Nspr(4,j-1)*exp(-1.*(nat_mort(1,j-1)+F45*sel(1,j-1)));
        }
        Nspr(1,nages)=Nspr(1,nages-1)*exp(-1.*nat_mort(1,nages-1))/ (1.-exp(-
1.*nat_mort(1,nages)));
        Nspr(2,nages)=Nspr(2,nages-1)*exp(-1.* (nat_mort(1,nages-1)+F55*sel(1,nages-
1)))/
                        (1.-exp(-1.*(nat_mort(1,nages)+F55*sel(1,nages))));
        Nspr(3,nages)=Nspr(3,nages-1)*exp(-1.*
                    (nat_mort(1,nages-1)+F50*sel(1,nages-1)))/
                        (1.-exp(-1.*(nat_mort(1,nages)+F50*sel(1,nages))));
        Nspr(4,nages)=Nspr(4,nages-1)*exp(-1.*
                    (nat_mort(1,nages-1)+F45*sel(1,nages-1)))/
                        (1.-exp(-1.*(nat_mort(1,nages)+F45*sel(1,nages))));

       for (j=1;j<=nages;j++)
       {
         SB0  +=Nspr(1,j)*maturity(j)*wt(1,endyr,j)*exp(-0.25*nat_mort(1,j));
         SBF55  +=Nspr(2,j)*maturity(j)*wt(1,endyr,j)*exp(-0.25*(
                  nat_mort(1,j)+F55*sel(1,j)));
         SBF50 +=Nspr(3,j)*maturity(j)*wt(1,endyr,j)*exp(-0.25*(
                  nat_mort(1,j)+F50*sel(1,j)));
         SBF45  +=Nspr(4,j)*maturity(j)*wt(1,endyr,j)*exp(-0.25*(
                  nat_mort(1,j)+F45*sel(1,j)));
   }
   sprpen =100.*square(SBF55/SB0-0.55);
   sprpen+=100.*square(SBF50/SB0-0.50);
   sprpen+=100.*square(SBF45/SB0-0.45);
  }


  // Sum all components---------------------------
  f+=sum(index_like);
  f+=sum(sel_like);
  f+=rec_like;
  f+=catch_like;
  f+=sum(age_like);
  f+=q_like;
  f+=fpen;
  f+=sprpen;

REPORT_SECTION
  report << "Estimated numbers of fish " << endl;
  report << natage << endl;
  report << "Estimated catch numbers " << endl;
  report << catage << endl;
  report << "Estimated F mortality " << endl;
  report << F << endl;
  report << "Observed Survey 1 " << endl;
  report << obs_srv << endl;
  report << "Predicted Survey 1 " << endl;
  report << pred_srv << endl;
  report << "Observed Prop " << endl;
  for (k=1;k<=2;k++)
  {
    for (i=1974;i<=endyr_fish;i++)
    {
      if (i<styr_fish) report <<  endl;
      if (i>=styr_fish) report << obs_p(k,i) << endl;
    }
  }
  report << "Predicted prop  " << endl;
  report << pred_p << endl;
  report << "Observed catch biomass " << endl;
  report << obs_catch_bio << endl;
  report << "predicted catch biomass " << endl;
  report << pred_catch_bio << endl;
  report << "Estimated annual fishing mortality " << endl;
```

```
  report << fmort << endl;
  report << "Estimated Selectivity " << endl;
  report << sel << endl;
  report << "Observed, Predicted Sex Ratio " << endl;
  report << (obs_sexr) << endl;
  for (i=styr;i<=endyr;i++)
    pred_sexr(i)=popn(1,i)/(popn(1,i)+popn(2,i));
  report << (pred_sexr) << endl;
  report << "totbiom" << endl;
  for (i=styr;i<=endyr;i++)
    report << (natage(1,i)*wt(1,i)) + (natage(2,i)*wt(2,i)) <<" ";
  report <<endl;
  report << "Natural Mortality (females, males)" << endl;
  report << nat_mort << endl;
  report << catchab_srv << endl;
  report << "Observed Whiting  " << endl;
  report << yrs_whi << endl;
  report << obs_whi << endl;
  report << "Predicted Whiting  " << endl;
  report << pred_whi << endl;
  report << "Observed logbook " << endl;
  report << yrs_log << endl;
  report << obs_log << endl;
  report << "Predicted logbook " << endl;
  report << pred_log << endl;
  report << "catchabilities, Survey, Whiting, Logbook" << endl;
  report << catchab_srv << endl;
  report << catchab_whi  << endl;
  report << catchab_log  << endl;

  report << "Observed Prop Survey data" << endl;
  report << obs_p_srv << endl;
  report << "Predicted prop survey" << endl;
  report << pred_p_srv << endl;
  report << "Survey Selectivity " << endl;
  report << sel_srv << endl;
  report << "Likelihoods: Survey, sel, rec, catch, age, q, Fpen"<<endl;
  report << "Survey: "<< index_like <<endl;
  report << "Selectivity: "<< sel_like  <<endl;
  report << "Recruitment: "<< rec_like  <<endl;
  report << "Catch_Biom: "<< catch_like<<endl;
  report << "AgeComp: "<< age_like  <<endl;
  report << "Catchability: "<< q_like    <<endl;
  report << "Fmort: "<< fpen      <<endl;
  report << "Sigma for Logbook CPUE data"      <<endl;
  report << sigmau      <<endl;
  report << "SBF50, F55, F50, F45  ok CPUE data"      <<endl;
  report << SBF50<< " " << F55<<" "<<F50<<" "<<F45<<" "<<endl;

TOP_OF_MAIN_SECTION
  gradient_structure::set_MAX_NVAR_OFFSET(1600);
  gradient_structure::set_GRADSTACK_BUFFER_SIZE(200000);
  gradient_structure::set_CMPDIF_BUFFER_SIZE(2000000);
  arrmblsize=500000;
```

11.2 Parameter file for RefCst

```
# Number of parameters = 171  Objective function value = 142.284  Maximum gradient
component = 4.65524e-05
# mean_log_rec:
8.67637
# avg_F:
-2.84391
# rec_dev:
```

```
 0.158821 -0.0771789 -0.375877 -0.335349 -0.121370 0.311020 0.451305 -0.274161 -0.595757
-0.388804 -0.0864577 0.870522 0.670039 -0.144524 0.937466 0.0154797 -0.490185 0.117072
0.530609 -0.664785 0.314042 0.884038 -0.148075 0.417081 0.698383 -0.492474 0.520022
0.899648 -0.731800 -0.877944 -1.01532 -0.926372 -0.0491709 5.29202e-05
# fmort_dev:
 -1.75532 -1.02865 -0.847033 -1.86260 -1.95124 -1.21299 -0.724255 -1.43033 -1.27902 -
0.352925 -0.0640395 0.557310 0.751326 0.808691 0.949941 1.01141 1.03347 0.468792 0.119512
0.480130 0.524171 0.653964 0.562800 0.392694 0.300138 0.740717 0.727182 0.740340 0.612983
0.844607 -0.263034 0.0431520 0.194369 0.253735
# q_dev_srv:
 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000
# q_dev_whi:
 0.0725748 0.294319 0.0813431 0.0288241 0.158307 0.120672 0.0585280 0.0290838 -0.109891 -
0.0798822 -0.183687 0.0521953 0.0267224 0.0921128 -0.247573 -0.438104 -0.131051 0.160887
0.0200024 0.114978 0.0158280 -0.136189
# q_dev_log:
 0.0357814 0.0381970 -0.0136050 -0.0630662 -0.148326 -0.0746424 0.0240453 -0.0449224 -
0.186918 0.113199 0.206954 0.113304
# M:
 0.110000 0.110000
# M_old:
0.250431
# sel_coffs:
 -4.30290 -3.21404 -2.14880 -1.19965 -0.470178 -0.0518207 0.146681 0.282914 0.348726
0.339925 0.313932 0.283672 0.250094 0.218264 0.187498 0.160164
 -4.52375 -3.30261 -2.11832 -1.09268 -0.346163 0.0582815 0.192289 0.248707 0.284705
0.278398 0.262451 0.243464 0.220338 0.200474 0.185871 0.174688
# fish_sel50:
 5.50000 5.50000
# fish_slope:
 5.00050 5.00050
# sel_coffs_srv:
 -2.13921 -1.59601 -1.13597 -0.798998 -0.551128 -0.360284 -0.174318 0.00620653 0.161255
0.250767 0.274807 0.271337 0.261953 0.251311 0.241031 0.233708
# log_q_srv:
-1.65553
# log_q_whi:
-11.6992
# log_q_log:
-4.51363
# F55:
0.0759488
# F50:
0.0903813
# F45:
0.107237
# rec_dev_future:
 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000
```